Linux Gpu Documentation

The kernel development community

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CONTENTS

CHAPTER

ONE

INTRODUCTION

The Linux DRM layer contains code intended to support the needs of complex graphics devices, usually containing programmable pipelines well suited to 3D graphics acceleration. Graphics drivers in the kernel may make use of DRM functions to make tasks like memory management, interrupt handling and DMA easier, and provide a uniform interface to applications.

A note on versions: this guide covers features found in the DRM tree, including the TTM memory manager, output configuration and mode setting, and the new vblank internals, in addition to all the regular features found in current kernels.

[Insert diagram of typical DRM stack here]

1.1 Style Guidelines

For consistency this documentation uses American English. Abbreviations are written as all-uppercase, for example: DRM, KMS, IOCTL, CRTC, and so on. To aid in reading, documentations make full use of the markup characters kerneldoc provides: @parameter for function parameters, @member for structure members (within the same structure), &struct structure to reference structures and function() for functions. These all get automatically hyperlinked if kerneldoc for the referenced objects exists. When referencing entries in function vtables (and structure members in general) please use &vtable_name.vfunc. Unfortunately this does not yet yield a direct link to the member, only the structure.

Except in special situations (to separate locked from unlocked variants) locking requirements for functions aren't documented in the kerneldoc. Instead locking should be check at runtime using e.g. `WARN_ON(!mutex_is_locked(...));`. Since it's much easier to ignore documentation than runtime noise this provides more value. And on top of that runtime checks do need to be updated when the locking rules change, increasing the chances that they're correct. Within the documentation the locking rules should be explained in the relevant structures: Either in the comment for the lock explaining what it protects, or data fields need a note about which lock protects them, or both.

Functions which have a non-`void` return value should have a section called "Returns" explaining the expected return values in different cases and their meanings. Currently there's no consensus whether that section name should be all uppercase or not, and whether it should end in a colon or not. Go with the file-local style. Other common section names are "Notes" with information for dangerous or tricky corner cases, and "FIXME" where the interface could be cleaned up.

Also read the guidelines for the kernel documentation at large.

1.1.1 Documentation Requirements for kAPI

All kernel APIs exported to other modules must be documented, including their datastructures and at least a short introductory section explaining the overall concepts. Documentation should be put into the code itself as kerneldoc comments as much as reasonable.

Do not blindly document everything, but document only what's relevant for driver authors: Internal functions of drm.ko and definitely static functions should not have formal kerneldoc comments. Use normal C comments if you feel like a comment is warranted. You may use kerneldoc syntax in the comment, but it shall not start with a /** kerneldoc marker. Similar for data structures, annotate anything entirely private with `/* private: */` comments as per the documentation guide.

1.2 Getting Started

Developers interested in helping out with the DRM subsystem are very welcome. Often people will resort to sending in patches for various issues reported by checkpatch or sparse. We welcome such contributions.

Anyone looking to kick it up a notch can find a list of janitorial tasks on the *TODO list*.

1.3 Contribution Process

Mostly the DRM subsystem works like any other kernel subsystem, see the main process guidelines and documentation for how things work. Here we just document some of the specialities of the GPU subsystem.

1.3.1 Feature Merge Deadlines

All feature work must be in the linux-next tree by the -rc6 release of the current release cycle, otherwise they must be postponed and can't reach the next merge window. All patches must have landed in the drm-next tree by latest -rc7, but if your branch is not in linux-next then this must have happened by -rc6 already.

After that point only bugfixes (like after the upstream merge window has closed with the -rc1 release) are allowed. No new platform enabling or new drivers are allowed.

This means that there's a blackout-period of about one month where feature work can't be merged. The recommended way to deal with that is having a -next tree that's always open, but making sure to not feed it into linux-next during the blackout period. As an example, drm-misc works like that.

1.3.2 Code of Conduct

As a freedesktop.org project, dri-devel, and the DRM community, follows the Contributor Covenant, found at: https://www.freedesktop.org/wiki/CodeOfConduct

Please conduct yourself in a respectful and civilised manner when interacting with community members on mailing lists, IRC, or bug trackers. The community represents the project as a whole, and abusive or bullying behaviour is not tolerated by the project.

CHAPTER

TWO

DRM INTERNALS

This chapter documents DRM internals relevant to driver authors and developers working to add support for the latest features to existing drivers.

First, we go over some typical driver initialization requirements, like setting up command buffers, creating an initial output configuration, and initializing core services. Subsequent sections cover core internals in more detail, providing implementation notes and examples.

The DRM layer provides several services to graphics drivers, many of them driven by the application interfaces it provides through libdrm, the library that wraps most of the DRM ioctls. These include vblank event handling, memory management, output management, framebuffer management, command submission & fencing, suspend/resume support, and DMA services.

2.1 Driver Initialization

At the core of every DRM driver is a *struct drm_driver* structure. Drivers typically statically initialize a drm_driver structure, and then pass it to *drm_dev_alloc()* to allocate a device instance. After the device instance is fully initialized it can be registered (which makes it accessible from userspace) using *drm_dev_register()*.

The *struct drm_driver* structure contains static information that describes the driver and features it supports, and pointers to methods that the DRM core will call to implement the DRM API. We will first go through the *struct drm_driver* static information fields, and will then describe individual operations in details as they get used in later sections.

2.1.1 Driver Information

Major, Minor and Patchlevel

int major; int minor; int patchlevel; The DRM core identifies driver versions by a major, minor and patch level triplet. The information is printed to the kernel log at initialization time and passed to userspace through the DRM_IOCTL_VERSION ioctl.

The major and minor numbers are also used to verify the requested driver API version passed to DRM_IOCTL_SET_VERSION. When the driver API changes between minor versions, applications can call DRM_IOCTL_SET_VERSION to select a specific version of the API. If the requested major isn't equal to the driver major, or the requested minor is larger than the driver minor, the DRM_IOCTL_SET_VERSION call will return an error. Otherwise the driver's set_version() method will be called with the requested version.

Name, Description and Date

char *name; char *desc; char *date; The driver name is printed to the kernel log at initialization time, used for IRQ registration and passed to userspace through DRM_IOCTL_VERSION.

The driver description is a purely informative string passed to userspace through the DRM_IOCTL_VERSION ioctl and otherwise unused by the kernel.

The driver date, formatted as YYYYMMDD, is meant to identify the date of the latest modification to the driver. However, as most drivers fail to update it, its value is mostly useless. The DRM core prints it to the kernel log at initialization time and passes it to userspace through the DRM_IOCTL_VERSION ioctl.

2.1.2 Device Instance and Driver Handling

A device instance for a drm driver is represented by *struct drm_device*. This is allocated and initialized with *devm_drm_dev_alloc()*, usually from bus-specific ->probe() callbacks implemented by the driver. The driver then needs to initialize all the various subsystems for the drm device like memory management, vblank handling, modesetting support and initial output configuration plus obviously initialize all the corresponding hardware bits. Finally when everything is up and running and ready for userspace the device instance can be published using *drm_dev_register()*.

There is also deprecated support for initalizing device instances using bus-specific helpers and the *drm_driver.load* callback. But due to backwards-compatibility needs the device instance have to be published too early, which requires unpretty global locking to make safe and is therefore only support for existing drivers not yet converted to the new scheme.

When cleaning up a device instance everything needs to be done in reverse: First unpublish the device instance with *drm_dev_unregister()*. Then clean up any other resources allocated at device initialization and drop the driver's reference to *drm_device* using *drm_dev_put()*.

Note that any allocation or resource which is visible to userspace must be released only when the final *drm_dev_put()* is called, and not when the driver is unbound from the underlying physical struct `device`. Best to use *drm_device* managed resources with *drmm_add_action()*, *drmm_kmalloc()* and related functions.

devres managed resources like devm_kmalloc() can only be used for resources directly related to the underlying hardware device, and only used in code paths fully protected by *drm_dev_enter()* and *drm_dev_exit()*.

Display driver example

The following example shows a typical structure of a DRM display driver. The example focus on the probe() function and the other functions that is almost always present and serves as a demonstration of *devm_drm_dev_alloc()*.

```
struct driver_device {
        struct drm_device drm;
        void *userspace_facing;
        struct clk *pclk;
};

static struct drm_driver driver_drm_driver = {
        [...]
};

static int driver_probe(struct platform_device *pdev)
{
        struct driver_device *priv;
        struct drm_device *drm;
        int ret;

        priv = devm_drm_dev_alloc(&pdev->dev, &driver_drm_driver,
                                  struct driver_device, drm);
        if (IS_ERR(priv))
                return PTR_ERR(priv);
        drm = &priv->drm;

        ret = drmm_mode_config_init(drm);
        if (ret)
                return ret;

        priv->userspace_facing = drmm_kzalloc(..., GFP_KERNEL);
        if (!priv->userspace_facing)
                return -ENOMEM;

        priv->pclk = devm_clk_get(dev, "PCLK");
        if (IS_ERR(priv->pclk))
                return PTR_ERR(priv->pclk);

        // Further setup, display pipeline etc

        platform_set_drvdata(pdev, drm);

        drm_mode_config_reset(drm);

        ret = drm_dev_register(drm);
        if (ret)
                return ret;

        drm_fbdev_generic_setup(drm, 32);
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```
        return 0;
}

// This function is called before the devm_ resources are released
static int driver_remove(struct platform_device *pdev)
{
        struct drm_device *drm = platform_get_drvdata(pdev);

        drm_dev_unregister(drm);
        drm_atomic_helper_shutdown(drm)

        return 0;
}

// This function is called on kernel restart and shutdown
static void driver_shutdown(struct platform_device *pdev)
{
        drm_atomic_helper_shutdown(platform_get_drvdata(pdev));
}

static int __maybe_unused driver_pm_suspend(struct device *dev)
{
        return drm_mode_config_helper_suspend(dev_get_drvdata(dev));
}

static int __maybe_unused driver_pm_resume(struct device *dev)
{
        drm_mode_config_helper_resume(dev_get_drvdata(dev));

        return 0;
}

static const struct dev_pm_ops driver_pm_ops = {
        SET_SYSTEM_SLEEP_PM_OPS(driver_pm_suspend, driver_pm_resume)
};

static struct platform_driver driver_driver = {
        .driver = {
                [...]
                .pm = &driver_pm_ops,
        },
        .probe = driver_probe,
        .remove = driver_remove,
        .shutdown = driver_shutdown,
};
module_platform_driver(driver_driver);
```

Drivers that want to support device unplugging (USB, DT overlay unload) should use *drm_dev_unplug()* instead of *drm_dev_unregister()*. The driver must protect regions that is accessing device resources to prevent use after they' re released. This is done using *drm_dev_enter()* and *drm_dev_exit()*. There is one shortcoming however, *drm_dev_unplug()* marks the drm_device as unplugged before *drm_atomic_helper_shutdown()* is called. This means that if the disable code paths are protected, they will not run on regular driver module unload, possibly leaving the hardware enabled.

enum **switch_power_state**

power state of drm device

Constants

DRM_SWITCH_POWER_ON
Power state is ON

DRM_SWITCH_POWER_OFF
Power state is OFF

DRM_SWITCH_POWER_CHANGING
Power state is changing

DRM_SWITCH_POWER_DYNAMIC_OFF
Suspended

struct **drm_device**

DRM device structure

Definition

```
struct drm_device {
  struct list_head legacy_dev_list;
  int if_version;
  struct kref ref;
  struct device *dev;
  struct {
    struct list_head resources;
    void *final_kfree;
    spinlock_t lock;
  } managed;
  struct drm_driver *driver;
  void *dev_private;
  struct drm_minor *primary;
  struct drm_minor *render;
  bool registered;
  struct drm_master *master;
  u32 driver_features;
  bool unplugged;
  struct inode *anon_inode;
  char *unique;
  struct mutex struct_mutex;
  struct mutex master_mutex;
  atomic_t open_count;
  struct mutex filelist_mutex;
  struct list_head filelist;
```

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```
  struct list_head filelist_internal;
  struct mutex clientlist_mutex;
  struct list_head clientlist;
  bool irq_enabled;
  int irq;
  bool vblank_disable_immediate;
  struct drm_vblank_crtc *vblank;
  spinlock_t vblank_time_lock;
  spinlock_t vbl_lock;
  u32 max_vblank_count;
  struct list_head vblank_event_list;
  spinlock_t event_lock;
  struct drm_agp_head *agp;
  struct pci_dev *pdev;
#ifdef __alpha__;
  struct pci_controller *hose;
#endif;
  unsigned int num_crtcs;
  struct drm_mode_config mode_config;
  struct mutex object_name_lock;
  struct idr object_name_idr;
  struct drm_vma_offset_manager *vma_offset_manager;
  struct drm_vram_mm *vram_mm;
  enum switch_power_state switch_power_state;
  struct drm_fb_helper *fb_helper;
};
```

Members

legacy_dev_list
List of devices per driver for stealth attach cleanup

if_version
Highest interface version set

ref
Object ref-count

dev
Device structure of bus-device

managed
Managed resources linked to the lifetime of this *drm_device* as tracked by **ref**.

driver
DRM driver managing the device

dev_private
DRM driver private data. This is deprecated and should be left set to NULL.

Instead of using this pointer it is recommended that drivers use *devm_drm_dev_alloc()* and embed struct *drm_device* in their larger per-device structure.

primary
Primary node

render
Render node

registered
Internally used by *drm_dev_register()* and *drm_connector_register()*.

master
Currently active master for this device. Protected by `master_mutex`

driver_features
per-device driver features

Drivers can clear specific flags here to disallow certain features on a per-device basis while still sharing a single *struct drm_driver* instance across all devices.

unplugged
Flag to tell if the device has been unplugged. See *drm_dev_enter()* and *drm_dev_is_unplugged()*.

anon_inode
inode for private address-space

unique
Unique name of the device

struct_mutex
Lock for others (not *drm_minor.master* and *drm_file.is_master*)

WARNING: Only drivers annotated with DRIVER_LEGACY should be using this.

master_mutex
Lock for *drm_minor.master* and *drm_file.is_master*

open_count
Usage counter for outstanding files open, protected by drm_global_mutex

filelist_mutex
Protects **filelist**.

filelist
List of userspace clients, linked through *drm_file.lhead*.

filelist_internal
List of open DRM files for in-kernel clients. Protected by `filelist_mutex`.

clientlist_mutex
Protects `clientlist` access.

clientlist
List of in-kernel clients. Protected by `clientlist_mutex`.

irq_enabled
Indicates that interrupt handling is enabled, specifically vblank handling. Drivers which don't use *drm_irq_install()* need to set this to true manually.

irq
Used by the *drm_irq_install()* and drm_irq_unistall() helpers.

vblank_disable_immediate
If true, vblank interrupt will be disabled immediately when the refcount drops to zero, as opposed to via the vblank disable timer.

This can be set to true it the hardware has a working vblank counter with high-precision timestamping (otherwise there are races) and the driver uses *drm_crtc_vblank_on()* and *drm_crtc_vblank_off()* appropriately. See also **max_vblank_count** and *drm_crtc_funcs.get_vblank_counter*.

vblank
Array of vblank tracking structures, one per *struct drm_crtc*. For historical reasons (vblank support predates kernel modesetting) this is free-standing and not part of *struct drm_crtc* itself. It must be initialized explicitly by calling *drm_vblank_init()*.

vblank_time_lock
Protects vblank count and time updates during vblank enable/disable

vbl_lock
Top-level vblank references lock, wraps the low-level **vblank_time_lock**.

max_vblank_count
Maximum value of the vblank registers. This value +1 will result in a wrap-around of the vblank register. It is used by the vblank core to handle wrap-arounds.

If set to zero the vblank core will try to guess the elapsed vblanks between times when the vblank interrupt is disabled through high-precision timestamps. That approach is suffering from small races and imprecision over longer time periods, hence exposing a hardware vblank counter is always recommended.

This is the statically configured device wide maximum. The driver can instead choose to use a runtime configurable per-crtc value *drm_vblank_crtc.max_vblank_count*, in which case **max_vblank_count** must be left at zero. See *drm_crtc_set_max_vblank_count()* on how to use the per-crtc value.

If non-zero, *drm_crtc_funcs.get_vblank_counter* must be set.

vblank_event_list
List of vblank events

event_lock
Protects **vblank_event_list** and event delivery in general. See *drm_send_event()* and *drm_send_event_locked()*.

agp
AGP data

pdev
PCI device structure

hose
PCI hose, only used on ALPHA platforms.

num_crtcs
Number of CRTCs on this device

mode_config
Current mode config

object_name_lock
GEM information

object_name_idr
GEM information

vma_offset_manager
GEM information

vram_mm
VRAM MM memory manager

switch_power_state
Power state of the client. Used by drivers supporting the switcheroo driver. The state is maintained in the *vga_switcheroo_client_ops.set_gpu_state* callback

fb_helper
Pointer to the fbdev emulation structure. Set by *drm_fb_helper_init()* and cleared by *drm_fb_helper_fini()*.

Description

This structure represent a complete card that may contain multiple heads.

enum **drm_driver_feature**

feature flags

Constants

DRIVER_GEM
Driver use the GEM memory manager. This should be set for all modern drivers.

DRIVER_MODESET
Driver supports mode setting interfaces (KMS).

DRIVER_RENDER
Driver supports dedicated render nodes. See also the *section on render nodes* for details.

DRIVER_ATOMIC
Driver supports the full atomic modesetting userspace API. Drivers which only use atomic internally, but do not the support the full userspace API (e.g. not all properties converted to atomic, or multi-plane updates are not guaranteed to be tear-free) should not set this flag.

DRIVER_SYNCOBJ
Driver supports *drm_syncobj* for explicit synchronization of command submission.

DRIVER_SYNCOBJ_TIMELINE
Driver supports the timeline flavor of *drm_syncobj* for explicit synchronization of command submission.

DRIVER_USE_AGP
: Set up DRM AGP support, see drm_agp_init(), the DRM core will manage AGP resources. New drivers don't need this.

DRIVER_LEGACY
: Denote a legacy driver using shadow attach. Do not use.

DRIVER_PCI_DMA
: Driver is capable of PCI DMA, mapping of PCI DMA buffers to userspace will be enabled. Only for legacy drivers. Do not use.

DRIVER_SG
: Driver can perform scatter/gather DMA, allocation and mapping of scatter/gather buffers will be enabled. Only for legacy drivers. Do not use.

DRIVER_HAVE_DMA
: Driver supports DMA, the userspace DMA API will be supported. Only for legacy drivers. Do not use.

DRIVER_HAVE_IRQ
: Legacy irq support. Only for legacy drivers. Do not use.

  New drivers can either use the *drm_irq_install()* and *drm_irq_uninstall()* helper functions, or roll their own irq support code by calling request_irq() directly.

DRIVER_KMS_LEGACY_CONTEXT
: Used only by nouveau for backwards compatibility with existing userspace. Do not use.

Description

See *drm_driver.driver_features*, drm_device.driver_features and *drm_core_check_feature()*.

struct **drm_driver**
: DRM driver structure

Definition

```
struct drm_driver {
  int (*load) (struct drm_device *, unsigned long flags);
  int (*open) (struct drm_device *, struct drm_file *);
  void (*postclose) (struct drm_device *, struct drm_file *);
  void (*lastclose) (struct drm_device *);
  void (*unload) (struct drm_device *);
  void (*release) (struct drm_device *);
  irqreturn_t(*irq_handler) (int irq, void *arg);
  void (*irq_preinstall) (struct drm_device *dev);
  int (*irq_postinstall) (struct drm_device *dev);
  void (*irq_uninstall) (struct drm_device *dev);
  void (*master_set)(struct drm_device *dev, struct drm_file *file_
↪priv, bool from_open);
  void (*master_drop)(struct drm_device *dev, struct drm_file *file_
↪priv);
  void (*debugfs_init)(struct drm_minor *minor);
```

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```
  void (*gem_free_object_unlocked) (struct drm_gem_object *obj);
  int (*gem_open_object) (struct drm_gem_object *, struct drm_file␣
↪*);
  void (*gem_close_object) (struct drm_gem_object *, struct drm_
↪file *);
  struct drm_gem_object *(*gem_create_object)(struct drm_device␣
↪*dev, size_t size);
  int (*prime_handle_to_fd)(struct drm_device *dev, struct drm_file␣
↪*file_priv, uint32_t handle, uint32_t flags, int *prime_fd);
  int (*prime_fd_to_handle)(struct drm_device *dev, struct drm_file␣
↪*file_priv, int prime_fd, uint32_t *handle);
  struct dma_buf * (*gem_prime_export)(struct drm_gem_object *obj,␣
↪int flags);
  struct drm_gem_object * (*gem_prime_import)(struct drm_device␣
↪*dev, struct dma_buf *dma_buf);
  int (*gem_prime_pin)(struct drm_gem_object *obj);
  void (*gem_prime_unpin)(struct drm_gem_object *obj);
  struct sg_table *(*gem_prime_get_sg_table)(struct drm_gem_object␣
↪*obj);
  struct drm_gem_object *(*gem_prime_import_sg_table)(struct drm_
↪device *dev,struct dma_buf_attachment *attach, struct sg_table␣
↪*sgt);
  void *(*gem_prime_vmap)(struct drm_gem_object *obj);
  void (*gem_prime_vunmap)(struct drm_gem_object *obj, void *vaddr);
  int (*gem_prime_mmap)(struct drm_gem_object *obj, struct vm_area_
↪struct *vma);
  int (*dumb_create)(struct drm_file *file_priv,struct drm_device␣
↪*dev, struct drm_mode_create_dumb *args);
  int (*dumb_map_offset)(struct drm_file *file_priv,struct drm_
↪device *dev, uint32_t handle, uint64_t *offset);
  int (*dumb_destroy)(struct drm_file *file_priv,struct drm_device␣
↪*dev, uint32_t handle);
  const struct vm_operations_struct *gem_vm_ops;
  int major;
  int minor;
  int patchlevel;
  char *name;
  char *desc;
  char *date;
  u32 driver_features;
  const struct drm_ioctl_desc *ioctls;
  int num_ioctls;
  const struct file_operations *fops;
};
```

Members

load
    Backward-compatible driver callback to complete initialization steps after the driver is registered. For this reason, may suffer from race conditions and its

use is deprecated for new drivers. It is therefore only supported for existing drivers not yet converted to the new scheme. See *devm_drm_dev_alloc()* and *drm_dev_register()* for proper and race-free way to set up a *struct drm_device*.

This is deprecated, do not use!

Returns:

Zero on success, non-zero value on failure.

open
Driver callback when a new *struct drm_file* is opened. Useful for setting up driver-private data structures like buffer allocators, execution contexts or similar things. Such driver-private resources must be released again in **postclose**.

Since the display/modeset side of DRM can only be owned by exactly one *struct drm_file* (see *drm_file.is_master* and *drm_device.master*) there should never be a need to set up any modeset related resources in this callback. Doing so would be a driver design bug.

Returns:

0 on success, a negative error code on failure, which will be promoted to userspace as the result of the open() system call.

postclose
One of the driver callbacks when a new *struct drm_file* is closed. Useful for tearing down driver-private data structures allocated in **open** like buffer allocators, execution contexts or similar things.

Since the display/modeset side of DRM can only be owned by exactly one *struct drm_file* (see *drm_file.is_master* and *drm_device.master*) there should never be a need to tear down any modeset related resources in this callback. Doing so would be a driver design bug.

lastclose
Called when the last *struct drm_file* has been closed and there' s currently no userspace client for the *struct drm_device*.

Modern drivers should only use this to force-restore the fbdev framebuffer using *drm_fb_helper_restore_fbdev_mode_unlocked()*. Anything else would indicate there' s something seriously wrong. Modern drivers can also use this to execute delayed power switching state changes, e.g. in conjunction with the *VGA Switcheroo* infrastructure.

This is called after **postclose** hook has been called.

NOTE:

All legacy drivers use this callback to de-initialize the hardware. This is purely because of the shadow-attach model, where the DRM kernel driver does not really own the hardware. Instead ownershipe is handled with the help of userspace through an inheritedly racy dance to set/unset the VT into raw mode.

Legacy drivers initialize the hardware in the **firstopen** callback, which isn' t even called for modern drivers.

unload
Reverse the effects of the driver load callback. Ideally, the clean up performed by the driver should happen in the reverse order of the initialization. Similarly to the load hook, this handler is deprecated and its usage should be dropped in favor of an open-coded teardown function at the driver layer. See *drm_dev_unregister()* and *drm_dev_put()* for the proper way to remove a *struct drm_device*.

The unload() hook is called right after unregistering the device.

release
Optional callback for destroying device data after the final reference is released, i.e. the device is being destroyed.

This is deprecated, clean up all memory allocations associated with a *drm_device* using *drmm_add_action()*, *drmm_kmalloc()* and related managed resources functions.

irq_handler
Interrupt handler called when using *drm_irq_install()*. Not used by drivers which implement their own interrupt handling.

irq_preinstall
Optional callback used by *drm_irq_install()* which is called before the interrupt handler is registered. This should be used to clear out any pending interrupts (from e.g. firmware based drives) and reset the interrupt handling registers.

irq_postinstall
Optional callback used by *drm_irq_install()* which is called after the interrupt handler is registered. This should be used to enable interrupt generation in the hardware.

irq_uninstall
Optional callback used by *drm_irq_uninstall()* which is called before the interrupt handler is unregistered. This should be used to disable interrupt generation in the hardware.

master_set
Called whenever the minor master is set. Only used by vmwgfx.

master_drop
Called whenever the minor master is dropped. Only used by vmwgfx.

debugfs_init
Allows drivers to create driver-specific debugfs files.

gem_free_object_unlocked
deconstructor for drm_gem_objects

This is deprecated and should not be used by new drivers. Use *drm_gem_object_funcs.free* instead.

gem_open_object
This callback is deprecated in favour of *drm_gem_object_funcs.open*.

Driver hook called upon gem handle creation

gem_close_object
: This callback is deprecated in favour of *drm_gem_object_funcs.close*.

  Driver hook called upon gem handle release

gem_create_object
: constructor for gem objects

  Hook for allocating the GEM object struct, for use by the CMA and SHMEM GEM helpers.

prime_handle_to_fd
: Main PRIME export function. Should be implemented with *drm_gem_prime_handle_to_fd()* for GEM based drivers.

  For an in-depth discussion see *PRIME buffer sharing documentation*.

prime_fd_to_handle
: Main PRIME import function. Should be implemented with *drm_gem_prime_fd_to_handle()* for GEM based drivers.

  For an in-depth discussion see *PRIME buffer sharing documentation*.

gem_prime_export
: Export hook for GEM drivers. Deprecated in favour of *drm_gem_object_funcs.export*.

gem_prime_import
: Import hook for GEM drivers.

  This defaults to *drm_gem_prime_import()* if not set.

gem_prime_pin
: Deprecated hook in favour of *drm_gem_object_funcs.pin*.

gem_prime_unpin
: Deprecated hook in favour of *drm_gem_object_funcs.unpin*.

gem_prime_get_sg_table
: Deprecated hook in favour of *drm_gem_object_funcs.get_sg_table*.

gem_prime_import_sg_table
: Optional hook used by the PRIME helper functions *drm_gem_prime_import()* respectively *drm_gem_prime_import_dev()*.

gem_prime_vmap
: Deprecated vmap hook for GEM drivers. Please use *drm_gem_object_funcs.vmap* instead.

gem_prime_vunmap
: Deprecated vunmap hook for GEM drivers. Please use *drm_gem_object_funcs.vunmap* instead.

gem_prime_mmap
: mmap hook for GEM drivers, used to implement dma-buf mmap in the PRIME helpers.

  FIXME: There’s way too much duplication going on here, and also moved to *drm_gem_object_funcs*.

dumb_create
: This creates a new dumb buffer in the driver' s backing storage manager (GEM, TTM or something else entirely) and returns the resulting buffer handle. This handle can then be wrapped up into a framebuffer modeset object.

  Note that userspace is not allowed to use such objects for render acceleration - drivers must create their own private ioctls for such a use case.

  Width, height and depth are specified in the `drm_mode_create_dumb` argument. The callback needs to fill the handle, pitch and size for the created buffer.

  Called by the user via ioctl.

  Returns:

  Zero on success, negative errno on failure.

dumb_map_offset
: Allocate an offset in the drm device node's address space to be able to memory map a dumb buffer.

  The default implementation is *drm_gem_create_mmap_offset()*. GEM based drivers must not overwrite this.

  Called by the user via ioctl.

  Returns:

  Zero on success, negative errno on failure.

dumb_destroy
: This destroys the userspace handle for the given dumb backing storage buffer. Since buffer objects must be reference counted in the kernel a buffer object won' t be immediately freed if a framebuffer modeset object still uses it.

  Called by the user via ioctl.

  The default implementation is *drm_gem_dumb_destroy()*. GEM based drivers must not overwrite this.

  Returns:

  Zero on success, negative errno on failure.

gem_vm_ops
: Driver private ops for this object

  For GEM drivers this is deprecated in favour of *drm_gem_object_funcs.vm_ops*.

major
: driver major number

minor
: driver minor number

patchlevel
: driver patch level

name
: driver name

desc
driver description

date
driver date

driver_features
Driver features, see *enum drm_driver_feature*. Drivers can disable some features on a per-instance basis using *drm_device.driver_features*.

ioctls
Array of driver-private IOCTL description entries. See the chapter on *IOCTL support in the userland interfaces chapter* for the full details.

num_ioctls
Number of entries in **ioctls**.

fops
File operations for the DRM device node. See the discussion in *file operations* for in-depth coverage and some examples.

Description

This structure represent the common code for a family of cards. There will be one *struct drm_device* for each card present in this family. It contains lots of vfunc entries, and a pile of those probably should be moved to more appropriate places like *drm_mode_config_funcs* or into a new operations structure for GEM drivers.

devm_drm_dev_alloc

`devm_drm_dev_alloc (parent, driver, type, member)`

Resource managed allocation of a *drm_device* instance

Parameters

parent
Parent device object

driver
DRM driver

type
the type of the struct which contains struct *drm_device*

member
the name of the *drm_device* within **type**.

Description

This allocates and initialize a new DRM device. No device registration is done. Call *drm_dev_register()* to advertice the device to user space and register it with other core subsystems. This should be done last in the device initialization sequence to make sure userspace can't access an inconsistent state.

The initial ref-count of the object is 1. Use *drm_dev_get()* and *drm_dev_put()* to take and drop further ref-counts.

It is recommended that drivers embed *struct drm_device* into their own device structure.

Note that this manages the lifetime of the resulting *drm_device* automatically using devres. The DRM device initialized with this function is automatically put on driver detach using *drm_dev_put()*.

Return

Pointer to new DRM device, or ERR_PTR on failure.

bool **drm_dev_is_unplugged**(struct *drm_device* *dev)

is a DRM device unplugged

Parameters

struct drm_device *dev
DRM device

Description

This function can be called to check whether a hotpluggable is unplugged. Unplugging itself is singalled through *drm_dev_unplug()*. If a device is unplugged, these two functions guarantee that any store before calling *drm_dev_unplug()* is visible to callers of this function after it completes

WARNING: This function fundamentally races against *drm_dev_unplug()*. It is recommended that drivers instead use the underlying *drm_dev_enter()* and *drm_dev_exit()* function pairs.

bool **drm_core_check_all_features**(const struct *drm_device* *dev, u32 features)

check driver feature flags mask

Parameters

const struct drm_device *dev
DRM device to check

u32 features
feature flag(s) mask

Description

This checks **dev** for driver features, see *drm_driver.driver_features*, *drm_device.driver_features*, and the various *enum drm_driver_feature* flags.

Returns true if all features in the **features** mask are supported, false otherwise.

bool **drm_core_check_feature**(const struct *drm_device* *dev, enum *drm_driver_feature* feature)

check driver feature flags

Parameters

const struct drm_device *dev
DRM device to check

enum drm_driver_feature feature
feature flag

Description

This checks **dev** for driver features, see *drm_driver.driver_features*, *drm_device.driver_features*, and the various *enum drm_driver_feature* flags.

Returns true if the **feature** is supported, false otherwise.

bool **drm_drv_uses_atomic_modeset**(struct *drm_device* *dev)

check if the driver implements atomic_commit()

Parameters

struct drm_device *dev
DRM device

Description

This check is useful if drivers do not have DRIVER_ATOMIC set but have atomic modesetting internally implemented.

void **drm_put_dev**(struct *drm_device* *dev)

Unregister and release a DRM device

Parameters

struct drm_device *dev
DRM device

Description

Called at module unload time or when a PCI device is unplugged.

Cleans up all DRM device, calling drm_lastclose().

Note

Use of this function is deprecated. It will eventually go away completely. Please use *drm_dev_unregister()* and *drm_dev_put()* explicitly instead to make sure that the device isn't userspace accessible any more while teardown is in progress, ensuring that userspace can't access an inconsistent state.

bool **drm_dev_enter**(struct *drm_device* *dev, int *idx)

Enter device critical section

Parameters

struct drm_device *dev
DRM device

int *idx
Pointer to index that will be passed to the matching *drm_dev_exit()*

Description

This function marks and protects the beginning of a section that should not be entered after the device has been unplugged. The section end is marked with *drm_dev_exit()*. Calls to this function can be nested.

Return

True if it is OK to enter the section, false otherwise.

void **`drm_dev_exit`**(int idx)

Exit device critical section

Parameters

`int idx`
index returned from *`drm_dev_enter()`*

Description

This function marks the end of a section that should not be entered after the device has been unplugged.

void **`drm_dev_unplug`**(struct *drm_device* *dev)

unplug a DRM device

Parameters

`struct drm_device *dev`
DRM device

Description

This unplugs a hotpluggable DRM device, which makes it inaccessible to userspace operations. Entry-points can use *`drm_dev_enter()`* and *`drm_dev_exit()`* to protect device resources in a race free manner. This essentially unregisters the device like *`drm_dev_unregister()`*, but can be called while there are still open users of **dev**.

struct *drm_device* ***`drm_dev_alloc`**(struct *drm_driver* *driver, struct device *parent)

Allocate new DRM device

Parameters

`struct drm_driver *driver`
DRM driver to allocate device for

`struct device *parent`
Parent device object

Description

This is the deprecated version of *`devm_drm_dev_alloc()`*, which does not support subclassing through embedding the struct *`drm_device`* in a driver private structure, and which does not support automatic cleanup through devres.

Return

Pointer to new DRM device, or ERR_PTR on failure.

void **`drm_dev_get`**(struct *drm_device* *dev)

Take reference of a DRM device

Parameters

`struct drm_device *dev`
device to take reference of or NULL

Description

This increases the ref-count of **dev** by one. You *must* already own a reference when calling this. Use *drm_dev_put()* to drop this reference again.

This function never fails. However, this function does not provide *any* guarantee whether the device is alive or running. It only provides a reference to the object and the memory associated with it.

void **drm_dev_put**(struct *drm_device* *dev)
Drop reference of a DRM device

Parameters

struct drm_device *dev
device to drop reference of or NULL

Description

This decreases the ref-count of **dev** by one. The device is destroyed if the ref-count drops to zero.

int **drm_dev_register**(struct *drm_device* *dev, unsigned long flags)
Register DRM device

Parameters

struct drm_device *dev
Device to register

unsigned long flags
Flags passed to the driver' s .load() function

Description

Register the DRM device **dev** with the system, advertise device to user-space and start normal device operation. **dev** must be initialized via drm_dev_init() previously.

Never call this twice on any device!

NOTE

To ensure backward compatibility with existing drivers method this function calls the *drm_driver.load* method after registering the device nodes, creating race conditions. Usage of the *drm_driver.load* methods is therefore deprecated, drivers must perform all initialization before calling *drm_dev_register()*.

Return

0 on success, negative error code on failure.

void **drm_dev_unregister**(struct *drm_device* *dev)
Unregister DRM device

Parameters

struct drm_device *dev
Device to unregister

Description

Unregister the DRM device from the system. This does the reverse of *drm_dev_register()* but does not deallocate the device. The caller must call *drm_dev_put()* to drop their final reference.

A special form of unregistering for hotpluggable devices is *drm_dev_unplug()*, which can be called while there are still open users of **dev**.

This should be called first in the device teardown code to make sure userspace can't access the device instance any more.

int **drm_dev_set_unique**(struct *drm_device* *dev, const char *name)

Set the unique name of a DRM device

Parameters

struct drm_device *dev
device of which to set the unique name

const char *name
unique name

Description

Sets the unique name of a DRM device using the specified string. This is already done by drm_dev_init(), drivers should only override the default unique name for backwards compatibility reasons.

Return

0 on success or a negative error code on failure.

2.1.3 Driver Load

Component Helper Usage

DRM drivers that drive hardware where a logical device consists of a pile of independent hardware blocks are recommended to use the component helper library. For consistency and better options for code reuse the following guidelines apply:

- The entire device initialization procedure should be run from the `component_master_ops.master_bind` callback, starting with *devm_drm_dev_alloc()*, then binding all components with component_bind_all() and finishing with *drm_dev_register()*.
- The opaque pointer passed to all components through component_bind_all() should point at *struct drm_device* of the device instance, not some driver specific private structure.
- The component helper fills the niche where further standardization of interfaces is not practical. When there already is, or will be, a standardized interface like *drm_bridge* or *drm_panel*, providing its own functions to find such components at driver load time, like *drm_of_find_panel_or_bridge()*, then the component helper should not be used.

IRQ Helper Library

The DRM core provides very simple support helpers to enable IRQ handling on a device through the *drm_irq_install()* and *drm_irq_uninstall()* functions. This only supports devices with a single interrupt on the main device stored in *drm_device.dev* and set as the device paramter in *drm_dev_alloc()*.

These IRQ helpers are strictly optional. Drivers which roll their own only need to set *drm_device.irq_enabled* to signal the DRM core that vblank interrupts are working. Since these helpers don't automatically clean up the requested interrupt like e.g. devm_request_irq() they're not really recommended.

int **drm_irq_install**(struct *drm_device* *dev, int irq)

install IRQ handler

Parameters

struct drm_device *dev
DRM device

int irq
IRQ number to install the handler for

Description

Initializes the IRQ related data. Installs the handler, calling the driver *drm_driver.irq_preinstall* and *drm_driver.irq_postinstall* functions before and after the installation.

This is the simplified helper interface provided for drivers with no special needs. Drivers which need to install interrupt handlers for multiple interrupts must instead set *drm_device.irq_enabled* to signal the DRM core that vblank interrupts are available.

irq must match the interrupt number that would be passed to request_irq(), if called directly instead of using this helper function.

drm_driver.irq_handler is called to handle the registered interrupt.

Return

Zero on success or a negative error code on failure.

int **drm_irq_uninstall**(struct *drm_device* *dev)

uninstall the IRQ handler

Parameters

struct drm_device *dev
DRM device

Description

Calls the driver's *drm_driver.irq_uninstall* function and unregisters the IRQ handler. This should only be called by drivers which used *drm_irq_install()* to set up their interrupt handler. Other drivers must only reset *drm_device.irq_enabled* to false.

Note that for kernel modesetting drivers it is a bug if this function fails. The sanity checks are only to catch buggy user modesetting drivers which call the same function through an ioctl.

Return

Zero on success or a negative error code on failure.

Memory Manager Initialization

Every DRM driver requires a memory manager which must be initialized at load time. DRM currently contains two memory managers, the Translation Table Manager (TTM) and the Graphics Execution Manager (GEM). This document describes the use of the GEM memory manager only. See ? for details.

Miscellaneous Device Configuration

Another task that may be necessary for PCI devices during configuration is mapping the video BIOS. On many devices, the VBIOS describes device configuration, LCD panel timings (if any), and contains flags indicating device state. Mapping the BIOS can be done using the pci_map_rom() call, a convenience function that takes care of mapping the actual ROM, whether it has been shadowed into memory (typically at address 0xc0000) or exists on the PCI device in the ROM BAR. Note that after the ROM has been mapped and any necessary information has been extracted, it should be unmapped; on many devices, the ROM address decoder is shared with other BARs, so leaving it mapped could cause undesired behaviour like hangs or memory corruption.

2.1.4 Managed Resources

Inspired by struct `device` managed resources, but tied to the lifetime of struct *drm_device*, which can outlive the underlying physical device, usually when userspace has some open files and other handles to resources still open.

Release actions can be added with *drmm_add_action()*, memory allocations can be done directly with *drmm_kmalloc()* and the related functions. Everything will be released on the final *drm_dev_put()* in reverse order of how the release actions have been added and memory has been allocated since driver loading started with *devm_drm_dev_alloc()*.

Note that release actions and managed memory can also be added and removed during the lifetime of the driver, all the functions are fully concurrent safe. But it is recommended to use managed resources only for resources that change rarely, if ever, during the lifetime of the *drm_device* instance.

void ***drmm_kmalloc**(struct *drm_device* *dev, size_t size, gfp_t gfp)

drm_device managed kmalloc()

Parameters

struct drm_device *dev
DRM device

size_t size
  size of the memory allocation

gfp_t gfp
  GFP allocation flags

Description

This is a *drm_device* managed version of kmalloc(). The allocated memory is automatically freed on the final *drm_dev_put()*. Memory can also be freed before the final *drm_dev_put()* by calling *drmm_kfree()*.

char ***drmm_kstrdup**(struct *drm_device* *dev, const char *s, gfp_t gfp)
  drm_device managed kstrdup()

Parameters

struct drm_device *dev
  DRM device

const char *s
  0-terminated string to be duplicated

gfp_t gfp
  GFP allocation flags

Description

This is a *drm_device* managed version of kstrdup(). The allocated memory is automatically freed on the final *drm_dev_put()* and works exactly like a memory allocation obtained by *drmm_kmalloc()*.

void **drmm_kfree**(struct *drm_device* *dev, void *data)
  drm_device managed kfree()

Parameters

struct drm_device *dev
  DRM device

void *data
  memory allocation to be freed

Description

This is a *drm_device* managed version of kfree() which can be used to release memory allocated through *drmm_kmalloc()* or any of its related functions before the final *drm_dev_put()* of **dev**.

drmm_add_action

`drmm_add_action (dev, action, data)`

  add a managed release action to a *drm_device*

Parameters

dev
  DRM device

action
  function which should be called when **dev** is released

data
: opaque pointer, passed to **action**

Description

This function adds the **release** action with optional parameter **data** to the list of cleanup actions for **dev**. The cleanup actions will be run in reverse order in the final *drm_dev_put()* call for **dev**.

drmm_add_action_or_reset

`drmm_add_action_or_reset (dev, action, data)`

add a managed release action to a *drm_device*

Parameters

dev
: DRM device

action
: function which should be called when **dev** is released

data
: opaque pointer, passed to **action**

Description

Similar to *drmm_add_action()*, with the only difference that upon failure **action** is directly called for any cleanup work necessary on failures.

void ***drmm_kzalloc**(struct *drm_device* *dev, size_t size, gfp_t gfp)

drm_device managed kzalloc()

Parameters

struct drm_device *dev
: DRM device

size_t size
: size of the memory allocation

gfp_t gfp
: GFP allocation flags

Description

This is a *drm_device* managed version of kzalloc(). The allocated memory is automatically freed on the final *drm_dev_put()*. Memory can also be freed before the final *drm_dev_put()* by calling *drmm_kfree()*.

void ***drmm_kmalloc_array**(struct *drm_device* *dev, size_t n, size_t size, gfp_t flags)

drm_device managed kmalloc_array()

Parameters

struct drm_device *dev
: DRM device

size_t n
: number of array elements to allocate

`size_t size`
: size of array member

`gfp_t flags`
: GFP allocation flags

Description

This is a *drm_device* managed version of kmalloc_array(). The allocated memory is automatically freed on the final *drm_dev_put()* and works exactly like a memory allocation obtained by *drmm_kmalloc()*.

void ***drmm_kcalloc**(struct *drm_device* *dev, size_t n, size_t size, gfp_t flags)

drm_device managed kcalloc()

Parameters

`struct drm_device *dev`
: DRM device

`size_t n`
: number of array elements to allocate

`size_t size`
: size of array member

`gfp_t flags`
: GFP allocation flags

Description

This is a *drm_device* managed version of kcalloc(). The allocated memory is automatically freed on the final *drm_dev_put()* and works exactly like a memory allocation obtained by *drmm_kmalloc()*.

2.1.5 Bus-specific Device Registration and PCI Support

A number of functions are provided to help with device registration. The functions deal with PCI and platform devices respectively and are only provided for historical reasons. These are all deprecated and shouldn't be used in new drivers. Besides that there's a few helpers for pci drivers.

drm_dma_handle_t ***drm_pci_alloc**(struct *drm_device* *dev, size_t size, size_t align)

Allocate a PCI consistent memory block, for DMA.

Parameters

`struct drm_device * dev`
: DRM device

`size_t size`
: size of block to allocate

`size_t align`
: alignment of block

Description

FIXME: This is a needless abstraction of the Linux dma-api and should be removed.

Return

A handle to the allocated memory block on success or NULL on failure.

void **drm_pci_free**(struct *drm_device* *dev, drm_dma_handle_t *dmah)
    Free a PCI consistent memory block

Parameters

struct drm_device * dev
    DRM device

drm_dma_handle_t * dmah
    handle to memory block

Description

FIXME: This is a needless abstraction of the Linux dma-api and should be removed.

int **drm_legacy_pci_init**(struct *drm_driver* *driver, struct pci_driver *pdriver)
    shadow-attach a legacy DRM PCI driver

Parameters

struct drm_driver *driver
    DRM device driver

struct pci_driver *pdriver
    PCI device driver

Description

This is only used by legacy dri1 drivers and deprecated.

Return

0 on success or a negative error code on failure.

void **drm_legacy_pci_exit**(struct *drm_driver* *driver, struct pci_driver *pdriver)
    unregister shadow-attach legacy DRM driver

Parameters

struct drm_driver *driver
    DRM device driver

struct pci_driver *pdriver
    PCI device driver

Description

Unregister a DRM driver shadow-attached through *drm_legacy_pci_init()*. This is deprecated and only used by dri1 drivers.

2.2 Open/Close, File Operations and IOCTLs

2.2.1 File Operations

Drivers must define the file operations structure that forms the DRM userspace API entry point, even though most of those operations are implemented in the DRM core. The resulting `struct file_operations` must be stored in the *`drm_driver.fops`* field. The mandatory functions are *`drm_open()`*, *`drm_read()`*, *`drm_ioctl()`* and *`drm_compat_ioctl()`* if CONFIG_COMPAT is enabled Note that drm_compat_ioctl will be NULL if CONFIG_COMPAT=n, so there' s no need to sprinkle #ifdef into the code. Drivers which implement private ioctls that require 32/64 bit compatibility support must provide their own `file_operations.compat_ioctl` handler that processes private ioctls and calls *`drm_compat_ioctl()`* for core ioctls.

In addition *`drm_read()`* and *`drm_poll()`* provide support for DRM events. DRM events are a generic and extensible means to send asynchronous events to userspace through the file descriptor. They are used to send vblank event and page flip completions by the KMS API. But drivers can also use it for their own needs, e.g. to signal completion of rendering.

For the driver-side event interface see *`drm_event_reserve_init()`* and *`drm_send_event()`* as the main starting points.

The memory mapping implementation will vary depending on how the driver manages memory. Legacy drivers will use the deprecated drm_legacy_mmap() function, modern drivers should use one of the provided memory-manager specific implementations. For GEM-based drivers this is *`drm_gem_mmap()`*, and for drivers which use the CMA GEM helpers it' s *`drm_gem_cma_mmap()`*.

No other file operations are supported by the DRM userspace API. Overall the following is an example `file_operations` structure:

```
static const example_drm_fops = {
        .owner = THIS_MODULE,
        .open = drm_open,
        .release = drm_release,
        .unlocked_ioctl = drm_ioctl,
        .compat_ioctl = drm_compat_ioctl, // NULL if CONFIG_COMPAT=n
        .poll = drm_poll,
        .read = drm_read,
        .llseek = no_llseek,
        .mmap = drm_gem_mmap,
};
```

For plain GEM based drivers there is the *`DEFINE_DRM_GEM_FOPS()`* macro, and for CMA based drivers there is the *`DEFINE_DRM_GEM_CMA_FOPS()`* macro to make this simpler.

The driver' s `file_operations` must be stored in *`drm_driver.fops`*.

For driver-private IOCTL handling see the more detailed discussion in *IOCTL support in the userland interfaces chapter*.

struct **drm_minor**

DRM device minor structure

Definition

```
struct drm_minor {
};
```

Members

Description

This structure represents a DRM minor number for device nodes in /dev. Entirely opaque to drivers and should never be inspected directly by drivers. Drivers instead should only interact with *struct drm_file* and of course *struct drm_device*, which is also where driver-private data and resources can be attached to.

struct **drm_pending_event**

Event queued up for userspace to read

Definition

```
struct drm_pending_event {
  struct completion *completion;
  void (*completion_release)(struct completion *completion);
  struct drm_event *event;
  struct dma_fence *fence;
  struct drm_file *file_priv;
  struct list_head link;
  struct list_head pending_link;
};
```

Members

completion

Optional pointer to a kernel internal completion signalled when *drm_send_event()* is called, useful to internally synchronize with non-blocking operations.

completion_release

Optional callback currently only used by the atomic modeset helpers to clean up the reference count for the structure **completion** is stored in.

event

Pointer to the actual event that should be sent to userspace to be read using *drm_read()*. Can be optional, since nowadays events are also used to signal kernel internal threads with **completion** or DMA transactions using **fence**.

fence

Optional DMA fence to unblock other hardware transactions which depend upon the nonblocking DRM operation this event represents.

file_priv

struct drm_file where **event** should be delivered to. Only set when **event** is set.

link
Double-linked list to keep track of this event. Can be used by the driver up to the point when it calls *drm_send_event()*, after that this list entry is owned by the core for its own book-keeping.

pending_link
Entry on *drm_file.pending_event_list*, to keep track of all pending events for **file_priv**, to allow correct unwinding of them when userspace closes the file before the event is delivered.

Description

This represents a DRM event. Drivers can use this as a generic completion mechanism, which supports kernel-internal `struct completion`, `struct dma_fence` and also the DRM-specific `struct drm_event` delivery mechanism.

struct **drm_file**
DRM file private data

Definition

```
struct drm_file {
  bool authenticated;
  bool stereo_allowed;
  bool universal_planes;
  bool atomic;
  bool aspect_ratio_allowed;
  bool writeback_connectors;
  bool was_master;
  bool is_master;
  struct drm_master *master;
  spinlock_t master_lookup_lock;
  struct pid *pid;
  drm_magic_t magic;
  struct list_head lhead;
  struct drm_minor *minor;
  struct idr object_idr;
  spinlock_t table_lock;
  struct idr syncobj_idr;
  spinlock_t syncobj_table_lock;
  struct file *filp;
  void *driver_priv;
  struct list_head fbs;
  struct mutex fbs_lock;
  struct list_head blobs;
  wait_queue_head_t event_wait;
  struct list_head pending_event_list;
  struct list_head event_list;
  int event_space;
  struct mutex event_read_lock;
  struct drm_prime_file_private prime;
};
```

Members

`authenticated`
Whether the client is allowed to submit rendering, which for legacy nodes means it must be authenticated.

See also the *section on primary nodes and authentication*.

`stereo_allowed`
True when the client has asked us to expose stereo 3D mode flags.

`universal_planes`
True if client understands CRTC primary planes and cursor planes in the plane list. Automatically set when **atomic** is set.

`atomic`
True if client understands atomic properties.

`aspect_ratio_allowed`
True, if client can handle picture aspect ratios, and has requested to pass this information along with the mode.

`writeback_connectors`
True if client understands writeback connectors

`was_master`
This client has or had, master capability. Protected by struct *`drm_device.master_mutex`*.

This is used to ensure that CAP_SYS_ADMIN is not enforced, if the client is or was master in the past.

`is_master`
This client is the creator of **master**. Protected by struct *`drm_device.master_mutex`*.

See also the *section on primary nodes and authentication*.

`master`
Master this node is currently associated with. Protected by struct *`drm_device.master_mutex`*, and serialized by **master_lookup_lock**.

Only relevant if *`drm_is_primary_client()`* returns true. Note that this only matches *`drm_device.master`* if the master is the currently active one.

When dereferencing this pointer, either hold struct *`drm_device.master_mutex`* for the duration of the pointer's use, or use *`drm_file_get_master()`* if struct *`drm_device.master_mutex`* is not currently held and there is no other need to hold it. This prevents **master** from being freed during use.

See also **authentication** and **is_master** and the *section on primary nodes and authentication*.

`pid`
Process that opened this file.

`magic`
Authentication magic, see **authenticated**.

lhead
: List of all open files of a DRM device, linked into *drm_device.filelist*. Protected by *drm_device.filelist_mutex*.

minor
: *struct drm_minor* for this file.

object_idr
: Mapping of mm object handles to object pointers. Used by the GEM subsystem. Protected by **table_lock**.

table_lock
: Protects **object_idr**.

syncobj_idr
: Mapping of sync object handles to object pointers.

syncobj_table_lock
: Protects **syncobj_idr**.

filp
: Pointer to the core file structure.

driver_priv
: Optional pointer for driver private data. Can be allocated in *drm_driver.open* and should be freed in *drm_driver.postclose*.

fbs
: List of *struct drm_framebuffer* associated with this file, using the *drm_framebuffer.filp_head* entry.

  Protected by **fbs_lock**. Note that the **fbs** list holds a reference on the framebuffer object to prevent it from untimely disappearing.

fbs_lock
: Protects **fbs**.

blobs
: User-created blob properties; this retains a reference on the property.

  Protected by **drm_mode_config.blob_lock**;

event_wait
: Waitqueue for new events added to **event_list**.

pending_event_list
: List of pending *struct drm_pending_event*, used to clean up pending events in case this file gets closed before the event is signalled. Uses the *drm_pending_event.pending_link* entry.

  Protect by *drm_device.event_lock*.

event_list
: List of *struct drm_pending_event*, ready for delivery to userspace through *drm_read()*. Uses the *drm_pending_event.link* entry.

  Protect by *drm_device.event_lock*.

event_space
: Available event space to prevent userspace from exhausting kernel memory.

Currently limited to the fairly arbitrary value of 4KB.

`event_read_lock`
: Serializes *`drm_read()`*.

`prime`
: Per-file buffer caches used by the PRIME buffer sharing code.

Description

This structure tracks DRM state per open file descriptor.

bool **`drm_is_primary_client`**(const struct *drm_file* *file_priv)
: is this an open file of the primary node

Parameters

`const struct drm_file *file_priv`
: DRM file

Description

Returns true if this is an open file of the primary node, i.e. *`drm_file.minor`* of **file_priv** is a primary minor.

See also the *section on primary nodes and authentication*.

bool **`drm_is_render_client`**(const struct *drm_file* *file_priv)
: is this an open file of the render node

Parameters

`const struct drm_file *file_priv`
: DRM file

Description

Returns true if this is an open file of the render node, i.e. *`drm_file.minor`* of **file_priv** is a render minor.

See also the *section on render nodes*.

int **`drm_open`**(struct *inode* *inode, struct file *filp)
: open method for DRM file

Parameters

`struct inode *inode`
: device inode

`struct file *filp`
: file pointer.

Description

This function must be used by drivers as their `file_operations.open` method. It looks up the correct DRM device and instantiates all the per-file resources for it. It also calls the *`drm_driver.open`* driver callback.

0 on success or negative errno value on falure.

Return

int **drm_release**(struct *inode* *inode, struct file *filp)

release method for DRM file

Parameters

struct inode *inode
device inode

struct file *filp
file pointer.

Description

This function must be used by drivers as their `file_operations.release` method. It frees any resources associated with the open file, and calls the *drm_driver.postclose* driver callback. If this is the last open file for the DRM device also proceeds to call the *drm_driver.lastclose* driver callback.

Always succeeds and returns 0.

Return

int **drm_release_noglobal**(struct *inode* *inode, struct file *filp)

release method for DRM file

Parameters

struct inode *inode
device inode

struct file *filp
file pointer.

Description

This function may be used by drivers as their `file_operations.release` method. It frees any resources associated with the open file prior to taking the drm_global_mutex, which then calls the *drm_driver.postclose* driver callback. If this is the last open file for the DRM device also proceeds to call the *drm_driver.lastclose* driver callback.

Always succeeds and returns 0.

Return

ssize_t **drm_read**(struct file *filp, char __user *buffer, size_t count, loff_t *offset)

read method for DRM file

Parameters

struct file *filp
file pointer

char __user *buffer
userspace destination pointer for the read

size_t count
count in bytes to read

loff_t *offset
offset to read

Description

This function must be used by drivers as their `file_operations.read` method iff they use DRM events for asynchronous signalling to userspace. Since events are used by the KMS API for vblank and page flip completion this means all modern display drivers must use it.

offset is ignored, DRM events are read like a pipe. Therefore drivers also must set the `file_operation.llseek` to no_llseek(). Polling support is provided by *`drm_poll()`*.

This function will only ever read a full event. Therefore userspace must supply a big enough buffer to fit any event to ensure forward progress. Since the maximum event space is currently 4K it' s recommended to just use that for safety.

Number of bytes read (always aligned to full events, and can be 0) or a negative error code on failure.

Return

__poll_t **`drm_poll`**(struct file *filp, struct poll_table_struct *wait)

poll method for DRM file

Parameters

`struct file *filp`
file pointer

`struct poll_table_struct *wait`
poll waiter table

Description

This function must be used by drivers as their `file_operations.read` method iff they use DRM events for asynchronous signalling to userspace. Since events are used by the KMS API for vblank and page flip completion this means all modern display drivers must use it.

See also *`drm_read()`*.

Mask of POLL flags indicating the current status of the file.

Return

int **`drm_event_reserve_init_locked`**(struct *drm_device* *dev, struct *drm_file* *file_priv, struct *drm_pending_event* *p, struct drm_event *e)

init a DRM event and reserve space for it

Parameters

`struct drm_device *dev`
DRM device

`struct drm_file *file_priv`
DRM file private data

`struct drm_pending_event *p`
tracking structure for the pending event

struct drm_event *e
actual event data to deliver to userspace

Description

This function prepares the passed in event for eventual delivery. If the event doesn't get delivered (because the IOCTL fails later on, before queuing up anything) then the even must be cancelled and freed using *drm_event_cancel_free()*. Successfully initialized events should be sent out using *drm_send_event()* or *drm_send_event_locked()* to signal completion of the asynchronous event to userspace.

If callers embedded **p** into a larger structure it must be allocated with kmalloc and **p** must be the first member element.

This is the locked version of *drm_event_reserve_init()* for callers which already hold *drm_device.event_lock*.

0 on success or a negative error code on failure.

Return

int **drm_event_reserve_init**(struct *drm_device* *dev, struct *drm_file* *file_priv, struct *drm_pending_event* *p, struct drm_event *e)

init a DRM event and reserve space for it

Parameters

struct drm_device *dev
DRM device

struct drm_file *file_priv
DRM file private data

struct drm_pending_event *p
tracking structure for the pending event

struct drm_event *e
actual event data to deliver to userspace

Description

This function prepares the passed in event for eventual delivery. If the event doesn't get delivered (because the IOCTL fails later on, before queuing up anything) then the even must be cancelled and freed using *drm_event_cancel_free()*. Successfully initialized events should be sent out using *drm_send_event()* or *drm_send_event_locked()* to signal completion of the asynchronous event to userspace.

If callers embedded **p** into a larger structure it must be allocated with kmalloc and **p** must be the first member element.

Callers which already hold *drm_device.event_lock* should use *drm_event_reserve_init_locked()* instead.

0 on success or a negative error code on failure.

Return

void **drm_event_cancel_free**(struct *drm_device* *dev, struct *drm_pending_event* *p)

free a DRM event and release its space

Parameters

struct drm_device *dev
DRM device

struct drm_pending_event *p
tracking structure for the pending event

Description

This function frees the event **p** initialized with *drm_event_reserve_init()* and releases any allocated space. It is used to cancel an event when the nonblocking operation could not be submitted and needed to be aborted.

void **drm_send_event_locked**(struct *drm_device* *dev, struct *drm_pending_event* *e)

send DRM event to file descriptor

Parameters

struct drm_device *dev
DRM device

struct drm_pending_event *e
DRM event to deliver

Description

This function sends the event **e**, initialized with *drm_event_reserve_init()*, to its associated userspace DRM file. Callers must already hold *drm_device.event_lock*, see *drm_send_event()* for the unlocked version.

Note that the core will take care of unlinking and disarming events when the corresponding DRM file is closed. Drivers need not worry about whether the DRM file for this event still exists and can call this function upon completion of the asynchronous work unconditionally.

void **drm_send_event**(struct *drm_device* *dev, struct *drm_pending_event* *e)

send DRM event to file descriptor

Parameters

struct drm_device *dev
DRM device

struct drm_pending_event *e
DRM event to deliver

Description

This function sends the event **e**, initialized with *drm_event_reserve_init()*, to its associated userspace DRM file. This function acquires *drm_device.event_lock*, see *drm_send_event_locked()* for callers which already hold this lock.

Note that the core will take care of unlinking and disarming events when the corresponding DRM file is closed. Drivers need not worry about whether the DRM file for this event still exists and can call this function upon completion of the asynchronous work unconditionally.

unsigned long **drm_get_unmapped_area**(struct *file* *file, unsigned long uaddr, unsigned long len, unsigned long pgoff, unsigned long flags, struct drm_vma_offset_manager *mgr)

Get an unused user-space virtual memory area suitable for huge page table entries.

Parameters

struct file *file
The struct file representing the address space being mmap()' d.

unsigned long uaddr
Start address suggested by user-space.

unsigned long len
Length of the area.

unsigned long pgoff
The page offset into the address space.

unsigned long flags
mmap flags

struct drm_vma_offset_manager *mgr
The address space manager used by the drm driver. This argument can probably be removed at some point when all drivers use the same address space manager.

Description

This function attempts to find an unused user-space virtual memory area that can accommodate the size we want to map, and that is properly aligned to facilitate huge page table entries matching actual huge pages or huge page aligned memory in buffer objects. Buffer objects are assumed to start at huge page boundary pfns (io memory) or be populated by huge pages aligned to the start of the buffer object (system- or coherent memory). Adapted from shmem_get_unmapped_area.

Return

aligned user-space address.

2.3 Misc Utilities

2.3.1 Printer

A simple wrapper for dev_printk(), seq_printf(), etc. Allows same debug code to be used for both debugfs and printk logging.

For example:

```
void log_some_info(struct drm_printer *p)
{
        drm_printf(p, "foo=%d\n", foo);
        drm_printf(p, "bar=%d\n", bar);
}

#ifdef CONFIG_DEBUG_FS
void debugfs_show(struct seq_file *f)
{
        struct drm_printer p = drm_seq_file_printer(f);
        log_some_info(&p);
}
#endif

void some_other_function(...)
{
        struct drm_printer p = drm_info_printer(drm->dev);
        log_some_info(&p);
}
```

struct **drm_printer**

drm output "stream"

Definition

```
struct drm_printer {
};
```

Members

Description

Do not use struct members directly. Use drm_printer_seq_file(), drm_printer_info(), etc to initialize. And *drm_printf()* for output.

void **drm_vprintf**(struct *drm_printer* *p, const char *fmt, va_list *va)

print to a *drm_printer* stream

Parameters

struct drm_printer *p
the *drm_printer*

const char *fmt
format string

va_list *va
the va_list

drm_printf_indent

`drm_printf_indent (printer, indent, fmt, ...)`

Print to a *drm_printer* stream with indentation

Parameters

printer
DRM printer

indent
Tab indentation level (max 5)

fmt
Format string

...
variable arguments

struct **drm_print_iterator**
local struct used with drm_printer_coredump

Definition

```
struct drm_print_iterator {
  void *data;
  ssize_t start;
  ssize_t remain;
};
```

Members

data
Pointer to the devcoredump output buffer

start
The offset within the buffer to start writing

remain
The number of bytes to write for this iteration

struct *drm_printer* **drm_coredump_printer**(struct *drm_print_iterator* *iter)
construct a *drm_printer* that can output to a buffer from the read function for devcoredump

Parameters

struct drm_print_iterator *iter
A pointer to a *struct drm_print_iterator* for the read instance

Description

This wrapper extends *drm_printf()* to work with a dev_coredumpm() callback function. The passed in drm_print_iterator struct contains the buffer pointer, size and offset as passed in from devcoredump.

For example:

```
void coredump_read(char *buffer, loff_t offset, size_t count,
        void *data, size_t datalen)
{
        struct drm_print_iterator iter;
        struct drm_printer p;
```

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```
        iter.data = buffer;
        iter.start = offset;
        iter.remain = count;

        p = drm_coredump_printer(&iter);

        drm_printf(p, "foo=%d\n", foo);
}

void makecoredump(...)
{
        ...
        dev_coredumpm(dev, THIS_MODULE, data, 0, GFP_KERNEL,
                coredump_read, ...)
}
```

Return

The *drm_printer* object

struct *drm_printer* **drm_seq_file_printer**(struct seq_file *f)

construct a *drm_printer* that outputs to seq_file

Parameters

struct seq_file *f
the struct seq_file to output to

Return

The *drm_printer* object

struct *drm_printer* **drm_info_printer**(struct device *dev)

construct a *drm_printer* that outputs to dev_printk()

Parameters

struct device *dev
the struct device pointer

Return

The *drm_printer* object

struct *drm_printer* **drm_debug_printer**(const char *prefix)

construct a *drm_printer* that outputs to pr_debug()

Parameters

const char *prefix
debug output prefix

Return

The *drm_printer* object

struct *drm_printer* **drm_err_printer**(const char *prefix)

construct a *drm_printer* that outputs to pr_err()

Parameters

const char *prefix
debug output prefix

Return

The *drm_printer* object

enum **drm_debug_category**

The DRM debug categories

Constants

DRM_UT_CORE
Used in the generic drm code: drm_ioctl.c, drm_mm.c, drm_memory.c, …

DRM_UT_DRIVER
Used in the vendor specific part of the driver: i915, radeon, …macro.

DRM_UT_KMS
Used in the modesetting code.

DRM_UT_PRIME
Used in the prime code.

DRM_UT_ATOMIC
Used in the atomic code.

DRM_UT_VBL
Used for verbose debug message in the vblank code.

DRM_UT_STATE
Used for verbose atomic state debugging.

DRM_UT_LEASE
Used in the lease code.

DRM_UT_DP
Used in the DP code.

DRM_UT_DRMRES
Used in the drm managed resources code.

Description

Each of the DRM debug logging macros use a specific category, and the logging is filtered by the drm.debug module parameter. This enum specifies the values for the interface.

Each DRM_DEBUG_<CATEGORY> macro logs to DRM_UT_<CATEGORY> category, except DRM_DEBUG() logs to DRM_UT_CORE.

Enabling verbose debug messages is done through the drm.debug parameter, each category being enabled by a bit:

- drm.debug=0x1 will enable CORE messages
- drm.debug=0x2 will enable DRIVER messages

- drm.debug=0x3 will enable CORE and DRIVER messages
- …
- drm.debug=0x1ff will enable all messages

An interesting feature is that it's possible to enable verbose logging at run-time by echoing the debug value in its sysfs node:

```
# echo 0xf > /sys/module/drm/parameters/debug
```

DRM_DEV_ERROR

`DRM_DEV_ERROR (dev, fmt, ...)`

Error output.

Parameters

dev
device pointer

fmt
printf() like format string.

...
variable arguments

DRM_DEV_ERROR_RATELIMITED

`DRM_DEV_ERROR_RATELIMITED (dev, fmt, ...)`

Rate limited error output.

Parameters

dev
device pointer

fmt
printf() like format string.

...
variable arguments

Description

Like DRM_ERROR() but won't flood the log.

DRM_DEV_DEBUG

`DRM_DEV_DEBUG (dev, fmt, ...)`

Debug output for generic drm code

Parameters

dev
device pointer

fmt
printf() like format string.

...
: variable arguments

DRM_DEV_DEBUG_DRIVER

`DRM_DEV_DEBUG_DRIVER (dev, fmt, ...)`

Debug output for vendor specific part of the driver

Parameters

dev
device pointer

fmt
printf() like format string.

...
variable arguments

DRM_DEV_DEBUG_KMS

`DRM_DEV_DEBUG_KMS (dev, fmt, ...)`

Debug output for modesetting code

Parameters

dev
device pointer

fmt
printf() like format string.

...
variable arguments

void **drm_puts**(struct *drm_printer* *p, const char *str)

print a const string to a *drm_printer* stream

Parameters

struct drm_printer *p
the drm printer

const char *str
const string

Description

Allow *drm_printer* types that have a constant string option to use it.

void **drm_printf**(struct *drm_printer* *p, const char *f, ...)

print to a *drm_printer* stream

Parameters

struct drm_printer *p
the *drm_printer*

const char *f
format string

...
    variable arguments

void **drm_print_bits**(struct *drm_printer* *p, unsigned long value, const char *const bits[], unsigned int nbits)

print bits to a *drm_printer* stream

Parameters

struct drm_printer *p
    the *drm_printer*

unsigned long value
    field value.

const char * const bits[]
    Array with bit names.

unsigned int nbits
    Size of bit names array.

Description

Print bits (in flag fields for example) in human readable form.

void **drm_print_regset32**(struct *drm_printer* *p, struct debugfs_regset32 *regset)

print the contents of registers to a *drm_printer* stream.

Parameters

struct drm_printer *p
    the drm printer

struct debugfs_regset32 *regset
    the list of registers to print.

Description

Often in driver debug, it' s useful to be able to either capture the contents of registers in the steady state using debugfs or at specific points during operation. This lets the driver have a single list of registers for both.

2.3.2 Utilities

Macros and inline functions that does not naturally belong in other places

for_each_if

`for_each_if (condition)`

helper for handling conditionals in various for_each macros

Parameters

condition
    The condition to check

Description

Typical use:

```
#define for_each_foo_bar(x, y) \'
        list_for_each_entry(x, y->list, head) \'
                for_each_if(x->something == SOMETHING)
```

The *for_each_if()* macro makes the use of for_each_foo_bar() less error prone.

bool **drm_can_sleep**(void)

returns true if currently okay to sleep

Parameters

void

no arguments

Description

This function shall not be used in new code. The check for running in atomic context may not work - see linux/preempt.h.

FIXME: All users of drm_can_sleep should be removed (see todo.rst)

Return

False if kgdb is active, we are in atomic context or irqs are disabled.

2.4 Legacy Support Code

The section very briefly covers some of the old legacy support code which is only used by old DRM drivers which have done a so-called shadow-attach to the underlying device instead of registering as a real driver. This also includes some of the old generic buffer management and command submission code. Do not use any of this in new and modern drivers.

2.4.1 Legacy Suspend/Resume

The DRM core provides some suspend/resume code, but drivers wanting full suspend/resume support should provide save() and restore() functions. These are called at suspend, hibernate, or resume time, and should perform any state save or restore required by your device across suspend or hibernate states.

int (*suspend) (*struct drm_device* *, pm_message_t state); int (*resume) (*struct drm_device* *); Those are legacy suspend and resume methods which *only* work with the legacy shadow-attach driver registration functions. New driver should use the power management interface provided by their bus type (usually through the `struct device_driver` dev_pm_ops) and set these methods to NULL.

2.4.2 Legacy DMA Services

This should cover how DMA mapping etc. is supported by the core. These functions are deprecated and should not be used.

CHAPTER

THREE

DRM MEMORY MANAGEMENT

Modern Linux systems require large amount of graphics memory to store frame buffers, textures, vertices and other graphics-related data. Given the very dynamic nature of many of that data, managing graphics memory efficiently is thus crucial for the graphics stack and plays a central role in the DRM infrastructure.

The DRM core includes two memory managers, namely Translation Table Maps (TTM) and Graphics Execution Manager (GEM). TTM was the first DRM memory manager to be developed and tried to be a one-size-fits-them all solution. It provides a single userspace API to accommodate the need of all hardware, supporting both Unified Memory Architecture (UMA) devices and devices with dedicated video RAM (i.e. most discrete video cards). This resulted in a large, complex piece of code that turned out to be hard to use for driver development.

GEM started as an Intel-sponsored project in reaction to TTM' s complexity. Its design philosophy is completely different: instead of providing a solution to every graphics memory-related problems, GEM identified common code between drivers and created a support library to share it. GEM has simpler initialization and execution requirements than TTM, but has no video RAM management capabilities and is thus limited to UMA devices.

3.1 The Translation Table Manager (TTM)

TTM design background and information belongs here.

3.1.1 TTM initialization

Warning This section is outdated.

Drivers wishing to support TTM must pass a filled `ttm_bo_driver` structure to ttm_bo_device_init, together with an initialized global reference to the memory manager. The ttm_bo_driver structure contains several fields with function pointers for initializing the TTM, allocating and freeing memory, waiting for command completion and fence synchronization, and memory migration.

The `struct drm_global_reference` is made up of several fields:

```
struct drm_global_reference {
        enum ttm_global_types global_type;
        size_t size;
```

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```
        void *object;
        int (*init) (struct drm_global_reference *);
        void (*release) (struct drm_global_reference *);
};
```

There should be one global reference structure for your memory manager as a whole, and there will be others for each object created by the memory manager at runtime. Your global TTM should have a type of TTM_GLOBAL_TTM_MEM. The size field for the global object should be sizeof(struct ttm_mem_global), and the init and release hooks should point at your driver-specific init and release routines, which probably eventually call ttm_mem_global_init and ttm_mem_global_release, respectively.

Once your global TTM accounting structure is set up and initialized by calling ttm_global_item_ref() on it, you need to create a buffer object TTM to provide a pool for buffer object allocation by clients and the kernel itself. The type of this object should be TTM_GLOBAL_TTM_BO, and its size should be sizeof(struct ttm_bo_global). Again, driver-specific init and release functions may be provided, likely eventually calling ttm_bo_global_ref_init() and ttm_bo_global_ref_release(), respectively. Also, like the previous object, ttm_global_item_ref() is used to create an initial reference count for the TTM, which will call your initialization function.

See the radeon_ttm.c file for an example of usage.

3.2 The Graphics Execution Manager (GEM)

The GEM design approach has resulted in a memory manager that doesn't provide full coverage of all (or even all common) use cases in its userspace or kernel API. GEM exposes a set of standard memory-related operations to userspace and a set of helper functions to drivers, and let drivers implement hardware-specific operations with their own private API.

The GEM userspace API is described in the GEM - the Graphics Execution Manager article on LWN. While slightly outdated, the document provides a good overview of the GEM API principles. Buffer allocation and read and write operations, described as part of the common GEM API, are currently implemented using driver-specific ioctls.

GEM is data-agnostic. It manages abstract buffer objects without knowing what individual buffers contain. APIs that require knowledge of buffer contents or purpose, such as buffer allocation or synchronization primitives, are thus outside of the scope of GEM and must be implemented using driver-specific ioctls.

On a fundamental level, GEM involves several operations:

- Memory allocation and freeing
- Command execution
- Aperture management at command execution time

Buffer object allocation is relatively straightforward and largely provided by Linux's shmem layer, which provides memory to back each object.

Device-specific operations, such as command execution, pinning, buffer read & write, mapping, and domain ownership transfers are left to driver-specific ioctls.

3.2.1 GEM Initialization

Drivers that use GEM must set the DRIVER_GEM bit in the struct *struct drm_driver* driver_features field. The DRM core will then automatically initialize the GEM core before calling the load operation. Behind the scene, this will create a DRM Memory Manager object which provides an address space pool for object allocation.

In a KMS configuration, drivers need to allocate and initialize a command ring buffer following core GEM initialization if required by the hardware. UMA devices usually have what is called a "stolen" memory region, which provides space for the initial framebuffer and large, contiguous memory regions required by the device. This space is typically not managed by GEM, and must be initialized separately into its own DRM MM object.

3.2.2 GEM Objects Creation

GEM splits creation of GEM objects and allocation of the memory that backs them in two distinct operations.

GEM objects are represented by an instance of struct *struct drm_gem_object*. Drivers usually need to extend GEM objects with private information and thus create a driver-specific GEM object structure type that embeds an instance of struct *struct drm_gem_object*.

To create a GEM object, a driver allocates memory for an instance of its specific GEM object type and initializes the embedded struct *struct drm_gem_object* with a call to *drm_gem_object_init()*. The function takes a pointer to the DRM device, a pointer to the GEM object and the buffer object size in bytes.

GEM uses shmem to allocate anonymous pageable memory. *drm_gem_object_init()* will create an shmfs file of the requested size and store it into the struct *struct drm_gem_object* filp field. The memory is used as either main storage for the object when the graphics hardware uses system memory directly or as a backing store otherwise.

Drivers are responsible for the actual physical pages allocation by calling shmem_read_mapping_page_gfp() for each page. Note that they can decide to allocate pages when initializing the GEM object, or to delay allocation until the memory is needed (for instance when a page fault occurs as a result of a userspace memory access or when the driver needs to start a DMA transfer involving the memory).

Anonymous pageable memory allocation is not always desired, for instance when the hardware requires physically contiguous system memory as is often the case in embedded devices. Drivers can create GEM objects with no shmfs backing (called private GEM objects) by initializing them with a call to *drm_gem_private_object_init()* instead of *drm_gem_object_init()*. Storage for private GEM objects must be managed by drivers.

3.2.3 GEM Objects Lifetime

All GEM objects are reference-counted by the GEM core. References can be acquired and release by calling *drm_gem_object_get()* and *drm_gem_object_put()* respectively.

When the last reference to a GEM object is released the GEM core calls the *struct drm_driver* gem_free_object_unlocked operation. That operation is mandatory for GEM-enabled drivers and must free the GEM object and all associated resources.

void (*gem_free_object) (*struct drm_gem_object* *obj); Drivers are responsible for freeing all GEM object resources. This includes the resources created by the GEM core, which need to be released with *drm_gem_object_release()*.

3.2.4 GEM Objects Naming

Communication between userspace and the kernel refers to GEM objects using local handles, global names or, more recently, file descriptors. All of those are 32-bit integer values; the usual Linux kernel limits apply to the file descriptors.

GEM handles are local to a DRM file. Applications get a handle to a GEM object through a driver-specific ioctl, and can use that handle to refer to the GEM object in other standard or driver-specific ioctls. Closing a DRM file handle frees all its GEM handles and dereferences the associated GEM objects.

To create a handle for a GEM object drivers call *drm_gem_handle_create()*. The function takes a pointer to the DRM file and the GEM object and returns a locally unique handle. When the handle is no longer needed drivers delete it with a call to *drm_gem_handle_delete()*. Finally the GEM object associated with a handle can be retrieved by a call to *drm_gem_object_lookup()*.

Handles don't take ownership of GEM objects, they only take a reference to the object that will be dropped when the handle is destroyed. To avoid leaking GEM objects, drivers must make sure they drop the reference(s) they own (such as the initial reference taken at object creation time) as appropriate, without any special consideration for the handle. For example, in the particular case of combined GEM object and handle creation in the implementation of the dumb_create operation, drivers must drop the initial reference to the GEM object before returning the handle.

GEM names are similar in purpose to handles but are not local to DRM files. They can be passed between processes to reference a GEM object globally. Names can't be used directly to refer to objects in the DRM API, applications must convert handles to names and names to handles using the DRM_IOCTL_GEM_FLINK and DRM_IOCTL_GEM_OPEN ioctls respectively. The conversion is handled by the DRM core without any driver-specific support.

GEM also supports buffer sharing with dma-buf file descriptors through PRIME. GEM-based drivers must use the provided helpers functions to implement the exporting and importing correctly. See ?. Since sharing file descriptors is inherently more secure than the easily guessable and global GEM names it is the preferred buffer sharing mechanism. Sharing buffers through GEM names is only supported for legacy userspace. Furthermore PRIME also allows cross-device buffer sharing since it is based on dma-bufs.

3.2.5 GEM Objects Mapping

Because mapping operations are fairly heavyweight GEM favours read/write-like access to buffers, implemented through driver-specific ioctls, over mapping buffers to userspace. However, when random access to the buffer is needed (to perform software rendering for instance), direct access to the object can be more efficient.

The mmap system call can't be used directly to map GEM objects, as they don't have their own file handle. Two alternative methods currently co-exist to map GEM objects to userspace. The first method uses a driver-specific ioctl to perform the mapping operation, calling do_mmap() under the hood. This is often considered dubious, seems to be discouraged for new GEM-enabled drivers, and will thus not be described here.

The second method uses the mmap system call on the DRM file handle. void *mmap(void *addr, size_t length, int prot, int flags, int fd, off_t offset); DRM identifies the GEM object to be mapped by a fake offset passed through the mmap offset argument. Prior to being mapped, a GEM object must thus be associated with a fake offset. To do so, drivers must call *drm_gem_create_mmap_offset()* on the object.

Once allocated, the fake offset value must be passed to the application in a driver-specific way and can then be used as the mmap offset argument.

The GEM core provides a helper method *drm_gem_mmap()* to handle object mapping. The method can be set directly as the mmap file operation handler. It will look up the GEM object based on the offset value and set the VMA operations to the *struct drm_driver* gem_vm_ops field. Note that *drm_gem_mmap()* doesn't map memory to userspace, but relies on the driver-provided fault handler to map pages individually.

To use *drm_gem_mmap()*, drivers must fill the struct *struct drm_driver* gem_vm_ops field with a pointer to VM operations.

The VM operations is a `struct vm_operations_struct` made up of several fields, the more interesting ones being:

```
struct vm_operations_struct {
        void (*open)(struct vm_area_struct * area);
        void (*close)(struct vm_area_struct * area);
        vm_fault_t (*fault)(struct vm_fault *vmf);
};
```

The open and close operations must update the GEM object reference count. Drivers can use the *drm_gem_vm_open()* and *drm_gem_vm_close()* helper functions directly as open and close handlers.

The fault operation handler is responsible for mapping individual pages to userspace when a page fault occurs. Depending on the memory allocation scheme, drivers can allocate pages at fault time, or can decide to allocate memory for the GEM object at the time the object is created.

Drivers that want to map the GEM object upfront instead of handling page faults can implement their own mmap file operation handler.

For platforms without MMU the GEM core provides a helper method *drm_gem_cma_get_unmapped_area()*. The mmap() routines will call this to get a proposed address for the mapping.

To use *drm_gem_cma_get_unmapped_area()*, drivers must fill the struct `struct file_operations` get_unmapped_area field with a pointer on *drm_gem_cma_get_unmapped_area()*.

More detailed information about get_unmapped_area can be found in Documentation/admin-guide/mm/nommu-mmap.rst

3.2.6 Memory Coherency

When mapped to the device or used in a command buffer, backing pages for an object are flushed to memory and marked write combined so as to be coherent with the GPU. Likewise, if the CPU accesses an object after the GPU has finished rendering to the object, then the object must be made coherent with the CPU' s view of memory, usually involving GPU cache flushing of various kinds. This core CPU<->GPU coherency management is provided by a device-specific ioctl, which evaluates an object' s current domain and performs any necessary flushing or synchronization to put the object into the desired coherency domain (note that the object may be busy, i.e. an active render target; in that case, setting the domain blocks the client and waits for rendering to complete before performing any necessary flushing operations).

3.2.7 Command Execution

Perhaps the most important GEM function for GPU devices is providing a command execution interface to clients. Client programs construct command buffers containing references to previously allocated memory objects, and then submit them to GEM. At that point, GEM takes care to bind all the objects into the GTT, execute the buffer, and provide necessary synchronization between clients accessing the same buffers. This often involves evicting some objects from the GTT and re-binding others (a fairly expensive operation), and providing relocation support which hides fixed GTT offsets from clients. Clients must take care not to submit command buffers that reference more objects than can fit in the GTT; otherwise, GEM will reject them and no rendering will occur. Similarly, if several objects in the buffer require fence registers to be allocated for correct rendering (e.g. 2D blits on pre-965 chips), care must be taken not to require more fence registers than are available to the client. Such resource management should be abstracted from the client in libdrm.

3.2.8 GEM Function Reference

struct **drm_gem_object_funcs**

GEM object functions

Definition

```
struct drm_gem_object_funcs {
  void (*free)(struct drm_gem_object *obj);
  int (*open)(struct drm_gem_object *obj, struct drm_file *file);
  void (*close)(struct drm_gem_object *obj, struct drm_file *file);
  void (*print_info)(struct drm_printer *p, unsigned int indent,␣
↪const struct drm_gem_object *obj);
  struct dma_buf *(*export)(struct drm_gem_object *obj, int flags);
  int (*pin)(struct drm_gem_object *obj);
  void (*unpin)(struct drm_gem_object *obj);
  struct sg_table *(*get_sg_table)(struct drm_gem_object *obj);
  void *(*vmap)(struct drm_gem_object *obj);
  void (*vunmap)(struct drm_gem_object *obj, void *vaddr);
  int (*mmap)(struct drm_gem_object *obj, struct vm_area_struct␣
↪*vma);
  const struct vm_operations_struct *vm_ops;
};
```

Members

free
Deconstructor for drm_gem_objects.

This callback is mandatory.

open
Called upon GEM handle creation.

This callback is optional.

close
Called upon GEM handle release.

This callback is optional.

print_info
If driver subclasses struct *drm_gem_object*, it can implement this optional hook for printing additional driver specific info.

drm_printf_indent() should be used in the callback passing it the indent argument.

This callback is called from drm_gem_print_info().

This callback is optional.

export
Export backing buffer as a dma_buf. If this is not set *drm_gem_prime_export()* is used.

This callback is optional.

pin
Pin backing buffer in memory. Used by the *drm_gem_map_attach()* helper.

This callback is optional.

unpin
Unpin backing buffer. Used by the *drm_gem_map_detach()* helper.

This callback is optional.

get_sg_table
Returns a Scatter-Gather table representation of the buffer. Used when exporting a buffer by the *drm_gem_map_dma_buf()* helper. Releasing is done by calling dma_unmap_sg_attrs() and sg_free_table() in drm_gem_unmap_buf(), therefore these helpers and this callback here cannot be used for sg tables pointing at driver private memory ranges.

See also *drm_prime_pages_to_sg()*.

vmap
Returns a virtual address for the buffer. Used by the *drm_gem_dmabuf_vmap()* helper.

This callback is optional.

vunmap
Releases the address previously returned by **vmap**. Used by the *drm_gem_dmabuf_vunmap()* helper.

This callback is optional.

mmap
Handle mmap() of the gem object, setup vma accordingly.

This callback is optional.

The callback is used by both *drm_gem_mmap_obj()* and *drm_gem_prime_mmap()*. When **mmap** is present **vm_ops** is not used, the **mmap** callback must set vma->vm_ops instead.

vm_ops
Virtual memory operations used with mmap.

This is optional but necessary for mmap support.

struct **drm_gem_object**
GEM buffer object

Definition

```
struct drm_gem_object {
  struct kref refcount;
  unsigned handle_count;
  struct drm_device *dev;
  struct file *filp;
  struct drm_vma_offset_node vma_node;
  size_t size;
  int name;
```

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```
  struct dma_buf *dma_buf;
  struct dma_buf_attachment *import_attach;
  struct dma_resv *resv;
  struct dma_resv _resv;
  const struct drm_gem_object_funcs *funcs;
};
```

Members

refcount
Reference count of this object

Please use *drm_gem_object_get()* to acquire and *drm_gem_object_put_locked()* or *drm_gem_object_put()* to release a reference to a GEM buffer object.

handle_count
This is the GEM file_priv handle count of this object.

Each handle also holds a reference. Note that when the handle_count drops to 0 any global names (e.g. the id in the flink namespace) will be cleared.

Protected by *drm_device.object_name_lock*.

dev
DRM dev this object belongs to.

filp
SHMEM file node used as backing storage for swappable buffer objects. GEM also supports driver private objects with driver-specific backing storage (contiguous CMA memory, special reserved blocks). In this case **filp** is NULL.

vma_node
Mapping info for this object to support mmap. Drivers are supposed to allocate the mmap offset using *drm_gem_create_mmap_offset()*. The offset itself can be retrieved using *drm_vma_node_offset_addr()*.

Memory mapping itself is handled by *drm_gem_mmap()*, which also checks that userspace is allowed to access the object.

size
Size of the object, in bytes. Immutable over the object's lifetime.

name
Global name for this object, starts at 1. 0 means unnamed. Access is covered by *drm_device.object_name_lock*. This is used by the GEM_FLINK and GEM_OPEN ioctls.

dma_buf
dma-buf associated with this GEM object.

Pointer to the dma-buf associated with this gem object (either through importing or exporting). We break the resulting reference loop when the last gem handle for this object is released.

Protected by *drm_device.object_name_lock*.

import_attach
dma-buf attachment backing this object.

Any foreign dma_buf imported as a gem object has this set to the attachment point for the device. This is invariant over the lifetime of a gem object.

The *drm_driver.gem_free_object_unlocked* callback is responsible for cleaning up the dma_buf attachment and references acquired at import time.

Note that the drm gem/prime core does not depend upon drivers setting this field any more. So for drivers where this doesn't make sense (e.g. virtual devices or a displaylink behind an usb bus) they can simply leave it as NULL.

resv
Pointer to reservation object associated with the this GEM object.

Normally (**resv** == &**_resv**) except for imported GEM objects.

_resv
A reservation object for this GEM object.

This is unused for imported GEM objects.

funcs
Optional GEM object functions. If this is set, it will be used instead of the corresponding *drm_driver* GEM callbacks.

New drivers should use this.

Description

This structure defines the generic parts for GEM buffer objects, which are mostly around handling mmap and userspace handles.

Buffer objects are often abbreviated to BO.

DEFINE_DRM_GEM_FOPS

`DEFINE_DRM_GEM_FOPS (name)`

macro to generate file operations for GEM drivers

Parameters

name
name for the generated structure

Description

This macro autogenerates a suitable `struct file_operations` for GEM based drivers, which can be assigned to *drm_driver.fops*. Note that this structure cannot be shared between drivers, because it contains a reference to the current module using THIS_MODULE.

Note that the declaration is already marked as static - if you need a non-static version of this you're probably doing it wrong and will break the THIS_MODULE reference by accident.

void **drm_gem_object_get**(struct *drm_gem_object* *obj)
acquire a GEM buffer object reference

Parameters

struct drm_gem_object *obj
GEM buffer object

Description

This function acquires an additional reference to **obj**. It is illegal to call this without already holding a reference. No locks required.

void **drm_gem_object_put**(struct *drm_gem_object* *obj)
drop a GEM buffer object reference

Parameters

struct drm_gem_object *obj
GEM buffer object

Description

This releases a reference to **obj**.

int **drm_gem_object_init**(struct *drm_device* *dev, struct *drm_gem_object* *obj, size_t size)
initialize an allocated shmem-backed GEM object

Parameters

struct drm_device *dev
drm_device the object should be initialized for

struct drm_gem_object *obj
drm_gem_object to initialize

size_t size
object size

Description

Initialize an already allocated GEM object of the specified size with shmfs backing store.

void **drm_gem_private_object_init**(struct *drm_device* *dev, struct *drm_gem_object* *obj, size_t size)
initialize an allocated private GEM object

Parameters

struct drm_device *dev
drm_device the object should be initialized for

struct drm_gem_object *obj
drm_gem_object to initialize

size_t size
object size

Description

Initialize an already allocated GEM object of the specified size with no GEM provided backing store. Instead the caller is responsible for backing the object and handling it.

int **drm_gem_handle_delete**(struct *drm_file* *filp, u32 handle)
deletes the given file-private handle

Parameters

struct drm_file *filp
drm file-private structure to use for the handle look up

u32 handle
userspace handle to delete

Description

Removes the GEM handle from the **filp** lookup table which has been added with *drm_gem_handle_create()*. If this is the last handle also cleans up linked resources like GEM names.

int **drm_gem_dumb_map_offset**(struct *drm_file* *file, struct *drm_device* *dev, u32 handle, u64 *offset)
return the fake mmap offset for a gem object

Parameters

struct drm_file *file
drm file-private structure containing the gem object

struct drm_device *dev
corresponding drm_device

u32 handle
gem object handle

u64 *offset
return location for the fake mmap offset

Description

This implements the *drm_driver.dumb_map_offset* kms driver callback for drivers which use gem to manage their backing storage.

Return

0 on success or a negative error code on failure.

int **drm_gem_dumb_destroy**(struct *drm_file* *file, struct *drm_device* *dev, uint32_t handle)
dumb fb callback helper for gem based drivers

Parameters

struct drm_file *file
drm file-private structure to remove the dumb handle from

struct drm_device *dev
corresponding drm_device

uint32_t handle
the dumb handle to remove

Description

This implements the *drm_driver.dumb_destroy* kms driver callback for drivers which use gem to manage their backing storage.

int **drm_gem_handle_create**(struct *drm_file* *file_priv, struct *drm_gem_object* *obj, u32 *handlep)

create a gem handle for an object

Parameters

struct drm_file *file_priv
drm file-private structure to register the handle for

struct drm_gem_object *obj
object to register

u32 *handlep
pointer to return the created handle to the caller

Description

Create a handle for this object. This adds a handle reference to the object, which includes a regular reference count. Callers will likely want to dereference the object afterwards.

Since this publishes **obj** to userspace it must be fully set up by this point, drivers must call this last in their buffer object creation callbacks.

void **drm_gem_free_mmap_offset**(struct *drm_gem_object* *obj)

release a fake mmap offset for an object

Parameters

struct drm_gem_object *obj
obj in question

Description

This routine frees fake offsets allocated by *drm_gem_create_mmap_offset()*.

Note that *drm_gem_object_release()* already calls this function, so drivers don' t have to take care of releasing the mmap offset themselves when freeing the GEM object.

int **drm_gem_create_mmap_offset_size**(struct *drm_gem_object* *obj, size_t size)

create a fake mmap offset for an object

Parameters

struct drm_gem_object *obj
obj in question

size_t size
the virtual size

Description

GEM memory mapping works by handing back to userspace a fake mmap offset it can use in a subsequent mmap(2) call. The DRM core code then looks up the object based on the offset and sets up the various memory mapping structures.

This routine allocates and attaches a fake offset for **obj**, in cases where the virtual size differs from the physical size (ie. *drm_gem_object.size*). Otherwise just use *drm_gem_create_mmap_offset()*.

This function is idempotent and handles an already allocated mmap offset transparently. Drivers do not need to check for this case.

int **drm_gem_create_mmap_offset**(struct *drm_gem_object* *obj)
    create a fake mmap offset for an object

Parameters

struct drm_gem_object *obj
    obj in question

Description

GEM memory mapping works by handing back to userspace a fake mmap offset it can use in a subsequent mmap(2) call. The DRM core code then looks up the object based on the offset and sets up the various memory mapping structures.

This routine allocates and attaches a fake offset for **obj**.

Drivers can call *drm_gem_free_mmap_offset()* before freeing **obj** to release the fake offset again.

struct page ****drm_gem_get_pages**(struct *drm_gem_object* *obj)
    helper to allocate backing pages for a GEM object from shmem

Parameters

struct drm_gem_object *obj
    obj in question

Description

This reads the page-array of the shmem-backing storage of the given gem object. An array of pages is returned. If a page is not allocated or swapped-out, this will allocate/swap-in the required pages. Note that the whole object is covered by the page-array and pinned in memory.

Use *drm_gem_put_pages()* to release the array and unpin all pages.

This uses the GFP-mask set on the shmem-mapping (see mapping_set_gfp_mask()). If you require other GFP-masks, you have to do those allocations yourself.

Note that you are not allowed to change gfp-zones during runtime. That is, shmem_read_mapping_page_gfp() must be called with the same gfp_zone(gfp) as set during initialization. If you have special zone constraints, set them after *drm_gem_object_init()* via mapping_set_gfp_mask(). shmem-core takes care to keep pages in the required zone during swap-in.

This function is only valid on objects initialized with *drm_gem_object_init()*, but not for those initialized with *drm_gem_private_object_init()* only.

void **drm_gem_put_pages**(struct *drm_gem_object* *obj, struct page **pages, bool dirty, bool accessed)
    helper to free backing pages for a GEM object

Parameters

`struct drm_gem_object *obj`
obj in question

`struct page **pages`
pages to free

`bool dirty`
if true, pages will be marked as dirty

`bool accessed`
if true, the pages will be marked as accessed

int **`drm_gem_objects_lookup`**(struct *drm_file* *filp, void __user *bo_handles, int count, struct *drm_gem_object* ***objs_out)
look up GEM objects from an array of handles

Parameters

`struct drm_file *filp`
DRM file private date

`void __user *bo_handles`
user pointer to array of userspace handle

`int count`
size of handle array

`struct drm_gem_object ***objs_out`
returned pointer to array of drm_gem_object pointers

Description

Takes an array of userspace handles and returns a newly allocated array of GEM objects.

For a single handle lookup, use *`drm_gem_object_lookup()`*.

objs filled in with GEM object pointers. Returned GEM objects need to be released with *`drm_gem_object_put()`*. -ENOENT is returned on a lookup failure. 0 is returned on success.

Return

struct *drm_gem_object* ***`drm_gem_object_lookup`**(struct *drm_file* *filp, u32 handle)
look up a GEM object from its handle

Parameters

`struct drm_file *filp`
DRM file private date

`u32 handle`
userspace handle

Return

Description

A reference to the object named by the handle if such exists on **filp**, NULL otherwise.

If looking up an array of handles, use *drm_gem_objects_lookup()*.

long **drm_gem_dma_resv_wait**(struct *drm_file* *filep, u32 handle, bool wait_all, unsigned long timeout)

Wait on GEM object's reservation's objects shared and/or exclusive fences.

Parameters

struct drm_file *filep
DRM file private date

u32 handle
userspace handle

bool wait_all
if true, wait on all fences, else wait on just exclusive fence

unsigned long timeout
timeout value in jiffies or zero to return immediately

Return

Description

Returns -ERESTARTSYS if interrupted, 0 if the wait timed out, or greater than 0 on success.

void **drm_gem_object_release**(struct *drm_gem_object* *obj)

release GEM buffer object resources

Parameters

struct drm_gem_object *obj
GEM buffer object

Description

This releases any structures and resources used by **obj** and is the invers of *drm_gem_object_init()*.

void **drm_gem_object_free**(struct *kref* *kref)

free a GEM object

Parameters

struct kref *kref
kref of the object to free

Description

Called after the last reference to the object has been lost.

Frees the object

void **drm_gem_object_put_locked**(struct *drm_gem_object* *obj)

release a GEM buffer object reference

Parameters

struct drm_gem_object *obj
GEM buffer object

Description

This releases a reference to **obj**. Callers must hold the *drm_device.struct_mutex* lock when calling this function, even when the driver doesn't use *drm_device.struct_mutex* for anything.

For drivers not encumbered with legacy locking use *drm_gem_object_put()* instead.

void **drm_gem_vm_open**(struct vm_area_struct *vma)

vma->ops->open implementation for GEM

Parameters

struct vm_area_struct *vma
VM area structure

Description

This function implements the #vm_operations_struct open() callback for GEM drivers. This must be used together with *drm_gem_vm_close()*.

void **drm_gem_vm_close**(struct vm_area_struct *vma)

vma->ops->close implementation for GEM

Parameters

struct vm_area_struct *vma
VM area structure

Description

This function implements the #vm_operations_struct close() callback for GEM drivers. This must be used together with *drm_gem_vm_open()*.

int **drm_gem_mmap_obj**(struct *drm_gem_object* *obj, unsigned long obj_size, struct vm_area_struct *vma)

memory map a GEM object

Parameters

struct drm_gem_object *obj
the GEM object to map

unsigned long obj_size
the object size to be mapped, in bytes

struct vm_area_struct *vma
VMA for the area to be mapped

Description

Set up the VMA to prepare mapping of the GEM object using the gem_vm_ops provided by the driver. Depending on their requirements, drivers can either provide a fault handler in their gem_vm_ops (in which case any accesses to the object will be trapped, to perform migration, GTT binding, surface register allocation, or performance monitoring), or mmap the buffer memory synchronously after calling drm_gem_mmap_obj.

This function is mainly intended to implement the DMABUF mmap operation, when the GEM object is not looked up based on its fake offset. To implement the DRM mmap operation, drivers should use the *drm_gem_mmap()* function.

drm_gem_mmap_obj() assumes the user is granted access to the buffer while *drm_gem_mmap()* prevents unprivileged users from mapping random objects. So callers must verify access restrictions before calling this helper.

Return 0 or success or -EINVAL if the object size is smaller than the VMA size, or if no gem_vm_ops are provided.

int **drm_gem_mmap**(struct file *filp, struct vm_area_struct *vma)

memory map routine for GEM objects

Parameters

struct file *filp
DRM file pointer

struct vm_area_struct *vma
VMA for the area to be mapped

Description

If a driver supports GEM object mapping, mmap calls on the DRM file descriptor will end up here.

Look up the GEM object based on the offset passed in (vma->vm_pgoff will contain the fake offset we created when the GTT map ioctl was called on the object) and map it with a call to *drm_gem_mmap_obj()*.

If the caller is not granted access to the buffer object, the mmap will fail with EACCES. Please see the vma manager for more information.

int **drm_gem_lock_reservations**(struct *drm_gem_object* **objs, int count, struct ww_acquire_ctx *acquire_ctx)

Sets up the ww context and acquires the lock on an array of GEM objects.

Parameters

struct drm_gem_object **objs
drm_gem_objects to lock

int count
Number of objects in **objs**

struct ww_acquire_ctx *acquire_ctx
struct ww_acquire_ctx that will be initialized as part of tracking this set of locked reservations.

Description

Once you' ve locked your reservations, you' ll want to set up space for your shared fences (if applicable), submit your job, then drm_gem_unlock_reservations().

int **drm_gem_fence_array_add**(struct xarray *fence_array, struct dma_fence *fence)

Adds the fence to an array of fences to be waited on, deduplicating fences from the same context.

Parameters

`struct xarray *fence_array`
array of dma_fence * for the job to block on.

`struct dma_fence *fence`
the dma_fence to add to the list of dependencies.

Return

0 on success, or an error on failing to expand the array.

int **`drm_gem_fence_array_add_implicit`**(struct xarray *fence_array, struct *drm_gem_object* *obj, bool write)

Adds the implicit dependencies tracked in the GEM object's reservation object to an array of dma_fences for use in scheduling a rendering job.

Parameters

`struct xarray *fence_array`
array of dma_fence * for the job to block on.

`struct drm_gem_object *obj`
the gem object to add new dependencies from.

`bool write`
whether the job might write the object (so we need to depend on shared fences in the reservation object).

Description

This should be called after *`drm_gem_lock_reservations()`* on your array of GEM objects used in the job but before updating the reservations with your own fences.

3.2.9 GEM CMA Helper Functions Reference

The Contiguous Memory Allocator reserves a pool of memory at early boot that is used to service requests for large blocks of contiguous memory.

The DRM GEM/CMA helpers use this allocator as a means to provide buffer objects that are physically contiguous in memory. This is useful for display drivers that are unable to map scattered buffers via an IOMMU.

struct **`drm_gem_cma_object`**
GEM object backed by CMA memory allocations

Definition

```
struct drm_gem_cma_object {
  struct drm_gem_object base;
  dma_addr_t paddr;
  struct sg_table *sgt;
  void *vaddr;
};
```

Members

base
: base GEM object

paddr
: physical address of the backing memory

sgt
: scatter/gather table for imported PRIME buffers. The table can have more than one entry but they are guaranteed to have contiguous DMA addresses.

vaddr
: kernel virtual address of the backing memory

DEFINE_DRM_GEM_CMA_FOPS

`DEFINE_DRM_GEM_CMA_FOPS (name)`

macro to generate file operations for CMA drivers

Parameters

name
: name for the generated structure

Description

This macro autogenerates a suitable `struct file_operations` for CMA based drivers, which can be assigned to *`drm_driver.fops`*. Note that this structure cannot be shared between drivers, because it contains a reference to the current module using THIS_MODULE.

Note that the declaration is already marked as static - if you need a non-static version of this you're probably doing it wrong and will break the THIS_MODULE reference by accident.

DRM_GEM_CMA_DRIVER_OPS_WITH_DUMB_CREATE

`DRM_GEM_CMA_DRIVER_OPS_WITH_DUMB_CREATE (dumb_create_func)`

CMA GEM driver operations

Parameters

dumb_create_func
: callback function for .dumb_create

Description

This macro provides a shortcut for setting the default GEM operations in the *`drm_driver`* structure.

This macro is a variant of DRM_GEM_CMA_DRIVER_OPS for drivers that override the default implementation of `struct rm_driver`.dumb_create. Use DRM_GEM_CMA_DRIVER_OPS if possible. Drivers that require a virtual address on imported buffers should use *`DRM_GEM_CMA_DRIVER_OPS_VMAP_WITH_DUMB_CREATE()`* instead.

DRM_GEM_CMA_DRIVER_OPS

`DRM_GEM_CMA_DRIVER_OPS ()`

CMA GEM driver operations

Parameters

Description

This macro provides a shortcut for setting the default GEM operations in the *drm_driver* structure.

Drivers that come with their own implementation of *struct drm_driver*.dumb_create should use *DRM_GEM_CMA_DRIVER_OPS_WITH_DUMB_CREATE()* instead. Use DRM_GEM_CMA_DRIVER_OPS if possible. Drivers that require a virtual address on imported buffers should use DRM_GEM_CMA_DRIVER_OPS_VMAP instead.

DRM_GEM_CMA_DRIVER_OPS_VMAP_WITH_DUMB_CREATE

`DRM_GEM_CMA_DRIVER_OPS_VMAP_WITH_DUMB_CREATE (dumb_create_func)`

CMA GEM driver operations ensuring a virtual address on the buffer

Parameters

dumb_create_func
callback function for .dumb_create

Description

This macro provides a shortcut for setting the default GEM operations in the *drm_driver* structure for drivers that need the virtual address also on imported buffers.

This macro is a variant of DRM_GEM_CMA_DRIVER_OPS_VMAP for drivers that override the default implementation of *struct drm_driver*.dumb_create. Use DRM_GEM_CMA_DRIVER_OPS_VMAP if possible. Drivers that do not require a virtual address on imported buffers should use *DRM_GEM_CMA_DRIVER_OPS_WITH_DUMB_CREATE()* instead.

DRM_GEM_CMA_DRIVER_OPS_VMAP

`DRM_GEM_CMA_DRIVER_OPS_VMAP ()`

CMA GEM driver operations ensuring a virtual address on the buffer

Parameters

Description

This macro provides a shortcut for setting the default GEM operations in the *drm_driver* structure for drivers that need the virtual address also on imported buffers.

Drivers that come with their own implementation of *struct drm_driver*.dumb_create should use *DRM_GEM_CMA_DRIVER_OPS_VMAP_WITH_DUMB_CREATE()* instead. Use DRM_GEM_CMA_DRIVER_OPS_VMAP if possible. Drivers that do not require a virtual address on imported buffers should use DRM_GEM_CMA_DRIVER_OPS instead.

struct *drm_gem_cma_object* ***drm_gem_cma_create**(struct *drm_device* *drm, size_t size)

allocate an object with the given size

Parameters

struct drm_device *drm
DRM device

size_t size
size of the object to allocate

Description

This function creates a CMA GEM object and allocates a contiguous chunk of memory as backing store. The backing memory has the writecombine attribute set.

Return

A *struct drm_gem_cma_object* * on success or an ERR_PTR()-encoded negative error code on failure.

void **drm_gem_cma_free_object**(struct *drm_gem_object* *gem_obj)
free resources associated with a CMA GEM object

Parameters

struct drm_gem_object *gem_obj
GEM object to free

Description

This function frees the backing memory of the CMA GEM object, cleans up the GEM object state and frees the memory used to store the object itself. If the buffer is imported and the virtual address is set, it is released. Drivers using the CMA helpers should set this as their *drm_driver.gem_free_object_unlocked* callback.

int **drm_gem_cma_dumb_create_internal**(struct *drm_file* *file_priv, struct *drm_device* *drm, struct drm_mode_create_dumb *args)
create a dumb buffer object

Parameters

struct drm_file *file_priv
DRM file-private structure to create the dumb buffer for

struct drm_device *drm
DRM device

struct drm_mode_create_dumb *args
IOCTL data

Description

This aligns the pitch and size arguments to the minimum required. This is an internal helper that can be wrapped by a driver to account for hardware with more specific alignment requirements. It should not be used directly as their *drm_driver.dumb_create* callback.

Return

0 on success or a negative error code on failure.

int **drm_gem_cma_dumb_create**(struct *drm_file* *file_priv, struct *drm_device* *drm, struct drm_mode_create_dumb *args)

create a dumb buffer object

Parameters

struct drm_file *file_priv
DRM file-private structure to create the dumb buffer for

struct drm_device *drm
DRM device

struct drm_mode_create_dumb *args
IOCTL data

Description

This function computes the pitch of the dumb buffer and rounds it up to an integer number of bytes per pixel. Drivers for hardware that doesn't have any additional restrictions on the pitch can directly use this function as their *drm_driver.dumb_create* callback.

For hardware with additional restrictions, drivers can adjust the fields set up by userspace and pass the IOCTL data along to the *drm_gem_cma_dumb_create_internal()* function.

Return

0 on success or a negative error code on failure.

int **drm_gem_cma_mmap**(struct file *filp, struct vm_area_struct *vma)

memory-map a CMA GEM object

Parameters

struct file *filp
file object

struct vm_area_struct *vma
VMA for the area to be mapped

Description

This function implements an augmented version of the GEM DRM file mmap operation for CMA objects: In addition to the usual GEM VMA setup it immediately faults in the entire object instead of using on-demaind faulting. Drivers which employ the CMA helpers should use this function as their ->mmap() handler in the DRM device file's file_operations structure.

Instead of directly referencing this function, drivers should use the *DEFINE_DRM_GEM_CMA_FOPS()*.macro.

Return

0 on success or a negative error code on failure.

unsigned long **drm_gem_cma_get_unmapped_area**(struct file *filp, unsigned long addr, unsigned long len, unsigned long pgoff, unsigned long flags) propose address for mapping in noMMU cases

Parameters

`struct file *filp`
file object

`unsigned long addr`
memory address

`unsigned long len`
buffer size

`unsigned long pgoff`
page offset

`unsigned long flags`
memory flags

Description

This function is used in noMMU platforms to propose address mapping for a given buffer. It's intended to be used as a direct handler for the struct `file_operations.get_unmapped_area` operation.

Return

mapping address on success or a negative error code on failure.

void **`drm_gem_cma_print_info`**(struct *drm_printer* *p, unsigned int indent, const struct *drm_gem_object* *obj)

Print *`drm_gem_cma_object`* info for debugfs

Parameters

`struct drm_printer *p`
DRM printer

`unsigned int indent`
Tab indentation level

`const struct drm_gem_object *obj`
GEM object

Description

This function can be used as the *`drm_driver->gem_print_info`* callback. It prints paddr and vaddr for use in e.g. debugfs output.

struct sg_table ***`drm_gem_cma_prime_get_sg_table`**(struct *drm_gem_object* *obj)

provide a scatter/gather table of pinned pages for a CMA GEM object

Parameters

`struct drm_gem_object *obj`
GEM object

Description

This function exports a scatter/gather table suitable for PRIME usage by calling the standard DMA mapping API. Drivers using the CMA helpers should set this as their *drm_driver.gem_prime_get_sg_table* callback.

Return

A pointer to the scatter/gather table of pinned pages or NULL on failure.

struct *drm_gem_object* ***drm_gem_cma_prime_import_sg_table**(struct *drm_device* *dev, struct dma_buf_attachment *attach, struct sg_table *sgt)

produce a CMA GEM object from another driver's scatter/gather table of pinned pages

Parameters

struct drm_device *dev
device to import into

struct dma_buf_attachment *attach
DMA-BUF attachment

struct sg_table *sgt
scatter/gather table of pinned pages

Description

This function imports a scatter/gather table exported via DMA-BUF by another driver. Imported buffers must be physically contiguous in memory (i.e. the scatter/gather table must contain a single entry). Drivers that use the CMA helpers should set this as their *drm_driver.gem_prime_import_sg_table* callback.

Return

A pointer to a newly created GEM object or an ERR_PTR-encoded negative error code on failure.

int **drm_gem_cma_prime_mmap**(struct *drm_gem_object* *obj, struct vm_area_struct *vma)

memory-map an exported CMA GEM object

Parameters

struct drm_gem_object *obj
GEM object

struct vm_area_struct *vma
VMA for the area to be mapped

Description

This function maps a buffer imported via DRM PRIME into a userspace process's address space. Drivers that use the CMA helpers should set this as their *drm_driver.gem_prime_mmap* callback.

Return

0 on success or a negative error code on failure.

void ***drm_gem_cma_prime_vmap**(struct *drm_gem_object* *obj)
map a CMA GEM object into the kernel's virtual address space

Parameters

struct drm_gem_object *obj
GEM object

Description

This function maps a buffer exported via DRM PRIME into the kernel's virtual address space. Since the CMA buffers are already mapped into the kernel virtual address space this simply returns the cached virtual address. Drivers using the CMA helpers should set this as their DRM driver's *drm_driver.gem_prime_vmap* callback.

Return

The kernel virtual address of the CMA GEM object's backing store.

void **drm_gem_cma_prime_vunmap**(struct *drm_gem_object* *obj, void *vaddr)
unmap a CMA GEM object from the kernel's virtual address space

Parameters

struct drm_gem_object *obj
GEM object

void *vaddr
kernel virtual address where the CMA GEM object was mapped

Description

This function removes a buffer exported via DRM PRIME from the kernel's virtual address space. This is a no-op because CMA buffers cannot be unmapped from kernel space. Drivers using the CMA helpers should set this as their *drm_driver.gem_prime_vunmap* callback.

struct *drm_gem_object* ***drm_gem_cma_create_object_default_funcs**(struct *drm_device* *dev, size_t size)
Create a CMA GEM object with a default function table

Parameters

struct drm_device *dev
DRM device

size_t size
Size of the object to allocate

Description

This sets the GEM object functions to the default CMA helper functions. This function can be used as the *drm_driver.gem_create_object* callback.

Return

A pointer to a allocated GEM object or an error pointer on failure.

struct *drm_gem_object* ***drm_gem_cma_prime_import_sg_table_vmap***(struct *drm_device* *dev, struct dma_buf_attachment *attach, struct sg_table *sgt)

PRIME import another driver' s scatter/gather table and get the virtual address of the buffer

Parameters

struct drm_device *dev
DRM device

struct dma_buf_attachment *attach
DMA-BUF attachment

struct sg_table *sgt
Scatter/gather table of pinned pages

Description

This function imports a scatter/gather table using *drm_gem_cma_prime_import_sg_table()* and uses dma_buf_vmap() to get the kernel virtual address. This ensures that a CMA GEM object always has its virtual address set. This address is released when the object is freed.

This function can be used as the *drm_driver.gem_prime_import_sg_table* callback. The *DRM_GEM_CMA_DRIVER_OPS_VMAP* macro provides a shortcut to set the necessary DRM driver operations.

Return

A pointer to a newly created GEM object or an ERR_PTR-encoded negative error code on failure.

3.2.10 GEM SHMEM Helper Function Reference

This library provides helpers for GEM objects backed by shmem buffers allocated using anonymous pageable memory.

struct **drm_gem_shmem_object**

GEM object backed by shmem

Definition

```
struct drm_gem_shmem_object {
  struct drm_gem_object base;
  struct mutex pages_lock;
  struct page **pages;
```

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```
  unsigned int pages_use_count;
  int madv;
  struct list_head madv_list;
  unsigned int pages_mark_dirty_on_put    : 1;
  unsigned int pages_mark_accessed_on_put : 1;
  struct sg_table *sgt;
  struct mutex vmap_lock;
  void *vaddr;
  unsigned int vmap_use_count;
  bool map_cached;
};
```

Members

base
Base GEM object

pages_lock
Protects the page table and use count

pages
Page table

pages_use_count
Reference count on the pages table. The pages are put when the count reaches zero.

madv
State for madvise

0 is active/inuse. A negative value is the object is purged. Positive values are driver specific and not used by the helpers.

madv_list
List entry for madvise tracking

Typically used by drivers to track purgeable objects

pages_mark_dirty_on_put
Mark pages as dirty when they are put.

pages_mark_accessed_on_put
Mark pages as accessed when they are put.

sgt
Scatter/gather table for imported PRIME buffers

vmap_lock
Protects the vmap address and use count

vaddr
Kernel virtual address of the backing memory

vmap_use_count
Reference count on the virtual address. The address are un-mapped when the count reaches zero.

map_cached
map object cached (instead of using writecombine).

DRM_GEM_SHMEM_DRIVER_OPS

`DRM_GEM_SHMEM_DRIVER_OPS ()`

Default shmem GEM operations

Parameters

Description

This macro provides a shortcut for setting the shmem GEM operations in the *drm_driver* structure.

struct *drm_gem_shmem_object* ***drm_gem_shmem_create**(struct *drm_device* *dev, size_t size)

Allocate an object with the given size

Parameters

struct drm_device *dev
DRM device

size_t size
Size of the object to allocate

Description

This function creates a shmem GEM object.

Return

A *struct drm_gem_shmem_object* * on success or an ERR_PTR()-encoded negative error code on failure.

void **drm_gem_shmem_free_object**(struct *drm_gem_object* *obj)

Free resources associated with a shmem GEM object

Parameters

struct drm_gem_object *obj
GEM object to free

Description

This function cleans up the GEM object state and frees the memory used to store the object itself. It should be used to implement *drm_gem_object_funcs.free*.

int **drm_gem_shmem_pin**(struct *drm_gem_object* *obj)

Pin backing pages for a shmem GEM object

Parameters

struct drm_gem_object *obj
GEM object

Description

This function makes sure the backing pages are pinned in memory while the buffer is exported. It should only be used to implement *drm_gem_object_funcs.pin*.

Return

0 on success or a negative error code on failure.

void **drm_gem_shmem_unpin**(struct *drm_gem_object* *obj)

Unpin backing pages for a shmem GEM object

Parameters

struct drm_gem_object *obj
GEM object

Description

This function removes the requirement that the backing pages are pinned in memory. It should only be used to implement *drm_gem_object_funcs.unpin*.

struct *drm_gem_object* ***drm_gem_shmem_create_object_cached**(struct *drm_device* *dev, size_t size)

Create a shmem buffer object with cached mappings

Parameters

struct drm_device *dev
DRM device

size_t size
Size of the object to allocate

Description

By default, shmem buffer objects use writecombine mappings. This function implements *struct drm_driver*.gem_create_object for shmem buffer objects with cached mappings.

Return

A *struct drm_gem_shmem_object* * on success or NULL negative on failure.

int **drm_gem_shmem_dumb_create**(struct *drm_file* *file, struct *drm_device* *dev, struct drm_mode_create_dumb *args)

Create a dumb shmem buffer object

Parameters

struct drm_file *file
DRM file structure to create the dumb buffer for

struct drm_device *dev
DRM device

struct drm_mode_create_dumb *args
IOCTL data

Description

This function computes the pitch of the dumb buffer and rounds it up to an integer number of bytes per pixel. Drivers for hardware that doesn' t have any additional restrictions on the pitch can directly use this function as their *drm_driver.dumb_create* callback.

For hardware with additional restrictions, drivers can adjust the fields set up by userspace before calling into this function.

Return

0 on success or a negative error code on failure.

int **drm_gem_shmem_mmap**(struct *drm_gem_object* *obj, struct vm_area_struct *vma)

Memory-map a shmem GEM object

Parameters

struct drm_gem_object *obj
gem object

struct vm_area_struct *vma
VMA for the area to be mapped

Description

This function implements an augmented version of the GEM DRM file mmap operation for shmem objects. Drivers which employ the shmem helpers should use this function as their *drm_gem_object_funcs.mmap* handler.

Return

0 on success or a negative error code on failure.

void **drm_gem_shmem_print_info**(struct *drm_printer* *p, unsigned int indent, const struct *drm_gem_object* *obj)

Print *drm_gem_shmem_object* info for debugfs

Parameters

struct drm_printer *p
DRM printer

unsigned int indent
Tab indentation level

const struct drm_gem_object *obj
GEM object

Description

This implements the *drm_gem_object_funcs.info* callback.

struct sg_table ***drm_gem_shmem_get_sg_table**(struct *drm_gem_object* *obj)

Provide a scatter/gather table of pinned pages for a shmem GEM object

Parameters

struct drm_gem_object *obj
GEM object

Description

This function exports a scatter/gather table suitable for PRIME usage by calling the standard DMA mapping API. Drivers should not call this function directly, instead it should only be used as an implementation for *drm_gem_object_funcs.get_sg_table*.

Drivers who need to acquire an scatter/gather table for objects need to call *drm_gem_shmem_get_pages_sgt()* instead.

Return

A pointer to the scatter/gather table of pinned pages or NULL on failure.

struct sg_table ***drm_gem_shmem_get_pages_sgt**(struct *drm_gem_object* *obj)

Pin pages, dma map them, and return a scatter/gather table for a shmem GEM object.

Parameters

struct drm_gem_object *obj
GEM object

Description

This function returns a scatter/gather table suitable for driver usage. If the sg table doesn't exist, the pages are pinned, dma-mapped, and a sg table created.

This is the main function for drivers to get at backing storage, and it hides and difference between dma-buf imported and natively allocated objects. *drm_gem_shmem_get_sg_table()* should not be directly called by drivers.

Return

A pointer to the scatter/gather table of pinned pages or errno on failure.

struct *drm_gem_object* ***drm_gem_shmem_prime_import_sg_table**(struct *drm_device* *dev, struct dma_buf_attachment *attach, struct sg_table *sgt)

Produce a shmem GEM object from another driver's scatter/gather table of pinned pages

Parameters

struct drm_device *dev
Device to import into

struct dma_buf_attachment *attach
DMA-BUF attachment

struct sg_table *sgt
Scatter/gather table of pinned pages

Description

This function imports a scatter/gather table exported via DMA-BUF by another driver. Drivers that use the shmem helpers should set this as their *drm_driver.gem_prime_import_sg_table* callback.

Return

A pointer to a newly created GEM object or an ERR_PTR-encoded negative error code on failure.

3.2.11 GEM VRAM Helper Functions Reference

This library provides *struct drm_gem_vram_object* (GEM VRAM), a GEM buffer object that is backed by video RAM (VRAM). It can be used for framebuffer devices with dedicated memory.

The data structure *struct drm_vram_mm* and its helpers implement a memory manager for simple framebuffer devices with dedicated video memory. GEM VRAM buffer objects are either placed in the video memory or remain evicted to system memory.

With the GEM interface userspace applications create, manage and destroy graphics buffers, such as an on-screen framebuffer. GEM does not provide an implementation of these interfaces. It' s up to the DRM driver to provide an implementation that suits the hardware. If the hardware device contains dedicated video memory, the DRM driver can use the VRAM helper library. Each active buffer object is stored in video RAM. Active buffer are used for drawing the current frame, typically something like the frame' s scanout buffer or the cursor image. If there' s no more space left in VRAM, inactive GEM objects can be moved to system memory.

To initialize the VRAM helper library call *drmm_vram_helper_init()*. The function allocates and initializes an instance of *struct drm_vram_mm* in *struct drm_device*.vram_mm . Use *DRM_GEM_VRAM_DRIVER* to initialize *struct drm_driver* and `DRM_VRAM_MM_FILE_OPERATIONS` to initialize `struct file_operations`; as illustrated below.

```
struct file_operations fops ={
        .owner = THIS_MODULE,
        DRM_VRAM_MM_FILE_OPERATION
};
struct drm_driver drv = {
        .driver_feature = DRM_ ... ,
        .fops = &fops,
        DRM_GEM_VRAM_DRIVER
};

int init_drm_driver()
{
        struct drm_device *dev;
        uint64_t vram_base;
        unsigned long vram_size;
        int ret;

        // setup device, vram base and size
        // ...

        ret = drmm_vram_helper_init(dev, vram_base, vram_size);
```

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```
        if (ret)
                return ret;
        return 0;
}
```

This creates an instance of *struct drm_vram_mm*, exports DRM userspace interfaces for GEM buffer management and initializes file operations to allow for accessing created GEM buffers. With this setup, the DRM driver manages an area of video RAM with VRAM MM and provides GEM VRAM objects to userspace.

You don't have to clean up the instance of VRAM MM. *drmm_vram_helper_init()* is a managed interface that installs a clean-up handler to run during the DRM device's release.

For drawing or scanout operations, rsp. buffer objects have to be pinned in video RAM. Call *drm_gem_vram_pin()* with DRM_GEM_VRAM_PL_FLAG_VRAM or DRM_GEM_VRAM_PL_FLAG_SYSTEM to pin a buffer object in video RAM or system memory. Call *drm_gem_vram_unpin()* to release the pinned object afterwards.

A buffer object that is pinned in video RAM has a fixed address within that memory region. Call *drm_gem_vram_offset()* to retrieve this value. Typically it's used to program the hardware's scanout engine for framebuffers, set the cursor overlay's image for a mouse cursor, or use it as input to the hardware's draing engine.

To access a buffer object's memory from the DRM driver, call *drm_gem_vram_vmap()*. It maps the buffer into kernel address space and returns the memory address. Use *drm_gem_vram_vunmap()* to release the mapping.

struct **drm_gem_vram_object**

GEM object backed by VRAM

Definition

```
struct drm_gem_vram_object {
  struct ttm_buffer_object bo;
  struct ttm_bo_kmap_obj kmap;
  unsigned int kmap_use_count;
  struct ttm_placement placement;
  struct ttm_place placements[2];
  int pin_count;
};
```

Members

bo
TTM buffer object

kmap
Mapping information for **bo**

kmap_use_count
Reference count on the virtual address. The address are un-mapped when the count reaches zero.

placement
TTM placement information. Supported placements are `TTM_PL_VRAM` and `TTM_PL_SYSTEM`

placements
TTM placement information.

pin_count
Pin counter

Description

The type *struct drm_gem_vram_object* represents a GEM object that is backed by VRAM. It can be used for simple framebuffer devices with dedicated memory. The buffer object can be evicted to system memory if video memory becomes scarce.

GEM VRAM objects perform reference counting for pin and mapping operations. So a buffer object that has been pinned N times with *drm_gem_vram_pin()* must be unpinned N times with *drm_gem_vram_unpin()*. The same applies to pairs of drm_gem_vram_kmap() and drm_gem_vram_kunmap(), as well as pairs of *drm_gem_vram_vmap()* and *drm_gem_vram_vunmap()*.

struct *drm_gem_vram_object* ***drm_gem_vram_of_bo**(struct ttm_buffer_object *bo)

Parameters

struct ttm_buffer_object *bo
the VRAM buffer object

Description

for field bo.

Return

The containing GEM VRAM object

struct *drm_gem_vram_object* ***drm_gem_vram_of_gem**(struct *drm_gem_object* *gem)

Parameters

struct drm_gem_object *gem
the GEM object

Description

for field gem.

Return

The containing GEM VRAM object

DRM_GEM_VRAM_DRIVER

`DRM_GEM_VRAM_DRIVER ()`

default callback functions for *struct drm_driver*

Parameters

Description

Drivers that use VRAM MM and GEM VRAM can use this macro to initialize *struct drm_driver* with default functions.

struct **drm_vram_mm**

An instance of VRAM MM

Definition

```
struct drm_vram_mm {
  uint64_t vram_base;
  size_t vram_size;
  struct ttm_bo_device bdev;
};
```

Members

vram_base
Base address of the managed video memory

vram_size
Size of the managed video memory in bytes

bdev
The TTM BO device.

Description

The fields *struct drm_vram_mm*.vram_base and *struct drm_vram_mm*.vrm_size are managed by VRAM MM, but are available for public read access. Use the field *struct drm_vram_mm*.bdev to access the TTM BO device.

struct *drm_vram_mm* ***drm_vram_mm_of_bdev**(struct ttm_bo_device *bdev)

Returns the container of type `struct ttm_bo_device` for field bdev.

Parameters

struct ttm_bo_device *bdev
the TTM BO device

Return

The containing instance of *struct drm_vram_mm*

struct *drm_gem_vram_object* ***drm_gem_vram_create**(struct *drm_device* *dev, size_t size, unsigned long pg_align)

Creates a VRAM-backed GEM object

Parameters

struct drm_device *dev
the DRM device

size_t size
the buffer size in bytes

unsigned long pg_align
the buffer's alignment in multiples of the page size

Return

A new instance of *`struct drm_gem_vram_object`* on success, or an ERR_PTR()-encoded error code otherwise.

void **`drm_gem_vram_put`**(struct *drm_gem_vram_object* *gbo)

Releases a reference to a VRAM-backed GEM object

Parameters

`struct drm_gem_vram_object *gbo`
the GEM VRAM object

Description

See ttm_bo_put() for more information.

u64 **`drm_gem_vram_mmap_offset`**(struct *drm_gem_vram_object* *gbo)

Returns a GEM VRAM object's mmap offset

Parameters

`struct drm_gem_vram_object *gbo`
the GEM VRAM object

Description

See *`drm_vma_node_offset_addr()`* for more information.

Return

The buffer object's offset for userspace mappings on success, or 0 if no offset is allocated.

s64 **`drm_gem_vram_offset`**(struct *drm_gem_vram_object* *gbo)

Returns a GEM VRAM object's offset in video memory

Parameters

`struct drm_gem_vram_object *gbo`
the GEM VRAM object

Description

This function returns the buffer object's offset in the device's video memory. The buffer object has to be pinned to `TTM_PL_VRAM`.

Return

The buffer object's offset in video memory on success, or a negative errno code otherwise.

int **`drm_gem_vram_pin`**(struct *drm_gem_vram_object* *gbo, unsigned long pl_flag)

Pins a GEM VRAM object in a region.

Parameters

`struct drm_gem_vram_object *gbo`
the GEM VRAM object

`unsigned long pl_flag`
a bitmask of possible memory regions

Description

Pinning a buffer object ensures that it is not evicted from a memory region. A pinned buffer object has to be unpinned before it can be pinned to another region. If the pl_flag argument is 0, the buffer is pinned at its current location (video RAM or system memory).

Small buffer objects, such as cursor images, can lead to memory fragmentation if they are pinned in the middle of video RAM. This is especially a problem on devices with only a small amount of video RAM. Fragmentation can prevent the primary framebuffer from fitting in, even though there's enough memory overall. The modifier DRM_GEM_VRAM_PL_FLAG_TOPDOWN marks the buffer object to be pinned at the high end of the memory region to avoid fragmentation.

Return

0 on success, or a negative error code otherwise.

int **drm_gem_vram_unpin**(struct *drm_gem_vram_object* *gbo)

Unpins a GEM VRAM object

Parameters

struct drm_gem_vram_object *gbo
the GEM VRAM object

Return

0 on success, or a negative error code otherwise.

void ***drm_gem_vram_vmap**(struct *drm_gem_vram_object* *gbo)

Pins and maps a GEM VRAM object into kernel address space

Parameters

struct drm_gem_vram_object *gbo
The GEM VRAM object to map

Description

The vmap function pins a GEM VRAM object to its current location, either system or video memory, and maps its buffer into kernel address space. As pinned object cannot be relocated, you should avoid pinning objects permanently. Call *drm_gem_vram_vunmap()* with the returned address to unmap and unpin the GEM VRAM object.

Return

The buffer's virtual address on success, or an ERR_PTR()-encoded error code otherwise.

void **drm_gem_vram_vunmap**(struct *drm_gem_vram_object* *gbo, void *vaddr)

Unmaps and unpins a GEM VRAM object

Parameters

struct drm_gem_vram_object *gbo
The GEM VRAM object to unmap

void *vaddr
The mapping's base address as returned by *drm_gem_vram_vmap()*

Description

A call to *drm_gem_vram_vunmap()* unmaps and unpins a GEM VRAM buffer. See the documentation for *drm_gem_vram_vmap()* for more information.

int **drm_gem_vram_fill_create_dumb**(struct *drm_file* *file, struct *drm_device* *dev, unsigned long pg_align, unsigned long pitch_align, struct drm_mode_create_dumb *args)

Helper for implementing *struct drm_driver*.dumb_create

Parameters

struct drm_file *file
the DRM file

struct drm_device *dev
the DRM device

unsigned long pg_align
the buffer' s alignment in multiples of the page size

unsigned long pitch_align
the scanline' s alignment in powers of 2

struct drm_mode_create_dumb *args
the arguments as provided to *struct drm_driver*.dumb_create

Description

This helper function fills `struct drm_mode_create_dumb`, which is used by *struct drm_driver*.dumb_create. Implementations of this interface should forwards their arguments to this helper, plus the driver-specific parameters.

Return

0 on success, or a negative error code otherwise.

int **drm_gem_vram_driver_dumb_create**(struct *drm_file* *file, struct *drm_device* *dev, struct drm_mode_create_dumb *args)

Implements *struct drm_driver*.dumb_create

Parameters

struct drm_file *file
the DRM file

struct drm_device *dev
the DRM device

struct drm_mode_create_dumb *args
the arguments as provided to *struct drm_driver*.dumb_create

Description

This function requires the driver to use **drm_device.vram_mm** for its instance of VRAM MM.

Return

0 on success, or a negative error code otherwise.

int **drm_gem_vram_driver_dumb_mmap_offset**(struct *drm_file* *file, struct *drm_device* *dev, uint32_t handle, uint64_t *offset)

Implements *struct drm_driver*.dumb_mmap_offset

Parameters

struct drm_file *file
DRM file pointer.

struct drm_device *dev
DRM device.

uint32_t handle
GEM handle

uint64_t *offset
Returns the mapping' s memory offset on success

Return

0 on success, or a negative errno code otherwise.

int **drm_gem_vram_plane_helper_prepare_fb**(struct *drm_plane* *plane, struct *drm_plane_state* *new_state)

- Implements *struct drm_plane_helper_funcs*.prepare_fb

Parameters

struct drm_plane *plane
a DRM plane

struct drm_plane_state *new_state
the plane' s new state

Description

During plane updates, this function sets the plane' s fence and pins the GEM VRAM objects of the plane' s new framebuffer to VRAM. Call *drm_gem_vram_plane_helper_cleanup_fb()* to unpin them.

Return

0 on success, or a negative errno code otherwise.

void **drm_gem_vram_plane_helper_cleanup_fb**(struct *drm_plane* *plane, struct *drm_plane_state* *old_state)

- Implements *struct drm_plane_helper_funcs*.cleanup_fb

Parameters

struct drm_plane *plane
a DRM plane

struct drm_plane_state *old_state
the plane' s old state

Description

During plane updates, this function unpins the GEM VRAM objects of the plane's old framebuffer from VRAM. Complements *drm_gem_vram_plane_helper_prepare_fb()*.

int **drm_gem_vram_simple_display_pipe_prepare_fb**(struct *drm_simple_display_pipe* *pipe, struct *drm_plane_state* *new_state)

- Implements *struct drm_simple_display_pipe_funcs*.prepare_fb

Parameters

struct drm_simple_display_pipe *pipe
a simple display pipe

struct drm_plane_state *new_state
the plane's new state

Description

During plane updates, this function pins the GEM VRAM objects of the plane's new framebuffer to VRAM. Call *drm_gem_vram_simple_display_pipe_cleanup_fb()* to unpin them.

Return

0 on success, or a negative errno code otherwise.

void **drm_gem_vram_simple_display_pipe_cleanup_fb**(struct *drm_simple_display_pipe* *pipe, struct *drm_plane_state* *old_state)

- Implements *struct drm_simple_display_pipe_funcs*.cleanup_fb

Parameters

struct drm_simple_display_pipe *pipe
a simple display pipe

struct drm_plane_state *old_state
the plane's old state

Description

During plane updates, this function unpins the GEM VRAM objects of the plane's old framebuffer from VRAM. Complements *drm_gem_vram_simple_display_pipe_prepare_fb()*.

void **drm_vram_mm_debugfs_init**(struct *drm_minor* *minor)
Register VRAM MM debugfs file.

Parameters

struct drm_minor *minor
drm minor device.

int **drmm_vram_helper_init**(struct *drm_device* *dev, uint64_t vram_base, size_t vram_size)

Initializes a device's instance of *struct drm_vram_mm*

Parameters

struct drm_device *dev
the DRM device

uint64_t vram_base
the base address of the video memory

size_t vram_size
the size of the video memory in bytes

Description

Creates a new instance of *struct drm_vram_mm* and stores it in struct *drm_device.vram_mm*. The instance is auto-managed and cleaned up as part of device cleanup. Calling this function multiple times will generate an error message.

Return

0 on success, or a negative errno code otherwise.

enum *drm_mode_status* **drm_vram_helper_mode_valid**(struct *drm_device* *dev, const struct *drm_display_mode* *mode)

Tests if a display mode's framebuffer fits into the available video memory.

Parameters

struct drm_device *dev
the DRM device

const struct drm_display_mode *mode
the mode to test

Description

This function tests if enough video memory is available for using the specified display mode. Atomic modesetting requires importing the designated framebuffer into video memory before evicting the active one. Hence, any framebuffer may consume at most half of the available VRAM. Display modes that require a larger framebuffer can not be used, even if the CRTC does support them. Each framebuffer is assumed to have 32-bit color depth.

Note

The function can only test if the display mode is supported in general. If there are too many framebuffers pinned to video memory, a display mode may still not be usable in practice. The color depth of 32-bit fits all current use case. A more flexible test can be added when necessary.

Return

MODE_OK if the display mode is supported, or an error code of type *enum drm_mode_status* otherwise.

3.2.12 GEM TTM Helper Functions Reference

This library provides helper functions for gem objects backed by ttm.

void **drm_gem_ttm_print_info**(struct *drm_printer* *p, unsigned int indent, const struct *drm_gem_object* *gem)

Print `ttm_buffer_object` info for debugfs

Parameters

struct drm_printer *p
DRM printer

unsigned int indent
Tab indentation level

const struct drm_gem_object *gem
GEM object

Description

This function can be used as *drm_gem_object_funcs.print_info* callback.

int **drm_gem_ttm_mmap**(struct *drm_gem_object* *gem, struct vm_area_struct *vma)

mmap `ttm_buffer_object`

Parameters

struct drm_gem_object *gem
GEM object.

struct vm_area_struct *vma
vm area.

Description

This function can be used as *drm_gem_object_funcs.mmap* callback.

3.3 VMA Offset Manager

The vma-manager is responsible to map arbitrary driver-dependent memory regions into the linear user address-space. It provides offsets to the caller which can then be used on the address_space of the drm-device. It takes care to not overlap regions, size them appropriately and to not confuse mm-core by inconsistent fake vm_pgoff fields. Drivers shouldn't use this for object placement in VMEM. This manager should only be used to manage mappings into linear user-space VMs.

We use drm_mm as backend to manage object allocations. But it is highly optimized for alloc/free calls, not lookups. Hence, we use an rb-tree to speed up offset lookups.

You must not use multiple offset managers on a single address_space. Otherwise, mm-core will be unable to tear down memory mappings as the VM will no longer be linear.

This offset manager works on page-based addresses. That is, every argument and return code (with the exception of *drm_vma_node_offset_addr()*) is given in number of pages, not number of bytes. That means, object sizes and offsets must always be page-aligned (as usual). If you want to get a valid byte-based user-space address for a given offset, please see *drm_vma_node_offset_addr()*.

Additionally to offset management, the vma offset manager also handles access management. For every open-file context that is allowed to access a given node, you must call *drm_vma_node_allow()*. Otherwise, an mmap() call on this open-file with the offset of the node will fail with -EACCES. To revoke access again, use *drm_vma_node_revoke()*. However, the caller is responsible for destroying already existing mappings, if required.

struct drm_vma_offset_node ***drm_vma_offset_exact_lookup_locked**(struct drm_vma_offset_manag *mgr, unsigned long start, unsigned long pages)

Look up node by exact address

Parameters

struct drm_vma_offset_manager *mgr
Manager object

unsigned long start
Start address (page-based, not byte-based)

unsigned long pages
Size of object (page-based)

Description

Same as *drm_vma_offset_lookup_locked()* but does not allow any offset into the node. It only returns the exact object with the given start address.

Return

Node at exact start address **start**.

void **drm_vma_offset_lock_lookup**(struct drm_vma_offset_manager *mgr)

Lock lookup for extended private use

Parameters

struct drm_vma_offset_manager *mgr
Manager object

Description

Lock VMA manager for extended lookups. Only locked VMA function calls are allowed while holding this lock. All other contexts are blocked from VMA until the lock is released via *drm_vma_offset_unlock_lookup()*.

Use this if you need to take a reference to the objects returned by *drm_vma_offset_lookup_locked()* before releasing this lock again.

This lock must not be used for anything else than extended lookups. You must not call any other VMA helpers while holding this lock.

Note

You' re in atomic-context while holding this lock!

void **drm_vma_offset_unlock_lookup**(struct drm_vma_offset_manager *mgr)

Unlock lookup for extended private use

Parameters

struct drm_vma_offset_manager *mgr

Manager object

Description

Release lookup-lock. See *drm_vma_offset_lock_lookup()* for more information.

void **drm_vma_node_reset**(struct drm_vma_offset_node *node)

Initialize or reset node object

Parameters

struct drm_vma_offset_node *node

Node to initialize or reset

Description

Reset a node to its initial state. This must be called before using it with any VMA offset manager.

This must not be called on an already allocated node, or you will leak memory.

unsigned long **drm_vma_node_start**(const struct drm_vma_offset_node *node)

Return start address for page-based addressing

Parameters

const struct drm_vma_offset_node *node

Node to inspect

Description

Return the start address of the given node. This can be used as offset into the linear VM space that is provided by the VMA offset manager. Note that this can only be used for page-based addressing. If you need a proper offset for user-space mappings, you must apply "<< PAGE_SHIFT" or use the *drm_vma_node_offset_addr()* helper instead.

Return

Start address of **node** for page-based addressing. 0 if the node does not have an offset allocated.

unsigned long **drm_vma_node_size**(struct drm_vma_offset_node *node)

Return size (page-based)

Parameters

`struct drm_vma_offset_node *node`
Node to inspect

Description

Return the size as number of pages for the given node. This is the same size that was passed to *`drm_vma_offset_add()`*. If no offset is allocated for the node, this is 0.

Return

Size of **node** as number of pages. 0 if the node does not have an offset allocated.

__u64 **`drm_vma_node_offset_addr`**(struct drm_vma_offset_node *node)
Return sanitized offset for user-space mmaps

Parameters

`struct drm_vma_offset_node *node`
Linked offset node

Description

Same as *`drm_vma_node_start()`* but returns the address as a valid offset that can be used for user-space mappings during mmap(). This must not be called on unlinked nodes.

Return

Offset of **node** for byte-based addressing. 0 if the node does not have an object allocated.

void **`drm_vma_node_unmap`**(struct drm_vma_offset_node *node, struct address_space *file_mapping)
Unmap offset node

Parameters

`struct drm_vma_offset_node *node`
Offset node

`struct address_space *file_mapping`
Address space to unmap **node** from

Description

Unmap all userspace mappings for a given offset node. The mappings must be associated with the **file_mapping** address-space. If no offset exists nothing is done.

This call is unlocked. The caller must guarantee that *`drm_vma_offset_remove()`* is not called on this node concurrently.

int **`drm_vma_node_verify_access`**(struct drm_vma_offset_node *node, struct *drm_file* *tag)
Access verification helper for TTM

Parameters

struct drm_vma_offset_node *node
Offset node

struct drm_file *tag
Tag of file to check

Description

This checks whether **tag** is granted access to **node**. It is the same as *drm_vma_node_is_allowed()* but suitable as drop-in helper for TTM verify_access() callbacks.

Return

0 if access is granted, -EACCES otherwise.

void **drm_vma_offset_manager_init**(struct drm_vma_offset_manager *mgr, unsigned long page_offset, unsigned long size)

Initialize new offset-manager

Parameters

struct drm_vma_offset_manager *mgr
Manager object

unsigned long page_offset
Offset of available memory area (page-based)

unsigned long size
Size of available address space range (page-based)

Description

Initialize a new offset-manager. The offset and area size available for the manager are given as **page_offset** and **size**. Both are interpreted as page-numbers, not bytes.

Adding/removing nodes from the manager is locked internally and protected against concurrent access. However, node allocation and destruction is left for the caller. While calling into the vma-manager, a given node must always be guaranteed to be referenced.

void **drm_vma_offset_manager_destroy**(struct drm_vma_offset_manager *mgr)

Destroy offset manager

Parameters

struct drm_vma_offset_manager *mgr
Manager object

Description

Destroy an object manager which was previously created via *drm_vma_offset_manager_init()*. The caller must remove all allocated nodes before destroying the manager. Otherwise, drm_mm will refuse to free the requested resources.

The manager must not be accessed after this function is called.

struct drm_vma_offset_node ***drm_vma_offset_lookup_locked**(struct drm_vma_offset_manager *mgr, unsigned long start, unsigned long pages)

Find node in offset space

Parameters

struct drm_vma_offset_manager *mgr
Manager object

unsigned long start
Start address for object (page-based)

unsigned long pages
Size of object (page-based)

Description

Find a node given a start address and object size. This returns the _best_ match for the given node. That is, **start** may point somewhere into a valid region and the given node will be returned, as long as the node spans the whole requested area (given the size in number of pages as **pages**).

Note that before lookup the vma offset manager lookup lock must be acquired with *drm_vma_offset_lock_lookup()*. See there for an example. This can then be used to implement weakly referenced lookups using kref_get_unless_zero().

```
drm_vma_offset_lock_lookup(mgr);
node = drm_vma_offset_lookup_locked(mgr);
if (node)
    kref_get_unless_zero(container_of(node, sth, entr));
drm_vma_offset_unlock_lookup(mgr);
```

Example

Return

Returns NULL if no suitable node can be found. Otherwise, the best match is returned. It's the caller's responsibility to make sure the node doesn't get destroyed before the caller can access it.

int **drm_vma_offset_add**(struct drm_vma_offset_manager *mgr, struct drm_vma_offset_node *node, unsigned long pages)

Add offset node to manager

Parameters

struct drm_vma_offset_manager *mgr
Manager object

struct drm_vma_offset_node *node
Node to be added

unsigned long pages
Allocation size visible to user-space (in number of pages)

Description

Add a node to the offset-manager. If the node was already added, this does nothing and return 0. **pages** is the size of the object given in number of pages. After this call succeeds, you can access the offset of the node until it is removed again.

If this call fails, it is safe to retry the operation or call *`drm_vma_offset_remove()`*, anyway. However, no cleanup is required in that case.

pages is not required to be the same size as the underlying memory object that you want to map. It only limits the size that user-space can map into their address space.

Return

0 on success, negative error code on failure.

void **`drm_vma_offset_remove`**(struct drm_vma_offset_manager *mgr, struct drm_vma_offset_node *node)

Remove offset node from manager

Parameters

`struct drm_vma_offset_manager *mgr`
Manager object

`struct drm_vma_offset_node *node`
Node to be removed

Description

Remove a node from the offset manager. If the node wasn't added before, this does nothing. After this call returns, the offset and size will be 0 until a new offset is allocated via *`drm_vma_offset_add()`* again. Helper functions like *`drm_vma_node_start()`* and *`drm_vma_node_offset_addr()`* will return 0 if no offset is allocated.

int **`drm_vma_node_allow`**(struct drm_vma_offset_node *node, struct *drm_file* *tag)

Add open-file to list of allowed users

Parameters

`struct drm_vma_offset_node *node`
Node to modify

`struct drm_file *tag`
Tag of file to remove

Description

Add **tag** to the list of allowed open-files for this node. If **tag** is already on this list, the ref-count is incremented.

The list of allowed-users is preserved across *`drm_vma_offset_add()`* and *`drm_vma_offset_remove()`* calls. You may even call it if the node is currently not added to any offset-manager.

You must remove all open-files the same number of times as you added them before destroying the node. Otherwise, you will leak memory.

This is locked against concurrent access internally.

Return

0 on success, negative error code on internal failure (out-of-mem)

void **drm_vma_node_revoke**(struct drm_vma_offset_node *node, struct *drm_file* *tag)

Remove open-file from list of allowed users

Parameters

struct drm_vma_offset_node *node
Node to modify

struct drm_file *tag
Tag of file to remove

Description

Decrement the ref-count of **tag** in the list of allowed open-files on **node**. If the ref-count drops to zero, remove **tag** from the list. You must call this once for every *drm_vma_node_allow()* on **tag**.

This is locked against concurrent access internally.

If **tag** is not on the list, nothing is done.

bool **drm_vma_node_is_allowed**(struct drm_vma_offset_node *node, struct *drm_file* *tag)

Check whether an open-file is granted access

Parameters

struct drm_vma_offset_node *node
Node to check

struct drm_file *tag
Tag of file to remove

Description

Search the list in **node** whether **tag** is currently on the list of allowed open-files (see *drm_vma_node_allow()*).

This is locked against concurrent access internally.

Return

true iff **filp** is on the list

3.4 PRIME Buffer Sharing

PRIME is the cross device buffer sharing framework in drm, originally created for the OPTIMUS range of multi-gpu platforms. To userspace PRIME buffers are dma-buf based file descriptors.

3.4.1 Overview and Lifetime Rules

Similar to GEM global names, PRIME file descriptors are also used to share buffer objects across processes. They offer additional security: as file descriptors must be explicitly sent over UNIX domain sockets to be shared between applications, they can't be guessed like the globally unique GEM names.

Drivers that support the PRIME API implement the *drm_driver.prime_handle_to_fd* and *drm_driver.prime_fd_to_handle* operations. GEM based drivers must use *drm_gem_prime_handle_to_fd()* and *drm_gem_prime_fd_to_handle()* to implement these. For GEM based drivers the actual driver interfaces is provided through the *drm_gem_object_funcs.export* and *drm_driver.gem_prime_import* hooks.

`dma_buf_ops` implementations for GEM drivers are all individually exported for drivers which need to overwrite or reimplement some of them.

Reference Counting for GEM Drivers

On the export the `dma_buf` holds a reference to the exported buffer object, usually a *drm_gem_object*. It takes this reference in the PRIME_HANDLE_TO_FD IOCTL, when it first calls *drm_gem_object_funcs.export* and stores the exporting GEM object in the `dma_buf.priv` field. This reference needs to be released when the final reference to the `dma_buf` itself is dropped and its `dma_buf_ops.release` function is called. For GEM-based drivers, the `dma_buf` should be exported using *drm_gem_dmabuf_export()* and then released by *drm_gem_dmabuf_release()*.

Thus the chain of references always flows in one direction, avoiding loops: importing GEM object -> dma-buf -> exported GEM bo. A further complication are the lookup caches for import and export. These are required to guarantee that any given object will always have only one uniqe userspace handle. This is required to allow userspace to detect duplicated imports, since some GEM drivers do fail command submissions if a given buffer object is listed more than once. These import and export caches in *drm_prime_file_private* only retain a weak reference, which is cleaned up when the corresponding object is released.

Self-importing: If userspace is using PRIME as a replacement for flink then it will get a fd->handle request for a GEM object that it created. Drivers should detect this situation and return back the underlying object from the dma-buf private. For GEM based drivers this is handled in *drm_gem_prime_import()* already.

3.4.2 PRIME Helper Functions

Drivers can implement *drm_gem_object_funcs.export* and *drm_driver.gem_prime_import* in terms of simpler APIs by using the helper functions *drm_gem_prime_export()* and *drm_gem_prime_import()*. These functions implement dma-buf support in terms of some lower-level helpers, which are again exported for drivers to use individually:

Exporting buffers

Optional pinning of buffers is handled at dma-buf attach and detach time in *drm_gem_map_attach()* and *drm_gem_map_detach()*. Backing storage itself is handled by *drm_gem_map_dma_buf()* and *drm_gem_unmap_dma_buf()*, which relies on *drm_gem_object_funcs.get_sg_table*.

For kernel-internal access there' s *drm_gem_dmabuf_vmap()* and *drm_gem_dmabuf_vunmap()*. Userspace mmap support is provided by *drm_gem_dmabuf_mmap()*.

Note that these export helpers can only be used if the underlying backing storage is fully coherent and either permanently pinned, or it is safe to pin it indefinitely.

FIXME: The underlying helper functions are named rather inconsistently.

Exporting buffers

Importing dma-bufs using *drm_gem_prime_import()* relies on *drm_driver.gem_prime_import_sg_table*.

Note that similarly to the export helpers this permanently pins the underlying backing storage. Which is ok for scanout, but is not the best option for sharing lots of buffers for rendering.

3.4.3 PRIME Function References

struct **drm_prime_file_private**

per-file tracking for PRIME

Definition

```
struct drm_prime_file_private {
};
```

Members

Description

This just contains the internal `struct dma_buf` and handle caches for each *struct drm_file* used by the PRIME core code.

struct dma_buf ***drm_gem_dmabuf_export**(struct *drm_device* *dev, struct dma_buf_export_info *exp_info)

`dma_buf` export implementation for GEM

Parameters

struct drm_device *dev
  parent device for the exported dmabuf

struct dma_buf_export_info *exp_info
  the export information used by dma_buf_export()

Description

This wraps dma_buf_export() for use by generic GEM drivers that are using *drm_gem_dmabuf_release()*. In addition to calling dma_buf_export(), we take a reference to the *drm_device* and the exported *drm_gem_object* (stored in `dma_buf_export_info.priv`) which is released by *drm_gem_dmabuf_release()*.

Returns the new dmabuf.

void **drm_gem_dmabuf_release**(struct *dma_buf* *dma_buf)

  dma_buf release implementation for GEM

Parameters

struct dma_buf *dma_buf
  buffer to be released

Description

Generic release function for dma_bufs exported as PRIME buffers. GEM drivers must use this in their `dma_buf_ops` structure as the release callback. *drm_gem_dmabuf_release()* should be used in conjunction with *drm_gem_dmabuf_export()*.

int **drm_gem_prime_fd_to_handle**(struct *drm_device* *dev, struct *drm_file* *file_priv, int prime_fd, uint32_t *handle)

  PRIME import function for GEM drivers

Parameters

struct drm_device *dev
  dev to export the buffer from

struct drm_file *file_priv
  drm file-private structure

int prime_fd
  fd id of the dma-buf which should be imported

uint32_t *handle
  pointer to storage for the handle of the imported buffer object

Description

This is the PRIME import function which must be used mandatorily by GEM drivers to ensure correct lifetime management of the underlying GEM object. The actual importing of GEM object from the dma-buf is done through the *drm_driver.gem_prime_import* driver callback.

Returns 0 on success or a negative error code on failure.

int **drm_gem_prime_handle_to_fd**(struct *drm_device* *dev, struct *drm_file* *file_priv, uint32_t handle, uint32_t flags, int *prime_fd)

PRIME export function for GEM drivers

Parameters

struct drm_device *dev
dev to export the buffer from

struct drm_file *file_priv
drm file-private structure

uint32_t handle
buffer handle to export

uint32_t flags
flags like DRM_CLOEXEC

int *prime_fd
pointer to storage for the fd id of the create dma-buf

Description

This is the PRIME export function which must be used mandatorily by GEM drivers to ensure correct lifetime management of the underlying GEM object. The actual exporting from GEM object to a dma-buf is done through the *drm_driver.gem_prime_export* driver callback.

int **drm_gem_map_attach**(struct *dma_buf* *dma_buf, struct dma_buf_attachment *attach)

dma_buf attach implementation for GEM

Parameters

struct dma_buf *dma_buf
buffer to attach device to

struct dma_buf_attachment *attach
buffer attachment data

Description

Calls *drm_gem_object_funcs.pin* for device specific handling. This can be used as the `dma_buf_ops.attach` callback. Must be used together with *drm_gem_map_detach()*.

Returns 0 on success, negative error code on failure.

void **drm_gem_map_detach**(struct *dma_buf* *dma_buf, struct dma_buf_attachment *attach)

dma_buf detach implementation for GEM

Parameters

struct dma_buf *dma_buf
buffer to detach from

struct dma_buf_attachment *attach
attachment to be detached

Description

Calls *drm_gem_object_funcs.pin* for device specific handling. Cleans up `dma_buf_attachment` from *drm_gem_map_attach()*. This can be used as the `dma_buf_ops.detach` callback.

struct sg_table ***drm_gem_map_dma_buf**(struct dma_buf_attachment *attach, enum dma_data_direction dir)

map_dma_buf implementation for GEM

Parameters

struct dma_buf_attachment *attach
attachment whose scatterlist is to be returned

enum dma_data_direction dir
direction of DMA transfer

Description

Calls *drm_gem_object_funcs.get_sg_table* and then maps the scatterlist. This can be used as the `dma_buf_ops.map_dma_buf` callback. Should be used together with *drm_gem_unmap_dma_buf()*.

Return

sg_table containing the scatterlist to be returned; returns ERR_PTR on error. May return -EINTR if it is interrupted by a signal.

void **drm_gem_unmap_dma_buf**(struct dma_buf_attachment *attach, struct sg_table *sgt, enum dma_data_direction dir)

unmap_dma_buf implementation for GEM

Parameters

struct dma_buf_attachment *attach
attachment to unmap buffer from

struct sg_table *sgt
scatterlist info of the buffer to unmap

enum dma_data_direction dir
direction of DMA transfer

Description

This can be used as the `dma_buf_ops.unmap_dma_buf` callback.

void ***drm_gem_dmabuf_vmap**(struct *dma_buf* *dma_buf)

dma_buf vmap implementation for GEM

Parameters

struct dma_buf *dma_buf
buffer to be mapped

Description

Sets up a kernel virtual mapping. This can be used as the `dma_buf_ops.vmap` callback. Calls into *drm_gem_object_funcs.vmap* for device specific handling.

Returns the kernel virtual address or NULL on failure.

void **drm_gem_dmabuf_vunmap**(struct *dma_buf* *dma_buf, void *vaddr)

dma_buf vunmap implementation for GEM

Parameters

struct dma_buf *dma_buf
buffer to be unmapped

void *vaddr
the virtual address of the buffer

Description

Releases a kernel virtual mapping. This can be used as the `dma_buf_ops.vunmap` callback. Calls into *drm_gem_object_funcs.vunmap* for device specific handling.

int **drm_gem_prime_mmap**(struct *drm_gem_object* *obj, struct vm_area_struct *vma)

PRIME mmap function for GEM drivers

Parameters

struct drm_gem_object *obj
GEM object

struct vm_area_struct *vma
Virtual address range

Description

This function sets up a userspace mapping for PRIME exported buffers using the same codepath that is used for regular GEM buffer mapping on the DRM fd. The fake GEM offset is added to vma->vm_pgoff and *drm_driver->fops*->mmap is called to set up the mapping.

Drivers can use this as their *drm_driver.gem_prime_mmap* callback.

int **drm_gem_dmabuf_mmap**(struct *dma_buf* *dma_buf, struct vm_area_struct *vma)

dma_buf mmap implementation for GEM

Parameters

struct dma_buf *dma_buf
buffer to be mapped

struct vm_area_struct *vma
virtual address range

Description

Provides memory mapping for the buffer. This can be used as the `dma_buf_ops.mmap` callback. It just forwards to *drm_driver.gem_prime_mmap*, which should be set to *drm_gem_prime_mmap()*.

FIXME: There's really no point to this wrapper, drivers which need anything else but drm_gem_prime_mmap can roll their own `dma_buf_ops.mmap` callback.

Returns 0 on success or a negative error code on failure.

struct sg_table ***drm_prime_pages_to_sg**(struct *drm_device* *dev, struct page **pages, unsigned int nr_pages)

converts a page array into an sg list

Parameters

struct drm_device *dev
DRM device

struct page **pages
pointer to the array of page pointers to convert

unsigned int nr_pages
length of the page vector

Description

This helper creates an sg table object from a set of pages the driver is responsible for mapping the pages into the importers address space for use with dma_buf itself.

This is useful for implementing *drm_gem_object_funcs.get_sg_table*.

unsigned long **drm_prime_get_contiguous_size**(struct sg_table *sgt)

returns the contiguous size of the buffer

Parameters

struct sg_table *sgt
sg_table describing the buffer to check

Description

This helper calculates the contiguous size in the DMA address space of the the buffer described by the provided sg_table.

This is useful for implementing *drm_gem_object_funcs.gem_prime_import_sg_table*.

struct dma_buf ***drm_gem_prime_export**(struct *drm_gem_object* *obj, int flags)

helper library implementation of the export callback

Parameters

struct drm_gem_object *obj
GEM object to export

int flags
flags like DRM_CLOEXEC and DRM_RDWR

Description

This is the implementation of the *drm_gem_object_funcs.export* functions for GEM drivers using the PRIME helpers. It is used as the default in *drm_gem_prime_handle_to_fd()*.

struct *drm_gem_object* ***drm_gem_prime_import_dev**(struct *drm_device* *dev, struct *dma_buf* *dma_buf, struct device *attach_dev)

core implementation of the import callback

Parameters

struct drm_device *dev
drm_device to import into

struct dma_buf *dma_buf
dma-buf object to import

struct device *attach_dev
struct device to dma_buf attach

Description

This is the core of *drm_gem_prime_import()*. It's designed to be called by drivers who want to use a different device structure than *drm_device.dev* for attaching via dma_buf. This function calls *drm_driver.gem_prime_import_sg_table* internally.

Drivers must arrange to call *drm_prime_gem_destroy()* from their *drm_gem_object_funcs.free* hook when using this function.

struct *drm_gem_object* ***drm_gem_prime_import**(struct *drm_device* *dev, struct *dma_buf* *dma_buf)

helper library implementation of the import callback

Parameters

struct drm_device *dev
drm_device to import into

struct dma_buf *dma_buf
dma-buf object to import

Description

This is the implementation of the gem_prime_import functions for GEM drivers using the PRIME helpers. Drivers can use this as their *drm_driver.gem_prime_import* implementation. It is used as the default implementation in *drm_gem_prime_fd_to_handle()*.

Drivers must arrange to call *drm_prime_gem_destroy()* from their *drm_gem_object_funcs.free* hook when using this function.

int **drm_prime_sg_to_page_addr_arrays**(struct sg_table *sgt, struct page **pages, dma_addr_t *addrs, int max_entries)

convert an sg table into a page array

Parameters

struct sg_table *sgt
scatter-gather table to convert

struct page **pages
optional array of page pointers to store the page array in

dma_addr_t *addrs
optional array to store the dma bus address of each page

int max_entries
size of both the passed-in arrays

Description

Exports an sg table into an array of pages and addresses. This is currently required by the TTM driver in order to do correct fault handling.

Drivers can use this in their *drm_driver.gem_prime_import_sg_table* implementation.

void **drm_prime_gem_destroy**(struct *drm_gem_object* *obj, struct sg_table *sg)
helper to clean up a PRIME-imported GEM object

Parameters

struct drm_gem_object *obj
GEM object which was created from a dma-buf

struct sg_table *sg
the sg-table which was pinned at import time

Description

This is the cleanup functions which GEM drivers need to call when they use *drm_gem_prime_import()* or *drm_gem_prime_import_dev()* to import dma-bufs.

3.5 DRM MM Range Allocator

3.5.1 Overview

drm_mm provides a simple range allocator. The drivers are free to use the resource allocator from the linux core if it suits them, the upside of drm_mm is that it's in the DRM core. Which means that it's easier to extend for some of the crazier special purpose needs of gpus.

The main data struct is *drm_mm*, allocations are tracked in *drm_mm_node*. Drivers are free to embed either of them into their own suitable datastructures. drm_mm itself will not do any memory allocations of its own, so if drivers choose not to embed nodes they need to still allocate them themselves.

The range allocator also supports reservation of preallocated blocks. This is useful for taking over initial mode setting configurations from the firmware, where an object needs to be created which exactly matches the firmware's scanout target. As long as the range is still free it can be inserted anytime after the allocator is initialized, which helps with avoiding looped dependencies in the driver load sequence.

drm_mm maintains a stack of most recently freed holes, which of all simplistic datastructures seems to be a fairly decent approach to clustering allocations and avoiding too much fragmentation. This means free space searches are O(num_holes). Given that all the fancy features drm_mm supports something better would be fairly complex and since gfx thrashing is a fairly steep cliff not a real concern. Removing a node again is O(1).

drm_mm supports a few features: Alignment and range restrictions can be supplied. Furthermore every *drm_mm_node* has a color value (which is just an opaque unsigned long) which in conjunction with a driver callback can be used to implement sophisticated placement restrictions. The i915 DRM driver uses this to implement guard pages between incompatible caching domains in the graphics TT.

Two behaviors are supported for searching and allocating: bottom-up and top-down. The default is bottom-up. Top-down allocation can be used if the memory area has different restrictions, or just to reduce fragmentation.

Finally iteration helpers to walk all nodes and all holes are provided as are some basic allocator dumpers for debugging.

Note that this range allocator is not thread-safe, drivers need to protect modifications with their own locking. The idea behind this is that for a full memory manager additional data needs to be protected anyway, hence internal locking would be fully redundant.

3.5.2 LRU Scan/Eviction Support

Very often GPUs need to have continuous allocations for a given object. When evicting objects to make space for a new one it is therefore not most efficient when we simply start to select all objects from the tail of an LRU until there' s a suitable hole: Especially for big objects or nodes that otherwise have special allocation constraints there' s a good chance we evict lots of (smaller) objects unnecessarily.

The DRM range allocator supports this use-case through the scanning interfaces. First a scan operation needs to be initialized with *drm_mm_scan_init()* or *drm_mm_scan_init_with_range()*. The driver adds objects to the roster, probably by walking an LRU list, but this can be freely implemented. Eviction candiates are added using *drm_mm_scan_add_block()* until a suitable hole is found or there are no further evictable objects. Eviction roster metadata is tracked in *struct drm_mm_scan*.

The driver must walk through all objects again in exactly the reverse order to restore the allocator state. Note that while the allocator is used in the scan mode no other operation is allowed.

Finally the driver evicts all objects selected (*drm_mm_scan_remove_block()* reported true) in the scan, and any overlapping nodes after color adjustment (*drm_mm_scan_color_evict()*). Adding and removing an object is O(1), and since freeing a node is also O(1) the overall complexity is O(scanned_objects). So like the free stack which needs to be walked before a scan operation even begins this is linear in the number of objects. It doesn' t seem to hurt too badly.

3.5.3 DRM MM Range Allocator Function References

enum **drm_mm_insert_mode**

control search and allocation behaviour

Constants

DRM_MM_INSERT_BEST

Search for the smallest hole (within the search range) that fits the desired node.

Allocates the node from the bottom of the found hole.

DRM_MM_INSERT_LOW
: Search for the lowest hole (address closest to 0, within the search range) that fits the desired node.

  Allocates the node from the bottom of the found hole.

DRM_MM_INSERT_HIGH
: Search for the highest hole (address closest to U64_MAX, within the search range) that fits the desired node.

  Allocates the node from the *top* of the found hole. The specified alignment for the node is applied to the base of the node (*drm_mm_node.start*).

DRM_MM_INSERT_EVICT
: Search for the most recently evicted hole (within the search range) that fits the desired node. This is appropriate for use immediately after performing an eviction scan (see *drm_mm_scan_init()*) and removing the selected nodes to form a hole.

  Allocates the node from the bottom of the found hole.

DRM_MM_INSERT_ONCE
: Only check the first hole for suitablity and report -ENOSPC immediately otherwise, rather than check every hole until a suitable one is found. Can only be used in conjunction with another search method such as DRM_MM_INSERT_HIGH or DRM_MM_INSERT_LOW.

DRM_MM_INSERT_HIGHEST
: Only check the highest hole (the hole with the largest address) and insert the node at the top of the hole or report -ENOSPC if unsuitable.

  Does not search all holes.

DRM_MM_INSERT_LOWEST
: Only check the lowest hole (the hole with the smallest address) and insert the node at the bottom of the hole or report -ENOSPC if unsuitable.

  Does not search all holes.

Description

The *struct drm_mm* range manager supports finding a suitable modes using a number of search trees. These trees are oranised by size, by address and in most recent eviction order. This allows the user to find either the smallest hole to reuse, the lowest or highest address to reuse, or simply reuse the most recent eviction that fits. When allocating the *drm_mm_node* from within the hole, the *drm_mm_insert_mode* also dictate whether to allocate the lowest matching address or the highest.

struct **drm_mm_node**
: allocated block in the DRM allocator

Definition

```
struct drm_mm_node {
  unsigned long color;
  u64 start;
```

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(continued from previous page)

```
  u64 size;
};
```

Members

color
  Opaque driver-private tag.

start
  Start address of the allocated block.

size
  Size of the allocated block.

Description

This represents an allocated block in a *drm_mm* allocator. Except for pre-reserved nodes inserted using *drm_mm_reserve_node()* the structure is entirely opaque and should only be accessed through the provided funcions. Since allocation of these nodes is entirely handled by the driver they can be embedded.

struct **drm_mm**
  DRM allocator

Definition

```
struct drm_mm {
  void (*color_adjust)(const struct drm_mm_node *node,unsigned long␣
↪color, u64 *start, u64 *end);
};
```

Members

color_adjust
  Optional driver callback to further apply restrictions on a hole. The node argument points at the node containing the hole from which the block would be allocated (see *drm_mm_hole_follows()* and friends). The other arguments are the size of the block to be allocated. The driver can adjust the start and end as needed to e.g. insert guard pages.

Description

DRM range allocator with a few special functions and features geared towards managing GPU memory. Except for the **color_adjust** callback the structure is entirely opaque and should only be accessed through the provided functions and macros. This structure can be embedded into larger driver structures.

struct **drm_mm_scan**
  DRM allocator eviction roaster data

Definition

```
struct drm_mm_scan {
};
```

Members

Description

This structure tracks data needed for the eviction roaster set up using *drm_mm_scan_init()*, and used with *drm_mm_scan_add_block()* and *drm_mm_scan_remove_block()*. The structure is entirely opaque and should only be accessed through the provided functions and macros. It is meant to be allocated temporarily by the driver on the stack.

bool **drm_mm_node_allocated**(const struct *drm_mm_node* *node)

checks whether a node is allocated

Parameters

const struct drm_mm_node *node
drm_mm_node to check

Description

Drivers are required to clear a node prior to using it with the drm_mm range manager.

Drivers should use this helper for proper encapsulation of drm_mm internals.

Return

True if the **node** is allocated.

bool **drm_mm_initialized**(const struct *drm_mm* *mm)

checks whether an allocator is initialized

Parameters

const struct drm_mm *mm
drm_mm to check

Description

Drivers should clear the *struct drm_mm* prior to initialisation if they want to use this function.

Drivers should use this helper for proper encapsulation of drm_mm internals.

Return

True if the **mm** is initialized.

bool **drm_mm_hole_follows**(const struct *drm_mm_node* *node)

checks whether a hole follows this node

Parameters

const struct drm_mm_node *node
drm_mm_node to check

Description

Holes are embedded into the drm_mm using the tail of a drm_mm_node. If you wish to know whether a hole follows this particular node, query this function. See also *drm_mm_hole_node_start()* and *drm_mm_hole_node_end()*.

Return

True if a hole follows the **node**.

u64 **drm_mm_hole_node_start**(const struct *drm_mm_node* *hole_node)
computes the start of the hole following **node**

Parameters

const struct drm_mm_node *hole_node
drm_mm_node which implicitly tracks the following hole

Description

This is useful for driver-specific debug dumpers. Otherwise drivers should not inspect holes themselves. Drivers must check first whether a hole indeed follows by looking at *drm_mm_hole_follows()*

Return

Start of the subsequent hole.

u64 **drm_mm_hole_node_end**(const struct *drm_mm_node* *hole_node)
computes the end of the hole following **node**

Parameters

const struct drm_mm_node *hole_node
drm_mm_node which implicitly tracks the following hole

Description

This is useful for driver-specific debug dumpers. Otherwise drivers should not inspect holes themselves. Drivers must check first whether a hole indeed follows by looking at *drm_mm_hole_follows()*.

Return

End of the subsequent hole.

drm_mm_nodes

`drm_mm_nodes (mm)`

list of nodes under the drm_mm range manager

Parameters

mm
the *struct drm_mm* range manager

Description

As the drm_mm range manager hides its node_list deep with its structure, extracting it looks painful and repetitive. This is not expected to be used outside of the *drm_mm_for_each_node()* macros and similar internal functions.

Return

The node list, may be empty.

drm_mm_for_each_node

`drm_mm_for_each_node (entry, mm)`

iterator to walk over all allocated nodes

Parameters

`entry`
: *`struct drm_mm_node`* to assign to in each iteration step

`mm`
: *`drm_mm`* allocator to walk

Description

This iterator walks over all nodes in the range allocator. It is implemented with list_for_each(), so not save against removal of elements.

`drm_mm_for_each_node_safe`

`drm_mm_for_each_node_safe (entry, next, mm)`

iterator to walk over all allocated nodes

Parameters

`entry`
: *`struct drm_mm_node`* to assign to in each iteration step

`next`
: *`struct drm_mm_node`* to store the next step

`mm`
: *`drm_mm`* allocator to walk

Description

This iterator walks over all nodes in the range allocator. It is implemented with list_for_each_safe(), so save against removal of elements.

`drm_mm_for_each_hole`

`drm_mm_for_each_hole (pos, mm, hole_start, hole_end)`

iterator to walk over all holes

Parameters

`pos`
: *`drm_mm_node`* used internally to track progress

`mm`
: *`drm_mm`* allocator to walk

`hole_start`
: ulong variable to assign the hole start to on each iteration

`hole_end`
: ulong variable to assign the hole end to on each iteration

Description

This iterator walks over all holes in the range allocator. It is implemented with list_for_each(), so not save against removal of elements. **entry** is used internally and will not reflect a real drm_mm_node for the very first hole. Hence users of this iterator may not access it.

Implementation Note: We need to inline list_for_each_entry in order to be able to set hole_start and hole_end on each iteration while keeping the macro sane.

int **drm_mm_insert_node_generic**(struct *drm_mm* *mm, struct *drm_mm_node* *node, u64 size, u64 alignment, unsigned long color, enum *drm_mm_insert_mode* mode)

search for space and insert **node**

Parameters

struct drm_mm *mm
drm_mm to allocate from

struct drm_mm_node *node
preallocate node to insert

u64 size
size of the allocation

u64 alignment
alignment of the allocation

unsigned long color
opaque tag value to use for this node

enum drm_mm_insert_mode mode
fine-tune the allocation search and placement

Description

This is a simplified version of *drm_mm_insert_node_in_range()* with no range restrictions applied.

The preallocated node must be cleared to 0.

Return

0 on success, -ENOSPC if there's no suitable hole.

int **drm_mm_insert_node**(struct *drm_mm* *mm, struct *drm_mm_node* *node, u64 size)

search for space and insert **node**

Parameters

struct drm_mm *mm
drm_mm to allocate from

struct drm_mm_node *node
preallocate node to insert

u64 size
size of the allocation

Description

This is a simplified version of *drm_mm_insert_node_generic()* with **color** set to 0.

The preallocated node must be cleared to 0.

Return

0 on success, -ENOSPC if there's no suitable hole.

bool **drm_mm_clean**(const struct *drm_mm* *mm)

checks whether an allocator is clean

Parameters

const struct drm_mm *mm
drm_mm allocator to check

Return

True if the allocator is completely free, false if there's still a node allocated in it.

drm_mm_for_each_node_in_range

`drm_mm_for_each_node_in_range (node__, mm__, start__, end__)`

iterator to walk over a range of allocated nodes

Parameters

node__
drm_mm_node structure to assign to in each iteration step

mm__
drm_mm allocator to walk

start__
starting offset, the first node will overlap this

end__
ending offset, the last node will start before this (but may overlap)

Description

This iterator walks over all nodes in the range allocator that lie between **start** and **end**. It is implemented similarly to list_for_each(), but using the internal interval tree to accelerate the search for the starting node, and so not safe against removal of elements. It assumes that **end** is within (or is the upper limit of) the drm_mm allocator. If [**start**, **end**] are beyond the range of the drm_mm, the iterator may walk over the special _unallocated_ *drm_mm.head_node*, and may even continue indefinitely.

void **drm_mm_scan_init**(struct *drm_mm_scan* *scan, struct *drm_mm* *mm, u64 size, u64 alignment, unsigned long color, enum *drm_mm_insert_mode* mode)

initialize lru scanning

Parameters

struct drm_mm_scan *scan
scan state

struct drm_mm *mm
drm_mm to scan

u64 size
size of the allocation

`u64 alignment`
alignment of the allocation

`unsigned long color`
opaque tag value to use for the allocation

`enum drm_mm_insert_mode mode`
fine-tune the allocation search and placement

Description

This is a simplified version of *`drm_mm_scan_init_with_range()`* with no range restrictions applied.

This simply sets up the scanning routines with the parameters for the desired hole.

Warning: As long as the scan list is non-empty, no other operations than adding/removing nodes to/from the scan list are allowed.

int **`drm_mm_reserve_node`**(struct *drm_mm* *mm, struct *drm_mm_node* *node)
insert an pre-initialized node

Parameters

`struct drm_mm *mm`
drm_mm allocator to insert **node** into

`struct drm_mm_node *node`
drm_mm_node to insert

Description

This functions inserts an already set-up *`drm_mm_node`* into the allocator, meaning that start, size and color must be set by the caller. All other fields must be cleared to 0. This is useful to initialize the allocator with preallocated objects which must be set-up before the range allocator can be set-up, e.g. when taking over a firmware framebuffer.

Return

0 on success, -ENOSPC if there's no hole where **node** is.

int **`drm_mm_insert_node_in_range`**(struct *drm_mm* *const mm, struct *drm_mm_node* *const node, u64 size, u64 alignment, unsigned long color, u64 range_start, u64 range_end, enum *drm_mm_insert_mode* mode)
ranged search for space and insert **node**

Parameters

`struct drm_mm * const mm`
drm_mm to allocate from

`struct drm_mm_node * const node`
preallocate node to insert

`u64 size`
size of the allocation

u64 alignment
alignment of the allocation

unsigned long color
opaque tag value to use for this node

u64 range_start
start of the allowed range for this node

u64 range_end
end of the allowed range for this node

enum drm_mm_insert_mode mode
fine-tune the allocation search and placement

Description

The preallocated **node** must be cleared to 0.

Return

0 on success, -ENOSPC if there's no suitable hole.

void **drm_mm_remove_node**(struct *drm_mm_node* *node)

Remove a memory node from the allocator.

Parameters

struct drm_mm_node *node
drm_mm_node to remove

Description

This just removes a node from its drm_mm allocator. The node does not need to be cleared again before it can be re-inserted into this or any other drm_mm allocator. It is a bug to call this function on a unallocated node.

void **drm_mm_replace_node**(struct *drm_mm_node* *old, struct *drm_mm_node* *new)

move an allocation from **old** to **new**

Parameters

struct drm_mm_node *old
drm_mm_node to remove from the allocator

struct drm_mm_node *new
drm_mm_node which should inherit **old**'s allocation

Description

This is useful for when drivers embed the drm_mm_node structure and hence can't move allocations by reassigning pointers. It's a combination of remove and insert with the guarantee that the allocation start will match.

void **drm_mm_scan_init_with_range**(struct *drm_mm_scan* *scan, struct *drm_mm* *mm, u64 size, u64 alignment, unsigned long color, u64 start, u64 end, enum *drm_mm_insert_mode* mode)

initialize range-restricted lru scanning

Parameters

struct drm_mm_scan *scan
scan state

struct drm_mm *mm
drm_mm to scan

u64 size
size of the allocation

u64 alignment
alignment of the allocation

unsigned long color
opaque tag value to use for the allocation

u64 start
start of the allowed range for the allocation

u64 end
end of the allowed range for the allocation

enum drm_mm_insert_mode mode
fine-tune the allocation search and placement

Description

This simply sets up the scanning routines with the parameters for the desired hole.

Warning: As long as the scan list is non-empty, no other operations than adding/removing nodes to/from the scan list are allowed.

bool **drm_mm_scan_add_block**(struct *drm_mm_scan* *scan, struct *drm_mm_node* *node)

add a node to the scan list

Parameters

struct drm_mm_scan *scan
the active drm_mm scanner

struct drm_mm_node *node
drm_mm_node to add

Description

Add a node to the scan list that might be freed to make space for the desired hole.

Return

True if a hole has been found, false otherwise.

bool **drm_mm_scan_remove_block**(struct *drm_mm_scan* *scan, struct *drm_mm_node* *node)

remove a node from the scan list

Parameters

struct drm_mm_scan *scan
the active drm_mm scanner

struct drm_mm_node *node
: drm_mm_node to remove

Description

Nodes **must** be removed in exactly the reverse order from the scan list as they have been added (e.g. using list_add() as they are added and then list_for_each() over that eviction list to remove), otherwise the internal state of the memory manager will be corrupted.

When the scan list is empty, the selected memory nodes can be freed. An immediately following drm_mm_insert_node_in_range_generic() or one of the simpler versions of that function with !DRM_MM_SEARCH_BEST will then return the just freed block (because it's at the top of the free_stack list).

Return

True if this block should be evicted, false otherwise. Will always return false when no hole has been found.

struct *drm_mm_node* ***drm_mm_scan_color_evict**(struct *drm_mm_scan* *scan)
: evict overlapping nodes on either side of hole

Parameters

struct drm_mm_scan *scan
: drm_mm scan with target hole

Description

After completing an eviction scan and removing the selected nodes, we may need to remove a few more nodes from either side of the target hole if mm.color_adjust is being used.

Return

A node to evict, or NULL if there are no overlapping nodes.

void **drm_mm_init**(struct *drm_mm* *mm, u64 start, u64 size)
: initialize a drm-mm allocator

Parameters

struct drm_mm *mm
: the drm_mm structure to initialize

u64 start
: start of the range managed by **mm**

u64 size
: end of the range managed by **mm**

Description

Note that **mm** must be cleared to 0 before calling this function.

void **drm_mm_takedown**(struct *drm_mm* *mm)
: clean up a drm_mm allocator

Parameters

struct drm_mm *mm
drm_mm allocator to clean up

Description

Note that it is a bug to call this function on an allocator which is not clean.

void **drm_mm_print**(const struct *drm_mm* *mm, struct *drm_printer* *p)
print allocator state

Parameters

const struct drm_mm *mm
drm_mm allocator to print

struct drm_printer *p
DRM printer to use

3.6 DRM Cache Handling

void **drm_clflush_pages**(struct page *pages[], unsigned long num_pages)
Flush dcache lines of a set of pages.

Parameters

struct page *pages[]
List of pages to be flushed.

unsigned long num_pages
Number of pages in the array.

Description

Flush every data cache line entry that points to an address belonging to a page in the array.

void **drm_clflush_sg**(struct sg_table *st)
Flush dcache lines pointing to a scather-gather.

Parameters

struct sg_table *st
struct sg_table.

Description

Flush every data cache line entry that points to an address in the sg.

void **drm_clflush_virt_range**(void *addr, unsigned long length)
Flush dcache lines of a region

Parameters

void *addr
Initial kernel memory address.

unsigned long length
Region size.

Description

Flush every data cache line entry that points to an address in the region requested.

3.7 DRM Sync Objects

DRM synchronisation objects (syncobj, see struct *drm_syncobj*) provide a container for a synchronization primitive which can be used by userspace to explicitly synchronize GPU commands, can be shared between userspace processes, and can be shared between different DRM drivers. Their primary use-case is to implement Vulkan fences and semaphores. The syncobj userspace API provides ioctls for several operations:

- Creation and destruction of syncobjs
- Import and export of syncobjs to/from a syncobj file descriptor
- Import and export a syncobj' s underlying fence to/from a sync file
- Reset a syncobj (set its fence to NULL)
- Signal a syncobj (set a trivially signaled fence)
- Wait for a syncobj' s fence to appear and be signaled

The syncobj userspace API also provides operations to manipulate a syncobj in terms of a timeline of struct `dma_fence_chain` rather than a single struct `dma_fence`, through the following operations:

- Signal a given point on the timeline
- Wait for a given point to appear and/or be signaled
- Import and export from/to a given point of a timeline

At it' s core, a syncobj is simply a wrapper around a pointer to a struct `dma_fence` which may be NULL. When a syncobj is first created, its pointer is either NULL or a pointer to an already signaled fence depending on whether the `DRM_SYNCOBJ_CREATE_SIGNALED` flag is passed to `DRM_IOCTL_SYNCOBJ_CREATE`.

If the syncobj is considered as a binary (its state is either signaled or unsignaled) primitive, when GPU work is enqueued in a DRM driver to signal the syncobj, the syncobj' s fence is replaced with a fence which will be signaled by the completion of that work. If the syncobj is considered as a timeline primitive, when GPU work is enqueued in a DRM driver to signal the a given point of the syncobj, a new struct `dma_fence_chain` pointing to the DRM driver' s fence and also pointing to the previous fence that was in the syncobj. The new struct `dma_fence_chain` fence replace the syncobj' s fence and will be signaled by completion of the DRM driver' s work and also any work associated with the fence previously in the syncobj.

When GPU work which waits on a syncobj is enqueued in a DRM driver, at the time the work is enqueued, it waits on the syncobj' s fence before submitting the work to hardware. That fence is either :

- The syncobj' s current fence if the syncobj is considered as a binary primitive.
- The struct `dma_fence` associated with a given point if the syncobj is considered as a timeline primitive.

If the syncobj's fence is NULL or not present in the syncobj's timeline, the enqueue operation is expected to fail.

With binary syncobj, all manipulation of the syncobjs' s fence happens in terms of the current fence at the time the ioctl is called by userspace regardless of whether that operation is an immediate host-side operation (signal or reset) or or an operation which is enqueued in some driver queue. `DRM_IOCTL_SYNCOBJ_RESET` and `DRM_IOCTL_SYNCOBJ_SIGNAL` can be used to manipulate a syncobj from the host by resetting its pointer to NULL or setting its pointer to a fence which is already signaled.

With a timeline syncobj, all manipulation of the synobj' s fence happens in terms of a u64 value referring to point in the timeline. See dma_fence_chain_find_seqno() to see how a given point is found in the timeline.

Note that applications should be careful to always use timeline set of ioctl() when dealing with syncobj considered as timeline. Using a binary set of ioctl() with a syncobj considered as timeline could result incorrect synchronization. The use of binary syncobj is supported through the timeline set of ioctl() by using a point value of 0, this will reproduce the behavior of the binary set of ioctl() (for example replace the syncobj' s fence when signaling).

3.7.1 Host-side wait on syncobjs

`DRM_IOCTL_SYNCOBJ_WAIT` takes an array of syncobj handles and does a host-side wait on all of the syncobj fences simultaneously. If `DRM_SYNCOBJ_WAIT_FLAGS_WAIT_ALL` is set, the wait ioctl will wait on all of the syncobj fences to be signaled before it returns. Otherwise, it returns once at least one syncobj fence has been signaled and the index of a signaled fence is written back to the client.

Unlike the enqueued GPU work dependencies which fail if they see a NULL fence in a syncobj, if `DRM_SYNCOBJ_WAIT_FLAGS_WAIT_FOR_SUBMIT` is set, the host-side wait will first wait for the syncobj to receive a non-NULL fence and then wait on that fence. If `DRM_SYNCOBJ_WAIT_FLAGS_WAIT_FOR_SUBMIT` is not set and any one of the syncobjs in the array has a NULL fence, -EINVAL will be returned. Assuming the syncobj starts off with a NULL fence, this allows a client to do a host wait in one thread (or process) which waits on GPU work submitted in another thread (or process) without having to manually synchronize between the two. This requirement is inherited from the Vulkan fence API.

Similarly, `DRM_IOCTL_SYNCOBJ_TIMELINE_WAIT` takes an array of syncobj handles as well as an array of u64 points and does a host-side wait on all of syncobj fences at the given points simultaneously.

`DRM_IOCTL_SYNCOBJ_TIMELINE_WAIT` also adds the ability to wait for a given fence to materialize on the timeline without waiting for the fence to be signaled by using the `DRM_SYNCOBJ_WAIT_FLAGS_WAIT_AVAILABLE` flag. This requirement is inherited from the wait-before-signal behavior required by the Vulkan timeline semaphore API.

3.7.2 Import/export of syncobjs

DRM_IOCTL_SYNCOBJ_FD_TO_HANDLE and DRM_IOCTL_SYNCOBJ_HANDLE_TO_FD provide two mechanisms for import/export of syncobjs.

The first lets the client import or export an entire syncobj to a file descriptor. These fd's are opaque and have no other use case, except passing the syncobj between processes. All exported file descriptors and any syncobj handles created as a result of importing those file descriptors own a reference to the same underlying struct *drm_syncobj* and the syncobj can be used persistently across all the processes with which it is shared. The syncobj is freed only once the last reference is dropped. Unlike dma-buf, importing a syncobj creates a new handle (with its own reference) for every import instead of de-duplicating. The primary use-case of this persistent import/export is for shared Vulkan fences and semaphores.

The second import/export mechanism, which is indicated by DRM_SYNCOBJ_FD_TO_HANDLE_FLAGS_IMPORT_SYNC_FILE or DRM_SYNCOBJ_HANDLE_TO_FD_FLAGS_EXPORT_SYNC_FILE lets the client import/export the syncobj's current fence from/to a sync_file. When a syncobj is exported to a sync file, that sync file wraps the sycnobj's fence at the time of export and any later signal or reset operations on the syncobj will not affect the exported sync file. When a sync file is imported into a syncobj, the syncobj's fence is set to the fence wrapped by that sync file. Because sync files are immutable, resetting or signaling the syncobj will not affect any sync files whose fences have been imported into the syncobj.

3.7.3 Import/export of timeline points in timeline syncobjs

DRM_IOCTL_SYNCOBJ_TRANSFER provides a mechanism to transfer a struct dma_fence_chain of a syncobj at a given u64 point to another u64 point into another syncobj.

Note that if you want to transfer a struct dma_fence_chain from a given point on a timeline syncobj from/into a binary syncobj, you can use the point 0 to mean take/replace the fence in the syncobj.

struct **drm_syncobj**

sync object.

Definition

```
struct drm_syncobj {
  struct kref refcount;
  struct dma_fence __rcu *fence;
  struct list_head cb_list;
  spinlock_t lock;
  struct file *file;
};
```

Members

refcount

Reference count of this object.

fence
NULL or a pointer to the fence bound to this object.

This field should not be used directly. Use *drm_syncobj_fence_get()* and *drm_syncobj_replace_fence()* instead.

cb_list
List of callbacks to call when the `fence` gets replaced.

lock
Protects `cb_list` and write-locks `fence`.

file
A file backing for this syncobj.

Description

This structure defines a generic sync object which wraps a `dma_fence`.

void **drm_syncobj_get**(struct *drm_syncobj* *obj)
acquire a syncobj reference

Parameters

struct drm_syncobj *obj
sync object

Description

This acquires an additional reference to **obj**. It is illegal to call this without already holding a reference. No locks required.

void **drm_syncobj_put**(struct *drm_syncobj* *obj)
release a reference to a sync object.

Parameters

struct drm_syncobj *obj
sync object.

struct dma_fence ***drm_syncobj_fence_get**(struct *drm_syncobj* *syncobj)
get a reference to a fence in a sync object

Parameters

struct drm_syncobj *syncobj
sync object.

Description

This acquires additional reference to *drm_syncobj.fence* contained in **obj**, if not NULL. It is illegal to call this without already holding a reference. No locks required.

Return

Either the fence of **obj** or NULL if there's none.

struct *drm_syncobj* ***drm_syncobj_find**(struct *drm_file* *file_private, u32 handle)
lookup and reference a sync object.

Parameters

struct drm_file *file_private
    drm file private pointer

u32 handle
    sync object handle to lookup.

Description

Returns a reference to the syncobj pointed to by handle or NULL. The reference must be released by calling *drm_syncobj_put()*.

void **drm_syncobj_add_point**(struct *drm_syncobj* *syncobj, struct dma_fence_chain *chain, struct dma_fence *fence, uint64_t point)

    add new timeline point to the syncobj

Parameters

struct drm_syncobj *syncobj
    sync object to add timeline point do

struct dma_fence_chain *chain
    chain node to use to add the point

struct dma_fence *fence
    fence to encapsulate in the chain node

uint64_t point
    sequence number to use for the point

Description

Add the chain node as new timeline point to the syncobj.

void **drm_syncobj_replace_fence**(struct *drm_syncobj* *syncobj, struct dma_fence *fence)

    replace fence in a sync object.

Parameters

struct drm_syncobj *syncobj
    Sync object to replace fence in

struct dma_fence *fence
    fence to install in sync file.

Description

This replaces the fence on a sync object.

int **drm_syncobj_find_fence**(struct *drm_file* *file_private, u32 handle, u64 point, u64 flags, struct dma_fence **fence)

    lookup and reference the fence in a sync object

Parameters

struct drm_file *file_private
    drm file private pointer

u32 handle
sync object handle to lookup.

u64 point
timeline point

u64 flags
DRM_SYNCOBJ_WAIT_FLAGS_WAIT_FOR_SUBMIT or not

struct dma_fence **fence
out parameter for the fence

Description

This is just a convenience function that combines *drm_syncobj_find()* and *drm_syncobj_fence_get()*.

Returns 0 on success or a negative error value on failure. On success **fence** contains a reference to the fence, which must be released by calling dma_fence_put().

void **drm_syncobj_free**(struct *kref* *kref)
free a sync object.

Parameters

struct kref *kref
kref to free.

Description

Only to be called from kref_put in drm_syncobj_put.

int **drm_syncobj_create**(struct *drm_syncobj* **out_syncobj, uint32_t flags, struct dma_fence *fence)
create a new syncobj

Parameters

struct drm_syncobj **out_syncobj
returned syncobj

uint32_t flags
DRM_SYNCOBJ_* flags

struct dma_fence *fence
if non-NULL, the syncobj will represent this fence

Description

This is the first function to create a sync object. After creating, drivers probably want to make it available to userspace, either through *drm_syncobj_get_handle()* or *drm_syncobj_get_fd()*.

Returns 0 on success or a negative error value on failure.

int **drm_syncobj_get_handle**(struct *drm_file* *file_private, struct *drm_syncobj* *syncobj, u32 *handle)
get a handle from a syncobj

Parameters

struct drm_file *file_private
    drm file private pointer

struct drm_syncobj *syncobj
    Sync object to export

u32 *handle
    out parameter with the new handle

Description

Exports a sync object created with *drm_syncobj_create()* as a handle on **file_private** to userspace.

Returns 0 on success or a negative error value on failure.

int **drm_syncobj_get_fd**(struct *drm_syncobj* *syncobj, int *p_fd)
    get a file descriptor from a syncobj

Parameters

struct drm_syncobj *syncobj
    Sync object to export

int *p_fd
    out parameter with the new file descriptor

Description

Exports a sync object created with *drm_syncobj_create()* as a file descriptor.

Returns 0 on success or a negative error value on failure.

signed long **drm_timeout_abs_to_jiffies**(int64_t timeout_nsec)
    calculate jiffies timeout from absolute value

Parameters

int64_t timeout_nsec
    timeout nsec component in ns, 0 for poll

Description

Calculate the timeout in jiffies from an absolute time in sec/nsec.

3.8 GPU Scheduler

3.8.1 Overview

The GPU scheduler provides entities which allow userspace to push jobs into software queues which are then scheduled on a hardware run queue. The software queues have a priority among them. The scheduler selects the entities from the run queue using a FIFO. The scheduler provides dependency handling features among jobs. The driver is supposed to provide callback functions for backend operations to the scheduler like submitting a job to hardware run queue, returning the dependencies of a job etc.

The organisation of the scheduler is the following:

1. Each hw run queue has one scheduler
2. Each scheduler has multiple run queues with different priorities (e.g., HIGH_HW,HIGH_SW, KERNEL, NORMAL)
3. Each scheduler run queue has a queue of entities to schedule
4. Entities themselves maintain a queue of jobs that will be scheduled on the hardware.

The jobs in a entity are always scheduled in the order that they were pushed.

3.8.2 Scheduler Function References

struct **drm_sched_entity**

A wrapper around a job queue (typically attached to the DRM file_priv).

Definition

```
struct drm_sched_entity {
  struct list_head                list;
  struct drm_sched_rq             *rq;
  struct drm_gpu_scheduler        **sched_list;
  unsigned int                    num_sched_list;
  enum drm_sched_priority         priority;
  spinlock_t rq_lock;
  struct spsc_queue               job_queue;
  atomic_t fence_seq;
  uint64_t fence_context;
  struct dma_fence                *dependency;
  struct dma_fence_cb             cb;
  atomic_t *guilty;
  struct dma_fence                *last_scheduled;
  struct task_struct              *last_user;
  bool stopped;
  struct completion               entity_idle;
};
```

Members

list
used to append this struct to the list of entities in the runqueue.

rq
runqueue on which this entity is currently scheduled.

sched_list
A list of schedulers (drm_gpu_schedulers). Jobs from this entity can be scheduled on any scheduler on this list.

num_sched_list
number of drm_gpu_schedulers in the sched_list.

priority
priority of the entity

rq_lock
lock to modify the runqueue to which this entity belongs.

job_queue
the list of jobs of this entity.

fence_seq
a linearly increasing seqno incremented with each new *drm_sched_fence* which is part of the entity.

fence_context
a unique context for all the fences which belong to this entity. The *drm_sched_fence.scheduled* uses the fence_context but *drm_sched_fence.finished* uses fence_context + 1.

dependency
the dependency fence of the job which is on the top of the job queue.

cb
callback for the dependency fence above.

guilty
points to ctx' s guilty.

last_scheduled
points to the finished fence of the last scheduled job.

last_user
last group leader pushing a job into the entity.

stopped
Marks the enity as removed from rq and destined for termination.

entity_idle
Signals when enityt is not in use

Description

Entities will emit jobs in order to their corresponding hardware ring, and the scheduler will alternate between entities based on scheduling policy.

struct **drm_sched_rq**

queue of entities to be scheduled.

Definition

```
struct drm_sched_rq {
  spinlock_t lock;
  struct drm_gpu_scheduler        *sched;
  struct list_head                entities;
  struct drm_sched_entity         *current_entity;
};
```

Members

lock
to modify the entities list.

sched
the scheduler to which this rq belongs to.

entities
list of the entities to be scheduled.

current_entity
the entity which is to be scheduled.

Description

Run queue is a set of entities scheduling command submissions for one specific ring. It implements the scheduling policy that selects the next entity to emit commands from.

struct **drm_sched_fence**

fences corresponding to the scheduling of a job.

Definition

```
struct drm_sched_fence {
  struct dma_fence                scheduled;
  struct dma_fence                finished;
  struct dma_fence                *parent;
  struct drm_gpu_scheduler        *sched;
  spinlock_t lock;
  void *owner;
};
```

Members

scheduled
this fence is what will be signaled by the scheduler when the job is scheduled.

finished
this fence is what will be signaled by the scheduler when the job is completed.

When setting up an out fence for the job, you should use this, since it' s available immediately upon *drm_sched_job_init()*, and the fence returned by the driver from run_job() won' t be created until the dependencies have resolved.

parent
the fence returned by *drm_sched_backend_ops.run_job* when scheduling the job on hardware. We signal the *drm_sched_fence.finished* fence once parent is signalled.

sched
the scheduler instance to which the job having this struct belongs to.

lock
the lock used by the scheduled and the finished fences.

owner
job owner for debugging

struct **drm_sched_job**

A job to be run by an entity.

Definition

```
struct drm_sched_job {
  struct spsc_node                queue_node;
  struct drm_gpu_scheduler        *sched;
  struct drm_sched_fence          *s_fence;
  struct dma_fence_cb             finish_cb;
  struct list_head                node;
  uint64_t id;
  atomic_t karma;
  enum drm_sched_priority         s_priority;
  struct drm_sched_entity  *entity;
  struct dma_fence_cb             cb;
};
```

Members

queue_node
: used to append this struct to the queue of jobs in an entity.

sched
: the scheduler instance on which this job is scheduled.

s_fence
: contains the fences for the scheduling of job.

finish_cb
: the callback for the finished fence.

node
: used to append this struct to the **drm_gpu_scheduler.ring_mirror_list**.

id
: a unique id assigned to each job scheduled on the scheduler.

karma
: increment on every hang caused by this job. If this exceeds the hang limit of the scheduler then the job is marked guilty and will not be scheduled further.

s_priority
: the priority of the job.

entity
: the entity to which this job belongs.

cb
: the callback for the parent fence in s_fence.

Description

A job is created by the driver using *drm_sched_job_init()*, and should call drm_sched_entity_push_job() once it wants the scheduler to schedule the job.

struct **drm_sched_backend_ops**

Definition

```
struct drm_sched_backend_ops {
  struct dma_fence *(*dependency)(struct drm_sched_job *sched_job,␣
↪struct drm_sched_entity *s_entity);
  struct dma_fence *(*run_job)(struct drm_sched_job *sched_job);
  void (*timedout_job)(struct drm_sched_job *sched_job);
  void (*free_job)(struct drm_sched_job *sched_job);
};
```

Members

dependency
Called when the scheduler is considering scheduling this job next, to get another struct dma_fence for this job to block on. Once it returns NULL, run_job() may be called.

run_job
Called to execute the job once all of the dependencies have been resolved. This may be called multiple times, if timedout_job() has happened and drm_sched_job_recovery() decides to try it again.

timedout_job
Called when a job has taken too long to execute, to trigger GPU recovery.

free_job
Called once the job' s finished fence has been signaled and it' s time to clean it up.

Description

Define the backend operations called by the scheduler, these functions should be implemented in driver side.

struct **drm_gpu_scheduler**

Definition

```
struct drm_gpu_scheduler {
  const struct drm_sched_backend_ops      *ops;
  uint32_t hw_submission_limit;
  long timeout;
  const char                          *name;
  struct drm_sched_rq                 sched_rq[DRM_SCHED_PRIORITY_
↪COUNT];
  wait_queue_head_t wake_up_worker;
  wait_queue_head_t job_scheduled;
  atomic_t hw_rq_count;
  atomic64_t job_id_count;
  struct delayed_work                 work_tdr;
  struct task_struct                  *thread;
  struct list_head                    ring_mirror_list;
  spinlock_t job_list_lock;
  int hang_limit;
  atomic_t score;
  bool ready;
```

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```
  bool free_guilty;
};
```

Members

ops
backend operations provided by the driver.

hw_submission_limit
the max size of the hardware queue.

timeout
the time after which a job is removed from the scheduler.

name
name of the ring for which this scheduler is being used.

sched_rq
priority wise array of run queues.

wake_up_worker
the wait queue on which the scheduler sleeps until a job is ready to be scheduled.

job_scheduled
once **drm_sched_entity_do_release** is called the scheduler waits on this wait queue until all the scheduled jobs are finished.

hw_rq_count
the number of jobs currently in the hardware queue.

job_id_count
used to assign unique id to the each job.

work_tdr
schedules a delayed call to **drm_sched_job_timedout** after the timeout interval is over.

thread
the kthread on which the scheduler which run.

ring_mirror_list
the list of jobs which are currently in the job queue.

job_list_lock
lock to protect the ring_mirror_list.

hang_limit
once the hangs by a job crosses this limit then it is marked guilty and it will be considered for scheduling further.

score
score to help loadbalancer pick a idle sched

ready
marks if the underlying HW is ready to work

`free_guilty`
A hit to time out handler to free the guilty job.

Description

One scheduler is implemented for each hardware ring.

bool **`drm_sched_dependency_optimized`**(struct dma_fence *fence, struct *drm_sched_entity* *entity)

Parameters

`struct dma_fence* fence`
the dependency fence

`struct drm_sched_entity *entity`
the entity which depends on the above fence

Description

Returns true if the dependency can be optimized and false otherwise

void **`drm_sched_fault`**(struct *drm_gpu_scheduler* *sched)
immediately start timeout handler

Parameters

`struct drm_gpu_scheduler *sched`
scheduler where the timeout handling should be started.

Description

Start timeout handling immediately when the driver detects a hardware fault.

unsigned long **`drm_sched_suspend_timeout`**(struct *drm_gpu_scheduler* *sched)
Suspend scheduler job timeout

Parameters

`struct drm_gpu_scheduler *sched`
scheduler instance for which to suspend the timeout

Description

Suspend the delayed work timeout for the scheduler. This is done by modifying the delayed work timeout to an arbitrary large value, MAX_SCHEDULE_TIMEOUT in this case.

Returns the timeout remaining

void **`drm_sched_resume_timeout`**(struct *drm_gpu_scheduler* *sched, unsigned long remaining)
Resume scheduler job timeout

Parameters

`struct drm_gpu_scheduler *sched`
scheduler instance for which to resume the timeout

`unsigned long remaining`
remaining timeout

Description

Resume the delayed work timeout for the scheduler.

void **drm_sched_stop**(struct *drm_gpu_scheduler* *sched, struct *drm_sched_job* *bad)

stop the scheduler

Parameters

struct drm_gpu_scheduler *sched
scheduler instance

struct drm_sched_job *bad
job which caused the time out

Description

Stop the scheduler and also removes and frees all completed jobs.

Note

bad job will not be freed as it might be used later and so it' s callers responsibility to release it manually if it' s not part of the mirror list any more.

void **drm_sched_start**(struct *drm_gpu_scheduler* *sched, bool full_recovery)

recover jobs after a reset

Parameters

struct drm_gpu_scheduler *sched
scheduler instance

bool full_recovery
proceed with complete sched restart

void **drm_sched_resubmit_jobs**(struct *drm_gpu_scheduler* *sched)

helper to relunch job from mirror ring list

Parameters

struct drm_gpu_scheduler *sched
scheduler instance

int **drm_sched_job_init**(struct *drm_sched_job* *job, struct *drm_sched_entity* *entity, void *owner)

init a scheduler job

Parameters

struct drm_sched_job *job
scheduler job to init

struct drm_sched_entity *entity
scheduler entity to use

void *owner
job owner for debugging

Description

Refer to drm_sched_entity_push_job() documentation for locking considerations.

Returns 0 for success, negative error code otherwise.

void **drm_sched_job_cleanup**(struct *drm_sched_job* *job)

clean up scheduler job resources

Parameters

struct drm_sched_job *job
scheduler job to clean up

struct *drm_gpu_scheduler* ***drm_sched_pick_best**(struct *drm_gpu_scheduler* **sched_list, unsigned int num_sched_list)

Get a drm sched from a sched_list with the least load

Parameters

struct drm_gpu_scheduler **sched_list
list of drm_gpu_schedulers

unsigned int num_sched_list
number of drm_gpu_schedulers in the sched_list

Description

Returns pointer of the sched with the least load or NULL if none of the drm_gpu_schedulers are ready

int **drm_sched_init**(struct *drm_gpu_scheduler* *sched, const struct *drm_sched_backend_ops* *ops, unsigned hw_submission, unsigned hang_limit, long timeout, const char *name)

Init a gpu scheduler instance

Parameters

struct drm_gpu_scheduler *sched
scheduler instance

const struct drm_sched_backend_ops *ops
backend operations for this scheduler

unsigned hw_submission
number of hw submissions that can be in flight

unsigned hang_limit
number of times to allow a job to hang before dropping it

long timeout
timeout value in jiffies for the scheduler

const char *name
name used for debugging

Description

Return 0 on success, otherwise error code.

void **drm_sched_fini**(struct *drm_gpu_scheduler* *sched)

Destroy a gpu scheduler

Parameters

`struct drm_gpu_scheduler *sched`
scheduler instance

Description

Tears down and cleans up the scheduler.

CHAPTER

FOUR

KERNEL MODE SETTING (KMS)

Drivers must initialize the mode setting core by calling *drmm_mode_config_init()* on the DRM device. The function initializes the *struct drm_device* mode_config field and never fails. Once done, mode configuration must be setup by initializing the following fields.

- int min_width, min_height; int max_width, max_height; Minimum and maximum width and height of the frame buffers in pixel units.
- *struct drm_mode_config_funcs* *funcs; Mode setting functions.

4.1 Overview

The basic object structure KMS presents to userspace is fairly simple. Framebuffers (represented by *struct drm_framebuffer*, see *Frame Buffer Abstraction*) feed into planes. Planes are represented by *struct drm_plane*, see *Plane Abstraction* for more details. One or more (or even no) planes feed their pixel data into a CRTC (represented by *struct drm_crtc*, see *CRTC Abstraction*) for blending. The precise blending step is explained in more detail in *Plane Composition Properties* and related chapters.

For the output routing the first step is encoders (represented by *struct drm_encoder*, see *Encoder Abstraction*). Those are really just internal artifacts of the helper libraries used to implement KMS drivers. Besides that they make it unecessarily more complicated for userspace to figure out which connections between a CRTC and a connector are possible, and what kind of cloning is supported, they serve no purpose in the userspace API. Unfortunately encoders have been exposed to userspace, hence can' t remove them at this point. Futhermore the exposed restrictions are often wrongly set by drivers, and in many cases not powerful enough to express the real restrictions. A CRTC can be connected to multiple encoders, and for an active CRTC there must be at least one encoder.

The final, and real, endpoint in the display chain is the connector (represented by *struct drm_connector*, see *Connector Abstraction*). Connectors can have different possible encoders, but the kernel driver selects which encoder to use for each connector. The use case is DVI, which could switch between an analog and a digital encoder. Encoders can also drive multiple different connectors. There is exactly one active connector for every active encoder.

Internally the output pipeline is a bit more complex and matches today' s hardware more closely:

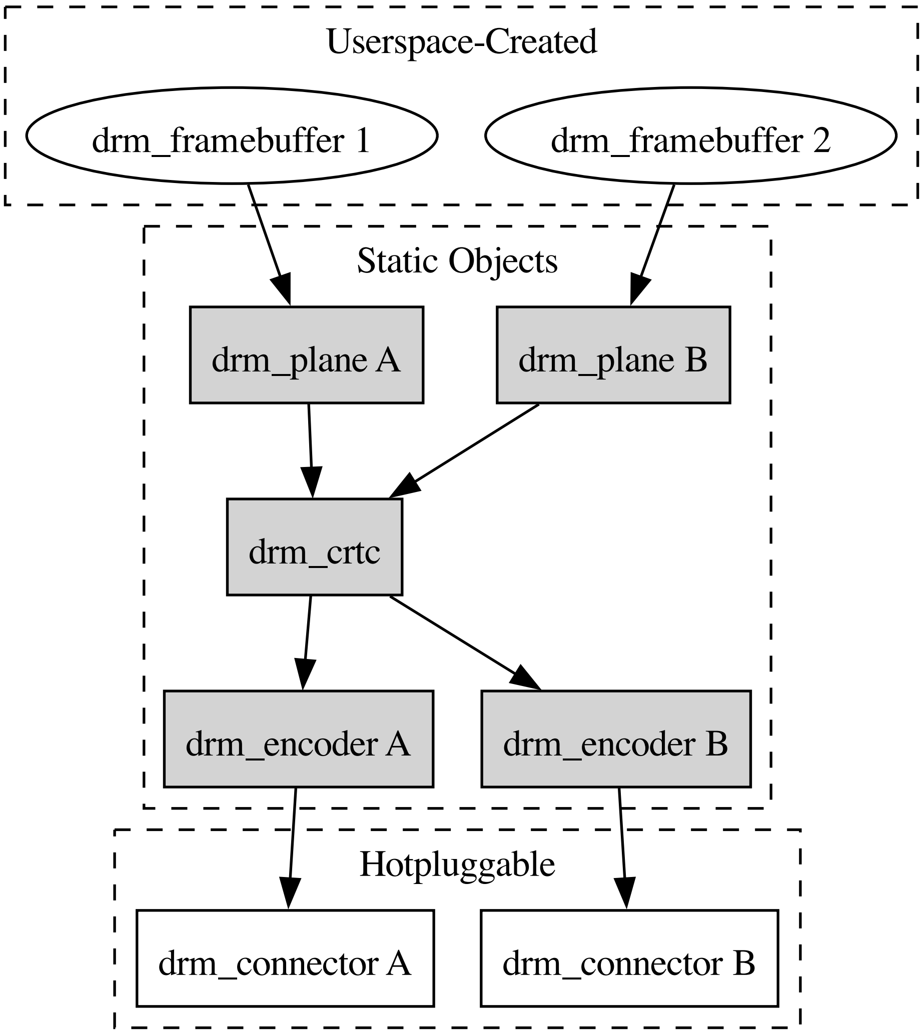

Fig. 1: KMS Display Pipeline Overview

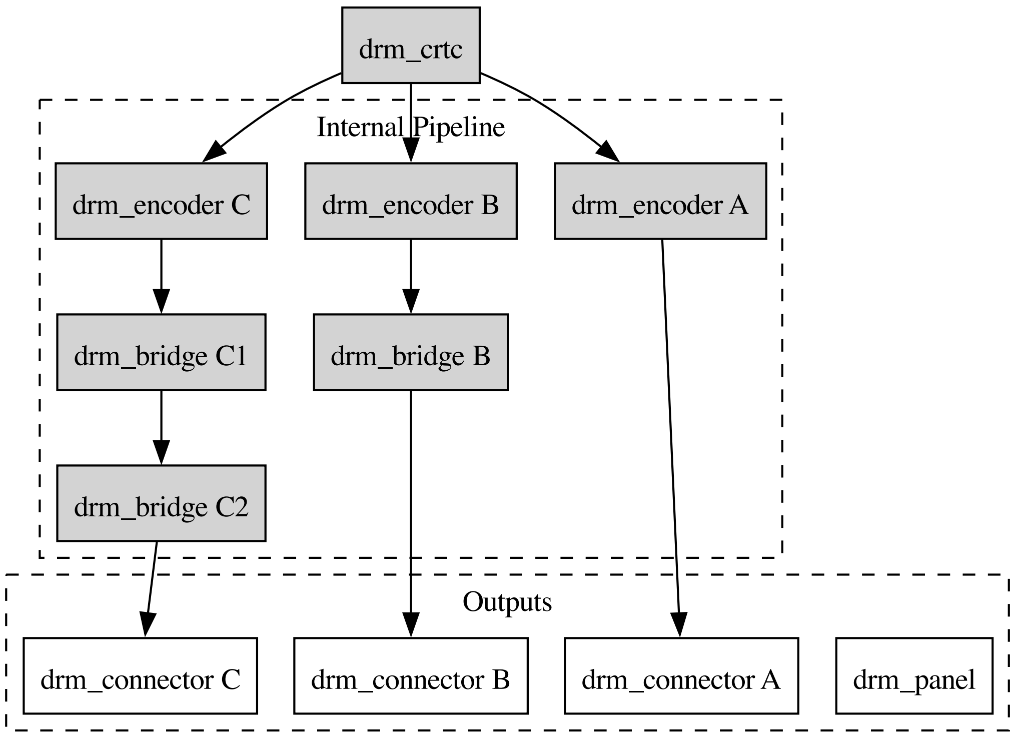

Fig. 2: KMS Output Pipeline

Internally two additional helper objects come into play. First, to be able to share code for encoders (sometimes on the same SoC, sometimes off-chip) one or more *Bridges* (represented by *struct drm_bridge*) can be linked to an encoder. This link is static and cannot be changed, which means the cross-bar (if there is any) needs to be mapped between the CRTC and any encoders. Often for drivers with bridges there' s no code left at the encoder level. Atomic drivers can leave out all the encoder callbacks to essentially only leave a dummy routing object behind, which is needed for backwards compatibility since encoders are exposed to userspace.

The second object is for panels, represented by *struct drm_panel*, see *Panel Helper Reference*. Panels do not have a fixed binding point, but are generally linked to the driver private structure that embeds *struct drm_connector*.

Note that currently the bridge chaining and interactions with connectors and panels are still in-flux and not really fully sorted out yet.

4.2 KMS Core Structures and Functions

struct **drm_mode_config_funcs**

basic driver provided mode setting functions

Definition

```
struct drm_mode_config_funcs {
  struct drm_framebuffer *(*fb_create)(struct drm_device *dev,
↪struct drm_file *file_priv, const struct drm_mode_fb_cmd2 *mode_
↪cmd);
  const struct drm_format_info *(*get_format_info)(const struct drm_
↪mode_fb_cmd2 *mode_cmd);
  void (*output_poll_changed)(struct drm_device *dev);
  enum drm_mode_status (*mode_valid)(struct drm_device *dev, const␣
↪struct drm_display_mode *mode);
  int (*atomic_check)(struct drm_device *dev, struct drm_atomic_
↪state *state);
  int (*atomic_commit)(struct drm_device *dev,struct drm_atomic_
↪state *state, bool nonblock);
  struct drm_atomic_state *(*atomic_state_alloc)(struct drm_device␣
↪*dev);
  void (*atomic_state_clear)(struct drm_atomic_state *state);
  void (*atomic_state_free)(struct drm_atomic_state *state);
};
```

Members

fb_create

Create a new framebuffer object. The core does basic checks on the requested metadata, but most of that is left to the driver. See struct drm_mode_fb_cmd2 for details.

To validate the pixel format and modifier drivers can use *drm_any_plane_has_format()* to make sure at least one plane supports the requested values. Note that the driver must first determine the actual modifier used if the request doesn't have it specified, ie. when (**mode_cmd->flags** & DRM_MODE_FB_MODIFIERS) == 0.

If the parameters are deemed valid and the backing storage objects in the underlying memory manager all exist, then the driver allocates a new *drm_framebuffer* structure, subclassed to contain driver-specific information (like the internal native buffer object references). It also needs to fill out all relevant metadata, which should be done by calling *drm_helper_mode_fill_fb_struct()*.

The initialization is finalized by calling *drm_framebuffer_init()*, which registers the framebuffer and makes it accessible to other threads.

RETURNS:

A new framebuffer with an initial reference count of 1 or a negative error code encoded with ERR_PTR().

get_format_info
Allows a driver to return custom format information for special fb layouts (eg. ones with auxiliary compression control planes).

RETURNS:

The format information specific to the given fb metadata, or NULL if none is found.

output_poll_changed
Callback used by helpers to inform the driver of output configuration changes.

Drivers implementing fbdev emulation with the helpers can call drm_fb_helper_hotplug_changed from this hook to inform the fbdev helper of output changes.

FIXME:

Except that there's no vtable for device-level helper callbacks there's no reason this is a core function.

mode_valid
Device specific validation of display modes. Can be used to reject modes that can never be supported. Only device wide constraints can be checked here. crtc/encoder/bridge/connector specific constraints should be checked in the .mode_valid() hook for each specific object.

atomic_check
This is the only hook to validate an atomic modeset update. This function must reject any modeset and state changes which the hardware or driver doesn't support. This includes but is of course not limited to:

- Checking that the modes, framebuffers, scaling and placement requirements and so on are within the limits of the hardware.
- Checking that any hidden shared resources are not oversubscribed. This can be shared PLLs, shared lanes, overall memory bandwidth, display fifo space (where shared between planes or maybe even CRTCs).

- Checking that virtualized resources exported to userspace are not oversubscribed. For various reasons it can make sense to expose more planes, crtcs or encoders than which are physically there. One example is dual-pipe operations (which generally should be hidden from userspace if when lockstepped in hardware, exposed otherwise), where a plane might need 1 hardware plane (if it's just on one pipe), 2 hardware planes (when it spans both pipes) or maybe even shared a hardware plane with a 2nd plane (if there' s a compatible plane requested on the area handled by the other pipe).
- Check that any transitional state is possible and that if requested, the update can indeed be done in the vblank period without temporarily disabling some functions.
- Check any other constraints the driver or hardware might have.
- This callback also needs to correctly fill out the *drm_crtc_state* in this update to make sure that *drm_atomic_crtc_needs_modeset()* reflects the nature of the possible update and returns true if and only if the update cannot be applied without tearing within one vblank on that CRTC. The core uses that information to reject updates which require a full modeset (i.e. blanking the screen, or at least pausing updates for a substantial amount of time) if userspace has disallowed that in its request.
- The driver also does not need to repeat basic input validation like done for the corresponding legacy entry points. The core does that before calling this hook.

See the documentation of **atomic_commit** for an exhaustive list of error conditions which don' t have to be checked at the in this callback.

See the documentation for *struct drm_atomic_state* for how exactly an atomic modeset update is described.

Drivers using the atomic helpers can implement this hook using *drm_atomic_helper_check()*, or one of the exported sub-functions of it.

RETURNS:

0 on success or one of the below negative error codes:

- -EINVAL, if any of the above constraints are violated.
- -EDEADLK, when returned from an attempt to acquire an additional *drm_modeset_lock* through *drm_modeset_lock()*.
- -ENOMEM, if allocating additional state sub-structures failed due to lack of memory.
- -EINTR, -EAGAIN or -ERESTARTSYS, if the IOCTL should be restarted. This can either be due to a pending signal, or because the driver needs to completely bail out to recover from an exceptional situation like a GPU hang. From a userspace point all errors are treated equally.

atomic_commit
This is the only hook to commit an atomic modeset update. The core guarantees that **atomic_check** has been called successfully before calling this

function, and that nothing has been changed in the interim.

See the documentation for *struct drm_atomic_state* for how exactly an atomic modeset update is described.

Drivers using the atomic helpers can implement this hook using *drm_atomic_helper_commit()*, or one of the exported sub-functions of it.

Nonblocking commits (as indicated with the nonblock parameter) must do any preparatory work which might result in an unsuccessful commit in the context of this callback. The only exceptions are hardware errors resulting in -EIO. But even in that case the driver must ensure that the display pipe is at least running, to avoid compositors crashing when pageflips don't work. Anything else, specifically committing the update to the hardware, should be done without blocking the caller. For updates which do not require a modeset this must be guaranteed.

The driver must wait for any pending rendering to the new framebuffers to complete before executing the flip. It should also wait for any pending rendering from other drivers if the underlying buffer is a shared dma-buf. Nonblocking commits must not wait for rendering in the context of this callback.

An application can request to be notified when the atomic commit has completed. These events are per-CRTC and can be distinguished by the CRTC index supplied in `drm_event` to userspace.

The drm core will supply a `struct drm_event` in each CRTC's *drm_crtc_state.event*. See the documentation for *drm_crtc_state.event* for more details about the precise semantics of this event.

NOTE:

Drivers are not allowed to shut down any display pipe successfully enabled through an atomic commit on their own. Doing so can result in compositors crashing if a page flip is suddenly rejected because the pipe is off.

RETURNS:

0 on success or one of the below negative error codes:

- -EBUSY, if a nonblocking updated is requested and there is an earlier updated pending. Drivers are allowed to support a queue of outstanding updates, but currently no driver supports that. Note that drivers must wait for preceding updates to complete if a synchronous update is requested, they are not allowed to fail the commit in that case.
- -ENOMEM, if the driver failed to allocate memory. Specifically this can happen when trying to pin framebuffers, which must only be done when committing the state.
- -ENOSPC, as a refinement of the more generic -ENOMEM to indicate that the driver has run out of vram, iommu space or similar GPU address space needed for framebuffer.
- -EIO, if the hardware completely died.
- -EINTR, -EAGAIN or -ERESTARTSYS, if the IOCTL should be restarted. This can either be due to a pending signal, or because the driver needs

to completely bail out to recover from an exceptional situation like a GPU hang. From a userspace point of view all errors are treated equally.

This list is exhaustive. Specifically this hook is not allowed to return -EINVAL (any invalid requests should be caught in **atomic_check**) or -EDEADLK (this function must not acquire additional modeset locks).

atomic_state_alloc
This optional hook can be used by drivers that want to subclass struct *drm_atomic_state* to be able to track their own driver-private global state easily. If this hook is implemented, drivers must also implement **atomic_state_clear** and **atomic_state_free**.

Subclassing of *drm_atomic_state* is deprecated in favour of using *drm_private_state* and *drm_private_obj*.

RETURNS:

A new *drm_atomic_state* on success or NULL on failure.

atomic_state_clear
This hook must clear any driver private state duplicated into the passed-in *drm_atomic_state*. This hook is called when the caller encountered a *drm_modeset_lock* deadlock and needs to drop all already acquired locks as part of the deadlock avoidance dance implemented in *drm_modeset_backoff()*.

Any duplicated state must be invalidated since a concurrent atomic update might change it, and the drm atomic interfaces always apply updates as relative changes to the current state.

Drivers that implement this must call *drm_atomic_state_default_clear()* to clear common state.

Subclassing of *drm_atomic_state* is deprecated in favour of using *drm_private_state* and *drm_private_obj*.

atomic_state_free
This hook needs driver private resources and the *drm_atomic_state* itself. Note that the core first calls *drm_atomic_state_clear()* to avoid code duplicate between the clear and free hooks.

Drivers that implement this must call *drm_atomic_state_default_release()* to release common resources.

Subclassing of *drm_atomic_state* is deprecated in favour of using *drm_private_state* and *drm_private_obj*.

Description

Some global (i.e. not per-CRTC, connector, etc) mode setting functions that involve drivers.

struct **drm_mode_config**
Mode configuration control structure

Definition

```
struct drm_mode_config {
  struct mutex mutex;
  struct drm_modeset_lock connection_mutex;
  struct drm_modeset_acquire_ctx *acquire_ctx;
  struct mutex idr_mutex;
  struct idr object_idr;
  struct idr tile_idr;
  struct mutex fb_lock;
  int num_fb;
  struct list_head fb_list;
  spinlock_t connector_list_lock;
  int num_connector;
  struct ida connector_ida;
  struct list_head connector_list;
  struct llist_head connector_free_list;
  struct work_struct connector_free_work;
  int num_encoder;
  struct list_head encoder_list;
  int num_total_plane;
  struct list_head plane_list;
  int num_crtc;
  struct list_head crtc_list;
  struct list_head property_list;
  struct list_head privobj_list;
  int min_width, min_height;
  int max_width, max_height;
  const struct drm_mode_config_funcs *funcs;
  resource_size_t fb_base;
  bool poll_enabled;
  bool poll_running;
  bool delayed_event;
  struct delayed_work output_poll_work;
  struct mutex blob_lock;
  struct list_head property_blob_list;
  struct drm_property *edid_property;
  struct drm_property *dpms_property;
  struct drm_property *path_property;
  struct drm_property *tile_property;
  struct drm_property *link_status_property;
  struct drm_property *plane_type_property;
  struct drm_property *prop_src_x;
  struct drm_property *prop_src_y;
  struct drm_property *prop_src_w;
  struct drm_property *prop_src_h;
  struct drm_property *prop_crtc_x;
  struct drm_property *prop_crtc_y;
  struct drm_property *prop_crtc_w;
  struct drm_property *prop_crtc_h;
  struct drm_property *prop_fb_id;
  struct drm_property *prop_in_fence_fd;
```

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```
  struct drm_property *prop_out_fence_ptr;
  struct drm_property *prop_crtc_id;
  struct drm_property *prop_fb_damage_clips;
  struct drm_property *prop_active;
  struct drm_property *prop_mode_id;
  struct drm_property *prop_vrr_enabled;
  struct drm_property *dvi_i_subconnector_property;
  struct drm_property *dvi_i_select_subconnector_property;
  struct drm_property *dp_subconnector_property;
  struct drm_property *tv_subconnector_property;
  struct drm_property *tv_select_subconnector_property;
  struct drm_property *tv_mode_property;
  struct drm_property *tv_left_margin_property;
  struct drm_property *tv_right_margin_property;
  struct drm_property *tv_top_margin_property;
  struct drm_property *tv_bottom_margin_property;
  struct drm_property *tv_brightness_property;
  struct drm_property *tv_contrast_property;
  struct drm_property *tv_flicker_reduction_property;
  struct drm_property *tv_overscan_property;
  struct drm_property *tv_saturation_property;
  struct drm_property *tv_hue_property;
  struct drm_property *scaling_mode_property;
  struct drm_property *aspect_ratio_property;
  struct drm_property *content_type_property;
  struct drm_property *degamma_lut_property;
  struct drm_property *degamma_lut_size_property;
  struct drm_property *ctm_property;
  struct drm_property *gamma_lut_property;
  struct drm_property *gamma_lut_size_property;
  struct drm_property *suggested_x_property;
  struct drm_property *suggested_y_property;
  struct drm_property *non_desktop_property;
  struct drm_property *panel_orientation_property;
  struct drm_property *writeback_fb_id_property;
  struct drm_property *writeback_pixel_formats_property;
  struct drm_property *writeback_out_fence_ptr_property;
  struct drm_property *hdr_output_metadata_property;
  struct drm_property *content_protection_property;
  struct drm_property *hdcp_content_type_property;
  uint32_t preferred_depth, prefer_shadow;
  bool prefer_shadow_fbdev;
  bool fbdev_use_iomem;
  bool quirk_addfb_prefer_xbgr_30bpp;
  bool quirk_addfb_prefer_host_byte_order;
  bool async_page_flip;
  bool allow_fb_modifiers;
  bool normalize_zpos;
  struct drm_property *modifiers_property;
```

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```
  uint32_t cursor_width, cursor_height;
  struct drm_atomic_state *suspend_state;
  const struct drm_mode_config_helper_funcs *helper_private;
};
```

Members

mutex
This is the big scary modeset BKL which protects everything that isn't protect otherwise. Scope is unclear and fuzzy, try to remove anything from under its protection and move it into more well-scoped locks.

The one important thing this protects is the use of **acquire_ctx**.

connection_mutex
This protects connector state and the connector to encoder to CRTC routing chain.

For atomic drivers specifically this protects *drm_connector.state*.

acquire_ctx
Global implicit acquire context used by atomic drivers for legacy IOCTLs. Deprecated, since implicit locking contexts make it impossible to use driver-private *struct drm_modeset_lock*. Users of this must hold **mutex**.

idr_mutex
Mutex for KMS ID allocation and management. Protects both **object_idr** and **tile_idr**.

object_idr
Main KMS ID tracking object. Use this idr for all IDs, fb, crtc, connector, modes - just makes life easier to have only one.

tile_idr
Use this idr for allocating new IDs for tiled sinks like use in some high-res DP MST screens.

fb_lock
Mutex to protect fb the global **fb_list** and **num_fb**.

num_fb
Number of entries on **fb_list**.

fb_list
List of all *struct drm_framebuffer*.

connector_list_lock
Protects **num_connector** and **connector_list** and **connector_free_list**.

num_connector
Number of connectors on this device. Protected by **connector_list_lock**.

connector_ida
ID allocator for connector indices.

connector_list
List of connector objects linked with *drm_connector.head*. Protected by **con-**

nector_list_lock. Only use *drm_for_each_connector_iter()* and *struct drm_connector_list_iter* to walk this list.

connector_free_list
List of connector objects linked with *drm_connector.free_head*. Protected by **connector_list_lock**. Used by *drm_for_each_connector_iter()* and *struct drm_connector_list_iter* to savely free connectors using **connector_free_work**.

connector_free_work
Work to clean up **connector_free_list**.

num_encoder
Number of encoders on this device. This is invariant over the lifetime of a device and hence doesn't need any locks.

encoder_list
List of encoder objects linked with *drm_encoder.head*. This is invariant over the lifetime of a device and hence doesn't need any locks.

num_total_plane
Number of universal (i.e. with primary/curso) planes on this device. This is invariant over the lifetime of a device and hence doesn't need any locks.

plane_list
List of plane objects linked with *drm_plane.head*. This is invariant over the lifetime of a device and hence doesn't need any locks.

num_crtc
Number of CRTCs on this device linked with *drm_crtc.head*. This is invariant over the lifetime of a device and hence doesn't need any locks.

crtc_list
List of CRTC objects linked with *drm_crtc.head*. This is invariant over the lifetime of a device and hence doesn't need any locks.

property_list
List of property type objects linked with *drm_property.head*. This is invariant over the lifetime of a device and hence doesn't need any locks.

privobj_list
List of private objects linked with *drm_private_obj.head*. This is invariant over the lifetime of a device and hence doesn't need any locks.

min_width
minimum fb pixel width on this device

min_height
minimum fb pixel height on this device

max_width
maximum fb pixel width on this device

max_height
maximum fb pixel height on this device

funcs
core driver provided mode setting functions

fb_base
: base address of the framebuffer

poll_enabled
: track polling support for this device

poll_running
: track polling status for this device

delayed_event
: track delayed poll uevent deliver for this device

output_poll_work
: delayed work for polling in process context

blob_lock
: Mutex for blob property allocation and management, protects **property_blob_list** and *drm_file.blobs*.

property_blob_list
: List of all the blob property objects linked with *drm_property_blob.head*. Protected by **blob_lock**.

edid_property
: Default connector property to hold the EDID of the currently connected sink, if any.

dpms_property
: Default connector property to control the connector's DPMS state.

path_property
: Default connector property to hold the DP MST path for the port.

tile_property
: Default connector property to store the tile position of a tiled screen, for sinks which need to be driven with multiple CRTCs.

link_status_property
: Default connector property for link status of a connector

plane_type_property
: Default plane property to differentiate CURSOR, PRIMARY and OVERLAY legacy uses of planes.

prop_src_x
: Default atomic plane property for the plane source position in the connected *drm_framebuffer*.

prop_src_y
: Default atomic plane property for the plane source position in the connected *drm_framebuffer*.

prop_src_w
: Default atomic plane property for the plane source position in the connected *drm_framebuffer*.

prop_src_h
: Default atomic plane property for the plane source position in the connected *drm_framebuffer*.

prop_crtc_x
Default atomic plane property for the plane destination position in the *drm_crtc* is being shown on.

prop_crtc_y
Default atomic plane property for the plane destination position in the *drm_crtc* is being shown on.

prop_crtc_w
Default atomic plane property for the plane destination position in the *drm_crtc* is being shown on.

prop_crtc_h
Default atomic plane property for the plane destination position in the *drm_crtc* is being shown on.

prop_fb_id
Default atomic plane property to specify the *drm_framebuffer*.

prop_in_fence_fd
Sync File fd representing the incoming fences for a Plane.

prop_out_fence_ptr
Sync File fd pointer representing the outgoing fences for a CRTC. Userspace should provide a pointer to a value of type s32, and then cast that pointer to u64.

prop_crtc_id
Default atomic plane property to specify the *drm_crtc*.

prop_fb_damage_clips
Optional plane property to mark damaged regions on the plane in framebuffer coordinates of the framebuffer attached to the plane.

The layout of blob data is simply an array of *drm_mode_rect*. Unlike plane src coordinates, damage clips are not in 16.16 fixed point.

prop_active
Default atomic CRTC property to control the active state, which is the simplified implementation for DPMS in atomic drivers.

prop_mode_id
Default atomic CRTC property to set the mode for a CRTC. A 0 mode implies that the CRTC is entirely disabled - all connectors must be of and active must be set to disabled, too.

prop_vrr_enabled
Default atomic CRTC property to indicate whether variable refresh rate should be enabled on the CRTC.

dvi_i_subconnector_property
Optional DVI-I property to differentiate between analog or digital mode.

dvi_i_select_subconnector_property
Optional DVI-I property to select between analog or digital mode.

dp_subconnector_property
Optional DP property to differentiate between different DP downstream port types.

tv_subconnector_property
Optional TV property to differentiate between different TV connector types.

tv_select_subconnector_property
Optional TV property to select between different TV connector types.

tv_mode_property
Optional TV property to select the output TV mode.

tv_left_margin_property
Optional TV property to set the left margin (expressed in pixels).

tv_right_margin_property
Optional TV property to set the right margin (expressed in pixels).

tv_top_margin_property
Optional TV property to set the right margin (expressed in pixels).

tv_bottom_margin_property
Optional TV property to set the right margin (expressed in pixels).

tv_brightness_property
Optional TV property to set the brightness.

tv_contrast_property
Optional TV property to set the contrast.

tv_flicker_reduction_property
Optional TV property to control the flicker reduction mode.

tv_overscan_property
Optional TV property to control the overscan setting.

tv_saturation_property
Optional TV property to set the saturation.

tv_hue_property
Optional TV property to set the hue.

scaling_mode_property
Optional connector property to control the upscaling, mostly used for built-in panels.

aspect_ratio_property
Optional connector property to control the HDMI infoframe aspect ratio setting.

content_type_property
Optional connector property to control the HDMI infoframe content type setting.

degamma_lut_property
Optional CRTC property to set the LUT used to convert the framebuffer's colors to linear gamma.

degamma_lut_size_property
Optional CRTC property for the size of the degamma LUT as supported by the driver (read-only).

ctm_property
Optional CRTC property to set the matrix used to convert colors after the lookup in the degamma LUT.

gamma_lut_property
Optional CRTC property to set the LUT used to convert the colors, after the CTM matrix, to the gamma space of the connected screen.

gamma_lut_size_property
Optional CRTC property for the size of the gamma LUT as supported by the driver (read-only).

suggested_x_property
Optional connector property with a hint for the position of the output on the host's screen.

suggested_y_property
Optional connector property with a hint for the position of the output on the host's screen.

non_desktop_property
Optional connector property with a hint that device isn't a standard display, and the console/desktop, should not be displayed on it.

panel_orientation_property
Optional connector property indicating how the lcd-panel is mounted inside the casing (e.g. normal or upside-down).

writeback_fb_id_property
Property for writeback connectors, storing the ID of the output framebuffer. See also: *drm_writeback_connector_init()*

writeback_pixel_formats_property
Property for writeback connectors, storing an array of the supported pixel formats for the writeback engine (read-only). See also: *drm_writeback_connector_init()*

writeback_out_fence_ptr_property
Property for writeback connectors, fd pointer representing the outgoing fences for a writeback connector. Userspace should provide a pointer to a value of type s32, and then cast that pointer to u64. See also: *drm_writeback_connector_init()*

hdr_output_metadata_property
Connector property containing hdr metatada. This will be provided by userspace compositors based on HDR content

content_protection_property
DRM ENUM property for content protection. See *drm_connector_attach_content_protection_property()*.

hdcp_content_type_property
DRM ENUM property for type of Protected Content.

preferred_depth
preferred RBG pixel depth, used by fb helpers

prefer_shadow
hint to userspace to prefer shadow-fb rendering

prefer_shadow_fbdev
Hint to framebuffer emulation to prefer shadow-fb rendering.

fbdev_use_iomem
Set to true if framebuffer reside in iomem. When set to true memcpy_toio() is used when copying the framebuffer in drm_fb_helper.drm_fb_helper_dirty_blit_real().

FIXME: This should be replaced with a per-mapping is_iomem flag (like ttm does), and then used everywhere in fbdev code.

quirk_addfb_prefer_xbgr_30bpp
Special hack for legacy ADDFB to keep nouveau userspace happy. Should only ever be set by the nouveau kernel driver.

quirk_addfb_prefer_host_byte_order
When set to true drm_mode_addfb() will pick host byte order pixel_format when calling drm_mode_addfb2(). This is how drm_mode_addfb() should have worked from day one. It didn't though, so we ended up with quirks in both kernel and userspace drivers to deal with the broken behavior. Simply fixing drm_mode_addfb() unconditionally would break these drivers, so add a quirk bit here to allow drivers opt-in.

async_page_flip
Does this device support async flips on the primary plane?

allow_fb_modifiers
Whether the driver supports fb modifiers in the ADDFB2.1 ioctl call.

normalize_zpos
If true the drm core will call *drm_atomic_normalize_zpos()* as part of atomic mode checking from *drm_atomic_helper_check()*

modifiers_property
Plane property to list support modifier/format combination.

cursor_width
hint to userspace for max cursor width

cursor_height
hint to userspace for max cursor height

suspend_state
Atomic state when suspended. Set by *drm_mode_config_helper_suspend()* and cleared by *drm_mode_config_helper_resume()*.

helper_private
mid-layer private data

Description

Core mode resource tracking structure. All CRTC, encoders, and connectors enumerated by the driver are added here, as are global properties. Some global restrictions are also here, e.g. dimension restrictions.

int **drm_mode_config_init**(struct *drm_device* *dev)
DRM mode_configuration structure initialization

Parameters

struct drm_device *dev
DRM device

Description

This is the unmanaged version of *drmm_mode_config_init()* for drivers which still explicitly call *drm_mode_config_cleanup()*.

FIXME: This function is deprecated and drivers should be converted over to *drmm_mode_config_init()*.

void **drm_mode_config_reset**(struct *drm_device* *dev)
call ->reset callbacks

Parameters

struct drm_device *dev
drm device

Description

This functions calls all the crtc's, encoder's and connector's ->reset callback. Drivers can use this in e.g. their driver load or resume code to reset hardware and software state.

int **drmm_mode_config_init**(struct *drm_device* *dev)
managed DRM mode_configuration structure initialization

Parameters

struct drm_device *dev
DRM device

Description

Initialize **dev**'s mode_config structure, used for tracking the graphics configuration of **dev**.

Since this initializes the modeset locks, no locking is possible. Which is no problem, since this should happen single threaded at init time. It is the driver's problem to ensure this guarantee.

Cleanup is automatically handled through registering drm_mode_config_cleanup with *drmm_add_action()*.

Return

0 on success, negative error value on failure.

void **drm_mode_config_cleanup**(struct *drm_device* *dev)
free up DRM mode_config info

Parameters

struct drm_device *dev
DRM device

Description

Free up all the connectors and CRTCs associated with this DRM device, then free up the framebuffers and associated buffer objects.

Note that since this /should/ happen single-threaded at driver/device teardown time, no locking is required. It's the driver's job to ensure that this guarantee actually holds true.

FIXME: With the managed *drmm_mode_config_init()* it is no longer necessary for drivers to explicitly call this function.

4.3 Modeset Base Object Abstraction

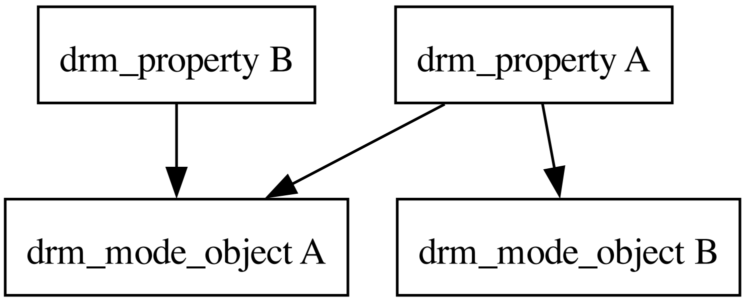

Fig. 3: Mode Objects and Properties

The base structure for all KMS objects is *struct drm_mode_object*. One of the base services it provides is tracking properties, which are especially important for the atomic IOCTL (see *Atomic Mode Setting*). The somewhat surprising part here is that properties are not directly instantiated on each object, but free-standing mode objects themselves, represented by *struct drm_property*, which only specify the type and value range of a property. Any given property can be attached multiple times to different objects using *drm_object_attach_property()*.

struct **drm_mode_object**

base structure for modeset objects

Definition

```
struct drm_mode_object {
  uint32_t id;
  uint32_t type;
  struct drm_object_properties *properties;
  struct kref refcount;
  void (*free_cb)(struct kref *kref);
};
```

Members

id
userspace visible identifier

type
type of the object, one of DRM_MODE_OBJECT_*

properties
properties attached to this object, including values

refcount
reference count for objects which with dynamic lifetime

free_cb
free function callback, only set for objects with dynamic lifetime

Description

Base structure for modeset objects visible to userspace. Objects can be looked up using *drm_mode_object_find()*. Besides basic uapi interface properties like **id** and **type** it provides two services:

- It tracks attached properties and their values. This is used by *drm_crtc*, *drm_plane* and *drm_connector*. Properties are attached by calling *drm_object_attach_property()* before the object is visible to userspace.
- For objects with dynamic lifetimes (as indicated by a non-NULL **free_cb**) it provides reference counting through *drm_mode_object_get()* and *drm_mode_object_put()*. This is used by *drm_framebuffer*, *drm_connector* and *drm_property_blob*. These objects provide specialized reference counting wrappers.

struct **drm_object_properties**
property tracking for *drm_mode_object*

Definition

```
struct drm_object_properties {
  int count;
  struct drm_property *properties[DRM_OBJECT_MAX_PROPERTY];
  uint64_t values[DRM_OBJECT_MAX_PROPERTY];
};
```

Members

count
number of valid properties, must be less than or equal to DRM_OBJECT_MAX_PROPERTY.

properties
Array of pointers to *drm_property*.

NOTE: if we ever start dynamically destroying properties (ie. not at *drm_mode_config_cleanup()* time), then we' d have to do a better job of detaching property from mode objects to avoid dangling property pointers:

values
Array to store the property values, matching **properties**. Do not

read/write values directly, but use *drm_object_property_get_value()* and *drm_object_property_set_value()*.

Note that atomic drivers do not store mutable properties in this array, but only the decoded values in the corresponding state structure. The decoding is done using the *drm_crtc.atomic_get_property* and *drm_crtc.atomic_set_property* hooks for *struct drm_crtc*. For *struct drm_plane* the hooks are *drm_plane_funcs.atomic_get_property* and *drm_plane_funcs.atomic_set_property*. And for *struct drm_connector* the hooks are *drm_connector_funcs.atomic_get_property* and *drm_connector_funcs.atomic_set_property* .

Hence atomic drivers should not use *drm_object_property_set_value()* and *drm_object_property_get_value()* on mutable objects, i.e. those without the DRM_MODE_PROP_IMMUTABLE flag set.

struct *drm_mode_object* ***drm_mode_object_find**(struct *drm_device* *dev, struct *drm_file* *file_priv, uint32_t id, uint32_t type)

look up a drm object with static lifetime

Parameters

struct drm_device *dev
drm device

struct drm_file *file_priv
drm file

uint32_t id
id of the mode object

uint32_t type
type of the mode object

Description

This function is used to look up a modeset object. It will acquire a reference for reference counted objects. This reference must be dropped again by callind *drm_mode_object_put()*.

void **drm_mode_object_put**(struct *drm_mode_object* *obj)

release a mode object reference

Parameters

struct drm_mode_object *obj
DRM mode object

Description

This function decrements the object’s refcount if it is a refcounted modeset object. It is a no-op on any other object. This is used to drop references acquired with *drm_mode_object_get()*.

void **drm_mode_object_get**(struct *drm_mode_object* *obj)

acquire a mode object reference

Parameters

struct drm_mode_object *obj
DRM mode object

Description

This function increments the object’ s refcount if it is a refcounted modeset object. It is a no-op on any other object. References should be dropped again by calling *drm_mode_object_put()*.

void **drm_object_attach_property**(struct *drm_mode_object* *obj, struct *drm_property* *property, uint64_t init_val)

attach a property to a modeset object

Parameters

struct drm_mode_object *obj
drm modeset object

struct drm_property *property
property to attach

uint64_t init_val
initial value of the property

Description

This attaches the given property to the modeset object with the given initial value. Currently this function cannot fail since the properties are stored in a statically sized array.

Note that all properties must be attached before the object itself is registered and accessible from userspace.

int **drm_object_property_set_value**(struct *drm_mode_object* *obj, struct *drm_property* *property, uint64_t val)

set the value of a property

Parameters

struct drm_mode_object *obj
drm mode object to set property value for

struct drm_property *property
property to set

uint64_t val
value the property should be set to

Description

This function sets a given property on a given object. This function only changes the software state of the property, it does not call into the driver’ s ->set_property callback.

Note that atomic drivers should not have any need to call this, the core will ensure consistency of values reported back to userspace through the appropriate ->atomic_get_property callback. Only legacy drivers should call this function to update the tracked value (after clamping and other restrictions have been applied).

Return

Zero on success, error code on failure.

int **drm_object_property_get_value**(struct *drm_mode_object* *obj, struct *drm_property* *property, uint64_t *val)

retrieve the value of a property

Parameters

struct drm_mode_object *obj
drm mode object to get property value from

struct drm_property *property
property to retrieve

uint64_t *val
storage for the property value

Description

This function retrieves the softare state of the given property for the given property. Since there is no driver callback to retrieve the current property value this might be out of sync with the hardware, depending upon the driver and property.

Atomic drivers should never call this function directly, the core will read out property values through the various ->atomic_get_property callbacks.

Return

Zero on success, error code on failure.

4.4 Atomic Mode Setting

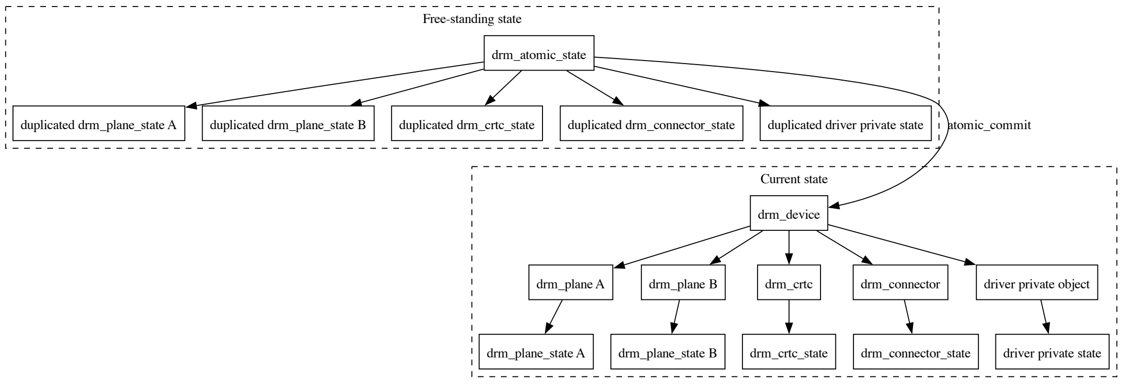

Fig. 4: Mode Objects and Properties

Atomic provides transactional modeset (including planes) updates, but a bit differently from the usual transactional approach of try-commit and rollback:

- Firstly, no hardware changes are allowed when the commit would fail. This allows us to implement the DRM_MODE_ATOMIC_TEST_ONLY mode, which allows userspace to explore whether certain configurations would work or not.

- This would still allow setting and rollback of just the software state, simplifying conversion of existing drivers. But auditing drivers for correctness of the atomic_check code becomes really hard with that: Rolling back changes in data structures all over the place is hard to get right.
- Lastly, for backwards compatibility and to support all use-cases, atomic updates need to be incremental and be able to execute in parallel. Hardware doesn't always allow it, but where possible plane updates on different CRTCs should not interfere, and not get stalled due to output routing changing on different CRTCs.

Taken all together there's two consequences for the atomic design:

- The overall state is split up into per-object state structures: *struct drm_plane_state* for planes, *struct drm_crtc_state* for CRTCs and *struct drm_connector_state* for connectors. These are the only objects with userspace-visible and settable state. For internal state drivers can subclass these structures through embeddeding, or add entirely new state structures for their globally shared hardware functions, see *struct drm_private_state*.
- An atomic update is assembled and validated as an entirely free-standing pile of structures within the *drm_atomic_state* container. Driver private state structures are also tracked in the same structure; see the next chapter. Only when a state is committed is it applied to the driver and modeset objects. This way rolling back an update boils down to releasing memory and unreferencing objects like framebuffers.

Locking of atomic state structures is internally using *struct drm_modeset_lock*. As a general rule the locking shouldn't be exposed to drivers, instead the right locks should be automatically acquired by any function that duplicates or peeks into a state, like e.g. *drm_atomic_get_crtc_state()*. Locking only protects the software data structure, ordering of committing state changes to hardware is sequenced using *struct drm_crtc_commit*.

Read on in this chapter, and also in *Atomic Modeset Helper Functions Reference* for more detailed coverage of specific topics.

4.4.1 Handling Driver Private State

Very often the DRM objects exposed to userspace in the atomic modeset api (*drm_connector*, *drm_crtc* and *drm_plane*) do not map neatly to the underlying hardware. Especially for any kind of shared resources (e.g. shared clocks, scaler units, bandwidth and fifo limits shared among a group of planes or CRTCs, and so on) it makes sense to model these as independent objects. Drivers then need to do similar state tracking and commit ordering for such private (since not exposed to userpace) objects as the atomic core and helpers already provide for connectors, planes and CRTCs.

To make this easier on drivers the atomic core provides some support to track driver private state objects using struct *drm_private_obj*, with the associated state struct *drm_private_state*.

Similar to userspace-exposed objects, private state structures can be acquired by calling *drm_atomic_get_private_obj_state()*. This also takes care of locking, hence drivers should not have a need to call *drm_modeset_lock()* directly. Sequence of the actual hardware state commit is not handled, drivers might need to keep track of *struct drm_crtc_commit* within subclassed structure of *drm_private_state* as necessary, e.g. similar to *drm_plane_state.commit*. See also *drm_atomic_state.fake_commit*.

All private state structures contained in a *drm_atomic_state* update can be iterated using *for_each_oldnew_private_obj_in_state()*, *for_each_new_private_obj_in_state()* and *for_each_old_private_obj_in_state()*. Drivers are recommended to wrap these for each type of driver private state object they have, filtering on *drm_private_obj.funcs* using *for_each_if()*, at least if they want to iterate over all objects of a given type.

An earlier way to handle driver private state was by subclassing struct *drm_atomic_state*. But since that encourages non-standard ways to implement the check/commit split atomic requires (by using e.g. "check and rollback or commit instead" of "duplicate state, check, then either commit or release duplicated state) it is deprecated in favour of using *drm_private_state*.

4.4.2 Atomic Mode Setting Function Reference

struct **drm_crtc_commit**

track modeset commits on a CRTC

Definition

```
struct drm_crtc_commit {
  struct drm_crtc *crtc;
  struct kref ref;
  struct completion flip_done;
  struct completion hw_done;
  struct completion cleanup_done;
  struct list_head commit_entry;
  struct drm_pending_vblank_event *event;
  bool abort_completion;
};
```

Members

crtc
DRM CRTC for this commit.

ref
Reference count for this structure. Needed to allow blocking on completions without the risk of the completion disappearing meanwhile.

flip_done
Will be signaled when the hardware has flipped to the new set of buffers. Signals at the same time as when the drm event for this commit is sent to userspace, or when an out-fence is singalled. Note that for most hardware, in most cases this happens after **hw_done** is signalled.

Completion of this stage is signalled implicitly by calling *drm_crtc_send_vblank_event()* on *drm_crtc_state.event*.

hw_done
Will be signalled when all hw register changes for this commit have been written out. Especially when disabling a pipe this can be much later than **flip_done**, since that can signal already when the screen goes black, whereas to fully shut down a pipe more register I/O is required.

Note that this does not need to include separately reference-counted resources like backing storage buffer pinning, or runtime pm management.

Drivers should call *drm_atomic_helper_commit_hw_done()* to signal completion of this stage.

cleanup_done
Will be signalled after old buffers have been cleaned up by calling *drm_atomic_helper_cleanup_planes()*. Since this can only happen after a vblank wait completed it might be a bit later. This completion is useful to throttle updates and avoid hardware updates getting ahead of the buffer cleanup too much.

Drivers should call *drm_atomic_helper_commit_cleanup_done()* to signal completion of this stage.

commit_entry
Entry on the per-CRTC *drm_crtc.commit_list*. Protected by $drm_crtc.commit_lock.

event
drm_pending_vblank_event pointer to clean up private events.

abort_completion
A flag that' s set after *drm_atomic_helper_setup_commit()* takes a second reference for the completion of $drm_crtc_state.event. It' s used by the free code to remove the second reference if commit fails.

Description

This structure is used to track pending modeset changes and atomic commit on a per-CRTC basis. Since updating the list should never block, this structure is reference counted to allow waiters to safely wait on an event to complete, without holding any locks.

It has 3 different events in total to allow a fine-grained synchronization between outstanding updates:

```
atomic commit thread                    hardware

write new state into hardware   ---->   ...
signal hw_done
                                        switch to new state on next
...                                     v/hblank

wait for buffers to show up             ...

...                                     send completion irq
                                        irq handler signals flip_
↪done
```

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```
cleanup old buffers

signal cleanup_done

wait for flip_done              <----
clean up atomic state
```

The important bit to know is that `cleanup_done` is the terminal event, but the ordering between `flip_done` and `hw_done` is entirely up to the specific driver and modeset state change.

For an implementation of how to use this look at *drm_atomic_helper_setup_commit()* from the atomic helper library.

struct **drm_private_state_funcs**

atomic state functions for private objects

Definition

```
struct drm_private_state_funcs {
  struct drm_private_state *(*atomic_duplicate_state)(struct drm_
→private_obj *obj);
  void (*atomic_destroy_state)(struct drm_private_obj *obj, struct␣
→drm_private_state *state);
};
```

Members

atomic_duplicate_state

Duplicate the current state of the private object and return it. It is an error to call this before obj->state has been initialized.

RETURNS:

Duplicated atomic state or NULL when obj->state is not initialized or allocation failed.

atomic_destroy_state

Frees the private object state created with **atomic_duplicate_state**.

Description

These hooks are used by atomic helpers to create, swap and destroy states of private objects. The structure itself is used as a vtable to identify the associated private object type. Each private object type that needs to be added to the atomic states is expected to have an implementation of these hooks and pass a pointer to its drm_private_state_funcs struct to *drm_atomic_get_private_obj_state()*.

struct **drm_private_obj**

base struct for driver private atomic object

Definition

```
struct drm_private_obj {
  struct list_head head;
```

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```
  struct drm_modeset_lock lock;
  struct drm_private_state *state;
  const struct drm_private_state_funcs *funcs;
};
```

Members

head
List entry used to attach a private object to a *drm_device* (queued to *drm_mode_config.privobj_list*).

lock
Modeset lock to protect the state object.

state
Current atomic state for this driver private object.

funcs
Functions to manipulate the state of this driver private object, see *drm_private_state_funcs*.

Description

A driver private object is initialized by calling *drm_atomic_private_obj_init()* and cleaned up by calling *drm_atomic_private_obj_fini()*.

Currently only tracks the state update functions and the opaque driver private state itself, but in the future might also track which *drm_modeset_lock* is required to duplicate and update this object's state.

All private objects must be initialized before the DRM device they are attached to is registered to the DRM subsystem (call to *drm_dev_register()*) and should stay around until this DRM device is unregistered (call to *drm_dev_unregister()*). In other words, private objects lifetime is tied to the DRM device lifetime. This implies that:

1/ all calls to drm_atomic_private_obj_init() must be done before calling
drm_dev_register()

2/ all calls to drm_atomic_private_obj_fini() must be done after calling
drm_dev_unregister()

drm_for_each_privobj

`drm_for_each_privobj (privobj, dev)`

private object iterator

Parameters

privobj
pointer to the current private object. Updated after each iteration

dev
the DRM device we want get private objects from

Description

Allows one to iterate over all private objects attached to **dev** struct **drm_private_state**

base struct for driver private object state

Definition

```
struct drm_private_state {
  struct drm_atomic_state *state;
};
```

Members

state

backpointer to global drm_atomic_state

Description

Currently only contains a backpointer to the overall atomic update, but in the future also might hold synchronization information similar to e.g. *drm_crtc.commit*.

struct **drm_atomic_state**

the global state object for atomic updates

Definition

```
struct drm_atomic_state {
  struct kref ref;
  struct drm_device *dev;
  bool allow_modeset : 1;
  bool legacy_cursor_update : 1;
  bool async_update : 1;
  bool duplicated : 1;
  struct __drm_planes_state *planes;
  struct __drm_crtcs_state *crtcs;
  int num_connector;
  struct __drm_connnectors_state *connectors;
  int num_private_objs;
  struct __drm_private_objs_state *private_objs;
  struct drm_modeset_acquire_ctx *acquire_ctx;
  struct drm_crtc_commit *fake_commit;
  struct work_struct commit_work;
};
```

Members

ref

count of all references to this state (will not be freed until zero)

dev

parent DRM device

allow_modeset

Allow full modeset. This is used by the ATOMIC IOCTL handler to implement the DRM_MODE_ATOMIC_ALLOW_MODESET flag. Drivers should never consult this flag, instead looking at the output of *drm_atomic_crtc_needs_modeset()*.

legacy_cursor_update
hint to enforce legacy cursor IOCTL semantics

async_update
hint for asynchronous plane update

duplicated
Indicates whether or not this atomic state was duplicated using *drm_atomic_helper_duplicate_state()*. Drivers and atomic helpers should use this to fixup normal inconsistencies in duplicated states.

planes
pointer to array of structures with per-plane data

crtcs
pointer to array of CRTC pointers

num_connector
size of the **connectors** and **connector_states** arrays

connectors
pointer to array of structures with per-connector data

num_private_objs
size of the **private_objs** array

private_objs
pointer to array of private object pointers

acquire_ctx
acquire context for this atomic modeset state update

fake_commit
Used for signaling unbound planes/connectors. When a connector or plane is not bound to any CRTC, it' s still important to preserve linearity to prevent the atomic states from being freed to early.

This commit (if set) is not bound to any CRTC, but will be completed when *drm_atomic_helper_commit_hw_done()* is called.

commit_work
Work item which can be used by the driver or helpers to execute the commit without blocking.

Description

States are added to an atomic update by calling *drm_atomic_get_crtc_state()*, *drm_atomic_get_plane_state()*, *drm_atomic_get_connector_state()*, or for private state structures, *drm_atomic_get_private_obj_state()*.

struct *drm_crtc_commit* ***drm_crtc_commit_get**(struct *drm_crtc_commit* *commit)

acquire a reference to the CRTC commit

Parameters

struct drm_crtc_commit *commit
CRTC commit

Description

Increases the reference of **commit**.

Return

The pointer to **commit**, with reference increased.

void **drm_crtc_commit_put**(struct *drm_crtc_commit* *commit)

release a reference to the CRTC commmit

Parameters

struct drm_crtc_commit *commit
CRTC commit

Description

This releases a reference to **commit** which is freed after removing the final reference. No locking required and callable from any context.

struct *drm_atomic_state* ***drm_atomic_state_get**(struct *drm_atomic_state* *state)

acquire a reference to the atomic state

Parameters

struct drm_atomic_state *state
The atomic state

Description

Returns a new reference to the **state**

void **drm_atomic_state_put**(struct *drm_atomic_state* *state)

release a reference to the atomic state

Parameters

struct drm_atomic_state *state
The atomic state

Description

This releases a reference to **state** which is freed after removing the final reference. No locking required and callable from any context.

struct *drm_crtc_state* ***drm_atomic_get_existing_crtc_state**(struct *drm_atomic_state* *state, struct *drm_crtc* *crtc)

get CRTC state, if it exists

Parameters

struct drm_atomic_state *state
global atomic state object

struct drm_crtc *crtc
CRTC to grab

Description

This function returns the CRTC state for the given CRTC, or NULL if the CRTC is not part of the global atomic state.

This function is deprecated, **drm_atomic_get_old_crtc_state** or **drm_atomic_get_new_crtc_state** should be used instead.

struct *drm_crtc_state* ***drm_atomic_get_old_crtc_state**(struct *drm_atomic_state* *state, struct *drm_crtc* *crtc)

get old CRTC state, if it exists

Parameters

struct drm_atomic_state *state
global atomic state object

struct drm_crtc *crtc
CRTC to grab

Description

This function returns the old CRTC state for the given CRTC, or NULL if the CRTC is not part of the global atomic state.

struct *drm_crtc_state* ***drm_atomic_get_new_crtc_state**(struct *drm_atomic_state* *state, struct *drm_crtc* *crtc)

get new CRTC state, if it exists

Parameters

struct drm_atomic_state *state
global atomic state object

struct drm_crtc *crtc
CRTC to grab

Description

This function returns the new CRTC state for the given CRTC, or NULL if the CRTC is not part of the global atomic state.

struct *drm_plane_state* ***drm_atomic_get_existing_plane_state**(struct *drm_atomic_state* *state, struct *drm_plane* *plane)

get plane state, if it exists

Parameters

struct drm_atomic_state *state
global atomic state object

struct drm_plane *plane
plane to grab

Description

This function returns the plane state for the given plane, or NULL if the plane is not part of the global atomic state.

This function is deprecated, **drm_atomic_get_old_plane_state** or **drm_atomic_get_new_plane_state** should be used instead.

struct *drm_plane_state* *`drm_atomic_get_old_plane_state`(struct *drm_atomic_state* *state, struct *drm_plane* *plane)

get plane state, if it exists

Parameters

`struct drm_atomic_state *state`
global atomic state object

`struct drm_plane *plane`
plane to grab

Description

This function returns the old plane state for the given plane, or NULL if the plane is not part of the global atomic state.

struct *drm_plane_state* *`drm_atomic_get_new_plane_state`(struct *drm_atomic_state* *state, struct *drm_plane* *plane)

get plane state, if it exists

Parameters

`struct drm_atomic_state *state`
global atomic state object

`struct drm_plane *plane`
plane to grab

Description

This function returns the new plane state for the given plane, or NULL if the plane is not part of the global atomic state.

struct *drm_connector_state* *`drm_atomic_get_existing_connector_state`(struct *drm_atomic_state* *state, struct *drm_connector* *connector)

get connector state, if it exists

Parameters

struct drm_atomic_state *state
global atomic state object

struct drm_connector *connector
connector to grab

Description

This function returns the connector state for the given connector, or NULL if the connector is not part of the global atomic state.

This function is deprecated, **drm_atomic_get_old_connector_state** or **drm_atomic_get_new_connector_state** should be used instead.

struct *drm_connector_state* ***drm_atomic_get_old_connector_state**(struct *drm_atomic_state* *state, struct *drm_connector* *connector)

get connector state, if it exists

Parameters

struct drm_atomic_state *state
global atomic state object

struct drm_connector *connector
connector to grab

Description

This function returns the old connector state for the given connector, or NULL if the connector is not part of the global atomic state.

struct *drm_connector_state* ***drm_atomic_get_new_connector_state**(struct *drm_atomic_state* *state, struct *drm_connector* *connector)

get connector state, if it exists

Parameters

struct drm_atomic_state *state
global atomic state object

struct drm_connector *connector
connector to grab

Description

This function returns the new connector state for the given connector, or NULL if the connector is not part of the global atomic state.

const struct *drm_plane_state* ***__drm_atomic_get_current_plane_state**(struct *drm_atomic_state* *state, struct *drm_plane* *plane)

get current plane state

Parameters

struct drm_atomic_state *state
global atomic state object

struct drm_plane *plane
plane to grab

Description

This function returns the plane state for the given plane, either from **state**, or if the plane isn't part of the atomic state update, from **plane**. This is useful in atomic check callbacks, when drivers need to peek at, but not change, state of other planes, since it avoids threading an error code back up the call chain.

WARNING:

Note that this function is in general unsafe since it doesn't check for the required locking for access state structures. Drivers must ensure that it is safe to access the returned state structure through other means. One common example is when planes are fixed to a single CRTC, and the driver knows that the CRTC lock is held already. In that case holding the CRTC lock gives a read-lock on all planes connected to that CRTC. But if planes can be reassigned things get more tricky. In that case it's better to use drm_atomic_get_plane_state and wire up full error handling.

Read-only pointer to the current plane state.

Return

for_each_oldnew_connector_in_state

`for_each_oldnew_connector_in_state (__state, connector, old_connector_state, new_connector_state, __i)`

iterate over all connectors in an atomic update

Parameters

__state
struct drm_atomic_state pointer

connector
struct drm_connector iteration cursor

old_connector_state
struct drm_connector_state iteration cursor for the old state

new_connector_state
struct drm_connector_state iteration cursor for the new state

__i
: int iteration cursor, for macro-internal use

Description

This iterates over all connectors in an atomic update, tracking both old and new state. This is useful in places where the state delta needs to be considered, for example in atomic check functions.

for_each_old_connector_in_state

`for_each_old_connector_in_state (__state, connector, old_connector_state, __i)`

iterate over all connectors in an atomic update

Parameters

__state
: *struct drm_atomic_state* pointer

connector
: *struct drm_connector* iteration cursor

old_connector_state
: *struct drm_connector_state* iteration cursor for the old state

__i
: int iteration cursor, for macro-internal use

Description

This iterates over all connectors in an atomic update, tracking only the old state. This is useful in disable functions, where we need the old state the hardware is still in.

for_each_new_connector_in_state

`for_each_new_connector_in_state (__state, connector, new_connector_state, __i)`

iterate over all connectors in an atomic update

Parameters

__state
: *struct drm_atomic_state* pointer

connector
: *struct drm_connector* iteration cursor

new_connector_state
: *struct drm_connector_state* iteration cursor for the new state

__i
: int iteration cursor, for macro-internal use

Description

This iterates over all connectors in an atomic update, tracking only the new state. This is useful in enable functions, where we need the new state the hardware should be in when the atomic commit operation has completed.

for_each_oldnew_crtc_in_state

`for_each_oldnew_crtc_in_state (__state, crtc, old_crtc_state, new_crtc_state, __i)`

iterate over all CRTCs in an atomic update

Parameters

__state
struct drm_atomic_state pointer

crtc
struct drm_crtc iteration cursor

old_crtc_state
struct drm_crtc_state iteration cursor for the old state

new_crtc_state
struct drm_crtc_state iteration cursor for the new state

__i
int iteration cursor, for macro-internal use

Description

This iterates over all CRTCs in an atomic update, tracking both old and new state. This is useful in places where the state delta needs to be considered, for example in atomic check functions.

for_each_old_crtc_in_state

`for_each_old_crtc_in_state (__state, crtc, old_crtc_state, __i)`

iterate over all CRTCs in an atomic update

Parameters

__state
struct drm_atomic_state pointer

crtc
struct drm_crtc iteration cursor

old_crtc_state
struct drm_crtc_state iteration cursor for the old state

__i
int iteration cursor, for macro-internal use

Description

This iterates over all CRTCs in an atomic update, tracking only the old state. This is useful in disable functions, where we need the old state the hardware is still in.

for_each_new_crtc_in_state

`for_each_new_crtc_in_state (__state, crtc, new_crtc_state, __i)`

iterate over all CRTCs in an atomic update

Parameters

__state
: *struct drm_atomic_state* pointer

crtc
: *struct drm_crtc* iteration cursor

new_crtc_state
: *struct drm_crtc_state* iteration cursor for the new state

__i
: int iteration cursor, for macro-internal use

Description

This iterates over all CRTCs in an atomic update, tracking only the new state. This is useful in enable functions, where we need the new state the hardware should be in when the atomic commit operation has completed.

for_each_oldnew_plane_in_state

`for_each_oldnew_plane_in_state (__state, plane, old_plane_state, new_plane_state, __i)`

iterate over all planes in an atomic update

Parameters

__state
: *struct drm_atomic_state* pointer

plane
: *struct drm_plane* iteration cursor

old_plane_state
: *struct drm_plane_state* iteration cursor for the old state

new_plane_state
: *struct drm_plane_state* iteration cursor for the new state

__i
: int iteration cursor, for macro-internal use

Description

This iterates over all planes in an atomic update, tracking both old and new state. This is useful in places where the state delta needs to be considered, for example in atomic check functions.

for_each_oldnew_plane_in_state_reverse

`for_each_oldnew_plane_in_state_reverse (__state, plane, old_plane_state, new_plane_state, __i)`

iterate over all planes in an atomic update in reverse order

Parameters

__state
: *struct drm_atomic_state* pointer

plane
: *struct drm_plane* iteration cursor

old_plane_state
: *struct drm_plane_state* iteration cursor for the old state

new_plane_state
: *struct drm_plane_state* iteration cursor for the new state

__i
: int iteration cursor, for macro-internal use

Description

This iterates over all planes in an atomic update in reverse order, tracking both old and new state. This is useful in places where the state delta needs to be considered, for example in atomic check functions.

for_each_old_plane_in_state

`for_each_old_plane_in_state (__state, plane, old_plane_state, __i)`

iterate over all planes in an atomic update

Parameters

__state
: *struct drm_atomic_state* pointer

plane
: *struct drm_plane* iteration cursor

old_plane_state
: *struct drm_plane_state* iteration cursor for the old state

__i
: int iteration cursor, for macro-internal use

Description

This iterates over all planes in an atomic update, tracking only the old state. This is useful in disable functions, where we need the old state the hardware is still in.

for_each_new_plane_in_state

`for_each_new_plane_in_state (__state, plane, new_plane_state, __i)`

iterate over all planes in an atomic update

Parameters

__state
: *struct drm_atomic_state* pointer

plane
: *struct drm_plane* iteration cursor

new_plane_state
: *struct drm_plane_state* iteration cursor for the new state

__i
: int iteration cursor, for macro-internal use

Description

This iterates over all planes in an atomic update, tracking only the new state. This is useful in enable functions, where we need the new state the hardware should be in when the atomic commit operation has completed.

for_each_oldnew_private_obj_in_state

`for_each_oldnew_private_obj_in_state (__state, obj, old_obj_state, new_obj_state, __i)`

iterate over all private objects in an atomic update

Parameters

__state
struct drm_atomic_state pointer

obj
struct drm_private_obj iteration cursor

old_obj_state
struct drm_private_state iteration cursor for the old state

new_obj_state
struct drm_private_state iteration cursor for the new state

__i
int iteration cursor, for macro-internal use

Description

This iterates over all private objects in an atomic update, tracking both old and new state. This is useful in places where the state delta needs to be considered, for example in atomic check functions.

for_each_old_private_obj_in_state

`for_each_old_private_obj_in_state (__state, obj, old_obj_state, __i)`

iterate over all private objects in an atomic update

Parameters

__state
struct drm_atomic_state pointer

obj
struct drm_private_obj iteration cursor

old_obj_state
struct drm_private_state iteration cursor for the old state

__i
int iteration cursor, for macro-internal use

Description

This iterates over all private objects in an atomic update, tracking only the old state. This is useful in disable functions, where we need the old state the hardware is still in.

`for_each_new_private_obj_in_state`

`for_each_new_private_obj_in_state (__state, obj, new_obj_state, __i)`

iterate over all private objects in an atomic update

Parameters

`__state`
`struct drm_atomic_state` pointer

`obj`
`struct drm_private_obj` iteration cursor

`new_obj_state`
`struct drm_private_state` iteration cursor for the new state

`__i`
int iteration cursor, for macro-internal use

Description

This iterates over all private objects in an atomic update, tracking only the new state. This is useful in enable functions, where we need the new state the hardware should be in when the atomic commit operation has completed.

bool **`drm_atomic_crtc_needs_modeset`**(const struct *drm_crtc_state* *state)

compute combined modeset need

Parameters

`const struct drm_crtc_state *state`
`drm_crtc_state` for the CRTC

Description

To give drivers flexibility *`struct drm_crtc_state`* has 3 booleans to track whether the state CRTC changed enough to need a full modeset cycle: mode_changed, active_changed and connectors_changed. This helper simply combines these three to compute the overall need for a modeset for **state**.

The atomic helper code sets these booleans, but drivers can and should change them appropriately to accurately represent whether a modeset is really needed. In general, drivers should avoid full modesets whenever possible.

For example if the CRTC mode has changed, and the hardware is able to enact the requested mode change without going through a full modeset, the driver should clear mode_changed in its *`drm_mode_config_funcs.atomic_check`* implementation.

bool **`drm_atomic_crtc_effectively_active`**(const struct *drm_crtc_state* *state)

compute whether CRTC is actually active

Parameters

`const struct drm_crtc_state *state`
`drm_crtc_state` for the CRTC

Description

When in self refresh mode, the crtc_state->active value will be false, since the CRTC is off. However in some cases we' re interested in whether the CRTC is active, or effectively active (ie: it' s connected to an active display). In these cases, use this function instead of just checking active.

struct **drm_bus_cfg**

bus configuration

Definition

```
struct drm_bus_cfg {
  u32 format;
  u32 flags;
};
```

Members

format

format used on this bus (one of the MEDIA_BUS_FMT_* format)

This field should not be directly modified by drivers (drm_atomic_bridge_chain_select_bus_fmts() takes care of the bus format negotiation).

flags

DRM_BUS_* flags used on this bus

Description

This structure stores the configuration of a physical bus between two components in an output pipeline, usually between two bridges, an encoder and a bridge, or a bridge and a connector.

The bus configuration is stored in *drm_bridge_state* separately for the input and output buses, as seen from the point of view of each bridge. The bus configuration of a bridge output is usually identical to the configuration of the next bridge' s input, but may differ if the signals are modified between the two bridges, for instance by an inverter on the board. The input and output configurations of a bridge may differ if the bridge modifies the signals internally, for instance by performing format conversion, or modifying signals polarities.

struct **drm_bridge_state**

Atomic bridge state object

Definition

```
struct drm_bridge_state {
  struct drm_private_state base;
  struct drm_bridge *bridge;
  struct drm_bus_cfg input_bus_cfg;
  struct drm_bus_cfg output_bus_cfg;
};
```

Members

base

inherit from *drm_private_state*

`bridge`
the bridge this state refers to

`input_bus_cfg`
input bus configuration

`output_bus_cfg`
input bus configuration

void **`drm_atomic_state_default_release`**(struct *drm_atomic_state* *state)
release memory initialized by drm_atomic_state_init

Parameters

`struct drm_atomic_state *state`
atomic state

Description

Free all the memory allocated by drm_atomic_state_init. This should only be used by drivers which are still subclassing *`drm_atomic_state`* and haven’ t switched to *`drm_private_state`* yet.

int **`drm_atomic_state_init`**(struct *drm_device* *dev, struct *drm_atomic_state* *state)
init new atomic state

Parameters

`struct drm_device *dev`
DRM device

`struct drm_atomic_state *state`
atomic state

Description

Default implementation for filling in a new atomic state. This should only be used by drivers which are still subclassing *`drm_atomic_state`* and haven’ t switched to *`drm_private_state`* yet.

struct *drm_atomic_state* ***`drm_atomic_state_alloc`**(struct *drm_device* *dev)
allocate atomic state

Parameters

`struct drm_device *dev`
DRM device

Description

This allocates an empty atomic state to track updates.

void **`drm_atomic_state_default_clear`**(struct *drm_atomic_state* *state)
clear base atomic state

Parameters

`struct drm_atomic_state *state`
atomic state

Description

Default implementation for clearing atomic state. This should only be used by drivers which are still subclassing *drm_atomic_state* and haven't switched to *drm_private_state* yet.

void **drm_atomic_state_clear**(struct *drm_atomic_state* *state)

clear state object

Parameters

struct drm_atomic_state *state
atomic state

Description

When the w/w mutex algorithm detects a deadlock we need to back off and drop all locks. So someone else could sneak in and change the current modeset configuration. Which means that all the state assembled in **state** is no longer an atomic update to the current state, but to some arbitrary earlier state. Which could break assumptions the driver's *drm_mode_config_funcs.atomic_check* likely relies on.

Hence we must clear all cached state and completely start over, using this function.

void **__drm_atomic_state_free**(struct kref *ref)

free all memory for an atomic state

Parameters

struct kref *ref
This atomic state to deallocate

Description

This frees all memory associated with an atomic state, including all the per-object state for planes, CRTCs and connectors.

struct *drm_crtc_state* ***drm_atomic_get_crtc_state**(struct *drm_atomic_state* *state, struct *drm_crtc* *crtc)

get CRTC state

Parameters

struct drm_atomic_state *state
global atomic state object

struct drm_crtc *crtc
CRTC to get state object for

Description

This function returns the CRTC state for the given CRTC, allocating it if needed. It will also grab the relevant CRTC lock to make sure that the state is consistent.

Either the allocated state or the error code encoded into the pointer. When the error is EDEADLK then the w/w mutex code has detected a deadlock and the entire atomic sequence must be restarted. All other errors are fatal.

Return

struct *drm_plane_state* ***drm_atomic_get_plane_state**(struct *drm_atomic_state* *state, struct *drm_plane* *plane)

get plane state

Parameters

struct drm_atomic_state *state
global atomic state object

struct drm_plane *plane
plane to get state object for

Description

This function returns the plane state for the given plane, allocating it if needed. It will also grab the relevant plane lock to make sure that the state is consistent.

Either the allocated state or the error code encoded into the pointer. When the error is EDEADLK then the w/w mutex code has detected a deadlock and the entire atomic sequence must be restarted. All other errors are fatal.

Return

void **drm_atomic_private_obj_init**(struct *drm_device* *dev, struct *drm_private_obj* *obj, struct *drm_private_state* *state, const struct *drm_private_state_funcs* *funcs)

initialize private object

Parameters

struct drm_device *dev
DRM device this object will be attached to

struct drm_private_obj *obj
private object

struct drm_private_state *state
initial private object state

const struct drm_private_state_funcs *funcs
pointer to the struct of function pointers that identify the object type

Description

Initialize the private object, which can be embedded into any driver private object that needs its own atomic state.

void **drm_atomic_private_obj_fini**(struct *drm_private_obj* *obj)

finalize private object

Parameters

struct drm_private_obj *obj
private object

Description

Finalize the private object.

struct *drm_private_state* ***drm_atomic_get_private_obj_state***(struct *drm_atomic_state* *state, struct *drm_private_obj* *obj)

get private object state

Parameters

struct drm_atomic_state *state
global atomic state

struct drm_private_obj *obj
private object to get the state for

Description

This function returns the private object state for the given private object, allocating the state if needed. It will also grab the relevant private object lock to make sure that the state is consistent.

Either the allocated state or the error code encoded into a pointer.

Return

struct *drm_private_state* ***drm_atomic_get_old_private_obj_state***(struct *drm_atomic_state* *state, struct *drm_private_obj* *obj)

Parameters

struct drm_atomic_state *state
global atomic state object

struct drm_private_obj *obj
private_obj to grab

Description

This function returns the old private object state for the given private_obj, or NULL if the private_obj is not part of the global atomic state.

struct *drm_private_state* ***drm_atomic_get_new_private_obj_state***(struct *drm_atomic_state* *state, struct *drm_private_obj* *obj)

Parameters

struct drm_atomic_state *state
global atomic state object

struct drm_private_obj *obj
private_obj to grab

Description

This function returns the new private object state for the given private_obj, or NULL if the private_obj is not part of the global atomic state.

struct *drm_connector* ***drm_atomic_get_old_connector_for_encoder**(struct *drm_atomic_state* *state, struct *drm_encoder* *encoder)

Get old connector for an encoder

Parameters

struct drm_atomic_state *state
Atomic state

struct drm_encoder *encoder
The encoder to fetch the connector state for

Description

This function finds and returns the connector that was connected to **encoder** as specified by the **state**.

If there is no connector in **state** which previously had **encoder** connected to it, this function will return NULL. While this may seem like an invalid use case, it is sometimes useful to differentiate commits which had no prior connectors attached to **encoder** vs ones that did (and to inspect their state). This is especially true in enable hooks because the pipeline has changed.

Return

The old connector connected to **encoder**, or NULL if the encoder is not connected.

struct *drm_connector* ***drm_atomic_get_new_connector_for_encoder**(struct *drm_atomic_state* *state, struct *drm_encoder* *encoder)

Get new connector for an encoder

Parameters

struct drm_atomic_state *state
Atomic state

struct drm_encoder *encoder
The encoder to fetch the connector state for

Description

This function finds and returns the connector that will be connected to **encoder** as specified by the **state**.

If there is no connector in **state** which will have **encoder** connected to it, this function will return NULL. While this may seem like an invalid use case, it is sometimes useful to differentiate commits which have no connectors attached to **encoder** vs ones that do (and to inspect their state). This is especially true in disable hooks because the pipeline will change.

Return

The new connector connected to **encoder**, or NULL if the encoder is not connected.

struct *drm_connector_state* ***drm_atomic_get_connector_state**(struct *drm_atomic_state* *state, struct *drm_connector* *connector)

get connector state

Parameters

struct drm_atomic_state *state
global atomic state object

struct drm_connector *connector
connector to get state object for

Description

This function returns the connector state for the given connector, allocating it if needed. It will also grab the relevant connector lock to make sure that the state is consistent.

Either the allocated state or the error code encoded into the pointer. When the error is EDEADLK then the w/w mutex code has detected a deadlock and the entire atomic sequence must be restarted. All other errors are fatal.

Return

struct *drm_bridge_state* ***drm_atomic_get_bridge_state**(struct *drm_atomic_state* *state, struct *drm_bridge* *bridge)

get bridge state

Parameters

struct drm_atomic_state *state
global atomic state object

struct drm_bridge *bridge
bridge to get state object for

Description

This function returns the bridge state for the given bridge, allocating it if needed. It will also grab the relevant bridge lock to make sure that the state is consistent.

Either the allocated state or the error code encoded into the pointer. When the error is EDEADLK then the w/w mutex code has detected a deadlock and the entire atomic sequence must be restarted.

Return

struct *drm_bridge_state* ***drm_atomic_get_old_bridge_state**(struct *drm_atomic_state* *state, struct *drm_bridge* *bridge)

get old bridge state, if it exists

Parameters

struct drm_atomic_state *state
global atomic state object

struct drm_bridge *bridge
bridge to grab

Description

This function returns the old bridge state for the given bridge, or NULL if the bridge is not part of the global atomic state.

struct *drm_bridge_state* ***drm_atomic_get_new_bridge_state**(struct *drm_atomic_state* *state, struct *drm_bridge* *bridge)

get new bridge state, if it exists

Parameters

struct drm_atomic_state *state
global atomic state object

struct drm_bridge *bridge
bridge to grab

Description

This function returns the new bridge state for the given bridge, or NULL if the bridge is not part of the global atomic state.

int **drm_atomic_add_encoder_bridges**(struct *drm_atomic_state* *state, struct *drm_encoder* *encoder)

add bridges attached to an encoder

Parameters

struct drm_atomic_state *state
atomic state

struct drm_encoder *encoder
DRM encoder

Description

This function adds all bridges attached to **encoder**. This is needed to add bridge states to **state** and make them available when *drm_bridge_funcs.atomic_check()*, *drm_bridge_funcs.atomic_pre_enable()*, *drm_bridge_funcs.atomic_enable()*, *drm_bridge_funcs.atomic_disable_post_disable()* are called.

Return

0 on success or can fail with -EDEADLK or -ENOMEM. When the error is EDEADLK then the w/w mutex code has detected a deadlock and the entire atomic sequence must be restarted. All other errors are fatal.

int **drm_atomic_add_affected_connectors**(struct *drm_atomic_state* *state, struct *drm_crtc* *crtc)

add connectors for CRTC

Parameters

struct drm_atomic_state *state
atomic state

struct drm_crtc *crtc
DRM CRTC

Description

This function walks the current configuration and adds all connectors currently using **crtc** to the atomic configuration **state**. Note that this function must acquire the connection mutex. This can potentially cause unneeded seralization if the update is just for the planes on one CRTC. Hence drivers and helpers should only call this when really needed (e.g. when a full modeset needs to happen due to some change).

Return

0 on success or can fail with -EDEADLK or -ENOMEM. When the error is EDEADLK then the w/w mutex code has detected a deadlock and the entire atomic sequence must be restarted. All other errors are fatal.

int **drm_atomic_add_affected_planes**(struct *drm_atomic_state* *state, struct *drm_crtc* *crtc)

add planes for CRTC

Parameters

struct drm_atomic_state *state
atomic state

struct drm_crtc *crtc
DRM CRTC

Description

This function walks the current configuration and adds all planes currently used by **crtc** to the atomic configuration **state**. This is useful when an atomic commit also needs to check all currently enabled plane on **crtc**, e.g. when changing the mode. It’s also useful when re-enabling a CRTC to avoid special code to force-enable all planes.

Since acquiring a plane state will always also acquire the w/w mutex of the current CRTC for that plane (if there is any) adding all the plane states for a CRTC will not reduce parallism of atomic updates.

Return

0 on success or can fail with -EDEADLK or -ENOMEM. When the error is EDEADLK then the w/w mutex code has detected a deadlock and the entire atomic sequence must be restarted. All other errors are fatal.

int **drm_atomic_check_only**(struct *drm_atomic_state* *state)

check whether a given config would work

Parameters

struct drm_atomic_state *state

atomic configuration to check

Description

Note that this function can return -EDEADLK if the driver needed to acquire more locks but encountered a deadlock. The caller must then do the usual w/w backoff dance and restart. All other errors are fatal.

Return

0 on success, negative error code on failure.

int **drm_atomic_commit**(struct *drm_atomic_state* *state)

commit configuration atomically

Parameters

struct drm_atomic_state *state

atomic configuration to check

Description

Note that this function can return -EDEADLK if the driver needed to acquire more locks but encountered a deadlock. The caller must then do the usual w/w backoff dance and restart. All other errors are fatal.

This function will take its own reference on **state**. Callers should always release their reference with *drm_atomic_state_put()*.

Return

0 on success, negative error code on failure.

int **drm_atomic_nonblocking_commit**(struct *drm_atomic_state* *state)

atomic nonblocking commit

Parameters

struct drm_atomic_state *state

atomic configuration to check

Description

Note that this function can return -EDEADLK if the driver needed to acquire more locks but encountered a deadlock. The caller must then do the usual w/w backoff dance and restart. All other errors are fatal.

This function will take its own reference on **state**. Callers should always release their reference with *drm_atomic_state_put()*.

Return

0 on success, negative error code on failure.

void **drm_state_dump**(struct *drm_device* *dev, struct *drm_printer* *p)

dump entire device atomic state

Parameters

struct drm_device *dev
the drm device

struct drm_printer *p
where to print the state to

Description

Just for debugging. Drivers might want an option to dump state to dmesg in case of error irq' s. (Hint, you probably want to ratelimit this!)

The caller must *drm_modeset_lock_all()*, or if this is called from error irq handler, it should not be enabled by default. (Ie. if you are debugging errors you might not care that this is racey. But calling this without all modeset locks held is not inherently safe.)

4.4.3 Atomic Mode Setting IOCTL and UAPI Functions

This file contains the marshalling and demarshalling glue for the atomic UAPI in all its forms: The monster ATOMIC IOCTL itself, code for GET_PROPERTY and SET_PROPERTY IOCTLs. Plus interface functions for compatibility helpers and drivers which have special needs to construct their own atomic updates, e.g. for load detect or similiar.

int **drm_atomic_set_mode_for_crtc**(struct *drm_crtc_state* *state, const struct *drm_display_mode* *mode)

set mode for CRTC

Parameters

struct drm_crtc_state *state
the CRTC whose incoming state to update

const struct drm_display_mode *mode
kernel-internal mode to use for the CRTC, or NULL to disable

Description

Set a mode (originating from the kernel) on the desired CRTC state and update the enable property.

Return

Zero on success, error code on failure. Cannot return -EDEADLK.

int **drm_atomic_set_mode_prop_for_crtc**(struct *drm_crtc_state* *state, struct *drm_property_blob* *blob)

set mode for CRTC

Parameters

struct drm_crtc_state *state
the CRTC whose incoming state to update

struct drm_property_blob *blob
pointer to blob property to use for mode

Description

Set a mode (originating from a blob property) on the desired CRTC state. This function will take a reference on the blob property for the CRTC state, and release the reference held on the state's existing mode property, if any was set.

Return

Zero on success, error code on failure. Cannot return -EDEADLK.

int **drm_atomic_set_crtc_for_plane**(struct *drm_plane_state* *plane_state, struct *drm_crtc* *crtc)

set CRTC for plane

Parameters

struct drm_plane_state *plane_state
the plane whose incoming state to update

struct drm_crtc *crtc
CRTC to use for the plane

Description

Changing the assigned CRTC for a plane requires us to grab the lock and state for the new CRTC, as needed. This function takes care of all these details besides updating the pointer in the state object itself.

Return

0 on success or can fail with -EDEADLK or -ENOMEM. When the error is EDEADLK then the w/w mutex code has detected a deadlock and the entire atomic sequence must be restarted. All other errors are fatal.

void **drm_atomic_set_fb_for_plane**(struct *drm_plane_state* *plane_state, struct *drm_framebuffer* *fb)

set framebuffer for plane

Parameters

struct drm_plane_state *plane_state
atomic state object for the plane

struct drm_framebuffer *fb
fb to use for the plane

Description

Changing the assigned framebuffer for a plane requires us to grab a reference to the new fb and drop the reference to the old fb, if there is one. This function takes care of all these details besides updating the pointer in the state object itself.

void **drm_atomic_set_fence_for_plane**(struct *drm_plane_state* *plane_state, struct dma_fence *fence)

set fence for plane

Parameters

struct drm_plane_state *plane_state
atomic state object for the plane

struct dma_fence *fence
dma_fence to use for the plane

Description

Helper to setup the plane_state fence in case it is not set yet. By using this drivers doesn't need to worry if the user choose implicit or explicit fencing.

This function will not set the fence to the state if it was set via explicit fencing interfaces on the atomic ioctl. In that case it will drop the reference to the fence as we are not storing it anywhere. Otherwise, if *drm_plane_state.fence* is not set this function we just set it with the received implicit fence. In both cases this function consumes a reference for **fence**.

This way explicit fencing can be used to overrule implicit fencing, which is important to make explicit fencing use-cases work: One example is using one buffer for 2 screens with different refresh rates. Implicit fencing will clamp rendering to the refresh rate of the slower screen, whereas explicit fence allows 2 independent render and display loops on a single buffer. If a driver allows obeys both implicit and explicit fences for plane updates, then it will break all the benefits of explicit fencing.

int **drm_atomic_set_crtc_for_connector**(struct *drm_connector_state* *conn_state, struct *drm_crtc* *crtc)

set CRTC for connector

Parameters

struct drm_connector_state *conn_state
atomic state object for the connector

struct drm_crtc *crtc
CRTC to use for the connector

Description

Changing the assigned CRTC for a connector requires us to grab the lock and state for the new CRTC, as needed. This function takes care of all these details besides updating the pointer in the state object itself.

Return

0 on success or can fail with -EDEADLK or -ENOMEM. When the error is EDEADLK then the w/w mutex code has detected a deadlock and the entire atomic sequence must be restarted. All other errors are fatal.

4.5 CRTC Abstraction

A CRTC represents the overall display pipeline. It receives pixel data from *drm_plane* and blends them together. The *drm_display_mode* is also attached to the CRTC, specifying display timings. On the output side the data is fed to one or more *drm_encoder*, which are then each connected to one *drm_connector*.

To create a CRTC, a KMS drivers allocates and zeroes an instances of *struct drm_crtc* (possibly as part of a larger structure) and registers it with a call to *drm_crtc_init_with_planes()*.

The CRTC is also the entry point for legacy modeset operations, see *drm_crtc_funcs.set_config*, legacy plane operations, see *drm_crtc_funcs.page_flip* and *drm_crtc_funcs.cursor_set2*, and other legacy operations like *drm_crtc_funcs.gamma_set*. For atomic drivers all these features are controlled through *drm_property* and *drm_mode_config_funcs.atomic_check* and *drm_mode_config_funcs.atomic_check*.

4.5.1 CRTC Functions Reference

struct **drm_crtc_state**
mutable CRTC state

Definition

```
struct drm_crtc_state {
  struct drm_crtc *crtc;
  bool enable;
  bool active;
  bool planes_changed : 1;
  bool mode_changed : 1;
  bool active_changed : 1;
  bool connectors_changed : 1;
  bool zpos_changed : 1;
  bool color_mgmt_changed : 1;
  bool no_vblank : 1;
  u32 plane_mask;
  u32 connector_mask;
  u32 encoder_mask;
  struct drm_display_mode adjusted_mode;
  struct drm_display_mode mode;
  struct drm_property_blob *mode_blob;
  struct drm_property_blob *degamma_lut;
  struct drm_property_blob *ctm;
  struct drm_property_blob *gamma_lut;
  u32 target_vblank;
  bool async_flip;
  bool vrr_enabled;
  bool self_refresh_active;
  struct drm_pending_vblank_event *event;
  struct drm_crtc_commit *commit;
```

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```
  struct drm_atomic_state *state;
};
```

Members

`crtc`
backpointer to the CRTC

`enable`
Whether the CRTC should be enabled, gates all other state. This controls reservations of shared resources. Actual hardware state is controlled by **active**.

`active`
Whether the CRTC is actively displaying (used for DPMS). Implies that **enable** is set. The driver must not release any shared resources if **active** is set to false but **enable** still true, because userspace expects that a DPMS ON always succeeds.

Hence drivers must not consult **active** in their various *drm_mode_config_funcs.atomic_check* callback to reject an atomic commit. They can consult it to aid in the computation of derived hardware state, since even in the DPMS OFF state the display hardware should be as much powered down as when the CRTC is completely disabled through setting **enable** to false.

`planes_changed`
Planes on this crtc are updated. Used by the atomic helpers and drivers to steer the atomic commit control flow.

`mode_changed`
mode or **enable** has been changed. Used by the atomic helpers and drivers to steer the atomic commit control flow. See also *drm_atomic_crtc_needs_modeset()*.

Drivers are supposed to set this for any CRTC state changes that require a full modeset. They can also reset it to false if e.g. a **mode** change can be done without a full modeset by only changing scaler settings.

`active_changed`
active has been toggled. Used by the atomic helpers and drivers to steer the atomic commit control flow. See also *drm_atomic_crtc_needs_modeset()*.

`connectors_changed`
Connectors to this crtc have been updated, either in their state or routing. Used by the atomic helpers and drivers to steer the atomic commit control flow. See also *drm_atomic_crtc_needs_modeset()*.

Drivers are supposed to set this as-needed from their own atomic check code, e.g. from *drm_encoder_helper_funcs.atomic_check*

`zpos_changed`
zpos values of planes on this crtc have been updated. Used by the atomic helpers and drivers to steer the atomic commit control flow.

color_mgmt_changed
Color management properties have changed (**gamma_lut**, **degamma_lut** or **ctm**). Used by the atomic helpers and drivers to steer the atomic commit control flow.

no_vblank
Reflects the ability of a CRTC to send VBLANK events. This state usually depends on the pipeline configuration. If set to true, DRM atomic helpers will send out a fake VBLANK event during display updates after all hardware changes have been committed. This is implemented in *drm_atomic_helper_fake_vblank()*.

One usage is for drivers and/or hardware without support for VBLANK interrupts. Such drivers typically do not initialize vblanking (i.e., call *drm_vblank_init()* with the number of CRTCs). For CRTCs without initialized vblanking, this field is set to true in *drm_atomic_helper_check_modeset()*, and a fake VBLANK event will be send out on each update of the display pipeline by *drm_atomic_helper_fake_vblank()*.

Another usage is CRTCs feeding a writeback connector operating in oneshot mode. In this case the fake VBLANK event is only generated when a job is queued to the writeback connector, and we want the core to fake VBLANK events when this part of the pipeline hasn' t changed but others had or when the CRTC and connectors are being disabled.

__drm_atomic_helper_crtc_duplicate_state() will not reset the value from the current state, the CRTC driver is then responsible for updating this field when needed.

Note that the combination of *drm_crtc_state.event* == NULL and *drm_crtc_state.no_blank* == true is valid and usually used when the writeback connector attached to the CRTC has a new job queued. In this case the driver will send the VBLANK event on its own when the writeback job is complete.

plane_mask
Bitmask of drm_plane_mask(plane) of planes attached to this CRTC.

connector_mask
Bitmask of drm_connector_mask(connector) of connectors attached to this CRTC.

encoder_mask
Bitmask of drm_encoder_mask(encoder) of encoders attached to this CRTC.

adjusted_mode
Internal display timings which can be used by the driver to handle differences between the mode requested by userspace in **mode** and what is actually programmed into the hardware.

For drivers using *drm_bridge*, this stores hardware display timings used between the CRTC and the first bridge. For other drivers, the meaning of the adjusted_mode field is purely driver implementation defined information, and will usually be used to store the hardware display timings used between the CRTC and encoder blocks.

mode
: Display timings requested by userspace. The driver should try to match the refresh rate as close as possible (but note that it' s undefined what exactly is close enough, e.g. some of the HDMI modes only differ in less than 1% of the refresh rate). The active width and height as observed by userspace for positioning planes must match exactly.

  For external connectors where the sink isn' t fixed (like with a built-in panel), this mode here should match the physical mode on the wire to the last details (i.e. including sync polarities and everything).

mode_blob
: *drm_property_blob* for **mode**, for exposing the mode to atomic userspace.

degamma_lut
: Lookup table for converting framebuffer pixel data before apply the color conversion matrix **ctm**. See *drm_crtc_enable_color_mgmt()*. The blob (if not NULL) is an array of `struct drm_color_lut`.

ctm
: Color transformation matrix. See *drm_crtc_enable_color_mgmt()*. The blob (if not NULL) is a `struct drm_color_ctm`.

gamma_lut
: Lookup table for converting pixel data after the color conversion matrix **ctm**. See *drm_crtc_enable_color_mgmt()*. The blob (if not NULL) is an array of `struct drm_color_lut`.

target_vblank
: Target vertical blank period when a page flip should take effect.

async_flip
: This is set when DRM_MODE_PAGE_FLIP_ASYNC is set in the legacy PAGE_FLIP IOCTL. It' s not wired up for the atomic IOCTL itself yet.

vrr_enabled
: Indicates if variable refresh rate should be enabled for the CRTC. Support for the requested vrr state will depend on driver and hardware capabiltiy - lacking support is not treated as failure.

self_refresh_active
: Used by the self refresh helpers to denote when a self refresh transition is occurring. This will be set on enable/disable callbacks when self refresh is being enabled or disabled. In some cases, it may not be desirable to fully shut off the crtc during self refresh. CRTC' s can inspect this flag and determine the best course of action.

event
: Optional pointer to a DRM event to signal upon completion of the state update. The driver must send out the event when the atomic commit operation completes. There are two cases:

  - The event is for a CRTC which is being disabled through this atomic commit. In that case the event can be send out any time after the hardware has stopped scanning out the current framebuffers. It should contain the timestamp and counter for the last vblank before the display pipeline was shut off. The simplest way to achieve that is calling *drm_crtc_send_vblank_event()* somewhen after *drm_crtc_vblank_off()* has been called.

- For a CRTC which is enabled at the end of the commit (even when it undergoes an full modeset) the vblank timestamp and counter must be for the vblank right before the first frame that scans out the new set of buffers. Again the event can only be sent out after the hardware has stopped scanning out the old buffers.
- Events for disabled CRTCs are not allowed, and drivers can ignore that case.

For very simple hardware without VBLANK interrupt, enabling *struct drm_crtc_state*.no_vblank makes DRM' s atomic commit helpers send a fake VBLANK event at the end of the display update after all hardware changes have been applied. See *drm_atomic_helper_fake_vblank()*.

For more complex hardware this can be handled by the *drm_crtc_send_vblank_event()* function, which the driver should call on the provided event upon completion of the atomic commit. Note that if the driver supports vblank signalling and timestamping the vblank counters and timestamps must agree with the ones returned from page flip events. With the current vblank helper infrastructure this can be achieved by holding a vblank reference while the page flip is pending, acquired through *drm_crtc_vblank_get()* and released with *drm_crtc_vblank_put()*. Drivers are free to implement their own vblank counter and timestamp tracking though, e.g. if they have accurate timestamp registers in hardware.

For hardware which supports some means to synchronize vblank interrupt delivery with committing display state there' s also *drm_crtc_arm_vblank_event()*. See the documentation of that function for a detailed discussion of the constraints it needs to be used safely.

If the device can' t notify of flip completion in a race-free way at all, then the event should be armed just after the page flip is committed. In the worst case the driver will send the event to userspace one frame too late. This doesn' t allow for a real atomic update, but it should avoid tearing.

commit
This tracks how the commit for this update proceeds through the various phases. This is never cleared, except when we destroy the state, so that subsequent commits can synchronize with previous ones.

state
backpointer to global drm_atomic_state

Description

Note that the distinction between **enable** and **active** is rather subtle: Flipping **active** while **enable** is set without changing anything else may never return in a failure from the *drm_mode_config_funcs.atomic_check* callback. Userspace assumes that a DPMS On will always succeed. In other words: **enable** controls resource assignment, **active** controls the actual hardware state.

The three booleans active_changed, connectors_changed and mode_changed are intended to indicate whether a full modeset is needed, rather than strictly describing what has changed in a commit. See also: *drm_atomic_crtc_needs_modeset()*

WARNING: Transitional helpers (like drm_helper_crtc_mode_set() or drm_helper_crtc_mode_set_base()) do not maintain many of the derived control state like **plane_mask** so drivers not converted over to atomic helpers should not rely on these being accurate!

struct **drm_crtc_funcs**

control CRTCs for a given device

Definition

```
struct drm_crtc_funcs {
  void (*reset)(struct drm_crtc *crtc);
  int (*cursor_set)(struct drm_crtc *crtc, struct drm_file *file_
↪priv, uint32_t handle, uint32_t width, uint32_t height);
  int (*cursor_set2)(struct drm_crtc *crtc, struct drm_file *file_
↪priv,uint32_t handle, uint32_t width, uint32_t height, int32_t␣
↪hot_x, int32_t hot_y);
  int (*cursor_move)(struct drm_crtc *crtc, int x, int y);
  int (*gamma_set)(struct drm_crtc *crtc, u16 *r, u16 *g, u16 *b,
↪uint32_t size, struct drm_modeset_acquire_ctx *ctx);
  void (*destroy)(struct drm_crtc *crtc);
  int (*set_config)(struct drm_mode_set *set, struct drm_modeset_
↪acquire_ctx *ctx);
  int (*page_flip)(struct drm_crtc *crtc,struct drm_framebuffer *fb,
↪struct drm_pending_vblank_event *event,uint32_t flags, struct drm_
↪modeset_acquire_ctx *ctx);
  int (*page_flip_target)(struct drm_crtc *crtc,struct drm_
↪framebuffer *fb,struct drm_pending_vblank_event *event,uint32_t␣
↪flags, uint32_t target, struct drm_modeset_acquire_ctx *ctx);
  int (*set_property)(struct drm_crtc *crtc, struct drm_property␣
↪*property, uint64_t val);
  struct drm_crtc_state *(*atomic_duplicate_state)(struct drm_crtc␣
↪*crtc);
  void (*atomic_destroy_state)(struct drm_crtc *crtc, struct drm_
↪crtc_state *state);
  int (*atomic_set_property)(struct drm_crtc *crtc,struct drm_crtc_
↪state *state,struct drm_property *property, uint64_t val);
  int (*atomic_get_property)(struct drm_crtc *crtc,const struct drm_
↪crtc_state *state,struct drm_property *property, uint64_t *val);
  int (*late_register)(struct drm_crtc *crtc);
  void (*early_unregister)(struct drm_crtc *crtc);
  int (*set_crc_source)(struct drm_crtc *crtc, const char *source);
  int (*verify_crc_source)(struct drm_crtc *crtc, const char␣
↪*source, size_t *values_cnt);
  const char *const *(*get_crc_sources)(struct drm_crtc *crtc, size_
↪t *count);
  void (*atomic_print_state)(struct drm_printer *p, const struct␣
↪drm_crtc_state *state);
  u32 (*get_vblank_counter)(struct drm_crtc *crtc);
  int (*enable_vblank)(struct drm_crtc *crtc);
  void (*disable_vblank)(struct drm_crtc *crtc);
```

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```
  bool (*get_vblank_timestamp)(struct drm_crtc *crtc,int *max_error,
↪ktime_t *vblank_time, bool in_vblank_irq);
};
```

Members

reset
: Reset CRTC hardware and software state to off. This function isn't called by the core directly, only through *drm_mode_config_reset()*. It's not a helper hook only for historical reasons.

  Atomic drivers can use *drm_atomic_helper_crtc_reset()* to reset atomic state using this hook.

cursor_set
: Update the cursor image. The cursor position is relative to the CRTC and can be partially or fully outside of the visible area.

  Note that contrary to all other KMS functions the legacy cursor entry points don't take a framebuffer object, but instead take directly a raw buffer object id from the driver's buffer manager (which is either GEM or TTM for current drivers).

  This entry point is deprecated, drivers should instead implement universal plane support and register a proper cursor plane using *drm_crtc_init_with_planes()*.

  This callback is optional

  RETURNS:

  0 on success or a negative error code on failure.

cursor_set2
: Update the cursor image, including hotspot information. The hotspot must not affect the cursor position in CRTC coordinates, but is only meant as a hint for virtualized display hardware to coordinate the guests and hosts cursor position. The cursor hotspot is relative to the cursor image. Otherwise this works exactly like **cursor_set**.

  This entry point is deprecated, drivers should instead implement universal plane support and register a proper cursor plane using *drm_crtc_init_with_planes()*.

  This callback is optional.

  RETURNS:

  0 on success or a negative error code on failure.

cursor_move
: Update the cursor position. The cursor does not need to be visible when this hook is called.

  This entry point is deprecated, drivers should instead implement universal plane support and register a proper cursor plane using *drm_crtc_init_with_planes()*.

This callback is optional.

RETURNS:

0 on success or a negative error code on failure.

gamma_set
Set gamma on the CRTC.

This callback is optional.

Atomic drivers who want to support gamma tables should implement the atomic color management support, enabled by calling *drm_crtc_enable_color_mgmt()*, which then supports the legacy gamma interface through the *drm_atomic_helper_legacy_gamma_set()* compatibility implementation.

destroy
Clean up CRTC resources. This is only called at driver unload time through *drm_mode_config_cleanup()* since a CRTC cannot be hotplugged in DRM.

set_config
This is the main legacy entry point to change the modeset state on a CRTC. All the details of the desired configuration are passed in a *struct drm_mode_set* - see there for details.

Drivers implementing atomic modeset should use *drm_atomic_helper_set_config()* to implement this hook.

RETURNS:

0 on success or a negative error code on failure.

page_flip
Legacy entry point to schedule a flip to the given framebuffer.

Page flipping is a synchronization mechanism that replaces the frame buffer being scanned out by the CRTC with a new frame buffer during vertical blanking, avoiding tearing (except when requested otherwise through the DRM_MODE_PAGE_FLIP_ASYNC flag). When an application requests a page flip the DRM core verifies that the new frame buffer is large enough to be scanned out by the CRTC in the currently configured mode and then calls this hook with a pointer to the new frame buffer.

The driver must wait for any pending rendering to the new framebuffer to complete before executing the flip. It should also wait for any pending rendering from other drivers if the underlying buffer is a shared dma-buf.

An application can request to be notified when the page flip has completed. The drm core will supply a `struct drm_event` in the event parameter in this case. This can be handled by the *drm_crtc_send_vblank_event()* function, which the driver should call on the provided event upon completion of the flip. Note that if the driver supports vblank signalling and timestamping the vblank counters and timestamps must agree with the ones returned from page flip events. With the current vblank helper infrastructure this can be achieved by holding a vblank reference while the page flip is pending, acquired through *drm_crtc_vblank_get()* and released with *drm_crtc_vblank_put()*. Drivers are free to implement their own vblank counter and timestamp tracking though, e.g. if they have accurate timestamp registers in hardware.

This callback is optional.

NOTE:

Very early versions of the KMS ABI mandated that the driver must block (but not reject) any rendering to the old framebuffer until the flip operation has completed and the old framebuffer is no longer visible. This requirement has been lifted, and userspace is instead expected to request delivery of an event and wait with recycling old buffers until such has been received.

RETURNS:

0 on success or a negative error code on failure. Note that if a page flip operation is already pending the callback should return -EBUSY. Pageflips on a disabled CRTC (either by setting a NULL mode or just runtime disabled through DPMS respectively the new atomic "ACTIVE" state) should result in an -EINVAL error code. Note that *drm_atomic_helper_page_flip()* checks this already for atomic drivers.

page_flip_target
Same as **page_flip** but with an additional parameter specifying the absolute target vertical blank period (as reported by *drm_crtc_vblank_count()*) when the flip should take effect.

Note that the core code calls drm_crtc_vblank_get before this entry point, and will call drm_crtc_vblank_put if this entry point returns any non-0 error code. It's the driver's responsibility to call drm_crtc_vblank_put after this entry point returns 0, typically when the flip completes.

set_property
This is the legacy entry point to update a property attached to the CRTC.

This callback is optional if the driver does not support any legacy driver-private properties. For atomic drivers it is not used because property handling is done entirely in the DRM core.

RETURNS:

0 on success or a negative error code on failure.

atomic_duplicate_state
Duplicate the current atomic state for this CRTC and return it. The core and helpers guarantee that any atomic state duplicated with this hook and still owned by the caller (i.e. not transferred to the driver by calling *drm_mode_config_funcs.atomic_commit*) will be cleaned up by calling the **atomic_destroy_state** hook in this structure.

This callback is mandatory for atomic drivers.

Atomic drivers which don't subclass *struct drm_crtc_state* should use *drm_atomic_helper_crtc_duplicate_state()*. Drivers that subclass the state structure to extend it with driver-private state should use *__drm_atomic_helper_crtc_duplicate_state()* to make sure shared state is duplicated in a consistent fashion across drivers.

It is an error to call this hook before *drm_crtc.state* has been initialized correctly.

NOTE:

If the duplicate state references refcounted resources this hook must acquire a reference for each of them. The driver must release these references again in **atomic_destroy_state**.

RETURNS:

Duplicated atomic state or NULL when the allocation failed.

`atomic_destroy_state`
Destroy a state duplicated with **atomic_duplicate_state** and release or unreference all resources it references

This callback is mandatory for atomic drivers.

`atomic_set_property`
Decode a driver-private property value and store the decoded value into the passed-in state structure. Since the atomic core decodes all standardized properties (even for extensions beyond the core set of properties which might not be implemented by all drivers) this requires drivers to subclass the state structure.

Such driver-private properties should really only be implemented for truly hardware/vendor specific state. Instead it is preferred to standardize atomic extension and decode the properties used to expose such an extension in the core.

Do not call this function directly, use drm_atomic_crtc_set_property() instead.

This callback is optional if the driver does not support any driver-private atomic properties.

NOTE:

This function is called in the state assembly phase of atomic modesets, which can be aborted for any reason (including on userspace's request to just check whether a configuration would be possible). Drivers MUST NOT touch any persistent state (hardware or software) or data structures except the passed in **state** parameter.

Also since userspace controls in which order properties are set this function must not do any input validation (since the state update is incomplete and hence likely inconsistent). Instead any such input validation must be done in the various atomic_check callbacks.

RETURNS:

0 if the property has been found, -EINVAL if the property isn't implemented by the driver (which should never happen, the core only asks for properties attached to this CRTC). No other validation is allowed by the driver. The core already checks that the property value is within the range (integer, valid enum value, …) the driver set when registering the property.

`atomic_get_property`
Reads out the decoded driver-private property. This is used to implement the

GETCRTC IOCTL.

Do not call this function directly, use drm_atomic_crtc_get_property() instead.

This callback is optional if the driver does not support any driver-private atomic properties.

RETURNS:

0 on success, -EINVAL if the property isn't implemented by the driver (which should never happen, the core only asks for properties attached to this CRTC).

late_register
This optional hook can be used to register additional userspace interfaces attached to the crtc like debugfs interfaces. It is called late in the driver load sequence from *drm_dev_register()*. Everything added from this callback should be unregistered in the early_unregister callback.

Returns:

0 on success, or a negative error code on failure.

early_unregister
This optional hook should be used to unregister the additional userspace interfaces attached to the crtc from **late_register**. It is called from *drm_dev_unregister()*, early in the driver unload sequence to disable userspace access before data structures are torndown.

set_crc_source
Changes the source of CRC checksums of frames at the request of userspace, typically for testing purposes. The sources available are specific of each driver and a NULL value indicates that CRC generation is to be switched off.

When CRC generation is enabled, the driver should call *drm_crtc_add_crc_entry()* at each frame, providing any information that characterizes the frame contents in the crcN arguments, as provided from the configured source. Drivers must accept an "auto" source name that will select a default source for this CRTC.

This may trigger an atomic modeset commit if necessary, to enable CRC generation.

Note that "auto" can depend upon the current modeset configuration, e.g. it could pick an encoder or output specific CRC sampling point.

This callback is optional if the driver does not support any CRC generation functionality.

RETURNS:

0 on success or a negative error code on failure.

verify_crc_source
verifies the source of CRC checksums of frames before setting the source for CRC and during crc open. Source parameter can be NULL while disabling crc source.

This callback is optional if the driver does not support any CRC generation functionality.

RETURNS:

0 on success or a negative error code on failure.

get_crc_sources
Driver callback for getting a list of all the available sources for CRC generation. This callback depends upon verify_crc_source, So verify_crc_source callback should be implemented before implementing this. Driver can pass full list of available crc sources, this callback does the verification on each crc-source before passing it to userspace.

This callback is optional if the driver does not support exporting of possible CRC sources list.

RETURNS:

a constant character pointer to the list of all the available CRC sources. On failure driver should return NULL. count should be updated with number of sources in list. if zero we don' t process any source from the list.

atomic_print_state
If driver subclasses *struct drm_crtc_state*, it should implement this optional hook for printing additional driver specific state.

Do not call this directly, use drm_atomic_crtc_print_state() instead.

get_vblank_counter
Driver callback for fetching a raw hardware vblank counter for the CRTC. It' s meant to be used by new drivers as the replacement of *drm_driver.get_vblank_counter* hook.

This callback is optional. If a device doesn' t have a hardware counter, the driver can simply leave the hook as NULL. The DRM core will account for missed vblank events while interrupts where disabled based on system timestamps.

Wraparound handling and loss of events due to modesetting is dealt with in the DRM core code, as long as drivers call *drm_crtc_vblank_off()* and *drm_crtc_vblank_on()* when disabling or enabling a CRTC.

See also *drm_device.vblank_disable_immediate* and *drm_device.max_vblank_count*.

Returns:

Raw vblank counter value.

enable_vblank
Enable vblank interrupts for the CRTC. It' s meant to be used by new drivers as the replacement of *drm_driver.enable_vblank* hook.

Returns:

Zero on success, appropriate errno if the vblank interrupt cannot be enabled.

disable_vblank
Disable vblank interrupts for the CRTC. It' s meant to be used by new drivers as the replacement of *drm_driver.disable_vblank* hook.

get_vblank_timestamp

Called by drm_get_last_vbltimestamp(). Should return a precise timestamp when the most recent vblank interval ended or will end.

Specifically, the timestamp in **vblank_time** should correspond as closely as possible to the time when the first video scanline of the video frame after the end of vblank will start scanning out, the time immediately after end of the vblank interval. If the **crtc** is currently inside vblank, this will be a time in the future. If the **crtc** is currently scanning out a frame, this will be the past start time of the current scanout. This is meant to adhere to the OpenML OML_sync_control extension specification.

Parameters:

crtc:
CRTC for which timestamp should be returned.

max_error:
Maximum allowable timestamp error in nanoseconds. Implementation should strive to provide timestamp with an error of at most max_error nanoseconds. Returns true upper bound on error for timestamp.

vblank_time:
Target location for returned vblank timestamp.

in_vblank_irq:
True when called from *drm_crtc_handle_vblank()*. Some drivers need to apply some workarounds for gpu-specific vblank irq quirks if flag is set.

Returns:

True on success, false on failure, which means the core should fallback to a simple timestamp taken in *drm_crtc_handle_vblank()*.

Description

The drm_crtc_funcs structure is the central CRTC management structure in the DRM. Each CRTC controls one or more connectors (note that the name CRTC is simply historical, a CRTC may control LVDS, VGA, DVI, TV out, etc. connectors, not just CRTs).

Each driver is responsible for filling out this structure at startup time, in addition to providing other modesetting features, like i2c and DDC bus accessors.

struct **drm_crtc**

central CRTC control structure

Definition

```
struct drm_crtc {
  struct drm_device *dev;
  struct device_node *port;
  struct list_head head;
  char *name;
  struct drm_modeset_lock mutex;
  struct drm_mode_object base;
```

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```
  struct drm_plane *primary;
  struct drm_plane *cursor;
  unsigned index;
  int cursor_x;
  int cursor_y;
  bool enabled;
  struct drm_display_mode mode;
  struct drm_display_mode hwmode;
  int x;
  int y;
  const struct drm_crtc_funcs *funcs;
  uint32_t gamma_size;
  uint16_t *gamma_store;
  const struct drm_crtc_helper_funcs *helper_private;
  struct drm_object_properties properties;
  struct drm_crtc_state *state;
  struct list_head commit_list;
  spinlock_t commit_lock;
#ifdef CONFIG_DEBUG_FS;
  struct dentry *debugfs_entry;
#endif;
  struct drm_crtc_crc crc;
  unsigned int fence_context;
  spinlock_t fence_lock;
  unsigned long fence_seqno;
  char timeline_name[32];
  struct drm_self_refresh_data *self_refresh_data;
};
```

Members

dev
parent DRM device

port
OF node used by *drm_of_find_possible_crtcs()*.

head
List of all CRTCs on **dev**, linked from *drm_mode_config.crtc_list*. Invariant over the lifetime of **dev** and therefore does not need locking.

name
human readable name, can be overwritten by the driver

mutex
This provides a read lock for the overall CRTC state (mode, dpms state, …) and a write lock for everything which can be update without a full modeset (fb, cursor data, CRTC properties …). A full modeset also need to grab *drm_mode_config.connection_mutex*.

For atomic drivers specifically this protects **state**.

base

base KMS object for ID tracking etc.

primary
Primary plane for this CRTC. Note that this is only relevant for legacy IOCTL, it specifies the plane implicitly used by the SETCRTC and PAGE_FLIP IOCTLs. It does not have any significance beyond that.

cursor
Cursor plane for this CRTC. Note that this is only relevant for legacy IOCTL, it specifies the plane implicitly used by the SETCURSOR and SETCURSOR2 IOCTLs. It does not have any significance beyond that.

index
Position inside the mode_config.list, can be used as an array index. It is invariant over the lifetime of the CRTC.

cursor_x
Current x position of the cursor, used for universal cursor planes because the SETCURSOR IOCTL only can update the framebuffer without supplying the coordinates. Drivers should not use this directly, atomic drivers should look at *drm_plane_state.crtc_x* of the cursor plane instead.

cursor_y
Current y position of the cursor, used for universal cursor planes because the SETCURSOR IOCTL only can update the framebuffer without supplying the coordinates. Drivers should not use this directly, atomic drivers should look at *drm_plane_state.crtc_y* of the cursor plane instead.

enabled
Is this CRTC enabled? Should only be used by legacy drivers, atomic drivers should instead consult *drm_crtc_state.enable* and *drm_crtc_state.active*. Atomic drivers can update this by calling *drm_atomic_helper_update_legacy_modeset_state()*.

mode
Current mode timings. Should only be used by legacy drivers, atomic drivers should instead consult *drm_crtc_state.mode*. Atomic drivers can update this by calling *drm_atomic_helper_update_legacy_modeset_state()*.

hwmode
Programmed mode in hw, after adjustments for encoders, crtc, panel scaling etc. Should only be used by legacy drivers, for high precision vblank timestamps in *drm_crtc_vblank_helper_get_vblank_timestamp()*.

Note that atomic drivers should not use this, but instead use *drm_crtc_state.adjusted_mode*. And for high-precision timestamps *drm_crtc_vblank_helper_get_vblank_timestamp()* used *drm_vblank_crtc.hwmode*, which is filled out by calling *drm_calc_timestamping_constants()*.

x
x position on screen. Should only be used by legacy drivers, atomic drivers should look at *drm_plane_state.crtc_x* of the primary plane instead. Updated by calling *drm_atomic_helper_update_legacy_modeset_state()*.

y
y position on screen. Should only be used by legacy drivers, atomic drivers

should look at *drm_plane_state.crtc_y* of the primary plane instead. Updated by calling *drm_atomic_helper_update_legacy_modeset_state()*.

funcs
CRTC control functions

gamma_size
Size of legacy gamma ramp reported to userspace. Set up by calling *drm_mode_crtc_set_gamma_size()*.

gamma_store
Gamma ramp values used by the legacy SETGAMMA and GETGAMMA IOCTls. Set up by calling *drm_mode_crtc_set_gamma_size()*.

helper_private
mid-layer private data

properties
property tracking for this CRTC

state
Current atomic state for this CRTC.

This is protected by **mutex**. Note that nonblocking atomic commits access the current CRTC state without taking locks. Either by going through the *struct drm_atomic_state* pointers, see *for_each_oldnew_crtc_in_state()*, *for_each_old_crtc_in_state()* and *for_each_new_crtc_in_state()*. Or through careful ordering of atomic commit operations as implemented in the atomic helpers, see *struct drm_crtc_commit*.

commit_list
List of *drm_crtc_commit* structures tracking pending commits. Protected by **commit_lock**. This list holds its own full reference, as does the ongoing commit.

"Note that the commit for a state change is also tracked in *drm_crtc_state.commit*. For accessing the immediately preceding commit in an atomic update it is recommended to just use that pointer in the old CRTC state, since accessing that doesn't need any locking or list-walking. **commit_list** should only be used to stall for framebuffer cleanup that's signalled through *drm_crtc_commit.cleanup_done*."

commit_lock
Spinlock to protect **commit_list**.

debugfs_entry
Debugfs directory for this CRTC.

crc
Configuration settings of CRC capture.

fence_context
timeline context used for fence operations.

fence_lock
spinlock to protect the fences in the fence_context.

fence_seqno
Seqno variable used as monotonic counter for the fences created on the CRTC'

s timeline.

timeline_name
The name of the CRTC' s fence timeline.

self_refresh_data
Holds the state for the self refresh helpers

Initialized via *drm_self_refresh_helper_init()*.

Description

Each CRTC may have one or more connectors associated with it. This structure allows the CRTC to be controlled.

struct **drm_mode_set**
new values for a CRTC config change

Definition

```
struct drm_mode_set {
  struct drm_framebuffer *fb;
  struct drm_crtc *crtc;
  struct drm_display_mode *mode;
  uint32_t x;
  uint32_t y;
  struct drm_connector **connectors;
  size_t num_connectors;
};
```

Members

fb
framebuffer to use for new config

crtc
CRTC whose configuration we' re about to change

mode
mode timings to use

x
position of this CRTC relative to **fb**

y
position of this CRTC relative to **fb**

connectors
array of connectors to drive with this CRTC if possible

num_connectors
size of **connectors** array

Description

This represents a modeset configuration for the legacy SETCRTC ioctl and is also used internally. Atomic drivers instead use *drm_atomic_state*.

unsigned int **drm_crtc_index**(const struct *drm_crtc* *crtc)

find the index of a registered CRTC

Parameters

const struct drm_crtc *crtc
CRTC to find index for

Description

Given a registered CRTC, return the index of that CRTC within a DRM device’ s list of CRTCs.

uint32_t **drm_crtc_mask**(const struct *drm_crtc* *crtc)

find the mask of a registered CRTC

Parameters

const struct drm_crtc *crtc
CRTC to find mask for

Description

Given a registered CRTC, return the mask bit of that CRTC for the *drm_encoder.possible_crtcs* and *drm_plane.possible_crtcs* fields.

struct *drm_crtc* ***drm_crtc_find**(struct *drm_device* *dev, struct *drm_file* *file_priv, uint32_t id)

look up a CRTC object from its ID

Parameters

struct drm_device *dev
DRM device

struct drm_file *file_priv
drm file to check for lease against.

uint32_t id
drm_mode_object ID

Description

This can be used to look up a CRTC from its userspace ID. Only used by drivers for legacy IOCTLs and interface, nowadays extensions to the KMS userspace interface should be done using *drm_property*.

drm_for_each_crtc

`drm_for_each_crtc (crtc, dev)`

iterate over all CRTCs

Parameters

crtc
a *struct drm_crtc* as the loop cursor

dev
the *struct drm_device*

Description

Iterate over all CRTCs of **dev**.

struct *drm_crtc* ***drm_crtc_from_index**(struct *drm_device* *dev, int idx)

find the registered CRTC at an index

Parameters

struct drm_device *dev
DRM device

int idx
index of registered CRTC to find for

Description

Given a CRTC index, return the registered CRTC from DRM device’ s list of CRTCs with matching index. This is the inverse of *drm_crtc_index()*. It’ s useful in the vblank callbacks (like *drm_driver.enable_vblank* or *drm_driver.disable_vblank*), since that still deals with indices instead of pointers to *struct drm_crtc*.”

int **drm_crtc_init_with_planes**(struct *drm_device* *dev, struct *drm_crtc* *crtc, struct *drm_plane* *primary, struct *drm_plane* *cursor, const struct *drm_crtc_funcs* *funcs, const char *name, ...)

Initialise a new CRTC object with specified primary and cursor planes.

Parameters

struct drm_device *dev
DRM device

struct drm_crtc *crtc
CRTC object to init

struct drm_plane *primary
Primary plane for CRTC

struct drm_plane *cursor
Cursor plane for CRTC

const struct drm_crtc_funcs *funcs
callbacks for the new CRTC

const char *name
printf style format string for the CRTC name, or NULL for default name

...
variable arguments

Description

Inits a new object created as base part of a driver crtc object. Drivers should use this function instead of *drm_crtc_init()*, which is only provided for backwards compatibility with drivers which do not yet support universal planes). For really simple hardware which has only 1 plane look at *drm_simple_display_pipe_init()* instead.

Return

Zero on success, error code on failure.

void **drm_crtc_cleanup**(struct *drm_crtc* *crtc)

Clean up the core crtc usage

Parameters

struct drm_crtc *crtc
CRTC to cleanup

Description

This function cleans up **crtc** and removes it from the DRM mode setting core. Note that the function does *not* free the crtc structure itself, this is the responsibility of the caller.

int **drm_mode_set_config_internal**(struct *drm_mode_set* *set)

helper to call *drm_mode_config_funcs.set_config*

Parameters

struct drm_mode_set *set
modeset config to set

Description

This is a little helper to wrap internal calls to the *drm_mode_config_funcs.set_config* driver interface. The only thing it adds is correct refcounting dance.

This should only be used by non-atomic legacy drivers.

Return

Zero on success, negative errno on failure.

int **drm_crtc_check_viewport**(const struct *drm_crtc* *crtc, int x, int y, const struct *drm_display_mode* *mode, const struct *drm_framebuffer* *fb)

Checks that a framebuffer is big enough for the CRTC viewport

Parameters

const struct drm_crtc *crtc
CRTC that framebuffer will be displayed on

int x
x panning

int y
y panning

const struct drm_display_mode *mode
mode that framebuffer will be displayed under

const struct drm_framebuffer *fb
framebuffer to check size of

4.6 Frame Buffer Abstraction

Frame buffers are abstract memory objects that provide a source of pixels to scanout to a CRTC. Applications explicitly request the creation of frame buffers through the DRM_IOCTL_MODE_ADDFB(2) ioctls and receive an opaque handle that can be passed to the KMS CRTC control, plane configuration and page flip functions.

Frame buffers rely on the underlying memory manager for allocating backing storage. When creating a frame buffer applications pass a memory handle (or a list of memory handles for multi-planar formats) through the `struct drm_mode_fb_cmd2` argument. For drivers using GEM as their userspace buffer management interface this would be a GEM handle. Drivers are however free to use their own backing storage object handles, e.g. vmwgfx directly exposes special TTM handles to userspace and so expects TTM handles in the create ioctl and not GEM handles.

Framebuffers are tracked with *struct drm_framebuffer*. They are published using *drm_framebuffer_init()* - after calling that function userspace can use and access the framebuffer object. The helper function *drm_helper_mode_fill_fb_struct()* can be used to pre-fill the required metadata fields.

The lifetime of a drm framebuffer is controlled with a reference count, drivers can grab additional references with *drm_framebuffer_get()* and drop them again with *drm_framebuffer_put()*. For driver-private framebuffers for which the last reference is never dropped (e.g. for the fbdev framebuffer when the struct *struct drm_framebuffer* is embedded into the fbdev helper struct) drivers can manually clean up a framebuffer at module unload time with *drm_framebuffer_unregister_private()*. But doing this is not recommended, and it's better to have a normal free-standing *struct drm_framebuffer*.

4.6.1 Frame Buffer Functions Reference

struct **drm_framebuffer_funcs**

framebuffer hooks

Definition

```
struct drm_framebuffer_funcs {
  void (*destroy)(struct drm_framebuffer *framebuffer);
  int (*create_handle)(struct drm_framebuffer *fb,struct drm_file␣
↪*file_priv, unsigned int *handle);
  int (*dirty)(struct drm_framebuffer *framebuffer,struct drm_file␣
↪*file_priv, unsigned flags,unsigned color, struct drm_clip_rect␣
↪*clips, unsigned num_clips);
};
```

Members

destroy
Clean up framebuffer resources, specifically also unreference the backing storage. The core guarantees to call this function for every framebuffer successfully created by calling *drm_mode_config_funcs.fb_create*. Drivers

must also call *drm_framebuffer_cleanup()* to release DRM core resources for this framebuffer.

create_handle
Create a buffer handle in the driver-specific buffer manager (either GEM or TTM) valid for the passed-in *struct drm_file*. This is used by the core to implement the GETFB IOCTL, which returns (for sufficiently priviledged user) also a native buffer handle. This can be used for seamless transitions between modesetting clients by copying the current screen contents to a private buffer and blending between that and the new contents.

GEM based drivers should call *drm_gem_handle_create()* to create the handle.

RETURNS:

0 on success or a negative error code on failure.

dirty
Optional callback for the dirty fb IOCTL.

Userspace can notify the driver via this callback that an area of the framebuffer has changed and should be flushed to the display hardware. This can also be used internally, e.g. by the fbdev emulation, though that' s not the case currently.

See documentation in drm_mode.h for the struct drm_mode_fb_dirty_cmd for more information as all the semantics and arguments have a one to one mapping on this function.

Atomic drivers should use *drm_atomic_helper_dirtyfb()* to implement this hook.

RETURNS:

0 on success or a negative error code on failure.

struct **drm_framebuffer**
frame buffer object

Definition

```
struct drm_framebuffer {
  struct drm_device *dev;
  struct list_head head;
  struct drm_mode_object base;
  char comm[TASK_COMM_LEN];
  const struct drm_format_info *format;
  const struct drm_framebuffer_funcs *funcs;
  unsigned int pitches[4];
  unsigned int offsets[4];
  uint64_t modifier;
  unsigned int width;
  unsigned int height;
  int flags;
  int hot_x;
```

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```
  int hot_y;
  struct list_head filp_head;
  struct drm_gem_object *obj[4];
};
```

Members

dev
DRM device this framebuffer belongs to

head
Place on the *drm_mode_config.fb_list*, access protected by *drm_mode_config.fb_lock*.

base
base modeset object structure, contains the reference count.

comm
Name of the process allocating the fb, used for fb dumping.

format
framebuffer format information

funcs
framebuffer vfunc table

pitches
Line stride per buffer. For userspace created object this is copied from drm_mode_fb_cmd2.

offsets
Offset from buffer start to the actual pixel data in bytes, per buffer. For userspace created object this is copied from drm_mode_fb_cmd2.

Note that this is a linear offset and does not take into account tiling or buffer laytou per **modifier**. It meant to be used when the actual pixel data for this framebuffer plane starts at an offset, e.g. when multiple planes are allocated within the same backing storage buffer object. For tiled layouts this generally means it **offsets** must at least be tile-size aligned, but hardware often has stricter requirements.

This should not be used to specifiy x/y pixel offsets into the buffer data (even for linear buffers). Specifying an x/y pixel offset is instead done through the source rectangle in *struct drm_plane_state*.

modifier
Data layout modifier. This is used to describe tiling, or also special layouts (like compression) of auxiliary buffers. For userspace created object this is copied from drm_mode_fb_cmd2.

width
Logical width of the visible area of the framebuffer, in pixels.

height
Logical height of the visible area of the framebuffer, in pixels.

flags
Framebuffer flags like DRM_MODE_FB_INTERLACED or DRM_MODE_FB_MODIFIERS.

hot_x
X coordinate of the cursor hotspot. Used by the legacy cursor IOCTL when the driver supports cursor through a DRM_PLANE_TYPE_CURSOR universal plane.

hot_y
Y coordinate of the cursor hotspot. Used by the legacy cursor IOCTL when the driver supports cursor through a DRM_PLANE_TYPE_CURSOR universal plane.

filp_head
Placed on `drm_file.fbs`, protected by `drm_file.fbs_lock`.

obj
GEM objects backing the framebuffer, one per plane (optional).

This is used by the GEM framebuffer helpers, see e.g. `drm_gem_fb_create()`.

Description

Note that the fb is refcounted for the benefit of driver internals, for example some hw, disabling a CRTC/plane is asynchronous, and scanout does not actually complete until the next vblank. So some cleanup (like releasing the reference(s) on the backing GEM bo(s)) should be deferred. In cases like this, the driver would like to hold a ref to the fb even though it has already been removed from userspace perspective. See `drm_framebuffer_get()` and `drm_framebuffer_put()`.

The refcount is stored inside the mode object **base**.

void **drm_framebuffer_get**(struct *drm_framebuffer* *fb)
acquire a framebuffer reference

Parameters

struct drm_framebuffer *fb
DRM framebuffer

Description

This function increments the framebuffer's reference count.

void **drm_framebuffer_put**(struct *drm_framebuffer* *fb)
release a framebuffer reference

Parameters

struct drm_framebuffer *fb
DRM framebuffer

Description

This function decrements the framebuffer's reference count and frees the framebuffer if the reference count drops to zero.

uint32_t **drm_framebuffer_read_refcount**(const struct *drm_framebuffer* *fb)
read the framebuffer reference count.

Parameters

const struct drm_framebuffer *fb
framebuffer

Description

This functions returns the framebuffer’ s reference count.

void **drm_framebuffer_assign**(struct *drm_framebuffer* **p, struct *drm_framebuffer* *fb)

store a reference to the fb

Parameters

struct drm_framebuffer **p
location to store framebuffer

struct drm_framebuffer *fb
new framebuffer (maybe NULL)

Description

This functions sets the location to store a reference to the framebuffer, unreferencing the framebuffer that was previously stored in that location.

struct **drm_afbc_framebuffer**

a special afbc frame buffer object

Definition

```
struct drm_afbc_framebuffer {
  struct drm_framebuffer base;
  u32 block_width;
  u32 block_height;
  u32 aligned_width;
  u32 aligned_height;
  u32 offset;
  u32 afbc_size;
};
```

Members

base
base framebuffer structure.

block_width
width of a single afbc block

block_height
height of a single afbc block

aligned_width
aligned frame buffer width

aligned_height
aligned frame buffer height

offset
offset of the first afbc header

afbc_size
minimum size of afbc buffer

Description

A derived class of *struct drm_framebuffer*, dedicated for afbc use cases.

int **drm_framebuffer_init**(struct *drm_device* *dev, struct *drm_framebuffer* *fb, const struct *drm_framebuffer_funcs* *funcs)

initialize a framebuffer

Parameters

struct drm_device *dev
DRM device

struct drm_framebuffer *fb
framebuffer to be initialized

const struct drm_framebuffer_funcs *funcs
…with these functions

Description

Allocates an ID for the framebuffer's parent mode object, sets its mode functions & device file and adds it to the master fd list.

IMPORTANT: This functions publishes the fb and makes it available for concurrent access by other users. Which means by this point the fb _must_ be fully set up - since all the fb attributes are invariant over its lifetime, no further locking but only correct reference counting is required.

Return

Zero on success, error code on failure.

struct *drm_framebuffer* ***drm_framebuffer_lookup**(struct *drm_device* *dev, struct *drm_file* *file_priv, uint32_t id)

look up a drm framebuffer and grab a reference

Parameters

struct drm_device *dev
drm device

struct drm_file *file_priv
drm file to check for lease against.

uint32_t id
id of the fb object

Description

If successful, this grabs an additional reference to the framebuffer - callers need to make sure to eventually unreference the returned framebuffer again, using *drm_framebuffer_put()*.

void **drm_framebuffer_unregister_private**(struct *drm_framebuffer* *fb)

unregister a private fb from the lookup idr

Parameters

`struct drm_framebuffer *fb`
fb to unregister

Description

Drivers need to call this when cleaning up driver-private framebuffers, e.g. those used for fbdev. Note that the caller must hold a reference of its own, i.e. the object may not be destroyed through this call (since it' ll lead to a locking inversion).

NOTE

This function is deprecated. For driver-private framebuffers it is not recommended to embed a framebuffer struct info fbdev struct, instead, a framebuffer pointer is preferred and *`drm_framebuffer_put()`* should be called when the framebuffer is to be cleaned up.

void **`drm_framebuffer_cleanup`**(struct *drm_framebuffer* *fb)
remove a framebuffer object

Parameters

`struct drm_framebuffer *fb`
framebuffer to remove

Description

Cleanup framebuffer. This function is intended to be used from the drivers *`drm_framebuffer_funcs.destroy`* callback. It can also be used to clean up driver private framebuffers embedded into a larger structure.

Note that this function does not remove the fb from active usage - if it is still used anywhere, hilarity can ensue since userspace could call getfb on the id and get back -EINVAL. Obviously no concern at driver unload time.

Also, the framebuffer will not be removed from the lookup idr - for user-created framebuffers this will happen in in the rmfb ioctl. For driver-private objects (e.g. for fbdev) drivers need to explicitly call drm_framebuffer_unregister_private.

void **`drm_framebuffer_remove`**(struct *drm_framebuffer* *fb)
remove and unreference a framebuffer object

Parameters

`struct drm_framebuffer *fb`
framebuffer to remove

Description

Scans all the CRTCs and planes in **dev**' s mode_config. If they' re using **fb**, removes it, setting it to NULL. Then drops the reference to the passed-in framebuffer. Might take the modeset locks.

Note that this function optimizes the cleanup away if the caller holds the last reference to the framebuffer. It is also guaranteed to not take the modeset locks in this case.

int **`drm_framebuffer_plane_width`**(int width, const struct *drm_framebuffer* *fb, int plane) width of the plane given the first plane

Parameters

`int width`
width of the first plane

`const struct drm_framebuffer *fb`
the framebuffer

`int plane`
plane index

Return

The width of **plane**, given that the width of the first plane is **width**.

int **`drm_framebuffer_plane_height`**(int height, const struct *drm_framebuffer* *fb, int plane)

height of the plane given the first plane

Parameters

`int height`
height of the first plane

`const struct drm_framebuffer *fb`
the framebuffer

`int plane`
plane index

Return

The height of **plane**, given that the height of the first plane is **height**.

4.7 DRM Format Handling

In the DRM subsystem, framebuffer pixel formats are described using the fourcc codes defined in *include/uapi/drm/drm_fourcc.h*. In addition to the fourcc code, a Format Modifier may optionally be provided, in order to further describe the buffer's format - for example tiling or compression.

4.7.1 Format Modifiers

Format modifiers are used in conjunction with a fourcc code, forming a unique fourcc:modifier pair. This format:modifier pair must fully define the format and data layout of the buffer, and should be the only way to describe that particular buffer.

Having multiple fourcc:modifier pairs which describe the same layout should be avoided, as such aliases run the risk of different drivers exposing different names for the same data format, forcing userspace to understand that they are aliases.

Format modifiers may change any property of the buffer, including the number of planes and/or the required allocation size. Format modifiers are vendor-namespaced, and as such the relationship between a fourcc code and a modifier is specific to the modifer being used. For example, some modifiers may preserve meaning - such as number of planes - from the fourcc code, whereas others may not.

Vendors should document their modifier usage in as much detail as possible, to ensure maximum compatibility across devices, drivers and applications.

The authoritative list of format modifier codes is found in *include/uapi/drm/drm_fourcc.h*

4.7.2 Format Functions Reference

struct **drm_format_info**
information about a DRM format

Definition

```
struct drm_format_info {
  u32 format;
  u8 depth;
  u8 num_planes;
  union {
    u8 cpp[4];
    u8 char_per_block[4];
  };
  u8 block_w[4];
  u8 block_h[4];
  u8 hsub;
  u8 vsub;
  bool has_alpha;
  bool is_yuv;
};
```

Members

format
4CC format identifier (DRM_FORMAT_*)

depth
Color depth (number of bits per pixel excluding padding bits), valid for a subset of RGB formats only. This is a legacy field, do not use in new code and set to 0 for new formats.

num_planes
Number of color planes (1 to 3)

{unnamed_union}
anonymous

cpp
Number of bytes per pixel (per plane), this is aliased with **char_per_block**.

It is deprecated in favour of using the triplet **char_per_block**, **block_w**, **block_h** for better describing the pixel format.

char_per_block
Number of bytes per block (per plane), where blocks are defined as a rectangle of pixels which are stored next to each other in a byte aligned memory region. Together with **block_w** and **block_h** this is used to properly describe tiles in tiled formats or to describe groups of pixels in packed formats for which the memory needed for a single pixel is not byte aligned.

cpp has been kept for historical reasons because there are a lot of places in drivers where it' s used. In drm core for generic code paths the preferred way is to use **char_per_block**, *drm_format_info_block_width()* and *drm_format_info_block_height()* which allows handling both block and non-block formats in the same way.

For formats that are intended to be used only with non-linear modifiers both **cpp** and **char_per_block** must be 0 in the generic format table. Drivers could supply accurate information from their drm_mode_config.get_format_info hook if they want the core to be validating the pitch.

block_w
Block width in pixels, this is intended to be accessed through *drm_format_info_block_width()*

block_h
Block height in pixels, this is intended to be accessed through *drm_format_info_block_height()*

hsub
Horizontal chroma subsampling factor

vsub
Vertical chroma subsampling factor

has_alpha
Does the format embeds an alpha component?

is_yuv
Is it a YUV format?

struct **drm_format_name_buf**
name of a DRM format

Definition

```
struct drm_format_name_buf {
  char str[32];
};
```

Members

str
string buffer containing the format name

bool **drm_format_info_is_yuv_packed**(const struct *drm_format_info* *info)
check that the format info matches a YUV format with data laid in a single plane

Parameters

const struct drm_format_info *info
format info

Return

A boolean indicating whether the format info matches a packed YUV format.

bool **drm_format_info_is_yuv_semiplanar**(const struct *drm_format_info* *info)
check that the format info matches a YUV format with data laid in two planes (luminance and chrominance)

Parameters

const struct drm_format_info *info
format info

Return

A boolean indicating whether the format info matches a semiplanar YUV format.

bool **drm_format_info_is_yuv_planar**(const struct *drm_format_info* *info)
check that the format info matches a YUV format with data laid in three planes (one for each YUV component)

Parameters

const struct drm_format_info *info
format info

Return

A boolean indicating whether the format info matches a planar YUV format.

bool **drm_format_info_is_yuv_sampling_410**(const struct *drm_format_info* *info)
check that the format info matches a YUV format with 4:1:0 sub-sampling

Parameters

const struct drm_format_info *info
format info

Return

A boolean indicating whether the format info matches a YUV format with 4:1:0 sub-sampling.

bool **drm_format_info_is_yuv_sampling_411**(const struct *drm_format_info* *info)
check that the format info matches a YUV format with 4:1:1 sub-sampling

Parameters

const struct drm_format_info *info
format info

Return

A boolean indicating whether the format info matches a YUV format with 4:1:1 sub-sampling.

bool **drm_format_info_is_yuv_sampling_420**(const struct *drm_format_info* *info)

check that the format info matches a YUV format with 4:2:0 sub-sampling

Parameters

const struct drm_format_info *info
format info

Return

A boolean indicating whether the format info matches a YUV format with 4:2:0 sub-sampling.

bool **drm_format_info_is_yuv_sampling_422**(const struct *drm_format_info* *info)

check that the format info matches a YUV format with 4:2:2 sub-sampling

Parameters

const struct drm_format_info *info
format info

Return

A boolean indicating whether the format info matches a YUV format with 4:2:2 sub-sampling.

bool **drm_format_info_is_yuv_sampling_444**(const struct *drm_format_info* *info)

check that the format info matches a YUV format with 4:4:4 sub-sampling

Parameters

const struct drm_format_info *info
format info

Return

A boolean indicating whether the format info matches a YUV format with 4:4:4 sub-sampling.

int **drm_format_info_plane_width**(const struct *drm_format_info* *info, int width, int plane)

width of the plane given the first plane

Parameters

const struct drm_format_info *info
pixel format info

int width
width of the first plane

int plane
plane index

Return

The width of **plane**, given that the width of the first plane is **width**.

int **drm_format_info_plane_height**(const struct *drm_format_info* *info, int height, int plane)

height of the plane given the first plane

Parameters

const struct drm_format_info *info
pixel format info

int height
height of the first plane

int plane
plane index

Return

The height of **plane**, given that the height of the first plane is **height**.

uint32_t **drm_mode_legacy_fb_format**(uint32_t bpp, uint32_t depth)

compute drm fourcc code from legacy description

Parameters

uint32_t bpp
bits per pixels

uint32_t depth
bit depth per pixel

Description

Computes a drm fourcc pixel format code for the given **bpp/depth** values. Useful in fbdev emulation code, since that deals in those values.

uint32_t **drm_driver_legacy_fb_format**(struct *drm_device* *dev, uint32_t bpp, uint32_t depth)

compute drm fourcc code from legacy description

Parameters

struct drm_device *dev
DRM device

uint32_t bpp
bits per pixels

uint32_t depth
bit depth per pixel

Description

Computes a drm fourcc pixel format code for the given **bpp/depth** values. Unlike *drm_mode_legacy_fb_format()* this looks at the drivers mode_config, and depending on the *drm_mode_config.quirk_addfb_prefer_host_byte_order* flag it returns little endian byte order or host byte order framebuffer formats.

const char ***drm_get_format_name**(uint32_t format, struct *drm_format_name_buf* *buf)

fill a string with a drm fourcc format's name

Parameters

uint32_t format
  format to compute name of

struct drm_format_name_buf *buf
  caller-supplied buffer

const struct *drm_format_info* ***drm_format_info**(u32 format)
  query information for a given format

Parameters

u32 format
  pixel format (DRM_FORMAT_*)

Description

The caller should only pass a supported pixel format to this function. Unsupported pixel formats will generate a warning in the kernel log.

Return

The instance of *struct drm_format_info* that describes the pixel format, or NULL if the format is unsupported.

const struct *drm_format_info* ***drm_get_format_info**(struct *drm_device* *dev, const struct drm_mode_fb_cmd2 *mode_cmd)
  query information for a given framebuffer configuration

Parameters

struct drm_device *dev
  DRM device

const struct drm_mode_fb_cmd2 *mode_cmd
  metadata from the userspace fb creation request

Return

The instance of *struct drm_format_info* that describes the pixel format, or NULL if the format is unsupported.

unsigned int **drm_format_info_block_width**(const struct *drm_format_info* *info, int plane)
  width in pixels of block.

Parameters

const struct drm_format_info *info
  pixel format info

int plane
  plane index

Return

The width in pixels of a block, depending on the plane index.

unsigned int **drm_format_info_block_height**(const struct *drm_format_info* *info, int plane)

height in pixels of a block

Parameters

const struct drm_format_info *info
pixel format info

int plane
plane index

Return

The height in pixels of a block, depending on the plane index.

uint64_t **drm_format_info_min_pitch**(const struct *drm_format_info* *info, int plane, unsigned int buffer_width)

computes the minimum required pitch in bytes

Parameters

const struct drm_format_info *info
pixel format info

int plane
plane index

unsigned int buffer_width
buffer width in pixels

Return

The minimum required pitch in bytes for a buffer by taking into consideration the pixel format information and the buffer width.

4.8 Dumb Buffer Objects

The KMS API doesn't standardize backing storage object creation and leaves it to driver-specific ioctls. Furthermore actually creating a buffer object even for GEM-based drivers is done through a driver-specific ioctl - GEM only has a common userspace interface for sharing and destroying objects. While not an issue for full-fledged graphics stacks that include device-specific userspace components (in libdrm for instance), this limit makes DRM-based early boot graphics unnecessarily complex.

Dumb objects partly alleviate the problem by providing a standard API to create dumb buffers suitable for scanout, which can then be used to create KMS frame buffers.

To support dumb objects drivers must implement the `drm_driver.dumb_create` operation. `drm_driver.dumb_destroy` defaults to `drm_gem_dumb_destroy()` if not set and `drm_driver.dumb_map_offset` defaults to `drm_gem_dumb_map_offset()`. See the callbacks for further details.

Note that dumb objects may not be used for gpu acceleration, as has been attempted on some ARM embedded platforms. Such drivers really must have a hardware-specific ioctl to allocate suitable buffer objects.

4.9 Plane Abstraction

A plane represents an image source that can be blended with or overlayed on top of a CRTC during the scanout process. Planes take their input data from a *drm_framebuffer* object. The plane itself specifies the cropping and scaling of that image, and where it is placed on the visible are of a display pipeline, represented by *drm_crtc*. A plane can also have additional properties that specify how the pixels are positioned and blended, like rotation or Z-position. All these properties are stored in *drm_plane_state*.

To create a plane, a KMS drivers allocates and zeroes an instances of *struct drm_plane* (possibly as part of a larger structure) and registers it with a call to *drm_universal_plane_init()*.

Cursor and overlay planes are optional. All drivers should provide one primary plane per CRTC to avoid surprising userspace too much. See *enum drm_plane_type* for a more in-depth discussion of these special uapi-relevant plane types. Special planes are associated with their CRTC by calling *drm_crtc_init_with_planes()*.

The type of a plane is exposed in the immutable "type" enumeration property, which has one of the following values: "Overlay" , "Primary" , "Cursor" .

4.9.1 Plane Functions Reference

struct **drm_plane_state**

mutable plane state

Definition

```
struct drm_plane_state {
  struct drm_plane *plane;
  struct drm_crtc *crtc;
  struct drm_framebuffer *fb;
  struct dma_fence *fence;
  int32_t crtc_x;
  int32_t crtc_y;
  uint32_t crtc_w, crtc_h;
  uint32_t src_x;
  uint32_t src_y;
  uint32_t src_h, src_w;
  u16 alpha;
  uint16_t pixel_blend_mode;
  unsigned int rotation;
  unsigned int zpos;
  unsigned int normalized_zpos;
```

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```
  enum drm_color_encoding color_encoding;
  enum drm_color_range color_range;
  struct drm_property_blob *fb_damage_clips;
  struct drm_rect src, dst;
  bool visible;
  struct drm_crtc_commit *commit;
  struct drm_atomic_state *state;
};
```

Members

plane
backpointer to the plane

crtc
Currently bound CRTC, NULL if disabled. Do not this write directly, use *drm_atomic_set_crtc_for_plane()*

fb
Currently bound framebuffer. Do not write this directly, use *drm_atomic_set_fb_for_plane()*

fence
Optional fence to wait for before scanning out **fb**. The core atomic code will set this when userspace is using explicit fencing. Do not write this field directly for a driver' s implicit fence, use *drm_atomic_set_fence_for_plane()* to ensure that an explicit fence is preserved.

Drivers should store any implicit fence in this from their *drm_plane_helper_funcs.prepare_fb* callback. See *drm_gem_fb_prepare_fb()* and *drm_gem_fb_simple_display_pipe_prepare_fb()* for suitable helpers.

crtc_x
Left position of visible portion of plane on crtc, signed dest location allows it to be partially off screen.

crtc_y
Upper position of visible portion of plane on crtc, signed dest location allows it to be partially off screen.

crtc_w
width of visible portion of plane on crtc

crtc_h
height of visible portion of plane on crtc

src_x
left position of visible portion of plane within plane (in 16.16 fixed point).

src_y
upper position of visible portion of plane within plane (in 16.16 fixed point).

src_h
height of visible portion of plane (in 16.16)

src_w
width of visible portion of plane (in 16.16)

alpha
Opacity of the plane with 0 as completely transparent and 0xffff as completely opaque. See *drm_plane_create_alpha_property()* for more details.

pixel_blend_mode
The alpha blending equation selection, describing how the pixels from the current plane are composited with the background. Value can be one of DRM_MODE_BLEND_*

rotation
Rotation of the plane. See *drm_plane_create_rotation_property()* for more details.

zpos
Priority of the given plane on crtc (optional).

User-space may set mutable zpos properties so that multiple active planes on the same CRTC have identical zpos values. This is a user-space bug, but drivers can solve the conflict by comparing the plane object IDs; the plane with a higher ID is stacked on top of a plane with a lower ID.

See *drm_plane_create_zpos_property()* and *drm_plane_create_zpos_immutable_prop* for more details.

normalized_zpos
Normalized value of zpos: unique, range from 0 to N-1 where N is the number of active planes for given crtc. Note that the driver must set *drm_mode_config.normalize_zpos* or call *drm_atomic_normalize_zpos()* to update this before it can be trusted.

color_encoding
Color encoding for non RGB formats

color_range
Color range for non RGB formats

fb_damage_clips
Blob representing damage (area in plane framebuffer that changed since last plane update) as an array of *drm_mode_rect* in framebuffer coodinates of the attached framebuffer. Note that unlike plane src, damage clips are not in 16.16 fixed point.

src
source coordinates of the plane (in 16.16).

When using *drm_atomic_helper_check_plane_state()*, the coordinates are clipped, but the driver may choose to use unclipped coordinates instead when the hardware performs the clipping automatically.

dst
clipped destination coordinates of the plane.

When using *drm_atomic_helper_check_plane_state()*, the coordinates are clipped, but the driver may choose to use unclipped coordinates instead when the hardware performs the clipping automatically.

visible
: Visibility of the plane. This can be false even if fb!=NULL and crtc!=NULL, due to clipping.

commit
: Tracks the pending commit to prevent use-after-free conditions, and for async plane updates.

  May be NULL.

state
: backpointer to global drm_atomic_state

Description

Please not that the destination coordinates **crtc_x**, **crtc_y**, **crtc_h** and **crtc_w** and the source coordinates **src_x**, **src_y**, **src_h** and **src_w** are the raw coordinates provided by userspace. Drivers should use *drm_atomic_helper_check_plane_state()* and only use the derived rectangles in **src** and **dst** to program the hardware.

struct **drm_plane_funcs**
: driver plane control functions

Definition

```
struct drm_plane_funcs {
  int (*update_plane)(struct drm_plane *plane,struct drm_crtc *crtc,
↪ struct drm_framebuffer *fb,int crtc_x, int crtc_y,unsigned int␣
↪crtc_w, unsigned int crtc_h,uint32_t src_x, uint32_t src_y,uint32_
↪t src_w, uint32_t src_h, struct drm_modeset_acquire_ctx *ctx);
  int (*disable_plane)(struct drm_plane *plane, struct drm_modeset_
↪acquire_ctx *ctx);
  void (*destroy)(struct drm_plane *plane);
  void (*reset)(struct drm_plane *plane);
  int (*set_property)(struct drm_plane *plane, struct drm_property␣
↪*property, uint64_t val);
  struct drm_plane_state *(*atomic_duplicate_state)(struct drm_
↪plane *plane);
  void (*atomic_destroy_state)(struct drm_plane *plane, struct drm_
↪plane_state *state);
  int (*atomic_set_property)(struct drm_plane *plane,struct drm_
↪plane_state *state,struct drm_property *property, uint64_t val);
  int (*atomic_get_property)(struct drm_plane *plane,const struct␣
↪drm_plane_state *state,struct drm_property *property, uint64_t␣
↪*val);
  int (*late_register)(struct drm_plane *plane);
  void (*early_unregister)(struct drm_plane *plane);
  void (*atomic_print_state)(struct drm_printer *p, const struct␣
↪drm_plane_state *state);
  bool (*format_mod_supported)(struct drm_plane *plane, uint32_t␣
↪format, uint64_t modifier);
};
```

Members

update_plane

This is the legacy entry point to enable and configure the plane for the given CRTC and framebuffer. It is never called to disable the plane, i.e. the passed-in crtc and fb paramters are never NULL.

The source rectangle in frame buffer memory coordinates is given by the src_x, src_y, src_w and src_h parameters (as 16.16 fixed point values). Devices that don' t support subpixel plane coordinates can ignore the fractional part.

The destination rectangle in CRTC coordinates is given by the crtc_x, crtc_y, crtc_w and crtc_h parameters (as integer values). Devices scale the source rectangle to the destination rectangle. If scaling is not supported, and the source rectangle size doesn' t match the destination rectangle size, the driver must return a -<errorname>EINVAL</errorname> error.

Drivers implementing atomic modeset should use *drm_atomic_helper_update_plane()* to implement this hook.

RETURNS:

0 on success or a negative error code on failure.

disable_plane

This is the legacy entry point to disable the plane. The DRM core calls this method in response to a DRM_IOCTL_MODE_SETPLANE IOCTL call with the frame buffer ID set to 0. Disabled planes must not be processed by the CRTC.

Drivers implementing atomic modeset should use *drm_atomic_helper_disable_plane()* to implement this hook.

RETURNS:

0 on success or a negative error code on failure.

destroy

Clean up plane resources. This is only called at driver unload time through *drm_mode_config_cleanup()* since a plane cannot be hotplugged in DRM.

reset

Reset plane hardware and software state to off. This function isn' t called by the core directly, only through *drm_mode_config_reset()*. It' s not a helper hook only for historical reasons.

Atomic drivers can use *drm_atomic_helper_plane_reset()* to reset atomic state using this hook.

set_property

This is the legacy entry point to update a property attached to the plane.

This callback is optional if the driver does not support any legacy driver-private properties. For atomic drivers it is not used because property handling is done entirely in the DRM core.

RETURNS:

0 on success or a negative error code on failure.

atomic_duplicate_state

Duplicate the current atomic state for this plane and return it. The core and helpers guarantee that any atomic state duplicated with this hook and still owned by the caller (i.e. not transferred to the driver by calling *drm_mode_config_funcs.atomic_commit*) will be cleaned up by calling the **atomic_destroy_state** hook in this structure.

This callback is mandatory for atomic drivers.

Atomic drivers which don't subclass *struct drm_plane_state* should use *drm_atomic_helper_plane_duplicate_state()*. Drivers that subclass the state structure to extend it with driver-private state should use *__drm_atomic_helper_plane_duplicate_state()* to make sure shared state is duplicated in a consistent fashion across drivers.

It is an error to call this hook before *drm_plane.state* has been initialized correctly.

NOTE:

If the duplicate state references refcounted resources this hook must acquire a reference for each of them. The driver must release these references again in **atomic_destroy_state**.

RETURNS:

Duplicated atomic state or NULL when the allocation failed.

atomic_destroy_state
Destroy a state duplicated with **atomic_duplicate_state** and release or unreference all resources it references

This callback is mandatory for atomic drivers.

atomic_set_property
Decode a driver-private property value and store the decoded value into the passed-in state structure. Since the atomic core decodes all standardized properties (even for extensions beyond the core set of properties which might not be implemented by all drivers) this requires drivers to subclass the state structure.

Such driver-private properties should really only be implemented for truly hardware/vendor specific state. Instead it is preferred to standardize atomic extension and decode the properties used to expose such an extension in the core.

Do not call this function directly, use drm_atomic_plane_set_property() instead.

This callback is optional if the driver does not support any driver-private atomic properties.

NOTE:

This function is called in the state assembly phase of atomic modesets, which can be aborted for any reason (including on userspace's request to just check whether a configuration would be possible). Drivers MUST NOT touch any persistent state (hardware or software) or data structures except the passed in **state** parameter.

Also since userspace controls in which order properties are set this function must not do any input validation (since the state update is incomplete and hence likely inconsistent). Instead any such input validation must be done in the various atomic_check callbacks.

RETURNS:

0 if the property has been found, -EINVAL if the property isn't implemented by the driver (which shouldn't ever happen, the core only asks for properties attached to this plane). No other validation is allowed by the driver. The core already checks that the property value is within the range (integer, valid enum value, …) the driver set when registering the property.

atomic_get_property
Reads out the decoded driver-private property. This is used to implement the GETPLANE IOCTL.

Do not call this function directly, use drm_atomic_plane_get_property() instead.

This callback is optional if the driver does not support any driver-private atomic properties.

RETURNS:

0 on success, -EINVAL if the property isn't implemented by the driver (which should never happen, the core only asks for properties attached to this plane).

late_register
This optional hook can be used to register additional userspace interfaces attached to the plane like debugfs interfaces. It is called late in the driver load sequence from *drm_dev_register()*. Everything added from this callback should be unregistered in the early_unregister callback.

Returns:

0 on success, or a negative error code on failure.

early_unregister
This optional hook should be used to unregister the additional userspace interfaces attached to the plane from **late_register**. It is called from *drm_dev_unregister()*, early in the driver unload sequence to disable userspace access before data structures are torndown.

atomic_print_state
If driver subclasses *struct drm_plane_state*, it should implement this optional hook for printing additional driver specific state.

Do not call this directly, use drm_atomic_plane_print_state() instead.

format_mod_supported
This optional hook is used for the DRM to determine if the given format/modifier combination is valid for the plane. This allows the DRM to generate the correct format bitmask (which formats apply to which modifier), and to valdiate modifiers at atomic_check time.

If not present, then any modifier in the plane's modifier list is allowed with any of the plane's formats.

Returns:

True if the given modifier is valid for that format on the plane. False otherwise.

enum **drm_plane_type**

uapi plane type enumeration

Constants

DRM_PLANE_TYPE_OVERLAY
Overlay planes represent all non-primary, non-cursor planes. Some drivers refer to these types of planes as "sprites" internally.

DRM_PLANE_TYPE_PRIMARY
Primary planes represent a "main" plane for a CRTC. Primary planes are the planes operated upon by CRTC modesetting and flipping operations described in the *drm_crtc_funcs.page_flip* and *drm_crtc_funcs.set_config* hooks.

DRM_PLANE_TYPE_CURSOR
Cursor planes represent a "cursor" plane for a CRTC. Cursor planes are the planes operated upon by the DRM_IOCTL_MODE_CURSOR and DRM_IOCTL_MODE_CURSOR2 IOCTLs.

Description

For historical reasons not all planes are made the same. This enumeration is used to tell the different types of planes apart to implement the different uapi semantics for them. For userspace which is universal plane aware and which is using that atomic IOCTL there's no difference between these planes (beyong what the driver and hardware can support of course).

For compatibility with legacy userspace, only overlay planes are made available to userspace by default. Userspace clients may set the DRM_CLIENT_CAP_UNIVERSAL_PLANES client capability bit to indicate that they wish to receive a universal plane list containing all plane types. See also *drm_for_each_legacy_plane()*.

WARNING: The values of this enum is UABI since they're exposed in the "type" property.

struct **drm_plane**

central DRM plane control structure

Definition

```
struct drm_plane {
  struct drm_device *dev;
  struct list_head head;
  char *name;
  struct drm_modeset_lock mutex;
  struct drm_mode_object base;
  uint32_t possible_crtcs;
  uint32_t *format_types;
  unsigned int format_count;
  bool format_default;
```

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```
  uint64_t *modifiers;
  unsigned int modifier_count;
  struct drm_crtc *crtc;
  struct drm_framebuffer *fb;
  struct drm_framebuffer *old_fb;
  const struct drm_plane_funcs *funcs;
  struct drm_object_properties properties;
  enum drm_plane_type type;
  unsigned index;
  const struct drm_plane_helper_funcs *helper_private;
  struct drm_plane_state *state;
  struct drm_property *alpha_property;
  struct drm_property *zpos_property;
  struct drm_property *rotation_property;
  struct drm_property *blend_mode_property;
  struct drm_property *color_encoding_property;
  struct drm_property *color_range_property;
};
```

Members

dev
DRM device this plane belongs to

head
List of all planes on **dev**, linked from *drm_mode_config.plane_list*. Invariant over the lifetime of **dev** and therefore does not need locking.

name
human readable name, can be overwritten by the driver

mutex
Protects modeset plane state, together with the *drm_crtc.mutex* of CRTC this plane is linked to (when active, getting activated or getting disabled).

For atomic drivers specifically this protects **state**.

base
base mode object

possible_crtcs
pipes this plane can be bound to constructed from *drm_crtc_mask()*

format_types
array of formats supported by this plane

format_count
Size of the array pointed at by **format_types**.

format_default
driver hasn’ t supplied supported formats for the plane. Used by the drm_plane_init compatibility wrapper only.

modifiers
array of modifiers supported by this plane

modifier_count
Size of the array pointed at by **modifier_count**.

crtc
Currently bound CRTC, only meaningful for non-atomic drivers. For atomic drivers this is forced to be NULL, atomic drivers should instead check *drm_plane_state.crtc*.

fb
Currently bound framebuffer, only meaningful for non-atomic drivers. For atomic drivers this is forced to be NULL, atomic drivers should instead check *drm_plane_state.fb*.

old_fb
Temporary tracking of the old fb while a modeset is ongoing. Only used by non-atomic drivers, forced to be NULL for atomic drivers.

funcs
plane control functions

properties
property tracking for this plane

type
Type of plane, see *enum drm_plane_type* for details.

index
Position inside the mode_config.list, can be used as an array index. It is invariant over the lifetime of the plane.

helper_private
mid-layer private data

state
Current atomic state for this plane.

This is protected by **mutex**. Note that nonblocking atomic commits access the current plane state without taking locks. Either by going through the *struct drm_atomic_state* pointers, see *for_each_oldnew_plane_in_state()*, *for_each_old_plane_in_state()* and *for_each_new_plane_in_state()*. Or through careful ordering of atomic commit operations as implemented in the atomic helpers, see *struct drm_crtc_commit*.

alpha_property
Optional alpha property for this plane. See *drm_plane_create_alpha_property()*.

zpos_property
Optional zpos property for this plane. See *drm_plane_create_zpos_property()*.

rotation_property
Optional rotation property for this plane. See *drm_plane_create_rotation_property()*.

blend_mode_property
Optional "pixel blend mode" enum property for this plane. Blend mode property represents the alpha blending equation selection, describing how the

pixels from the current plane are composited with the background.

`color_encoding_property`
Optional "COLOR_ENCODING" enum property for specifying color encoding for non RGB formats. See *`drm_plane_create_color_properties()`*.

`color_range_property`
Optional "COLOR_RANGE" enum property for specifying color range for non RGB formats. See *`drm_plane_create_color_properties()`*.

Description

Planes represent the scanout hardware of a display block. They receive their input data from a *`drm_framebuffer`* and feed it to a *`drm_crtc`*. Planes control the color conversion, see *Plane Composition Properties* for more details, and are also involved in the color conversion of input pixels, see *Color Management Properties* for details on that.

unsigned int **`drm_plane_index`**(const struct *drm_plane* *plane)
find the index of a registered plane

Parameters

`const struct drm_plane *plane`
plane to find index for

Description

Given a registered plane, return the index of that plane within a DRM device' s list of planes.

u32 **`drm_plane_mask`**(const struct *drm_plane* *plane)
find the mask of a registered plane

Parameters

`const struct drm_plane *plane`
plane to find mask for

struct *drm_plane* ***`drm_plane_find`**(struct *drm_device* *dev, struct *drm_file* *file_priv, uint32_t id)
find a *`drm_plane`*

Parameters

`struct drm_device *dev`
DRM device

`struct drm_file *file_priv`
drm file to check for lease against.

`uint32_t id`
plane id

Description

Returns the plane with **id**, NULL if it doesn' t exist. Simple wrapper around *`drm_mode_object_find()`*.

drm_for_each_plane_mask

`drm_for_each_plane_mask (plane, dev, plane_mask)`

iterate over planes specified by bitmask

Parameters

plane
: the loop cursor

dev
: the DRM device

plane_mask
: bitmask of plane indices

Description

Iterate over all planes specified by bitmask.

drm_for_each_legacy_plane

`drm_for_each_legacy_plane (plane, dev)`

iterate over all planes for legacy userspace

Parameters

plane
: the loop cursor

dev
: the DRM device

Description

Iterate over all legacy planes of **dev**, excluding primary and cursor planes. This is useful for implementing userspace apis when userspace is not universal plane aware. See also *enum drm_plane_type*.

drm_for_each_plane

`drm_for_each_plane (plane, dev)`

iterate over all planes

Parameters

plane
: the loop cursor

dev
: the DRM device

Description

Iterate over all planes of **dev**, include primary and cursor planes.

unsigned int **drm_plane_get_damage_clips_count**(const struct *drm_plane_state* *state)

Returns damage clips count.

Parameters

const struct drm_plane_state *state
Plane state.

Description

Simple helper to get the number of *drm_mode_rect* clips set by user-space during plane update.

Return

Number of clips in plane fb_damage_clips blob property.

struct *drm_mode_rect* ***drm_plane_get_damage_clips**(const struct *drm_plane_state* *state)

Returns damage clips.

Parameters

const struct drm_plane_state *state
Plane state.

Description

Note that this function returns uapi type *drm_mode_rect*. Drivers might instead be interested in internal *drm_rect* which can be obtained by calling *drm_helper_get_plane_damage_clips()*.

Return

Damage clips in plane fb_damage_clips blob property.

int **drm_universal_plane_init**(struct *drm_device* *dev, struct *drm_plane* *plane, uint32_t possible_crtcs, const struct *drm_plane_funcs* *funcs, const uint32_t *formats, unsigned int format_count, const uint64_t *format_modifiers, enum *drm_plane_type* type, const char *name, ...)

Initialize a new universal plane object

Parameters

struct drm_device *dev
DRM device

struct drm_plane *plane
plane object to init

uint32_t possible_crtcs
bitmask of possible CRTCs

const struct drm_plane_funcs *funcs
callbacks for the new plane

const uint32_t *formats
array of supported formats (DRM_FORMAT_*)

unsigned int format_count
number of elements in **formats**

const uint64_t *format_modifiers
: array of struct drm_format modifiers terminated by DRM_FORMAT_MOD_INVALID

enum drm_plane_type type
: type of plane (overlay, primary, cursor)

const char *name
: printf style format string for the plane name, or NULL for default name

...
: variable arguments

Description

Initializes a plane object of type **type**.

Return

Zero on success, error code on failure.

int **drm_plane_init**(struct *drm_device* *dev, struct *drm_plane* *plane, uint32_t possible_crtcs, const struct *drm_plane_funcs* *funcs, const uint32_t *formats, unsigned int format_count, bool is_primary)

Initialize a legacy plane

Parameters

struct drm_device *dev
: DRM device

struct drm_plane *plane
: plane object to init

uint32_t possible_crtcs
: bitmask of possible CRTCs

const struct drm_plane_funcs *funcs
: callbacks for the new plane

const uint32_t *formats
: array of supported formats (DRM_FORMAT_*)

unsigned int format_count
: number of elements in **formats**

bool is_primary
: plane type (primary vs overlay)

Description

Legacy API to initialize a DRM plane.

New drivers should call *drm_universal_plane_init()* instead.

Return

Zero on success, error code on failure.

void **drm_plane_cleanup**(struct *drm_plane* *plane)

Clean up the core plane usage

Parameters

struct drm_plane *plane
plane to cleanup

Description

This function cleans up **plane** and removes it from the DRM mode setting core. Note that the function does *not* free the plane structure itself, this is the responsibility of the caller.

struct *drm_plane* ***drm_plane_from_index**(struct *drm_device* *dev, int idx)

find the registered plane at an index

Parameters

struct drm_device *dev
DRM device

int idx
index of registered plane to find for

Description

Given a plane index, return the registered plane from DRM device’s list of planes with matching index. This is the inverse of *drm_plane_index()*.

void **drm_plane_force_disable**(struct *drm_plane* *plane)

Forcibly disable a plane

Parameters

struct drm_plane *plane
plane to disable

Description

Forces the plane to be disabled.

Used when the plane’s current framebuffer is destroyed, and when restoring fbdev mode.

Note that this function is not suitable for atomic drivers, since it doesn’t wire through the lock acquisition context properly and hence can’t handle retries or driver private locks. You probably want to use *drm_atomic_helper_disable_plane()* or *drm_atomic_helper_disable_planes_on_crtc()* instead.

int **drm_mode_plane_set_obj_prop**(struct *drm_plane* *plane, struct *drm_property* *property, uint64_t value)

set the value of a property

Parameters

struct drm_plane *plane
drm plane object to set property value for

`struct drm_property *property`
property to set

`uint64_t value`
value the property should be set to

Description

This functions sets a given property on a given plane object. This function calls the driver' s ->set_property callback and changes the software state of the property if the callback succeeds.

Return

Zero on success, error code on failure.

bool **`drm_any_plane_has_format`**(struct *drm_device* *dev, u32 format, u64 modifier)

Check whether any plane supports this format and modifier combination

Parameters

`struct drm_device *dev`
DRM device

`u32 format`
pixel format (DRM_FORMAT_*)

`u64 modifier`
data layout modifier

Return

Whether at least one plane supports the specified format and modifier combination.

4.10 Display Modes Function Reference

enum **`drm_mode_status`**

hardware support status of a mode

Constants

`MODE_OK`
Mode OK

`MODE_HSYNC`
hsync out of range

`MODE_VSYNC`
vsync out of range

`MODE_H_ILLEGAL`
mode has illegal horizontal timings

`MODE_V_ILLEGAL`
mode has illegal vertical timings

MODE_BAD_WIDTH
requires an unsupported linepitch

MODE_NOMODE
no mode with a matching name

MODE_NO_INTERLACE
interlaced mode not supported

MODE_NO_DBLESCAN
doublescan mode not supported

MODE_NO_VSCAN
multiscan mode not supported

MODE_MEM
insufficient video memory

MODE_VIRTUAL_X
mode width too large for specified virtual size

MODE_VIRTUAL_Y
mode height too large for specified virtual size

MODE_MEM_VIRT
insufficient video memory given virtual size

MODE_NOCLOCK
no fixed clock available

MODE_CLOCK_HIGH
clock required is too high

MODE_CLOCK_LOW
clock required is too low

MODE_CLOCK_RANGE
clock/mode isn’t in a ClockRange

MODE_BAD_HVALUE
horizontal timing was out of range

MODE_BAD_VVALUE
vertical timing was out of range

MODE_BAD_VSCAN
VScan value out of range

MODE_HSYNC_NARROW
horizontal sync too narrow

MODE_HSYNC_WIDE
horizontal sync too wide

MODE_HBLANK_NARROW
horizontal blanking too narrow

MODE_HBLANK_WIDE
horizontal blanking too wide

MODE_VSYNC_NARROW
vertical sync too narrow

MODE_VSYNC_WIDE
vertical sync too wide

MODE_VBLANK_NARROW
vertical blanking too narrow

MODE_VBLANK_WIDE
vertical blanking too wide

MODE_PANEL
exceeds panel dimensions

MODE_INTERLACE_WIDTH
width too large for interlaced mode

MODE_ONE_WIDTH
only one width is supported

MODE_ONE_HEIGHT
only one height is supported

MODE_ONE_SIZE
only one resolution is supported

MODE_NO_REDUCED
monitor doesn't accept reduced blanking

MODE_NO_STEREO
stereo modes not supported

MODE_NO_420
ycbcr 420 modes not supported

MODE_STALE
mode has become stale

MODE_BAD
unspecified reason

MODE_ERROR
error condition

Description

This enum is used to filter out modes not supported by the driver/hardware combination.

DRM_SIMPLE_MODE

`DRM_SIMPLE_MODE (hd, vd, hd_mm, vd_mm)`

Simple display mode

Parameters

hd
Horizontal resolution, width

vd
  Vertical resolution, height

hd_mm
  Display width in millimeters

vd_mm
  Display height in millimeters

Description

This macro initializes a *drm_display_mode* that only contains info about resolution and physical size.

struct **drm_display_mode**
  DRM kernel-internal display mode structure

Definition

```
struct drm_display_mode {
  int clock;
  u16 hdisplay;
  u16 hsync_start;
  u16 hsync_end;
  u16 htotal;
  u16 hskew;
  u16 vdisplay;
  u16 vsync_start;
  u16 vsync_end;
  u16 vtotal;
  u16 vscan;
  u32 flags;
  int crtc_clock;
  u16 crtc_hdisplay;
  u16 crtc_hblank_start;
  u16 crtc_hblank_end;
  u16 crtc_hsync_start;
  u16 crtc_hsync_end;
  u16 crtc_htotal;
  u16 crtc_hskew;
  u16 crtc_vdisplay;
  u16 crtc_vblank_start;
  u16 crtc_vblank_end;
  u16 crtc_vsync_start;
  u16 crtc_vsync_end;
  u16 crtc_vtotal;
  u16 width_mm;
  u16 height_mm;
  u8 type;
  bool expose_to_userspace;
  struct list_head head;
  char name[DRM_DISPLAY_MODE_LEN];
  enum drm_mode_status status;
```

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```
  enum hdmi_picture_aspect picture_aspect_ratio;
};
```

Members

`clock`
Pixel clock in kHz.

`hdisplay`
horizontal display size

`hsync_start`
horizontal sync start

`hsync_end`
horizontal sync end

`htotal`
horizontal total size

`hskew`
horizontal skew?!

`vdisplay`
vertical display size

`vsync_start`
vertical sync start

`vsync_end`
vertical sync end

`vtotal`
vertical total size

`vscan`
vertical scan?!

`flags`
Sync and timing flags:

- DRM_MODE_FLAG_PHSYNC: horizontal sync is active high.
- DRM_MODE_FLAG_NHSYNC: horizontal sync is active low.
- DRM_MODE_FLAG_PVSYNC: vertical sync is active high.
- DRM_MODE_FLAG_NVSYNC: vertical sync is active low.
- DRM_MODE_FLAG_INTERLACE: mode is interlaced.
- DRM_MODE_FLAG_DBLSCAN: mode uses doublescan.
- DRM_MODE_FLAG_CSYNC: mode uses composite sync.
- DRM_MODE_FLAG_PCSYNC: composite sync is active high.
- DRM_MODE_FLAG_NCSYNC: composite sync is active low.
- DRM_MODE_FLAG_HSKEW: hskew provided (not used?).

- DRM_MODE_FLAG_BCAST: <deprecated>
- DRM_MODE_FLAG_PIXMUX: <deprecated>
- DRM_MODE_FLAG_DBLCLK: double-clocked mode.
- DRM_MODE_FLAG_CLKDIV2: half-clocked mode.

Additionally there's flags to specify how 3D modes are packed:

- DRM_MODE_FLAG_3D_NONE: normal, non-3D mode.
- DRM_MODE_FLAG_3D_FRAME_PACKING: 2 full frames for left and right.
- DRM_MODE_FLAG_3D_FIELD_ALTERNATIVE: interleaved like fields.
- DRM_MODE_FLAG_3D_LINE_ALTERNATIVE: interleaved lines.
- DRM_MODE_FLAG_3D_SIDE_BY_SIDE_FULL: side-by-side full frames.
- DRM_MODE_FLAG_3D_L_DEPTH: ?
- DRM_MODE_FLAG_3D_L_DEPTH_GFX_GFX_DEPTH: ?
- DRM_MODE_FLAG_3D_TOP_AND_BOTTOM: frame split into top and bottom parts.
- DRM_MODE_FLAG_3D_SIDE_BY_SIDE_HALF: frame split into left and right parts.

crtc_clock
Actual pixel or dot clock in the hardware. This differs from the logical **clock** when e.g. using interlacing, double-clocking, stereo modes or other fancy stuff that changes the timings and signals actually sent over the wire.

This is again in kHz.

Note that with digital outputs like HDMI or DP there's usually a massive confusion between the dot clock and the signal clock at the bit encoding level. Especially when a 8b/10b encoding is used and the difference is exactly a factor of 10.

crtc_hdisplay
hardware mode horizontal display size

crtc_hblank_start
hardware mode horizontal blank start

crtc_hblank_end
hardware mode horizontal blank end

crtc_hsync_start
hardware mode horizontal sync start

crtc_hsync_end
hardware mode horizontal sync end

crtc_htotal
hardware mode horizontal total size

crtc_hskew
hardware mode horizontal skew?!

crtc_vdisplay
hardware mode vertical display size

crtc_vblank_start
hardware mode vertical blank start

crtc_vblank_end
hardware mode vertical blank end

crtc_vsync_start
hardware mode vertical sync start

crtc_vsync_end
hardware mode vertical sync end

crtc_vtotal
hardware mode vertical total size

width_mm
Addressable size of the output in mm, projectors should set this to 0.

height_mm
Addressable size of the output in mm, projectors should set this to 0.

type
A bitmask of flags, mostly about the source of a mode. Possible flags are:

- DRM_MODE_TYPE_PREFERRED: Preferred mode, usually the native resolution of an LCD panel. There should only be one preferred mode per connector at any given time.
- DRM_MODE_TYPE_DRIVER: Mode created by the driver, which is all of them really. Drivers must set this bit for all modes they create and expose to userspace.
- DRM_MODE_TYPE_USERDEF: Mode defined or selected via the kernel command line.

Plus a big list of flags which shouldn't be used at all, but are still around since these flags are also used in the userspace ABI. We no longer accept modes with these types though:

- DRM_MODE_TYPE_BUILTIN: Meant for hard-coded modes, unused. Use DRM_MODE_TYPE_DRIVER instead.
- DRM_MODE_TYPE_DEFAULT: Again a leftover, use DRM_MODE_TYPE_PREFERRED instead.
- DRM_MODE_TYPE_CLOCK_C and DRM_MODE_TYPE_CRTC_C: Define leftovers which are stuck around for hysterical raisins only. No one has an idea what they were meant for. Don't use.

expose_to_userspace
Indicates whether the mode is to be exposed to the userspace. This is to maintain a set of exposed modes while preparing user-mode's list in drm_mode_getconnector ioctl. The purpose of this only lies in the ioctl function, and is not to be used outside the function.

head
struct list_head for mode lists.

name
: Human-readable name of the mode, filled out with *drm_mode_set_name()*.

status
: Status of the mode, used to filter out modes not supported by the hardware. See enum *drm_mode_status*.

picture_aspect_ratio
: Field for setting the HDMI picture aspect ratio of a mode.

Description

The horizontal and vertical timings are defined per the following diagram.

```
         Active                 Front           Sync           Back
         Region                 Porch                          Porch
<-----------------------><----------------><-------------><---------
↪----->
  //////////////////////|
 ////////////////////// |
//////////////////////  |..................               ..........
↪......
                                           _______________
<----- [hv]display ----->
<------------- [hv]sync_start ------------>
<--------------------- [hv]sync_end --------------------->
<-------------------------------- [hv]total ------------------------
↪----->*
```

This structure contains two copies of timings. First are the plain timings, which specify the logical mode, as it would be for a progressive 1:1 scanout at the refresh rate userspace can observe through vblank timestamps. Then there's the hardware timings, which are corrected for interlacing, double-clocking and similar things. They are provided as a convenience, and can be appropriately computed using *drm_mode_set_crtcinfo()*.

For printing you can use DRM_MODE_FMT and *DRM_MODE_ARG()*.

DRM_MODE_FMT

`DRM_MODE_FMT ()`

printf string for *struct drm_display_mode*

Parameters

DRM_MODE_ARG

`DRM_MODE_ARG (m)`

printf arguments for *struct drm_display_mode*

Parameters

m
: display mode

bool **drm_mode_is_stereo**(const struct *drm_display_mode* *mode)

check for stereo mode flags

Parameters

const struct drm_display_mode *mode

drm_display_mode to check

Return

True if the mode is one of the stereo modes (like side-by-side), false if not.

void **drm_mode_debug_printmodeline**(const struct *drm_display_mode* *mode)

print a mode to dmesg

Parameters

const struct drm_display_mode *mode

mode to print

Description

Describe **mode** using DRM_DEBUG.

struct *drm_display_mode* ***drm_mode_create**(struct *drm_device* *dev)

create a new display mode

Parameters

struct drm_device *dev

DRM device

Description

Create a new, cleared drm_display_mode with kzalloc, allocate an ID for it and return it.

Return

Pointer to new mode on success, NULL on error.

void **drm_mode_destroy**(struct *drm_device* *dev, struct *drm_display_mode* *mode)

remove a mode

Parameters

struct drm_device *dev

DRM device

struct drm_display_mode *mode

mode to remove

Description

Release **mode**' s unique ID, then free it **mode** structure itself using kfree.

void **drm_mode_probed_add**(struct *drm_connector* *connector, struct *drm_display_mode* *mode)

add a mode to a connector' s probed_mode list

Parameters

struct drm_connector *connector
connector the new mode

struct drm_display_mode *mode
mode data

Description

Add **mode** to **connector**' s probed_mode list for later use. This list should then in a second step get filtered and all the modes actually supported by the hardware moved to the **connector**' s modes list.

struct *drm_display_mode* ***drm_cvt_mode**(struct *drm_device* *dev, int hdisplay, int vdisplay, int vrefresh, bool reduced, bool interlaced, bool margins)

create a modeline based on the CVT algorithm

Parameters

struct drm_device *dev
drm device

int hdisplay
hdisplay size

int vdisplay
vdisplay size

int vrefresh
vrefresh rate

bool reduced
whether to use reduced blanking

bool interlaced
whether to compute an interlaced mode

bool margins
whether to add margins (borders)

Description

This function is called to generate the modeline based on CVT algorithm according to the hdisplay, vdisplay, vrefresh. It is based from the VESA(TM) Coordinated Video Timing Generator by Graham Loveridge April 9, 2003 available at http://www.elo.utfsm.cl/~elo212/docs/CVTd6r1.xls

And it is copied from xf86CVTmode in xserver/hw/xfree86/modes/xf86cvt.c. What I have done is to translate it by using integer calculation.

Return

The modeline based on the CVT algorithm stored in a drm_display_mode object. The display mode object is allocated with *drm_mode_create()*. Returns NULL when no mode could be allocated.

struct *drm_display_mode* ***drm_gtf_mode_complex***(struct *drm_device* *dev, int hdisplay, int vdisplay, int vrefresh, bool interlaced, int margins, int GTF_M, int GTF_2C, int GTF_K, int GTF_2J)

create the modeline based on the full GTF algorithm

Parameters

struct drm_device *dev
drm device

int hdisplay
hdisplay size

int vdisplay
vdisplay size

int vrefresh
vrefresh rate.

bool interlaced
whether to compute an interlaced mode

int margins
desired margin (borders) size

int GTF_M
extended GTF formula parameters

int GTF_2C
extended GTF formula parameters

int GTF_K
extended GTF formula parameters

int GTF_2J
extended GTF formula parameters

Description

GTF feature blocks specify C and J in multiples of 0.5, so we pass them in here multiplied by two. For a C of 40, pass in 80.

Return

The modeline based on the full GTF algorithm stored in a drm_display_mode object. The display mode object is allocated with *drm_mode_create()*. Returns NULL when no mode could be allocated.

struct *drm_display_mode* ***drm_gtf_mode***(struct *drm_device* *dev, int hdisplay, int vdisplay, int vrefresh, bool interlaced, int margins)

create the modeline based on the GTF algorithm

Parameters

struct drm_device *dev
drm device

int hdisplay
hdisplay size

int vdisplay
vdisplay size

int vrefresh
vrefresh rate.

bool interlaced
whether to compute an interlaced mode

int margins
desired margin (borders) size

Description

return the modeline based on GTF algorithm

This function is to create the modeline based on the GTF algorithm. Generalized Timing Formula is derived from:

> GTF Spreadsheet by Andy Morrish (1/5/97) available at https://www.vesa.org

And it is copied from the file of xserver/hw/xfree86/modes/xf86gtf.c. What I have done is to translate it by using integer calculation. I also refer to the function of fb_get_mode in the file of drivers/video/fbmon.c

Standard GTF parameters:

```
M = 600
C = 40
K = 128
J = 20
```

Return

The modeline based on the GTF algorithm stored in a drm_display_mode object. The display mode object is allocated with *drm_mode_create()*. Returns NULL when no mode could be allocated.

void **drm_display_mode_from_videomode**(const struct videomode *vm, struct *drm_display_mode* *dmode)

fill in **dmode** using **vm**,

Parameters

const struct videomode *vm
videomode structure to use as source

struct drm_display_mode *dmode
drm_display_mode structure to use as destination

Description

Fills out **dmode** using the display mode specified in **vm**.

void **drm_display_mode_to_videomode**(const struct *drm_display_mode* *dmode, struct videomode *vm)

fill in **vm** using **dmode**,

Parameters

const struct drm_display_mode *dmode
drm_display_mode structure to use as source

struct videomode *vm
videomode structure to use as destination

Description

Fills out **vm** using the display mode specified in **dmode**.

void **drm_bus_flags_from_videomode**(const struct videomode *vm, u32 *bus_flags)

extract information about pixelclk and DE polarity from videomode and store it in a separate variable

Parameters

const struct videomode *vm
videomode structure to use

u32 *bus_flags
information about pixelclk, sync and DE polarity will be stored here

Description

Sets DRM_BUS_FLAG_DE_(LOW|HIGH), DRM_BUS_FLAG_PIXDATA_DRIVE_(POS|NEG)EDGE and DISPLAY_FLAGS_SYNC_(POS|NEG)EDGE in **bus_flags** according to DISPLAY_FLAGS found in **vm**

int **of_get_drm_display_mode**(struct device_node *np, struct *drm_display_mode* *dmode, u32 *bus_flags, int index)

get a drm_display_mode from devicetree

Parameters

struct device_node *np
device_node with the timing specification

struct drm_display_mode *dmode
will be set to the return value

u32 *bus_flags
information about pixelclk, sync and DE polarity

int index
index into the list of display timings in devicetree

Description

This function is expensive and should only be used, if only one mode is to be read from DT. To get multiple modes start with of_get_display_timings and work with that instead.

Return

0 on success, a negative errno code when no of videomode node was found.

void **drm_mode_set_name**(struct *drm_display_mode* *mode)

set the name on a mode

Parameters

struct drm_display_mode *mode
name will be set in this mode

Description

Set the name of **mode** to a standard format which is <hdisplay>x<vdisplay> with an optional 'i' suffix for interlaced modes.

int **drm_mode_vrefresh**(const struct *drm_display_mode* *mode)

get the vrefresh of a mode

Parameters

const struct drm_display_mode *mode
mode

Return

modes' s vrefresh rate in Hz, rounded to the nearest integer. Calculates the value first if it is not yet set.

void **drm_mode_get_hv_timing**(const struct *drm_display_mode* *mode, int *hdisplay, int *vdisplay)

Fetches hdisplay/vdisplay for given mode

Parameters

const struct drm_display_mode *mode
mode to query

int *hdisplay
hdisplay value to fill in

int *vdisplay
vdisplay value to fill in

Description

The vdisplay value will be doubled if the specified mode is a stereo mode of the appropriate layout.

void **drm_mode_set_crtcinfo**(struct *drm_display_mode* *p, int adjust_flags)

set CRTC modesetting timing parameters

Parameters

struct drm_display_mode *p
mode

int adjust_flags
a combination of adjustment flags

Description

Setup the CRTC modesetting timing parameters for **p**, adjusting if necessary.

- The CRTC_INTERLACE_HALVE_V flag can be used to halve vertical timings of interlaced modes.
- The CRTC_STEREO_DOUBLE flag can be used to compute the timings for buffers containing two eyes (only adjust the timings when needed, eg. for "frame packing" or "side by side full").
- The CRTC_NO_DBLSCAN and CRTC_NO_VSCAN flags request that adjustment *not* be performed for doublescan and vscan > 1 modes respectively.

void **drm_mode_copy**(struct *drm_display_mode* *dst, const struct *drm_display_mode* *src)

copy the mode

Parameters

struct drm_display_mode *dst
mode to overwrite

const struct drm_display_mode *src
mode to copy

Description

Copy an existing mode into another mode, preserving the object id and list head of the destination mode.

struct *drm_display_mode* ***drm_mode_duplicate**(struct *drm_device* *dev, const struct *drm_display_mode* *mode)

allocate and duplicate an existing mode

Parameters

struct drm_device *dev
drm_device to allocate the duplicated mode for

const struct drm_display_mode *mode
mode to duplicate

Description

Just allocate a new mode, copy the existing mode into it, and return a pointer to it. Used to create new instances of established modes.

Return

Pointer to duplicated mode on success, NULL on error.

bool **drm_mode_match**(const struct *drm_display_mode* *mode1, const struct *drm_display_mode* *mode2, unsigned int match_flags)

test modes for (partial) equality

Parameters

const struct drm_display_mode *mode1
first mode

const struct drm_display_mode *mode2
second mode

unsigned int match_flags
which parts need to match (DRM_MODE_MATCH_*)

Description

Check to see if **mode1** and **mode2** are equivalent.

Return

True if the modes are (partially) equal, false otherwise.

bool **drm_mode_equal**(const struct *drm_display_mode* *mode1, const struct *drm_display_mode* *mode2)

test modes for equality

Parameters

const struct drm_display_mode *mode1
first mode

const struct drm_display_mode *mode2
second mode

Description

Check to see if **mode1** and **mode2** are equivalent.

Return

True if the modes are equal, false otherwise.

bool **drm_mode_equal_no_clocks**(const struct *drm_display_mode* *mode1, const struct *drm_display_mode* *mode2)

test modes for equality

Parameters

const struct drm_display_mode *mode1
first mode

const struct drm_display_mode *mode2
second mode

Description

Check to see if **mode1** and **mode2** are equivalent, but don't check the pixel clocks.

Return

True if the modes are equal, false otherwise.

bool **drm_mode_equal_no_clocks_no_stereo**(const struct *drm_display_mode* *mode1, const struct *drm_display_mode* *mode2)

test modes for equality

Parameters

const struct drm_display_mode *mode1
first mode

const struct drm_display_mode *mode2
: second mode

Description

Check to see if **mode1** and **mode2** are equivalent, but don't check the pixel clocks nor the stereo layout.

Return

True if the modes are equal, false otherwise.

enum *drm_mode_status* **drm_mode_validate_driver**(struct *drm_device* *dev, const struct *drm_display_mode* *mode)

make sure the mode is somewhat sane

Parameters

struct drm_device *dev
: drm device

const struct drm_display_mode *mode
: mode to check

Description

First do basic validation on the mode, and then allow the driver to check for device/driver specific limitations via the optional *drm_mode_config_helper_funcs.mode_valid* hook.

Return

The mode status

enum *drm_mode_status* **drm_mode_validate_size**(const struct *drm_display_mode* *mode, int maxX, int maxY)

make sure modes adhere to size constraints

Parameters

const struct drm_display_mode *mode
: mode to check

int maxX
: maximum width

int maxY
: maximum height

Description

This function is a helper which can be used to validate modes against size limitations of the DRM device/connector. If a mode is too big its status member is updated with the appropriate validation failure code. The list itself is not changed.

Return

The mode status

enum *drm_mode_status* **drm_mode_validate_ycbcr420**(const struct *drm_display_mode* *mode, struct *drm_connector* *connector)

add 'ycbcr420-only' modes only when allowed

Parameters

const struct drm_display_mode *mode
mode to check

struct drm_connector *connector
drm connector under action

Description

This function is a helper which can be used to filter out any YCBCR420 only mode, when the source doesn't support it.

Return

The mode status

void **drm_mode_prune_invalid**(struct *drm_device* *dev, struct list_head *mode_list, bool verbose)

remove invalid modes from mode list

Parameters

struct drm_device *dev
DRM device

struct list_head *mode_list
list of modes to check

bool verbose
be verbose about it

Description

This helper function can be used to prune a display mode list after validation has been completed. All modes whose status is not MODE_OK will be removed from the list, and if **verbose** the status code and mode name is also printed to dmesg.

void **drm_mode_sort**(struct list_head *mode_list)

sort mode list

Parameters

struct list_head *mode_list
list of drm_display_mode structures to sort

Description

Sort **mode_list** by favorability, moving good modes to the head of the list.

void **drm_connector_list_update**(struct *drm_connector* *connector)

update the mode list for the connector

Parameters

`struct drm_connector *connector`
the connector to update

Description

This moves the modes from the **connector** probed_modes list to the actual mode list. It compares the probed mode against the current list and only adds different/new modes.

This is just a helper functions doesn't validate any modes itself and also doesn't prune any invalid modes. Callers need to do that themselves.

bool **`drm_mode_parse_command_line_for_connector`**(const char *mode_option, const struct *drm_connector* *connector, struct *drm_cmdline_mode* *mode)

parse command line modeline for connector

Parameters

`const char *mode_option`
optional per connector mode option

`const struct drm_connector *connector`
connector to parse modeline for

`struct drm_cmdline_mode *mode`
preallocated drm_cmdline_mode structure to fill out

Description

This parses **mode_option** command line modeline for modes and options to configure the connector. If **mode_option** is NULL the default command line modeline in fb_mode_option will be parsed instead.

This uses the same parameters as the fb modedb.c, except for an extra force-enable, force-enable-digital and force-disable bit at the end:

```
<xres>x<yres>[M][R][-<bpp>][@<refresh>][i][m][eDd]
```

Additionals options can be provided following the mode, using a comma to separate each option. Valid options can be found in Documentation/fb/modedb.rst.

The intermediate drm_cmdline_mode structure is required to store additional options from the command line modline like the force-enable/disable flag.

Return

True if a valid modeline has been parsed, false otherwise.

struct *drm_display_mode* ***`drm_mode_create_from_cmdline_mode`**(struct *drm_device* *dev, struct *drm_cmdline_mode* *cmd)

convert a command line modeline into a DRM display mode

Parameters

`struct drm_device *dev`
DRM device to create the new mode for

`struct drm_cmdline_mode *cmd`
input command line modeline

Return

Pointer to converted mode on success, NULL on error.

bool **`drm_mode_is_420_only`**(const struct *drm_display_info* *display, const struct *drm_display_mode* *mode)

if a given videomode can be only supported in YCBCR420 output format

Parameters

`const struct drm_display_info *display`
display under action

`const struct drm_display_mode *mode`
video mode to be tested.

Return

true if the mode can be supported in YCBCR420 format false if not.

bool **`drm_mode_is_420_also`**(const struct *drm_display_info* *display, const struct *drm_display_mode* *mode)

if a given videomode can be supported in YCBCR420 output format also (along with RGB/YCBCR444/422)

Parameters

`const struct drm_display_info *display`
display under action.

`const struct drm_display_mode *mode`
video mode to be tested.

Return

true if the mode can be support YCBCR420 format false if not.

bool **`drm_mode_is_420`**(const struct *drm_display_info* *display, const struct *drm_display_mode* *mode)

if a given videomode can be supported in YCBCR420 output format

Parameters

`const struct drm_display_info *display`
display under action.

`const struct drm_display_mode *mode`
video mode to be tested.

Return

true if the mode can be supported in YCBCR420 format false if not.

4.11 Connector Abstraction

In DRM connectors are the general abstraction for display sinks, and include also fixed panels or anything else that can display pixels in some form. As opposed to all other KMS objects representing hardware (like CRTC, encoder or plane abstractions) connectors can be hotplugged and unplugged at runtime. Hence they are reference-counted using `drm_connector_get()` and `drm_connector_put()`.

KMS driver must create, initialize, register and attach at a `struct drm_connector` for each such sink. The instance is created as other KMS objects and initialized by setting the following fields. The connector is initialized with a call to `drm_connector_init()` with a pointer to the `struct drm_connector_funcs` and a connector type, and then exposed to userspace with a call to `drm_connector_register()`.

Connectors must be attached to an encoder to be used. For devices that map connectors to encoders 1:1, the connector should be attached at initialization time with a call to `drm_connector_attach_encoder()`. The driver must also set the `drm_connector.encoder` field to point to the attached encoder.

For connectors which are not fixed (like built-in panels) the driver needs to support hotplug notifications. The simplest way to do that is by using the probe helpers, see `drm_kms_helper_poll_init()` for connectors which don't have hardware support for hotplug interrupts. Connectors with hardware hotplug support can instead use e.g. `drm_helper_hpd_irq_event()`.

4.11.1 Connector Functions Reference

enum **drm_connector_status**

status for a `drm_connector`

Constants

connector_status_connected
The connector is definitely connected to a sink device, and can be enabled.

connector_status_disconnected
The connector isn't connected to a sink device which can be autodetect. For digital outputs like DP or HDMI (which can be realiable probed) this means there's really nothing there. It is driver-dependent whether a connector with this status can be lit up or not.

connector_status_unknown
The connector's status could not be reliably detected. This happens when probing would either cause flicker (like load-detection when the connector is in use), or when a hardware resource isn't available (like when load-detection needs a free CRTC). It should be possible to light up the connector with one of the listed fallback modes. For default configuration userspace should only try to light up connectors with unknown status when there's not connector with **connector_status_connected**.

Description

This enum is used to track the connector status. There are no separate #defines for the uapi!

enum **drm_connector_registration_state**

userspace registration status for a *drm_connector*

Constants

DRM_CONNECTOR_INITIALIZING
The connector has just been created, but has yet to be exposed to userspace. There should be no additional restrictions to how the state of this connector may be modified.

DRM_CONNECTOR_REGISTERED
The connector has been fully initialized and registered with sysfs, as such it has been exposed to userspace. There should be no additional restrictions to how the state of this connector may be modified.

DRM_CONNECTOR_UNREGISTERED
The connector has either been exposed to userspace and has since been unregistered and removed from userspace, or the connector was unregistered before it had a chance to be exposed to userspace (e.g. still in the **DRM_CONNECTOR_INITIALIZING** state). When a connector is unregistered, there are additional restrictions to how its state may be modified:

- An unregistered connector may only have its DPMS changed from On->Off. Once DPMS is changed to Off, it may not be switched back to On.
- Modesets are not allowed on unregistered connectors, unless they would result in disabling its assigned CRTCs. This means disabling a CRTC on an unregistered connector is OK, but enabling one is not.
- Removing a CRTC from an unregistered connector is OK, but new CRTCs may never be assigned to an unregistered connector.

Description

This enum is used to track the status of initializing a connector and registering it with userspace, so that DRM can prevent bogus modesets on connectors that no longer exist.

struct **drm_scrambling**

Definition

```
struct drm_scrambling {
  bool supported;
  bool low_rates;
};
```

Members

supported
scrambling supported for rates > 340 Mhz.

low_rates
scrambling supported for rates <= 340 Mhz.

struct **drm_hdmi_info**

runtime information about the connected HDMI sink

Definition

```
struct drm_hdmi_info {
  struct drm_scdc scdc;
  unsigned long y420_vdb_modes[BITS_TO_LONGS(256)];
  unsigned long y420_cmdb_modes[BITS_TO_LONGS(256)];
  u64 y420_cmdb_map;
  u8 y420_dc_modes;
};
```

Members

scdc
sink' s scdc support and capabilities

y420_vdb_modes
bitmap of modes which can support ycbcr420 output only (not normal RGB/YCBCR444/422 outputs). The max VIC defined by the CEA-861-G spec is 219, so the size is 256 bits to map up to 256 VICs.

y420_cmdb_modes
bitmap of modes which can support ycbcr420 output also, along with normal HDMI outputs. The max VIC defined by the CEA-861-G spec is 219, so the size is 256 bits to map up to 256 VICs.

y420_cmdb_map
bitmap of SVD index, to extraxt vcb modes

y420_dc_modes
bitmap of deep color support index

Description

Describes if a given display supports advanced HDMI 2.0 features. This information is available in CEA-861-F extension blocks (like HF-VSDB).

enum **drm_link_status**

connector' s link_status property value

Constants

DRM_LINK_STATUS_GOOD
DP Link is Good as a result of successful link training

DRM_LINK_STATUS_BAD
DP Link is BAD as a result of link training failure

Description

This enum is used as the connector' s link status property value. It is set to the values defined in uapi.

enum **drm_panel_orientation**

panel_orientation info for *drm_display_info*

Constants

DRM_MODE_PANEL_ORIENTATION_UNKNOWN
The drm driver has not provided any panel orientation information (normal for non panels) in this case the "panel orientation" connector prop will not be attached.

DRM_MODE_PANEL_ORIENTATION_NORMAL
The top side of the panel matches the top side of the device' s casing.

DRM_MODE_PANEL_ORIENTATION_BOTTOM_UP
The top side of the panel matches the bottom side of the device' s casing, iow the panel is mounted upside-down.

DRM_MODE_PANEL_ORIENTATION_LEFT_UP
The left side of the panel matches the top side of the device' s casing.

DRM_MODE_PANEL_ORIENTATION_RIGHT_UP
The right side of the panel matches the top side of the device' s casing.

Description

This enum is used to track the (LCD) panel orientation. There are no separate #defines for the uapi!

struct **drm_monitor_range_info**
Panel' s Monitor range in EDID for *drm_display_info*

Definition

```
struct drm_monitor_range_info {
  u8 min_vfreq;
  u8 max_vfreq;
};
```

Members

min_vfreq
This is the min supported refresh rate in Hz from EDID' s detailed monitor range.

max_vfreq
This is the max supported refresh rate in Hz from EDID' s detailed monitor range

Description

This struct is used to store a frequency range supported by panel as parsed from EDID' s detailed monitor range descriptor block.

enum **drm_bus_flags**
bus_flags info for *drm_display_info*

Constants

DRM_BUS_FLAG_DE_LOW
The Data Enable signal is active low

DRM_BUS_FLAG_DE_HIGH
The Data Enable signal is active high

DRM_BUS_FLAG_PIXDATA_DRIVE_POSEDGE
Data is driven on the rising edge of the pixel clock

DRM_BUS_FLAG_PIXDATA_DRIVE_NEGEDGE
Data is driven on the falling edge of the pixel clock

DRM_BUS_FLAG_PIXDATA_SAMPLE_POSEDGE
Data is sampled on the rising edge of the pixel clock

DRM_BUS_FLAG_PIXDATA_SAMPLE_NEGEDGE
Data is sampled on the falling edge of the pixel clock

DRM_BUS_FLAG_DATA_MSB_TO_LSB
Data is transmitted MSB to LSB on the bus

DRM_BUS_FLAG_DATA_LSB_TO_MSB
Data is transmitted LSB to MSB on the bus

DRM_BUS_FLAG_SYNC_DRIVE_POSEDGE
Sync signals are driven on the rising edge of the pixel clock

DRM_BUS_FLAG_SYNC_DRIVE_NEGEDGE
Sync signals are driven on the falling edge of the pixel clock

DRM_BUS_FLAG_SYNC_SAMPLE_POSEDGE
Sync signals are sampled on the rising edge of the pixel clock

DRM_BUS_FLAG_SYNC_SAMPLE_NEGEDGE
Sync signals are sampled on the falling edge of the pixel clock

DRM_BUS_FLAG_SHARP_SIGNALS
Set if the Sharp-specific signals (SPL, CLS, PS, REV) must be used

Description

This enum defines signal polarities and clock edge information for signals on a bus as bitmask flags.

The clock edge information is conveyed by two sets of symbols, DRM_BUS_FLAGS_*_DRIVE_* and DRM_BUS_FLAGS_*_SAMPLE_*. When this enum is used to describe a bus from the point of view of the transmitter, the *_DRIVE_* flags should be used. When used from the point of view of the receiver, the *_SAMPLE_* flags should be used. The *_DRIVE_* and *_SAMPLE_* flags alias each other, with the *_SAMPLE_POSEDGE and *_SAMPLE_NEGEDGE flags being equal to *_DRIVE_NEGEDGE and *_DRIVE_POSEDGE respectively. This simplifies code as signals are usually sampled on the opposite edge of the driving edge. Transmitters and receivers may however need to take other signal timings into account to convert between driving and sample edges.

struct **drm_display_info**
runtime data about the connected sink

Definition

```
struct drm_display_info {
  unsigned int width_mm;
  unsigned int height_mm;
  unsigned int bpc;
```

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```
  enum subpixel_order subpixel_order;
#define DRM_COLOR_FORMAT_RGB444         (1<<0);
#define DRM_COLOR_FORMAT_YCRCB444       (1<<1);
#define DRM_COLOR_FORMAT_YCRCB422       (1<<2);
#define DRM_COLOR_FORMAT_YCRCB420       (1<<3);
  int panel_orientation;
  u32 color_formats;
  const u32 *bus_formats;
  unsigned int num_bus_formats;
  u32 bus_flags;
  int max_tmds_clock;
  bool dvi_dual;
  bool is_hdmi;
  bool has_hdmi_infoframe;
  bool rgb_quant_range_selectable;
  u8 edid_hdmi_dc_modes;
  u8 cea_rev;
  struct drm_hdmi_info hdmi;
  bool non_desktop;
  struct drm_monitor_range_info monitor_range;
};
```

Members

width_mm
Physical width in mm.

height_mm
Physical height in mm.

bpc
Maximum bits per color channel. Used by HDMI and DP outputs.

subpixel_order
Subpixel order of LCD panels.

panel_orientation
Read only connector property for built-in panels, indicating the orientation of the panel vs the device's casing. *drm_connector_init()* sets this to DRM_MODE_PANEL_ORIENTATION_UNKNOWN. When not UNKNOWN this gets used by the drm_fb_helpers to rotate the fb to compensate and gets exported as prop to userspace.

color_formats
HDMI Color formats, selects between RGB and YCrCb modes. Used DRM_COLOR_FORMAT_ defines, which are _not_ the same ones as used to describe the pixel format in framebuffers, and also don't match the formats in **bus_formats** which are shared with v4l.

bus_formats
Pixel data format on the wire, somewhat redundant with **color_formats**. Array of size **num_bus_formats** encoded using MEDIA_BUS_FMT_ defines shared with v4l and media drivers.

num_bus_formats
Size of **bus_formats** array.

bus_flags
Additional information (like pixel signal polarity) for the pixel data on the bus, using *enum drm_bus_flags* values DRM_BUS_FLAGS_.

max_tmds_clock
Maximum TMDS clock rate supported by the sink in kHz. 0 means undefined.

dvi_dual
Dual-link DVI sink?

is_hdmi
True if the sink is an HDMI device.

This field shall be used instead of calling *drm_detect_hdmi_monitor()* when possible.

has_hdmi_infoframe
Does the sink support the HDMI infoframe?

rgb_quant_range_selectable
Does the sink support selecting the RGB quantization range?

edid_hdmi_dc_modes
Mask of supported hdmi deep color modes. Even more stuff redundant with **bus_formats**.

cea_rev
CEA revision of the HDMI sink.

hdmi
advance features of a HDMI sink.

non_desktop
Non desktop display (HMD).

monitor_range
Frequency range supported by monitor range descriptor

Description

Describes a given display (e.g. CRT or flat panel) and its limitations. For fixed display sinks like built-in panels there’ s not much difference between this and *struct drm_connector*. But for sinks with a real cable this structure is meant to describe all the things at the other end of the cable.

For sinks which provide an EDID this can be filled out by calling *drm_add_edid_modes()*.

struct **drm_connector_tv_margins**
TV connector related margins

Definition

```
struct drm_connector_tv_margins {
  unsigned int bottom;
  unsigned int left;
```

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```
  unsigned int right;
  unsigned int top;
};
```

Members

bottom
Bottom margin in pixels.

left
Left margin in pixels.

right
Right margin in pixels.

top
Top margin in pixels.

Description

Describes the margins in pixels to put around the image on TV connectors to deal with overscan.

struct **drm_tv_connector_state**
TV connector related states

Definition

```
struct drm_tv_connector_state {
  enum drm_mode_subconnector subconnector;
  struct drm_connector_tv_margins margins;
  unsigned int mode;
  unsigned int brightness;
  unsigned int contrast;
  unsigned int flicker_reduction;
  unsigned int overscan;
  unsigned int saturation;
  unsigned int hue;
};
```

Members

subconnector
selected subconnector

margins
TV margins

mode
TV mode

brightness
brightness in percent

contrast
contrast in percent

`flicker_reduction`
flicker reduction in percent

`overscan`
overscan in percent

`saturation`
saturation in percent

`hue`
hue in percent

struct **`drm_connector_state`**
mutable connector state

Definition

```
struct drm_connector_state {
  struct drm_connector *connector;
  struct drm_crtc *crtc;
  struct drm_encoder *best_encoder;
  enum drm_link_status link_status;
  struct drm_atomic_state *state;
  struct drm_crtc_commit *commit;
  struct drm_tv_connector_state tv;
  bool self_refresh_aware;
  enum hdmi_picture_aspect picture_aspect_ratio;
  unsigned int content_type;
  unsigned int hdcp_content_type;
  unsigned int scaling_mode;
  unsigned int content_protection;
  u32 colorspace;
  struct drm_writeback_job *writeback_job;
  u8 max_requested_bpc;
  u8 max_bpc;
  struct drm_property_blob *hdr_output_metadata;
};
```

Members

`connector`
backpointer to the connector

`crtc`
CRTC to connect connector to, NULL if disabled.

Do not change this directly, use *`drm_atomic_set_crtc_for_connector()`* instead.

`best_encoder`
Used by the atomic helpers to select the encoder, through the *`drm_connector_helper_funcs.atomic_best_encoder`* or *`drm_connector_helper_funcs.best_encoder`* callbacks.

This is also used in the atomic helpers to map encoders to their current and previous connectors, see *`drm_atomic_get_old_connector_for_encoder()`*

and *drm_atomic_get_new_connector_for_encoder()*.

NOTE: Atomic drivers must fill this out (either themselves or through helpers), for otherwise the GETCONNECTOR and GETENCODER IOCTLs will not return correct data to userspace.

link_status
Connector link_status to keep track of whether link is GOOD or BAD to notify userspace if retraining is necessary.

state
backpointer to global drm_atomic_state

commit
Tracks the pending commit to prevent use-after-free conditions.

Is only set when **crtc** is NULL.

tv
TV connector state

self_refresh_aware
This tracks whether a connector is aware of the self refresh state. It should be set to true for those connector implementations which understand the self refresh state. This is needed since the crtc registers the self refresh helpers and it doesn't know if the connectors downstream have implemented self refresh entry/exit.

Drivers should set this to true in atomic_check if they know how to handle self_refresh requests.

picture_aspect_ratio
Connector property to control the HDMI infoframe aspect ratio setting.

The `DRM_MODE_PICTURE_ASPECT_*` values much match the values for `enum hdmi_picture_aspect`

content_type
Connector property to control the HDMI infoframe content type setting. The `DRM_MODE_CONTENT_TYPE_*` values much match the values.

hdcp_content_type
Connector property to pass the type of protected content. This is most commonly used for HDCP.

scaling_mode
Connector property to control the upscaling, mostly used for built-in panels.

content_protection
Connector property to request content protection. This is most commonly used for HDCP.

colorspace
State variable for Connector property to request colorspace change on Sink. This is most commonly used to switch to wider color gamuts like BT2020.

writeback_job
Writeback job for writeback connectors

Holds the framebuffer and out-fence for a writeback connector. As the writeback completion may be asynchronous to the normal commit cycle, the writeback job lifetime is managed separately from the normal atomic state by this object.

See also: *drm_writeback_queue_job()* and *drm_writeback_signal_completion()*

max_requested_bpc
Connector property to limit the maximum bit depth of the pixels.

max_bpc
Connector max_bpc based on the requested max_bpc property and the connector bpc limitations obtained from edid.

hdr_output_metadata
DRM blob property for HDR output metadata

struct **drm_connector_funcs**

control connectors on a given device

Definition

```
struct drm_connector_funcs {
  int (*dpms)(struct drm_connector *connector, int mode);
  void (*reset)(struct drm_connector *connector);
  enum drm_connector_status (*detect)(struct drm_connector␣
↪*connector, bool force);
  void (*force)(struct drm_connector *connector);
  int (*fill_modes)(struct drm_connector *connector, uint32_t max_
↪width, uint32_t max_height);
  int (*set_property)(struct drm_connector *connector, struct drm_
↪property *property, uint64_t val);
  int (*late_register)(struct drm_connector *connector);
  void (*early_unregister)(struct drm_connector *connector);
  void (*destroy)(struct drm_connector *connector);
  struct drm_connector_state *(*atomic_duplicate_state)(struct drm_
↪connector *connector);
  void (*atomic_destroy_state)(struct drm_connector *connector,␣
↪struct drm_connector_state *state);
  int (*atomic_set_property)(struct drm_connector *connector,struct␣
↪drm_connector_state *state,struct drm_property *property, uint64_
↪t val);
  int (*atomic_get_property)(struct drm_connector *connector,const␣
↪struct drm_connector_state *state,struct drm_property *property,␣
↪uint64_t *val);
  void (*atomic_print_state)(struct drm_printer *p, const struct␣
↪drm_connector_state *state);
  void (*oob_hotplug_event)(struct drm_connector *connector);
};
```

Members

dpms
Legacy entry point to set the per-connector DPMS state. Legacy DPMS is exposed as a standard property on the connector, but diverted to this callback

in the drm core. Note that atomic drivers don't implement the 4 level DPMS support on the connector any more, but instead only have an on/off "ACTIVE" property on the CRTC object.

This hook is not used by atomic drivers, remapping of the legacy DPMS property is entirely handled in the DRM core.

RETURNS:

0 on success or a negative error code on failure.

`reset`
Reset connector hardware and software state to off. This function isn't called by the core directly, only through *`drm_mode_config_reset()`*. It's not a helper hook only for historical reasons.

Atomic drivers can use *`drm_atomic_helper_connector_reset()`* to reset atomic state using this hook.

`detect`
Check to see if anything is attached to the connector. The parameter force is set to false whilst polling, true when checking the connector due to a user request. force can be used by the driver to avoid expensive, destructive operations during automated probing.

This callback is optional, if not implemented the connector will be considered as always being attached.

FIXME:

Note that this hook is only called by the probe helper. It's not in the helper library vtable purely for historical reasons. The only DRM core entry point to probe connector state is **fill_modes**.

Note that the helper library will already hold *`drm_mode_config.connection_mutex`*. Drivers which need to grab additional locks to avoid races with concurrent modeset changes need to use *`drm_connector_helper_funcs.detect_ctx`* instead.

RETURNS:

drm_connector_status indicating the connector's status.

`force`
This function is called to update internal encoder state when the connector is forced to a certain state by userspace, either through the sysfs interfaces or on the kernel cmdline. In that case the **detect** callback isn't called.

FIXME:

Note that this hook is only called by the probe helper. It's not in the helper library vtable purely for historical reasons. The only DRM core entry point to probe connector state is **fill_modes**.

`fill_modes`
Entry point for output detection and basic mode validation. The driver should reprobe the output if needed (e.g. when hotplug handling is unreliable), add all detected modes to *`drm_connector.modes`* and filter out any the device can'

t support in any configuration. It also needs to filter out any modes wider or higher than the parameters max_width and max_height indicate.

The drivers must also prune any modes no longer valid from *drm_connector.modes*. Furthermore it must update *drm_connector.status* and *drm_connector.edid*. If no EDID has been received for this output connector->edid must be NULL.

Drivers using the probe helpers should use *drm_helper_probe_single_connector_modes()* to implement this function.

RETURNS:

The number of modes detected and filled into *drm_connector.modes*.

set_property
This is the legacy entry point to update a property attached to the connector.

This callback is optional if the driver does not support any legacy driver-private properties. For atomic drivers it is not used because property handling is done entirely in the DRM core.

RETURNS:

0 on success or a negative error code on failure.

late_register
This optional hook can be used to register additional userspace interfaces attached to the connector, light backlight control, i2c, DP aux or similar interfaces. It is called late in the driver load sequence from *drm_connector_register()* when registering all the core drm connector interfaces. Everything added from this callback should be unregistered in the early_unregister callback.

This is called while holding *drm_connector.mutex*.

Returns:

0 on success, or a negative error code on failure.

early_unregister
This optional hook should be used to unregister the additional userspace interfaces attached to the connector from late_register(). It is called from *drm_connector_unregister()*, early in the driver unload sequence to disable userspace access before data structures are torndown.

This is called while holding *drm_connector.mutex*.

destroy
Clean up connector resources. This is called at driver unload time through *drm_mode_config_cleanup()*. It can also be called at runtime when a connector is being hot-unplugged for drivers that support connector hotplugging (e.g. DisplayPort MST).

atomic_duplicate_state
Duplicate the current atomic state for this connector and return it. The core and helpers guarantee that any atomic state duplicated with this hook and still owned by the caller (i.e. not transferred to the driver by calling

drm_mode_config_funcs.atomic_commit) will be cleaned up by calling the **atomic_destroy_state** hook in this structure.

This callback is mandatory for atomic drivers.

Atomic drivers which don't subclass *struct drm_connector_state* should use *drm_atomic_helper_connector_duplicate_state()*. Drivers that subclass the state structure to extend it with driver-private state should use *__drm_atomic_helper_connector_duplicate_state()* to make sure shared state is duplicated in a consistent fashion across drivers.

It is an error to call this hook before *drm_connector.state* has been initialized correctly.

NOTE:

If the duplicate state references refcounted resources this hook must acquire a reference for each of them. The driver must release these references again in **atomic_destroy_state**.

RETURNS:

Duplicated atomic state or NULL when the allocation failed.

atomic_destroy_state
Destroy a state duplicated with **atomic_duplicate_state** and release or unreference all resources it references

This callback is mandatory for atomic drivers.

atomic_set_property
Decode a driver-private property value and store the decoded value into the passed-in state structure. Since the atomic core decodes all standardized properties (even for extensions beyond the core set of properties which might not be implemented by all drivers) this requires drivers to subclass the state structure.

Such driver-private properties should really only be implemented for truly hardware/vendor specific state. Instead it is preferred to standardize atomic extension and decode the properties used to expose such an extension in the core.

Do not call this function directly, use drm_atomic_connector_set_property() instead.

This callback is optional if the driver does not support any driver-private atomic properties.

NOTE:

This function is called in the state assembly phase of atomic modesets, which can be aborted for any reason (including on userspace's request to just check whether a configuration would be possible). Drivers MUST NOT touch any persistent state (hardware or software) or data structures except the passed in **state** parameter.

Also since userspace controls in which order properties are set this function must not do any input validation (since the state update is incomplete and hence likely inconsistent). Instead any such input validation must be done in the various atomic_check callbacks.

RETURNS:

0 if the property has been found, -EINVAL if the property isn't implemented by the driver (which shouldn't ever happen, the core only asks for properties attached to this connector). No other validation is allowed by the driver. The core already checks that the property value is within the range (integer, valid enum value, …) the driver set when registering the property.

atomic_get_property
Reads out the decoded driver-private property. This is used to implement the GETCONNECTOR IOCTL.

Do not call this function directly, use drm_atomic_connector_get_property() instead.

This callback is optional if the driver does not support any driver-private atomic properties.

RETURNS:

0 on success, -EINVAL if the property isn't implemented by the driver (which shouldn't ever happen, the core only asks for properties attached to this connector).

atomic_print_state
If driver subclasses *struct drm_connector_state*, it should implement this optional hook for printing additional driver specific state.

Do not call this directly, use drm_atomic_connector_print_state() instead.

oob_hotplug_event
This will get called when a hotplug-event for a drm-connector has been received from a source outside the display driver / device.

Description

Each CRTC may have one or more connectors attached to it. The functions below allow the core DRM code to control connectors, enumerate available modes, etc.

struct **drm_cmdline_mode**
DRM Mode passed through the kernel command-line

Definition

```
struct drm_cmdline_mode {
  char name[DRM_DISPLAY_MODE_LEN];
  bool specified;
  bool refresh_specified;
  bool bpp_specified;
  int xres;
  int yres;
  int bpp;
  int refresh;
  bool rb;
```

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```
  bool interlace;
  bool cvt;
  bool margins;
  enum drm_connector_force force;
  unsigned int rotation_reflection;
  enum drm_panel_orientation panel_orientation;
  struct drm_connector_tv_margins tv_margins;
};
```

Members

name
Name of the mode.

specified
Has a mode been read from the command-line?

refresh_specified
Did the mode have a preferred refresh rate?

bpp_specified
Did the mode have a preferred BPP?

xres
Active resolution on the X axis, in pixels.

yres
Active resolution on the Y axis, in pixels.

bpp
Bits per pixels for the mode.

refresh
Refresh rate, in Hertz.

rb
Do we need to use reduced blanking?

interlace
The mode is interlaced.

cvt
The timings will be calculated using the VESA Coordinated Video Timings instead of looking up the mode from a table.

margins
Add margins to the mode calculation (1.8% of xres rounded down to 8 pixels and 1.8% of yres).

force
Ignore the hotplug state of the connector, and force its state to one of the DRM_FORCE_* values.

rotation_reflection
Initial rotation and reflection of the mode setup from the command line. See DRM_MODE_ROTATE_* and DRM_MODE_REFLECT_*. The only rotations supported are DRM_MODE_ROTATE_0 and DRM_MODE_ROTATE_180.

panel_orientation
drm-connector "panel orientation" property override value, DRM_MODE_PANEL_ORIENTATION_UNKNOWN if not set.

tv_margins
TV margins to apply to the mode.

Description

Each connector can have an initial mode with additional options passed through the kernel command line. This structure allows to express those parameters and will be filled by the command-line parser.

struct **drm_connector**

central DRM connector control structure

Definition

```
struct drm_connector {
  struct drm_device *dev;
  struct device *kdev;
  struct device_attribute *attr;
  struct fwnode_handle *fwnode;
  struct list_head head;
  struct list_head global_connector_list_entry;
  struct drm_mode_object base;
  char *name;
  struct mutex mutex;
  unsigned index;
  int connector_type;
  int connector_type_id;
  bool interlace_allowed;
  bool doublescan_allowed;
  bool stereo_allowed;
  bool ycbcr_420_allowed;
  enum drm_connector_registration_state registration_state;
  struct list_head modes;
  enum drm_connector_status status;
  struct list_head probed_modes;
  struct drm_display_info display_info;
  const struct drm_connector_funcs *funcs;
  struct drm_property_blob *edid_blob_ptr;
  struct drm_object_properties properties;
  struct drm_property *scaling_mode_property;
  struct drm_property *vrr_capable_property;
  struct drm_property *colorspace_property;
  struct drm_property_blob *path_blob_ptr;
  struct drm_property *max_bpc_property;
#define DRM_CONNECTOR_POLL_HPD (1 << 0);
#define DRM_CONNECTOR_POLL_CONNECT (1 << 1);
#define DRM_CONNECTOR_POLL_DISCONNECT (1 << 2);
  uint8_t polled;
  int dpms;
```

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```
  const struct drm_connector_helper_funcs *helper_private;
  struct drm_cmdline_mode cmdline_mode;
  enum drm_connector_force force;
  bool override_edid;
  u64 epoch_counter;
  u32 possible_encoders;
  struct drm_encoder *encoder;
#define MAX_ELD_BYTES   128;
  uint8_t eld[MAX_ELD_BYTES];
  bool latency_present[2];
  int video_latency[2];
  int audio_latency[2];
  struct i2c_adapter *ddc;
  int null_edid_counter;
  unsigned bad_edid_counter;
  bool edid_corrupt;
  u8 real_edid_checksum;
  struct dentry *debugfs_entry;
  struct drm_connector_state *state;
  struct drm_property_blob *tile_blob_ptr;
  bool has_tile;
  struct drm_tile_group *tile_group;
  bool tile_is_single_monitor;
  uint8_t num_h_tile, num_v_tile;
  uint8_t tile_h_loc, tile_v_loc;
  uint16_t tile_h_size, tile_v_size;
  struct llist_node free_node;
  struct hdr_sink_metadata hdr_sink_metadata;
};
```

Members

dev
: parent DRM device

kdev
: kernel device for sysfs attributes

attr
: sysfs attributes

fwnode
: associated fwnode supplied by platform firmware

  Drivers can set this to associate a fwnode with a connector, drivers are expected to get a reference on the fwnode when setting this. *drm_connector_cleanup()* will call fwnode_handle_put() on this.

head
: List of all connectors on a **dev**, linked from *drm_mode_config.connector_list*. Protected by *drm_mode_config.connector_list_lock*, but please only use *drm_connector_list_iter* to walk this list.

global_connector_list_entry
Connector entry in the global connector-list, used by drm_connector_find_by_fwnode().

base
base KMS object

name
human readable name, can be overwritten by the driver

mutex
Lock for general connector state, but currently only protects **registered**. Most of the connector state is still protected by *drm_mode_config.mutex*.

index
Compacted connector index, which matches the position inside the mode_config.list for drivers not supporting hot-add/removing. Can be used as an array index. It is invariant over the lifetime of the connector.

connector_type
one of the DRM_MODE_CONNECTOR_<foo> types from drm_mode.h

connector_type_id
index into connector type enum

interlace_allowed
Can this connector handle interlaced modes? Only used by *drm_helper_probe_single_connector_modes()* for mode filtering.

doublescan_allowed
Can this connector handle doublescan? Only used by *drm_helper_probe_single_connector_modes()* for mode filtering.

stereo_allowed
Can this connector handle stereo modes? Only used by *drm_helper_probe_single_connector_modes()* for mode filtering.

ycbcr_420_allowed
This bool indicates if this connector is capable of handling YCBCR 420 output. While parsing the EDID blocks it's very helpful to know if the source is capable of handling YCBCR 420 outputs.

registration_state
Is this connector initializing, exposed (registered) with userspace, or unregistered?

Protected by **mutex**.

modes
Modes available on this connector (from fill_modes() + user). Protected by *drm_mode_config.mutex*.

status
One of the drm_connector_status enums (connected, not, or unknown). Protected by *drm_mode_config.mutex*.

probed_modes
These are modes added by probing with DDC or the BIOS, before filtering is applied. Used by the probe helpers. Protected by *drm_mode_config.mutex*.

display_info
: Display information is filled from EDID information when a display is detected. For non hot-pluggable displays such as flat panels in embedded systems, the driver should initialize the *drm_display_info.width_mm* and *drm_display_info.height_mm* fields with the physical size of the display.

  Protected by *drm_mode_config.mutex*.

funcs
: connector control functions

edid_blob_ptr
: DRM property containing EDID if present. Protected by *drm_mode_config.mutex*. This should be updated only by calling *drm_connector_update_edid_property()*.

properties
: property tracking for this connector

scaling_mode_property
: Optional atomic property to control the upscaling. See *drm_connector_attach_content_protection_property()*.

vrr_capable_property
: Optional property to help userspace query hardware support for variable refresh rate on a connector. connector. Drivers can add the property to a connector by calling *drm_connector_attach_vrr_capable_property()*.

  This should be updated only by calling *drm_connector_set_vrr_capable_property()*.

colorspace_property
: Connector property to set the suitable colorspace supported by the sink.

path_blob_ptr
: DRM blob property data for the DP MST path property. This should only be updated by calling *drm_connector_set_path_property()*.

max_bpc_property
: Default connector property for the max bpc to be driven out of the connector.

polled
: Connector polling mode, a combination of

  DRM_CONNECTOR_POLL_HPD
  : The connector generates hotplug events and doesn' t need to be periodically polled. The CONNECT and DISCONNECT flags must not be set together with the HPD flag.

  DRM_CONNECTOR_POLL_CONNECT
  : Periodically poll the connector for connection.

  DRM_CONNECTOR_POLL_DISCONNECT
  : Periodically poll the connector for disconnection, without causing flickering even when the connector is in use. DACs should rarely do this without a lot of testing.

  Set to 0 for connectors that don' t support connection status discovery.

dpms
: Current dpms state. For legacy drivers the *drm_connector_funcs.dpms* callback must update this. For atomic drivers, this is handled by the core atomic code, and drivers must only take *drm_crtc_state.active* into account.

helper_private
: mid-layer private data

cmdline_mode
: mode line parsed from the kernel cmdline for this connector

force
: a DRM_FORCE_<foo> state for forced mode sets

override_edid
: has the EDID been overwritten through debugfs for testing?

epoch_counter
: used to detect any other changes in connector, besides status

possible_encoders
: Bit mask of encoders that can drive this connector, *drm_encoder_index()* determines the index into the bitfield and the bits are set with *drm_connector_attach_encoder()*.

encoder
: Currently bound encoder driving this connector, if any. Only really meaningful for non-atomic drivers. Atomic drivers should instead look at *drm_connector_state.best_encoder*, and in case they need the CRTC driving this output, *drm_connector_state.crtc*.

eld
: EDID-like data, if present

latency_present
: AV delay info from ELD, if found

video_latency
: Video latency info from ELD, if found. [0]: progressive, [1]: interlaced

audio_latency
: audio latency info from ELD, if found [0]: progressive, [1]: interlaced

ddc
: associated ddc adapter. A connector usually has its associated ddc adapter. If a driver uses this field, then an appropriate symbolic link is created in connector sysfs directory to make it easy for the user to tell which i2c adapter is for a particular display.

  The field should be set by calling *drm_connector_init_with_ddc()*.

null_edid_counter
: track sinks that give us all zeros for the EDID. Needed to workaround some HW bugs where we get all 0s

bad_edid_counter
: track sinks that give us an EDID with invalid checksum

edid_corrupt
: Indicates whether the last read EDID was corrupt. Used in Displayport compliance testing - Displayport Link CTS Core 1.2 rev1.1 4.2.2.6

real_edid_checksum
: real edid checksum for corrupted edid block. Required in Displayport 1.4 compliance testing rev1.1 4.2.2.6

debugfs_entry
: debugfs directory for this connector

state
: Current atomic state for this connector.

  This is protected by *drm_mode_config.connection_mutex*. Note that nonblocking atomic commits access the current connector state without taking locks. Either by going through the *struct drm_atomic_state* pointers, see *for_each_oldnew_connector_in_state()*, *for_each_old_connector_in_state()* and *for_each_new_connector_in_state()*. Or through careful ordering of atomic commit operations as implemented in the atomic helpers, see *struct drm_crtc_commit*.

tile_blob_ptr
: DRM blob property data for the tile property (used mostly by DP MST). This is meant for screens which are driven through separate display pipelines represented by *drm_crtc*, which might not be running with genlocked clocks. For tiled panels which are genlocked, like dual-link LVDS or dual-link DSI, the driver should try to not expose the tiling and virtualize both *drm_crtc* and *drm_plane* if needed.

  This should only be updated by calling *drm_connector_set_tile_property()*.

has_tile
: is this connector connected to a tiled monitor

tile_group
: tile group for the connected monitor

tile_is_single_monitor
: whether the tile is one monitor housing

num_h_tile
: number of horizontal tiles in the tile group

num_v_tile
: number of vertical tiles in the tile group

tile_h_loc
: horizontal location of this tile

tile_v_loc
: vertical location of this tile

tile_h_size
: horizontal size of this tile.

tile_v_size
: vertical size of this tile.

free_node
List used only by *drm_connector_list_iter* to be able to clean up a connector from any context, in conjunction with *drm_mode_config.connector_free_work*.

hdr_sink_metadata
HDR Metadata Information read from sink

Description

Each connector may be connected to one or more CRTCs, or may be clonable by another connector if they can share a CRTC. Each connector also has a specific position in the broader display (referred to as a 'screen' though it could span multiple monitors).

struct *drm_connector* ***drm_connector_lookup**(struct *drm_device* *dev, struct *drm_file* *file_priv, uint32_t id)

lookup connector object

Parameters

struct drm_device *dev
DRM device

struct drm_file *file_priv
drm file to check for lease against.

uint32_t id
connector object id

Description

This function looks up the connector object specified by id add takes a reference to it.

void **drm_connector_get**(struct *drm_connector* *connector)

acquire a connector reference

Parameters

struct drm_connector *connector
DRM connector

Description

This function increments the connector's refcount.

void **drm_connector_put**(struct *drm_connector* *connector)

release a connector reference

Parameters

struct drm_connector *connector
DRM connector

Description

This function decrements the connector's reference count and frees the object if the reference count drops to zero.

bool **drm_connector_is_unregistered**(struct *drm_connector* *connector)
has the connector been unregistered from userspace?

Parameters

struct drm_connector *connector
DRM connector

Description

Checks whether or not **connector** has been unregistered from userspace.

Return

True if the connector was unregistered, false if the connector is registered or has not yet been registered with userspace.

struct **drm_tile_group**
Tile group metadata

Definition

```
struct drm_tile_group {
  struct kref refcount;
  struct drm_device *dev;
  int id;
  u8 group_data[8];
};
```

Members

refcount
reference count

dev
DRM device

id
tile group id exposed to userspace

group_data
Sink-private data identifying this group

Description

group_data corresponds to displayid vend/prod/serial for external screens with an EDID.

struct **drm_connector_list_iter**
connector_list iterator

Definition

```
struct drm_connector_list_iter {
};
```

Members

Description

This iterator tracks state needed to be able to walk the connector_list within *struct drm_mode_config*. Only use together with *drm_connector_list_iter_begin()*, *drm_connector_list_iter_end()* and *drm_connector_list_iter_next()* respectively the convenience macro *drm_for_each_connector_iter()*.

drm_for_each_connector_iter

`drm_for_each_connector_iter (connector, iter)`

connector_list iterator macro

Parameters

connector
struct drm_connector pointer used as cursor

iter
struct drm_connector_list_iter

Description

Note that **connector** is only valid within the list body, if you want to use **connector** after calling *drm_connector_list_iter_end()* then you need to grab your own reference first using *drm_connector_get()*.

drm_connector_for_each_possible_encoder

`drm_connector_for_each_possible_encoder (connector, encoder)`

iterate connector's possible encoders

Parameters

connector
struct drm_connector pointer

encoder
struct drm_encoder pointer used as cursor

const char ***drm_get_connector_type_name**(unsigned int type)

return a string for connector type

Parameters

unsigned int type
The connector type (DRM_MODE_CONNECTOR_*)

Return

the name of the connector type, or NULL if the type is not valid.

int **drm_connector_init**(struct *drm_device* *dev, struct *drm_connector* *connector, const struct *drm_connector_funcs* *funcs, int connector_type)

Init a preallocated connector

Parameters

struct drm_device *dev
DRM device

struct drm_connector *connector
: the connector to init

const struct drm_connector_funcs *funcs
: callbacks for this connector

int connector_type
: user visible type of the connector

Description

Initialises a preallocated connector. Connectors should be subclassed as part of driver connector objects.

Return

Zero on success, error code on failure.

int **drm_connector_init_with_ddc**(struct *drm_device* *dev, struct *drm_connector* *connector, const struct *drm_connector_funcs* *funcs, int connector_type, struct i2c_adapter *ddc)

Init a preallocated connector

Parameters

struct drm_device *dev
: DRM device

struct drm_connector *connector
: the connector to init

const struct drm_connector_funcs *funcs
: callbacks for this connector

int connector_type
: user visible type of the connector

struct i2c_adapter *ddc
: pointer to the associated ddc adapter

Description

Initialises a preallocated connector. Connectors should be subclassed as part of driver connector objects.

Ensures that the ddc field of the connector is correctly set.

Return

Zero on success, error code on failure.

void **drm_connector_attach_edid_property**(struct *drm_connector* *connector)

attach edid property.

Parameters

struct drm_connector *connector
: the connector

Description

Some connector types like DRM_MODE_CONNECTOR_VIRTUAL do not get a edid property attached by default. This function can be used to explicitly enable the edid property in these cases.

int **drm_connector_attach_encoder**(struct *drm_connector* *connector, struct *drm_encoder* *encoder)

attach a connector to an encoder

Parameters

struct drm_connector *connector
connector to attach

struct drm_encoder *encoder
encoder to attach **connector** to

Description

This function links up a connector to an encoder. Note that the routing restrictions between encoders and crtcs are exposed to userspace through the possible_clones and possible_crtcs bitmasks.

Return

Zero on success, negative errno on failure.

bool **drm_connector_has_possible_encoder**(struct *drm_connector* *connector, struct *drm_encoder* *encoder)

check if the connector and encoder are associated with each other

Parameters

struct drm_connector *connector
the connector

struct drm_encoder *encoder
the encoder

Return

True if **encoder** is one of the possible encoders for **connector**.

void **drm_connector_cleanup**(struct *drm_connector* *connector)

cleans up an initialised connector

Parameters

struct drm_connector *connector
connector to cleanup

Description

Cleans up the connector but doesn’t free the object.

int **drm_connector_register**(struct *drm_connector* *connector)

register a connector

Parameters

struct drm_connector *connector
the connector to register

Description

Register userspace interfaces for a connector. Only call this for connectors which can be hotplugged after *drm_dev_register()* has been called already, e.g. DP MST connectors. All other connectors will be registered automatically when calling *drm_dev_register()*.

Return

Zero on success, error code on failure.

void **drm_connector_unregister**(struct *drm_connector* *connector)

unregister a connector

Parameters

struct drm_connector *connector
the connector to unregister

Description

Unregister userspace interfaces for a connector. Only call this for connectors which have registered explicitly by calling *drm_dev_register()*, since connectors are unregistered automatically when *drm_dev_unregister()* is called.

const char ***drm_get_connector_status_name**(enum *drm_connector_status* status)

return a string for connector status

Parameters

enum drm_connector_status status
connector status to compute name of

Description

In contrast to the other drm_get_*_name functions this one here returns a const pointer and hence is threadsafe.

void **drm_connector_list_iter_begin**(struct *drm_device* *dev, struct *drm_connector_list_iter* *iter)

initialize a connector_list iterator

Parameters

struct drm_device *dev
DRM device

struct drm_connector_list_iter *iter
connector_list iterator

Description

Sets **iter** up to walk the *drm_mode_config.connector_list* of **dev**. **iter** must always be cleaned up again by calling *drm_connector_list_iter_end()*. Iteration itself happens using *drm_connector_list_iter_next()* or *drm_for_each_connector_iter()*.

struct *drm_connector* ***drm_connector_list_iter_next**(struct *drm_connector_list_iter* *iter) return next connector

Parameters

`struct drm_connector_list_iter *iter`
connector_list iterator

Description

Returns the next connector for **iter**, or NULL when the list walk has completed.

void **`drm_connector_list_iter_end`**(struct *drm_connector_list_iter* *iter)
tear down a connector_list iterator

Parameters

`struct drm_connector_list_iter *iter`
connector_list iterator

Description

Tears down **iter** and releases any resources (like *`drm_connector`* references) acquired while walking the list. This must always be called, both when the iteration completes fully or when it was aborted without walking the entire list.

const char ***`drm_get_subpixel_order_name`**(enum subpixel_order order)
return a string for a given subpixel enum

Parameters

`enum subpixel_order order`
enum of subpixel_order

Description

Note you could abuse this and return something out of bounds, but that would be a caller error. No unscrubbed user data should make it here.

int **`drm_display_info_set_bus_formats`**(struct *drm_display_info* *info, const u32 *formats, unsigned int num_formats)
set the supported bus formats

Parameters

`struct drm_display_info *info`
display info to store bus formats in

`const u32 *formats`
array containing the supported bus formats

`unsigned int num_formats`
the number of entries in the fmts array

Description

Store the supported bus formats in display info structure. See MEDIA_BUS_FMT_* definitions in include/uapi/linux/media-bus-format.h for a full list of available formats.

int **drm_mode_create_dvi_i_properties**(struct *drm_device* *dev)
create DVI-I specific connector properties

Parameters

struct drm_device *dev
DRM device

Description

Called by a driver the first time a DVI-I connector is made.

void **drm_connector_attach_dp_subconnector_property**(struct *drm_connector* *connector)

create subconnector property for DP

Parameters

struct drm_connector *connector
drm_connector to attach property

Description

Called by a driver when DP connector is created.

int **drm_connector_attach_content_type_property**(struct *drm_connector* *connector)

attach content-type property

Parameters

struct drm_connector *connector
connector to attach content type property on.

Description

Called by a driver the first time a HDMI connector is made.

void **drm_hdmi_avi_infoframe_content_type**(struct hdmi_avi_infoframe *frame, const struct *drm_connector_state* *conn_state)

fill the HDMI AVI infoframe content type information, based on correspondent DRM property.

Parameters

struct hdmi_avi_infoframe *frame
HDMI AVI infoframe

const struct drm_connector_state *conn_state
DRM display connector state

void **drm_connector_attach_tv_margin_properties**(struct *drm_connector* *connector)

attach TV connector margin properties

Parameters

struct drm_connector *connector
DRM connector

Description

Called by a driver when it needs to attach TV margin props to a connector. Typically used on SDTV and HDMI connectors.

int **drm_mode_create_tv_margin_properties**(struct *drm_device* *dev)

create TV connector margin properties

Parameters

struct drm_device *dev
DRM device

Description

Called by a driver's HDMI connector initialization routine, this function creates the TV margin properties for a given device. No need to call this function for an SDTV connector, it's already called from *drm_mode_create_tv_properties()*.

int **drm_mode_create_tv_properties**(struct *drm_device* *dev, unsigned int num_modes, const char *const modes[])

create TV specific connector properties

Parameters

struct drm_device *dev
DRM device

unsigned int num_modes
number of different TV formats (modes) supported

const char * const modes[]
array of pointers to strings containing name of each format

Description

Called by a driver's TV initialization routine, this function creates the TV specific connector properties for a given device. Caller is responsible for allocating a list of format names and passing them to this routine.

int **drm_mode_create_scaling_mode_property**(struct *drm_device* *dev)

create scaling mode property

Parameters

struct drm_device *dev
DRM device

Description

Called by a driver the first time it's needed, must be attached to desired connectors.

Atomic drivers should use *drm_connector_attach_scaling_mode_property()* instead to correctly assign *drm_connector_state.picture_aspect_ratio* in the atomic state.

int **drm_connector_attach_vrr_capable_property**(struct *drm_connector* *connector)

creates the vrr_capable property

Parameters

struct drm_connector *connector
connector to create the vrr_capable property on.

Description

This is used by atomic drivers to add support for querying variable refresh rate capability for a connector.

Return

Zero on success, negative errno on failure.

int **drm_connector_attach_scaling_mode_property**(struct *drm_connector* *connector, u32 scaling_mode_mask)

attach atomic scaling mode property

Parameters

struct drm_connector *connector
connector to attach scaling mode property on.

u32 scaling_mode_mask
or'ed mask of BIT(DRM_MODE_SCALE_*).

Description

This is used to add support for scaling mode to atomic drivers. The scaling mode will be set to *drm_connector_state.picture_aspect_ratio* and can be used from *drm_connector_helper_funcs->atomic_check* for validation.

This is the atomic version of *drm_mode_create_scaling_mode_property()*.

Return

Zero on success, negative errno on failure.

int **drm_mode_create_aspect_ratio_property**(struct *drm_device* *dev)

create aspect ratio property

Parameters

struct drm_device *dev
DRM device

Description

Called by a driver the first time it's needed, must be attached to desired connectors.

Return

Zero on success, negative errno on failure.

int **drm_mode_create_hdmi_colorspace_property**(struct *drm_connector* *connector)

create hdmi colorspace property

Parameters

struct drm_connector *connector
connector to create the Colorspace property on.

Description

Called by a driver the first time it's needed, must be attached to desired HDMI connectors.

Return

Zero on success, negative errno on failure.

int **drm_mode_create_dp_colorspace_property**(struct *drm_connector* *connector)

create dp colorspace property

Parameters

struct drm_connector *connector
connector to create the Colorspace property on.

Description

Called by a driver the first time it's needed, must be attached to desired DP connectors.

Return

Zero on success, negative errno on failure.

int **drm_mode_create_content_type_property**(struct *drm_device* *dev)

create content type property

Parameters

struct drm_device *dev
DRM device

Description

Called by a driver the first time it's needed, must be attached to desired connectors.

Return

Zero on success, negative errno on failure.

int **drm_mode_create_suggested_offset_properties**(struct *drm_device* *dev)

create suggests offset properties

Parameters

struct drm_device *dev
DRM device

Description

Create the suggested x/y offset property for connectors.

int **drm_connector_set_path_property**(struct *drm_connector* *connector, const char *path)

set tile property on connector

Parameters

`struct drm_connector *connector`
connector to set property on.

`const char *path`
path to use for property; must not be NULL.

Description

This creates a property to expose to userspace to specify a connector path. This is mainly used for DisplayPort MST where connectors have a topology and we want to allow userspace to give them more meaningful names.

Return

Zero on success, negative errno on failure.

int **drm_connector_set_tile_property**(struct *drm_connector* *connector)
set tile property on connector

Parameters

`struct drm_connector *connector`
connector to set property on.

Description

This looks up the tile information for a connector, and creates a property for userspace to parse if it exists. The property is of the form of 8 integers using ':' as a separator. This is used for dual port tiled displays with DisplayPort SST or DisplayPort MST connectors.

Return

Zero on success, errno on failure.

int **drm_connector_update_edid_property**(struct *drm_connector* *connector, const struct *edid* *edid)
update the edid property of a connector

Parameters

`struct drm_connector *connector`
drm connector

`const struct edid *edid`
new value of the edid property

Description

This function creates a new blob modeset object and assigns its id to the connector' s edid property. Since we also parse tile information from EDID' s displayID block, we also set the connector' s tile property here. See *`drm_connector_set_tile_property()`* for more details.

Return

Zero on success, negative errno on failure.

void **drm_connector_set_link_status_property**(struct *drm_connector* *connector, uint64_t link_status)

Set link status property of a connector

Parameters

struct drm_connector *connector
drm connector

uint64_t link_status
new value of link status property (0: Good, 1: Bad)

Description

In usual working scenario, this link status property will always be set to "GOOD" . If something fails during or after a mode set, the kernel driver may set this link status property to "BAD" . The caller then needs to send a hotplug uevent for userspace to re-check the valid modes through GET_CONNECTOR_IOCTL and retry modeset.

The reason for adding this property is to handle link training failures, but it is not limited to DP or link training. For example, if we implement asynchronous setcrtc, this property can be used to report any failures in that.

Note

Drivers cannot rely on userspace to support this property and issue a modeset. As such, they may choose to handle issues (like re-training a link) without userspace' s intervention.

int **drm_connector_attach_max_bpc_property**(struct *drm_connector* *connector, int min, int max)

attach "max bpc" property

Parameters

struct drm_connector *connector
connector to attach max bpc property on.

int min
The minimum bit depth supported by the connector.

int max
The maximum bit depth supported by the connector.

Description

This is used to add support for limiting the bit depth on a connector.

Return

Zero on success, negative errno on failure.

void **drm_connector_set_vrr_capable_property**(struct *drm_connector* *connector, bool capable)

sets the variable refresh rate capable property for a connector

Parameters

struct drm_connector *connector
drm connector

bool capable
True if the connector is variable refresh rate capable

Description

Should be used by atomic drivers to update the indicated support for variable refresh rate over a connector.

int **drm_connector_set_panel_orientation**(struct *drm_connector* *connector, enum *drm_panel_orientation* panel_orientation)

sets the connector's panel_orientation

Parameters

struct drm_connector *connector
connector for which to set the panel-orientation property.

enum drm_panel_orientation panel_orientation
drm_panel_orientation value to set

Description

This function sets the connector's panel_orientation and attaches a "panel orientation" property to the connector.

Calling this function on a connector where the panel_orientation has already been set is a no-op (e.g. the orientation has been overridden with a kernel commandline option).

It is allowed to call this function with a panel_orientation of DRM_MODE_PANEL_ORIENTATION_UNKNOWN, in which case it is a no-op.

Return

Zero on success, negative errno on failure.

int **drm_connector_set_panel_orientation_with_quirk**(struct *drm_connector* *connector, enum *drm_panel_orientation* panel_orientation, int width, int height)

set the connector's panel_orientation after checking for quirks

Parameters

struct drm_connector *connector
connector for which to init the panel-orientation property.

enum drm_panel_orientation panel_orientation
drm_panel_orientation value to set

int width
width in pixels of the panel, used for panel quirk detection

int height
height in pixels of the panel, used for panel quirk detection

Description

Like *drm_connector_set_panel_orientation()*, but with a check for platform specific (e.g. DMI based) quirks overriding the passed in panel_orientation.

Return

Zero on success, negative errno on failure.

void **drm_connector_oob_hotplug_event**(struct fwnode_handle *connector_fwnode)

Report out-of-band hotplug event to connector

Parameters

struct fwnode_handle *connector_fwnode
undescribed

Description

On some hardware a hotplug event notification may come from outside the display driver / device. An example of this is some USB Type-C setups where the hardware muxes the DisplayPort data and aux-lines but does not pass the altmode HPD status bit to the GPU’s DP HPD pin.

This function can be used to report these out-of-band events after obtaining a drm_connector reference through calling drm_connector_find_by_fwnode().

void **drm_mode_put_tile_group**(struct *drm_device* *dev, struct *drm_tile_group* *tg)

drop a reference to a tile group.

Parameters

struct drm_device *dev
DRM device

struct drm_tile_group *tg
tile group to drop reference to.

Description

drop reference to tile group and free if 0.

struct *drm_tile_group* ***drm_mode_get_tile_group**(struct *drm_device* *dev, const char topology[8])

get a reference to an existing tile group

Parameters

struct drm_device *dev
DRM device

const char topology[8]
8-bytes unique per monitor.

Description

Use the unique bytes to get a reference to an existing tile group.

Return

tile group or NULL if not found.

struct *drm_tile_group* ***drm_mode_create_tile_group**(struct *drm_device* *dev, const char topology[8])

create a tile group from a displayid description

Parameters

struct drm_device *dev
DRM device

const char topology[8]
8-bytes unique per monitor.

Description

Create a tile group for the unique monitor, and get a unique identifier for the tile group.

Return

new tile group or NULL.

4.11.2 Writeback Connectors

struct **drm_writeback_connector**

DRM writeback connector

Definition

```
struct drm_writeback_connector {
  struct drm_connector base;
  struct drm_encoder encoder;
  struct drm_property_blob *pixel_formats_blob_ptr;
  spinlock_t job_lock;
  struct list_head job_queue;
  unsigned int fence_context;
  spinlock_t fence_lock;
  unsigned long fence_seqno;
  char timeline_name[32];
};
```

Members

base
base drm_connector object

encoder
Internal encoder used by the connector to fulfill the DRM framework requirements. The users of the **drm_writeback_connector** control the behaviour of the **encoder** by passing the **enc_funcs** parameter to *drm_writeback_connector_init()* function.

pixel_formats_blob_ptr
DRM blob property data for the pixel formats list on writeback connectors See also *drm_writeback_connector_init()*

job_lock
Protects job_queue

job_queue
Holds a list of a connector's writeback jobs; the last item is the most recent. The first item may be either waiting for the hardware to begin writing, or currently being written.

See also: *drm_writeback_queue_job()* and *drm_writeback_signal_completion()*

fence_context
timeline context used for fence operations.

fence_lock
spinlock to protect the fences in the fence_context.

fence_seqno
Seqno variable used as monotonic counter for the fences created on the connector's timeline.

timeline_name
The name of the connector's fence timeline.

struct **drm_writeback_job**
DRM writeback job

Definition

```
struct drm_writeback_job {
  struct drm_writeback_connector *connector;
  bool prepared;
  struct work_struct cleanup_work;
  struct list_head list_entry;
  struct drm_framebuffer *fb;
  struct dma_fence *out_fence;
  void *priv;
};
```

Members

connector
Back-pointer to the writeback connector associated with the job

prepared
Set when the job has been prepared with drm_writeback_prepare_job()

cleanup_work
Used to allow drm_writeback_signal_completion to defer dropping the framebuffer reference to a workqueue

list_entry
List item for the writeback connector's **job_queue**

fb
Framebuffer to be written to by the writeback connector. Do not set directly, use drm_writeback_set_fb()

out_fence
Fence which will signal once the writeback has completed

priv
Driver-private data

Writeback connectors are used to expose hardware which can write the output from a CRTC to a memory buffer. They are used and act similarly to other types of connectors, with some important differences:

- Writeback connectors don't provide a way to output visually to the user.
- Writeback connectors are visible to userspace only when the client sets DRM_CLIENT_CAP_WRITEBACK_CONNECTORS.
- Writeback connectors don't have EDID.

A framebuffer may only be attached to a writeback connector when the connector is attached to a CRTC. The WRITEBACK_FB_ID property which sets the framebuffer applies only to a single commit (see below). A framebuffer may not be attached while the CRTC is off.

Unlike with planes, when a writeback framebuffer is removed by userspace DRM makes no attempt to remove it from active use by the connector. This is because no method is provided to abort a writeback operation, and in any case making a new commit whilst a writeback is ongoing is undefined (see WRITEBACK_OUT_FENCE_PTR below). As soon as the current writeback is finished, the framebuffer will automatically no longer be in active use. As it will also have already been removed from the framebuffer list, there will be no way for any userspace application to retrieve a reference to it in the intervening period.

Writeback connectors have some additional properties, which userspace can use to query and control them:

"WRITEBACK_FB_ID" :
Write-only object property storing a DRM_MODE_OBJECT_FB: it stores the framebuffer to be written by the writeback connector. This property is similar to the FB_ID property on planes, but will always read as zero and is not preserved across commits. Userspace must set this property to an output buffer every time it wishes the buffer to get filled.

"WRITEBACK_PIXEL_FORMATS" :
Immutable blob property to store the supported pixel formats table. The data is an array of u32 DRM_FORMAT_* fourcc values. Userspace can use this blob to find out what pixel formats are supported by the connector's writeback engine.

"WRITEBACK_OUT_FENCE_PTR" :
Userspace can use this property to provide a pointer for the kernel to fill with a sync_file file descriptor, which will signal once the writeback is finished. The value should be the address of a 32-bit signed integer, cast to a u64. Userspace should wait for this fence to signal before making another commit affecting any of the same CRTCs, Planes or Connectors. **Failure to do so will result in undefined behaviour.** For this reason it is strongly recommended that all userspace applications making use of writeback connectors

always retrieve an out-fence for the commit and use it appropriately. From userspace, this property will always read as zero.

int **drm_writeback_connector_init**(struct *drm_device* *dev, struct *drm_writeback_connector* *wb_connector, const struct *drm_connector_funcs* *con_funcs, const struct *drm_encoder_helper_funcs* *enc_helper_funcs, const u32 *formats, int n_formats)

Initialize a writeback connector and its properties

Parameters

struct drm_device *dev
DRM device

struct drm_writeback_connector *wb_connector
Writeback connector to initialize

const struct drm_connector_funcs *con_funcs
Connector funcs vtable

const struct drm_encoder_helper_funcs *enc_helper_funcs
Encoder helper funcs vtable to be used by the internal encoder

const u32 *formats
Array of supported pixel formats for the writeback engine

int n_formats
Length of the formats array

Description

This function creates the writeback-connector-specific properties if they have not been already created, initializes the connector as type DRM_MODE_CONNECTOR_WRITEBACK, and correctly initializes the property values. It will also create an internal encoder associated with the drm_writeback_connector and set it to use the **enc_helper_funcs** vtable for the encoder helper.

Drivers should always use this function instead of *drm_connector_init()* to set up writeback connectors.

Return

0 on success, or a negative error code

void **drm_writeback_queue_job**(struct *drm_writeback_connector* *wb_connector, struct *drm_connector_state* *conn_state)

Queue a writeback job for later signalling

Parameters

struct drm_writeback_connector *wb_connector
The writeback connector to queue a job on

struct drm_connector_state *conn_state
The connector state containing the job to queue

Description

This function adds the job contained in **conn_state** to the job_queue for a writeback connector. It takes ownership of the writeback job and sets the **conn_state->writeback_job** to NULL, and so no access to the job may be performed by the caller after this function returns.

Drivers must ensure that for a given writeback connector, jobs are queued in exactly the same order as they will be completed by the hardware (and signaled via drm_writeback_signal_completion).

For every call to *drm_writeback_queue_job()* there must be exactly one call to *drm_writeback_signal_completion()*

See also: *drm_writeback_signal_completion()*

void **drm_writeback_signal_completion**(struct *drm_writeback_connector* *wb_connector, int status)

Signal the completion of a writeback job

Parameters

struct drm_writeback_connector *wb_connector
The writeback connector whose job is complete

int status
Status code to set in the writeback out_fence (0 for success)

Description

Drivers should call this to signal the completion of a previously queued writeback job. It should be called as soon as possible after the hardware has finished writing, and may be called from interrupt context. It is the driver's responsibility to ensure that for a given connector, the hardware completes writeback jobs in the same order as they are queued.

Unless the driver is holding its own reference to the framebuffer, it must not be accessed after calling this function.

See also: *drm_writeback_queue_job()*

4.12 Encoder Abstraction

Encoders represent the connecting element between the CRTC (as the overall pixel pipeline, represented by *struct drm_crtc*) and the connectors (as the generic sink entity, represented by *struct drm_connector*). An encoder takes pixel data from a CRTC and converts it to a format suitable for any attached connector. Encoders are objects exposed to userspace, originally to allow userspace to infer cloning and connector/CRTC restrictions. Unfortunately almost all drivers get this wrong, making the uabi pretty much useless. On top of that the exposed restrictions are too simple for today's hardware, and the recommended way to infer restrictions is by using the DRM_MODE_ATOMIC_TEST_ONLY flag for the atomic IOCTL.

Otherwise encoders aren' t used in the uapi at all (any modeset request from userspace directly connects a connector with a CRTC), drivers are therefore free to use them however they wish. Modeset helper libraries make strong use of encoders to facilitate code sharing. But for more complex settings it is usually better to move shared code into a separate *drm_bridge*. Compared to encoders, bridges also have the benefit of being purely an internal abstraction since they are not exposed to userspace at all.

Encoders are initialized with *drm_encoder_init()* and cleaned up using *drm_encoder_cleanup()*.

4.12.1 Encoder Functions Reference

struct **drm_encoder_funcs**

encoder controls

Definition

```
struct drm_encoder_funcs {
  void (*reset)(struct drm_encoder *encoder);
  void (*destroy)(struct drm_encoder *encoder);
  int (*late_register)(struct drm_encoder *encoder);
  void (*early_unregister)(struct drm_encoder *encoder);
};
```

Members

reset
Reset encoder hardware and software state to off. This function isn't called by the core directly, only through *drm_mode_config_reset()*. It' s not a helper hook only for historical reasons.

destroy
Clean up encoder resources. This is only called at driver unload time through *drm_mode_config_cleanup()* since an encoder cannot be hotplugged in DRM.

late_register
This optional hook can be used to register additional userspace interfaces attached to the encoder like debugfs interfaces. It is called late in the driver load sequence from *drm_dev_register()*. Everything added from this callback should be unregistered in the early_unregister callback.

Returns:

0 on success, or a negative error code on failure.

early_unregister
This optional hook should be used to unregister the additional userspace interfaces attached to the encoder from **late_register**. It is called from *drm_dev_unregister()*, early in the driver unload sequence to disable userspace access before data structures are torndown.

Description

Encoders sit between CRTCs and connectors.

struct **drm_encoder**
central DRM encoder structure

Definition

```
struct drm_encoder {
  struct drm_device *dev;
  struct list_head head;
  struct drm_mode_object base;
  char *name;
  int encoder_type;
  unsigned index;
  uint32_t possible_crtcs;
  uint32_t possible_clones;
  struct drm_crtc *crtc;
  struct list_head bridge_chain;
  const struct drm_encoder_funcs *funcs;
  const struct drm_encoder_helper_funcs *helper_private;
};
```

Members

dev
parent DRM device

head
list management

base
base KMS object

name
human readable name, can be overwritten by the driver

encoder_type
One of the DRM_MODE_ENCODER_<foo> types in drm_mode.h. The following encoder types are defined thus far:

- DRM_MODE_ENCODER_DAC for VGA and analog on DVI-I/DVI-A.
- DRM_MODE_ENCODER_TMDS for DVI, HDMI and (embedded) DisplayPort.
- DRM_MODE_ENCODER_LVDS for display panels, or in general any panel with a proprietary parallel connector.
- DRM_MODE_ENCODER_TVDAC for TV output (Composite, S-Video, Component, SCART).
- DRM_MODE_ENCODER_VIRTUAL for virtual machine displays
- DRM_MODE_ENCODER_DSI for panels connected using the DSI serial bus.
- DRM_MODE_ENCODER_DPI for panels connected using the DPI parallel bus.

- DRM_MODE_ENCODER_DPMST for special fake encoders used to allow mutliple DP MST streams to share one physical encoder.

index
: Position inside the mode_config.list, can be used as an array index. It is invariant over the lifetime of the encoder.

possible_crtcs
: Bitmask of potential CRTC bindings, using *drm_crtc_index()* as the index into the bitfield. The driver must set the bits for all *drm_crtc* objects this encoder can be connected to before calling *drm_dev_register()*.

  You will get a WARN if you get this wrong in the driver.

  Note that since CRTC objects can't be hotplugged the assigned indices are stable and hence known before registering all objects.

possible_clones
: Bitmask of potential sibling encoders for cloning, using *drm_encoder_index()* as the index into the bitfield. The driver must set the bits for all *drm_encoder* objects which can clone a *drm_crtc* together with this encoder before calling *drm_dev_register()*. Drivers should set the bit representing the encoder itself, too. Cloning bits should be set such that when two encoders can be used in a cloned configuration, they both should have each another bits set.

  As an exception to the above rule if the driver doesn't implement any cloning it can leave **possible_clones** set to 0. The core will automagically fix this up by setting the bit for the encoder itself.

  You will get a WARN if you get this wrong in the driver.

  Note that since encoder objects can't be hotplugged the assigned indices are stable and hence known before registering all objects.

crtc
: Currently bound CRTC, only really meaningful for non-atomic drivers. Atomic drivers should instead check *drm_connector_state.crtc*.

bridge_chain
: Bridges attached to this encoder. Drivers shall not access this field directly.

funcs
: control functions

helper_private
: mid-layer private data

Description

CRTCs drive pixels to encoders, which convert them into signals appropriate for a given connector or set of connectors.

unsigned int **drm_encoder_index**(const struct *drm_encoder* *encoder)
: find the index of a registered encoder

Parameters

const struct drm_encoder *encoder
: encoder to find index for

Description

Given a registered encoder, return the index of that encoder within a DRM device's list of encoders.

u32 **drm_encoder_mask**(const struct *drm_encoder* *encoder)

find the mask of a registered encoder

Parameters

const struct drm_encoder *encoder
encoder to find mask for

Description

Given a registered encoder, return the mask bit of that encoder for an encoder's possible_clones field.

bool **drm_encoder_crtc_ok**(struct *drm_encoder* *encoder, struct *drm_crtc* *crtc)

can a given crtc drive a given encoder?

Parameters

struct drm_encoder *encoder
encoder to test

struct drm_crtc *crtc
crtc to test

Description

Returns false if **encoder** can't be driven by **crtc**, true otherwise.

struct *drm_encoder* ***drm_encoder_find**(struct *drm_device* *dev, struct *drm_file* *file_priv, uint32_t id)

find a *drm_encoder*

Parameters

struct drm_device *dev
DRM device

struct drm_file *file_priv
drm file to check for lease against.

uint32_t id
encoder id

Description

Returns the encoder with **id**, NULL if it doesn't exist. Simple wrapper around *drm_mode_object_find()*.

drm_for_each_encoder_mask

`drm_for_each_encoder_mask (encoder, dev, encoder_mask)`

iterate over encoders specified by bitmask

Parameters

encoder
the loop cursor

dev
the DRM device

encoder_mask
bitmask of encoder indices

Description

Iterate over all encoders specified by bitmask.

drm_for_each_encoder

`drm_for_each_encoder (encoder, dev)`

iterate over all encoders

Parameters

encoder
the loop cursor

dev
the DRM device

Description

Iterate over all encoders of **dev**.

int **drm_encoder_init**(struct *drm_device* *dev, struct *drm_encoder* *encoder, const struct *drm_encoder_funcs* *funcs, int encoder_type, const char *name, ...)

Init a preallocated encoder

Parameters

struct drm_device *dev
drm device

struct drm_encoder *encoder
the encoder to init

const struct drm_encoder_funcs *funcs
callbacks for this encoder

int encoder_type
user visible type of the encoder

const char *name
printf style format string for the encoder name, or NULL for default name

...
variable arguments

Description

Initialises a preallocated encoder. Encoder should be subclassed as part of driver encoder objects. At driver unload time *drm_encoder_cleanup()* should be called from the driver's *drm_encoder_funcs.destroy* hook.

Return

Zero on success, error code on failure.

void **drm_encoder_cleanup**(struct *drm_encoder* *encoder)

cleans up an initialised encoder

Parameters

struct drm_encoder *encoder

encoder to cleanup

Description

Cleans up the encoder but doesn't free the object.

4.13 KMS Locking

As KMS moves toward more fine grained locking, and atomic ioctl where userspace can indirectly control locking order, it becomes necessary to use ww_mutex and acquire-contexts to avoid deadlocks. But because the locking is more distributed around the driver code, we want a bit of extra utility/tracking out of our acquire-ctx. This is provided by *struct drm_modeset_lock* and *struct drm_modeset_acquire_ctx*.

For basic principles of ww_mutex, see: Documentation/locking/ww-mutex-design.rst

The basic usage pattern is to:

```
drm_modeset_acquire_init(ctx, DRM_MODESET_ACQUIRE_INTERRUPTIBLE)
retry:
foreach (lock in random_ordered_set_of_locks) {
    ret = drm_modeset_lock(lock, ctx)
    if (ret == -EDEADLK) {
        ret = drm_modeset_backoff(ctx);
        if (!ret)
            goto retry;
    }
    if (ret)
        goto out;
}
... do stuff ...
out:
drm_modeset_drop_locks(ctx);
drm_modeset_acquire_fini(ctx);
```

For convenience this control flow is implemented in *DRM_MODESET_LOCK_ALL_BEGIN()* and *DRM_MODESET_LOCK_ALL_END()* for the case where all modeset locks need to be taken through *drm_modeset_lock_all_ctx()*.

If all that is needed is a single modeset lock, then the *struct drm_modeset_acquire_ctx* is not needed and the locking can be simplified by passing a NULL instead of ctx in the *drm_modeset_lock()* call or calling *drm_modeset_lock_single_interruptible()*. To unlock afterwards call *drm_modeset_unlock()*.

On top of these per-object locks using ww_mutex there's also an overall *drm_mode_config.mutex*, for protecting everything else. Mostly this means probe state of connectors, and preventing hotplug add/removal of connectors.

Finally there's a bunch of dedicated locks to protect drm core internal lists and lookup data structures.

struct **drm_modeset_acquire_ctx**

locking context (see ww_acquire_ctx)

Definition

```
struct drm_modeset_acquire_ctx {
  struct ww_acquire_ctx ww_ctx;
  struct drm_modeset_lock *contended;
  struct list_head locked;
  bool trylock_only;
  bool interruptible;
};
```

Members

ww_ctx
base acquire ctx

contended
used internally for -EDEADLK handling

locked
list of held locks

trylock_only
trylock mode used in atomic contexts/panic notifiers

interruptible
whether interruptible locking should be used.

Description

Each thread competing for a set of locks must use one acquire ctx. And if any lock fxn returns -EDEADLK, it must backoff and retry.

struct **drm_modeset_lock**

used for locking modeset resources.

Definition

```
struct drm_modeset_lock {
  struct ww_mutex mutex;
  struct list_head head;
};
```

Members

mutex
resource locking

head
used to hold its place on `drm_atomi_state.locked` list when part of an atomic update

Description

Used for locking CRTCs and other modeset resources.

void **drm_modeset_lock_fini**(struct *drm_modeset_lock* *lock)
cleanup lock

Parameters

struct drm_modeset_lock *lock
lock to cleanup

bool **drm_modeset_is_locked**(struct *drm_modeset_lock* *lock)
equivalent to mutex_is_locked()

Parameters

struct drm_modeset_lock *lock
lock to check

void **drm_modeset_lock_assert_held**(struct *drm_modeset_lock* *lock)
equivalent to lockdep_assert_held()

Parameters

struct drm_modeset_lock *lock
lock to check

DRM_MODESET_LOCK_ALL_BEGIN

`DRM_MODESET_LOCK_ALL_BEGIN (dev, ctx, flags, ret)`

Helper to acquire modeset locks

Parameters

dev
drm device

ctx
local modeset acquire context, will be dereferenced

flags
DRM_MODESET_ACQUIRE_* flags to pass to *drm_modeset_acquire_init()*

ret
local ret/err/etc variable to track error status

Description

Use these macros to simplify grabbing all modeset locks using a local context. This has the advantage of reducing boilerplate, but also properly checking return values where appropriate.

Any code run between BEGIN and END will be holding the modeset locks.

This must be paired with *DRM_MODESET_LOCK_ALL_END()*. We will jump back and forth between the labels on deadlock and error conditions.

Drivers can acquire additional modeset locks. If any lock acquisition fails, the control flow needs to jump to *DRM_MODESET_LOCK_ALL_END()* with the **ret** parameter containing the return value of *drm_modeset_lock()*.

Return

The only possible value of ret immediately after *DRM_MODESET_LOCK_ALL_BEGIN()* is 0, so no error checking is necessary

DRM_MODESET_LOCK_ALL_END

`DRM_MODESET_LOCK_ALL_END (dev, ctx, ret)`

Helper to release and cleanup modeset locks

Parameters

dev
drm device

ctx
local modeset acquire context, will be dereferenced

ret
local ret/err/etc variable to track error status

Description

The other side of *DRM_MODESET_LOCK_ALL_BEGIN()*. It will bounce back to BEGIN if ret is -EDEADLK.

It' s important that you use the same ret variable for begin and end so deadlock conditions are properly handled.

Return

ret will be untouched unless it is -EDEADLK on entry. That means that if you successfully acquire the locks, ret will be whatever your code sets it to. If there is a deadlock or other failure with acquire or backoff, ret will be set to that failure. In both of these cases the code between BEGIN/END will not be run, so the failure will reflect the inability to grab the locks.

void **drm_modeset_lock_all**(struct *drm_device* *dev)

take all modeset locks

Parameters

struct drm_device *dev
DRM device

Description

This function takes all modeset locks, suitable where a more fine-grained scheme isn' t (yet) implemented. Locks must be dropped by calling the *drm_modeset_unlock_all()* function.

This function is deprecated. It allocates a lock acquisition context and stores it in *drm_device.mode_config*. This facilitate conversion of existing code because it removes the need to manually deal with the acquisition context, but it is also brittle because the context is global and care must be taken not to nest calls. New code should use the *drm_modeset_lock_all_ctx()* function and pass in the context explicitly.

void **drm_modeset_unlock_all**(struct *drm_device* *dev)

drop all modeset locks

Parameters

struct drm_device *dev
DRM device

Description

This function drops all modeset locks taken by a previous call to the *drm_modeset_lock_all()* function.

This function is deprecated. It uses the lock acquisition context stored in *drm_device.mode_config*. This facilitates conversion of existing code because it removes the need to manually deal with the acquisition context, but it is also brittle because the context is global and care must be taken not to nest calls. New code should pass the acquisition context directly to the *drm_modeset_drop_locks()* function.

void **drm_warn_on_modeset_not_all_locked**(struct *drm_device* *dev)

check that all modeset locks are locked

Parameters

struct drm_device *dev
device

Description

Useful as a debug assert.

void **drm_modeset_acquire_init**(struct *drm_modeset_acquire_ctx* *ctx, uint32_t flags)

initialize acquire context

Parameters

struct drm_modeset_acquire_ctx *ctx
the acquire context

uint32_t flags
0 or DRM_MODESET_ACQUIRE_INTERRUPTIBLE

Description

When passing DRM_MODESET_ACQUIRE_INTERRUPTIBLE to **flags**, all calls to *drm_modeset_lock()* will perform an interruptible wait.

void **drm_modeset_acquire_fini**(struct *drm_modeset_acquire_ctx* *ctx)

cleanup acquire context

Parameters

struct drm_modeset_acquire_ctx *ctx
    the acquire context

void **drm_modeset_drop_locks**(struct *drm_modeset_acquire_ctx* *ctx)
    drop all locks

Parameters

struct drm_modeset_acquire_ctx *ctx
    the acquire context

Description

Drop all locks currently held against this acquire context.

int **drm_modeset_backoff**(struct *drm_modeset_acquire_ctx* *ctx)
    deadlock avoidance backoff

Parameters

struct drm_modeset_acquire_ctx *ctx
    the acquire context

Description

If deadlock is detected (ie. *drm_modeset_lock()* returns -EDEADLK), you must call this function to drop all currently held locks and block until the contended lock becomes available.

This function returns 0 on success, or -ERESTARTSYS if this context is initialized with `DRM_MODESET_ACQUIRE_INTERRUPTIBLE` and the wait has been interrupted.

void **drm_modeset_lock_init**(struct *drm_modeset_lock* *lock)
    initialize lock

Parameters

struct drm_modeset_lock *lock
    lock to init

int **drm_modeset_lock**(struct *drm_modeset_lock* *lock, struct *drm_modeset_acquire_ctx* *ctx)
    take modeset lock

Parameters

struct drm_modeset_lock *lock
    lock to take

struct drm_modeset_acquire_ctx *ctx
    acquire ctx

Description

If **ctx** is not NULL, then its ww acquire context is used and the lock will be tracked by the context and can be released by calling *drm_modeset_drop_locks()*. If -EDEADLK is returned, this means a deadlock scenario has been detected and it is an error to attempt to take any more locks without first calling *drm_modeset_backoff()*.

If the **ctx** is not NULL and initialized with `DRM_MODESET_ACQUIRE_INTERRUPTIBLE`, this function will fail with -ERESTARTSYS when interrupted.

If **ctx** is NULL then the function call behaves like a normal, uninterruptible non-nesting mutex_lock() call.

int **`drm_modeset_lock_single_interruptible`**(struct *drm_modeset_lock* *lock)

take a single modeset lock

Parameters

`struct drm_modeset_lock *lock`
lock to take

Description

This function behaves as *`drm_modeset_lock()`* with a NULL context, but performs interruptible waits.

This function returns 0 on success, or -ERESTARTSYS when interrupted.

void **`drm_modeset_unlock`**(struct *drm_modeset_lock* *lock)

drop modeset lock

Parameters

`struct drm_modeset_lock *lock`
lock to release

int **`drm_modeset_lock_all_ctx`**(struct *drm_device* *dev, struct *drm_modeset_acquire_ctx* *ctx)

take all modeset locks

Parameters

`struct drm_device *dev`
DRM device

`struct drm_modeset_acquire_ctx *ctx`
lock acquisition context

Description

This function takes all modeset locks, suitable where a more fine-grained scheme isn't (yet) implemented.

Unlike *`drm_modeset_lock_all()`*, it doesn't take the *`drm_mode_config.mutex`* since that lock isn't required for modeset state changes. Callers which need to grab that lock too need to do so outside of the acquire context **ctx**.

Locks acquired with this function should be released by calling the *`drm_modeset_drop_locks()`* function on **ctx**.

See also: *`DRM_MODESET_LOCK_ALL_BEGIN()`* and *`DRM_MODESET_LOCK_ALL_END()`*

Return

0 on success or a negative error-code on failure.

4.14 KMS Properties

4.14.1 Property Types and Blob Property Support

Properties as represented by *drm_property* are used to extend the modeset interface exposed to userspace. For the atomic modeset IOCTL properties are even the only way to transport metadata about the desired new modeset configuration from userspace to the kernel. Properties have a well-defined value range, which is enforced by the drm core. See the documentation of the flags member of *struct drm_property* for an overview of the different property types and ranges.

Properties don' t store the current value directly, but need to be instatiated by attaching them to a *drm_mode_object* with *drm_object_attach_property()*.

Property values are only 64bit. To support bigger piles of data (like gamma tables, color correction matrices or large structures) a property can instead point at a *drm_property_blob* with that additional data.

Properties are defined by their symbolic name, userspace must keep a per-object mapping from those names to the property ID used in the atomic IOCTL and in the get/set property IOCTL.

struct **drm_property_enum**

symbolic values for enumerations

Definition

```
struct drm_property_enum {
  uint64_t value;
  struct list_head head;
  char name[DRM_PROP_NAME_LEN];
};
```

Members

value
numeric property value for this enum entry

head
list of enum values, linked to *drm_property.enum_list*

name
symbolic name for the enum

Description

For enumeration and bitmask properties this structure stores the symbolic decoding for each value. This is used for example for the rotation property.

struct **drm_property**

modeset object property

Definition

```
struct drm_property {
  struct list_head head;
```

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```
  struct drm_mode_object base;
  uint32_t flags;
  char name[DRM_PROP_NAME_LEN];
  uint32_t num_values;
  uint64_t *values;
  struct drm_device *dev;
  struct list_head enum_list;
};
```

Members

head
per-device list of properties, for cleanup.

base
base KMS object

flags
Property flags and type. A property needs to be one of the following types:

DRM_MODE_PROP_RANGE
Range properties report their minimum and maximum admissible unsigned values. The KMS core verifies that values set by application fit in that range. The range is unsigned. Range properties are created using *drm_property_create_range()*.

DRM_MODE_PROP_SIGNED_RANGE
Range properties report their minimum and maximum admissible unsigned values. The KMS core verifies that values set by application fit in that range. The range is signed. Range properties are created using *drm_property_create_signed_range()*.

DRM_MODE_PROP_ENUM
Enumerated properties take a numerical value that ranges from 0 to the number of enumerated values defined by the property minus one, and associate a free-formed string name to each value. Applications can retrieve the list of defined value-name pairs and use the numerical value to get and set property instance values. Enum properties are created using *drm_property_create_enum()*.

DRM_MODE_PROP_BITMASK
Bitmask properties are enumeration properties that additionally restrict all enumerated values to the 0..63 range. Bitmask property instance values combine one or more of the enumerated bits defined by the property. Bitmask properties are created using *drm_property_create_bitmask()*.

DRM_MODE_PROB_OBJECT
Object properties are used to link modeset objects. This is used extensively in the atomic support to create the display pipeline, by linking *drm_framebuffer* to *drm_plane*, *drm_plane* to *drm_crtc* and *drm_connector* to *drm_crtc*. An object property can only link to a specific type of *drm_mode_object*, this limit is enforced by the core. Object properties are created using *drm_property_create_object()*.

Object properties work like blob properties, but in a more general fashion. They are limited to atomic drivers and must have the DRM_MODE_PROP_ATOMIC flag set.

DRM_MODE_PROP_BLOB
Blob properties store a binary blob without any format restriction. The binary blobs are created as KMS standalone objects, and blob property instance values store the ID of their associated blob object. Blob properties are created by calling *drm_property_create()* with DRM_MODE_PROP_BLOB as the type.

Actual blob objects to contain blob data are created using *drm_property_create_blob()*, or through the corresponding IOCTL.

Besides the built-in limit to only accept blob objects blob properties work exactly like object properties. The only reasons blob properties exist is backwards compatibility with existing userspace.

In addition a property can have any combination of the below flags:

DRM_MODE_PROP_ATOMIC
Set for properties which encode atomic modeset state. Such properties are not exposed to legacy userspace.

DRM_MODE_PROP_IMMUTABLE
Set for properties whose values cannot be changed by userspace. The kernel is allowed to update the value of these properties. This is generally used to expose probe state to userspace, e.g. the EDID, or the connector path property on DP MST sinks. Kernel can update the value of an immutable property by calling *drm_object_property_set_value()*.

`name`
symbolic name of the properties

`num_values`
size of the **values** array.

`values`
Array with limits and values for the property. The interpretation of these limits is dependent upon the type per **flags**.

`dev`
DRM device

`enum_list`
List of `drm_prop_enum_list` structures with the symbolic names for enum and bitmask values.

Description

This structure represent a modeset object property. It combines both the name of the property with the set of permissible values. This means that when a driver wants to use a property with the same name on different objects, but with different value ranges, then it must create property for each one. An example would be rotation of *drm_plane*, when e.g. the primary plane cannot be rotated. But if both the name and the value range match, then the same property structure can be instantiated multiple times for the same object. Userspace must be able to cope with this and cannot assume that the same symbolic property will have the same modeset object ID on all modeset objects.

Properties are created by one of the special functions, as explained in detail in the **flags** structure member.

To actually expose a property it must be attached to each object using *drm_object_attach_property()*. Currently properties can only be attached to *drm_connector*, *drm_crtc* and *drm_plane*.

Properties are also used as the generic metadatatransport for the atomic IOCTL. Everything that was set directly in structures in the legacy modeset IOCTLs (like the plane source or destination windows, or e.g. the links to the CRTC) is exposed as a property with the DRM_MODE_PROP_ATOMIC flag set.

struct **drm_property_blob**

Blob data for *drm_property*

Definition

```
struct drm_property_blob {
  struct drm_mode_object base;
  struct drm_device *dev;
  struct list_head head_global;
  struct list_head head_file;
  size_t length;
  void *data;
};
```

Members

base
base KMS object

dev
DRM device

head_global
entry on the global blob list in *drm_mode_config.property_blob_list*.

head_file
entry on the per-file blob list in *drm_file.blobs* list.

length
size of the blob in bytes, invariant over the lifetime of the object

data
actual data, embedded at the end of this structure

Description

Blobs are used to store bigger values than what fits directly into the 64 bits available for a *drm_property*.

Blobs are reference counted using *drm_property_blob_get()* and *drm_property_blob_put()*. They are created using *drm_property_create_blob()*.

bool **drm_property_type_is**(struct *drm_property* *property, uint32_t type)

check the type of a property

Parameters

struct drm_property *property
property to check

uint32_t type
property type to compare with

Description

This is a helper function becauase the uapi encoding of property types is a bit special for historical reasons.

struct *drm_property* ***drm_property_find**(struct *drm_device* *dev, struct *drm_file* *file_priv, uint32_t id)

find property object

Parameters

struct drm_device *dev
DRM device

struct drm_file *file_priv
drm file to check for lease against.

uint32_t id
property object id

Description

This function looks up the property object specified by id and returns it.

struct *drm_property* ***drm_property_create**(struct *drm_device* *dev, u32 flags, const char *name, int num_values)

create a new property type

Parameters

struct drm_device *dev
drm device

u32 flags
flags specifying the property type

const char *name
name of the property

int num_values
number of pre-defined values

Description

This creates a new generic drm property which can then be attached to a drm object with *drm_object_attach_property()*. The returned property object must be freed with *drm_property_destroy()*, which is done automatically when calling *drm_mode_config_cleanup()*.

Return

A pointer to the newly created property on success, NULL on failure.

struct *drm_property* ***drm_property_create_enum**(struct *drm_device* *dev, u32 flags, const char *name, const struct drm_prop_enum_list *props, int num_values)

create a new enumeration property type

Parameters

struct drm_device *dev
drm device

u32 flags
flags specifying the property type

const char *name
name of the property

const struct drm_prop_enum_list *props
enumeration lists with property values

int num_values
number of pre-defined values

Description

This creates a new generic drm property which can then be attached to a drm object with *drm_object_attach_property()*. The returned property object must be freed with *drm_property_destroy()*, which is done automatically when calling *drm_mode_config_cleanup()*.

Userspace is only allowed to set one of the predefined values for enumeration properties.

Return

A pointer to the newly created property on success, NULL on failure.

struct *drm_property* ***drm_property_create_bitmask**(struct *drm_device* *dev, u32 flags, const char *name, const struct drm_prop_enum_list *props, int num_props, uint64_t supported_bits)

create a new bitmask property type

Parameters

struct drm_device *dev
drm device

u32 flags
flags specifying the property type

const char *name
name of the property

const struct drm_prop_enum_list *props
enumeration lists with property bitflags

int num_props
: size of the **props** array

uint64_t supported_bits
: bitmask of all supported enumeration values

Description

This creates a new bitmask drm property which can then be attached to a drm object with *drm_object_attach_property()*. The returned property object must be freed with *drm_property_destroy()*, which is done automatically when calling *drm_mode_config_cleanup()*.

Compared to plain enumeration properties userspace is allowed to set any or' ed together combination of the predefined property bitflag values

Return

A pointer to the newly created property on success, NULL on failure.

struct *drm_property* ***drm_property_create_range**(struct *drm_device* *dev, u32 flags, const char *name, uint64_t min, uint64_t max)

create a new unsigned ranged property type

Parameters

struct drm_device *dev
: drm device

u32 flags
: flags specifying the property type

const char *name
: name of the property

uint64_t min
: minimum value of the property

uint64_t max
: maximum value of the property

Description

This creates a new generic drm property which can then be attached to a drm object with *drm_object_attach_property()*. The returned property object must be freed with *drm_property_destroy()*, which is done automatically when calling *drm_mode_config_cleanup()*.

Userspace is allowed to set any unsigned integer value in the (min, max) range inclusive.

Return

A pointer to the newly created property on success, NULL on failure.

struct *drm_property* ***drm_property_create_signed_range**(struct *drm_device* *dev, u32 flags, const char *name, int64_t min, int64_t max) create a new signed ranged property type

Parameters

struct drm_device *dev
drm device

u32 flags
flags specifying the property type

const char *name
name of the property

int64_t min
minimum value of the property

int64_t max
maximum value of the property

Description

This creates a new generic drm property which can then be attached to a drm object with *drm_object_attach_property()*. The returned property object must be freed with *drm_property_destroy()*, which is done automatically when calling *drm_mode_config_cleanup()*.

Userspace is allowed to set any signed integer value in the (min, max) range inclusive.

Return

A pointer to the newly created property on success, NULL on failure.

struct *drm_property* ***drm_property_create_object**(struct *drm_device* *dev, u32 flags, const char *name, uint32_t type)

create a new object property type

Parameters

struct drm_device *dev
drm device

u32 flags
flags specifying the property type

const char *name
name of the property

uint32_t type
object type from DRM_MODE_OBJECT_* defines

Description

This creates a new generic drm property which can then be attached to a drm object with *drm_object_attach_property()*. The returned property object must be freed with *drm_property_destroy()*, which is done automatically when calling *drm_mode_config_cleanup()*.

Userspace is only allowed to set this to any property value of the given **type**. Only useful for atomic properties, which is enforced.

Return

A pointer to the newly created property on success, NULL on failure.

struct *drm_property* ***drm_property_create_bool**(struct *drm_device* *dev, u32 flags, const char *name)

create a new boolean property type

Parameters

struct drm_device *dev
drm device

u32 flags
flags specifying the property type

const char *name
name of the property

Description

This creates a new generic drm property which can then be attached to a drm object with *drm_object_attach_property()*. The returned property object must be freed with *drm_property_destroy()*, which is done automatically when calling *drm_mode_config_cleanup()*.

This is implemented as a ranged property with only {0, 1} as valid values.

Return

A pointer to the newly created property on success, NULL on failure.

int **drm_property_add_enum**(struct *drm_property* *property, uint64_t value, const char *name)

add a possible value to an enumeration property

Parameters

struct drm_property *property
enumeration property to change

uint64_t value
value of the new enumeration

const char *name
symbolic name of the new enumeration

Description

This functions adds enumerations to a property.

It’ s use is deprecated, drivers should use one of the more specific helpers to directly create the property with all enumerations already attached.

Return

Zero on success, error code on failure.

void **drm_property_destroy**(struct *drm_device* *dev, struct *drm_property* *property)

destroy a drm property

Parameters

struct drm_device *dev
drm device

struct drm_property *property
property to destry

Description

This function frees a property including any attached resources like enumeration values.

struct *drm_property_blob* ***drm_property_create_blob**(struct *drm_device* *dev, size_t length, const void *data)

Create new blob property

Parameters

struct drm_device *dev
DRM device to create property for

size_t length
Length to allocate for blob data

const void *data
If specified, copies data into blob

Description

Creates a new blob property for a specified DRM device, optionally copying data. Note that blob properties are meant to be invariant, hence the data must be filled out before the blob is used as the value of any property.

Return

New blob property with a single reference on success, or an ERR_PTR value on failure.

void **drm_property_blob_put**(struct *drm_property_blob* *blob)

release a blob property reference

Parameters

struct drm_property_blob *blob
DRM blob property

Description

Releases a reference to a blob property. May free the object.

struct *drm_property_blob* ***drm_property_blob_get**(struct *drm_property_blob* *blob)

acquire blob property reference

Parameters

struct drm_property_blob *blob
DRM blob property

Description

Acquires a reference to an existing blob property. Returns **blob**, which allows this to be used as a shorthand in assignments.

struct *drm_property_blob* ***drm_property_lookup_blob**(struct *drm_device* *dev, uint32_t id)

look up a blob property and take a reference

Parameters

struct drm_device *dev
drm device

uint32_t id
id of the blob property

Description

If successful, this takes an additional reference to the blob property. callers need to make sure to eventually unreference the returned property again, using *drm_property_blob_put()*.

Return

NULL on failure, pointer to the blob on success.

int **drm_property_replace_global_blob**(struct *drm_device* *dev, struct *drm_property_blob* **replace, size_t length, const void *data, struct *drm_mode_object* *obj_holds_id, struct *drm_property* *prop_holds_id)

replace existing blob property

Parameters

struct drm_device *dev
drm device

struct drm_property_blob **replace
location of blob property pointer to be replaced

size_t length
length of data for new blob, or 0 for no data

const void *data
content for new blob, or NULL for no data

struct drm_mode_object *obj_holds_id
optional object for property holding blob ID

struct drm_property *prop_holds_id
optional property holding blob ID **return** 0 on success or error on failure

Description

This function will replace a global property in the blob list, optionally updating a property which holds the ID of that property.

If length is 0 or data is NULL, no new blob will be created, and the holding property, if specified, will be set to 0.

Access to the replace pointer is assumed to be protected by the caller, e.g. by holding the relevant modesetting object lock for its parent.

For example, a drm_connector has a 'PATH' property, which contains the ID of a blob property with the value of the MST path information. Calling this function with replace pointing to the connector's path_blob_ptr, length and data set for the new path information, obj_holds_id set to the connector's base object, and prop_holds_id set to the path property name, will perform a completely atomic update. The access to path_blob_ptr is protected by the caller holding a lock on the connector.

bool **drm_property_replace_blob**(struct *drm_property_blob* **blob, struct *drm_property_blob* *new_blob)

replace a blob property

Parameters

struct drm_property_blob **blob
a pointer to the member blob to be replaced

struct drm_property_blob *new_blob
the new blob to replace with

Return

true if the blob was in fact replaced.

4.14.2 Standard Connector Properties

DRM connectors have a few standardized properties:

EDID:
Blob property which contains the current EDID read from the sink. This is useful to parse sink identification information like vendor, model and serial. Drivers should update this property by calling *drm_connector_update_edid_property()*, usually after having parsed the EDID using *drm_add_edid_modes()*. Userspace cannot change this property.

DPMS:
Legacy property for setting the power state of the connector. For atomic drivers this is only provided for backwards compatibility with existing drivers, it remaps to controlling the "ACTIVE" property on the CRTC the connector is linked to. Drivers should never set this property directly, it is handled by the DRM core by calling the *drm_connector_funcs.dpms* callback. For atomic drivers the remapping to the "ACTIVE" property is implemented in the DRM core.

Note that this property cannot be set through the MODE_ATOMIC ioctl, userspace must use "ACTIVE" on the CRTC instead.

WARNING:

For userspace also running on legacy drivers the "DPMS" semantics are a lot more complicated. First, userspace cannot rely on the "DPMS" value returned by the GETCONNECTOR actually reflecting reality, because many drivers fail to update it. For atomic drivers this is taken care of in `drm_atomic_helper_update_legacy_modeset_state()`.

The second issue is that the DPMS state is only well-defined when the connector is connected to a CRTC. In atomic the DRM core enforces that "ACTIVE" is off in such a case, no such checks exists for "DPMS" .

Finally, when enabling an output using the legacy SETCONFIG ioctl then "DPMS" is forced to ON. But see above, that might not be reflected in the software value on legacy drivers.

Summarizing: Only set "DPMS" when the connector is known to be enabled, assume that a successful SETCONFIG call also sets "DPMS" to on, and never read back the value of "DPMS" because it can be incorrect.

PATH:
Connector path property to identify how this sink is physically connected. Used by DP MST. This should be set by calling `drm_connector_set_path_property()`, in the case of DP MST with the path property the MST manager created. Userspace cannot change this property.

TILE:
Connector tile group property to indicate how a set of DRM connector compose together into one logical screen. This is used by both high-res external screens (often only using a single cable, but exposing multiple DP MST sinks), or high-res integrated panels (like dual-link DSI) which are not genlocked. Note that for tiled panels which are genlocked, like dual-link LVDS or dual-link DSI, the driver should try to not expose the tiling and virtualise both `drm_crtc` and `drm_plane` if needed. Drivers should update this value using `drm_connector_set_tile_property()`. Userspace cannot change this property.

link-status:
Connector link-status property to indicate the status of link. The default value of link-status is "GOOD". If something fails during or after modeset, the kernel driver may set this to "BAD"and issue a hotplug uevent. Drivers should update this value using `drm_connector_set_link_status_property()`.

When user-space receives the hotplug uevent and detects a "BAD" link-status, the sink doesn' t receive pixels anymore (e.g. the screen becomes completely black). The list of available modes may have changed. User-space is expected to pick a new mode if the current one has disappeared and perform a new modeset with link-status set to "GOOD" to re-enable the connector.

If multiple connectors share the same CRTC and one of them gets a "BAD" link-status, the other are unaffected (ie. the sinks still continue to receive pixels).

When user-space performs an atomic commit on a connector with a "BAD" link-status without resetting the property to "GOOD" , the sink may still not receive pixels. When user-space performs an atomic commit which resets the link-status property to "GOOD" without the ALLOW_MODESET flag set, it might fail because a modeset is required.

User-space can only change link-status to "GOOD", changing it to "BAD" is a no-op.

For backwards compatibility with non-atomic userspace the kernel tries to automatically set the link-status back to "GOOD" in the SETCRTC IOCTL. This might fail if the mode is no longer valid, similar to how it might fail if a different screen has been connected in the interim.

non_desktop:
Indicates the output should be ignored for purposes of displaying a standard desktop environment or console. This is most likely because the output device is not rectilinear.

Content Protection:
This property is used by userspace to request the kernel protect future content communicated over the link. When requested, kernel will apply the appropriate means of protection (most often HDCP), and use the property to tell userspace the protection is active.

Drivers can set this up by calling *drm_connector_attach_content_protection_property(* on initialization.

The value of this property can be one of the following:

DRM_MODE_CONTENT_PROTECTION_UNDESIRED = 0
The link is not protected, content is transmitted in the clear.

DRM_MODE_CONTENT_PROTECTION_DESIRED = 1
Userspace has requested content protection, but the link is not currently protected. When in this state, kernel should enable Content Protection as soon as possible.

DRM_MODE_CONTENT_PROTECTION_ENABLED = 2
Userspace has requested content protection, and the link is protected. Only the driver can set the property to this value. If userspace attempts to set to ENABLED, kernel will return -EINVAL.

A few guidelines:

- DESIRED state should be preserved until userspace de-asserts it by setting the property to UNDESIRED. This means ENABLED should only transition to UNDESIRED when the user explicitly requests it.
- If the state is DESIRED, kernel should attempt to re-authenticate the link whenever possible. This includes across disable/enable, dpms, hotplug, downstream device changes, link status failures, etc..
- Kernel sends uevent with the connector id and property id through **drm_hdcp_update_content_protection**, upon below kernel triggered scenarios:
  - DESIRED -> ENABLED (authentication success)
  - ENABLED -> DESIRED (termination of authentication)
- Please note no uevents for userspace triggered property state changes, which can't fail such as
  - DESIRED/ENABLED -> UNDESIRED

  - UNDESIRED -> DESIRED

- Userspace is responsible for polling the property or listen to uevents to determine when the value transitions from ENABLED to DESIRED. This signifies the link is no longer protected and userspace should take appropriate action (whatever that might be).

HDCP Content Type:

This Enum property is used by the userspace to declare the content type of the display stream, to kernel. Here display stream stands for any display content that userspace intended to display through HDCP encryption.

Content Type of a stream is decided by the owner of the stream, as “HDCP Type0” or “HDCP Type1”.

The value of the property can be one of the below:

- “HDCP Type0”: DRM_MODE_HDCP_CONTENT_TYPE0 = 0
- “HDCP Type1”: DRM_MODE_HDCP_CONTENT_TYPE1 = 1

When kernel starts the HDCP authentication (see “Content Protection” for details), it uses the content type in “HDCP Content Type” for performing the HDCP authentication with the display sink.

Please note in HDCP spec versions, a link can be authenticated with HDCP 2.2 for Content Type 0/Content Type 1. Where as a link can be authenticated with HDCP1.4 only for Content Type 0(though it is implicit in nature. As there is no reference for Content Type in HDCP1.4).

HDCP2.2 authentication protocol itself takes the “Content Type” as a parameter, which is a input for the DP HDCP2.2 encryption algo.

In case of Type 0 content protection request, kernel driver can choose either of HDCP spec versions 1.4 and 2.2. When HDCP2.2 is used for “HDCP Type 0”, a HDCP 2.2 capable repeater in the downstream can send that content to a HDCP 1.4 authenticated HDCP sink (Type0 link). But if the content is classified as “HDCP Type 1”, above mentioned HDCP 2.2 repeater wont send the content to the HDCP sink as it can’t authenticate the HDCP1.4 capable sink for “HDCP Type 1”.

Please note userspace can be ignorant of the HDCP versions used by the kernel driver to achieve the “HDCP Content Type”.

At current scenario, classifying a content as Type 1 ensures that the content will be displayed only through the HDCP2.2 encrypted link.

Note that the HDCP Content Type property is introduced at HDCP 2.2, and defaults to type 0. It is only exposed by drivers supporting HDCP 2.2 (hence supporting Type 0 and Type 1). Based on how next versions of HDCP specs are defined content Type could be used for higher versions too.

If content type is changed when “Content Protection” is not UNDESIRED, then kernel will disable the HDCP and re-enable with new type in the same atomic commit. And when “Content Protection” is ENABLED, it means that link is HDCP authenticated and encrypted, for the transmission of the Type of stream mentioned at “HDCP Content Type”.

HDR_OUTPUT_METADATA:

Connector property to enable userspace to send HDR Metadata to driver. This metadata is based on the composition and blending policies decided by user, taking into account the hardware and sink capabilities. The driver gets this metadata and creates a Dynamic Range and Mastering Infoframe (DRM) in case of HDMI, SDP packet (Non-audio INFOFRAME SDP v1.3) for DP. This is then sent to sink. This notifies the sink of the upcoming frame' s Color Encoding and Luminance parameters.

Userspace first need to detect the HDR capabilities of sink by reading and parsing the EDID. Details of HDR metadata for HDMI are added in CTA 861.G spec. For DP , its defined in VESA DP Standard v1.4. It needs to then get the metadata information of the video/game/app content which are encoded in HDR (basically using HDR transfer functions). With this information it needs to decide on a blending policy and compose the relevant layers/overlays into a common format. Once this blending is done, userspace will be aware of the metadata of the composed frame to be send to sink. It then uses this property to communicate this metadata to driver which then make a Infoframe packet and sends to sink based on the type of encoder connected.

Userspace will be responsible to do Tone mapping operation in case:

- Some layers are HDR and others are SDR
- HDR layers luminance is not same as sink

It will even need to do colorspace conversion and get all layers to one common colorspace for blending. It can use either GL, Media or display engine to get this done based on the capabilities of the associated hardware.

Driver expects metadata to be put in *`struct hdr_output_metadata`* structure from userspace. This is received as blob and stored in *`drm_connector_state.hdr_output_metadata`*. It parses EDID and saves the sink metadata in *`struct hdr_sink_metadata`*, as *`drm_connector.hdr_sink_metadata`*. Driver uses *`drm_hdmi_infoframe_set_hdr_metadata()`* helper to set the HDR metadata, *`hdmi_drm_infoframe_pack()`* to pack the infoframe as per spec, in case of HDMI encoder.

max bpc:

This range property is used by userspace to limit the bit depth. When used the driver would limit the bpc in accordance with the valid range supported by the hardware and sink. Drivers to use the function *`drm_connector_attach_max_bpc_property()`* to create and attach the property to the connector during initialization.

Connectors also have one standardized atomic property:

CRTC_ID:

Mode object ID of the *`drm_crtc`* this connector should be connected to.

Connectors for LCD panels may also have one standardized property:

panel orientation:

On some devices the LCD panel is mounted in the casing in such a way that the up/top side of the panel does not match with the top side of the device. Userspace can use this property to check for this. Note that input coordinates from touchscreens (input devices with INPUT_PROP_DIRECT) will still map 1:1 to the actual LCD panel coordinates, so if userspace rotates the picture to adjust for the orientation it must also apply the same transformation to the touchscreen input coordinates. This property is initialized by calling *drm_connector_set_panel_orientation()* or *drm_connector_set_panel_orientation_with_quirk()*

scaling mode:
This property defines how a non-native mode is upscaled to the native mode of an LCD panel:

None:
No upscaling happens, scaling is left to the panel. Not all drivers expose this mode.

Full:
The output is upscaled to the full resolution of the panel, ignoring the aspect ratio.

Center:
No upscaling happens, the output is centered within the native resolution the panel.

Full aspect:
The output is upscaled to maximize either the width or height while retaining the aspect ratio.

This property should be set up by calling *drm_connector_attach_scaling_mode_property* Note that drivers can also expose this property to external outputs, in which case they must support "None", which should be the default (since external screens have a built-in scaler).

subconnector:
This property is used by DVI-I, TVout and DisplayPort to indicate different connector subtypes. Enum values more or less match with those from main connector types. For DVI-I and TVout there is also a matching property "select subconnector" allowing to switch between signal types. DP subconnector corresponds to a downstream port.

Colorspace:
This property helps select a suitable colorspace based on the sink capability. Modern sink devices support wider gamut like BT2020. This helps switch to BT2020 mode if the BT2020 encoded video stream is being played by the user, same for any other colorspace. Thereby giving a good visual experience to users.

The expectation from userspace is that it should parse the EDID and get supported colorspaces. Use this property and switch to the one supported. Sink supported colorspaces should be retrieved by userspace from EDID and driver will not explicitly expose them.

Basically the expectation from userspace is:

- Set up CRTC DEGAMMA/CTM/GAMMA to convert to some sink colorspace

- Set this new property to let the sink know what it converted the CRTC output to.
- This property is just to inform sink what colorspace source is trying to drive.

Because between HDMI and DP have different colorspaces, *drm_mode_create_hdmi_colorspace_property()* is used for HDMI connector and *drm_mode_create_dp_colorspace_property()* is used for DP connector.

4.14.3 HDMI Specific Connector Properties

content type (HDMI specific):
Indicates content type setting to be used in HDMI infoframes to indicate content type for the external device, so that it adjusts its display settings accordingly.

The value of this property can be one of the following:

No Data:
Content type is unknown

Graphics:
Content type is graphics

Photo:
Content type is photo

Cinema:
Content type is cinema

Game:
Content type is game

Drivers can set up this property by calling *drm_connector_attach_content_type_property()*. Decoding to infoframe values is done through *drm_hdmi_avi_infoframe_content_type()*.

4.14.4 Standard CRTC Properties

DRM CRTCs have a few standardized properties:

ACTIVE:
Atomic property for setting the power state of the CRTC. When set to 1 the CRTC will actively display content. When set to 0 the CRTC will be powered off. There is no expectation that user-space will reset CRTC resources like the mode and planes when setting ACTIVE to 0.

User-space can rely on an ACTIVE change to 1 to never fail an atomic test as long as no other property has changed. If a change to ACTIVE fails an atomic test, this is a driver bug. For this reason setting ACTIVE to 0 must not release internal resources (like reserved memory bandwidth or clock generators).

Note that the legacy DPMS property on connectors is internally routed to control this property for atomic drivers.

MODE_ID:
Atomic property for setting the CRTC display timings. The value is the ID of a blob containing the DRM mode info. To disable the CRTC, user-space must set this property to 0.

Setting MODE_ID to 0 will release reserved resources for the CRTC.

4.14.5 Plane Composition Properties

The basic plane composition model supported by standard plane properties only has a source rectangle (in logical pixels within the *drm_framebuffer*), with sub-pixel accuracy, which is scaled up to a pixel-aligned destination rectangle in the visible area of a *drm_crtc*. The visible area of a CRTC is defined by the horizontal and vertical visible pixels (stored in **hdisplay** and **vdisplay**) of the requested mode (stored in *drm_crtc_state.mode*). These two rectangles are both stored in the *drm_plane_state*.

For the atomic ioctl the following standard (atomic) properties on the plane object encode the basic plane composition model:

SRC_X:
X coordinate offset for the source rectangle within the *drm_framebuffer*, in 16.16 fixed point. Must be positive.

SRC_Y:
Y coordinate offset for the source rectangle within the *drm_framebuffer*, in 16.16 fixed point. Must be positive.

SRC_W:
Width for the source rectangle within the *drm_framebuffer*, in 16.16 fixed point. SRC_X plus SRC_W must be within the width of the source framebuffer. Must be positive.

SRC_H:
Height for the source rectangle within the *drm_framebuffer*, in 16.16 fixed point. SRC_Y plus SRC_H must be within the height of the source framebuffer. Must be positive.

CRTC_X:
X coordinate offset for the destination rectangle. Can be negative.

CRTC_Y:
Y coordinate offset for the destination rectangle. Can be negative.

CRTC_W:
Width for the destination rectangle. CRTC_X plus CRTC_W can extend past the currently visible horizontal area of the *drm_crtc*.

CRTC_H:
Height for the destination rectangle. CRTC_Y plus CRTC_H can extend past the currently visible vertical area of the *drm_crtc*.

FB_ID:
Mode object ID of the *drm_framebuffer* this plane should scan out.

CRTC_ID:
Mode object ID of the *drm_crtc* this plane should be connected to.

Note that the source rectangle must fully lie within the bounds of the *drm_framebuffer*. The destination rectangle can lie outside of the visible area of the current mode of the CRTC. It must be apprpriately clipped by the driver, which can be done by calling drm_plane_helper_check_update(). Drivers are also allowed to round the subpixel sampling positions appropriately, but only to the next full pixel. No pixel outside of the source rectangle may ever be sampled, which is important when applying more sophisticated filtering than just a bilinear one when scaling. The filtering mode when scaling is unspecified.

On top of this basic transformation additional properties can be exposed by the driver:

alpha:
Alpha is setup with *drm_plane_create_alpha_property()*. It controls the plane-wide opacity, from transparent (0) to opaque (0xffff). It can be combined with pixel alpha. The pixel values in the framebuffers are expected to not be pre-multiplied by the global alpha associated to the plane.

rotation:
Rotation is set up with *drm_plane_create_rotation_property()*. It adds a rotation and reflection step between the source and destination rectangles. Without this property the rectangle is only scaled, but not rotated or reflected.

Possbile values:

"rotate-<degrees>" :
Signals that a drm plane is rotated <degrees> degrees in counter clockwise direction.

"reflect-<axis>" :
Signals that the contents of a drm plane is reflected along the <axis> axis, in the same way as mirroring.

reflect-x:

```
|o |     | o|
|  |  -> |  |
| v|     |v |
```

reflect-y:

```
|o |     | ^|
|  |  -> |  |
| v|     |o |
```

zpos:
Z position is set up with *drm_plane_create_zpos_immutable_property()* and *drm_plane_create_zpos_property()*. It controls the visibility of overlapping planes. Without this property the primary plane is always below the cursor plane, and ordering between all other planes is undefined. The positive Z axis points towards the user, i.e. planes with lower Z position values are underneath planes with higher Z position values. Two planes with the same Z position value have undefined ordering. Note that the Z position value can also be immutable, to inform userspace about the hard-coded stacking of planes, see *drm_plane_create_zpos_immutable_property()*. If any plane

has a zpos property (either mutable or immutable), then all planes shall have a zpos property.

pixel blend mode:
Pixel blend mode is set up with *drm_plane_create_blend_mode_property()*. It adds a blend mode for alpha blending equation selection, describing how the pixels from the current plane are composited with the background.

Three alpha blending equations are defined:

"None" :
Blend formula that ignores the pixel alpha:

```
out.rgb = plane_alpha * fg.rgb +
        (1 - plane_alpha) * bg.rgb
```

"Pre-multiplied" :
Blend formula that assumes the pixel color values have been already pre-multiplied with the alpha channel values:

```
out.rgb = plane_alpha * fg.rgb +
        (1 - (plane_alpha * fg.alpha)) * bg.rgb
```

"Coverage" :
Blend formula that assumes the pixel color values have not been pre-multiplied and will do so when blending them to the background color values:

```
out.rgb = plane_alpha * fg.alpha * fg.rgb +
        (1 - (plane_alpha * fg.alpha)) * bg.rgb
```

Using the following symbols:

"fg.rgb" :
Each of the RGB component values from the plane's pixel

"fg.alpha" :
Alpha component value from the plane's pixel. If the plane's pixel format has no alpha component, then this is assumed to be 1.0. In these cases, this property has no effect, as all three equations become equivalent.

"bg.rgb" :
Each of the RGB component values from the background

"plane_alpha" :
Plane alpha value set by the plane "alpha" property. If the plane does not expose the "alpha" property, then this is assumed to be 1.0

IN_FORMATS:
Blob property which contains the set of buffer format and modifier pairs supported by this plane. The blob is a drm_format_modifier_blob struct. Without this property the plane doesn't support buffers with modifiers. Userspace cannot change this property.

Note that all the property extensions described here apply either to the plane or the CRTC (e.g. for the background color, which currently is not exposed and assumed to be black).

int **drm_plane_create_alpha_property**(struct *drm_plane* *plane)

create a new alpha property

Parameters

struct drm_plane *plane
drm plane

Description

This function creates a generic, mutable, alpha property and enables support for it in the DRM core. It is attached to **plane**.

The alpha property will be allowed to be within the bounds of 0 (transparent) to 0xffff (opaque).

Return

0 on success, negative error code on failure.

int **drm_plane_create_rotation_property**(struct *drm_plane* *plane, unsigned int rotation, unsigned int supported_rotations)

create a new rotation property

Parameters

struct drm_plane *plane
drm plane

unsigned int rotation
initial value of the rotation property

unsigned int supported_rotations
bitmask of supported rotations and reflections

Description

This creates a new property with the selected support for transformations.

Since a rotation by 180° degress is the same as reflecting both along the x and the y axis the rotation property is somewhat redundant. Drivers can use *drm_rotation_simplify()* to normalize values of this property.

The property exposed to userspace is a bitmask property (see *drm_property_create_bitmask()*) called "rotation" and has the following bitmask enumaration values:

DRM_MODE_ROTATE_0:
"rotate-0"

DRM_MODE_ROTATE_90:
"rotate-90"

DRM_MODE_ROTATE_180:
"rotate-180"

DRM_MODE_ROTATE_270:
“rotate-270”

DRM_MODE_REFLECT_X:
“reflect-x”

DRM_MODE_REFLECT_Y:
“reflect-y”

Rotation is the specified amount in degrees in counter clockwise direction, the X and Y axis are within the source rectangle, i.e. the X/Y axis before rotation. After reflection, the rotation is applied to the image sampled from the source rectangle, before scaling it to fit the destination rectangle.

unsigned int **drm_rotation_simplify**(unsigned int rotation, unsigned int supported_rotations)

Try to simplify the rotation

Parameters

unsigned int rotation
Rotation to be simplified

unsigned int supported_rotations
Supported rotations

Description

Attempt to simplify the rotation to a form that is supported. Eg. if the hardware supports everything except DRM_MODE_REFLECT_X one could call this function like this:

drm_rotation_simplify(rotation, DRM_MODE_ROTATE_0 |
DRM_MODE_ROTATE_90 | DRM_MODE_ROTATE_180 | DRM_MODE_ROTATE_270 | DRM_MODE_REFLECT_Y);

to eliminate the DRM_MODE_ROTATE_X flag. Depending on what kind of transforms the hardware supports, this function may not be able to produce a supported transform, so the caller should check the result afterwards.

int **drm_plane_create_zpos_property**(struct *drm_plane* *plane, unsigned int zpos, unsigned int min, unsigned int max)

create mutable zpos property

Parameters

struct drm_plane *plane
drm plane

unsigned int zpos
initial value of zpos property

unsigned int min
minimal possible value of zpos property

unsigned int max
maximal possible value of zpos property

Description

This function initializes generic mutable zpos property and enables support for it in drm core. Drivers can then attach this property to planes to enable support for configurable planes arrangement during blending operation. Drivers that attach a mutable zpos property to any plane should call the *drm_atomic_normalize_zpos()* helper during their implementation of *drm_mode_config_funcs.atomic_check()*, which will update the normalized zpos values and store them in *drm_plane_state.normalized_zpos*. Usually min should be set to 0 and max to maximal number of planes for given crtc - 1.

If zpos of some planes cannot be changed (like fixed background or cursor/topmost planes), drivers shall adjust the min/max values and assign those planes immutable zpos properties with lower or higher values (for more information, see *drm_plane_create_zpos_immutable_property()* function). In such case drivers shall also assign proper initial zpos values for all planes in its plane_reset() callback, so the planes will be always sorted properly.

See also *drm_atomic_normalize_zpos()*.

The property exposed to userspace is called "zpos".

Return

Zero on success, negative errno on failure.

int **drm_plane_create_zpos_immutable_property**(struct *drm_plane* *plane, unsigned int zpos)

create immuttable zpos property

Parameters

struct drm_plane *plane
drm plane

unsigned int zpos
value of zpos property

Description

This function initializes generic immutable zpos property and enables support for it in drm core. Using this property driver lets userspace to get the arrangement of the planes for blending operation and notifies it that the hardware (or driver) doesn't support changing of the planes' order. For mutable zpos see *drm_plane_create_zpos_property()*.

The property exposed to userspace is called "zpos".

Return

Zero on success, negative errno on failure.

int **drm_atomic_normalize_zpos**(struct *drm_device* *dev, struct *drm_atomic_state* *state)

calculate normalized zpos values for all crtcs

Parameters

struct drm_device *dev
DRM device

struct drm_atomic_state *state
atomic state of DRM device

Description

This function calculates normalized zpos value for all modified planes in the provided atomic state of DRM device.

For every CRTC this function checks new states of all planes assigned to it and calculates normalized zpos value for these planes. Planes are compared first by their zpos values, then by plane id (if zpos is equal). The plane with lowest zpos value is at the bottom. The *drm_plane_state.normalized_zpos* is then filled with unique values from 0 to number of active planes in crtc minus one.

RETURNS Zero for success or -errno

int **drm_plane_create_blend_mode_property**(struct *drm_plane* *plane, unsigned int supported_modes)

create a new blend mode property

Parameters

struct drm_plane *plane
drm plane

unsigned int supported_modes
bitmask of supported modes, must include BIT(DRM_MODE_BLEND_PREMULTI). Current DRM assumption is that alpha is premultiplied, and old userspace can break if the property defaults to anything else.

Description

This creates a new property describing the blend mode.

The property exposed to userspace is an enumeration property (see *drm_property_create_enum()*) called "pixel blend mode" and has the following enumeration values:

"None" :
Blend formula that ignores the pixel alpha.

"Pre-multiplied" :
Blend formula that assumes the pixel color values have been already pre-multiplied with the alpha channel values.

"Coverage" :
Blend formula that assumes the pixel color values have not been pre-multiplied and will do so when blending them to the background color values.

Return

Zero for success or -errno

FB_DAMAGE_CLIPS

FB_DAMAGE_CLIPS is an optional plane property which provides a means to specify a list of damage rectangles on a plane in framebuffer coordinates of the framebuffer attached to the plane. In current context damage is the area of plane framebuffer that has changed since last plane update (also called page-flip), irrespective of whether currently attached framebuffer is same as framebuffer attached during last plane update or not.

FB_DAMAGE_CLIPS is a hint to kernel which could be helpful for some drivers to optimize internally especially for virtual devices where each framebuffer change needs to be transmitted over network, usb, etc.

Since FB_DAMAGE_CLIPS is a hint so it is an optional property. User-space can ignore damage clips property and in that case driver will do a full plane update. In case damage clips are provided then it is guaranteed that the area inside damage clips will be updated to plane. For efficiency driver can do full update or can update more than specified in damage clips. Since driver is free to read more, user-space must always render the entire visible framebuffer. Otherwise there can be corruptions. Also, if a user-space provides damage clips which doesn' t encompass the actual damage to framebuffer (since last plane update) can result in incorrect rendering.

FB_DAMAGE_CLIPS is a blob property with the layout of blob data is simply an array of *drm_mode_rect*. Unlike plane *drm_plane_state.src* coordinates, damage clips are not in 16.16 fixed point. Similar to plane src in framebuffer, damage clips cannot be negative. In damage clip, x1/y1 are inclusive and x2/y2 are exclusive. While kernel does not error for overlapped damage clips, it is strongly discouraged.

Drivers that are interested in damage interface for plane should enable FB_DAMAGE_CLIPS property by calling *drm_plane_enable_fb_damage_clips()*. Drivers implementing damage can use *drm_atomic_helper_damage_iter_init()* and *drm_atomic_helper_damage_iter_next()* helper iterator function to get damage rectangles clipped to *drm_plane_state.src*.

void **drm_plane_enable_fb_damage_clips**(struct *drm_plane* *plane)

Enables plane fb damage clips property.

Parameters

struct drm_plane *plane
Plane on which to enable damage clips property.

Description

This function lets driver to enable the damage clips property on a plane.

void **drm_atomic_helper_check_plane_damage**(struct *drm_atomic_state* *state, struct *drm_plane_state* *plane_state)

Verify plane damage on atomic_check.

Parameters

struct drm_atomic_state *state
The driver state object.

struct drm_plane_state *plane_state
Plane state for which to verify damage.

Description

This helper function makes sure that damage from plane state is discarded for full modeset. If there are more reasons a driver would want to do a full plane update rather than processing individual damage regions, then those cases should be taken care of here.

Note that *drm_plane_state.fb_damage_clips* == NULL in plane state means that full plane update should happen. It also ensure helper iterator will return *drm_plane_state.src* as damage.

int **drm_atomic_helper_dirtyfb**(struct *drm_framebuffer* *fb, struct *drm_file* *file_priv, unsigned int flags, unsigned int color, struct drm_clip_rect *clips, unsigned int num_clips)

Helper for dirtyfb.

Parameters

struct drm_framebuffer *fb
DRM framebuffer.

struct drm_file *file_priv
Drm file for the ioctl call.

unsigned int flags
Dirty fb annotate flags.

unsigned int color
Color for annotate fill.

struct drm_clip_rect *clips
Dirty region.

unsigned int num_clips
Count of clip in clips.

Description

A helper to implement *drm_framebuffer_funcs.dirty* using damage interface during plane update. If num_clips is 0 then this helper will do a full plane update. This is the same behaviour expected by DIRTFB IOCTL.

Note that this helper is blocking implementation. This is what current drivers and userspace expect in their DIRTYFB IOCTL implementation, as a way to rate-limit userspace and make sure its rendering doesn't get ahead of uploading new data too much.

Return

Zero on success, negative errno on failure.

void **drm_atomic_helper_damage_iter_init**(struct *drm_atomic_helper_damage_iter* *iter, const struct *drm_plane_state* *old_state, const struct *drm_plane_state* *state)

Initialize the damage iterator.

Parameters

`struct drm_atomic_helper_damage_iter *iter`
The iterator to initialize.

`const struct drm_plane_state *old_state`
Old plane state for validation.

`const struct drm_plane_state *state`
Plane state from which to iterate the damage clips.

Description

Initialize an iterator, which clips plane damage *drm_plane_state.fb_damage_clips* to plane *drm_plane_state.src*. This iterator returns full plane src in case damage is not present because either user-space didn't sent or driver discarded it (it want to do full plane update). Currently this iterator returns full plane src in case plane src changed but that can be changed in future to return damage.

For the case when plane is not visible or plane update should not happen the first call to iter_next will return false. Note that this helper use clipped *drm_plane_state.src*, so driver calling this helper should have called *drm_atomic_helper_check_plane_state()* earlier.

bool **drm_atomic_helper_damage_iter_next**(struct *drm_atomic_helper_damage_iter* *iter, struct *drm_rect* *rect)

Advance the damage iterator.

Parameters

`struct drm_atomic_helper_damage_iter *iter`
The iterator to advance.

`struct drm_rect *rect`
Return a rectangle in fb coordinate clipped to plane src.

Description

Since plane src is in 16.16 fixed point and damage clips are whole number, this iterator round off clips that intersect with plane src. Round down for x1/y1 and round up for x2/y2 for the intersected coordinate. Similar rounding off for full plane src, in case it's returned as damage. This iterator will skip damage clips outside of plane src.

If the first call to iterator next returns false then it means no need to update the plane.

Return

True if the output is valid, false if reached the end.

bool **drm_atomic_helper_damage_merged**(const struct *drm_plane_state* *old_state, struct *drm_plane_state* *state, struct *drm_rect* *rect)

Merged plane damage

Parameters

`const struct drm_plane_state *old_state`
Old plane state for validation.

`struct drm_plane_state *state`
Plane state from which to iterate the damage clips.

`struct drm_rect *rect`
Returns the merged damage rectangle

Description

This function merges any valid plane damage clips into one rectangle and returns it in **rect**.

For details see: *`drm_atomic_helper_damage_iter_init()`* and *`drm_atomic_helper_damage_iter_next()`*.

Return

True if there is valid plane damage otherwise false.

`drm_atomic_for_each_plane_damage`

`drm_atomic_for_each_plane_damage (iter, rect)`

Iterator macro for plane damage.

Parameters

`iter`
The iterator to advance.

`rect`
Return a rectangle in fb coordinate clipped to plane src.

Description

Note that if the first call to iterator macro return false then no need to do plane update. Iterator will return full plane src when damage is not passed by user-space.

struct **`drm_atomic_helper_damage_iter`**

Closure structure for damage iterator.

Definition

```
struct drm_atomic_helper_damage_iter {
};
```

Members

Description

This structure tracks state needed to walk the list of plane damage clips.

struct *drm_rect* ***drm_helper_get_plane_damage_clips**(const struct *drm_plane_state* *state)

Returns damage clips in *drm_rect*.

Parameters

const struct drm_plane_state *state
Plane state.

Description

Returns plane damage rectangles in internal *drm_rect*. Currently *drm_rect* can be obtained by simply typecasting *drm_mode_rect*. This is because both are signed 32 and during *drm_atomic_check_only()* it is verified that damage clips are inside fb.

Return

Clips in plane fb_damage_clips blob property.

4.14.6 Color Management Properties

Color management or color space adjustments is supported through a set of 5 properties on the *drm_crtc* object. They are set up by calling *drm_crtc_enable_color_mgmt()*.

"DEGAMMA_LUT" :
Blob property to set the degamma lookup table (LUT) mapping pixel data from the framebuffer before it is given to the transformation matrix. The data is interpreted as an array of `struct drm_color_lut` elements. Hardware might choose not to use the full precision of the LUT elements nor use all the elements of the LUT (for example the hardware might choose to interpolate between LUT[0] and LUT[4]).

Setting this to NULL (blob property value set to 0) means a linear/pass-thru gamma table should be used. This is generally the driver boot-up state too. Drivers can access this blob through *drm_crtc_state.degamma_lut*.

"DEGAMMA_LUT_SIZE" :
Unsinged range property to give the size of the lookup table to be set on the DEGAMMA_LUT property (the size depends on the underlying hardware). If drivers support multiple LUT sizes then they should publish the largest size, and sub-sample smaller sized LUTs (e.g. for split-gamma modes) appropriately.

"CTM" :
Blob property to set the current transformation matrix (CTM) apply to pixel data after the lookup through the degamma LUT and before the lookup through the gamma LUT. The data is interpreted as a struct `drm_color_ctm`.

Setting this to NULL (blob property value set to 0) means a unit/pass-thru matrix should be used. This is generally the driver boot-up state too. Drivers can access the blob for the color conversion matrix through *drm_crtc_state.ctm*.

"GAMMA_LUT" :
: Blob property to set the gamma lookup table (LUT) mapping pixel data after the transformation matrix to data sent to the connector. The data is interpreted as an array of `struct drm_color_lut` elements. Hardware might choose not to use the full precision of the LUT elements nor use all the elements of the LUT (for example the hardware might choose to interpolate between LUT[0] and LUT[4]).

  Setting this to NULL (blob property value set to 0) means a linear/pass-thru gamma table should be used. This is generally the driver boot-up state too. Drivers can access this blob through *`drm_crtc_state.gamma_lut`*.

"GAMMA_LUT_SIZE" :
: Unsigned range property to give the size of the lookup table to be set on the GAMMA_LUT property (the size depends on the underlying hardware). If drivers support multiple LUT sizes then they should publish the largest size, and sub-sample smaller sized LUTs (e.g. for split-gamma modes) appropriately.

There is also support for a legacy gamma table, which is set up by calling *`drm_mode_crtc_set_gamma_size()`*. Drivers which support both should use *`drm_atomic_helper_legacy_gamma_set()`* to alias the legacy gamma ramp with the "GAMMA_LUT" property above.

Support for different non RGB color encodings is controlled through *`drm_plane`* specific COLOR_ENCODING and COLOR_RANGE properties. They are set up by calling *`drm_plane_create_color_properties()`*.

"COLOR_ENCODING"
: Optional plane enum property to support different non RGB color encodings. The driver can provide a subset of standard enum values supported by the DRM plane.

"COLOR_RANGE"
: Optional plane enum property to support different non RGB color parameter ranges. The driver can provide a subset of standard enum values supported by the DRM plane.

u64 **`drm_color_ctm_s31_32_to_qm_n`**(u64 user_input, u32 m, u32 n)

Parameters

`u64 user_input`
: input value

`u32 m`
: number of integer bits, only support m <= 32, include the sign-bit

`u32 n`
: number of fractional bits, only support n <= 32

Description

Convert and clamp S31.32 sign-magnitude to Qm.n (signed 2's complement). The sign-bit BIT(m+n-1) and above are 0 for positive value and 1 for negative the range of value is [-2^(m-1), 2^(m-1) - 2^-n]

For example A Q3.12 format number: - required bit: 3 + 12 = 15bits - range: [-2^2, 2^2 - 2^−15]

NOTE

the m can be zero if all bit_precision are used to present fractional
bits like Q0.32

void **drm_crtc_enable_color_mgmt**(struct *drm_crtc* *crtc, uint degamma_lut_size, bool has_ctm, uint gamma_lut_size)

enable color management properties

Parameters

struct drm_crtc *crtc
DRM CRTC

uint degamma_lut_size
the size of the degamma lut (before CSC)

bool has_ctm
whether to attach ctm_property for CSC matrix

uint gamma_lut_size
the size of the gamma lut (after CSC)

Description

This function lets the driver enable the color correction properties on a CRTC. This includes 3 degamma, csc and gamma properties that userspace can set and 2 size properties to inform the userspace of the lut sizes. Each of the properties are optional. The gamma and degamma properties are only attached if their size is not 0 and ctm_property is only attached if has_ctm is true.

Drivers should use *drm_atomic_helper_legacy_gamma_set()* to implement the legacy *drm_crtc_funcs.gamma_set* callback.

int **drm_mode_crtc_set_gamma_size**(struct *drm_crtc* *crtc, int gamma_size)

set the gamma table size

Parameters

struct drm_crtc *crtc
CRTC to set the gamma table size for

int gamma_size
size of the gamma table

Description

Drivers which support gamma tables should set this to the supported gamma table size when initializing the CRTC. Currently the drm core only supports a fixed gamma table size.

Return

Zero on success, negative errno on failure.

int **drm_plane_create_color_properties**(struct *drm_plane* *plane, u32 supported_encodings, u32 supported_ranges, enum drm_color_encoding default_encoding, enum drm_color_range default_range)

color encoding related plane properties

Parameters

struct drm_plane *plane
plane object

u32 supported_encodings
bitfield indicating supported color encodings

u32 supported_ranges
bitfileld indicating supported color ranges

enum drm_color_encoding default_encoding
default color encoding

enum drm_color_range default_range
default color range

Description

Create and attach plane specific COLOR_ENCODING and COLOR_RANGE properties to **plane**. The supported encodings and ranges should be provided in supported_encodings and supported_ranges bitmasks. Each bit set in the bitmask indicates that its number as enum value is supported.

int **drm_color_lut_check**(const struct *drm_property_blob* *lut, u32 tests)

check validity of lookup table

Parameters

const struct drm_property_blob *lut
property blob containing LUT to check

u32 tests
bitmask of tests to run

Description

Helper to check whether a userspace-provided lookup table is valid and satisfies hardware requirements. Drivers pass a bitmask indicating which of the tests in *drm_color_lut_tests* should be performed.

Returns 0 on success, -EINVAL on failure.

u32 **drm_color_lut_extract**(u32 user_input, int bit_precision)

clamp and round LUT entries

Parameters

u32 user_input
input value

int bit_precision
number of bits the hw LUT supports

Description

Extract a degamma/gamma LUT value provided by user (in the form of `drm_color_lut` entries) and round it to the precision supported by the hardware.

int **drm_color_lut_size**(const struct *drm_property_blob* *blob)
calculate the number of entries in the LUT

Parameters

const struct drm_property_blob *blob
blob containing the LUT

Return

The number of entries in the color LUT stored in **blob**.

enum **drm_color_lut_tests**
hw-specific LUT tests to perform

Constants

DRM_COLOR_LUT_EQUAL_CHANNELS
Checks whether the entries of a LUT all have equal values for the red, green, and blue channels. Intended for hardware that only accepts a single value per LUT entry and assumes that value applies to all three color components.

DRM_COLOR_LUT_NON_DECREASING
Checks whether the entries of a LUT are always flat or increasing (never decreasing).

Description

The *drm_color_lut_check()* function takes a bitmask of the values here to determine which tests to apply to a userspace-provided LUT.

4.14.7 Tile Group Property

Tile groups are used to represent tiled monitors with a unique integer identifier. Tiled monitors using DisplayID v1.3 have a unique 8-byte handle, we store this in a tile group, so we have a common identifier for all tiles in a monitor group. The property is called "TILE". Drivers can manage tile groups using *drm_mode_create_tile_group()*, *drm_mode_put_tile_group()* and *drm_mode_get_tile_group()*. But this is only needed for internal panels where the tile group information is exposed through a non-standard way.

4.14.8 Explicit Fencing Properties

Explicit fencing allows userspace to control the buffer synchronization between devices. A Fence or a group of fences are transfered to/from userspace using Sync File fds and there are two DRM properties for that. IN_FENCE_FD on each DRM Plane to send fences to the kernel and OUT_FENCE_PTR on each DRM CRTC to receive fences from the kernel.

As a contrast, with implicit fencing the kernel keeps track of any ongoing rendering, and automatically ensures that the atomic update waits for any pending rendering to complete. For shared buffers represented with a `struct dma_buf` this is tracked in `struct dma_resv`. Implicit syncing is how Linux traditionally worked (e.g. DRI2/3 on X.org), whereas explicit fencing is what Android wants.

"IN_FENCE_FD" :

Use this property to pass a fence that DRM should wait on before proceeding with the Atomic Commit request and show the framebuffer for the plane on the screen. The fence can be either a normal fence or a merged one, the sync_file framework will handle both cases and use a fence_array if a merged fence is received. Passing -1 here means no fences to wait on.

If the Atomic Commit request has the DRM_MODE_ATOMIC_TEST_ONLY flag it will only check if the Sync File is a valid one.

On the driver side the fence is stored on the **fence** parameter of *struct drm_plane_state*. Drivers which also support implicit fencing should set the implicit fence using *drm_atomic_set_fence_for_plane()*, to make sure there' s consistent behaviour between drivers in precedence of implicit vs. explicit fencing.

"OUT_FENCE_PTR" :

Use this property to pass a file descriptor pointer to DRM. Once the Atomic Commit request call returns OUT_FENCE_PTR will be filled with the file descriptor number of a Sync File. This Sync File contains the CRTC fence that will be signaled when all framebuffers present on the Atomic Commit * request for that given CRTC are scanned out on the screen.

The Atomic Commit request fails if a invalid pointer is passed. If the Atomic Commit request fails for any other reason the out fence fd returned will be -1. On a Atomic Commit with the DRM_MODE_ATOMIC_TEST_ONLY flag the out fence will also be set to -1.

Note that out-fences don' t have a special interface to drivers and are internally represented by a *struct drm_pending_vblank_event* in struct *drm_crtc_state*, which is also used by the nonblocking atomic commit helpers and for the DRM event handling for existing userspace.

4.14.9 Variable Refresh Properties

Variable refresh rate capable displays can dynamically adjust their refresh rate by extending the duration of their vertical front porch until page flip or timeout occurs. This can reduce or remove stuttering and latency in scenarios where the page flip does not align with the vblank interval.

An example scenario would be an application flipping at a constant rate of 48Hz on a 60Hz display. The page flip will frequently miss the vblank interval and the same contents will be displayed twice. This can be observed as stuttering for content with motion.

If variable refresh rate was active on a display that supported a variable refresh range from 35Hz to 60Hz no stuttering would be observable for the example scenario. The minimum supported variable refresh rate of 35Hz is below the page flip frequency and the vertical front porch can be extended until the page flip occurs. The vblank interval will be directly aligned to the page flip rate.

Not all userspace content is suitable for use with variable refresh rate. Large and frequent changes in vertical front porch duration may worsen perceived stuttering for input sensitive applications.

Panel brightness will also vary with vertical front porch duration. Some panels may have noticeable differences in brightness between the minimum vertical front porch duration and the maximum vertical front porch duration. Large and frequent changes in vertical front porch duration may produce observable flickering for such panels.

Userspace control for variable refresh rate is supported via properties on the *drm_connector* and *drm_crtc* objects.

"vrr_capable" :

Optional *drm_connector* boolean property that drivers should attach with *drm_connector_attach_vrr_capable_property()* on connectors that could support variable refresh rates. Drivers should update the property value by calling *drm_connector_set_vrr_capable_property()*.

Absence of the property should indicate absence of support.

"VRR_ENABLED" :

Default *drm_crtc* boolean property that notifies the driver that the content on the CRTC is suitable for variable refresh rate presentation. The driver will take this property as a hint to enable variable refresh rate support if the receiver supports it, ie. if the "vrr_capable" property is true on the *drm_connector* object. The vertical front porch duration will be extended until page-flip or timeout when enabled.

The minimum vertical front porch duration is defined as the vertical front porch duration for the current mode.

The maximum vertical front porch duration is greater than or equal to the minimum vertical front porch duration. The duration is derived from the minimum supported variable refresh rate for the connector.

The driver may place further restrictions within these minimum and maximum bounds.

4.14.10 Existing KMS Properties

The following table gives description of drm properties exposed by various modules/drivers. Because this table is very unwieldy, do not add any new properties here. Instead document them in a section above.

Owner Module/Drivers	Group	Property Name	Type	Property Values	Object attached	Description/Restrictions
	DVI-I	“subconnector”	ENUM	{ “Unknown” , “DVI-D” , “DVI-A” }	Connector	TBD
		“select subconnector”	ENUM	{ “Automatic” , “DVI-D” , “DVI-A” }	Connector	TBD
	TV	“subconnector”	ENUM	{ “Unknown” , “Composite” , “SVIDEO” , “Component” , “SCART” }	Connector	TBD
		“select subconnector”	ENUM	{ “Automatic” , “Composite” , “SVIDEO” , “Component” , “SCART” }	Connector	TBD
		“mode”	ENUM	{ “NTSC_M” , “NTSC_J” , “NTSC_44 , “PAL_B” } etc.	Connector	TBD
		“left margin”	RANGE	Min=0, Max=100	Connector	TBD
		“right margin”	RANGE	Min=0, Max=100	Connector	TBD
		“top margin”	RANGE	Min=0, Max=100	Connector	TBD

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Owner Module/Drivers	Group	Property Name	Type	Property Values	Object attached	Description/Restrictions
		“bottom margin”	RANGE	Min=0, Max=100	Connector	TBD
		“brightness”	RANGE	Min=0, Max=100	Connector	TBD
		“contrast”	RANGE	Min=0, Max=100	Connector	TBD
		“flicker reduction”	RANGE	Min=0, Max=100	Connector	TBD
		“overscan”	RANGE	Min=0, Max=100	Connector	TBD
		“saturation”	RANGE	Min=0, Max=100	Connector	TBD
		“hue”	RANGE	Min=0, Max=100	Connector	TBD
	Virtual GPU	“suggested X”	RANGE	Min=0, Max=0xfff	Connector	property to suggest an X offset for a connector
		“suggested Y”	RANGE	Min=0, Max=0xfff	Connector	property to suggest an Y offset for a connector
	Optional	“aspect ratio”	ENUM	{ “None” , “4:3” , “16:9” }	Connector	TDB

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Owner Module/Drivers	Group	Property Name	Type	Property Values	Object attached	Description/Restrictions
i915	Generic	"Broadcast RGB"	ENUM	{ "Automatic" , "Full" , "Limited 16:235" }	Connector	When this property is set to Limited 16:235 and CTM is set, the hardware will be programmed with the result of the multiplication of CTM by the limited range matrix to ensure the pixels normaly in the range 0..1.0 are remapped to the range 16/255..235/255.
		"audio"	ENUM	{ "force-dvi", "off" , "auto" , "on" }	Connector	TBD
	SDVO-TV	"mode"	ENUM	{ "NTSC_M" , "NTSC_J" , "NTSC_44 , "PAL_B" } etc.	Connector	TBD

continues on next page

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Owner Module/Drivers	Group	Property Name	Type	Property Values	Object attached	Description/Restrictions
		"left_marg	RANGE	Min=0, Max= SDVO dependent	Connector	TBD
		"right_mar	RANGE	Min=0, Max= SDVO dependent	Connector	TBD
		"top_margi	RANGE	Min=0, Max= SDVO dependent	Connector	TBD
		"bottom_margi	RANGE	Min=0, Max= SDVO dependent	Connector	TBD
		"hpos"	RANGE	Min=0, Max= SDVO dependent	Connector	TBD
		"vpos"	RANGE	Min=0, Max= SDVO dependent	Connector	TBD
		"contrast"	RANGE	Min=0, Max= SDVO dependent	Connector	TBD
		"saturation"	RANGE	Min=0, Max= SDVO dependent	Connector	TBD
		"hue"	RANGE	Min=0, Max= SDVO dependent	Connector	TBD

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Owner Module/Drivers	Group	Property Name	Type	Property Values	Object attached	Description/Restrictions
		"sharpness"	RANGE	Min=0, Max= SDVO dependent	Connector	TBD
		"flicker_filt	RANGE	Min=0, Max= SDVO dependent	Connector	TBD
		"flicker_filt	RANGE	Min=0, Max= SDVO dependent	Connector	TBD
		"flicker_filt	RANGE	Min=0, Max= SDVO dependent	Connector	TBD
		"tv_chroma	RANGE	Min=0, Max= SDVO dependent	Connector	TBD
		"tv_luma_f	RANGE	Min=0, Max= SDVO dependent	Connector	TBD
		"dot_crawl	RANGE	Min=0, Max=1	Connector	TBD
	SDVO-TV/LVDS	"brightness"	RANGE	Min=0, Max= SDVO dependent	Connector	TBD
CDV gma-500	Generic	"Broadcast RGB"	ENUM	{ "Full" , "Limited 16:235" }	Connector	TBD
		"Broadcast RGB"	ENUM	{ "off" , "auto" , "on" }	Connector	TBD
Poulsbo	Generic	"backlight"	RANGE	Min=0, Max=100	Connector	TBD

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Owner Module/Drivers	Group	Property Name	Type	Property Values	Object attached	Description/Restrictions
	SDVO-TV	"mode"	ENUM	{ "NTSC_M" , "NTSC_J" , "NTSC_443 , "PAL_B" } etc.	Connector	TBD
		"left_marg	RANGE	Min=0, Max= SDVO dependent	Connector	TBD
		"right_mar	RANGE	Min=0, Max= SDVO dependent	Connector	TBD
		"top_margi	RANGE	Min=0, Max= SDVO dependent	Connector	TBD
		"bottom_margi	RANGE	Min=0, Max= SDVO dependent	Connector	TBD
		"hpos"	RANGE	Min=0, Max= SDVO dependent	Connector	TBD
		"vpos"	RANGE	Min=0, Max= SDVO dependent	Connector	TBD
		"contrast"	RANGE	Min=0, Max= SDVO dependent	Connector	TBD

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Owner Module/Drivers	Group	Property Name	Type	Property Values	Object attached	Description/Restrictions
		“saturation”	RANGE	Min=0, Max= SDVO dependent	Connector	TBD
		“hue”	RANGE	Min=0, Max= SDVO dependent	Connector	TBD
		“sharpness”	RANGE	Min=0, Max= SDVO dependent	Connector	TBD
		“flicker_filt	RANGE	Min=0, Max= SDVO dependent	Connector	TBD
		“flicker_filt	RANGE	Min=0, Max= SDVO dependent	Connector	TBD
		“flicker_filt	RANGE	Min=0, Max= SDVO dependent	Connector	TBD
		“tv_chroma	RANGE	Min=0, Max= SDVO dependent	Connector	TBD
		“tv_luma_f	RANGE	Min=0, Max= SDVO dependent	Connector	TBD
		“dot_crawl	RANGE	Min=0, Max=1	Connector	TBD

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Owner Module/Drivers	Group	Property Name	Type	Property Values	Object attached	Description/Restrictions
	SDVO-TV/LVDS	"brightness"	RANGE	Min=0, Max= SDVO dependent	Connector	TBD
armada	CRTC	"CSC_YUV	ENUM	{ "Auto" , "CCIR601" , "CCIR709" }	CRTC	TBD
		"CSC_RGB	ENUM	{ "Auto" , "Computer system" , "Studio" }	CRTC	TBD
	Overlay	"colorkey"	RANGE	Min=0, Max=0xfff	Plane	TBD
		"colorkey_min	RANGE	Min=0, Max=0xfff	Plane	TBD
		"colorkey_max	RANGE	Min=0, Max=0xfff	Plane	TBD
		"colorkey_val"	RANGE	Min=0, Max=0xfff	Plane	TBD
		"colorkey_alph	RANGE	Min=0, Max=0xfff	Plane	TBD
		"colorkey_mod	ENUM	{ "disabled" , "Y component" , "U component" , "V component" , "RGB" , "R component" , "G component" , "B component" }	Plane	TBD
		"brightness"	RANGE	Min=0, Max=256 + 255	Plane	TBD

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Table 1 – continued from previous page

Owner Module/Drivers	Group	Property Name	Type	Property Values	Object attached	Description/Restrictions
		"contrast"	RANGE	Min=0, Max=0x7ff	Plane	TBD
		"saturation"	RANGE	Min=0, Max=0x7ff	Plane	TBD
exynos	CRTC	"mode"	ENUM	{ "normal" , "blank" }	CRTC	TBD
i2c/ch7006	Generic	"scale"	RANGE	Min=0, Max=2	Connector	TBD
	TV	"mode"	ENUM	{ "PAL" , "PAL-M" ," PAL-N" }, " PAL-Nc" , "PAL-60" , "NTSC-M" , "NTSC-J" }	Connector	TBD
nouveau	NV10 Overlay	"colorkey"	RANGE	Min=0, Max=0x01	Plane	TBD
		"contrast"	RANGE	Min=0, Max=8192 1	Plane	TBD
		"brightness"	RANGE	Min=0, Max=1024	Plane	TBD
		"hue"	RANGE	Min=0, Max=359	Plane	TBD
		"saturation"	RANGE	Min=0, Max=8192 1	Plane	TBD
		"iturbt_709	RANGE	Min=0, Max=1	Plane	TBD
	Nv04 Overlay	"colorkey"	RANGE	Min=0, Max=0x01	Plane	TBD
		"brightness"	RANGE	Min=0, Max=1024	Plane	TBD
	Display	"dithering mode"	ENUM	{ "auto" , "off", "on" }	Connector	TBD

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Table 1 – continued from previous page

Owner Module/Drivers	Group	Property Name	Type	Property Values	Object attached	Description/Restrictions
		“dithering depth”	ENUM	{ “auto” , “off” , “on” , “static 2x2” , “dynamic 2x2” , “temporal” }	Connector	TBD
		“underscan”	ENUM	{ “auto” , “6 bpc” , “8 bpc” }	Connector	TBD
		“underscan hborder”	RANGE	Min=0, Max=128	Connector	TBD
		“underscan vborder”	RANGE	Min=0, Max=128	Connector	TBD
		“vibrant hue”	RANGE	Min=0, Max=180	Connector	TBD
		“color vibrance”	RANGE	Min=0, Max=200	Connector	TBD
omap	Generic	“zorder”	RANGE	Min=0, Max=3	CRTC, Plane	TBD
qxl	Generic	“hotplug_mode	RANGE	Min=0, Max=1	Connector	TBD
radeon	DVI-I	“coherent”	RANGE	Min=0, Max=1	Connector	TBD
	DAC enable load detect	“load detection”	RANGE	Min=0, Max=1	Connector	TBD
	TV Standard	“tv standard”	ENUM	{ “ntsc” , “pal” , “pal-m” , “pal-60” , “ntsc-j” , “scart-pal” , “pal-cn” , “secam” }	Connector	TBD

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Owner Module/Drivers	Group	Property Name	Type	Property Values	Object attached	Description/Restrictions
	legacy TMDS PLL detect	"tmds_pll"	ENUM	{ "driver", "bios" }	•	TBD
	Underscan	"underscan"	ENUM	{ "off", "on", "auto" }	Connector	TBD
		"underscan hborder"	RANGE	Min=0, Max=128	Connector	TBD
		"underscan vborder"	RANGE	Min=0, Max=128	Connector	TBD
	Audio	"audio"	ENUM	{ "off", "on", "auto" }	Connector	TBD
	FMT Dithering	"dither"	ENUM	{ "off", "on" }	Connector	TBD
		"colorkey"	RANGE	Min=0, Max=0x01	Plane	TBD

4.15 Vertical Blanking

From the computer's perspective, every time the monitor displays a new frame the scanout engine has "scanned out" the display image from top to bottom, one row of pixels at a time. The current row of pixels is referred to as the current scanline.

In addition to the display's visible area, there's usually a couple of extra scanlines which aren't actually displayed on the screen. These extra scanlines don't contain image data and are occasionally used for features like audio and infoframes. The region made up of these scanlines is referred to as the vertical blanking region, or vblank for short.

For historical reference, the vertical blanking period was designed to give the electron gun (on CRTs) enough time to move back to the top of the screen to start scanning out the next frame. Similar for horizontal blanking periods. They were designed to give the electron gun enough time to move back to the other side of the screen to start scanning the next scanline.

```
physical →    ______________________________________
top of       |                                      |
display      |                                      |
             |               New frame              |
```

(continues on next page)

(continued from previous page)

```
             |                                        |
             |↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓|
             |~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~| ← Scanline,
             |↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓↓|   updates the
             |                                        |   frame as it
             |                                        |   travels␣
↪down
             |                                        |   ("sacn out
↪")
             |               Old frame                |
             |                                        |
             |                                        |
             |                                        |
             |                                        |   physical
             |                                        |   bottom of
vertical     |________________________________________| ← display
blanking     ┆xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx┆
region   →    ┆xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx┆
             ┆xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx┆
start of →     ________________________________________
new frame
```

"Physical top of display" is the reference point for the high-precision/ corrected timestamp.

On a lot of display hardware, programming needs to take effect during the vertical blanking period so that settings like gamma, the image buffer buffer to be scanned out, etc. can safely be changed without showing any visual artifacts on the screen. In some unforgiving hardware, some of this programming has to both start and end in the same vblank. To help with the timing of the hardware programming, an interrupt is usually available to notify the driver when it can start the updating of registers. The interrupt is in this context named the vblank interrupt.

The vblank interrupt may be fired at different points depending on the hardware. Some hardware implementations will fire the interrupt when the new frame start, other implementations will fire the interrupt at different points in time.

Vertical blanking plays a major role in graphics rendering. To achieve tear-free display, users must synchronize page flips and/or rendering to vertical blanking. The DRM API offers ioctls to perform page flips synchronized to vertical blanking and wait for vertical blanking.

The DRM core handles most of the vertical blanking management logic, which involves filtering out spurious interrupts, keeping race-free blanking counters, coping with counter wrap-around and resets and keeping use counts. It relies on the driver to generate vertical blanking interrupts and optionally provide a hardware vertical blanking counter.

Drivers must initialize the vertical blanking handling core with a call to *drm_vblank_init()*. Minimally, a driver needs to implement *drm_crtc_funcs.enable_vblank* and *drm_crtc_funcs.disable_vblank* plus call *drm_crtc_handle_vblank()* in its vblank interrupt handler for working vblank support.

Vertical blanking interrupts can be enabled by the DRM core or by drivers themselves (for instance to handle page flipping operations). The DRM core maintains a vertical blanking use count to ensure that the interrupts are not disabled while a user still needs them. To increment the use count, drivers call *drm_crtc_vblank_get()* and release the vblank reference again with *drm_crtc_vblank_put()*. In between these two calls vblank interrupts are guaranteed to be enabled.

On many hardware disabling the vblank interrupt cannot be done in a race-free manner, see *drm_driver.vblank_disable_immediate* and *drm_driver.max_vblank_count*. In that case the vblank core only disables the vblanks after a timer has expired, which can be configured through the `vblankoffdelay` module parameter.

Drivers for hardware without support for vertical-blanking interrupts must not call *drm_vblank_init()*. For such drivers, atomic helpers will automatically generate fake vblank events as part of the display update. This functionality also can be controlled by the driver by enabling and disabling *struct drm_crtc_state*.no_vblank.

4.15.1 Vertical Blanking and Interrupt Handling Functions Reference

struct **drm_pending_vblank_event**

pending vblank event tracking

Definition

```
struct drm_pending_vblank_event {
  struct drm_pending_event base;
  unsigned int pipe;
  u64 sequence;
  union {
    struct drm_event base;
    struct drm_event_vblank vbl;
    struct drm_event_crtc_sequence seq;
  } event;
};
```

Members

base
Base structure for tracking pending DRM events.

pipe
drm_crtc_index() of the *drm_crtc* this event is for.

sequence
frame event should be triggered at

event
Actual event which will be sent to userspace.

event.base
DRM event base class.

event.vbl
Event payload for vblank events, requested through either the MODE_PAGE_FLIP or MODE_ATOMIC IOCTL. Also generated by the legacy WAIT_VBLANK IOCTL, but new userspace should use MODE_QUEUE_SEQUENCE and `event.seq` instead.

event.seq
Event payload for the MODE_QUEUEU_SEQUENCE IOCTL.

struct **drm_vblank_crtc**
vblank tracking for a CRTC

Definition

```
struct drm_vblank_crtc {
  struct drm_device *dev;
  wait_queue_head_t queue;
  struct timer_list disable_timer;
  seqlock_t seqlock;
  atomic64_t count;
  ktime_t time;
  atomic_t refcount;
  u32 last;
  u32 max_vblank_count;
  unsigned int inmodeset;
  unsigned int pipe;
  int framedur_ns;
  int linedur_ns;
  struct drm_display_mode hwmode;
  bool enabled;
  struct kthread_worker *worker;
  struct list_head pending_work;
  wait_queue_head_t work_wait_queue;
};
```

Members

dev
Pointer to the *drm_device*.

queue
Wait queue for vblank waiters.

disable_timer
Disable timer for the delayed vblank disabling hysteresis logic. Vblank disabling is controlled through the drm_vblank_offdelay module option and the setting of the *drm_device.max_vblank_count* value.

seqlock
Protect vblank count and time.

count
Current software vblank counter.

Note that for a given vblank counter value *drm_crtc_handle_vblank()* and *drm_crtc_vblank_count()* or *drm_crtc_vblank_count_and_time()* provide a barrier: Any writes done before calling *drm_crtc_handle_vblank()* will be visible to callers of the later functions, iff the vblank count is the same or a later one.

IMPORTANT: This guarantee requires barriers, therefor never access this field directly. Use *drm_crtc_vblank_count()* instead.

time
Vblank timestamp corresponding to **count**.

refcount
Number of users/waiters of the vblank interrupt. Only when this refcount reaches 0 can the hardware interrupt be disabled using **disable_timer**.

last
Protected by *drm_device.vbl_lock*, used for wraparound handling.

max_vblank_count
Maximum value of the vblank registers for this crtc. This value +1 will result in a wrap-around of the vblank register. It is used by the vblank core to handle wrap-arounds.

If set to zero the vblank core will try to guess the elapsed vblanks between times when the vblank interrupt is disabled through high-precision timestamps. That approach is suffering from small races and imprecision over longer time periods, hence exposing a hardware vblank counter is always recommended.

This is the runtime configurable per-crtc maximum set through *drm_crtc_set_max_vblank_count()*. If this is used the driver must leave the device wide *drm_device.max_vblank_count* at zero.

If non-zero, *drm_crtc_funcs.get_vblank_counter* must be set.

inmodeset
Tracks whether the vblank is disabled due to a modeset. For legacy driver bit 2 additionally tracks whether an additional temporary vblank reference has been acquired to paper over the hardware counter resetting/jumping. KMS drivers should instead just call *drm_crtc_vblank_off()* and *drm_crtc_vblank_on()*, which explicitly save and restore the vblank count.

pipe
drm_crtc_index() of the *drm_crtc* corresponding to this structure.

framedur_ns
Frame/Field duration in ns, used by *drm_crtc_vblank_helper_get_vblank_timestamp()* and computed by *drm_calc_timestamping_constants()*.

linedur_ns
Line duration in ns, used by *drm_crtc_vblank_helper_get_vblank_timestamp()* and computed by *drm_calc_timestamping_constants()*.

hwmode
Cache of the current hardware display mode. Only valid when **enabled** is set. This is used by helpers like

drm_crtc_vblank_helper_get_vblank_timestamp(). We can't just access the hardware mode by e.g. looking at *drm_crtc_state.adjusted_mode*, because that one is really hard to get from interrupt context.

enabled
Tracks the enabling state of the corresponding *drm_crtc* to avoid double-disabling and hence corrupting saved state. Needed by drivers not using atomic KMS, since those might go through their CRTC disabling functions multiple times.

worker
The `kthread_worker` used for executing vblank works.

pending_work
A list of scheduled *drm_vblank_work* items that are waiting for a future vblank.

work_wait_queue
The wait queue used for signaling that a *drm_vblank_work* item has either finished executing, or was cancelled.

Description

This structure tracks the vblank state for one CRTC.

Note that for historical reasons - the vblank handling code is still shared with legacy/non-kms drivers - this is a free-standing structure not directly connected to *struct drm_crtc*. But all public interface functions are taking a *struct drm_crtc* to hide this implementation detail.

u64 **drm_crtc_accurate_vblank_count**(struct *drm_crtc* *crtc)
retrieve the master vblank counter

Parameters

struct drm_crtc *crtc
which counter to retrieve

Description

This function is similar to *drm_crtc_vblank_count()* but this function interpolates to handle a race with vblank interrupts using the high precision timestamping support.

This is mostly useful for hardware that can obtain the scanout position, but doesn't have a hardware frame counter.

int **drm_vblank_init**(struct *drm_device* *dev, unsigned int num_crtcs)
initialize vblank support

Parameters

struct drm_device *dev
DRM device

unsigned int num_crtcs
number of CRTCs supported by **dev**

Description

This function initializes vblank support for **num_crtcs** display pipelines. Cleanup is handled automatically through a cleanup function added with *drmm_add_action_or_reset()*.

Return

Zero on success or a negative error code on failure.

bool **drm_dev_has_vblank**(const struct *drm_device* *dev)

test if vblanking has been initialized for a device

Parameters

const struct drm_device *dev

the device

Description

Drivers may call this function to test if vblank support is initialized for a device. For most hardware this means that vblanking can also be enabled.

Atomic helpers use this function to initialize *drm_crtc_state.no_vblank*. See also *drm_atomic_helper_check_modeset()*.

Return

True if vblanking has been initialized for the given device, false otherwise.

wait_queue_head_t ***drm_crtc_vblank_waitqueue**(struct *drm_crtc* *crtc)

get vblank waitqueue for the CRTC

Parameters

struct drm_crtc *crtc

which CRTC's vblank waitqueue to retrieve

Description

This function returns a pointer to the vblank waitqueue for the CRTC. Drivers can use this to implement vblank waits using wait_event() and related functions.

void **drm_calc_timestamping_constants**(struct *drm_crtc* *crtc, const struct *drm_display_mode* *mode)

calculate vblank timestamp constants

Parameters

struct drm_crtc *crtc

drm_crtc whose timestamp constants should be updated.

const struct drm_display_mode *mode

display mode containing the scanout timings

Description

Calculate and store various constants which are later needed by vblank and swap-completion timestamping, e.g, by *drm_crtc_vblank_helper_get_vblank_timestamp()*. They are derived from CRTC's true scanout timing, so they take things like panel scaling or other adjustments into account.

bool **drm_crtc_vblank_helper_get_vblank_timestamp_internal**(struct *drm_crtc* *crtc, int *max_error, ktime_t *vblank_time, bool in_vblank_irq, drm_vblank_get_scanout_p get_scanout_position)

precise vblank timestamp helper

Parameters

struct drm_crtc *crtc
CRTC whose vblank timestamp to retrieve

int *max_error
Desired maximum allowable error in timestamps (nanosecs) On return contains true maximum error of timestamp

ktime_t *vblank_time
Pointer to time which should receive the timestamp

bool in_vblank_irq
True when called from *drm_crtc_handle_vblank()*. Some drivers need to apply some workarounds for gpu-specific vblank irq quirks if flag is set.

drm_vblank_get_scanout_position_func get_scanout_position
Callback function to retrieve the scanout position. See **struct** drm_crtc_helper_funcs.get_scanout_position.

Description

Implements calculation of exact vblank timestamps from given drm_display_mode timings and current video scanout position of a CRTC.

The current implementation only handles standard video modes. For double scan and interlaced modes the driver is supposed to adjust the hardware mode (taken from *drm_crtc_state.adjusted* mode for atomic modeset drivers) to match the scanout position reported.

Note that atomic drivers must call *drm_calc_timestamping_constants()* before enabling a CRTC. The atomic helpers already take care of that in *drm_atomic_helper_calc_timestamping_constants()*.

Returns true on success, and false on failure, i.e. when no accurate timestamp could be acquired.

Return

bool **drm_crtc_vblank_helper_get_vblank_timestamp**(struct *drm_crtc* *crtc, int *max_error, ktime_t *vblank_time, bool in_vblank_irq)

precise vblank timestamp helper

Parameters

struct drm_crtc *crtc
CRTC whose vblank timestamp to retrieve

int *max_error
Desired maximum allowable error in timestamps (nanosecs) On return contains true maximum error of timestamp

ktime_t *vblank_time
Pointer to time which should receive the timestamp

bool in_vblank_irq
True when called from *drm_crtc_handle_vblank()*. Some drivers need to apply some workarounds for gpu-specific vblank irq quirks if flag is set.

Description

Implements calculation of exact vblank timestamps from given drm_display_mode timings and current video scanout position of a CRTC. This can be directly used as the *drm_crtc_funcs.get_vblank_timestamp* implementation of a kms driver if *drm_crtc_helper_funcs.get_scanout_position* is implemented.

The current implementation only handles standard video modes. For double scan and interlaced modes the driver is supposed to adjust the hardware mode (taken from *drm_crtc_state.adjusted* mode for atomic modeset drivers) to match the scanout position reported.

Note that atomic drivers must call *drm_calc_timestamping_constants()* before enabling a CRTC. The atomic helpers already take care of that in *drm_atomic_helper_calc_timestamping_constants()*.

Returns true on success, and false on failure, i.e. when no accurate timestamp could be acquired.

Return

u64 **drm_crtc_vblank_count**(struct *drm_crtc* *crtc)
retrieve "cooked" vblank counter value

Parameters

struct drm_crtc *crtc
which counter to retrieve

Description

Fetches the "cooked" vblank count value that represents the number of vblank events since the system was booted, including lost events due to modesetting activity. Note that this timer isn't correct against a racing vblank interrupt (since it only reports the software vblank counter), see *drm_crtc_accurate_vblank_count()* for such use-cases.

Note that for a given vblank counter value *drm_crtc_handle_vblank()* and *drm_crtc_vblank_count()* or *drm_crtc_vblank_count_and_time()* provide a barrier: Any writes done before calling *drm_crtc_handle_vblank()* will be visible to callers of the later functions, iff the vblank count is the same or a later one.

See also *drm_vblank_crtc.count*.

Return

The software vblank counter.

u64 **drm_crtc_vblank_count_and_time**(struct *drm_crtc* *crtc, ktime_t *vblanktime)

retrieve "cooked"vblank counter value and the system timestamp corresponding to that vblank counter value

Parameters

struct drm_crtc *crtc
which counter to retrieve

ktime_t *vblanktime
Pointer to time to receive the vblank timestamp.

Description

Fetches the "cooked" vblank count value that represents the number of vblank events since the system was booted, including lost events due to modesetting activity. Returns corresponding system timestamp of the time of the vblank interval that corresponds to the current vblank counter value.

Note that for a given vblank counter value *drm_crtc_handle_vblank()* and *drm_crtc_vblank_count()* or *drm_crtc_vblank_count_and_time()* provide a barrier: Any writes done before calling *drm_crtc_handle_vblank()* will be visible to callers of the later functions, iff the vblank count is the same or a later one.

See also *drm_vblank_crtc.count*.

void **drm_crtc_arm_vblank_event**(struct *drm_crtc* *crtc, struct *drm_pending_vblank_event* *e)

arm vblank event after pageflip

Parameters

struct drm_crtc *crtc
the source CRTC of the vblank event

struct drm_pending_vblank_event *e
the event to send

Description

A lot of drivers need to generate vblank events for the very next vblank interrupt. For example when the page flip interrupt happens when the page flip gets armed, but not when it actually executes within the next vblank period. This helper function implements exactly the required vblank arming behaviour.

1. Driver commits new hardware state into vblank-synchronized registers.
2. A vblank happens, committing the hardware state. Also the corresponding vblank interrupt is fired off and fully processed by the interrupt handler.
3. The atomic commit operation proceeds to call *drm_crtc_arm_vblank_event()*.
4. The event is only send out for the next vblank, which is wrong.

An equivalent race can happen when the driver calls *drm_crtc_arm_vblank_event()* before writing out the new hardware state.

The only way to make this work safely is to prevent the vblank from firing (and the hardware from committing anything else) until the entire atomic commit sequence has run to completion. If the hardware does not have such a feature (e.g. using a "go" bit), then it is unsafe to use this functions. Instead drivers need to manually send out the event from their interrupt handler by calling *drm_crtc_send_vblank_event()* and make sure that there's no possible race with the hardware committing the atomic update.

Caller must hold a vblank reference for the event **e** acquired by a *drm_crtc_vblank_get()*, which will be dropped when the next vblank arrives.

NOTE

Drivers using this to send out the *drm_crtc_state.event* as part of an atomic commit must ensure that the next vblank happens at exactly the same time as the atomic commit is committed to the hardware. This function itself does **not** protect against the next vblank interrupt racing with either this function call or the atomic commit operation. A possible sequence could be:

void **drm_crtc_send_vblank_event**(struct *drm_crtc* *crtc, struct *drm_pending_vblank_event* *e)

helper to send vblank event after pageflip

Parameters

struct drm_crtc *crtc
the source CRTC of the vblank event

struct drm_pending_vblank_event *e
the event to send

Description

Updates sequence # and timestamp on event for the most recently processed vblank, and sends it to userspace. Caller must hold event lock.

See *drm_crtc_arm_vblank_event()* for a helper which can be used in certain situation, especially to send out events for atomic commit operations.

int **drm_crtc_vblank_get**(struct *drm_crtc* *crtc)

get a reference count on vblank events

Parameters

struct drm_crtc *crtc
which CRTC to own

Description

Acquire a reference count on vblank events to avoid having them disabled while in use.

Return

Zero on success or a negative error code on failure.

void **drm_crtc_vblank_put**(struct *drm_crtc* *crtc)

give up ownership of vblank events

Parameters

struct drm_crtc *crtc

which counter to give up

Description

Release ownership of a given vblank counter, turning off interrupts if possible. Disable interrupts after drm_vblank_offdelay milliseconds.

void **drm_wait_one_vblank**(struct *drm_device* *dev, unsigned int pipe)

wait for one vblank

Parameters

struct drm_device *dev

DRM device

unsigned int pipe

CRTC index

Description

This waits for one vblank to pass on **pipe**, using the irq driver interfaces. It is a failure to call this when the vblank irq for **pipe** is disabled, e.g. due to lack of driver support or because the crtc is off.

This is the legacy version of *drm_crtc_wait_one_vblank()*.

void **drm_crtc_wait_one_vblank**(struct *drm_crtc* *crtc)

wait for one vblank

Parameters

struct drm_crtc *crtc

DRM crtc

Description

This waits for one vblank to pass on **crtc**, using the irq driver interfaces. It is a failure to call this when the vblank irq for **crtc** is disabled, e.g. due to lack of driver support or because the crtc is off.

void **drm_crtc_vblank_off**(struct *drm_crtc* *crtc)

disable vblank events on a CRTC

Parameters

struct drm_crtc *crtc

CRTC in question

Description

Drivers can use this function to shut down the vblank interrupt handling when disabling a crtc. This function ensures that the latest vblank frame count is stored so that drm_vblank_on can restore it again.

Drivers must use this function when the hardware vblank counter can get reset, e.g. when suspending or disabling the **crtc** in general.

void **drm_crtc_vblank_reset**(struct *drm_crtc* *crtc)

reset vblank state to off on a CRTC

Parameters

struct drm_crtc *crtc
CRTC in question

Description

Drivers can use this function to reset the vblank state to off at load time. Drivers should use this together with the *drm_crtc_vblank_off()* and *drm_crtc_vblank_on()* functions. The difference compared to *drm_crtc_vblank_off()* is that this function doesn't save the vblank counter and hence doesn't need to call any driver hooks.

This is useful for recovering driver state e.g. on driver load, or on resume.

void **drm_crtc_set_max_vblank_count**(struct *drm_crtc* *crtc, u32 max_vblank_count)

configure the hw max vblank counter value

Parameters

struct drm_crtc *crtc
CRTC in question

u32 max_vblank_count
max hardware vblank counter value

Description

Update the maximum hardware vblank counter value for **crtc** at runtime. Useful for hardware where the operation of the hardware vblank counter depends on the currently active display configuration.

For example, if the hardware vblank counter does not work when a specific connector is active the maximum can be set to zero. And when that specific connector isn't active the maximum can again be set to the appropriate non-zero value.

If used, must be called before drm_vblank_on().

void **drm_crtc_vblank_on**(struct *drm_crtc* *crtc)

enable vblank events on a CRTC

Parameters

struct drm_crtc *crtc
CRTC in question

Description

This functions restores the vblank interrupt state captured with *drm_crtc_vblank_off()* again and is generally called when enabling **crtc**. Note that calls to *drm_crtc_vblank_on()* and *drm_crtc_vblank_off()* can be unbalanced and so can also be unconditionally called in driver load code to reflect the current hardware state of the crtc.

void **drm_vblank_restore**(struct *drm_device* *dev, unsigned int pipe)

estimate missed vblanks and update vblank count.

Parameters

`struct drm_device *dev`
DRM device

`unsigned int pipe`
CRTC index

Description

Power manamement features can cause frame counter resets between vblank disable and enable. Drivers can use this function in their *`drm_crtc_funcs.enable_vblank`* implementation to estimate missed vblanks since the last *`drm_crtc_funcs.disable_vblank`* using timestamps and update the vblank counter.

This function is the legacy version of *`drm_crtc_vblank_restore()`*.

void **`drm_crtc_vblank_restore`**(struct *drm_crtc* *crtc)
estimate missed vblanks and update vblank count.

Parameters

`struct drm_crtc *crtc`
CRTC in question

Description

Power manamement features can cause frame counter resets between vblank disable and enable. Drivers can use this function in their *`drm_crtc_funcs.enable_vblank`* implementation to estimate missed vblanks since the last *`drm_crtc_funcs.disable_vblank`* using timestamps and update the vblank counter.

bool **`drm_handle_vblank`**(struct *drm_device* *dev, unsigned int pipe)
handle a vblank event

Parameters

`struct drm_device *dev`
DRM device

`unsigned int pipe`
index of CRTC where this event occurred

Description

Drivers should call this routine in their vblank interrupt handlers to update the vblank counter and send any signals that may be pending.

This is the legacy version of *`drm_crtc_handle_vblank()`*.

bool **`drm_crtc_handle_vblank`**(struct *drm_crtc* *crtc)
handle a vblank event

Parameters

`struct drm_crtc *crtc`
where this event occurred

Description

Drivers should call this routine in their vblank interrupt handlers to update the vblank counter and send any signals that may be pending.

This is the native KMS version of *drm_handle_vblank()*.

Note that for a given vblank counter value *drm_crtc_handle_vblank()* and *drm_crtc_vblank_count()* or *drm_crtc_vblank_count_and_time()* provide a barrier: Any writes done before calling *drm_crtc_handle_vblank()* will be visible to callers of the later functions, iff the vblank count is the same or a later one.

See also *drm_vblank_crtc.count*.

Return

True if the event was successfully handled, false on failure.

4.16 Vertical Blank Work

Many DRM drivers need to program hardware in a time-sensitive manner, many times with a deadline of starting and finishing within a certain region of the scanout. Most of the time the safest way to accomplish this is to simply do said time-sensitive programming in the driver's IRQ handler, which allows drivers to avoid being preempted during these critical regions. Or even better, the hardware may even handle applying such time-critical programming independently of the CPU.

While there's a decent amount of hardware that's designed so that the CPU doesn't need to be concerned with extremely time-sensitive programming, there's a few situations where it can't be helped. Some unforgiving hardware may require that certain time-sensitive programming be handled completely by the CPU, and said programming may even take too long to handle in an IRQ handler. Another such situation would be where the driver needs to perform a task that needs to complete within a specific scanout period, but might possibly block and thus cannot be handled in an IRQ context. Both of these situations can't be solved perfectly in Linux since we're not a realtime kernel, and thus the scheduler may cause us to miss our deadline if it decides to preempt us. But for some drivers, it's good enough if we can lower our chance of being preempted to an absolute minimum.

This is where *drm_vblank_work* comes in. *drm_vblank_work* provides a simple generic delayed work implementation which delays work execution until a particular vblank has passed, and then executes the work at realtime priority. This provides the best possible chance at performing time-sensitive hardware programming on time, even when the system is under heavy load. *drm_vblank_work* also supports rescheduling, so that self re-arming work items can be easily implemented.

4.16.1 Vertical Blank Work Functions Reference

struct **drm_vblank_work**

A delayed work item which delays until a target vblank passes, and then executes at realtime priority outside of IRQ context.

Definition

```
struct drm_vblank_work {
  struct kthread_work base;
  struct drm_vblank_crtc *vblank;
  u64 count;
  int cancelling;
  struct list_head node;
};
```

Members

base
The base kthread_work item which will be executed by *drm_vblank_crtc.worker*. Drivers should not interact with this directly, and instead rely on *drm_vblank_work_init()* to initialize this.

vblank
A pointer to *drm_vblank_crtc* this work item belongs to.

count
The target vblank this work will execute on. Drivers should not modify this value directly, and instead use *drm_vblank_work_schedule()*

cancelling
The number of *drm_vblank_work_cancel_sync()* calls that are currently running. A work item cannot be rescheduled until all calls have finished.

node
The position of this work item in *drm_vblank_crtc.pending_work*.

Description

See also: *drm_vblank_work_schedule()* *drm_vblank_work_init()* *drm_vblank_work_cancel_sync()* *drm_vblank_work_flush()*

to_drm_vblank_work

`to_drm_vblank_work (_work)`

Retrieve the respective *drm_vblank_work* item from a kthread_work

Parameters

_work
The kthread_work embedded inside a *drm_vblank_work*

int **drm_vblank_work_schedule**(struct *drm_vblank_work* *work, u64 count, bool nextonmiss)

schedule a vblank work

Parameters

`struct drm_vblank_work *work`
vblank work to schedule

`u64 count`
target vblank count

`bool nextonmiss`
defer until the next vblank if target vblank was missed

Description

Schedule **work** for execution once the crtc vblank count reaches **count**.

If the crtc vblank count has already reached **count** and **nextonmiss** is `false` the work starts to execute immediately.

If the crtc vblank count has already reached **count** and **nextonmiss** is `true` the work is deferred until the next vblank (as if **count** has been specified as crtc vblank count + 1).

If **work** is already scheduled, this function will reschedule said work using the new **count**. This can be used for self-rearming work items.

Return

`1` if **work** was successfully (re)scheduled, `0` if it was either already scheduled or cancelled, or a negative error code on failure.

bool **`drm_vblank_work_cancel_sync`**(struct *drm_vblank_work* *work)
cancel a vblank work and wait for it to finish executing

Parameters

`struct drm_vblank_work *work`
vblank work to cancel

Description

Cancel an already scheduled vblank work and wait for its execution to finish.

On return, **work** is guaranteed to no longer be scheduled or running, even if it's self-arming.

Return

`True` if the work was cancelled before it started to execute, `false` otherwise.

void **`drm_vblank_work_flush`**(struct *drm_vblank_work* *work)
wait for a scheduled vblank work to finish executing

Parameters

`struct drm_vblank_work *work`
vblank work to flush

Description

Wait until **work** has finished executing once.

void **`drm_vblank_work_init`**(struct *drm_vblank_work* *work, struct *drm_crtc* *crtc, void (*func)(struct kthread_work *work))
initialize a vblank work item

Parameters

`struct drm_vblank_work *work`
vblank work item

`struct drm_crtc *crtc`
CRTC whose vblank will trigger the work execution

`void (*func)(struct kthread_work *work)`
work function to be executed

Description

Initialize a vblank work item for a specific crtc.

CHAPTER

FIVE

MODE SETTING HELPER FUNCTIONS

The DRM subsystem aims for a strong separation between core code and helper libraries. Core code takes care of general setup and teardown and decoding userspace requests to kernel internal objects. Everything else is handled by a large set of helper libraries, which can be combined freely to pick and choose for each driver what fits, and avoid shared code where special behaviour is needed.

This distinction between core code and helpers is especially strong in the modesetting code, where there's a shared userspace ABI for all drivers. This is in contrast to the render side, where pretty much everything (with very few exceptions) can be considered optional helper code.

There are a few areas these helpers can grouped into:

- Helpers to implement modesetting. The important ones here are the atomic helpers. Old drivers still often use the legacy CRTC helpers. They both share the same set of common helper vtables. For really simple drivers (anything that would have been a great fit in the deprecated fbdev subsystem) there's also the simple display pipe helpers.
- There's a big pile of helpers for handling outputs. First the generic bridge helpers for handling encoder and transcoder IP blocks. Second the panel helpers for handling panel-related information and logic. Plus then a big set of helpers for the various sink standards (DisplayPort, HDMI, MIPI DSI). Finally there's also generic helpers for handling output probing, and for dealing with EDIDs.
- The last group of helpers concerns itself with the frontend side of a display pipeline: Planes, handling rectangles for visibility checking and scissoring, flip queues and assorted bits.

5.1 Modeset Helper Reference for Common Vtables

The DRM mode setting helper functions are common code for drivers to use if they wish. Drivers are not forced to use this code in their implementations but it would be useful if the code they do use at least provides a consistent interface and operation to userspace. Therefore it is highly recommended to use the provided helpers as much as possible.

Because there is only one pointer per modeset object to hold a vfunc table for helper libraries they are by necessity shared among the different helpers.

To make this clear all the helper vtables are pulled together in this location here.

struct **drm_crtc_helper_funcs**

helper operations for CRTCs

Definition

```
struct drm_crtc_helper_funcs {
  void (*dpms)(struct drm_crtc *crtc, int mode);
  void (*prepare)(struct drm_crtc *crtc);
  void (*commit)(struct drm_crtc *crtc);
  enum drm_mode_status (*mode_valid)(struct drm_crtc *crtc, const␣
↪struct drm_display_mode *mode);
  bool (*mode_fixup)(struct drm_crtc *crtc,const struct drm_display_
↪mode *mode, struct drm_display_mode *adjusted_mode);
  int (*mode_set)(struct drm_crtc *crtc, struct drm_display_mode␣
↪*mode,struct drm_display_mode *adjusted_mode, int x, int y,␣
↪struct drm_framebuffer *old_fb);
  void (*mode_set_nofb)(struct drm_crtc *crtc);
  int (*mode_set_base)(struct drm_crtc *crtc, int x, int y, struct␣
↪drm_framebuffer *old_fb);
  int (*mode_set_base_atomic)(struct drm_crtc *crtc,struct drm_
↪framebuffer *fb, int x, int y, enum mode_set_atomic);
  void (*disable)(struct drm_crtc *crtc);
  int (*atomic_check)(struct drm_crtc *crtc, struct drm_crtc_state␣
↪*state);
  void (*atomic_begin)(struct drm_crtc *crtc, struct drm_crtc_state␣
↪*old_crtc_state);
  void (*atomic_flush)(struct drm_crtc *crtc, struct drm_crtc_state␣
↪*old_crtc_state);
  void (*atomic_enable)(struct drm_crtc *crtc, struct drm_crtc_
↪state *old_crtc_state);
  void (*atomic_disable)(struct drm_crtc *crtc, struct drm_crtc_
↪state *old_crtc_state);
  bool (*get_scanout_position)(struct drm_crtc *crtc,bool in_vblank_
↪irq, int *vpos, int *hpos,ktime_t *stime, ktime_t *etime, const␣
↪struct drm_display_mode *mode);
};
```

Members

dpms

Callback to control power levels on the CRTC. If the mode passed in is unsupported, the provider must use the next lowest power level. This is used by the legacy CRTC helpers to implement DPMS functionality in *drm_helper_connector_dpms()*.

This callback is also used to disable a CRTC by calling it with DRM_MODE_DPMS_OFF if the **disable** hook isn't used.

This callback is used by the legacy CRTC helpers. Atomic helpers also support using this hook for enabling and disabling a CRTC to facilitate transitions to atomic, but it is deprecated. Instead **atomic_enable** and **atomic_disable** should be used.

prepare

This callback should prepare the CRTC for a subsequent modeset, which in practice means the driver should disable the CRTC if it is running. Most drivers ended up implementing this by calling their **dpms** hook with DRM_MODE_DPMS_OFF.

This callback is used by the legacy CRTC helpers. Atomic helpers also support using this hook for disabling a CRTC to facilitate transitions to atomic, but it is deprecated. Instead **atomic_disable** should be used.

commit

This callback should commit the new mode on the CRTC after a modeset, which in practice means the driver should enable the CRTC. Most drivers ended up implementing this by calling their **dpms** hook with DRM_MODE_DPMS_ON.

This callback is used by the legacy CRTC helpers. Atomic helpers also support using this hook for enabling a CRTC to facilitate transitions to atomic, but it is deprecated. Instead **atomic_enable** should be used.

mode_valid

This callback is used to check if a specific mode is valid in this crtc. This should be implemented if the crtc has some sort of restriction in the modes it can display. For example, a given crtc may be responsible to set a clock value. If the clock can not produce all the values for the available modes then this callback can be used to restrict the number of modes to only the ones that can be displayed.

This hook is used by the probe helpers to filter the mode list in *drm_helper_probe_single_connector_modes()*, and it is used by the atomic helpers to validate modes supplied by userspace in *drm_atomic_helper_check_modeset()*.

This function is optional.

NOTE:

Since this function is both called from the check phase of an atomic commit, and the mode validation in the probe paths it is not allowed to look at anything else but the passed-in mode, and validate it against configuration-invariant hardware constraints. Any further limits which depend upon the configuration can only be checked in **mode_fixup** or **atomic_check**.

RETURNS:

drm_mode_status Enum

mode_fixup

This callback is used to validate a mode. The parameter mode is the display mode that userspace requested, adjusted_mode is the mode the encoders need to be fed with. Note that this is the inverse semantics of the meaning for the *drm_encoder* and *drm_bridge_funcs.mode_fixup* vfunc. If the CRTC cannot support the requested conversion from mode to adjusted_mode it should reject the modeset. See also *drm_crtc_state.adjusted_mode* for more details.

This function is used by both legacy CRTC helpers and atomic helpers. With atomic helpers it is optional.

NOTE:

This function is called in the check phase of atomic modesets, which can be aborted for any reason (including on userspace's request to just check whether a configuration would be possible). Atomic drivers MUST NOT touch any persistent state (hardware or software) or data structures except the passed in adjusted_mode parameter.

This is in contrast to the legacy CRTC helpers where this was allowed.

Atomic drivers which need to inspect and adjust more state should instead use the **atomic_check** callback, but note that they're not perfectly equivalent: **mode_valid** is called from *drm_atomic_helper_check_modeset()*, but **atomic_check** is called from *drm_atomic_helper_check_planes()*, because originally it was meant for plane update checks only.

Also beware that userspace can request its own custom modes, neither core nor helpers filter modes to the list of probe modes reported by the GETCONNECTOR IOCTL and stored in *drm_connector.modes*. To ensure that modes are filtered consistently put any CRTC constraints and limits checks into **mode_valid**.

RETURNS:

True if an acceptable configuration is possible, false if the modeset operation should be rejected.

mode_set

This callback is used by the legacy CRTC helpers to set a new mode, position and framebuffer. Since it ties the primary plane to every mode change it is incompatible with universal plane support. And since it can't update other planes it's incompatible with atomic modeset support.

This callback is only used by CRTC helpers and deprecated.

RETURNS:

0 on success or a negative error code on failure.

mode_set_nofb

This callback is used to update the display mode of a CRTC without changing anything of the primary plane configuration. This fits the requirement of atomic and hence is used by the atomic helpers. It is also used by the transitional plane helpers to implement a **mode_set** hook in drm_helper_crtc_mode_set().

Note that the display pipe is completely off when this function is called. Atomic drivers which need hardware to be running before they program the new display mode (e.g. because they implement runtime PM) should not use this hook. This is because the helper library calls this hook only once per mode change and not every time the display pipeline is suspended using either DPMS or the new "ACTIVE" property. Which means register values set in this callback might get reset when the CRTC is suspended, but not restored. Such drivers should instead move all their CRTC setup into the **atomic_enable** callback.

This callback is optional.

`mode_set_base`

This callback is used by the legacy CRTC helpers to set a new framebuffer and scanout position. It is optional and used as an optimized fast-path instead of a full mode set operation with all the resulting flickering. If it is not present *`drm_crtc_helper_set_config()`* will fall back to a full modeset, using the **mode_set** callback. Since it can't update other planes it's incompatible with atomic modeset support.

This callback is only used by the CRTC helpers and deprecated.

RETURNS:

0 on success or a negative error code on failure.

`mode_set_base_atomic`

This callback is used by the fbdev helpers to set a new framebuffer and scanout without sleeping, i.e. from an atomic calling context. It is only used to implement kgdb support.

This callback is optional and only needed for kgdb support in the fbdev helpers.

RETURNS:

0 on success or a negative error code on failure.

`disable`

This callback should be used to disable the CRTC. With the atomic drivers it is called after all encoders connected to this CRTC have been shut off already using their own *`drm_encoder_helper_funcs.disable`* hook. If that sequence is too simple drivers can just add their own hooks and call it from this CRTC callback here by looping over all encoders connected to it using for_each_encoder_on_crtc().

This hook is used both by legacy CRTC helpers and atomic helpers. Atomic drivers don't need to implement it if there's no need to disable anything at the CRTC level. To ensure that runtime PM handling (using either DPMS or the new "ACTIVE"property) works **disable** must be the inverse of **atomic_enable** for atomic drivers. Atomic drivers should consider to use **atomic_disable** instead of this one.

NOTE:

With legacy CRTC helpers there's a big semantic difference between **disable** and other hooks (like **prepare** or **dpms**) used to shut down a CRTC: **disable** is only called when also logically disabling the display pipeline and needs to release any resources acquired in **mode_set** (like shared PLLs, or again release pinned framebuffers).

Therefore **disable** must be the inverse of **mode_set** plus **commit** for drivers still using legacy CRTC helpers, which is different from the rules under atomic.

`atomic_check`

Drivers should check plane-update related CRTC constraints in this hook.

They can also check mode related limitations but need to be aware of the calling order, since this hook is used by *drm_atomic_helper_check_planes()* whereas the preparations needed to check output routing and the display mode is done in *drm_atomic_helper_check_modeset()*. Therefore drivers that want to check output routing and display mode constraints in this callback must ensure that *drm_atomic_helper_check_modeset()* has been called beforehand. This is calling order used by the default helper implementation in *drm_atomic_helper_check()*.

When using *drm_atomic_helper_check_planes()* this hook is called after the *drm_plane_helper_funcs.atomic_check* hook for planes, which allows drivers to assign shared resources requested by planes in this callback here. For more complicated dependencies the driver can call the provided check helpers multiple times until the computed state has a final configuration and everything has been checked.

This function is also allowed to inspect any other object's state and can add more state objects to the atomic commit if needed. Care must be taken though to ensure that state check and compute functions for these added states are all called, and derived state in other objects all updated. Again the recommendation is to just call check helpers until a maximal configuration is reached.

This callback is used by the atomic modeset helpers and by the transitional plane helpers, but it is optional.

NOTE:

This function is called in the check phase of an atomic update. The driver is not allowed to change anything outside of the free-standing state objects passed-in or assembled in the overall *drm_atomic_state* update tracking structure.

Also beware that userspace can request its own custom modes, neither core nor helpers filter modes to the list of probe modes reported by the GETCONNECTOR IOCTL and stored in *drm_connector.modes*. To ensure that modes are filtered consistently put any CRTC constraints and limits checks into **mode_valid**.

RETURNS:

0 on success, -EINVAL if the state or the transition can't be supported, -ENOMEM on memory allocation failure and -EDEADLK if an attempt to obtain another state object ran into a *drm_modeset_lock* deadlock.

atomic_begin

Drivers should prepare for an atomic update of multiple planes on a CRTC in this hook. Depending upon hardware this might be vblank evasion, blocking updates by setting bits or doing preparatory work for e.g. manual update display.

This hook is called before any plane commit functions are called.

Note that the power state of the display pipe when this function is called depends upon the exact helpers and calling sequence the driver has picked. See *drm_atomic_helper_commit_planes()* for a discussion of the tradeoffs and variants of plane commit helpers.

This callback is used by the atomic modeset helpers and by the transitional plane helpers, but it is optional.

atomic_flush

Drivers should finalize an atomic update of multiple planes on a CRTC in this hook. Depending upon hardware this might include checking that vblank evasion was successful, unblocking updates by setting bits or setting the GO bit to flush out all updates.

Simple hardware or hardware with special requirements can commit and flush out all updates for all planes from this hook and forgo all the other commit hooks for plane updates.

This hook is called after any plane commit functions are called.

Note that the power state of the display pipe when this function is called depends upon the exact helpers and calling sequence the driver has picked. See *drm_atomic_helper_commit_planes()* for a discussion of the tradeoffs and variants of plane commit helpers.

This callback is used by the atomic modeset helpers and by the transitional plane helpers, but it is optional.

atomic_enable

This callback should be used to enable the CRTC. With the atomic drivers it is called before all encoders connected to this CRTC are enabled through the encoder' s own *drm_encoder_helper_funcs.enable* hook. If that sequence is too simple drivers can just add their own hooks and call it from this CRTC callback here by looping over all encoders connected to it using for_each_encoder_on_crtc().

This hook is used only by atomic helpers, for symmetry with **atomic_disable**. Atomic drivers don't need to implement it if there's no need to enable anything at the CRTC level. To ensure that runtime PM handling (using either DPMS or the new "ACTIVE" property) works **atomic_enable** must be the inverse of **atomic_disable** for atomic drivers.

Drivers can use the **old_crtc_state** input parameter if the operations needed to enable the CRTC don' t depend solely on the new state but also on the transition between the old state and the new state.

This function is optional.

atomic_disable

This callback should be used to disable the CRTC. With the atomic drivers it is called after all encoders connected to this CRTC have been shut off already using their own *drm_encoder_helper_funcs.disable* hook. If that sequence is too simple drivers can just add their own hooks and call it from this CRTC callback here by looping over all encoders connected to it using for_each_encoder_on_crtc().

This hook is used only by atomic helpers. Atomic drivers don' t need to implement it if there' s no need to disable anything at the CRTC level.

Comparing to **disable**, this one provides the additional input parameter **old_crtc_state** which could be used to access the old state. Atomic drivers should consider to use this one instead of **disable**.

This function is optional.

`get_scanout_position`
Called by vblank timestamping code.

Returns the current display scanout position from a CRTC and an optional accurate ktime_get() timestamp of when the position was measured. Note that this is a helper callback which is only used if a driver uses *`drm_crtc_vblank_helper_get_vblank_timestamp()`* for the **drm_crtc_funcs.get_vblank_timestamp** callback.

Parameters:

crtc:
The CRTC.

in_vblank_irq:
True when called from *`drm_crtc_handle_vblank()`*. Some drivers need to apply some workarounds for gpu-specific vblank irq quirks if the flag is set.

vpos:
Target location for current vertical scanout position.

hpos:
Target location for current horizontal scanout position.

stime:
Target location for timestamp taken immediately before scanout position query. Can be NULL to skip timestamp.

etime:
Target location for timestamp taken immediately after scanout position query. Can be NULL to skip timestamp.

mode:
Current display timings.

Returns vpos as a positive number while in active scanout area. Returns vpos as a negative number inside vblank, counting the number of scanlines to go until end of vblank, e.g., -1 means "one scanline until start of active scanout / end of vblank."

Returns:

True on success, false if a reliable scanout position counter could not be read out.

Description

These hooks are used by the legacy CRTC helpers, the transitional plane helpers and the new atomic modesetting helpers.

void **`drm_crtc_helper_add`**(struct *drm_crtc* *crtc, const struct *drm_crtc_helper_funcs* *funcs)

sets the helper vtable for a crtc

Parameters

struct drm_crtc *crtc
DRM CRTC

const struct drm_crtc_helper_funcs *funcs
helper vtable to set for **crtc**

struct **drm_encoder_helper_funcs**
helper operations for encoders

Definition

```
struct drm_encoder_helper_funcs {
  void (*dpms)(struct drm_encoder *encoder, int mode);
  enum drm_mode_status (*mode_valid)(struct drm_encoder *crtc,␣
↪const struct drm_display_mode *mode);
  bool (*mode_fixup)(struct drm_encoder *encoder,const struct drm_
↪display_mode *mode, struct drm_display_mode *adjusted_mode);
  void (*prepare)(struct drm_encoder *encoder);
  void (*commit)(struct drm_encoder *encoder);
  void (*mode_set)(struct drm_encoder *encoder,struct drm_display_
↪mode *mode, struct drm_display_mode *adjusted_mode);
  void (*atomic_mode_set)(struct drm_encoder *encoder,struct drm_
↪crtc_state *crtc_state, struct drm_connector_state *conn_state);
  enum drm_connector_status (*detect)(struct drm_encoder *encoder,␣
↪struct drm_connector *connector);
  void (*atomic_disable)(struct drm_encoder *encoder, struct drm_
↪atomic_state *state);
  void (*atomic_enable)(struct drm_encoder *encoder, struct drm_
↪atomic_state *state);
  void (*disable)(struct drm_encoder *encoder);
  void (*enable)(struct drm_encoder *encoder);
  int (*atomic_check)(struct drm_encoder *encoder,struct drm_crtc_
↪state *crtc_state, struct drm_connector_state *conn_state);
};
```

Members

dpms
Callback to control power levels on the encoder. If the mode passed in is unsupported, the provider must use the next lowest power level. This is used by the legacy encoder helpers to implement DPMS functionality in *drm_helper_connector_dpms()*.

This callback is also used to disable an encoder by calling it with DRM_MODE_DPMS_OFF if the **disable** hook isn' t used.

This callback is used by the legacy CRTC helpers. Atomic helpers also support using this hook for enabling and disabling an encoder to facilitate transitions to atomic, but it is deprecated. Instead **enable** and **disable** should be used.

mode_valid
This callback is used to check if a specific mode is valid in this encoder. This should be implemented if the encoder has some sort of restriction in the modes it can display. For example, a given encoder may be responsible to set a clock value. If the clock can not produce all the values for the available

modes then this callback can be used to restrict the number of modes to only the ones that can be displayed.

This hook is used by the probe helpers to filter the mode list in *drm_helper_probe_single_connector_modes()*, and it is used by the atomic helpers to validate modes supplied by userspace in *drm_atomic_helper_check_modeset()*.

This function is optional.

NOTE:

Since this function is both called from the check phase of an atomic commit, and the mode validation in the probe paths it is not allowed to look at anything else but the passed-in mode, and validate it against configuration-invariant hardware constraints. Any further limits which depend upon the configuration can only be checked in **mode_fixup** or **atomic_check**.

RETURNS:

drm_mode_status Enum

mode_fixup

This callback is used to validate and adjust a mode. The parameter mode is the display mode that should be fed to the next element in the display chain, either the final *drm_connector* or a *drm_bridge*. The parameter adjusted_mode is the input mode the encoder requires. It can be modified by this callback and does not need to match mode. See also *drm_crtc_state.adjusted_mode* for more details.

This function is used by both legacy CRTC helpers and atomic helpers. This hook is optional.

NOTE:

This function is called in the check phase of atomic modesets, which can be aborted for any reason (including on userspace's request to just check whether a configuration would be possible). Atomic drivers MUST NOT touch any persistent state (hardware or software) or data structures except the passed in adjusted_mode parameter.

This is in contrast to the legacy CRTC helpers where this was allowed.

Atomic drivers which need to inspect and adjust more state should instead use the **atomic_check** callback. If **atomic_check** is used, this hook isn't called since **atomic_check** allows a strict superset of the functionality of **mode_fixup**.

Also beware that userspace can request its own custom modes, neither core nor helpers filter modes to the list of probe modes reported by the GETCONNECTOR IOCTL and stored in *drm_connector.modes*. To ensure that modes are filtered consistently put any encoder constraints and limits checks into **mode_valid**.

RETURNS:

True if an acceptable configuration is possible, false if the modeset operation should be rejected.

`prepare`
: This callback should prepare the encoder for a subsequent modeset, which in practice means the driver should disable the encoder if it is running. Most drivers ended up implementing this by calling their **dpms** hook with DRM_MODE_DPMS_OFF.

  This callback is used by the legacy CRTC helpers. Atomic helpers also support using this hook for disabling an encoder to facilitate transitions to atomic, but it is deprecated. Instead **disable** should be used.

`commit`
: This callback should commit the new mode on the encoder after a modeset, which in practice means the driver should enable the encoder. Most drivers ended up implementing this by calling their **dpms** hook with DRM_MODE_DPMS_ON.

  This callback is used by the legacy CRTC helpers. Atomic helpers also support using this hook for enabling an encoder to facilitate transitions to atomic, but it is deprecated. Instead **enable** should be used.

`mode_set`
: This callback is used to update the display mode of an encoder.

  Note that the display pipe is completely off when this function is called. Drivers which need hardware to be running before they program the new display mode (because they implement runtime PM) should not use this hook, because the helper library calls it only once and not every time the display pipeline is suspend using either DPMS or the new "ACTIVE" property. Such drivers should instead move all their encoder setup into the **enable** callback.

  This callback is used both by the legacy CRTC helpers and the atomic modeset helpers. It is optional in the atomic helpers.

  NOTE:

  If the driver uses the atomic modeset helpers and needs to inspect the connector state or connector display info during mode setting, **atomic_mode_set** can be used instead.

`atomic_mode_set`
: This callback is used to update the display mode of an encoder.

  Note that the display pipe is completely off when this function is called. Drivers which need hardware to be running before they program the new display mode (because they implement runtime PM) should not use this hook, because the helper library calls it only once and not every time the display pipeline is suspended using either DPMS or the new "ACTIVE" property. Such drivers should instead move all their encoder setup into the **enable** callback.

  This callback is used by the atomic modeset helpers in place of the **mode_set** callback, if set by the driver. It is optional and should be used instead of **mode_set** if the driver needs to inspect the connector state or display info, since there is no direct way to go from the encoder to the current connector.

`detect`
: This callback can be used by drivers who want to do detection on the encoder object instead of in connector functions.

It is not used by any helper and therefore has purely driver-specific semantics. New drivers shouldn't use this and instead just implement their own private callbacks.

FIXME:

This should just be converted into a pile of driver vfuncs. Currently radeon, amdgpu and nouveau are using it.

`atomic_disable`
This callback should be used to disable the encoder. With the atomic drivers it is called before this encoder's CRTC has been shut off using their own *`drm_crtc_helper_funcs.atomic_disable`* hook. If that sequence is too simple drivers can just add their own driver private encoder hooks and call them from CRTC's callback by looping over all encoders connected to it using for_each_encoder_on_crtc().

This callback is a variant of **disable** that provides the atomic state to the driver. If **atomic_disable** is implemented, **disable** is not called by the helpers.

This hook is only used by atomic helpers. Atomic drivers don't need to implement it if there's no need to disable anything at the encoder level. To ensure that runtime PM handling (using either DPMS or the new "ACTIVE" property) works **atomic_disable** must be the inverse of **atomic_enable**.

`atomic_enable`
This callback should be used to enable the encoder. It is called after this encoder's CRTC has been enabled using their own *`drm_crtc_helper_funcs.atomic_enable`* hook. If that sequence is too simple drivers can just add their own driver private encoder hooks and call them from CRTC's callback by looping over all encoders connected to it using for_each_encoder_on_crtc().

This callback is a variant of **enable** that provides the atomic state to the driver. If **atomic_enable** is implemented, **enable** is not called by the helpers.

This hook is only used by atomic helpers, it is the opposite of **atomic_disable**. Atomic drivers don't need to implement it if there's no need to enable anything at the encoder level. To ensure that runtime PM handling works **atomic_enable** must be the inverse of **atomic_disable**.

`disable`
This callback should be used to disable the encoder. With the atomic drivers it is called before this encoder's CRTC has been shut off using their own *`drm_crtc_helper_funcs.disable`* hook. If that sequence is too simple drivers can just add their own driver private encoder hooks and call them from CRTC's callback by looping over all encoders connected to it using for_each_encoder_on_crtc().

This hook is used both by legacy CRTC helpers and atomic helpers. Atomic drivers don't need to implement it if there's no need to disable anything at the encoder level. To ensure that runtime PM handling (using either DPMS or the new "ACTIVE" property) works **disable** must be the inverse of **enable** for atomic drivers.

For atomic drivers also consider **atomic_disable** and save yourself from having to read the NOTE below!

NOTE:

With legacy CRTC helpers there' s a big semantic difference between **disable** and other hooks (like **prepare** or **dpms**) used to shut down a encoder: **disable** is only called when also logically disabling the display pipeline and needs to release any resources acquired in **mode_set** (like shared PLLs, or again release pinned framebuffers).

Therefore **disable** must be the inverse of **mode_set** plus **commit** for drivers still using legacy CRTC helpers, which is different from the rules under atomic.

`enable`

This callback should be used to enable the encoder. With the atomic drivers it is called after this encoder' s CRTC has been enabled using their own *`drm_crtc_helper_funcs.enable`* hook. If that sequence is too simple drivers can just add their own driver private encoder hooks and call them from CRTC' s callback by looping over all encoders connected to it using for_each_encoder_on_crtc().

This hook is only used by atomic helpers, it is the opposite of **disable**. Atomic drivers don' t need to implement it if there' s no need to enable anything at the encoder level. To ensure that runtime PM handling (using either DPMS or the new "ACTIVE" property) works **enable** must be the inverse of **disable** for atomic drivers.

`atomic_check`

This callback is used to validate encoder state for atomic drivers. Since the encoder is the object connecting the CRTC and connector it gets passed both states, to be able to validate interactions and update the CRTC to match what the encoder needs for the requested connector.

Since this provides a strict superset of the functionality of **mode_fixup** (the requested and adjusted modes are both available through the passed in *`struct drm_crtc_state`*) **mode_fixup** is not called when **atomic_check** is implemented.

This function is used by the atomic helpers, but it is optional.

NOTE:

This function is called in the check phase of an atomic update. The driver is not allowed to change anything outside of the free-standing state objects passed-in or assembled in the overall *`drm_atomic_state`* update tracking structure.

Also beware that userspace can request its own custom modes, neither core nor helpers filter modes to the list of probe modes reported by the GETCONNECTOR IOCTL and stored in *`drm_connector.modes`*. To ensure that modes are filtered consistently put any encoder constraints and limits checks into **mode_valid**.

RETURNS:

0 on success, -EINVAL if the state or the transition can' t be supported, -ENOMEM on memory allocation failure and -EDEADLK if an attempt to obtain another state object ran into a *`drm_modeset_lock`* deadlock.

Description

These hooks are used by the legacy CRTC helpers, the transitional plane helpers and the new atomic modesetting helpers.

void **drm_encoder_helper_add**(struct *drm_encoder* *encoder, const struct *drm_encoder_helper_funcs* *funcs)

sets the helper vtable for an encoder

Parameters

struct drm_encoder *encoder
DRM encoder

const struct drm_encoder_helper_funcs *funcs
helper vtable to set for **encoder**

struct **drm_connector_helper_funcs**

helper operations for connectors

Definition

```
struct drm_connector_helper_funcs {
  int (*get_modes)(struct drm_connector *connector);
  int (*detect_ctx)(struct drm_connector *connector,struct drm_
↪modeset_acquire_ctx *ctx, bool force);
  enum drm_mode_status (*mode_valid)(struct drm_connector␣
↪*connector, struct drm_display_mode *mode);
  int (*mode_valid_ctx)(struct drm_connector *connector,struct drm_
↪display_mode *mode,struct drm_modeset_acquire_ctx *ctx, enum drm_
↪mode_status *status);
  struct drm_encoder *(*best_encoder)(struct drm_connector␣
↪*connector);
  struct drm_encoder *(*atomic_best_encoder)(struct drm_connector␣
↪*connector, struct drm_connector_state *connector_state);
  int (*atomic_check)(struct drm_connector *connector, struct drm_
↪atomic_state *state);
  void (*atomic_commit)(struct drm_connector *connector, struct drm_
↪connector_state *state);
  int (*prepare_writeback_job)(struct drm_writeback_connector␣
↪*connector, struct drm_writeback_job *job);
  void (*cleanup_writeback_job)(struct drm_writeback_connector␣
↪*connector, struct drm_writeback_job *job);
};
```

Members

get_modes
This function should fill in all modes currently valid for the sink into the *drm_connector.probed_modes* list. It should also update the EDID property by calling *drm_connector_update_edid_property()*.

The usual way to implement this is to cache the EDID retrieved in the probe callback somewhere in the driver-private connector structure. In this function drivers then parse the modes in the EDID and add them by calling *drm_add_edid_modes()*. But connectors that driver a fixed panel can also manually add specific modes using *drm_mode_probed_add()*. Drivers which manually add modes should also make sure that the *drm_connector.display_info*, *drm_connector.width_mm* and *drm_connector.height_mm* fields are filled in.

Virtual drivers that just want some standard VESA mode with a given resolution can call *drm_add_modes_noedid()*, and mark the preferred one using *drm_set_preferred_mode()*.

This function is only called after the **detect** hook has indicated that a sink is connected and when the EDID isn't overridden through sysfs or the kernel commandline.

This callback is used by the probe helpers in e.g. *drm_helper_probe_single_connector_modes()*.

To avoid races with concurrent connector state updates, the helper libraries always call this with the *drm_mode_config.connection_mutex* held. Because of this it's safe to inspect *drm_connector->state*.

RETURNS:

The number of modes added by calling *drm_mode_probed_add()*.

detect_ctx

Check to see if anything is attached to the connector. The parameter force is set to false whilst polling, true when checking the connector due to a user request. force can be used by the driver to avoid expensive, destructive operations during automated probing.

This callback is optional, if not implemented the connector will be considered as always being attached.

This is the atomic version of *drm_connector_funcs.detect*.

To avoid races against concurrent connector state updates, the helper libraries always call this with ctx set to a valid context, and *drm_mode_config.connection_mutex* will always be locked with the ctx parameter set to this ctx. This allows taking additional locks as required.

RETURNS:

drm_connector_status indicating the connector's status, or the error code returned by *drm_modeset_lock()*, -EDEADLK.

mode_valid

Callback to validate a mode for a connector, irrespective of the specific display configuration.

This callback is used by the probe helpers to filter the mode list (which is usually derived from the EDID data block from the sink). See e.g. *drm_helper_probe_single_connector_modes()*.

This function is optional.

NOTE:

This only filters the mode list supplied to userspace in the GETCONNECTOR IOCTL. Compared to *drm_encoder_helper_funcs.mode_valid*, *drm_crtc_helper_funcs.mode_valid* and *drm_bridge_funcs.*

mode_valid, which are also called by the atomic helpers from *drm_atomic_helper_check_modeset()*. This allows userspace to force and ignore sink constraint (like the pixel clock limits in the screen' s EDID), which is useful for e.g. testing, or working around a broken EDID. Any source hardware constraint (which always need to be enforced) therefore should be checked in one of the above callbacks, and not this one here.

To avoid races with concurrent connector state updates, the helper libraries always call this with the *drm_mode_config.connection_mutex* held. Because of this it' s safe to inspect *drm_connector->state*.

RETURNS:

Either *drm_mode_status.MODE_OK* or one of the failure reasons in *enum drm_mode_status*.

mode_valid_ctx

Callback to validate a mode for a connector, irrespective of the specific display configuration.

This callback is used by the probe helpers to filter the mode list (which is usually derived from the EDID data block from the sink). See e.g. *drm_helper_probe_single_connector_modes()*.

This function is optional, and is the atomic version of *drm_connector_helper_funcs.mode_valid*.

To allow for accessing the atomic state of modesetting objects, the helper libraries always call this with ctx set to a valid context, and *drm_mode_config.connection_mutex* will always be locked with the ctx parameter set to **ctx**. This allows for taking additional locks as required.

Even though additional locks may be acquired, this callback is still expected not to take any constraints into account which would be influenced by the currently set display state - such constraints should be handled in the driver' s atomic check. For example, if a connector shares display bandwidth with other connectors then it would be ok to validate the minimum bandwidth requirement of a mode against the maximum possible bandwidth of the connector. But it wouldn' t be ok to take the current bandwidth usage of other connectors into account, as this would change depending on the display state.

Returns: 0 if *drm_connector_helper_funcs.mode_valid_ctx* succeeded and wrote the *enum drm_mode_status* value to **status**, or a negative error code otherwise.

best_encoder

This function should select the best encoder for the given connector.

This function is used by both the atomic helpers (in the *drm_atomic_helper_check_modeset()* function) and in the legacy CRTC helpers.

NOTE:

In atomic drivers this function is called in the check phase of an atomic update. The driver is not allowed to change or inspect anything outside of arguments passed-in. Atomic drivers which need to inspect dynamic configuration state should instead use **atomic_best_encoder**.

You can leave this function to NULL if the connector is only attached to a single encoder. In this case, the core will call drm_connector_get_single_encoder() for you.

RETURNS:

Encoder that should be used for the given connector and connector state, or NULL if no suitable encoder exists. Note that the helpers will ensure that encoders aren't used twice, drivers should not check for this.

atomic_best_encoder

This is the atomic version of **best_encoder** for atomic drivers which need to select the best encoder depending upon the desired configuration and can't select it statically.

This function is used by *drm_atomic_helper_check_modeset()*. If it is not implemented, the core will fallback to **best_encoder** (or drm_connector_get_single_encoder() if **best_encoder** is NULL).

NOTE:

This function is called in the check phase of an atomic update. The driver is not allowed to change anything outside of the free-standing state objects passed-in or assembled in the overall *drm_atomic_state* update tracking structure.

RETURNS:

Encoder that should be used for the given connector and connector state, or NULL if no suitable encoder exists. Note that the helpers will ensure that encoders aren't used twice, drivers should not check for this.

atomic_check

This hook is used to validate connector state. This function is called from *drm_atomic_helper_check_modeset*, and is called when a connector property is set, or a modeset on the crtc is forced.

Because *drm_atomic_helper_check_modeset* may be called multiple times, this function should handle being called multiple times as well.

This function is also allowed to inspect any other object's state and can add more state objects to the atomic commit if needed. Care must be taken though to ensure that state check and compute functions for these added states are all called, and derived state in other objects all updated. Again the recommendation is to just call check helpers until a maximal configuration is reached.

NOTE:

This function is called in the check phase of an atomic update. The driver is not allowed to change anything outside of the free-standing state objects passed-in or assembled in the overall *drm_atomic_state* update tracking structure.

RETURNS:

0 on success, -EINVAL if the state or the transition can't be supported, -ENOMEM on memory allocation failure and -EDEADLK if an attempt to obtain another state object ran into a *drm_modeset_lock* deadlock.

atomic_commit
This hook is to be used by drivers implementing writeback connectors that need a point when to commit the writeback job to the hardware. The writeback_job to commit is available in *drm_connector_state.writeback_job*.

This hook is optional.

This callback is used by the atomic modeset helpers.

prepare_writeback_job
As writeback jobs contain a framebuffer, drivers may need to prepare and clean them up the same way they can prepare and clean up framebuffers for planes. This optional connector operation is used to support the preparation of writeback jobs. The job prepare operation is called from *drm_atomic_helper_prepare_planes()* for struct *drm_writeback_connector* connectors only.

This operation is optional.

This callback is used by the atomic modeset helpers.

cleanup_writeback_job
This optional connector operation is used to support the cleanup of writeback jobs. The job cleanup operation is called from the existing drm_writeback_cleanup_job() function, invoked both when destroying the job as part of an aborted commit, or when the job completes.

This operation is optional.

This callback is used by the atomic modeset helpers.

Description

These functions are used by the atomic and legacy modeset helpers and by the probe helpers.

void **drm_connector_helper_add**(struct *drm_connector* *connector, const struct *drm_connector_helper_funcs* *funcs)

sets the helper vtable for a connector

Parameters

struct drm_connector *connector
DRM connector

const struct drm_connector_helper_funcs *funcs
helper vtable to set for **connector**

struct **drm_plane_helper_funcs**

helper operations for planes

Definition

```
struct drm_plane_helper_funcs {
  int (*prepare_fb)(struct drm_plane *plane, struct drm_plane_state␣
↪*new_state);
  void (*cleanup_fb)(struct drm_plane *plane, struct drm_plane_
↪state *old_state);
```

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```
  int (*atomic_check)(struct drm_plane *plane, struct drm_plane_
↪state *state);
  void (*atomic_update)(struct drm_plane *plane, struct drm_plane_
↪state *old_state);
  void (*atomic_disable)(struct drm_plane *plane, struct drm_plane_
↪state *old_state);
  int (*atomic_async_check)(struct drm_plane *plane, struct drm_
↪plane_state *state);
  void (*atomic_async_update)(struct drm_plane *plane, struct drm_
↪plane_state *new_state);
};
```

Members

`prepare_fb`

This hook is to prepare a framebuffer for scanout by e.g. pinning its backing storage or relocating it into a contiguous block of VRAM. Other possible preparatory work includes flushing caches.

This function must not block for outstanding rendering, since it is called in the context of the atomic IOCTL even for async commits to be able to return any errors to userspace. Instead the recommended way is to fill out the *`drm_plane_state.fence`* of the passed-in *`drm_plane_state`*. If the driver doesn't support native fences then equivalent functionality should be implemented through private members in the plane structure.

Drivers which always have their buffers pinned should use *`drm_gem_fb_prepare_fb()`* for this hook.

The helpers will call **cleanup_fb** with matching arguments for every successful call to this hook.

This callback is used by the atomic modeset helpers and by the transitional plane helpers, but it is optional.

RETURNS:

0 on success or one of the following negative error codes allowed by the *`drm_mode_config_funcs.atomic_commit`* vfunc. When using helpers this callback is the only one which can fail an atomic commit, everything else must complete successfully.

`cleanup_fb`

This hook is called to clean up any resources allocated for the given framebuffer and plane configuration in **prepare_fb**.

This callback is used by the atomic modeset helpers and by the transitional plane helpers, but it is optional.

`atomic_check`

Drivers should check plane specific constraints in this hook.

When using *`drm_atomic_helper_check_planes()`* plane's **atomic_check** hooks are called before the ones for CRTCs, which allows drivers to request shared resources that the CRTC controls here. For more complicated dependencies the driver can call the provided check helpers multiple times until the computed state has a final configuration and everything has been checked.

This function is also allowed to inspect any other object’s state and can add more state objects to the atomic commit if needed. Care must be taken though to ensure that state check and compute functions for these added states are all called, and derived state in other objects all updated. Again the recommendation is to just call check helpers until a maximal configuration is reached.

This callback is used by the atomic modeset helpers and by the transitional plane helpers, but it is optional.

NOTE:

This function is called in the check phase of an atomic update. The driver is not allowed to change anything outside of the free-standing state objects passed-in or assembled in the overall *drm_atomic_state* update tracking structure.

RETURNS:

0 on success, -EINVAL if the state or the transition can’t be supported, -ENOMEM on memory allocation failure and -EDEADLK if an attempt to obtain another state object ran into a *drm_modeset_lock* deadlock.

atomic_update
Drivers should use this function to update the plane state. This hook is called in-between the *drm_crtc_helper_funcs.atomic_begin* and drm_crtc_helper_funcs.atomic_flush callbacks.

Note that the power state of the display pipe when this function is called depends upon the exact helpers and calling sequence the driver has picked. See *drm_atomic_helper_commit_planes()* for a discussion of the tradeoffs and variants of plane commit helpers.

This callback is used by the atomic modeset helpers and by the transitional plane helpers, but it is optional.

atomic_disable
Drivers should use this function to unconditionally disable a plane. This hook is called in-between the *drm_crtc_helper_funcs.atomic_begin* and drm_crtc_helper_funcs.atomic_flush callbacks. It is an alternative to **atomic_update**, which will be called for disabling planes, too, if the **atomic_disable** hook isn’t implemented.

This hook is also useful to disable planes in preparation of a modeset, by calling *drm_atomic_helper_disable_planes_on_crtc()* from the *drm_crtc_helper_funcs.disable* hook.

Note that the power state of the display pipe when this function is called depends upon the exact helpers and calling sequence the driver has picked. See *drm_atomic_helper_commit_planes()* for a discussion of the tradeoffs and variants of plane commit helpers.

This callback is used by the atomic modeset helpers and by the transitional plane helpers, but it is optional.

atomic_async_check
Drivers should set this function pointer to check if the plane state can be updated in a async fashion. Here async means "not vblank synchronized".

This hook is called by drm_atomic_async_check() to establish if a given update can be committed asynchronously, that is, if it can jump ahead of the state currently queued for update.

RETURNS:

Return 0 on success and any error returned indicates that the update can not be applied in asynchronous manner.

atomic_async_update
Drivers should set this function pointer to perform asynchronous updates of planes, that is, jump ahead of the currently queued state and update the plane. Here async means "not vblank synchronized".

This hook is called by *drm_atomic_helper_async_commit()*.

An async update will happen on legacy cursor updates. An async update won't happen if there is an outstanding commit modifying the same plane.

Note that unlike *drm_plane_helper_funcs.atomic_update* this hook takes the new *drm_plane_state* as parameter. When doing async_update drivers shouldn't replace the *drm_plane_state* but update the current one with the new plane configurations in the new plane_state.

Drivers should also swap the framebuffers between current plane state (*drm_plane.state*) and new_state. This is required since cleanup for async commits is performed on the new state, rather than old state like for traditional commits. Since we want to give up the reference on the current (old) fb instead of our brand new one, swap them in the driver during the async commit.

FIXME:

- It only works for single plane updates
- Async Pageflips are not supported yet
- Some hw might still scan out the old buffer until the next vblank, however we let go of the fb references as soon as we run this hook. For now drivers must implement their own workers for deferring if needed, until a common solution is created.

Description

These functions are used by the atomic helpers and by the transitional plane helpers.

void **drm_plane_helper_add**(struct *drm_plane* *plane, const struct *drm_plane_helper_funcs* *funcs)

sets the helper vtable for a plane

Parameters

struct drm_plane *plane
DRM plane

const struct drm_plane_helper_funcs *funcs
helper vtable to set for **plane**

struct **drm_mode_config_helper_funcs**
global modeset helper operations

Definition

```
struct drm_mode_config_helper_funcs {
  void (*atomic_commit_tail)(struct drm_atomic_state *state);
};
```

Members

atomic_commit_tail
This hook is used by the default atomic_commit() hook implemented in *drm_atomic_helper_commit()* together with the nonblocking commit helpers (see *drm_atomic_helper_setup_commit()* for a starting point) to implement blocking and nonblocking commits easily. It is not used by the atomic helpers

This function is called when the new atomic state has already been swapped into the various state pointers. The passed in state therefore contains copies of the old/previous state. This hook should commit the new state into hardware. Note that the helpers have already waited for preceeding atomic commits and fences, but drivers can add more waiting calls at the start of their implementation, e.g. to wait for driver-internal request for implicit syncing, before starting to commit the update to the hardware.

After the atomic update is committed to the hardware this hook needs to call *drm_atomic_helper_commit_hw_done()*. Then wait for the upate to be executed by the hardware, for example using *drm_atomic_helper_wait_for_vblanks()* or *drm_atomic_helper_wait_for_flip_done()*, and then clean up the old framebuffers using *drm_atomic_helper_cleanup_planes()*.

When disabling a CRTC this hook _must_ stall for the commit to complete. Vblank waits don't work on disabled CRTC, hence the core can't take care of this. And it also can't rely on the vblank event, since that can be signalled already when the screen shows black, which can happen much earlier than the last hardware access needed to shut off the display pipeline completely.

This hook is optional, the default implementation is *drm_atomic_helper_commit_tail()*.

Description

These helper functions are used by the atomic helpers.

5.2 Atomic Modeset Helper Functions Reference

5.2.1 Overview

This helper library provides implementations of check and commit functions on top of the CRTC modeset helper callbacks and the plane helper callbacks. It also provides convenience implementations for the atomic state handling callbacks for drivers which don' t need to subclass the drm core structures to add their own additional internal state.

This library also provides default implementations for the check callback in *drm_atomic_helper_check()* and for the commit callback with *drm_atomic_helper_commit()*. But the individual stages and callbacks are exposed to allow drivers to mix and match and e.g. use the plane helpers only together with a driver private modeset implementation.

This library also provides implementations for all the legacy driver interfaces on top of the atomic interface. See *drm_atomic_helper_set_config()*, *drm_atomic_helper_disable_plane()*, *drm_atomic_helper_disable_plane()* and the various functions to implement set_property callbacks. New drivers must not implement these functions themselves but must use the provided helpers.

The atomic helper uses the same function table structures as all other modesetting helpers. See the documentation for *struct drm_crtc_helper_funcs*, struct *drm_encoder_helper_funcs* and *struct drm_connector_helper_funcs*. It also shares the *struct drm_plane_helper_funcs* function table with the plane helpers.

5.2.2 Implementing Asynchronous Atomic Commit

Nonblocking atomic commits should use struct *drm_crtc_commit* to sequence different operations against each another. Locks, especially struct *drm_modeset_lock*, should not be held in worker threads or any other asynchronous context used to commit the hardware state.

drm_atomic_helper_commit() implements the recommended sequence for nonblocking commits, using *drm_atomic_helper_setup_commit()* internally:

1. Run *drm_atomic_helper_prepare_planes()*. Since this can fail and we need to propagate out of memory/VRAM errors to userspace, it must be called synchronously.

2. Synchronize with any outstanding nonblocking commit worker threads which might be affected by the new state update. This is handled by *drm_atomic_helper_setup_commit()*.

Asynchronous workers need to have sufficient parallelism to be able to run different atomic commits on different CRTCs in parallel. The simplest way to achieve this is by running them on the `system_unbound_wq` work queue. Note that drivers are not required to split up atomic commits and run an individual commit in parallel - userspace is supposed to do that if it cares. But it might be beneficial to do that for modesets, since those necessarily must be done as one global operation, and enabling or disabling a CRTC can take a long time. But even that is not required.

IMPORTANT: A *drm_atomic_state* update for multiple CRTCs is sequenced against all CRTCs therein. Therefore for atomic state updates which only flip planes the driver must not get the struct *drm_crtc_state* of unrelated CRTCs in its atomic check code: This would prevent committing of atomic updates to multiple CRTCs in parallel. In general, adding additional state structures should be avoided as much as possible, because this reduces parallelism in (nonblocking) commits, both due to locking and due to commit sequencing requirements.

3. The software state is updated synchronously with *drm_atomic_helper_swap_state()*. Doing this under the protection of all modeset locks means concurrent callers never see inconsistent state. Note that commit workers do not hold any locks; their access is only coordinated through ordering. If workers would access state only through the pointers in the free-standing state objects (currently not the case for any driver) then even multiple pending commits could be in-flight at the same time.

4. Schedule a work item to do all subsequent steps, using the split-out commit helpers: a) pre-plane commit b) plane commit c) post-plane commit and then cleaning up the framebuffers after the old framebuffer is no longer being displayed. The scheduled work should synchronize against other workers using the *drm_crtc_commit* infrastructure as needed. See *drm_atomic_helper_setup_commit()* for more details.

5.2.3 Helper Functions Reference

`drm_atomic_crtc_for_each_plane`

`drm_atomic_crtc_for_each_plane (plane, crtc)`

iterate over planes currently attached to CRTC

Parameters

`plane`
the loop cursor

`crtc`
the CRTC whose planes are iterated

Description

This iterates over the current state, useful (for example) when applying atomic state after it has been checked and swapped. To iterate over the planes which *will* be attached (more useful in code called from *drm_mode_config_funcs.atomic_check*) see *drm_atomic_crtc_state_for_each_plane()*.

`drm_atomic_crtc_state_for_each_plane`

`drm_atomic_crtc_state_for_each_plane (plane, crtc_state)`

iterate over attached planes in new state

Parameters

`plane`
the loop cursor

crtc_state
the incoming CRTC state

Description

Similar to drm_crtc_for_each_plane(), but iterates the planes that will be attached if the specified state is applied. Useful during for example in code called from *drm_mode_config_funcs.atomic_check* operations, to validate the incoming state.

drm_atomic_crtc_state_for_each_plane_state

`drm_atomic_crtc_state_for_each_plane_state (plane, plane_state, crtc_state)`

iterate over attached planes in new state

Parameters

plane
the loop cursor

plane_state
loop cursor for the plane's state, must be const

crtc_state
the incoming CRTC state

Description

Similar to drm_crtc_for_each_plane(), but iterates the planes that will be attached if the specified state is applied. Useful during for example in code called from *drm_mode_config_funcs.atomic_check* operations, to validate the incoming state.

Compared to just *drm_atomic_crtc_state_for_each_plane()* this also fills in a const plane_state. This is useful when a driver just wants to peek at other active planes on this CRTC, but does not need to change it.

bool **drm_atomic_plane_disabling**(struct *drm_plane_state* *old_plane_state, struct *drm_plane_state* *new_plane_state)

check whether a plane is being disabled

Parameters

struct drm_plane_state *old_plane_state
old atomic plane state

struct drm_plane_state *new_plane_state
new atomic plane state

Description

Checks the atomic state of a plane to determine whether it's being disabled or not. This also WARNs if it detects an invalid state (both CRTC and FB need to either both be NULL or both be non-NULL).

Return

True if the plane is being disabled, false otherwise.

int **drm_atomic_helper_check_modeset**(struct *drm_device* *dev, struct *drm_atomic_state* *state)

validate state object for modeset changes

Parameters

struct drm_device *dev
DRM device

struct drm_atomic_state *state
the driver state object

Description

Check the state object to see if the requested state is physically possible. This does all the CRTC and connector related computations for an atomic update and adds any additional connectors needed for full modesets. It calls the various per-object callbacks in the follow order:

1. *drm_connector_helper_funcs.atomic_best_encoder* for determining the new encoder.
2. *drm_connector_helper_funcs.atomic_check* to validate the connector state.
3. If it' s determined a modeset is needed then all connectors on the affected CRTC are added and *drm_connector_helper_funcs.atomic_check* is run on them.
4. *drm_encoder_helper_funcs.mode_valid*, *drm_bridge_funcs.mode_valid* and *drm_crtc_helper_funcs.mode_valid* are called on the affected components.
5. *drm_bridge_funcs.mode_fixup* is called on all encoder bridges.
6. *drm_encoder_helper_funcs.atomic_check* is called to validate any encoder state. This function is only called when the encoder will be part of a configured CRTC, it must not be used for implementing connector property validation. If this function is NULL, `drm_atomic_encoder_helper_funcs.mode_fixup` is called instead.
7. *drm_crtc_helper_funcs.mode_fixup* is called last, to fix up the mode with CRTC constraints.

drm_crtc_state.mode_changed is set when the input mode is changed. *drm_crtc_state.connectors_changed* is set when a connector is added or removed from the CRTC. *drm_crtc_state.active_changed* is set when *drm_crtc_state.active* changes, which is used for DPMS. *drm_crtc_state.no_vblank* is set from the result of *drm_dev_has_vblank()*. See also: *drm_atomic_crtc_needs_modeset()*

IMPORTANT:

Drivers which set *drm_crtc_state.mode_changed* (e.g. in their *drm_plane_helper_funcs.atomic_check* hooks if a plane update can' t be done without a full modeset) _must_ call this function afterwards after that change. It is permitted to call this function multiple times for the same update, e.g. when the *drm_crtc_helper_funcs.atomic_check* functions depend upon the adjusted dotclock for fifo space allocation and watermark computation.

Return

Zero for success or -errno

int **drm_atomic_helper_check_plane_state**(struct *drm_plane_state* *plane_state, const struct *drm_crtc_state* *crtc_state, int min_scale, int max_scale, bool can_position, bool can_update_disabled)

Check plane state for validity

Parameters

struct drm_plane_state *plane_state
plane state to check

const struct drm_crtc_state *crtc_state
CRTC state to check

int min_scale
minimum **src**:**dest** scaling factor in 16.16 fixed point

int max_scale
maximum **src**:**dest** scaling factor in 16.16 fixed point

bool can_position
is it legal to position the plane such that it doesn't cover the entire CRTC? This will generally only be false for primary planes.

bool can_update_disabled
can the plane be updated while the CRTC is disabled?

Description

Checks that a desired plane update is valid, and updates various bits of derived state (clipped coordinates etc.). Drivers that provide their own plane handling rather than helper-provided implementations may still wish to call this function to avoid duplication of error checking code.

Return

Zero if update appears valid, error code on failure

int **drm_atomic_helper_check_planes**(struct *drm_device* *dev, struct *drm_atomic_state* *state)

validate state object for planes changes

Parameters

struct drm_device *dev
DRM device

struct drm_atomic_state *state
the driver state object

Description

Check the state object to see if the requested state is physically possible. This does all the plane update related checks using by calling into the *drm_crtc_helper_funcs.atomic_check* and *drm_plane_helper_funcs.atomic_check* hooks provided by the driver.

It also sets *drm_crtc_state.planes_changed* to indicate that a CRTC has updated planes.

Return

Zero for success or -errno

int **drm_atomic_helper_check**(struct *drm_device* *dev, struct *drm_atomic_state* *state)

validate state object

Parameters

struct drm_device *dev
DRM device

struct drm_atomic_state *state
the driver state object

Description

Check the state object to see if the requested state is physically possible. Only CRTCs and planes have check callbacks, so for any additional (global) checking that a driver needs it can simply wrap that around this function. Drivers without such needs can directly use this as their *drm_mode_config_funcs.atomic_check* callback.

This just wraps the two parts of the state checking for planes and modeset state in the default order: First it calls *drm_atomic_helper_check_modeset()* and then *drm_atomic_helper_check_planes()*. The assumption is that the **drm_plane_helper_funcs.atomic_check** and **drm_crtc_helper_funcs.atomic_check** functions depend upon an updated adjusted_mode.clock to e.g. properly compute watermarks.

Note that zpos normalization will add all enable planes to the state which might not desired for some drivers. For example enable/disable of a cursor plane which have fixed zpos value would trigger all other enabled planes to be forced to the state change.

Return

Zero for success or -errno

void **drm_atomic_helper_update_legacy_modeset_state**(struct *drm_device* *dev, struct *drm_atomic_state* *old_state)

update legacy modeset state

Parameters

struct drm_device *dev
DRM device

struct drm_atomic_state *old_state
atomic state object with old state structures

Description

This function updates all the various legacy modeset state pointers in connectors, encoders and CRTCs.

Drivers can use this for building their own atomic commit if they don't have a pure helper-based modeset implementation.

Since these updates are not synchronized with lockings, only code paths called from *drm_mode_config_helper_funcs.atomic_commit_tail* can look at the legacy state filled out by this helper. Defacto this means this helper and the legacy state pointers are only really useful for transitioning an existing driver to the atomic world.

void **drm_atomic_helper_calc_timestamping_constants**(struct *drm_atomic_state* *state)

update vblank timestamping constants

Parameters

struct drm_atomic_state *state
atomic state object

Description

Updates the timestamping constants used for precise vblank timestamps by calling *drm_calc_timestamping_constants()* for all enabled crtcs in **state**.

void **drm_atomic_helper_commit_modeset_disables**(struct *drm_device* *dev, struct *drm_atomic_state* *old_state)

modeset commit to disable outputs

Parameters

struct drm_device *dev
DRM device

struct drm_atomic_state *old_state
atomic state object with old state structures

Description

This function shuts down all the outputs that need to be shut down and prepares them (if required) with the new mode.

For compatibility with legacy CRTC helpers this should be called before *drm_atomic_helper_commit_planes()*, which is what the default commit function does. But drivers with different needs can group the modeset commits together and do the plane commits at the end. This is useful for drivers doing runtime PM since planes updates then only happen when the CRTC is actually enabled.

void **drm_atomic_helper_commit_modeset_enables**(struct *drm_device* *dev, struct *drm_atomic_state* *old_state)

modeset commit to enable outputs

Parameters

struct drm_device *dev
DRM device

struct drm_atomic_state *old_state
atomic state object with old state structures

Description

This function enables all the outputs with the new configuration which had to be turned off for the update.

For compatibility with legacy CRTC helpers this should be called after *drm_atomic_helper_commit_planes()*, which is what the default commit function does. But drivers with different needs can group the modeset commits together and do the plane commits at the end. This is useful for drivers doing runtime PM since planes updates then only happen when the CRTC is actually enabled.

int **drm_atomic_helper_wait_for_fences**(struct *drm_device* *dev, struct *drm_atomic_state* *state, bool pre_swap)

wait for fences stashed in plane state

Parameters

struct drm_device *dev
DRM device

struct drm_atomic_state *state
atomic state object with old state structures

bool pre_swap
If true, do an interruptible wait, and **state** is the new state. Otherwise **state** is the old state.

Description

For implicit sync, driver should fish the exclusive fence out from the incoming fb' s and stash it in the drm_plane_state. This is called after *drm_atomic_helper_swap_state()* so it uses the current plane state (and just uses the atomic state to find the changed planes)

Note that **pre_swap** is needed since the point where we block for fences moves around depending upon whether an atomic commit is blocking or non-blocking. For non-blocking commit all waiting needs to happen after *drm_atomic_helper_swap_state()* is called, but for blocking commits we want to wait **before** we do anything that can' t be easily rolled back. That is before we call *drm_atomic_helper_swap_state()*.

Returns zero if success or < 0 if dma_fence_wait() fails.

void **drm_atomic_helper_wait_for_vblanks**(struct *drm_device* *dev, struct *drm_atomic_state* *old_state)

wait for vblank on CRTCs

Parameters

struct drm_device *dev
DRM device

struct drm_atomic_state *old_state
atomic state object with old state structures

Description

Helper to, after atomic commit, wait for vblanks on all affected CRTCs (ie. before cleaning up old framebuffers using *drm_atomic_helper_cleanup_planes()*). It will only wait on CRTCs where the framebuffers have actually changed to optimize for the legacy cursor and plane update use-case.

Drivers using the nonblocking commit tracking support initialized by calling *drm_atomic_helper_setup_commit()* should look at *drm_atomic_helper_wait_for_flip_done()* as an alternative.

void **drm_atomic_helper_wait_for_flip_done**(struct *drm_device* *dev, struct *drm_atomic_state* *old_state)

wait for all page flips to be done

Parameters

struct drm_device *dev
DRM device

struct drm_atomic_state *old_state
atomic state object with old state structures

Description

Helper to, after atomic commit, wait for page flips on all affected crtcs (ie. before cleaning up old framebuffers using *drm_atomic_helper_cleanup_planes()*). Compared to *drm_atomic_helper_wait_for_vblanks()* this waits for the completion on all CRTCs, assuming that cursors-only updates are signalling their completion immediately (or using a different path).

This requires that drivers use the nonblocking commit tracking support initialized using *drm_atomic_helper_setup_commit()*.

void **drm_atomic_helper_commit_tail**(struct *drm_atomic_state* *old_state)

commit atomic update to hardware

Parameters

struct drm_atomic_state *old_state
atomic state object with old state structures

Description

This is the default implementation for the *drm_mode_config_helper_funcs.atomic_commit_tail* hook, for drivers that do not support runtime_pm or do not need the CRTC to be enabled to perform a commit. Otherwise, see *drm_atomic_helper_commit_tail_rpm()*.

Note that the default ordering of how the various stages are called is to match the legacy modeset helper library closest.

void **drm_atomic_helper_commit_tail_rpm**(struct *drm_atomic_state* *old_state)

commit atomic update to hardware

Parameters

struct drm_atomic_state *old_state
new modeset state to be committed

Description

This is an alternative implementation for the *drm_mode_config_helper_funcs.atomic_commit_tail* hook, for drivers that support runtime_pm or need the CRTC to be enabled to perform a commit. Otherwise, one should use the default implementation *drm_atomic_helper_commit_tail()*.

int **drm_atomic_helper_async_check**(struct *drm_device* *dev, struct *drm_atomic_state* *state)

check if state can be commited asynchronously

Parameters

struct drm_device *dev
DRM device

struct drm_atomic_state *state
the driver state object

Description

This helper will check if it is possible to commit the state asynchronously. Async commits are not supposed to swap the states like normal sync commits but just do in-place changes on the current state.

It will return 0 if the commit can happen in an asynchronous fashion or error if not. Note that error just mean it can't be commited asynchronously, if it fails the commit should be treated like a normal synchronous commit.

void **drm_atomic_helper_async_commit**(struct *drm_device* *dev, struct *drm_atomic_state* *state)

commit state asynchronously

Parameters

struct drm_device *dev
DRM device

struct drm_atomic_state *state
the driver state object

Description

This function commits a state asynchronously, i.e., not vblank synchronized. It should be used on a state only when drm_atomic_async_check() succeeds. Async commits are not supposed to swap the states like normal sync commits, but just do in-place changes on the current state.

TODO: Implement full swap instead of doing in-place changes.

int **drm_atomic_helper_commit**(struct *drm_device* *dev, struct *drm_atomic_state* *state, bool nonblock)

commit validated state object

Parameters

struct drm_device *dev
DRM device

struct drm_atomic_state *state
the driver state object

bool nonblock
whether nonblocking behavior is requested.

Description

This function commits a with *drm_atomic_helper_check()* pre-validated state object. This can still fail when e.g. the framebuffer reservation fails. This function implements nonblocking commits, using *drm_atomic_helper_setup_commit()* and related functions.

Committing the actual hardware state is done through the *drm_mode_config_helper_funcs.atomic_commit_tail* callback, or its default implementation *drm_atomic_helper_commit_tail()*.

Return

Zero for success or -errno.

int **drm_atomic_helper_setup_commit**(struct *drm_atomic_state* *state, bool nonblock)

setup possibly nonblocking commit

Parameters

struct drm_atomic_state *state
new modeset state to be committed

bool nonblock
whether nonblocking behavior is requested.

Description

This function prepares **state** to be used by the atomic helper's support for nonblocking commits. Drivers using the nonblocking commit infrastructure should always call this function from their *drm_mode_config_funcs.atomic_commit* hook.

To be able to use this support drivers need to use a few more helper functions. *drm_atomic_helper_wait_for_dependencies()* must be called before actually committing the hardware state, and for nonblocking commits this call must be placed in the async worker. See also *drm_atomic_helper_swap_state()* and its stall parameter, for when a driver's commit hooks look at the *drm_crtc.state*, *drm_plane.state* or *drm_connector.state* pointer directly.

Completion of the hardware commit step must be signalled using *drm_atomic_helper_commit_hw_done()*. After this step the driver is not allowed to read or change any permanent software or hardware modeset state. The only exception is state protected by other means than *drm_modeset_lock* locks. Only the free standing **state** with pointers to the old state structures can be inspected, e.g. to clean up old buffers using *drm_atomic_helper_cleanup_planes()*.

At the very end, before cleaning up **state** drivers must call *drm_atomic_helper_commit_cleanup_done()*.

This is all implemented by in *drm_atomic_helper_commit()*, giving drivers a complete and easy-to-use default implementation of the atomic_commit() hook.

The tracking of asynchronously executed and still pending commits is done using the core structure *drm_crtc_commit*.

By default there' s no need to clean up resources allocated by this function explicitly: *drm_atomic_state_default_clear()* will take care of that automatically.

0 on success. -EBUSY when userspace schedules nonblocking commits too fast, -ENOMEM on allocation failures and -EINTR when a signal is pending.

Return

void **drm_atomic_helper_wait_for_dependencies**(struct *drm_atomic_state* *old_state)

wait for required preceeding commits

Parameters

struct drm_atomic_state *old_state
atomic state object with old state structures

Description

This function waits for all preceeding commits that touch the same CRTC as **old_state** to both be committed to the hardware (as signalled by *drm_atomic_helper_commit_hw_done()*) and executed by the hardware (as signalled by calling *drm_crtc_send_vblank_event()* on the *drm_crtc_state.event*).

This is part of the atomic helper support for nonblocking commits, see *drm_atomic_helper_setup_commit()* for an overview.

void **drm_atomic_helper_fake_vblank**(struct *drm_atomic_state* *old_state)

fake VBLANK events if needed

Parameters

struct drm_atomic_state *old_state
atomic state object with old state structures

Description

This function walks all CRTCs and fakes VBLANK events on those with *drm_crtc_state.no_vblank* set to true and *drm_crtc_state.event* != NULL. The primary use of this function is writeback connectors working in oneshot mode and faking VBLANK events. In this case they only fake the VBLANK event when a job is queued, and any change to the pipeline that does not touch the connector is leading to timeouts when calling *drm_atomic_helper_wait_for_vblanks()* or *drm_atomic_helper_wait_for_flip_done()*. In addition to writeback connectors, this function can also fake VBLANK events for CRTCs without VBLANK interrupt.

This is part of the atomic helper support for nonblocking commits, see *drm_atomic_helper_setup_commit()* for an overview.

void **drm_atomic_helper_commit_hw_done**(struct *drm_atomic_state* *old_state)

setup possible nonblocking commit

Parameters

struct drm_atomic_state *old_state
atomic state object with old state structures

Description

This function is used to signal completion of the hardware commit step. After this step the driver is not allowed to read or change any permanent software or hardware modeset state. The only exception is state protected by other means than *drm_modeset_lock* locks.

Drivers should try to postpone any expensive or delayed cleanup work after this function is called.

This is part of the atomic helper support for nonblocking commits, see *drm_atomic_helper_setup_commit()* for an overview.

void **drm_atomic_helper_commit_cleanup_done**(struct *drm_atomic_state* *old_state)

signal completion of commit

Parameters

struct drm_atomic_state *old_state
atomic state object with old state structures

Description

This signals completion of the atomic update **old_state**, including any cleanup work. If used, it must be called right before calling *drm_atomic_state_put()*.

This is part of the atomic helper support for nonblocking commits, see *drm_atomic_helper_setup_commit()* for an overview.

int **drm_atomic_helper_prepare_planes**(struct *drm_device* *dev, struct *drm_atomic_state* *state)

prepare plane resources before commit

Parameters

struct drm_device *dev
DRM device

struct drm_atomic_state *state
atomic state object with new state structures

Description

This function prepares plane state, specifically framebuffers, for the new configuration, by calling *drm_plane_helper_funcs.prepare_fb*. If any failure is encountered this function will call *drm_plane_helper_funcs.cleanup_fb* on any already successfully prepared framebuffer.

Return

0 on success, negative error code on failure.

void **drm_atomic_helper_commit_planes**(struct *drm_device* *dev, struct *drm_atomic_state* *old_state, uint32_t flags)

commit plane state

Parameters

struct drm_device *dev
DRM device

struct drm_atomic_state *old_state
atomic state object with old state structures

uint32_t flags
flags for committing plane state

Description

This function commits the new plane state using the plane and atomic helper functions for planes and CRTCs. It assumes that the atomic state has already been pushed into the relevant object state pointers, since this step can no longer fail.

It still requires the global state object **old_state** to know which planes and crtcs need to be updated though.

Note that this function does all plane updates across all CRTCs in one step. If the hardware can't support this approach look at *drm_atomic_helper_commit_planes_on_crtc()* instead.

Plane parameters can be updated by applications while the associated CRTC is disabled. The DRM/KMS core will store the parameters in the plane state, which will be available to the driver when the CRTC is turned on. As a result most drivers don't need to be immediately notified of plane updates for a disabled CRTC.

Unless otherwise needed, drivers are advised to set the ACTIVE_ONLY flag in **flags** in order not to receive plane update notifications related to a disabled CRTC. This avoids the need to manually ignore plane updates in driver code when the driver and/or hardware can't or just don't need to deal with updates on disabled CRTCs, for example when supporting runtime PM.

Drivers may set the NO_DISABLE_AFTER_MODESET flag in **flags** if the relevant display controllers require to disable a CRTC's planes when the CRTC is disabled. This function would skip the *drm_plane_helper_funcs.atomic_disable* call for a plane if the CRTC of the old plane state needs a modesetting operation. Of course, the drivers need to disable the planes in their CRTC disable callbacks since no one else would do that.

The *drm_atomic_helper_commit()* default implementation doesn't set the ACTIVE_ONLY flag to most closely match the behaviour of the legacy helpers. This should not be copied blindly by drivers.

void **drm_atomic_helper_commit_planes_on_crtc**(struct *drm_crtc_state* *old_crtc_state)

commit plane state for a CRTC

Parameters

`struct drm_crtc_state *old_crtc_state`
atomic state object with the old CRTC state

Description

This function commits the new plane state using the plane and atomic helper functions for planes on the specific CRTC. It assumes that the atomic state has already been pushed into the relevant object state pointers, since this step can no longer fail.

This function is useful when plane updates should be done CRTC-by-CRTC instead of one global step like *`drm_atomic_helper_commit_planes()`* does.

This function can only be savely used when planes are not allowed to move between different CRTCs because this function doesn't handle inter-CRTC depencies. Callers need to ensure that either no such depencies exist, resolve them through ordering of commit calls or through some other means.

void **`drm_atomic_helper_disable_planes_on_crtc`**(struct *drm_crtc_state* *old_crtc_state, bool atomic)

helper to disable CRTC's planes

Parameters

`struct drm_crtc_state *old_crtc_state`
atomic state object with the old CRTC state

`bool atomic`
if set, synchronize with CRTC's atomic_begin/flush hooks

Description

Disables all planes associated with the given CRTC. This can be used for instance in the CRTC helper atomic_disable callback to disable all planes.

If the atomic-parameter is set the function calls the CRTC's atomic_begin hook before and atomic_flush hook after disabling the planes.

It is a bug to call this function without having implemented the *`drm_plane_helper_funcs.atomic_disable`* plane hook.

void **`drm_atomic_helper_cleanup_planes`**(struct *drm_device* *dev, struct *drm_atomic_state* *old_state)

cleanup plane resources after commit

Parameters

`struct drm_device *dev`
DRM device

`struct drm_atomic_state *old_state`
atomic state object with old state structures

Description

This function cleans up plane state, specifically framebuffers, from the old configuration. Hence the old configuration must be perserved in **old_state** to be able to call this function.

This function must also be called on the new state when the atomic update fails at any point after calling *drm_atomic_helper_prepare_planes()*.

int **drm_atomic_helper_swap_state**(struct *drm_atomic_state* *state, bool stall)

store atomic state into current sw state

Parameters

struct drm_atomic_state *state
atomic state

bool stall
stall for preceeding commits

Description

This function stores the atomic state into the current state pointers in all driver objects. It should be called after all failing steps have been done and succeeded, but before the actual hardware state is committed.

For cleanup and error recovery the current state for all changed objects will be swapped into **state**.

With that sequence it fits perfectly into the plane prepare/cleanup sequence:

1. Call *drm_atomic_helper_prepare_planes()* with the staged atomic state.
2. Do any other steps that might fail.
3. Put the staged state into the current state pointers with this function.
4. Actually commit the hardware state.

5. Call *drm_atomic_helper_cleanup_planes()* with **state**, which since step 3 contains the old state. Also do any other cleanup required with that state.

stall must be set when nonblocking commits for this driver directly access the *drm_plane.state*, *drm_crtc.state* or *drm_connector.state* pointer. With the current atomic helpers this is almost always the case, since the helpers don' t pass the right state structures to the callbacks.

Returns 0 on success. Can return -ERESTARTSYS when **stall** is true and the waiting for the previous commits has been interrupted.

Return

int **drm_atomic_helper_update_plane**(struct *drm_plane* *plane, struct *drm_crtc* *crtc, struct *drm_framebuffer* *fb, int crtc_x, int crtc_y, unsigned int crtc_w, unsigned int crtc_h, uint32_t src_x, uint32_t src_y, uint32_t src_w, uint32_t src_h, struct *drm_modeset_acquire_ctx* *ctx)

Helper for primary plane update using atomic

Parameters

`struct drm_plane *plane`
plane object to update

`struct drm_crtc *crtc`
owning CRTC of owning plane

`struct drm_framebuffer *fb`
framebuffer to flip onto plane

`int crtc_x`
x offset of primary plane on **crtc**

`int crtc_y`
y offset of primary plane on **crtc**

`unsigned int crtc_w`
width of primary plane rectangle on **crtc**

`unsigned int crtc_h`
height of primary plane rectangle on **crtc**

`uint32_t src_x`
x offset of **fb** for panning

`uint32_t src_y`
y offset of **fb** for panning

`uint32_t src_w`
width of source rectangle in **fb**

`uint32_t src_h`
height of source rectangle in **fb**

`struct drm_modeset_acquire_ctx *ctx`
lock acquire context

Description

Provides a default plane update handler using the atomic driver interface.

Return

Zero on success, error code on failure

int **`drm_atomic_helper_disable_plane`**(struct *drm_plane* *plane, struct *drm_modeset_acquire_ctx* *ctx)

Helper for primary plane disable using * atomic

Parameters

`struct drm_plane *plane`
plane to disable

`struct drm_modeset_acquire_ctx *ctx`
lock acquire context

Description

Provides a default plane disable handler using the atomic driver interface.

Return

Zero on success, error code on failure

int **drm_atomic_helper_set_config**(struct *drm_mode_set* *set, struct *drm_modeset_acquire_ctx* *ctx)

set a new config from userspace

Parameters

struct drm_mode_set *set
mode set configuration

struct drm_modeset_acquire_ctx *ctx
lock acquisition context

Description

Provides a default CRTC set_config handler using the atomic driver interface.

NOTE

For backwards compatibility with old userspace this automatically resets the "link-status"property to GOOD, to force any link re-training. The SETCRTC ioctl does not define whether an update does need a full modeset or just a plane update, hence we're allowed to do that. See also *drm_connector_set_link_status_property()*.

Return

Returns 0 on success, negative errno numbers on failure.

int **drm_atomic_helper_disable_all**(struct *drm_device* *dev, struct *drm_modeset_acquire_ctx* *ctx)

disable all currently active outputs

Parameters

struct drm_device *dev
DRM device

struct drm_modeset_acquire_ctx *ctx
lock acquisition context

Description

Loops through all connectors, finding those that aren't turned off and then turns them off by setting their DPMS mode to OFF and deactivating the CRTC that they are connected to.

This is used for example in suspend/resume to disable all currently active functions when suspending. If you just want to shut down everything at e.g. driver unload, look at *drm_atomic_helper_shutdown()*.

Note that if callers haven't already acquired all modeset locks this might return -EDEADLK, which must be handled by calling *drm_modeset_backoff()*.

See also: *drm_atomic_helper_suspend()*, *drm_atomic_helper_resume()* and *drm_atomic_helper_shutdown()*.

Return

0 on success or a negative error code on failure.

void **drm_atomic_helper_shutdown**(struct *drm_device* *dev)

shutdown all CRTC

Parameters

struct drm_device *dev
DRM device

Description

This shuts down all CRTC, which is useful for driver unloading. Shutdown on suspend should instead be handled with *drm_atomic_helper_suspend()*, since that also takes a snapshot of the modeset state to be restored on resume.

This is just a convenience wrapper around *drm_atomic_helper_disable_all()*, and it is the atomic version of drm_crtc_force_disable_all().

struct *drm_atomic_state* ***drm_atomic_helper_duplicate_state**(struct *drm_device* *dev, struct *drm_modeset_acquire_ctx* *ctx)

duplicate an atomic state object

Parameters

struct drm_device *dev
DRM device

struct drm_modeset_acquire_ctx *ctx
lock acquisition context

Description

Makes a copy of the current atomic state by looping over all objects and duplicating their respective states. This is used for example by suspend/ resume support code to save the state prior to suspend such that it can be restored upon resume.

Note that this treats atomic state as persistent between save and restore. Drivers must make sure that this is possible and won't result in confusion or erroneous behaviour.

Note that if callers haven't already acquired all modeset locks this might return -EDEADLK, which must be handled by calling *drm_modeset_backoff()*.

See also: *drm_atomic_helper_suspend()*, *drm_atomic_helper_resume()*

Return

A pointer to the copy of the atomic state object on success or an ERR_PTR()-encoded error code on failure.

struct *drm_atomic_state* ***drm_atomic_helper_suspend**(struct *drm_device* *dev)

subsystem-level suspend helper

Parameters

struct drm_device *dev
DRM device

Description

Duplicates the current atomic state, disables all active outputs and then returns a pointer to the original atomic state to the caller. Drivers can pass this pointer to the *drm_atomic_helper_resume()* helper upon resume to restore the output configuration that was active at the time the system entered suspend.

Note that it is potentially unsafe to use this. The atomic state object returned by this function is assumed to be persistent. Drivers must ensure that this holds true. Before calling this function, drivers must make sure to suspend fbdev emulation so that nothing can be using the device.

See also: *drm_atomic_helper_duplicate_state()*, *drm_atomic_helper_disable_all()*, *drm_atomic_helper_resume()*, *drm_atomic_helper_commit_duplicated_state()*

Return

A pointer to a copy of the state before suspend on success or an ERR_PTR()- encoded error code on failure. Drivers should store the returned atomic state object and pass it to the *drm_atomic_helper_resume()* helper upon resume.

int **drm_atomic_helper_commit_duplicated_state**(struct *drm_atomic_state* *state, struct *drm_modeset_acquire_ctx* *ctx)

commit duplicated state

Parameters

struct drm_atomic_state *state
duplicated atomic state to commit

struct drm_modeset_acquire_ctx *ctx
pointer to acquire_ctx to use for commit.

Description

The state returned by *drm_atomic_helper_duplicate_state()* and *drm_atomic_helper_suspend()* is partially invalid, and needs to be fixed up before commit.

See also: *drm_atomic_helper_suspend()*

Return

0 on success or a negative error code on failure.

int **drm_atomic_helper_resume**(struct *drm_device* *dev, struct *drm_atomic_state* *state)

subsystem-level resume helper

Parameters

struct drm_device *dev
DRM device

struct drm_atomic_state *state
atomic state to resume to

Description

Calls *drm_mode_config_reset()* to synchronize hardware and software states, grabs all modeset locks and commits the atomic state object. This can be used in conjunction with the *drm_atomic_helper_suspend()* helper to implement suspend/resume for drivers that support atomic mode-setting.

See also: *drm_atomic_helper_suspend()*

Return

0 on success or a negative error code on failure.

int **drm_atomic_helper_page_flip**(struct *drm_crtc* *crtc, struct *drm_framebuffer* *fb, struct *drm_pending_vblank_event* *event, uint32_t flags, struct *drm_modeset_acquire_ctx* *ctx)

execute a legacy page flip

Parameters

struct drm_crtc *crtc
DRM CRTC

struct drm_framebuffer *fb
DRM framebuffer

struct drm_pending_vblank_event *event
optional DRM event to signal upon completion

uint32_t flags
flip flags for non-vblank sync'ed updates

struct drm_modeset_acquire_ctx *ctx
lock acquisition context

Description

Provides a default *drm_crtc_funcs.page_flip* implementation using the atomic driver interface.

See also: *drm_atomic_helper_page_flip_target()*

Return

Returns 0 on success, negative errno numbers on failure.

int **drm_atomic_helper_page_flip_target**(struct *drm_crtc* *crtc, struct *drm_framebuffer* *fb, struct *drm_pending_vblank_event* *event, uint32_t flags, uint32_t target, struct *drm_modeset_acquire_ctx* *ctx)

do page flip on target vblank period.

Parameters

struct drm_crtc *crtc
DRM CRTC

struct drm_framebuffer *fb
DRM framebuffer

struct drm_pending_vblank_event *event
optional DRM event to signal upon completion

uint32_t flags
flip flags for non-vblank sync'ed updates

uint32_t target
specifying the target vblank period when the flip to take effect

struct drm_modeset_acquire_ctx *ctx
lock acquisition context

Description

Provides a default *drm_crtc_funcs.page_flip_target* implementation. Similar to *drm_atomic_helper_page_flip()* with extra parameter to specify target vblank period to flip.

Return

Returns 0 on success, negative errno numbers on failure.

int **drm_atomic_helper_legacy_gamma_set**(struct *drm_crtc* *crtc, u16 *red, u16 *green, u16 *blue, uint32_t size, struct *drm_modeset_acquire_ctx* *ctx)

set the legacy gamma correction table

Parameters

struct drm_crtc *crtc
CRTC object

u16 *red
red correction table

u16 *green
green correction table

u16 *blue
green correction table

uint32_t size
size of the tables

struct drm_modeset_acquire_ctx *ctx
lock acquire context

Description

Implements support for legacy gamma correction table for drivers that support color management through the DEGAMMA_LUT/GAMMA_LUT properties. See *drm_crtc_enable_color_mgmt()* and the containing chapter for how the atomic color management and gamma tables work.

u32 ***drm_atomic_helper_bridge_propagate_bus_fmt**(struct *drm_bridge* *bridge, struct *drm_bridge_state* *bridge_state, struct *drm_crtc_state* *crtc_state, struct *drm_connector_state* *conn_state, u32 output_fmt, unsigned int *num_input_fmts)

Propagate output format to the input end of a bridge

Parameters

struct drm_bridge *bridge
bridge control structure

struct drm_bridge_state *bridge_state
new bridge state

struct drm_crtc_state *crtc_state
new CRTC state

struct drm_connector_state *conn_state
new connector state

u32 output_fmt
tested output bus format

unsigned int *num_input_fmts
will contain the size of the returned array

Description

This helper is a pluggable implementation of the *drm_bridge_funcs.atomic_get_input_bus_fmts* operation for bridges that don't modify the bus configuration between their input and their output. It returns an array of input formats with a single element set to **output_fmt**.

Return

a valid format array of size **num_input_fmts**, or NULL if the allocation failed

5.2.4 Atomic State Reset and Initialization

Both the drm core and the atomic helpers assume that there is always the full and correct atomic software state for all connectors, CRTCs and planes available. Which is a bit a problem on driver load and also after system suspend. One way to solve this is to have a hardware state read-out infrastructure which reconstructs the full software state (e.g. the i915 driver).

The simpler solution is to just reset the software state to everything off, which is easiest to do by calling *drm_mode_config_reset()*. To facilitate this the atomic helpers provide default reset implementations for all hooks.

On the upside the precise state tracking of atomic simplifies system suspend and resume a lot. For drivers using *drm_mode_config_reset()* a complete recipe is implemented in *drm_atomic_helper_suspend()* and *drm_atomic_helper_resume()*. For other drivers the building blocks are split out, see the documentation for these functions.

5.2.5 Atomic State Helper Reference

void **__drm_atomic_helper_crtc_state_reset**(struct *drm_crtc_state* *crtc_state, struct *drm_crtc* *crtc)

reset the CRTC state

Parameters

struct drm_crtc_state *crtc_state
atomic CRTC state, must not be NULL

struct drm_crtc *crtc
CRTC object, must not be NULL

Description

Initializes the newly allocated **crtc_state** with default values. This is useful for drivers that subclass the CRTC state.

void **__drm_atomic_helper_crtc_reset**(struct *drm_crtc* *crtc, struct *drm_crtc_state* *crtc_state)

reset state on CRTC

Parameters

struct drm_crtc *crtc
drm CRTC

struct drm_crtc_state *crtc_state
CRTC state to assign

Description

Initializes the newly allocated **crtc_state** and assigns it to the *drm_crtc->state* pointer of **crtc**, usually required when initializing the drivers or when called from the *drm_crtc_funcs.reset* hook.

This is useful for drivers that subclass the CRTC state.

void **drm_atomic_helper_crtc_reset**(struct *drm_crtc* *crtc)

default *drm_crtc_funcs.reset* hook for CRTCs

Parameters

struct drm_crtc *crtc
drm CRTC

Description

Resets the atomic state for **crtc** by freeing the state pointer (which might be NULL, e.g. at driver load time) and allocating a new empty state object.

void **__drm_atomic_helper_crtc_duplicate_state**(struct *drm_crtc* *crtc, struct *drm_crtc_state* *state)

copy atomic CRTC state

Parameters

struct drm_crtc *crtc
CRTC object

struct drm_crtc_state *state
atomic CRTC state

Description

Copies atomic state from a CRTC' s current state and resets inferred values. This is useful for drivers that subclass the CRTC state.

struct *drm_crtc_state* ***drm_atomic_helper_crtc_duplicate_state**(struct *drm_crtc* *crtc)

default state duplicate hook

Parameters

struct drm_crtc *crtc
drm CRTC

Description

Default CRTC state duplicate hook for drivers which don' t have their own subclassed CRTC state structure.

void **__drm_atomic_helper_crtc_destroy_state**(struct *drm_crtc_state* *state)

release CRTC state

Parameters

struct drm_crtc_state *state
CRTC state object to release

Description

Releases all resources stored in the CRTC state without actually freeing the memory of the CRTC state. This is useful for drivers that subclass the CRTC state.

void **drm_atomic_helper_crtc_destroy_state**(struct *drm_crtc* *crtc, struct *drm_crtc_state* *state)

default state destroy hook

Parameters

struct drm_crtc *crtc
drm CRTC

struct drm_crtc_state *state
CRTC state object to release

Description

Default CRTC state destroy hook for drivers which don't have their own subclassed CRTC state structure.

void **__drm_atomic_helper_plane_state_reset**(struct *drm_plane_state* *plane_state, struct *drm_plane* *plane)

resets plane state to default values

Parameters

struct drm_plane_state *plane_state
atomic plane state, must not be NULL

struct drm_plane *plane
plane object, must not be NULL

Description

Initializes the newly allocated **plane_state** with default values. This is useful for drivers that subclass the CRTC state.

void **__drm_atomic_helper_plane_reset**(struct *drm_plane* *plane, struct *drm_plane_state* *plane_state)

reset state on plane

Parameters

struct drm_plane *plane
drm plane

struct drm_plane_state *plane_state
plane state to assign

Description

Initializes the newly allocated **plane_state** and assigns it to the `drm_crtc->state` pointer of **plane**, usually required when initializing the drivers or when called from the `drm_plane_funcs.reset` hook.

This is useful for drivers that subclass the plane state.

void **drm_atomic_helper_plane_reset**(struct *drm_plane* *plane)

default `drm_plane_funcs.reset` hook for planes

Parameters

struct drm_plane *plane
drm plane

Description

Resets the atomic state for **plane** by freeing the state pointer (which might be NULL, e.g. at driver load time) and allocating a new empty state object.

void **__drm_atomic_helper_plane_duplicate_state**(struct *drm_plane* *plane, struct *drm_plane_state* *state)

copy atomic plane state

Parameters

struct drm_plane *plane
plane object

struct drm_plane_state *state
atomic plane state

Description

Copies atomic state from a plane's current state. This is useful for drivers that subclass the plane state.

struct *drm_plane_state* ***drm_atomic_helper_plane_duplicate_state**(struct *drm_plane* *plane)

default state duplicate hook

Parameters

struct drm_plane *plane
drm plane

Description

Default plane state duplicate hook for drivers which don't have their own subclassed plane state structure.

void **__drm_atomic_helper_plane_destroy_state**(struct *drm_plane_state* *state)

release plane state

Parameters

struct drm_plane_state *state
plane state object to release

Description

Releases all resources stored in the plane state without actually freeing the memory of the plane state. This is useful for drivers that subclass the plane state.

void **drm_atomic_helper_plane_destroy_state**(struct *drm_plane* *plane, struct *drm_plane_state* *state)

default state destroy hook

Parameters

struct drm_plane *plane
drm plane

struct drm_plane_state *state
plane state object to release

Description

Default plane state destroy hook for drivers which don't have their own subclassed plane state structure.

void **__drm_atomic_helper_connector_state_reset**(struct *drm_connector_state* *conn_state, struct *drm_connector* *connector)

reset the connector state

Parameters

struct drm_connector_state *conn_state
atomic connector state, must not be NULL

struct drm_connector *connector
connectotr object, must not be NULL

Description

Initializes the newly allocated **conn_state** with default values. This is useful for drivers that subclass the connector state.

void **__drm_atomic_helper_connector_reset**(struct *drm_connector* *connector, struct *drm_connector_state* *conn_state)

reset state on connector

Parameters

struct drm_connector *connector
drm connector

struct drm_connector_state *conn_state
connector state to assign

Description

Initializes the newly allocated **conn_state** and assigns it to the `drm_connector->state` pointer of **connector**, usually required when initializing the drivers or when called from the `drm_connector_funcs.reset` hook.

This is useful for drivers that subclass the connector state.

void **drm_atomic_helper_connector_reset**(struct *drm_connector* *connector)

default `drm_connector_funcs.reset` hook for connectors

Parameters

struct drm_connector *connector
drm connector

Description

Resets the atomic state for **connector** by freeing the state pointer (which might be NULL, e.g. at driver load time) and allocating a new empty state object.

void **drm_atomic_helper_connector_tv_reset**(struct *drm_connector* *connector)

Resets TV connector properties

Parameters

struct drm_connector *connector
DRM connector

Description

Resets the TV-related properties attached to a connector.

void **__drm_atomic_helper_connector_duplicate_state**(struct *drm_connector* *connector, struct *drm_connector_state* *state)

copy atomic connector state

Parameters

struct drm_connector *connector
connector object

struct drm_connector_state *state
atomic connector state

Description

Copies atomic state from a connector's current state. This is useful for drivers that subclass the connector state.

struct *drm_connector_state* ***drm_atomic_helper_connector_duplicate_state**(struct *drm_connect* *con-nec-tor)

default state duplicate hook

Parameters

struct drm_connector *connector
drm connector

Description

Default connector state duplicate hook for drivers which don't have their own subclassed connector state structure.

void **__drm_atomic_helper_connector_destroy_state**(struct *drm_connector_state* *state)

release connector state

Parameters

struct drm_connector_state *state
connector state object to release

Description

Releases all resources stored in the connector state without actually freeing the memory of the connector state. This is useful for drivers that subclass the connector state.

void **drm_atomic_helper_connector_destroy_state**(struct *drm_connector* *connector, struct *drm_connector_state* *state)

default state destroy hook

Parameters

struct drm_connector *connector
drm connector

struct drm_connector_state *state
connector state object to release

Description

Default connector state destroy hook for drivers which don't have their own subclassed connector state structure.

void **__drm_atomic_helper_private_obj_duplicate_state**(struct *drm_private_obj* *obj, struct *drm_private_state* *state)

copy atomic private state

Parameters

struct drm_private_obj *obj
CRTC object

struct drm_private_state *state
new private object state

Description

Copies atomic state from a private objects's current state and resets inferred values. This is useful for drivers that subclass the private state.

void **__drm_atomic_helper_bridge_duplicate_state**(struct *drm_bridge* *bridge, struct *drm_bridge_state* *state)

Copy atomic bridge state

Parameters

struct drm_bridge *bridge
bridge object

struct drm_bridge_state *state
atomic bridge state

Description

Copies atomic state from a bridge's current state and resets inferred values. This is useful for drivers that subclass the bridge state.

struct *drm_bridge_state* ***drm_atomic_helper_bridge_duplicate_state**(struct *drm_bridge* *bridge)

Duplicate a bridge state object

Parameters

`struct drm_bridge *bridge`
bridge object

Description

Allocates a new bridge state and initializes it with the current bridge state values. This helper is meant to be used as a bridge *drm_bridge_funcs.atomic_duplicate_state* hook for bridges that don't subclass the bridge state.

void **drm_atomic_helper_bridge_destroy_state**(struct *drm_bridge* *bridge, struct *drm_bridge_state* *state)

Destroy a bridge state object

Parameters

`struct drm_bridge *bridge`
the bridge this state refers to

`struct drm_bridge_state *state`
bridge state to destroy

Description

Destroys a bridge state previously created by *drm_atomic_helper_bridge_reset`() or :c:type:`drm_atomic_helper_bridge_duplicate_state`(). This helper is meant to be used as a bridge :c:type:`drm_bridge_funcs.atomic_destroy_state* hook for bridges that don't subclass the bridge state.

void **__drm_atomic_helper_bridge_reset**(struct *drm_bridge* *bridge, struct *drm_bridge_state* *state)

Initialize a bridge state to its default

Parameters

`struct drm_bridge *bridge`
the bridge this state refers to

`struct drm_bridge_state *state`
bridge state to initialize

Description

Initializes the bridge state to default values. This is meant to be called by the bridge *drm_bridge_funcs.atomic_reset* hook for bridges that subclass the bridge state.

struct *drm_bridge_state* ***drm_atomic_helper_bridge_reset**(struct *drm_bridge* *bridge)

Allocate and initialize a bridge state to its default

Parameters

struct drm_bridge *bridge
the bridge this state refers to

Description

Allocates the bridge state and initializes it to default values. This helper is meant to be used as a bridge *drm_bridge_funcs.atomic_reset* hook for bridges that don't subclass the bridge state.

5.3 Simple KMS Helper Reference

This helper library provides helpers for drivers for simple display hardware.

drm_simple_display_pipe_init() initializes a simple display pipeline which has only one full-screen scanout buffer feeding one output. The pipeline is represented by *struct drm_simple_display_pipe* and binds together *drm_plane*, *drm_crtc* and *drm_encoder* structures into one fixed entity. Some flexibility for code reuse is provided through a separately allocated *drm_connector* object and supporting optional *drm_bridge* encoder drivers.

Many drivers require only a very simple encoder that fulfills the minimum requirements of the display pipeline and does not add additional functionality. The function *drm_simple_encoder_init()* provides an implementation of such an encoder.

struct **drm_simple_display_pipe_funcs**
helper operations for a simple display pipeline

Definition

```
struct drm_simple_display_pipe_funcs {
  enum drm_mode_status (*mode_valid)(struct drm_simple_display_pipe␣
↪*pipe, const struct drm_display_mode *mode);
  void (*enable)(struct drm_simple_display_pipe *pipe,struct drm_
↪crtc_state *crtc_state, struct drm_plane_state *plane_state);
  void (*disable)(struct drm_simple_display_pipe *pipe);
  int (*check)(struct drm_simple_display_pipe *pipe,struct drm_
↪plane_state *plane_state, struct drm_crtc_state *crtc_state);
  void (*update)(struct drm_simple_display_pipe *pipe, struct drm_
↪plane_state *old_plane_state);
  int (*prepare_fb)(struct drm_simple_display_pipe *pipe, struct␣
↪drm_plane_state *plane_state);
  void (*cleanup_fb)(struct drm_simple_display_pipe *pipe, struct␣
↪drm_plane_state *plane_state);
  int (*enable_vblank)(struct drm_simple_display_pipe *pipe);
  void (*disable_vblank)(struct drm_simple_display_pipe *pipe);
};
```

Members

mode_valid
This callback is used to check if a specific mode is valid in the crtc used in this simple display pipe. This should be implemented if the display pipe has some

sort of restriction in the modes it can display. For example, a given display pipe may be responsible to set a clock value. If the clock can not produce all the values for the available modes then this callback can be used to restrict the number of modes to only the ones that can be displayed. Another reason can be bandwidth mitigation: the memory port on the display controller can have bandwidth limitations not allowing pixel data to be fetched at any rate.

This hook is used by the probe helpers to filter the mode list in *drm_helper_probe_single_connector_modes()*, and it is used by the atomic helpers to validate modes supplied by userspace in *drm_atomic_helper_check_modeset()*.

This function is optional.

NOTE:

Since this function is both called from the check phase of an atomic commit, and the mode validation in the probe paths it is not allowed to look at anything else but the passed-in mode, and validate it against configuration-invariant hardware constraints.

RETURNS:

drm_mode_status Enum

enable
This function should be used to enable the pipeline. It is called when the underlying crtc is enabled. This hook is optional.

disable
This function should be used to disable the pipeline. It is called when the underlying crtc is disabled. This hook is optional.

check
This function is called in the check phase of an atomic update, specifically when the underlying plane is checked. The simple display pipeline helpers already check that the plane is not scaled, fills the entire visible area and is always enabled when the crtc is also enabled. This hook is optional.

RETURNS:

0 on success, -EINVAL if the state or the transition can't be supported, -ENOMEM on memory allocation failure and -EDEADLK if an attempt to obtain another state object ran into a *drm_modeset_lock* deadlock.

update
This function is called when the underlying plane state is updated. This hook is optional.

This is the function drivers should submit the *drm_pending_vblank_event* from. Using either *drm_crtc_arm_vblank_event()*, when the driver supports vblank interrupt handling, or *drm_crtc_send_vblank_event()* for more complex case. In case the hardware lacks vblank support entirely, drivers can set *struct drm_crtc_state*.no_vblank in *struct drm_simple_display_pipe_funcs*.check and let DRM's atomic helper fake a vblank event.

prepare_fb
Optional, called by *drm_plane_helper_funcs.prepare_fb*. Please read the documentation for the *drm_plane_helper_funcs.prepare_fb* hook for more details.

Drivers which always have their buffers pinned should use *drm_gem_fb_simple_display_pipe_prepare_fb()* for this hook.

cleanup_fb
Optional, called by *drm_plane_helper_funcs.cleanup_fb*. Please read the documentation for the *drm_plane_helper_funcs.cleanup_fb* hook for more details.

enable_vblank
Optional, called by *drm_crtc_funcs.enable_vblank*. Please read the documentation for the *drm_crtc_funcs.enable_vblank* hook for more details.

disable_vblank
Optional, called by *drm_crtc_funcs.disable_vblank*. Please read the documentation for the *drm_crtc_funcs.disable_vblank* hook for more details.

struct **drm_simple_display_pipe**
simple display pipeline

Definition

```
struct drm_simple_display_pipe {
  struct drm_crtc crtc;
  struct drm_plane plane;
  struct drm_encoder encoder;
  struct drm_connector *connector;
  const struct drm_simple_display_pipe_funcs *funcs;
};
```

Members

crtc
CRTC control structure

plane
Plane control structure

encoder
Encoder control structure

connector
Connector control structure

funcs
Pipeline control functions (optional)

Description

Simple display pipeline with plane, crtc and encoder collapsed into one entity. It should be initialized by calling *drm_simple_display_pipe_init()*.

int **drm_simple_encoder_init**(struct *drm_device* *dev, struct *drm_encoder* *encoder, int encoder_type)

Initialize a preallocated encoder with basic functionality.

Parameters

`struct drm_device *dev`
drm device

`struct drm_encoder *encoder`
the encoder to initialize

`int encoder_type`
user visible type of the encoder

Description

Initialises a preallocated encoder that has no further functionality. Settings for possible CRTC and clones are left to their initial values. The encoder will be cleaned up automatically as part of the mode-setting cleanup.

The caller of *`drm_simple_encoder_init()`* is responsible for freeing the encoder's memory after the encoder has been cleaned up. At the moment this only works reliably if the encoder data structure is stored in the device structure. Free the encoder's memory as part of the device release function.

FIXME: Later improvements to DRM's resource management may allow for
an automated kfree() of the encoder's memory.

Return

Zero on success, error code on failure.

int **`drm_simple_display_pipe_attach_bridge`**(struct *drm_simple_display_pipe* *pipe, struct *drm_bridge* *bridge)

Attach a bridge to the display pipe

Parameters

`struct drm_simple_display_pipe *pipe`
simple display pipe object

`struct drm_bridge *bridge`
bridge to attach

Description

Makes it possible to still use the drm_simple_display_pipe helpers when a DRM bridge has to be used.

Note that you probably want to initialize the pipe by passing a NULL connector to *`drm_simple_display_pipe_init()`*.

Return

Zero on success, negative error code on failure.

int **drm_simple_display_pipe_init**(struct *drm_device* *dev, struct *drm_simple_display_pipe* *pipe, const struct *drm_simple_display_pipe_funcs* *funcs, const uint32_t *formats, unsigned int format_count, const uint64_t *format_modifiers, struct *drm_connector* *connector)

Initialize a simple display pipeline

Parameters

struct drm_device *dev
DRM device

struct drm_simple_display_pipe *pipe
simple display pipe object to initialize

const struct drm_simple_display_pipe_funcs *funcs
callbacks for the display pipe (optional)

const uint32_t *formats
array of supported formats (DRM_FORMAT_*)

unsigned int format_count
number of elements in **formats**

const uint64_t *format_modifiers
array of formats modifiers

struct drm_connector *connector
connector to attach and register (optional)

Description

Sets up a display pipeline which consist of a really simple plane-crtc-encoder pipe.

If a connector is supplied, the pipe will be coupled with the provided connector. You may supply a NULL connector when using drm bridges, that handle connectors themselves (see `drm_simple_display_pipe_attach_bridge()`).

Teardown of a simple display pipe is all handled automatically by the drm core through calling `drm_mode_config_cleanup()`. Drivers afterwards need to release the memory for the structure themselves.

Return

Zero on success, negative error code on failure.

5.4 fbdev Helper Functions Reference

The fb helper functions are useful to provide an fbdev on top of a drm kernel mode setting driver. They can be used mostly independently from the crtc helper functions used by many drivers to implement the kernel mode setting interfaces.

Drivers that support a dumb buffer with a virtual address and mmap support, should try out the generic fbdev emulation using *drm_fbdev_generic_setup()*. It will automatically set up deferred I/O if the driver requires a shadow buffer.

At runtime drivers should restore the fbdev console by using *drm_fb_helper_lastclose()* as their *drm_driver.lastclose* callback. They should also notify the fb helper code from updates to the output configuration by using *drm_fb_helper_output_poll_changed()* as their *drm_mode_config_funcs.output_poll_changed* callback.

For suspend/resume consider using *drm_mode_config_helper_suspend()* and *drm_mode_config_helper_resume()* which takes care of fbdev as well.

All other functions exported by the fb helper library can be used to implement the fbdev driver interface by the driver.

It is possible, though perhaps somewhat tricky, to implement race-free hotplug detection using the fbdev helpers. The *drm_fb_helper_prepare()* helper must be called first to initialize the minimum required to make hotplug detection work. Drivers also need to make sure to properly set up the *drm_mode_config.funcs* member. After calling *drm_kms_helper_poll_init()* it is safe to enable interrupts and start processing hotplug events. At the same time, drivers should initialize all modeset objects such as CRTCs, encoders and connectors. To finish up the fbdev helper initialization, the *drm_fb_helper_init()* function is called. To probe for all attached displays and set up an initial configuration using the detected hardware, drivers should call *drm_fb_helper_initial_config()*.

If *drm_framebuffer_funcs.dirty* is set, the drm_fb_helper_{cfb,sys}_{write,fillrect,copyarea,i functions will accumulate changes and schedule *drm_fb_helper.dirty_work* to run right away. This worker then calls the dirty() function ensuring that it will always run in process context since the fb_*() function could be running in atomic context. If *drm_fb_helper_deferred_io()* is used as the deferred_io callback it will also schedule dirty_work with the damage collected from the mmap page writes.

Deferred I/O is not compatible with SHMEM. Such drivers should request an fbdev shadow buffer and call *drm_fbdev_generic_setup()* instead.

struct **drm_fb_helper_surface_size**
describes fbdev size and scanout surface size

Definition

```
struct drm_fb_helper_surface_size {
  u32 fb_width;
  u32 fb_height;
  u32 surface_width;
  u32 surface_height;
```

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```
  u32 surface_bpp;
  u32 surface_depth;
};
```

Members

`fb_width`
fbdev width

`fb_height`
fbdev height

`surface_width`
scanout buffer width

`surface_height`
scanout buffer height

`surface_bpp`
scanout buffer bpp

`surface_depth`
scanout buffer depth

Description

Note that the scanout surface width/height may be larger than the fbdev width/height. In case of multiple displays, the scanout surface is sized according to the largest width/height (so it is large enough for all CRTCs to scanout). But the fbdev width/height is sized to the minimum width/ height of all the displays. This ensures that fbcon fits on the smallest of the attached displays. fb_width/fb_height is used by *drm_fb_helper_fill_info()* to fill out the `fb_info.var` structure.

struct **`drm_fb_helper_funcs`**

driver callbacks for the fbdev emulation library

Definition

```
struct drm_fb_helper_funcs {
  int (*fb_probe)(struct drm_fb_helper *helper, struct drm_fb_
↪helper_surface_size *sizes);
};
```

Members

`fb_probe`
Driver callback to allocate and initialize the fbdev info structure. Furthermore it also needs to allocate the DRM framebuffer used to back the fbdev.

This callback is mandatory.

RETURNS:

The driver should return 0 on success and a negative error code on failure.

Description

Driver callbacks used by the fbdev emulation helper library.

struct **drm_fb_helper**

main structure to emulate fbdev on top of KMS

Definition

```
struct drm_fb_helper {
  struct drm_client_dev client;
  struct drm_client_buffer *buffer;
  struct drm_framebuffer *fb;
  struct drm_device *dev;
  const struct drm_fb_helper_funcs *funcs;
  struct fb_info *fbdev;
  u32 pseudo_palette[17];
  struct drm_clip_rect dirty_clip;
  spinlock_t dirty_lock;
  struct work_struct dirty_work;
  struct work_struct resume_work;
  struct mutex lock;
  struct list_head kernel_fb_list;
  bool delayed_hotplug;
  bool deferred_setup;
  int preferred_bpp;
};
```

Members

client
DRM client used by the generic fbdev emulation.

buffer
Framebuffer used by the generic fbdev emulation.

fb
Scanout framebuffer object

dev
DRM device

funcs
driver callbacks for fb helper

fbdev
emulated fbdev device info struct

pseudo_palette
fake palette of 16 colors

dirty_clip
clip rectangle used with deferred_io to accumulate damage to the screen buffer

dirty_lock
spinlock protecting **dirty_clip**

dirty_work
worker used to flush the framebuffer

resume_work
: worker used during resume if the console lock is already taken

lock
: Top-level FBDEV helper lock. This protects all internal data structures and lists, such as **connector_info** and **crtc_info**.

  FIXME: fbdev emulation locking is a mess and long term we want to protect all helper internal state with this lock as well as reduce core KMS locking as much as possible.

kernel_fb_list
: Entry on the global kernel_fb_helper_list, used for kgdb entry/exit.

delayed_hotplug
: A hotplug was received while fbdev wasn' t in control of the DRM device, i.e. another KMS master was active. The output configuration needs to be reprobe when fbdev is in control again.

deferred_setup
: If no outputs are connected (disconnected or unknown) the FB helper code will defer setup until at least one of the outputs shows up. This field keeps track of the status so that setup can be retried at every hotplug event until it succeeds eventually.

  Protected by **lock**.

preferred_bpp
: Temporary storage for the driver' s preferred BPP setting passed to FB helper initialization. This needs to be tracked so that deferred FB helper setup can pass this on.

  See also: **deferred_setup**

Description

This is the main structure used by the fbdev helpers. Drivers supporting fbdev emulation should embedded this into their overall driver structure. Drivers must also fill out a *struct drm_fb_helper_funcs* with a few operations.

DRM_FB_HELPER_DEFAULT_OPS

`DRM_FB_HELPER_DEFAULT_OPS ()`

helper define for drm drivers

Parameters

Description

Helper define to register default implementations of drm_fb_helper functions. To be used in struct fb_ops of drm drivers.

int **drm_fb_helper_remove_conflicting_framebuffers**(struct apertures_struct *a, const char *name, bool primary)

remove firmware-configured framebuffers

Parameters

struct apertures_struct *a
memory range, users of which are to be removed

const char *name
requesting driver name

bool primary
also kick vga16fb if present

Description

This function removes framebuffer devices (initialized by firmware/bootloader) which use memory range described by **a**. If **a** is NULL all such devices are removed.

int **drm_fb_helper_remove_conflicting_pci_framebuffers**(struct pci_dev *pdev, const char *name)
remove firmware-configured framebuffers for PCI devices

Parameters

struct pci_dev *pdev
PCI device

const char *name
requesting driver name

Description

This function removes framebuffer devices (eg. initialized by firmware) using memory range configured for any of **pdev**' s memory bars.

The function assumes that PCI device with shadowed ROM drives a primary display and so kicks out vga16fb.

int **drm_fb_helper_debug_enter**(struct fb_info *info)
implementation for `fb_ops.fb_debug_enter`

Parameters

struct fb_info *info
fbdev registered by the helper

int **drm_fb_helper_debug_leave**(struct fb_info *info)
implementation for `fb_ops.fb_debug_leave`

Parameters

struct fb_info *info
fbdev registered by the helper

int **drm_fb_helper_restore_fbdev_mode_unlocked**(struct *drm_fb_helper* *fb_helper)
restore fbdev configuration

Parameters

struct drm_fb_helper *fb_helper
driver-allocated fbdev helper, can be NULL

Description

This should be called from driver's drm *drm_driver.lastclose* callback when implementing an fbcon on top of kms using this helper. This ensures that the user isn't greeted with a black screen when e.g. X dies.

Return

Zero if everything went ok, negative error code otherwise.

int **drm_fb_helper_blank**(int blank, struct fb_info *info)

implementation for `fb_ops.fb_blank`

Parameters

int blank
desired blanking state

struct fb_info *info
fbdev registered by the helper

void **drm_fb_helper_prepare**(struct *drm_device* *dev, struct *drm_fb_helper* *helper, const struct *drm_fb_helper_funcs* *funcs)

setup a drm_fb_helper structure

Parameters

struct drm_device *dev
DRM device

struct drm_fb_helper *helper
driver-allocated fbdev helper structure to set up

const struct drm_fb_helper_funcs *funcs
pointer to structure of functions associate with this helper

Description

Sets up the bare minimum to make the framebuffer helper usable. This is useful to implement race-free initialization of the polling helpers.

int **drm_fb_helper_init**(struct *drm_device* *dev, struct *drm_fb_helper* *fb_helper)

initialize a *struct drm_fb_helper*

Parameters

struct drm_device *dev
drm device

struct drm_fb_helper *fb_helper
driver-allocated fbdev helper structure to initialize

Description

This allocates the structures for the fbdev helper with the given limits. Note that this won't yet touch the hardware (through the driver interfaces) nor register the fbdev. This is only done in *drm_fb_helper_initial_config()* to allow driver writes more control over the exact init sequence.

Drivers must call *drm_fb_helper_prepare()* before calling this function.

Return

Zero if everything went ok, nonzero otherwise.

struct fb_info ***drm_fb_helper_alloc_fbi**(struct *drm_fb_helper* *fb_helper)

allocate fb_info and some of its members

Parameters

struct drm_fb_helper *fb_helper
driver-allocated fbdev helper

Description

A helper to alloc fb_info and the members cmap and apertures. Called by the driver within the fb_probe fb_helper callback function. Drivers do not need to release the allocated fb_info structure themselves, this is automatically done when calling *drm_fb_helper_fini()*.

Return

fb_info pointer if things went okay, pointer containing error code otherwise

void **drm_fb_helper_unregister_fbi**(struct *drm_fb_helper* *fb_helper)

unregister fb_info framebuffer device

Parameters

struct drm_fb_helper *fb_helper
driver-allocated fbdev helper, can be NULL

Description

A wrapper around unregister_framebuffer, to release the fb_info framebuffer device. This must be called before releasing all resources for **fb_helper** by calling *drm_fb_helper_fini()*.

void **drm_fb_helper_fini**(struct *drm_fb_helper* *fb_helper)

finalize a *struct drm_fb_helper*

Parameters

struct drm_fb_helper *fb_helper
driver-allocated fbdev helper, can be NULL

Description

This cleans up all remaining resources associated with **fb_helper**.

void **drm_fb_helper_deferred_io**(struct fb_info *info, struct list_head *pagelist)

fbdev deferred_io callback function

Parameters

struct fb_info *info
fb_info struct pointer

struct list_head *pagelist
list of dirty mmap framebuffer pages

Description

This function is used as the `fb_deferred_io.deferred_io` callback function for flushing the fbdev mmap writes.

ssize_t **drm_fb_helper_sys_read**(struct fb_info *info, char __user *buf, size_t count, loff_t *ppos)

wrapper around fb_sys_read

Parameters

struct fb_info *info
fb_info struct pointer

char __user *buf
userspace buffer to read from framebuffer memory

size_t count
number of bytes to read from framebuffer memory

loff_t *ppos
read offset within framebuffer memory

Description

A wrapper around fb_sys_read implemented by fbdev core

ssize_t **drm_fb_helper_sys_write**(struct fb_info *info, const char __user *buf, size_t count, loff_t *ppos)

wrapper around fb_sys_write

Parameters

struct fb_info *info
fb_info struct pointer

const char __user *buf
userspace buffer to write to framebuffer memory

size_t count
number of bytes to write to framebuffer memory

loff_t *ppos
write offset within framebuffer memory

Description

A wrapper around fb_sys_write implemented by fbdev core

void **drm_fb_helper_sys_fillrect**(struct fb_info *info, const struct fb_fillrect *rect)

wrapper around sys_fillrect

Parameters

struct fb_info *info
fbdev registered by the helper

const struct fb_fillrect *rect
info about rectangle to fill

Description

A wrapper around sys_fillrect implemented by fbdev core

void **drm_fb_helper_sys_copyarea**(struct fb_info *info, const struct fb_copyarea *area)

wrapper around sys_copyarea

Parameters

struct fb_info *info
fbdev registered by the helper

const struct fb_copyarea *area
info about area to copy

Description

A wrapper around sys_copyarea implemented by fbdev core

void **drm_fb_helper_sys_imageblit**(struct fb_info *info, const struct fb_image *image)

wrapper around sys_imageblit

Parameters

struct fb_info *info
fbdev registered by the helper

const struct fb_image *image
info about image to blit

Description

A wrapper around sys_imageblit implemented by fbdev core

void **drm_fb_helper_cfb_fillrect**(struct fb_info *info, const struct fb_fillrect *rect)

wrapper around cfb_fillrect

Parameters

struct fb_info *info
fbdev registered by the helper

const struct fb_fillrect *rect
info about rectangle to fill

Description

A wrapper around cfb_fillrect implemented by fbdev core

void **drm_fb_helper_cfb_copyarea**(struct fb_info *info, const struct fb_copyarea *area)

wrapper around cfb_copyarea

Parameters

struct fb_info *info
fbdev registered by the helper

const struct fb_copyarea *area
info about area to copy

Description

A wrapper around cfb_copyarea implemented by fbdev core

void **drm_fb_helper_cfb_imageblit**(struct fb_info *info, const struct fb_image *image)

wrapper around cfb_imageblit

Parameters

struct fb_info *info
fbdev registered by the helper

const struct fb_image *image
info about image to blit

Description

A wrapper around cfb_imageblit implemented by fbdev core

void **drm_fb_helper_set_suspend**(struct *drm_fb_helper* *fb_helper, bool suspend)

wrapper around fb_set_suspend

Parameters

struct drm_fb_helper *fb_helper
driver-allocated fbdev helper, can be NULL

bool suspend
whether to suspend or resume

Description

A wrapper around fb_set_suspend implemented by fbdev core. Use *drm_fb_helper_set_suspend_unlocked()* if you don' t need to take the lock yourself

void **drm_fb_helper_set_suspend_unlocked**(struct *drm_fb_helper* *fb_helper, bool suspend)

wrapper around fb_set_suspend that also takes the console lock

Parameters

struct drm_fb_helper *fb_helper
driver-allocated fbdev helper, can be NULL

bool suspend
whether to suspend or resume

Description

A wrapper around fb_set_suspend() that takes the console lock. If the lock isn' t available on resume, a worker is tasked with waiting for the lock to become available. The console lock can be pretty contented on resume due to all the printk activity.

This function can be called multiple times with the same state since `fb_info.state` is checked to see if fbdev is running or not before locking.

Use *drm_fb_helper_set_suspend()* if you need to take the lock yourself.

int **drm_fb_helper_setcmap**(struct fb_cmap *cmap, struct fb_info *info)

implementation for `fb_ops.fb_setcmap`

Parameters

struct fb_cmap *cmap
cmap to set

struct fb_info *info
fbdev registered by the helper

int **drm_fb_helper_ioctl**(struct fb_info *info, unsigned int cmd, unsigned long arg)

legacy ioctl implementation

Parameters

struct fb_info *info
fbdev registered by the helper

unsigned int cmd
ioctl command

unsigned long arg
ioctl argument

Description

A helper to implement the standard fbdev ioctl. Only FBIO_WAITFORVSYNC is implemented for now.

int **drm_fb_helper_check_var**(struct fb_var_screeninfo *var, struct fb_info *info)

implementation for `fb_ops.fb_check_var`

Parameters

struct fb_var_screeninfo *var
screeninfo to check

struct fb_info *info
fbdev registered by the helper

int **drm_fb_helper_set_par**(struct fb_info *info)

implementation for `fb_ops.fb_set_par`

Parameters

struct fb_info *info
fbdev registered by the helper

Description

This will let fbcon do the mode init and is called at initialization time by the fbdev core when registering the driver, and later on through the hotplug callback.

int **drm_fb_helper_pan_display**(struct fb_var_screeninfo *var, struct fb_info *info)

implementation for `fb_ops.fb_pan_display`

Parameters

struct fb_var_screeninfo *var
updated screen information

struct fb_info *info
fbdev registered by the helper

void **drm_fb_helper_fill_info**(struct fb_info *info, struct *drm_fb_helper* *fb_helper, struct *drm_fb_helper_surface_size* *sizes)

initializes fbdev information

Parameters

struct fb_info *info
fbdev instance to set up

struct drm_fb_helper *fb_helper
fb helper instance to use as template

struct drm_fb_helper_surface_size *sizes
describes fbdev size and scanout surface size

Description

Sets up the variable and fixed fbdev metainformation from the given fb helper instance and the drm framebuffer allocated in *`drm_fb_helper.fb`*.

Drivers should call this (or their equivalent setup code) from their *`drm_fb_helper_funcs.fb_probe`* callback after having allocated the fbdev backing storage framebuffer.

int **drm_fb_helper_initial_config**(struct *drm_fb_helper* *fb_helper, int bpp_sel)

setup a sane initial connector configuration

Parameters

struct drm_fb_helper *fb_helper
fb_helper device struct

int bpp_sel
bpp value to use for the framebuffer configuration

Description

Scans the CRTCs and connectors and tries to put together an initial setup. At the moment, this is a cloned configuration across all heads with a new framebuffer object as the backing store.

Note that this also registers the fbdev and so allows userspace to call into the driver through the fbdev interfaces.

This function will call down into the *drm_fb_helper_funcs.fb_probe* callback to let the driver allocate and initialize the fbdev info structure and the drm framebuffer used to back the fbdev. *drm_fb_helper_fill_info()* is provided as a helper to setup simple default values for the fbdev info structure.

HANG DEBUGGING:

When you have fbcon support built-in or already loaded, this function will do a full modeset to setup the fbdev console. Due to locking misdesign in the VT/fbdev subsystem that entire modeset sequence has to be done while holding console_lock. Until console_unlock is called no dmesg lines will be sent out to consoles, not even serial console. This means when your driver crashes, you will see absolutely nothing else but a system stuck in this function, with no further output. Any kind of printk() you place within your own driver or in the drm core modeset code will also never show up.

Standard debug practice is to run the fbcon setup without taking the console_lock as a hack, to be able to see backtraces and crashes on the serial line. This can be done by setting the fb.lockless_register_fb=1 kernel cmdline option.

The other option is to just disable fbdev emulation since very likely the first modeset from userspace will crash in the same way, and is even easier to debug. This can be done by setting the drm_kms_helper.fbdev_emulation=0 kernel cmdline option.

Return

Zero if everything went ok, nonzero otherwise.

int **drm_fb_helper_hotplug_event**(struct *drm_fb_helper* *fb_helper)

respond to a hotplug notification by probing all the outputs attached to the fb

Parameters

struct drm_fb_helper *fb_helper

driver-allocated fbdev helper, can be NULL

Description

Scan the connectors attached to the fb_helper and try to put together a setup after notification of a change in output configuration.

Called at runtime, takes the mode config locks to be able to check/change the modeset configuration. Must be run from process context (which usually means either the output polling work or a work item launched from the driver’s hotplug interrupt).

Note that drivers may call this even before calling drm_fb_helper_initial_config but only after drm_fb_helper_init. This allows for a race-free fbcon setup and will make sure that the fbdev emulation will not miss any hotplug events.

Return

0 on success and a non-zero error code otherwise.

void **drm_fb_helper_lastclose**(struct *drm_device* *dev)

DRM driver lastclose helper for fbdev emulation

Parameters

struct drm_device *dev
DRM device

Description

This function can be used as the *drm_driver->lastclose* callback for drivers that only need to call *drm_fb_helper_restore_fbdev_mode_unlocked()*.

void **drm_fb_helper_output_poll_changed**(struct *drm_device* *dev)
DRM mode config .output_poll_changed helper for fbdev emulation

Parameters

struct drm_device *dev
DRM device

Description

This function can be used as the *drm_mode_config_funcs.output_poll_changed* callback for drivers that only need to call *drm_fb_helper_hotplug_event()*.

void **drm_fbdev_generic_setup**(struct *drm_device* *dev, unsigned int preferred_bpp)
Setup generic fbdev emulation

Parameters

struct drm_device *dev
DRM device

unsigned int preferred_bpp
Preferred bits per pixel for the device. **dev->mode_config.preferred_depth** is used if this is zero.

Description

This function sets up generic fbdev emulation for drivers that supports dumb buffers with a virtual address and that can be mmap' ed. *drm_fbdev_generic_setup()* shall be called after the DRM driver registered the new DRM device with *drm_dev_register()*.

Restore, hotplug events and teardown are all taken care of. Drivers that do suspend/resume need to call *drm_fb_helper_set_suspend_unlocked()* themselves. Simple drivers might use *drm_mode_config_helper_suspend()*.

Drivers that set the dirty callback on their framebuffer will get a shadow fbdev buffer that is blitted onto the real buffer. This is done in order to make deferred I/O work with all kinds of buffers. A shadow buffer can be requested explicitly by setting *struct drm_mode_config*.prefer_shadow or *struct drm_mode_config*.prefer_shadow_fbdev to true beforehand. This is required to use generic fbdev emulation with SHMEM helpers.

This function is safe to call even when there are no connectors present. Setup will be retried on the next hotplug event.

The fbdev is destroyed by *drm_dev_unregister()*.

5.5 format Helper Functions Reference

void **drm_fb_memcpy**(void *dst, void *vaddr, struct *drm_framebuffer* *fb, struct *drm_rect* *clip)

Copy clip buffer

Parameters

void *dst
Destination buffer

void *vaddr
Source buffer

struct drm_framebuffer *fb
DRM framebuffer

struct drm_rect *clip
Clip rectangle area to copy

Description

This function does not apply clipping on dst, i.e. the destination is a small buffer containing the clip rect only.

void **drm_fb_memcpy_dstclip**(void __iomem *dst, void *vaddr, struct *drm_framebuffer* *fb, struct *drm_rect* *clip)

Copy clip buffer

Parameters

void __iomem *dst
Destination buffer (iomem)

void *vaddr
Source buffer

struct drm_framebuffer *fb
DRM framebuffer

struct drm_rect *clip
Clip rectangle area to copy

Description

This function applies clipping on dst, i.e. the destination is a full (iomem) framebuffer but only the clip rect content is copied over.

void **drm_fb_swab**(void *dst, void *src, struct *drm_framebuffer* *fb, struct *drm_rect* *clip, bool cached)

Swap bytes into clip buffer

Parameters

void *dst
Destination buffer

void *src
Source buffer

struct drm_framebuffer *fb
DRM framebuffer

struct drm_rect *clip
Clip rectangle area to copy

bool cached
Source buffer is mapped cached (eg. not write-combined)

Description

If **cached** is false a temporary buffer is used to cache one pixel line at a time to speed up slow uncached reads.

This function does not apply clipping on dst, i.e. the destination is a small buffer containing the clip rect only.

void **drm_fb_xrgb8888_to_rgb565**(void *dst, void *vaddr, struct *drm_framebuffer* *fb, struct *drm_rect* *clip, bool swab)

Convert XRGB8888 to RGB565 clip buffer

Parameters

void *dst
RGB565 destination buffer

void *vaddr
XRGB8888 source buffer

struct drm_framebuffer *fb
DRM framebuffer

struct drm_rect *clip
Clip rectangle area to copy

bool swab
Swap bytes

Description

Drivers can use this function for RGB565 devices that don't natively support XRGB8888.

This function does not apply clipping on dst, i.e. the destination is a small buffer containing the clip rect only.

void **drm_fb_xrgb8888_to_rgb565_dstclip**(void __iomem *dst, unsigned int dst_pitch, void *vaddr, struct *drm_framebuffer* *fb, struct *drm_rect* *clip, bool swab)

Convert XRGB8888 to RGB565 clip buffer

Parameters

void __iomem *dst
RGB565 destination buffer (iomem)

unsigned int dst_pitch
destination buffer pitch

void *vaddr
XRGB8888 source buffer

struct drm_framebuffer *fb
DRM framebuffer

struct drm_rect *clip
Clip rectangle area to copy

bool swab
Swap bytes

Description

Drivers can use this function for RGB565 devices that don't natively support XRGB8888.

This function applies clipping on dst, i.e. the destination is a full (iomem) framebuffer but only the clip rect content is copied over.

void **drm_fb_xrgb8888_to_rgb888_dstclip**(void __iomem *dst, unsigned int dst_pitch, void *vaddr, struct *drm_framebuffer* *fb, struct *drm_rect* *clip)

Convert XRGB8888 to RGB888 clip buffer

Parameters

void __iomem *dst
RGB565 destination buffer (iomem)

unsigned int dst_pitch
destination buffer pitch

void *vaddr
XRGB8888 source buffer

struct drm_framebuffer *fb
DRM framebuffer

struct drm_rect *clip
Clip rectangle area to copy

Description

Drivers can use this function for RGB888 devices that don't natively support XRGB8888.

This function applies clipping on dst, i.e. the destination is a full (iomem) framebuffer but only the clip rect content is copied over.

void **drm_fb_xrgb8888_to_gray8**(u8 *dst, void *vaddr, struct *drm_framebuffer* *fb, struct *drm_rect* *clip)

Convert XRGB8888 to grayscale

Parameters

u8 *dst
8-bit grayscale destination buffer

void *vaddr
XRGB8888 source buffer

struct drm_framebuffer *fb
DRM framebuffer

struct drm_rect *clip
Clip rectangle area to copy

Description

Drm doesn't have native monochrome or grayscale support. Such drivers can announce the commonly supported XR24 format to userspace and use this function to convert to the native format.

Monochrome drivers will use the most significant bit, where 1 means foreground color and 0 background color.

ITU BT.601 is used for the RGB -> luma (brightness) conversion.

5.6 Framebuffer CMA Helper Functions Reference

Provides helper functions for creating a cma (contiguous memory allocator) backed framebuffer.

drm_gem_fb_create() is used in the *drm_mode_config_funcs.fb_create* callback function to create a cma backed framebuffer.

struct *drm_gem_cma_object* ***drm_fb_cma_get_gem_obj**(struct *drm_framebuffer* *fb, unsigned int plane)

Get CMA GEM object for framebuffer

Parameters

struct drm_framebuffer *fb
The framebuffer

unsigned int plane
Which plane

Description

Return the CMA GEM object for given framebuffer.

This function will usually be called from the CRTC callback functions.

dma_addr_t **drm_fb_cma_get_gem_addr**(struct *drm_framebuffer* *fb, struct *drm_plane_state* *state, unsigned int plane)

Get physical address for framebuffer, for pixel formats where values are grouped in blocks this will get you the beginning of the block

Parameters

struct drm_framebuffer *fb
The framebuffer

`struct drm_plane_state *state`
Which state of drm plane

`unsigned int plane`
Which plane Return the CMA GEM address for given framebuffer.

Description

This function will usually be called from the PLANE callback functions.

5.7 Framebuffer GEM Helper Reference

This library provides helpers for drivers that don't subclass *`drm_framebuffer`* and use *`drm_gem_object`* for their backing storage.

Drivers without additional needs to validate framebuffers can simply use *`drm_gem_fb_create()`* and everything is wired up automatically. Other drivers can use all parts independently.

struct *drm_gem_object* ***`drm_gem_fb_get_obj`***(struct *drm_framebuffer* *fb, unsigned int plane)
Get GEM object backing the framebuffer

Parameters

`struct drm_framebuffer *fb`
Framebuffer

`unsigned int plane`
Plane index

Description

No additional reference is taken beyond the one that the `drm_frambuffer` already holds.

Return

Pointer to *`drm_gem_object`* for the given framebuffer and plane index or NULL if it does not exist.

void **`drm_gem_fb_destroy`**(struct *drm_framebuffer* *fb)
Free GEM backed framebuffer

Parameters

`struct drm_framebuffer *fb`
Framebuffer

Description

Frees a GEM backed framebuffer with its backing buffer(s) and the structure itself. Drivers can use this as their *`drm_framebuffer_funcs->destroy`* callback.

int **`drm_gem_fb_create_handle`**(struct *drm_framebuffer* *fb, struct *drm_file* *file, unsigned int *handle)
Create handle for GEM backed framebuffer

Parameters

struct drm_framebuffer *fb
Framebuffer

struct drm_file *file
DRM file to register the handle for

unsigned int *handle
Pointer to return the created handle

Description

This function creates a handle for the GEM object backing the framebuffer. Drivers can use this as their *drm_framebuffer_funcs->create_handle* callback. The GETFB IOCTL calls into this callback.

Return

0 on success or a negative error code on failure.

int **drm_gem_fb_init_with_funcs**(struct *drm_device* *dev, struct *drm_framebuffer* *fb, struct *drm_file* *file, const struct drm_mode_fb_cmd2 *mode_cmd, const struct *drm_framebuffer_funcs* *funcs)

Helper function for implementing *drm_mode_config_funcs.fb_create* callback in cases when the driver allocates a subclass of *struct drm_framebuffer*

Parameters

struct drm_device *dev
DRM device

struct drm_framebuffer *fb
framebuffer object

struct drm_file *file
DRM file that holds the GEM handle(s) backing the framebuffer

const struct drm_mode_fb_cmd2 *mode_cmd
Metadata from the userspace framebuffer creation request

const struct drm_framebuffer_funcs *funcs
vtable to be used for the new framebuffer object

Description

This function can be used to set *drm_framebuffer_funcs* for drivers that need custom framebuffer callbacks. Use *drm_gem_fb_create()* if you don't need to change *drm_framebuffer_funcs*. The function does buffer size validation. The buffer size validation is for a general case, though, so users should pay attention to the checks being appropriate for them or, at least, non-conflicting.

Return

Zero or a negative error code.

struct *drm_framebuffer* ***drm_gem_fb_create_with_funcs**(struct *drm_device* *dev, struct *drm_file* *file, const struct drm_mode_fb_cmd2 *mode_cmd, const struct *drm_framebuffer_funcs* *funcs)

Helper function for the *drm_mode_config_funcs.fb_create* callback

Parameters

struct drm_device *dev
DRM device

struct drm_file *file
DRM file that holds the GEM handle(s) backing the framebuffer

const struct drm_mode_fb_cmd2 *mode_cmd
Metadata from the userspace framebuffer creation request

const struct drm_framebuffer_funcs *funcs
vtable to be used for the new framebuffer object

Description

This function can be used to set *drm_framebuffer_funcs* for drivers that need custom framebuffer callbacks. Use *drm_gem_fb_create()* if you don't need to change *drm_framebuffer_funcs*. The function does buffer size validation.

Return

Pointer to a *drm_framebuffer* on success or an error pointer on failure.

struct *drm_framebuffer* ***drm_gem_fb_create**(struct *drm_device* *dev, struct *drm_file* *file, const struct drm_mode_fb_cmd2 *mode_cmd)

Helper function for the *drm_mode_config_funcs.fb_create* callback

Parameters

struct drm_device *dev
DRM device

struct drm_file *file
DRM file that holds the GEM handle(s) backing the framebuffer

const struct drm_mode_fb_cmd2 *mode_cmd
Metadata from the userspace framebuffer creation request

Description

This function creates a new framebuffer object described by `drm_mode_fb_cmd2`. This description includes handles for the buffer(s) backing the framebuffer.

If your hardware has special alignment or pitch requirements these should be checked before calling this function. The function does buffer size validation. Use *drm_gem_fb_create_with_dirty()* if you need framebuffer flushing.

Drivers can use this as their *drm_mode_config_funcs.fb_create* callback. The ADDFB2 IOCTL calls into this callback.

Return

Pointer to a *drm_framebuffer* on success or an error pointer on failure.

struct *drm_framebuffer* ***drm_gem_fb_create_with_dirty**(struct *drm_device* *dev, struct *drm_file* *file, const struct drm_mode_fb_cmd2 *mode_cmd)

Helper function for the *drm_mode_config_funcs.fb_create* callback

Parameters

struct drm_device *dev
DRM device

struct drm_file *file
DRM file that holds the GEM handle(s) backing the framebuffer

const struct drm_mode_fb_cmd2 *mode_cmd
Metadata from the userspace framebuffer creation request

Description

This function creates a new framebuffer object described by `drm_mode_fb_cmd2`. This description includes handles for the buffer(s) backing the framebuffer. *drm_atomic_helper_dirtyfb()* is used for the dirty callback giving framebuffer flushing through the atomic machinery. Use *drm_gem_fb_create()* if you don' t need the dirty callback. The function does buffer size validation.

Drivers should also call *drm_plane_enable_fb_damage_clips()* on all planes to enable userspace to use damage clips also with the ATOMIC IOCTL.

Drivers can use this as their *drm_mode_config_funcs.fb_create* callback. The ADDFB2 IOCTL calls into this callback.

Return

Pointer to a *drm_framebuffer* on success or an error pointer on failure.

int **drm_gem_fb_afbc_init**(struct *drm_device* *dev, const struct drm_mode_fb_cmd2 *mode_cmd, struct *drm_afbc_framebuffer* *afbc_fb)

Helper function for drivers using afbc to fill and validate all the afbc-specific *struct drm_afbc_framebuffer* members

Parameters

struct drm_device *dev
DRM device

const struct drm_mode_fb_cmd2 *mode_cmd
Metadata from the userspace framebuffer creation request

struct drm_afbc_framebuffer *afbc_fb
afbc framebuffer

Description

This function can be used by drivers which support afbc to complete the preparation of *struct drm_afbc_framebuffer*. It must be called after allocating the said struct and calling *drm_gem_fb_init_with_funcs()*. It is caller' s responsibility to put afbc_fb->base.obj objects in case the call is unsuccessful.

Return

Zero on success or a negative error value on failure.

int **drm_gem_fb_prepare_fb**(struct *drm_plane* *plane, struct *drm_plane_state* *state)

Prepare a GEM backed framebuffer

Parameters

struct drm_plane *plane
Plane

struct drm_plane_state *state
Plane state the fence will be attached to

Description

This function extracts the exclusive fence from *drm_gem_object.resv* and attaches it to plane state for the atomic helper to wait on. This is necessary to correctly implement implicit synchronization for any buffers shared as a struct `dma_buf`. This function can be used as the *drm_plane_helper_funcs.prepare_fb* callback.

There is no need for *drm_plane_helper_funcs.cleanup_fb* hook for simple gem based framebuffer drivers which have their buffers always pinned in memory.

See *drm_atomic_set_fence_for_plane()* for a discussion of implicit and explicit fencing in atomic modeset updates.

int **drm_gem_fb_simple_display_pipe_prepare_fb**(struct *drm_simple_display_pipe* *pipe, struct *drm_plane_state* *plane_state)

prepare_fb helper for *drm_simple_display_pipe*

Parameters

struct drm_simple_display_pipe *pipe
Simple display pipe

struct drm_plane_state *plane_state
Plane state

Description

This function uses *drm_gem_fb_prepare_fb()* to extract the exclusive fence from *drm_gem_object.resv* and attaches it to plane state for the atomic helper to wait on. This is necessary to correctly implement implicit synchronization for any buffers shared as a struct `dma_buf`. Drivers can use this as their *drm_simple_display_pipe_funcs.prepare_fb* callback.

See *drm_atomic_set_fence_for_plane()* for a discussion of implicit and explicit fencing in atomic modeset updates.

5.8 Bridges

5.8.1 Overview

struct drm_bridge represents a device that hangs on to an encoder. These are handy when a regular *drm_encoder* entity isn't enough to represent the entire encoder chain.

A bridge is always attached to a single *drm_encoder* at a time, but can be either connected to it directly, or through a chain of bridges:

```
[ CRTC ---> ] Encoder ---> Bridge A ---> Bridge B
```

Here, the output of the encoder feeds to bridge A, and that furthers feeds to bridge B. Bridge chains can be arbitrarily long, and shall be fully linear: Chaining multiple bridges to the output of a bridge, or the same bridge to the output of different bridges, is not supported.

Display drivers are responsible for linking encoders with the first bridge in the chains. This is done by acquiring the appropriate bridge with *of_drm_find_bridge()* or *drm_of_find_panel_or_bridge()*, or creating it for a panel with *drm_panel_bridge_add_typed()* (or the managed version *devm_drm_panel_bridge_add_typed()*). Once acquired, the bridge shall be attached to the encoder with a call to *drm_bridge_attach()*.

Bridges are responsible for linking themselves with the next bridge in the chain, if any. This is done the same way as for encoders, with the call to *drm_bridge_attach()* occurring in the *drm_bridge_funcs.attach* operation.

Once these links are created, the bridges can participate along with encoder functions to perform mode validation and fixup (through *drm_bridge_chain_mode_valid()* and *drm_atomic_bridge_chain_check()*), mode setting (through *drm_bridge_chain_mode_set()*), enable (through *drm_atomic_bridge_chain_pre_enable()* and *drm_atomic_bridge_chain_enable()*) and disable (through *drm_atomic_bridge_chain_disable()* and *drm_atomic_bridge_chain_post_disable()*). Those functions call the corresponding operations provided in *drm_bridge_funcs* in sequence for all bridges in the chain.

For display drivers that use the atomic helpers *drm_atomic_helper_check_modeset()*, *drm_atomic_helper_commit_modeset_enables()* and *drm_atomic_helper_commit_modeset_disables()* (either directly in hand-rolled commit check and commit tail handlers, or through the higher-level *drm_atomic_helper_check()* and *drm_atomic_helper_commit_tail()* or *drm_atomic_helper_commit_tail_rpm()* helpers), this is done transparently and requires no intervention from the driver. For other drivers, the relevant DRM bridge chain functions shall be called manually.

Bridges also participate in implementing the *drm_connector* at the end of the bridge chain. Display drivers may use the *drm_bridge_connector_init()* helper to create the *drm_connector*, or implement it manually on top of the connector-related operations exposed by the bridge (see the overview documentation of bridge operations for more details).

drm_bridge, like *drm_panel*, aren't *drm_mode_object* entities like planes, CRTCs, encoders or connectors and hence are not visible to userspace. They just provide additional hooks to get the desired output at the end of the encoder chain.

5.8.2 Bridge Operations

Bridge drivers expose operations through the *drm_bridge_funcs* structure. The DRM internals (atomic and CRTC helpers) use the helpers defined in drm_bridge.c to call bridge operations. Those operations are divided in three big categories to support different parts of the bridge usage.

- The encoder-related operations support control of the bridges in the chain, and are roughly counterparts to the *drm_encoder_helper_funcs* operations. They are used by the legacy CRTC and the atomic modeset helpers to perform mode validation, fixup and setting, and enable and disable the bridge automatically.

  The enable and disable operations are split in *drm_bridge_funcs.pre_enable*, *drm_bridge_funcs.enable*, *drm_bridge_funcs.disable* and *drm_bridge_funcs.post_disable* to provide finer-grained control.

  Bridge drivers may implement the legacy version of those operations, or the atomic version (prefixed with atomic_), in which case they shall also implement the atomic state bookkeeping operations (*drm_bridge_funcs.atomic_duplicate_state*, *drm_bridge_funcs.atomic_destroy_state* and *drm_bridge_funcs.reset*). Mixing atomic and non-atomic versions of the operations is not supported.

- The bus format negotiation operations *drm_bridge_funcs.atomic_get_output_bus_fmts* and *drm_bridge_funcs.atomic_get_input_bus_fmts* allow bridge drivers to negotiate the formats transmitted between bridges in the chain when multiple formats are supported. Negotiation for formats is performed transparently for display drivers by the atomic modeset helpers. Only atomic versions of those operations exist, bridge drivers that need to implement them shall thus also implement the atomic version of the encoder-related operations. This feature is not supported by the legacy CRTC helpers.

- The connector-related operations support implementing a *drm_connector* based on a chain of bridges. DRM bridges traditionally create a *drm_connector* for bridges meant to be used at the end of the chain. This puts additional burden on bridge drivers, especially for bridges that may be used in the middle of a chain or at the end of it. Furthermore, it requires all operations of the *drm_connector* to be handled by a single bridge, which doesn't always match the hardware architecture.

  To simplify bridge drivers and make the connector implementation more flexible, a new model allows bridges to unconditionally skip creation of *drm_connector* and instead expose *drm_bridge_funcs* operations to support an externally-implemented *drm_connector*.

Those operations are *drm_bridge_funcs.detect*, *drm_bridge_funcs.get_modes*, *drm_bridge_funcs.get_edid*, *drm_bridge_funcs.hpd_notify*, *drm_bridge_funcs.hpd_enable* and *drm_bridge_funcs.hpd_disable*. When implemented, display drivers shall create a *drm_connector* instance for each chain of bridges, and implement those connector instances based on the bridge connector operations.

Bridge drivers shall implement the connector-related operations for all the features that the bridge hardware support. For instance, if a bridge supports reading EDID, the *drm_bridge_funcs.get_edid* shall be implemented. This however doesn't mean that the DDC lines are wired to the bridge on a particular platform, as they could also be connected to an I2C controller of the SoC. Support for the connector-related operations on the running platform is reported through the *drm_bridge.ops* flags. Bridge drivers shall detect which operations they can support on the platform (usually this information is provided by ACPI or DT), and set the *drm_bridge.ops* flags for all supported operations. A flag shall only be set if the corresponding *drm_bridge_funcs* operation is implemented, but an implemented operation doesn't necessarily imply that the corresponding flag will be set. Display drivers shall use the *drm_bridge.ops* flags to decide which bridge to delegate a connector operation to. This mechanism allows providing a single static const *drm_bridge_funcs* instance in bridge drivers, improving security by storing function pointers in read-only memory.

In order to ease transition, bridge drivers may support both the old and new models by making connector creation optional and implementing the connected-related bridge operations. Connector creation is then controlled by the flags argument to the *drm_bridge_attach()* function. Display drivers that support the new model and create connectors themselves shall set the `DRM_BRIDGE_ATTACH_NO_CONNECTOR` flag, and bridge drivers shall then skip connector creation. For intermediate bridges in the chain, the flag shall be passed to the *drm_bridge_attach()* call for the downstream bridge. Bridge drivers that implement the new model only shall return an error from their *drm_bridge_funcs.attach* handler when the `DRM_BRIDGE_ATTACH_NO_CONNECTOR` flag is not set. New display drivers should use the new model, and convert the bridge drivers they use if needed, in order to gradually transition to the new model.

5.8.3 Bridge Connector Helper

The DRM bridge connector helper object provides a DRM connector implementation that wraps a chain of *struct drm_bridge*. The connector operations are fully implemented based on the operations of the bridges in the chain, and don't require any intervention from the display controller driver at runtime.

To use the helper, display controller drivers create a bridge connector with a call to *drm_bridge_connector_init()*. This associates the newly created connector with the chain of bridges passed to the function and registers it with the DRM device. At that point the connector becomes fully usable, no further operation is needed.

The DRM bridge connector operations are implemented based on the operations provided by the bridges in the chain. Each connector operation is delegated to the bridge closest to the connector (at the end of the chain) that provides the relevant functionality.

To make use of this helper, all bridges in the chain shall report bridge operation flags (*drm_bridge->ops*) and bridge output type (*drm_bridge->type*), as well as the DRM_BRIDGE_ATTACH_NO_CONNECTOR attach flag (none of the bridges shall create a DRM connector directly).

5.8.4 Bridge Helper Reference

enum **drm_bridge_attach_flags**

Flags for *drm_bridge_funcs.attach*

Constants

DRM_BRIDGE_ATTACH_NO_CONNECTOR
When this flag is set the bridge shall not create a drm_connector.

struct **drm_bridge_funcs**

drm_bridge control functions

Definition

```
struct drm_bridge_funcs {
  int (*attach)(struct drm_bridge *bridge, enum drm_bridge_attach_
↪flags flags);
  void (*detach)(struct drm_bridge *bridge);
  enum drm_mode_status (*mode_valid)(struct drm_bridge *bridge,
↪const struct drm_display_info *info, const struct drm_display_
↪mode *mode);
  bool (*mode_fixup)(struct drm_bridge *bridge,const struct drm_
↪display_mode *mode, struct drm_display_mode *adjusted_mode);
  void (*disable)(struct drm_bridge *bridge);
  void (*post_disable)(struct drm_bridge *bridge);
  void (*mode_set)(struct drm_bridge *bridge,const struct drm_
↪display_mode *mode, const struct drm_display_mode *adjusted_mode);
  void (*pre_enable)(struct drm_bridge *bridge);
  void (*enable)(struct drm_bridge *bridge);
  void (*atomic_pre_enable)(struct drm_bridge *bridge, struct drm_
↪bridge_state *old_bridge_state);
  void (*atomic_enable)(struct drm_bridge *bridge, struct drm_
↪bridge_state *old_bridge_state);
  void (*atomic_disable)(struct drm_bridge *bridge, struct drm_
↪bridge_state *old_bridge_state);
  void (*atomic_post_disable)(struct drm_bridge *bridge, struct drm_
↪bridge_state *old_bridge_state);
  struct drm_bridge_state *(*atomic_duplicate_state)(struct drm_
↪bridge *bridge);
  void (*atomic_destroy_state)(struct drm_bridge *bridge, struct␣
↪drm_bridge_state *state);
  u32 *(*atomic_get_output_bus_fmts)(struct drm_bridge *bridge,
↪struct drm_bridge_state *bridge_state,struct drm_crtc_state *crtc_
```

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```
↪state,struct drm_connector_state *conn_state, unsigned int *num_
↪output_fmts);
  u32 *(*atomic_get_input_bus_fmts)(struct drm_bridge *bridge,
↪struct drm_bridge_state *bridge_state,struct drm_crtc_state *crtc_
↪state,struct drm_connector_state *conn_state,u32 output_fmt,␣
↪unsigned int *num_input_fmts);
  int (*atomic_check)(struct drm_bridge *bridge,struct drm_bridge_
↪state *bridge_state,struct drm_crtc_state *crtc_state, struct drm_
↪connector_state *conn_state);
  struct drm_bridge_state *(*atomic_reset)(struct drm_bridge␣
↪*bridge);
  enum drm_connector_status (*detect)(struct drm_bridge *bridge);
  int (*get_modes)(struct drm_bridge *bridge, struct drm_connector␣
↪*connector);
  struct edid *(*get_edid)(struct drm_bridge *bridge, struct drm_
↪connector *connector);
  void (*hpd_notify)(struct drm_bridge *bridge, enum drm_connector_
↪status status);
  void (*hpd_enable)(struct drm_bridge *bridge);
  void (*hpd_disable)(struct drm_bridge *bridge);
};
```

Members

attach
This callback is invoked whenever our bridge is being attached to a *drm_encoder*. The flags argument tunes the behaviour of the attach operation (see DRM_BRIDGE_ATTACH_*).

The **attach** callback is optional.

RETURNS:

Zero on success, error code on failure.

detach
This callback is invoked whenever our bridge is being detached from a *drm_encoder*.

The **detach** callback is optional.

mode_valid
This callback is used to check if a specific mode is valid in this bridge. This should be implemented if the bridge has some sort of restriction in the modes it can display. For example, a given bridge may be responsible to set a clock value. If the clock can not produce all the values for the available modes then this callback can be used to restrict the number of modes to only the ones that can be displayed.

This hook is used by the probe helpers to filter the mode list in *drm_helper_probe_single_connector_modes()*, and it is used by the atomic helpers to validate modes supplied by userspace in *drm_atomic_helper_check_modeset()*.

The **mode_valid** callback is optional.

NOTE:

Since this function is both called from the check phase of an atomic commit, and the mode validation in the probe paths it is not allowed to look at anything else but the passed-in mode, and validate it against configuration-invariant hardware constraints. Any further limits which depend upon the configuration can only be checked in **mode_fixup**.

RETURNS:

drm_mode_status Enum

mode_fixup
This callback is used to validate and adjust a mode. The parameter mode is the display mode that should be fed to the next element in the display chain, either the final *drm_connector* or the next *drm_bridge*. The parameter adjusted_mode is the input mode the bridge requires. It can be modified by this callback and does not need to match mode. See also *drm_crtc_state.adjusted_mode* for more details.

This is the only hook that allows a bridge to reject a modeset. If this function passes all other callbacks must succeed for this configuration.

The mode_fixup callback is optional. *drm_bridge_funcs.mode_fixup()* is not called when *drm_bridge_funcs.atomic_check()* is implemented, so only one of them should be provided.

NOTE:

This function is called in the check phase of atomic modesets, which can be aborted for any reason (including on userspace's request to just check whether a configuration would be possible). Drivers MUST NOT touch any persistent state (hardware or software) or data structures except the passed in **state** parameter.

Also beware that userspace can request its own custom modes, neither core nor helpers filter modes to the list of probe modes reported by the GETCONNECTOR IOCTL and stored in *drm_connector.modes*. To ensure that modes are filtered consistently put any bridge constraints and limits checks into **mode_valid**.

RETURNS:

True if an acceptable configuration is possible, false if the modeset operation should be rejected.

disable
This callback should disable the bridge. It is called right before the preceding element in the display pipe is disabled. If the preceding element is a bridge this means it's called before that bridge's **disable** vfunc. If the preceding element is a *drm_encoder* it's called right before the *drm_encoder_helper_funcs.disable*, *drm_encoder_helper_funcs.prepare* or *drm_encoder_helper_funcs.dpms* hook.

The bridge can assume that the display pipe (i.e. clocks and timing signals) feeding it is still running when this callback is called.

The **disable** callback is optional.

post_disable
This callback should disable the bridge. It is called right after the preceding element in the display pipe is disabled. If the preceding element is a bridge this means it's called after that bridge's **post_disable** function. If the preceding element is a *drm_encoder* it's called right after the encoder's *drm_encoder_helper_funcs.disable*, *drm_encoder_helper_funcs.prepare* or *drm_encoder_helper_funcs.dpms* hook.

The bridge must assume that the display pipe (i.e. clocks and timing signals) feeding it is no longer running when this callback is called.

The **post_disable** callback is optional.

mode_set
This callback should set the given mode on the bridge. It is called after the **mode_set** callback for the preceding element in the display pipeline has been called already. If the bridge is the first element then this would be *drm_encoder_helper_funcs.mode_set*. The display pipe (i.e. clocks and timing signals) is off when this function is called.

The adjusted_mode parameter is the mode output by the CRTC for the first bridge in the chain. It can be different from the mode parameter that contains the desired mode for the connector at the end of the bridges chain, for instance when the first bridge in the chain performs scaling. The adjusted mode is mostly useful for the first bridge in the chain and is likely irrelevant for the other bridges.

For atomic drivers the adjusted_mode is the mode stored in *drm_crtc_state.adjusted_mode*.

NOTE:

If a need arises to store and access modes adjusted for other locations than the connection between the CRTC and the first bridge, the DRM framework will have to be extended with DRM bridge states.

pre_enable
This callback should enable the bridge. It is called right before the preceding element in the display pipe is enabled. If the preceding element is a bridge this means it's called before that bridge's **pre_enable** function. If the preceding element is a *drm_encoder* it's called right before the encoder's *drm_encoder_helper_funcs.enable*, *drm_encoder_helper_funcs.commit* or *drm_encoder_helper_funcs.dpms* hook.

The display pipe (i.e. clocks and timing signals) feeding this bridge will not yet be running when this callback is called. The bridge must not enable the display link feeding the next bridge in the chain (if there is one) when this callback is called.

The **pre_enable** callback is optional.

enable
This callback should enable the bridge. It is called right after the preceding element in the display pipe is enabled. If the preceding element is a bridge this means it's called after that bridge's **enable** function. If the

preceding element is a *drm_encoder* it’ s called right after the encoder’ s *drm_encoder_helper_funcs.enable*, *drm_encoder_helper_funcs.commit* or *drm_encoder_helper_funcs.dpms* hook.

The bridge can assume that the display pipe (i.e. clocks and timing signals) feeding it is running when this callback is called. This callback must enable the display link feeding the next bridge in the chain if there is one.

The **enable** callback is optional.

atomic_pre_enable
This callback should enable the bridge. It is called right before the preceding element in the display pipe is enabled. If the preceding element is a bridge this means it’s called before that bridge’s **atomic_pre_enable** or **pre_enable** function. If the preceding element is a *drm_encoder* it’ s called right before the encoder’ s *drm_encoder_helper_funcs.atomic_enable* hook.

The display pipe (i.e. clocks and timing signals) feeding this bridge will not yet be running when this callback is called. The bridge must not enable the display link feeding the next bridge in the chain (if there is one) when this callback is called.

Note that this function will only be invoked in the context of an atomic commit. It will not be invoked from *drm_bridge_chain_pre_enable*. It would be prudent to also provide an implementation of **pre_enable** if you are expecting driver calls into *drm_bridge_chain_pre_enable*.

The **atomic_pre_enable** callback is optional.

atomic_enable
This callback should enable the bridge. It is called right after the preceding element in the display pipe is enabled. If the preceding element is a bridge this means it’ s called after that bridge’ s **atomic_enable** or **enable** function. If the preceding element is a *drm_encoder* it’ s called right after the encoder’ s *drm_encoder_helper_funcs.atomic_enable* hook.

The bridge can assume that the display pipe (i.e. clocks and timing signals) feeding it is running when this callback is called. This callback must enable the display link feeding the next bridge in the chain if there is one.

Note that this function will only be invoked in the context of an atomic commit. It will not be invoked from *drm_bridge_chain_enable*. It would be prudent to also provide an implementation of **enable** if you are expecting driver calls into *drm_bridge_chain_enable*.

The **atomic_enable** callback is optional.

atomic_disable
This callback should disable the bridge. It is called right before the preceding element in the display pipe is disabled. If the preceding element is a bridge this means it’ s called before that bridge’ s **atomic_disable** or **disable** vfunc. If the preceding element is a *drm_encoder* it’ s called right before the *drm_encoder_helper_funcs.atomic_disable* hook.

The bridge can assume that the display pipe (i.e. clocks and timing signals) feeding it is still running when this callback is called.

Note that this function will only be invoked in the context of an atomic commit. It will not be invoked from *drm_bridge_chain_disable*. It would be prudent to also provide an implementation of **disable** if you are expecting driver calls into *drm_bridge_chain_disable*.

The **atomic_disable** callback is optional.

atomic_post_disable
This callback should disable the bridge. It is called right after the preceding element in the display pipe is disabled. If the preceding element is a bridge this means it's called after that bridge's **atomic_post_disable** or **post_disable** function. If the preceding element is a *drm_encoder* it's called right after the encoder's *drm_encoder_helper_funcs.atomic_disable* hook.

The bridge must assume that the display pipe (i.e. clocks and timing signals) feeding it is no longer running when this callback is called.

Note that this function will only be invoked in the context of an atomic commit. It will not be invoked from *drm_bridge_chain_post_disable*. It would be prudent to also provide an implementation of **post_disable** if you are expecting driver calls into *drm_bridge_chain_post_disable*.

The **atomic_post_disable** callback is optional.

atomic_duplicate_state
Duplicate the current bridge state object (which is guaranteed to be non-NULL).

The atomic_duplicate_state hook is mandatory if the bridge implements any of the atomic hooks, and should be left unassigned otherwise. For bridges that don't subclass *drm_bridge_state*, the *drm_atomic_helper_bridge_duplicate_state()* helper function shall be used to implement this hook.

RETURNS: A valid drm_bridge_state object or NULL if the allocation fails.

atomic_destroy_state
Destroy a bridge state object previously allocated by *drm_bridge_funcs.atomic_duplicate_state()*.

The atomic_destroy_state hook is mandatory if the bridge implements any of the atomic hooks, and should be left unassigned otherwise. For bridges that don't subclass *drm_bridge_state*, the *drm_atomic_helper_bridge_destroy_state()* helper function shall be used to implement this hook.

atomic_get_output_bus_fmts
Return the supported bus formats on the output end of a bridge. The returned array must be allocated with kmalloc() and will be freed by the caller. If the allocation fails, NULL should be returned. num_output_fmts must be set to the returned array size. Formats listed in the returned array should be listed in decreasing preference order (the core will try all formats until it finds one that works).

This method is only called on the last element of the bridge chain as part of the bus format negotiation process that happens in *drm_atomic_bridge_chain_select_bus_fmts`(). This method is* *optional. When not implemented, the core will fall back to :c:type:`drm_connector.display_info*.bus_formats[0] if *drm_connector.display_info*.num_bus_formats > 0, or to MEDIA_BUS_FMT_FIXED otherwise.

atomic_get_input_bus_fmts
Return the supported bus formats on the input end of a bridge for a specific output bus format.

The returned array must be allocated with kmalloc() and will be freed by the caller. If the allocation fails, NULL should be returned. num_input_fmts must be set to the returned array size. Formats listed in the returned array should be listed in decreasing preference order (the core will try all formats until it finds one that works). When the format is not supported NULL should be returned and num_input_fmts should be set to 0.

This method is called on all elements of the bridge chain as part of the bus format negotiation process that happens in drm_atomic_bridge_chain_select_bus_fmts(). This method is optional. When not implemented, the core will bypass bus format negotiation on this element of the bridge without failing, and the previous element in the chain will be passed MEDIA_BUS_FMT_FIXED as its output bus format.

Bridge drivers that need to support being linked to bridges that are not supporting bus format negotiation should handle the output_fmt == MEDIA_BUS_FMT_FIXED case appropriately, by selecting a sensible default value or extracting this information from somewhere else (FW property, *drm_display_mode*, *drm_display_info*, …)

Note: Even if input format selection on the first bridge has no impact on the negotiation process (bus format negotiation stops once we reach the first element of the chain), drivers are expected to return accurate input formats as the input format may be used to configure the CRTC output appropriately.

atomic_check
This method is responsible for checking bridge state correctness. It can also check the state of the surrounding components in chain to make sure the whole pipeline can work properly.

drm_bridge_funcs.atomic_check() hooks are called in reverse order (from the last to the first bridge).

This method is optional. *drm_bridge_funcs.mode_fixup()* is not called when *drm_bridge_funcs.atomic_check()* is implemented, so only one of them should be provided.

If drivers need to tweak *drm_bridge_state.input_bus_cfg*.flags or *drm_bridge_state.output_bus_cfg*.flags it should happen in this function. By default the *drm_bridge_state.output_bus_cfg*.flags field is set to the next bridge *drm_bridge_state.input_bus_cfg*.flags value or *drm_connector.display_info*.bus_flags if the bridge is the last element in the chain.

RETURNS: zero if the check passed, a negative error code otherwise.

atomic_reset
Reset the bridge to a predefined state (or retrieve its current state) and return

a *drm_bridge_state* object matching this state. This function is called at attach time.

The atomic_reset hook is mandatory if the bridge implements any of the atomic hooks, and should be left unassigned otherwise. For bridges that don't subclass *drm_bridge_state*, the *drm_atomic_helper_bridge_reset()* helper function shall be used to implement this hook.

Note that the atomic_reset() semantics is not exactly matching the reset() semantics found on other components (connector, plane, …).

1. The reset operation happens when the bridge is attached, not when *drm_mode_config_reset()* is called
2. It's meant to be used exclusively on bridges that have been converted to the ATOMIC API

RETURNS: A valid drm_bridge_state object in case of success, an ERR_PTR() giving the reason of the failure otherwise.

detect
Check if anything is attached to the bridge output.

This callback is optional, if not implemented the bridge will be considered as always having a component attached to its output. Bridges that implement this callback shall set the DRM_BRIDGE_OP_DETECT flag in their *drm_bridge->ops*.

RETURNS:

drm_connector_status indicating the bridge output status.

get_modes
Fill all modes currently valid for the sink into the *drm_connector* with *drm_mode_probed_add()*.

The **get_modes** callback is mostly intended to support non-probeable displays such as many fixed panels. Bridges that support reading EDID shall leave **get_modes** unimplemented and implement the *drm_bridge_funcs->get_edid* callback instead.

This callback is optional. Bridges that implement it shall set the DRM_BRIDGE_OP_MODES flag in their *drm_bridge->ops*.

The connector parameter shall be used for the sole purpose of filling modes, and shall not be stored internally by bridge drivers for future usage.

RETURNS:

The number of modes added by calling *drm_mode_probed_add()*.

get_edid
Read and parse the EDID data of the connected display.

The **get_edid** callback is the preferred way of reporting mode information for a display connected to the bridge output. Bridges that support reading EDID shall implement this callback and leave the **get_modes** callback unimplemented.

The caller of this operation shall first verify the output connection status and refrain from reading EDID from a disconnected output.

This callback is optional. Bridges that implement it shall set the DRM_BRIDGE_OP_EDID flag in their *drm_bridge->ops*.

The connector parameter shall be used for the sole purpose of EDID retrieval and parsing, and shall not be stored internally by bridge drivers for future usage.

RETURNS:

An edid structure newly allocated with kmalloc() (or similar) on success, or NULL otherwise. The caller is responsible for freeing the returned edid structure with kfree().

hpd_notify
Notify the bridge of hot plug detection.

This callback is optional, it may be implemented by bridges that need to be notified of display connection or disconnection for internal reasons. One use case is to reset the internal state of CEC controllers for HDMI bridges.

hpd_enable
Enable hot plug detection. From now on the bridge shall call *drm_bridge_hpd_notify()* each time a change is detected in the output connection status, until hot plug detection gets disabled with **hpd_disable**.

This callback is optional and shall only be implemented by bridges that support hot-plug notification without polling. Bridges that implement it shall also implement the **hpd_disable** callback and set the DRM_BRIDGE_OP_HPD flag in their *drm_bridge->ops*.

hpd_disable
Disable hot plug detection. Once this function returns the bridge shall not call *drm_bridge_hpd_notify()* when a change in the output connection status occurs.

This callback is optional and shall only be implemented by bridges that support hot-plug notification without polling. Bridges that implement it shall also implement the **hpd_enable** callback and set the DRM_BRIDGE_OP_HPD flag in their *drm_bridge->ops*.

struct **drm_bridge_timings**

timing information for the bridge

Definition

```
struct drm_bridge_timings {
  u32 input_bus_flags;
  u32 setup_time_ps;
  u32 hold_time_ps;
  bool dual_link;
};
```

Members

input_bus_flags
Tells what additional settings for the pixel data on the bus this bridge requires (like pixel signal polarity). See also *drm_display_info->bus_flags*.

setup_time_ps
Defines the time in picoseconds the input data lines must be stable before the clock edge.

hold_time_ps
Defines the time in picoseconds taken for the bridge to sample the input signal after the clock edge.

dual_link
True if the bus operates in dual-link mode. The exact meaning is dependent on the bus type. For LVDS buses, this indicates that even- and odd-numbered pixels are received on separate links.

enum **drm_bridge_ops**
Bitmask of operations supported by the bridge

Constants

DRM_BRIDGE_OP_DETECT
The bridge can detect displays connected to its output. Bridges that set this flag shall implement the *drm_bridge_funcs->detect* callback.

DRM_BRIDGE_OP_EDID
The bridge can retrieve the EDID of the display connected to its output. Bridges that set this flag shall implement the *drm_bridge_funcs->get_edid* callback.

DRM_BRIDGE_OP_HPD
The bridge can detect hot-plug and hot-unplug without requiring polling. Bridges that set this flag shall implement the *drm_bridge_funcs->hpd_enable* and *drm_bridge_funcs->hpd_disable* callbacks if they support enabling and disabling hot-plug detection dynamically.

DRM_BRIDGE_OP_MODES
The bridge can retrieve the modes supported by the display at its output. This does not include reading EDID which is separately covered by **DRM_BRIDGE_OP_EDID**. Bridges that set this flag shall implement the *drm_bridge_funcs->get_modes* callback.

struct **drm_bridge**
central DRM bridge control structure

Definition

```
struct drm_bridge {
  struct drm_private_obj base;
  struct drm_device *dev;
  struct drm_encoder *encoder;
  struct list_head chain_node;
#ifdef CONFIG_OF;
  struct device_node *of_node;
```

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```
#endif;
  struct list_head list;
  const struct drm_bridge_timings *timings;
  const struct drm_bridge_funcs *funcs;
  void *driver_private;
  enum drm_bridge_ops ops;
  int type;
  bool interlace_allowed;
  struct i2c_adapter *ddc;
  struct mutex hpd_mutex;
  void (*hpd_cb)(void *data, enum drm_connector_status status);
  void *hpd_data;
};
```

Members

`base`
inherit from `drm_private_object`

`dev`
DRM device this bridge belongs to

`encoder`
encoder to which this bridge is connected

`chain_node`
used to form a bridge chain

`of_node`
device node pointer to the bridge

`list`
to keep track of all added bridges

`timings`
the timing specification for the bridge, if any (may be NULL)

`funcs`
control functions

`driver_private`
pointer to the bridge driver’ s internal context

`ops`
bitmask of operations supported by the bridge

`type`
Type of the connection at the bridge output (DRM_MODE_CONNECTOR_*). For bridges at the end of this chain this identifies the type of connected display.

`interlace_allowed`
Indicate that the bridge can handle interlaced modes.

`ddc`
Associated I2C adapter for DDC access, if any.

hpd_mutex
: Protects the **hpd_cb** and **hpd_data** fields.

hpd_cb
: Hot plug detection callback, registered with *drm_bridge_hpd_enable()*.

hpd_data
: Private data passed to the Hot plug detection callback **hpd_cb**.

struct *drm_bridge* ***drm_bridge_get_next_bridge**(struct *drm_bridge* *bridge)

Get the next bridge in the chain

Parameters

struct drm_bridge *bridge
: bridge object

Return

the next bridge in the chain after **bridge**, or NULL if **bridge** is the last.

struct *drm_bridge* ***drm_bridge_get_prev_bridge**(struct *drm_bridge* *bridge)

Get the previous bridge in the chain

Parameters

struct drm_bridge *bridge
: bridge object

Return

the previous bridge in the chain, or NULL if **bridge** is the first.

struct *drm_bridge* ***drm_bridge_chain_get_first_bridge**(struct *drm_encoder* *encoder)

Get the first bridge in the chain

Parameters

struct drm_encoder *encoder
: encoder object

Return

the first bridge in the chain, or NULL if **encoder** has no bridge attached to it.

drm_for_each_bridge_in_chain

`drm_for_each_bridge_in_chain (encoder, bridge)`

Iterate over all bridges present in a chain

Parameters

encoder
: the encoder to iterate bridges on

bridge
: a bridge pointer updated to point to the current bridge at each iteration

Description

Iterate over all bridges present in the bridge chain attached to **encoder**.

void **drm_bridge_add**(struct *drm_bridge* *bridge)

add the given bridge to the global bridge list

Parameters

struct drm_bridge *bridge
bridge control structure

void **drm_bridge_remove**(struct *drm_bridge* *bridge)

remove the given bridge from the global bridge list

Parameters

struct drm_bridge *bridge
bridge control structure

int **drm_bridge_attach**(struct *drm_encoder* *encoder, struct *drm_bridge* *bridge, struct *drm_bridge* *previous, enum *drm_bridge_attach_flags* flags)

attach the bridge to an encoder's chain

Parameters

struct drm_encoder *encoder
DRM encoder

struct drm_bridge *bridge
bridge to attach

struct drm_bridge *previous
previous bridge in the chain (optional)

enum drm_bridge_attach_flags flags
DRM_BRIDGE_ATTACH_* flags

Description

Called by a kms driver to link the bridge to an encoder's chain. The previous argument specifies the previous bridge in the chain. If NULL, the bridge is linked directly at the encoder's output. Otherwise it is linked at the previous bridge's output.

If non-NULL the previous bridge must be already attached by a call to this function.

Note that bridges attached to encoders are auto-detached during encoder cleanup in `drm_encoder_cleanup()`, so `drm_bridge_attach()` should generally *not* be balanced with a drm_bridge_detach() in driver code.

Return

Zero on success, error code on failure

bool **drm_bridge_chain_mode_fixup**(struct *drm_bridge* *bridge, const struct *drm_display_mode* *mode, struct *drm_display_mode* *adjusted_mode)

fixup proposed mode for all bridges in the encoder chain

Parameters

struct drm_bridge *bridge
bridge control structure

const struct drm_display_mode *mode
desired mode to be set for the bridge

struct drm_display_mode *adjusted_mode
updated mode that works for this bridge

Description

Calls *drm_bridge_funcs.mode_fixup* for all the bridges in the encoder chain, starting from the first bridge to the last.

Note

the bridge passed should be the one closest to the encoder

Return

true on success, false on failure

enum *drm_mode_status* **drm_bridge_chain_mode_valid**(struct *drm_bridge* *bridge, const struct *drm_display_info* *info, const struct *drm_display_mode* *mode)

validate the mode against all bridges in the encoder chain.

Parameters

struct drm_bridge *bridge
bridge control structure

const struct drm_display_info *info
display info against which the mode shall be validated

const struct drm_display_mode *mode
desired mode to be validated

Description

Calls *drm_bridge_funcs.mode_valid* for all the bridges in the encoder chain, starting from the first bridge to the last. If at least one bridge does not accept the mode the function returns the error code.

Note

the bridge passed should be the one closest to the encoder.

Return

MODE_OK on success, drm_mode_status Enum error code on failure

void **drm_bridge_chain_disable**(struct *drm_bridge* *bridge)

disables all bridges in the encoder chain

Parameters

struct drm_bridge *bridge
bridge control structure

Description

Calls *drm_bridge_funcs.disable* op for all the bridges in the encoder chain, starting from the last bridge to the first. These are called before calling the encoder's prepare op.

Note

the bridge passed should be the one closest to the encoder

void **drm_bridge_chain_post_disable**(struct *drm_bridge* *bridge)

cleans up after disabling all bridges in the encoder chain

Parameters

struct drm_bridge *bridge
bridge control structure

Description

Calls *drm_bridge_funcs.post_disable* op for all the bridges in the encoder chain, starting from the first bridge to the last. These are called after completing the encoder's prepare op.

Note

the bridge passed should be the one closest to the encoder

void **drm_bridge_chain_mode_set**(struct *drm_bridge* *bridge, const struct *drm_display_mode* *mode, const struct *drm_display_mode* *adjusted_mode)

set proposed mode for all bridges in the encoder chain

Parameters

struct drm_bridge *bridge
bridge control structure

const struct drm_display_mode *mode
desired mode to be set for the encoder chain

const struct drm_display_mode *adjusted_mode
updated mode that works for this encoder chain

Description

Calls *drm_bridge_funcs.mode_set* op for all the bridges in the encoder chain, starting from the first bridge to the last.

Note

the bridge passed should be the one closest to the encoder

void **drm_bridge_chain_pre_enable**(struct *drm_bridge* *bridge)

prepares for enabling all bridges in the encoder chain

Parameters

struct drm_bridge *bridge
bridge control structure

Description

Calls *drm_bridge_funcs.pre_enable* op for all the bridges in the encoder chain, starting from the last bridge to the first. These are called before calling the encoder’ s commit op.

Note

the bridge passed should be the one closest to the encoder

void **drm_bridge_chain_enable**(struct *drm_bridge* *bridge)

enables all bridges in the encoder chain

Parameters

struct drm_bridge *bridge
bridge control structure

Description

Calls *drm_bridge_funcs.enable* op for all the bridges in the encoder chain, starting from the first bridge to the last. These are called after completing the encoder’ s commit op.

Note that the bridge passed should be the one closest to the encoder

void **drm_atomic_bridge_chain_disable**(struct *drm_bridge* *bridge, struct *drm_atomic_state* *old_state)

disables all bridges in the encoder chain

Parameters

struct drm_bridge *bridge
bridge control structure

struct drm_atomic_state *old_state
old atomic state

Description

Calls *drm_bridge_funcs.atomic_disable* (falls back on *drm_bridge_funcs.disable*) op for all the bridges in the encoder chain, starting from the last bridge to the first. These are called before calling *drm_encoder_helper_funcs.atomic_disable*

Note

the bridge passed should be the one closest to the encoder

void **drm_atomic_bridge_chain_post_disable**(struct *drm_bridge* *bridge, struct *drm_atomic_state* *old_state)

cleans up after disabling all bridges in the encoder chain

Parameters

struct drm_bridge *bridge
bridge control structure

struct drm_atomic_state *old_state
old atomic state

Description

Calls *drm_bridge_funcs.atomic_post_disable* (falls back on *drm_bridge_funcs.post_disable*) op for all the bridges in the encoder chain, starting from the first bridge to the last. These are called after completing *drm_encoder_helper_funcs.atomic_disable*

Note

the bridge passed should be the one closest to the encoder

void **drm_atomic_bridge_chain_pre_enable**(struct *drm_bridge* *bridge, struct *drm_atomic_state* *old_state)

prepares for enabling all bridges in the encoder chain

Parameters

struct drm_bridge *bridge
bridge control structure

struct drm_atomic_state *old_state
old atomic state

Description

Calls *drm_bridge_funcs.atomic_pre_enable* (falls back on *drm_bridge_funcs.pre_enable*) op for all the bridges in the encoder chain, starting from the last bridge to the first. These are called before calling *drm_encoder_helper_funcs.atomic_enable*

Note

the bridge passed should be the one closest to the encoder

void **drm_atomic_bridge_chain_enable**(struct *drm_bridge* *bridge, struct *drm_atomic_state* *old_state)

enables all bridges in the encoder chain

Parameters

struct drm_bridge *bridge
bridge control structure

struct drm_atomic_state *old_state
old atomic state

Description

Calls *drm_bridge_funcs.atomic_enable* (falls back on *drm_bridge_funcs.enable*) op for all the bridges in the encoder chain, starting from the first bridge to the last. These are called after completing *drm_encoder_helper_funcs.atomic_enable*

Note

the bridge passed should be the one closest to the encoder

int **drm_atomic_bridge_chain_check**(struct *drm_bridge* *bridge, struct *drm_crtc_state* *crtc_state, struct *drm_connector_state* *conn_state)

Do an atomic check on the bridge chain

Parameters

struct drm_bridge *bridge
bridge control structure

struct drm_crtc_state *crtc_state
new CRTC state

struct drm_connector_state *conn_state
new connector state

Description

First trigger a bus format negotiation before calling *drm_bridge_funcs.atomic_check()* (falls back on *drm_bridge_funcs.mode_fixup()*) op for all the bridges in the encoder chain, starting from the last bridge to the first. These are called before calling *drm_encoder_helper_funcs.atomic_check()*

Return

0 on success, a negative error code on failure

enum *drm_connector_status* **drm_bridge_detect**(struct *drm_bridge* *bridge)
check if anything is attached to the bridge output

Parameters

struct drm_bridge *bridge
bridge control structure

Description

If the bridge supports output detection, as reported by the DRM_BRIDGE_OP_DETECT bridge ops flag, call *drm_bridge_funcs.detect* for the bridge and return the connection status. Otherwise return connector_status_unknown.

Return

The detection status on success, or connector_status_unknown if the bridge doesn't support output detection.

int **drm_bridge_get_modes**(struct *drm_bridge* *bridge, struct *drm_connector* *connector)
fill all modes currently valid for the sink into the **connector**

Parameters

struct drm_bridge *bridge
bridge control structure

struct drm_connector *connector
the connector to fill with modes

Description

If the bridge supports output modes retrieval, as reported by the DRM_BRIDGE_OP_MODES bridge ops flag, call *drm_bridge_funcs.get_modes* to fill the connector with all valid modes and return the number of modes added. Otherwise return 0.

Return

The number of modes added to the connector.

struct edid ***drm_bridge_get_edid**(struct *drm_bridge* *bridge, struct *drm_connector* *connector)

get the EDID data of the connected display

Parameters

struct drm_bridge *bridge
bridge control structure

struct drm_connector *connector
the connector to read EDID for

Description

If the bridge supports output EDID retrieval, as reported by the DRM_BRIDGE_OP_EDID bridge ops flag, call *drm_bridge_funcs.get_edid* to get the EDID and return it. Otherwise return NULL.

Return

The retrieved EDID on success, or NULL otherwise.

void **drm_bridge_hpd_enable**(struct *drm_bridge* *bridge, void (*cb)(void *data, enum *drm_connector_status* status), void *data)

enable hot plug detection for the bridge

Parameters

struct drm_bridge *bridge
bridge control structure

void (*cb)(void *data, enum drm_connector_status status)
hot-plug detection callback

void *data
data to be passed to the hot-plug detection callback

Description

Call *drm_bridge_funcs.hpd_enable* if implemented and register the given **cb** and **data** as hot plug notification callback. From now on the **cb** will be called with **data** when an output status change is detected by the bridge, until hot plug notification gets disabled with *drm_bridge_hpd_disable()*.

Hot plug detection is supported only if the DRM_BRIDGE_OP_HPD flag is set in bridge->ops. This function shall not be called when the flag is not set.

Only one hot plug detection callback can be registered at a time, it is an error to call this function when hot plug detection is already enabled for the bridge.

void **drm_bridge_hpd_disable**(struct *drm_bridge* *bridge)

disable hot plug detection for the bridge

Parameters

struct drm_bridge *bridge
  bridge control structure

Description

Call *drm_bridge_funcs.hpd_disable* if implemented and unregister the hot plug detection callback previously registered with *drm_bridge_hpd_enable()*. Once this function returns the callback will not be called by the bridge when an output status change occurs.

Hot plug detection is supported only if the DRM_BRIDGE_OP_HPD flag is set in bridge->ops. This function shall not be called when the flag is not set.

void **drm_bridge_hpd_notify**(struct *drm_bridge* *bridge, enum *drm_connector_status* status)
  notify hot plug detection events

Parameters

struct drm_bridge *bridge
  bridge control structure

enum drm_connector_status status
  output connection status

Description

Bridge drivers shall call this function to report hot plug events when they detect a change in the output status, when hot plug detection has been enabled by *drm_bridge_hpd_enable()*.

This function shall be called in a context that can sleep.

struct *drm_bridge* ***of_drm_find_bridge**(struct device_node *np)
  find the bridge corresponding to the device node in the global bridge list

Parameters

struct device_node *np
  device node

Return

drm_bridge control struct on success, NULL on failure

5.8.5 Bridge Connector Helper Reference

void **drm_bridge_connector_enable_hpd**(struct *drm_connector* *connector)
  Enable hot-plug detection for the connector

Parameters

struct drm_connector *connector
  The DRM bridge connector

Description

This function enables hot-plug detection for the given bridge connector. This is typically used by display drivers in their resume handler.

void **drm_bridge_connector_disable_hpd**(struct *drm_connector* *connector)

Disable hot-plug detection for the connector

Parameters

struct drm_connector *connector
The DRM bridge connector

Description

This function disables hot-plug detection for the given bridge connector. This is typically used by display drivers in their suspend handler.

struct *drm_connector* ***drm_bridge_connector_init**(struct *drm_device* *drm, struct *drm_encoder* *encoder)

Initialise a connector for a chain of bridges

Parameters

struct drm_device *drm
the DRM device

struct drm_encoder *encoder
the encoder where the bridge chain starts

Description

Allocate, initialise and register a `drm_bridge_connector` with the **drm** device. The connector is associated with a chain of bridges that starts at the **encoder**. All bridges in the chain shall report bridge operation flags (*drm_bridge->ops*) and bridge output type (*drm_bridge->type*), and none of them may create a DRM connector directly.

Returns a pointer to the new connector on success, or a negative error pointer otherwise.

5.8.6 Panel-Bridge Helper Reference

struct *drm_bridge* ***drm_panel_bridge_add**(struct *drm_panel* *panel)

Creates a *drm_bridge* and *drm_connector* that just calls the appropriate functions from *drm_panel*.

Parameters

struct drm_panel *panel
The drm_panel being wrapped. Must be non-NULL.

Description

For drivers converting from directly using drm_panel: The expected usage pattern is that during either encoder module probe or DSI host attach, a drm_panel will be looked up through *drm_of_find_panel_or_bridge()*. *drm_panel_bridge_add()* is used to wrap that panel in the new bridge, and the result can then be passed to *drm_bridge_attach()*. The *drm_panel_prepare()* and related functions can be dropped from the encoder driver (they're now called by the KMS helpers before calling into the encoder), along with connector creation. When done with the bridge (after *drm_mode_config_cleanup()* if the bridge has already been attached), then *drm_panel_bridge_remove()* to free it.

The connector type is set to **panel->connector_type**, which must be set to a known type. Calling this function with a panel whose connector type is DRM_MODE_CONNECTOR_Unknown will return ERR_PTR(-EINVAL).

See *devm_drm_panel_bridge_add()* for an automatically managed version of this function.

struct *drm_bridge* ***drm_panel_bridge_add_typed**(struct *drm_panel* *panel, u32 connector_type)

Creates a *drm_bridge* and *drm_connector* with an explicit connector type.

Parameters

struct drm_panel *panel
The drm_panel being wrapped. Must be non-NULL.

u32 connector_type
The connector type (DRM_MODE_CONNECTOR_*)

Description

This is just like *drm_panel_bridge_add()*, but forces the connector type to **connector_type** instead of infering it from the panel.

This function is deprecated and should not be used in new drivers. Use *drm_panel_bridge_add()* instead, and fix panel drivers as necessary if they don't report a connector type.

void **drm_panel_bridge_remove**(struct *drm_bridge* *bridge)

Unregisters and frees a drm_bridge created by *drm_panel_bridge_add()*.

Parameters

struct drm_bridge *bridge
The drm_bridge being freed.

struct *drm_bridge* ***devm_drm_panel_bridge_add**(struct device *dev, struct *drm_panel* *panel)

Creates a managed *drm_bridge* and *drm_connector* that just calls the appropriate functions from *drm_panel*.

Parameters

struct device *dev
device to tie the bridge lifetime to

struct drm_panel *panel
The drm_panel being wrapped. Must be non-NULL.

Description

This is the managed version of *drm_panel_bridge_add()* which automatically calls *drm_panel_bridge_remove()* when **dev** is unbound.

struct *drm_bridge* ***devm_drm_panel_bridge_add_typed**(struct device *dev, struct *drm_panel* *panel, u32 connector_type)

Creates a managed *drm_bridge* and *drm_connector* with an explicit connector type.

Parameters

struct device *dev
device to tie the bridge lifetime to

struct drm_panel *panel
The drm_panel being wrapped. Must be non-NULL.

u32 connector_type
The connector type (DRM_MODE_CONNECTOR_*)

Description

This is just like *devm_drm_panel_bridge_add()*, but forces the connector type to **connector_type** instead of infering it from the panel.

This function is deprecated and should not be used in new drivers. Use *devm_drm_panel_bridge_add()* instead, and fix panel drivers as necessary if they don't report a connector type.

struct *drm_connector* ***drm_panel_bridge_connector**(struct *drm_bridge* *bridge)

return the connector for the panel bridge

Parameters

struct drm_bridge *bridge
The drm_bridge.

Description

drm_panel_bridge creates the connector. This function gives external access to the connector.

Return

Pointer to drm_connector

5.9 Panel Helper Reference

The DRM panel helpers allow drivers to register panel objects with a central registry and provide functions to retrieve those panels in display drivers.

For easy integration into drivers using the *drm_bridge* infrastructure please take look at *drm_panel_bridge_add()* and *devm_drm_panel_bridge_add()*.

struct **drm_panel_funcs**

perform operations on a given panel

Definition

```
struct drm_panel_funcs {
  int (*prepare)(struct drm_panel *panel);
```

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```
  int (*enable)(struct drm_panel *panel);
  int (*disable)(struct drm_panel *panel);
  int (*unprepare)(struct drm_panel *panel);
  int (*get_modes)(struct drm_panel *panel, struct drm_connector␣
↪*connector);
  int (*get_timings)(struct drm_panel *panel, unsigned int num_
↪timings, struct display_timing *timings);
};
```

Members

prepare
Turn on panel and perform set up.

This function is optional.

enable
Enable panel (turn on back light, etc.).

This function is optional.

disable
Disable panel (turn off back light, etc.).

This function is optional.

unprepare
Turn off panel.

This function is optional.

get_modes
Add modes to the connector that the panel is attached to and returns the number of modes added.

This function is mandatory.

get_timings
Copy display timings into the provided array and return the number of display timings available.

This function is optional.

Description

The .prepare() function is typically called before the display controller starts to transmit video data. Panel drivers can use this to turn the panel on and wait for it to become ready. If additional configuration is required (via a control bus such as I2C, SPI or DSI for example) this is a good time to do that.

After the display controller has started transmitting video data, it's safe to call the .enable() function. This will typically enable the backlight to make the image on screen visible. Some panels require a certain amount of time or frames before the image is displayed. This function is responsible for taking this into account before enabling the backlight to avoid visual glitches.

Before stopping video transmission from the display controller it can be necessary to turn off the panel to avoid visual glitches. This is done in the .disable() function.

Analogously to .enable() this typically involves turning off the backlight and waiting for some time to make sure no image is visible on the panel. It is then safe for the display controller to cease transmission of video data.

To save power when no video data is transmitted, a driver can power down the panel. This is the job of the .unprepare() function.

Backlight can be handled automatically if configured using *drm_panel_of_backlight()*. Then the driver does not need to implement the functionality to enable/disable backlight.

struct **drm_panel**

DRM panel object

Definition

```
struct drm_panel {
  struct device *dev;
  struct backlight_device *backlight;
  const struct drm_panel_funcs *funcs;
  int connector_type;
  struct list_head list;
};
```

Members

dev
: Parent device of the panel.

backlight
: Backlight device, used to turn on backlight after the call to enable(), and to turn off backlight before the call to disable(). backlight is set by *drm_panel_of_backlight()* and drivers shall not assign it.

funcs
: Operations that can be performed on the panel.

connector_type
: Type of the panel as a DRM_MODE_CONNECTOR_* value. This is used to initialise the drm_connector corresponding to the panel with the correct connector type.

list
: Panel entry in registry.

void **drm_panel_init**(struct *drm_panel* *panel, struct device *dev, const struct *drm_panel_funcs* *funcs, int connector_type)

initialize a panel

Parameters

struct drm_panel *panel
: DRM panel

struct device *dev
: parent device of the panel

const struct drm_panel_funcs *funcs
: panel operations

int connector_type
: the connector type (DRM_MODE_CONNECTOR_*) corresponding to the panel interface

Description

Initialize the panel structure for subsequent registration with *drm_panel_add()*.

void **drm_panel_add**(struct *drm_panel* *panel)
: add a panel to the global registry

Parameters

struct drm_panel *panel
: panel to add

Description

Add a panel to the global registry so that it can be looked up by display drivers.

void **drm_panel_remove**(struct *drm_panel* *panel)
: remove a panel from the global registry

Parameters

struct drm_panel *panel
: DRM panel

Description

Removes a panel from the global registry.

int **drm_panel_prepare**(struct *drm_panel* *panel)
: power on a panel

Parameters

struct drm_panel *panel
: DRM panel

Description

Calling this function will enable power and deassert any reset signals to the panel. After this has completed it is possible to communicate with any integrated circuitry via a command bus.

Return

0 on success or a negative error code on failure.

int **drm_panel_unprepare**(struct *drm_panel* *panel)
: power off a panel

Parameters

struct drm_panel *panel
: DRM panel

Description

Calling this function will completely power off a panel (assert the panel’ s reset, turn off power supplies, …). After this function has completed, it is usually no longer possible to communicate with the panel until another call to *drm_panel_prepare()*.

Return

0 on success or a negative error code on failure.

int **drm_panel_enable**(struct *drm_panel* *panel)

enable a panel

Parameters

struct drm_panel *panel
DRM panel

Description

Calling this function will cause the panel display drivers to be turned on and the backlight to be enabled. Content will be visible on screen after this call completes.

Return

0 on success or a negative error code on failure.

int **drm_panel_disable**(struct *drm_panel* *panel)

disable a panel

Parameters

struct drm_panel *panel
DRM panel

Description

This will typically turn off the panel’ s backlight or disable the display drivers. For smart panels it should still be possible to communicate with the integrated circuitry via any command bus after this call.

Return

0 on success or a negative error code on failure.

int **drm_panel_get_modes**(struct *drm_panel* *panel, struct *drm_connector* *connector)

probe the available display modes of a panel

Parameters

struct drm_panel *panel
DRM panel

struct drm_connector *connector
DRM connector

Description

The modes probed from the panel are automatically added to the connector that the panel is attached to.

Return

The number of modes available from the panel on success, or 0 on failure (no modes).

struct *drm_panel* ***of_drm_find_panel**(const struct device_node *np)

look up a panel using a device tree node

Parameters

const struct device_node *np
device tree node of the panel

Description

Searches the set of registered panels for one that matches the given device tree node. If a matching panel is found, return a pointer to it.

Possible error codes returned by this function:

- EPROBE_DEFER: the panel device has not been probed yet, and the caller should retry later
- ENODEV: the device is not available (status != "okay" or "ok")

Return

A pointer to the panel registered for the specified device tree node or an ERR_PTR() if no panel matching the device tree node can be found.

int **of_drm_get_panel_orientation**(const struct device_node *np, enum *drm_panel_orientation* *orientation)

look up the orientation of the panel through the "rotation" binding from a device tree node

Parameters

const struct device_node *np
device tree node of the panel

enum drm_panel_orientation *orientation
orientation enum to be filled in

Description

Looks up the rotation of a panel in the device tree. The orientation of the panel is expressed as a property name "rotation" in the device tree. The rotation in the device tree is counter clockwise.

Return

0 when a valid rotation value (0, 90, 180, or 270) is read or the rotation property doesn't exist. Return a negative error code on failure.

int **drm_panel_of_backlight**(struct *drm_panel* *panel)

use backlight device node for backlight

Parameters

struct drm_panel *panel
DRM panel

Description

Use this function to enable backlight handling if your panel uses device tree and has a backlight phandle.

When the panel is enabled backlight will be enabled after a successful call to *drm_panel_funcs.enable()*

When the panel is disabled backlight will be disabled before the call to *drm_panel_funcs.disable()*.

A typical implementation for a panel driver supporting device tree will call this function at probe time. Backlight will then be handled transparently without requiring any intervention from the driver. *drm_panel_of_backlight()* must be called after the call to *drm_panel_init()*.

Return

0 on success or a negative error code on failure.

int **drm_get_panel_orientation_quirk**(int width, int height)

Check for panel orientation quirks

Parameters

int width
width in pixels of the panel

int height
height in pixels of the panel

Description

This function checks for platform specific (e.g. DMI based) quirks providing info on panel_orientation for systems where this cannot be probed from the hard-/firmware. To avoid false-positive this function takes the panel resolution as argument and checks that against the resolution expected by the quirk-table entry.

Note this function is also used outside of the drm-subsys, by for example the efifb code. Because of this this function gets compiled into its own kernel-module when built as a module.

Return

A DRM_MODE_PANEL_ORIENTATION_* value if there is a quirk for this system, or DRM_MODE_PANEL_ORIENTATION_UNKNOWN if there is no quirk.

5.10 Panel Self Refresh Helper Reference

This helper library provides an easy way for drivers to leverage the atomic framework to implement panel self refresh (SR) support. Drivers are responsible for initializing and cleaning up the SR helpers on load/unload (see *drm_self_refresh_helper_init*/*drm_self_refresh_helper_cleanup*). The connector is responsible for setting *drm_connector_state.self_refresh_aware* to true at runtime if it is SR-aware (meaning it knows how to initiate self refresh on the panel).

Once a crtc has enabled SR using *drm_self_refresh_helper_init*, the helpers will monitor activity and call back into the driver to enable/disable SR as appropriate. The best way to think about this is that it's a DPMS on/off request with *drm_crtc_state.self_refresh_active* set in crtc state that tells you to disable/enable SR on the panel instead of power-cycling it.

During SR, drivers may choose to fully disable their crtc/encoder/bridge hardware (in which case no driver changes are necessary), or they can inspect *drm_crtc_state.self_refresh_active* if they want to enter low power mode without full disable (in case full disable/enable is too slow).

SR will be deactivated if there are any atomic updates affecting the pipe that is in SR mode. If a crtc is driving multiple connectors, all connectors must be SR aware and all will enter/exit SR mode at the same time.

If the crtc and connector are SR aware, but the panel connected does not support it (or is otherwise unable to enter SR), the driver should fail atomic_check when *drm_crtc_state.self_refresh_active* is true.

void **drm_self_refresh_helper_update_avg_times**(struct *drm_atomic_state* *state, unsigned int commit_time_ms, unsigned int new_self_refresh_mask)

Updates a crtc's SR time averages

Parameters

struct drm_atomic_state *state
the state which has just been applied to hardware

unsigned int commit_time_ms
the amount of time in ms that this commit took to complete

unsigned int new_self_refresh_mask
bitmask of crtc's that have self_refresh_active in new state

Description

Called after *drm_mode_config_funcs.atomic_commit_tail*, this function will update the average entry/exit self refresh times on self refresh transitions. These averages will be used when calculating how long to delay before entering self refresh mode after activity.

void **drm_self_refresh_helper_alter_state**(struct *drm_atomic_state* *state)

Alters the atomic state for SR exit

Parameters

struct drm_atomic_state *state
the state currently being checked

Description

Called at the end of atomic check. This function checks the state for flags incompatible with self refresh exit and changes them. This is a bit disingenuous since userspace is expecting one thing and we're giving it another. However in order to keep self refresh entirely hidden from userspace, this is required.

At the end, we queue up the self refresh entry work so we can enter PSR after the desired delay.

int **drm_self_refresh_helper_init**(struct *drm_crtc* *crtc)

Initializes self refresh helpers for a crtc

Parameters

struct drm_crtc *crtc
the crtc which supports self refresh supported displays

Description

Returns zero if successful or -errno on failure

void **drm_self_refresh_helper_cleanup**(struct *drm_crtc* *crtc)

Cleans up self refresh helpers for a crtc

Parameters

struct drm_crtc *crtc
the crtc to cleanup

5.11 HDCP Helper Functions Reference

int **drm_hdcp_check_ksvs_revoked**(struct *drm_device* *drm_dev, u8 *ksvs, u32 ksv_count)

Check the revoked status of the IDs

Parameters

struct drm_device *drm_dev
drm_device for which HDCP revocation check is requested

u8 *ksvs
List of KSVs (HDCP receiver IDs)

u32 ksv_count
KSV count passed in through **ksvs**

Description

This function reads the HDCP System renewability Message(SRM Table) from userspace as a firmware and parses it for the revoked HDCP KSVs(Receiver IDs) detected by DCP LLC. Once the revoked KSVs are known, revoked state of the KSVs in the list passed in by display drivers are decided and response is sent.

SRM should be presented in the name of "display_hdcp_srm.bin".

Format of the SRM table, that userspace needs to write into the binary file, is defined at: 1. Renewability chapter on 55th page of HDCP 1.4 specification https://www.digital-cp.com/sites/default/files/specifications/HDCP``20Specification````20Rev1_4_Secure``.pdf
2. Renewability chapter on 63rd page of HDCP 2.2 specification https://www.digital-cp.com/sites/default/files/specifications/HDCP``20on````20HDMI````20Specification````20Rev2_2_Final1``.pdf

Return

Count of the revoked KSVs or -ve error number incase of the failure.

int **drm_connector_attach_content_protection_property**(struct *drm_connector* *connector, bool hdcp_content_type)

attach content protection property

Parameters

struct drm_connector *connector
connector to attach CP property on.

bool hdcp_content_type
is HDCP Content Type property needed for connector

Description

This is used to add support for content protection on select connectors. Content Protection is intentionally vague to allow for different underlying technologies, however it is most implemented by HDCP.

When hdcp_content_type is true enum property called HDCP Content Type is created (if it is not already) and attached to the connector.

This property is used for sending the protected content' s stream type from userspace to kernel on selected connectors. Protected content provider will decide their type of their content and declare the same to kernel.

Content type will be used during the HDCP 2.2 authentication. Content type will be set to `drm_connector_state.hdcp_content_type`.

The content protection will be set to `drm_connector_state.content_protection`

When kernel triggered content protection state change like DESIRED->ENABLED and ENABLED->DESIRED, will use `drm_hdcp_update_content_protection()` to update the content protection state of a connector.

Return

Zero on success, negative errno on failure.

void **drm_hdcp_update_content_protection**(struct *drm_connector* *connector, u64 val)

Updates the content protection state of a connector

Parameters

struct drm_connector *connector
drm_connector on which content protection state needs an update

u64 val
New state of the content protection property

Description

This function can be used by display drivers, to update the kernel triggered content protection state changes of a drm_connector such as DESIRED->ENABLED and ENABLED->DESIRED. No uevent for DESIRED->UNDESIRED or ENABLED->UNDESIRED, as userspace is triggering such state change and kernel performs it without fail.This function update the new state of the property into the connector's state and generate an uevent to notify the userspace.

5.12 Display Port Helper Functions Reference

These functions contain some common logic and helpers at various abstraction levels to deal with Display Port sink devices and related things like DP aux channel transfers, EDID reading over DP aux channels, decoding certain DPCD blocks, …

The DisplayPort AUX channel is an abstraction to allow generic, driver- independent access to AUX functionality. Drivers can take advantage of this by filling in the fields of the drm_dp_aux structure.

Transactions are described using a hardware-independent drm_dp_aux_msg structure, which is passed into a driver's .transfer() implementation. Both native and I2C-over-AUX transactions are supported.

struct **dp_sdp_header**

DP secondary data packet header

Definition

```
struct dp_sdp_header {
  u8 HB0;
  u8 HB1;
  u8 HB2;
  u8 HB3;
};
```

Members

HB0
Secondary Data Packet ID

HB1
Secondary Data Packet Type

HB2
Secondary Data Packet Specific header, Byte 0

HB3
Secondary Data packet Specific header, Byte 1

struct **dp_sdp**

DP secondary data packet

Definition

```
struct dp_sdp {
  struct dp_sdp_header sdp_header;
  u8 db[32];
};
```

Members

`sdp_header`
DP secondary data packet header

`db`
DP secondaray data packet data blocks VSC SDP Payload for PSR db[0]: Stereo Interface db[1]: 0 - PSR State; 1 - Update RFB; 2 - CRC Valid db[2]: CRC value bits 7:0 of the R or Cr component db[3]: CRC value bits 15:8 of the R or Cr component db[4]: CRC value bits 7:0 of the G or Y component db[5]: CRC value bits 15:8 of the G or Y component db[6]: CRC value bits 7:0 of the B or Cb component db[7]: CRC value bits 15:8 of the B or Cb component db[8] - db[31]: Reserved VSC SDP Payload for Pixel Encoding/Colorimetry Format db[0] - db[15]: Reserved db[16]: Pixel Encoding and Colorimetry Formats db[17]: Dynamic Range and Component Bit Depth db[18]: Content Type db[19] - db[31]: Reserved

enum **`dp_pixelformat`**
drm DP Pixel encoding formats

Constants

`DP_PIXELFORMAT_RGB`
RGB pixel encoding format

`DP_PIXELFORMAT_YUV444`
YCbCr 4:4:4 pixel encoding format

`DP_PIXELFORMAT_YUV422`
YCbCr 4:2:2 pixel encoding format

`DP_PIXELFORMAT_YUV420`
YCbCr 4:2:0 pixel encoding format

`DP_PIXELFORMAT_Y_ONLY`
Y Only pixel encoding format

`DP_PIXELFORMAT_RAW`
RAW pixel encoding format

`DP_PIXELFORMAT_RESERVED`
Reserved pixel encoding format

Description

This enum is used to indicate DP VSC SDP Pixel encoding formats. It is based on DP 1.4 spec [Table 2-117: VSC SDP Payload for DB16 through DB18]

enum **`dp_colorimetry`**
drm DP Colorimetry formats

Constants

`DP_COLORIMETRY_DEFAULT`
sRGB (IEC 61966-2-1) or ITU-R BT.601 colorimetry format

`DP_COLORIMETRY_RGB_WIDE_FIXED`
RGB wide gamut fixed point colorimetry format

`DP_COLORIMETRY_BT709_YCC`
ITU-R BT.709 colorimetry format

DP_COLORIMETRY_RGB_WIDE_FLOAT
RGB wide gamut floating point (scRGB (IEC 61966-2-2)) colorimetry format

DP_COLORIMETRY_XVYCC_601
xvYCC601 colorimetry format

DP_COLORIMETRY_OPRGB
OpRGB colorimetry format

DP_COLORIMETRY_XVYCC_709
xvYCC709 colorimetry format

DP_COLORIMETRY_DCI_P3_RGB
DCI-P3 (SMPTE RP 431-2) colorimetry format

DP_COLORIMETRY_SYCC_601
sYCC601 colorimetry format

DP_COLORIMETRY_RGB_CUSTOM
RGB Custom Color Profile colorimetry format

DP_COLORIMETRY_OPYCC_601
opYCC601 colorimetry format

DP_COLORIMETRY_BT2020_RGB
ITU-R BT.2020 R' G' B' colorimetry format

DP_COLORIMETRY_BT2020_CYCC
ITU-R BT.2020 Y' c C' bc C' rc colorimetry format

DP_COLORIMETRY_BT2020_YCC
ITU-R BT.2020 Y' C' b C' r colorimetry format

Description

This enum is used to indicate DP VSC SDP Colorimetry formats. It is based on DP 1.4 spec [Table 2-117: VSC SDP Payload for DB16 through DB18] and a name of enum member follows DRM_MODE_COLORIMETRY definition.

enum **dp_dynamic_range**

drm DP Dynamic Range

Constants

DP_DYNAMIC_RANGE_VESA
VESA range

DP_DYNAMIC_RANGE_CTA
CTA range

Description

This enum is used to indicate DP VSC SDP Dynamic Range. It is based on DP 1.4 spec [Table 2-117: VSC SDP Payload for DB16 through DB18]

enum **dp_content_type**

drm DP Content Type

Constants

DP_CONTENT_TYPE_NOT_DEFINED
Not defined type

DP_CONTENT_TYPE_GRAPHICS
Graphics type

DP_CONTENT_TYPE_PHOTO
Photo type

DP_CONTENT_TYPE_VIDEO
Video type

DP_CONTENT_TYPE_GAME
Game type

Description

This enum is used to indicate DP VSC SDP Content Types. It is based on DP 1.4 spec [Table 2-117: VSC SDP Payload for DB16 through DB18] CTA-861-G defines content types and expected processing by a sink device

struct **drm_dp_vsc_sdp**
drm DP VSC SDP

Definition

```
struct drm_dp_vsc_sdp {
  unsigned char sdp_type;
  unsigned char revision;
  unsigned char length;
  enum dp_pixelformat pixelformat;
  enum dp_colorimetry colorimetry;
  int bpc;
  enum dp_dynamic_range dynamic_range;
  enum dp_content_type content_type;
};
```

Members

sdp_type
secondary-data packet type

revision
revision number

length
number of valid data bytes

pixelformat
pixel encoding format

colorimetry
colorimetry format

bpc
bit per color

dynamic_range
dynamic range information

content_type
CTA-861-G defines content types and expected processing by a sink device

Description

This structure represents a DP VSC SDP of drm It is based on DP 1.4 spec [Table 2-116: VSC SDP Header Bytes] and [Table 2-117: VSC SDP Payload for DB16 through DB18]

struct **drm_dp_aux_msg**
DisplayPort AUX channel transaction

Definition

```
struct drm_dp_aux_msg {
  unsigned int address;
  u8 request;
  u8 reply;
  void *buffer;
  size_t size;
};
```

Members

address
address of the (first) register to access

request
contains the type of transaction (see DP_AUX_* macros)

reply
upon completion, contains the reply type of the transaction

buffer
pointer to a transmission or reception buffer

size
size of **buffer**

struct **drm_dp_aux_cec**
DisplayPort CEC-Tunneling-over-AUX

Definition

```
struct drm_dp_aux_cec {
  struct mutex lock;
  struct cec_adapter *adap;
  struct drm_connector *connector;
  struct delayed_work unregister_work;
};
```

Members

lock
mutex protecting this struct

adap
the CEC adapter for CEC-Tunneling-over-AUX support.

connector
the connector this CEC adapter is associated with

unregister_work
unregister the CEC adapter

struct **drm_dp_aux**

DisplayPort AUX channel

Definition

```
struct drm_dp_aux {
  const char *name;
  struct i2c_adapter ddc;
  struct device *dev;
  struct drm_crtc *crtc;
  struct mutex hw_mutex;
  struct work_struct crc_work;
  u8 crc_count;
  ssize_t (*transfer)(struct drm_dp_aux *aux, struct drm_dp_aux_msg␣
↪*msg);
  unsigned i2c_nack_count;
  unsigned i2c_defer_count;
  struct drm_dp_aux_cec cec;
  bool is_remote;
};
```

Members

name
user-visible name of this AUX channel and the I2C-over-AUX adapter

ddc
I2C adapter that can be used for I2C-over-AUX communication

dev
pointer to struct device that is the parent for this AUX channel

crtc
backpointer to the crtc that is currently using this AUX channel

hw_mutex
internal mutex used for locking transfers

crc_work
worker that captures CRCs for each frame

crc_count
counter of captured frame CRCs

transfer
transfers a message representing a single AUX transaction

i2c_nack_count
Counts I2C NACKs, used for DP validation.

i2c_defer_count
Counts I2C DEFERs, used for DP validation.

cec
struct containing fields used for CEC-Tunneling-over-AUX.

is_remote
Is this AUX CH actually using sideband messaging.

Description

The .dev field should be set to a pointer to the device that implements the AUX channel.

The .name field may be used to specify the name of the I2C adapter. If set to NULL, dev_name() of .dev will be used.

Drivers provide a hardware-specific implementation of how transactions are executed via the .transfer() function. A pointer to a drm_dp_aux_msg structure describing the transaction is passed into this function. Upon success, the implementation should return the number of payload bytes that were transferred, or a negative error-code on failure. Helpers propagate errors from the .transfer() function, with the exception of the -EBUSY error, which causes a transaction to be retried. On a short, helpers will return -EPROTO to make it simpler to check for failure.

An AUX channel can also be used to transport I2C messages to a sink. A typical application of that is to access an EDID that's present in the sink device. The .transfer() function can also be used to execute such transactions. The *drm_dp_aux_register()* function registers an I2C adapter that can be passed to *drm_probe_ddc()*. Upon removal, drivers should call *drm_dp_aux_unregister()* to remove the I2C adapter. The I2C adapter uses long transfers by default; if a partial response is received, the adapter will drop down to the size given by the partial response for this transaction only.

Note that the aux helper code assumes that the .transfer() function only modifies the reply field of the drm_dp_aux_msg structure. The retry logic and i2c helpers assume this is the case.

ssize_t **drm_dp_dpcd_readb**(struct *drm_dp_aux* *aux, unsigned int offset, u8 *valuep)

read a single byte from the DPCD

Parameters

struct drm_dp_aux *aux
DisplayPort AUX channel

unsigned int offset
address of the register to read

u8 *valuep
location where the value of the register will be stored

Description

Returns the number of bytes transferred (1) on success, or a negative error code on failure.

ssize_t **drm_dp_dpcd_writeb**(struct *drm_dp_aux* *aux, unsigned int offset, u8 value) write a single byte to the DPCD

Parameters

`struct drm_dp_aux *aux`
DisplayPort AUX channel

`unsigned int offset`
address of the register to write

`u8 value`
value to write to the register

Description

Returns the number of bytes transferred (1) on success, or a negative error code on failure.

struct **`drm_dp_desc`**

DP branch/sink device descriptor

Definition

```
struct drm_dp_desc {
  struct drm_dp_dpcd_ident ident;
  u32 quirks;
};
```

Members

`ident`
DP device identification from DPCD 0x400 (sink) or 0x500 (branch).

`quirks`
Quirks; use *`drm_dp_has_quirk()`* to query for the quirks.

enum **`drm_dp_quirk`**

Display Port sink/branch device specific quirks

Constants

`DP_DPCD_QUIRK_CONSTANT_N`
The device requires main link attributes Mvid and Nvid to be limited to 16 bits. So will give a constant value (0x8000) for compatability.

`DP_DPCD_QUIRK_NO_PSR`
The device does not support PSR even if reports that it supports or driver still need to implement proper handling for such device.

`DP_DPCD_QUIRK_NO_SINK_COUNT`
The device does not set SINK_COUNT to a non-zero value. The driver should ignore SINK_COUNT during detection. Note that *`drm_dp_read_sink_count_cap()`* automatically checks for this quirk.

`DP_DPCD_QUIRK_DSC_WITHOUT_VIRTUAL_DPCD`
The device supports MST DSC despite not supporting Virtual DPCD. The DSC caps can be read from the physical aux instead.

DP_QUIRK_FORCE_DPCD_BACKLIGHT
: The device is telling the truth when it says that it uses DPCD backlight controls, even if the system' s firmware disagrees. This quirk should be checked against both the ident and panel EDID. When present, the driver should honor the DPCD backlight capabilities advertised.

DP_DPCD_QUIRK_CAN_DO_MAX_LINK_RATE_3_24_GBPS
: The device supports a link rate of 3.24 Gbps (multiplier 0xc) despite the DP_MAX_LINK_RATE register reporting a lower max multiplier.

Description

Display Port sink and branch devices in the wild have a variety of bugs, try to collect them here. The quirks are shared, but it' s up to the drivers to implement workarounds for them. Note that because some devices have unreliable OUIDs, the EDID of sinks should also be checked for quirks using *drm_dp_get_edid_quirks()*.

bool **drm_dp_has_quirk**(const struct *drm_dp_desc* *desc, u32 edid_quirks, enum *drm_dp_quirk* quirk)

does the DP device have a specific quirk

Parameters

const struct drm_dp_desc *desc
: Device descriptor filled by *drm_dp_read_desc()*

u32 edid_quirks
: Optional quirk bitmask filled by *drm_dp_get_edid_quirks()*

enum drm_dp_quirk quirk
: Quirk to query for

Description

Return true if DP device identified by **desc** has **quirk**.

struct **drm_dp_phy_test_params**

DP Phy Compliance parameters

Definition

```
struct drm_dp_phy_test_params {
  int link_rate;
  u8 num_lanes;
  u8 phy_pattern;
  u8 hbr2_reset[2];
  u8 custom80[10];
  bool enhanced_frame_cap;
};
```

Members

link_rate
: Requested Link rate from DPCD 0x219

num_lanes
: Number of lanes requested by sing through DPCD 0x220

phy_pattern
DP Phy test pattern from DPCD 0x248

hbr2_reset
DP HBR2_COMPLIANCE_SCRAMBLER_RESET from DCPD 0x24A and 0x24B

custom80
DP Test_80BIT_CUSTOM_PATTERN from DPCDs 0x250 through 0x259

enhanced_frame_cap
flag for enhanced frame capability.

ssize_t **drm_dp_dpcd_read**(struct *drm_dp_aux* *aux, unsigned int offset, void *buffer, size_t size)

read a series of bytes from the DPCD

Parameters

struct drm_dp_aux *aux
DisplayPort AUX channel (SST or MST)

unsigned int offset
address of the (first) register to read

void *buffer
buffer to store the register values

size_t size
number of bytes in **buffer**

Description

Returns the number of bytes transferred on success, or a negative error code on failure. -EIO is returned if the request was NAKed by the sink or if the retry count was exceeded. If not all bytes were transferred, this function returns -EPROTO. Errors from the underlying AUX channel transfer function, with the exception of -EBUSY (which causes the transaction to be retried), are propagated to the caller.

ssize_t **drm_dp_dpcd_write**(struct *drm_dp_aux* *aux, unsigned int offset, void *buffer, size_t size)

write a series of bytes to the DPCD

Parameters

struct drm_dp_aux *aux
DisplayPort AUX channel (SST or MST)

unsigned int offset
address of the (first) register to write

void *buffer
buffer containing the values to write

size_t size
number of bytes in **buffer**

Description

Returns the number of bytes transferred on success, or a negative error code on failure. -EIO is returned if the request was NAKed by the sink or if the retry count was exceeded. If not all bytes were transferred, this function returns -EPROTO. Errors from the underlying AUX channel transfer function, with the exception of -EBUSY (which causes the transaction to be retried), are propagated to the caller.

int **drm_dp_dpcd_read_link_status**(struct *drm_dp_aux* *aux, u8 status[DP_LINK_STATUS_SIZE])

read DPCD link status (bytes 0x202-0x207)

Parameters

struct drm_dp_aux *aux
DisplayPort AUX channel

u8 status[DP_LINK_STATUS_SIZE]
buffer to store the link status in (must be at least 6 bytes)

Description

Returns the number of bytes transferred on success or a negative error code on failure.

bool **drm_dp_downstream_is_type**(const u8 dpcd[DP_RECEIVER_CAP_SIZE], const u8 port_cap[4], u8 type)

is the downstream facing port of certain type?

Parameters

const u8 dpcd[DP_RECEIVER_CAP_SIZE]
DisplayPort configuration data

const u8 port_cap[4]
port capabilities

u8 type
port type to be checked. Can be: `DP_DS_PORT_TYPE_DP`, `DP_DS_PORT_TYPE_VGA`, `DP_DS_PORT_TYPE_DVI`, `DP_DS_PORT_TYPE_HDMI`, `DP_DS_PORT_TYPE_NON_EDID`, `DP_DS_PORT_TYPE_DP_DUALMODE` or `DP_DS_PORT_TYPE_WIRELESS`.

Description

Caveat: Only works with DPCD 1.1+ port caps.

Return

whether the downstream facing port matches the type.

bool **drm_dp_downstream_is_tmds**(const u8 dpcd[DP_RECEIVER_CAP_SIZE], const u8 port_cap[4], const struct *edid* *edid)

is the downstream facing port TMDS?

Parameters

const u8 dpcd[DP_RECEIVER_CAP_SIZE]
DisplayPort configuration data

const u8 port_cap[4]
  port capabilities

const struct edid *edid
  EDID

Return

whether the downstream facing port is TMDS (HDMI/DVI).

bool **drm_dp_send_real_edid_checksum**(struct *drm_dp_aux* *aux, u8 real_edid_checksum)

  send back real edid checksum value

Parameters

struct drm_dp_aux *aux
  DisplayPort AUX channel

u8 real_edid_checksum
  real edid checksum for the last block

Return

True on success

int **drm_dp_read_dpcd_caps**(struct *drm_dp_aux* *aux, u8 dpcd[DP_RECEIVER_CAP_SIZE])

  read DPCD caps and extended DPCD caps if available

Parameters

struct drm_dp_aux *aux
  DisplayPort AUX channel

u8 dpcd[DP_RECEIVER_CAP_SIZE]
  Buffer to store the resulting DPCD in

Description

Attempts to read the base DPCD caps for **aux**. Additionally, this function checks for and reads the extended DPRX caps (`DP_DP13_DPCD_REV`) if present.

Return

`0` if the DPCD was read successfully, negative error code otherwise.

int **drm_dp_read_downstream_info**(struct *drm_dp_aux* *aux, const u8 dpcd[DP_RECEIVER_CAP_SIZE], u8 downstream_ports[DP_MAX_DOWNSTREAM_PORTS])

  read DPCD downstream port info if available

Parameters

struct drm_dp_aux *aux
  DisplayPort AUX channel

const u8 dpcd[DP_RECEIVER_CAP_SIZE]
  A cached copy of the port's DPCD

u8 downstream_ports[DP_MAX_DOWNSTREAM_PORTS]
buffer to store the downstream port info in

Description

See also: drm_dp_downstream_max_clock() *drm_dp_downstream_max_bpc()*

Return

0 if either the downstream port info was read successfully or there was no downstream info to read, or a negative error code otherwise.

int **drm_dp_downstream_max_dotclock**(const u8 dpcd[DP_RECEIVER_CAP_SIZE], const u8 port_cap[4])
extract downstream facing port max dot clock

Parameters

const u8 dpcd[DP_RECEIVER_CAP_SIZE]
DisplayPort configuration data

const u8 port_cap[4]
port capabilities

Return

Downstream facing port max dot clock in kHz on success, or 0 if max clock not defined

int **drm_dp_downstream_max_tmds_clock**(const u8 dpcd[DP_RECEIVER_CAP_SIZE], const u8 port_cap[4], const struct *edid* *edid)
extract downstream facing port max TMDS clock

Parameters

const u8 dpcd[DP_RECEIVER_CAP_SIZE]
DisplayPort configuration data

const u8 port_cap[4]
port capabilities

const struct edid *edid
EDID

Return

HDMI/DVI downstream facing port max TMDS clock in kHz on success, or 0 if max TMDS clock not defined

int **drm_dp_downstream_min_tmds_clock**(const u8 dpcd[DP_RECEIVER_CAP_SIZE], const u8 port_cap[4], const struct *edid* *edid)
extract downstream facing port min TMDS clock

Parameters

`const u8 dpcd[DP_RECEIVER_CAP_SIZE]`
DisplayPort configuration data

`const u8 port_cap[4]`
port capabilities

`const struct edid *edid`
EDID

Return

HDMI/DVI downstream facing port min TMDS clock in kHz on success, or 0 if max TMDS clock not defined

int **`drm_dp_downstream_max_bpc`**(const u8 dpcd[DP_RECEIVER_CAP_SIZE], const u8 port_cap[4], const struct *edid* *edid)

extract downstream facing port max bits per component

Parameters

`const u8 dpcd[DP_RECEIVER_CAP_SIZE]`
DisplayPort configuration data

`const u8 port_cap[4]`
downstream facing port capabilities

`const struct edid *edid`
EDID

Return

Max bpc on success or 0 if max bpc not defined

bool **`drm_dp_downstream_420_passthrough`**(const u8 dpcd[DP_RECEIVER_CAP_SIZE], const u8 port_cap[4])

determine downstream facing port YCbCr 4:2:0 pass-through capability

Parameters

`const u8 dpcd[DP_RECEIVER_CAP_SIZE]`
DisplayPort configuration data

`const u8 port_cap[4]`
downstream facing port capabilities

Return

whether the downstream facing port can pass through YCbCr 4:2:0

bool **`drm_dp_downstream_444_to_420_conversion`**(const u8 dpcd[DP_RECEIVER_CAP_SIZE], const u8 port_cap[4])

determine downstream facing port YCbCr 4:4:4->4:2:0 conversion capability

Parameters

`const u8 dpcd[DP_RECEIVER_CAP_SIZE]`
DisplayPort configuration data

const u8 port_cap[4]
downstream facing port capabilities

Return

whether the downstream facing port can convert YCbCr 4:4:4 to 4:2:0

struct *drm_display_mode* ***drm_dp_downstream_mode**(struct *drm_device* *dev, const u8 dpcd[DP_RECEIVER_CAP_SIZE], const u8 port_cap[4])

return a mode for downstream facing port

Parameters

struct drm_device *dev
DRM device

const u8 dpcd[DP_RECEIVER_CAP_SIZE]
DisplayPort configuration data

const u8 port_cap[4]
port capabilities

Description

Provides a suitable mode for downstream facing ports without EDID.

Return

A new drm_display_mode on success or NULL on failure

int **drm_dp_downstream_id**(struct *drm_dp_aux* *aux, char id[6])

identify branch device

Parameters

struct drm_dp_aux *aux
DisplayPort AUX channel

char id[6]
DisplayPort branch device id

Description

Returns branch device id on success or NULL on failure

void **drm_dp_downstream_debug**(struct seq_file *m, const u8 dpcd[DP_RECEIVER_CAP_SIZE], const u8 port_cap[4], const struct *edid* *edid, struct *drm_dp_aux* *aux)

debug DP branch devices

Parameters

struct seq_file *m
pointer for debugfs file

const u8 dpcd[DP_RECEIVER_CAP_SIZE]
DisplayPort configuration data

const u8 port_cap[4]
: port capabilities

const struct edid *edid
: EDID

struct drm_dp_aux *aux
: DisplayPort AUX channel

enum drm_mode_subconnector **drm_dp_subconnector_type**(const u8 dpcd[DP_RECEIVER_CAP_SIZE], const u8 port_cap[4])

get DP branch device type

Parameters

const u8 dpcd[DP_RECEIVER_CAP_SIZE]
: DisplayPort configuration data

const u8 port_cap[4]
: port capabilities

void **drm_dp_set_subconnector_property**(struct *drm_connector* *connector, enum *drm_connector_status* status, const u8 *dpcd, const u8 port_cap[4])

set subconnector for DP connector

Parameters

struct drm_connector *connector
: connector to set property on

enum drm_connector_status status
: connector status

const u8 *dpcd
: DisplayPort configuration data

const u8 port_cap[4]
: port capabilities

Description

Called by a driver on every detect event.

bool **drm_dp_read_sink_count_cap**(struct *drm_connector* *connector, const u8 dpcd[DP_RECEIVER_CAP_SIZE], const struct *drm_dp_desc* *desc)

Check whether a given connector has a valid sink count

Parameters

struct drm_connector *connector
: The DRM connector to check

const u8 dpcd[DP_RECEIVER_CAP_SIZE]
: A cached copy of the connector’s DPCD RX capabilities

`const struct drm_dp_desc *desc`
  A cached copy of the connector's DP descriptor

Description

See also: *`drm_dp_read_sink_count()`*

Return

`True` if the (e)DP connector has a valid sink count that should be probed, `false` otherwise.

int **`drm_dp_read_sink_count`**(struct *drm_dp_aux* *aux)
  Retrieve the sink count for a given sink

Parameters

`struct drm_dp_aux *aux`
  The DP AUX channel to use

Description

See also: *`drm_dp_read_sink_count_cap()`*

Return

The current sink count reported by **aux**, or a negative error code otherwise.

void **`drm_dp_remote_aux_init`**(struct *drm_dp_aux* *aux)
  minimally initialise a remote aux channel

Parameters

`struct drm_dp_aux *aux`
  DisplayPort AUX channel

Description

Used for remote aux channel in general. Merely initialize the crc work struct.

void **`drm_dp_aux_init`**(struct *drm_dp_aux* *aux)
  minimally initialise an aux channel

Parameters

`struct drm_dp_aux *aux`
  DisplayPort AUX channel

Description

If you need to use the drm_dp_aux's i2c adapter prior to registering it with the outside world, call *`drm_dp_aux_init()`* first. You must still call *`drm_dp_aux_register()`* once the connector has been registered to allow userspace access to the auxiliary DP channel.

int **`drm_dp_aux_register`**(struct *drm_dp_aux* *aux)
  initialise and register aux channel

Parameters

`struct drm_dp_aux *aux`
  DisplayPort AUX channel

Description

Automatically calls *drm_dp_aux_init()* if this hasn't been done yet. This should only be called when the underlying *struct drm_connector* is initialiazed already. Therefore the best place to call this is from *drm_connector_funcs.late_register*. Not that drivers which don't follow this will Oops when CONFIG_DRM_DP_AUX_CHARDEV is enabled.

Drivers which need to use the aux channel before that point (e.g. at driver load time, before *drm_dev_register()* has been called) need to call *drm_dp_aux_init()*.

Returns 0 on success or a negative error code on failure.

void **drm_dp_aux_unregister**(struct *drm_dp_aux* *aux)

unregister an AUX adapter

Parameters

struct drm_dp_aux *aux
DisplayPort AUX channel

int **drm_dp_psr_setup_time**(const u8 psr_cap[EDP_PSR_RECEIVER_CAP_SIZE])

PSR setup in time usec

Parameters

const u8 psr_cap[EDP_PSR_RECEIVER_CAP_SIZE]
PSR capabilities from DPCD

Return

PSR setup time for the panel in microseconds, negative error code on failure.

int **drm_dp_start_crc**(struct *drm_dp_aux* *aux, struct *drm_crtc* *crtc)

start capture of frame CRCs

Parameters

struct drm_dp_aux *aux
DisplayPort AUX channel

struct drm_crtc *crtc
CRTC displaying the frames whose CRCs are to be captured

Description

Returns 0 on success or a negative error code on failure.

int **drm_dp_stop_crc**(struct *drm_dp_aux* *aux)

stop capture of frame CRCs

Parameters

struct drm_dp_aux *aux
DisplayPort AUX channel

Description

Returns 0 on success or a negative error code on failure.

u32 **drm_dp_get_edid_quirks**(const struct *edid* *edid)

Check the EDID of a DP device to find additional DP-specific quirks

Parameters

const struct edid *edid
The EDID to check

Description

While OUIDs are meant to be used to recognize a DisplayPort device, a lot of manufacturers don' t seem to like following standards and neglect to fill the dev-ID in, making it impossible to only use OUIDs for determining quirks in some cases. This function can be used to check the EDID and look up any additional DP quirks. The bits returned by this function correspond to the quirk bits in *drm_dp_quirk*.

Return

a bitmask of quirks, if any. The driver can check this using *drm_dp_has_quirk()*.

int **drm_dp_read_desc**(struct *drm_dp_aux* *aux, struct *drm_dp_desc* *desc, bool is_branch)

read sink/branch descriptor from DPCD

Parameters

struct drm_dp_aux *aux
DisplayPort AUX channel

struct drm_dp_desc *desc
Device descriptor to fill from DPCD

bool is_branch
true for branch devices, false for sink devices

Description

Read DPCD 0x400 (sink) or 0x500 (branch) into **desc**. Also debug log the identification.

Returns 0 on success or a negative error code on failure.

u8 **drm_dp_dsc_sink_max_slice_count**(const u8 dsc_dpcd[DP_DSC_RECEIVER_CAP_SIZE], bool is_edp)

Get the max slice count supported by the DSC sink.

Parameters

const u8 dsc_dpcd[DP_DSC_RECEIVER_CAP_SIZE]
DSC capabilities from DPCD

bool is_edp
true if its eDP, false for DP

Description

Read the slice capabilities DPCD register from DSC sink to get the maximum slice count supported. This is used to populate the DSC parameters in the *struct* *drm_dsc_config* by the driver. Driver creates an infoframe using these parameters to populate *struct drm_dsc_pps_infoframe*. These are sent to the sink using DSC infoframe using the helper function drm_dsc_pps_infoframe_pack()

Return

Maximum slice count supported by DSC sink or 0 its invalid

u8 **drm_dp_dsc_sink_line_buf_depth**(const u8 dsc_dpcd[DP_DSC_RECEIVER_CAP_SIZE])

Get the line buffer depth in bits

Parameters

const u8 dsc_dpcd[DP_DSC_RECEIVER_CAP_SIZE]
DSC capabilities from DPCD

Description

Read the DSC DPCD register to parse the line buffer depth in bits which is number of bits of precision within the decoder line buffer supported by the DSC sink. This is used to populate the DSC parameters in the *struct drm_dsc_config* by the driver. Driver creates an infoframe using these parameters to populate *struct drm_dsc_pps_infoframe*. These are sent to the sink using DSC infoframe using the helper function drm_dsc_pps_infoframe_pack()

Return

Line buffer depth supported by DSC panel or 0 its invalid

int **drm_dp_dsc_sink_supported_input_bpcs**(const u8 dsc_dpcd[DP_DSC_RECEIVER_CAP_SIZE], u8 dsc_bpc[3])

Get all the input bits per component values supported by the DSC sink.

Parameters

const u8 dsc_dpcd[DP_DSC_RECEIVER_CAP_SIZE]
DSC capabilities from DPCD

u8 dsc_bpc[3]
An array to be filled by this helper with supported input bpcs.

Description

Read the DSC DPCD from the sink device to parse the supported bits per component values. This is used to populate the DSC parameters in the *struct drm_dsc_config* by the driver. Driver creates an infoframe using these parameters to populate *struct drm_dsc_pps_infoframe*. These are sent to the sink using DSC infoframe using the helper function drm_dsc_pps_infoframe_pack()

Return

Number of input BPC values parsed from the DPCD

int **drm_dp_get_phy_test_pattern**(struct *drm_dp_aux* *aux, struct *drm_dp_phy_test_params* *data)

get the requested pattern from the sink.

Parameters

struct drm_dp_aux *aux
DisplayPort AUX channel

struct drm_dp_phy_test_params *data
DP phy compliance test parameters.

Description

Returns 0 on success or a negative error code on failure.

int **drm_dp_set_phy_test_pattern**(struct *drm_dp_aux* *aux, struct *drm_dp_phy_test_params* *data, u8 dp_rev)

set the pattern to the sink.

Parameters

struct drm_dp_aux *aux
DisplayPort AUX channel

struct drm_dp_phy_test_params *data
DP phy compliance test parameters.

u8 dp_rev
DP revision to use for compliance testing

Description

Returns 0 on success or a negative error code on failure.

5.13 Display Port CEC Helper Functions Reference

These functions take care of supporting the CEC-Tunneling-over-AUX feature of DisplayPort-to-HDMI adapters.

void **drm_dp_cec_irq**(struct *drm_dp_aux* *aux)

handle CEC interrupt, if any

Parameters

struct drm_dp_aux *aux
DisplayPort AUX channel

Description

Should be called when handling an IRQ_HPD request. If CEC-tunneling-over-AUX is present, then it will check for a CEC_IRQ and handle it accordingly.

void **drm_dp_cec_register_connector**(struct *drm_dp_aux* *aux, struct *drm_connector* *connector)

register a new connector

Parameters

struct drm_dp_aux *aux
DisplayPort AUX channel

struct drm_connector *connector
drm connector

Description

A new connector was registered with associated CEC adapter name and CEC adapter parent device. After registering the name and parent drm_dp_cec_set_edid() is called to check if the connector supports CEC and to register a CEC adapter if that is the case.

void **drm_dp_cec_unregister_connector**(struct *drm_dp_aux* *aux)

unregister the CEC adapter, if any

Parameters

struct drm_dp_aux *aux
DisplayPort AUX channel

5.14 Display Port Dual Mode Adaptor Helper Functions Reference

Helper functions to deal with DP dual mode (aka. DP++) adaptors.

Type 1: Adaptor registers (if any) and the sink DDC bus may be accessed via I2C.

Type 2: Adaptor registers and sink DDC bus can be accessed either via I2C or I2C-over-AUX. Source devices may choose to implement either of these access methods.

enum **drm_lspcon_mode**

Constants

DRM_LSPCON_MODE_INVALID
No LSPCON.

DRM_LSPCON_MODE_LS
Level shifter mode of LSPCON which drives DP++ to HDMI 1.4 conversion.

DRM_LSPCON_MODE_PCON
Protocol converter mode of LSPCON which drives DP++ to HDMI 2.0 active conversion.

enum **drm_dp_dual_mode_type**

Type of the DP dual mode adaptor

Constants

DRM_DP_DUAL_MODE_NONE
No DP dual mode adaptor

DRM_DP_DUAL_MODE_UNKNOWN
Could be either none or type 1 DVI adaptor

DRM_DP_DUAL_MODE_TYPE1_DVI
Type 1 DVI adaptor

DRM_DP_DUAL_MODE_TYPE1_HDMI
Type 1 HDMI adaptor

DRM_DP_DUAL_MODE_TYPE2_DVI
Type 2 DVI adaptor

DRM_DP_DUAL_MODE_TYPE2_HDMI
Type 2 HDMI adaptor

DRM_DP_DUAL_MODE_LSPCON
Level shifter / protocol converter

ssize_t **drm_dp_dual_mode_read**(struct i2c_adapter *adapter, u8 offset, void *buffer, size_t size)

Read from the DP dual mode adaptor register(s)

Parameters

struct i2c_adapter *adapter
I2C adapter for the DDC bus

u8 offset
register offset

void *buffer
buffer for return data

size_t size
sizo of the buffer

Description

Reads **size** bytes from the DP dual mode adaptor registers starting at **offset**.

Return

0 on success, negative error code on failure

ssize_t **drm_dp_dual_mode_write**(struct i2c_adapter *adapter, u8 offset, const void *buffer, size_t size)

Write to the DP dual mode adaptor register(s)

Parameters

struct i2c_adapter *adapter
I2C adapter for the DDC bus

u8 offset
register offset

const void *buffer
buffer for write data

size_t size
sizo of the buffer

Description

Writes **size** bytes to the DP dual mode adaptor registers starting at **offset**.

Return

0 on success, negative error code on failure

enum *drm_dp_dual_mode_type* **drm_dp_dual_mode_detect**(struct i2c_adapter *adapter)

Identify the DP dual mode adaptor

Parameters

struct i2c_adapter *adapter
I2C adapter for the DDC bus

Description

Attempt to identify the type of the DP dual mode adaptor used.

Note that when the answer is **DRM_DP_DUAL_MODE_UNKNOWN** it's not certain whether we're dealing with a native HDMI port or a type 1 DVI dual mode adaptor. The driver will have to use some other hardware/driver specific mechanism to make that distinction.

Return

The type of the DP dual mode adaptor used

int **drm_dp_dual_mode_max_tmds_clock**(enum *drm_dp_dual_mode_type* type, struct i2c_adapter *adapter)

Max TMDS clock for DP dual mode adaptor

Parameters

enum drm_dp_dual_mode_type type
DP dual mode adaptor type

struct i2c_adapter *adapter
I2C adapter for the DDC bus

Description

Determine the max TMDS clock the adaptor supports based on the type of the dual mode adaptor and the DP_DUAL_MODE_MAX_TMDS_CLOCK register (on type2 adaptors). As some type 1 adaptors have problems with registers (see comments in *drm_dp_dual_mode_detect()*) we don't read the register on those, instead we simply assume a 165 MHz limit based on the specification.

Return

Maximum supported TMDS clock rate for the DP dual mode adaptor in kHz.

int **drm_dp_dual_mode_get_tmds_output**(enum *drm_dp_dual_mode_type* type, struct i2c_adapter *adapter, bool *enabled)

Get the state of the TMDS output buffers in the DP dual mode adaptor

Parameters

enum drm_dp_dual_mode_type type
DP dual mode adaptor type

struct i2c_adapter *adapter
I2C adapter for the DDC bus

bool *enabled
current state of the TMDS output buffers

Description

Get the state of the TMDS output buffers in the adaptor. For type2 adaptors this is queried from the DP_DUAL_MODE_TMDS_OEN register. As some type 1 adaptors have problems with registers (see comments in *drm_dp_dual_mode_detect()*) we don't read the register on those, instead we simply assume that the buffers are always enabled.

Return

0 on success, negative error code on failure

int **drm_dp_dual_mode_set_tmds_output**(enum *drm_dp_dual_mode_type* type, struct i2c_adapter *adapter, bool enable)

Enable/disable TMDS output buffers in the DP dual mode adaptor

Parameters

enum drm_dp_dual_mode_type type
DP dual mode adaptor type

struct i2c_adapter *adapter
I2C adapter for the DDC bus

bool enable
enable (as opposed to disable) the TMDS output buffers

Description

Set the state of the TMDS output buffers in the adaptor. For type2 this is set via the DP_DUAL_MODE_TMDS_OEN register. Type1 adaptors do not support any register writes.

Return

0 on success, negative error code on failure

const char ***drm_dp_get_dual_mode_type_name**(enum *drm_dp_dual_mode_type* type)

Get the name of the DP dual mode adaptor type as a string

Parameters

enum drm_dp_dual_mode_type type
DP dual mode adaptor type

Return

String representation of the DP dual mode adaptor type

int **drm_lspcon_get_mode**(struct i2c_adapter *adapter, enum *drm_lspcon_mode* *mode)

Parameters

struct i2c_adapter *adapter
I2C-over-aux adapter

enum drm_lspcon_mode *mode
current lspcon mode of operation output variable

Description

reading offset (0x80, 0x41)

Return

0 on success, sets the current_mode value to appropriate mode -error on failure

int **drm_lspcon_set_mode**(struct i2c_adapter *adapter, enum *drm_lspcon_mode* mode)

Parameters

struct i2c_adapter *adapter
I2C-over-aux adapter

enum drm_lspcon_mode mode
required mode of operation

Description

writing offset (0x80, 0x40)

Return

0 on success, -error on failure/timeout

5.15 Display Port MST Helpers

5.15.1 Overview

These functions contain parts of the DisplayPort 1.2a MultiStream Transport protocol. The helpers contain a topology manager and bandwidth manager. The helpers encapsulate the sending and received of sideband msgs.

Topology refcount overview

The refcounting schemes for *struct drm_dp_mst_branch* and *struct drm_dp_mst_port* are somewhat unusual. Both ports and branch devices have two different kinds of refcounts: topology refcounts, and malloc refcounts.

Topology refcounts are not exposed to drivers, and are handled internally by the DP MST helpers. The helpers use them in order to prevent the in-memory topology state from being changed in the middle of critical operations like changing the internal state of payload allocations. This means each branch and port will be considered to be connected to the rest of the topology until its topology refcount reaches zero. Additionally, for ports this means that their associated *struct drm_connector* will stay registered with userspace until the port' s refcount reaches 0.

Malloc refcount overview

Malloc references are used to keep a *struct drm_dp_mst_port* or *struct drm_dp_mst_branch* allocated even after all of its topology references have been dropped, so that the driver or MST helpers can safely access each branch' s last known state before it was disconnected from the topology. When the malloc refcount of a port or branch reaches 0, the memory allocation containing the *struct drm_dp_mst_branch* or *struct drm_dp_mst_port* respectively will be freed.

For *struct drm_dp_mst_branch*, malloc refcounts are not currently exposed to drivers. As of writing this documentation, there are no drivers that have a usecase for accessing *struct drm_dp_mst_branch* outside of the MST helpers. Exposing this API to drivers in a race-free manner would take more tweaking of the refcounting scheme, however patches are welcome provided there is a legitimate driver usecase for this.

Refcount relationships in a topology

Let' s take a look at why the relationship between topology and malloc refcounts is designed the way it is.

As you can see in the above figure, every branch increments the topology refcount of its children, and increments the malloc refcount of its parent. Additionally, every payload increments the malloc refcount of its assigned port by 1.

So, what would happen if MSTB #3 from the above figure was unplugged from the system, but the driver hadn' t yet removed payload #2 from port #3? The topology would start to look like the figure below.

Whenever a port or branch device' s topology refcount reaches zero, it will decrement the topology refcounts of all its children, the malloc refcount of its parent, and finally its own malloc refcount. For MSTB #4 and port #4, this means they both have been disconnected from the topology and freed from memory. But, because payload #2 is still holding a reference to port #3, port #3 is removed from the topology but its *struct drm_dp_mst_port* is still accessible from memory. This also means port #3 has not yet decremented the malloc refcount of MSTB #3, so its *struct drm_dp_mst_branch* will also stay allocated in memory until port #3' s malloc refcount reaches 0.

This relationship is necessary because in order to release payload #2, we need to be able to figure out the last relative of port #3 that' s still connected to the topology. In this case, we would travel up the topology as shown below.

And finally, remove payload #2 by communicating with port #2 through sideband transactions.

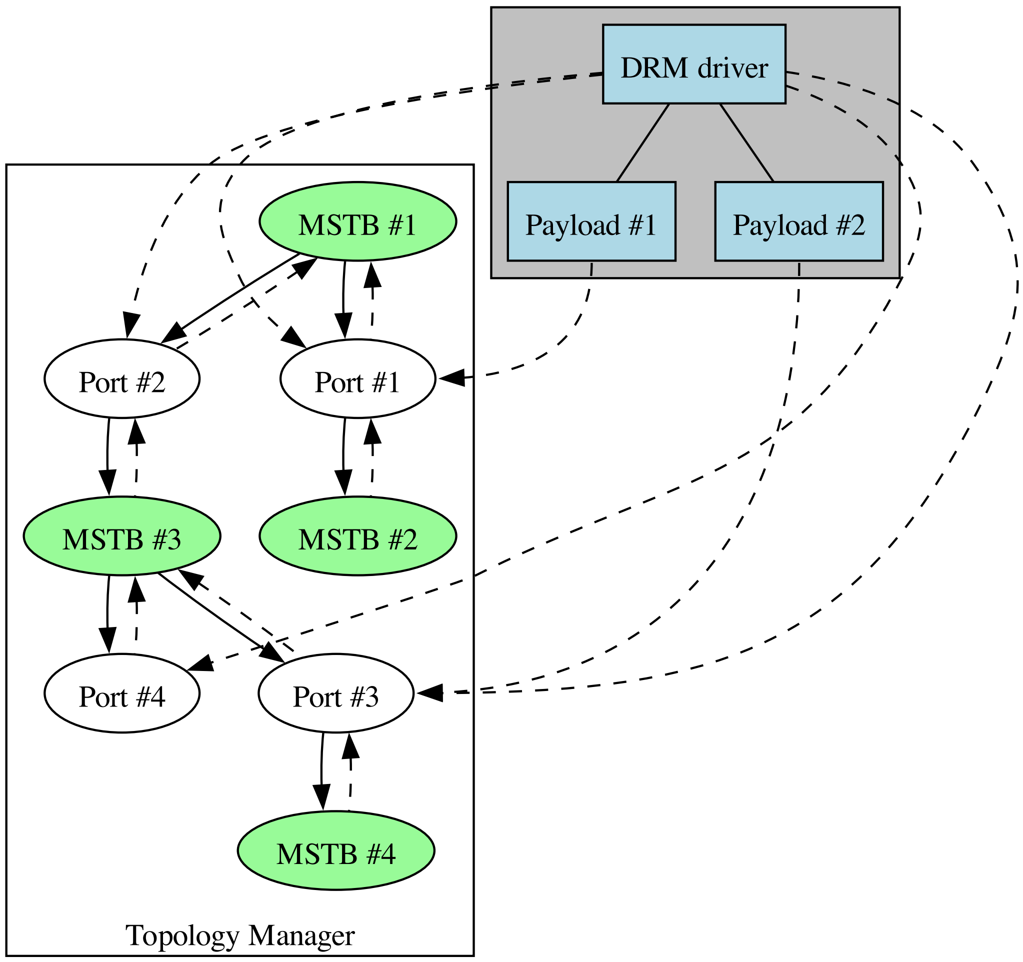


Fig. 1: An example of topology and malloc refs in a DP MST topology with two active payloads. Topology refcount increments are indicated by solid lines, and malloc refcount increments are indicated by dashed lines. Each starts from the branch which incremented the refcount, and ends at the branch to which the refcount belongs to, i.e. the arrow points the same way as the C pointers used to reference a structure.

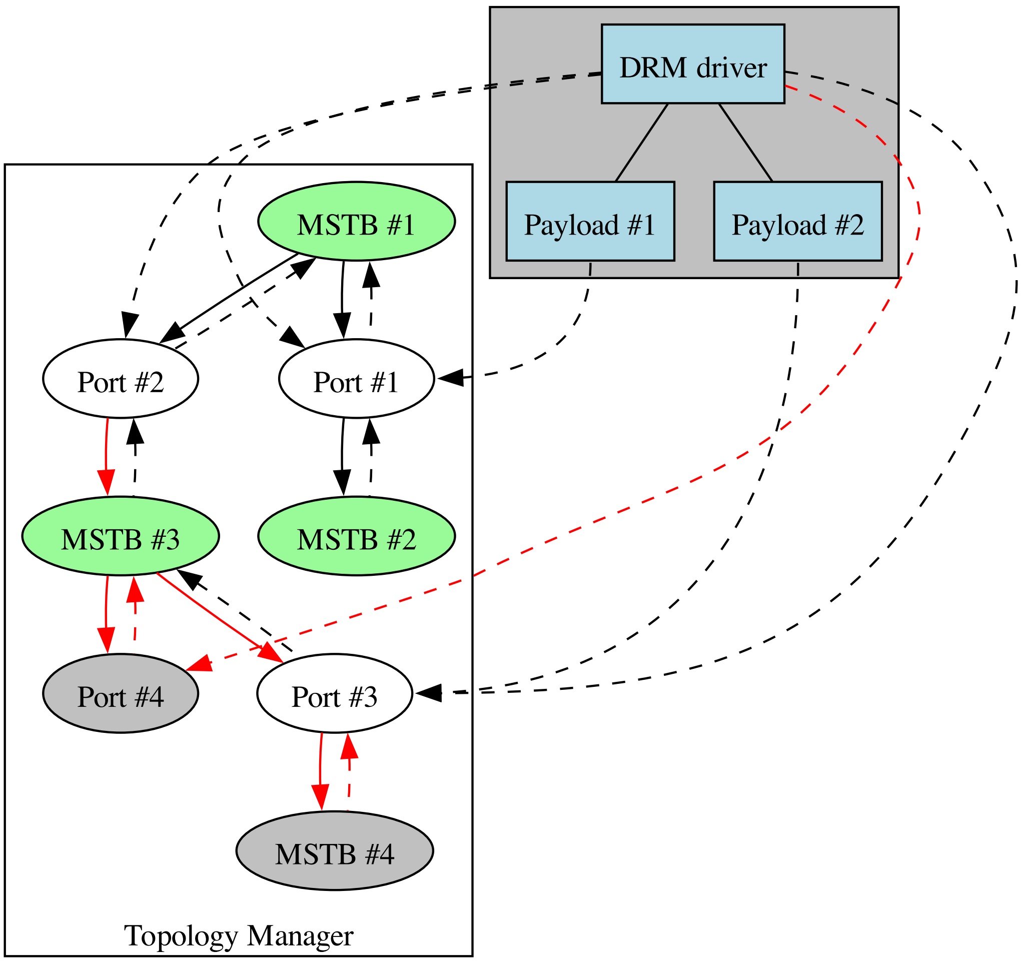
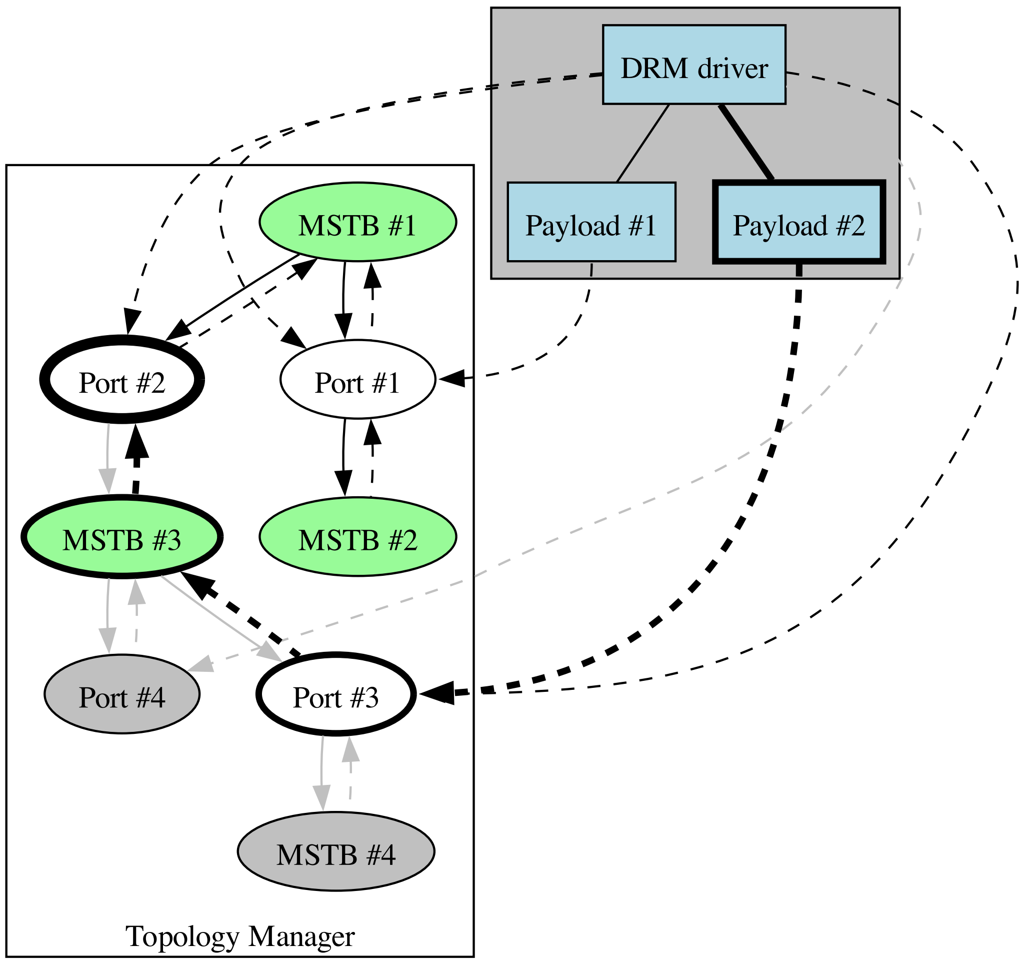


Fig. 2: Ports and branch devices which have been released from memory are colored grey, and references which have been removed are colored red.


DRM driver
Payload #1
Payload #2
MSTB #1
Port #2
Port #1
MSTB #3
MSTB #2
Port #4
Port #3
MSTB #4
Topology Manager

5.15.2 Functions Reference

struct **drm_dp_vcpi**

Virtual Channel Payload Identifier

Definition

```
struct drm_dp_vcpi {
  int vcpi;
  int pbn;
  int aligned_pbn;
  int num_slots;
};
```

Members

vcpi
Virtual channel ID.

pbn
Payload Bandwidth Number for this channel

aligned_pbn
PBN aligned with slot size

num_slots
number of slots for this PBN

struct **drm_dp_mst_port**

MST port

Definition

```
struct drm_dp_mst_port {
  struct kref topology_kref;
  struct kref malloc_kref;
#if IS_ENABLED(CONFIG_DRM_DEBUG_DP_MST_TOPOLOGY_REFS);
  struct drm_dp_mst_topology_ref_history topology_ref_history;
#endif;
  u8 port_num;
  bool input;
  bool mcs;
  bool ddps;
  u8 pdt;
  bool ldps;
  u8 dpcd_rev;
  u8 num_sdp_streams;
  u8 num_sdp_stream_sinks;
  uint16_t full_pbn;
  struct list_head next;
  struct drm_dp_mst_branch *mstb;
  struct drm_dp_aux aux;
  struct drm_dp_mst_branch *parent;
  struct drm_dp_vcpi vcpi;
```

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```
  struct drm_connector *connector;
  struct drm_dp_mst_topology_mgr *mgr;
  struct edid *cached_edid;
  bool has_audio;
  bool fec_capable;
};
```

Members

topology_kref
refcount for this port's lifetime in the topology, only the DP MST helpers should need to touch this

malloc_kref
refcount for the memory allocation containing this structure. See *drm_dp_mst_get_port_malloc()* and *drm_dp_mst_put_port_malloc()*.

topology_ref_history
A history of each topology reference/dereference. See CONFIG_DRM_DEBUG_DP_MST_TOPOLOGY_REFS.

port_num
port number

input
if this port is an input port. Protected by *drm_dp_mst_topology_mgr.base*.lock.

mcs
message capability status - DP 1.2 spec. Protected by *drm_dp_mst_topology_mgr.base*.lock.

ddps
DisplayPort Device Plug Status - DP 1.2. Protected by *drm_dp_mst_topology_mgr.base*.lock.

pdt
Peer Device Type. Protected by *drm_dp_mst_topology_mgr.base*.lock.

ldps
Legacy Device Plug Status. Protected by *drm_dp_mst_topology_mgr.base*.lock.

dpcd_rev
DPCD revision of device on this port. Protected by *drm_dp_mst_topology_mgr.base*.lock.

num_sdp_streams
Number of simultaneous streams. Protected by *drm_dp_mst_topology_mgr.base*.lock.

num_sdp_stream_sinks
Number of stream sinks. Protected by *drm_dp_mst_topology_mgr.base*.lock.

full_pbn
Max possible bandwidth for this port. Protected by

drm_dp_mst_topology_mgr.base.lock.

next
link to next port on this branch device

mstb
the branch device connected to this port, if there is one. This should be considered protected for reading by *drm_dp_mst_topology_mgr.lock*. There are two exceptions to this: *drm_dp_mst_topology_mgr.up_req_work* and *drm_dp_mst_topology_mgr.work*, which do not grab *drm_dp_mst_topology_mgr.lock* during reads but are the only updaters of this list and are protected from writing concurrently by *drm_dp_mst_topology_mgr.probe_lock*.

aux
i2c aux transport to talk to device connected to this port, protected by *drm_dp_mst_topology_mgr.base*.lock.

parent
branch device parent of this port

vcpi
Virtual Channel Payload info for this port.

connector
DRM connector this port is connected to. Protected by *drm_dp_mst_topology_mgr.base*.lock.

mgr
topology manager this port lives under.

cached_edid
for DP logical ports - make tiling work by ensuring that the EDID for all connectors is read immediately.

has_audio
Tracks whether the sink connector to this port is audio-capable.

fec_capable
bool indicating if FEC can be supported up to that point in the MST topology.

Description

This structure represents an MST port endpoint on a device somewhere in the MST topology.

struct **drm_dp_mst_branch**
MST branch device.

Definition

```
struct drm_dp_mst_branch {
  struct kref topology_kref;
  struct kref malloc_kref;
#if IS_ENABLED(CONFIG_DRM_DEBUG_DP_MST_TOPOLOGY_REFS);
  struct drm_dp_mst_topology_ref_history topology_ref_history;
#endif;
```

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```
  struct list_head destroy_next;
  u8 rad[8];
  u8 lct;
  int num_ports;
  struct list_head ports;
  struct drm_dp_mst_port *port_parent;
  struct drm_dp_mst_topology_mgr *mgr;
  bool link_address_sent;
  u8 guid[16];
};
```

Members

topology_kref
: refcount for this branch device's lifetime in the topology, only the DP MST helpers should need to touch this

malloc_kref
: refcount for the memory allocation containing this structure. See *drm_dp_mst_get_mstb_malloc()* and *drm_dp_mst_put_mstb_malloc()*.

topology_ref_history
: A history of each topology reference/dereference. See CONFIG_DRM_DEBUG_DP_MST_TOPOLOGY_REFS.

destroy_next
: linked-list entry used by drm_dp_delayed_destroy_work()

rad
: Relative Address to talk to this branch device.

lct
: Link count total to talk to this branch device.

num_ports
: number of ports on the branch.

ports
: the list of ports on this branch device. This should be considered protected for reading by *drm_dp_mst_topology_mgr.lock*. There are two exceptions to this: *drm_dp_mst_topology_mgr.up_req_work* and *drm_dp_mst_topology_mgr.work*, which do not grab *drm_dp_mst_topology_mgr.lock* during reads but are the only updaters of this list and are protected from updating the list concurrently by **drm_dp_mst_topology_mgr.probe_lock**

port_parent
: pointer to the port parent, NULL if toplevel.

mgr
: topology manager for this branch device.

link_address_sent
: if a link address message has been sent to this device yet.

guid
guid for DP 1.2 branch device. port under this branch can be identified by port #.

Description

This structure represents an MST branch device, there is one primary branch device at the root, along with any other branches connected to downstream port of parent branches.

struct **drm_dp_mst_topology_mgr**
DisplayPort MST manager

Definition

```
struct drm_dp_mst_topology_mgr {
  struct drm_private_obj base;
  struct drm_device *dev;
  const struct drm_dp_mst_topology_cbs *cbs;
  int max_dpcd_transaction_bytes;
  struct drm_dp_aux *aux;
  int max_payloads;
  int conn_base_id;
  struct drm_dp_sideband_msg_rx up_req_recv;
  struct drm_dp_sideband_msg_rx down_rep_recv;
  struct mutex lock;
  struct mutex probe_lock;
  bool mst_state : 1;
  bool payload_id_table_cleared : 1;
  struct drm_dp_mst_branch *mst_primary;
  u8 dpcd[DP_RECEIVER_CAP_SIZE];
  u8 sink_count;
  int pbn_div;
  const struct drm_private_state_funcs *funcs;
  struct mutex qlock;
  struct list_head tx_msg_downq;
  struct mutex payload_lock;
  struct drm_dp_vcpi **proposed_vcpis;
  struct drm_dp_payload *payloads;
  unsigned long payload_mask;
  unsigned long vcpi_mask;
  wait_queue_head_t tx_waitq;
  struct work_struct work;
  struct work_struct tx_work;
  struct list_head destroy_port_list;
  struct list_head destroy_branch_device_list;
  struct mutex delayed_destroy_lock;
  struct workqueue_struct *delayed_destroy_wq;
  struct work_struct delayed_destroy_work;
  struct list_head up_req_list;
  struct mutex up_req_lock;
  struct work_struct up_req_work;
```

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```
#if IS_ENABLED(CONFIG_DRM_DEBUG_DP_MST_TOPOLOGY_REFS);
  struct mutex topology_ref_history_lock;
#endif;
};
```

Members

base
: Base private object for atomic

dev
: device pointer for adding i2c devices etc.

cbs
: callbacks for connector addition and destruction.

max_dpcd_transaction_bytes
: maximum number of bytes to read/write in one go.

aux
: AUX channel for the DP MST connector this topolgy mgr is controlling.

max_payloads
: maximum number of payloads the GPU can generate.

conn_base_id
: DRM connector ID this mgr is connected to. Only used to build the MST connector path value.

up_req_recv
: Message receiver state for up requests.

down_rep_recv
: Message receiver state for replies to down requests.

lock
: protects **mst_state**, **mst_primary**, **dpcd**, and **payload_id_table_cleared**.

probe_lock
: Prevents **work** and **up_req_work**, the only writers of *drm_dp_mst_port.mstb* and *drm_dp_mst_branch.ports*, from racing while they update the topology.

mst_state
: If this manager is enabled for an MST capable port. False if no MST sink/branch devices is connected.

payload_id_table_cleared
: Whether or not we’ ve cleared the payload ID table for **mst_primary**. Protected by **lock**.

mst_primary
: Pointer to the primary/first branch device.

dpcd
: Cache of DPCD for primary port.

sink_count
: Sink count from DEVICE_SERVICE_IRQ_VECTOR_ESI0.

pbn_div
PBN to slots divisor.

funcs
Atomic helper callbacks

qlock
protects **tx_msg_downq** and `drm_dp_sideband_msg_tx.state`

tx_msg_downq
List of pending down requests

payload_lock
Protect payload information.

proposed_vcpis
Array of pointers for the new VCPI allocation. The VCPI structure itself is *drm_dp_mst_port.vcpi*, and the size of this array is determined by **max_payloads**.

payloads
Array of payloads. The size of this array is determined by **max_payloads**.

payload_mask
Elements of **payloads** actually in use. Since reallocation of active outputs isn't possible gaps can be created by disabling outputs out of order compared to how they've been enabled.

vcpi_mask
Similar to **payload_mask**, but for **proposed_vcpis**.

tx_waitq
Wait to queue stall for the tx worker.

work
Probe work.

tx_work
Sideband transmit worker. This can nest within the main **work** worker for each transaction **work** launches.

destroy_port_list
List of to be destroyed connectors.

destroy_branch_device_list
List of to be destroyed branch devices.

delayed_destroy_lock
Protects **destroy_port_list** and **destroy_branch_device_list**.

delayed_destroy_wq
Workqueue used for delayed_destroy_work items. A dedicated WQ makes it possible to drain any requeued work items on it.

delayed_destroy_work
Work item to destroy MST port and branch devices, needed to avoid locking inversion.

up_req_list
List of pending up requests from the topology that need to be processed, in chronological order.

up_req_lock
Protects **up_req_list**

up_req_work
Work item to process up requests received from the topology. Needed to avoid blocking hotplug handling and sideband transmissions.

topology_ref_history_lock
protects *drm_dp_mst_port.topology_ref_history* and *drm_dp_mst_branch.topology_ref_history*.

Description

This struct represents the toplevel displayport MST topology manager. There should be one instance of this for every MST capable DP connector on the GPU.

bool **__drm_dp_mst_state_iter_get**(struct *drm_atomic_state* *state, struct *drm_dp_mst_topology_mgr* **mgr, struct drm_dp_mst_topology_state **old_state, struct drm_dp_mst_topology_state **new_state, int i)

private atomic state iterator function for macro-internal use

Parameters

struct drm_atomic_state *state
struct drm_atomic_state pointer

struct drm_dp_mst_topology_mgr **mgr
pointer to the *struct drm_dp_mst_topology_mgr* iteration cursor

struct drm_dp_mst_topology_state **old_state
optional pointer to the old `struct drm_dp_mst_topology_state` iteration cursor

struct drm_dp_mst_topology_state **new_state
optional pointer to the new `struct drm_dp_mst_topology_state` iteration cursor

int i
int iteration cursor, for macro-internal use

Description

Used by *for_each_oldnew_mst_mgr_in_state()*, *for_each_old_mst_mgr_in_state()*, and *for_each_new_mst_mgr_in_state()*. Don't call this directly.

Return

True if the current *struct drm_private_obj* is a *struct drm_dp_mst_topology_mgr*, false otherwise.

for_each_oldnew_mst_mgr_in_state

```
for_each_oldnew_mst_mgr_in_state (__state, mgr, old_state,
new_state, __i)
```

iterate over all DP MST topology managers in an atomic update

Parameters

__state
: *struct drm_atomic_state* pointer

mgr
: *struct drm_dp_mst_topology_mgr* iteration cursor

old_state
: `struct drm_dp_mst_topology_state` iteration cursor for the old state

new_state
: `struct drm_dp_mst_topology_state` iteration cursor for the new state

__i
: int iteration cursor, for macro-internal use

Description

This iterates over all DRM DP MST topology managers in an atomic update, tracking both old and new state. This is useful in places where the state delta needs to be considered, for example in atomic check functions.

for_each_old_mst_mgr_in_state

`for_each_old_mst_mgr_in_state (__state, mgr, old_state, __i)`

iterate over all DP MST topology managers in an atomic update

Parameters

__state
: *struct drm_atomic_state* pointer

mgr
: *struct drm_dp_mst_topology_mgr* iteration cursor

old_state
: `struct drm_dp_mst_topology_state` iteration cursor for the old state

__i
: int iteration cursor, for macro-internal use

Description

This iterates over all DRM DP MST topology managers in an atomic update, tracking only the old state. This is useful in disable functions, where we need the old state the hardware is still in.

for_each_new_mst_mgr_in_state

`for_each_new_mst_mgr_in_state (__state, mgr, new_state, __i)`

iterate over all DP MST topology managers in an atomic update

Parameters

__state
: *struct drm_atomic_state* pointer

mgr
: *struct drm_dp_mst_topology_mgr* iteration cursor

new_state
: `struct drm_dp_mst_topology_state` iteration cursor for the new state

__i
: int iteration cursor, for macro-internal use

Description

This iterates over all DRM DP MST topology managers in an atomic update, tracking only the new state. This is useful in enable functions, where we need the new state the hardware should be in when the atomic commit operation has completed.

void **drm_dp_mst_get_port_malloc**(struct *drm_dp_mst_port* *port)
: Increment the malloc refcount of an MST port

Parameters

struct drm_dp_mst_port *port
: The *struct drm_dp_mst_port* to increment the malloc refcount of

Description

Increments *drm_dp_mst_port.malloc_kref*. When *drm_dp_mst_port.malloc_kref* reaches 0, the memory allocation for **port** will be released and **port** may no longer be used.

Because **port** could potentially be freed at any time by the DP MST helpers if *drm_dp_mst_port.malloc_kref* reaches 0, including during a call to this function, drivers that which to make use of *struct drm_dp_mst_port* should ensure that they grab at least one main malloc reference to their MST ports in `drm_dp_mst_topology_cbs.add_connector`. This callback is called before there is any chance for *drm_dp_mst_port.malloc_kref* to reach 0.

See also: *drm_dp_mst_put_port_malloc()*

void **drm_dp_mst_put_port_malloc**(struct *drm_dp_mst_port* *port)
: Decrement the malloc refcount of an MST port

Parameters

struct drm_dp_mst_port *port
: The *struct drm_dp_mst_port* to decrement the malloc refcount of

Description

Decrements *drm_dp_mst_port.malloc_kref*. When *drm_dp_mst_port.malloc_kref* reaches 0, the memory allocation for **port** will be released and **port** may no longer be used.

See also: *drm_dp_mst_get_port_malloc()*

int **drm_dp_mst_connector_late_register**(struct *drm_connector* *connector, struct *drm_dp_mst_port* *port)
: Late MST connector registration

Parameters

`struct drm_connector *connector`
  The MST connector

`struct drm_dp_mst_port *port`
  The MST port for this connector

Description

Helper to register the remote aux device for this MST port. Drivers should call this from their mst connector's late_register hook to enable MST aux devices.

Return

0 on success, negative error code on failure.

void **`drm_dp_mst_connector_early_unregister`**(struct *drm_connector* *connector, struct *drm_dp_mst_port* *port)

  Early MST connector unregistration

Parameters

`struct drm_connector *connector`
  The MST connector

`struct drm_dp_mst_port *port`
  The MST port for this connector

Description

Helper to unregister the remote aux device for this MST port, registered by *`drm_dp_mst_connector_late_register()`*. Drivers should call this from their mst connector's early_unregister hook.

int **`drm_dp_update_payload_part1`**(struct *drm_dp_mst_topology_mgr* *mgr)

  Execute payload update part 1

Parameters

`struct drm_dp_mst_topology_mgr *mgr`
  manager to use.

Description

This iterates over all proposed virtual channels, and tries to allocate space in the link for them. For 0->slots transitions, this step just writes the VCPI to the MST device. For slots->0 transitions, this writes the updated VCPIs and removes the remote VC payloads.

after calling this the driver should generate ACT and payload packets.

int **`drm_dp_update_payload_part2`**(struct *drm_dp_mst_topology_mgr* *mgr)

  Execute payload update part 2

Parameters

`struct drm_dp_mst_topology_mgr *mgr`
  manager to use.

Description

This iterates over all proposed virtual channels, and tries to allocate space in the link for them. For 0->slots transitions, this step writes the remote VC payload commands. For slots->0 this just resets some internal state.

int **drm_dp_get_vc_payload_bw**(int link_rate, int link_lane_count)

get the VC payload BW for an MST link

Parameters

int link_rate
link rate in 10kbits/s units

int link_lane_count
lane count

Description

Calculate the total bandwidth of a MultiStream Transport link. The returned value is in units of PBNs/(timeslots/1 MTP). This value can be used to convert the number of PBNs required for a given stream to the number of timeslots this stream requires in each MTP.

bool **drm_dp_read_mst_cap**(struct *drm_dp_aux* *aux, const u8 dpcd[DP_RECEIVER_CAP_SIZE])

check whether or not a sink supports MST

Parameters

struct drm_dp_aux *aux
The DP AUX channel to use

const u8 dpcd[DP_RECEIVER_CAP_SIZE]
A cached copy of the DPCD capabilities for this sink

Return

`True` if the sink supports MST, `false` otherwise

int **drm_dp_mst_topology_mgr_set_mst**(struct *drm_dp_mst_topology_mgr* *mgr, bool mst_state)

Set the MST state for a topology manager

Parameters

struct drm_dp_mst_topology_mgr *mgr
manager to set state for

bool mst_state
true to enable MST on this connector - false to disable.

Description

This is called by the driver when it detects an MST capable device plugged into a DP MST capable port, or when a DP MST capable device is unplugged.

void **drm_dp_mst_topology_mgr_suspend**(struct *drm_dp_mst_topology_mgr* *mgr)

suspend the MST manager

Parameters

struct drm_dp_mst_topology_mgr *mgr
manager to suspend

Description

This function tells the MST device that we can' t handle UP messages anymore. This should stop it from sending any since we are suspended.

int **drm_dp_mst_topology_mgr_resume**(struct *drm_dp_mst_topology_mgr* *mgr, bool sync)
resume the MST manager

Parameters

struct drm_dp_mst_topology_mgr *mgr
manager to resume

bool sync
whether or not to perform topology reprobing synchronously

Description

This will fetch DPCD and see if the device is still there, if it is, it will rewrite the MSTM control bits, and return.

If the device fails this returns -1, and the driver should do a full MST reprobe, in case we were undocked.

During system resume (where it is assumed that the driver will be calling *drm_atomic_helper_resume()*) this function should be called beforehand with **sync** set to true. In contexts like runtime resume where the driver is not expected to be calling *drm_atomic_helper_resume()*, this function should be called with **sync** set to false in order to avoid deadlocking.

Return

-1 if the MST topology was removed while we were suspended, 0 otherwise.

int **drm_dp_mst_hpd_irq**(struct *drm_dp_mst_topology_mgr* *mgr, u8 *esi, bool *handled)
MST hotplug IRQ notify

Parameters

struct drm_dp_mst_topology_mgr *mgr
manager to notify irq for.

u8 *esi
4 bytes from SINK_COUNT_ESI

bool *handled
whether the hpd interrupt was consumed or not

Description

This should be called from the driver when it detects a short IRQ, along with the value of the DEVICE_SERVICE_IRQ_VECTOR_ESI0. The topology manager will process the sideband messages received as a result of this.

int **drm_dp_mst_detect_port**(struct *drm_connector* *connector, struct *drm_modeset_acquire_ctx* *ctx, struct *drm_dp_mst_topology_mgr* *mgr, struct *drm_dp_mst_port* *port)

get connection status for an MST port

Parameters

struct drm_connector *connector
DRM connector for this port

struct drm_modeset_acquire_ctx *ctx
The acquisition context to use for grabbing locks

struct drm_dp_mst_topology_mgr *mgr
manager for this port

struct drm_dp_mst_port *port
pointer to a port

Description

This returns the current connection state for a port.

struct edid ***drm_dp_mst_get_edid**(struct *drm_connector* *connector, struct *drm_dp_mst_topology_mgr* *mgr, struct *drm_dp_mst_port* *port)

get EDID for an MST port

Parameters

struct drm_connector *connector
toplevel connector to get EDID for

struct drm_dp_mst_topology_mgr *mgr
manager for this port

struct drm_dp_mst_port *port
unverified pointer to a port.

Description

This returns an EDID for the port connected to a connector, It validates the pointer still exists so the caller doesn't require a reference.

int **drm_dp_find_vcpi_slots**(struct *drm_dp_mst_topology_mgr* *mgr, int pbn)

Find VCPI slots for this PBN value

Parameters

struct drm_dp_mst_topology_mgr *mgr
manager to use

int pbn
payload bandwidth to convert into slots.

Description

Calculate the number of VCPI slots that will be required for the given PBN value. This function is deprecated, and should not be used in atomic drivers.

Return

The total slots required for this port, or error.

int **drm_dp_atomic_find_vcpi_slots**(struct *drm_atomic_state* *state, struct *drm_dp_mst_topology_mgr* *mgr, struct *drm_dp_mst_port* *port, int pbn, int pbn_div)

Find and add VCPI slots to the state

Parameters

struct drm_atomic_state *state
global atomic state

struct drm_dp_mst_topology_mgr *mgr
MST topology manager for the port

struct drm_dp_mst_port *port
port to find vcpi slots for

int pbn
bandwidth required for the mode in PBN

int pbn_div
divider for DSC mode that takes FEC into account

Description

Allocates VCPI slots to **port**, replacing any previous VCPI allocations it may have had. Any atomic drivers which support MST must call this function in their *drm_encoder_helper_funcs.atomic_check()* callback to change the current VCPI allocation for the new state, but only when *drm_crtc_state.mode_changed* or *drm_crtc_state.connectors_changed* is set to ensure compatibility with userspace applications that still use the legacy modesetting UAPI.

Allocations set by this function are not checked against the bandwidth restraints of **mgr** until the driver calls *drm_dp_mst_atomic_check()*.

Additionally, it is OK to call this function multiple times on the same **port** as needed. It is not OK however, to call this function and *drm_dp_atomic_release_vcpi_slots()* in the same atomic check phase.

See also: *drm_dp_atomic_release_vcpi_slots()* *drm_dp_mst_atomic_check()*

Return

Total slots in the atomic state assigned for this port, or a negative error code if the port no longer exists

int **drm_dp_atomic_release_vcpi_slots**(struct *drm_atomic_state* *state, struct *drm_dp_mst_topology_mgr* *mgr, struct *drm_dp_mst_port* *port)

Release allocated vcpi slots

Parameters

struct drm_atomic_state *state
global atomic state

struct drm_dp_mst_topology_mgr *mgr
MST topology manager for the port

struct drm_dp_mst_port *port
The port to release the VCPI slots from

Description

Releases any VCPI slots that have been allocated to a port in the atomic state. Any atomic drivers which support MST must call this function in their *drm_connector_helper_funcs.atomic_check()* callback when the connector will no longer have VCPI allocated (e.g. because its CRTC was removed) when it had VCPI allocated in the previous atomic state.

It is OK to call this even if **port** has been removed from the system. Additionally, it is OK to call this function multiple times on the same **port** as needed. It is not OK however, to call this function and *drm_dp_atomic_find_vcpi_slots()* on the same **port** in a single atomic check phase.

See also: *drm_dp_atomic_find_vcpi_slots()* *drm_dp_mst_atomic_check()*

Return

0 if all slots for this port were added back to `drm_dp_mst_topology_state.avail_slots` or negative error code

bool **drm_dp_mst_allocate_vcpi**(struct *drm_dp_mst_topology_mgr* *mgr, struct *drm_dp_mst_port* *port, int pbn, int slots)

Allocate a virtual channel

Parameters

struct drm_dp_mst_topology_mgr *mgr
manager for this port

struct drm_dp_mst_port *port
port to allocate a virtual channel for.

int pbn
payload bandwidth number to request

int slots
returned number of slots for this PBN.

void **drm_dp_mst_reset_vcpi_slots**(struct *drm_dp_mst_topology_mgr* *mgr, struct *drm_dp_mst_port* *port)

Reset number of slots to 0 for VCPI

Parameters

struct drm_dp_mst_topology_mgr *mgr
manager for this port

struct drm_dp_mst_port *port
unverified pointer to a port.

Description

This just resets the number of slots for the ports VCPI for later programming.

void **drm_dp_mst_deallocate_vcpi**(struct *drm_dp_mst_topology_mgr* *mgr, struct *drm_dp_mst_port* *port)

deallocate a VCPI

Parameters

struct drm_dp_mst_topology_mgr *mgr
manager for this port

struct drm_dp_mst_port *port
port to deallocate vcpi for

Description

This can be called unconditionally, regardless of whether *drm_dp_mst_allocate_vcpi()* succeeded or not.

int **drm_dp_check_act_status**(struct *drm_dp_mst_topology_mgr* *mgr)

Polls for ACT handled status.

Parameters

struct drm_dp_mst_topology_mgr *mgr
manager to use

Description

Tries waiting for the MST hub to finish updating it's payload table by polling for the ACT handled bit for up to 3 seconds (yes-some hubs really take that long).

Return

0 if the ACT was handled in time, negative error code on failure.

int **drm_dp_calc_pbn_mode**(int clock, int bpp, bool dsc)

Calculate the PBN for a mode.

Parameters

int clock
dot clock for the mode

int bpp
bpp for the mode.

bool dsc
DSC mode. If true, bpp has units of 1/16 of a bit per pixel

Description

This uses the formula in the spec to calculate the PBN value for a mode.

void **drm_dp_mst_dump_topology**(struct seq_file *m, struct *drm_dp_mst_topology_mgr* *mgr)

Parameters

struct seq_file *m
seq_file to dump output to

struct drm_dp_mst_topology_mgr *mgr
manager to dump current topology for.

Description

helper to dump MST topology to a seq file for debugfs.

int **drm_dp_mst_add_affected_dsc_crtcs**(struct *drm_atomic_state* *state, struct *drm_dp_mst_topology_mgr* *mgr)

Parameters

struct drm_atomic_state *state
Pointer to the new struct drm_dp_mst_topology_state

struct drm_dp_mst_topology_mgr *mgr
MST topology manager

Description

Whenever there is a change in mst topology DSC configuration would have to be recalculated therefore we need to trigger modeset on all affected CRTCs in that topology

See also: *drm_dp_mst_atomic_enable_dsc()*

int **drm_dp_mst_atomic_enable_dsc**(struct *drm_atomic_state* *state, struct *drm_dp_mst_port* *port, int pbn, int pbn_div, bool enable)
Set DSC Enable Flag to On/Off

Parameters

struct drm_atomic_state *state
Pointer to the new drm_atomic_state

struct drm_dp_mst_port *port
Pointer to the affected MST Port

int pbn
Newly recalculated bw required for link with DSC enabled

int pbn_div
Divider to calculate correct number of pbn per slot

bool enable
Boolean flag to enable or disable DSC on the port

Description

This function enables DSC on the given Port by recalculating its vcpi from pbn provided and sets dsc_enable flag to keep track of which ports have DSC enabled

int **drm_dp_mst_atomic_check**(struct *drm_atomic_state* *state)
Check that the new state of an MST topology in an atomic update is valid

Parameters

struct drm_atomic_state *state
Pointer to the new `struct drm_dp_mst_topology_state`

Description

Checks the given topology state for an atomic update to ensure that it's valid. This includes checking whether there's enough bandwidth to support the new VCPI allocations in the atomic update.

Any atomic drivers supporting DP MST must make sure to call this after checking the rest of their state in their *drm_mode_config_funcs.atomic_check()* callback.

See also: *drm_dp_atomic_find_vcpi_slots()* *drm_dp_atomic_release_vcpi_slots()*

0 if the new state is valid, negative error code otherwise.

Return

struct drm_dp_mst_topology_state ***drm_atomic_get_mst_topology_state**(struct *drm_atomic_state* *state, struct *drm_dp_mst_topol* *mgr)

Parameters

struct drm_atomic_state *state
global atomic state

struct drm_dp_mst_topology_mgr *mgr
MST topology manager, also the private object in this case

Description

This function wraps drm_atomic_get_priv_obj_state() passing in the MST atomic state vtable so that the private object state returned is that of a MST topology object. Also, *drm_atomic_get_private_obj_state()* expects the caller to care of the locking, so warn if don't hold the connection_mutex.

The MST topology state or error pointer.

Return

int **drm_dp_mst_topology_mgr_init**(struct *drm_dp_mst_topology_mgr* *mgr, struct *drm_device* *dev, struct *drm_dp_aux* *aux, int max_dpcd_transaction_bytes, int max_payloads, int conn_base_id)

initialise a topology manager

Parameters

struct drm_dp_mst_topology_mgr *mgr
manager struct to initialise

struct drm_device *dev
device providing this structure - for i2c addition.

struct drm_dp_aux *aux
DP helper aux channel to talk to this device

int max_dpcd_transaction_bytes
hw specific DPCD transaction limit

int max_payloads
maximum number of payloads this GPU can source

int conn_base_id
the connector object ID the MST device is connected to.

Description

Return 0 for success, or negative error code on failure

void **drm_dp_mst_topology_mgr_destroy**(struct *drm_dp_mst_topology_mgr* *mgr)

destroy topology manager.

Parameters

struct drm_dp_mst_topology_mgr *mgr
manager to destroy

struct *drm_dp_aux* ***drm_dp_mst_dsc_aux_for_port**(struct *drm_dp_mst_port* *port)

Find the correct aux for DSC

Parameters

struct drm_dp_mst_port *port
The port to check. A leaf of the MST tree with an attached display.

Description

Depending on the situation, DSC may be enabled via the endpoint aux, the immediately upstream aux, or the connector's physical aux.

This is both the correct aux to read DSC_CAPABILITY and the correct aux to write DSC_ENABLED.

This operation can be expensive (up to four aux reads), so the caller should cache the return.

Return

NULL if DSC cannot be enabled on this port, otherwise the aux device

5.15.3 Topology Lifetime Internals

These functions aren't exported to drivers, but are documented here to help make the MST topology helpers easier to understand

void **drm_dp_mst_get_mstb_malloc**(struct *drm_dp_mst_branch* *mstb)

Increment the malloc refcount of a branch device

Parameters

struct drm_dp_mst_branch *mstb
The *struct drm_dp_mst_branch* to increment the malloc refcount of

Description

Increments *drm_dp_mst_branch.malloc_kref*. When *drm_dp_mst_branch.malloc_kref* reaches 0, the memory allocation for **mstb** will be released and **mstb** may no longer be used.

See also: *drm_dp_mst_put_mstb_malloc()*

void **drm_dp_mst_put_mstb_malloc**(struct *drm_dp_mst_branch* *mstb)
Decrement the malloc refcount of a branch device

Parameters

struct drm_dp_mst_branch *mstb
The *struct drm_dp_mst_branch* to decrement the malloc refcount of

Description

Decrements *drm_dp_mst_branch.malloc_kref*. When *drm_dp_mst_branch.malloc_kref* reaches 0, the memory allocation for **mstb** will be released and **mstb** may no longer be used.

See also: *drm_dp_mst_get_mstb_malloc()*

int **drm_dp_mst_topology_try_get_mstb**(struct *drm_dp_mst_branch* *mstb)
Increment the topology refcount of a branch device unless it's zero

Parameters

struct drm_dp_mst_branch *mstb
struct drm_dp_mst_branch to increment the topology refcount of

Description

Attempts to grab a topology reference to **mstb**, if it hasn't yet been removed from the topology (e.g. *drm_dp_mst_branch.topology_kref* has reached 0). Holding a topology reference implies that a malloc reference will be held to **mstb** as long as the user holds the topology reference.

Care should be taken to ensure that the user has at least one malloc reference to **mstb**. If you already have a topology reference to **mstb**, you should use *drm_dp_mst_topology_get_mstb()* instead.

See also: *drm_dp_mst_topology_get_mstb()* *drm_dp_mst_topology_put_mstb()*

Return

- 1: A topology reference was grabbed successfully
- 0: **port** is no longer in the topology, no reference was grabbed

void **drm_dp_mst_topology_get_mstb**(struct *drm_dp_mst_branch* *mstb)
Increment the topology refcount of a branch device

Parameters

struct drm_dp_mst_branch *mstb
The *struct drm_dp_mst_branch* to increment the topology refcount of

Description

Increments *drm_dp_mst_branch.topology_refcount* without checking whether or not it's already reached 0. This is only valid to use in scenarios where you are already guaranteed to have at least one active topology reference to **mstb**. Otherwise, *drm_dp_mst_topology_try_get_mstb()* must be used.

See also: *drm_dp_mst_topology_try_get_mstb()* *drm_dp_mst_topology_put_mstb()*

void **drm_dp_mst_topology_put_mstb**(struct *drm_dp_mst_branch* *mstb)
release a topology reference to a branch device

Parameters

struct drm_dp_mst_branch *mstb
The *struct drm_dp_mst_branch* to release the topology reference from

Description

Releases a topology reference from **mstb** by decrementing *drm_dp_mst_branch.topology_kref*.

See also: *drm_dp_mst_topology_try_get_mstb()* *drm_dp_mst_topology_get_mstb()*

int **drm_dp_mst_topology_try_get_port**(struct *drm_dp_mst_port* *port)
Increment the topology refcount of a port unless it's zero

Parameters

struct drm_dp_mst_port *port
struct drm_dp_mst_port to increment the topology refcount of

Description

Attempts to grab a topology reference to **port**, if it hasn't yet been removed from the topology (e.g. *drm_dp_mst_port.topology_kref* has reached 0). Holding a topology reference implies that a malloc reference will be held to **port** as long as the user holds the topology reference.

Care should be taken to ensure that the user has at least one malloc reference to **port**. If you already have a topology reference to **port**, you should use *drm_dp_mst_topology_get_port()* instead.

See also: *drm_dp_mst_topology_get_port()* *drm_dp_mst_topology_put_port()*

Return

- 1: A topology reference was grabbed successfully
- 0: **port** is no longer in the topology, no reference was grabbed

void **drm_dp_mst_topology_get_port**(struct *drm_dp_mst_port* *port)
Increment the topology refcount of a port

Parameters

struct drm_dp_mst_port *port
The *struct drm_dp_mst_port* to increment the topology refcount of

Description

Increments *drm_dp_mst_port.topology_refcount* without checking whether or not it's already reached 0. This is only valid to use in scenarios where you are already guaranteed to have at least one active topology reference to **port**. Otherwise, *drm_dp_mst_topology_try_get_port()* must be used.

See also: *drm_dp_mst_topology_try_get_port()* *drm_dp_mst_topology_put_port()*

void **drm_dp_mst_topology_put_port**(struct *drm_dp_mst_port* *port)

release a topology reference to a port

Parameters

struct drm_dp_mst_port *port

The *struct drm_dp_mst_port* to release the topology reference from

Description

Releases a topology reference from **port** by decrementing *drm_dp_mst_port.topology_kref*.

See also: *drm_dp_mst_topology_try_get_port()* *drm_dp_mst_topology_get_port()*

5.16 MIPI DBI Helper Functions Reference

This library provides helpers for MIPI Display Bus Interface (DBI) compatible display controllers.

Many controllers for tiny lcd displays are MIPI compliant and can use this library. If a controller uses registers 0x2A and 0x2B to set the area to update and uses register 0x2C to write to frame memory, it is most likely MIPI compliant.

Only MIPI Type 1 displays are supported since a full frame memory is needed.

There are 3 MIPI DBI implementation types:

A. Motorola 6800 type parallel bus

B. Intel 8080 type parallel bus

C. SPI type with 3 options:

   1. 9-bit with the Data/Command signal as the ninth bit
   2. Same as above except it's sent as 16 bits
   3. 8-bit with the Data/Command signal as a separate D/CX pin

Currently mipi_dbi only supports Type C options 1 and 3 with *mipi_dbi_spi_init()*.

struct **mipi_dbi**

MIPI DBI interface

Definition

```
struct mipi_dbi {
  struct mutex cmdlock;
  int (*command)(struct mipi_dbi *dbi, u8 *cmd, u8 *param, size_t␣
↪num);
```

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```
  const u8 *read_commands;
  bool swap_bytes;
  struct gpio_desc *reset;
  struct spi_device *spi;
  struct gpio_desc *dc;
  void *tx_buf9;
  size_t tx_buf9_len;
};
```

Members

cmdlock
    Command lock

command
    Bus specific callback executing commands.

read_commands

Array of read commands terminated by a zero entry.
    Reading is disabled if this is NULL.

swap_bytes
    Swap bytes in buffer before transfer

reset
    Optional reset gpio

spi
    SPI device

dc
    Optional D/C gpio.

tx_buf9
    Buffer used for Option 1 9-bit conversion

tx_buf9_len
    Size of tx_buf9.

struct **mipi_dbi_dev**
    MIPI DBI device

Definition

```
struct mipi_dbi_dev {
  struct drm_device drm;
  struct drm_simple_display_pipe pipe;
  struct drm_connector connector;
  struct drm_display_mode mode;
  u16 *tx_buf;
  unsigned int rotation;
  unsigned int left_offset;
  unsigned int top_offset;
  struct backlight_device *backlight;
```

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```
  struct regulator *regulator;
  struct mipi_dbi dbi;
};
```

Members

`drm`
DRM device

`pipe`
Display pipe structure

`connector`
Connector

`mode`
Fixed display mode

`tx_buf`
Buffer used for transfer (copy clip rect area)

`rotation`
initial rotation in degrees Counter Clock Wise

`left_offset`

Horizontal offset of the display relative to the
controller’ s driver array

`top_offset`

Vertical offset of the display relative to the
controller’ s driver array

`backlight`
backlight device (optional)

`regulator`
power regulator (optional)

`dbi`
MIPI DBI interface

`mipi_dbi_command`

`mipi_dbi_command (dbi, cmd, seq...)`

MIPI DCS command with optional parameter(s)

Parameters

`dbi`
MIPI DBI structure

`cmd`
Command

`seq...`
Optional parameter(s)

Description

Send MIPI DCS command to the controller. Use *mipi_dbi_command_read()* for get/read.

Return

Zero on success, negative error code on failure.

int **mipi_dbi_command_read**(struct *mipi_dbi* *dbi, u8 cmd, u8 *val)

MIPI DCS read command

Parameters

struct mipi_dbi *dbi
MIPI DBI structure

u8 cmd
Command

u8 *val
Value read

Description

Send MIPI DCS read command to the controller.

Return

Zero on success, negative error code on failure.

int **mipi_dbi_command_buf**(struct *mipi_dbi* *dbi, u8 cmd, u8 *data, size_t len)

MIPI DCS command with parameter(s) in an array

Parameters

struct mipi_dbi *dbi
MIPI DBI structure

u8 cmd
Command

u8 *data
Parameter buffer

size_t len
Buffer length

Return

Zero on success, negative error code on failure.

int **mipi_dbi_buf_copy**(void *dst, struct *drm_framebuffer* *fb, struct *drm_rect* *clip, bool swap)

Copy a framebuffer, transforming it if necessary

Parameters

void *dst
The destination buffer

struct drm_framebuffer *fb
The source framebuffer

struct drm_rect *clip
Clipping rectangle of the area to be copied

bool swap
When true, swap MSB/LSB of 16-bit values

Return

Zero on success, negative error code on failure.

void **mipi_dbi_pipe_update**(struct *drm_simple_display_pipe* *pipe, struct *drm_plane_state* *old_state)

Display pipe update helper

Parameters

struct drm_simple_display_pipe *pipe
Simple display pipe

struct drm_plane_state *old_state
Old plane state

Description

This function handles framebuffer flushing and vblank events. Drivers can use this as their *drm_simple_display_pipe_funcs->update* callback.

void **mipi_dbi_enable_flush**(struct *mipi_dbi_dev* *dbidev, struct *drm_crtc_state* *crtc_state, struct *drm_plane_state* *plane_state)

MIPI DBI enable helper

Parameters

struct mipi_dbi_dev *dbidev
MIPI DBI device structure

struct drm_crtc_state *crtc_state
CRTC state

struct drm_plane_state *plane_state
Plane state

Description

Flushes the whole framebuffer and enables the backlight. Drivers can use this in their *drm_simple_display_pipe_funcs->enable* callback.

Note

Drivers which don't use *mipi_dbi_pipe_update()* because they have custom framebuffer flushing, can't use this function since they both use the same flushing code.

void **mipi_dbi_pipe_disable**(struct *drm_simple_display_pipe* *pipe)

MIPI DBI pipe disable helper

Parameters

struct drm_simple_display_pipe *pipe
Display pipe

Description

This function disables backlight if present, if not the display memory is blanked. The regulator is disabled if in use. Drivers can use this as their *drm_simple_display_pipe_funcs->disable* callback.

int **mipi_dbi_dev_init_with_formats**(struct *mipi_dbi_dev* *dbidev, const struct *drm_simple_display_pipe_funcs* *funcs, const uint32_t *formats, unsigned int format_count, const struct *drm_display_mode* *mode, unsigned int rotation, size_t tx_buf_size)

MIPI DBI device initialization with custom formats

Parameters

struct mipi_dbi_dev *dbidev
MIPI DBI device structure to initialize

const struct drm_simple_display_pipe_funcs *funcs
Display pipe functions

const uint32_t *formats
Array of supported formats (DRM_FORMAT_*).

unsigned int format_count
Number of elements in **formats**

const struct drm_display_mode *mode
Display mode

unsigned int rotation
Initial rotation in degrees Counter Clock Wise

size_t tx_buf_size
Allocate a transmit buffer of this size.

Description

This function sets up a *drm_simple_display_pipe* with a *drm_connector* that has one fixed *drm_display_mode* which is rotated according to **rotation**. This mode is used to set the mode config min/max width/height properties.

Use *mipi_dbi_dev_init()* if you don't need custom formats.

Note

Some of the helper functions expects RGB565 to be the default format and the transmit buffer sized to fit that.

Return

Zero on success, negative error code on failure.

int **mipi_dbi_dev_init**(struct *mipi_dbi_dev* *dbidev, const struct *drm_simple_display_pipe_funcs* *funcs, const struct *drm_display_mode* *mode, unsigned int rotation)

MIPI DBI device initialization

Parameters

struct mipi_dbi_dev *dbidev
MIPI DBI device structure to initialize

const struct drm_simple_display_pipe_funcs *funcs
Display pipe functions

const struct drm_display_mode *mode
Display mode

unsigned int rotation
Initial rotation in degrees Counter Clock Wise

Description

This function sets up a *drm_simple_display_pipe* with a *drm_connector* that has one fixed *drm_display_mode* which is rotated according to **rotation**. This mode is used to set the mode config min/max width/height properties. Additionally *mipi_dbi.tx_buf* is allocated.

Supported formats: Native RGB565 and emulated XRGB8888.

Return

Zero on success, negative error code on failure.

void **mipi_dbi_hw_reset**(struct *mipi_dbi* *dbi)
Hardware reset of controller

Parameters

struct mipi_dbi *dbi
MIPI DBI structure

Description

Reset controller if the *mipi_dbi->reset* gpio is set.

bool **mipi_dbi_display_is_on**(struct *mipi_dbi* *dbi)
Check if display is on

Parameters

struct mipi_dbi *dbi
MIPI DBI structure

Description

This function checks the Power Mode register (if readable) to see if display output is turned on. This can be used to see if the bootloader has already turned on the display avoiding flicker when the pipeline is enabled.

Return

true if the display can be verified to be on, false otherwise.

int **mipi_dbi_poweron_reset**(struct *mipi_dbi_dev* *dbidev)
MIPI DBI poweron and reset

Parameters

struct mipi_dbi_dev *dbidev
MIPI DBI device structure

Description

This function enables the regulator if used and does a hardware and software reset.

Return

Zero on success, or a negative error code.

int **mipi_dbi_poweron_conditional_reset**(struct *mipi_dbi_dev* *dbidev)

MIPI DBI poweron and conditional reset

Parameters

struct mipi_dbi_dev *dbidev
MIPI DBI device structure

Description

This function enables the regulator if used and if the display is off, it does a hardware and software reset. If *mipi_dbi_display_is_on()* determines that the display is on, no reset is performed.

Return

Zero if the controller was reset, 1 if the display was already on, or a negative error code.

u32 **mipi_dbi_spi_cmd_max_speed**(struct spi_device *spi, size_t len)

get the maximum SPI bus speed

Parameters

struct spi_device *spi
SPI device

size_t len
The transfer buffer length.

Description

Many controllers have a max speed of 10MHz, but can be pushed way beyond that. Increase reliability by running pixel data at max speed and the rest at 10MHz, preventing transfer glitches from messing up the init settings.

int **mipi_dbi_spi_init**(struct spi_device *spi, struct *mipi_dbi* *dbi, struct gpio_desc *dc)

Initialize MIPI DBI SPI interface

Parameters

struct spi_device *spi
SPI device

struct mipi_dbi *dbi
MIPI DBI structure to initialize

struct gpio_desc *dc
D/C gpio (optional)

Description

This function sets *mipi_dbi->command*, enables *mipi_dbi->read_commands* for the usual read commands. It should be followed by a call to *mipi_dbi_dev_init()* or a driver-specific init.

If **dc** is set, a Type C Option 3 interface is assumed, if not Type C Option 1.

If the SPI master driver doesn't support the necessary bits per word, the following transformation is used:

- 9-bit: reorder buffer as 9x 8-bit words, padded with no-op command.
- 16-bit: if big endian send as 8-bit, if little endian swap bytes

Return

Zero on success, negative error code on failure.

int **mipi_dbi_spi_transfer**(struct spi_device *spi, u32 speed_hz, u8 bpw, const void *buf, size_t len)

SPI transfer helper

Parameters

struct spi_device *spi
SPI device

u32 speed_hz
Override speed (optional)

u8 bpw
Bits per word

const void *buf
Buffer to transfer

size_t len
Buffer length

Description

This SPI transfer helper breaks up the transfer of **buf** into chunks which the SPI controller driver can handle.

Return

Zero on success, negative error code on failure.

void **mipi_dbi_debugfs_init**(struct *drm_minor* *minor)

Create debugfs entries

Parameters

struct drm_minor *minor
DRM minor

Description

This function creates a 'command' debugfs file for sending commands to the controller or getting the read command values. Drivers can use this as their *drm_driver->debugfs_init* callback.

5.17 MIPI DSI Helper Functions Reference

These functions contain some common logic and helpers to deal with MIPI DSI peripherals.

Helpers are provided for a number of standard MIPI DSI command as well as a subset of the MIPI DCS command set.

struct **mipi_dsi_msg**

read/write DSI buffer

Definition

```
struct mipi_dsi_msg {
  u8 channel;
  u8 type;
  u16 flags;
  size_t tx_len;
  const void *tx_buf;
  size_t rx_len;
  void *rx_buf;
};
```

Members

channel
virtual channel id

type
payload data type

flags
flags controlling this message transmission

tx_len
length of **tx_buf**

tx_buf
data to be written

rx_len
length of **rx_buf**

rx_buf
data to be read, or NULL

struct **mipi_dsi_packet**

represents a MIPI DSI packet in protocol format

Definition

```
struct mipi_dsi_packet {
  size_t size;
  u8 header[4];
  size_t payload_length;
```

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```
  const u8 *payload;
};
```

Members

size
: size (in bytes) of the packet

header
: the four bytes that make up the header (Data ID, Word Count or Packet Data, and ECC)

payload_length
: number of bytes in the payload

payload
: a pointer to a buffer containing the payload, if any

struct **mipi_dsi_host_ops**
: DSI bus operations

Definition

```
struct mipi_dsi_host_ops {
  int (*attach)(struct mipi_dsi_host *host, struct mipi_dsi_device␣
↪*dsi);
  int (*detach)(struct mipi_dsi_host *host, struct mipi_dsi_device␣
↪*dsi);
  ssize_t (*transfer)(struct mipi_dsi_host *host, const struct mipi_
↪dsi_msg *msg);
};
```

Members

attach
: attach DSI device to DSI host

detach
: detach DSI device from DSI host

transfer
: transmit a DSI packet

Description

DSI packets transmitted by .transfer() are passed in as mipi_dsi_msg structures. This structure contains information about the type of packet being transmitted as well as the transmit and receive buffers. When an error is encountered during transmission, this function will return a negative error code. On success it shall return the number of bytes transmitted for write packets or the number of bytes received for read packets.

Note that typically DSI packet transmission is atomic, so the .transfer() function will seldomly return anything other than the number of bytes contained in the transmit buffer on success.

struct **mipi_dsi_host**

DSI host device

Definition

```
struct mipi_dsi_host {
  struct device *dev;
  const struct mipi_dsi_host_ops *ops;
  struct list_head list;
};
```

Members

dev
driver model device node for this DSI host

ops
DSI host operations

list
list management

struct **mipi_dsi_device_info**

template for creating a mipi_dsi_device

Definition

```
struct mipi_dsi_device_info {
  char type[DSI_DEV_NAME_SIZE];
  u32 channel;
  struct device_node *node;
};
```

Members

type
DSI peripheral chip type

channel
DSI virtual channel assigned to peripheral

node
pointer to OF device node or NULL

Description

This is populated and passed to mipi_dsi_device_new to create a new DSI device

struct **mipi_dsi_device**

DSI peripheral device

Definition

```
struct mipi_dsi_device {
  struct mipi_dsi_host *host;
  struct device dev;
  bool attached;
```

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```
  char name[DSI_DEV_NAME_SIZE];
  unsigned int channel;
  unsigned int lanes;
  enum mipi_dsi_pixel_format format;
  unsigned long mode_flags;
  unsigned long hs_rate;
  unsigned long lp_rate;
};
```

Members

`host`
DSI host for this peripheral

`dev`
driver model device node for this peripheral

`attached`
the DSI device has been successfully attached

`name`
DSI peripheral chip type

`channel`
virtual channel assigned to the peripheral

`lanes`
number of active data lanes

`format`
pixel format for video mode

`mode_flags`
DSI operation mode related flags

`hs_rate`
maximum lane frequency for high speed mode in hertz, this should be set to the real limits of the hardware, zero is only accepted for legacy drivers

`lp_rate`
maximum lane frequency for low power mode in hertz, this should be set to the real limits of the hardware, zero is only accepted for legacy drivers

int **`mipi_dsi_pixel_format_to_bpp`**(enum mipi_dsi_pixel_format fmt)
obtain the number of bits per pixel for any given pixel format defined by the MIPI DSI specification

Parameters

`enum mipi_dsi_pixel_format fmt`
MIPI DSI pixel format

Return

The number of bits per pixel of the given pixel format.

enum **`mipi_dsi_dcs_tear_mode`**
Tearing Effect Output Line mode

Constants

MIPI_DSI_DCS_TEAR_MODE_VBLANK
the TE output line consists of V-Blanking information only

MIPI_DSI_DCS_TEAR_MODE_VHBLANK
the TE output line consists of both V-Blanking and H-Blanking information

struct **mipi_dsi_driver**
DSI driver

Definition

```
struct mipi_dsi_driver {
  struct device_driver driver;
  int(*probe)(struct mipi_dsi_device *dsi);
  int(*remove)(struct mipi_dsi_device *dsi);
  void (*shutdown)(struct mipi_dsi_device *dsi);
};
```

Members

driver
device driver model driver

probe
callback for device binding

remove
callback for device unbinding

shutdown
called at shutdown time to quiesce the device

struct *mipi_dsi_device* ***of_find_mipi_dsi_device_by_node**(struct device_node *np)

find the MIPI DSI device matching a device tree node

Parameters

struct device_node *np
device tree node

Return

A pointer to the MIPI DSI device corresponding to np or NULL if no
such device exists (or has not been registered yet).

struct *mipi_dsi_device* ***mipi_dsi_device_register_full**(struct *mipi_dsi_host* *host, const struct *mipi_dsi_device_info* *info)

create a MIPI DSI device

Parameters

struct mipi_dsi_host *host
DSI host to which this device is connected

`const struct mipi_dsi_device_info *info`
pointer to template containing DSI device information

Description

Create a MIPI DSI device by using the device information provided by mipi_dsi_device_info template

Return

A pointer to the newly created MIPI DSI device, or, a pointer encoded with an error

void **`mipi_dsi_device_unregister`**(struct *mipi_dsi_device* *dsi)
unregister MIPI DSI device

Parameters

`struct mipi_dsi_device *dsi`
DSI peripheral device

struct *mipi_dsi_host* ***`of_find_mipi_dsi_host_by_node`**(struct device_node *node)
find the MIPI DSI host matching a device tree node

Parameters

`struct device_node *node`
device tree node

Return

A pointer to the MIPI DSI host corresponding to **node** or NULL if no such device exists (or has not been registered yet).

int **`mipi_dsi_attach`**(struct *mipi_dsi_device* *dsi)
attach a DSI device to its DSI host

Parameters

`struct mipi_dsi_device *dsi`
DSI peripheral

int **`mipi_dsi_detach`**(struct *mipi_dsi_device* *dsi)
detach a DSI device from its DSI host

Parameters

`struct mipi_dsi_device *dsi`
DSI peripheral

bool **`mipi_dsi_packet_format_is_short`**(u8 type)
check if a packet is of the short format

Parameters

`u8 type`
MIPI DSI data type of the packet

Return

true if the packet for the given data type is a short packet, false otherwise.

bool **mipi_dsi_packet_format_is_long**(u8 type)
    check if a packet is of the long format

Parameters

u8 type
    MIPI DSI data type of the packet

Return

true if the packet for the given data type is a long packet, false otherwise.

int **mipi_dsi_create_packet**(struct *mipi_dsi_packet* *packet, const struct *mipi_dsi_msg* *msg)
    create a packet from a message according to the DSI protocol

Parameters

struct mipi_dsi_packet *packet
    pointer to a DSI packet structure

const struct mipi_dsi_msg *msg
    message to translate into a packet

Return

0 on success or a negative error code on failure.

int **mipi_dsi_shutdown_peripheral**(struct *mipi_dsi_device* *dsi)
    sends a Shutdown Peripheral command

Parameters

struct mipi_dsi_device *dsi
    DSI peripheral device

Return

0 on success or a negative error code on failure.

int **mipi_dsi_turn_on_peripheral**(struct *mipi_dsi_device* *dsi)
    sends a Turn On Peripheral command

Parameters

struct mipi_dsi_device *dsi
    DSI peripheral device

Return

0 on success or a negative error code on failure.

ssize_t **mipi_dsi_compression_mode**(struct *mipi_dsi_device* *dsi, bool enable)
    enable/disable DSC on the peripheral

Parameters

struct mipi_dsi_device *dsi
    DSI peripheral device

bool enable
    Whether to enable or disable the DSC

Description

Enable or disable Display Stream Compression on the peripheral using the default Picture Parameter Set and VESA DSC 1.1 algorithm.

Return

0 on success or a negative error code on failure.

ssize_t **mipi_dsi_picture_parameter_set**(struct *mipi_dsi_device* *dsi, const struct *drm_dsc_picture_parameter_set* *pps)

transmit the DSC PPS to the peripheral

Parameters

struct mipi_dsi_device *dsi
DSI peripheral device

const struct drm_dsc_picture_parameter_set *pps
VESA DSC 1.1 Picture Parameter Set

Description

Transmit the VESA DSC 1.1 Picture Parameter Set to the peripheral.

Return

0 on success or a negative error code on failure.

ssize_t **mipi_dsi_generic_write**(struct *mipi_dsi_device* *dsi, const void *payload, size_t size)

transmit data using a generic write packet

Parameters

struct mipi_dsi_device *dsi
DSI peripheral device

const void *payload
buffer containing the payload

size_t size
size of payload buffer

Description

This function will automatically choose the right data type depending on the payload length.

Return

The number of bytes transmitted on success or a negative error code on failure.

ssize_t **mipi_dsi_generic_read**(struct *mipi_dsi_device* *dsi, const void *params, size_t num_params, void *data, size_t size)

receive data using a generic read packet

Parameters

struct mipi_dsi_device *dsi
DSI peripheral device

const void *params
buffer containing the request parameters

size_t num_params
number of request parameters

void *data
buffer in which to return the received data

size_t size
size of receive buffer

Description

This function will automatically choose the right data type depending on the number of parameters passed in.

Return

The number of bytes successfully read or a negative error code on failure.

ssize_t **mipi_dsi_dcs_write_buffer**(struct *mipi_dsi_device* *dsi, const void *data, size_t len)

transmit a DCS command with payload

Parameters

struct mipi_dsi_device *dsi
DSI peripheral device

const void *data
buffer containing data to be transmitted

size_t len
size of transmission buffer

Description

This function will automatically choose the right data type depending on the command payload length.

Return

The number of bytes successfully transmitted or a negative error code on failure.

ssize_t **mipi_dsi_dcs_write**(struct *mipi_dsi_device* *dsi, u8 cmd, const void *data, size_t len)

send DCS write command

Parameters

struct mipi_dsi_device *dsi
DSI peripheral device

u8 cmd
DCS command

const void *data
buffer containing the command payload

size_t len
command payload length

Description

This function will automatically choose the right data type depending on the command payload length.

Return

The number of bytes successfully transmitted or a negative error code on failure.

ssize_t **mipi_dsi_dcs_read**(struct *mipi_dsi_device* *dsi, u8 cmd, void *data, size_t len)
send DCS read request command

Parameters

struct mipi_dsi_device *dsi
DSI peripheral device

u8 cmd
DCS command

void *data
buffer in which to receive data

size_t len
size of receive buffer

Return

The number of bytes read or a negative error code on failure.

int **mipi_dsi_dcs_nop**(struct *mipi_dsi_device* *dsi)
send DCS nop packet

Parameters

struct mipi_dsi_device *dsi
DSI peripheral device

Return

0 on success or a negative error code on failure.

int **mipi_dsi_dcs_soft_reset**(struct *mipi_dsi_device* *dsi)
perform a software reset of the display module

Parameters

struct mipi_dsi_device *dsi
DSI peripheral device

Return

0 on success or a negative error code on failure.

int **mipi_dsi_dcs_get_power_mode**(struct *mipi_dsi_device* *dsi, u8 *mode)
query the display module’s current power mode

Parameters

struct mipi_dsi_device *dsi
DSI peripheral device

u8 *mode
return location for the current power mode

Return

0 on success or a negative error code on failure.

int **mipi_dsi_dcs_get_pixel_format**(struct *mipi_dsi_device* *dsi, u8 *format)
gets the pixel format for the RGB image data used by the interface

Parameters

struct mipi_dsi_device *dsi
DSI peripheral device

u8 *format
return location for the pixel format

Return

0 on success or a negative error code on failure.

int **mipi_dsi_dcs_enter_sleep_mode**(struct *mipi_dsi_device* *dsi)
disable all unnecessary blocks inside the display module except interface communication

Parameters

struct mipi_dsi_device *dsi
DSI peripheral device

Return

0 on success or a negative error code on failure.

int **mipi_dsi_dcs_exit_sleep_mode**(struct *mipi_dsi_device* *dsi)
enable all blocks inside the display module

Parameters

struct mipi_dsi_device *dsi
DSI peripheral device

Return

0 on success or a negative error code on failure.

int **mipi_dsi_dcs_set_display_off**(struct *mipi_dsi_device* *dsi)
stop displaying the image data on the display device

Parameters

struct mipi_dsi_device *dsi
DSI peripheral device

Return

0 on success or a negative error code on failure.

int **mipi_dsi_dcs_set_display_on**(struct *mipi_dsi_device* *dsi)
start displaying the image data on the display device

Parameters

struct mipi_dsi_device *dsi
DSI peripheral device

Return

0 on success or a negative error code on failure

int **mipi_dsi_dcs_set_column_address**(struct *mipi_dsi_device* *dsi, u16 start, u16 end)
define the column extent of the frame memory accessed by the host processor

Parameters

struct mipi_dsi_device *dsi
DSI peripheral device

u16 start
first column of frame memory

u16 end
last column of frame memory

Return

0 on success or a negative error code on failure.

int **mipi_dsi_dcs_set_page_address**(struct *mipi_dsi_device* *dsi, u16 start, u16 end)
define the page extent of the frame memory accessed by the host processor

Parameters

struct mipi_dsi_device *dsi
DSI peripheral device

u16 start
first page of frame memory

u16 end
last page of frame memory

Return

0 on success or a negative error code on failure.

int **mipi_dsi_dcs_set_tear_off**(struct *mipi_dsi_device* *dsi)
turn off the display module’ s Tearing Effect output signal on the TE signal line

Parameters

struct mipi_dsi_device *dsi
DSI peripheral device

Return

0 on success or a negative error code on failure

int **mipi_dsi_dcs_set_tear_on**(struct *mipi_dsi_device* *dsi, enum *mipi_dsi_dcs_tear_mode* mode)

turn on the display module' s Tearing Effect output signal on the TE signal line.

Parameters

struct mipi_dsi_device *dsi
DSI peripheral device

enum mipi_dsi_dcs_tear_mode mode
the Tearing Effect Output Line mode

Return

0 on success or a negative error code on failure

int **mipi_dsi_dcs_set_pixel_format**(struct *mipi_dsi_device* *dsi, u8 format)

sets the pixel format for the RGB image data used by the interface

Parameters

struct mipi_dsi_device *dsi
DSI peripheral device

u8 format
pixel format

Return

0 on success or a negative error code on failure.

int **mipi_dsi_dcs_set_tear_scanline**(struct *mipi_dsi_device* *dsi, u16 scanline)

set the scanline to use as trigger for the Tearing Effect output signal of the display module

Parameters

struct mipi_dsi_device *dsi
DSI peripheral device

u16 scanline
scanline to use as trigger

Return

0 on success or a negative error code on failure

int **mipi_dsi_dcs_set_display_brightness**(struct *mipi_dsi_device* *dsi, u16 brightness)

sets the brightness value of the display

Parameters

struct mipi_dsi_device *dsi
DSI peripheral device

u16 brightness
brightness value

Return

0 on success or a negative error code on failure.

int **mipi_dsi_dcs_get_display_brightness**(struct *mipi_dsi_device* *dsi, u16 *brightness)

gets the current brightness value of the display

Parameters

struct mipi_dsi_device *dsi
DSI peripheral device

u16 *brightness
brightness value

Return

0 on success or a negative error code on failure.

int **mipi_dsi_dcs_set_display_brightness_large**(struct *mipi_dsi_device* *dsi, u16 brightness)

sets the 16-bit brightness value of the display

Parameters

struct mipi_dsi_device *dsi
DSI peripheral device

u16 brightness
brightness value

Return

0 on success or a negative error code on failure.

int **mipi_dsi_dcs_get_display_brightness_large**(struct *mipi_dsi_device* *dsi, u16 *brightness)

gets the current 16-bit brightness value of the display

Parameters

struct mipi_dsi_device *dsi
DSI peripheral device

u16 *brightness
brightness value

Return

0 on success or a negative error code on failure.

int **mipi_dsi_driver_register_full**(struct *mipi_dsi_driver* *drv, struct module *owner)

register a driver for DSI devices

Parameters

struct mipi_dsi_driver *drv
DSI driver structure

struct module *owner
owner module

Return

0 on success or a negative error code on failure.

void **mipi_dsi_driver_unregister**(struct *mipi_dsi_driver* *drv)
unregister a driver for DSI devices

Parameters

struct mipi_dsi_driver *drv
DSI driver structure

Return

0 on success or a negative error code on failure.

5.18 Display Stream Compression Helper Functions Reference

VESA specification for DP 1.4 adds a new feature called Display Stream Compression (DSC) used to compress the pixel bits before sending it on DP/eDP/MIPI DSI interface. DSC is required to be enabled so that the existing display interfaces can support high resolutions at higher frames rates uisng the maximum available link capacity of these interfaces.

These functions contain some common logic and helpers to deal with VESA Display Stream Compression standard required for DSC on Display Port/eDP or MIPI display interfaces.

struct **drm_dsc_rc_range_parameters**
DSC Rate Control range parameters

Definition

```
struct drm_dsc_rc_range_parameters {
  u8 range_min_qp;
  u8 range_max_qp;
  u8 range_bpg_offset;
};
```

Members

range_min_qp
Min Quantization Parameters allowed for this range

range_max_qp
Max Quantization Parameters allowed for this range

range_bpg_offset
Bits/group offset to apply to target for this group

Description

This defines different rate control parameters used by the DSC engine to compress the frame.

struct **drm_dsc_config**

Parameters required to configure DSC

Definition

```
struct drm_dsc_config {
  u8 line_buf_depth;
  u8 bits_per_component;
  bool convert_rgb;
  u8 slice_count;
  u16 slice_width;
  u16 slice_height;
  bool simple_422;
  u16 pic_width;
  u16 pic_height;
  u8 rc_tgt_offset_high;
  u8 rc_tgt_offset_low;
  u16 bits_per_pixel;
  u8 rc_edge_factor;
  u8 rc_quant_incr_limit1;
  u8 rc_quant_incr_limit0;
  u16 initial_xmit_delay;
  u16 initial_dec_delay;
  bool block_pred_enable;
  u8 first_line_bpg_offset;
  u16 initial_offset;
  u16 rc_buf_thresh[DSC_NUM_BUF_RANGES - 1];
  struct drm_dsc_rc_range_parameters rc_range_params[DSC_NUM_BUF_
↪RANGES];
  u16 rc_model_size;
  u8 flatness_min_qp;
  u8 flatness_max_qp;
  u8 initial_scale_value;
  u16 scale_decrement_interval;
  u16 scale_increment_interval;
  u16 nfl_bpg_offset;
  u16 slice_bpg_offset;
  u16 final_offset;
  bool vbr_enable;
  u8 mux_word_size;
  u16 slice_chunk_size;
  u16 rc_bits;
  u8 dsc_version_minor;
  u8 dsc_version_major;
  bool native_422;
  bool native_420;
  u8 second_line_bpg_offset;
  u16 nsl_bpg_offset;
```

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```
  u16 second_line_offset_adj;
};
```

Members

line_buf_depth
Bits per component for previous reconstructed line buffer

bits_per_component
Bits per component to code (8/10/12)

convert_rgb
Flag to indicate if RGB - YCoCg conversion is needed True if RGB input, False if YCoCg input

slice_count
Number fo slices per line used by the DSC encoder

slice_width
Width of each slice in pixels

slice_height
Slice height in pixels

simple_422
True if simple 4_2_2 mode is enabled else False

pic_width
Width of the input display frame in pixels

pic_height
Vertical height of the input display frame

rc_tgt_offset_high
Offset to bits/group used by RC to determine QP adjustment

rc_tgt_offset_low
Offset to bits/group used by RC to determine QP adjustment

bits_per_pixel
Target bits per pixel with 4 fractional bits, bits_per_pixel << 4

rc_edge_factor
Factor to determine if an edge is present based on the bits produced

rc_quant_incr_limit1
Slow down incrementing once the range reaches this value

rc_quant_incr_limit0
Slow down incrementing once the range reaches this value

initial_xmit_delay
Number of pixels to delay the initial transmission

initial_dec_delay
Initial decoder delay, number of pixel times that the decoder accumulates data in its rate buffer before starting to decode and output pixels.

block_pred_enable
True if block prediction is used to code any groups within the picture. False if BP not used

first_line_bpg_offset
Number of additional bits allocated for each group on the first line of slice.

initial_offset
Value to use for RC model offset at slice start

rc_buf_thresh
Thresholds defining each of the buffer ranges

rc_range_params
Parameters for each of the RC ranges defined in *struct drm_dsc_rc_range_parameters*

rc_model_size
Total size of RC model

flatness_min_qp
Minimum QP where flatness information is sent

flatness_max_qp
Maximum QP where flatness information is sent

initial_scale_value
Initial value for the scale factor

scale_decrement_interval
Specifies number of group times between decrementing the scale factor at beginning of a slice.

scale_increment_interval
Number of group times between incrementing the scale factor value used at the beginning of a slice.

nfl_bpg_offset
Non first line BPG offset to be used

slice_bpg_offset
BPG offset used to enforce slice bit

final_offset
Final RC linear transformation offset value

vbr_enable
True if VBR mode is enabled, false if disabled

mux_word_size
Mux word size (in bits) for SSM mode

slice_chunk_size
The (max) size in bytes of the "chunks" that are used in slice multiplexing.

rc_bits
Rate control buffer size in bits

dsc_version_minor
DSC minor version

dsc_version_major
DSC major version

native_422
True if Native 4:2:2 supported, else false

native_420
True if Native 4:2:0 supported else false.

second_line_bpg_offset
Additional bits/grp for seconnd line of slice for native 4:2:0

nsl_bpg_offset
Num of bits deallocated for each grp that is not in second line of slice

second_line_offset_adj
Offset adjustment for second line in Native 4:2:0 mode

Description

Driver populates this structure with all the parameters required to configure the display stream compression on the source.

struct **drm_dsc_picture_parameter_set**
Represents 128 bytes of Picture Parameter Set

Definition

```
struct drm_dsc_picture_parameter_set {
  u8 dsc_version;
  u8 pps_identifier;
  u8 pps_reserved;
  u8 pps_3;
  u8 pps_4;
  u8 bits_per_pixel_low;
  __be16 pic_height;
  __be16 pic_width;
  __be16 slice_height;
  __be16 slice_width;
  __be16 chunk_size;
  u8 initial_xmit_delay_high;
  u8 initial_xmit_delay_low;
  __be16 initial_dec_delay;
  u8 pps20_reserved;
  u8 initial_scale_value;
  __be16 scale_increment_interval;
  u8 scale_decrement_interval_high;
  u8 scale_decrement_interval_low;
  u8 pps26_reserved;
  u8 first_line_bpg_offset;
  __be16 nfl_bpg_offset;
  __be16 slice_bpg_offset;
  __be16 initial_offset;
  __be16 final_offset;
  u8 flatness_min_qp;
```

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```
  u8 flatness_max_qp;
  __be16 rc_model_size;
  u8 rc_edge_factor;
  u8 rc_quant_incr_limit0;
  u8 rc_quant_incr_limit1;
  u8 rc_tgt_offset;
  u8 rc_buf_thresh[DSC_NUM_BUF_RANGES - 1];
  __be16 rc_range_parameters[DSC_NUM_BUF_RANGES];
  u8 native_422_420;
  u8 second_line_bpg_offset;
  __be16 nsl_bpg_offset;
  __be16 second_line_offset_adj;
  u32 pps_long_94_reserved;
  u32 pps_long_98_reserved;
  u32 pps_long_102_reserved;
  u32 pps_long_106_reserved;
  u32 pps_long_110_reserved;
  u32 pps_long_114_reserved;
  u32 pps_long_118_reserved;
  u32 pps_long_122_reserved;
  __be16 pps_short_126_reserved;
};
```

Members

dsc_version
: PPS0[3:0] - dsc_version_minor: Contains Minor version of DSC PPS0[7:4] - dsc_version_major: Contains major version of DSC

pps_identifier
: PPS1[7:0] - Application specific identifier that can be used to differentiate between different PPS tables.

pps_reserved
: PPS2[7:0]- RESERVED Byte

pps_3
: PPS3[3:0] - linebuf_depth: Contains linebuffer bit depth used to generate the bitstream. (0x0 - 16 bits for DSC 1.2, 0x8 - 8 bits, 0xA - 10 bits, 0xB - 11 bits, 0xC - 12 bits, 0xD - 13 bits, 0xE - 14 bits for DSC1.2, 0xF - 14 bits for DSC 1.2. PPS3[7:4] - bits_per_component: Bits per component for the original pixels of the encoded picture. 0x0 = 16bpc (allowed only when dsc_version_minor = 0x2) 0x8 = 8bpc, 0xA = 10bpc, 0xC = 12bpc, 0xE = 14bpc (also allowed only when dsc_minor_version = 0x2)

pps_4
: PPS4[1:0] -These are the most significant 2 bits of compressed BPP bits_per_pixel[9:0] syntax element. PPS4[2] - vbr_enable: 0 = VBR disabled, 1 = VBR enabled PPS4[3] - simple_422: Indicates if decoder drops samples to reconstruct the 4:2:2 picture. PPS4[4] - Convert_rgb: Indicates if DSC color space conversion is active. PPS4[5] - blobk_pred_enable: Indicates if BP is used to code any groups in picture PPS4[7:6] - Reseved bits

bits_per_pixel_low
PPS5[7:0] - This indicates the lower significant 8 bits of the compressed BPP bits_per_pixel[9:0] element.

pic_height
PPS6[7:0], PPS7[7:0] -pic_height: Specifies the number of pixel rows within the raster.

pic_width
PPS8[7:0], PPS9[7:0] - pic_width: Number of pixel columns within the raster.

slice_height
PPS10[7:0], PPS11[7:0] - Slice height in units of pixels.

slice_width
PPS12[7:0], PPS13[7:0] - Slice width in terms of pixels.

chunk_size
PPS14[7:0], PPS15[7:0] - Size in units of bytes of the chunks that are used for slice multiplexing.

initial_xmit_delay_high
PPS16[1:0] - Most Significant two bits of initial transmission delay. It specifies the number of pixel times that the encoder waits before transmitting data from its rate buffer. PPS16[7:2] - Reserved

initial_xmit_delay_low
PPS17[7:0] - Least significant 8 bits of initial transmission delay.

initial_dec_delay
PPS18[7:0], PPS19[7:0] - Initial decoding delay which is the number of pixel times that the decoder accumulates data in its rate buffer before starting to decode and output pixels.

pps20_reserved
PPS20[7:0] - Reserved

initial_scale_value
PPS21[5:0] - Initial rcXformScale factor used at beginning of a slice. PPS21[7:6] - Reserved

scale_increment_interval
PPS22[7:0], PPS23[7:0] - Number of group times between incrementing the rcXformScale factor at end of a slice.

scale_decrement_interval_high
PPS24[3:0] - Higher 4 bits indicating number of group times between decrementing the rcXformScale factor at beginning of a slice. PPS24[7:4] - Reserved

scale_decrement_interval_low
PPS25[7:0] - Lower 8 bits of scale decrement interval

pps26_reserved
PPS26[7:0]

first_line_bpg_offset
PPS27[4:0] - Number of additional bits that are allocated for each group on first line of a slice. PPS27[7:5] - Reserved

nfl_bpg_offset
PPS28[7:0], PPS29[7:0] - Number of bits including frac bits deallocated for each group for groups after the first line of slice.

slice_bpg_offset
PPS30, PPS31[7:0] - Number of bits that are deallocated for each group to enforce the slice constraint.

initial_offset
PPS32,33[7:0] - Initial value for rcXformOffset

final_offset
PPS34,35[7:0] - Maximum end-of-slice value for rcXformOffset

flatness_min_qp
PPS36[4:0] - Minimum QP at which flatness is signaled and flatness QP adjustment is made. PPS36[7:5] - Reserved

flatness_max_qp
PPS37[4:0] - Max QP at which flatness is signalled and the flatness adjustment is made. PPS37[7:5] - Reserved

rc_model_size
PPS38,39[7:0] - Number of bits within RC Model.

rc_edge_factor
PPS40[3:0] - Ratio of current activity vs, previous activity to determine presence of edge. PPS40[7:4] - Reserved

rc_quant_incr_limit0
PPS41[4:0] - QP threshold used in short term RC PPS41[7:5] - Reserved

rc_quant_incr_limit1
PPS42[4:0] - QP threshold used in short term RC PPS42[7:5] - Reserved

rc_tgt_offset
PPS43[3:0] - Lower end of the variability range around the target bits per group that is allowed by short term RC. PPS43[7:4]- Upper end of the variability range around the target bits per group that i allowed by short term rc.

rc_buf_thresh
PPS44[7:0] - PPS57[7:0] - Specifies the thresholds in RC model for the 15 ranges defined by 14 thresholds.

rc_range_parameters
PPS58[7:0] - PPS87[7:0] Parameters that correspond to each of the 15 ranges.

native_422_420
PPS88[0] - 0 = Native 4:2:2 not used 1 = Native 4:2:2 used PPS88[1] - 0 = Native 4:2:0 not use 1 = Native 4:2:0 used PPS88[7:2] - Reserved 6 bits

second_line_bpg_offset
PPS89[4:0] - Additional bits/group budget for the second line of a slice in Native 4:2:0 mode. Set to 0 if DSC minor version is 1 or native420 is 0. PPS89[7:5] - Reserved

nsl_bpg_offset
PPS90[7:0], PPS91[7:0] - Number of bits that are deallocated for each group

that is not in the second line of a slice.

second_line_offset_adj
PPS92[7:0], PPS93[7:0] - Used as offset adjustment for the second line in Native 4:2:0 mode.

pps_long_94_reserved
PPS 94, 95, 96, 97 - Reserved

pps_long_98_reserved
PPS 98, 99, 100, 101 - Reserved

pps_long_102_reserved
PPS 102, 103, 104, 105 - Reserved

pps_long_106_reserved
PPS 106, 107, 108, 109 - reserved

pps_long_110_reserved
PPS 110, 111, 112, 113 - reserved

pps_long_114_reserved
PPS 114 - 117 - reserved

pps_long_118_reserved
PPS 118 - 121 - reserved

pps_long_122_reserved
PPS 122- 125 - reserved

pps_short_126_reserved
PPS 126, 127 - reserved

Description

The VESA DSC standard defines picture parameter set (PPS) which display stream compression encoders must communicate to decoders. The PPS is encapsulated in 128 bytes (PPS 0 through PPS 127). The fields in this structure are as per Table 4.1 in Vesa DSC specification v1.1/v1.2. The PPS fields that span over more than a byte should be stored in Big Endian format.

struct **drm_dsc_pps_infoframe**

DSC infoframe carrying the Picture Parameter Set Metadata

Definition

```
struct drm_dsc_pps_infoframe {
  struct dp_sdp_header pps_header;
  struct drm_dsc_picture_parameter_set pps_payload;
};
```

Members

pps_header
Header for PPS as per DP SDP header format of type *struct dp_sdp_header*

pps_payload
PPS payload fields as per DSC specification Table 4-1 as represented in *struct drm_dsc_picture_parameter_set*

Description

This structure represents the DSC PPS infoframe required to send the Picture Parameter Set metadata required before enabling VESA Display Stream Compression. This is based on the DP Secondary Data Packet structure and comprises of SDP Header as defined *struct dp_sdp_header* in drm_dp_helper.h and PPS payload defined in *struct drm_dsc_picture_parameter_set*.

void **drm_dsc_dp_pps_header_init**(struct *dp_sdp_header* *pps_header)

Initializes the PPS Header for DisplayPort as per the DP 1.4 spec.

Parameters

struct dp_sdp_header *pps_header
Secondary data packet header for DSC Picture Parameter Set as defined in *struct dp_sdp_header*

Description

DP 1.4 spec defines the secondary data packet for sending the picture parameter infoframes from the source to the sink. This function populates the SDP header defined in *struct dp_sdp_header*.

void **drm_dsc_pps_payload_pack**(struct *drm_dsc_picture_parameter_set* *pps_payload, const struct *drm_dsc_config* *dsc_cfg)

Populates the DSC PPS

Parameters

struct drm_dsc_picture_parameter_set *pps_payload
Bitwise struct for DSC Picture Parameter Set. This is defined by *struct drm_dsc_picture_parameter_set*

const struct drm_dsc_config *dsc_cfg
DSC Configuration data filled by driver as defined by *struct drm_dsc_config*

Description

DSC source device sends a picture parameter set (PPS) containing the information required by the sink to decode the compressed frame. Driver populates the DSC PPS struct using the DSC configuration parameters in the order expected by the DSC Display Sink device. For the DSC, the sink device expects the PPS payload in big endian format for fields that span more than 1 byte.

int **drm_dsc_compute_rc_parameters**(struct *drm_dsc_config* *vdsc_cfg)

Write rate control parameters to the dsc configuration defined in *struct drm_dsc_config* in accordance with the DSC 1.2 specification. Some configuration fields must be present beforehand.

Parameters

struct drm_dsc_config *vdsc_cfg
DSC Configuration data partially filled by driver

5.19 Output Probing Helper Functions Reference

This library provides some helper code for output probing. It provides an implementation of the core *drm_connector_funcs.fill_modes* interface with *drm_helper_probe_single_connector_modes()*.

It also provides support for polling connectors with a work item and for generic hotplug interrupt handling where the driver doesn't or cannot keep track of a per-connector hpd interrupt.

This helper library can be used independently of the modeset helper library. Drivers can also overwrite different parts e.g. use their own hotplug handling code to avoid probing unrelated outputs.

The probe helpers share the function table structures with other display helper libraries. See *struct drm_connector_helper_funcs* for the details.

void **drm_kms_helper_poll_enable**(struct *drm_device* *dev)

re-enable output polling.

Parameters

struct drm_device *dev

drm_device

Description

This function re-enables the output polling work, after it has been temporarily disabled using *drm_kms_helper_poll_disable()*, for example over suspend/resume.

Drivers can call this helper from their device resume implementation. It is not an error to call this even when output polling isn't enabled.

Note that calls to enable and disable polling must be strictly ordered, which is automatically the case when they're only call from suspend/resume callbacks.

int **drm_helper_probe_detect**(struct *drm_connector* *connector, struct *drm_modeset_acquire_ctx* *ctx, bool force)

probe connector status

Parameters

struct drm_connector *connector

connector to probe

struct drm_modeset_acquire_ctx *ctx

acquire_ctx, or NULL to let this function handle locking.

bool force

Whether destructive probe operations should be performed.

Description

This function calls the detect callbacks of the connector. This function returns *drm_connector_status*, or if **ctx** is set, it might also return -EDEADLK.

int **drm_helper_probe_single_connector_modes**(struct *drm_connector* *connector, uint32_t maxX, uint32_t maxY) get complete set of display modes

Parameters

`struct drm_connector *connector`
connector to probe

`uint32_t maxX`
max width for modes

`uint32_t maxY`
max height for modes

Description

Based on the helper callbacks implemented by **connector** in struct *drm_connector_helper_funcs* try to detect all valid modes. Modes will first be added to the connector's probed_modes list, then culled (based on validity and the **maxX**, **maxY** parameters) and put into the normal modes list.

Intended to be used as a generic implementation of the *drm_connector_funcs.fill_modes()* vfunc for drivers that use the CRTC helpers for output mode filtering and detection.

The basic procedure is as follows

1. All modes currently on the connector's modes list are marked as stale
2. New modes are added to the connector's probed_modes list with *drm_mode_probed_add()*. New modes start their life with status as OK. Modes are added from a single source using the following priority order.
   - *drm_connector_helper_funcs.get_modes* vfunc
   - if the connector status is connector_status_connected, standard VESA DMT modes up to 1024x768 are automatically added (*drm_add_modes_noedid()*)

   Finally modes specified via the kernel command line (video=…) are added in addition to what the earlier probes produced (drm_helper_probe_add_cmdline_mode()). These modes are generated using the VESA GTF/CVT formulas.
3. Modes are moved from the probed_modes list to the modes list. Potential duplicates are merged together (see *drm_connector_list_update()*). After this step the probed_modes list will be empty again.
4. Any non-stale mode on the modes list then undergoes validation
   - drm_mode_validate_basic() performs basic sanity checks
   - *drm_mode_validate_size()* filters out modes larger than **maxX** and **maxY** (if specified)
   - drm_mode_validate_flag() checks the modes against basic connector capabilities (interlace_allowed,doublescan_allowed,stereo_allowed)
   - the optional *drm_connector_helper_funcs.mode_valid* or *drm_connector_helper_funcs.mode_valid_ctx* helpers can perform driver and/or sink specific checks

- the optional *drm_crtc_helper_funcs.mode_valid*, *drm_bridge_funcs.mode_valid* and *drm_encoder_helper_funcs.mode_valid* helpers can perform driver and/or source specific checks which are also enforced by the modeset/atomic helpers

5. Any mode whose status is not OK is pruned from the connector's modes list, accompanied by a debug message indicating the reason for the mode's rejection (see *drm_mode_prune_invalid()*).

Return

The number of modes found on **connector**.

void **drm_kms_helper_hotplug_event**(struct *drm_device* *dev)

fire off KMS hotplug events

Parameters

struct drm_device *dev

drm_device whose connector state changed

Description

This function fires off the uevent for userspace and also calls the output_poll_changed function, which is most commonly used to inform the fbdev emulation code and allow it to update the fbcon output configuration.

Drivers should call this from their hotplug handling code when a change is detected. Note that this function does not do any output detection of its own, like *drm_helper_hpd_irq_event()* does - this is assumed to be done by the driver already.

This function must be called from process context with no mode setting locks held.

bool **drm_kms_helper_is_poll_worker**(void)

is `current` task an output poll worker?

Parameters

void

no arguments

Description

Determine if `current` task is an output poll worker. This can be used to select distinct code paths for output polling versus other contexts.

One use case is to avoid a deadlock between the output poll worker and the autosuspend worker wherein the latter waits for polling to finish upon calling *drm_kms_helper_poll_disable()*, while the former waits for runtime suspend to finish upon calling pm_runtime_get_sync() in a connector ->detect hook.

void **drm_kms_helper_poll_disable**(struct *drm_device* *dev)

disable output polling

Parameters

struct drm_device *dev

drm_device

Description

This function disables the output polling work.

Drivers can call this helper from their device suspend implementation. It is not an error to call this even when output polling isn't enabled or already disabled. Polling is re-enabled by calling *drm_kms_helper_poll_enable()*.

Note that calls to enable and disable polling must be strictly ordered, which is automatically the case when they're only call from suspend/resume callbacks.

void **drm_kms_helper_poll_init**(struct *drm_device* *dev)
initialize and enable output polling

Parameters

struct drm_device *dev
drm_device

Description

This function intializes and then also enables output polling support for **dev**. Drivers which do not have reliable hotplug support in hardware can use this helper infrastructure to regularly poll such connectors for changes in their connection state.

Drivers can control which connectors are polled by setting the DRM_CONNECTOR_POLL_CONNECT and DRM_CONNECTOR_POLL_DISCONNECT flags. On connectors where probing live outputs can result in visual distortion drivers should not set the DRM_CONNECTOR_POLL_DISCONNECT flag to avoid this. Connectors which have no flag or only DRM_CONNECTOR_POLL_HPD set are completely ignored by the polling logic.

Note that a connector can be both polled and probed from the hotplug handler, in case the hotplug interrupt is known to be unreliable.

void **drm_kms_helper_poll_fini**(struct *drm_device* *dev)
disable output polling and clean it up

Parameters

struct drm_device *dev
drm_device

bool **drm_helper_hpd_irq_event**(struct *drm_device* *dev)
hotplug processing

Parameters

struct drm_device *dev
drm_device

Description

Drivers can use this helper function to run a detect cycle on all connectors which have the DRM_CONNECTOR_POLL_HPD flag set in their `polled` member. All other connectors are ignored, which is useful to avoid reprobing fixed panels.

This helper function is useful for drivers which can' t or don' t track hotplug interrupts for each connector.

Drivers which support hotplug interrupts for each connector individually and which have a more fine-grained detect logic should bypass this code and directly call *drm_kms_helper_hotplug_event()* in case the connector state changed.

This function must be called from process context with no mode setting locks held.

Note that a connector can be both polled and probed from the hotplug handler, in case the hotplug interrupt is known to be unreliable.

5.20 EDID Helper Functions Reference

int **drm_eld_mnl**(const uint8_t *eld)

Get ELD monitor name length in bytes.

Parameters

const uint8_t *eld

pointer to an eld memory structure with mnl set

const uint8_t ***drm_eld_sad**(const uint8_t *eld)

Get ELD SAD structures.

Parameters

const uint8_t *eld

pointer to an eld memory structure with sad_count set

int **drm_eld_sad_count**(const uint8_t *eld)

Get ELD SAD count.

Parameters

const uint8_t *eld

pointer to an eld memory structure with sad_count set

int **drm_eld_calc_baseline_block_size**(const uint8_t *eld)

Calculate baseline block size in bytes

Parameters

const uint8_t *eld

pointer to an eld memory structure with mnl and sad_count set

Description

This is a helper for determining the payload size of the baseline block, in bytes, for e.g. setting the Baseline_ELD_Len field in the ELD header block.

int **drm_eld_size**(const uint8_t *eld)

Get ELD size in bytes

Parameters

const uint8_t *eld

pointer to a complete eld memory structure

Description

The returned value does not include the vendor block. It's vendor specific, and comprises of the remaining bytes in the ELD memory buffer after *drm_eld_size()* bytes of header and baseline block.

The returned value is guaranteed to be a multiple of 4.

u8 **drm_eld_get_spk_alloc**(const uint8_t *eld)

Get speaker allocation

Parameters

const uint8_t *eld
pointer to an ELD memory structure

Description

The returned value is the speakers mask. User has to use `DRM_ELD_SPEAKER` field definitions to identify speakers.

u8 **drm_eld_get_conn_type**(const uint8_t *eld)

Get device type hdmi/dp connected

Parameters

const uint8_t *eld
pointer to an ELD memory structure

Description

The caller need to use `DRM_ELD_CONN_TYPE_HDMI` or `DRM_ELD_CONN_TYPE_DP` to identify the display type connected.

int **drm_edid_header_is_valid**(const u8 *raw_edid)

sanity check the header of the base EDID block

Parameters

const u8 *raw_edid
pointer to raw base EDID block

Description

Sanity check the header of the base EDID block.

Return

8 if the header is perfect, down to 0 if it's totally wrong.

bool **drm_edid_are_equal**(const struct edid *edid1, const struct edid *edid2)

compare two edid blobs.

Parameters

const struct edid *edid1
pointer to first blob

const struct edid *edid2
pointer to second blob This helper can be used during probing to determine if edid had changed.

bool **drm_edid_block_valid**(u8 *raw_edid, int block, bool print_bad_edid, bool *edid_corrupt)

Sanity check the EDID block (base or extension)

Parameters

u8 *raw_edid
pointer to raw EDID block

int block
type of block to validate (0 for base, extension otherwise)

bool print_bad_edid
if true, dump bad EDID blocks to the console

bool *edid_corrupt
if true, the header or checksum is invalid

Description

Validate a base or extension EDID block and optionally dump bad blocks to the console.

Return

True if the block is valid, false otherwise.

bool **drm_edid_is_valid**(struct *edid* *edid)

sanity check EDID data

Parameters

struct edid *edid
EDID data

Description

Sanity-check an entire EDID record (including extensions)

Return

True if the EDID data is valid, false otherwise.

int **drm_add_override_edid_modes**(struct *drm_connector* *connector)

add modes from override/firmware EDID

Parameters

struct drm_connector *connector
connector we' re probing

Description

Add modes from the override/firmware EDID, if available. Only to be used from *drm_helper_probe_single_connector_modes()* as a fallback for when DDC probe failed during *drm_get_edid()* and caused the override/firmware EDID to be skipped.

Return

The number of modes added or 0 if we couldn' t find any.

struct edid ***drm_do_get_edid**(struct *drm_connector* *connector, int (*get_edid_block)(void *data, u8 *buf, unsigned int block, size_t len), void *data)

get EDID data using a custom EDID block read function

Parameters

struct drm_connector *connector
connector we' re probing

int (*get_edid_block)(void *data, u8 *buf, unsigned int block, size_t len)
EDID block read function

void *data
private data passed to the block read function

Description

When the I2C adapter connected to the DDC bus is hidden behind a device that exposes a different interface to read EDID blocks this function can be used to get EDID data using a custom block read function.

As in the general case the DDC bus is accessible by the kernel at the I2C level, drivers must make all reasonable efforts to expose it as an I2C adapter and use *drm_get_edid()* instead of abusing this function.

The EDID may be overridden using debugfs override_edid or firmare EDID (drm_load_edid_firmware() and drm.edid_firmware parameter), in this priority order. Having either of them bypasses actual EDID reads.

Return

Pointer to valid EDID or NULL if we couldn' t find any.

bool **drm_probe_ddc**(struct i2c_adapter *adapter)

probe DDC presence

Parameters

struct i2c_adapter *adapter
I2C adapter to probe

Return

True on success, false on failure.

struct edid ***drm_get_edid**(struct *drm_connector* *connector, struct i2c_adapter *adapter)

get EDID data, if available

Parameters

struct drm_connector *connector
connector we' re probing

struct i2c_adapter *adapter
I2C adapter to use for DDC

Description

Poke the given I2C channel to grab EDID data if possible. If found, attach it to the connector.

Return

Pointer to valid EDID or NULL if we couldn't find any.

struct edid ***drm_get_edid_switcheroo**(struct *drm_connector* *connector, struct i2c_adapter *adapter)

get EDID data for a vga_switcheroo output

Parameters

struct drm_connector *connector
connector we're probing

struct i2c_adapter *adapter
I2C adapter to use for DDC

Description

Wrapper around *drm_get_edid()* for laptops with dual GPUs using one set of outputs. The wrapper adds the requisite vga_switcheroo calls to temporarily switch DDC to the GPU which is retrieving EDID.

Return

Pointer to valid EDID or `NULL` if we couldn't find any.

struct *edid* ***drm_edid_duplicate**(const struct *edid* *edid)

duplicate an EDID and the extensions

Parameters

const struct edid *edid
EDID to duplicate

Return

Pointer to duplicated EDID or NULL on allocation failure.

u8 **drm_match_cea_mode**(const struct *drm_display_mode* *to_match)

look for a CEA mode matching given mode

Parameters

const struct drm_display_mode *to_match
display mode

Return

The CEA Video ID (VIC) of the mode or 0 if it isn't a CEA-861 mode.

struct *drm_display_mode* ***drm_display_mode_from_cea_vic**(struct *drm_device* *dev, u8 video_code)

return a mode for CEA VIC

Parameters

struct drm_device *dev
DRM device

`u8 video_code`
  CEA VIC of the mode

Description

Creates a new mode matching the specified CEA VIC.

Return

A new drm_display_mode on success or NULL on failure

void **`drm_edid_get_monitor_name`**(struct *edid* *edid, char *name, int bufsize)
  fetch the monitor name from the edid

Parameters

`struct edid *edid`
  monitor EDID information

`char *name`
  pointer to a character array to hold the name of the monitor

`int bufsize`
  The size of the name buffer (should be at least 14 chars.)

int **`drm_edid_to_sad`**(struct *edid* *edid, struct cea_sad **sads)
  extracts SADs from EDID

Parameters

`struct edid *edid`
  EDID to parse

`struct cea_sad **sads`
  pointer that will be set to the extracted SADs

Description

Looks for CEA EDID block and extracts SADs (Short Audio Descriptors) from it.

Note

The returned pointer needs to be freed using kfree().

Return

The number of found SADs or negative number on error.

int **`drm_edid_to_speaker_allocation`**(struct *edid* *edid, u8 **sadb)
  extracts Speaker Allocation Data Blocks from EDID

Parameters

`struct edid *edid`
  EDID to parse

`u8 **sadb`
  pointer to the speaker block

Description

Looks for CEA EDID block and extracts the Speaker Allocation Data Block from it.

Note

The returned pointer needs to be freed using kfree().

Return

The number of found Speaker Allocation Blocks or negative number on error.

int **drm_av_sync_delay**(struct *drm_connector* *connector, const struct *drm_display_mode* *mode)

compute the HDMI/DP sink audio-video sync delay

Parameters

struct drm_connector *connector
connector associated with the HDMI/DP sink

const struct drm_display_mode *mode
the display mode

Return

The HDMI/DP sink's audio-video sync delay in milliseconds or 0 if the sink doesn't support audio or video.

bool **drm_detect_hdmi_monitor**(struct *edid* *edid)

detect whether monitor is HDMI

Parameters

struct edid *edid
monitor EDID information

Description

Parse the CEA extension according to CEA-861-B.

Drivers that have added the modes parsed from EDID to drm_display_info should use *drm_display_info.is_hdmi* instead of calling this function.

Return

True if the monitor is HDMI, false if not or unknown.

bool **drm_detect_monitor_audio**(struct *edid* *edid)

check monitor audio capability

Parameters

struct edid *edid
EDID block to scan

Description

Monitor should have CEA extension block. If monitor has 'basic audio', but no CEA audio blocks, it's 'basic audio' only. If there is any audio extension block and supported audio format, assume at least 'basic audio' support, even if 'basic audio' is not defined in EDID.

Return

True if the monitor supports audio, false otherwise.

enum hdmi_quantization_range **drm_default_rgb_quant_range**(const struct *drm_display_mode* *mode)

default RGB quantization range

Parameters

const struct drm_display_mode *mode
display mode

Description

Determine the default RGB quantization range for the mode, as specified in CEA-861.

Return

The default RGB quantization range for the mode

int **drm_add_edid_modes**(struct *drm_connector* *connector, struct *edid* *edid)

add modes from EDID data, if available

Parameters

struct drm_connector *connector
connector we're probing

struct edid *edid
EDID data

Description

Add the specified modes to the connector's mode list. Also fills out the *drm_display_info* structure and ELD in **connector** with any information which can be derived from the edid.

Return

The number of modes added or 0 if we couldn't find any.

int **drm_add_modes_noedid**(struct *drm_connector* *connector, int hdisplay, int vdisplay)

add modes for the connectors without EDID

Parameters

struct drm_connector *connector
connector we're probing

int hdisplay
the horizontal display limit

int vdisplay
the vertical display limit

Description

Add the specified modes to the connector's mode list. Only when the hdisplay/vdisplay is not beyond the given limit, it will be added.

Return

The number of modes added or 0 if we couldn't find any.

void **drm_set_preferred_mode**(struct *drm_connector* *connector, int hpref, int vpref)

Sets the preferred mode of a connector

Parameters

struct drm_connector *connector
connector whose mode list should be processed

int hpref
horizontal resolution of preferred mode

int vpref
vertical resolution of preferred mode

Description

Marks a mode as preferred if it matches the resolution specified by **hpref** and **vpref**.

int **drm_hdmi_infoframe_set_hdr_metadata**(struct hdmi_drm_infoframe *frame, const struct *drm_connector_state* *conn_state)

fill an HDMI DRM infoframe with HDR metadata from userspace

Parameters

struct hdmi_drm_infoframe *frame
HDMI DRM infoframe

const struct drm_connector_state *conn_state
Connector state containing HDR metadata

Return

0 on success or a negative error code on failure.

int **drm_hdmi_avi_infoframe_from_display_mode**(struct hdmi_avi_infoframe *frame, const struct *drm_connector* *connector, const struct *drm_display_mode* *mode)

fill an HDMI AVI infoframe with data from a DRM display mode

Parameters

struct hdmi_avi_infoframe *frame
HDMI AVI infoframe

const struct drm_connector *connector
the connector

const struct drm_display_mode *mode
DRM display mode

Return

0 on success or a negative error code on failure.

void **drm_hdmi_avi_infoframe_colorspace**(struct hdmi_avi_infoframe *frame, const struct *drm_connector_state* *conn_state)

fill the HDMI AVI infoframe colorspace information

Parameters

struct hdmi_avi_infoframe *frame
HDMI AVI infoframe

const struct drm_connector_state *conn_state
connector state

void **drm_hdmi_avi_infoframe_quant_range**(struct hdmi_avi_infoframe *frame, const struct *drm_connector* *connector, const struct *drm_display_mode* *mode, enum hdmi_quantization_range rgb_quant_range)

fill the HDMI AVI infoframe quantization range information

Parameters

struct hdmi_avi_infoframe *frame
HDMI AVI infoframe

const struct drm_connector *connector
the connector

const struct drm_display_mode *mode
DRM display mode

enum hdmi_quantization_range rgb_quant_range
RGB quantization range (Q)

void **drm_hdmi_avi_infoframe_bars**(struct hdmi_avi_infoframe *frame, const struct *drm_connector_state* *conn_state)

fill the HDMI AVI infoframe bar information

Parameters

struct hdmi_avi_infoframe *frame
HDMI AVI infoframe

const struct drm_connector_state *conn_state
connector state

int **drm_hdmi_vendor_infoframe_from_display_mode**(struct hdmi_vendor_infoframe *frame, const struct *drm_connector* *connector, const struct *drm_display_mode* *mode)

fill an HDMI infoframe with data from a DRM display mode

Parameters

struct hdmi_vendor_infoframe *frame
  HDMI vendor infoframe

const struct drm_connector *connector
  the connector

const struct drm_display_mode *mode
  DRM display mode

Description

Note that there' s is a need to send HDMI vendor infoframes only when using a 4k or stereoscopic 3D mode. So when giving any other mode as input this function will return -EINVAL, error that can be safely ignored.

Return

0 on success or a negative error code on failure.

5.21 SCDC Helper Functions Reference

Status and Control Data Channel (SCDC) is a mechanism introduced by the HDMI 2.0 specification. It is a point-to-point protocol that allows the HDMI source and HDMI sink to exchange data. The same I2C interface that is used to access EDID serves as the transport mechanism for SCDC.

int **drm_scdc_readb**(struct i2c_adapter *adapter, u8 offset, u8 *value)
  read a single byte from SCDC

Parameters

struct i2c_adapter *adapter
  I2C adapter

u8 offset
  offset of register to read

u8 *value
  return location for the register value

Description

Reads a single byte from SCDC. This is a convenience wrapper around the *drm_scdc_read()* function.

Return

0 on success or a negative error code on failure.

int **drm_scdc_writeb**(struct i2c_adapter *adapter, u8 offset, u8 value)
  write a single byte to SCDC

Parameters

struct i2c_adapter *adapter
  I2C adapter

u8 offset
  offset of register to read

`u8 value`
: return location for the register value

Description

Writes a single byte to SCDC. This is a convenience wrapper around the *`drm_scdc_write()`* function.

Return

0 on success or a negative error code on failure.

ssize_t **`drm_scdc_read`**(struct i2c_adapter *adapter, u8 offset, void *buffer, size_t size)

read a block of data from SCDC

Parameters

`struct i2c_adapter *adapter`
: I2C controller

`u8 offset`
: start offset of block to read

`void *buffer`
: return location for the block to read

`size_t size`
: size of the block to read

Description

Reads a block of data from SCDC, starting at a given offset.

Return

0 on success, negative error code on failure.

ssize_t **`drm_scdc_write`**(struct i2c_adapter *adapter, u8 offset, const void *buffer, size_t size)

write a block of data to SCDC

Parameters

`struct i2c_adapter *adapter`
: I2C controller

`u8 offset`
: start offset of block to write

`const void *buffer`
: block of data to write

`size_t size`
: size of the block to write

Description

Writes a block of data to SCDC, starting at a given offset.

Return

0 on success, negative error code on failure.

bool **`drm_scdc_get_scrambling_status`**(struct i2c_adapter *adapter)

what is status of scrambling?

Parameters

`struct i2c_adapter *adapter`
I2C adapter for DDC channel

Description

Reads the scrambler status over SCDC, and checks the scrambling status.

Return

True if the scrambling is enabled, false otherwise.

bool **`drm_scdc_set_scrambling`**(struct i2c_adapter *adapter, bool enable)

enable scrambling

Parameters

`struct i2c_adapter *adapter`
I2C adapter for DDC channel

`bool enable`
bool to indicate if scrambling is to be enabled/disabled

Description

Writes the TMDS config register over SCDC channel, and: enables scrambling when enable = 1 disables scrambling when enable = 0

Return

True if scrambling is set/reset successfully, false otherwise.

bool **`drm_scdc_set_high_tmds_clock_ratio`**(struct i2c_adapter *adapter, bool set)

set TMDS clock ratio

Parameters

`struct i2c_adapter *adapter`
I2C adapter for DDC channel

`bool set`
ret or reset the high clock ratio

TMDS clock ratio calculations go like this:

TMDS character = 10 bit TMDS encoded value

TMDS character rate = The rate at which TMDS characters are transmitted (Mcsc)

TMDS bit rate = 10x TMDS character rate

As per the spec:

TMDS clock rate for pixel clock < 340 MHz = 1x the character rate = 1/10 pixel clock rate

TMDS clock rate for pixel clock > 340 MHz = 0.25x the character rate = 1/40 pixel clock rate

Writes to the TMDS config register over SCDC channel, and:

sets TMDS clock ratio to 1/40 when set = 1

sets TMDS clock ratio to 1/10 when set = 0

Return

True if write is successful, false otherwise.

5.22 HDMI Infoframes Helper Reference

Strictly speaking this is not a DRM helper library but generally useable by any driver interfacing with HDMI outputs like v4l or alsa drivers. But it nicely fits into the overall topic of mode setting helper libraries and hence is also included here.

struct **hdr_sink_metadata**

HDR sink metadata

Definition

```
struct hdr_sink_metadata {
  __u32 metadata_type;
  union {
    struct hdr_static_metadata hdmi_type1;
  };
};
```

Members

metadata_type
Static_Metadata_Descriptor_ID.

{unnamed_union}
anonymous

hdmi_type1
HDR Metadata Infoframe.

Description

Metadata Information read from Sink’ s EDID

union **hdmi_infoframe**

overall union of all abstract infoframe representations

Definition

```
union hdmi_infoframe {
  struct hdmi_any_infoframe any;
  struct hdmi_avi_infoframe avi;
  struct hdmi_spd_infoframe spd;
  union hdmi_vendor_any_infoframe vendor;
  struct hdmi_audio_infoframe audio;
  struct hdmi_drm_infoframe drm;
};
```

Members

`any`
generic infoframe

`avi`
avi infoframe

`spd`
spd infoframe

`vendor`
union of all vendor infoframes

`audio`
audio infoframe

`drm`
Dynamic Range and Mastering infoframe

Description

This is used by the generic pack function. This works since all infoframes have the same header which also indicates which type of infoframe should be packed.

void **`hdmi_avi_infoframe_init`**(struct hdmi_avi_infoframe *frame)
initialize an HDMI AVI infoframe

Parameters

`struct hdmi_avi_infoframe *frame`
HDMI AVI infoframe

int **`hdmi_avi_infoframe_check`**(struct hdmi_avi_infoframe *frame)
check a HDMI AVI infoframe

Parameters

`struct hdmi_avi_infoframe *frame`
HDMI AVI infoframe

Description

Validates that the infoframe is consistent and updates derived fields (eg. length) based on other fields.

Returns 0 on success or a negative error code on failure.

ssize_t **`hdmi_avi_infoframe_pack_only`**(const struct hdmi_avi_infoframe *frame, void *buffer, size_t size)
write HDMI AVI infoframe to binary buffer

Parameters

`const struct hdmi_avi_infoframe *frame`
HDMI AVI infoframe

`void *buffer`
destination buffer

`size_t size`
size of buffer

Description

Packs the information contained in the **frame** structure into a binary representation that can be written into the corresponding controller registers. Also computes the checksum as required by section 5.3.5 of the HDMI 1.4 specification.

Returns the number of bytes packed into the binary buffer or a negative error code on failure.

ssize_t **hdmi_avi_infoframe_pack**(struct hdmi_avi_infoframe *frame, void *buffer, size_t size)

check a HDMI AVI infoframe, and write it to binary buffer

Parameters

struct hdmi_avi_infoframe *frame
HDMI AVI infoframe

void *buffer
destination buffer

size_t size
size of buffer

Description

Validates that the infoframe is consistent and updates derived fields (eg. length) based on other fields, after which it packs the information contained in the **frame** structure into a binary representation that can be written into the corresponding controller registers. This function also computes the checksum as required by section 5.3.5 of the HDMI 1.4 specification.

Returns the number of bytes packed into the binary buffer or a negative error code on failure.

int **hdmi_spd_infoframe_init**(struct hdmi_spd_infoframe *frame, const char *vendor, const char *product)

initialize an HDMI SPD infoframe

Parameters

struct hdmi_spd_infoframe *frame
HDMI SPD infoframe

const char *vendor
vendor string

const char *product
product string

Description

Returns 0 on success or a negative error code on failure.

int **hdmi_spd_infoframe_check**(struct hdmi_spd_infoframe *frame)

check a HDMI SPD infoframe

Parameters

struct hdmi_spd_infoframe *frame
HDMI SPD infoframe

Description

Validates that the infoframe is consistent and updates derived fields (eg. length) based on other fields.

Returns 0 on success or a negative error code on failure.

ssize_t **hdmi_spd_infoframe_pack_only**(const struct hdmi_spd_infoframe *frame, void *buffer, size_t size)

write HDMI SPD infoframe to binary buffer

Parameters

const struct hdmi_spd_infoframe *frame
HDMI SPD infoframe

void *buffer
destination buffer

size_t size
size of buffer

Description

Packs the information contained in the **frame** structure into a binary representation that can be written into the corresponding controller registers. Also computes the checksum as required by section 5.3.5 of the HDMI 1.4 specification.

Returns the number of bytes packed into the binary buffer or a negative error code on failure.

ssize_t **hdmi_spd_infoframe_pack**(struct hdmi_spd_infoframe *frame, void *buffer, size_t size)

check a HDMI SPD infoframe, and write it to binary buffer

Parameters

struct hdmi_spd_infoframe *frame
HDMI SPD infoframe

void *buffer
destination buffer

size_t size
size of buffer

Description

Validates that the infoframe is consistent and updates derived fields (eg. length) based on other fields, after which it packs the information contained in the **frame** structure into a binary representation that can be written into the corresponding controller registers. This function also computes the checksum as required by section 5.3.5 of the HDMI 1.4 specification.

Returns the number of bytes packed into the binary buffer or a negative error code on failure.

int **hdmi_audio_infoframe_init**(struct hdmi_audio_infoframe *frame)

initialize an HDMI audio infoframe

Parameters

`struct hdmi_audio_infoframe *frame`
HDMI audio infoframe

Description

Returns 0 on success or a negative error code on failure.

int **`hdmi_audio_infoframe_check`**(struct hdmi_audio_infoframe *frame)
check a HDMI audio infoframe

Parameters

`struct hdmi_audio_infoframe *frame`
HDMI audio infoframe

Description

Validates that the infoframe is consistent and updates derived fields (eg. length) based on other fields.

Returns 0 on success or a negative error code on failure.

ssize_t **`hdmi_audio_infoframe_pack_only`**(const struct hdmi_audio_infoframe *frame, void *buffer, size_t size)
write HDMI audio infoframe to binary buffer

Parameters

`const struct hdmi_audio_infoframe *frame`
HDMI audio infoframe

`void *buffer`
destination buffer

`size_t size`
size of buffer

Description

Packs the information contained in the **frame** structure into a binary representation that can be written into the corresponding controller registers. Also computes the checksum as required by section 5.3.5 of the HDMI 1.4 specification.

Returns the number of bytes packed into the binary buffer or a negative error code on failure.

ssize_t **`hdmi_audio_infoframe_pack`**(struct hdmi_audio_infoframe *frame, void *buffer, size_t size)
check a HDMI Audio infoframe, and write it to binary buffer

Parameters

`struct hdmi_audio_infoframe *frame`
HDMI Audio infoframe

`void *buffer`
destination buffer

`size_t size`
size of buffer

Description

Validates that the infoframe is consistent and updates derived fields (eg. length) based on other fields, after which it packs the information contained in the **frame** structure into a binary representation that can be written into the corresponding controller registers. This function also computes the checksum as required by section 5.3.5 of the HDMI 1.4 specification.

Returns the number of bytes packed into the binary buffer or a negative error code on failure.

int **hdmi_vendor_infoframe_init**(struct hdmi_vendor_infoframe *frame)

initialize an HDMI vendor infoframe

Parameters

struct hdmi_vendor_infoframe *frame
HDMI vendor infoframe

Description

Returns 0 on success or a negative error code on failure.

int **hdmi_vendor_infoframe_check**(struct hdmi_vendor_infoframe *frame)

check a HDMI vendor infoframe

Parameters

struct hdmi_vendor_infoframe *frame
HDMI infoframe

Description

Validates that the infoframe is consistent and updates derived fields (eg. length) based on other fields.

Returns 0 on success or a negative error code on failure.

ssize_t **hdmi_vendor_infoframe_pack_only**(const struct hdmi_vendor_infoframe *frame, void *buffer, size_t size)

write a HDMI vendor infoframe to binary buffer

Parameters

const struct hdmi_vendor_infoframe *frame
HDMI infoframe

void *buffer
destination buffer

size_t size
size of buffer

Description

Packs the information contained in the **frame** structure into a binary representation that can be written into the corresponding controller registers. Also computes the checksum as required by section 5.3.5 of the HDMI 1.4 specification.

Returns the number of bytes packed into the binary buffer or a negative error code on failure.

ssize_t **hdmi_vendor_infoframe_pack**(struct hdmi_vendor_infoframe *frame, void *buffer, size_t size)

check a HDMI Vendor infoframe, and write it to binary buffer

Parameters

struct hdmi_vendor_infoframe *frame
HDMI Vendor infoframe

void *buffer
destination buffer

size_t size
size of buffer

Description

Validates that the infoframe is consistent and updates derived fields (eg. length) based on other fields, after which it packs the information contained in the **frame** structure into a binary representation that can be written into the corresponding controller registers. This function also computes the checksum as required by section 5.3.5 of the HDMI 1.4 specification.

Returns the number of bytes packed into the binary buffer or a negative error code on failure.

int **hdmi_drm_infoframe_init**(struct hdmi_drm_infoframe *frame)

initialize an HDMI Dynaminc Range and mastering infoframe

Parameters

struct hdmi_drm_infoframe *frame
HDMI DRM infoframe

Description

Returns 0 on success or a negative error code on failure.

int **hdmi_drm_infoframe_check**(struct hdmi_drm_infoframe *frame)

check a HDMI DRM infoframe

Parameters

struct hdmi_drm_infoframe *frame
HDMI DRM infoframe

Description

Validates that the infoframe is consistent. Returns 0 on success or a negative error code on failure.

ssize_t **hdmi_drm_infoframe_pack_only**(const struct hdmi_drm_infoframe *frame, void *buffer, size_t size)

write HDMI DRM infoframe to binary buffer

Parameters

const struct hdmi_drm_infoframe *frame
HDMI DRM infoframe

void *buffer
destination buffer

size_t size
size of buffer

Description

Packs the information contained in the **frame** structure into a binary representation that can be written into the corresponding controller registers. Also computes the checksum as required by section 5.3.5 of the HDMI 1.4 specification.

Returns the number of bytes packed into the binary buffer or a negative error code on failure.

ssize_t **hdmi_drm_infoframe_pack**(struct hdmi_drm_infoframe *frame, void *buffer, size_t size)

check a HDMI DRM infoframe, and write it to binary buffer

Parameters

struct hdmi_drm_infoframe *frame
HDMI DRM infoframe

void *buffer
destination buffer

size_t size
size of buffer

Description

Validates that the infoframe is consistent and updates derived fields (eg. length) based on other fields, after which it packs the information contained in the **frame** structure into a binary representation that can be written into the corresponding controller registers. This function also computes the checksum as required by section 5.3.5 of the HDMI 1.4 specification.

Returns the number of bytes packed into the binary buffer or a negative error code on failure.

int **hdmi_infoframe_check**(union *hdmi_infoframe* *frame)

check a HDMI infoframe

Parameters

union hdmi_infoframe *frame
HDMI infoframe

Description

Validates that the infoframe is consistent and updates derived fields (eg. length) based on other fields.

Returns 0 on success or a negative error code on failure.

ssize_t **hdmi_infoframe_pack_only**(const union *hdmi_infoframe* *frame, void *buffer, size_t size)

write a HDMI infoframe to binary buffer

Parameters

`const union hdmi_infoframe *frame`
HDMI infoframe

`void *buffer`
destination buffer

`size_t size`
size of buffer

Description

Packs the information contained in the **frame** structure into a binary representation that can be written into the corresponding controller registers. Also computes the checksum as required by section 5.3.5 of the HDMI 1.4 specification.

Returns the number of bytes packed into the binary buffer or a negative error code on failure.

ssize_t **`hdmi_infoframe_pack`**(union *hdmi_infoframe* *frame, void *buffer, size_t size)

check a HDMI infoframe, and write it to binary buffer

Parameters

`union hdmi_infoframe *frame`
HDMI infoframe

`void *buffer`
destination buffer

`size_t size`
size of buffer

Description

Validates that the infoframe is consistent and updates derived fields (eg. length) based on other fields, after which it packs the information contained in the **frame** structure into a binary representation that can be written into the corresponding controller registers. This function also computes the checksum as required by section 5.3.5 of the HDMI 1.4 specification.

Returns the number of bytes packed into the binary buffer or a negative error code on failure.

void **`hdmi_infoframe_log`**(const char *level, struct device *dev, const union *hdmi_infoframe* *frame)

log info of HDMI infoframe

Parameters

`const char *level`
logging level

`struct device *dev`
device

`const union hdmi_infoframe *frame`
HDMI infoframe

int **hdmi_drm_infoframe_unpack_only**(struct hdmi_drm_infoframe *frame, const void *buffer, size_t size)

unpack binary buffer of CTA-861-G DRM infoframe DataBytes to a HDMI DRM infoframe

Parameters

struct hdmi_drm_infoframe *frame
HDMI DRM infoframe

const void *buffer
source buffer

size_t size
size of buffer

Description

Unpacks CTA-861-G DRM infoframe DataBytes contained in the binary **buffer** into a structured **frame** of the HDMI Dynamic Range and Mastering (DRM) infoframe.

Returns 0 on success or a negative error code on failure.

int **hdmi_infoframe_unpack**(union *hdmi_infoframe* *frame, const void *buffer, size_t size)

unpack binary buffer to a HDMI infoframe

Parameters

union hdmi_infoframe *frame
HDMI infoframe

const void *buffer
source buffer

size_t size
size of buffer

Description

Unpacks the information contained in binary buffer **buffer** into a structured **frame** of a HDMI infoframe. Also verifies the checksum as required by section 5.3.5 of the HDMI 1.4 specification.

Returns 0 on success or a negative error code on failure.

5.23 Rectangle Utilities Reference

Utility functions to help manage rectangular areas for clipping, scaling, etc. calculations.

struct **drm_rect**

two dimensional rectangle

Definition

```
struct drm_rect {
  int x1, y1, x2, y2;
};
```

Members

x1
: horizontal starting coordinate (inclusive)

y1
: vertical starting coordinate (inclusive)

x2
: horizontal ending coordinate (exclusive)

y2
: vertical ending coordinate (exclusive)

DRM_RECT_FMT

`DRM_RECT_FMT ()`

printf string for *struct drm_rect*

Parameters

DRM_RECT_ARG

`DRM_RECT_ARG (r)`

printf arguments for *struct drm_rect*

Parameters

r
: rectangle struct

DRM_RECT_FP_FMT

`DRM_RECT_FP_FMT ()`

printf string for *struct drm_rect* in 16.16 fixed point

Parameters

DRM_RECT_FP_ARG

`DRM_RECT_FP_ARG (r)`

printf arguments for *struct drm_rect* in 16.16 fixed point

Parameters

r
: rectangle struct

Description

This is useful for e.g. printing plane source rectangles, which are in 16.16 fixed point.

void **drm_rect_init**(struct *drm_rect* *r, int x, int y, int width, int height)

initialize the rectangle from x/y/w/h

Parameters

struct drm_rect *r
rectangle

int x
x coordinate

int y
y coordinate

int width
width

int height
height

void **drm_rect_adjust_size**(struct *drm_rect* *r, int dw, int dh)

adjust the size of the rectangle

Parameters

struct drm_rect *r
rectangle to be adjusted

int dw
horizontal adjustment

int dh
vertical adjustment

Description

Change the size of rectangle **r** by **dw** in the horizontal direction, and by **dh** in the vertical direction, while keeping the center of **r** stationary.

Positive **dw** and **dh** increase the size, negative values decrease it.

void **drm_rect_translate**(struct *drm_rect* *r, int dx, int dy)

translate the rectangle

Parameters

struct drm_rect *r
rectangle to be tranlated

int dx
horizontal translation

int dy
vertical translation

Description

Move rectangle **r** by **dx** in the horizontal direction, and by **dy** in the vertical direction.

void **drm_rect_translate_to**(struct *drm_rect* *r, int x, int y)
translate the rectangle to an absolute position

Parameters

struct drm_rect *r
rectangle to be tranlated

int x
horizontal position

int y
vertical position

Description

Move rectangle **r** to **x** in the horizontal direction, and to **y** in the vertical direction.

void **drm_rect_downscale**(struct *drm_rect* *r, int horz, int vert)
downscale a rectangle

Parameters

struct drm_rect *r
rectangle to be downscaled

int horz
horizontal downscale factor

int vert
vertical downscale factor

Description

Divide the coordinates of rectangle **r** by **horz** and **vert**.

int **drm_rect_width**(const struct *drm_rect* *r)
determine the rectangle width

Parameters

const struct drm_rect *r
rectangle whose width is returned

Return

The width of the rectangle.

int **drm_rect_height**(const struct *drm_rect* *r)
determine the rectangle height

Parameters

const struct drm_rect *r
rectangle whose height is returned

Return

The height of the rectangle.

bool **drm_rect_visible**(const struct *drm_rect* *r)

determine if the rectangle is visible

Parameters

const struct drm_rect *r

rectangle whose visibility is returned

Return

`true` if the rectangle is visible, `false` otherwise.

bool **drm_rect_equals**(const struct *drm_rect* *r1, const struct *drm_rect* *r2)

determine if two rectangles are equal

Parameters

const struct drm_rect *r1

first rectangle

const struct drm_rect *r2

second rectangle

Return

`true` if the rectangles are equal, `false` otherwise.

bool **drm_rect_intersect**(struct *drm_rect* *r1, const struct *drm_rect* *r2)

intersect two rectangles

Parameters

struct drm_rect *r1

first rectangle

const struct drm_rect *r2

second rectangle

Description

Calculate the intersection of rectangles **r1** and **r2**. **r1** will be overwritten with the intersection.

Return

`true` if rectangle **r1** is still visible after the operation, `false` otherwise.

bool **drm_rect_clip_scaled**(struct *drm_rect* *src, struct *drm_rect* *dst, const struct *drm_rect* *clip)

perform a scaled clip operation

Parameters

struct drm_rect *src

source window rectangle

struct drm_rect *dst

destination window rectangle

const struct drm_rect *clip

clip rectangle

Description

Clip rectangle **dst** by rectangle **clip**. Clip rectangle **src** by the the corresponding amounts, retaining the vertical and horizontal scaling factors from **src** to **dst**.

`true` if rectangle **dst** is still visible after being clipped, `false` otherwise.

Return

int **drm_rect_calc_hscale**(const struct *drm_rect* *src, const struct *drm_rect* *dst, int min_hscale, int max_hscale)

calculate the horizontal scaling factor

Parameters

const struct drm_rect *src
source window rectangle

const struct drm_rect *dst
destination window rectangle

int min_hscale
minimum allowed horizontal scaling factor

int max_hscale
maximum allowed horizontal scaling factor

Description

Calculate the horizontal scaling factor as (**src** width) / (**dst** width).

If the scale is below 1 << 16, round down. If the scale is above 1 << 16, round up. This will calculate the scale with the most pessimistic limit calculation.

Return

The horizontal scaling factor, or errno of out of limits.

int **drm_rect_calc_vscale**(const struct *drm_rect* *src, const struct *drm_rect* *dst, int min_vscale, int max_vscale)

calculate the vertical scaling factor

Parameters

const struct drm_rect *src
source window rectangle

const struct drm_rect *dst
destination window rectangle

int min_vscale
minimum allowed vertical scaling factor

int max_vscale
maximum allowed vertical scaling factor

Description

Calculate the vertical scaling factor as (**src** height) / (**dst** height).

If the scale is below 1 << 16, round down. If the scale is above 1 << 16, round up. This will calculate the scale with the most pessimistic limit calculation.

Return

The vertical scaling factor, or errno of out of limits.

void **drm_rect_debug_print**(const char *prefix, const struct *drm_rect* *r, bool fixed_point)

print the rectangle information

Parameters

const char *prefix
prefix string

const struct drm_rect *r
rectangle to print

bool fixed_point
rectangle is in 16.16 fixed point format

void **drm_rect_rotate**(struct *drm_rect* *r, int width, int height, unsigned int rotation)

Rotate the rectangle

Parameters

struct drm_rect *r
rectangle to be rotated

int width
Width of the coordinate space

int height
Height of the coordinate space

unsigned int rotation
Transformation to be applied

Description

Apply **rotation** to the coordinates of rectangle **r**.

width and **height** combined with **rotation** define the location of the new origin.

width correcsponds to the horizontal and **height** to the vertical axis of the untransformed coordinate space.

void **drm_rect_rotate_inv**(struct *drm_rect* *r, int width, int height, unsigned int rotation)

Inverse rotate the rectangle

Parameters

struct drm_rect *r
rectangle to be rotated

int width
Width of the coordinate space

int height
Height of the coordinate space

unsigned int rotation
Transformation whose inverse is to be applied

Description

Apply the inverse of **rotation** to the coordinates of rectangle **r**.

width and **height** combined with **rotation** define the location of the new origin.

width correcsponds to the horizontal and **height** to the vertical axis of the original untransformed coordinate space, so that you never have to flip them when doing a rotatation and its inverse. That is, if you do

```
drm_rect_rotate(&r, width, height, rotation);
drm_rect_rotate_inv(&r, width, height, rotation);
```

you will always get back the original rectangle.

5.24 Flip-work Helper Reference

Util to queue up work to run from work-queue context after flip/vblank. Typically this can be used to defer unref of framebuffer' s, cursor bo' s, etc until after vblank. The APIs are all thread-safe. Moreover, drm_flip_work_queue_task and drm_flip_work_queue can be called in atomic context.

struct **drm_flip_task**
flip work task

Definition

```
struct drm_flip_task {
  struct list_head node;
  void *data;
};
```

Members

node
list entry element

data
data to pass to *drm_flip_work.func*

struct **drm_flip_work**
flip work queue

Definition

```
struct drm_flip_work {
  const char *name;
  drm_flip_func_t func;
  struct work_struct worker;
  struct list_head queued;
  struct list_head commited;
```

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```
  spinlock_t lock;
};
```

Members

name
: debug name

func
: callback fxn called for each committed item

worker
: worker which calls **func**

queued
: queued tasks

commited
: commited tasks

lock
: lock to access queued and commited lists

struct *drm_flip_task* ***drm_flip_work_allocate_task**(void *data, gfp_t flags)

allocate a flip-work task

Parameters

void *data
: data associated to the task

gfp_t flags
: allocator flags

Description

Allocate a drm_flip_task object and attach private data to it.

void **drm_flip_work_queue_task**(struct *drm_flip_work* *work, struct *drm_flip_task* *task)

queue a specific task

Parameters

struct drm_flip_work *work
: the flip-work

struct drm_flip_task *task
: the task to handle

Description

Queues task, that will later be run (passed back to drm_flip_func_t func) on a work queue after `drm_flip_work_commit()` is called.

void **drm_flip_work_queue**(struct *drm_flip_work* *work, void *val)

queue work

Parameters

struct drm_flip_work *work
the flip-work

void *val
the value to queue

Description

Queues work, that will later be run (passed back to drm_flip_func_t func) on a work queue after *drm_flip_work_commit()* is called.

void **drm_flip_work_commit**(struct *drm_flip_work* *work, struct workqueue_struct *wq)

commit queued work

Parameters

struct drm_flip_work *work
the flip-work

struct workqueue_struct *wq
the work-queue to run the queued work on

Description

Trigger work previously queued by *drm_flip_work_queue()* to run on a workqueue. The typical usage would be to queue work (via *drm_flip_work_queue()*) at any point (from vblank irq and/or prior), and then from vblank irq commit the queued work.

void **drm_flip_work_init**(struct *drm_flip_work* *work, const char *name, drm_flip_func_t func)

initialize flip-work

Parameters

struct drm_flip_work *work
the flip-work to initialize

const char *name
debug name

drm_flip_func_t func
the callback work function

Description

Initializes/allocates resources for the flip-work

void **drm_flip_work_cleanup**(struct *drm_flip_work* *work)

cleans up flip-work

Parameters

struct drm_flip_work *work
the flip-work to cleanup

Description

Destroy resources allocated for the flip-work

5.25 Auxiliary Modeset Helpers

This helper library contains various one-off functions which don't really fit anywhere else in the DRM modeset helper library.

void **drm_helper_move_panel_connectors_to_head**(struct *drm_device* *dev)

move panels to the front in the connector list

Parameters

struct drm_device *dev
drm device to operate on

Description

Some userspace presumes that the first connected connector is the main display, where it's supposed to display e.g. the login screen. For laptops, this should be the main panel. Use this function to sort all (eDP/LVDS/DSI) panels to the front of the connector list, instead of painstakingly trying to initialize them in the right order.

void **drm_helper_mode_fill_fb_struct**(struct *drm_device* *dev, struct *drm_framebuffer* *fb, const struct drm_mode_fb_cmd2 *mode_cmd)

fill out framebuffer metadata

Parameters

struct drm_device *dev
DRM device

struct drm_framebuffer *fb
drm_framebuffer object to fill out

const struct drm_mode_fb_cmd2 *mode_cmd
metadata from the userspace fb creation request

Description

This helper can be used in a drivers fb_create callback to pre-fill the fb's metadata fields.

int **drm_crtc_init**(struct *drm_device* *dev, struct *drm_crtc* *crtc, const struct *drm_crtc_funcs* *funcs)

Legacy CRTC initialization function

Parameters

struct drm_device *dev
DRM device

struct drm_crtc *crtc
CRTC object to init

const struct drm_crtc_funcs *funcs
callbacks for the new CRTC

Description

Initialize a CRTC object with a default helper-provided primary plane and no cursor plane.

Note that we make some assumptions about hardware limitations that may not be true for all hardware:

1. Primary plane cannot be repositioned.
2. Primary plane cannot be scaled.
3. Primary plane must cover the entire CRTC.
4. Subpixel positioning is not supported.
5. The primary plane must always be on if the CRTC is enabled.

This is purely a backwards compatibility helper for old drivers. Drivers should instead implement their own primary plane. Atomic drivers must do so. Drivers with the above hardware restriction can look into using *struct drm_simple_display_pipe*, which encapsulates the above limitations into a nice interface.

Return

Zero on success, error code on failure.

int **drm_mode_config_helper_suspend**(struct *drm_device* *dev)

Modeset suspend helper

Parameters

struct drm_device *dev
DRM device

Description

This helper function takes care of suspending the modeset side. It disables output polling if initialized, suspends fbdev if used and finally calls *drm_atomic_helper_suspend()*. If suspending fails, fbdev and polling is re-enabled.

See also: *drm_kms_helper_poll_disable()* and *drm_fb_helper_set_suspend_unlocked()*.

Return

Zero on success, negative error code on error.

int **drm_mode_config_helper_resume**(struct *drm_device* *dev)

Modeset resume helper

Parameters

struct drm_device *dev
DRM device

Description

This helper function takes care of resuming the modeset side. It calls *drm_atomic_helper_resume()*, resumes fbdev if used and enables output polling if initiaized.

See also: *drm_fb_helper_set_suspend_unlocked()* and *drm_kms_helper_poll_enable()*.

Return

Zero on success, negative error code on error.

5.26 OF/DT Helpers

A set of helper functions to aid DRM drivers in parsing standard DT properties.

uint32_t **drm_of_crtc_port_mask**(struct *drm_device* *dev, struct device_node *port)

find the mask of a registered CRTC by port OF node

Parameters

struct drm_device *dev
DRM device

struct device_node *port
port OF node

Description

Given a port OF node, return the possible mask of the corresponding CRTC within a device' s list of CRTCs. Returns zero if not found.

uint32_t **drm_of_find_possible_crtcs**(struct *drm_device* *dev, struct device_node *port)

find the possible CRTCs for an encoder port

Parameters

struct drm_device *dev
DRM device

struct device_node *port
encoder port to scan for endpoints

Description

Scan all endpoints attached to a port, locate their attached CRTCs, and generate the DRM mask of CRTCs which may be attached to this encoder.

See Documentation/devicetree/bindings/graph.txt for the bindings.

void **drm_of_component_match_add**(struct device *master, struct component_match **matchptr, int (*compare)(struct device*, void*), struct device_node *node)

Add a component helper OF node match rule

Parameters

struct device *master
master device

`struct component_match **matchptr`
  component match pointer

`int (*compare)(struct device *, void *)`
  compare function used for matching component

`struct device_node *node`
  of_node

int **`drm_of_component_probe`**(struct device *dev, int (*compare_of)(struct device*, void*), const struct component_master_ops *m_ops)

  Generic probe function for a component based master

Parameters

`struct device *dev`
  master device containing the OF node

`int (*compare_of)(struct device *, void *)`
  compare function used for matching components

`const struct component_master_ops *m_ops`
  component master ops to be used

Description

Parse the platform device OF node and bind all the components associated with the master. Interface ports are added before the encoders in order to satisfy their .bind requirements See Documentation/devicetree/bindings/graph.txt for the bindings.

Returns zero if successful, or one of the standard error codes if it fails.

int **`drm_of_find_panel_or_bridge`**(const struct device_node *np, int port, int endpoint, struct *drm_panel* **panel, struct *drm_bridge* **bridge)

  return connected panel or bridge device

Parameters

`const struct device_node *np`
  device tree node containing encoder output ports

`int port`
  port in the device tree node

`int endpoint`
  endpoint in the device tree node

`struct drm_panel **panel`
  pointer to hold returned drm_panel

`struct drm_bridge **bridge`
  pointer to hold returned drm_bridge

Description

Given a DT node' s port and endpoint number, find the connected node and return either the associated *`struct drm_panel`* or drm_bridge device. Either **panel** or **bridge** must not be NULL.

Returns zero if successful, or one of the standard error codes if it fails.

int **drm_of_lvds_get_dual_link_pixel_order**(const struct device_node *port1, const struct device_node *port2)

Get LVDS dual-link pixel order

Parameters

const struct device_node *port1
First DT port node of the Dual-link LVDS source

const struct device_node *port2
Second DT port node of the Dual-link LVDS source

Description

An LVDS dual-link connection is made of two links, with even pixels transitting on one link, and odd pixels on the other link. This function returns, for two ports of an LVDS dual-link source, which port shall transmit the even and odd pixels, based on the requirements of the connected sink.

The pixel order is determined from the dual-lvds-even-pixels and dual-lvds-odd-pixels properties in the sink' s DT port nodes. If those properties are not present, or if their usage is not valid, this function returns -EINVAL.

If either port is not connected, this function returns -EPIPE.

port1 and **port2** are typically DT sibling nodes, but may have different parents when, for instance, two separate LVDS encoders carry the even and odd pixels.

Return

- DRM_LVDS_DUAL_LINK_EVEN_ODD_PIXELS - **port1** carries even pixels and **port2** carries odd pixels
- DRM_LVDS_DUAL_LINK_ODD_EVEN_PIXELS - **port1** carries odd pixels and **port2** carries even pixels
- -EINVAL - **port1** and **port2** are not connected to a dual-link LVDS sink, or the sink configuration is invalid
- -EPIPE - when **port1** or **port2** are not connected

5.27 Legacy Plane Helper Reference

This helper library has two parts. The first part has support to implement primary plane support on top of the normal CRTC configuration interface. Since the legacy *drm_mode_config_funcs.set_config* interface ties the primary plane together with the CRTC state this does not allow userspace to disable the primary plane itself. The default primary plane only expose XRBG8888 and ARGB8888 as valid pixel formats for the attached framebuffer.

Drivers are highly recommended to implement proper support for primary planes, and newly merged drivers must not rely upon these transitional helpers.

The second part also implements transitional helpers which allow drivers to gradually switch to the atomic helper infrastructure for plane updates. Once that switch is complete drivers shouldn' t use these any longer, instead using the proper legacy implementations for update and disable plane hooks provided by the atomic helpers.

Again drivers are strongly urged to switch to the new interfaces.

The plane helpers share the function table structures with other helpers, specifically also the atomic helpers. See *struct drm_plane_helper_funcs* for the details.

void **drm_primary_helper_destroy**(struct *drm_plane* *plane)

Helper for primary plane destruction

Parameters

struct drm_plane *plane
plane to destroy

Description

Provides a default plane destroy handler for primary planes. This handler is called during CRTC destruction. We disable the primary plane, remove it from the DRM plane list, and deallocate the plane structure.

5.28 Legacy CRTC/Modeset Helper Functions Reference

The CRTC modeset helper library provides a default set_config implementation in *drm_crtc_helper_set_config()*. Plus a few other convenience functions using the same callbacks which drivers can use to e.g. restore the modeset configuration on resume with *drm_helper_resume_force_mode()*.

Note that this helper library doesn't track the current power state of CRTCs and encoders. It can call callbacks like *drm_encoder_helper_funcs.dpms* even though the hardware is already in the desired state. This deficiency has been fixed in the atomic helpers.

The driver callbacks are mostly compatible with the atomic modeset helpers, except for the handling of the primary plane: Atomic helpers require that the primary plane is implemented as a real standalone plane and not directly tied to the CRTC state. For easier transition this library provides functions to implement the old semantics required by the CRTC helpers using the new plane and atomic helper callbacks.

Drivers are strongly urged to convert to the atomic helpers (by way of first converting to the plane helpers). New drivers must not use these functions but need to implement the atomic interface instead, potentially using the atomic helpers for that.

These legacy modeset helpers use the same function table structures as all other modesetting helpers. See the documentation for struct *drm_crtc_helper_funcs*, *struct drm_encoder_helper_funcs* and struct *drm_connector_helper_funcs*.

bool **drm_helper_encoder_in_use**(struct *drm_encoder* *encoder)

check if a given encoder is in use

Parameters

struct drm_encoder *encoder
encoder to check

Description

Checks whether **encoder** is with the current mode setting output configuration in use by any connector. This doesn't mean that it is actually enabled since the DPMS state is tracked separately.

Return

True if **encoder** is used, false otherwise.

bool **drm_helper_crtc_in_use**(struct *drm_crtc* *crtc)
check if a given CRTC is in a mode_config

Parameters

struct drm_crtc *crtc
CRTC to check

Description

Checks whether **crtc** is with the current mode setting output configuration in use by any connector. This doesn't mean that it is actually enabled since the DPMS state is tracked separately.

Return

True if **crtc** is used, false otherwise.

void **drm_helper_disable_unused_functions**(struct *drm_device* *dev)
disable unused objects

Parameters

struct drm_device *dev
DRM device

Description

This function walks through the entire mode setting configuration of **dev**. It will remove any CRTC links of unused encoders and encoder links of disconnected connectors. Then it will disable all unused encoders and CRTCs either by calling their disable callback if available or by calling their dpms callback with DRM_MODE_DPMS_OFF.

This function is part of the legacy modeset helper library and will cause major confusion with atomic drivers. This is because atomic helpers guarantee to never call ->disable() hooks on a disabled function, or ->enable() hooks on an enabled functions. *drm_helper_disable_unused_functions()* on the other hand throws such guarantees into the wind and calls disable hooks unconditionally on unused functions.

NOTE

bool **drm_crtc_helper_set_mode**(struct *drm_crtc* *crtc, struct *drm_display_mode* *mode, int x, int y, struct *drm_framebuffer* *old_fb)
internal helper to set a mode

Parameters

`struct drm_crtc *crtc`
CRTC to program

`struct drm_display_mode *mode`
mode to use

`int x`
horizontal offset into the surface

`int y`
vertical offset into the surface

`struct drm_framebuffer *old_fb`
old framebuffer, for cleanup

Description

Try to set **mode** on **crtc**. Give **crtc** and its associated connectors a chance to fixup or reject the mode prior to trying to set it. This is an internal helper that drivers could e.g. use to update properties that require the entire output pipe to be disabled and re-enabled in a new configuration. For example for changing whether audio is enabled on a hdmi link or for changing panel fitter or dither attributes. It is also called by the *`drm_crtc_helper_set_config()`* helper function to drive the mode setting sequence.

Return

True if the mode was set successfully, false otherwise.

int **`drm_crtc_helper_set_config`**(struct *drm_mode_set* *set, struct *drm_modeset_acquire_ctx* *ctx)

set a new config from userspace

Parameters

`struct drm_mode_set *set`
mode set configuration

`struct drm_modeset_acquire_ctx *ctx`
lock acquire context, not used here

Description

The *`drm_crtc_helper_set_config()`* helper function implements the of *`drm_crtc_funcs.set_config`* callback for drivers using the legacy CRTC helpers.

It first tries to locate the best encoder for each connector by calling the connector **drm_connector_helper_funcs.best_encoder** helper operation.

After locating the appropriate encoders, the helper function will call the mode_fixup encoder and CRTC helper operations to adjust the requested mode, or reject it completely in which case an error will be returned to the application. If the new configuration after mode adjustment is identical to the current configuration the helper function will return without performing any other operation.

If the adjusted mode is identical to the current mode but changes to the frame buffer need to be applied, the *`drm_crtc_helper_set_config()`* function will call the CRTC *`drm_crtc_helper_funcs.mode_set_base`* helper operation.

If the adjusted mode differs from the current mode, or if the ->mode_set_base() helper operation is not provided, the helper function performs a full mode set sequence by calling the ->prepare(), ->mode_set() and ->commit() CRTC and encoder helper operations, in that order. Alternatively it can also use the dpms and disable helper operations. For details see *`struct drm_crtc_helper_funcs`* and struct *`drm_encoder_helper_funcs`*.

This function is deprecated. New drivers must implement atomic modeset support, for which this function is unsuitable. Instead drivers should use *`drm_atomic_helper_set_config()`*.

Return

Returns 0 on success, negative errno numbers on failure.

int **`drm_helper_connector_dpms`**(struct *drm_connector* *connector, int mode)

connector dpms helper implementation

Parameters

`struct drm_connector *connector`
affected connector

`int mode`
DPMS mode

Description

The *`drm_helper_connector_dpms()`* helper function implements the *`drm_connector_funcs.dpms`* callback for drivers using the legacy CRTC helpers.

This is the main helper function provided by the CRTC helper framework for implementing the DPMS connector attribute. It computes the new desired DPMS state for all encoders and CRTCs in the output mesh and calls the *`drm_crtc_helper_funcs.dpms`* and *`drm_encoder_helper_funcs.dpms`* callbacks provided by the driver.

This function is deprecated. New drivers must implement atomic modeset support, where DPMS is handled in the DRM core.

Return

Always returns 0.

void **`drm_helper_resume_force_mode`**(struct *drm_device* *dev)

force-restore mode setting configuration

Parameters

`struct drm_device *dev`
drm_device which should be restored

Description

Drivers which use the mode setting helpers can use this function to force-restore the mode setting configuration e.g. on resume or when something else might have trampled over the hw state (like some overzealous old BIOSen tended to do).

This helper doesn’t provide a error return value since restoring the old config should never fail due to resource allocation issues since the driver has successfully set the restored configuration already. Hence this should boil down to the equivalent of a few dpms on calls, which also don’t provide an error code.

Drivers where simply restoring an old configuration again might fail (e.g. due to slight differences in allocating shared resources when the configuration is restored in a different order than when userspace set it up) need to use their own restore logic.

This function is deprecated. New drivers should implement atomic mode- setting and use the atomic suspend/resume helpers.

See also: *drm_atomic_helper_suspend()*, *drm_atomic_helper_resume()*

int **drm_helper_force_disable_all**(struct *drm_device* *dev)

Forcibly turn off all enabled CRTCs

Parameters

struct drm_device *dev

DRM device whose CRTCs to turn off

Description

Drivers may want to call this on unload to ensure that all displays are unlit and the GPU is in a consistent, low power state. Takes modeset locks.

Note

This should only be used by non-atomic legacy drivers. For an atomic version look at *drm_atomic_helper_shutdown()*.

Return

Zero on success, error code on failure.

CHAPTER

SIX

USERLAND INTERFACES

The DRM core exports several interfaces to applications, generally intended to be used through corresponding libdrm wrapper functions. In addition, drivers export device-specific interfaces for use by userspace drivers & device-aware applications through ioctls and sysfs files.

External interfaces include: memory mapping, context management, DMA operations, AGP management, vblank control, fence management, memory management, and output management.

Cover generic ioctls and sysfs layout here. We only need high-level info, since man pages should cover the rest.

6.1 libdrm Device Lookup

BEWARE THE DRAGONS! MIND THE TRAPDOORS!

In an attempt to warn anyone else who' s trying to figure out what' s going on here, I' ll try to summarize the story. First things first, let' s clear up the names, because the kernel internals, libdrm and the ioctls are all named differently:

- GET_UNIQUE ioctl, implemented by drm_getunique is wrapped up in libdrm through the drmGetBusid function.
- The libdrm drmSetBusid function is backed by the SET_UNIQUE ioctl. All that code is nerved in the kernel with `drm_invalid_op()`.
- The internal set_busid kernel functions and driver callbacks are exclusively use by the SET_VERSION ioctl, because only drm 1.0 (which is nerved) allowed userspace to set the busid through the above ioctl.
- Other ioctls and functions involved are named consistently.

For anyone wondering what' s the difference between drm 1.1 and 1.4: Correctly handling pci domains in the busid on ppc. Doing this correctly was only implemented in libdrm in 2010, hence can' t be nerved yet. No one knows what' s special with drm 1.2 and 1.3.

Now the actual horror story of how device lookup in drm works. At large, there' s 2 different ways, either by busid, or by device driver name.

Opening by busid is fairly simple:

1. First call SET_VERSION to make sure pci domains are handled properly. As a side-effect this fills out the unique name in the master structure.
2. Call GET_UNIQUE to read out the unique name from the master structure, which matches the busid thanks to step 1. If it doesn't, proceed to try the next device node.

Opening by name is slightly different:

1. Directly call VERSION to get the version and to match against the driver name returned by that ioctl. Note that SET_VERSION is not called, which means the the unique name for the master node just opening is _not_ filled out. This despite that with current drm device nodes are always bound to one device, and can't be runtime assigned like with drm 1.0.
2. Match driver name. If it mismatches, proceed to the next device node.
3. Call GET_UNIQUE, and check whether the unique name has length zero (by checking that the first byte in the string is 0). If that's not the case libdrm skips and proceeds to the next device node. Probably this is just copypasta from drm 1.0 times where a set unique name meant that the driver was in use already, but that's just conjecture.

Long story short: To keep the open by name logic working, GET_UNIQUE must _not_ return a unique string when SET_VERSION hasn't been called yet, otherwise libdrm breaks. Even when that unique string can't ever change, and is totally irrelevant for actually opening the device because runtime assignable device instances were only support in drm 1.0, which is long dead. But the libdrm code in drmOpenByName somehow survived, hence this can't be broken.

6.2 Primary Nodes, DRM Master and Authentication

struct drm_master is used to track groups of clients with open primary/legacy device nodes. For every *struct drm_file* which has had at least once successfully became the device master (either through the SET_MASTER IOCTL, or implicitly through opening the primary device node when no one else is the current master that time) there exists one *drm_master*. This is noted in *drm_file.is_master*. All other clients have just a pointer to the *drm_master* they are associated with.

In addition only one *drm_master* can be the current master for a *drm_device*. It can be switched through the DROP_MASTER and SET_MASTER IOCTL, or implicitly through closing/openeing the primary device node. See also *drm_is_current_master()*.

Clients can authenticate against the current master (if it matches their own) using the GETMAGIC and AUTHMAGIC IOCTLs. Together with exchanging masters, this allows controlled access to the device for an entire group of mutually trusted clients.

bool **drm_is_current_master**(struct *drm_file* *fpriv)

checks whether **priv** is the current master

Parameters

struct drm_file *fpriv
DRM file private

Description

Checks whether **fpriv** is current master on its device. This decides whether a client is allowed to run DRM_MASTER IOCTLs.

Most of the modern IOCTL which require DRM_MASTER are for kernel modesetting - the current master is assumed to own the non-shareable display hardware.

struct *drm_master* ***drm_master_get**(struct *drm_master* *master)
reference a master pointer

Parameters

struct drm_master *master
struct drm_master

Description

Increments the reference count of **master** and returns a pointer to **master**.

struct *drm_master* ***drm_file_get_master**(struct *drm_file* *file_priv)
reference *drm_file.master* of **file_priv**

Parameters

struct drm_file *file_priv
DRM file private

Description

Increments the reference count of **file_priv**' s *drm_file.master* and returns the *drm_file.master*. If **file_priv** has no *drm_file.master*, returns NULL.

Master pointers returned from this function should be unreferenced using *drm_master_put()*.

void **drm_master_put**(struct *drm_master* **master)
unreference and clear a master pointer

Parameters

struct drm_master **master
pointer to a pointer of *struct drm_master*

Description

This decrements the *drm_master* behind **master** and sets it to NULL.

struct **drm_master**
drm master structure

Definition

```
struct drm_master {
  struct kref refcount;
  struct drm_device *dev;
```

(continues on next page)

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```
  char *unique;
  int unique_len;
  struct idr magic_map;
  void *driver_priv;
  struct drm_master *lessor;
  int lessee_id;
  struct list_head lessee_list;
  struct list_head lessees;
  struct idr leases;
  struct idr lessee_idr;
};
```

Members

refcount
Refcount for this master object.

dev
Link back to the DRM device

unique
Unique identifier: e.g. busid. Protected by *drm_device.master_mutex*.

unique_len
Length of unique field. Protected by *drm_device.master_mutex*.

magic_map
Map of used authentication tokens. Protected by *drm_device.master_mutex*.

driver_priv
Pointer to driver-private information.

lessor
Lease holder

lessee_id
id for lessees. Owners always have id 0

lessee_list
other lessees of the same master

lessees
drm_masters leasing from this one

leases
Objects leased to this drm_master.

lessee_idr
All lessees under this owner (only used where lessor == NULL)

Description

Note that master structures are only relevant for the legacy/primary device nodes, hence there can only be one per device, not one per drm_minor.

6.3 Open-Source Userspace Requirements

The DRM subsystem has stricter requirements than most other kernel subsystems on what the userspace side for new uAPI needs to look like. This section here explains what exactly those requirements are, and why they exist.

The short summary is that any addition of DRM uAPI requires corresponding open-sourced userspace patches, and those patches must be reviewed and ready for merging into a suitable and canonical upstream project.

GFX devices (both display and render/GPU side) are really complex bits of hardware, with userspace and kernel by necessity having to work together really closely. The interfaces, for rendering and modesetting, must be extremely wide and flexible, and therefore it is almost always impossible to precisely define them for every possible corner case. This in turn makes it really practically infeasible to differentiate between behaviour that's required by userspace, and which must not be changed to avoid regressions, and behaviour which is only an accidental artifact of the current implementation.

Without access to the full source code of all userspace users that means it becomes impossible to change the implementation details, since userspace could depend upon the accidental behaviour of the current implementation in minute details. And debugging such regressions without access to source code is pretty much impossible. As a consequence this means:

- The Linux kernel's "no regression" policy holds in practice only for open-source userspace of the DRM subsystem. DRM developers are perfectly fine if closed-source blob drivers in userspace use the same uAPI as the open drivers, but they must do so in the exact same way as the open drivers. Creative (ab)use of the interfaces will, and in the past routinely has, lead to breakage.
- Any new userspace interface must have an open-source implementation as demonstration vehicle.

The other reason for requiring open-source userspace is uAPI review. Since the kernel and userspace parts of a GFX stack must work together so closely, code review can only assess whether a new interface achieves its goals by looking at both sides. Making sure that the interface indeed covers the use-case fully leads to a few additional requirements:

- The open-source userspace must not be a toy/test application, but the real thing. Specifically it needs to handle all the usual error and corner cases. These are often the places where new uAPI falls apart and hence essential to assess the fitness of a proposed interface.
- The userspace side must be fully reviewed and tested to the standards of that userspace project. For e.g. mesa this means piglit testcases and review on the mailing list. This is again to ensure that the new interface actually gets the job done. The userspace-side reviewer should also provide an Acked-by on the kernel uAPI patch indicating that they believe the proposed uAPI is sound and sufficiently documented and validated for userspace's consumption.
- The userspace patches must be against the canonical upstream, not some vendor fork. This is to make sure that no one cheats on the review and testing

requirements by doing a quick fork.

- The kernel patch can only be merged after all the above requirements are met, but it **must** be merged to either drm-next or drm-misc-next **before** the userspace patches land. uAPI always flows from the kernel, doing things the other way round risks divergence of the uAPI definitions and header files.

These are fairly steep requirements, but have grown out from years of shared pain and experience with uAPI added hastily, and almost always regretted about just as fast. GFX devices change really fast, requiring a paradigm shift and entire new set of uAPI interfaces every few years at least. Together with the Linux kernel’s guarantee to keep existing userspace running for 10+ years this is already rather painful for the DRM subsystem, with multiple different uAPIs for the same thing co-existing. If we add a few more complete mistakes into the mix every year it would be entirely unmanageable.

6.4 Render nodes

DRM core provides multiple character-devices for user-space to use. Depending on which device is opened, user-space can perform a different set of operations (mainly ioctls). The primary node is always created and called card<num>. Additionally, a currently unused control node, called controlD<num> is also created. The primary node provides all legacy operations and historically was the only interface used by userspace. With KMS, the control node was introduced. However, the planned KMS control interface has never been written and so the control node stays unused to date.

With the increased use of offscreen renderers and GPGPU applications, clients no longer require running compositors or graphics servers to make use of a GPU. But the DRM API required unprivileged clients to authenticate to a DRM-Master prior to getting GPU access. To avoid this step and to grant clients GPU access without authenticating, render nodes were introduced. Render nodes solely serve render clients, that is, no modesetting or privileged ioctls can be issued on render nodes. Only non-global rendering commands are allowed. If a driver supports render nodes, it must advertise it via the DRIVER_RENDER DRM driver capability. If not supported, the primary node must be used for render clients together with the legacy drmAuth authentication procedure.

If a driver advertises render node support, DRM core will create a separate render node called renderD<num>. There will be one render node per device. No ioctls except PRIME-related ioctls will be allowed on this node. Especially GEM_OPEN will be explicitly prohibited. Render nodes are designed to avoid the buffer-leaks, which occur if clients guess the flink names or mmap offsets on the legacy interface. Additionally to this basic interface, drivers must mark their driver-dependent render-only ioctls as DRM_RENDER_ALLOW so render clients can use them. Driver authors must be careful not to allow any privileged ioctls on render nodes.

With render nodes, user-space can now control access to the render node via basic file-system access-modes. A running graphics server which authenticates clients on the privileged primary/legacy node is no longer required. Instead, a client can open the render node and is immediately granted GPU access. Communication between clients (or servers) is done via PRIME. FLINK from render node to legacy node is not supported. New clients must not use the insecure FLINK interface.

Besides dropping all modeset/global ioctls, render nodes also drop the DRM-Master concept. There is no reason to associate render clients with a DRM-Master as they are independent of any graphics server. Besides, they must work without any running master, anyway. Drivers must be able to run without a master object if they support render nodes. If, on the other hand, a driver requires shared state between clients which is visible to user-space and accessible beyond open-file boundaries, they cannot support render nodes.

6.5 Device Hot-Unplug

Note: The following is the plan. Implementation is not there yet (2020 May).

Graphics devices (display and/or render) may be connected via USB (e.g. display adapters or docking stations) or Thunderbolt (e.g. eGPU). An end user is able to hot-unplug this kind of devices while they are being used, and expects that the very least the machine does not crash. Any damage from hot-unplugging a DRM device needs to be limited as much as possible and userspace must be given the chance to handle it if it wants to. Ideally, unplugging a DRM device still lets a desktop continue to run, but that is going to need explicit support throughout the whole graphics stack: from kernel and userspace drivers, through display servers, via window system protocols, and in applications and libraries.

Other scenarios that should lead to the same are: unrecoverable GPU crash, PCI device disappearing off the bus, or forced unbind of a driver from the physical device.

In other words, from userspace perspective everything needs to keep on working more or less, until userspace stops using the disappeared DRM device and closes it completely. Userspace will learn of the device disappearance from the device removed uevent, ioctls returning ENODEV (or driver-specific ioctls returning driver-specific things), or open() returning ENXIO.

Only after userspace has closed all relevant DRM device and dmabuf file descriptors and removed all mmaps, the DRM driver can tear down its instance for the device that no longer exists. If the same physical device somehow comes back in the mean time, it shall be a new DRM device.

Similar to PIDs, chardev minor numbers are not recycled immediately. A new DRM device always picks the next free minor number compared to the previous one allocated, and wraps around when minor numbers are exhausted.

The goal raises at least the following requirements for the kernel and drivers.

6.5.1 Requirements for KMS UAPI

- KMS connectors must change their status to disconnected.
- Legacy modesets and pageflips, and atomic commits, both real and TEST_ONLY, and any other ioctls either fail with ENODEV or fake success.
- Pending non-blocking KMS operations deliver the DRM events userspace is expecting. This applies also to ioctls that faked success.
- open() on a device node whose underlying device has disappeared will fail with ENXIO.
- Attempting to create a DRM lease on a disappeared DRM device will fail with ENODEV. Existing DRM leases remain and work as listed above.

6.5.2 Requirements for Render and Cross-Device UAPI

- All GPU jobs that can no longer run must have their fences force-signalled to avoid inflicting hangs on userspace. The associated error code is ENODEV.
- Some userspace APIs already define what should happen when the device disappears (OpenGL, GL ES: GL_KHR_robustness; Vulkan: VK_ERROR_DEVICE_LOST; etc.). DRM drivers are free to implement this behaviour the way they see best, e.g. returning failures in driver-specific ioctls and handling those in userspace drivers, or rely on uevents, and so on.
- dmabuf which point to memory that has disappeared will either fail to import with ENODEV or continue to be successfully imported if it would have succeeded before the disappearance. See also about memory maps below for already imported dmabufs.
- Attempting to import a dmabuf to a disappeared device will either fail with ENODEV or succeed if it would have succeeded without the disappearance.
- open() on a device node whose underlying device has disappeared will fail with ENXIO.

6.5.3 Requirements for Memory Maps

Memory maps have further requirements that apply to both existing maps and maps created after the device has disappeared. If the underlying memory disappears, the map is created or modified such that reads and writes will still complete successfully but the result is undefined. This applies to both userspace mmap()' d memory and memory pointed to by dmabuf which might be mapped to other devices (cross-device dmabuf imports).

Raising SIGBUS is not an option, because userspace cannot realistically handle it. Signal handlers are global, which makes them extremely difficult to use correctly from libraries like those that Mesa produces. Signal handlers are not composable, you can' t have different handlers for GPU1 and GPU2 from different vendors, and a third handler for mmapped regular files. Threads cause additional pain with signal handling as well.

6.6 IOCTL Support on Device Nodes

First things first, driver private IOCTLs should only be needed for drivers supporting rendering. Kernel modesetting is all standardized, and extended through properties. There are a few exceptions in some existing drivers, which define IOCTL for use by the display DRM master, but they all predate properties.

Now if you do have a render driver you always have to support it through driver private properties. There' s a few steps needed to wire all the things up.

First you need to define the structure for your IOCTL in your driver private UAPI header in `include/uapi/drm/my_driver_drm.h`:

```
struct my_driver_operation {
        u32 some_thing;
        u32 another_thing;
};
```

Please make sure that you follow all the best practices from `Documentation/process/botching-up-ioctls.rst`. Note that *`drm_ioctl()`* automatically zero-extends structures, hence make sure you can add more stuff at the end, i.e. don' t put a variable sized array there.

Then you need to define your IOCTL number, using one of DRM_IO(), DRM_IOR(), DRM_IOW() or DRM_IOWR(). It must start with the DRM_IOCTL_ prefix:

```
##define DRM_IOCTL_MY_DRIVER_OPERATION  *         DRM_IOW(DRM_
↪COMMAND_BASE, struct my_driver_operation)
```

DRM driver private IOCTL must be in the range from DRM_COMMAND_BASE to DRM_COMMAND_END. Finally you need an array of *`struct drm_ioctl_desc`* to wire up the handlers and set the access rights:

```
static const struct drm_ioctl_desc my_driver_ioctls[] = {
    DRM_IOCTL_DEF_DRV(MY_DRIVER_OPERATION, my_driver_operation,
            DRM_AUTH|DRM_RENDER_ALLOW),
};
```

And then assign this to the *`drm_driver.ioctls`* field in your driver structure.

See the separate chapter on *file operations* for how the driver-specific IOCTLs are wired up.

6.6.1 Recommended IOCTL Return Values

In theory a driver' s IOCTL callback is only allowed to return very few error codes. In practice it's good to abuse a few more. This section documents common practice within the DRM subsystem:

ENOENT:
Strictly this should only be used when a file doesn' t exist e.g. when calling the open() syscall. We reuse that to signal any kind of object lookup failure,

e.g. for unknown GEM buffer object handles, unknown KMS object handles and similar cases.

ENOSPC:
Some drivers use this to differentiate "out of kernel memory" from "out of VRAM". Sometimes also applies to other limited gpu resources used for rendering (e.g. when you have a special limited compression buffer). Sometimes resource allocation/reservation issues in command submission IOCTLs are also signalled through EDEADLK.

Simply running out of kernel/system memory is signalled through ENOMEM.

EPERM/EACCES:
Returned for an operation that is valid, but needs more privileges. E.g. root-only or much more common, DRM master-only operations return this when called by unpriviledged clients. There's no clear difference between EACCES and EPERM.

ENODEV:
The device is not present anymore or is not yet fully initialized.

EOPNOTSUPP:
Feature (like PRIME, modesetting, GEM) is not supported by the driver.

ENXIO:
Remote failure, either a hardware transaction (like i2c), but also used when the exporting driver of a shared dma-buf or fence doesn't support a feature needed.

EINTR:
DRM drivers assume that userspace restarts all IOCTLs. Any DRM IOCTL can return EINTR and in such a case should be restarted with the IOCTL parameters left unchanged.

EIO:
The GPU died and couldn't be resurrected through a reset. Modesetting hardware failures are signalled through the "link status" connector property.

EINVAL:
Catch-all for anything that is an invalid argument combination which cannot work.

IOCTL also use other error codes like ETIME, EFAULT, EBUSY, ENOTTY but their usage is in line with the common meanings. The above list tries to just document DRM specific patterns. Note that ENOTTY has the slightly unintuitive meaning of "this IOCTL does not exist", and is used exactly as such in DRM.

`drm_ioctl_t`

Typedef: DRM ioctl function type.

Syntax

```
typedef int drm_ioctl_t (struct drm_device *dev, void *data,
struct drm_file *file_priv)
```

Parameters

`struct drm_device *dev`
DRM device inode

void *data
: private pointer of the ioctl call

struct drm_file *file_priv
: DRM file this ioctl was made on

Description

This is the DRM ioctl typedef. Note that `drm_ioctl()` has alrady copied **data** into kernel-space, and will also copy it back, depending upon the read/write settings in the ioctl command code.

drm_ioctl_compat_t

Typedef: compatibility DRM ioctl function type.

Syntax

```
typedef int drm_ioctl_compat_t (struct file *filp, unsigned
int cmd, unsigned long arg)
```

Parameters

struct file *filp
: file pointer

unsigned int cmd
: ioctl command code

unsigned long arg
: DRM file this ioctl was made on

Description

Just a typedef to make declaring an array of compatibility handlers easier. New drivers shouldn't screw up the structure layout for their ioctl structures and hence never need this.

enum **drm_ioctl_flags**

DRM ioctl flags

Constants

DRM_AUTH
: This is for ioctl which are used for rendering, and require that the file descriptor is either for a render node, or if it's a legacy/primary node, then it must be authenticated.

DRM_MASTER
: This must be set for any ioctl which can change the modeset or display state. Userspace must call the ioctl through a primary node, while it is the active master.

  Note that read-only modeset ioctl can also be called by unauthenticated clients, or when a master is not the currently active one.

DRM_ROOT_ONLY
: Anything that could potentially wreak a master file descriptor needs to have this flag set. Current that's only for the SETMASTER and DROPMASTER ioctl, which e.g. logind can call to force a non-behaving master (display compositor) into compliance.

This is equivalent to callers with the SYSADMIN capability.

DRM_UNLOCKED
Whether *drm_ioctl_desc.func* should be called with the DRM BKL held or not. Enforced as the default for all modern drivers, hence there should never be a need to set this flag.

Do not use anywhere else than for the VBLANK_WAIT IOCTL, which is the only legacy IOCTL which needs this.

DRM_RENDER_ALLOW
This is used for all ioctl needed for rendering only, for drivers which support render nodes. This should be all new render drivers, and hence it should be always set for any ioctl with DRM_AUTH set. Note though that read-only query ioctl might have this set, but have not set DRM_AUTH because they do not require authentication.

Description

Various flags that can be set in *drm_ioctl_desc.flags* to control how userspace can use a given ioctl.

struct **drm_ioctl_desc**
DRM driver ioctl entry

Definition

```
struct drm_ioctl_desc {
  unsigned int cmd;
  enum drm_ioctl_flags flags;
  drm_ioctl_t *func;
  const char *name;
};
```

Members

cmd
ioctl command number, without flags

flags
a bitmask of *enum drm_ioctl_flags*

func
handler for this ioctl

name
user-readable name for debug output

Description

For convenience it's easier to create these using the *DRM_IOCTL_DEF_DRV()* macro.

DRM_IOCTL_DEF_DRV

`DRM_IOCTL_DEF_DRV (ioctl, _func, _flags)`

helper macro to fill out a *struct drm_ioctl_desc*

Parameters

`ioctl`
: ioctl command suffix

`_func`
: handler for the ioctl

`_flags`
: a bitmask of *`enum drm_ioctl_flags`*

Description

Small helper macro to create a *`struct drm_ioctl_desc`* entry. The ioctl command number is constructed by prepending `DRM_IOCTL\_` and passing that to DRM_IOCTL_NR().

int **`drm_noop`**(struct *drm_device* *dev, void *data, struct *drm_file* *file_priv)

DRM no-op ioctl implemntation

Parameters

`struct drm_device *dev`
: DRM device for the ioctl

`void *data`
: data pointer for the ioctl

`struct drm_file *file_priv`
: DRM file for the ioctl call

Description

This no-op implementation for drm ioctls is useful for deprecated functionality where we can't return a failure code because existing userspace checks the result of the ioctl, but doesn't care about the action.

Always returns successfully with 0.

int **`drm_invalid_op`**(struct *drm_device* *dev, void *data, struct *drm_file* *file_priv)

DRM invalid ioctl implemntation

Parameters

`struct drm_device *dev`
: DRM device for the ioctl

`void *data`
: data pointer for the ioctl

`struct drm_file *file_priv`
: DRM file for the ioctl call

Description

This no-op implementation for drm ioctls is useful for deprecated functionality where we really don't want to allow userspace to call the ioctl any more. This is the case for old ums interfaces for drivers that transitioned to kms gradually and so kept the old legacy tables around. This only applies to radeon and i915 kms drivers, other drivers shouldn't need to use this function.

Always fails with a return value of -EINVAL.

int **drm_ioctl_permit**(u32 flags, struct *drm_file* *file_priv)

Check ioctl permissions against caller

Parameters

u32 flags
ioctl permission flags.

struct drm_file *file_priv
Pointer to *struct drm_file* identifying the caller.

Description

Checks whether the caller is allowed to run an ioctl with the indicated permissions.

Return

Zero if allowed, -EACCES otherwise.

long **drm_ioctl**(struct file *filp, unsigned int cmd, unsigned long arg)

ioctl callback implementation for DRM drivers

Parameters

struct file *filp
file this ioctl is called on

unsigned int cmd
ioctl cmd number

unsigned long arg
user argument

Description

Looks up the ioctl function in the DRM core and the driver dispatch table, stored in *drm_driver.ioctls*. It checks for necessary permission by calling *drm_ioctl_permit()*, and dispatches to the respective function.

Return

Zero on success, negative error code on failure.

bool **drm_ioctl_flags**(unsigned int nr, unsigned int *flags)

Check for core ioctl and return ioctl permission flags

Parameters

unsigned int nr
ioctl number

unsigned int *flags
where to return the ioctl permission flags

Description

This ioctl is only used by the vmwgfx driver to augment the access checks done by the drm core and insofar a pretty decent layering violation. This shouldn't be used by any drivers.

Return

True if the **nr** corresponds to a DRM core ioctl number, false otherwise.

long **drm_compat_ioctl**(struct file *filp, unsigned int cmd, unsigned long arg)

32bit IOCTL compatibility handler for DRM drivers

Parameters

struct file *filp
file this ioctl is called on

unsigned int cmd
ioctl cmd number

unsigned long arg
user argument

Description

Compatibility handler for 32 bit userspace running on 64 kernels. All actual IOCTL handling is forwarded to *drm_ioctl()*, while marshalling structures as appropriate. Note that this only handles DRM core IOCTLs, if the driver has botched IOCTL itself, it must handle those by wrapping this function.

Return

Zero on success, negative error code on failure.

6.7 Testing and validation

6.7.1 Testing Requirements for userspace API

New cross-driver userspace interface extensions, like new IOCTL, new KMS properties, new files in sysfs or anything else that constitutes an API change should have driver-agnostic testcases in IGT for that feature, if such a test can be reasonably made using IGT for the target hardware.

6.7.2 Validating changes with IGT

There's a collection of tests that aims to cover the whole functionality of DRM drivers and that can be used to check that changes to DRM drivers or the core don't regress existing functionality. This test suite is called IGT and its code and instructions to build and run can be found in https://gitlab.freedesktop.org/drm/igt-gpu-tools/.

6.7.3 Using VKMS to test DRM API

VKMS is a software-only model of a KMS driver that is useful for testing and for running compositors. VKMS aims to enable a virtual display without the need for a hardware display capability. These characteristics made VKMS a perfect tool for validating the DRM core behavior and also support the compositor developer. VKMS makes it possible to test DRM functions in a virtual machine without display, simplifying the validation of some of the core changes.

To Validate changes in DRM API with VKMS, start setting the kernel: make sure to enable VKMS module; compile the kernel with the VKMS enabled and install it in the target machine. VKMS can be run in a Virtual Machine (QEMU, virtme or similar). It's recommended the use of KVM with the minimum of 1GB of RAM and four cores.

It's possible to run the IGT-tests in a VM in two ways:

1. Use IGT inside a VM
2. Use IGT from the host machine and write the results in a shared directory.

As follow, there is an example of using a VM with a shared directory with the host machine to run igt-tests. As an example it's used virtme:

```
$ virtme-run --rwdir /path/for/shared_dir --kdir=path/for/kernel/
↪directory --mods=auto
```

Run the igt-tests in the guest machine, as example it's ran the 'kms_flip' tests:

```
$ /path/for/igt-gpu-tools/scripts/run-tests.sh -p -s -t "kms_flip.*
↪" -v
```

In this example, instead of build the igt_runner, Piglit is used (-p option); it's created html summary of the tests results and it's saved in the folder "igt-gpu-tools/results" ; it's executed only the igt-tests matching the -t option.

6.7.4 Display CRC Support

DRM device drivers can provide to userspace CRC information of each frame as it reached a given hardware component (a CRC sampling "source").

Userspace can control generation of CRCs in a given CRTC by writing to the file dri/0/crtc-N/crc/control in debugfs, with N being the index of the CRTC. Accepted values are source names (which are driver-specific) and the "auto" keyword, which will let the driver select a default source of frame CRCs for this CRTC.

Once frame CRC generation is enabled, userspace can capture them by reading the dri/0/crtc-N/crc/data file. Each line in that file contains the frame number in the first field and then a number of unsigned integer fields containing the CRC data. Fields are separated by a single space and the number of CRC fields is source-specific.

Note that though in some cases the CRC is computed in a specified way and on the frame contents as supplied by userspace (eDP 1.3), in general the CRC computation is performed in an unspecified way and on frame contents that have been already processed in also an unspecified way and thus userspace cannot rely on being able to generate matching CRC values for the frame contents that it submits. In this general case, the maximum userspace can do is to compare the reported CRCs of frames that should have the same contents.

On the driver side the implementation effort is minimal, drivers only need to implement *drm_crtc_funcs.set_crc_source* and *drm_crtc_funcs.verify_crc_source*. The debugfs files are automatically set up if those vfuncs are set. CRC samples need to be captured in the driver by calling *drm_crtc_add_crc_entry()*. Depending on the driver and HW requirements, *drm_crtc_funcs.set_crc_source* may result in a commit (even a full modeset).

CRC results must be reliable across non-full-modeset atomic commits, so if a commit via DRM_IOCTL_MODE_ATOMIC would disable or otherwise interfere with CRC generation, then the driver must mark that commit as a full modeset (*drm_atomic_crtc_needs_modeset()* should return true). As a result, to ensure consistent results, generic userspace must re-setup CRC generation after a legacy SETCRTC or an atomic commit with DRM_MODE_ATOMIC_ALLOW_MODESET.

int **drm_crtc_add_crc_entry**(struct *drm_crtc* *crtc, bool has_frame, uint32_t frame, uint32_t *crcs)

Add entry with CRC information for a frame

Parameters

struct drm_crtc *crtc
CRTC to which the frame belongs

bool has_frame
whether this entry has a frame number to go with

uint32_t frame
number of the frame these CRCs are about

uint32_t *crcs
array of CRC values, with length matching #drm_crtc_crc.values_cnt

Description

For each frame, the driver polls the source of CRCs for new data and calls this function to add them to the buffer from where userspace reads.

6.7.5 Debugfs Support

struct **drm_info_list**

debugfs info list entry

Definition

```
struct drm_info_list {
  const char *name;
  int (*show)(struct seq_file*, void*);
  u32 driver_features;
  void *data;
};
```

Members

name
file name

show
Show callback. `seq_file->private` will be set to the *struct drm_info_node* corresponding to the instance of this info on a given *struct drm_minor*.

driver_features
Required driver features for this entry

data
Driver-private data, should not be device-specific.

Description

This structure represents a debugfs file to be created by the drm core.

struct **drm_info_node**
Per-minor debugfs node structure

Definition

```
struct drm_info_node {
  struct drm_minor *minor;
  const struct drm_info_list *info_ent;
};
```

Members

minor
struct drm_minor for this node.

info_ent
template for this node.

Description

This structure represents a debugfs file, as an instantiation of a *struct drm_info_list* on a *struct drm_minor*.

FIXME:

No it doesn't make a hole lot of sense that we duplicate debugfs entries for both the render and the primary nodes, but that's how this has organically grown. It should probably be fixed, with a compatibility link, if needed.

void **drm_debugfs_create_files**(const struct *drm_info_list* *files, int count, struct dentry *root, struct *drm_minor* *minor)
Initialize a given set of debugfs files for DRM minor

Parameters

const struct drm_info_list *files
The array of files to create

int count
The number of files given

struct dentry *root
DRI debugfs dir entry.

struct drm_minor *minor
device minor number

Description

Create a given set of debugfs files represented by an array of *struct drm_info_list* in the given root directory. These files will be removed automatically on drm_debugfs_cleanup().

6.8 Sysfs Support

DRM provides very little additional support to drivers for sysfs interactions, beyond just all the standard stuff. Drivers who want to expose additional sysfs properties and property groups can attach them at either *drm_device.dev* or *drm_connector.kdev*.

Registration is automatically handled when calling *drm_dev_register()*, or *drm_connector_register()* in case of hot-plugged connectors. Unregistration is also automatically handled by *drm_dev_unregister()* and *drm_connector_unregister()*.

void **drm_sysfs_hotplug_event**(struct *drm_device* *dev)

generate a DRM uevent

Parameters

struct drm_device *dev
DRM device

Description

Send a uevent for the DRM device specified by **dev**. Currently we only set HOTPLUG=1 in the uevent environment, but this could be expanded to deal with other types of events.

Any new uapi should be using the *drm_sysfs_connector_status_event()* for uevents on connector status change.

void **drm_sysfs_connector_status_event**(struct *drm_connector* *connector, struct *drm_property* *property)

generate a DRM uevent for connector property status change

Parameters

struct drm_connector *connector
connector on which property status changed

struct drm_property *property
connector property whose status changed.

Description

Send a uevent for the DRM device specified by **dev**. Currently we set HOTPLUG=1 and connector id along with the attached property id related to the status change.

int **drm_class_device_register**(struct device *dev)

register new device with the DRM sysfs class

Parameters

struct device *dev
device to register

Description

Registers a new `struct device` within the DRM sysfs class. Essentially only used by ttm to have a place for its global settings. Drivers should never use this.

void **drm_class_device_unregister**(struct device *dev)
unregister device with the DRM sysfs class

Parameters

struct device *dev
device to unregister

Description

Unregisters a `struct device` from the DRM sysfs class. Essentially only used by ttm to have a place for its global settings. Drivers should never use this.

6.9 VBlank event handling

The DRM core exposes two vertical blank related ioctls:

DRM_IOCTL_WAIT_VBLANK
This takes a struct drm_wait_vblank structure as its argument, and it is used to block or request a signal when a specified vblank event occurs.

DRM_IOCTL_MODESET_CTL
This was only used for user-mode-settind drivers around modesetting changes to allow the kernel to update the vblank interrupt after mode setting, since on many devices the vertical blank counter is reset to 0 at some point during modeset. Modern drivers should not call this any more since with kernel mode setting it is a no-op.

6.10 Userspace API Structures

DRM exposes many UAPI and structure definition to have a consistent and standardized interface with user. Userspace can refer to these structure definitions and UAPI formats to communicate to driver

struct **hdr_metadata_infoframe**
HDR Metadata Infoframe Data.

Definition

```
struct hdr_metadata_infoframe {
  __u8 eotf;
  __u8 metadata_type;
  struct {
    __u16 x, y;
  } display_primaries[3];
  struct {
    __u16 x, y;
  } white_point;
  __u16 max_display_mastering_luminance;
  __u16 min_display_mastering_luminance;
  __u16 max_cll;
```

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```
  __u16 max_fall;
};
```

Members

`eotf`
Electro-Optical Transfer Function (EOTF) used in the stream.

`metadata_type`
Static_Metadata_Descriptor_ID.

`display_primaries`
Color Primaries of the Data. These are coded as unsigned 16-bit values in units of 0.00002, where 0x0000 represents zero and 0xC350 represents 1.0000. **display_primaries.x**: X cordinate of color primary. **display_primaries.y**: Y cordinate of color primary.

`white_point`
White Point of Colorspace Data. These are coded as unsigned 16-bit values in units of 0.00002, where 0x0000 represents zero and 0xC350 represents 1.0000. **white_point.x**: X cordinate of whitepoint of color primary. **white_point.y**: Y cordinate of whitepoint of color primary.

`max_display_mastering_luminance`
Max Mastering Display Luminance. This value is coded as an unsigned 16-bit value in units of 1 cd/m2, where 0x0001 represents 1 cd/m2 and 0xFFFF represents 65535 cd/m2.

`min_display_mastering_luminance`
Min Mastering Display Luminance. This value is coded as an unsigned 16-bit value in units of 0.0001 cd/m2, where 0x0001 represents 0.0001 cd/m2 and 0xFFFF represents 6.5535 cd/m2.

`max_cll`
Max Content Light Level. This value is coded as an unsigned 16-bit value in units of 1 cd/m2, where 0x0001 represents 1 cd/m2 and 0xFFFF represents 65535 cd/m2.

`max_fall`
Max Frame Average Light Level. This value is coded as an unsigned 16-bit value in units of 1 cd/m2, where 0x0001 represents 1 cd/m2 and 0xFFFF represents 65535 cd/m2.

Description

HDR Metadata Infoframe as per CTA 861.G spec. This is expected to match exactly with the spec.

Userspace is expected to pass the metadata information as per the format described in this structure.

struct **`hdr_output_metadata`**
HDR output metadata

Definition

```
struct hdr_output_metadata {
  __u32 metadata_type;
  union {
    struct hdr_metadata_infoframe hdmi_metadata_type1;
  };
};
```

Members

metadata_type
Static_Metadata_Descriptor_ID.

{unnamed_union}
anonymous

hdmi_metadata_type1
HDR Metadata Infoframe.

Description

Metadata Information to be passed from userspace

struct **drm_mode_create_blob**
Create New block property

Definition

```
struct drm_mode_create_blob {
  __u64 data;
  __u32 length;
  __u32 blob_id;
};
```

Members

data
Pointer to data to copy.

length
Length of data to copy.

blob_id
new property ID. Create a new ‘blob’ data property, copying length bytes from data pointer, and returning new blob ID.

struct **drm_mode_destroy_blob**
Destroy user blob

Definition

```
struct drm_mode_destroy_blob {
  __u32 blob_id;
};
```

Members

blob_id
blob_id to destroy Destroy a user-created blob property.

struct **drm_mode_create_lease**
Create lease

Definition

```
struct drm_mode_create_lease {
  __u64 object_ids;
  __u32 object_count;
  __u32 flags;
  __u32 lessee_id;
  __u32 fd;
};
```

Members

object_ids
Pointer to array of object ids.

object_count
Number of object ids.

flags
flags for new FD.

lessee_id
unique identifier for lessee.

fd
file descriptor to new drm_master file. Lease mode resources, creating another drm_master.

struct **drm_mode_list_lessees**
List lessees

Definition

```
struct drm_mode_list_lessees {
  __u32 count_lessees;
  __u32 pad;
  __u64 lessees_ptr;
};
```

Members

count_lessees
Number of lessees.

pad
pad.

lessees_ptr
Pointer to lessess. List lesses from a drm_master

struct **drm_mode_get_lease**
Get Lease

Definition

```
struct drm_mode_get_lease {
  __u32 count_objects;
  __u32 pad;
  __u64 objects_ptr;
};
```

Members

count_objects
Number of leased objects.

pad
pad.

objects_ptr
Pointer to objects. Get leased objects

struct **drm_mode_revoke_lease**
Revoke lease

Definition

```
struct drm_mode_revoke_lease {
  __u32 lessee_id;
};
```

Members

lessee_id
Unique ID of lessee. Revoke lease

struct **drm_mode_rect**
Two dimensional rectangle.

Definition

```
struct drm_mode_rect {
  __s32 x1;
  __s32 y1;
  __s32 x2;
  __s32 y2;
};
```

Members

x1
Horizontal starting coordinate (inclusive).

y1
Vertical starting coordinate (inclusive).

x2
Horizontal ending coordinate (exclusive).

y2
Vertical ending coordinate (exclusive).

Description

With drm subsystem using `struct drm_rect` to manage rectangular area this export it to user-space.

Currently used by drm_mode_atomic blob property FB_DAMAGE_CLIPS.

CHAPTER

SEVEN

KERNEL CLIENTS

This library provides support for clients running in the kernel like fbdev and bootsplash.

GEM drivers which provide a GEM based dumb buffer with a virtual address are supported.

struct **drm_client_funcs**

DRM client callbacks

Definition

```
struct drm_client_funcs {
  struct module *owner;
  void (*unregister)(struct drm_client_dev *client);
  int (*restore)(struct drm_client_dev *client);
  int (*hotplug)(struct drm_client_dev *client);
};
```

Members

owner

The module owner

unregister

Called when *drm_device* is unregistered. The client should respond by releasing its resources using *drm_client_release()*.

This callback is optional.

restore

Called on drm_lastclose(). The first client instance in the list that returns zero gets the privilege to restore and no more clients are called. This callback is not called after **unregister** has been called.

Note that the core does not guarantee exclusion against concurrent *drm_open()*. Clients need to ensure this themselves, for example by using drm_master_internal_acquire() and drm_master_internal_release().

This callback is optional.

hotplug

Called on *drm_kms_helper_hotplug_event()*. This callback is not called after **unregister** has been called.

This callback is optional.

struct **drm_client_dev**
DRM client instance

Definition

```
struct drm_client_dev {
  struct drm_device *dev;
  const char *name;
  struct list_head list;
  const struct drm_client_funcs *funcs;
  struct drm_file *file;
  struct mutex modeset_mutex;
  struct drm_mode_set *modesets;
};
```

Members

dev
DRM device

name
Name of the client.

list
List of all clients of a DRM device, linked into *drm_device.clientlist*. Protected by *drm_device.clientlist_mutex*.

funcs
DRM client functions (optional)

file
DRM file

modeset_mutex
Protects **modesets**.

modesets
CRTC configurations

struct **drm_client_buffer**
DRM client buffer

Definition

```
struct drm_client_buffer {
  struct drm_client_dev *client;
  u32 handle;
  u32 pitch;
  struct drm_gem_object *gem;
  void *vaddr;
  struct drm_framebuffer *fb;
};
```

Members

client
DRM client

`handle`
Buffer handle

`pitch`
Buffer pitch

`gem`
GEM object backing this buffer

`vaddr`
Virtual address for the buffer

`fb`
DRM framebuffer

`drm_client_for_each_modeset`

`drm_client_for_each_modeset (modeset, client)`

Iterate over client modesets

Parameters

`modeset`
`drm_mode_set` loop cursor

`client`
DRM client

`drm_client_for_each_connector_iter`

`drm_client_for_each_connector_iter (connector, iter)`

connector_list iterator macro

Parameters

`connector`
`struct drm_connector` pointer used as cursor

`iter`
`struct drm_connector_list_iter`

Description

This iterates the connectors that are useable for internal clients (excludes write-back connectors).

For more info see *`drm_for_each_connector_iter()`*.

int **`drm_client_init`**(struct *drm_device* *dev, struct *drm_client_dev* *client, const char *name, const struct *drm_client_funcs* *funcs)

Initialise a DRM client

Parameters

`struct drm_device *dev`
DRM device

`struct drm_client_dev *client`
DRM client

const char *name
Client name

const struct drm_client_funcs *funcs
DRM client functions (optional)

Description

This initialises the client and opens a *drm_file*. Use *drm_client_register()* to complete the process. The caller needs to hold a reference on **dev** before calling this function. The client is freed when the *drm_device* is unregistered. See *drm_client_release()*.

Return

Zero on success or negative error code on failure.

void **drm_client_register**(struct *drm_client_dev* *client)

Register client

Parameters

struct drm_client_dev *client
DRM client

Description

Add the client to the *drm_device* client list to activate its callbacks. **client** must be initialized by a call to *drm_client_init()*. After *drm_client_register()* it is no longer permissible to call *drm_client_release()* directly (outside the unregister callback), instead cleanup will happen automatically on driver unload.

void **drm_client_release**(struct *drm_client_dev* *client)

Release DRM client resources

Parameters

struct drm_client_dev *client
DRM client

Description

Releases resources by closing the *drm_file* that was opened by *drm_client_init()*. It is called automatically if the *drm_client_funcs.unregister* callback is _not_ set.

This function should only be called from the unregister callback. An exception is fbdev which cannot free the buffer if userspace has open file descriptors.

Note

Clients cannot initiate a release by themselves. This is done to keep the code simple. The driver has to be unloaded before the client can be unloaded.

void **drm_client_dev_hotplug**(struct *drm_device* *dev)

Send hotplug event to clients

Parameters

struct drm_device *dev
DRM device

Description

This function calls the *drm_client_funcs.hotplug* callback on the attached clients.

drm_kms_helper_hotplug_event() calls this function, so drivers that use it don't need to call this function themselves.

void ***drm_client_buffer_vmap**(struct *drm_client_buffer* *buffer)

Map DRM client buffer into address space

Parameters

struct drm_client_buffer *buffer
DRM client buffer

Description

This function maps a client buffer into kernel address space. If the buffer is already mapped, it returns the mapping's address.

Client buffer mappings are not ref' counted. Each call to *drm_client_buffer_vmap()* should be followed by a call to *drm_client_buffer_vunmap()*; or the client buffer should be mapped throughout its lifetime.

Return

The mapped memory's address

void **drm_client_buffer_vunmap**(struct *drm_client_buffer* *buffer)

Unmap DRM client buffer

Parameters

struct drm_client_buffer *buffer
DRM client buffer

Description

This function removes a client buffer's memory mapping. Calling this function is only required by clients that manage their buffer mappings by themselves.

struct *drm_client_buffer* ***drm_client_framebuffer_create**(struct *drm_client_dev* *client, u32 width, u32 height, u32 format)

Create a client framebuffer

Parameters

struct drm_client_dev *client
DRM client

u32 width
Framebuffer width

u32 height
Framebuffer height

u32 format
Buffer format

Description

This function creates a *drm_client_buffer* which consists of a *drm_framebuffer* backed by a dumb buffer. Call *drm_client_framebuffer_delete()* to free the buffer.

Return

Pointer to a client buffer or an error pointer on failure.

void **drm_client_framebuffer_delete**(struct *drm_client_buffer* *buffer)
Delete a client framebuffer

Parameters

struct drm_client_buffer *buffer
DRM client buffer (can be NULL)

int **drm_client_framebuffer_flush**(struct *drm_client_buffer* *buffer, struct *drm_rect* *rect)
Manually flush client framebuffer

Parameters

struct drm_client_buffer *buffer
DRM client buffer (can be NULL)

struct drm_rect *rect
Damage rectangle (if NULL flushes all)

Description

This calls *drm_framebuffer_funcs->dirty* (if present) to flush buffer changes for drivers that need it.

Return

Zero on success or negative error code on failure.

int **drm_client_modeset_probe**(struct *drm_client_dev* *client, unsigned int width, unsigned int height)
Probe for displays

Parameters

struct drm_client_dev *client
DRM client

unsigned int width
Maximum display mode width (optional)

unsigned int height
Maximum display mode height (optional)

Description

This function sets up display pipelines for enabled connectors and stores the config in the client' s modeset array.

Return

Zero on success or negative error code on failure.

bool **drm_client_rotation**(struct *drm_mode_set* *modeset, unsigned int *rotation)

Check the initial rotation value

Parameters

struct drm_mode_set *modeset
DRM modeset

unsigned int *rotation
Returned rotation value

Description

This function checks if the primary plane in **modeset** can hw rotate to match the rotation needed on its connector.

Note

Currently only 0 and 180 degrees are supported.

Return

True if the plane can do the rotation, false otherwise.

int **drm_client_modeset_check**(struct *drm_client_dev* *client)

Check modeset configuration

Parameters

struct drm_client_dev *client
DRM client

Description

Check modeset configuration.

Return

Zero on success or negative error code on failure.

int **drm_client_modeset_commit_locked**(struct *drm_client_dev* *client)

Force commit CRTC configuration

Parameters

struct drm_client_dev *client
DRM client

Description

Commit modeset configuration to crtcs without checking if there is a DRM master. The assumption is that the caller already holds an internal DRM master reference acquired with drm_master_internal_acquire().

Return

Zero on success or negative error code on failure.

int **drm_client_modeset_commit**(struct *drm_client_dev* *client)

Commit CRTC configuration

Parameters

struct drm_client_dev *client
DRM client

Description

Commit modeset configuration to crtcs.

Return

Zero on success or negative error code on failure.

int **drm_client_modeset_dpms**(struct *drm_client_dev* *client, int mode)

Set DPMS mode

Parameters

struct drm_client_dev *client
DRM client

int mode
DPMS mode

Note

For atomic drivers **mode** is reduced to on/off.

Return

Zero on success or negative error code on failure.

CHAPTER

EIGHT

GPU DRIVER DOCUMENTATION

8.1 drm/amdgpu AMDgpu driver

The drm/amdgpu driver supports all AMD Radeon GPUs based on the Graphics Core Next (GCN) architecture.

8.1.1 Module Parameters

The amdgpu driver supports the following module parameters:

vramlimit (int)

Restrict the total amount of VRAM in MiB for testing. The default is 0 (Use full VRAM).

vis_vramlimit (int)

Restrict the amount of CPU visible VRAM in MiB for testing. The default is 0 (Use full CPU visible VRAM).

gartsize (uint)

Restrict the size of GART in Mib (32, 64, etc.) for testing. The default is -1 (The size depends on asic).

gttsize (int)

Restrict the size of GTT domain in MiB for testing. The default is -1 (It' s VRAM size if 3GB < VRAM < 3/4 RAM, otherwise 3/4 RAM size).

moverate (int)

Set maximum buffer migration rate in MB/s. The default is -1 (8 MB/s).

benchmark (int)

Run benchmarks. The default is 0 (Skip benchmarks).

test (int)

Test BO GTT->VRAM and VRAM->GTT GPU copies. The default is 0 (Skip test, only set 1 to run test).

audio (int)

Set HDMI/DPAudio. Only affects non-DC display handling. The default is -1 (Enabled), set 0 to disabled it.

disp_priority (int)

Set display Priority (1 = normal, 2 = high). Only affects non-DC display handling. The default is 0 (auto).

hw_i2c (int)

To enable hw i2c engine. Only affects non-DC display handling. The default is 0 (Disabled).

pcie_gen2 (int)

To disable PCIE Gen2/3 mode (0 = disable, 1 = enable). The default is -1 (auto, enabled).

msi (int)

To disable Message Signaled Interrupts (MSI) functionality (1 = enable, 0 = disable). The default is -1 (auto, enabled).

lockup_timeout (string)

Set GPU scheduler timeout value in ms.

The format can be [Non-Compute] or [GFX,Compute,SDMA,Video]. That is there can be one or multiple values specified. 0 and negative values are invalidated. They will be adjusted to the default timeout.

- With one value specified, the setting will apply to all non-compute jobs.
- With multiple values specified, the first one will be for GFX. The second one is for Compute. The third and fourth ones are for SDMA and Video.

By default(with no lockup_timeout settings), the timeout for all non-compute(GFX, SDMA and Video) jobs is 10000. And there is no timeout enforced on compute jobs.

dpm (int)

Override for dynamic power management setting (0 = disable, 1 = enable, 2 = enable sw smu driver for vega20) The default is -1 (auto).

fw_load_type (int)

Set different firmware loading type for debugging (0 = direct, 1 = SMU, 2 = PSP). The default is -1 (auto).

aspm (int)

To disable ASPM (1 = enable, 0 = disable). The default is -1 (auto, enabled).

runpm (int)

Override for runtime power management control for dGPUs in PX/HG laptops. The amdgpu driver can dynamically power down the dGPU on PX/HG laptops when it is idle. The default is -1 (auto enable). Setting the value to 0 disables this functionality.

ip_block_mask (uint)

Override what IP blocks are enabled on the GPU. Each GPU is a collection of IP blocks (gfx, display, video, etc.). Use this parameter to disable specific blocks. Note that the IP blocks do not have a fixed index. Some asics may not have some IPs or may include multiple instances of an IP so the ordering various from asic to asic. See the driver output in the kernel log for the list of IPs on the asic. The default is 0xffffffff (enable all blocks on a device).

bapm (int)

Bidirectional Application Power Management (BAPM) used to dynamically share TDP between CPU and GPU. Set value 0 to disable it. The default -1 (auto, enabled)

deep_color (int)

Set 1 to enable Deep Color support. Only affects non-DC display handling. The default is 0 (disabled).

vm_size (int)

Override the size of the GPU' s per client virtual address space in GiB. The default is -1 (automatic for each asic).

vm_fragment_size (int)

Override VM fragment size in bits (4, 5, etc. 4 = 64K, 9 = 2M). The default is -1 (automatic for each asic).

vm_block_size (int)

Override VM page table size in bits (default depending on vm_size and hw setup). The default is -1 (automatic for each asic).

vm_fault_stop (int)

Stop on VM fault for debugging (0 = never, 1 = print first, 2 = always). The default is 0 (No stop).

vm_debug (int)

Debug VM handling (0 = disabled, 1 = enabled). The default is 0 (Disabled).

vm_update_mode (int)

Override VM update mode. VM updated by using CPU (0 = never, 1 = Graphics only, 2 = Compute only, 3 = Both). The default is -1 (Only in large BAR(LB) systems Compute VM tables will be updated by CPU, otherwise 0, never).

exp_hw_support (int)

Enable experimental hw support (1 = enable). The default is 0 (disabled).

dc (int)

Disable/Enable Display Core driver for debugging (1 = enable, 0 = disable). The default is -1 (automatic for each asic).

sched_jobs (int)

Override the max number of jobs supported in the sw queue. The default is 32.

sched_hw_submission (int)

Override the max number of HW submissions. The default is 2.

ppfeaturemask (hexint)

Override power features enabled. See enum PP_FEATURE_MASK in drivers/gpu/drm/amd/include/amd_shared.h. The default is the current set of stable power features.

forcelongtraining (uint)

Force long memory training in resume. The default is zero, indicates short training in resume.

pcie_gen_cap (uint)

Override PCIE gen speed capabilities. See the CAIL flags in drivers/gpu/drm/amd/include/amd_pcie.h. The default is 0 (automatic for each asic).

pcie_lane_cap (uint)

Override PCIE lanes capabilities. See the CAIL flags in drivers/gpu/drm/amd/include/amd_pcie.h. The default is 0 (automatic for each asic).

cg_mask (uint)

Override Clockgating features enabled on GPU (0 = disable clock gating). See the AMD_CG_SUPPORT flags in drivers/gpu/drm/amd/include/amd_shared.h. The default is 0xffffffff (all enabled).

pg_mask (uint)

Override Powergating features enabled on GPU (0 = disable power gating). See the AMD_PG_SUPPORT flags in drivers/gpu/drm/amd/include/amd_shared.h. The default is 0xffffffff (all enabled).

sdma_phase_quantum (uint)

Override SDMA context switch phase quantum (x 1K GPU clock cycles, 0 = no change). The default is 32.

disable_cu (charp)

Set to disable CUs (It’s set like se.sh.cu,…). The default is NULL.

virtual_display (charp)

Set to enable virtual display feature. This feature provides a virtual display hardware on headless boards or in virtualized environments. It will be set like xxxx:xx:xx.x,x;xxxx:xx:xx.x,x. It’s the pci address of the device, plus the number of crtcs to expose. E.g., 0000:26:00.0,4 would enable 4 virtual crtcs on the pci device at 26:00.0. The default is NULL.

job_hang_limit (int)

Set how much time allow a job hang and not drop it. The default is 0.

lbpw (int)

Override Load Balancing Per Watt (LBPW) support (1 = enable, 0 = disable). The default is -1 (auto, enabled).

gpu_recovery (int)

Set to enable GPU recovery mechanism (1 = enable, 0 = disable). The default is -1 (auto, disabled except SRIOV).

emu_mode (int)

Set value 1 to enable emulation mode. This is only needed when running on an emulator. The default is 0 (disabled).

ras_enable (int)

Enable RAS features on the GPU (0 = disable, 1 = enable, -1 = auto (default))

ras_mask (uint)

Mask of RAS features to enable (default 0xffffffff), only valid when ras_enable == 1 See the flags in drivers/gpu/drm/amd/amdgpu/amdgpu_ras.h

si_support (int)

Set SI support driver. This parameter works after set config CONFIG_DRM_AMDGPU_SI. For SI asic, when radeon driver is enabled, set value 0 to use radeon driver, while set value 1 to use amdgpu driver. The default is using radeon driver when it available, otherwise using amdgpu driver.

cik_support (int)

Set CIK support driver. This parameter works after set config CONFIG_DRM_AMDGPU_CIK. For CIK asic, when radeon driver is enabled, set value 0 to use radeon driver, while set value 1 to use amdgpu driver. The default is using radeon driver when it available, otherwise using amdgpu driver.

smu_memory_pool_size (uint)

It is used to reserve gtt for smu debug usage, setting value 0 to disable it. The actual size is value * 256MiB. E.g. 0x1 = 256Mbyte, 0x2 = 512Mbyte, 0x4 = 1 Gbyte, 0x8 = 2GByte. The default is 0 (disabled).

async_gfx_ring (int)

It is used to enable gfx rings that could be configured with different prioritites or equal priorities

mcbp (int)

It is used to enable mid command buffer preemption. (0 = disabled (default), 1 = enabled)

discovery (int)

Allow driver to discover hardware IP information from IP Discovery table at the top of VRAM. (-1 = auto (default), 0 = disabled, 1 = enabled)

mes (int)

Enable Micro Engine Scheduler. This is a new hw scheduling engine for gfx, sdma, and compute. (0 = disabled (default), 1 = enabled)

noretry (int)

Disable retry faults in the GPU memory controller. (0 = retry enabled, 1 = retry disabled, -1 auto (default))

force_asic_type (int)

A non negative value used to specify the asic type for all supported GPUs.

sched_policy (int)

Set scheduling policy. Default is HWS(hardware scheduling) with over-subscription. Setting 1 disables over-subscription. Setting 2 disables HWS and statically assigns queues to HQDs.

hws_max_conc_proc (int)

Maximum number of processes that HWS can schedule concurrently. The maximum is the number of VMIDs assigned to the HWS, which is also the default.

cwsr_enable (int)

CWSR(compute wave store and resume) allows the GPU to preempt shader execution in the middle of a compute wave. Default is 1 to enable this feature. Setting 0 disables it.

max_num_of_queues_per_device (int)

Maximum number of queues per device. Valid setting is between 1 and 4096. Default is 4096.

send_sigterm (int)

Send sigterm to HSA process on unhandled exceptions. Default is not to send sigterm but just print errors on dmesg. Setting 1 enables sending sigterm.

debug_largebar (int)

Set debug_largebar as 1 to enable simulating large-bar capability on non-large bar system. This limits the VRAM size reported to ROCm applications to the visible size, usually 256MB. Default value is 0, diabled.

ignore_crat (int)

Ignore CRAT table during KFD initialization. By default, KFD uses the ACPI CRAT table to get information about AMD APUs. This option can serve as a workaround on systems with a broken CRAT table.

Default is auto (according to asic type, iommu_v2, and crat table, to decide wehter use CRAT)

halt_if_hws_hang (int)

Halt if HWS hang is detected. Default value, 0, disables the halt on hang. Setting 1 enables halt on hang.

hws_gws_support(bool)

Assume that HWS supports GWS barriers regardless of what firmware version check says. Default value: false (rely on MEC2 firmware version check).

queue_preemption_timeout_ms (int)

queue preemption timeout in ms (1 = Minimum, 9000 = default)

debug_evictions(bool)

Enable extra debug messages to help determine the cause of evictions

no_system_mem_limit(bool)

Disable system memory limit, to support multiple process shared memory

dcfeaturemask (uint)

Override display features enabled. See enum DC_FEATURE_MASK in drivers/gpu/drm/amd/include/amd_shared.h. The default is the current set of stable display features.

dcdebugmask (uint)

Override display features enabled. See enum DC_DEBUG_MASK in drivers/gpu/drm/amd/include/amd_shared.h.

abmlevel (uint)

Override the default ABM (Adaptive Backlight Management) level used for DC enabled hardware. Requires DMCU to be supported and loaded. Valid levels are 0-4. A value of 0 indicates that ABM should be disabled by default. Values 1-4 control the maximum allowable brightness reduction via the ABM algorithm, with 1 being the least reduction and 4 being the most reduction.

Defaults to 0, or disabled. Userspace can still override this level later after boot.

tmz (int)

Trusted Memory Zone (TMZ) is a method to protect data being written to or read from memory.

The default value: 0 (off). TODO: change to auto till it is completed.

reset_method (int)

GPU reset method (-1 = auto (default), 0 = legacy, 1 = mode0, 2 = mode1, 3 = mode2, 4 = baco)

bad_page_threshold (int)

Bad page threshold is to specify the threshold value of faulty pages detected by RAS ECC, that may result in GPU entering bad status if total faulty pages by ECC exceed threshold value and leave it for user's further check.

8.1.2 Core Driver Infrastructure

This section covers core driver infrastructure.

Memory Domains

`AMDGPU_GEM_DOMAIN_CPU` System memory that is not GPU accessible. Memory in this pool could be swapped out to disk if there is pressure.

`AMDGPU_GEM_DOMAIN_GTT` GPU accessible system memory, mapped into the GPU's virtual address space via gart. Gart memory linearizes non-contiguous pages of system memory, allows GPU access system memory in a linezrized fashion.

`AMDGPU_GEM_DOMAIN_VRAM` Local video memory. For APUs, it is memory carved out by the BIOS.

`AMDGPU_GEM_DOMAIN_GDS` Global on-chip data storage used to share data across shader threads.

`AMDGPU_GEM_DOMAIN_GWS` Global wave sync, used to synchronize the execution of all the waves on a device.

`AMDGPU_GEM_DOMAIN_OA` Ordered append, used by 3D or Compute engines for appending data.

Buffer Objects

This defines the interfaces to operate on an `amdgpu_bo` buffer object which represents memory used by driver (VRAM, system memory, etc.). The driver provides DRM/GEM APIs to userspace. DRM/GEM APIs then use these interfaces to create/destroy/set buffer object which are then managed by the kernel TTM memory manager. The interfaces are also used internally by kernel clients, including gfx, uvd, etc. for kernel managed allocations used by the GPU.

void **amdgpu_bo_subtract_pin_size**(struct amdgpu_bo *bo)

Remove BO from pin_size accounting

Parameters

struct amdgpu_bo *bo
amdgpu_bo buffer object

Description

This function is called when a BO stops being pinned, and updates the `amdgpu_device` pin_size values accordingly.

bool **amdgpu_bo_is_amdgpu_bo**(struct ttm_buffer_object *bo)

check if the buffer object is an `amdgpu_bo`

Parameters

struct ttm_buffer_object *bo
buffer object to be checked

Description

Uses destroy function associated with the object to determine if this is an `amdgpu_bo`.

Return

true if the object belongs to `amdgpu_bo`, false if not.

void **amdgpu_bo_placement_from_domain**(struct amdgpu_bo *abo, u32 domain)

set buffer' s placement

Parameters

struct amdgpu_bo *abo
`amdgpu_bo` buffer object whose placement is to be set

u32 domain
requested domain

Description

Sets buffer's placement according to requested domain and the buffer's flags.

int **amdgpu_bo_create_reserved**(struct amdgpu_device *adev, unsigned long size, int align, u32 domain, struct amdgpu_bo **bo_ptr, u64 *gpu_addr, void **cpu_addr)

create reserved BO for kernel use

Parameters

struct amdgpu_device *adev
amdgpu device object

unsigned long size
size for the new BO

int align
alignment for the new BO

u32 domain
where to place it

struct amdgpu_bo **bo_ptr
used to initialize BOs in structures

u64 *gpu_addr
GPU addr of the pinned BO

void **cpu_addr
optional CPU address mapping

Description

Allocates and pins a BO for kernel internal use, and returns it still reserved.

Note

For bo_ptr new BO is only created if bo_ptr points to NULL.

Return

0 on success, negative error code otherwise.

int **amdgpu_bo_create_kernel**(struct amdgpu_device *adev, unsigned long size, int align, u32 domain, struct amdgpu_bo **bo_ptr, u64 *gpu_addr, void **cpu_addr)

create BO for kernel use

Parameters

struct amdgpu_device *adev
amdgpu device object

unsigned long size
size for the new BO

int align
alignment for the new BO

u32 domain
where to place it

struct amdgpu_bo **bo_ptr
: used to initialize BOs in structures

u64 *gpu_addr
: GPU addr of the pinned BO

void **cpu_addr
: optional CPU address mapping

Description

Allocates and pins a BO for kernel internal use.

Note

For bo_ptr new BO is only created if bo_ptr points to NULL.

Return

0 on success, negative error code otherwise.

int **amdgpu_bo_create_kernel_at**(struct amdgpu_device *adev, uint64_t offset, uint64_t size, uint32_t domain, struct amdgpu_bo **bo_ptr, void **cpu_addr)

create BO for kernel use at specific location

Parameters

struct amdgpu_device *adev
: amdgpu device object

uint64_t offset
: offset of the BO

uint64_t size
: size of the BO

uint32_t domain
: where to place it

struct amdgpu_bo **bo_ptr
: used to initialize BOs in structures

void **cpu_addr
: optional CPU address mapping

Description

Creates a kernel BO at a specific offset in the address space of the domain.

Return

0 on success, negative error code otherwise.

void **amdgpu_bo_free_kernel**(struct amdgpu_bo **bo, u64 *gpu_addr, void **cpu_addr)

free BO for kernel use

Parameters

struct amdgpu_bo **bo
: amdgpu BO to free

u64 *gpu_addr
pointer to where the BO' s GPU memory space address was stored

void **cpu_addr
pointer to where the BO' s CPU memory space address was stored

Description

unmaps and unpin a BO for kernel internal use.

int **amdgpu_bo_create**(struct amdgpu_device *adev, struct amdgpu_bo_param *bp, struct amdgpu_bo **bo_ptr)

create an `amdgpu_bo` buffer object

Parameters

struct amdgpu_device *adev
amdgpu device object

struct amdgpu_bo_param *bp
parameters to be used for the buffer object

struct amdgpu_bo **bo_ptr
pointer to the buffer object pointer

Description

Creates an `amdgpu_bo` buffer object; and if requested, also creates a shadow object. Shadow object is used to backup the original buffer object, and is always in GTT.

Return

0 for success or a negative error code on failure.

int **amdgpu_bo_validate**(struct amdgpu_bo *bo)

validate an `amdgpu_bo` buffer object

Parameters

struct amdgpu_bo *bo
pointer to the buffer object

Description

Sets placement according to domain; and changes placement and caching policy of the buffer object according to the placement. This is used for validating shadow bos. It calls ttm_bo_validate() to make sure the buffer is resident where it needs to be.

Return

0 for success or a negative error code on failure.

int **amdgpu_bo_restore_shadow**(struct amdgpu_bo *shadow, struct dma_fence **fence)

restore an `amdgpu_bo` shadow

Parameters

struct amdgpu_bo *shadow
`amdgpu_bo` shadow to be restored

struct dma_fence **fence
dma_fence associated with the operation

Description

Copies a buffer object's shadow content back to the object. This is used for recovering a buffer from its shadow in case of a gpu reset where vram context may be lost.

Return

0 for success or a negative error code on failure.

int **amdgpu_bo_kmap**(struct amdgpu_bo *bo, void **ptr)
map an `amdgpu_bo` buffer object

Parameters

struct amdgpu_bo *bo
`amdgpu_bo` buffer object to be mapped

void **ptr
kernel virtual address to be returned

Description

Calls ttm_bo_kmap() to set up the kernel virtual mapping; calls *amdgpu_bo_kptr()* to get the kernel virtual address.

Return

0 for success or a negative error code on failure.

void ***amdgpu_bo_kptr**(struct amdgpu_bo *bo)
returns a kernel virtual address of the buffer object

Parameters

struct amdgpu_bo *bo
`amdgpu_bo` buffer object

Description

Calls ttm_kmap_obj_virtual() to get the kernel virtual address

Return

the virtual address of a buffer object area.

void **amdgpu_bo_kunmap**(struct amdgpu_bo *bo)
unmap an `amdgpu_bo` buffer object

Parameters

struct amdgpu_bo *bo
`amdgpu_bo` buffer object to be unmapped

Description

Unmaps a kernel map set up by *amdgpu_bo_kmap()*.

struct amdgpu_bo ***amdgpu_bo_ref**(struct amdgpu_bo *bo)

reference an `amdgpu_bo` buffer object

Parameters

`struct amdgpu_bo *bo`
`amdgpu_bo` buffer object

Description

References the contained `ttm_buffer_object`.

Return

a refcounted pointer to the `amdgpu_bo` buffer object.

void **amdgpu_bo_unref**(struct amdgpu_bo **bo)

unreference an `amdgpu_bo` buffer object

Parameters

`struct amdgpu_bo **bo`
`amdgpu_bo` buffer object

Description

Unreferences the contained `ttm_buffer_object` and clear the pointer

int **amdgpu_bo_pin_restricted**(struct amdgpu_bo *bo, u32 domain, u64 min_offset, u64 max_offset)

pin an `amdgpu_bo` buffer object

Parameters

`struct amdgpu_bo *bo`
`amdgpu_bo` buffer object to be pinned

`u32 domain`
domain to be pinned to

`u64 min_offset`
the start of requested address range

`u64 max_offset`
the end of requested address range

Description

Pins the buffer object according to requested domain and address range. If the memory is unbound gart memory, binds the pages into gart table. Adjusts pin_count and pin_size accordingly.

Pinning means to lock pages in memory along with keeping them at a fixed offset. It is required when a buffer can not be moved, for example, when a display buffer is being scanned out.

Compared with *`amdgpu_bo_pin()`*, this function gives more flexibility on where to pin a buffer if there are specific restrictions on where a buffer must be located.

Return

0 for success or a negative error code on failure.

int **amdgpu_bo_pin**(struct amdgpu_bo *bo, u32 domain)

pin an amdgpu_bo buffer object

Parameters

struct amdgpu_bo *bo
amdgpu_bo buffer object to be pinned

u32 domain
domain to be pinned to

Description

A simple wrapper to *amdgpu_bo_pin_restricted()*. Provides a simpler API for buffers that do not have any strict restrictions on where a buffer must be located.

Return

0 for success or a negative error code on failure.

int **amdgpu_bo_unpin**(struct amdgpu_bo *bo)

unpin an amdgpu_bo buffer object

Parameters

struct amdgpu_bo *bo
amdgpu_bo buffer object to be unpinned

Description

Decreases the pin_count, and clears the flags if pin_count reaches 0. Changes placement and pin size accordingly.

Return

0 for success or a negative error code on failure.

int **amdgpu_bo_evict_vram**(struct amdgpu_device *adev)

evict VRAM buffers

Parameters

struct amdgpu_device *adev
amdgpu device object

Description

Evicts all VRAM buffers on the lru list of the memory type. Mainly used for evicting vram at suspend time.

Return

0 for success or a negative error code on failure.

int **amdgpu_bo_init**(struct amdgpu_device *adev)

initialize memory manager

Parameters

struct amdgpu_device *adev
amdgpu device object

Description

Calls amdgpu_ttm_init() to initialize amdgpu memory manager.

Return

0 for success or a negative error code on failure.

int **`amdgpu_bo_late_init`**(struct amdgpu_device *adev)
    late init

Parameters

`struct amdgpu_device *adev`
    amdgpu device object

Description

Calls amdgpu_ttm_late_init() to free resources used earlier during initialization.

Return

0 for success or a negative error code on failure.

void **`amdgpu_bo_fini`**(struct amdgpu_device *adev)
    tear down memory manager

Parameters

`struct amdgpu_device *adev`
    amdgpu device object

Description

Reverses *`amdgpu_bo_init()`* to tear down memory manager.

int **`amdgpu_bo_fbdev_mmap`**(struct amdgpu_bo *bo, struct vm_area_struct *vma)
    mmap fbdev memory

Parameters

`struct amdgpu_bo *bo`
    amdgpu_bo buffer object

`struct vm_area_struct *vma`
    vma as input from the fbdev mmap method

Description

Calls ttm_fbdev_mmap() to mmap fbdev memory if it is backed by a bo.

Return

0 for success or a negative error code on failure.

int **`amdgpu_bo_set_tiling_flags`**(struct amdgpu_bo *bo, u64 tiling_flags)
    set tiling flags

Parameters

`struct amdgpu_bo *bo`
    amdgpu_bo buffer object

u64 tiling_flags
new flags

Description

Sets buffer object's tiling flags with the new one. Used by GEM ioctl or kernel driver to set the tiling flags on a buffer.

Return

0 for success or a negative error code on failure.

void **amdgpu_bo_get_tiling_flags**(struct amdgpu_bo *bo, u64 *tiling_flags)
get tiling flags

Parameters

struct amdgpu_bo *bo
amdgpu_bo buffer object

u64 *tiling_flags
returned flags

Description

Gets buffer object's tiling flags. Used by GEM ioctl or kernel driver to set the tiling flags on a buffer.

int **amdgpu_bo_set_metadata**(struct amdgpu_bo *bo, void *metadata, uint32_t metadata_size, uint64_t flags)
set metadata

Parameters

struct amdgpu_bo *bo
amdgpu_bo buffer object

void *metadata
new metadata

uint32_t metadata_size
size of the new metadata

uint64_t flags
flags of the new metadata

Description

Sets buffer object's metadata, its size and flags. Used via GEM ioctl.

Return

0 for success or a negative error code on failure.

int **amdgpu_bo_get_metadata**(struct amdgpu_bo *bo, void *buffer, size_t buffer_size, uint32_t *metadata_size, uint64_t *flags)
get metadata

Parameters

struct amdgpu_bo *bo
amdgpu_bo buffer object

void *buffer
returned metadata

size_t buffer_size
size of the buffer

uint32_t *metadata_size
size of the returned metadata

uint64_t *flags
flags of the returned metadata

Description

Gets buffer object' s metadata, its size and flags. buffer_size shall not be less than metadata_size. Used via GEM ioctl.

Return

0 for success or a negative error code on failure.

void **amdgpu_bo_move_notify**(struct ttm_buffer_object *bo, bool evict, struct ttm_resource *new_mem)

notification about a memory move

Parameters

struct ttm_buffer_object *bo
pointer to a buffer object

bool evict
if this move is evicting the buffer from the graphics address space

struct ttm_resource *new_mem
new information of the bufer object

Description

Marks the corresponding amdgpu_bo buffer object as invalid, also performs bookkeeping. TTM driver callback which is called when ttm moves a buffer.

void **amdgpu_bo_release_notify**(struct ttm_buffer_object *bo)

notification about a BO being released

Parameters

struct ttm_buffer_object *bo
pointer to a buffer object

Description

Wipes VRAM buffers whose contents should not be leaked before the memory is released.

int **amdgpu_bo_fault_reserve_notify**(struct ttm_buffer_object *bo)

notification about a memory fault

Parameters

struct ttm_buffer_object *bo
: pointer to a buffer object

Description

Notifies the driver we are taking a fault on this BO and have reserved it, also performs bookkeeping. TTM driver callback for dealing with vm faults.

Return

0 for success or a negative error code on failure.

void **amdgpu_bo_fence**(struct amdgpu_bo *bo, struct dma_fence *fence, bool shared)

add fence to buffer object

Parameters

struct amdgpu_bo *bo
: buffer object in question

struct dma_fence *fence
: fence to add

bool shared
: true if fence should be added shared

int **amdgpu_bo_sync_wait_resv**(struct amdgpu_device *adev, struct dma_resv *resv, enum amdgpu_sync_mode sync_mode, void *owner, bool intr)

Wait for BO reservation fences

Parameters

struct amdgpu_device *adev
: amdgpu device pointer

struct dma_resv *resv
: reservation object to sync to

enum amdgpu_sync_mode sync_mode
: synchronization mode

void *owner
: fence owner

bool intr
: Whether the wait is interruptible

Description

Extract the fences from the reservation object and waits for them to finish.

Return

0 on success, errno otherwise.

int **amdgpu_bo_sync_wait**(struct amdgpu_bo *bo, void *owner, bool intr)

Wrapper for amdgpu_bo_sync_wait_resv

Parameters

`struct amdgpu_bo *bo`
buffer object to wait for

`void *owner`
fence owner

`bool intr`
Whether the wait is interruptible

Description

Wrapper to wait for fences in a BO.

Return

0 on success, errno otherwise.

u64 **`amdgpu_bo_gpu_offset`**(struct amdgpu_bo *bo)
return GPU offset of bo

Parameters

`struct amdgpu_bo *bo`
amdgpu object for which we query the offset

Note

object should either be pinned or reserved when calling this function, it might be useful to add check for this for debugging.

Return

current GPU offset of the object.

u64 **`amdgpu_bo_gpu_offset_no_check`**(struct amdgpu_bo *bo)
return GPU offset of bo

Parameters

`struct amdgpu_bo *bo`
amdgpu object for which we query the offset

Return

current GPU offset of the object without raising warnings.

uint32_t **`amdgpu_bo_get_preferred_pin_domain`**(struct amdgpu_device *adev, uint32_t domain)
get preferred domain for scanout

Parameters

`struct amdgpu_device *adev`
amdgpu device object

`uint32_t domain`
allowed *memory domains*

Return

Which of the allowed domains is preferred for pinning the BO for scanout.

PRIME Buffer Sharing

The following callback implementations are used for *sharing GEM buffer objects between different devices via PRIME*.

void ***amdgpu_gem_prime_vmap**(struct *drm_gem_object* *obj)

  `dma_buf_ops.vmap` implementation

Parameters

struct drm_gem_object *obj
  GEM BO

Description

Sets up an in-kernel virtual mapping of the BO' s memory.

Return

The virtual address of the mapping or an error pointer.

void **amdgpu_gem_prime_vunmap**(struct *drm_gem_object* *obj, void *vaddr)

  `dma_buf_ops.vunmap` implementation

Parameters

struct drm_gem_object *obj
  GEM BO

void *vaddr
  Virtual address (unused)

Description

Tears down the in-kernel virtual mapping of the BO' s memory.

int **amdgpu_gem_prime_mmap**(struct *drm_gem_object* *obj, struct vm_area_struct *vma)

  drm_driver.gem_prime_mmap implementation

Parameters

struct drm_gem_object *obj
  GEM BO

struct vm_area_struct *vma
  Virtual memory area

Description

Sets up a userspace mapping of the BO' s memory in the given virtual memory area.

Return

0 on success or a negative error code on failure.

int **amdgpu_dma_buf_attach**(struct dma_buf *dmabuf, struct dma_buf_attachment *attach)

  `dma_buf_ops.attach` implementation

Parameters

struct dma_buf *dmabuf
DMA-buf where we attach to

struct dma_buf_attachment *attach
attachment to add

Description

Add the attachment as user to the exported DMA-buf.

void **amdgpu_dma_buf_detach**(struct dma_buf *dmabuf, struct dma_buf_attachment *attach)

`dma_buf_ops.detach` implementation

Parameters

struct dma_buf *dmabuf
DMA-buf where we remove the attachment from

struct dma_buf_attachment *attach
the attachment to remove

Description

Called when an attachment is removed from the DMA-buf.

int **amdgpu_dma_buf_pin**(struct dma_buf_attachment *attach)

`dma_buf_ops.pin` implementation

Parameters

struct dma_buf_attachment *attach
attachment to pin down

Description

Pin the BO which is backing the DMA-buf so that it can't move any more.

void **amdgpu_dma_buf_unpin**(struct dma_buf_attachment *attach)

`dma_buf_ops.unpin` implementation

Parameters

struct dma_buf_attachment *attach
attachment to unpin

Description

Unpin a previously pinned BO to make it movable again.

struct sg_table ***amdgpu_dma_buf_map**(struct dma_buf_attachment *attach, enum dma_data_direction dir)

`dma_buf_ops.map_dma_buf` implementation

Parameters

struct dma_buf_attachment *attach
DMA-buf attachment

enum dma_data_direction dir
DMA direction

Description

Makes sure that the shared DMA buffer can be accessed by the target device. For now, simply pins it to the GTT domain, where it should be accessible by all DMA devices.

Return

sg_table filled with the DMA addresses to use or ERR_PRT with negative error code.

void **amdgpu_dma_buf_unmap**(struct dma_buf_attachment *attach, struct sg_table *sgt, enum dma_data_direction dir)

`dma_buf_ops.unmap_dma_buf` implementation

Parameters

struct dma_buf_attachment *attach
DMA-buf attachment

struct sg_table *sgt
sg_table to unmap

enum dma_data_direction dir
DMA direction

Description

This is called when a shared DMA buffer no longer needs to be accessible by another device. For now, simply unpins the buffer from GTT.

int **amdgpu_dma_buf_begin_cpu_access**(struct *dma_buf* *dma_buf, enum dma_data_direction direction)

`dma_buf_ops.begin_cpu_access` implementation

Parameters

struct dma_buf *dma_buf
Shared DMA buffer

enum dma_data_direction direction
Direction of DMA transfer

Description

This is called before CPU access to the shared DMA buffer's memory. If it's a read access, the buffer is moved to the GTT domain if possible, for optimal CPU read performance.

Return

0 on success or a negative error code on failure.

struct dma_buf ***amdgpu_gem_prime_export**(struct *drm_gem_object* *gobj, int flags)

drm_driver.gem_prime_export implementation

Parameters

struct drm_gem_object *gobj
GEM BO

int flags
Flags such as DRM_CLOEXEC and DRM_RDWR.

Description

The main work is done by the *drm_gem_prime_export* helper.

Return

Shared DMA buffer representing the GEM BO from the given device.

struct *drm_gem_object* ***amdgpu_dma_buf_create_obj**(struct *drm_device* *dev, struct *dma_buf* *dma_buf)

create BO for DMA-buf import

Parameters

struct drm_device *dev
DRM device

struct dma_buf *dma_buf
DMA-buf

Description

Creates an empty SG BO for DMA-buf import.

Return

A new GEM BO of the given DRM device, representing the memory described by the given DMA-buf attachment and scatter/gather table.

void **amdgpu_dma_buf_move_notify**(struct dma_buf_attachment *attach)

attach.move_notify implementation

Parameters

struct dma_buf_attachment *attach
the DMA-buf attachment

Description

Invalidate the DMA-buf attachment, making sure that the we re-create the mapping before the next use.

struct *drm_gem_object* ***amdgpu_gem_prime_import**(struct *drm_device* *dev, struct *dma_buf* *dma_buf)

drm_driver.gem_prime_import implementation

Parameters

struct drm_device *dev
DRM device

struct dma_buf *dma_buf
Shared DMA buffer

Description

Import a dma_buf into a the driver and potentially create a new GEM object.

Return

GEM BO representing the shared DMA buffer for the given device.

bool **amdgpu_dmabuf_is_xgmi_accessible**(struct amdgpu_device *adev, struct amdgpu_bo *bo)

Check if xgmi available for P2P transfer

Parameters

struct amdgpu_device *adev
amdgpu_device pointer of the importer

struct amdgpu_bo *bo
amdgpu buffer object

Return

True if dmabuf accessible over xgmi, false otherwise.

MMU Notifier

For coherent userptr handling registers an MMU notifier to inform the driver about updates on the page tables of a process.

When somebody tries to invalidate the page tables we block the update until all operations on the pages in question are completed, then those pages are marked as accessed and also dirty if it wasn't a read only access.

New command submissions using the userptrs in question are delayed until all page table invalidation are completed and we once more see a coherent process address space.

bool **amdgpu_mn_invalidate_gfx**(struct mmu_interval_notifier *mni, const struct mmu_notifier_range *range, unsigned long cur_seq)

callback to notify about mm change

Parameters

struct mmu_interval_notifier *mni
the range (mm) is about to update

const struct mmu_notifier_range *range
details on the invalidation

unsigned long cur_seq
Value to pass to mmu_interval_set_seq()

Description

Block for operations on BOs to finish and mark pages as accessed and potentially dirty.

bool **amdgpu_mn_invalidate_hsa**(struct mmu_interval_notifier *mni, const struct mmu_notifier_range *range, unsigned long cur_seq)

callback to notify about mm change

Parameters

`struct mmu_interval_notifier *mni`
    the range (mm) is about to update

`const struct mmu_notifier_range *range`
    details on the invalidation

`unsigned long cur_seq`
    Value to pass to mmu_interval_set_seq()

Description

We temporarily evict the BO attached to this range. This necessitates evicting all user-mode queues of the process.

int **`amdgpu_mn_register`**(struct amdgpu_bo *bo, unsigned long addr)
    register a BO for notifier updates

Parameters

`struct amdgpu_bo *bo`
    amdgpu buffer object

`unsigned long addr`
    userptr addr we should monitor

Description

Registers a mmu_notifier for the given BO at the specified address. Returns 0 on success, -ERRNO if anything goes wrong.

void **`amdgpu_mn_unregister`**(struct amdgpu_bo *bo)
    unregister a BO for notifier updates

Parameters

`struct amdgpu_bo *bo`
    amdgpu buffer object

Description

Remove any registration of mmu notifier updates from the buffer object.

AMDGPU Virtual Memory

GPUVM is similar to the legacy gart on older asics, however rather than there being a single global gart table for the entire GPU, there are multiple VM page tables active at any given time. The VM page tables can contain a mix vram pages and system memory pages and system memory pages can be mapped as snooped (cached system pages) or unsnooped (uncached system pages). Each VM has an ID associated with it and there is a page table associated with each VMID. When execting a command buffer, the kernel tells the the ring what VMID to use for that command buffer. VMIDs are allocated dynamically as commands are submitted. The userspace drivers maintain their own address space and the kernel sets up their pages tables accordingly when they submit their command buffers and a VMID is assigned. Cayman/Trinity support up to 8 active VMs at any given time; SI supports 16.

struct **amdgpu_prt_cb**

Helper to disable partial resident texture feature from a fence callback

Definition

```
struct amdgpu_prt_cb {
  struct amdgpu_device *adev;
  struct dma_fence_cb cb;
};
```

Members

adev
amdgpu device

cb
callback

unsigned **amdgpu_vm_level_shift**(struct amdgpu_device *adev, unsigned level)

return the addr shift for each level

Parameters

struct amdgpu_device *adev
amdgpu_device pointer

unsigned level
VMPT level

Return

The number of bits the pfn needs to be right shifted for a level.

unsigned **amdgpu_vm_num_entries**(struct amdgpu_device *adev, unsigned level)

return the number of entries in a PD/PT

Parameters

struct amdgpu_device *adev
amdgpu_device pointer

unsigned level
VMPT level

Return

The number of entries in a page directory or page table.

unsigned **amdgpu_vm_num_ats_entries**(struct amdgpu_device *adev)

return the number of ATS entries in the root PD

Parameters

struct amdgpu_device *adev
amdgpu_device pointer

Return

The number of entries in the root page directory which needs the ATS setting.

uint32_t **amdgpu_vm_entries_mask**(struct amdgpu_device *adev, unsigned int level)

the mask to get the entry number of a PD/PT

Parameters

struct amdgpu_device *adev
amdgpu_device pointer

unsigned int level
VMPT level

Return

The mask to extract the entry number of a PD/PT from an address.

unsigned **amdgpu_vm_bo_size**(struct amdgpu_device *adev, unsigned level)

returns the size of the BOs in bytes

Parameters

struct amdgpu_device *adev
amdgpu_device pointer

unsigned level
VMPT level

Return

The size of the BO for a page directory or page table in bytes.

void **amdgpu_vm_bo_evicted**(struct amdgpu_vm_bo_base *vm_bo)

vm_bo is evicted

Parameters

struct amdgpu_vm_bo_base *vm_bo
vm_bo which is evicted

Description

State for PDs/PTs and per VM BOs which are not at the location they should be.

void **amdgpu_vm_bo_moved**(struct amdgpu_vm_bo_base *vm_bo)

vm_bo is moved

Parameters

struct amdgpu_vm_bo_base *vm_bo
vm_bo which is moved

Description

State for per VM BOs which are moved, but that change is not yet reflected in the page tables.

void **amdgpu_vm_bo_idle**(struct amdgpu_vm_bo_base *vm_bo)

vm_bo is idle

Parameters

struct amdgpu_vm_bo_base *vm_bo
vm_bo which is now idle

Description

State for PDs/PTs and per VM BOs which have gone through the state machine and are now idle.

void **amdgpu_vm_bo_invalidated**(struct amdgpu_vm_bo_base *vm_bo)
vm_bo is invalidated

Parameters

struct amdgpu_vm_bo_base *vm_bo
vm_bo which is now invalidated

Description

State for normal BOs which are invalidated and that change not yet reflected in the PTs.

void **amdgpu_vm_bo_relocated**(struct amdgpu_vm_bo_base *vm_bo)
vm_bo is reloacted

Parameters

struct amdgpu_vm_bo_base *vm_bo
vm_bo which is relocated

Description

State for PDs/PTs which needs to update their parent PD. For the root PD, just move to idle state.

void **amdgpu_vm_bo_done**(struct amdgpu_vm_bo_base *vm_bo)
vm_bo is done

Parameters

struct amdgpu_vm_bo_base *vm_bo
vm_bo which is now done

Description

State for normal BOs which are invalidated and that change has been updated in the PTs.

void **amdgpu_vm_bo_base_init**(struct amdgpu_vm_bo_base *base, struct amdgpu_vm *vm, struct amdgpu_bo *bo)
Adds bo to the list of bos associated with the vm

Parameters

struct amdgpu_vm_bo_base *base
base structure for tracking BO usage in a VM

struct amdgpu_vm *vm
vm to which bo is to be added

struct amdgpu_bo *bo
amdgpu buffer object

Description

Initialize a bo_va_base structure and add it to the appropriate lists

struct amdgpu_vm_pt ***amdgpu_vm_pt_parent**(struct amdgpu_vm_pt *pt)

get the parent page directory

Parameters

struct amdgpu_vm_pt *pt
child page table

Description

Helper to get the parent entry for the child page table. NULL if we are at the root page directory.

void **amdgpu_vm_pt_start**(struct amdgpu_device *adev, struct amdgpu_vm *vm, uint64_t start, struct amdgpu_vm_pt_cursor *cursor)

start PD/PT walk

Parameters

struct amdgpu_device *adev
amdgpu_device pointer

struct amdgpu_vm *vm
amdgpu_vm structure

uint64_t start
start address of the walk

struct amdgpu_vm_pt_cursor *cursor
state to initialize

Description

Initialize a amdgpu_vm_pt_cursor to start a walk.

bool **amdgpu_vm_pt_descendant**(struct amdgpu_device *adev, struct amdgpu_vm_pt_cursor *cursor)

go to child node

Parameters

struct amdgpu_device *adev
amdgpu_device pointer

struct amdgpu_vm_pt_cursor *cursor
current state

Description

Walk to the child node of the current node.

Return

True if the walk was possible, false otherwise.

bool **amdgpu_vm_pt_sibling**(struct amdgpu_device *adev, struct amdgpu_vm_pt_cursor *cursor)

go to sibling node

Parameters

`struct amdgpu_device *adev`
: amdgpu_device pointer

`struct amdgpu_vm_pt_cursor *cursor`
: current state

Description

Walk to the sibling node of the current node.

Return

True if the walk was possible, false otherwise.

bool **`amdgpu_vm_pt_ancestor`**(struct amdgpu_vm_pt_cursor *cursor)
: go to parent node

Parameters

`struct amdgpu_vm_pt_cursor *cursor`
: current state

Description

Walk to the parent node of the current node.

Return

True if the walk was possible, false otherwise.

void **`amdgpu_vm_pt_next`**(struct amdgpu_device *adev, struct amdgpu_vm_pt_cursor *cursor)
: get next PD/PT in hieratchy

Parameters

`struct amdgpu_device *adev`
: amdgpu_device pointer

`struct amdgpu_vm_pt_cursor *cursor`
: current state

Description

Walk the PD/PT tree to the next node.

void **`amdgpu_vm_pt_first_dfs`**(struct amdgpu_device *adev, struct amdgpu_vm *vm, struct amdgpu_vm_pt_cursor *start, struct amdgpu_vm_pt_cursor *cursor)
: start a deep first search

Parameters

`struct amdgpu_device *adev`
: amdgpu_device structure

`struct amdgpu_vm *vm`
: amdgpu_vm structure

`struct amdgpu_vm_pt_cursor *start`
: optional cursor to start with

struct amdgpu_vm_pt_cursor *cursor
    state to initialize

Description

Starts a deep first traversal of the PD/PT tree.

bool **amdgpu_vm_pt_continue_dfs**(struct amdgpu_vm_pt_cursor *start, struct amdgpu_vm_pt *entry)

    check if the deep first search should continue

Parameters

struct amdgpu_vm_pt_cursor *start
    starting point for the search

struct amdgpu_vm_pt *entry
    current entry

Return

True when the search should continue, false otherwise.

void **amdgpu_vm_pt_next_dfs**(struct amdgpu_device *adev, struct amdgpu_vm_pt_cursor *cursor)

    get the next node for a deep first search

Parameters

struct amdgpu_device *adev
    amdgpu_device structure

struct amdgpu_vm_pt_cursor *cursor
    current state

Description

Move the cursor to the next node in a deep first search.

void **amdgpu_vm_get_pd_bo**(struct amdgpu_vm *vm, struct list_head *validated, struct amdgpu_bo_list_entry *entry)

    add the VM PD to a validation list

Parameters

struct amdgpu_vm *vm
    vm providing the BOs

struct list_head *validated
    head of validation list

struct amdgpu_bo_list_entry *entry
    entry to add

Description

Add the page directory to the list of BOs to validate for command submission.

void **amdgpu_vm_del_from_lru_notify**(struct ttm_buffer_object *bo)

    update bulk_moveable flag

Parameters

struct ttm_buffer_object *bo
BO which was removed from the LRU

Description

Make sure the bulk_moveable flag is updated when a BO is removed from the LRU.

void **amdgpu_vm_move_to_lru_tail**(struct amdgpu_device *adev, struct amdgpu_vm *vm)
move all BOs to the end of LRU

Parameters

struct amdgpu_device *adev
amdgpu device pointer

struct amdgpu_vm *vm
vm providing the BOs

Description

Move all BOs to the end of LRU and remember their positions to put them together.

int **amdgpu_vm_validate_pt_bos**(struct amdgpu_device *adev, struct amdgpu_vm *vm, int (*validate)(void *p, struct amdgpu_bo *bo), void *param)
validate the page table BOs

Parameters

struct amdgpu_device *adev
amdgpu device pointer

struct amdgpu_vm *vm
vm providing the BOs

int (*validate)(void *p, struct amdgpu_bo *bo)
callback to do the validation

void *param
parameter for the validation callback

Description

Validate the page table BOs on command submission if neccessary.

Return

Validation result.

bool **amdgpu_vm_ready**(struct amdgpu_vm *vm)
check VM is ready for updates

Parameters

struct amdgpu_vm *vm
VM to check

Description

Check if all VM PDs/PTs are ready for updates

Return

True if VM is not evicting.

int **amdgpu_vm_clear_bo**(struct amdgpu_device *adev, struct amdgpu_vm *vm, struct amdgpu_bo *bo, bool immediate)

initially clear the PDs/PTs

Parameters

struct amdgpu_device *adev
amdgpu_device pointer

struct amdgpu_vm *vm
VM to clear BO from

struct amdgpu_bo *bo
BO to clear

bool immediate
use an immediate update

Description

Root PD needs to be reserved when calling this.

Return

0 on success, errno otherwise.

void **amdgpu_vm_bo_param**(struct amdgpu_device *adev, struct amdgpu_vm *vm, int level, bool immediate, struct amdgpu_bo_param *bp)

fill in parameters for PD/PT allocation

Parameters

struct amdgpu_device *adev
amdgpu_device pointer

struct amdgpu_vm *vm
requesting vm

int level
the page table level

bool immediate
use a immediate update

struct amdgpu_bo_param *bp
resulting BO allocation parameters

int **amdgpu_vm_alloc_pts**(struct amdgpu_device *adev, struct amdgpu_vm *vm, struct amdgpu_vm_pt_cursor *cursor, bool immediate)

Allocate a specific page table

Parameters

struct amdgpu_device *adev
    amdgpu_device pointer

struct amdgpu_vm *vm
    VM to allocate page tables for

struct amdgpu_vm_pt_cursor *cursor
    Which page table to allocate

bool immediate
    use an immediate update

Description

Make sure a specific page table or directory is allocated.

Return

1 if page table needed to be allocated, 0 if page table was already allocated, negative errno if an error occurred.

void **amdgpu_vm_free_table**(struct amdgpu_vm_pt *entry)
    fre one PD/PT

Parameters

struct amdgpu_vm_pt *entry
    PDE to free

void **amdgpu_vm_free_pts**(struct amdgpu_device *adev, struct amdgpu_vm *vm, struct amdgpu_vm_pt_cursor *start)
    free PD/PT levels

Parameters

struct amdgpu_device *adev
    amdgpu device structure

struct amdgpu_vm *vm
    amdgpu vm structure

struct amdgpu_vm_pt_cursor *start
    optional cursor where to start freeing PDs/PTs

Description

Free the page directory or page table level and all sub levels.

void **amdgpu_vm_check_compute_bug**(struct amdgpu_device *adev)
    check whether asic has compute vm bug

Parameters

struct amdgpu_device *adev
    amdgpu_device pointer

bool **amdgpu_vm_need_pipeline_sync**(struct amdgpu_ring *ring, struct amdgpu_job *job)
    Check if pipe sync is needed for job.

Parameters

`struct amdgpu_ring *ring`
ring on which the job will be submitted

`struct amdgpu_job *job`
job to submit

Return

True if sync is needed.

int **`amdgpu_vm_flush`**(struct amdgpu_ring *ring, struct amdgpu_job *job, bool need_pipe_sync)

hardware flush the vm

Parameters

`struct amdgpu_ring *ring`
ring to use for flush

`struct amdgpu_job *job`
related job

`bool need_pipe_sync`
is pipe sync needed

Description

Emit a VM flush when it is necessary.

Return

0 on success, errno otherwise.

struct amdgpu_bo_va ***`amdgpu_vm_bo_find`**(struct amdgpu_vm *vm, struct amdgpu_bo *bo)

find the bo_va for a specific vm & bo

Parameters

`struct amdgpu_vm *vm`
requested vm

`struct amdgpu_bo *bo`
requested buffer object

Description

Find **bo** inside the requested vm. Search inside the **bos** vm list for the requested vm Returns the found bo_va or NULL if none is found

Object has to be reserved!

Return

Found bo_va or NULL.

uint64_t **`amdgpu_vm_map_gart`**(const dma_addr_t *pages_addr, uint64_t addr)

Resolve gart mapping of addr

Parameters

const dma_addr_t *pages_addr
optional DMA address to use for lookup

uint64_t addr
the unmapped addr

Description

Look up the physical address of the page that the pte resolves to.

Return

The pointer for the page table entry.

int **amdgpu_vm_update_pde**(struct amdgpu_vm_update_params *params, struct amdgpu_vm *vm, struct amdgpu_vm_pt *entry)

update a single level in the hierarchy

Parameters

struct amdgpu_vm_update_params *params
parameters for the update

struct amdgpu_vm *vm
requested vm

struct amdgpu_vm_pt *entry
entry to update

Description

Makes sure the requested entry in parent is up to date.

void **amdgpu_vm_invalidate_pds**(struct amdgpu_device *adev, struct amdgpu_vm *vm)

mark all PDs as invalid

Parameters

struct amdgpu_device *adev
amdgpu_device pointer

struct amdgpu_vm *vm
related vm

Description

Mark all PD level as invalid after an error.

int **amdgpu_vm_update_pdes**(struct amdgpu_device *adev, struct amdgpu_vm *vm, bool immediate)

make sure that all directories are valid

Parameters

struct amdgpu_device *adev
amdgpu_device pointer

struct amdgpu_vm *vm
requested vm

bool immediate
submit immediately to the paging queue

Description

Makes sure all directories are up to date.

Return

0 for success, error for failure.

void **amdgpu_vm_fragment**(struct amdgpu_vm_update_params *params, uint64_t start, uint64_t end, uint64_t flags, unsigned int *frag, uint64_t *frag_end)

get fragment for PTEs

Parameters

struct amdgpu_vm_update_params *params
see amdgpu_vm_update_params definition

uint64_t start
first PTE to handle

uint64_t end
last PTE to handle

uint64_t flags
hw mapping flags

unsigned int *frag
resulting fragment size

uint64_t *frag_end
end of this fragment

Description

Returns the first possible fragment for the start and end address.

int **amdgpu_vm_update_ptes**(struct amdgpu_vm_update_params *params, uint64_t start, uint64_t end, uint64_t dst, uint64_t flags)

make sure that page tables are valid

Parameters

struct amdgpu_vm_update_params *params
see amdgpu_vm_update_params definition

uint64_t start
start of GPU address range

uint64_t end
end of GPU address range

uint64_t dst
destination address to map to, the next dst inside the function

uint64_t flags
mapping flags

Description

Update the page tables in the range **start** - **end**.

Return

0 for success, -EINVAL for failure.

int **amdgpu_vm_bo_update_mapping**(struct amdgpu_device *adev, struct amdgpu_vm *vm, bool immediate, bool unlocked, struct dma_resv *resv, uint64_t start, uint64_t last, uint64_t flags, uint64_t addr, dma_addr_t *pages_addr, struct dma_fence **fence)

update a mapping in the vm page table

Parameters

struct amdgpu_device *adev
amdgpu_device pointer

struct amdgpu_vm *vm
requested vm

bool immediate
immediate submission in a page fault

bool unlocked
unlocked invalidation during MM callback

struct dma_resv *resv
fences we need to sync to

uint64_t start
start of mapped range

uint64_t last
last mapped entry

uint64_t flags
flags for the entries

uint64_t addr
addr to set the area to

dma_addr_t *pages_addr
DMA addresses to use for mapping

struct dma_fence **fence
optional resulting fence

Description

Fill in the page table entries between **start** and **last**.

Return

0 for success, -EINVAL for failure.

int **amdgpu_vm_bo_split_mapping**(struct amdgpu_device *adev, struct dma_resv *resv, dma_addr_t *pages_addr, struct amdgpu_vm *vm, struct amdgpu_bo_va_mapping *mapping, uint64_t flags, struct amdgpu_device *bo_adev, struct *drm_mm_node* *nodes, struct dma_fence **fence)

split a mapping into smaller chunks

Parameters

struct amdgpu_device *adev
amdgpu_device pointer

struct dma_resv *resv
fences we need to sync to

dma_addr_t *pages_addr
DMA addresses to use for mapping

struct amdgpu_vm *vm
requested vm

struct amdgpu_bo_va_mapping *mapping
mapped range and flags to use for the update

uint64_t flags
HW flags for the mapping

struct amdgpu_device *bo_adev
amdgpu_device pointer that bo actually been allocated

struct drm_mm_node *nodes
array of drm_mm_nodes with the MC addresses

struct dma_fence **fence
optional resulting fence

Description

Split the mapping into smaller chunks so that each update fits into a SDMA IB.

Return

0 for success, -EINVAL for failure.

int **amdgpu_vm_bo_update**(struct amdgpu_device *adev, struct amdgpu_bo_va *bo_va, bool clear)

update all BO mappings in the vm page table

Parameters

struct amdgpu_device *adev
amdgpu_device pointer

struct amdgpu_bo_va *bo_va
requested BO and VM object

bool clear
if true clear the entries

Description

Fill in the page table entries for **bo_va**.

Return

0 for success, -EINVAL for failure.

void **amdgpu_vm_update_prt_state**(struct amdgpu_device *adev)
update the global PRT state

Parameters

struct amdgpu_device *adev
amdgpu_device pointer

void **amdgpu_vm_prt_get**(struct amdgpu_device *adev)
add a PRT user

Parameters

struct amdgpu_device *adev
amdgpu_device pointer

void **amdgpu_vm_prt_put**(struct amdgpu_device *adev)
drop a PRT user

Parameters

struct amdgpu_device *adev
amdgpu_device pointer

void **amdgpu_vm_prt_cb**(struct dma_fence *fence, struct dma_fence_cb *_cb)
callback for updating the PRT status

Parameters

struct dma_fence *fence
fence for the callback

struct dma_fence_cb *_cb
the callback function

void **amdgpu_vm_add_prt_cb**(struct amdgpu_device *adev, struct dma_fence *fence)
add callback for updating the PRT status

Parameters

struct amdgpu_device *adev
amdgpu_device pointer

struct dma_fence *fence
fence for the callback

void **amdgpu_vm_free_mapping**(struct amdgpu_device *adev, struct amdgpu_vm *vm, struct amdgpu_bo_va_mapping *mapping, struct dma_fence *fence)
free a mapping

Parameters

struct amdgpu_device *adev
amdgpu_device pointer

struct amdgpu_vm *vm
requested vm

struct amdgpu_bo_va_mapping *mapping
mapping to be freed

struct dma_fence *fence
fence of the unmap operation

Description

Free a mapping and make sure we decrease the PRT usage count if applicable.

void **amdgpu_vm_prt_fini**(struct amdgpu_device *adev, struct amdgpu_vm *vm)
finish all prt mappings

Parameters

struct amdgpu_device *adev
amdgpu_device pointer

struct amdgpu_vm *vm
requested vm

Description

Register a cleanup callback to disable PRT support after VM dies.

int **amdgpu_vm_clear_freed**(struct amdgpu_device *adev, struct amdgpu_vm *vm, struct dma_fence **fence)
clear freed BOs in the PT

Parameters

struct amdgpu_device *adev
amdgpu_device pointer

struct amdgpu_vm *vm
requested vm

struct dma_fence **fence
optional resulting fence (unchanged if no work needed to be done or if an error occurred)

Description

Make sure all freed BOs are cleared in the PT. PTs have to be reserved and mutex must be locked!

Return

0 for success.

int **amdgpu_vm_handle_moved**(struct amdgpu_device *adev, struct amdgpu_vm *vm)
handle moved BOs in the PT

Parameters

struct amdgpu_device *adev
amdgpu_device pointer

struct amdgpu_vm *vm
requested vm

Description

Make sure all BOs which are moved are updated in the PTs.

PTs have to be reserved!

Return

0 for success.

struct amdgpu_bo_va ***amdgpu_vm_bo_add**(struct amdgpu_device *adev, struct amdgpu_vm *vm, struct amdgpu_bo *bo)

add a bo to a specific vm

Parameters

struct amdgpu_device *adev
amdgpu_device pointer

struct amdgpu_vm *vm
requested vm

struct amdgpu_bo *bo
amdgpu buffer object

Description

Add **bo** into the requested vm. Add **bo** to the list of bos associated with the vm

Object has to be reserved!

Return

Newly added bo_va or NULL for failure

void **amdgpu_vm_bo_insert_map**(struct amdgpu_device *adev, struct amdgpu_bo_va *bo_va, struct amdgpu_bo_va_mapping *mapping)

insert a new mapping

Parameters

struct amdgpu_device *adev
amdgpu_device pointer

struct amdgpu_bo_va *bo_va
bo_va to store the address

struct amdgpu_bo_va_mapping *mapping
the mapping to insert

Description

Insert a new mapping into all structures.

int **amdgpu_vm_bo_map**(struct amdgpu_device *adev, struct amdgpu_bo_va *bo_va, uint64_t saddr, uint64_t offset, uint64_t size, uint64_t flags)

map bo inside a vm

Parameters

struct amdgpu_device *adev
amdgpu_device pointer

struct amdgpu_bo_va *bo_va
bo_va to store the address

uint64_t saddr
where to map the BO

uint64_t offset
requested offset in the BO

uint64_t size
BO size in bytes

uint64_t flags
attributes of pages (read/write/valid/etc.)

Description

Add a mapping of the BO at the specefied addr into the VM.

Object has to be reserved and unreserved outside!

Return

0 for success, error for failure.

int **amdgpu_vm_bo_replace_map**(struct amdgpu_device *adev, struct amdgpu_bo_va *bo_va, uint64_t saddr, uint64_t offset, uint64_t size, uint64_t flags)

map bo inside a vm, replacing existing mappings

Parameters

struct amdgpu_device *adev
amdgpu_device pointer

struct amdgpu_bo_va *bo_va
bo_va to store the address

uint64_t saddr
where to map the BO

uint64_t offset
requested offset in the BO

uint64_t size
BO size in bytes

uint64_t flags
attributes of pages (read/write/valid/etc.)

Description

Add a mapping of the BO at the specefied addr into the VM. Replace existing mappings as we do so.

Object has to be reserved and unreserved outside!

Return

0 for success, error for failure.

int **amdgpu_vm_bo_unmap**(struct amdgpu_device *adev, struct amdgpu_bo_va *bo_va, uint64_t saddr)

remove bo mapping from vm

Parameters

struct amdgpu_device *adev
amdgpu_device pointer

struct amdgpu_bo_va *bo_va
bo_va to remove the address from

uint64_t saddr
where to the BO is mapped

Description

Remove a mapping of the BO at the specefied addr from the VM.

Object has to be reserved and unreserved outside!

Return

0 for success, error for failure.

int **amdgpu_vm_bo_clear_mappings**(struct amdgpu_device *adev, struct amdgpu_vm *vm, uint64_t saddr, uint64_t size)

remove all mappings in a specific range

Parameters

struct amdgpu_device *adev
amdgpu_device pointer

struct amdgpu_vm *vm
VM structure to use

uint64_t saddr
start of the range

uint64_t size
size of the range

Description

Remove all mappings in a range, split them as appropriate.

Return

0 for success, error for failure.

struct amdgpu_bo_va_mapping ***amdgpu_vm_bo_lookup_mapping**(struct amdgpu_vm *vm, uint64_t addr)

find mapping by address

Parameters

struct amdgpu_vm *vm
the requested VM

uint64_t addr
the address

Description

Find a mapping by it’ s address.

Return

The amdgpu_bo_va_mapping matching for addr or NULL

void **amdgpu_vm_bo_trace_cs**(struct amdgpu_vm *vm, struct ww_acquire_ctx *ticket)

trace all reserved mappings

Parameters

struct amdgpu_vm *vm
the requested vm

struct ww_acquire_ctx *ticket
CS ticket

Description

Trace all mappings of BOs reserved during a command submission.

void **amdgpu_vm_bo_rmv**(struct amdgpu_device *adev, struct amdgpu_bo_va *bo_va)

remove a bo to a specific vm

Parameters

struct amdgpu_device *adev
amdgpu_device pointer

struct amdgpu_bo_va *bo_va
requested bo_va

Description

Remove **bo_va->bo** from the requested vm.

Object have to be reserved!

bool **amdgpu_vm_evictable**(struct amdgpu_bo *bo)

check if we can evict a VM

Parameters

struct amdgpu_bo *bo
A page table of the VM.

Description

Check if it is possible to evict a VM.

void **amdgpu_vm_bo_invalidate**(struct amdgpu_device *adev, struct amdgpu_bo *bo, bool evicted)

mark the bo as invalid

Parameters

struct amdgpu_device *adev
amdgpu_device pointer

struct amdgpu_bo *bo
amdgpu buffer object

bool evicted
is the BO evicted

Description

Mark **bo** as invalid.

uint32_t **amdgpu_vm_get_block_size**(uint64_t vm_size)

calculate VM page table size as power of two

Parameters

uint64_t vm_size
VM size

Return

VM page table as power of two

void **amdgpu_vm_adjust_size**(struct amdgpu_device *adev, uint32_t min_vm_size, uint32_t fragment_size_default, unsigned max_level, unsigned max_bits)

adjust vm size, block size and fragment size

Parameters

struct amdgpu_device *adev
amdgpu_device pointer

uint32_t min_vm_size
the minimum vm size in GB if it’s set auto

uint32_t fragment_size_default
Default PTE fragment size

unsigned max_level
max VMPT level

unsigned max_bits
max address space size in bits

long **amdgpu_vm_wait_idle**(struct amdgpu_vm *vm, long timeout)
wait for the VM to become idle

Parameters

struct amdgpu_vm *vm
VM object to wait for

long timeout
timeout to wait for VM to become idle

int **amdgpu_vm_init**(struct amdgpu_device *adev, struct amdgpu_vm *vm, int vm_context, u32 pasid)
initialize a vm instance

Parameters

struct amdgpu_device *adev
amdgpu_device pointer

struct amdgpu_vm *vm
requested vm

int vm_context
Indicates if it GFX or Compute context

u32 pasid
Process address space identifier

Description

Init **vm** fields.

Return

0 for success, error for failure.

int **amdgpu_vm_check_clean_reserved**(struct amdgpu_device *adev, struct amdgpu_vm *vm)
check if a VM is clean

Parameters

struct amdgpu_device *adev
amdgpu_device pointer

struct amdgpu_vm *vm
the VM to check

Description

check all entries of the root PD, if any subsequent PDs are allocated, it means there are page table creating and filling, and is no a clean VM

Return

0 if this VM is clean

int **amdgpu_vm_make_compute**(struct amdgpu_device *adev, struct amdgpu_vm *vm, u32 pasid)
Turn a GFX VM into a compute VM

Parameters

struct amdgpu_device *adev
amdgpu_device pointer

struct amdgpu_vm *vm
requested vm

u32 pasid
pasid to use

Description

This only works on GFX VMs that don't have any BOs added and no page tables allocated yet.

Changes the following VM parameters: - use_cpu_for_update - pte_supports_ats - pasid (old PASID is released, because compute manages its own PASIDs)

Reinitializes the page directory to reflect the changed ATS setting.

Return

0 for success, -errno for errors.

void **amdgpu_vm_release_compute**(struct amdgpu_device *adev, struct amdgpu_vm *vm)
release a compute vm

Parameters

struct amdgpu_device *adev
amdgpu_device pointer

struct amdgpu_vm *vm
a vm turned into compute vm by calling amdgpu_vm_make_compute

Description

This is a correspondant of amdgpu_vm_make_compute. It decouples compute pasid from vm. Compute should stop use of vm after this call.

void **amdgpu_vm_fini**(struct amdgpu_device *adev, struct amdgpu_vm *vm)
tear down a vm instance

Parameters

struct amdgpu_device *adev
amdgpu_device pointer

struct amdgpu_vm *vm
requested vm

Description

Tear down **vm**. Unbind the VM and remove all bos from the vm bo list

void **amdgpu_vm_manager_init**(struct amdgpu_device *adev)
init the VM manager

Parameters

struct amdgpu_device *adev
amdgpu_device pointer

Description

Initialize the VM manager structures

void **amdgpu_vm_manager_fini**(struct amdgpu_device *adev)
cleanup VM manager

Parameters

struct amdgpu_device *adev
amdgpu_device pointer

Description

Cleanup the VM manager and free resources.

int **amdgpu_vm_ioctl**(struct *drm_device* *dev, void *data, struct *drm_file* *filp)
Manages VMID reservation for vm hubs.

Parameters

struct drm_device *dev
drm device pointer

void *data
drm_amdgpu_vm

struct drm_file *filp
drm file pointer

Return

0 for success, -errno for errors.

void **amdgpu_vm_get_task_info**(struct amdgpu_device *adev, u32 pasid, struct amdgpu_task_info *task_info)
Extracts task info for a PASID.

Parameters

struct amdgpu_device *adev
drm device pointer

u32 pasid
PASID identifier for VM

struct amdgpu_task_info *task_info
task_info to fill.

void **amdgpu_vm_set_task_info**(struct amdgpu_vm *vm)
Sets VMs task info.

Parameters

struct amdgpu_vm *vm
vm for which to set the info

bool **`amdgpu_vm_handle_fault`**(struct amdgpu_device *adev, u32 pasid, uint64_t addr)

graceful handling of VM faults.

Parameters

`struct amdgpu_device *adev`
amdgpu device pointer

`u32 pasid`
PASID of the VM

`uint64_t addr`
Address of the fault

Description

Try to gracefully handle a VM fault. Return true if the fault was handled and shouldn't be reported any more.

Interrupt Handling

Interrupts generated within GPU hardware raise interrupt requests that are passed to amdgpu IRQ handler which is responsible for detecting source and type of the interrupt and dispatching matching handlers. If handling an interrupt requires calling kernel functions that may sleep processing is dispatched to work handlers.

If MSI functionality is not disabled by module parameter then MSI support will be enabled.

For GPU interrupt sources that may be driven by another driver, IRQ domain support is used (with mapping between virtual and hardware IRQs).

void **`amdgpu_hotplug_work_func`**(struct work_struct *work)

work handler for display hotplug event

Parameters

`struct work_struct *work`
work struct pointer

Description

This is the hotplug event work handler (all ASICs). The work gets scheduled from the IRQ handler if there was a hotplug interrupt. It walks through the connector table and calls hotplug handler for each connector. After this, it sends a DRM hotplug event to alert userspace.

This design approach is required in order to defer hotplug event handling from the IRQ handler to a work handler because hotplug handler has to use mutexes which cannot be locked in an IRQ handler (since `mutex_lock` may sleep).

void **`amdgpu_irq_disable_all`**(struct amdgpu_device *adev)

disable *all* interrupts

Parameters

struct amdgpu_device *adev
  amdgpu device pointer

Description

Disable all types of interrupts from all sources.

irqreturn_t **amdgpu_irq_handler**(int irq, void *arg)
  IRQ handler

Parameters

int irq
  IRQ number (unused)

void *arg
  pointer to DRM device

Description

IRQ handler for amdgpu driver (all ASICs).

Return

result of handling the IRQ, as defined by `irqreturn_t`

void **amdgpu_irq_handle_ih1**(struct work_struct *work)
  kick of processing for IH1

Parameters

struct work_struct *work
  work structure in struct amdgpu_irq

Description

Kick of processing IH ring 1.

void **amdgpu_irq_handle_ih2**(struct work_struct *work)
  kick of processing for IH2

Parameters

struct work_struct *work
  work structure in struct amdgpu_irq

Description

Kick of processing IH ring 2.

bool **amdgpu_msi_ok**(struct amdgpu_device *adev)
  check whether MSI functionality is enabled

Parameters

struct amdgpu_device *adev
  amdgpu device pointer (unused)

Description

Checks whether MSI functionality has been disabled via module parameter (all ASICs).

Return

true if MSIs are allowed to be enabled or *false* otherwise

int **amdgpu_irq_init**(struct amdgpu_device *adev)
initialize interrupt handling

Parameters

struct amdgpu_device *adev
amdgpu device pointer

Description

Sets up work functions for hotplug and reset interrupts, enables MSI functionality, initializes vblank, hotplug and reset interrupt handling.

Return

0 on success or error code on failure

void **amdgpu_irq_fini**(struct amdgpu_device *adev)
shut down interrupt handling

Parameters

struct amdgpu_device *adev
amdgpu device pointer

Description

Tears down work functions for hotplug and reset interrupts, disables MSI functionality, shuts down vblank, hotplug and reset interrupt handling, turns off interrupts from all sources (all ASICs).

int **amdgpu_irq_add_id**(struct amdgpu_device *adev, unsigned client_id, unsigned src_id, struct amdgpu_irq_src *source)
register IRQ source

Parameters

struct amdgpu_device *adev
amdgpu device pointer

unsigned client_id
client id

unsigned src_id
source id

struct amdgpu_irq_src *source
IRQ source pointer

Description

Registers IRQ source on a client.

Return

0 on success or error code otherwise

void **amdgpu_irq_dispatch**(struct amdgpu_device *adev, struct amdgpu_ih_ring *ih)

dispatch IRQ to IP blocks

Parameters

struct amdgpu_device *adev
amdgpu device pointer

struct amdgpu_ih_ring *ih
interrupt ring instance

Description

Dispatches IRQ to IP blocks.

int **amdgpu_irq_update**(struct amdgpu_device *adev, struct amdgpu_irq_src *src, unsigned type)

update hardware interrupt state

Parameters

struct amdgpu_device *adev
amdgpu device pointer

struct amdgpu_irq_src *src
interrupt source pointer

unsigned type
type of interrupt

Description

Updates interrupt state for the specific source (all ASICs).

void **amdgpu_irq_gpu_reset_resume_helper**(struct amdgpu_device *adev)

update interrupt states on all sources

Parameters

struct amdgpu_device *adev
amdgpu device pointer

Description

Updates state of all types of interrupts on all sources on resume after reset.

int **amdgpu_irq_get**(struct amdgpu_device *adev, struct amdgpu_irq_src *src, unsigned type)

enable interrupt

Parameters

struct amdgpu_device *adev
amdgpu device pointer

struct amdgpu_irq_src *src
interrupt source pointer

unsigned type
type of interrupt

Description

Enables specified type of interrupt on the specified source (all ASICs).

Return

0 on success or error code otherwise

int **amdgpu_irq_put**(struct amdgpu_device *adev, struct amdgpu_irq_src *src, unsigned type)

disable interrupt

Parameters

struct amdgpu_device *adev
amdgpu device pointer

struct amdgpu_irq_src *src
interrupt source pointer

unsigned type
type of interrupt

Description

Enables specified type of interrupt on the specified source (all ASICs).

Return

0 on success or error code otherwise

bool **amdgpu_irq_enabled**(struct amdgpu_device *adev, struct amdgpu_irq_src *src, unsigned type)

check whether interrupt is enabled or not

Parameters

struct amdgpu_device *adev
amdgpu device pointer

struct amdgpu_irq_src *src
interrupt source pointer

unsigned type
type of interrupt

Description

Checks whether the given type of interrupt is enabled on the given source.

Return

true if interrupt is enabled, *false* if interrupt is disabled or on invalid parameters

int **amdgpu_irqdomain_map**(struct irq_domain *d, unsigned int irq, irq_hw_number_t hwirq)

create mapping between virtual and hardware IRQ numbers

Parameters

struct irq_domain *d
amdgpu IRQ domain pointer (unused)

unsigned int irq
  virtual IRQ number

irq_hw_number_t hwirq
  hardware irq number

Description

Current implementation assigns simple interrupt handler to the given virtual IRQ.

Return

0 on success or error code otherwise

int **amdgpu_irq_add_domain**(struct amdgpu_device *adev)
  create a linear IRQ domain

Parameters

struct amdgpu_device *adev
  amdgpu device pointer

Description

Creates an IRQ domain for GPU interrupt sources that may be driven by another driver (e.g., ACP).

Return

0 on success or error code otherwise

void **amdgpu_irq_remove_domain**(struct amdgpu_device *adev)
  remove the IRQ domain

Parameters

struct amdgpu_device *adev
  amdgpu device pointer

Description

Removes the IRQ domain for GPU interrupt sources that may be driven by another driver (e.g., ACP).

unsigned **amdgpu_irq_create_mapping**(struct amdgpu_device *adev, unsigned src_id)
  create mapping between domain Linux IRQs

Parameters

struct amdgpu_device *adev
  amdgpu device pointer

unsigned src_id
  IH source id

Description

Creates mapping between a domain IRQ (GPU IH src id) and a Linux IRQ Use this for components that generate a GPU interrupt, but are driven by a different driver (e.g., ACP).

Return

Linux IRQ

IP Blocks

GPUs are composed of IP (intellectual property) blocks. These IP blocks provide various functionalities: display, graphics, video decode, etc. The IP blocks that comprise a particular GPU are listed in the GPU' s respective SoC file. amdgpu_device.c acquires the list of IP blocks for the GPU in use on initialization. It can then operate on this list to perform standard driver operations such as: init, fini, suspend, resume, etc.

IP block implementations are named using the following convention: <functionality>_v<version> (E.g.: gfx_v6_0).

enum **amd_ip_block_type**

Used to classify IP blocks by functionality.

Constants

AMD_IP_BLOCK_TYPE_COMMON
GPU Family

AMD_IP_BLOCK_TYPE_GMC
Graphics Memory Controller

AMD_IP_BLOCK_TYPE_IH
Interrupt Handler

AMD_IP_BLOCK_TYPE_SMC
System Management Controller

AMD_IP_BLOCK_TYPE_PSP
Platform Security Processor

AMD_IP_BLOCK_TYPE_DCE
Display and Compositing Engine

AMD_IP_BLOCK_TYPE_GFX
Graphics and Compute Engine

AMD_IP_BLOCK_TYPE_SDMA
System DMA Engine

AMD_IP_BLOCK_TYPE_UVD
Unified Video Decoder

AMD_IP_BLOCK_TYPE_VCE
Video Compression Engine

AMD_IP_BLOCK_TYPE_ACP
Audio Co-Processor

AMD_IP_BLOCK_TYPE_VCN
Video Core/Codec Next

AMD_IP_BLOCK_TYPE_MES
Micro-Engine Scheduler

AMD_IP_BLOCK_TYPE_JPEG
JPEG Engine

struct **amd_ip_funcs**
general hooks for managing amdgpu IP Blocks

Definition

```
struct amd_ip_funcs {
  char *name;
  int (*early_init)(void *handle);
  int (*late_init)(void *handle);
  int (*sw_init)(void *handle);
  int (*sw_fini)(void *handle);
  int (*hw_init)(void *handle);
  int (*hw_fini)(void *handle);
  void (*late_fini)(void *handle);
  int (*suspend)(void *handle);
  int (*resume)(void *handle);
  bool (*is_idle)(void *handle);
  int (*wait_for_idle)(void *handle);
  bool (*check_soft_reset)(void *handle);
  int (*pre_soft_reset)(void *handle);
  int (*soft_reset)(void *handle);
  int (*post_soft_reset)(void *handle);
  int (*set_clockgating_state)(void *handle, enum amd_clockgating_
↪state state);
  int (*set_powergating_state)(void *handle, enum amd_powergating_
↪state state);
  void (*get_clockgating_state)(void *handle, u32 *flags);
  int (*enable_umd_pstate)(void *handle, enum amd_dpm_forced_level␣
↪*level);
};
```

Members

name
Name of IP block

early_init
sets up early driver state (pre sw_init), does not configure hw - Optional

late_init
sets up late driver/hw state (post hw_init) - Optional

sw_init
sets up driver state, does not configure hw

sw_fini
tears down driver state, does not configure hw

hw_init
sets up the hw state

hw_fini
tears down the hw state

late_fini
    final cleanup

suspend
    handles IP specific hw/sw changes for suspend

resume
    handles IP specific hw/sw changes for resume

is_idle
    returns current IP block idle status

wait_for_idle
    poll for idle

check_soft_reset
    check soft reset the IP block

pre_soft_reset
    pre soft reset the IP block

soft_reset
    soft reset the IP block

post_soft_reset
    post soft reset the IP block

set_clockgating_state
    enable/disable cg for the IP block

set_powergating_state
    enable/disable pg for the IP block

get_clockgating_state
    get current clockgating status

enable_umd_pstate
    enable UMD powerstate

Description

These hooks provide an interface for controlling the operational state of IP blocks. After acquiring a list of IP blocks for the GPU in use, the driver can make chip-wide state changes by walking this list and making calls to hooks from each IP block. This list is ordered to ensure that the driver initializes the IP blocks in a safe sequence.

8.1.3 AMDGPU XGMI Support

AMDGPU XGMI Support

XGMI is a high speed interconnect that joins multiple GPU cards into a homogeneous memory space that is organized by a collective hive ID and individual node IDs, both of which are 64-bit numbers.

The file xgmi_device_id contains the unique per GPU device ID and is stored in the /sys/class/drm/card${cardno}/device/ directory.

Inside the device directory a sub-directory 'xgmi_hive_info' is created which contains the hive ID and the list of nodes.

The hive ID is stored in:
/sys/class/drm/card${cardno}/device/xgmi_hive_info/xgmi_hive_id

The node information is stored in numbered directories:
/sys/class/drm/card${cardno}/device/xgmi_hive_info/node${nodeno}/xgmi_device_id

Each device has their own xgmi_hive_info direction with a mirror set of node subdirectories.

The XGMI memory space is built by contiguously adding the power of two padded VRAM space from each node to each other.

8.1.4 AMDGPU RAS Support

The AMDGPU RAS interfaces are exposed via sysfs (for informational queries) and debugfs (for error injection).

RAS debugfs/sysfs Control and Error Injection Interfaces

It accepts struct ras_debug_if who has two members.

First member: ras_debug_if::head or ras_debug_if::inject.

head is used to indicate which IP block will be under control.

head has four members, they are block, type, sub_block_index, name. block: which IP will be under control. type: what kind of error will be enabled/disabled/injected. sub_block_index: some IPs have subcomponets. say, GFX, sDMA. name: the name of IP.

inject has two more members than head, they are address, value. As their names indicate, inject operation will write the value to the address.

The second member: struct ras_debug_if::op. It has three kinds of operations.

- 0: disable RAS on the block. Take ::head as its data.
- 1: enable RAS on the block. Take ::head as its data.
- 2: inject errors on the block. Take ::inject as its data.

How to use the interface?

Programs

Copy the struct ras_debug_if in your codes and initialize it. Write the struct to the control node.

Shells

```
echo op block [error [sub_block address value]] > .../ras/ras_ctrl
```

Parameters:

op: disable, enable, inject
disable: only block is needed enable: block and error are needed inject: error, address, value are needed

block: umc, sdma, gfx, ………
see ras_block_string[] for details

error: ue, ce
ue: multi_uncorrectable ce: single_correctable

sub_block:
sub block index, pass 0 if there is no sub block

here are some examples for bash commands:

```
echo inject umc ue 0x0 0x0 0x0 > /sys/kernel/debug/dri/0/ras/ras_
↪ctrl
echo inject umc ce 0 0 0 > /sys/kernel/debug/dri/0/ras/ras_ctrl
echo disable umc > /sys/kernel/debug/dri/0/ras/ras_ctrl
```

How to check the result?

For disable/enable, please check ras features at /sys/class/drm/card[0/1/2…]/device/ras/features

For inject, please check corresponding err count at /sys/class/drm/card[0/1/2…]/device/ras/[gfx/sdma/…]_err_count

Note: Operations are only allowed on blocks which are supported. Please check ras mask at /sys/module/amdgpu/parameters/ras_mask to see which blocks support RAS on a particular asic.

RAS Reboot Behavior for Unrecoverable Errors

Normally when there is an uncorrectable error, the driver will reset the GPU to recover. However, in the event of an unrecoverable error, the driver provides an interface to reboot the system automatically in that event.

The following file in debugfs provides that interface: /sys/kernel/debug/dri/[0/1/2 …]/ras/auto_reboot

Usage:

```
echo true > .../ras/auto_reboot
```

RAS Error Count sysfs Interface

It allows the user to read the error count for each IP block on the gpu through /sys/class/drm/card[0/1/2⋯]/device/ras/[gfx/sdma/⋯]_err_count

It outputs the multiple lines which report the uncorrected (ue) and corrected (ce) error counts.

The format of one line is below,

[ce|ue]: count

Example:

```
ue: 0
ce: 1
```

RAS EEPROM debugfs Interface

Some boards contain an EEPROM which is used to persistently store a list of bad pages which experiences ECC errors in vram. This interface provides a way to reset the EEPROM, e.g., after testing error injection.

Usage:

```
echo 1 > ../ras/ras_eeprom_reset
```

will reset EEPROM table to 0 entries.

RAS VRAM Bad Pages sysfs Interface

It allows user to read the bad pages of vram on the gpu through /sys/class/drm/card[0/1/2⋯]/device/ras/gpu_vram_bad_pages

It outputs multiple lines, and each line stands for one gpu page.

The format of one line is below, gpu pfn : gpu page size : flags

gpu pfn and gpu page size are printed in hex format. flags can be one of below character,

R: reserved, this gpu page is reserved and not able to use.

P: pending for reserve, this gpu page is marked as bad, will be reserved in next window of page_reserve.

F: unable to reserve. this gpu page can't be reserved due to some reasons.

Examples:

```
0x00000001 : 0x00001000 : R
0x00000002 : 0x00001000 : P
```

Sample Code

Sample code for testing error injection can be found here: https://cgit.freedesktop.org/mesa/drm/tree/tests/amdgpu/ras_tests.c

This is part of the libdrm amdgpu unit tests which cover several areas of the GPU. There are four sets of tests:

RAS Basic Test

The test verifies the RAS feature enabled status and makes sure the necessary sysfs and debugfs files are present.

RAS Query Test

This test checks the RAS availability and enablement status for each supported IP block as well as the error counts.

RAS Inject Test

This test injects errors for each IP.

RAS Disable Test

This test tests disabling of RAS features for each IP block.

8.1.5 GPU Power/Thermal Controls and Monitoring

This section covers hwmon and power/thermal controls.

HWMON Interfaces

The amdgpu driver exposes the following sensor interfaces:

- GPU temperature (via the on-die sensor)
- GPU voltage
- Northbridge voltage (APUs only)
- GPU power
- GPU fan
- GPU gfx/compute engine clock
- GPU memory clock (dGPU only)

hwmon interfaces for GPU temperature:

- temp[1-3]_input: the on die GPU temperature in millidegrees Celsius - temp2_input and temp3_input are supported on SOC15 dGPUs only
- temp[1-3]_label: temperature channel label - temp2_label and temp3_label are supported on SOC15 dGPUs only
- temp[1-3]_crit: temperature critical max value in millidegrees Celsius - temp2_crit and temp3_crit are supported on SOC15 dGPUs only

- temp[1-3]_crit_hyst: temperature hysteresis for critical limit in millidegrees Celsius - temp2_crit_hyst and temp3_crit_hyst are supported on SOC15 dGPUs only
- temp[1-3]_emergency: temperature emergency max value(asic shutdown) in millidegrees Celsius - these are supported on SOC15 dGPUs only

hwmon interfaces for GPU voltage:

- in0_input: the voltage on the GPU in millivolts
- in1_input: the voltage on the Northbridge in millivolts

hwmon interfaces for GPU power:

- power1_average: average power used by the GPU in microWatts
- power1_cap_min: minimum cap supported in microWatts
- power1_cap_max: maximum cap supported in microWatts
- power1_cap: selected power cap in microWatts

hwmon interfaces for GPU fan:

- pwm1: pulse width modulation fan level (0-255)
- pwm1_enable: pulse width modulation fan control method (0: no fan speed control, 1: manual fan speed control using pwm interface, 2: automatic fan speed control)
- pwm1_min: pulse width modulation fan control minimum level (0)
- pwm1_max: pulse width modulation fan control maximum level (255)
- fan1_min: an minimum value Unit: revolution/min (RPM)
- fan1_max: an maxmum value Unit: revolution/max (RPM)
- fan1_input: fan speed in RPM
- fan[1-*]_target: Desired fan speed Unit: revolution/min (RPM)
- fan[1-*]_enable: Enable or disable the sensors.1: Enable 0: Disable

hwmon interfaces for GPU clocks:

- freq1_input: the gfx/compute clock in hertz
- freq2_input: the memory clock in hertz

You can use hwmon tools like sensors to view this information on your system.

GPU sysfs Power State Interfaces

GPU power controls are exposed via sysfs files.

power_dpm_state

The power_dpm_state file is a legacy interface and is only provided for backwards compatibility. The amdgpu driver provides a sysfs API for adjusting certain power related parameters. The file power_dpm_state is used for this. It accepts the following arguments:

- battery
- balanced
- performance

battery

On older GPUs, the vbios provided a special power state for battery operation. Selecting battery switched to this state. This is no longer provided on newer GPUs so the option does nothing in that case.

balanced

On older GPUs, the vbios provided a special power state for balanced operation. Selecting balanced switched to this state. This is no longer provided on newer GPUs so the option does nothing in that case.

performance

On older GPUs, the vbios provided a special power state for performance operation. Selecting performance switched to this state. This is no longer provided on newer GPUs so the option does nothing in that case.

power_dpm_force_performance_level

The amdgpu driver provides a sysfs API for adjusting certain power related parameters. The file power_dpm_force_performance_level is used for this. It accepts the following arguments:

- auto
- low
- high
- manual
- profile_standard
- profile_min_sclk
- profile_min_mclk
- profile_peak

auto

When auto is selected, the driver will attempt to dynamically select the optimal power profile for current conditions in the driver.

low

When low is selected, the clocks are forced to the lowest power state.

high

When high is selected, the clocks are forced to the highest power state.

manual

When manual is selected, the user can manually adjust which power states are enabled for each clock domain via the sysfs pp_dpm_mclk, pp_dpm_sclk, and pp_dpm_pcie files and adjust the power state transition heuristics via the pp_power_profile_mode sysfs file.

profile_standard profile_min_sclk profile_min_mclk profile_peak

When the profiling modes are selected, clock and power gating are disabled and the clocks are set for different profiling cases. This mode is recommended for profiling specific work loads where you do not want clock or power gating for clock fluctuation to interfere with your results. profile_standard sets the clocks to a fixed clock level which varies from asic to asic. profile_min_sclk forces the sclk to the lowest level. profile_min_mclk forces the mclk to the lowest level. profile_peak sets all clocks (mclk, sclk, pcie) to the highest levels.

pp_table

The amdgpu driver provides a sysfs API for uploading new powerplay tables. The file pp_table is used for this. Reading the file will dump the current power play table. Writing to the file will attempt to upload a new powerplay table and re-initialize powerplay using that new table.

pp_od_clk_voltage

The amdgpu driver provides a sysfs API for adjusting the clocks and voltages in each power level within a power state. The pp_od_clk_voltage is used for this.

Note that the actual memory controller clock rate are exposed, not the effective memory clock of the DRAMs. To translate it, use the following formula:

Clock conversion (Mhz):

HBM: effective_memory_clock = memory_controller_clock * 1

G5: effective_memory_clock = memory_controller_clock * 1

G6: effective_memory_clock = memory_controller_clock * 2

DRAM data rate (MT/s):

HBM: effective_memory_clock * 2 = data_rate

G5: effective_memory_clock * 4 = data_rate

G6: effective_memory_clock * 8 = data_rate

Bandwidth (MB/s):

data_rate * vram_bit_width / 8 = memory_bandwidth

Some examples:

G5 on RX460:

memory_controller_clock = 1750 Mhz

effective_memory_clock = 1750 Mhz * 1 = 1750 Mhz

data rate = 1750 * 4 = 7000 MT/s

memory_bandwidth = 7000 * 128 bits / 8 = 112000 MB/s

G6 on RX5700:

memory_controller_clock = 875 Mhz

effective_memory_clock = 875 Mhz * 2 = 1750 Mhz

data rate = 1750 * 8 = 14000 MT/s

memory_bandwidth = 14000 * 256 bits / 8 = 448000 MB/s

< For Vega10 and previous ASICs >

Reading the file will display:

- a list of engine clock levels and voltages labeled OD_SCLK
- a list of memory clock levels and voltages labeled OD_MCLK
- a list of valid ranges for sclk, mclk, and voltage labeled OD_RANGE

To manually adjust these settings, first select manual using power_dpm_force_performance_level. Enter a new value for each level by writing a string that contains "s/m level clock voltage" to the file. E.g., "s 1 500 820" will update sclk level 1 to be 500 MHz at 820 mV; "m 0 350 810" will update mclk level 0 to be 350 MHz at 810 mV. When you have edited all of the states as needed, write "c" (commit) to the file to commit your changes. If you want to reset to the default power levels, write "r" (reset) to the file to reset them.

< For Vega20 and newer ASICs >

Reading the file will display:

- minimum and maximum engine clock labeled OD_SCLK
- maximum memory clock labeled OD_MCLK
- three <frequency, voltage> points labeled OD_VDDC_CURVE. They can be used to calibrate the sclk voltage curve.
- a list of valid ranges for sclk, mclk, and voltage curve points labeled OD_RANGE

To manually adjust these settings:

- First select manual using power_dpm_force_performance_level

- For clock frequency setting, enter a new value by writing a string that contains "s/m index clock" to the file. The index should be 0 if to set minimum clock. And 1 if to set maximum clock. E.g., "s 0 500" will update minimum sclk to be 500 MHz. "m 1 800" will update maximum mclk to be 800Mhz.

  For sclk voltage curve, enter the new values by writing a string that contains "vc point clock voltage" to the file. The points are indexed by 0, 1 and 2. E.g., "vc 0 300 600" will update point1 with clock set as 300Mhz and voltage as 600mV. "vc 2 1000 1000" will update point3 with clock set as 1000Mhz and voltage 1000mV.
- When you have edited all of the states as needed, write "c" (commit) to the file to commit your changes
- If you want to reset to the default power levels, write "r" (reset) to the file to reset them

pp_dpm_*

The amdgpu driver provides a sysfs API for adjusting what power levels are enabled for a given power state. The files pp_dpm_sclk, pp_dpm_mclk, pp_dpm_socclk, pp_dpm_fclk, pp_dpm_dcefclk and pp_dpm_pcie are used for this.

pp_dpm_socclk and pp_dpm_dcefclk interfaces are only available for Vega10 and later ASICs. pp_dpm_fclk interface is only available for Vega20 and later ASICs.

Reading back the files will show you the available power levels within the power state and the clock information for those levels.

To manually adjust these states, first select manual using power_dpm_force_performance_level. Secondly, enter a new value for each level by inputing a string that contains "echo xx xx xx > pp_dpm_sclk/mclk/pcie" E.g.,

```
echo "4 5 6" > pp_dpm_sclk
```

will enable sclk levels 4, 5, and 6.

NOTE: change to the dcefclk max dpm level is not supported now

pp_power_profile_mode

The amdgpu driver provides a sysfs API for adjusting the heuristics related to switching between power levels in a power state. The file pp_power_profile_mode is used for this.

Reading this file outputs a list of all of the predefined power profiles and the relevant heuristics settings for that profile.

To select a profile or create a custom profile, first select manual using power_dpm_force_performance_level. Writing the number of a predefined profile to pp_power_profile_mode will enable those heuristics. To create a custom set of heuristics, write a string of numbers to the file starting with the number of the custom profile along with a setting for each heuristic parameter. Due to differences across asic families the heuristic parameters vary from family to family.

*_busy_percent

The amdgpu driver provides a sysfs API for reading how busy the GPU is as a percentage. The file gpu_busy_percent is used for this. The SMU firmware computes a percentage of load based on the aggregate activity level in the IP cores.

The amdgpu driver provides a sysfs API for reading how busy the VRAM is as a percentage. The file mem_busy_percent is used for this. The SMU firmware computes a percentage of load based on the aggregate activity level in the IP cores.

gpu_metrics

The amdgpu driver provides a sysfs API for retrieving current gpu metrics data. The file gpu_metrics is used for this. Reading the file will dump all the current gpu metrics data.

These data include temperature, frequency, engines utilization, power consume, throttler status, fan speed and cpu core statistics(available for APU only). That' s it will give a snapshot of all sensors at the same time.

8.1.6 GPU Product Information

Information about the GPU can be obtained on certain cards via sysfs

product_name

The amdgpu driver provides a sysfs API for reporting the product name for the device The file serial_number is used for this and returns the product name as returned from the FRU. NOTE: This is only available for certain server cards

product_number

The amdgpu driver provides a sysfs API for reporting the product name for the device The file serial_number is used for this and returns the product name as returned from the FRU. NOTE: This is only available for certain server cards

serial_number

The amdgpu driver provides a sysfs API for reporting the serial number for the device The file serial_number is used for this and returns the serial number as returned from the FRU. NOTE: This is only available for certain server cards

unique_id

The amdgpu driver provides a sysfs API for providing a unique ID for the GPU The file unique_id is used for this. This will provide a Unique ID that will persist from machine to machine

NOTE: This will only work for GFX9 and newer. This file will be absent on unsupported ASICs (GFX8 and older)

8.1.7 GPU Memory Usage Information

Various memory accounting can be accessed via sysfs

mem_info_vram_total

The amdgpu driver provides a sysfs API for reporting current total VRAM available on the device The file mem_info_vram_total is used for this and returns the total amount of VRAM in bytes

mem_info_vram_used

The amdgpu driver provides a sysfs API for reporting current total VRAM available on the device The file mem_info_vram_used is used for this and returns the total amount of currently used VRAM in bytes

mem_info_vis_vram_total

The amdgpu driver provides a sysfs API for reporting current total visible VRAM available on the device The file mem_info_vis_vram_total is used for this and returns the total amount of visible VRAM in bytes

mem_info_vis_vram_used

The amdgpu driver provides a sysfs API for reporting current total of used visible VRAM The file mem_info_vis_vram_used is used for this and returns the total amount of currently used visible VRAM in bytes

mem_info_gtt_total

The amdgpu driver provides a sysfs API for reporting current total size of the GTT. The file mem_info_gtt_total is used for this, and returns the total size of the GTT block, in bytes

mem_info_gtt_used

The amdgpu driver provides a sysfs API for reporting current total amount of used GTT. The file mem_info_gtt_used is used for this, and returns the current used size of the GTT block, in bytes

8.1.8 PCIe Accounting Information

pcie_bw

The amdgpu driver provides a sysfs API for estimating how much data has been received and sent by the GPU in the last second through PCIe. The file pcie_bw is used for this. The Perf counters count the number of received and sent messages and return those values, as well as the maximum payload size of a PCIe packet (mps). Note that it is not possible to easily and quickly obtain the size of each packet transmitted, so we output the max payload size (mps) to allow for quick estimation of the PCIe bandwidth usage

pcie_replay_count

The amdgpu driver provides a sysfs API for reporting the total number of PCIe replays (NAKs) The file pcie_replay_count is used for this and returns the total number of replays as a sum of the NAKs generated and NAKs received

8.2 drm/amd/display - Display Core (DC)

placeholder - general description of supported platforms, what dc is, etc.

Because it is partially shared with other operating systems, the Display Core Driver is divided in two pieces.

1. **Display Core (DC)** contains the OS-agnostic components. Things like hardware programming and resource management are handled here.
2. **Display Manager (DM)** contains the OS-dependent components. Hooks to the amdgpu base driver and DRM are implemented here.

It doesn't help that the entire package is frequently referred to as DC. But with the context in mind, it should be clear.

When CONFIG_DRM_AMD_DC is enabled, DC will be initialized by default for supported ASICs. To force disable, set *amdgpu.dc=0* on kernel command line. Likewise, to force enable on unsupported ASICs, set *amdgpu.dc=1*.

To determine if DC is loaded, search dmesg for the following entry:

```
Display Core initialized with <version number here>
```

8.2.1 AMDgpu Display Manager

The AMDgpu display manager, **amdgpu_dm** (or even simpler, **dm**) sits between DRM and DC. It acts as a liason, converting DRM requests into DC requests, and DC responses into DRM responses.

The root control structure is *`struct amdgpu_display_manager`*.

struct **`dm_compressor_info`**

Buffer info used by frame buffer compression

Definition

```
struct dm_compressor_info {
  void *cpu_addr;
  struct amdgpu_bo *bo_ptr;
  uint64_t gpu_addr;
};
```

Members

`cpu_addr`
MMIO cpu addr

`bo_ptr`
Pointer to the buffer object

`gpu_addr`
MMIO gpu addr

struct **`amdgpu_dm_backlight_caps`**

Information about backlight

Definition

```
struct amdgpu_dm_backlight_caps {
  union dpcd_sink_ext_caps *ext_caps;
  u32 aux_min_input_signal;
  u32 aux_max_input_signal;
  int min_input_signal;
  int max_input_signal;
  bool caps_valid;
  bool aux_support;
};
```

Members

`ext_caps`
Keep the data struct with all the information about the display support for HDR.

`aux_min_input_signal`
Min brightness value supported by the display

aux_max_input_signal
Max brightness value supported by the display in nits.

min_input_signal
minimum possible input in range 0-255.

max_input_signal
maximum possible input in range 0-255.

caps_valid
true if these values are from the ACPI interface.

aux_support
Describes if the display supports AUX backlight.

Description

Describe the backlight support for ACPI or eDP AUX.

struct **amdgpu_display_manager**
Central amdgpu display manager device

Definition

```
struct amdgpu_display_manager {
  struct dc *dc;
  struct dmub_srv *dmub_srv;
  struct dmub_srv_fb_info *dmub_fb_info;
  const struct firmware *dmub_fw;
  struct amdgpu_bo *dmub_bo;
  u64 dmub_bo_gpu_addr;
  void *dmub_bo_cpu_addr;
  uint32_t dmcub_fw_version;
  struct cgs_device *cgs_device;
  struct amdgpu_device *adev;
  struct drm_device *ddev;
  u16 display_indexes_num;
  struct drm_private_obj atomic_obj;
  struct mutex dc_lock;
  struct mutex audio_lock;
  struct drm_audio_component *audio_component;
  bool audio_registered;
  struct list_head irq_handler_list_low_tab[DAL_IRQ_SOURCES_NUMBER];
  struct list_head irq_handler_list_high_tab[DAL_IRQ_SOURCES_
↪NUMBER];
  struct common_irq_params pflip_params[DC_IRQ_SOURCE_PFLIP_LAST -␣
↪DC_IRQ_SOURCE_PFLIP_FIRST + 1];
  struct common_irq_params vblank_params[DC_IRQ_SOURCE_VBLANK6 - DC_
↪IRQ_SOURCE_VBLANK1 + 1];
  struct common_irq_params vupdate_params[DC_IRQ_SOURCE_VUPDATE6 -␣
↪DC_IRQ_SOURCE_VUPDATE1 + 1];
  spinlock_t irq_handler_list_table_lock;
  struct backlight_device *backlight_dev;
  const struct dc_link *backlight_link;
```

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```
  struct amdgpu_dm_backlight_caps backlight_caps;
  struct mod_freesync *freesync_module;
#ifdef CONFIG_DRM_AMD_DC_HDCP;
  struct hdcp_workqueue *hdcp_workqueue;
#endif;
  struct drm_atomic_state *cached_state;
  struct dc_state *cached_dc_state;
  struct dm_compressor_info compressor;
  const struct firmware *fw_dmcu;
  uint32_t dmcu_fw_version;
  const struct gpu_info_soc_bounding_box_v1_0 *soc_bounding_box;
  struct amdgpu_encoder mst_encoders[AMDGPU_DM_MAX_CRTC];
  bool force_timing_sync;
};
```

Members

dc
: Display Core control structure

dmub_srv
: DMUB service, used for controlling the DMUB on hardware that supports it. The pointer to the dmub_srv will be NULL on hardware that does not support it.

dmub_fb_info
: Framebuffer regions for the DMUB.

dmub_fw
: DMUB firmware, required on hardware that has DMUB support.

dmub_bo
: Buffer object for the DMUB.

dmub_bo_gpu_addr
: GPU virtual address for the DMUB buffer object.

dmub_bo_cpu_addr
: CPU address for the DMUB buffer object.

dmcub_fw_version
: DMCUB firmware version.

cgs_device
: The Common Graphics Services device. It provides an interface for accessing registers.

adev
: AMDGPU base driver structure

ddev
: DRM base driver structure

display_indexes_num
: Max number of display streams supported

atomic_obj
In combination with `dm_atomic_state` it helps manage global atomic state that doesn't map cleanly into existing drm resources, like `dc_context`.

dc_lock
Guards access to DC functions that can issue register write sequences.

audio_lock
Guards access to audio instance changes.

audio_component
Used to notify ELD changes to sound driver.

audio_registered
True if the audio component has been registered successfully, false otherwise.

irq_handler_list_low_tab
Low priority IRQ handler table.

It is a n*m table consisting of n IRQ sources, and m handlers per IRQ source. Low priority IRQ handlers are deferred to a workqueue to be processed. Hence, they can sleep.

Note that handlers are called in the same order as they were registered (FIFO).

irq_handler_list_high_tab
High priority IRQ handler table.

It is a n*m table, same as `irq_handler_list_low_tab`. However, handlers in this table are not deferred and are called immediately.

pflip_params
Page flip IRQ parameters, passed to registered handlers when triggered.

vblank_params
Vertical blanking IRQ parameters, passed to registered handlers when triggered.

vupdate_params
Vertical update IRQ parameters, passed to registered handlers when triggered.

irq_handler_list_table_lock
Synchronizes access to IRQ tables

backlight_dev
Backlight control device

backlight_link
Link on which to control backlight

backlight_caps
Capabilities of the backlight device

freesync_module
Module handling freesync calculations

hdcp_workqueue
AMDGPU content protection queue

cached_state
: Caches device atomic state for suspend/resume

cached_dc_state
: Cached state of content streams

compressor
: Frame buffer compression buffer. See *struct dm_compressor_info*

fw_dmcu
: Reference to DMCU firmware

dmcu_fw_version
: Version of the DMCU firmware

soc_bounding_box
: gpu_info FW provided soc bounding box struct or 0 if not available in FW

mst_encoders
: fake encoders used for DP MST.

force_timing_sync
: set via debugfs. When set, indicates that all connected displays will be forced to synchronize.

Lifecycle

DM (and consequently DC) is registered in the amdgpu base driver as a IP block. When CONFIG_DRM_AMD_DC is enabled, the DM device IP block is added to the base driver's device list to be initialized and torn down accordingly.

The functions to do so are provided as hooks in *struct amd_ip_funcs*.

int **dm_hw_init**(void *handle)

Initialize DC device

Parameters

void *handle
: The base driver device containing the amdgpu_dm device.

Description

Initialize the *struct amdgpu_display_manager* device. This involves calling the initializers of each DM component, then populating the struct with them.

Although the function implies hardware initialization, both hardware and software are initialized here. Splitting them out to their relevant init hooks is a future TODO item.

Some notable things that are initialized here:

- Display Core, both software and hardware
- DC modules that we need (freesync and color management)
- DRM software states
- Interrupt sources and handlers

- Vblank support
- Debug FS entries, if enabled

int **dm_hw_fini**(void *handle)

Teardown DC device

Parameters

void *handle

The base driver device containing the amdgpu_dm device.

Description

Teardown components within *struct amdgpu_display_manager* that require cleanup. This involves cleaning up the DRM device, DC, and any modules that were loaded. Also flush IRQ workqueues and disable them.

Interrupts

DM provides another layer of IRQ management on top of what the base driver already provides. This is something that could be cleaned up, and is a future TODO item.

The base driver provides IRQ source registration with DRM, handler registration into the base driver's IRQ table, and a handler callback *amdgpu_irq_handler()*, with which DRM calls on interrupts. This generic handler looks up the IRQ table, and calls the respective `amdgpu_irq_src_funcs.process` hookups.

What DM provides on top are two IRQ tables specifically for top-half and bottom-half IRQ handling, with the bottom-half implementing workqueues:

- *amdgpu_display_manager.irq_handler_list_high_tab*
- *amdgpu_display_manager.irq_handler_list_low_tab*

They override the base driver's IRQ table, and the effect can be seen in the hooks that DM provides for `amdgpu_irq_src_funcs.process`. They are all set to the DM generic handler *amdgpu_dm_irq_handler()*, which looks up DM's IRQ tables. However, in order for base driver to recognize this hook, DM still needs to register the IRQ with the base driver. See dce110_register_irq_handlers() and dcn10_register_irq_handlers().

To expose DC's hardware interrupt toggle to the base driver, DM implements `amdgpu_irq_src_funcs.set` hooks. Base driver calls it through *amdgpu_irq_update()* to enable or disable the interrupt.

struct **amdgpu_dm_irq_handler_data**

Data for DM interrupt handlers.

Definition

```
struct amdgpu_dm_irq_handler_data {
  struct list_head list;
  interrupt_handler handler;
  void *handler_arg;
  struct amdgpu_display_manager *dm;
```

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```
  enum dc_irq_source irq_source;
  struct work_struct work;
};
```

Members

`list`
  Linked list entry referencing the next/previous handler

`handler`
  Handler function

`handler_arg`
  Argument passed to the handler when triggered

`dm`
  DM which this handler belongs to

`irq_source`
  DC interrupt source that this handler is registered for

void **`dm_irq_work_func`**(struct work_struct *work)

  Handle an IRQ outside of the interrupt handler proper.

Parameters

`struct work_struct *work`
  work struct

void ***`amdgpu_dm_irq_register_interrupt`**(struct amdgpu_device *adev, struct dc_interrupt_params *int_params, void (*ih)(void*), void *handler_args)

  Register a handler within DM.

Parameters

`struct amdgpu_device *adev`
  The base driver device containing the DM device.

`struct dc_interrupt_params *int_params`
  Interrupt parameters containing the source, and handler context

`void (*ih)(void *)`
  Function pointer to the interrupt handler to register

`void *handler_args`
  Arguments passed to the handler when the interrupt occurs

Description

Register an interrupt handler for the given IRQ source, under the given context. The context can either be high or low. High context handlers are executed directly within ISR context, while low context is executed within a workqueue, thereby allowing operations that sleep.

Registered handlers are called in a FIFO manner, i.e. the most recently registered handler will be called first.

Return

Handler data *struct amdgpu_dm_irq_handler_data* containing the IRQ
source, handler function, and args

void **amdgpu_dm_irq_unregister_interrupt**(struct amdgpu_device *adev, enum dc_irq_source irq_source, void *ih)

Remove a handler from the DM IRQ table

Parameters

struct amdgpu_device *adev
The base driver device containing the DM device

enum dc_irq_source irq_source
IRQ source to remove the given handler from

void *ih
Function pointer to the interrupt handler to unregister

Description

Go through both low and high context IRQ tables, and find the given handler for the given irq source. If found, remove it. Otherwise, do nothing.

int **amdgpu_dm_irq_init**(struct amdgpu_device *adev)

Initialize DM IRQ management

Parameters

struct amdgpu_device *adev
The base driver device containing the DM device

Description

Initialize DM's high and low context IRQ tables.

The N by M table contains N IRQ sources, with M *struct amdgpu_dm_irq_handler_data* hooked together in a linked list. The list_heads are initialized here. When an interrupt n is triggered, all m handlers are called in sequence, FIFO according to registration order.

The low context table requires special steps to initialize, since handlers will be deferred to a workqueue. See `struct irq_list_head`.

void **amdgpu_dm_irq_fini**(struct amdgpu_device *adev)

Tear down DM IRQ management

Parameters

struct amdgpu_device *adev
The base driver device containing the DM device

Description

Flush all work within the low context IRQ table.

int **amdgpu_dm_irq_handler**(struct amdgpu_device *adev, struct amdgpu_irq_src *source, struct amdgpu_iv_entry *entry)

Generic DM IRQ handler

Parameters

`struct amdgpu_device *adev`
: amdgpu base driver device containing the DM device

`struct amdgpu_irq_src *source`
: Unused

`struct amdgpu_iv_entry *entry`
: Data about the triggered interrupt

Description

Calls all registered high irq work immediately, and schedules work for low irq. The DM IRQ table is used to find the corresponding handlers.

void **`amdgpu_dm_hpd_init`**(struct amdgpu_device *adev)

hpd setup callback.

Parameters

`struct amdgpu_device *adev`
: amdgpu_device pointer

Description

Setup the hpd pins used by the card (evergreen+). Enable the pin, set the polarity, and enable the hpd interrupts.

void **`amdgpu_dm_hpd_fini`**(struct amdgpu_device *adev)

hpd tear down callback.

Parameters

`struct amdgpu_device *adev`
: amdgpu_device pointer

Description

Tear down the hpd pins used by the card (evergreen+). Disable the hpd interrupts.

void **`dm_pflip_high_irq`**(void *interrupt_params)

Handle pageflip interrupt

Parameters

`void *interrupt_params`
: ignored

Description

Handles the pageflip interrupt by notifying all interested parties that the pageflip has been completed.

void **`dm_crtc_high_irq`**(void *interrupt_params)

Handles CRTC interrupt

Parameters

`void *interrupt_params`
: used for determining the CRTC instance

Description

Handles the CRTC/VSYNC interrupt by notfying DRM' s VBLANK event handler.

Atomic Implementation

WIP

void **amdgpu_dm_atomic_commit_tail**(struct *drm_atomic_state* *state)

AMDgpu DM' s commit tail implementation.

Parameters

struct drm_atomic_state *state
The atomic state to commit

Description

This will tell DC to commit the constructed DC state from atomic_check, programming the hardware. Any failures here implies a hardware failure, since atomic check should have filtered anything non-kosher.

int **amdgpu_dm_atomic_check**(struct *drm_device* *dev, struct *drm_atomic_state* *state)

Atomic check implementation for AMDgpu DM.

Parameters

struct drm_device *dev
The DRM device

struct drm_atomic_state *state
The atomic state to commit

Description

Validate that the given atomic state is programmable by DC into hardware. This involves constructing a `struct dc_state` reflecting the new hardware state we wish to commit, then querying DC to see if it is programmable. It' s important not to modify the existing DC state. Otherwise, atomic_check may unexpectedly commit hardware changes.

When validating the DC state, it' s important that the right locks are acquired. For full updates case which removes/adds/updates streams on one CRTC while flipping on another CRTC, acquiring global lock will guarantee that any such full update commit will wait for completion of any outstanding flip using DRMs synchronization events.

Note that DM adds the affected connectors for all CRTCs in state, when that might not seem necessary. This is because DC stream creation requires the DC sink, which is tied to the DRM connector state. Cleaning this up should be possible but non-trivial - a possible TODO item.

Return

-Error code if validation failed.

8.2.2 Display Core

WIP

8.3 drm/i915 Intel GFX Driver

The drm/i915 driver supports all (with the exception of some very early models) integrated GFX chipsets with both Intel display and rendering blocks. This excludes a set of SoC platforms with an SGX rendering unit, those have basic support through the gma500 drm driver.

8.3.1 Core Driver Infrastructure

This section covers core driver infrastructure used by both the display and the GEM parts of the driver.

Runtime Power Management

The i915 driver supports dynamic enabling and disabling of entire hardware blocks at runtime. This is especially important on the display side where software is supposed to control many power gates manually on recent hardware, since on the GT side a lot of the power management is done by the hardware. But even there some manual control at the device level is required.

Since i915 supports a diverse set of platforms with a unified codebase and hardware engineers just love to shuffle functionality around between power domains there's a sizeable amount of indirection required. This file provides generic functions to the driver for grabbing and releasing references for abstract power domains. It then maps those to the actual power wells present for a given platform.

intel_wakeref_t **intel_runtime_pm_get_raw**(struct intel_runtime_pm *rpm)

grab a raw runtime pm reference

Parameters

struct intel_runtime_pm *rpm

the intel_runtime_pm structure

Description

This is the unlocked version of intel_display_power_is_enabled() and should only be used from error capture and recovery code where deadlocks are possible. This function grabs a device-level runtime pm reference (mostly used for asynchronous PM management from display code) and ensures that it is powered up. Raw references are not considered during wakelock assert checks.

Any runtime pm reference obtained by this function must have a symmetric call to *intel_runtime_pm_put_raw()* to release the reference again.

Return

the wakeref cookie to pass to *intel_runtime_pm_put_raw()*, evaluates as True if the wakeref was acquired, or False otherwise.

intel_wakeref_t **intel_runtime_pm_get**(struct intel_runtime_pm *rpm)

grab a runtime pm reference

Parameters

struct intel_runtime_pm *rpm
the intel_runtime_pm structure

Description

This function grabs a device-level runtime pm reference (mostly used for GEM code to ensure the GTT or GT is on) and ensures that it is powered up.

Any runtime pm reference obtained by this function must have a symmetric call to *intel_runtime_pm_put()* to release the reference again.

Return

the wakeref cookie to pass to *intel_runtime_pm_put()*

intel_wakeref_t **__intel_runtime_pm_get_if_active**(struct intel_runtime_pm *rpm, bool ignore_usecount)

grab a runtime pm reference if device is active

Parameters

struct intel_runtime_pm *rpm
the intel_runtime_pm structure

bool ignore_usecount
get a ref even if dev->power.usage_count is 0

Description

This function grabs a device-level runtime pm reference if the device is already active and ensures that it is powered up. It is illegal to try and access the HW should intel_runtime_pm_get_if_active() report failure.

If **ignore_usecount**=true, a reference will be acquired even if there is no user requiring the device to be powered up (dev->power.usage_count == 0). If the function returns false in this case then it's guaranteed that the device's runtime suspend hook has been called already or that it will be called (and hence it's also guaranteed that the device's runtime resume hook will be called eventually).

Any runtime pm reference obtained by this function must have a symmetric call to *intel_runtime_pm_put()* to release the reference again.

Return

the wakeref cookie to pass to *intel_runtime_pm_put()*, evaluates as True if the wakeref was acquired, or False otherwise.

intel_wakeref_t **intel_runtime_pm_get_noresume**(struct intel_runtime_pm *rpm)

grab a runtime pm reference

Parameters

`struct intel_runtime_pm *rpm`
: the intel_runtime_pm structure

Description

This function grabs a device-level runtime pm reference (mostly used for GEM code to ensure the GTT or GT is on).

It will _not_ power up the device but instead only check that it's powered on. Therefore it is only valid to call this functions from contexts where the device is known to be powered up and where trying to power it up would result in hilarity and deadlocks. That pretty much means only the system suspend/resume code where this is used to grab runtime pm references for delayed setup down in work items.

Any runtime pm reference obtained by this function must have a symmetric call to *`intel_runtime_pm_put()`* to release the reference again.

Return

the wakeref cookie to pass to *`intel_runtime_pm_put()`*

void **`intel_runtime_pm_put_raw`**(struct intel_runtime_pm *rpm, intel_wakeref_t wref)

release a raw runtime pm reference

Parameters

`struct intel_runtime_pm *rpm`
: the intel_runtime_pm structure

`intel_wakeref_t wref`
: wakeref acquired for the reference that is being released

Description

This function drops the device-level runtime pm reference obtained by *`intel_runtime_pm_get_raw()`* and might power down the corresponding hardware block right away if this is the last reference.

void **`intel_runtime_pm_put_unchecked`**(struct intel_runtime_pm *rpm)

release an unchecked runtime pm reference

Parameters

`struct intel_runtime_pm *rpm`
: the intel_runtime_pm structure

Description

This function drops the device-level runtime pm reference obtained by *`intel_runtime_pm_get()`* and might power down the corresponding hardware block right away if this is the last reference.

This function exists only for historical reasons and should be avoided in new code, as the correctness of its use cannot be checked. Always use *`intel_runtime_pm_put()`* instead.

void **intel_runtime_pm_put**(struct intel_runtime_pm *rpm, intel_wakeref_t wref)

release a runtime pm reference

Parameters

struct intel_runtime_pm *rpm
the intel_runtime_pm structure

intel_wakeref_t wref
wakeref acquired for the reference that is being released

Description

This function drops the device-level runtime pm reference obtained by *intel_runtime_pm_get()* and might power down the corresponding hardware block right away if this is the last reference.

void **intel_runtime_pm_enable**(struct intel_runtime_pm *rpm)

enable runtime pm

Parameters

struct intel_runtime_pm *rpm
the intel_runtime_pm structure

Description

This function enables runtime pm at the end of the driver load sequence.

Note that this function does currently not enable runtime pm for the subordinate display power domains. That is done by intel_power_domains_enable().

void **intel_uncore_forcewake_get**(struct intel_uncore *uncore, enum forcewake_domains fw_domains)

grab forcewake domain references

Parameters

struct intel_uncore *uncore
the intel_uncore structure

enum forcewake_domains fw_domains
forcewake domains to get reference on

Description

This function can be used get GT's forcewake domain references. Normal register access will handle the forcewake domains automatically. However if some sequence requires the GT to not power down a particular forcewake domains this function should be called at the beginning of the sequence. And subsequently the reference should be dropped by symmetric call to intel_unforce_forcewake_put(). Usually caller wants all the domains to be kept awake so the **fw_domains** would be then FORCEWAKE_ALL.

void **intel_uncore_forcewake_user_get**(struct intel_uncore *uncore)

claim forcewake on behalf of userspace

Parameters

struct intel_uncore *uncore
the intel_uncore structure

Description

This function is a wrapper around *intel_uncore_forcewake_get()* to acquire the GT powerwell and in the process disable our debugging for the duration of userspace' s bypass.

void **intel_uncore_forcewake_user_put**(struct intel_uncore *uncore)
release forcewake on behalf of userspace

Parameters

struct intel_uncore *uncore
the intel_uncore structure

Description

This function complements *intel_uncore_forcewake_user_get()* and releases the GT powerwell taken on behalf of the userspace bypass.

void **intel_uncore_forcewake_get__locked**(struct intel_uncore *uncore, enum forcewake_domains fw_domains)
grab forcewake domain references

Parameters

struct intel_uncore *uncore
the intel_uncore structure

enum forcewake_domains fw_domains
forcewake domains to get reference on

Description

See *intel_uncore_forcewake_get()*. This variant places the onus on the caller to explicitly handle the dev_priv->uncore.lock spinlock.

void **intel_uncore_forcewake_put**(struct intel_uncore *uncore, enum forcewake_domains fw_domains)
release a forcewake domain reference

Parameters

struct intel_uncore *uncore
the intel_uncore structure

enum forcewake_domains fw_domains
forcewake domains to put references

Description

This function drops the device-level forcewakes for specified domains obtained by *intel_uncore_forcewake_get()*.

void **intel_uncore_forcewake_flush**(struct intel_uncore *uncore, enum forcewake_domains fw_domains)
flush the delayed release

Parameters

struct intel_uncore *uncore
  the intel_uncore structure

enum forcewake_domains fw_domains
  forcewake domains to flush

void **intel_uncore_forcewake_put__locked**(struct intel_uncore *uncore, enum forcewake_domains fw_domains)

  grab forcewake domain references

Parameters

struct intel_uncore *uncore
  the intel_uncore structure

enum forcewake_domains fw_domains
  forcewake domains to get reference on

Description

See *intel_uncore_forcewake_put()*. This variant places the onus on the caller to explicitly handle the dev_priv->uncore.lock spinlock.

int **__intel_wait_for_register_fw**(struct intel_uncore *uncore, i915_reg_t reg, u32 mask, u32 value, unsigned int fast_timeout_us, unsigned int slow_timeout_ms, u32 *out_value)

  wait until register matches expected state

Parameters

struct intel_uncore *uncore
  the struct intel_uncore

i915_reg_t reg
  the register to read

u32 mask
  mask to apply to register value

u32 value
  expected value

unsigned int fast_timeout_us
  fast timeout in microsecond for atomic/tight wait

unsigned int slow_timeout_ms
  slow timeout in millisecond

u32 *out_value
  optional placeholder to hold registry value

Description

This routine waits until the target register **reg** contains the expected **value** after applying the **mask**, i.e. it waits until

```
(I915_READ_FW(reg) & mask) == value
```

Otherwise, the wait will timeout after **slow_timeout_ms** milliseconds. For atomic context **slow_timeout_ms** must be zero and **fast_timeout_us** must be not larger than 20,0000 microseconds.

Note that this routine assumes the caller holds forcewake asserted, it is not suitable for very long waits. See intel_wait_for_register() if you wish to wait without holding forcewake for the duration (i.e. you expect the wait to be slow).

Return

0 if the register matches the desired condition, or -ETIMEDOUT.

int **__intel_wait_for_register**(struct intel_uncore *uncore, i915_reg_t reg, u32 mask, u32 value, unsigned int fast_timeout_us, unsigned int slow_timeout_ms, u32 *out_value)

wait until register matches expected state

Parameters

struct intel_uncore *uncore
the struct intel_uncore

i915_reg_t reg
the register to read

u32 mask
mask to apply to register value

u32 value
expected value

unsigned int fast_timeout_us
fast timeout in microsecond for atomic/tight wait

unsigned int slow_timeout_ms
slow timeout in millisecond

u32 *out_value
optional placeholder to hold registry value

Description

This routine waits until the target register **reg** contains the expected **value** after applying the **mask**, i.e. it waits until

```
(I915_READ(reg) & mask) == value
```

Otherwise, the wait will timeout after **timeout_ms** milliseconds.

Return

0 if the register matches the desired condition, or -ETIMEDOUT.

enum forcewake_domains **intel_uncore_forcewake_for_reg**(struct intel_uncore *uncore, i915_reg_t reg, unsigned int op) which forcewake domains are needed to access a register

Parameters

`struct intel_uncore *uncore`
pointer to struct intel_uncore

`i915_reg_t reg`
register in question

`unsigned int op`
operation bitmask of FW_REG_READ and/or FW_REG_WRITE

Description

Returns a set of forcewake domains required to be taken with for example intel_uncore_forcewake_get for the specified register to be accessible in the specified mode (read, write or read/write) with raw mmio accessors.

NOTE

On Gen6 and Gen7 write forcewake domain (FORCEWAKE_RENDER) requires the callers to do FIFO management on their own or risk losing writes.

Interrupt Handling

These functions provide the basic support for enabling and disabling the interrupt handling support. There's a lot more functionality in i915_irq.c and related files, but that will be described in separate chapters.

void **`intel_irq_init`**(struct drm_i915_private *dev_priv)
initializes irq support

Parameters

`struct drm_i915_private *dev_priv`
i915 device instance

Description

This function initializes all the irq support including work items, timers and all the vtables. It does not setup the interrupt itself though.

void **`intel_runtime_pm_disable_interrupts`**(struct drm_i915_private *dev_priv)
runtime interrupt disabling

Parameters

`struct drm_i915_private *dev_priv`
i915 device instance

Description

This function is used to disable interrupts at runtime, both in the runtime pm and the system suspend/resume code.

void **intel_runtime_pm_enable_interrupts**(struct drm_i915_private *dev_priv)
runtime interrupt enabling

Parameters

struct drm_i915_private *dev_priv
i915 device instance

Description

This function is used to enable interrupts at runtime, both in the runtime pm and the system suspend/resume code.

Intel GVT-g Guest Support(vGPU)

Intel GVT-g is a graphics virtualization technology which shares the GPU among multiple virtual machines on a time-sharing basis. Each virtual machine is presented a virtual GPU (vGPU), which has equivalent features as the underlying physical GPU (pGPU), so i915 driver can run seamlessly in a virtual machine. This file provides vGPU specific optimizations when running in a virtual machine, to reduce the complexity of vGPU emulation and to improve the overall performance.

A primary function introduced here is so-called "address space ballooning" technique. Intel GVT-g partitions global graphics memory among multiple VMs, so each VM can directly access a portion of the memory without hypervisor's intervention, e.g. filling textures or queuing commands. However with the partitioning an unmodified i915 driver would assume a smaller graphics memory starting from address ZERO, then requires vGPU emulation module to translate the graphics address between 'guest view' and 'host view', for all registers and command opcodes which contain a graphics memory address. To reduce the complexity, Intel GVT-g introduces "address space ballooning", by telling the exact partitioning knowledge to each guest i915 driver, which then reserves and prevents non-allocated portions from allocation. Thus vGPU emulation module only needs to scan and validate graphics addresses without complexity of address translation.

void **intel_vgpu_detect**(struct drm_i915_private *dev_priv)
detect virtual GPU

Parameters

struct drm_i915_private *dev_priv
i915 device private

Description

This function is called at the initialization stage, to detect whether running on a vGPU.

void **intel_vgt_deballoon**(struct i915_ggtt *ggtt)
deballoon reserved graphics address trunks

Parameters

struct i915_ggtt *ggtt
the global GGTT from which we reserved earlier

Description

This function is called to deallocate the ballooned-out graphic memory, when driver is unloaded or when ballooning fails.

int **intel_vgt_balloon**(struct i915_ggtt *ggtt)
balloon out reserved graphics address trunks

Parameters

struct i915_ggtt *ggtt
the global GGTT from which to reserve

Description

This function is called at the initialization stage, to balloon out the graphic address space allocated to other vGPUs, by marking these spaces as reserved. The ballooning related knowledge(starting address and size of the mappable/unmappable graphic memory) is described in the vgt_if structure in a reserved mmio range.

To give an example, the drawing below depicts one typical scenario after ballooning. Here the vGPU1 has 2 pieces of graphic address spaces ballooned out each for the mappable and the non-mappable part. From the vGPU1 point of view, the total size is the same as the physical one, with the start address of its graphic space being zero. Yet there are some portions ballooned out(the shadow part, which are marked as reserved by drm allocator). From the host point of view, the graphic address space is partitioned by multiple vGPUs in different VMs.

```
                       vGPU1 view         Host view
            0 ------> +-----------+     +-----------+
              ^       |###########|     |   vGPU3   |
              |       |###########|     +-----------+
              |       |###########|     |   vGPU2   |
              |       +-----------+     +-----------+
       mappable GM    | available | ==> |   vGPU1   |
              |       +-----------+     +-----------+
              |       |###########|     |           |
              v       |###########|     |   Host    |
              +=======+===========+     +===========+
              ^       |###########|     |   vGPU3   |
              |       |###########|     +-----------+
              |       |###########|     |   vGPU2   |
              |       +-----------+     +-----------+
     unmappable GM    | available | ==> |   vGPU1   |
              |       +-----------+     +-----------+
              |       |###########|     |           |
              |       |###########|     |   Host    |
              v       |###########|     |           |
total GM size ------> +-----------+     +-----------+
```

Return

zero on success, non-zero if configuration invalid or ballooning failed

Intel GVT-g Host Support(vGPU device model)

Intel GVT-g is a graphics virtualization technology which shares the GPU among multiple virtual machines on a time-sharing basis. Each virtual machine is presented a virtual GPU (vGPU), which has equivalent features as the underlying physical GPU (pGPU), so i915 driver can run seamlessly in a virtual machine.

To virtualize GPU resources GVT-g driver depends on hypervisor technology e.g KVM/VFIO/mdev, Xen, etc. to provide resource access trapping capability and be virtualized within GVT-g device module. More architectural design doc is available on https://01.org/group/2230/documentation-list.

void **intel_gvt_sanitize_options**(struct drm_i915_private *dev_priv)

sanitize GVT related options

Parameters

struct drm_i915_private *dev_priv
drm i915 private data

Description

This function is called at the i915 options sanitize stage.

int **intel_gvt_init**(struct drm_i915_private *dev_priv)

initialize GVT components

Parameters

struct drm_i915_private *dev_priv
drm i915 private data

Description

This function is called at the initialization stage to create a GVT device.

Return

Zero on success, negative error code if failed.

void **intel_gvt_driver_remove**(struct drm_i915_private *dev_priv)

cleanup GVT components when i915 driver is unbinding

Parameters

struct drm_i915_private *dev_priv
drm i915 private *

Description

This function is called at the i915 driver unloading stage, to shutdown GVT components and release the related resources.

void **intel_gvt_resume**(struct drm_i915_private *dev_priv)

GVT resume routine wapper

Parameters

struct drm_i915_private *dev_priv
drm i915 private *

Description

This function is called at the i915 driver resume stage to restore required HW status for GVT so that vGPU can continue running after resumed.

Workarounds

This file is intended as a central place to implement most[1] of the required workarounds for hardware to work as originally intended. They fall in five basic categories depending on how/when they are applied:

- Workarounds that touch registers that are saved/restored to/from the HW context image. The list is emitted (via Load Register Immediate commands) everytime a new context is created.
- GT workarounds. The list of these WAs is applied whenever these registers revert to default values (on GPU reset, suspend/resume[2], etc..).
- Display workarounds. The list is applied during display clock-gating initialization.
- Workarounds that whitelist a privileged register, so that UMDs can manage them directly. This is just a special case of a MMMIO workaround (as we write the list of these to/be-whitelisted registers to some special HW registers).
- Workaround batchbuffers, that get executed automatically by the hardware on every HW context restore.

Layout

Keep things in this file ordered by WA type, as per the above (context, GT, display, register whitelist, batchbuffer). Then, inside each type, keep the following order:

- Infrastructure functions and macros
- WAs per platform in standard gen/chrono order
- Public functions to init or apply the given workaround type.

[1] Please notice that there are other WAs that, due to their nature, cannot be applied from a central place. Those are peppered around the rest of the code, as needed.

[2] Technically, some registers are powercontext saved & restored, so they survive a suspend/resume. In practice, writing them again is not too costly and simplifies things. We can revisit this in the future.

8.3.2 Display Hardware Handling

This section covers everything related to the display hardware including the mode setting infrastructure, plane, sprite and cursor handling and display, output probing and related topics.

Mode Setting Infrastructure

The i915 driver is thus far the only DRM driver which doesn't use the common DRM helper code to implement mode setting sequences. Thus it has its own tailor-made infrastructure for executing a display configuration change.

Frontbuffer Tracking

Many features require us to track changes to the currently active frontbuffer, especially rendering targeted at the frontbuffer.

To be able to do so we track frontbuffers using a bitmask for all possible frontbuffer slots through *intel_frontbuffer_track()*. The functions in this file are then called when the contents of the frontbuffer are invalidated, when frontbuffer rendering has stopped again to flush out all the changes and when the frontbuffer is exchanged with a flip. Subsystems interested in frontbuffer changes (e.g. PSR, FBC, DRRS) should directly put their callbacks into the relevant places and filter for the frontbuffer slots that they are interested int.

On a high level there are two types of powersaving features. The first one work like a special cache (FBC and PSR) and are interested when they should stop caching and when to restart caching. This is done by placing callbacks into the invalidate and the flush functions: At invalidate the caching must be stopped and at flush time it can be restarted. And maybe they need to know when the frontbuffer changes (e.g. when the hw doesn't initiate an invalidate and flush on its own) which can be achieved with placing callbacks into the flip functions.

The other type of display power saving feature only cares about busyness (e.g. DRRS). In that case all three (invalidate, flush and flip) indicate busyness. There is no direct way to detect idleness. Instead an idle timer work delayed work should be started from the flush and flip functions and cancelled as soon as busyness is detected.

bool **intel_frontbuffer_invalidate**(struct intel_frontbuffer *front, enum fb_op_origin origin)

invalidate frontbuffer object

Parameters

struct intel_frontbuffer *front
GEM object to invalidate

enum fb_op_origin origin
which operation caused the invalidation

Description

This function gets called every time rendering on the given object starts and front-buffer caching (fbc, low refresh rate for DRRS, panel self refresh) must be invalidated. For ORIGIN_CS any subsequent invalidation will be delayed until the rendering completes or a flip on this frontbuffer plane is scheduled.

void **intel_frontbuffer_flush**(struct intel_frontbuffer *front, enum fb_op_origin origin)

flush frontbuffer object

Parameters

struct intel_frontbuffer *front
GEM object to flush

enum fb_op_origin origin
which operation caused the flush

Description

This function gets called every time rendering on the given object has completed and frontbuffer caching can be started again.

void **frontbuffer_flush**(struct drm_i915_private *i915, unsigned int frontbuffer_bits, enum fb_op_origin origin)

flush frontbuffer

Parameters

struct drm_i915_private *i915
i915 device

unsigned int frontbuffer_bits
frontbuffer plane tracking bits

enum fb_op_origin origin
which operation caused the flush

Description

This function gets called every time rendering on the given planes has completed and frontbuffer caching can be started again. Flushes will get delayed if they're blocked by some outstanding asynchronous rendering.

Can be called without any locks held.

void **intel_frontbuffer_flip_prepare**(struct drm_i915_private *i915, unsigned frontbuffer_bits)

prepare asynchronous frontbuffer flip

Parameters

struct drm_i915_private *i915
i915 device

unsigned frontbuffer_bits
frontbuffer plane tracking bits

Description

This function gets called after scheduling a flip on **obj**. The actual frontbuffer flushing will be delayed until completion is signalled with intel_frontbuffer_flip_complete. If an invalidate happens in between this flush will be cancelled.

Can be called without any locks held.

void **intel_frontbuffer_flip_complete**(struct drm_i915_private *i915, unsigned frontbuffer_bits)

complete asynchronous frontbuffer flip

Parameters

struct drm_i915_private *i915
i915 device

unsigned frontbuffer_bits
frontbuffer plane tracking bits

Description

This function gets called after the flip has been latched and will complete on the next vblank. It will execute the flush if it hasn't been cancelled yet.

Can be called without any locks held.

void **intel_frontbuffer_flip**(struct drm_i915_private *i915, unsigned frontbuffer_bits)

synchronous frontbuffer flip

Parameters

struct drm_i915_private *i915
i915 device

unsigned frontbuffer_bits
frontbuffer plane tracking bits

Description

This function gets called after scheduling a flip on **obj**. This is for synchronous plane updates which will happen on the next vblank and which will not get delayed by pending gpu rendering.

Can be called without any locks held.

void **intel_frontbuffer_track**(struct intel_frontbuffer *old, struct intel_frontbuffer *new, unsigned int frontbuffer_bits)

update frontbuffer tracking

Parameters

struct intel_frontbuffer *old
current buffer for the frontbuffer slots

struct intel_frontbuffer *new
new buffer for the frontbuffer slots

`unsigned int frontbuffer_bits`
bitmask of frontbuffer slots

Description

This updates the frontbuffer tracking bits **frontbuffer_bits** by clearing them from **old** and setting them in **new**. Both **old** and **new** can be NULL.

Display FIFO Underrun Reporting

The i915 driver checks for display fifo underruns using the interrupt signals provided by the hardware. This is enabled by default and fairly useful to debug display issues, especially watermark settings.

If an underrun is detected this is logged into dmesg. To avoid flooding logs and occupying the cpu underrun interrupts are disabled after the first occurrence until the next modeset on a given pipe.

Note that underrun detection on gmch platforms is a bit more ugly since there is no interrupt (despite that the signalling bit is in the PIPESTAT pipe interrupt register). Also on some other platforms underrun interrupts are shared, which means that if we detect an underrun we need to disable underrun reporting on all pipes.

The code also supports underrun detection on the PCH transcoder.

bool **`intel_set_cpu_fifo_underrun_reporting`**(struct drm_i915_private *dev_priv, enum *pipe* pipe, bool enable)

set cpu fifo underrrun reporting state

Parameters

`struct drm_i915_private *dev_priv`
i915 device instance

`enum pipe pipe`
(CPU) pipe to set state for

`bool enable`
whether underruns should be reported or not

Description

This function sets the fifo underrun state for **pipe**. It is used in the modeset code to avoid false positives since on many platforms underruns are expected when disabling or enabling the pipe.

Notice that on some platforms disabling underrun reports for one pipe disables for all due to shared interrupts. Actual reporting is still per-pipe though.

Returns the previous state of underrun reporting.

bool **`intel_set_pch_fifo_underrun_reporting`**(struct drm_i915_private *dev_priv, enum pipe pch_transcoder, bool enable)

set PCH fifo underrun reporting state

Parameters

`struct drm_i915_private *dev_priv`
: i915 device instance

`enum pipe pch_transcoder`
: the PCH transcoder (same as pipe on IVB and older)

`bool enable`
: whether underruns should be reported or not

Description

This function makes us disable or enable PCH fifo underruns for a specific PCH transcoder. Notice that on some PCHs (e.g. CPT/PPT), disabling FIFO underrun reporting for one transcoder may also disable all the other PCH error interruts for the other transcoders, due to the fact that there' s just one interrupt mask/enable bit for all the transcoders.

Returns the previous state of underrun reporting.

void **`intel_cpu_fifo_underrun_irq_handler`**(struct drm_i915_private *dev_priv, enum *pipe* pipe)

handle CPU fifo underrun interrupt

Parameters

`struct drm_i915_private *dev_priv`
: i915 device instance

`enum pipe pipe`
: (CPU) pipe to set state for

Description

This handles a CPU fifo underrun interrupt, generating an underrun warning into dmesg if underrun reporting is enabled and then disables the underrun interrupt to avoid an irq storm.

void **`intel_pch_fifo_underrun_irq_handler`**(struct drm_i915_private *dev_priv, enum pipe pch_transcoder)

handle PCH fifo underrun interrupt

Parameters

`struct drm_i915_private *dev_priv`
: i915 device instance

`enum pipe pch_transcoder`
: the PCH transcoder (same as pipe on IVB and older)

Description

This handles a PCH fifo underrun interrupt, generating an underrun warning into dmesg if underrun reporting is enabled and then disables the underrun interrupt to avoid an irq storm.

void **`intel_check_cpu_fifo_underruns`**(struct drm_i915_private *dev_priv)

check for CPU fifo underruns immediately

Parameters

struct drm_i915_private *dev_priv
i915 device instance

Description

Check for CPU fifo underruns immediately. Useful on IVB/HSW where the shared error interrupt may have been disabled, and so CPU fifo underruns won't necessarily raise an interrupt, and on GMCH platforms where underruns never raise an interrupt.

void **intel_check_pch_fifo_underruns**(struct drm_i915_private *dev_priv)
check for PCH fifo underruns immediately

Parameters

struct drm_i915_private *dev_priv
i915 device instance

Description

Check for PCH fifo underruns immediately. Useful on CPT/PPT where the shared error interrupt may have been disabled, and so PCH fifo underruns won't necessarily raise an interrupt.

Plane Configuration

This section covers plane configuration and composition with the primary plane, sprites, cursors and overlays. This includes the infrastructure to do atomic vsync'ed updates of all this state and also tightly coupled topics like watermark setup and computation, framebuffer compression and panel self refresh.

Atomic Plane Helpers

The functions here are used by the atomic plane helper functions to implement legacy plane updates (i.e., drm_plane->update_plane() and drm_plane->disable_plane()). This allows plane updates to use the atomic state infrastructure and perform plane updates as separate prepare/check/commit/cleanup steps.

struct *drm_plane_state* ***intel_plane_duplicate_state**(struct *drm_plane* *plane)
duplicate plane state

Parameters

struct drm_plane *plane
drm plane

Description

Allocates and returns a copy of the plane state (both common and Intel-specific) for the specified plane.

Return

The newly allocated plane state, or NULL on failure.

void **intel_plane_destroy_state**(struct *drm_plane* *plane, struct *drm_plane_state* *state)

destroy plane state

Parameters

struct drm_plane *plane
drm plane

struct drm_plane_state *state
state object to destroy

Description

Destroys the plane state (both common and Intel-specific) for the specified plane.

Output Probing

This section covers output probing and related infrastructure like the hotplug interrupt storm detection and mitigation code. Note that the i915 driver still uses most of the common DRM helper code for output probing, so those sections fully apply.

Hotplug

Simply put, hotplug occurs when a display is connected to or disconnected from the system. However, there may be adapters and docking stations and Display Port short pulses and MST devices involved, complicating matters.

Hotplug in i915 is handled in many different levels of abstraction.

The platform dependent interrupt handling code in i915_irq.c enables, disables, and does preliminary handling of the interrupts. The interrupt handlers gather the hotplug detect (HPD) information from relevant registers into a platform independent mask of hotplug pins that have fired.

The platform independent interrupt handler *intel_hpd_irq_handler()* in intel_hotplug.c does hotplug irq storm detection and mitigation, and passes further processing to appropriate bottom halves (Display Port specific and regular hotplug).

The Display Port work function i915_digport_work_func() calls into intel_dp_hpd_pulse() via hooks, which handles DP short pulses and DP MST long pulses, with failures and non-MST long pulses triggering regular hotplug processing on the connector.

The regular hotplug work function i915_hotplug_work_func() calls connector detect hooks, and, if connector status changes, triggers sending of hotplug uevent to userspace via *drm_kms_helper_hotplug_event()*.

Finally, the userspace is responsible for triggering a modeset upon receiving the hotplug uevent, disabling or enabling the crtc as needed.

The hotplug interrupt storm detection and mitigation code keeps track of the number of interrupts per hotplug pin per a period of time, and if the number of interrupts exceeds a certain threshold, the interrupt is disabled for a while before being re-enabled. The intention is to mitigate issues raising from broken hardware triggering massive amounts of interrupts and grinding the system to a halt.

Current implementation expects that hotplug interrupt storm will not be seen when display port sink is connected, hence on platforms whose DP callback is handled by i915_digport_work_func reenabling of hpd is not performed (it was never expected to be disabled in the first place ;)) this is specific to DP sinks handled by this routine and any other display such as HDMI or DVI enabled on the same port will have proper logic since it will use i915_hotplug_work_func where this logic is handled.

enum hpd_pin **intel_hpd_pin_default**(struct drm_i915_private *dev_priv, enum *port* port)

return default pin associated with certain port.

Parameters

struct drm_i915_private *dev_priv
private driver data pointer

enum port port
the hpd port to get associated pin

Description

It is only valid and used by digital port encoder.

Return pin that is associatade with **port**.

bool **intel_hpd_irq_storm_detect**(struct drm_i915_private *dev_priv, enum hpd_pin pin, bool long_hpd)

gather stats and detect HPD IRQ storm on a pin

Parameters

struct drm_i915_private *dev_priv
private driver data pointer

enum hpd_pin pin
the pin to gather stats on

bool long_hpd
whether the HPD IRQ was long or short

Description

Gather stats about HPD IRQs from the specified **pin**, and detect IRQ storms. Only the pin specific stats and state are changed, the caller is responsible for further action.

The number of IRQs that are allowed within **HPD_STORM_DETECT_PERIOD** is stored in **dev_priv->hotplug.hpd_storm_threshold** which defaults to **HPD_STORM_DEFAULT_THRESHOLD**. Long IRQs count as +10 to this threshold, and short IRQs count as +1. If this threshold is exceeded, it's considered an IRQ storm and the IRQ state is set to **HPD_MARK_DISABLED**.

By default, most systems will only count long IRQs towards `dev_priv->hotplug.hpd_storm_threshold`. However, some older systems also suffer from short IRQ storms and must also track these. Because short IRQ storms are naturally caused by sideband interactions with DP MST devices, short IRQ detection is only enabled for systems without DP MST support. Systems which are new enough to support DP MST are far less likely to suffer from IRQ storms at all, so this is fine.

The HPD threshold can be controlled through i915_hpd_storm_ctl in debugfs, and should only be adjusted for automated hotplug testing.

Return true if an IRQ storm was detected on **pin**.

void **intel_hpd_trigger_irq**(struct intel_digital_port *dig_port)

trigger an hpd irq event for a port

Parameters

struct intel_digital_port *dig_port
digital port

Description

Trigger an HPD interrupt event for the given port, emulating a short pulse generated by the sink, and schedule the dig port work to handle it.

void **intel_hpd_irq_handler**(struct drm_i915_private *dev_priv, u32 pin_mask, u32 long_mask)

main hotplug irq handler

Parameters

struct drm_i915_private *dev_priv
drm_i915_private

u32 pin_mask
a mask of hpd pins that have triggered the irq

u32 long_mask
a mask of hpd pins that may be long hpd pulses

Description

This is the main hotplug irq handler for all platforms. The platform specific irq handlers call the platform specific hotplug irq handlers, which read and decode the appropriate registers into bitmasks about hpd pins that have triggered (**pin_mask**), and which of those pins may be long pulses (**long_mask**). The **long_mask** is ignored if the port corresponding to the pin is not a digital port.

Here, we do hotplug irq storm detection and mitigation, and pass further processing to appropriate bottom halves.

void **intel_hpd_init**(struct drm_i915_private *dev_priv)

initializes and enables hpd support

Parameters

struct drm_i915_private *dev_priv
i915 device instance

Description

This function enables the hotplug support. It requires that interrupts have already been enabled with intel_irq_init_hw(). From this point on hotplug and poll request can run concurrently to other code, so locking rules must be obeyed.

This is a separate step from interrupt enabling to simplify the locking rules in the driver load and resume code.

Also see: *intel_hpd_poll_init()*, which enables connector polling

void **intel_hpd_poll_init**(struct drm_i915_private *dev_priv)

enables/disables polling for connectors with hpd

Parameters

struct drm_i915_private *dev_priv

i915 device instance

Description

This function enables polling for all connectors, regardless of whether or not they support hotplug detection. Under certain conditions HPD may not be functional. On most Intel GPUs, this happens when we enter runtime suspend. On Valleyview and Cherryview systems, this also happens when we shut off all of the powerwells.

Since this function can get called in contexts where we' re already holding dev->mode_config.mutex, we do the actual hotplug enabling in a seperate worker.

Also see: *intel_hpd_init()*, which restores hpd handling.

High Definition Audio

The graphics and audio drivers together support High Definition Audio over HDMI and Display Port. The audio programming sequences are divided into audio codec and controller enable and disable sequences. The graphics driver handles the audio codec sequences, while the audio driver handles the audio controller sequences.

The disable sequences must be performed before disabling the transcoder or port. The enable sequences may only be performed after enabling the transcoder and port, and after completed link training. Therefore the audio enable/disable sequences are part of the modeset sequence.

The codec and controller sequences could be done either parallel or serial, but generally the ELDV/PD change in the codec sequence indicates to the audio driver that the controller sequence should start. Indeed, most of the co-operation between the graphics and audio drivers is handled via audio related registers. (The notable exception is the power management, not covered here.)

The struct *i915_audio_component* is used to interact between the graphics and audio drivers. The struct `i915_audio_component_ops` **ops** in it is defined in graphics driver and called in audio driver. The struct `i915_audio_component_audio_ops` **audio_ops** is called from i915 driver.

void **intel_audio_codec_enable**(struct intel_encoder *encoder, const struct intel_crtc_state *crtc_state, const struct *drm_connector_state* *conn_state)

Enable the audio codec for HD audio

Parameters

`struct intel_encoder *encoder`
encoder on which to enable audio

`const struct intel_crtc_state *crtc_state`
pointer to the current crtc state.

`const struct drm_connector_state *conn_state`
pointer to the current connector state.

Description

The enable sequences may only be performed after enabling the transcoder and port, and after completed link training.

void **`intel_audio_codec_disable`**(struct intel_encoder *encoder, const struct intel_crtc_state *old_crtc_state, const struct *drm_connector_state* *old_conn_state)

Disable the audio codec for HD audio

Parameters

`struct intel_encoder *encoder`
encoder on which to disable audio

`const struct intel_crtc_state *old_crtc_state`
pointer to the old crtc state.

`const struct drm_connector_state *old_conn_state`
pointer to the old connector state.

Description

The disable sequences must be performed before disabling the transcoder or port.

void **`intel_init_audio_hooks`**(struct drm_i915_private *dev_priv)

Set up chip specific audio hooks

Parameters

`struct drm_i915_private *dev_priv`
device private

void **`i915_audio_component_init`**(struct drm_i915_private *dev_priv)

initialize and register the audio component

Parameters

`struct drm_i915_private *dev_priv`
i915 device instance

Description

This will register with the component framework a child component which will bind dynamically to the snd_hda_intel driver's corresponding master component when the latter is registered. During binding the child initializes an instance of *`struct i915_audio_component`* which it receives from the master. The master can then start to use the interface defined by this struct. Each side can break the binding at any point by deregistering its own component after which each side's component unbind callback is called.

We ignore any error during registration and continue with reduced functionality (i.e. without HDMI audio).

void **i915_audio_component_cleanup**(struct drm_i915_private *dev_priv)

deregister the audio component

Parameters

struct drm_i915_private *dev_priv
i915 device instance

Description

Deregisters the audio component, breaking any existing binding to the corresponding snd_hda_intel driver's master component.

void **intel_audio_init**(struct drm_i915_private *dev_priv)

Initialize the audio driver either using component framework or using lpe audio bridge

Parameters

struct drm_i915_private *dev_priv
the i915 drm device private data

void **intel_audio_deinit**(struct drm_i915_private *dev_priv)

deinitialize the audio driver

Parameters

struct drm_i915_private *dev_priv
the i915 drm device private data

struct **i915_audio_component**

Used for direct communication between i915 and hda drivers

Definition

```
struct i915_audio_component {
  struct drm_audio_component      base;
  int aud_sample_rate[MAX_PORTS];
};
```

Members

base
the drm_audio_component base class

aud_sample_rate
the array of audio sample rate per port

Intel HDMI LPE Audio Support

Motivation: Atom platforms (e.g. valleyview and cherryTrail) integrates a DMA-based interface as an alternative to the traditional HDaudio path. While this mode is unrelated to the LPE aka SST audio engine, the documentation refers to this mode as LPE so we keep this notation for the sake of consistency.

The interface is handled by a separate standalone driver maintained in the ALSA subsystem for simplicity. To minimize the interaction between the two subsystems, a bridge is setup between the hdmi-lpe-audio and i915: 1. Create a platform device to share MMIO/IRQ resources 2. Make the platform device child of i915 device for runtime PM. 3. Create IRQ chip to forward the LPE audio irqs. the hdmi-lpe-audio driver probes the lpe audio device and creates a new sound card

Threats: Due to the restriction in Linux platform device model, user need manually uninstall the hdmi-lpe-audio driver before uninstalling i915 module, otherwise we might run into use-after-free issues after i915 removes the platform device: even though hdmi-lpe-audio driver is released, the modules is still in "installed" status.

Implementation: The MMIO/REG platform resources are created according to the registers specification. When forwarding LPE audio irqs, the flow control handler selection depends on the platform, for example on valleyview handle_simple_irq is enough.

void **intel_lpe_audio_irq_handler**(struct drm_i915_private *dev_priv)

forwards the LPE audio irq

Parameters

struct drm_i915_private *dev_priv
the i915 drm device private data

Description

the LPE Audio irq is forwarded to the irq handler registered by LPE audio driver.

int **intel_lpe_audio_init**(struct drm_i915_private *dev_priv)

detect and setup the bridge between HDMI LPE Audio driver and i915

Parameters

struct drm_i915_private *dev_priv
the i915 drm device private data

Return

0 if successful. non-zero if detection or llocation/initialization fails

void **intel_lpe_audio_teardown**(struct drm_i915_private *dev_priv)

destroy the bridge between HDMI LPE audio driver and i915

Parameters

struct drm_i915_private *dev_priv
the i915 drm device private data

Description

release all the resources for LPE audio <-> i915 bridge.

void **intel_lpe_audio_notify**(struct drm_i915_private *dev_priv, enum *pipe* pipe, enum *port* port, const void *eld, int ls_clock, bool dp_output)

notify lpe audio event audio driver and i915

Parameters

struct drm_i915_private *dev_priv
the i915 drm device private data

enum pipe pipe
pipe

enum port port
port

const void *eld
ELD data

int ls_clock
Link symbol clock in kHz

bool dp_output
Driving a DP output?

Description

Notify lpe audio driver of eld change.

Panel Self Refresh PSR (PSR/SRD)

Since Haswell Display controller supports Panel Self-Refresh on display panels witch have a remote frame buffer (RFB) implemented according to PSR spec in eDP1.3. PSR feature allows the display to go to lower standby states when system is idle but display is on as it eliminates display refresh request to DDR memory completely as long as the frame buffer for that display is unchanged.

Panel Self Refresh must be supported by both Hardware (source) and Panel (sink).

PSR saves power by caching the framebuffer in the panel RFB, which allows us to power down the link and memory controller. For DSI panels the same idea is called "manual mode".

The implementation uses the hardware-based PSR support which automatically enters/exits self-refresh mode. The hardware takes care of sending the required DP aux message and could even retrain the link (that part isn't enabled yet though). The hardware also keeps track of any frontbuffer changes to know when to exit self-refresh mode again. Unfortunately that part doesn't work too well, hence why the i915 PSR support uses the software frontbuffer tracking to make sure it doesn't miss a screen update. For this integration *intel_psr_invalidate()* and *intel_psr_flush()* get called by the frontbuffer tracking code. Note that because of locking issues the self-refresh re-enable code is done from a work queue, which must be correctly synchronized/cancelled when shutting down the pipe."

DC3CO (DC3 clock off)

On top of PSR2, GEN12 adds a intermediate power savings state that turns clock off automatically during PSR2 idle state. The smaller overhead of DC3co entry/exit vs. the overhead of PSR2 deep sleep entry/exit allows the HW to enter a low-power state even when page flipping periodically (for instance a 30fps video playback scenario).

Every time a flips occurs PSR2 will get out of deep sleep state(if it was), so DC3CO is enabled and tgl_dc3co_disable_work is schedule to run after 6 frames, if no other flip occurs and the function above is executed, DC3CO is disabled and PSR2 is configured to enter deep sleep, resetting again in case of another flip. Front buffer modifications do not trigger DC3CO activation on purpose as it would bring a lot of complexity and most of the moderns systems will only use page flips.

void **intel_psr_enable**(struct *intel_dp* *intel_dp, const struct intel_crtc_state *crtc_state, const struct *drm_connector_state* *conn_state)

Enable PSR

Parameters

struct intel_dp *intel_dp
Intel DP

const struct intel_crtc_state *crtc_state
new CRTC state

const struct drm_connector_state *conn_state
new CONNECTOR state

Description

This function can only be called after the pipe is fully trained and enabled.

void **intel_psr_disable**(struct *intel_dp* *intel_dp, const struct intel_crtc_state *old_crtc_state)

Disable PSR

Parameters

struct intel_dp *intel_dp
Intel DP

const struct intel_crtc_state *old_crtc_state
old CRTC state

Description

This function needs to be called before disabling pipe.

void **intel_psr_update**(struct *intel_dp* *intel_dp, const struct intel_crtc_state *crtc_state, const struct *drm_connector_state* *conn_state)

Update PSR state

Parameters

struct intel_dp *intel_dp
Intel DP

const struct intel_crtc_state *crtc_state
    new CRTC state

const struct drm_connector_state *conn_state
    new CONNECTOR state

Description

This functions will update PSR states, disabling, enabling or switching PSR version when executing fastsets. For full modeset, *intel_psr_disable()* and *intel_psr_enable()* should be called instead.

int **intel_psr_wait_for_idle**(const struct intel_crtc_state *new_crtc_state, u32 *out_value)

    wait for PSR1 to idle

Parameters

const struct intel_crtc_state *new_crtc_state
    new CRTC state

u32 *out_value
    PSR status in case of failure

Description

This function is expected to be called from pipe_update_start() where it is not expected to race with PSR enable or disable.

Return

0 on success or -ETIMEOUT if PSR status does not idle.

void **intel_psr_invalidate**(struct drm_i915_private *dev_priv, unsigned frontbuffer_bits, enum fb_op_origin origin)

    Invalidade PSR

Parameters

struct drm_i915_private *dev_priv
    i915 device

unsigned frontbuffer_bits
    frontbuffer plane tracking bits

enum fb_op_origin origin
    which operation caused the invalidate

Description

Since the hardware frontbuffer tracking has gaps we need to integrate with the software frontbuffer tracking. This function gets called every time frontbuffer rendering starts and a buffer gets dirtied. PSR must be disabled if the frontbuffer mask contains a buffer relevant to PSR.

Dirty frontbuffers relevant to PSR are tracked in busy_frontbuffer_bits."

void **intel_psr_flush**(struct drm_i915_private *dev_priv, unsigned frontbuffer_bits, enum fb_op_origin origin)

    Flush PSR

Parameters

`struct drm_i915_private *dev_priv`
: i915 device

`unsigned frontbuffer_bits`
: frontbuffer plane tracking bits

`enum fb_op_origin origin`
: which operation caused the flush

Description

Since the hardware frontbuffer tracking has gaps we need to integrate with the software frontbuffer tracking. This function gets called every time frontbuffer rendering has completed and flushed out to memory. PSR can be enabled again if no other frontbuffer relevant to PSR is dirty.

Dirty frontbuffers relevant to PSR are tracked in busy_frontbuffer_bits.

void **`intel_psr_init`**(struct drm_i915_private *dev_priv)

Init basic PSR work and mutex.

Parameters

`struct drm_i915_private *dev_priv`
: i915 device private

Description

This function is called only once at driver load to initialize basic PSR stuff.

Frame Buffer Compression (FBC)

FBC tries to save memory bandwidth (and so power consumption) by compressing the amount of memory used by the display. It is total transparent to user space and completely handled in the kernel.

The benefits of FBC are mostly visible with solid backgrounds and variation-less patterns. It comes from keeping the memory footprint small and having fewer memory pages opened and accessed for refreshing the display.

i915 is responsible to reserve stolen memory for FBC and configure its offset on proper registers. The hardware takes care of all compress/decompress. However there are many known cases where we have to forcibly disable it to allow proper screen updates.

bool **`intel_fbc_is_active`**(struct drm_i915_private *dev_priv)

Is FBC active?

Parameters

`struct drm_i915_private *dev_priv`
: i915 device instance

Description

This function is used to verify the current state of FBC.

FIXME: This should be tracked in the plane config eventually instead of queried at runtime for most callers.

void **`__intel_fbc_disable`**(struct drm_i915_private *dev_priv)

  disable FBC

Parameters

`struct drm_i915_private *dev_priv`
  i915 device instance

Description

This is the low level function that actually disables FBC. Callers should grab the FBC lock.

void **`intel_fbc_choose_crtc`**(struct drm_i915_private *dev_priv, struct intel_atomic_state *state)

  select a CRTC to enable FBC on

Parameters

`struct drm_i915_private *dev_priv`
  i915 device instance

`struct intel_atomic_state *state`
  the atomic state structure

Description

This function looks at the proposed state for CRTCs and planes, then chooses which pipe is going to have FBC by setting intel_crtc_state->enable_fbc to true.

Later, intel_fbc_enable is going to look for state->enable_fbc and then maybe enable FBC for the chosen CRTC. If it does, it will set dev_priv->fbc.crtc.

void **`intel_fbc_enable`**(struct intel_atomic_state *state, struct intel_crtc *crtc)

Parameters

`struct intel_atomic_state *state`
  corresponding *`drm_crtc_state`* for **crtc**

`struct intel_crtc *crtc`
  the CRTC

Description

This function checks if the given CRTC was chosen for FBC, then enables it if possible. Notice that it doesn't activate FBC. It is valid to call intel_fbc_enable multiple times for the same pipe without an intel_fbc_disable in the middle, as long as it is deactivated.

void **`intel_fbc_disable`**(struct intel_crtc *crtc)

  disable FBC if it's associated with crtc

Parameters

`struct intel_crtc *crtc`
  the CRTC

Description

This function disables FBC if it's associated with the provided CRTC.

void **intel_fbc_global_disable**(struct drm_i915_private *dev_priv)
globally disable FBC

Parameters

struct drm_i915_private *dev_priv
i915 device instance

Description

This function disables FBC regardless of which CRTC is associated with it.

void **intel_fbc_handle_fifo_underrun_irq**(struct drm_i915_private *dev_priv)
disable FBC when we get a FIFO underrun

Parameters

struct drm_i915_private *dev_priv
i915 device instance

Description

Without FBC, most underruns are harmless and don't really cause too many problems, except for an annoying message on dmesg. With FBC, underruns can become black screens or even worse, especially when paired with bad watermarks. So in order for us to be on the safe side, completely disable FBC in case we ever detect a FIFO underrun on any pipe. An underrun on any pipe already suggests that watermarks may be bad, so try to be as safe as possible.

This function is called from the IRQ handler.

void **intel_fbc_init**(struct drm_i915_private *dev_priv)
Initialize FBC

Parameters

struct drm_i915_private *dev_priv
the i915 device

Description

This function might be called during PM init process.

Display Refresh Rate Switching (DRRS)

Display Refresh Rate Switching (DRRS) is a power conservation feature which enables swtching between low and high refresh rates, dynamically, based on the usage scenario. This feature is applicable for internal panels.

Indication that the panel supports DRRS is given by the panel EDID, which would list multiple refresh rates for one resolution.

DRRS is of 2 types - static and seamless. Static DRRS involves changing refresh rate (RR) by doing a full modeset (may appear as a blink on screen) and is used in dock-undock scenario. Seamless DRRS involves changing RR without any visual effect to the user and can be used during normal system usage. This is done by programming certain registers.

Support for static/seamless DRRS may be indicated in the VBT based on inputs from the panel spec.

DRRS saves power by switching to low RR based on usage scenarios.

The implementation is based on frontbuffer tracking implementation. When there is a disturbance on the screen triggered by user activity or a periodic system activity, DRRS is disabled (RR is changed to high RR). When there is no movement on screen, after a timeout of 1 second, a switch to low RR is made.

For integration with frontbuffer tracking code, *intel_edp_drrs_invalidate()* and *intel_edp_drrs_flush()* are called.

DRRS can be further extended to support other internal panels and also the scenario of video playback wherein RR is set based on the rate requested by userspace.

void **intel_dp_set_drrs_state**(struct drm_i915_private *dev_priv, const struct intel_crtc_state *crtc_state, int refresh_rate)

program registers for RR switch to take effect

Parameters

struct drm_i915_private *dev_priv
i915 device

const struct intel_crtc_state *crtc_state
a pointer to the active intel_crtc_state

int refresh_rate
RR to be programmed

Description

This function gets called when refresh rate (RR) has to be changed from one frequency to another. Switches can be between high and low RR supported by the panel or to any other RR based on media playback (in this case, RR value needs to be passed from user space).

The caller of this function needs to take a lock on dev_priv->drrs.

void **intel_edp_drrs_enable**(struct *intel_dp* *intel_dp, const struct intel_crtc_state *crtc_state)

init drrs struct if supported

Parameters

struct intel_dp *intel_dp
DP struct

const struct intel_crtc_state *crtc_state
A pointer to the active crtc state.

Description

Initializes frontbuffer_bits and drrs.dp void **intel_edp_drrs_disable**(struct *intel_dp* *intel_dp, const struct intel_crtc_state *old_crtc_state)

Disable DRRS

Parameters

struct intel_dp *intel_dp
DP struct

const struct intel_crtc_state *old_crtc_state
Pointer to old crtc_state.

void **intel_edp_drrs_invalidate**(struct drm_i915_private *dev_priv, unsigned int frontbuffer_bits)

Disable Idleness DRRS

Parameters

struct drm_i915_private *dev_priv
i915 device

unsigned int frontbuffer_bits
frontbuffer plane tracking bits

Description

This function gets called everytime rendering on the given planes start. Hence DRRS needs to be Upclocked, i.e. (LOW_RR -> HIGH_RR).

Dirty frontbuffers relevant to DRRS are tracked in busy_frontbuffer_bits.

void **intel_edp_drrs_flush**(struct drm_i915_private *dev_priv, unsigned int frontbuffer_bits)

Restart Idleness DRRS

Parameters

struct drm_i915_private *dev_priv
i915 device

unsigned int frontbuffer_bits
frontbuffer plane tracking bits

Description

This function gets called every time rendering on the given planes has completed or flip on a crtc is completed. So DRRS should be upclocked (LOW_RR -> HIGH_RR). And also Idleness detection should be started again, if no other planes are dirty.

Dirty frontbuffers relevant to DRRS are tracked in busy_frontbuffer_bits.

struct *drm_display_mode* ***intel_dp_drrs_init**(struct intel_connector *connector, struct *drm_display_mode* *fixed_mode)

Init basic DRRS work and mutex.

Parameters

struct intel_connector *connector
eDP connector

struct drm_display_mode *fixed_mode
preferred mode of panel

Description

This function is called only once at driver load to initialize basic DRRS stuff.

Return

Downclock mode if panel supports it, else return NULL. DRRS support is determined by the presence of downclock mode (apart from VBT setting).

DPIO

VLV, CHV and BXT have slightly peculiar display PHYs for driving DP/HDMI ports. DPIO is the name given to such a display PHY. These PHYs don't follow the standard programming model using direct MMIO registers, and instead their registers must be accessed trough IOSF sideband. VLV has one such PHY for driving ports B and C, and CHV adds another PHY for driving port D. Each PHY responds to specific IOSF-SB port.

Each display PHY is made up of one or two channels. Each channel houses a common lane part which contains the PLL and other common logic. CH0 common lane also contains the IOSF-SB logic for the Common Register Interface (CRI) ie. the DPIO registers. CRI clock must be running when any DPIO registers are accessed.

In addition to having their own registers, the PHYs are also controlled through some dedicated signals from the display controller. These include PLL reference clock enable, PLL enable, and CRI clock selection, for example.

Eeach channel also has two splines (also called data lanes), and each spline is made up of one Physical Access Coding Sub-Layer (PCS) block and two TX lanes. So each channel has two PCS blocks and four TX lanes. The TX lanes are used as DP lanes or TMDS data/clock pairs depending on the output type.

Additionally the PHY also contains an AUX lane with AUX blocks for each channel. This is used for DP AUX communication, but this fact isn' t really relevant for the driver since AUX is controlled from the display controller side. No DPIO registers need to be accessed during AUX communication,

Generally on VLV/CHV the common lane corresponds to the pipe and the spline (PCS/TX) corresponds to the port.

For dual channel PHY (VLV/CHV):

pipe A == CMN/PLL/REF CH0

pipe B == CMN/PLL/REF CH1

port B == PCS/TX CH0

port C == PCS/TX CH1

This is especially important when we cross the streams ie. drive port B with pipe B, or port C with pipe A.

For single channel PHY (CHV):

pipe C == CMN/PLL/REF CH0

port D == PCS/TX CH0

On BXT the entire PHY channel corresponds to the port. That means the PLL is also now associated with the port rather than the pipe, and so the clock needs to be routed to the appropriate transcoder. Port A PLL is directly connected to transcoder EDP and port B/C PLLs can be routed to any transcoder A/B/C.

Note: DDI0 is digital port B, DD1 is digital port C, and DDI2 is digital port D (CHV) or port A (BXT).

```
Dual channel PHY (VLV/CHV/BXT)
---------------------------------
|      CH0      |      CH1      |
|  CMN/PLL/REF  |  CMN/PLL/REF  |
|---------------|---------------| Display PHY
| PCS01 | PCS23 | PCS01 | PCS23 |
|-------|-------|-------|-------|
|TX0|TX1|TX2|TX3|TX0|TX1|TX2|TX3|
---------------------------------
|     DDI0      |     DDI1      | DP/HDMI ports
---------------------------------

Single channel PHY (CHV/BXT)
-----------------
|      CH0      |
|  CMN/PLL/REF  |
|---------------| Display PHY
| PCS01 | PCS23 |
|-------|-------|
|TX0|TX1|TX2|TX3|
-----------------
|     DDI2      | DP/HDMI port
-----------------
```

CSR firmware support for DMC

Display Context Save and Restore (CSR) firmware support added from gen9 onwards to drive newly added DMC (Display microcontroller) in display engine to save and restore the state of display engine when it enter into low-power state and comes back to normal.

void **intel_csr_load_program**(struct drm_i915_private *dev_priv)

write the firmware from memory to register.

Parameters

struct drm_i915_private *dev_priv
i915 drm device.

Description

CSR firmware is read from a .bin file and kept in internal memory one time. Everytime display comes back from low power state this function is called to copy the firmware from internal memory to registers.

void **`intel_csr_ucode_init`**(struct drm_i915_private *dev_priv)

initialize the firmware loading.

Parameters

`struct drm_i915_private *dev_priv`
i915 drm device.

Description

This function is called at the time of loading the display driver to read firmware from a .bin file and copied into a internal memory.

void **`intel_csr_ucode_suspend`**(struct drm_i915_private *dev_priv)

prepare CSR firmware before system suspend

Parameters

`struct drm_i915_private *dev_priv`
i915 drm device

Description

Prepare the DMC firmware before entering system suspend. This includes flushing pending work items and releasing any resources acquired during init.

void **`intel_csr_ucode_resume`**(struct drm_i915_private *dev_priv)

init CSR firmware during system resume

Parameters

`struct drm_i915_private *dev_priv`
i915 drm device

Description

Reinitialize the DMC firmware during system resume, reacquiring any resources released in *`intel_csr_ucode_suspend()`*.

void **`intel_csr_ucode_fini`**(struct drm_i915_private *dev_priv)

unload the CSR firmware.

Parameters

`struct drm_i915_private *dev_priv`
i915 drm device.

Description

Firmmware unloading includes freeing the internal memory and reset the firmware loading status.

Video BIOS Table (VBT)

The Video BIOS Table, or VBT, provides platform and board specific configuration information to the driver that is not discoverable or available through other means. The configuration is mostly related to display hardware. The VBT is available via the ACPI OpRegion or, on older systems, in the PCI ROM.

The VBT consists of a VBT Header (defined as *struct vbt_header*), a BDB Header (*struct bdb_header*), and a number of BIOS Data Blocks (BDB) that contain the actual configuration information. The VBT Header, and thus the VBT, begins with "$VBT" signature. The VBT Header contains the offset of the BDB Header. The data blocks are concatenated after the BDB Header. The data blocks have a 1-byte Block ID, 2-byte Block Size, and Block Size bytes of data. (Block 53, the MIPI Sequence Block is an exception.)

The driver parses the VBT during load. The relevant information is stored in driver private data for ease of use, and the actual VBT is not read after that.

bool **intel_bios_is_valid_vbt**(const void *buf, size_t size)

  does the given buffer contain a valid VBT

Parameters

const void *buf
  pointer to a buffer to validate

size_t size
  size of the buffer

Description

Returns true on valid VBT.

void **intel_bios_init**(struct drm_i915_private *dev_priv)

  find VBT and initialize settings from the BIOS

Parameters

struct drm_i915_private *dev_priv
  i915 device instance

Description

Parse and initialize settings from the Video BIOS Tables (VBT). If the VBT was not found in ACPI OpRegion, try to find it in PCI ROM first. Also initialize some defaults if the VBT is not present at all.

void **intel_bios_driver_remove**(struct drm_i915_private *dev_priv)

  Free any resources allocated by *intel_bios_init()*

Parameters

struct drm_i915_private *dev_priv
  i915 device instance

bool **intel_bios_is_tv_present**(struct drm_i915_private *dev_priv)

  is integrated TV present in VBT

Parameters

`struct drm_i915_private *dev_priv`
  i915 device instance

Description

Return true if TV is present. If no child devices were parsed from VBT, assume TV is present.

bool **`intel_bios_is_lvds_present`**(struct drm_i915_private *dev_priv, u8 *i2c_pin)

  is LVDS present in VBT

Parameters

`struct drm_i915_private *dev_priv`
  i915 device instance

`u8 *i2c_pin`
  i2c pin for LVDS if present

Description

Return true if LVDS is present. If no child devices were parsed from VBT, assume LVDS is present.

bool **`intel_bios_is_port_present`**(struct drm_i915_private *dev_priv, enum *port* port)

  is the specified digital port present

Parameters

`struct drm_i915_private *dev_priv`
  i915 device instance

`enum port port`
  port to check

Description

Return true if the device in `port` is present.

bool **`intel_bios_is_port_edp`**(struct drm_i915_private *dev_priv, enum *port* port)

  is the device in given port eDP

Parameters

`struct drm_i915_private *dev_priv`
  i915 device instance

`enum port port`
  port to check

Description

Return true if the device in `port` is eDP.

bool **`intel_bios_is_dsi_present`**(struct drm_i915_private *dev_priv, enum *port* *port)

  is DSI present in VBT

Parameters

struct drm_i915_private *dev_priv
: i915 device instance

enum port *port
: port for DSI if present

Description

Return true if DSI is present, and return the port in `port`.

bool **intel_bios_is_port_hpd_inverted**(const struct drm_i915_private *i915, enum *port* port)

is HPD inverted for `port`

Parameters

const struct drm_i915_private *i915
: i915 device instance

enum port port
: port to check

Description

Return true if HPD should be inverted for `port`.

bool **intel_bios_is_lspcon_present**(const struct drm_i915_private *i915, enum *port* port)

if LSPCON is attached on `port`

Parameters

const struct drm_i915_private *i915
: i915 device instance

enum port port
: port to check

Description

Return true if LSPCON is present on this port

struct **vbt_header**

VBT Header structure

Definition

```
struct vbt_header {
  u8 signature[20];
  u16 version;
  u16 header_size;
  u16 vbt_size;
  u8 vbt_checksum;
  u8 reserved0;
  u32 bdb_offset;
  u32 aim_offset[4];
};
```

Members

signature
VBT signature, always starts with "$VBT"

version
Version of this structure

header_size
Size of this structure

vbt_size
Size of VBT (VBT Header, BDB Header and data blocks)

vbt_checksum
Checksum

reserved0
Reserved

bdb_offset
Offset of *struct bdb_header* from beginning of VBT

aim_offset
Offsets of add-in data blocks from beginning of VBT

struct **bdb_header**

BDB Header structure

Definition

```
struct bdb_header {
  u8 signature[16];
  u16 version;
  u16 header_size;
  u16 bdb_size;
};
```

Members

signature
BDB signature "BIOS_DATA_BLOCK"

version
Version of the data block definitions

header_size
Size of this structure

bdb_size
Size of BDB (BDB Header and data blocks)

Display clocks

The display engine uses several different clocks to do its work. There are two main clocks involved that aren't directly related to the actual pixel clock or any symbol/bit clock of the actual output port. These are the core display clock (CDCLK) and RAWCLK.

CDCLK clocks most of the display pipe logic, and thus its frequency must be high enough to support the rate at which pixels are flowing through the pipes. Downscaling must also be accounted as that increases the effective pixel rate.

On several platforms the CDCLK frequency can be changed dynamically to minimize power consumption for a given display configuration. Typically changes to the CDCLK frequency require all the display pipes to be shut down while the frequency is being changed.

On SKL+ the DMC will toggle the CDCLK off/on during DC5/6 entry/exit. DMC will not change the active CDCLK frequency however, so that part will still be performed by the driver directly.

RAWCLK is a fixed frequency clock, often used by various auxiliary blocks such as AUX CH or backlight PWM. Hence the only thing we really need to know about RAWCLK is its frequency so that various dividers can be programmed correctly.

void **intel_cdclk_init_hw**(struct drm_i915_private *i915)

Initialize CDCLK hardware

Parameters

struct drm_i915_private *i915
i915 device

Description

Initialize CDCLK. This consists mainly of initializing dev_priv->cdclk.hw and sanitizing the state of the hardware if needed. This is generally done only during the display core initialization sequence, after which the DMC will take care of turning CDCLK off/on as needed.

void **intel_cdclk_uninit_hw**(struct drm_i915_private *i915)

Uninitialize CDCLK hardware

Parameters

struct drm_i915_private *i915
i915 device

Description

Uninitialize CDCLK. This is done only during the display core uninitialization sequence.

bool **intel_cdclk_needs_modeset**(const struct intel_cdclk_config *a, const struct intel_cdclk_config *b)

Determine if changong between the CDCLK configurations requires a modeset on all pipes

Parameters

const struct intel_cdclk_config *a
first CDCLK configuration

const struct intel_cdclk_config *b
second CDCLK configuration

Return

True if changing between the two CDCLK configurations requires all pipes to be off, false if not.

bool **intel_cdclk_can_cd2x_update**(struct drm_i915_private *dev_priv, const struct intel_cdclk_config *a, const struct intel_cdclk_config *b)

Determine if changing between the two CDCLK configurations requires only a cd2x divider update

Parameters

struct drm_i915_private *dev_priv
i915 device

const struct intel_cdclk_config *a
first CDCLK configuration

const struct intel_cdclk_config *b
second CDCLK configuration

Return

True if changing between the two CDCLK configurations can be done with just a cd2x divider update, false if not.

bool **intel_cdclk_changed**(const struct intel_cdclk_config *a, const struct intel_cdclk_config *b)

Determine if two CDCLK configurations are different

Parameters

const struct intel_cdclk_config *a
first CDCLK configuration

const struct intel_cdclk_config *b
second CDCLK configuration

Return

True if the CDCLK configurations don't match, false if they do.

void **intel_set_cdclk**(struct drm_i915_private *dev_priv, const struct intel_cdclk_config *cdclk_config, enum *pipe* pipe)

Push the CDCLK configuration to the hardware

Parameters

struct drm_i915_private *dev_priv
i915 device

const struct intel_cdclk_config *cdclk_config
new CDCLK configuration

enum pipe pipe
pipe with which to synchronize the update

Description

Program the hardware based on the passed in CDCLK state, if necessary.

void **intel_set_cdclk_pre_plane_update**(struct intel_atomic_state *state)
Push the CDCLK state to the hardware

Parameters

struct intel_atomic_state *state
intel atomic state

Description

Program the hardware before updating the HW plane state based on the new CDCLK state, if necessary.

void **intel_set_cdclk_post_plane_update**(struct intel_atomic_state *state)
Push the CDCLK state to the hardware

Parameters

struct intel_atomic_state *state
intel atomic state

Description

Program the hardware after updating the HW plane state based on the new CDCLK state, if necessary.

void **intel_update_max_cdclk**(struct drm_i915_private *dev_priv)
Determine the maximum support CDCLK frequency

Parameters

struct drm_i915_private *dev_priv
i915 device

Description

Determine the maximum CDCLK frequency the platform supports, and also derive the maximum dot clock frequency the maximum CDCLK frequency allows.

void **intel_update_cdclk**(struct drm_i915_private *dev_priv)
Determine the current CDCLK frequency

Parameters

struct drm_i915_private *dev_priv
i915 device

Description

Determine the current CDCLK frequency.

u32 **intel_read_rawclk**(struct drm_i915_private *dev_priv)
Determine the current RAWCLK frequency

Parameters

struct drm_i915_private *dev_priv
i915 device

Description

Determine the current RAWCLK frequency. RAWCLK is a fixed frequency clock so this needs to done only once.

void **intel_init_cdclk_hooks**(struct drm_i915_private *dev_priv)
Initialize CDCLK related modesetting hooks

Parameters

struct drm_i915_private *dev_priv
i915 device

Display PLLs

Display PLLs used for driving outputs vary by platform. While some have per-pipe or per-encoder dedicated PLLs, others allow the use of any PLL from a pool. In the latter scenario, it is possible that multiple pipes share a PLL if their configurations match.

This file provides an abstraction over display PLLs. The function *intel_shared_dpll_init()* initializes the PLLs for the given platform. The users of a PLL are tracked and that tracking is integrated with the atomic modset interface. During an atomic operation, required PLLs can be reserved for a given CRTC and encoder configuration by calling *intel_reserve_shared_dplls()* and previously reserved PLLs can be released with *intel_release_shared_dplls()*. Changes to the users are first staged in the atomic state, and then made effective by calling *intel_shared_dpll_swap_state()* during the atomic commit phase.

struct *intel_shared_dpll* ***intel_get_shared_dpll_by_id**(struct drm_i915_private *dev_priv, enum *intel_dpll_id* id)
get a DPLL given its id

Parameters

struct drm_i915_private *dev_priv
i915 device instance

enum intel_dpll_id id
pll id

Return

A pointer to the DPLL with **id**

enum *intel_dpll_id* **intel_get_shared_dpll_id**(struct drm_i915_private *dev_priv, struct *intel_shared_dpll* *pll)
get the id of a DPLL

Parameters

`struct drm_i915_private *dev_priv`
i915 device instance

`struct intel_shared_dpll *pll`
the DPLL

Return

The id of **pll**

void **`intel_prepare_shared_dpll`**(const struct intel_crtc_state *crtc_state)
call a dpll's prepare hook

Parameters

`const struct intel_crtc_state *crtc_state`
CRTC, and its state, which has a shared dpll

Description

This calls the PLL's prepare hook if it has one and if the PLL is not already enabled. The prepare hook is platform specific.

void **`intel_enable_shared_dpll`**(const struct intel_crtc_state *crtc_state)
enable a CRTC's shared DPLL

Parameters

`const struct intel_crtc_state *crtc_state`
CRTC, and its state, which has a shared DPLL

Description

Enable the shared DPLL used by **crtc**.

void **`intel_disable_shared_dpll`**(const struct intel_crtc_state *crtc_state)
disable a CRTC's shared DPLL

Parameters

`const struct intel_crtc_state *crtc_state`
CRTC, and its state, which has a shared DPLL

Description

Disable the shared DPLL used by **crtc**.

void **`intel_shared_dpll_swap_state`**(struct intel_atomic_state *state)
make atomic DPLL configuration effective

Parameters

`struct intel_atomic_state *state`
atomic state

Description

This is the dpll version of *`drm_atomic_helper_swap_state()`* since the helper does not handle driver-specific global state.

For consistency with atomic helpers this function does a complete swap, i.e. it also puts the current state into **state**, even though there is no need for that at this moment.

void **icl_set_active_port_dpll**(struct intel_crtc_state *crtc_state, enum icl_port_dpll_id port_dpll_id)

select the active port DPLL for a given CRTC

Parameters

struct intel_crtc_state *crtc_state
state for the CRTC to select the DPLL for

enum icl_port_dpll_id port_dpll_id
the active **port_dpll_id** to select

Description

Select the given **port_dpll_id** instance from the DPLLs reserved for the CRTC.

void **intel_shared_dpll_init**(struct *drm_device* *dev)

Initialize shared DPLLs

Parameters

struct drm_device *dev
drm device

Description

Initialize shared DPLLs for **dev**.

bool **intel_reserve_shared_dplls**(struct intel_atomic_state *state, struct intel_crtc *crtc, struct intel_encoder *encoder)

reserve DPLLs for CRTC and encoder combination

Parameters

struct intel_atomic_state *state
atomic state

struct intel_crtc *crtc
CRTC to reserve DPLLs for

struct intel_encoder *encoder
encoder

Description

This function reserves all required DPLLs for the given CRTC and encoder combination in the current atomic commit **state** and the new **crtc** atomic state.

The new configuration in the atomic commit **state** is made effective by calling *intel_shared_dpll_swap_state()*.

The reserved DPLLs should be released by calling *intel_release_shared_dplls()*.

Return

True if all required DPLLs were successfully reserved.

void **intel_release_shared_dplls**(struct intel_atomic_state *state, struct intel_crtc *crtc)

end use of DPLLs by CRTC in atomic state

Parameters

struct intel_atomic_state *state
atomic state

struct intel_crtc *crtc
crtc from which the DPLLs are to be released

Description

This function releases all DPLLs reserved by *intel_reserve_shared_dplls()* from the current atomic commit **state** and the old **crtc** atomic state.

The new configuration in the atomic commit **state** is made effective by calling *intel_shared_dpll_swap_state()*.

void **intel_update_active_dpll**(struct intel_atomic_state *state, struct intel_crtc *crtc, struct intel_encoder *encoder)

update the active DPLL for a CRTC/encoder

Parameters

struct intel_atomic_state *state
atomic state

struct intel_crtc *crtc
the CRTC for which to update the active DPLL

struct intel_encoder *encoder
encoder determining the type of port DPLL

Description

Update the active DPLL for the given **crtc/encoder** in **crtc**'s atomic state, from the port DPLLs reserved previously by *intel_reserve_shared_dplls()*. The DPLL selected will be based on the current mode of the encoder' s port.

int **intel_dpll_get_freq**(struct drm_i915_private *i915, const struct *intel_shared_dpll* *pll)

calculate the DPLL' s output frequency

Parameters

struct drm_i915_private *i915
i915 device

const struct intel_shared_dpll *pll
DPLL for which to calculate the output frequency

Description

Return the output frequency corresponding to **pll**' s current state.

void **intel_dpll_dump_hw_state**(struct drm_i915_private *dev_priv, const struct intel_dpll_hw_state *hw_state)

write hw_state to dmesg

Parameters

struct drm_i915_private *dev_priv
: i915 drm device

const struct intel_dpll_hw_state *hw_state
: hw state to be written to the log

Description

Write the relevant values in **hw_state** to dmesg using drm_dbg_kms.

enum **intel_dpll_id**
: possible DPLL ids

Constants

DPLL_ID_PRIVATE
: non-shared dpll in use

DPLL_ID_PCH_PLL_A
: DPLL A in ILK, SNB and IVB

DPLL_ID_PCH_PLL_B
: DPLL B in ILK, SNB and IVB

DPLL_ID_WRPLL1
: HSW and BDW WRPLL1

DPLL_ID_WRPLL2
: HSW and BDW WRPLL2

DPLL_ID_SPLL
: HSW and BDW SPLL

DPLL_ID_LCPLL_810
: HSW and BDW 0.81 GHz LCPLL

DPLL_ID_LCPLL_1350
: HSW and BDW 1.35 GHz LCPLL

DPLL_ID_LCPLL_2700
: HSW and BDW 2.7 GHz LCPLL

DPLL_ID_SKL_DPLL0
: SKL and later DPLL0

DPLL_ID_SKL_DPLL1
: SKL and later DPLL1

DPLL_ID_SKL_DPLL2
: SKL and later DPLL2

DPLL_ID_SKL_DPLL3
: SKL and later DPLL3

DPLL_ID_ICL_DPLL0
: ICL/TGL combo PHY DPLL0

DPLL_ID_ICL_DPLL1
: ICL/TGL combo PHY DPLL1

DPLL_ID_EHL_DPLL4
EHL combo PHY DPLL4

DPLL_ID_ICL_TBTPLL
ICL/TGL TBT PLL

DPLL_ID_ICL_MGPLL1

ICL MG PLL 1 port 1 (C),
TGL TC PLL 1 port 1 (TC1)

DPLL_ID_ICL_MGPLL2

ICL MG PLL 1 port 2 (D)
TGL TC PLL 1 port 2 (TC2)

DPLL_ID_ICL_MGPLL3

ICL MG PLL 1 port 3 (E)
TGL TC PLL 1 port 3 (TC3)

DPLL_ID_ICL_MGPLL4

ICL MG PLL 1 port 4 (F)
TGL TC PLL 1 port 4 (TC4)

DPLL_ID_TGL_MGPLL5
TGL TC PLL port 5 (TC5)

DPLL_ID_TGL_MGPLL6
TGL TC PLL port 6 (TC6)

Description

Enumeration of possible IDs for a DPLL. Real shared dpll ids must be >= 0.

struct **intel_shared_dpll_state**
hold the DPLL atomic state

Definition

```
struct intel_shared_dpll_state {
  unsigned crtc_mask;
  struct intel_dpll_hw_state hw_state;
};
```

Members

crtc_mask
mask of CRTC using this DPLL, active or not

hw_state
hardware configuration for the DPLL stored in struct intel_dpll_hw_state.

Description

This structure holds an atomic state for the DPLL, that can represent either its current state (in struct *intel_shared_dpll*) or a desired future state which would be applied by an atomic mode set (stored in a struct intel_atomic_state).

See also *intel_reserve_shared_dplls()* and *intel_release_shared_dplls()*.

struct **intel_shared_dpll_funcs**

platform specific hooks for managing DPLLs

Definition

```
struct intel_shared_dpll_funcs {
  void (*prepare)(struct drm_i915_private *dev_priv, struct intel_
↪shared_dpll *pll);
  void (*enable)(struct drm_i915_private *dev_priv, struct intel_
↪shared_dpll *pll);
  void (*disable)(struct drm_i915_private *dev_priv, struct intel_
↪shared_dpll *pll);
  bool (*get_hw_state)(struct drm_i915_private *dev_priv,struct␣
↪intel_shared_dpll *pll, struct intel_dpll_hw_state *hw_state);
  int (*get_freq)(struct drm_i915_private *i915, const struct intel_
↪shared_dpll *pll);
};
```

Members

prepare
Optional hook to perform operations prior to enabling the PLL. Called from *intel_prepare_shared_dpll()* function unless the PLL is already enabled.

enable
Hook for enabling the pll, called from *intel_enable_shared_dpll()* if the pll is not already enabled.

disable
Hook for disabling the pll, called from *intel_disable_shared_dpll()* only when it is safe to disable the pll, i.e., there are no more tracked users for it.

get_hw_state
Hook for reading the values currently programmed to the DPLL registers. This is used for initial hw state readout and state verification after a mode set.

get_freq
Hook for calculating the pll's output frequency based on its current state.

struct **dpll_info**

display PLL platform specific info

Definition

```
struct dpll_info {
  const char *name;
  const struct intel_shared_dpll_funcs *funcs;
  enum intel_dpll_id id;
#define INTEL_DPLL_ALWAYS_ON    (1 << 0);
  u32 flags;
};
```

Members

name
DPLL name; used for logging

funcs
platform specific hooks

id
unique indentifier for this DPLL; should match the index in the dev_priv->shared_dplls array

flags

INTEL_DPLL_ALWAYS_ON
Inform the state checker that the DPLL is kept enabled even if not in use by any CRTC.

struct **intel_shared_dpll**

display PLL with tracked state and users

Definition

```
struct intel_shared_dpll {
  struct intel_shared_dpll_state state;
  unsigned active_mask;
  bool on;
  const struct dpll_info *info;
  intel_wakeref_t wakeref;
};
```

Members

state
Store the state for the pll, including its hw state and CRTCs using it.

active_mask
mask of active CRTCs (i.e. DPMS on) using this DPLL

on
is the PLL actually active? Disabled during modeset

info
platform specific info

wakeref
In some platforms a device-level runtime pm reference may need to be grabbed to disable DC states while this DPLL is enabled

Display State Buffer

A DSB (Display State Buffer) is a queue of MMIO instructions in the memory which can be offloaded to DSB HW in Display Controller. DSB HW is a DMA engine that can be programmed to download the DSB from memory. It allows driver to batch submit display HW programming. This helps to reduce loading time and CPU activity, thereby making the context switch faster. DSB Support added from Gen12 Intel graphics based platform.

DSB's can access only the pipe, plane, and transcoder Data Island Packet registers.

DSB HW can support only register writes (both indexed and direct MMIO writes). There are no registers reads possible with DSB HW engine.

void **intel_dsb_indexed_reg_write**(const struct intel_crtc_state *crtc_state, i915_reg_t reg, u32 val)

Write to the DSB context for auto increment register.

Parameters

const struct intel_crtc_state *crtc_state
intel_crtc_state structure

i915_reg_t reg
register address.

u32 val
value.

Description

This function is used for writing register-value pair in command buffer of DSB for auto-increment register. During command buffer overflow, a warning is thrown and rest all erroneous condition register programming is done through mmio write.

void **intel_dsb_reg_write**(const struct intel_crtc_state *crtc_state, i915_reg_t reg, u32 val)

Write to the DSB context for normal register.

Parameters

const struct intel_crtc_state *crtc_state
intel_crtc_state structure

i915_reg_t reg
register address.

u32 val
value.

Description

This function is used for writing register-value pair in command buffer of DSB. During command buffer overflow, a warning is thrown and rest all erroneous condition register programming is done through mmio write.

void **intel_dsb_commit**(const struct intel_crtc_state *crtc_state)

Trigger workload execution of DSB.

Parameters

const struct intel_crtc_state *crtc_state
intel_crtc_state structure

Description

This function is used to do actual write to hardware using DSB. On errors, fall back to MMIO. Also this function help to reset the context.

void **intel_dsb_prepare**(struct intel_crtc_state *crtc_state)
Allocate, pin and map the DSB command buffer.

Parameters

struct intel_crtc_state *crtc_state
intel_crtc_state structure to prepare associated dsb instance.

Description

This function prepare the command buffer which is used to store dsb instructions with data.

void **intel_dsb_cleanup**(struct intel_crtc_state *crtc_state)
To cleanup DSB context.

Parameters

struct intel_crtc_state *crtc_state
intel_crtc_state structure to cleanup associated dsb instance.

Description

This function cleanup the DSB context by unpinning and releasing the VMA object associated with it.

8.3.3 Memory Management and Command Submission

This sections covers all things related to the GEM implementation in the i915 driver.

Intel GPU Basics

An Intel GPU has multiple engines. There are several engine types.

- RCS engine is for rendering 3D and performing compute, this is named *I915_EXEC_RENDER* in user space.
- BCS is a blitting (copy) engine, this is named *I915_EXEC_BLT* in user space.
- VCS is a video encode and decode engine, this is named *I915_EXEC_BSD* in user space
- VECS is video enhancement engine, this is named *I915_EXEC_VEBOX* in user space.
- The enumeration *I915_EXEC_DEFAULT* does not refer to specific engine; instead it is to be used by user space to specify a default rendering engine (for 3D) that may or may not be the same as RCS.

The Intel GPU family is a family of integrated GPU' s using Unified Memory Access. For having the GPU "do work" , user space will feed the GPU batch buffers via one of the ioctls *DRM_IOCTL_I915_GEM_EXECBUFFER2* or *DRM_IOCTL_I915_GEM_EXECBUFFER2_WR*. Most such batchbuffers will instruct the GPU to perform work (for example rendering) and that work needs memory from which to read and memory to which to write. All memory is encapsulated within GEM buffer objects (usually created with the ioctl *DRM_IOCTL_I915_GEM_CREATE*). An ioctl providing a batchbuffer for the GPU to create will also list all GEM buffer objects that the batchbuffer reads and/or writes. For implementation details of memory management see *GEM BO Management Implementation Details*.

The i915 driver allows user space to create a context via the ioctl *DRM_IOCTL_I915_GEM_CONTEXT_CREATE* which is identified by a 32-bit integer. Such a context should be viewed by user-space as -loosely- analogous to the idea of a CPU process of an operating system. The i915 driver guarantees that commands issued to a fixed context are to be executed so that writes of a previously issued command are seen by reads of following commands. Actions issued between different contexts (even if from the same file descriptor) are NOT given that guarantee and the only way to synchronize across contexts (even from the same file descriptor) is through the use of fences. At least as far back as Gen4, also have that a context carries with it a GPU HW context; the HW context is essentially (most of atleast) the state of a GPU. In addition to the ordering guarantees, the kernel will restore GPU state via HW context when commands are issued to a context, this saves user space the need to restore (most of atleast) the GPU state at the start of each batchbuffer. The non-deprecated ioctls to submit batchbuffer work can pass that ID (in the lower bits of drm_i915_gem_execbuffer2::rsvd1) to identify what context to use with the command.

The GPU has its own memory management and address space. The kernel driver maintains the memory translation table for the GPU. For older GPUs (i.e. those before Gen8), there is a single global such translation table, a global Graphics Translation Table (GTT). For newer generation GPUs each context has its own translation table, called Per-Process Graphics Translation Table (PPGTT). Of important note, is that although PPGTT is named per-process it is actually per context. When user space submits a batchbuffer, the kernel walks the list of GEM buffer objects used by the batchbuffer and guarantees that not only is the memory of each such GEM buffer object resident but it is also present in the (PP)GTT. If the GEM buffer object is not yet placed in the (PP)GTT, then it is given an address. Two consequences of this are: the kernel needs to edit the batchbuffer submitted to write the correct value of the GPU address when a GEM BO is assigned a GPU address and the kernel might evict a different GEM BO from the (PP)GTT to make address room for another GEM BO. Consequently, the ioctls submitting a batchbuffer for execution also include a list of all locations within buffers that refer to GPU-addresses so that the kernel can edit the buffer correctly. This process is dubbed relocation.

Locking Guidelines

Note: This is a description of how the locking should be after refactoring is done. Does not necessarily reflect what the locking looks like while WIP.

1. All locking rules and interface contracts with cross-driver interfaces (dma-buf, dma_fence) need to be followed.
2. No struct_mutex anywhere in the code
3. dma_resv will be the outermost lock (when needed) and ww_acquire_ctx is to be hoisted at highest level and passed down within i915_gem_ctx in the call chain
4. While holding lru/memory manager (buddy, drm_mm, whatever) locks system memory allocations are not allowed
   - Enforce this by priming lockdep (with fs_reclaim). If we allocate memory while holding these looks we get a rehash of the shrinker vs. struct_mutex saga, and that would be real bad.
5. Do not nest different lru/memory manager locks within each other. Take them in turn to update memory allocations, relying on the object's dma_resv ww_mutex to serialize against other operations.
6. The suggestion for lru/memory managers locks is that they are small enough to be spinlocks.
7. All features need to come with exhaustive kernel selftests and/or IGT tests when appropriate
8. All LMEM uAPI paths need to be fully restartable (_interruptible() for all locks/waits/sleeps)
   - Error handling validation through signal injection. Still the best strategy we have for validating GEM uAPI corner cases. Must be excessively used in the IGT, and we need to check that we really have full path coverage of all error cases.
   - -EDEADLK handling with ww_mutex

GEM BO Management Implementation Details

A VMA represents a GEM BO that is bound into an address space. Therefore, a VMA's presence cannot be guaranteed before binding, or after unbinding the object into/from the address space.

To make things as simple as possible (ie. no refcounting), a VMA's lifetime will always be <= an objects lifetime. So object refcounting should cover us.

Buffer Object Eviction

This section documents the interface functions for evicting buffer objects to make space available in the virtual gpu address spaces. Note that this is mostly orthogonal to shrinking buffer objects caches, which has the goal to make main memory (shared with the gpu through the unified memory architecture) available.

int **i915_gem_evict_something**(struct i915_address_space *vm, u64 min_size, u64 alignment, unsigned long color, u64 start, u64 end, unsigned flags)

Evict vmas to make room for binding a new one

Parameters

struct i915_address_space *vm
address space to evict from

u64 min_size
size of the desired free space

u64 alignment
alignment constraint of the desired free space

unsigned long color
color for the desired space

u64 start
start (inclusive) of the range from which to evict objects

u64 end
end (exclusive) of the range from which to evict objects

unsigned flags
additional flags to control the eviction algorithm

Description

This function will try to evict vmas until a free space satisfying the requirements is found. Callers must check first whether any such hole exists already before calling this function.

This function is used by the object/vma binding code.

Since this function is only used to free up virtual address space it only ignores pinned vmas, and not object where the backing storage itself is pinned. Hence obj->pages_pin_count does not protect against eviction.

To clarify: This is for freeing up virtual address space, not for freeing memory in e.g. the shrinker.

int **i915_gem_evict_for_node**(struct i915_address_space *vm, struct *drm_mm_node* *target, unsigned int flags)

Evict vmas to make room for binding a new one

Parameters

struct i915_address_space *vm
address space to evict from

struct drm_mm_node *target
range (and color) to evict for

unsigned int flags
additional flags to control the eviction algorithm

Description

This function will try to evict vmas that overlap the target node.

To clarify: This is for freeing up virtual address space, not for freeing memory in e.g. the shrinker.

int **i915_gem_evict_vm**(struct i915_address_space *vm)
Evict all idle vmas from a vm

Parameters

struct i915_address_space *vm
Address space to cleanse

Description

This function evicts all vmas from a vm.

This is used by the execbuf code as a last-ditch effort to defragment the address space.

To clarify: This is for freeing up virtual address space, not for freeing memory in e.g. the shrinker.

Buffer Object Memory Shrinking

This section documents the interface function for shrinking memory usage of buffer object caches. Shrinking is used to make main memory available. Note that this is mostly orthogonal to evicting buffer objects, which has the goal to make space in gpu virtual address spaces.

unsigned long **i915_gem_shrink**(struct drm_i915_private *i915, unsigned long target, unsigned long *nr_scanned, unsigned int shrink)
Shrink buffer object caches

Parameters

struct drm_i915_private *i915
i915 device

unsigned long target
amount of memory to make available, in pages

unsigned long *nr_scanned
optional output for number of pages scanned (incremental)

unsigned int shrink
control flags for selecting cache types

Description

This function is the main interface to the shrinker. It will try to release up to **target** pages of main memory backing storage from buffer objects. Selection of the specific caches can be done with **flags**. This is e.g. useful when purgeable objects should be removed from caches preferentially.

Note that it's not guaranteed that released amount is actually available as free system memory - the pages might still be in-used to due to other reasons (like cpu mmaps) or the mm core has reused them before we could grab them. Therefore code that needs to explicitly shrink buffer objects caches (e.g. to avoid deadlocks in memory reclaim) must fall back to *i915_gem_shrink_all()*.

Also note that any kind of pinning (both per-vma address space pins and backing storage pins at the buffer object level) result in the shrinker code having to skip the object.

Return

The number of pages of backing storage actually released.

unsigned long **i915_gem_shrink_all**(struct drm_i915_private *i915)

Shrink buffer object caches completely

Parameters

struct drm_i915_private *i915
i915 device

Description

This is a simple wraper around *i915_gem_shrink()* to aggressively shrink all caches completely. It also first waits for and retires all outstanding requests to also be able to release backing storage for active objects.

This should only be used in code to intentionally quiescent the gpu or as a last-ditch effort when memory seems to have run out.

Return

The number of pages of backing storage actually released.

Batchbuffer Parsing

Motivation: Certain OpenGL features (e.g. transform feedback, performance monitoring) require userspace code to submit batches containing commands such as MI_LOAD_REGISTER_IMM to access various registers. Unfortunately, some generations of the hardware will noop these commands in "unsecure" batches (which includes all userspace batches submitted via i915) even though the commands may be safe and represent the intended programming model of the device.

The software command parser is similar in operation to the command parsing done in hardware for unsecure batches. However, the software parser allows some operations that would be noop'd by hardware, if the parser determines the operation is safe, and submits the batch as "secure" to prevent hardware parsing.

Threats: At a high level, the hardware (and software) checks attempt to prevent granting userspace undue privileges. There are three categories of privilege.

First, commands which are explicitly defined as privileged or which should only be used by the kernel driver. The parser rejects such commands

Second, commands which access registers. To support correct/enhanced userspace functionality, particularly certain OpenGL extensions, the parser provides a whitelist of registers which userspace may safely access

Third, commands which access privileged memory (i.e. GGTT, HWS page, etc). The parser always rejects such commands.

The majority of the problematic commands fall in the MI_* range, with only a few specific commands on each engine (e.g. PIPE_CONTROL and MI_FLUSH_DW).

Implementation: Each engine maintains tables of commands and registers which the parser uses in scanning batch buffers submitted to that engine.

Since the set of commands that the parser must check for is significantly smaller than the number of commands supported, the parser tables contain only those commands required by the parser. This generally works because command opcode ranges have standard command length encodings. So for commands that the parser does not need to check, it can easily skip them. This is implemented via a per-engine length decoding vfunc.

Unfortunately, there are a number of commands that do not follow the standard length encoding for their opcode range, primarily amongst the MI_* commands. To handle this, the parser provides a way to define explicit "skip" entries in the per-engine command tables.

Other command table entries map fairly directly to high level categories mentioned above: rejected, register whitelist. The parser implements a number of checks, including the privileged memory checks, via a general bitmasking mechanism.

int **intel_engine_init_cmd_parser**(struct intel_engine_cs *engine)

set cmd parser related fields for an engine

Parameters

struct intel_engine_cs *engine
the engine to initialize

Description

Optionally initializes fields related to batch buffer command parsing in the struct intel_engine_cs based on whether the platform requires software command parsing.

void **intel_engine_cleanup_cmd_parser**(struct intel_engine_cs *engine)

clean up cmd parser related fields

Parameters

struct intel_engine_cs *engine
the engine to clean up

Description

Releases any resources related to command parsing that may have been initialized for the specified engine.

int **intel_engine_cmd_parser**(struct intel_engine_cs *engine, struct i915_vma *batch, unsigned long batch_offset, unsigned long batch_length, struct i915_vma *shadow, bool trampoline)

parse a batch buffer for privilege violations

Parameters

struct intel_engine_cs *engine
the engine on which the batch is to execute

struct i915_vma *batch
the batch buffer in question

unsigned long batch_offset
byte offset in the batch at which execution starts

unsigned long batch_length
length of the commands in batch_obj

struct i915_vma *shadow
validated copy of the batch buffer in question

bool trampoline
whether to emit a conditional trampoline at the end of the batch

Description

Parses the specified batch buffer looking for privilege violations as described in the overview.

Return

non-zero if the parser finds violations or otherwise fails; -EACCES if the batch appears legal but should use hardware parsing

int **i915_cmd_parser_get_version**(struct drm_i915_private *dev_priv)

get the cmd parser version number

Parameters

struct drm_i915_private *dev_priv
i915 device private

Description

The cmd parser maintains a simple increasing integer version number suitable for passing to userspace clients to determine what operations are permitted.

Return

the current version number of the cmd parser

User Batchbuffer Execution

Userspace submits commands to be executed on the GPU as an instruction stream within a GEM object we call a batchbuffer. This instructions may refer to other GEM objects containing auxiliary state such as kernels, samplers, render targets and even secondary batchbuffers. Userspace does not know where in the GPU memory these objects reside and so before the batchbuffer is passed to the GPU for execution, those addresses in the batchbuffer and auxiliary objects are updated. This is known as relocation, or patching. To try and avoid having to relocate each object on the next execution, userspace is told the location of those objects in this pass, but this remains just a hint as the kernel may choose a new location for any object in the future.

At the level of talking to the hardware, submitting a batchbuffer for the GPU to execute is to add content to a buffer from which the HW command streamer is reading.

1. Add a command to load the HW context. For Logical Ring Contexts, i.e. Execlists, this command is not placed on the same buffer as the remaining items.
2. Add a command to invalidate caches to the buffer.
3. Add a batchbuffer start command to the buffer; the start command is essentially a token together with the GPU address of the batchbuffer to be executed.
4. Add a pipeline flush to the buffer.
5. Add a memory write command to the buffer to record when the GPU is done executing the batchbuffer. The memory write writes the global sequence number of the request, `i915_request::global_seqno`; the i915 driver uses the current value in the register to determine if the GPU has completed the batchbuffer.
6. Add a user interrupt command to the buffer. This command instructs the GPU to issue an interrupt when the command, pipeline flush and memory write are completed.
7. Inform the hardware of the additional commands added to the buffer (by updating the tail pointer).

Processing an execbuf ioctl is conceptually split up into a few phases.

1. Validation - Ensure all the pointers, handles and flags are valid.
2. Reservation - Assign GPU address space for every object
3. Relocation - Update any addresses to point to the final locations
4. Serialisation - Order the request with respect to its dependencies
5. Construction - Construct a request to execute the batchbuffer
6. Submission (at some point in the future execution)

Reserving resources for the execbuf is the most complicated phase. We neither want to have to migrate the object in the address space, nor do we want to have to update any relocations pointing to this object. Ideally, we want to leave the object where it is and for all the existing relocations to match. If the object is given a new address, or if userspace thinks the object is elsewhere, we have to parse all the relocation entries and update the addresses. Userspace can set the I915_EXEC_NORELOC flag to hint that all the target addresses in all of its objects match the value in the relocation entries and that they all match the presumed offsets given by the list of execbuffer objects. Using this knowledge, we know that if we haven' t moved any buffers, all the relocation entries are valid and we can skip the update. (If userspace is wrong, the likely outcome is an impromptu GPU hang.) The requirement for using I915_EXEC_NO_RELOC are:

> The addresses written in the objects must match the corresponding reloc.presumed_offset which in turn must match the corresponding execobject.offset.
>
> Any render targets written to in the batch must be flagged with EXEC_OBJECT_WRITE.
>
> To avoid stalling, execobject.offset should match the current address of that object within the active context.

The reservation is done is multiple phases. First we try and keep any object already bound in its current location - so as long as meets the constraints imposed by the new execbuffer. Any object left unbound after the first pass is then fitted into any available idle space. If an object does not fit, all objects are removed from the reservation and the process rerun after sorting the objects into a priority order (more difficult to fit objects are tried first). Failing that, the entire VM is cleared and we try to fit the execbuf once last time before concluding that it simply will not fit.

A small complication to all of this is that we allow userspace not only to specify an alignment and a size for the object in the address space, but we also allow userspace to specify the exact offset. This objects are simpler to place (the location is known a priori) all we have to do is make sure the space is available.

Once all the objects are in place, patching up the buried pointers to point to the final locations is a fairly simple job of walking over the relocation entry arrays, looking up the right address and rewriting the value into the object. Simple! … The relocation entries are stored in user memory and so to access them we have to copy them into a local buffer. That copy has to avoid taking any pagefaults as they may lead back to a GEM object requiring the struct_mutex (i.e. recursive deadlock). So once again we split the relocation into multiple passes. First we try to do everything within an atomic context (avoid the pagefaults) which requires that we never wait. If we detect that we may wait, or if we need to fault, then we have to fallback to a slower path. The slowpath has to drop the mutex. (Can you hear alarm bells yet?) Dropping the mutex means that we lose all the state we have built up so far for the execbuf and we must reset any global data. However, we do leave the objects pinned in their final locations - which is a potential issue for concurrent execbufs. Once we have left the mutex, we can allocate and copy all the relocation entries into a large array at our leisure, reacquire the mutex, reclaim all the objects and other state and then proceed to update any incorrect addresses with the objects.

As we process the relocation entries, we maintain a record of whether the object is being written to. Using NORELOC, we expect userspace to provide this information instead. We also check whether we can skip the relocation by comparing the expected value inside the relocation entry with the target' s final address. If they differ, we have to map the current object and rewrite the 4 or 8 byte pointer within.

Serialising an execbuf is quite simple according to the rules of the GEM ABI. Execution within each context is ordered by the order of submission. Writes to any GEM object are in order of submission and are exclusive. Reads from a GEM object are unordered with respect to other reads, but ordered by writes. A write submitted after a read cannot occur before the read, and similarly any read submitted after a write cannot occur before the write. Writes are ordered between engines such that only one write occurs at any time (completing any reads beforehand) - using semaphores where available and CPU serialisation otherwise. Other GEM access obey the same rules, any write (either via mmaps using set-domain, or via pwrite) must flush all GPU reads before starting, and any read (either using set-domain or pread) must flush all GPU writes before starting. (Note we only employ a barrier before, we currently rely on userspace not concurrently starting a new execution whilst reading or writing to an object. This may be an advantage or not depending on how much you trust userspace not to shoot themselves in the foot.) Serialisation may just result in the request being inserted into a DAG awaiting its turn, but most simple is to wait on the CPU until all dependencies are resolved.

After all of that, is just a matter of closing the request and handing it to the hardware (well, leaving it in a queue to be executed). However, we also offer the ability for batchbuffers to be run with elevated privileges so that they access otherwise hidden registers. (Used to adjust L3 cache etc.) Before any batch is given extra privileges we first must check that it contains no nefarious instructions, we check that each instruction is from our whitelist and all registers are also from an allowed list. We first copy the user' s batchbuffer to a shadow (so that the user doesn' t have access to it, either by the CPU or GPU as we scan it) and then parse each instruction. If everything is ok, we set a flag telling the hardware to run the batchbuffer in trusted mode, otherwise the ioctl is rejected.

Logical Rings, Logical Ring Contexts and Execlists

Motivation: GEN8 brings an expansion of the HW contexts: "Logical Ring Contexts" . These expanded contexts enable a number of new abilities, especially "Execlists" (also implemented in this file).

One of the main differences with the legacy HW contexts is that logical ring contexts incorporate many more things to the context' s state, like PDPs or ringbuffer control registers:

The reason why PDPs are included in the context is straightforward: as PPGTTs (per-process GTTs) are actually per-context, having the PDPs contained there mean you don' t need to do a ppgtt->switch_mm yourself, instead, the GPU will do it for you on the context switch.

But, what about the ringbuffer control registers (head, tail, etc..)? shouldn' t we just need a set of those per engine command streamer? This is where the name "Logical Rings" starts to make sense: by virtualizing the rings, the engine cs shifts to a new "ring buffer" with every context switch. When you want to submit a workload to the GPU you: A) choose your context, B) find its appropriate virtualized ring, C) write commands to it and then, finally, D) tell the GPU to switch to that context.

Instead of the legacy MI_SET_CONTEXT, the way you tell the GPU to switch to a contexts is via a context execution list, ergo "Execlists".

LRC implementation: Regarding the creation of contexts, we have:

- One global default context.
- One local default context for each opened fd.
- One local extra context for each context create ioctl call.

Now that ringbuffers belong per-context (and not per-engine, like before) and that contexts are uniquely tied to a given engine (and not reusable, like before) we need:

- One ringbuffer per-engine inside each context.
- One backing object per-engine inside each context.

The global default context starts its life with these new objects fully allocated and populated. The local default context for each opened fd is more complex, because we don't know at creation time which engine is going to use them. To handle this, we have implemented a deferred creation of LR contexts:

The local context starts its life as a hollow or blank holder, that only gets populated for a given engine once we receive an execbuffer. If later on we receive another execbuffer ioctl for the same context but a different engine, we allocate/populate a new ringbuffer and context backing object and so on.

Finally, regarding local contexts created using the ioctl call: as they are only allowed with the render ring, we can allocate & populate them right away (no need to defer anything, at least for now).

Execlists implementation: Execlists are the new method by which, on gen8+ hardware, workloads are submitted for execution (as opposed to the legacy, ringbuffer-based, method). This method works as follows:

When a request is committed, its commands (the BB start and any leading or trailing commands, like the seqno breadcrumbs) are placed in the ringbuffer for the appropriate context. The tail pointer in the hardware context is not updated at this time, but instead, kept by the driver in the ringbuffer structure. A structure representing this request is added to a request queue for the appropriate engine: this structure contains a copy of the context's tail after the request was written to the ring buffer and a pointer to the context itself.

If the engine's request queue was empty before the request was added, the queue is processed immediately. Otherwise the queue will be processed during a context switch interrupt. In any case, elements on the queue will get sent (in pairs) to the GPU's ExecLists Submit Port (ELSP, for short) with a globally unique 20-bits submission ID.

When execution of a request completes, the GPU updates the context status buffer with a context complete event and generates a context switch interrupt. During the interrupt handling, the driver examines the events in the buffer: for each context complete event, if the announced ID matches that on the head of the request queue, then that request is retired and removed from the queue.

After processing, if any requests were retired and the queue is not empty then a new execution list can be submitted. The two requests at the front of the queue are next to be submitted but since a context may not occur twice in an execution list, if subsequent requests have the same ID as the first then the two requests must be combined. This is done simply by discarding requests at the head of the queue until either only one requests is left (in which case we use a NULL second context) or the first two requests have unique IDs.

By always executing the first two requests in the queue the driver ensures that the GPU is kept as busy as possible. In the case where a single context completes but a second context is still executing, the request for this second context will be at the head of the queue when we remove the first one. This request will then be resubmitted along with a new request for a different context, which will cause the hardware to continue executing the second request and queue the new request (the GPU detects the condition of a context getting preempted with the same context and optimizes the context switch flow by not doing preemption, but just sampling the new tail pointer).

Global GTT views

Background and previous state

Historically objects could exists (be bound) in global GTT space only as singular instances with a view representing all of the object’ s backing pages in a linear fashion. This view will be called a normal view.

To support multiple views of the same object, where the number of mapped pages is not equal to the backing store, or where the layout of the pages is not linear, concept of a GGTT view was added.

One example of an alternative view is a stereo display driven by a single image. In this case we would have a framebuffer looking like this (2x2 pages):

> 12 34

Above would represent a normal GGTT view as normally mapped for GPU or CPU rendering. In contrast, fed to the display engine would be an alternative view which could look something like this:

> 1212 3434

In this example both the size and layout of pages in the alternative view is different from the normal view.

Implementation and usage

GGTT views are implemented using VMAs and are distinguished via enum i915_ggtt_view_type and struct i915_ggtt_view.

A new flavour of core GEM functions which work with GGTT bound objects were added with the _ggtt_ infix, and sometimes with _view postfix to avoid renaming in large amounts of code. They take the struct i915_ggtt_view parameter encapsulating all metadata required to implement a view.

As a helper for callers which are only interested in the normal view, globally const i915_ggtt_view_normal singleton instance exists. All old core GEM API functions, the ones not taking the view parameter, are operating on, or with the normal GGTT view.

Code wanting to add or use a new GGTT view needs to:

1. Add a new enum with a suitable name.
2. Extend the metadata in the i915_ggtt_view structure if required.
3. Add support to i915_get_vma_pages().

New views are required to build a scatter-gather table from within the i915_get_vma_pages function. This table is stored in the vma.ggtt_view and exists for the lifetime of an VMA.

Core API is designed to have copy semantics which means that passed in struct i915_ggtt_view does not need to be persistent (left around after calling the core API functions).

int **i915_gem_gtt_reserve**(struct i915_address_space *vm, struct *drm_mm_node* *node, u64 size, u64 offset, unsigned long color, unsigned int flags)

reserve a node in an address_space (GTT)

Parameters

struct i915_address_space *vm
the `struct i915_address_space`

struct drm_mm_node *node
the *struct drm_mm_node* (typically i915_vma.mode)

u64 size
how much space to allocate inside the GTT, must be #I915_GTT_PAGE_SIZE aligned

u64 offset
where to insert inside the GTT, must be #I915_GTT_MIN_ALIGNMENT aligned, and the node (**offset** + **size**) must fit within the address space

unsigned long color
color to apply to node, if this node is not from a VMA, color must be #I915_COLOR_UNEVICTABLE

unsigned int flags
control search and eviction behaviour

Description

i915_gem_gtt_reserve() tries to insert the **node** at the exact **offset** inside the address space (using **size** and **color**). If the **node** does not fit, it tries to evict any overlapping nodes from the GTT, including any neighbouring nodes if the colors do not match (to ensure guard pages between differing domains). See *i915_gem_evict_for_node()* for the gory details on the eviction algorithm. #PIN_NONBLOCK may used to prevent waiting on evicting active overlapping objects, and any overlapping node that is pinned or marked as unevictable will also result in failure.

Return

0 on success, -ENOSPC if no suitable hole is found, -EINTR if asked to wait for eviction and interrupted.

int **i915_gem_gtt_insert**(struct i915_address_space *vm, struct *drm_mm_node* *node, u64 size, u64 alignment, unsigned long color, u64 start, u64 end, unsigned int flags)

insert a node into an address_space (GTT)

Parameters

struct i915_address_space *vm
the `struct i915_address_space`

struct drm_mm_node *node
the *struct drm_mm_node* (typically i915_vma.node)

u64 size
how much space to allocate inside the GTT, must be #I915_GTT_PAGE_SIZE aligned

u64 alignment
required alignment of starting offset, may be 0 but if specified, this must be a power-of-two and at least #I915_GTT_MIN_ALIGNMENT

unsigned long color
color to apply to node

u64 start
start of any range restriction inside GTT (0 for all), must be #I915_GTT_PAGE_SIZE aligned

u64 end
end of any range restriction inside GTT (U64_MAX for all), must be #I915_GTT_PAGE_SIZE aligned if not U64_MAX

unsigned int flags
control search and eviction behaviour

Description

i915_gem_gtt_insert() first searches for an available hole into which is can insert the node. The hole address is aligned to **alignment** and its **size** must then fit entirely within the [**start**, **end**] bounds. The nodes on either side of the hole must match **color**, or else a guard page will be inserted between the two nodes (or the node evicted). If no suitable hole is found, first a victim is randomly selected and tested for eviction, otherwise then the LRU list of objects within the GTT is scanned to find the first set of replacement nodes to create the hole. Those old overlapping nodes are evicted from the GTT (and so must be rebound before any future use). Any node that is currently pinned cannot be evicted (see i915_vma_pin()). Similar if the node' s VMA is currently active and #PIN_NONBLOCK is specified, that node is also skipped when searching for an eviction candidate. See *i915_gem_evict_something()* for the gory details on the eviction algorithm.

Return

0 on success, -ENOSPC if no suitable hole is found, -EINTR if asked to wait for eviction and interrupted.

GTT Fences and Swizzling

void **i915_vma_revoke_fence**(struct i915_vma *vma)
force-remove fence for a VMA

Parameters

struct i915_vma *vma
vma to map linearly (not through a fence reg)

Description

This function force-removes any fence from the given object, which is useful if the kernel wants to do untiled GTT access.

int **i915_vma_pin_fence**(struct i915_vma *vma)
set up fencing for a vma

Parameters

struct i915_vma *vma
vma to map through a fence reg

Description

When mapping objects through the GTT, userspace wants to be able to write to them without having to worry about swizzling if the object is tiled. This function walks the fence regs looking for a free one for **obj**, stealing one if it can' t find any.

It then sets up the reg based on the object' s properties: address, pitch and tiling format.

For an untiled surface, this removes any existing fence.

0 on success, negative error code on failure.

Return

struct i915_fence_reg ***i915_reserve_fence**(struct i915_ggtt *ggtt)
Reserve a fence for vGPU

Parameters

struct i915_ggtt *ggtt
Global GTT

Description

This function walks the fence regs looking for a free one and remove it from the fence_list. It is used to reserve fence for vGPU to use.

void **i915_unreserve_fence**(struct i915_fence_reg *fence)
Reclaim a reserved fence

Parameters

struct i915_fence_reg *fence
the fence reg

Description

This function add a reserved fence register from vGPU to the fence_list.

void **intel_ggtt_restore_fences**(struct i915_ggtt *ggtt)

restore fence state

Parameters

struct i915_ggtt *ggtt
Global GTT

Description

Restore the hw fence state to match the software tracking again, to be called after a gpu reset and on resume. Note that on runtime suspend we only cancel the fences, to be reacquired by the user later.

void **detect_bit_6_swizzle**(struct i915_ggtt *ggtt)

detect bit 6 swizzling pattern

Parameters

struct i915_ggtt *ggtt
Global GGTT

Description

Detects bit 6 swizzling of address lookup between IGD access and CPU access through main memory.

void **i915_gem_object_do_bit_17_swizzle**(struct drm_i915_gem_object *obj, struct sg_table *pages)

fixup bit 17 swizzling

Parameters

struct drm_i915_gem_object *obj
i915 GEM buffer object

struct sg_table *pages
the scattergather list of physical pages

Description

This function fixes up the swizzling in case any page frame number for this object has changed in bit 17 since that state has been saved with *i915_gem_object_save_bit_17_swizzle()*.

This is called when pinning backing storage again, since the kernel is free to move unpinned backing storage around (either by directly moving pages or by swapping them out and back in again).

void **i915_gem_object_save_bit_17_swizzle**(struct drm_i915_gem_object *obj, struct sg_table *pages)

save bit 17 swizzling

Parameters

struct drm_i915_gem_object *obj
i915 GEM buffer object

struct sg_table *pages
the scattergather list of physical pages

Description

This function saves the bit 17 of each page frame number so that swizzling can be fixed up later on with `i915_gem_object_do_bit_17_swizzle()`. This must be called before the backing storage can be unpinned.

Global GTT Fence Handling

Important to avoid confusions: "fences" in the i915 driver are not execution fences used to track command completion but hardware detiler objects which wrap a given range of the global GTT. Each platform has only a fairly limited set of these objects.

Fences are used to detile GTT memory mappings. They' re also connected to the hardware frontbuffer render tracking and hence interact with frontbuffer compression. Furthermore on older platforms fences are required for tiled objects used by the display engine. They can also be used by the render engine - they' re required for blitter commands and are optional for render commands. But on gen4+ both display (with the exception of fbc) and rendering have their own tiling state bits and don' t need fences.

Also note that fences only support X and Y tiling and hence can' t be used for the fancier new tiling formats like W, Ys and Yf.

Finally note that because fences are such a restricted resource they're dynamically associated with objects. Furthermore fence state is committed to the hardware lazily to avoid unnecessary stalls on gen2/3. Therefore code must explicitly call i915_gem_object_get_fence() to synchronize fencing status for cpu access. Also note that some code wants an unfenced view, for those cases the fence can be removed forcefully with i915_gem_object_put_fence().

Internally these functions will synchronize with userspace access by removing CPU ptes into GTT mmaps (not the GTT ptes themselves) as needed.

Hardware Tiling and Swizzling Details

The idea behind tiling is to increase cache hit rates by rearranging pixel data so that a group of pixel accesses are in the same cacheline. Performance improvement from doing this on the back/depth buffer are on the order of 30%.

Intel architectures make this somewhat more complicated, though, by adjustments made to addressing of data when the memory is in interleaved mode (matched pairs of DIMMS) to improve memory bandwidth. For interleaved memory, the CPU sends every sequential 64 bytes to an alternate memory channel so it can get the bandwidth from both.

The GPU also rearranges its accesses for increased bandwidth to interleaved memory, and it matches what the CPU does for non-tiled. However, when tiled it does it a little differently, since one walks addresses not just in the X direction but also Y. So, along with alternating channels when bit 6 of the address flips, it also alternates when other bits flip – Bits 9 (every 512 bytes, an X tile scanline) and 10 (every two X tile scanlines) are common to both the 915 and 965-class hardware.

The CPU also sometimes XORs in higher bits as well, to improve bandwidth doing strided access like we do so frequently in graphics. This is called "Channel XOR Randomization" in the MCH documentation. The result is that the CPU is XORing in either bit 11 or bit 17 to bit 6 of its address decode.

All of this bit 6 XORing has an effect on our memory management, as we need to make sure that the 3d driver can correctly address object contents.

If we don't have interleaved memory, all tiling is safe and no swizzling is required.

When bit 17 is XORed in, we simply refuse to tile at all. Bit 17 is not just a page offset, so as we page an object out and back in, individual pages in it will have different bit 17 addresses, resulting in each 64 bytes being swapped with its neighbor!

Otherwise, if interleaved, we have to tell the 3d driver what the address swizzling it needs to do is, since it's writing with the CPU to the pages (bit 6 and potentially bit 11 XORed in), and the GPU is reading from the pages (bit 6, 9, and 10 XORed in), resulting in a cumulative bit swizzling required by the CPU of XORing in bit 6, 9, 10, and potentially 11, in order to match what the GPU expects.

Object Tiling IOCTLs

u32 **i915_gem_fence_size**(struct drm_i915_private *i915, u32 size, unsigned int tiling, unsigned int stride)

required global GTT size for a fence

Parameters

struct drm_i915_private *i915
i915 device

u32 size
object size

unsigned int tiling
tiling mode

unsigned int stride
tiling stride

Description

Return the required global GTT size for a fence (view of a tiled object), taking into account potential fence register mapping.

u32 **i915_gem_fence_alignment**(struct drm_i915_private *i915, u32 size, unsigned int tiling, unsigned int stride)

required global GTT alignment for a fence

Parameters

struct drm_i915_private *i915
i915 device

u32 size
object size

`unsigned int tiling`
tiling mode

`unsigned int stride`
tiling stride

Description

Return the required global GTT alignment for a fence (a view of a tiled object), taking into account potential fence register mapping.

int **`i915_gem_set_tiling_ioctl`**(struct *drm_device* *dev, void *data, struct *drm_file* *file)

IOCTL handler to set tiling mode

Parameters

`struct drm_device *dev`
DRM device

`void *data`
data pointer for the ioctl

`struct drm_file *file`
DRM file for the ioctl call

Description

Sets the tiling mode of an object, returning the required swizzling of bit 6 of addresses in the object.

Called by the user via ioctl.

Return

Zero on success, negative errno on failure.

int **`i915_gem_get_tiling_ioctl`**(struct *drm_device* *dev, void *data, struct *drm_file* *file)

IOCTL handler to get tiling mode

Parameters

`struct drm_device *dev`
DRM device

`void *data`
data pointer for the ioctl

`struct drm_file *file`
DRM file for the ioctl call

Description

Returns the current tiling mode and required bit 6 swizzling for the object.

Called by the user via ioctl.

Return

Zero on success, negative errno on failure.

i915_gem_set_tiling_ioctl() and *i915_gem_get_tiling_ioctl()* is the userspace interface to declare fence register requirements.

In principle GEM doesn't care at all about the internal data layout of an object, and hence it also doesn't care about tiling or swizzling. There's two exceptions:

- For X and Y tiling the hardware provides detilers for CPU access, so called fences. Since there's only a limited amount of them the kernel must manage these, and therefore userspace must tell the kernel the object tiling if it wants to use fences for detiling.
- On gen3 and gen4 platforms have a swizzling pattern for tiled objects which depends upon the physical page frame number. When swapping such objects the page frame number might change and the kernel must be able to fix this up and hence now the tiling. Note that on a subset of platforms with asymmetric memory channel population the swizzling pattern changes in an unknown way, and for those the kernel simply forbids swapping completely.

Since neither of this applies for new tiling layouts on modern platforms like W, Ys and Yf tiling GEM only allows object tiling to be set to X or Y tiled. Anything else can be handled in userspace entirely without the kernel's invovlement.

8.3.4 Microcontrollers

Starting from gen9, three microcontrollers are available on the HW: the graphics microcontroller (GuC), the HEVC/H.265 microcontroller (HuC) and the display microcontroller (DMC). The driver is responsible for loading the firmwares on the microcontrollers; the GuC and HuC firmwares are transferred to WOPCM using the DMA engine, while the DMC firmware is written through MMIO.

WOPCM

WOPCM Layout

The layout of the WOPCM will be fixed after writing to GuC WOPCM size and offset registers whose values are calculated and determined by HuC/GuC firmware size and set of hardware requirements/restrictions as shown below:

```
  +=========> +====================+ <== WOPCM Top
  ^           |  HW contexts RSVD  |
  |     +===> +====================+ <== GuC WOPCM Top
  |     ^     |                    |
  |     |     |                    |
  |     |     |                    |
  |    GuC    |                    |
  |   WOPCM   |                    |
  |    Size   +--------------------+
WOPCM   |     |    GuC FW RSVD     |
  |     |     +--------------------+
  |     |     |   GuC Stack RSVD   |
  |     |     +------------------- +
```

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```
  |      v      |   GuC WOPCM RSVD   |
  |      +===> +====================+ <== GuC WOPCM base
  |            |     WOPCM RSVD     |
  |            +------------------- + <== HuC Firmware Top
  v            |       HuC FW       |
  +=========> +====================+ <== WOPCM Base
```

GuC accessible WOPCM starts at GuC WOPCM base and ends at GuC WOPCM top. The top part of the WOPCM is reserved for hardware contexts (e.g. RC6 context).

GuC

The GuC is a microcontroller inside the GT HW, introduced in gen9. The GuC is designed to offload some of the functionality usually performed by the host driver; currently the main operations it can take care of are:

- Authentication of the HuC, which is required to fully enable HuC usage.
- Low latency graphics context scheduling (a.k.a. GuC submission).
- GT Power management.

The enable_guc module parameter can be used to select which of those operations to enable within GuC. Note that not all the operations are supported on all gen9+ platforms.

Enabling the GuC is not mandatory and therefore the firmware is only loaded if at least one of the operations is selected. However, not loading the GuC might result in the loss of some features that do require the GuC (currently just the HuC, but more are expected to land in the future).

GuC Firmware Layout

The GuC/HuC firmware layout looks like this:

```
+======================================================================+
|  Firmware blob                                                       ␣
↪    |
+===============+===============+============+============+============+
|  CSS header   |     uCode     |  RSA key   |  modulus   | ␣
↪exponent  |
+===============+===============+============+============+============+
 <-header size->                 <---header size continued ---------
↪-->
 <--- size -----------------------------------------------------------
↪-->
                                 <-key size->
                                              <-mod size->
                                                           <-exp␣
↪size->
```

The firmware may or may not have modulus key and exponent data. The header, uCode and RSA signature are must-have components that will be used by driver. Length of each components, which is all in dwords, can be found in header. In the case that modulus and exponent are not present in fw, a.k.a truncated image, the length value still appears in header.

Driver will do some basic fw size validation based on the following rules:

1. Header, uCode and RSA are must-have components.
2. All firmware components, if they present, are in the sequence illustrated in the layout table above.
3. Length info of each component can be found in header, in dwords.
4. Modulus and exponent key are not required by driver. They may not appear in fw. So driver will load a truncated firmware in this case.

GuC Memory Management

GuC can't allocate any memory for its own usage, so all the allocations must be handled by the host driver. GuC accesses the memory via the GGTT, with the exception of the top and bottom parts of the 4GB address space, which are instead re-mapped by the GuC HW to memory location of the FW itself (WOPCM) or other parts of the HW. The driver must take care not to place objects that the GuC is going to access in these reserved ranges. The layout of the GuC address space is shown below:

```
   +===========> +====================+ <== FFFF_FFFF
   ^             |      Reserved      |
   |             +====================+ <== GUC_GGTT_TOP
   |             |                    |
   |             |        DRAM        |
  GuC            |                    |
Address    +===> +====================+ <== GuC ggtt_pin_bias
 Space     ^     |                    |
   |       |     |                    |
   |      GuC    |        GuC         |
   |     WOPCM   |       WOPCM        |
   |      Size   |                    |
   |       |     |                    |
   v       v     |                    |
   +=======+===> +====================+ <== 0000_0000
```

The lower part of GuC Address Space [0, ggtt_pin_bias) is mapped to GuC WOPCM while upper part of GuC Address Space [ggtt_pin_bias, GUC_GGTT_TOP) is mapped to DRAM. The value of the GuC ggtt_pin_bias is the GuC WOPCM size.

struct i915_vma ***intel_guc_allocate_vma**(struct intel_guc *guc, u32 size)

Allocate a GGTT VMA for GuC usage

Parameters

struct intel_guc *guc
the guc

u32 size
size of area to allocate (both virtual space and memory)

Description

This is a wrapper to create an object for use with the GuC. In order to use it inside the GuC, an object needs to be pinned lifetime, so we allocate both some backing storage and a range inside the Global GTT. We must pin it in the GGTT somewhere other than than [0, GUC ggtt_pin_bias) because that range is reserved inside GuC.

Return

A i915_vma if successful, otherwise an ERR_PTR.

GuC-specific firmware loader

int **intel_guc_fw_upload**(struct intel_guc *guc)
load GuC uCode to device

Parameters

struct intel_guc *guc
intel_guc structure

Description

Called from intel_uc_init_hw() during driver load, resume from sleep and after a GPU reset.

The firmware image should have already been fetched into memory, so only check that fetch succeeded, and then transfer the image to the h/w.

Return

non-zero code on error

GuC-based command submission

IMPORTANT NOTE: GuC submission is currently not supported in i915. The GuC firmware is moving to an updated submission interface and we plan to turn submission back on when that lands. The below documentation (and related code) matches the old submission model and will be updated as part of the upgrade to the new flow.

GuC stage descriptor: During initialization, the driver allocates a static pool of 1024 such descriptors, and shares them with the GuC. Currently, we only use one descriptor. This stage descriptor lets the GuC know about the workqueue and process descriptor. Theoretically, it also lets the GuC know about our HW contexts (context ID, etc⋯), but we actually employ a kind of submission where the GuC uses the LRCA sent via the work item instead. This is called a “proxy” submission.

The Scratch registers: There are 16 MMIO-based registers start from 0xC180. The kernel driver writes a value to the action register (SOFT_SCRATCH_0) along with any data. It then triggers an interrupt on the GuC via another register write (0xC4C8). Firmware writes a success/fail code back to the action register after processes the request. The kernel driver polls waiting for this update and then proceeds.

Work Items: There are several types of work items that the host may place into a workqueue, each with its own requirements and limitations. Currently only WQ_TYPE_INORDER is needed to support legacy submission via GuC, which represents in-order queue. The kernel driver packs ring tail pointer and an ELSP context descriptor dword into Work Item. See guc_add_request()

HuC

The HuC is a dedicated microcontroller for usage in media HEVC (High Efficiency Video Coding) operations. Userspace can directly use the firmware capabilities by adding HuC specific commands to batch buffers.

The kernel driver is only responsible for loading the HuC firmware and triggering its security authentication, which is performed by the GuC. For The GuC to correctly perform the authentication, the HuC binary must be loaded before the GuC one. Loading the HuC is optional; however, not using the HuC might negatively impact power usage and/or performance of media workloads, depending on the use-cases.

See https://github.com/intel/media-driver for the latest details on HuC functionality.

int **intel_huc_auth**(struct intel_huc *huc)

Authenticate HuC uCode

Parameters

struct intel_huc *huc

intel_huc structure

Description

Called after HuC and GuC firmware loading during intel_uc_init_hw().

This function invokes the GuC action to authenticate the HuC firmware, passing the offset of the RSA signature to intel_guc_auth_huc(). It then waits for up to 50ms for firmware verification ACK.

HuC Memory Management

Similarly to the GuC, the HuC can’t do any memory allocations on its own, with the difference being that the allocations for HuC usage are handled by the userspace driver instead of the kernel one. The HuC accesses the memory via the PPGTT belonging to the context loaded on the VCS executing the HuC-specific commands.

HuC Firmware Layout

The HuC FW layout is the same as the GuC one, see *GuC Firmware Layout*

DMC

See *CSR firmware support for DMC*

8.3.5 Tracing

This sections covers all things related to the tracepoints implemented in the i915 driver.

i915_ppgtt_create and i915_ppgtt_release

With full ppgtt enabled each process using drm will allocate at least one translation table. With these traces it is possible to keep track of the allocation and of the lifetime of the tables; this can be used during testing/debug to verify that we are not leaking ppgtts. These traces identify the ppgtt through the vm pointer, which is also printed by the i915_vma_bind and i915_vma_unbind tracepoints.

i915_context_create and i915_context_free

These tracepoints are used to track creation and deletion of contexts. If full ppgtt is enabled, they also print the address of the vm assigned to the context.

8.3.6 Perf

Overview

Gen graphics supports a large number of performance counters that can help driver and application developers understand and optimize their use of the GPU.

This i915 perf interface enables userspace to configure and open a file descriptor representing a stream of GPU metrics which can then be read() as a stream of sample records.

The interface is particularly suited to exposing buffered metrics that are captured by DMA from the GPU, unsynchronized with and unrelated to the CPU.

Streams representing a single context are accessible to applications with a corresponding drm file descriptor, such that OpenGL can use the interface without special privileges. Access to system-wide metrics requires root privileges by default, unless changed via the dev.i915.perf_event_paranoid sysctl option.

Comparison with Core Perf

The interface was initially inspired by the core Perf infrastructure but some notable differences are:

i915 perf file descriptors represent a "stream" instead of an "event"; where a perf event primarily corresponds to a single 64bit value, while a stream might sample sets of tightly-coupled counters, depending on the configuration. For example the Gen OA unit isn't designed to support orthogonal configurations of individual counters; it's configured for a set of related counters. Samples for an i915 perf stream capturing OA metrics will include a set of counter values packed in a compact HW specific format. The OA unit supports a number of different packing formats which can be selected by the user opening the stream. Perf has support for grouping events, but each event in the group is configured, validated and authenticated individually with separate system calls.

i915 perf stream configurations are provided as an array of u64 (key,value) pairs, instead of a fixed struct with multiple miscellaneous config members, interleaved with event-type specific members.

i915 perf doesn't support exposing metrics via an mmap'd circular buffer. The supported metrics are being written to memory by the GPU unsynchronized with the CPU, using HW specific packing formats for counter sets. Sometimes the constraints on HW configuration require reports to be filtered before it would be acceptable to expose them to unprivileged applications - to hide the metrics of other processes/contexts. For these use cases a read() based interface is a good fit, and provides an opportunity to filter data as it gets copied from the GPU mapped buffers to userspace buffers.

Issues hit with first prototype based on Core Perf

The first prototype of this driver was based on the core perf infrastructure, and while we did make that mostly work, with some changes to perf, we found we were breaking or working around too many assumptions baked into perf's currently cpu centric design.

In the end we didn't see a clear benefit to making perf's implementation and interface more complex by changing design assumptions while we knew we still wouldn't be able to use any existing perf based userspace tools.

Also considering the Gen specific nature of the Observability hardware and how userspace will sometimes need to combine i915 perf OA metrics with side-band OA data captured via MI_REPORT_PERF_COUNT commands; we're expecting the interface to be used by a platform specific userspace such as OpenGL or tools. This is to say; we aren't inherently missing out on having a standard vendor/architecture agnostic interface by not using perf.

For posterity, in case we might re-visit trying to adapt core perf to be better suited to exposing i915 metrics these were the main pain points we hit:

- The perf based OA PMU driver broke some significant design assumptions:

  Existing perf pmus are used for profiling work on a cpu and we were introducing the idea of _IS_DEVICE pmus with different security implications, the need to fake cpu-related data (such as user/kernel registers) to fit with perf' s current design, and adding _DEVICE records as a way to forward device-specific status records.

The OA unit writes reports of counters into a circular buffer, without involvement from the CPU, making our PMU driver the first of a kind.

Given the way we were periodically forward data from the GPU-mapped, OA buffer to perf' s buffer, those bursts of sample writes looked to perf like we were sampling too fast and so we had to subvert its throttling checks.

Perf supports groups of counters and allows those to be read via transactions internally but transactions currently seem designed to be explicitly initiated from the cpu (say in response to a userspace read()) and while we could pull a report out of the OA buffer we can' t trigger a report from the cpu on demand.

Related to being report based; the OA counters are configured in HW as a set while perf generally expects counter configurations to be orthogonal. Although counters can be associated with a group leader as they are opened, there' s no clear precedent for being able to provide group-wide configuration attributes (for example we want to let userspace choose the OA unit report format used to capture all counters in a set, or specify a GPU context to filter metrics on). We avoided using perf' s grouping feature and forwarded OA reports to userspace via perf' s 'raw' sample field. This suited our userspace well considering how coupled the counters are when dealing with normalizing. It would be inconvenient to split counters up into separate events, only to require userspace to recombine them. For Mesa it' s also convenient to be forwarded raw, periodic reports for combining with the side-band raw reports it captures using MI_REPORT_PERF_COUNT commands.

- As a side note on perf' s grouping feature; there was also some concern that using PERF_FORMAT_GROUP as a way to pack together counter values would quite drastically inflate our sample sizes, which would likely lower the effective sampling resolutions we could use when the available memory bandwidth is limited.

  With the OA unit' s report formats, counters are packed together as 32 or 40bit values, with the largest report size being 256 bytes.

  PERF_FORMAT_GROUP values are 64bit, but there doesn' t appear to be a documented ordering to the values, implying PERF_FORMAT_ID must also be used to add a 64bit ID before each value; giving 16 bytes per counter.

Related to counter orthogonality; we can't time share the OA unit, while event scheduling is a central design idea within perf for allowing userspace to open + enable more events than can be configured in HW at any one time. The OA unit is not designed to allow re-configuration while in use. We can' t reconfigure the OA unit without losing internal OA unit state which we can't access explicitly to save and restore. Reconfiguring the OA unit is also relatively slow, involving ~100 register writes. From userspace Mesa also depends on a stable OA configuration when emitting MI_REPORT_PERF_COUNT commands and importantly the OA unit can' t be disabled while there are outstanding MI_RPC commands lest we hang the command streamer.

The contents of sample records aren' t extensible by device drivers (i.e. the sample_type bits). As an example; Sourab Gupta had been looking to attach GPU timestamps to our OA samples. We were shoehorning OA reports into sample records by using the 'raw' field, but it's tricky to pack more than one thing into this field because events/core.c currently only lets a pmu give a single raw data pointer plus len which will be copied into the ring buffer. To include more than the OA report we'd have to copy the report into an intermediate larger buffer. I'd been considering allowing a vector of data+len values to be specified for copying the raw data, but it felt like a kludge to being using the raw field for this purpose.

- It felt like our perf based PMU was making some technical compromises just for the sake of using perf:

  perf_event_open() requires events to either relate to a pid or a specific cpu core, while our device pmu related to neither. Events opened with a pid will be automatically enabled/disabled according to the scheduling of that process - so not appropriate for us. When an event is related to a cpu id, perf ensures pmu methods will be invoked via an inter process interrupt on that core. To avoid invasive changes our userspace opened OA perf events for a specific cpu. This was workable but it meant the majority of the OA driver ran in atomic context, including all OA report forwarding, which wasn't really necessary in our case and seems to make our locking requirements somewhat complex as we handled the interaction with the rest of the i915 driver.

i915 Driver Entry Points

This section covers the entrypoints exported outside of i915_perf.c to integrate with drm/i915 and to handle the *DRM_I915_PERF_OPEN* ioctl.

void **i915_perf_init**(struct drm_i915_private *i915)

initialize i915-perf state on module bind

Parameters

struct drm_i915_private *i915
i915 device instance

Description

Initializes i915-perf state without exposing anything to userspace.

Note

i915-perf initialization is split into an 'init' and 'register' phase with the *i915_perf_register()* exposing state to userspace.

void **i915_perf_fini**(struct drm_i915_private *i915)

Counter part to *i915_perf_init()*

Parameters

struct drm_i915_private *i915
i915 device instance

void **i915_perf_register**(struct drm_i915_private *i915)

exposes i915-perf to userspace

Parameters

struct drm_i915_private *i915
i915 device instance

Description

In particular OA metric sets are advertised under a sysfs metrics/ directory allowing userspace to enumerate valid IDs that can be used to open an i915-perf stream.

void **i915_perf_unregister**(struct drm_i915_private *i915)
hide i915-perf from userspace

Parameters

struct drm_i915_private *i915
i915 device instance

Description

i915-perf state cleanup is split up into an 'unregister' and 'deinit' phase where the interface is first hidden from userspace by *i915_perf_unregister()* before cleaning up remaining state in *i915_perf_fini()*.

int **i915_perf_open_ioctl**(struct *drm_device* *dev, void *data, struct *drm_file* *file)
DRM ioctl() for userspace to open a stream FD

Parameters

struct drm_device *dev
drm device

void *data
ioctl data copied from userspace (unvalidated)

struct drm_file *file
drm file

Description

Validates the stream open parameters given by userspace including flags and an array of u64 key, value pair properties.

Very little is assumed up front about the nature of the stream being opened (for instance we don't assume it's for periodic OA unit metrics). An i915-perf stream is expected to be a suitable interface for other forms of buffered data written by the GPU besides periodic OA metrics.

Note we copy the properties from userspace outside of the i915 perf mutex to avoid an awkward lockdep with mmap_lock.

Most of the implementation details are handled by *i915_perf_open_ioctl_locked()* after taking the `perf->lock` mutex for serializing with any non-file-operation driver hooks.

Return

A newly opened i915 Perf stream file descriptor or negative error code on failure.

int **i915_perf_release**(struct *inode* *inode, struct *file* *file)
handles userspace close() of a stream file

Parameters

struct inode *inode
anonymous inode associated with file

struct file *file
An i915 perf stream file

Description

Cleans up any resources associated with an open i915 perf stream file.

NB: close() can't really fail from the userspace point of view.

Return

zero on success or a negative error code.

int **i915_perf_add_config_ioctl**(struct *drm_device* *dev, void *data, struct *drm_file* *file)
DRM ioctl() for userspace to add a new OA config

Parameters

struct drm_device *dev
drm device

void *data
ioctl data (pointer to struct drm_i915_perf_oa_config) copied from userspace (unvalidated)

struct drm_file *file
drm file

Description

Validates the submitted OA register to be saved into a new OA config that can then be used for programming the OA unit and its NOA network.

Return

A new allocated config number to be used with the perf open ioctl or a negative error code on failure.

int **i915_perf_remove_config_ioctl**(struct *drm_device* *dev, void *data, struct *drm_file* *file)
DRM ioctl() for userspace to remove an OA config

Parameters

struct drm_device *dev
drm device

void *data
ioctl data (pointer to u64 integer) copied from userspace

struct drm_file *file
drm file

Description

Configs can be removed while being used, the will stop appearing in sysfs and their content will be freed when the stream using the config is closed.

Return

0 on success or a negative error code on failure.

i915 Perf Stream

This section covers the stream-semantics-agnostic structures and functions for representing an i915 perf stream FD and associated file operations.

struct **i915_perf_stream**

state for a single open stream FD

Definition

```
struct i915_perf_stream {
  struct i915_perf *perf;
  struct intel_uncore *uncore;
  struct intel_engine_cs *engine;
  u32 sample_flags;
  int sample_size;
  struct i915_gem_context *ctx;
  bool enabled;
  bool hold_preemption;
  const struct i915_perf_stream_ops *ops;
  struct i915_oa_config *oa_config;
  struct llist_head oa_config_bos;
  struct intel_context *pinned_ctx;
  u32 specific_ctx_id;
  u32 specific_ctx_id_mask;
  struct hrtimer poll_check_timer;
  wait_queue_head_t poll_wq;
  bool pollin;
  bool periodic;
  int period_exponent;
  struct {
    struct i915_vma *vma;
    u8 *vaddr;
    u32 last_ctx_id;
    int format;
    int format_size;
    int size_exponent;
    spinlock_t ptr_lock;
    u32 aging_tail;
    u64 aging_timestamp;
    u32 head;
    u32 tail;
  } oa_buffer;
```

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```
  struct i915_vma *noa_wait;
  u64 poll_oa_period;
};
```

Members

perf
: i915_perf backpointer

uncore
: mmio access path

engine
: Engine associated with this performance stream.

sample_flags
: Flags representing the *DRM_I915_PERF_PROP_SAMPLE_** properties given when opening a stream, representing the contents of a single sample as read() by userspace.

sample_size
: Considering the configured contents of a sample combined with the required header size, this is the total size of a single sample record.

ctx
: `NULL` if measuring system-wide across all contexts or a specific context that is being monitored.

enabled
: Whether the stream is currently enabled, considering whether the stream was opened in a disabled state and based on *I915_PERF_IOCTL_ENABLE* and *I915_PERF_IOCTL_DISABLE* calls.

hold_preemption
: Whether preemption is put on hold for command submissions done on the **ctx**. This is useful for some drivers that cannot easily post process the OA buffer context to subtract delta of performance counters not associated with **ctx**.

ops
: The callbacks providing the implementation of this specific type of configured stream.

oa_config
: The OA configuration used by the stream.

oa_config_bos
: A list of struct i915_oa_config_bo allocated lazily each time **oa_config** changes.

pinned_ctx
: The OA context specific information.

specific_ctx_id
: The id of the specific context.

specific_ctx_id_mask
The mask used to masking specific_ctx_id bits.

poll_check_timer
High resolution timer that will periodically check for data in the circular OA buffer for notifying userspace (e.g. during a read() or poll()).

poll_wq
The wait queue that hrtimer callback wakes when it sees data ready to read in the circular OA buffer.

pollin
Whether there is data available to read.

periodic
Whether periodic sampling is currently enabled.

period_exponent
The OA unit sampling frequency is derived from this.

oa_buffer
State of the OA buffer.

noa_wait
A batch buffer doing a wait on the GPU for the NOA logic to be reprogrammed.

poll_oa_period
The period in nanoseconds at which the OA buffer should be checked for available data.

struct **i915_perf_stream_ops**
the OPs to support a specific stream type

Definition

```
struct i915_perf_stream_ops {
  void (*enable)(struct i915_perf_stream *stream);
  void (*disable)(struct i915_perf_stream *stream);
  void (*poll_wait)(struct i915_perf_stream *stream,struct file␣
↪*file, poll_table *wait);
  int (*wait_unlocked)(struct i915_perf_stream *stream);
  int (*read)(struct i915_perf_stream *stream,char __user *buf,size_
↪t count, size_t *offset);
  void (*destroy)(struct i915_perf_stream *stream);
};
```

Members

enable
Enables the collection of HW samples, either in response to *I915_PERF_IOCTL_ENABLE* or implicitly called when stream is opened without *I915_PERF_FLAG_DISABLED*.

disable
Disables the collection of HW samples, either in response to *I915_PERF_IOCTL_DISABLE* or implicitly called before destroying the stream.

poll_wait
Call poll_wait, passing a wait queue that will be woken once there is something ready to read() for the stream

wait_unlocked
For handling a blocking read, wait until there is something to ready to read() for the stream. E.g. wait on the same wait queue that would be passed to poll_wait().

read
Copy buffered metrics as records to userspace **buf**: the userspace, destination buffer **count**: the number of bytes to copy, requested by userspace **offset**: zero at the start of the read, updated as the read proceeds, it represents how many bytes have been copied so far and the buffer offset for copying the next record.

Copy as many buffered i915 perf samples and records for this stream to userspace as will fit in the given buffer.

Only write complete records; returning `-ENOSPC` if there isn't room for a complete record.

Return any error condition that results in a short read such as `-ENOSPC` or `-EFAULT`, even though these may be squashed before returning to userspace.

destroy
Cleanup any stream specific resources.

The stream will always be disabled before this is called.

int **read_properties_unlocked**(struct i915_perf *perf, u64 __user *uprops, u32 n_props, struct *perf_open_properties* *props)

validate + copy userspace stream open properties

Parameters

struct i915_perf *perf
i915 perf instance

u64 __user *uprops
The array of u64 key value pairs given by userspace

u32 n_props
The number of key value pairs expected in **uprops**

struct perf_open_properties *props
The stream configuration built up while validating properties

Description

Note this function only validates properties in isolation it doesn't validate that the combination of properties makes sense or that all properties necessary for a particular kind of stream have been set.

Note that there currently aren't any ordering requirements for properties so we shouldn't validate or assume anything about ordering here. This doesn't rule out defining new properties with ordering requirements in the future.

int **i915_perf_open_ioctl_locked**(struct i915_perf *perf, struct drm_i915_perf_open_param *param, struct *perf_open_properties* *props, struct *drm_file* *file)

DRM ioctl() for userspace to open a stream FD

Parameters

struct i915_perf *perf
i915 perf instance

struct drm_i915_perf_open_param *param
The open parameters passed to 'DRM_I915_PERF_OPEN`

struct perf_open_properties *props
individually validated u64 property value pairs

struct drm_file *file
drm file

Description

See i915_perf_ioctl_open() for interface details.

Implements further stream config validation and stream initialization on behalf of *i915_perf_open_ioctl()* with the `perf->lock` mutex taken to serialize with any non-file-operation driver hooks.

In the case where userspace is interested in OA unit metrics then further config validation and stream initialization details will be handled by *i915_oa_stream_init()*. The code here should only validate config state that will be relevant to all stream types / backends.

Note

at this point the **props** have only been validated in isolation and it' s still necessary to validate that the combination of properties makes sense.

Return

zero on success or a negative error code.

void **i915_perf_destroy_locked**(struct *i915_perf_stream* *stream)

destroy an i915 perf stream

Parameters

struct i915_perf_stream *stream
An i915 perf stream

Description

Frees all resources associated with the given i915 perf **stream**, disabling any associated data capture in the process.

Note

The `perf->lock` mutex has been taken to serialize with any non-file-operation driver hooks.

ssize_t **i915_perf_read**(struct *file* *file, char __user *buf, size_t count, loff_t *ppos)

handles read() FOP for i915 perf stream FDs

Parameters

struct file *file
An i915 perf stream file

char __user *buf
destination buffer given by userspace

size_t count
the number of bytes userspace wants to read

loff_t *ppos
(inout) file seek position (unused)

Description

The entry point for handling a read() on a stream file descriptor from userspace. Most of the work is left to the i915_perf_read_locked() and *i915_perf_stream_ops->read* but to save having stream implementations (of which we might have multiple later) we handle blocking read here.

We can also consistently treat trying to read from a disabled stream as an IO error so implementations can assume the stream is enabled while reading.

Return

The number of bytes copied or a negative error code on failure.

long **i915_perf_ioctl**(struct *file* *file, unsigned int cmd, unsigned long arg)

support ioctl() usage with i915 perf stream FDs

Parameters

struct file *file
An i915 perf stream file

unsigned int cmd
the ioctl request

unsigned long arg
the ioctl data

Description

Implementation deferred to *i915_perf_ioctl_locked()*.

Return

zero on success or a negative error code. Returns -EINVAL for an unknown ioctl request.

void **i915_perf_enable_locked**(struct *i915_perf_stream* *stream)

handle *I915_PERF_IOCTL_ENABLE* ioctl

Parameters

struct i915_perf_stream *stream
A disabled i915 perf stream

Description

[Re]enables the associated capture of data for this stream.

If a stream was previously enabled then there's currently no intention to provide userspace any guarantee about the preservation of previously buffered data.

void **i915_perf_disable_locked**(struct *i915_perf_stream* *stream)

handle *I915_PERF_IOCTL_DISABLE* ioctl

Parameters

struct i915_perf_stream *stream
An enabled i915 perf stream

Description

Disables the associated capture of data for this stream.

The intention is that disabling an re-enabling a stream will ideally be cheaper than destroying and re-opening a stream with the same configuration, though there are no formal guarantees about what state or buffered data must be retained between disabling and re-enabling a stream.

Note

while a stream is disabled it's considered an error for userspace to attempt to read from the stream (-EIO).

__poll_t **i915_perf_poll**(struct *file* *file, poll_table *wait)

call poll_wait() with a suitable wait queue for stream

Parameters

struct file *file
An i915 perf stream file

poll_table *wait
poll() state table

Description

For handling userspace polling on an i915 perf stream, this ensures poll_wait() gets called with a wait queue that will be woken for new stream data.

Note

Implementation deferred to *i915_perf_poll_locked()*

Return

any poll events that are ready without sleeping

__poll_t **i915_perf_poll_locked**(struct *i915_perf_stream* *stream, struct *file* *file, poll_table *wait)

poll_wait() with a suitable wait queue for stream

Parameters

struct i915_perf_stream *stream
An i915 perf stream

struct file *file
An i915 perf stream file

poll_table *wait
poll() state table

Description

For handling userspace polling on an i915 perf stream, this calls through to *i915_perf_stream_ops->poll_wait* to call poll_wait() with a wait queue that will be woken for new stream data.

Note

The `perf->lock` mutex has been taken to serialize with any non-file-operation driver hooks.

Return

any poll events that are ready without sleeping

i915 Perf Observation Architecture Stream

struct **i915_oa_ops**
Gen specific implementation of an OA unit stream

Definition

```
struct i915_oa_ops {
  bool (*is_valid_b_counter_reg)(struct i915_perf *perf, u32 addr);
  bool (*is_valid_mux_reg)(struct i915_perf *perf, u32 addr);
  bool (*is_valid_flex_reg)(struct i915_perf *perf, u32 addr);
  int (*enable_metric_set)(struct i915_perf_stream *stream, struct␣
↪i915_active *active);
  void (*disable_metric_set)(struct i915_perf_stream *stream);
  void (*oa_enable)(struct i915_perf_stream *stream);
  void (*oa_disable)(struct i915_perf_stream *stream);
  int (*read)(struct i915_perf_stream *stream,char __user *buf,size_
↪t count, size_t *offset);
  u32 (*oa_hw_tail_read)(struct i915_perf_stream *stream);
};
```

Members

is_valid_b_counter_reg
Validates register's address for programming boolean counters for a particular platform.

is_valid_mux_reg
Validates register's address for programming mux for a particular platform.

is_valid_flex_reg
Validates register's address for programming flex EU filtering for a particular platform.

enable_metric_set
Selects and applies any MUX configuration to set up the Boolean and Custom

(B/C) counters that are part of the counter reports being sampled. May apply system constraints such as disabling EU clock gating as required.

disable_metric_set
Remove system constraints associated with using the OA unit.

oa_enable
Enable periodic sampling

oa_disable
Disable periodic sampling

read
Copy data from the circular OA buffer into a given userspace buffer.

oa_hw_tail_read
read the OA tail pointer register

In particular this enables us to share all the fiddly code for handling the OA unit tail pointer race that affects multiple generations.

int **i915_oa_stream_init**(struct *i915_perf_stream* *stream, struct drm_i915_perf_open_param *param, struct *perf_open_properties* *props)

validate combined props for OA stream and init

Parameters

struct i915_perf_stream *stream
An i915 perf stream

struct drm_i915_perf_open_param *param
The open parameters passed to *DRM_I915_PERF_OPEN*

struct perf_open_properties *props
The property state that configures stream (individually validated)

Description

While *read_properties_unlocked()* validates properties in isolation it doesn't ensure that the combination necessarily makes sense.

At this point it has been determined that userspace wants a stream of OA metrics, but still we need to further validate the combined properties are OK.

If the configuration makes sense then we can allocate memory for a circular OA buffer and apply the requested metric set configuration.

Return

zero on success or a negative error code.

int **i915_oa_read**(struct *i915_perf_stream* *stream, char __user *buf, size_t count, size_t *offset)

just calls through to *i915_oa_ops->read*

Parameters

struct i915_perf_stream *stream
An i915-perf stream opened for OA metrics

char __user *buf
: destination buffer given by userspace

size_t count
: the number of bytes userspace wants to read

size_t *offset
: (inout): the current position for writing into **buf**

Description

Updates **offset** according to the number of bytes successfully copied into the userspace buffer.

Return

zero on success or a negative error code

void **i915_oa_stream_enable**(struct *i915_perf_stream* *stream)
: handle *I915_PERF_IOCTL_ENABLE* for OA stream

Parameters

struct i915_perf_stream *stream
: An i915 perf stream opened for OA metrics

Description

[Re]enables hardware periodic sampling according to the period configured when opening the stream. This also starts a hrtimer that will periodically check for data in the circular OA buffer for notifying userspace (e.g. during a read() or poll()).

void **i915_oa_stream_disable**(struct *i915_perf_stream* *stream)
: handle *I915_PERF_IOCTL_DISABLE* for OA stream

Parameters

struct i915_perf_stream *stream
: An i915 perf stream opened for OA metrics

Description

Stops the OA unit from periodically writing counter reports into the circular OA buffer. This also stops the hrtimer that periodically checks for data in the circular OA buffer, for notifying userspace.

int **i915_oa_wait_unlocked**(struct *i915_perf_stream* *stream)
: handles blocking IO until OA data available

Parameters

struct i915_perf_stream *stream
: An i915-perf stream opened for OA metrics

Description

Called when userspace tries to read() from a blocking stream FD opened for OA metrics. It waits until the hrtimer callback finds a non-empty OA buffer and wakes us.

Note

it's acceptable to have this return with some false positives since any subsequent read handling will return -EAGAIN if there isn't really data ready for userspace yet.

Return

zero on success or a negative error code

void **i915_oa_poll_wait**(struct *i915_perf_stream* *stream, struct *file* *file, poll_table *wait)

call poll_wait() for an OA stream poll()

Parameters

struct i915_perf_stream *stream
An i915-perf stream opened for OA metrics

struct file *file
An i915 perf stream file

poll_table *wait
poll() state table

Description

For handling userspace polling on an i915 perf stream opened for OA metrics, this starts a poll_wait with the wait queue that our hrtimer callback wakes when it sees data ready to read in the circular OA buffer.

Other i915 Perf Internals

This section simply includes all other currently documented i915 perf internals, in no particular order, but may include some more minor utilities or platform specific details than found in the more high-level sections.

struct **perf_open_properties**

for validated properties given to open a stream

Definition

```
struct perf_open_properties {
  u32 sample_flags;
  u64 single_context:1;
  u64 hold_preemption:1;
  u64 ctx_handle;
  int metrics_set;
  int oa_format;
  bool oa_periodic;
  int oa_period_exponent;
  struct intel_engine_cs *engine;
  bool has_sseu;
  struct intel_sseu sseu;
  u64 poll_oa_period;
};
```

Members

`sample_flags`
: *DRM_I915_PERF_PROP_SAMPLE_** properties are tracked as flags

`single_context`
: Whether a single or all gpu contexts should be monitored

`hold_preemption`
: Whether the preemption is disabled for the filtered context

`ctx_handle`
: A gem ctx handle for use with **single_context**

`metrics_set`
: An ID for an OA unit metric set advertised via sysfs

`oa_format`
: An OA unit HW report format

`oa_periodic`
: Whether to enable periodic OA unit sampling

`oa_period_exponent`
: The OA unit sampling period is derived from this

`engine`
: The engine (typically rcs0) being monitored by the OA unit

`has_sseu`
: Whether **sseu** was specified by userspace

`sseu`
: internal SSEU configuration computed either from the userspace specified configuration in the opening parameters or a default value (see get_default_sseu_config())

`poll_oa_period`
: The period in nanoseconds at which the CPU will check for OA data availability

Description

As *`read_properties_unlocked()`* enumerates and validates the properties given to open a stream of metrics the configuration is built up in the structure which starts out zero initialized.

bool **`oa_buffer_check_unlocked`**(struct *i915_perf_stream* *stream)
: check for data and update tail ptr state

Parameters

`struct i915_perf_stream *stream`
: i915 stream instance

Description

This is either called via fops (for blocking reads in user ctx) or the poll check hrtimer (atomic ctx) to check the OA buffer tail pointer and check if there is data available for userspace to read.

This function is central to providing a workaround for the OA unit tail pointer having a race with respect to what data is visible to the CPU. It is responsible for reading tail pointers from the hardware and giving the pointers time to 'age' before they are made available for reading. (See description of OA_TAIL_MARGIN_NSEC above for further details.)

Besides returning true when there is data available to read() this function also updates the tail, aging_tail and aging_timestamp in the oa_buffer object.

Note

It's safe to read OA config state here unlocked, assuming that this is only called while the stream is enabled, while the global OA configuration can't be modified.

Return

`true` if the OA buffer contains data, else `false`

int **append_oa_status**(struct *i915_perf_stream* *stream, char __user *buf, size_t count, size_t *offset, enum drm_i915_perf_record_type type)

Appends a status record to a userspace read() buffer.

Parameters

struct i915_perf_stream *stream
An i915-perf stream opened for OA metrics

char __user *buf
destination buffer given by userspace

size_t count
the number of bytes userspace wants to read

size_t *offset
(inout): the current position for writing into **buf**

enum drm_i915_perf_record_type type
The kind of status to report to userspace

Description

Writes a status record (such as *DRM_I915_PERF_RECORD_OA_REPORT_LOST*) into the userspace read() buffer.

The **buf offset** will only be updated on success.

Return

0 on success, negative error code on failure.

int **append_oa_sample**(struct *i915_perf_stream* *stream, char __user *buf, size_t count, size_t *offset, const u8 *report)

Copies single OA report into userspace read() buffer.

Parameters

struct i915_perf_stream *stream
An i915-perf stream opened for OA metrics

char __user *buf
destination buffer given by userspace

size_t count
: the number of bytes userspace wants to read

size_t *offset
: (inout): the current position for writing into **buf**

const u8 *report
: A single OA report to (optionally) include as part of the sample

Description

The contents of a sample are configured through *DRM_I915_PERF_PROP_SAMPLE_** properties when opening a stream, tracked as *stream->sample_flags*. This function copies the requested components of a single sample to the given read() **buf**.

The **buf offset** will only be updated on success.

Return

0 on success, negative error code on failure.

int **gen8_append_oa_reports**(struct *i915_perf_stream* *stream, char __user *buf, size_t count, size_t *offset)

Parameters

struct i915_perf_stream *stream
: An i915-perf stream opened for OA metrics

char __user *buf
: destination buffer given by userspace

size_t count
: the number of bytes userspace wants to read

size_t *offset
: (inout): the current position for writing into **buf**

Description

Notably any error condition resulting in a short read (`-ENOSPC` or `-EFAULT`) will be returned even though one or more records may have been successfully copied. In this case it' s up to the caller to decide if the error should be squashed before returning to userspace.

Note

reports are consumed from the head, and appended to the tail, so the tail chases the head?⋯If you think that' s mad and back-to-front you' re not alone, but this follows the Gen PRM naming convention.

Return

0 on success, negative error code on failure.

int **gen8_oa_read**(struct *i915_perf_stream* *stream, char __user *buf, size_t count, size_t *offset)

copy status records then buffered OA reports

Parameters

`struct i915_perf_stream *stream`
: An i915-perf stream opened for OA metrics

`char __user *buf`
: destination buffer given by userspace

`size_t count`
: the number of bytes userspace wants to read

`size_t *offset`
: (inout): the current position for writing into **buf**

Description

Checks OA unit status registers and if necessary appends corresponding status records for userspace (such as for a buffer full condition) and then initiate appending any buffered OA reports.

Updates **offset** according to the number of bytes successfully copied into the userspace buffer.

NB: some data may be successfully copied to the userspace buffer even if an error is returned, and this is reflected in the updated **offset**.

Return

zero on success or a negative error code

int **`gen7_append_oa_reports`**(struct *i915_perf_stream* *stream, char __user *buf, size_t count, size_t *offset)

Parameters

`struct i915_perf_stream *stream`
: An i915-perf stream opened for OA metrics

`char __user *buf`
: destination buffer given by userspace

`size_t count`
: the number of bytes userspace wants to read

`size_t *offset`
: (inout): the current position for writing into **buf**

Description

Notably any error condition resulting in a short read (`-ENOSPC` or `-EFAULT`) will be returned even though one or more records may have been successfully copied. In this case it's up to the caller to decide if the error should be squashed before returning to userspace.

Note

reports are consumed from the head, and appended to the tail, so the tail chases the head?…If you think that's mad and back-to-front you're not alone, but this follows the Gen PRM naming convention.

Return

0 on success, negative error code on failure.

int **gen7_oa_read**(struct *i915_perf_stream* *stream, char __user *buf, size_t count, size_t *offset)

copy status records then buffered OA reports

Parameters

struct i915_perf_stream *stream
An i915-perf stream opened for OA metrics

char __user *buf
destination buffer given by userspace

size_t count
the number of bytes userspace wants to read

size_t *offset
(inout): the current position for writing into **buf**

Description

Checks Gen 7 specific OA unit status registers and if necessary appends corresponding status records for userspace (such as for a buffer full condition) and then initiate appending any buffered OA reports.

Updates **offset** according to the number of bytes successfully copied into the userspace buffer.

Return

zero on success or a negative error code

int **oa_get_render_ctx_id**(struct *i915_perf_stream* *stream)

determine and hold ctx hw id

Parameters

struct i915_perf_stream *stream
An i915-perf stream opened for OA metrics

Description

Determine the render context hw id, and ensure it remains fixed for the lifetime of the stream. This ensures that we don't have to worry about updating the context ID in OACONTROL on the fly.

Return

zero on success or a negative error code

void **oa_put_render_ctx_id**(struct *i915_perf_stream* *stream)

counterpart to oa_get_render_ctx_id releases hold

Parameters

struct i915_perf_stream *stream
An i915-perf stream opened for OA metrics

Description

In case anything needed doing to ensure the context HW ID would remain valid for the lifetime of the stream, then that can be undone here.

long **`i915_perf_ioctl_locked`**(struct *i915_perf_stream* *stream, unsigned int cmd, unsigned long arg)

support ioctl() usage with i915 perf stream FDs

Parameters

`struct i915_perf_stream *stream`
An i915 perf stream

`unsigned int cmd`
the ioctl request

`unsigned long arg`
the ioctl data

Note

The `perf->lock` mutex has been taken to serialize with any non-file-operation driver hooks.

Return

zero on success or a negative error code. Returns -EINVAL for an unknown ioctl request.

int **`i915_perf_ioctl_version`**(void)

Version of the i915-perf subsystem

Parameters

`void`
no arguments

Description

This version number is used by userspace to detect available features.

8.3.7 Style

The drm/i915 driver codebase has some style rules in addition to (and, in some cases, deviating from) the kernel coding style.

Register macro definition style

The style guide for `i915_reg.h`.

Follow the style described here for new macros, and while changing existing macros. Do **not** mass change existing definitions just to update the style.

File Layout

Keep helper macros near the top. For example, _PIPE() and friends.

Prefix macros that generally should not be used outside of this file with underscore '_'. For example, _PIPE() and friends, single instances of registers that are defined solely for the use by function-like macros.

Avoid using the underscore prefixed macros outside of this file. There are exceptions, but keep them to a minimum.

There are two basic types of register definitions: Single registers and register groups. Register groups are registers which have two or more instances, for example one per pipe, port, transcoder, etc. Register groups should be defined using function-like macros.

For single registers, define the register offset first, followed by register contents.

For register groups, define the register instance offsets first, prefixed with underscore, followed by a function-like macro choosing the right instance based on the parameter, followed by register contents.

Define the register contents (i.e. bit and bit field macros) from most significant to least significant bit. Indent the register content macros using two extra spaces between `#define` and the macro name.

Define bit fields using `REG_GENMASK(h, l)`. Define bit field contents using `REG_FIELD_PREP(mask, value)`. This will define the values already shifted in place, so they can be directly OR'd together. For convenience, function-like macros may be used to define bit fields, but do note that the macros may be needed to read as well as write the register contents.

Define bits using `REG_BIT(N)`. Do **not** add `_BIT` suffix to the name.

Group the register and its contents together without blank lines, separate from other registers and their contents with one blank line.

Indent macro values from macro names using TABs. Align values vertically. Use braces in macro values as needed to avoid unintended precedence after macro substitution. Use spaces in macro values according to kernel coding style. Use lower case in hexadecimal values.

Naming

Try to name registers according to the specs. If the register name changes in the specs from platform to another, stick to the original name.

Try to re-use existing register macro definitions. Only add new macros for new register offsets, or when the register contents have changed enough to warrant a full redefinition.

When a register macro changes for a new platform, prefix the new macro using the platform acronym or generation. For example, `SKL_` or `GEN8_`. The prefix signifies the start platform/generation using the register.

When a bit (field) macro changes or gets added for a new platform, while retaining the existing register macro, add a platform acronym or generation suffix to the name. For example, _SKL or _GEN8.

Examples

(Note that the values in the example are indented using spaces instead of TABs to avoid misalignment in generated documentation. Use TABs in the definitions.):

```
#define _FOO_A                      0xf000
#define _FOO_B                      0xf001
#define FOO(pipe)                   _MMIO_PIPE(pipe, _FOO_A, _FOO_B)
#define   FOO_ENABLE                REG_BIT(31)
#define   FOO_MODE_MASK             REG_GENMASK(19, 16)
#define   FOO_MODE_BAR              REG_FIELD_PREP(FOO_MODE_MASK, 0)
#define   FOO_MODE_BAZ              REG_FIELD_PREP(FOO_MODE_MASK, 1)
#define   FOO_MODE_QUX_SNB          REG_FIELD_PREP(FOO_MODE_MASK, 2)

#define BAR                         _MMIO(0xb000)
#define GEN8_BAR                    _MMIO(0xb888)
```

8.4 drm/mcde ST-Ericsson MCDE Multi-channel display engine

The MCDE (short for multi-channel display engine) is a graphics controller found in the Ux500 chipsets, such as NovaThor U8500. It was initially conceptualized by ST Microelectronics for the successor of the Nomadik line, STn8500 but productified in the ST-Ericsson U8500 where is was used for mass-market deployments in Android phones from Samsung and Sony Ericsson.

It can do 1080p30 on SDTV CCIR656, DPI-2, DBI-2 or DSI for panels with or without frame buffering and can convert most input formats including most variants of RGB and YUV.

The hardware has four display pipes, and the layout is a little bit like this:

```
Memory     -> Overlay -> Channel -> FIFO -> 5 formatters -> DSI/DPI
External      0..5       0..3       A,B,    3 x DSI         bridge
source 0..9                         C0,C1   2 x DPI
```

FIFOs A and B are for LCD and HDMI while FIFO CO/C1 are for panels with embedded buffer. 3 of the formatters are for DSI. 2 of the formatters are for DPI.

Behind the formatters are the DSI or DPI ports that route to the external pins of the chip. As there are 3 DSI ports and one DPI port, it is possible to configure up to 4 display pipelines (effectively using channels 0..3) for concurrent use.

In the current DRM/KMS setup, we use one external source, one overlay, one FIFO and one formatter which we connect to the simple CMA framebuffer helpers. We then provide a bridge to the DSI port, and on the DSI port bridge we connect hang a panel bridge or other bridge. This may be subject to change as we exploit more of the hardware capabilities.

TODO:

- Enabled damaged rectangles using *drm_plane_enable_fb_damage_clips()* so we can selectively just transmit the damaged area to a command-only display.
- Enable mixing of more planes, possibly at the cost of moving away from using the simple framebuffer pipeline.
- Enable output to bridges such as the AV8100 HDMI encoder from the DSI bridge.

8.5 drm/meson AmLogic Meson Video Processing Unit

VPU Handles the Global Video Processing, it includes management of the clocks gates, blocks reset lines and power domains.

What is missing :

- Full reset of entire video processing HW blocks
- Scaling and setup of the VPU clock
- Bus clock gates
- Powering up video processing HW blocks
- Powering Up HDMI controller and PHY

8.5.1 Video Processing Unit

The Amlogic Meson Display controller is composed of several components that are going to be documented below:

```
DMC|---------------VPU (Video Processing Unit)----------------|-----
↪-HHI------|
   | vd1   ________     _______________    ____________________     |    ␣
↪          |
D  |-------|      |----|               |    |                    |    |  ␣
↪HDMI PLL    |
D  | vd2   | VIU  |    | Video Post |    | Video Encoders |<---|-----
↪VCLK       |
R  |-------|      |----| Processing |    |                    |    |    ␣
↪          |
   | osd2  |      |    |               |---| Enci ----------|----|-----
↪VDAC------|
R  |-------| CSC  |----| Scalers    |    | Encp ----------|----|----
↪HDMI-TX----|
A  | osd1  |      |    | Blenders   |    | Encl ----------|----|-----
↪----------|
M  |-------|______|----|_______________|    |____________________|    |    ␣
```

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```
↪               |
____|_________________________________________________________________________|______
↪_____________|
```

8.5.2 Video Input Unit

VIU Handles the Pixel scanout and the basic Colorspace conversions We handle the following features :

- OSD1 RGB565/RGB888/xRGB8888 scanout
- RGB conversion to x/cb/cr
- Progressive or Interlace buffer scanout
- OSD1 Commit on Vsync
- HDR OSD matrix for GXL/GXM

What is missing :

- BGR888/xBGR8888/BGRx8888/BGRx8888 modes
- YUV4:2:2 Y0CbY1Cr scanout
- Conversion to YUV 4:4:4 from 4:2:2 input
- Colorkey Alpha matching
- Big endian scanout
- X/Y reverse scanout
- Global alpha setup
- OSD2 support, would need interlace switching on vsync
- OSD1 full scaling to support TV overscan

8.5.3 Video Post Processing

VPP Handles all the Post Processing after the Scanout from the VIU We handle the following post processings :

- **Postblend, Blends the OSD1 only**
  We exclude OSD2, VS1, VS1 and Preblend output
- **Vertical OSD Scaler for OSD1 only, we disable vertical scaler and**
  use it only for interlace scanout
- Intermediate FIFO with default Amlogic values

What is missing :

- Preblend for video overlay pre-scaling
- OSD2 support for cursor framebuffer
- Video pre-scaling before postblend

- Full Vertical/Horizontal OSD scaling to support TV overscan
- HDR conversion

8.5.4 Video Encoder

VENC Handle the pixels encoding to the output formats. We handle the following encodings :

- CVBS Encoding via the ENCI encoder and VDAC digital to analog converter
- TMDS/HDMI Encoding via ENCI_DIV and ENCP
- Setup of more clock rates for HDMI modes

What is missing :

- LCD Panel encoding via ENCL
- TV Panel encoding via ENCT

VENC paths :

```
       _____   _____   ____________________
vd1---|     |-|     | | VENC     /---------|----VDAC
vd2---| VIU |-| VPP |-|-----ENCI/-ENCI_DVI-|-|
osd1--|     |-|     | | \                  | X--HDMI-TX
osd2--|_____|-|_____| |  |\-ENCP--ENCP_DVI-|-|
                      |  |                 |
                      |  \--ENCL-----------|----LVDS
                      |____________________|
```

The ENCI is designed for PAl or NTSC encoding and can go through the VDAC directly for CVBS encoding or through the ENCI_DVI encoder for HDMI. The ENCP is designed for Progressive encoding but can also generate 1080i interlaced pixels, and was initialy desined to encode pixels for VDAC to output RGB ou YUV analog outputs. It’s output is only used through the ENCP_DVI encoder for HDMI. The ENCL LVDS encoder is not implemented.

The ENCI and ENCP encoders needs specially defined parameters for each supported mode and thus cannot be determined from standard video timings.

The ENCI end ENCP DVI encoders are more generic and can generate any timings from the pixel data generated by ENCI or ENCP, so can use the standard video timings are source for HW parameters.

8.5.5 Video Clocks

VCLK is the “Pixel Clock” frequency generator from a dedicated PLL. We handle the following encodings :

- CVBS 27MHz generator via the VCLK2 to the VENCI and VDAC blocks
- HDMI Pixel Clocks generation

What is missing :

- Genenate Pixel clocks for 2K/4K 10bit formats

Clock generator scheme :

```
 __________   _________            _____
|          | |         |          |     |--ENCI
| HDMI PLL |-| PLL_DIV |--- VCLK--|     |--ENCL
|__________| |_________| \        | MUX |--ENCP
                          --VCLK2-|     |--VDAC
                                  |_____|--HDMI-TX
```

Final clocks can take input for either VCLK or VCLK2, but VCLK is the preferred path for HDMI clocking and VCLK2 is the preferred path for CVBS VDAC clocking.

VCLK and VCLK2 have fixed divided clocks paths for /1, /2, /4, /6 or /12.

The PLL_DIV can achieve an additional fractional dividing like 1.5, 3.5, 3.75…to generate special 2K and 4K 10bit clocks.

8.5.6 HDMI Video Output

HDMI Output is composed of :

- A Synopsys DesignWare HDMI Controller IP
- A TOP control block controlling the Clocks and PHY
- A custom HDMI PHY in order convert video to TMDS signal

```
 ___________________________________
|            HDMI TOP               |<= HPD
|___________________________________|
|                  |                |
|  Synopsys HDMI   |   HDMI PHY     |=> TMDS
|    Controller    |________________|
|___________________________________|<=> DDC
```

The HDMI TOP block only supports HPD sensing. The Synopsys HDMI Controller interrupt is routed through the TOP Block interrupt. Communication to the TOP Block and the Synopsys HDMI Controller is done a pair of addr+read/write registers. The HDMI PHY is configured by registers in the HHI register block.

Pixel data arrives in 4:4:4 format from the VENC block and the VPU HDMI mux selects either the ENCI encoder for the 576i or 480i formats or the ENCP encoder for all the other formats including interlaced HD formats. The VENC uses a DVI encoder on top of the ENCI or ENCP encoders to generate DVI timings for the HDMI controller.

GXBB, GXL and GXM embeds the Synopsys DesignWare HDMI TX IP version 2.01a with HDCP and I2C & S/PDIF audio source interfaces.

We handle the following features :

- HPD Rise & Fall interrupt
- HDMI Controller Interrupt
- HDMI PHY Init for 480i to 1080p60
- VENC & HDMI Clock setup for 480i to 1080p60
- VENC Mode setup for 480i to 1080p60

What is missing :

- PHY, Clock and Mode setup for 2k && 4k modes
- SDDC Scrambling mode for HDMI 2.0a
- HDCP Setup
- CEC Management

8.6 drm/pl111 ARM PrimeCell PL110 and PL111 CLCD Driver

The PL110/PL111 is a simple LCD controller that can support TFT and STN displays. This driver exposes a standard KMS interface for them.

The driver currently doesn’t expose the cursor. The DRM API for cursors requires support for 64x64 ARGB8888 cursor images, while the hardware can only support 64x64 monochrome with masking cursors. While one could imagine trying to hack something together to look at the ARGB8888 and program reasonable in monochrome, we just don’t expose the cursor at all instead, and leave cursor support to the application software cursor layer.

TODO:

- Fix race between setting plane base address and getting IRQ for vsync firing the pageflip completion.
- Read back hardware state at boot to skip reprogramming the hardware when doing a no-op modeset.
- Use the CLKSEL bit to support switching between the two external clock parents.

8.7 drm/tegra NVIDIA Tegra GPU and display driver

NVIDIA Tegra SoCs support a set of display, graphics and video functions via the host1x controller. host1x supplies command streams, gathered from a push buffer provided directly by the CPU, to its clients via channels. Software, or blocks amongst themselves, can use syncpoints for synchronization.

Up until, but not including, Tegra124 (aka Tegra K1) the drm/tegra driver supports the built-in GPU, comprised of the gr2d and gr3d engines. Starting with Tegra124 the GPU is based on the NVIDIA desktop GPU architecture and supported by the drm/nouveau driver.

The drm/tegra driver supports NVIDIA Tegra SoC generations since Tegra20. It has three parts:

- A host1x driver that provides infrastructure and access to the host1x services.
- A KMS driver that supports the display controllers as well as a number of outputs, such as RGB, HDMI, DSI, and DisplayPort.
- A set of custom userspace IOCTLs that can be used to submit jobs to the GPU and video engines via host1x.

8.7.1 Driver Infrastructure

The various host1x clients need to be bound together into a logical device in order to expose their functionality to users. The infrastructure that supports this is implemented in the host1x driver. When a driver is registered with the infrastructure it provides a list of compatible strings specifying the devices that it needs. The infrastructure creates a logical device and scan the device tree for matching device nodes, adding the required clients to a list. Drivers for individual clients register with the infrastructure as well and are added to the logical host1x device.

Once all clients are available, the infrastructure will initialize the logical device using a driver-provided function which will set up the bits specific to the subsystem and in turn initialize each of its clients.

Similarly, when one of the clients is unregistered, the infrastructure will destroy the logical device by calling back into the driver, which ensures that the subsystem specific bits are torn down and the clients destroyed in turn.

Host1x Infrastructure Reference

struct **host1x_client_ops**
host1x client operations

Definition

```
struct host1x_client_ops {
  int (*init)(struct host1x_client *client);
  int (*exit)(struct host1x_client *client);
  int (*suspend)(struct host1x_client *client);
```

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```
  int (*resume)(struct host1x_client *client);
};
```

Members

init
host1x client initialization code

exit
host1x client tear down code

suspend
host1x client suspend code

resume
host1x client resume code

struct **host1x_client**

host1x client structure

Definition

```
struct host1x_client {
  struct list_head list;
  struct device *host;
  struct device *dev;
  struct iommu_group *group;
  const struct host1x_client_ops *ops;
  enum host1x_class class;
  struct host1x_channel *channel;
  struct host1x_syncpt **syncpts;
  unsigned int num_syncpts;
  struct host1x_client *parent;
  unsigned int usecount;
  struct mutex lock;
};
```

Members

list
list node for the host1x client

host
pointer to struct device representing the host1x controller

dev
pointer to struct device backing this host1x client

group
IOMMU group that this client is a member of

ops
host1x client operations

class
host1x class represented by this client

channel
    host1x channel associated with this client

syncpts
    array of syncpoints requested for this client

num_syncpts
    number of syncpoints requested for this client

parent
    pointer to parent structure

usecount
    reference count for this structure

lock
    mutex for mutually exclusive concurrency

struct **host1x_driver**

host1x logical device driver

Definition

```
struct host1x_driver {
  struct device_driver driver;
  const struct of_device_id *subdevs;
  struct list_head list;
  int (*probe)(struct host1x_device *device);
  int (*remove)(struct host1x_device *device);
  void (*shutdown)(struct host1x_device *device);
};
```

Members

driver
    core driver

subdevs
    table of OF device IDs matching subdevices for this driver

list
    list node for the driver

probe
    called when the host1x logical device is probed

remove
    called when the host1x logical device is removed

shutdown
    called when the host1x logical device is shut down

int **host1x_device_init**(struct host1x_device *device)

initialize a host1x logical device

Parameters

struct host1x_device *device
    host1x logical device

Description

The driver for the host1x logical device can call this during execution of its *host1x_driver.probe* implementation to initialize each of its clients. The client drivers access the subsystem specific driver data using the *host1x_client.parent* field and driver data associated with it (usually by calling dev_get_drvdata()).

int **host1x_device_exit**(struct host1x_device *device)

uninitialize host1x logical device

Parameters

struct host1x_device *device
host1x logical device

Description

When the driver for a host1x logical device is unloaded, it can call this function to tear down each of its clients. Typically this is done after a subsystem-specific data structure is removed and the functionality can no longer be used.

int **host1x_driver_register_full**(struct *host1x_driver* *driver, struct module *owner)

register a host1x driver

Parameters

struct host1x_driver *driver
host1x driver

struct module *owner
owner module

Description

Drivers for host1x logical devices call this function to register a driver with the infrastructure. Note that since these drive logical devices, the registration of the driver actually triggers tho logical device creation. A logical device will be created for each host1x instance.

void **host1x_driver_unregister**(struct *host1x_driver* *driver)

unregister a host1x driver

Parameters

struct host1x_driver *driver
host1x driver

Description

Unbinds the driver from each of the host1x logical devices that it is bound to, effectively removing the subsystem devices that they represent.

void **__host1x_client_init**(struct *host1x_client* *client, struct lock_class_key *key)

initialize a host1x client

Parameters

struct host1x_client *client
host1x client

struct lock_class_key *key
lock class key for the client-specific mutex

void **host1x_client_exit**(struct *host1x_client* *client)
uninitialize a host1x client

Parameters

struct host1x_client *client
host1x client

int **__host1x_client_register**(struct *host1x_client* *client)
register a host1x client

Parameters

struct host1x_client *client
host1x client

Description

Registers a host1x client with each host1x controller instance. Note that each client will only match their parent host1x controller and will only be associated with that instance. Once all clients have been registered with their parent host1x controller, the infrastructure will set up the logical device and call *host1x_device_init()*, which will in turn call each client' s *host1x_client_ops.init* implementation.

int **host1x_client_unregister**(struct *host1x_client* *client)
unregister a host1x client

Parameters

struct host1x_client *client
host1x client

Description

Removes a host1x client from its host1x controller instance. If a logical device has already been initialized, it will be torn down.

Host1x Syncpoint Reference

u32 **host1x_syncpt_id**(struct host1x_syncpt *sp)
retrieve syncpoint ID

Parameters

struct host1x_syncpt *sp
host1x syncpoint

Description

Given a pointer to a struct host1x_syncpt, retrieves its ID. This ID is often used as a value to program into registers that control how hardware blocks interact with syncpoints.

u32 **host1x_syncpt_incr_max**(struct host1x_syncpt *sp, u32 incrs)

update the value sent to hardware

Parameters

struct host1x_syncpt *sp
host1x syncpoint

u32 incrs
number of increments

int **host1x_syncpt_incr**(struct host1x_syncpt *sp)

increment syncpoint value from CPU, updating cache

Parameters

struct host1x_syncpt *sp
host1x syncpoint

int **host1x_syncpt_wait**(struct host1x_syncpt *sp, u32 thresh, long timeout, u32 *value)

wait for a syncpoint to reach a given value

Parameters

struct host1x_syncpt *sp
host1x syncpoint

u32 thresh
threshold

long timeout
maximum time to wait for the syncpoint to reach the given value

u32 *value
return location for the syncpoint value

struct host1x_syncpt ***host1x_syncpt_request**(struct *host1x_client* *client, unsigned long flags)

request a syncpoint

Parameters

struct host1x_client *client
client requesting the syncpoint

unsigned long flags
flags

Description

host1x client drivers can use this function to allocate a syncpoint for subsequent use. A syncpoint returned by this function will be reserved for use by the client exclusively. When no longer using a syncpoint, a host1x client driver needs to release it using *host1x_syncpt_free()*.

void **host1x_syncpt_free**(struct host1x_syncpt *sp)

free a requested syncpoint

Parameters

struct host1x_syncpt *sp
    host1x syncpoint

Description

Release a syncpoint previously allocated using *host1x_syncpt_request()*. A host1x client driver should call this when the syncpoint is no longer in use. Note that client drivers must ensure that the syncpoint doesn't remain under the control of hardware after calling this function, otherwise two clients may end up trying to access the same syncpoint concurrently.

u32 **host1x_syncpt_read_max**(struct host1x_syncpt *sp)
    read maximum syncpoint value

Parameters

struct host1x_syncpt *sp
    host1x syncpoint

Description

The maximum syncpoint value indicates how many operations there are in queue, either in channel or in a software thread.

u32 **host1x_syncpt_read_min**(struct host1x_syncpt *sp)
    read minimum syncpoint value

Parameters

struct host1x_syncpt *sp
    host1x syncpoint

Description

The minimum syncpoint value is a shadow of the current sync point value in hardware.

u32 **host1x_syncpt_read**(struct host1x_syncpt *sp)
    read the current syncpoint value

Parameters

struct host1x_syncpt *sp
    host1x syncpoint

struct host1x_syncpt ***host1x_syncpt_get**(struct host1x *host, unsigned int id)
    obtain a syncpoint by ID

Parameters

struct host1x *host
    host1x controller

unsigned int id
    syncpoint ID

struct host1x_syncpt_base ***host1x_syncpt_get_base**(struct host1x_syncpt *sp)
    obtain the wait base associated with a syncpoint

Parameters

struct host1x_syncpt *sp
host1x syncpoint

u32 **host1x_syncpt_base_id**(struct host1x_syncpt_base *base)
retrieve the ID of a syncpoint wait base

Parameters

struct host1x_syncpt_base *base
host1x syncpoint wait base

8.7.2 KMS driver

The display hardware has remained mostly backwards compatible over the various Tegra SoC generations, up until Tegra186 which introduces several changes that make it difficult to support with a parameterized driver.

Display Controllers

Tegra SoCs have two display controllers, each of which can be associated with zero or more outputs. Outputs can also share a single display controller, but only if they run with compatible display timings. Two display controllers can also share a single framebuffer, allowing cloned configurations even if modes on two outputs don't match. A display controller is modelled as a CRTC in KMS terms.

On Tegra186, the number of display controllers has been increased to three. A display controller can no longer drive all of the outputs. While two of these controllers can drive both DSI outputs and both SOR outputs, the third cannot drive any DSI.

Windows

A display controller controls a set of windows that can be used to composite multiple buffers onto the screen. While it is possible to assign arbitrary Z ordering to individual windows (by programming the corresponding blending registers), this is currently not supported by the driver. Instead, it will assume a fixed Z ordering of the windows (window A is the root window, that is, the lowest, while windows B and C are overlaid on top of window A). The overlay windows support multiple pixel formats and can automatically convert from YUV to RGB at scanout time. This makes them useful for displaying video content. In KMS, each window is modelled as a plane. Each display controller has a hardware cursor that is exposed as a cursor plane.

Outputs

The type and number of supported outputs varies between Tegra SoC generations. All generations support at least HDMI. While earlier generations supported the very simple RGB interfaces (one per display controller), recent generations no longer do and instead provide standard interfaces such as DSI and eDP/DP.

Outputs are modelled as a composite encoder/connector pair.

RGB/LVDS

This interface is no longer available since Tegra124. It has been replaced by the more standard DSI and eDP interfaces.

HDMI

HDMI is supported on all Tegra SoCs. Starting with Tegra210, HDMI is provided by the versatile SOR output, which supports eDP, DP and HDMI. The SOR is able to support HDMI 2.0, though support for this is currently not merged.

DSI

Although Tegra has supported DSI since Tegra30, the controller has changed in several ways in Tegra114. Since none of the publicly available development boards prior to Dalmore (Tegra114) have made use of DSI, only Tegra114 and later are supported by the drm/tegra driver.

eDP/DP

eDP was first introduced in Tegra124 where it was used to drive the display panel for notebook form factors. Tegra210 added support for full DisplayPort support, though this is currently not implemented in the drm/tegra driver.

8.7.3 Userspace Interface

The userspace interface provided by drm/tegra allows applications to create GEM buffers, access and control syncpoints as well as submit command streams to host1x.

GEM Buffers

The `DRM_IOCTL_TEGRA_GEM_CREATE` IOCTL is used to create a GEM buffer object with Tegra-specific flags. This is useful for buffers that should be tiled, or that are to be scanned out upside down (useful for 3D content).

After a GEM buffer object has been created, its memory can be mapped by an application using the mmap offset returned by the `DRM_IOCTL_TEGRA_GEM_MMAP` IOCTL.

Syncpoints

The current value of a syncpoint can be obtained by executing the `DRM_IOCTL_TEGRA_SYNCPT_READ` IOCTL. Incrementing the syncpoint is achieved using the `DRM_IOCTL_TEGRA_SYNCPT_INCR` IOCTL.

Userspace can also request blocking on a syncpoint. To do so, it needs to execute the `DRM_IOCTL_TEGRA_SYNCPT_WAIT` IOCTL, specifying the value of the syncpoint to wait for. The kernel will release the application when the syncpoint reaches that value or after a specified timeout.

Command Stream Submission

Before an application can submit command streams to host1x it needs to open a channel to an engine using the `DRM_IOCTL_TEGRA_OPEN_CHANNEL` IOCTL. Client IDs are used to identify the target of the channel. When a channel is no longer needed, it can be closed using the `DRM_IOCTL_TEGRA_CLOSE_CHANNEL` IOCTL. To retrieve the syncpoint associated with a channel, an application can use the `DRM_IOCTL_TEGRA_GET_SYNCPT`.

After opening a channel, submitting command streams is easy. The application writes commands into the memory backing a GEM buffer object and passes these to the `DRM_IOCTL_TEGRA_SUBMIT` IOCTL along with various other parameters, such as the syncpoints or relocations used in the job submission.

8.8 drm/tve200 Faraday TV Encoder 200

The Faraday TV Encoder TVE200 is also known as the Gemini TV Interface Controller (TVC) and is found in the Gemini Chipset from Storlink Semiconductor (later Storm Semiconductor, later Cortina Systems) but also in the Grain Media GM8180 chipset. On the Gemini the module is connected to 8 data lines and a single clock line, comprising an 8-bit BT.656 interface.

This is a very basic YUV display driver. The datasheet specifies that it supports the ITU BT.656 standard. It requires a 27 MHz clock which is the hallmark of any TV encoder supporting both PAL and NTSC.

This driver exposes a standard KMS interface for this TV encoder.

8.9 drm/v3d Broadcom V3D Graphics Driver

This driver supports the Broadcom V3D 3.3 and 4.1 OpenGL ES GPUs. For V3D 2.x support, see the VC4 driver.

The V3D GPU includes a tiled render (composed of a bin and render pipelines), the TFU (texture formatting unit), and the CSD (compute shader dispatch).

8.9.1 GPU buffer object (BO) management

Compared to VC4 (V3D 2.x), V3D 3.3 introduces an MMU between the GPU and the bus, allowing us to use shmem objects for our storage instead of CMA.

Physically contiguous objects may still be imported to V3D, but the driver doesn't allocate physically contiguous objects on its own. Display engines requiring physically contiguous allocations should look into Mesa's "renderonly" support (as used by the Mesa pl111 driver) for an example of how to integrate with V3D.

Long term, we should support evicting pages from the MMU when under memory pressure (thus the v3d_bo_get_pages() refcounting), but that's not a high priority since our systems tend to not have swap.

Address space management

The V3D 3.x hardware (compared to VC4) now includes an MMU. It has a single level of page tables for the V3D's 4GB address space to map to AXI bus addresses, thus it could need up to 4MB of physically contiguous memory to store the PTEs.

Because the 4MB of contiguous memory for page tables is precious, and switching between them is expensive, we load all BOs into the same 4GB address space.

To protect clients from each other, we should use the GMP to quickly mask out (at 128kb granularity) what pages are available to each client. This is not yet implemented.

GPU Scheduling

The shared DRM GPU scheduler is used to coordinate submitting jobs to the hardware. Each DRM fd (roughly a client process) gets its own scheduler entity, which will process jobs in order. The GPU scheduler will round-robin between clients to submit the next job.

For simplicity, and in order to keep latency low for interactive jobs when bulk background jobs are queued up, we submit a new job to the HW only when it has completed the last one, instead of filling up the CT[01]Q FIFOs with jobs. Similarly, we use v3d_job_dependency() to manage the dependency between bin and render, instead of having the clients submit jobs using the HW's semaphores to interlock between them.

8.9.2 Interrupts

When we take a bin, render, TFU done, or CSD done interrupt, we need to signal the fence for that job so that the scheduler can queue up the next one and unblock any waiters.

When we take the binner out of memory interrupt, we need to allocate some new memory and pass it to the binner so that the current job can make progress.

8.10 drm/vc4 Broadcom VC4 Graphics Driver

The Broadcom VideoCore 4 (present in the Raspberry Pi) contains a OpenGL ES 2.0-compatible 3D engine called V3D, and a highly configurable display output pipeline that supports HDMI, DSI, DPI, and Composite TV output.

The 3D engine also has an interface for submitting arbitrary compute shader-style jobs using the same shader processor as is used for vertex and fragment shaders in GLES 2.0. However, given that the hardware isn't able to expose any standard interfaces like OpenGL compute shaders or OpenCL, it isn't supported by this driver.

8.10.1 Display Hardware Handling

This section covers everything related to the display hardware including the mode setting infrastructure, plane, sprite and cursor handling and display, output probing and related topics.

Pixel Valve (DRM CRTC)

In VC4, the Pixel Valve is what most closely corresponds to the DRM's concept of a CRTC. The PV generates video timings from the encoder's clock plus its configuration. It pulls scaled pixels from the HVS at that timing, and feeds it to the encoder.

However, the DRM CRTC also collects the configuration of all the DRM planes attached to it. As a result, the CRTC is also responsible for writing the display list for the HVS channel that the CRTC will use.

The 2835 has 3 different pixel valves. pv0 in the audio power domain feeds DSI0 or DPI, while pv1 feeds DS1 or SMI. pv2 in the image domain can feed either HDMI or the SDTV controller. The pixel valve chooses from the CPRMAN clocks (HSM for HDMI, VEC for SDTV, etc.) according to which output type is chosen in the mux.

For power management, the pixel valve's registers are all clocked by the AXI clock, while the timings and FIFOs make use of the output-specific clock. Since the encoders also directly consume the CPRMAN clocks, and know what timings they need, they are the ones that set the clock.

HVS

The Hardware Video Scaler (HVS) is the piece of hardware that does translation, scaling, colorspace conversion, and compositing of pixels stored in framebuffers into a FIFO of pixels going out to the Pixel Valve (CRTC). It operates at the system clock rate (the system audio clock gate, specifically), which is much higher than the pixel clock rate.

There is a single global HVS, with multiple output FIFOs that can be consumed by the PVs. This file just manages the resources for the HVS, while the vc4_crtc.c code actually drives HVS setup for each CRTC.

HVS planes

Each DRM plane is a layer of pixels being scanned out by the HVS.

At atomic modeset check time, we compute the HVS display element state that would be necessary for displaying the plane (giving us a chance to figure out if a plane configuration is invalid), then at atomic flush time the CRTC will ask us to write our element state into the region of the HVS that it has allocated for us.

HDMI encoder

The HDMI core has a state machine and a PHY. On BCM2835, most of the unit operates off of the HSM clock from CPRMAN. It also internally uses the PLLH_PIX clock for the PHY.

HDMI infoframes are kept within a small packet ram, where each packet can be individually enabled for including in a frame.

HDMI audio is implemented entirely within the HDMI IP block. A register in the HDMI encoder takes SPDIF frames from the DMA engine and transfers them over an internal MAI (multi-channel audio interconnect) bus to the encoder side for insertion into the video blank regions.

The driver's HDMI encoder does not yet support power management. The HDMI encoder's power domain and the HSM/pixel clocks are kept continuously running, and only the HDMI logic and packet ram are powered off/on at disable/enable time.

The driver does not yet support CEC control, though the HDMI encoder block has CEC support.

DSI encoder

BCM2835 contains two DSI modules, DSI0 and DSI1. DSI0 is a single-lane DSI controller, while DSI1 is a more modern 4-lane DSI controller.

Most Raspberry Pi boards expose DSI1 as their "DISPLAY" connector, while the compute module brings both DSI0 and DSI1 out.

This driver has been tested for DSI1 video-mode display only currently, with most of the information necessary for DSI0 hopefully present.

DPI encoder

The VC4 DPI hardware supports MIPI DPI type 4 and Nokia ViSSI signals. On BCM2835, these can be routed out to GPIO0-27 with the ALT2 function.

VEC (Composite TV out) encoder

The VEC encoder generates PAL or NTSC composite video output.

TV mode selection is done by an atomic property on the encoder, because a drm_mode_modeinfo is insufficient to distinguish between PAL and PAL-M or NTSC and NTSC-J.

8.10.2 Memory Management and 3D Command Submission

This section covers the GEM implementation in the vc4 driver.

GPU buffer object (BO) management

The VC4 GPU architecture (both scanout and rendering) has direct access to system memory with no MMU in between. To support it, we use the GEM CMA helper functions to allocate contiguous ranges of physical memory for our BOs.

Since the CMA allocator is very slow, we keep a cache of recently freed BOs around so that the kernel's allocation of objects for 3D rendering can return quickly.

V3D binner command list (BCL) validation

Since the VC4 has no IOMMU between it and system memory, a user with access to execute command lists could escalate privilege by overwriting system memory (drawing to it as a framebuffer) or reading system memory it shouldn't (reading it as a vertex buffer or index buffer)

We validate binner command lists to ensure that all accesses are within the bounds of the GEM objects referenced by the submitted job. It explicitly whitelists packets, and looks at the offsets in any address fields to make sure they're contained within the BOs they reference.

Note that because CL validation is already reading the user-submitted CL and writing the validated copy out to the memory that the GPU will actually read, this is also where GEM relocation processing (turning BO references into actual addresses for the GPU to use) happens.

V3D render command list (RCL) generation

In the V3D hardware, render command lists are what load and store tiles of a framebuffer and optionally call out to binner-generated command lists to do the 3D drawing for that tile.

In the VC4 driver, render command list generation is performed by the kernel instead of userspace. We do this because validating a user-submitted command list is hard to get right and has high CPU overhead, while the number of valid configurations for render command lists is actually fairly low.

Shader validator for VC4

Since the VC4 has no IOMMU between it and system memory, a user with access to execute shaders could escalate privilege by overwriting system memory (using the VPM write address register in the general-purpose DMA mode) or reading system memory it shouldn’t (reading it as a texture, uniform data, or direct-addressed TMU lookup).

The shader validator walks over a shader’s BO, ensuring that its accesses are appropriately bounded, and recording where texture accesses are made so that we can do relocations for them in the uniform stream.

Shader BO are immutable for their lifetimes (enforced by not allowing mmaps, GEM prime export, or rendering to from a CL), so this validation is only performed at BO creation time.

V3D Interrupts

We have an interrupt status register (V3D_INTCTL) which reports interrupts, and where writing 1 bits clears those interrupts. There are also a pair of interrupt registers (V3D_INTENA/V3D_INTDIS) where writing a 1 to their bits enables or disables that specific interrupt, and 0s written are ignored (reading either one returns the set of enabled interrupts).

When we take a binning flush done interrupt, we need to submit the next frame for binning and move the finished frame to the render thread.

When we take a render frame interrupt, we need to wake the processes waiting for some frame to be done, and get the next frame submitted ASAP (so the hardware doesn’t sit idle when there’s work to do).

When we take the binner out of memory interrupt, we need to allocate some new memory and pass it to the binner so that the current job can make progress.

8.11 drm/vkms Virtual Kernel Modesetting

VKMS is a software-only model of a KMS driver that is useful for testing and for running X (or similar) on headless machines. VKMS aims to enable a virtual display with no need of a hardware display capability, releasing the GPU in DRM API tests.

8.11.1 TODO

CRC API Improvements

- Optimize CRC computation `compute_crc()` and plane blending `blend()`
- Use the alpha value to blend vaddr_src with vaddr_dst instead of overwriting it in `blend()`.
- Add igt test to check cleared alpha value for XRGB plane format.
- Add igt test to check extreme alpha values i.e. fully opaque and fully transparent (intermediate values are affected by hw-specific rounding modes).

Runtime Configuration

We want to be able to reconfigure vkms instance without having to reload the module. Use/Test-cases:

- Hotplug/hotremove connectors on the fly (to be able to test DP MST handling of compositors).
- Configure planes/crtcs/connectors (we'd need some code to have more than 1 of them first).
- Change output configuration: Plug/unplug screens, change EDID, allow changing the refresh rate.

The currently proposed solution is to expose vkms configuration through configfs. All existing module options should be supported through configfs too.

Add Plane Features

There's lots of plane features we could add support for:

- Real overlay planes, not just cursor.
- Full alpha blending on all planes.
- Rotation, scaling.
- Additional buffer formats, especially YUV formats for video like NV12. Low/high bpp RGB formats would also be interesting.
- Async updates (currently only possible on cursor plane using the legacy cursor api).

For all of these, we also want to review the igt test coverage and make sure all relevant igt testcases work on vkms.

Writeback support

Currently vkms only computes a CRC for each frame. Once we have additional plane features, we could write back the entire composited frame, and expose it as:

- Writeback connector. This is useful for testing compositors if you don't have hardware with writeback support.
- As a v4l device. This is useful for debugging compositors on special vkms configurations, so that developers see what's really going on.

Prime Buffer Sharing

We already have vgem, which is a gem driver for testing rendering, similar to how vkms is for testing the modeset side. Adding buffer sharing support to vkms allows us to test them together, to test synchronization and lots of other features. Also, this allows compositors to test whether they work correctly on SoC chips, where the display and rendering is very often split between 2 drivers.

Output Features

- Variable refresh rate/freesync support. This probably needs prime buffer sharing support, so that we can use vgem fences to simulate rendering in testing. Also needs support to specify the EDID.
- Add support for link status, so that compositors can validate their runtime fallbacks when e.g. a Display Port link goes bad.
- All the hotplug handling describe under "Runtime Configuration".

Atomic Check using eBPF

Atomic drivers have lots of restrictions which are not exposed to userspace in any explicit form through e.g. possible property values. Userspace can only inquiry about these limits through the atomic IOCTL, possibly using the TEST_ONLY flag. Trying to add configurable code for all these limits, to allow compositors to be tested against them, would be rather futile exercise. Instead we could add support for eBPF to validate any kind of atomic state, and implement a library of different restrictions.

This needs a bunch of features (plane compositing, multiple outputs, …) enabled already to make sense.

8.12 drm/bridge/dw-hdmi Synopsys DesignWare HDMI Controller

8.12.1 Synopsys DesignWare HDMI Controller

This section covers everything related to the Synopsys DesignWare HDMI Controller implemented as a DRM bridge.

Supported Input Formats and Encodings

Depending on the Hardware configuration of the Controller IP, it supports a subset of the following input formats and encodings on its internal 48bit bus.

Format Name	Format Code	Encodings
RGB 4:4:4 8bit	MEDIA_BUS_FMT_R	V4L2_YCBCR_ENC_DEFAULT
RGB 4:4:4 10bits	MEDIA_BUS_FMT_R	V4L2_YCBCR_ENC_DEFAULT
RGB 4:4:4 12bits	MEDIA_BUS_FMT_R	V4L2_YCBCR_ENC_DEFAULT
RGB 4:4:4 16bits	MEDIA_BUS_FMT_R	V4L2_YCBCR_ENC_DEFAULT
YCbCr 4:4:4 8bit	MEDIA_BUS_FMT_Y	V4L2_YCBCR_ENC_601 or V4L2_YCBCR_ENC_709 or V4L2_YCBCR_ENC_XV601 or V4L2_YCBCR_ENC_XV709
YCbCr 4:4:4 10bits	MEDIA_BUS_FMT_Y	V4L2_YCBCR_ENC_601 or V4L2_YCBCR_ENC_709 or V4L2_YCBCR_ENC_XV601 or V4L2_YCBCR_ENC_XV709
YCbCr 4:4:4 12bits	MEDIA_BUS_FMT_Y	V4L2_YCBCR_ENC_601 or V4L2_YCBCR_ENC_709 or V4L2_YCBCR_ENC_XV601 or V4L2_YCBCR_ENC_XV709
YCbCr 4:4:4 16bits	MEDIA_BUS_FMT_Y	V4L2_YCBCR_ENC_601 or V4L2_YCBCR_ENC_709 or V4L2_YCBCR_ENC_XV601 or V4L2_YCBCR_ENC_XV709
YCbCr 4:2:2 8bit	MEDIA_BUS_FMT_U	V4L2_YCBCR_ENC_601 or V4L2_YCBCR_ENC_709
YCbCr 4:2:2 10bits	MEDIA_BUS_FMT_U	V4L2_YCBCR_ENC_601 or V4L2_YCBCR_ENC_709
YCbCr 4:2:2 12bits	MEDIA_BUS_FMT_U	V4L2_YCBCR_ENC_601 or V4L2_YCBCR_ENC_709
YCbCr 4:2:0 8bit	MEDIA_BUS_FMT_U	V4L2_YCBCR_ENC_601 or V4L2_YCBCR_ENC_709
YCbCr 4:2:0 10bits	MEDIA_BUS_FMT_U	V4L2_YCBCR_ENC_601 or V4L2_YCBCR_ENC_709
YCbCr 4:2:0 12bits	MEDIA_BUS_FMT_U	V4L2_YCBCR_ENC_601 or V4L2_YCBCR_ENC_709
YCbCr 4:2:0 16bits	MEDIA_BUS_FMT_U	V4L2_YCBCR_ENC_601 or V4L2_YCBCR_ENC_709

8.13 drm/xen-front Xen para-virtualized frontend driver

This frontend driver implements Xen para-virtualized display according to the display protocol described at include/xen/interface/io/displif.h

8.13.1 Driver modes of operation in terms of display buffers used

Depending on the requirements for the para-virtualized environment, namely requirements dictated by the accompanying DRM/(v)GPU drivers running in both host and guest environments, display buffers can be allocated by either frontend driver or backend.

Buffers allocated by the frontend driver

In this mode of operation driver allocates buffers from system memory.

Note! If used with accompanying DRM/(v)GPU drivers this mode of operation may require IOMMU support on the platform, so accompanying DRM/vGPU hardware can still reach display buffer memory while importing PRIME buffers from the frontend driver.

Buffers allocated by the backend

This mode of operation is run-time configured via guest domain configuration through XenStore entries.

For systems which do not provide IOMMU support, but having specific requirements for display buffers it is possible to allocate such buffers at backend side and share those with the frontend. For example, if host domain is 1:1 mapped and has DRM/GPU hardware expecting physically contiguous memory, this allows implementing zero-copying use-cases.

Note, while using this scenario the following should be considered:

1. If guest domain dies then pages/grants received from the backend cannot be claimed back
2. Misbehaving guest may send too many requests to the backend exhausting its grant references and memory (consider this from security POV)

8.13.2 Driver limitations

1. Only primary plane without additional properties is supported.
2. Only one video mode per connector supported which is configured via XenStore.
3. All CRTCs operate at fixed frequency of 60Hz.

8.14 Arm Framebuffer Compression (AFBC)

AFBC is a proprietary lossless image compression protocol and format. It provides fine-grained random access and minimizes the amount of data transferred between IP blocks.

AFBC can be enabled on drivers which support it via use of the AFBC format modifiers defined in drm_fourcc.h. See DRM_FORMAT_MOD_ARM_AFBC(*).

All users of the AFBC modifiers must follow the usage guidelines laid out in this document, to ensure compatibility across different AFBC producers and consumers.

8.14.1 Components and Ordering

AFBC streams can contain several components - where a component corresponds to a color channel (i.e. R, G, B, X, A, Y, Cb, Cr). The assignment of input/output color channels must be consistent between the encoder and the decoder for correct operation, otherwise the consumer will interpret the decoded data incorrectly.

Furthermore, when the lossless colorspace transform is used (AFBC_FORMAT_MOD_YTR, which should be enabled for RGB buffers for maximum compression efficiency), the component order must be:

- Component 0: R
- Component 1: G
- Component 2: B

The component ordering is communicated via the fourcc code in the fourcc:modifier pair. In general, component '0' is considered to reside in the least-significant bits of the corresponding linear format. For example, COMP(bits):

- DRM_FORMAT_ABGR8888
  - Component 0: R(8)
  - Component 1: G(8)
  - Component 2: B(8)
  - Component 3: A(8)
- DRM_FORMAT_BGR888
  - Component 0: R(8)
  - Component 1: G(8)
  - Component 2: B(8)
- DRM_FORMAT_YUYV
  - Component 0: Y(8)
  - Component 1: Cb(8, 2x1 subsampled)
  - Component 2: Cr(8, 2x1 subsampled)

In AFBC, 'X' components are not treated any differently from any other component. Therefore, an AFBC buffer with fourcc DRM_FORMAT_XBGR8888 encodes with 4 components, like so:

- DRM_FORMAT_XBGR8888
  - Component 0: R(8)
  - Component 1: G(8)
  - Component 2: B(8)
  - Component 3: X(8)

Please note, however, that the inclusion of a "wasted" 'X' channel is bad for compression efficiency, and so it's recommended to avoid formats containing 'X' bits. If a fourth component is required/expected by the encoder/decoder, then it is recommended to instead use an equivalent format with alpha, setting all alpha bits to '1'. If there is no requirement for a fourth component, then a format which doesn't include alpha can be used, e.g. DRM_FORMAT_BGR888.

8.14.2 Number of Planes

Formats which are typically multi-planar in linear layouts (e.g. YUV 420), can be encoded into one, or multiple, AFBC planes. As with component order, the encoder and decoder must agree about the number of planes in order to correctly decode the buffer. The fourcc code is used to determine the number of encoded planes in an AFBC buffer, matching the number of planes for the linear (unmodified) format. Within each plane, the component ordering also follows the fourcc code:

For example:

- DRM_FORMAT_YUYV: nplanes = 1
  - Plane 0:
    - Component 0: Y(8)
    - Component 1: Cb(8, 2x1 subsampled)
    - Component 2: Cr(8, 2x1 subsampled)
- DRM_FORMAT_NV12: nplanes = 2
  - Plane 0:
    - Component 0: Y(8)
  - Plane 1:
    - Component 0: Cb(8, 2x1 subsampled)
    - Component 1: Cr(8, 2x1 subsampled)

8.14.3 Cross-device interoperability

For maximum compatibility across devices, the table below defines canonical formats for use between AFBC-enabled devices. Formats which are listed here must be used exactly as specified when using the AFBC modifiers. Formats which are not listed should be avoided.

Table 1: AFBC formats

Fourcc code	Description	Planes/Components
DRM_FORMAT_ABGR210	10-bit per component RGB, with 2-bit alpha	**Plane 0: 4 components** • Component 0: R(10) • Component 1: G(10) • Component 2: B(10) • Component 3: A(2)
DRM_FORMAT_ABGR888	8-bit per component RGB, with 8-bit alpha	**Plane 0: 4 components** • Component 0: R(8) • Component 1: G(8) • Component 2: B(8) • Component 3: A(8)
DRM_FORMAT_BGR888	8-bit per component RGB	**Plane 0: 3 components** • Component 0: R(8) • Component 1: G(8) • Component 2: B(8)
DRM_FORMAT_BGR565	5/6-bit per component RGB	**Plane 0: 3 components** • Component 0: R(5) • Component 1: G(6) • Component 2: B(5)
DRM_FORMAT_ABGR155	5-bit per component RGB, with 1-bit alpha	**Plane 0: 4 components** • Component 0: R(5) • Component 1: G(5) • Component 2: B(5) • Component 3: A(1)

8.15 drm/komeda Arm display driver

The drm/komeda driver supports the Arm display processor D71 and later products, this document gives a brief overview of driver design: how it works and why design it like that.

8.15.1 Overview of D71 like display IPs

From D71, Arm display IP begins to adopt a flexible and modularized architecture. A display pipeline is made up of multiple individual and functional pipeline stages called components, and every component has some specific capabilities that can give the flowed pipeline pixel data a particular processing.

Typical D71 components:

Layer

Layer is the first pipeline stage, which prepares the pixel data for the next stage. It fetches the pixel from memory, decodes it if it' s AFBC, rotates the source image, unpacks or converts YUV pixels to the device internal RGB pixels, then adjusts the color_space of pixels if needed.

Scaler

As its name suggests, scaler takes responsibility for scaling, and D71 also supports image enhancements by scaler. The usage of scaler is very flexible and can be connected to layer output for layer scaling, or connected to compositor and scale the whole display frame and then feed the output data into wb_layer which will then write it into memory.

Compositor (compiz)

Compositor blends multiple layers or pixel data flows into one single display frame. its output frame can be fed into post image processor for showing it on the monitor or fed into wb_layer and written to memory at the same time. user can also insert a scaler between compositor and wb_layer to down scale the display frame first and then write to memory.

Writeback Layer (wb_layer)

Writeback layer does the opposite things of Layer, which connects to compiz and writes the composition result to memory.

Post image processor (improc)

Post image processor adjusts frame data like gamma and color space to fit the requirements of the monitor.

Timing controller (timing_ctrlr)

Final stage of display pipeline, Timing controller is not for the pixel handling, but only for controlling the display timing.

Merger

D71 scaler mostly only has the half horizontal input/output capabilities compared with Layer, like if Layer supports 4K input size, the scaler only can support 2K input/output in the same time. To achieve the ful frame scaling, D71 introduces Layer Split, which splits the whole image to two half parts and feeds them to two Layers A and B, and does the scaling independently. After scaling the result need to be fed to merger to merge two part images together, and then output merged result to compiz.

Splitter

Similar to Layer Split, but Splitter is used for writeback, which splits the compiz result to two parts and then feed them to two scalers.

8.15.2 Possible D71 Pipeline usage

Benefitting from the modularized architecture, D71 pipelines can be easily adjusted to fit different usages. And D71 has two pipelines, which support two types of working mode:

- Dual display mode Two pipelines work independently and separately to drive two display outputs.
- Single display mode Two pipelines work together to drive only one display output.

  On this mode, pipeline_B doesn't work indenpendently, but outputs its composition result into pipeline_A, and its pixel timing also derived from pipeline_A.timing_ctrlr. The pipeline_B works just like a "slave" of pipeline_A(master)

Single pipeline data flow

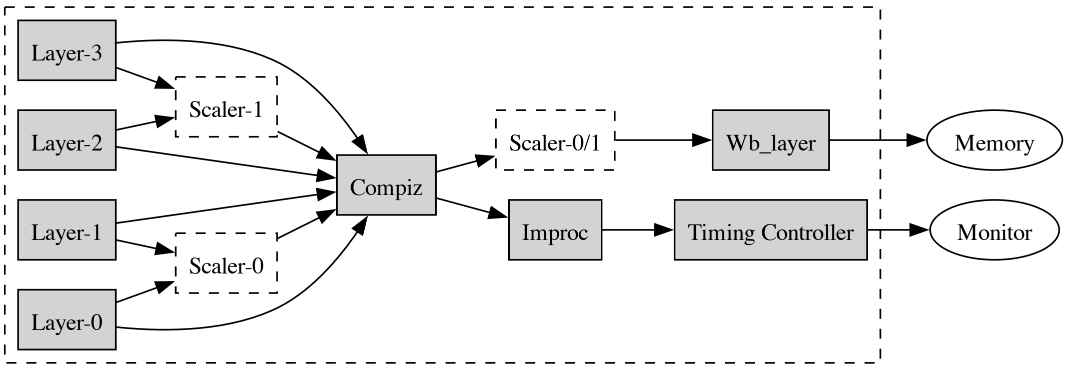

Fig. 1: Single pipeline data flow

Dual pipeline with Slave enabled

Sub-pipelines for input and output

A complete display pipeline can be easily divided into three sub-pipelines according to the in/out usage.

Layer(input) pipeline

Writeback(output) pipeline

Display output pipeline

In the following section we' ll see these three sub-pipelines will be handled by KMS-plane/wb_conn/crtc respectively.

8.15.3 Komeda Resource abstraction

struct komeda_pipeline/component

To fully utilize and easily access/configure the HW, the driver side also uses a similar architecture: Pipeline/Component to describe the HW features and capabilities, and a specific component includes two parts:

- Data flow controlling.
- Specific component capabilities and features.

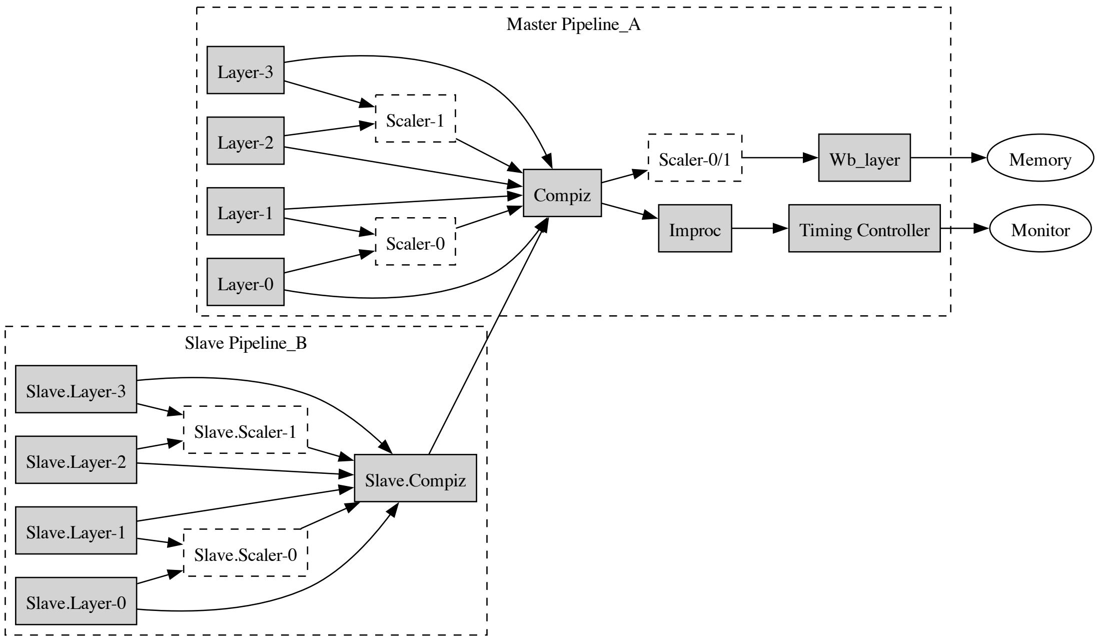

Fig. 2: Slave pipeline enabled data flow

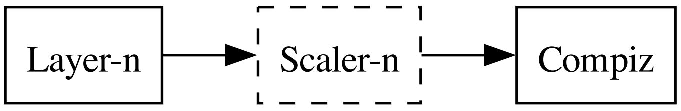

Fig. 3: Layer (input) data flow

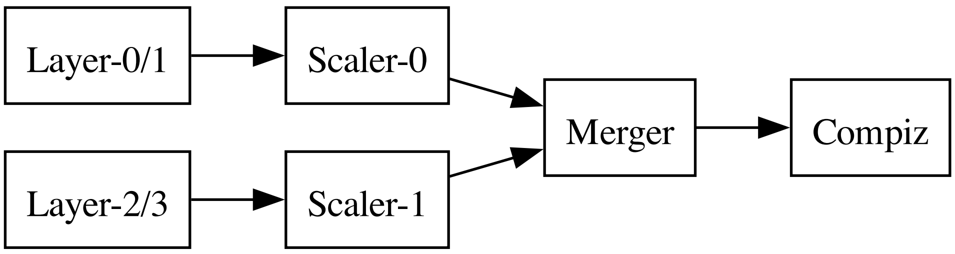

Fig. 4: Layer Split pipeline

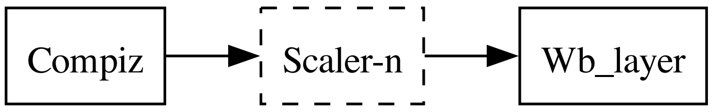

Fig. 5: Writeback(output) data flow

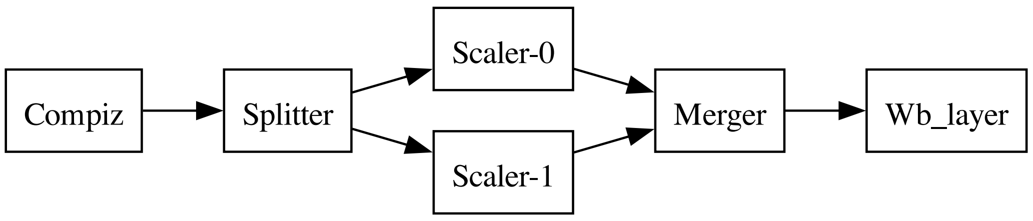

Fig. 6: Writeback(output) Split data flow

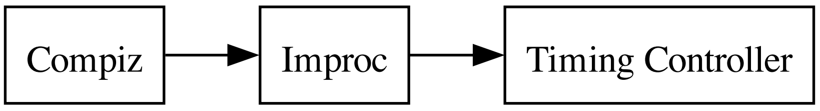

Fig. 7: display output data flow

So the driver defines a common header *struct komeda_component* to describe the data flow control and all specific components are a subclass of this base structure.

struct **komeda_component**

Definition

```
struct komeda_component {
  struct drm_private_obj obj;
  struct komeda_pipeline *pipeline;
  char name[32];
  u32 __iomem *reg;
  u32 id;
  u32 hw_id;
  u8 max_active_inputs;
  u8 max_active_outputs;
  u32 supported_inputs;
  u32 supported_outputs;
  const struct komeda_component_funcs *funcs;
};
```

Members

obj
treat component as private obj

pipeline
the komeda pipeline this component belongs to

name
component name

reg
component register base, which is initialized by chip and used by chip only

id
component id

hw_id
component hw id, which is initialized by chip and used by chip only

max_active_inputs
max_active_outputs:

maximum number of inputs/outputs that can be active at the same time Note: the number isn' t the bit number of **supported_inputs** or **supported_outputs**, but may be less than it, since component may not support enabling all **supported_inputs**/outputs at the same time.

max_active_outputs
maximum number of outputs

supported_inputs
supported_outputs:

bitmask of BIT(component->id) for the supported inputs/outputs, describes the possibilities of how a component is linked into a pipeline.

supported_outputs
bitmask of supported output componenet ids

funcs
chip functions to access HW

Description

struct komeda_component describe the data flow capabilities for how to link a component into the display pipeline. all specified components are subclass of this structure.

struct **komeda_component_output**

Definition

```
struct komeda_component_output {
  struct komeda_component *component;
  u8 output_port;
};
```

Members

component
indicate which component the data comes from

output_port
the output port of the *komeda_component_output.component*

Description

a component has multiple outputs, if want to know where the data comes from, only know the component is not enough, we still need to know its output port

struct **komeda_component_state**

Definition

```
struct komeda_component_state {
  struct drm_private_state obj;
  struct komeda_component *component;
  union {
    struct drm_crtc *crtc;
    struct drm_plane *plane;
    struct drm_connector *wb_conn;
    void *binding_user;
  };
  u16 active_inputs;
  u16 changed_active_inputs;
  u16 affected_inputs;
  struct komeda_component_output inputs[KOMEDA_COMPONENT_N_INPUTS];
};
```

Members

obj
tracking component_state by drm_atomic_state

component
: backpointer to the component

{unnamed_union}
: anonymous

crtc
: backpointer for user crtc

plane
: backpointer for user plane

wb_conn
: backpointer for user wb_connector

binding_user
: currently bound user, the user can be **crtc**, **plane** or **wb_conn**, which is valid decided by **component** and **inputs**

  - Layer: its user always is plane.
  - compiz/improc/timing_ctrlr: the user is crtc.
  - wb_layer: wb_conn;
  - scaler: plane when input is layer, wb_conn if input is compiz.

active_inputs
: active_inputs is bitmask of **inputs** index

  - active_inputs = changed_active_inputs | unchanged_active_inputs
  - affected_inputs = old->active_inputs | new->active_inputs;
  - disabling_inputs = affected_inputs ^ active_inputs;
  - changed_inputs = disabling_inputs | changed_active_inputs;

  NOTE: changed_inputs doesn’ t include all active_input but only **changed_active_inputs**, and this bitmask can be used in chip level for dirty update.

changed_active_inputs
: bitmask of the changed **active_inputs**

affected_inputs
: bitmask for affected **inputs**

inputs
: the specific inputs[i] only valid on BIT(i) has been set in **active_inputs**, if not the inputs[i] is undefined.

Description

component_state is the data flow configuration of the component, and it’ s the superclass of all specific component_state like **komeda_layer_state**, **komeda_scaler_state**

struct **komeda_pipeline**

Definition

```
struct komeda_pipeline {
  struct drm_private_obj obj;
  struct komeda_dev *mdev;
  struct clk *pxlclk;
  int id;
  u32 avail_comps;
  u32 standalone_disabled_comps;
  int n_layers;
  struct komeda_layer *layers[KOMEDA_PIPELINE_MAX_LAYERS];
  int n_scalers;
  struct komeda_scaler *scalers[KOMEDA_PIPELINE_MAX_SCALERS];
  struct komeda_compiz *compiz;
  struct komeda_splitter *splitter;
  struct komeda_merger *merger;
  struct komeda_layer  *wb_layer;
  struct komeda_improc *improc;
  struct komeda_timing_ctrlr *ctrlr;
  const struct komeda_pipeline_funcs *funcs;
  struct device_node *of_node;
  struct device_node *of_output_port;
  struct device_node *of_output_links[2];
  bool dual_link;
};
```

Members

`obj`
    link pipeline as private obj of drm_atomic_state

`mdev`
    the parent komeda_dev

`pxlclk`
    pixel clock

`id`
    pipeline id

`avail_comps`
    available components mask of pipeline

`standalone_disabled_comps`
    When disable the pipeline, some components can not be disabled together with others, but need a sparated and standalone disable. The standalone_disabled_comps are the components which need to be disabled standalone, and this concept also introduce concept of two phase. phase 1: for disabling the common components. phase 2: for disabling the standalong_disabled_comps.

`n_layers`
    the number of layer on **layers**

`layers`
    the pipeline layers

n_scalers
  the number of scaler on **scalers**

scalers
  the pipeline scalers

compiz
  compositor

splitter
  for split the compiz output to two half data flows

merger
  merger

wb_layer
  writeback layer

improc
  post image processor

ctrlr
  timing controller

funcs
  chip private pipeline functions

of_node
  pipeline dt node

of_output_port
  pipeline output port

of_output_links
  output connector device nodes

dual_link
  true if of_output_links[0] and [1] are both valid

Description

Represent a complete display pipeline and hold all functional components.

struct **komeda_pipeline_state**

Definition

```
struct komeda_pipeline_state {
  struct drm_private_state obj;
  struct komeda_pipeline *pipe;
  struct drm_crtc *crtc;
  u32 active_comps;
};
```

Members

obj
  tracking pipeline_state by drm_atomic_state

pipe
backpointer to the pipeline

crtc
currently bound crtc

active_comps
bitmask - BIT(component->id) of active components

NOTE

Unlike the pipeline, pipeline_state doesn’ t gather any component_state into it. It because all component will be managed by drm_atomic_state.

8.15.4 Resource discovery and initialization

Pipeline and component are used to describe how to handle the pixel data. We still need a @*struct komeda_dev* to describe the whole view of the device, and the control-abilites of device.

We have &komeda_dev, &komeda_pipeline, &komeda_component. Now fill devices with pipelines. Since komeda is not for D71 only but also intended for later products, of course we’ d better share as much as possible between different products. To achieve this, split the komeda device into two layers: CORE and CHIP.

- CORE: for common features and capabilities handling.
- CHIP: for register programing and HW specific feature (limitation) handling.

CORE can access CHIP by three chip function structures:

- *struct komeda_dev_funcs*
- struct komeda_pipeline_funcs
- struct komeda_component_funcs

struct **komeda_dev_funcs**

Definition

```
struct komeda_dev_funcs {
  void (*init_format_table)(struct komeda_dev *mdev);
  int (*enum_resources)(struct komeda_dev *mdev);
  void (*cleanup)(struct komeda_dev *mdev);
  int (*connect_iommu)(struct komeda_dev *mdev);
  int (*disconnect_iommu)(struct komeda_dev *mdev);
  irqreturn_t (*irq_handler)(struct komeda_dev *mdev, struct komeda_
→events *events);
  int (*enable_irq)(struct komeda_dev *mdev);
  int (*disable_irq)(struct komeda_dev *mdev);
  void (*on_off_vblank)(struct komeda_dev *mdev, int master_pipe,␣
→bool on);
  void (*dump_register)(struct komeda_dev *mdev, struct seq_file␣
→*seq);
  int (*change_opmode)(struct komeda_dev *mdev, int new_mode);
```

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```
  void (*flush)(struct komeda_dev *mdev, int master_pipe, u32␣
↪active_pipes);
};
```

Members

init_format_table
: initialize *komeda_dev->format_table*, this function should be called before the enum_resource

enum_resources
: for CHIP to report or add pipeline and component resources to CORE

cleanup
: call to chip to cleanup komeda_dev->chip data

connect_iommu
: Optional, connect to external iommu

disconnect_iommu
: Optional, disconnect to external iommu

irq_handler
: for CORE to get the HW event from the CHIP when interrupt happened.

enable_irq
: enable irq

disable_irq
: disable irq

on_off_vblank
: notify HW to on/off vblank

dump_register
: Optional, dump registers to seq_file

change_opmode
: Notify HW to switch to a new display operation mode.

flush
: Notify the HW to flush or kickoff the update

Description

Supplied by chip level and returned by the chip entry function xxx_identify,

struct **komeda_dev**

Definition

```
struct komeda_dev {
  struct device *dev;
  u32 __iomem   *reg_base;
  struct device_dma_parameters dma_parms;
  struct komeda_chip_info chip;
  struct komeda_format_caps_table fmt_tbl;
```

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```
  struct clk *aclk;
  int irq;
  struct mutex lock;
  u32 dpmode;
  int n_pipelines;
  struct komeda_pipeline *pipelines[KOMEDA_MAX_PIPELINES];
  const struct komeda_dev_funcs *funcs;
  void *chip_data;
  struct iommu_domain *iommu;
  struct dentry *debugfs_root;
  u16 err_verbosity;
#define KOMEDA_DEV_PRINT_ERR_EVENTS BIT(0);
#define KOMEDA_DEV_PRINT_WARN_EVENTS BIT(1);
#define KOMEDA_DEV_PRINT_INFO_EVENTS BIT(2);
#define KOMEDA_DEV_PRINT_DUMP_STATE_ON_EVENT BIT(8);
#define KOMEDA_DEV_PRINT_DISABLE_RATELIMIT BIT(12);
};
```

Members

dev
  the base device structure

reg_base
  the base address of komeda io space

dma_parms
  the dma parameters of komeda

chip
  the basic chip information

fmt_tbl
  initialized by *komeda_dev_funcs->init_format_table*

aclk
  HW main engine clk

irq
  irq number

lock
  used to protect dpmode

dpmode
  current display mode

n_pipelines
  the number of pipe in **pipelines**

pipelines
  the komeda pipelines

funcs
  chip funcs to access to HW

chip_data
chip data will be added by *komeda_dev_funcs.enum_resources()* and destroyed by *komeda_dev_funcs.cleanup()*

iommu
iommu domain

debugfs_root
root directory of komeda debugfs

err_verbosity
bitmask for how much extra info to print on error

See KOMEDA_DEV_* macros for details. Low byte contains the debug level categories, the high byte contains extra debug options.

Description

Pipeline and component are used to describe how to handle the pixel data. komeda_device is for describing the whole view of the device, and the controlabilites of device.

8.15.5 Format handling

struct **komeda_format_caps**

Definition

```
struct komeda_format_caps {
  u32 hw_id;
  u32 fourcc;
  u32 supported_layer_types;
  u32 supported_rots;
  u32 supported_afbc_layouts;
  u64 supported_afbc_features;
};
```

Members

hw_id
hw format id, hw specific value.

fourcc
drm fourcc format.

supported_layer_types
indicate which layer supports this format

supported_rots
allowed rotations for this format

supported_afbc_layouts
supported afbc layerout

supported_afbc_features
supported afbc features

Description

komeda_format_caps is for describing ARM display specific features and limitations for a specific format, and format_caps will be linked into `komeda_framebuffer` like a extension of *drm_format_info*.

NOTE

one fourcc may has two different format_caps items for fourcc and fourcc+modifier

struct **komeda_format_caps_table**

format_caps mananger

Definition

```
struct komeda_format_caps_table {
  u32 n_formats;
  const struct komeda_format_caps *format_caps;
  bool (*format_mod_supported)(const struct komeda_format_caps␣
↪*caps, u32 layer_type, u64 modifier, u32 rot);
};
```

Members

n_formats
the size of format_caps list.

format_caps
format_caps list.

format_mod_supported
Optional. Some HW may have special requirements or limitations which can not be described by format_caps, this func supply HW the ability to do the further HW specific check.

struct **komeda_fb**

Entending drm_framebuffer with komeda attribute

Definition

```
struct komeda_fb {
  struct drm_framebuffer base;
  const struct komeda_format_caps *format_caps;
  bool is_va;
  u32 aligned_w;
  u32 aligned_h;
  u32 afbc_size;
  u32 offset_payload;
};
```

Members

base
drm_framebuffer

format_caps
    extends drm_format_info for komeda specific information

is_va
    if smmu is enabled, it will be true

aligned_w
    aligned frame buffer width

aligned_h
    aligned frame buffer height

afbc_size
    minimum size of afbc

offset_payload
    start of afbc body buffer

8.15.6 Attach komeda_dev to DRM-KMS

Komeda abstracts resources by pipeline/component, but DRM-KMS uses crtc/plane/connector. One KMS-obj cannot represent only one single component, since the requirements of a single KMS object cannot simply be achieved by a single component, usually that needs multiple components to fit the requirement. Like set mode, gamma, ctm for KMS all target on CRTC-obj, but komeda needs compiz, improc and timing_ctrlr to work together to fit these requirements. And a KMS-Plane may require multiple komeda resources: layer/scaler/compiz.

So, one KMS-Obj represents a sub-pipeline of komeda resources.

- Plane: *Layer(input) pipeline*
- Wb_connector: *Writeback(output) pipeline*
- Crtc: *Display output pipeline*

So, for komeda, we treat KMS crtc/plane/connector as users of pipeline and component, and at any one time a pipeline/component only can be used by one user. And pipeline/component will be treated as private object of DRM-KMS; the state will be managed by drm_atomic_state as well.

How to map plane to Layer(input) pipeline

Komeda has multiple Layer input pipelines, see: - *Single pipeline data flow* - *Dual pipeline with Slave enabled*

The easiest way is binding a plane to a fixed Layer pipeline, but consider the komeda capabilities:

- Layer Split, See *Layer(input) pipeline*

  Layer_Split is quite complicated feature, which splits a big image into two parts and handles it by two layers and two scalers individually. But it imports an edge problem or effect in the middle of the image after the split. To avoid such a problem, it needs a complicated Split calculation and some special configurations to the layer and scaler. We' d better hide such HW related complexity to user mode.

- Slave pipeline, See *Dual pipeline with Slave enabled*

  Since the compiz component doesn' t output alpha value, the slave pipeline only can be used for bottom layers composition. The komeda driver wants to hide this limitation to the user. The way to do this is to pick a suitable Layer according to plane_state->zpos.

So for komeda, the KMS-plane doesn' t represent a fixed komeda layer pipeline, but multiple Layers with same capabilities. Komeda will select one or more Layers to fit the requirement of one KMS-plane.

Make component/pipeline to be drm_private_obj

Add *drm_private_obj* to *komeda_component*, *komeda_pipeline*

```
struct komeda_component {
    struct drm_private_obj obj;
    ...
}

struct komeda_pipeline {
    struct drm_private_obj obj;
    ...
}
```

Tracking component_state/pipeline_state by drm_atomic_state

Add *drm_private_state* and user to *komeda_component_state*, *komeda_pipeline_state*

```
struct komeda_component_state {
    struct drm_private_state obj;
    void *binding_user;
    ...
}

struct komeda_pipeline_state {
    struct drm_private_state obj;
    struct drm_crtc *crtc;
    ...
}
```

komeda component validation

Komeda has multiple types of components, but the process of validation are similar, usually including the following steps:

```
int komeda_xxxx_validate(struct komeda_component_xxx xxx_comp,
            struct komeda_component_output *input_dflow,
            struct drm_plane/crtc/connector *user,
            struct drm_plane/crtc/connector_state, *user_state)
{
     setup 1: check if component is needed, like the scaler is␣
↪optional depending
              on the user_state; if unneeded, just return, and the␣
↪caller will
              put the data flow into next stage.
     Setup 2: check user_state with component features and␣
↪capabilities to see
              if requirements can be met; if not, return fail.
     Setup 3: get component_state from drm_atomic_state, and try␣
↪set to set
              user to component; fail if component has been␣
↪assigned to another
              user already.
     Setup 3: configure the component_state, like set its input␣
↪component,
              convert user_state to component specific state.
     Setup 4: adjust the input_dflow and prepare it for the next␣
↪stage.
}
```

komeda_kms Abstraction

struct **komeda_plane**

komeda instance of drm_plane

Definition

```
struct komeda_plane {
  struct drm_plane base;
  struct komeda_layer *layer;
};
```

Members

base

drm_plane

layer

represents available layer input pipelines for this plane.

NOTE: the layer is not for a specific Layer, but indicate a group of Layers with same capabilities.

struct **komeda_plane_state**

Definition

```
struct komeda_plane_state {
  struct drm_plane_state base;
  struct list_head zlist_node;
  u8 layer_split : 1;
};
```

Members

base
  drm_plane_state

zlist_node
  zorder list node

layer_split
  on/off layer_split

Description

The plane_state can be split into two data flow (left/right) and handled by two layers *komeda_plane.layer* and *komeda_plane.layer*.right

struct **komeda_wb_connector**

Definition

```
struct komeda_wb_connector {
  struct drm_writeback_connector base;
  struct komeda_layer *wb_layer;
};
```

Members

base
  drm_writeback_connector

wb_layer
  represents associated writeback pipeline of komeda

struct **komeda_crtc**

Definition

```
struct komeda_crtc {
  struct drm_crtc base;
  struct komeda_pipeline *master;
  struct komeda_pipeline *slave;
  u32 slave_planes;
  struct komeda_wb_connector *wb_conn;
  struct completion *disable_done;
};
```

Members

base
  drm_crtc

master
  only master has display output

slave
  optional

  Doesn’t have its own display output, the handled data flow will merge into the master.

slave_planes
  komeda slave planes mask

wb_conn
  komeda write back connector

disable_done
  this flip_done is for tracing the disable

struct **komeda_crtc_state**

Definition

```
struct komeda_crtc_state {
  struct drm_crtc_state base;
  u32 affected_pipes;
  u32 active_pipes;
  u64 clock_ratio;
  u32 max_slave_zorder;
};
```

Members

base
  drm_crtc_state

affected_pipes
  the affected pipelines in once display instance

active_pipes
  the active pipelines in once display instance

clock_ratio
  ratio of (aclk << 32)/pxlclk

max_slave_zorder
  the maximum of slave zorder

komde_kms Functions

int **komeda_crtc_atomic_check**(struct *drm_crtc* *crtc, struct *drm_crtc_state* *state)

build display output data flow

Parameters

struct drm_crtc *crtc
DRM crtc

struct drm_crtc_state *state
the crtc state object

Description

crtc_atomic_check is the final check stage, so beside build a display data pipeline according to the crtc_state, but still needs to release or disable the unclaimed pipeline resources.

Return

Zero for success or -errno

int **komeda_plane_atomic_check**(struct *drm_plane* *plane, struct *drm_plane_state* *state)

build input data flow

Parameters

struct drm_plane *plane
DRM plane

struct drm_plane_state *state
the plane state object

Return

Zero for success or -errno

8.15.7 Build komeda to be a Linux module driver

Now we have two level devices:

- komeda_dev: describes the real display hardware.
- komeda_kms_dev: attachs or connects komeda_dev to DRM-KMS.

All komeda operations are supplied or operated by komeda_dev or komeda_kms_dev, the module driver is only a simple wrapper to pass the Linux command (probe/remove/pm) into komeda_dev or komeda_kms_dev.

CHAPTER

NINE

BACKLIGHT SUPPORT

The backlight core supports implementing backlight drivers.

A backlight driver registers a driver using *devm_backlight_device_register()*. The properties of the backlight driver such as type and max_brightness must be specified. When the core detect changes in for example brightness or power state the update_status() operation is called. The backlight driver shall implement this operation and use it to adjust backlight.

Several sysfs attributes are provided by the backlight core:

```
- brightness         R/W, set the requested brightness level
- actual_brightness  RO, the brightness level used by the HW
- max_brightness     RO, the maximum  brightness level supported
```

See Documentation/ABI/stable/sysfs-class-backlight for the full list.

The backlight can be adjusted using the sysfs interface, and the backlight driver may also support adjusting backlight using a hot-key or some other platform or firmware specific way.

The driver must implement the get_brightness() operation if the HW do not support all the levels that can be specified in brightness, thus providing user-space access to the actual level via the actual_brightness attribute.

When the backlight changes this is reported to user-space using an uevent connected to the actual_brightness attribute. When brightness is set by platform specific means, for example a hot-key to adjust backlight, the driver must notify the backlight core that brightness has changed using *backlight_force_update()*.

The backlight driver core receives notifications from fbdev and if the event is FB_EVENT_BLANK and if the value of blank, from the FBIOBLANK ioctrl, results in a change in the backlight state the update_status() operation is called.

enum **backlight_update_reason**

what method was used to update backlight

Constants

BACKLIGHT_UPDATE_HOTKEY
The backlight was updated using a hot-key.

BACKLIGHT_UPDATE_SYSFS
The backlight was updated using sysfs.

Description

A driver indicates the method (reason) used for updating the backlight when calling *backlight_force_update()*.

enum **backlight_type**

the type of backlight control

Constants

BACKLIGHT_RAW
The backlight is controlled using hardware registers.

BACKLIGHT_PLATFORM
The backlight is controlled using a platform-specific interface.

BACKLIGHT_FIRMWARE
The backlight is controlled using a standard firmware interface.

BACKLIGHT_TYPE_MAX
Number of entries.

Description

The type of interface used to control the backlight.

enum **backlight_notification**

the type of notification

Constants

BACKLIGHT_REGISTERED
The backlight device is registered.

BACKLIGHT_UNREGISTERED
The backlight revice is unregistered.

Description

The notifications that is used for notification sent to the receiver that registered notifications using *backlight_register_notifier()*.

struct **backlight_ops**

backlight operations

Definition

```
struct backlight_ops {
  unsigned int options;
#define BL_CORE_SUSPENDRESUME   (1 << 0);
  int (*update_status)(struct backlight_device *);
  int (*get_brightness)(struct backlight_device *);
  int (*check_fb)(struct backlight_device *bd, struct fb_info␣
↪*info);
};
```

Members

options
Configure how operations are called from the core.

The options parameter is used to adjust the behaviour of the core. Set BL_CORE_SUSPENDRESUME to get the update_status() operation called upon suspend and resume.

update_status
Operation called when properties have changed.

Notify the backlight driver some property has changed. The update_status operation is protected by the update_lock.

The backlight driver is expected to use *backlight_is_blank()* to check if the display is blanked and set brightness accordingly. update_status() is called when any of the properties has changed.

RETURNS:

0 on success, negative error code if any failure occurred.

get_brightness
Return the current backlight brightness.

The driver may implement this as a readback from the HW. This operation is optional and if not present then the current brightness property value is used.

RETURNS:

A brightness value which is 0 or a positive number. On failure a negative error code is returned.

check_fb
Check the framebuffer device.

Check if given framebuffer device is the one bound to this backlight. This operation is optional and if not implemented it is assumed that the fbdev is always the one bound to the backlight.

RETURNS:

If info is NULL or the info matches the fbdev bound to the backlight return true. If info does not match the fbdev bound to the backlight return false.

Description

The backlight operations are specified when the backlight device is registered.

struct **backlight_properties**
backlight properties

Definition

```
struct backlight_properties {
  int brightness;
  int max_brightness;
  int power;
  int fb_blank;
  enum backlight_type type;
  unsigned int state;
#define BL_CORE_SUSPENDED       (1 << 0)        ;
```

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```
#define BL_CORE_FBBLANK          (1 << 1)        ;
  enum backlight_scale scale;
};
```

Members

`brightness`
The current brightness requested by the user.

The backlight core makes sure the range is (0 to max_brightness) when the brightness is set via the sysfs attribute: /sys/class/backlight/<backlight>/brightness.

This value can be set in the backlight_properties passed to *`devm_backlight_device_register()`* to set a default brightness value.

`max_brightness`
The maximum brightness value.

This value must be set in the backlight_properties passed to *`devm_backlight_device_register()`* and shall not be modified by the driver after registration.

`power`
The current power mode.

User space can configure the power mode using the sysfs attribute: /sys/class/backlight/<backlight>/bl_power When the power property is updated update_status() is called.

The possible values are: (0: full on, 1 to 3: power saving modes; 4: full off), see FB_BLANK_XXX.

When the backlight device is enabled **power** is set to FB_BLANK_UNBLANK. When the backlight device is disabled **power** is set to FB_BLANK_POWERDOWN.

`fb_blank`
The power state from the FBIOBLANK ioctl.

When the FBIOBLANK ioctl is called **fb_blank** is set to the blank parameter and the update_status() operation is called.

When the backlight device is enabled **fb_blank** is set to FB_BLANK_UNBLANK. When the backlight device is disabled **fb_blank** is set to FB_BLANK_POWERDOWN.

Backlight drivers should avoid using this property. It has been replaced by state & BL_CORE_FBLANK (although most drivers should use *`backlight_is_blank()`* as the preferred means to get the blank state).

fb_blank is deprecated and will be removed.

`type`
The type of backlight supported.

The backlight type allows userspace to make appropriate policy decisions based on the backlight type.

This value must be set in the backlight_properties passed to *devm_backlight_device_register()*.

state
The state of the backlight core.

The state is a bitmask. BL_CORE_FBBLANK is set when the display is expected to be blank. BL_CORE_SUSPENDED is set when the driver is suspended.

backlight drivers are expected to use *backlight_is_blank()* in their update_status() operation rather than reading the state property.

The state is maintained by the core and drivers may not modify it.

scale
The type of the brightness scale.

Description

This structure defines all the properties of a backlight.

struct **backlight_device**
backlight device data

Definition

```
struct backlight_device {
  struct backlight_properties props;
  struct mutex update_lock;
  struct mutex ops_lock;
  const struct backlight_ops *ops;
  struct notifier_block fb_notif;
  struct list_head entry;
  struct device dev;
  bool fb_bl_on[FB_MAX];
  int use_count;
};
```

Members

props
Backlight properties

update_lock
The lock used when calling the update_status() operation.

update_lock is an internal backlight lock that serialise access to the update_status() operation. The backlight core holds the update_lock when calling the update_status() operation. The update_lock shall not be used by backlight drivers.

ops_lock
The lock used around everything related to backlight_ops.

ops_lock is an internal backlight lock that protects the ops pointer and is used around all accesses to ops and when the operations are invoked. The ops_lock shall not be used by backlight drivers.

`ops`
: Pointer to the backlight operations.

  If ops is NULL, the driver that registered this device has been unloaded, and if class_get_devdata() points to something in the body of that driver, it is also invalid.

`fb_notif`
: The framebuffer notifier block

`entry`
: List entry of all registered backlight devices

`dev`
: Parent device.

`fb_bl_on`
: The state of individual fbdev’s.

  Multiple fbdev’s may share one backlight device. The fb_bl_on records the state of the individual fbdev.

`use_count`
: The number of uses of fb_bl_on.

Description

This structure holds all data required by a backlight device.

int **`backlight_update_status`**(struct *backlight_device* *bd)
: force an update of the backlight device status

Parameters

`struct backlight_device *bd`
: the backlight device

int **`backlight_enable`**(struct *backlight_device* *bd)
: Enable backlight

Parameters

`struct backlight_device *bd`
: the backlight device to enable

int **`backlight_disable`**(struct *backlight_device* *bd)
: Disable backlight

Parameters

`struct backlight_device *bd`
: the backlight device to disable

bool **`backlight_is_blank`**(const struct *backlight_device* *bd)
: Return true if display is expected to be blank

Parameters

`const struct backlight_device *bd`
: the backlight device

Description

Display is expected to be blank if any of these is true:

```
1) if power in not UNBLANK
2) if fb_blank is not UNBLANK
3) if state indicate BLANK or SUSPENDED
```

Returns true if display is expected to be blank, false otherwise.

int **backlight_get_brightness**(const struct *backlight_device* *bd)

Returns the current brightness value

Parameters

const struct backlight_device *bd
the backlight device

Description

Returns the current brightness value, taking in consideration the current state. If *backlight_is_blank()* returns true then return 0 as brightness otherwise return the current brightness property value.

Backlight drivers are expected to use this function in their update_status() operation to get the brightness value.

void ***bl_get_data**(struct *backlight_device* *bl_dev)

access devdata

Parameters

struct backlight_device *bl_dev
pointer to backlight device

Description

When a backlight device is registered the driver has the possibility to supply a void * devdata. *bl_get_data()* return a pointer to the devdata.

pointer to devdata stored while registering the backlight device.

Return

void **backlight_force_update**(struct *backlight_device* *bd, enum *backlight_update_reason* reason)

tell the backlight subsystem that hardware state has changed

Parameters

struct backlight_device *bd
the backlight device to update

enum backlight_update_reason reason
reason for update

Description

Updates the internal state of the backlight in response to a hardware event, and generates an uevent to notify userspace. A backlight driver shall call *backlight_force_update()* when the backlight is changed using, for example, a hot-key. The updated brightness is read using get_brightness() and the brightness value is reported using an uevent.

struct *backlight_device* ***backlight_device_get_by_name**(const char *name)

Get backlight device by name

Parameters

const char *name
Device name

Description

This function looks up a backlight device by its name. It obtains a reference on the backlight device and it is the caller's responsibility to drop the reference by calling backlight_put().

Return

A pointer to the backlight device if found, otherwise NULL.

int **backlight_register_notifier**(struct notifier_block *nb)

get notified of backlight (un)registration

Parameters

struct notifier_block *nb
notifier block with the notifier to call on backlight (un)registration

Description

Register a notifier to get notified when backlight devices get registered or unregistered.

0 on success, otherwise a negative error code

Return

int **backlight_unregister_notifier**(struct notifier_block *nb)

unregister a backlight notifier

Parameters

struct notifier_block *nb
notifier block to unregister

Description

Register a notifier to get notified when backlight devices get registered or unregistered.

0 on success, otherwise a negative error code

Return

struct *backlight_device* ***devm_backlight_device_register***(struct device *dev, const char *name, struct device *parent, void *devdata, const struct *backlight_ops* *ops, const struct *backlight_properties* *props)

register a new backlight device

Parameters

struct device *dev
the device to register

const char *name
the name of the device

struct device *parent
a pointer to the parent device (often the same as **dev**)

void *devdata
an optional pointer to be stored for private driver use

const struct backlight_ops *ops
the backlight operations structure

const struct backlight_properties *props
the backlight properties

Description

Creates and registers new backlight device. When a backlight device is registered the configuration must be specified in the **props** parameter. See description of *backlight_properties*.

struct backlight on success, or an ERR_PTR on error

Return

void **devm_backlight_device_unregister**(struct device *dev, struct *backlight_device* *bd)

unregister backlight device

Parameters

struct device *dev
the device to unregister

struct backlight_device *bd
the backlight device to unregister

Description

Deallocates a backlight allocated with *devm_backlight_device_register()*. Normally this function will not need to be called and the resource management code will ensure that the resources are freed.

struct *backlight_device* ***of_find_backlight_by_node**(struct device_node *node)

find backlight device by device-tree node

Parameters

struct device_node *node
device-tree node of the backlight device

Description

Returns a pointer to the backlight device corresponding to the given DT node or NULL if no such backlight device exists or if the device hasn' t been probed yet.

This function obtains a reference on the backlight device and it is the caller' s responsibility to drop the reference by calling put_device() on the backlight device' s .dev field.

struct *backlight_device* ***devm_of_find_backlight**(struct device *dev)

find backlight for a device

Parameters

struct device *dev
the device

Description

This function looks for a property named 'backlight' on the DT node connected to **dev** and looks up the backlight device. The lookup is device managed so the reference to the backlight device is automatically dropped on driver detach.

A pointer to the backlight device if found. Error pointer -EPROBE_DEFER if the DT property is set, but no backlight device is found. NULL if there' s no backlight property.

Return

CHAPTER

TEN

VGA SWITCHEROO

vga_switcheroo is the Linux subsystem for laptop hybrid graphics. These come in two flavors:

- muxed: Dual GPUs with a multiplexer chip to switch outputs between GPUs.
- muxless: Dual GPUs but only one of them is connected to outputs. The other one is merely used to offload rendering, its results are copied over PCIe into the framebuffer. On Linux this is supported with DRI PRIME.

Hybrid graphics started to appear in the late Naughties and were initially all muxed. Newer laptops moved to a muxless architecture for cost reasons. A notable exception is the MacBook Pro which continues to use a mux. Muxes come with varying capabilities: Some switch only the panel, others can also switch external displays. Some switch all display pins at once while others can switch just the DDC lines. (To allow EDID probing for the inactive GPU.) Also, muxes are often used to cut power to the discrete GPU while it is not used.

DRM drivers register GPUs with vga_switcheroo, these are henceforth called clients. The mux is called the handler. Muxless machines also register a handler to control the power state of the discrete GPU, its ->switchto callback is a no-op for obvious reasons. The discrete GPU is often equipped with an HDA controller for the HDMI/DP audio signal, this will also register as a client so that vga_switcheroo can take care of the correct suspend/resume order when changing the discrete GPU' s power state. In total there can thus be up to three clients: Two vga clients (GPUs) and one audio client (on the discrete GPU). The code is mostly prepared to support machines with more than two GPUs should they become available.

The GPU to which the outputs are currently switched is called the active client in vga_switcheroo parlance. The GPU not in use is the inactive client. When the inactive client' s DRM driver is loaded, it will be unable to probe the panel' s EDID and hence depends on VBIOS to provide its display modes. If the VBIOS modes are bogus or if there is no VBIOS at all (which is common on the MacBook Pro), a client may alternatively request that the DDC lines are temporarily switched to it, provided that the handler supports this. Switching only the DDC lines and not the entire output avoids unnecessary flickering.

10.1 Modes of Use

10.1.1 Manual switching and manual power control

In this mode of use, the file /sys/kernel/debug/vgaswitcheroo/switch can be read to retrieve the current vga_switcheroo state and commands can be written to it to change the state. The file appears as soon as two GPU drivers and one handler have registered with vga_switcheroo. The following commands are understood:

- OFF: Power off the device not in use.
- ON: Power on the device not in use.
- IGD: Switch to the integrated graphics device. Power on the integrated GPU if necessary, power off the discrete GPU. Prerequisite is that no user space processes (e.g. Xorg, alsactl) have opened device files of the GPUs or the audio client. If the switch fails, the user may invoke lsof(8) or fuser(1) on /dev/dri/ and /dev/snd/controlC1 to identify processes blocking the switch.
- DIS: Switch to the discrete graphics device.
- DIGD: Delayed switch to the integrated graphics device. This will perform the switch once the last user space process has closed the device files of the GPUs and the audio client.
- DDIS: Delayed switch to the discrete graphics device.
- MIGD: Mux-only switch to the integrated graphics device. Does not remap console or change the power state of either gpu. If the integrated GPU is currently off, the screen will turn black. If it is on, the screen will show whatever happens to be in VRAM. Either way, the user has to blindly enter the command to switch back.
- MDIS: Mux-only switch to the discrete graphics device.

For GPUs whose power state is controlled by the driver' s runtime pm, the ON and OFF commands are a no-op (see next section).

For muxless machines, the IGD/DIS, DIGD/DDIS and MIGD/MDIS commands should not be used.

10.1.2 Driver power control

In this mode of use, the discrete GPU automatically powers up and down at the discretion of the driver' s runtime pm. On muxed machines, the user may still influence the muxer state by way of the debugfs interface, however the ON and OFF commands become a no-op for the discrete GPU.

This mode is the default on Nvidia HybridPower/Optimus and ATI PowerXpress. Specifying nouveau.runpm=0, radeon.runpm=0 or amdgpu.runpm=0 on the kernel command line disables it.

After the GPU has been suspended, the handler needs to be called to cut power to the GPU. Likewise it needs to reinstate power before the GPU can resume. This is achieved by *vga_switcheroo_init_domain_pm_ops()*, which augments the GPU' s suspend/resume functions by the requisite calls to the handler.

When the audio device resumes, the GPU needs to be woken. This is achieved by a PCI quirk which calls device_link_add() to declare a dependency on the GPU. That way, the GPU is kept awake whenever and as long as the audio device is in use.

On muxed machines, if the mux is initially switched to the discrete GPU, the user ends up with a black screen when the GPU powers down after boot. As a workaround, the mux is forced to the integrated GPU on runtime suspend, cf. https://bugs.freedesktop.org/show_bug.cgi?id=75917

10.2 API

10.2.1 Public functions

int **vga_switcheroo_register_handler**(const struct *vga_switcheroo_handler* *handler, enum *vga_switcheroo_handler_flags_t* handler_flags)

register handler

Parameters

const struct vga_switcheroo_handler *handler
handler callbacks

enum vga_switcheroo_handler_flags_t handler_flags
handler flags

Description

Register handler. Enable vga_switcheroo if two vga clients have already registered.

Return

0 on success, -EINVAL if a handler was already registered.

void **vga_switcheroo_unregister_handler**(void)

unregister handler

Parameters

void
no arguments

Description

Unregister handler. Disable vga_switcheroo.

enum *vga_switcheroo_handler_flags_t* **vga_switcheroo_handler_flags**(void)

obtain handler flags

Parameters

void
no arguments

Description

Helper for clients to obtain the handler flags bitmask.

Return

Handler flags. A value of 0 means that no handler is registered or that the handler has no special capabilities.

int **vga_switcheroo_register_client**(struct pci_dev *pdev, const struct *vga_switcheroo_client_ops* *ops, bool driver_power_control)

register vga client

Parameters

struct pci_dev *pdev
client pci device

const struct vga_switcheroo_client_ops *ops
client callbacks

bool driver_power_control
whether power state is controlled by the driver's runtime pm

Description

Register vga client (GPU). Enable vga_switcheroo if another GPU and a handler have already registered. The power state of the client is assumed to be ON. Beforehand, *vga_switcheroo_client_probe_defer()* shall be called to ensure that all prerequisites are met.

Return

0 on success, -ENOMEM on memory allocation error.

int **vga_switcheroo_register_audio_client**(struct pci_dev *pdev, const struct *vga_switcheroo_client_ops* *ops, struct pci_dev *vga_dev)

register audio client

Parameters

struct pci_dev *pdev
client pci device

const struct vga_switcheroo_client_ops *ops
client callbacks

struct pci_dev *vga_dev
pci device which is bound to current audio client

Description

Register audio client (audio device on a GPU). The client is assumed to use runtime PM. Beforehand, *vga_switcheroo_client_probe_defer()* shall be called to ensure that all prerequisites are met.

Return

0 on success, -ENOMEM on memory allocation error, -EINVAL on getting client id error.

bool **`vga_switcheroo_client_probe_defer`**(struct pci_dev *pdev)

whether to defer probing a given client

Parameters

`struct pci_dev *pdev`
client pci device

Description

Determine whether any prerequisites are not fulfilled to probe a given client. Drivers shall invoke this early on in their ->probe callback and return `-EPROBE_DEFER` if it evaluates to `true`. Thou shalt not register the client ere thou hast called this.

Return

`true` if probing should be deferred, otherwise `false`.

enum *vga_switcheroo_state* **`vga_switcheroo_get_client_state`**(struct pci_dev *pdev)

obtain power state of a given client

Parameters

`struct pci_dev *pdev`
client pci device

Description

Obtain power state of a given client as seen from vga_switcheroo. The function is only called from hda_intel.c.

Return

Power state.

void **`vga_switcheroo_unregister_client`**(struct pci_dev *pdev)

unregister client

Parameters

`struct pci_dev *pdev`
client pci device

Description

Unregister client. Disable vga_switcheroo if this is a vga client (GPU).

void **`vga_switcheroo_client_fb_set`**(struct pci_dev *pdev, struct fb_info *info)

set framebuffer of a given client

Parameters

`struct pci_dev *pdev`
client pci device

`struct fb_info *info`
framebuffer

Description

Set framebuffer of a given client. The console will be remapped to this on switching.

int **vga_switcheroo_lock_ddc**(struct pci_dev *pdev)

temporarily switch DDC lines to a given client

Parameters

struct pci_dev *pdev
client pci device

Description

Temporarily switch DDC lines to the client identified by **pdev** (but leave the outputs otherwise switched to where they are). This allows the inactive client to probe EDID. The DDC lines must afterwards be switched back by calling *vga_switcheroo_unlock_ddc()*, even if this function returns an error.

Return

Previous DDC owner on success or a negative int on error. Specifically, -ENODEV if no handler has registered or if the handler does not support switching the DDC lines. Also, a negative value returned by the handler is propagated back to the caller. The return value has merely an informational purpose for any caller which might be interested in it. It is acceptable to ignore the return value and simply rely on the result of the subsequent EDID probe, which will be NULL if DDC switching failed.

int **vga_switcheroo_unlock_ddc**(struct pci_dev *pdev)

switch DDC lines back to previous owner

Parameters

struct pci_dev *pdev
client pci device

Description

Switch DDC lines back to the previous owner after calling *vga_switcheroo_lock_ddc()*. This must be called even if *vga_switcheroo_lock_ddc()* returned an error.

Return

Previous DDC owner on success (i.e. the client identifier of **pdev**) or a negative int on error. Specifically, -ENODEV if no handler has registered or if the handler does not support switching the DDC lines. Also, a negative value returned by the handler is propagated back to the caller. Finally, invoking this function without calling *vga_switcheroo_lock_ddc()* first is not allowed and will result in -EINVAL.

int **vga_switcheroo_process_delayed_switch**(void)

helper for delayed switching

Parameters

void
no arguments

Description

Process a delayed switch if one is pending. DRM drivers should call this from their ->lastclose callback.

Return

0 on success. -EINVAL if no delayed switch is pending, if the client has unregistered in the meantime or if there are other clients blocking the switch. If the actual switch fails, an error is reported and 0 is returned.

int **vga_switcheroo_init_domain_pm_ops**(struct device *dev, struct dev_pm_domain *domain)

helper for driver power control

Parameters

struct device *dev
vga client device

struct dev_pm_domain *domain
power domain

Description

Helper for GPUs whose power state is controlled by the driver's runtime pm. After the GPU has been suspended, the handler needs to be called to cut power to the GPU. Likewise it needs to reinstate power before the GPU can resume. To this end, this helper augments the suspend/resume functions by the requisite calls to the handler. It needs only be called on platforms where the power switch is separate to the device being powered down.

10.2.2 Public structures

struct **vga_switcheroo_handler**

handler callbacks

Definition

```
struct vga_switcheroo_handler {
  int (*init)(void);
  int (*switchto)(enum vga_switcheroo_client_id id);
  int (*switch_ddc)(enum vga_switcheroo_client_id id);
  int (*power_state)(enum vga_switcheroo_client_id id, enum vga_
→switcheroo_state state);
  enum vga_switcheroo_client_id (*get_client_id)(struct pci_dev␣
→*pdev);
};
```

Members

init
initialize handler. Optional. This gets called when vga_switcheroo is enabled, i.e. when two vga clients have registered. It allows the handler to perform some delayed initialization that depends on the existence of the vga clients.

Currently only the radeon and amdgpu drivers use this. The return value is ignored

switchto
switch outputs to given client. Mandatory. For muxless machines this should be a no-op. Returning 0 denotes success, anything else failure (in which case the switch is aborted)

switch_ddc
switch DDC lines to given client. Optional. Should return the previous DDC owner on success or a negative int on failure

power_state
cut or reinstate power of given client. Optional. The return value is ignored

get_client_id
determine if given pci device is integrated or discrete GPU. Mandatory

Description

Handler callbacks. The multiplexer itself. The **switchto** and **get_client_id** methods are mandatory, all others may be set to NULL.

struct **vga_switcheroo_client_ops**
client callbacks

Definition

```
struct vga_switcheroo_client_ops {
  void (*set_gpu_state)(struct pci_dev *dev, enum vga_switcheroo_
→state);
  void (*reprobe)(struct pci_dev *dev);
  bool (*can_switch)(struct pci_dev *dev);
  void (*gpu_bound)(struct pci_dev *dev, enum vga_switcheroo_client_
→id);
};
```

Members

set_gpu_state
do the equivalent of suspend/resume for the card. Mandatory. This should not cut power to the discrete GPU, which is the job of the handler

reprobe
poll outputs. Optional. This gets called after waking the GPU and switching the outputs to it

can_switch
check if the device is in a position to switch now. Mandatory. The client should return false if a user space process has one of its device files open

gpu_bound
notify the client id to audio client when the GPU is bound.

Description

Client callbacks. A client can be either a GPU or an audio device on a GPU. The **set_gpu_state** and **can_switch** methods are mandatory, **reprobe** may be set to

NULL. For audio clients, the **reprobe** member is bogus. OTOH, **gpu_bound** is only for audio clients, and not used for GPU clients.

10.2.3 Public constants

enum **`vga_switcheroo_handler_flags_t`**

handler flags bitmask

Constants

`VGA_SWITCHEROO_CAN_SWITCH_DDC`
whether the handler is able to switch the DDC lines separately. This signals to clients that they should call *`drm_get_edid_switcheroo()`* to probe the EDID

`VGA_SWITCHEROO_NEEDS_EDP_CONFIG`
whether the handler is unable to switch the AUX channel separately. This signals to clients that the active GPU needs to train the link and communicate the link parameters to the inactive GPU (mediated by vga_switcheroo). The inactive GPU may then skip the AUX handshake and set up its output with these pre-calibrated values (DisplayPort specification v1.1a, section 2.5.3.3)

Description

Handler flags bitmask. Used by handlers to declare their capabilities upon registering with vga_switcheroo.

enum **`vga_switcheroo_client_id`**

client identifier

Constants

`VGA_SWITCHEROO_UNKNOWN_ID`
initial identifier assigned to vga clients. Determining the id requires the handler, so GPUs are given their true id in a delayed fashion in vga_switcheroo_enable()

`VGA_SWITCHEROO_IGD`
integrated graphics device

`VGA_SWITCHEROO_DIS`
discrete graphics device

`VGA_SWITCHEROO_MAX_CLIENTS`
currently no more than two GPUs are supported

Description

Client identifier. Audio clients use the same identifier & 0x100.

enum **`vga_switcheroo_state`**

client power state

Constants

`VGA_SWITCHEROO_OFF`
off

VGA_SWITCHEROO_ON
    on

VGA_SWITCHEROO_NOT_FOUND
    client has not registered with vga_switcheroo. Only used in *vga_switcheroo_get_client_state()* which in turn is only called from hda_intel.c

Description

Client power state.

10.2.4 Private structures

struct **vgasr_priv**

    vga_switcheroo private data

Definition

```
struct vgasr_priv {
  bool active;
  bool delayed_switch_active;
  enum vga_switcheroo_client_id delayed_client_id;
  struct dentry *debugfs_root;
  int registered_clients;
  struct list_head clients;
  const struct vga_switcheroo_handler *handler;
  enum vga_switcheroo_handler_flags_t handler_flags;
  struct mutex mux_hw_lock;
  int old_ddc_owner;
};
```

Members

active
    whether vga_switcheroo is enabled. Prerequisite is the registration of two GPUs and a handler

delayed_switch_active
    whether a delayed switch is pending

delayed_client_id
    client to which a delayed switch is pending

debugfs_root
    directory for vga_switcheroo debugfs interface

registered_clients
    number of registered GPUs (counting only vga clients, not audio clients)

clients
    list of registered clients

handler
    registered handler

handler_flags
flags of registered handler

mux_hw_lock
protects mux state (in particular while DDC lines are temporarily switched)

old_ddc_owner
client to which DDC lines will be switched back on unlock

Description

vga_switcheroo private data. Currently only one vga_switcheroo instance per system is supported.

struct **vga_switcheroo_client**
registered client

Definition

```
struct vga_switcheroo_client {
  struct pci_dev *pdev;
  struct fb_info *fb_info;
  enum vga_switcheroo_state pwr_state;
  const struct vga_switcheroo_client_ops *ops;
  enum vga_switcheroo_client_id id;
  bool active;
  bool driver_power_control;
  struct list_head list;
  struct pci_dev *vga_dev;
};
```

Members

pdev
client pci device

fb_info
framebuffer to which console is remapped on switching

pwr_state
current power state if manual power control is used. For driver power control, call vga_switcheroo_pwr_state().

ops
client callbacks

id
client identifier. Determining the id requires the handler, so gpus are initially assigned VGA_SWITCHEROO_UNKNOWN_ID and later given their true id in vga_switcheroo_enable()

active
whether the outputs are currently switched to this client

driver_power_control
whether power state is controlled by the driver' s runtime pm. If true, writing ON and OFF to the vga_switcheroo debugfs interface is a no-op so as not to interfere with runtime pm

list
client list

vga_dev
pci device, indicate which GPU is bound to current audio client

Description

Registered client. A client can be either a GPU or an audio device on a GPU. For audio clients, the **fb_info** and **active** members are bogus. For GPU clients, the **vga_dev** is bogus.

10.3 Handlers

10.3.1 apple-gmux Handler

gmux is a microcontroller built into the MacBook Pro to support dual GPUs: A Lattice XP2 on pre-retinas, a Renesas R4F2113 on retinas.

(The MacPro6,1 2013 also has a gmux, however it is unclear why since it has dual GPUs but no built-in display.)

gmux is connected to the LPC bus of the southbridge. Its I/O ports are accessed differently depending on the microcontroller: Driver functions to access a pre-retina gmux are infixed `_pio_`, those for a retina gmux are infixed `_index_`.

gmux is also connected to a GPIO pin of the southbridge and thereby is able to trigger an ACPI GPE. On the MBP5 2008/09 it's GPIO pin 22 of the Nvidia MCP79, on all following generations it's GPIO pin 6 of the Intel PCH. The GPE merely signals that an interrupt occurred, the actual type of event is identified by reading a gmux register.

Graphics mux

On pre-retinas, the LVDS outputs of both GPUs feed into gmux which muxes either of them to the panel. One of the tricks gmux has up its sleeve is to lengthen the blanking interval of its output during a switch to synchronize it with the GPU switched to. This allows for a flicker-free switch that is imperceptible by the user (US 8,687,007 B2).

On retinas, muxing is no longer done by gmux itself, but by a separate chip which is controlled by gmux. The chip is triple sourced, it is either an NXP CBTL06142, TI HD3SS212 or Pericom PI3VDP12412. The panel is driven with eDP instead of LVDS since the pixel clock required for retina resolution exceeds LVDS' limits.

Pre-retinas are able to switch the panel's DDC pins separately. This is handled by a TI SN74LV4066A which is controlled by gmux. The inactive GPU can thus probe the panel's EDID without switching over the entire panel. Retinas lack this functionality as the chips used for eDP muxing are incapable of switching the AUX channel separately (see the linked data sheets, Pericom would be capable but this is unused). However the retina panel has the

NO_AUX_HANDSHAKE_LINK_TRAINING bit set in its DPCD, allowing the inactive GPU to skip the AUX handshake and set up the output with link parameters pre-calibrated by the active GPU.

The external DP port is only fully switchable on the first two unibody MacBook Pro generations, MBP5 2008/09 and MBP6 2010. This is done by an NXP CBTL06141 which is controlled by gmux. It' s the predecessor of the eDP mux on retinas, the difference being support for 2.7 versus 5.4 Gbit/s.

The following MacBook Pro generations replaced the external DP port with a combined DP/Thunderbolt port and lost the ability to switch it between GPUs, connecting it either to the discrete GPU or the Thunderbolt controller. Oddly enough, while the full port is no longer switchable, AUX and HPD are still switchable by way of an NXP CBTL03062 (on pre-retinas MBP8 2011 and MBP9 2012) or two TI TS3DS10224 (on retinas) under the control of gmux. Since the integrated GPU is missing the main link, external displays appear to it as phantoms which fail to link-train.

gmux receives the HPD signal of all display connectors and sends an interrupt on hotplug. On generations which cannot switch external ports, the discrete GPU can then be woken to drive the newly connected display. The ability to switch AUX on these generations could be used to improve reliability of hotplug detection by having the integrated GPU poll the ports while the discrete GPU is asleep, but currently we do not make use of this feature.

Our switching policy for the external port is that on those generations which are able to switch it fully, the port is switched together with the panel when IGD / DIS commands are issued to vga_switcheroo. It is thus possible to drive e.g. a beamer on battery power with the integrated GPU. The user may manually switch to the discrete GPU if more performance is needed.

On all newer generations, the external port can only be driven by the discrete GPU. If a display is plugged in while the panel is switched to the integrated GPU, *both* GPUs will be in use for maximum performance. To decrease power consumption, the user may manually switch to the discrete GPU, thereby suspending the integrated GPU.

gmux' initial switch state on bootup is user configurable via the EFI variable `gpu-power-prefs-fa4ce28d-b62f-4c99-9cc3-6815686e30f9` (5th byte, 1 = IGD, 0 = DIS). Based on this setting, the EFI firmware tells gmux to switch the panel and the external DP connector and allocates a framebuffer for the selected GPU.

Power control

gmux is able to cut power to the discrete GPU. It automatically takes care of the correct sequence to tear down and bring up the power rails for core voltage, VRAM and PCIe.

Backlight control

On single GPU MacBooks, the PWM signal for the backlight is generated by the GPU. On dual GPU MacBook Pros by contrast, either GPU may be suspended to conserve energy. Hence the PWM signal needs to be generated by a separate backlight driver which is controlled by gmux. The earliest generation MBP5 2008/09 uses a TI LP8543 backlight driver. All newer models use a TI LP8545.

Public functions

bool **apple_gmux_present**(void)

detect if gmux is built into the machine

Parameters

void

no arguments

Description

Drivers may use this to activate quirks specific to dual GPU MacBook Pros and Mac Pros, e.g. for deferred probing, runtime pm and backlight.

Return

`true` if gmux is present and the kernel was configured with CONFIG_APPLE_GMUX, `false` otherwise.

CHAPTER

ELEVEN

VGA ARBITER

Graphic devices are accessed through ranges in I/O or memory space. While most modern devices allow relocation of such ranges, some "Legacy" VGA devices implemented on PCI will typically have the same "hard-decoded" addresses as they did on ISA. For more details see "PCI Bus Binding to IEEE Std 1275-1994 Standard for Boot (Initialization Configuration) Firmware Revision 2.1" Section 7, Legacy Devices.

The Resource Access Control (RAC) module inside the X server [0] existed for the legacy VGA arbitration task (besides other bus management tasks) when more than one legacy device co-exists on the same machine. But the problem happens when these devices are trying to be accessed by different userspace clients (e.g. two server in parallel). Their address assignments conflict. Moreover, ideally, being a userspace application, it is not the role of the X server to control bus resources. Therefore an arbitration scheme outside of the X server is needed to control the sharing of these resources. This document introduces the operation of the VGA arbiter implemented for the Linux kernel.

11.1 vgaarb kernel/userspace ABI

The vgaarb is a module of the Linux Kernel. When it is initially loaded, it scans all PCI devices and adds the VGA ones inside the arbitration. The arbiter then enables/disables the decoding on different devices of the VGA legacy instructions. Devices which do not want/need to use the arbiter may explicitly tell it by calling *vga_set_legacy_decoding()*.

The kernel exports a char device interface (/dev/vga_arbiter) to the clients, which has the following semantics:

open
: Opens a user instance of the arbiter. By default, it's attached to the default VGA device of the system.

close
: Close a user instance. Release locks made by the user

read
: Return a string indicating the status of the target like:

  "<card_ID>,decodes=<io_state>,owns=<io_state>,locks=<io_state> (ic,mc)"

An IO state string is of the form {io,mem,io+mem,none}, mc and ic are respectively mem and io lock counts (for debugging/ diagnostic only). "decodes" indicate what the card currently decodes, "owns" indicates what is currently enabled on it, and "locks" indicates what is locked by this card. If the card is unplugged, we get "invalid" then for card_ID and an -ENODEV error is returned for any command until a new card is targeted.

write
Write a command to the arbiter. List of commands:

target <card_ID>
switch target to card <card_ID> (see below)

lock <io_state>
acquires locks on target ("none" is an invalid io_state)

trylock <io_state>
non-blocking acquire locks on target (returns EBUSY if unsuccessful)

unlock <io_state>
release locks on target

unlock all
release all locks on target held by this user (not implemented yet)

decodes <io_state>
set the legacy decoding attributes for the card

poll
event if something changes on any card (not just the target)

card_ID is of the form "PCI:domain:bus:dev.fn". It can be set to "default" to go back to the system default card (TODO: not implemented yet). Currently, only PCI is supported as a prefix, but the userland API may support other bus types in the future, even if the current kernel implementation doesn't.

Note about locks:

The driver keeps track of which user has which locks on which card. It supports stacking, like the kernel one. This complexifies the implementation a bit, but makes the arbiter more tolerant to user space problems and able to properly cleanup in all cases when a process dies. Currently, a max of 16 cards can have locks simultaneously issued from user space for a given user (file descriptor instance) of the arbiter.

In the case of devices hot-{un,}plugged, there is a hook - pci_notify() - to notify them being added/removed in the system and automatically added/removed in the arbiter.

There is also an in-kernel API of the arbiter in case DRM, vgacon, or other drivers want to use it.

11.2 In-kernel interface

void **vga_set_legacy_decoding**(struct pci_dev *pdev, unsigned int decodes)

Parameters

struct pci_dev *pdev
pci device of the VGA card

unsigned int decodes
bit mask of what legacy regions the card decodes

Indicates to the arbiter if the card decodes legacy VGA IOs, legacy VGA Memory, both, or none. All cards default to both, the card driver (fbdev for example) should tell the arbiter if it has disabled legacy decoding, so the card can be left out of the arbitration process (and can be safe to take interrupts at any time.

int **vga_get_interruptible**(struct pci_dev *pdev, unsigned int rsrc)

Parameters

struct pci_dev *pdev
pci device of the VGA card or NULL for the system default

unsigned int rsrc
bit mask of resources to acquire and lock

Description

Shortcut to vga_get with interruptible set to true.

On success, release the VGA resource again with *vga_put()*.

int **vga_get_uninterruptible**(struct pci_dev *pdev, unsigned int rsrc)
shortcut to *vga_get()*

Parameters

struct pci_dev *pdev
pci device of the VGA card or NULL for the system default

unsigned int rsrc
bit mask of resources to acquire and lock

Description

Shortcut to vga_get with interruptible set to false.

On success, release the VGA resource again with *vga_put()*.

struct pci_dev ***vga_default_device**(void)
return the default VGA device, for vgacon

Parameters

void
no arguments

Description

This can be defined by the platform. The default implementation is rather dumb and will probably only work properly on single vga card setups and/or x86 platforms.

If your VGA default device is not PCI, you'll have to return NULL here. In this case, I assume it will not conflict with any PCI card. If this is not true, I'll have to define two archs hooks for enabling/disabling the VGA default device if that is possible. This may be a problem with real _ISA_ VGA cards, in addition to a PCI one. I don't know at this point how to deal with that card. Can theirs IOs be disabled at all ? If not, then I suppose it's a matter of having the proper arch hook telling us about it, so we basically never allow anybody to succeed a `vga_get()`…

int **`vga_remove_vgacon`**(struct pci_dev *pdev)

deactivete vga console

Parameters

`struct pci_dev *pdev`
pci device.

Description

Unbind and unregister vgacon in case pdev is the default vga device. Can be called by gpu drivers on initialization to make sure vga register access done by vgacon will not disturb the device.

int **`vga_get`**(struct pci_dev *pdev, unsigned int rsrc, int interruptible)

acquire & locks VGA resources

Parameters

`struct pci_dev *pdev`
pci device of the VGA card or NULL for the system default

`unsigned int rsrc`
bit mask of resources to acquire and lock

`int interruptible`
blocking should be interruptible by signals ?

Description

This function acquires VGA resources for the given card and mark those resources locked. If the resource requested are "normal" (and not legacy) resources, the arbiter will first check whether the card is doing legacy decoding for that type of resource. If yes, the lock is "converted" into a legacy resource lock.

The arbiter will first look for all VGA cards that might conflict and disable their IOs and/or Memory access, including VGA forwarding on P2P bridges if necessary, so that the requested resources can be used. Then, the card is marked as locking these resources and the IO and/or Memory accesses are enabled on the card (including VGA forwarding on parent P2P bridges if any).

This function will block if some conflicting card is already locking one of the required resources (or any resource on a different bus segment, since P2P bridges don't differentiate VGA memory and IO afaik). You can indicate whether this blocking should be interruptible by a signal (for userland interface) or not.

Must not be called at interrupt time or in atomic context. If the card already owns the resources, the function succeeds. Nested calls are supported (a per-resource counter is maintained)

On success, release the VGA resource again with *vga_put()*.

0 on success, negative error code on failure.

Return

void **vga_put**(struct pci_dev *pdev, unsigned int rsrc)

release lock on legacy VGA resources

Parameters

struct pci_dev *pdev
pci device of VGA card or NULL for system default

unsigned int rsrc
but mask of resource to release

Description

This fuction releases resources previously locked by *vga_get()* or vga_tryget(). The resources aren't disabled right away, so that a subsequence *vga_get()* on the same card will succeed immediately. Resources have a counter, so locks are only released if the counter reaches 0.

int **vga_client_register**(struct pci_dev *pdev, void *cookie, void (*irq_set_state)(void *cookie, bool state), unsigned int (*set_vga_decode)(void *cookie, bool decode))

register or unregister a VGA arbitration client

Parameters

struct pci_dev *pdev
pci device of the VGA client

void *cookie
client cookie to be used in callbacks

void (*irq_set_state)(void *cookie, bool state)
irq state change callback

unsigned int (*set_vga_decode)(void *cookie, bool decode)
vga decode change callback

Description

Clients have two callback mechanisms they can use.

irq_set_state callback: If a client can't disable its GPUs VGA resources, then we need to be able to ask it to turn off its irqs when we turn off its mem and io decoding.

set_vga_decode callback: If a client can disable its GPU VGA resource, it will get a callback from this to set the encode/decode state.

Rationale: we cannot disable VGA decode resources unconditionally some single GPU laptops seem to require ACPI or BIOS access to the VGA registers to control things like backlights etc. Hopefully newer multi-GPU laptops do something saner, and desktops won't have any special ACPI for this. The driver will get a callback when VGA arbitration is first used by userspace since some older X servers have issues.

This function does not check whether a client for **pdev** has been registered already.

To unregister just call this function with **irq_set_state** and **set_vga_decode** both set to NULL for the same **pdev** as originally used to register them.

Return

0 on success, -1 on failure

11.3 libpciaccess

To use the vga arbiter char device it was implemented an API inside the libpciaccess library. One field was added to struct pci_device (each device on the system):

```
/* the type of resource decoded by the device */
int vgaarb_rsrc;
```

Besides it, in pci_system were added:

```
int vgaarb_fd;
int vga_count;
struct pci_device *vga_target;
struct pci_device *vga_default_dev;
```

The vga_count is used to track how many cards are being arbitrated, so for instance, if there is only one card, then it can completely escape arbitration.

These functions below acquire VGA resources for the given card and mark those resources as locked. If the resources requested are "normal" (and not legacy) resources, the arbiter will first check whether the card is doing legacy decoding for that type of resource. If yes, the lock is "converted" into a legacy resource lock. The arbiter will first look for all VGA cards that might conflict and disable their IOs and/or Memory access, including VGA forwarding on P2P bridges if necessary, so that the requested resources can be used. Then, the card is marked as locking these resources and the IO and/or Memory access is enabled on the card (including VGA forwarding on parent P2P bridges if any). In the case of vga_arb_lock(), the function will block if some conflicting card is already locking one of the required resources (or any resource on a different bus segment, since P2P bridges don't differentiate VGA memory and IO afaik). If the card already owns the resources, the function succeeds. vga_arb_trylock() will return (-EBUSY) instead of blocking. Nested calls are supported (a per-resource counter is maintained).

Set the target device of this client.

```
int  pci_device_vgaarb_set_target   (struct pci_device *dev);
```

For instance, in x86 if two devices on the same bus want to lock different resources, both will succeed (lock). If devices are in different buses and trying to lock different resources, only the first who tried succeeds.

```
int  pci_device_vgaarb_lock         (void);
int  pci_device_vgaarb_trylock      (void);
```

Unlock resources of device.

```
int  pci_device_vgaarb_unlock       (void);
```

Indicates to the arbiter if the card decodes legacy VGA IOs, legacy VGA Memory, both, or none. All cards default to both, the card driver (fbdev for example) should tell the arbiter if it has disabled legacy decoding, so the card can be left out of the arbitration process (and can be safe to take interrupts at any time.

```
int  pci_device_vgaarb_decodes      (int new_vgaarb_rsrc);
```

Connects to the arbiter device, allocates the struct

```
int  pci_device_vgaarb_init         (void);
```

Close the connection

```
void pci_device_vgaarb_fini         (void);
```

11.4 xf86VGAArbiter (X server implementation)

X server basically wraps all the functions that touch VGA registers somehow.

11.5 References

Benjamin Herrenschmidt (IBM?) started this work when he discussed such design with the Xorg community in 2005 [1, 2]. In the end of 2007, Paulo Zanoni and Tiago Vignatti (both of C3SL/Federal University of Paraná) proceeded his work enhancing the kernel code to adapt as a kernel module and also did the implementation of the user space side [3]. Now (2009) Tiago Vignatti and Dave Airlie finally put this work in shape and queued to Jesse Barnes' PCI tree.

0) https://cgit.freedesktop.org/xorg/xserver/commit/?id=4b42448a2388d40f257774fbffdccaea87bd0347

1) https://lists.freedesktop.org/archives/xorg/2005-March/006663.html

2) https://lists.freedesktop.org/archives/xorg/2005-March/006745.html

3) https://lists.freedesktop.org/archives/xorg/2007-October/029507.html

CHAPTER

TWELVE

TODO LIST

This section contains a list of smaller janitorial tasks in the kernel DRM graphics subsystem useful as newbie projects. Or for slow rainy days.

12.1 Difficulty

To make it easier task are categorized into different levels:

Starter: Good tasks to get started with the DRM subsystem.

Intermediate: Tasks which need some experience with working in the DRM subsystem, or some specific GPU/display graphics knowledge. For debugging issue it’s good to have the relevant hardware (or a virtual driver set up) available for testing.

Advanced: Tricky tasks that need fairly good understanding of the DRM subsystem and graphics topics. Generally need the relevant hardware for development and testing.

12.1.1 Subsystem-wide refactorings

12.2 Remove custom dumb_map_offset implementations

All GEM based drivers should be using `drm_gem_create_mmap_offset()` instead. Audit each individual driver, make sure it’ll work with the generic implementation (there’s lots of outdated locking leftovers in various implementations), and then remove it.

Contact: Daniel Vetter, respective driver maintainers

Level: Intermediate

12.3 Convert existing KMS drivers to atomic modesetting

3.19 has the atomic modeset interfaces and helpers, so drivers can now be converted over. Modern compositors like Wayland or Surfaceflinger on Android really want an atomic modeset interface, so this is all about the bright future.

There is a conversion guide for atomic and all you need is a GPU for a non-converted driver (again virtual HW drivers for KVM are still all suitable).

As part of this drivers also need to convert to universal plane (which means exposing primary & cursor as proper plane objects). But that's much easier to do by directly using the new atomic helper driver callbacks.

Contact: Daniel Vetter, respective driver maintainers

Level: Advanced

12.4 Clean up the clipped coordination confusion around planes

We have a helper to get this right with drm_plane_helper_check_update(), but it's not consistently used. This should be fixed, preferrably in the atomic helpers (and drivers then moved over to clipped coordinates). Probably the helper should also be moved from drm_plane_helper.c to the atomic helpers, to avoid confusion - the other helpers in that file are all deprecated legacy helpers.

Contact: Ville Syrjälä, Daniel Vetter, driver maintainers

Level: Advanced

12.5 Improve plane atomic_check helpers

Aside from the clipped coordinates right above there's a few suboptimal things with the current helpers:

- drm_plane_helper_funcs->atomic_check gets called for enabled or disabled planes. At best this seems to confuse drivers, worst it means they blow up when the plane is disabled without the CRTC. The only special handling is resetting values in the plane state structures, which instead should be moved into the drm_plane_funcs->atomic_duplicate_state functions.
- Once that's done, helpers could stop calling ->atomic_check for disabled planes.
- Then we could go through all the drivers and remove the more-or-less confused checks for plane_state->fb and plane_state->crtc.

Contact: Daniel Vetter

Level: Advanced

12.6 Convert early atomic drivers to async commit helpers

For the first year the atomic modeset helpers didn't support asynchronous / non-blocking commits, and every driver had to hand-roll them. This is fixed now, but there's still a pile of existing drivers that easily could be converted over to the new infrastructure.

One issue with the helpers is that they require that drivers handle completion events for atomic commits correctly. But fixing these bugs is good anyway.

Contact: Daniel Vetter, respective driver maintainers

Level: Advanced

12.7 Fallout from atomic KMS

`drm_atomic_helper.c` provides a batch of functions which implement legacy IOCTLs on top of the new atomic driver interface. Which is really nice for gradual conversion of drivers, but unfortunately the semantic mismatches are a bit too severe. So there's some follow-up work to adjust the function interfaces to fix these issues:

- atomic needs the lock acquire context. At the moment that's passed around implicitly with some horrible hacks, and it's also allocate with `GFP_NOFAIL` behind the scenes. All legacy paths need to start allocating the acquire context explicitly on stack and then also pass it down into drivers explicitly so that the legacy-on-atomic functions can use them.

  Except for some driver code this is done. This task should be finished by adding WARN_ON(!drm_drv_uses_atomic_modeset) in *`drm_modeset_lock_all()`*.

- A bunch of the vtable hooks are now in the wrong place: DRM has a split between core vfunc tables (named `drm_foo_funcs`), which are used to implement the userspace ABI. And then there's the optional hooks for the helper libraries (name `drm_foo_helper_funcs`), which are purely for internal use. Some of these hooks should be move from `_funcs` to `_helper_funcs` since they are not part of the core ABI. There's a `FIXME` comment in the kerneldoc for each such case in `drm_crtc.h`.

Contact: Daniel Vetter

Level: Intermediate

12.8 Get rid of dev->struct_mutex from GEM drivers

`dev->struct_mutex` is the Big DRM Lock from legacy days and infested everything. Nowadays in modern drivers the only bit where it' s mandatory is serializing GEM buffer object destruction. Which unfortunately means drivers have to keep track of that lock and either call `unreference` or `unreference_locked` depending upon context.

Core GEM doesn' t have a need for `struct_mutex` any more since kernel 4.8, and there' s a `gem_free_object_unlocked` callback for any drivers which are entirely `struct_mutex` free.

For drivers that need `struct_mutex` it should be replaced with a driver- private lock. The tricky part is the BO free functions, since those can' t reliably take that lock any more. Instead state needs to be protected with suitable subordinate locks or some cleanup work pushed to a worker thread. For performance-critical drivers it might also be better to go with a more fine-grained per-buffer object and per-context lockings scheme. Currently only the `msm` and *i915* drivers use `struct_mutex`.

Contact: Daniel Vetter, respective driver maintainers

Level: Advanced

12.9 Convert logging to drm_* functions with drm_device paramater

For drivers which could have multiple instances, it is necessary to differentiate between which is which in the logs. Since DRM_INFO/WARN/ERROR don' t do this, drivers used dev_info/warn/err to make this differentiation. We now have drm_* variants of the drm print functions, so we can start to convert those drivers back to using drm-formatted specific log messages.

Before you start this conversion please contact the relevant maintainers to make sure your work will be merged - not everyone agrees that the DRM dmesg macros are better.

Contact: Sean Paul, Maintainer of the driver you plan to convert

Level: Starter

12.10 Convert drivers to use simple modeset suspend/resume

Most drivers (except i915 and nouveau) that use drm_atomic_helper_suspend/resume() can probably be converted to use drm_mode_config_helper_suspend/resume(). Also there' s still open-coded version of the atomic suspend/resume code in older atomic modeset drivers.

Contact: Maintainer of the driver you plan to convert

Level: Intermediate

12.11 Convert drivers to use drm_fbdev_generic_setup()

Most drivers can use *drm_fbdev_generic_setup()*. Driver have to implement atomic modesetting and GEM vmap support. Current generic fbdev emulation expects the framebuffer in system memory (or system-like memory).

Contact: Maintainer of the driver you plan to convert

Level: Intermediate

12.12 drm_framebuffer_funcs and drm_mode_config_funcs.fb_cre cleanup

A lot more drivers could be switched over to the drm_gem_framebuffer helpers. Various hold-ups:

- Need to switch over to the generic dirty tracking code using drm_atomic_helper_dirtyfb first (e.g. qxl).
- Need to switch to *drm_fbdev_generic_setup()*, otherwise a lot of the custom fb setup code can't be deleted.
- Many drivers wrap *drm_gem_fb_create()* only to check for valid formats. For atomic drivers we could check for valid formats by calling drm_plane_check_pixel_format() against all planes, and pass if any plane supports the format. For non-atomic that's not possible since like the format list for the primary plane is fake and we'd therefor reject valid formats.
- Many drivers subclass drm_framebuffer, we'd need a embedding compatible version of the varios drm_gem_fb_create functions. Maybe called drm_gem_fb_create/_with_dirty/_with_funcs as needed.

Contact: Daniel Vetter

Level: Intermediate

12.13 Clean up mmap forwarding

A lot of drivers forward gem mmap calls to dma-buf mmap for imported buffers. And also a lot of them forward dma-buf mmap to the gem mmap implementations. There's *drm_gem_prime_mmap()* for this now, but still needs to be rolled out.

Contact: Daniel Vetter

Level: Intermediate

12.14 Generic fbdev defio support

The defio support code in the fbdev core has some very specific requirements, which means drivers need to have a special framebuffer for fbdev. The main issue is that it uses some fields in struct page itself, which breaks shmem gem objects (and other things). To support defio, affected drivers require the use of a shadow buffer, which may add CPU and memory overhead.

Possible solution would be to write our own defio mmap code in the drm fbdev emulation. It would need to fully wrap the existing mmap ops, forwarding everything after it has done the write-protect/mkwrite trickery:

- In the drm_fbdev_fb_mmap helper, if we need defio, change the default page prots to write-protected with something like this:

  ```
  vma->vm_page_prot = pgprot_wrprotect(vma->vm_page_prot);
  ```

- Set the mkwrite and fsync callbacks with similar implementions to the core fbdev defio stuff. These should all work on plain ptes, they don't actually require a struct page. uff. These should all work on plain ptes, they don't actually require a struct page.
- Track the dirty pages in a separate structure (bitfield with one bit per page should work) to avoid clobbering struct page.

Might be good to also have some igt testcases for this.

Contact: Daniel Vetter, Noralf Tronnes

Level: Advanced

12.15 idr_init_base()

DRM core&drivers uses a lot of idr (integer lookup directories) for mapping userspace IDs to internal objects, and in most places ID=0 means NULL and hence is never used. Switching to idr_init_base() for these would make the idr more efficient.

Contact: Daniel Vetter

Level: Starter

12.16 struct drm_gem_object_funcs

GEM objects can now have a function table instead of having the callbacks on the DRM driver struct. This is now the preferred way and drivers can be moved over.

We also need a 2nd version of the CMA define that doesn't require the vmapping to be present (different hook for prime importing). Plus this needs to be rolled out to all drivers using their own implementations, too.

Level: Intermediate

12.17 Use DRM_MODESET_LOCK_ALL_* helpers instead of boilerplate

For cases where drivers are attempting to grab the modeset locks with a local acquire context. Replace the boilerplate code surrounding *drm_modeset_lock_all_ctx()* with *DRM_MODESET_LOCK_ALL_BEGIN()* and *DRM_MODESET_LOCK_ALL_END()* instead.

This should also be done for all places where *drm_modeset_lock_all()* is still used.

As a reference, take a look at the conversions already completed in drm core.

Contact: Sean Paul, respective driver maintainers

Level: Starter

12.18 Rename CMA helpers to DMA helpers

CMA (standing for contiguous memory allocator) is really a bit an accident of what these were used for first, a much better name would be DMA helpers. In the text these should even be called coherent DMA memory helpers (so maybe CDM, but no one knows what that means) since underneath they just use dma_alloc_coherent.

Contact: Laurent Pinchart, Daniel Vetter

Level: Intermediate (mostly because it is a huge tasks without good partial milestones, not technically itself that challenging)

12.19 connector register/unregister fixes

- For most connectors it's a no-op to call drm_connector_register/unregister directly from driver code, drm_dev_register/unregister take care of this already. We can remove all of them.
- For dp drivers it's a bit more a mess, since we need the connector to be registered when calling drm_dp_aux_register. Fix this by instead calling drm_dp_aux_init, and moving the actual registering into a late_register callback as recommended in the kerneldoc.

Level: Intermediate

12.20 Remove load/unload callbacks from all non-DRIVER_LEGACY drivers

The load/unload callbacks in struct &drm_driver are very much midlayers, plus for historical reasons they get the ordering wrong (and we can't fix that) between setting up the &drm_driver structure and calling *drm_dev_register()*.

- Rework drivers to no longer use the load/unload callbacks, directly coding the load/unload sequence into the driver's probe function.
- Once all non-DRIVER_LEGACY drivers are converted, disallow the load/unload callbacks for all modern drivers.

Contact: Daniel Vetter

Level: Intermediate

12.21 Replace drm_detect_hdmi_monitor() with drm_display_info.is_hdmi

Once EDID is parsed, the monitor HDMI support information is available through drm_display_info.is_hdmi. Many drivers still call *drm_detect_hdmi_monitor()* to retrieve the same information, which is less efficient.

Audit each individual driver calling *drm_detect_hdmi_monitor()* and switch to drm_display_info.is_hdmi if applicable.

Contact: Laurent Pinchart, respective driver maintainers

Level: Intermediate

12.22 Consolidate custom driver modeset properties

Before atomic modeset took place, many drivers where creating their own properties. Among other things, atomic brought the requirement that custom, driver specific properties should not be used.

For this task, we aim to introduce core helpers or reuse the existing ones if available:

A quick, unconfirmed, examples list.

Introduce core helpers: - audio (amdgpu, intel, gma500, radeon) - brightness, contrast, etc (armada, nouveau) - overlay only (?) - broadcast rgb (gma500, intel) - colorkey (armada, nouveau, rcar) - overlay only (?) - dither (amdgpu, nouveau, radeon) - varies across drivers - underscan family (amdgpu, radeon, nouveau)

Already in core: - colorspace (sti) - tv format names, enhancements (gma500, intel) - tv overscan, margins, etc. (gma500, intel) - zorder (omapdrm) - same as zpos (?)

Contact: Emil Velikov, respective driver maintainers

Level: Intermediate

12.23 Plumb drm_atomic_state all over

Currently various atomic functions take just a single or a handful of object states (eg. plane state). While that single object state can suffice for some simple cases, we often have to dig out additional object states for dealing with various dependencies between the individual objects or the hardware they represent. The process of digging out the additional states is rather non-intuitive and error prone.

To fix that most functions should rather take the overall drm_atomic_state as one of their parameters. The other parameters would generally be the object(s) we mainly want to interact with.

For example, instead of

```
int (*atomic_check)(struct drm_plane *plane, struct drm_plane_state␣
↪*state);
```

we would have something like

```
int (*atomic_check)(struct drm_plane *plane, struct drm_atomic_
↪state *state);
```

The implementation can then trivially gain access to any required object state(s) via *drm_atomic_get_plane_state()*, *drm_atomic_get_new_plane_state()*, *drm_atomic_get_old_plane_state()*, and their equivalents for other object types.

Additionally many drivers currently access the object->state pointer directly in their commit functions. That is not going to work if we eg. want to allow deeper commit pipelines as those pointers could then point to the states corresponding to a future commit instead of the current commit we're trying to process. Also non-blocking commits execute locklessly so there are serious concerns with dereferencing the object->state pointers without holding the locks that protect them. Use of *drm_atomic_get_new_plane_state()*, *drm_atomic_get_old_plane_state()*, etc. avoids these problems as well since they relate to a specific commit via the passed in drm_atomic_state.

Contact: Ville Syrjälä, Daniel Vetter

Level: Intermediate

12.23.1 Core refactorings

12.24 Make panic handling work

This is a really varied tasks with lots of little bits and pieces:

- The panic path can't be tested currently, leading to constant breaking. The main issue here is that panics can be triggered from hardirq contexts and hence all panic related callback can run in hardirq context. It would be awesome if we could test at least the fbdev helper code and driver code by e.g. trigger calls through drm debugfs files. hardirq context could be achieved by using an IPI to the local processor.

- There's a massive confusion of different panic handlers. DRM fbdev emulation helpers have one, but on top of that the fbcon code itself also has one. We need to make sure that they stop fighting over each another.
- `drm_can_sleep()` is a mess. It hides real bugs in normal operations and isn't a full solution for panic paths. We need to make sure that it only returns true if there's a panic going on for real, and fix up all the fallout.
- The panic handler must never sleep, which also means it can't ever `mutex_lock()`. Also it can't grab any other lock unconditionally, not even spinlocks (because NMI and hardirq can panic too). We need to either make sure to not call such paths, or trylock everything. Really tricky.
- For the above locking troubles reasons it's pretty much impossible to attempt a synchronous modeset from panic handlers. The only thing we could try to achive is an atomic `set_base` of the primary plane, and hope that it shows up. Everything else probably needs to be delayed to some worker or something else which happens later on. Otherwise it just kills the box harder, prevent the panic from going out on e.g. netconsole.
- There's also proposal for a simplied DRM console instead of the full-blown fbcon and DRM fbdev emulation. Any kind of panic handling tricks should obviously work for both console, in case we ever get kmslog merged.

Contact: Daniel Vetter

Level: Advanced

12.25 Clean up the debugfs support

There's a bunch of issues with it:

- The drm_info_list ->show() function doesn't even bother to cast to the drm structure for you. This is lazy.
- We probably want to have some support for debugfs files on crtc/connectors and maybe other kms objects directly in core. There's even drm_print support in the funcs for these objects to dump kms state, so it's all there. And then the ->show() functions should obviously give you a pointer to the right object.
- The drm_info_list stuff is centered on drm_minor instead of drm_device. For anything we want to print drm_device (or maybe drm_file) is the right thing.
- The drm_driver->debugfs_init hooks we have is just an artifact of the old midlayered load sequence. DRM debugfs should work more like sysfs, where you can create properties/files for an object anytime you want, and the core takes care of publishing/unpuplishing all the files at register/unregister time. Drivers shouldn't need to worry about these technicalities, and fixing this (together with the drm_minor->drm_device move) would allow us to remove debugfs_init.
- Drop the return code and error checking from all debugfs functions. Greg KH is working on this already.

Contact: Daniel Vetter

Level: Intermediate

12.26 KMS cleanups

Some of these date from the very introduction of KMS in 2008 …

- Make ->funcs and ->helper_private vtables optional. There's a bunch of empty function tables in drivers, but before we can remove them we need to make sure that all the users in helpers and drivers do correctly check for a NULL vtable.
- Cleanup up the various ->destroy callbacks. A lot of them just wrapt the drm_*_cleanup implementations and can be removed. Some tack a kfree() at the end, for which we could add drm_*_cleanup_kfree(). And then there's the (for historical reasons) misnamed *drm_primary_helper_destroy()* function.

Level: Intermediate

12.27 Remove automatic page mapping from dma-buf importing

When importing dma-bufs, the dma-buf and PRIME frameworks automatically map imported pages into the importer's DMA area. *drm_gem_prime_fd_to_handle()* and *drm_gem_prime_handle_to_fd()* require that importers call dma_buf_attach() even if they never do actual device DMA, but only CPU access through dma_buf_vmap(). This is a problem for USB devices, which do not support DMA operations.

To fix the issue, automatic page mappings should be removed from the buffer-sharing code. Fixing this is a bit more involved, since the import/export cache is also tied to &drm_gem_object.import_attach. Meanwhile we paper over this problem for USB devices by fishing out the USB host controller device, as long as that supports DMA. Otherwise importing can still needlessly fail.

Contact: Thomas Zimmermann <tzimmermann@suse.de>, Daniel Vetter

Level: Advanced

12.27.1 Better Testing

12.28 Enable trinity for DRM

And fix up the fallout. Should be really interesting …

Level: Advanced

12.29 Make KMS tests in i-g-t generic

The i915 driver team maintains an extensive testsuite for the i915 DRM driver, including tons of testcases for corner-cases in the modesetting API. It would be awesome if those tests (at least the ones not relying on Intel-specific GEM features) could be made to run on any KMS driver.

Basic work to run i-g-t tests on non-i915 is done, what' s now missing is mass-converting things over. For modeset tests we also first need a bit of infrastructure to use dumb buffers for untiled buffers, to be able to run all the non-i915 specific modeset tests.

Level: Advanced

12.30 Extend virtual test driver (VKMS)

See the documentation of *VKMS* for more details. This is an ideal internship task, since it only requires a virtual machine and can be sized to fit the available time.

Contact: Daniel Vetter

Level: See details

12.31 Backlight Refactoring

Backlight drivers have a triple enable/disable state, which is a bit overkill. Plan to fix this:

1. Roll out `backlight_enable()` and `backlight_disable()` helpers everywhere. This has started already.
2. In all, only look at one of the three status bits set by the above helpers.
3. Remove the other two status bits.

Contact: Daniel Vetter

Level: Intermediate

12.31.1 Driver Specific

12.32 AMD DC Display Driver

AMD DC is the display driver for AMD devices starting with Vega. There has been a bunch of progress cleaning it up but there' s still plenty of work to be done.

See drivers/gpu/drm/amd/display/TODO for tasks.

Contact: Harry Wentland, Alex Deucher

12.32.1 Bootsplash

There is support in place now for writing internal DRM clients making it possible to pick up the bootsplash work that was rejected because it was written for fbdev.

- [v6,8/8] drm/client: Hack: Add bootsplash example https://patchwork.freedesktop.org/patch/306579/
- [RFC PATCH v2 00/13] Kernel based bootsplash https://lkml.org/lkml/2017/12/13/764

Contact: Sam Ravnborg

Level: Advanced

12.32.2 Outside DRM

12.33 Convert fbdev drivers to DRM

There are plenty of fbdev drivers for older hardware. Some hwardware has become obsolete, but some still provides good(-enough) framebuffers. The drivers that are still useful should be converted to DRM and afterwards removed from fbdev.

Very simple fbdev drivers can best be converted by starting with a new DRM driver. Simple KMS helpers and SHMEM should be able to handle any existing hardware. The new driver' s call-back functions are filled from existing fbdev code.

More complex fbdev drivers can be refactored step-by-step into a DRM driver with the help of the DRM fbconv helpers. [1] These helpers provide the transition layer between the DRM core infrastructure and the fbdev driver interface. Create a new DRM driver on top of the fbconv helpers, copy over the fbdev driver, and hook it up to the DRM code. Examples for several fbdev drivers are available at [1] and a tutorial of this process available at [2]. The result is a primitive DRM driver that can run X11 and Weston.

- [1] https://gitlab.freedesktop.org/tzimmermann/linux/tree/fbconv
- [2] https://gitlab.freedesktop.org/tzimmermann/linux/blob/fbconv/drivers/gpu/drm/drm_fbconv_helper.c

Contact: Thomas Zimmermann <tzimmermann@suse.de>

Level: Advanced