The Linux graphics stack, Optimus and the Nouveau driver

Cooperative rendering across GPUs on Linux

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Summary

1. Introduction to the Linux graphics stack
   - General overview
   - Kernel space
   - User space
2. Kepler support
3. Kernel
4. Userspace
5. Tools
6. Community

General overview of the Linux Graphics stack

The graphics stack before 2005

- The X-Server provided everything:
  - Modesetting (CRTC & plane management);
  - 2D/3D acceleration;
  - Video rendering acceleration;
  - Input management.
- The X-Server talked to the GPU directly, as root.

The current graphics stack

- The X-Server got split into more than 200 components:
  - Privileged operations in the kernel;
  - 2D drivers got put into different shared objects;
  - 3D acceleration got put in mesa;
  - The list is too long ;)

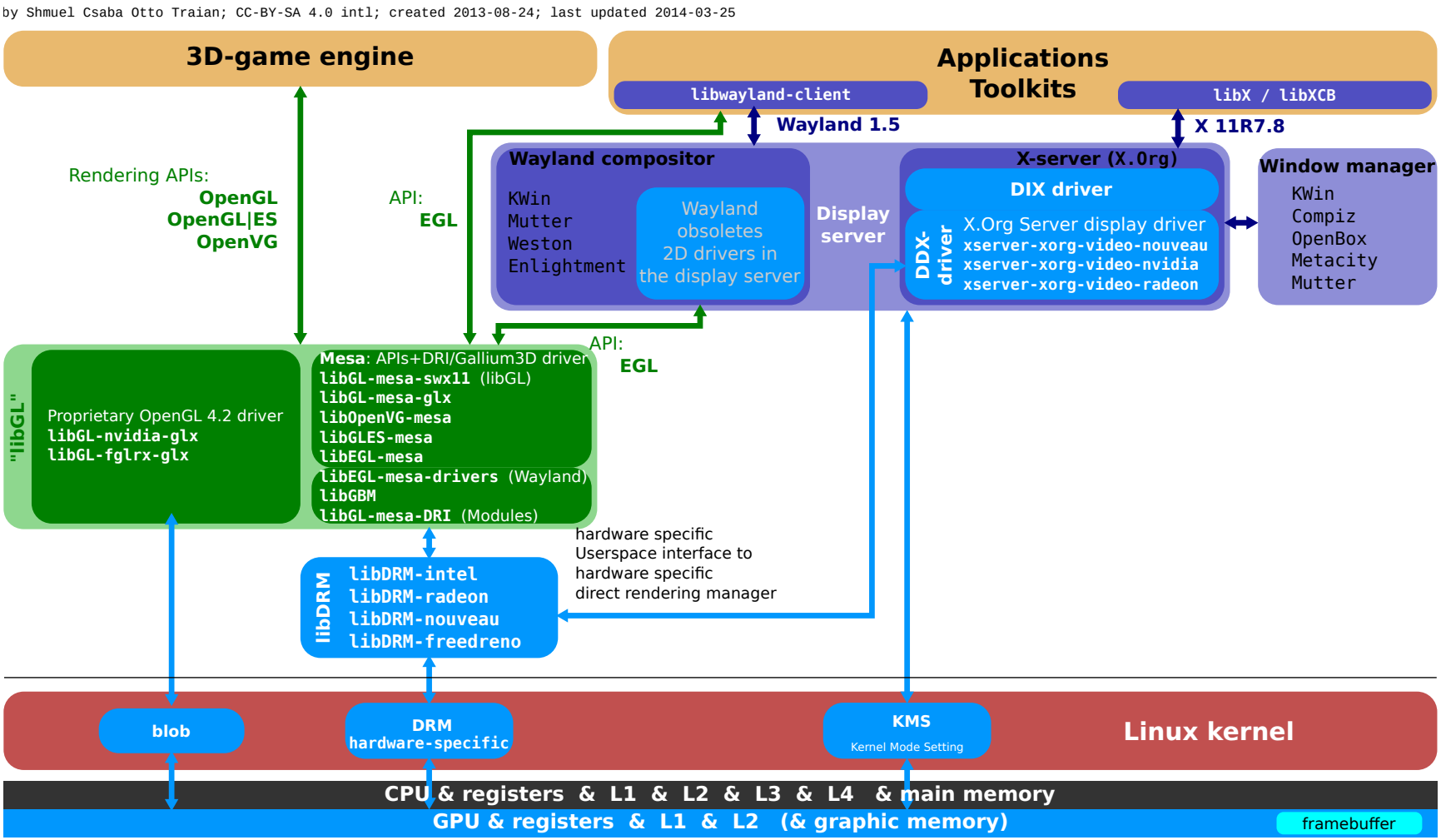

Figure: General overview of the Linux graphics stack

The kernel space

Direct Rendering Manager (DRM) : The common code

- This common code provides:
  - Kernel ModeSetting (KMS): CRTC & plane management;
  - Video memory management via GEM (with a TTM backend?);
  - Nodes with different capabilities (master or render nodes).

DRM open source drivers

- i810/i915: Intel;
- nouveau: NVIDIA;
- radeon: AMD/ATI;
- vmwgfx: VMware;
- many SoC GPUs (armada, exynos, msm, omap, tegra, ...).

Architecture of the X-Server

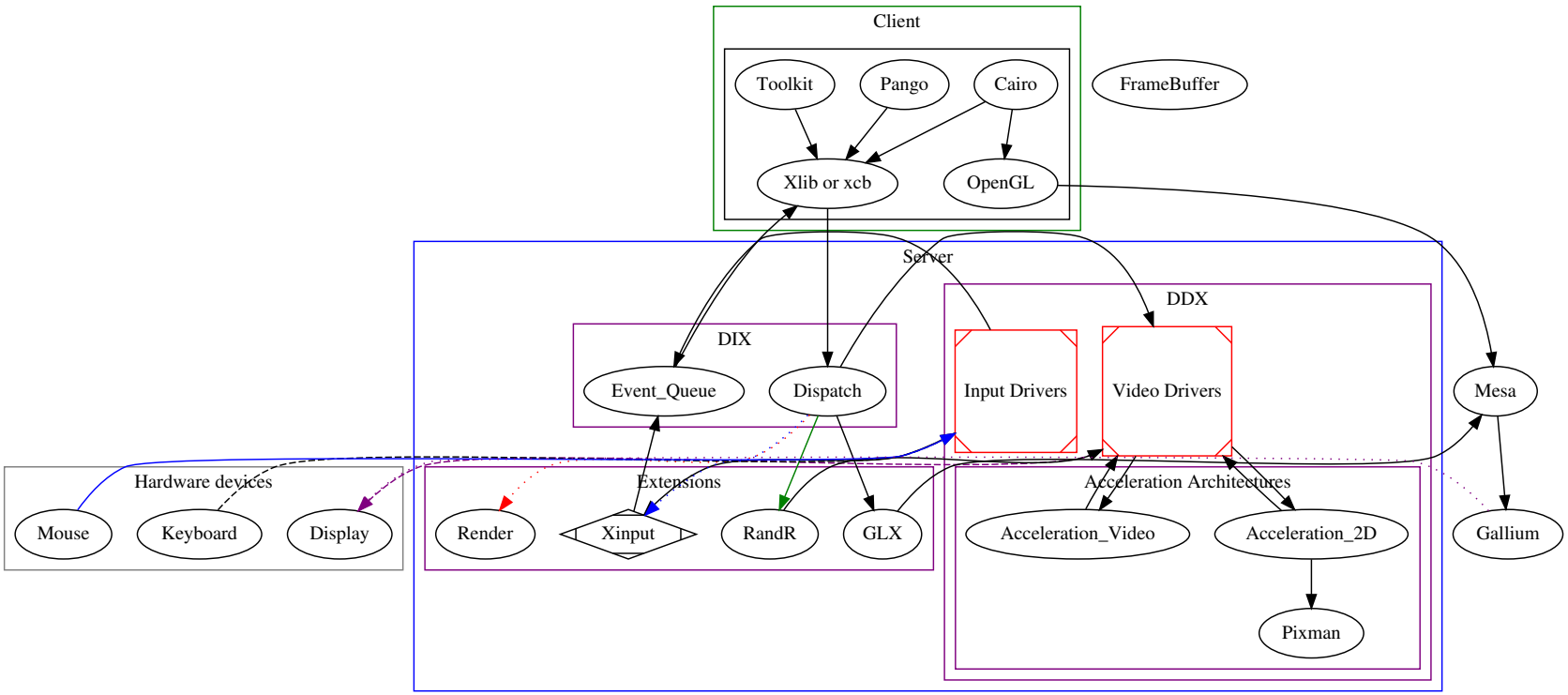

Figure: General overview of the X-Server's internal architecture

Architecture of Mesa

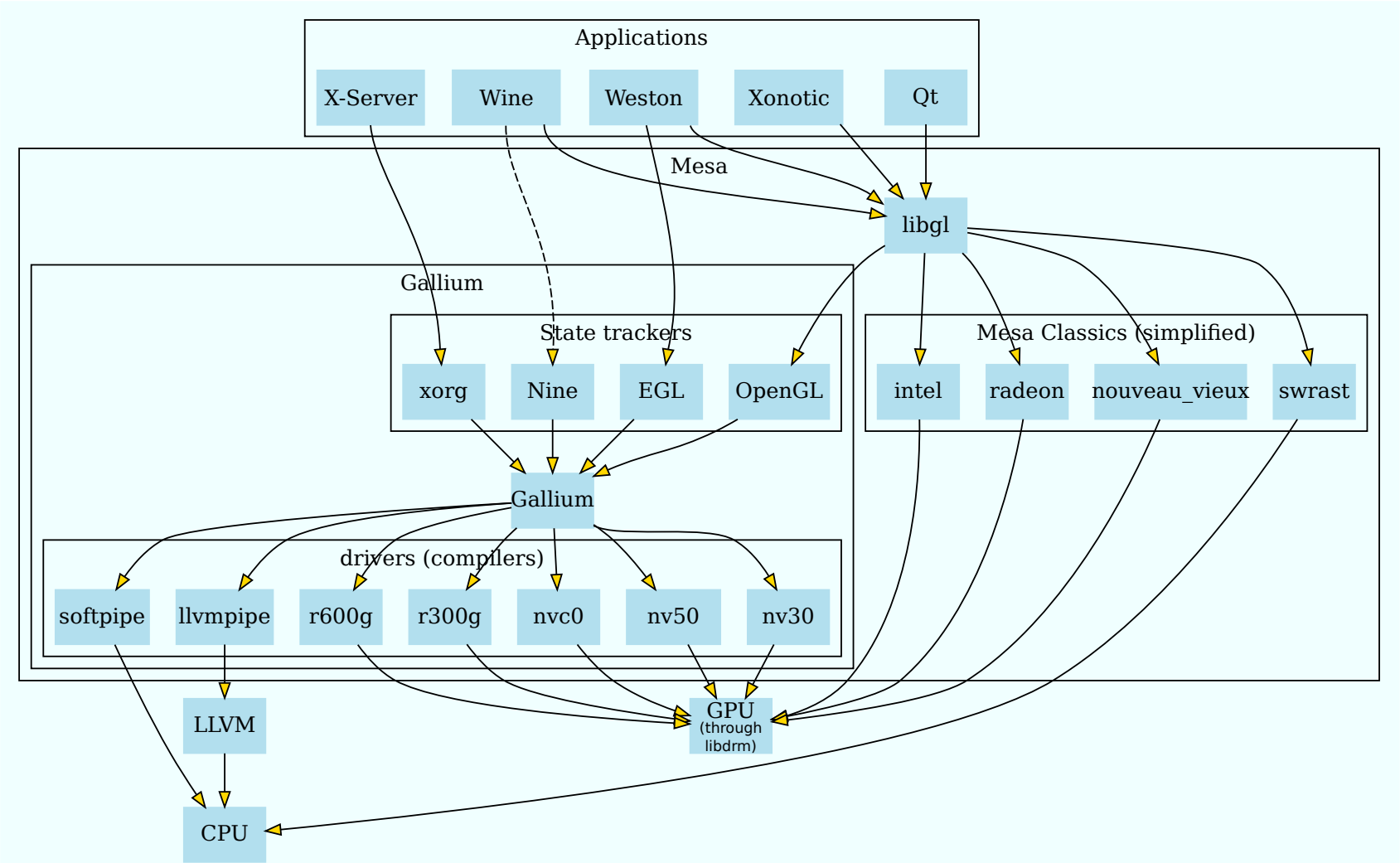

Figure: General overview of Mesa's internal architecture

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Kepler support

Kepler

- New NVIDIA card family released in March 2012;
- Modesetting support released on the same day;
- Un-released 3D support happened a few days later;
- 2D/3D accel support released less than a month after (after libdrm2).

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- Optimus/prime
- Power Management

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Kernel updates

Kernel updates

- Nouveau left staging (Linux 3.4);
- Major internal re-architecturing, called core (Linux 3.7);

The core architecture

- Separate code per-chipset;
- Can partially be used from the userspace;
- Kind of object-oriented (ctor, dtor, init & fini);
- Should limit regressions when adding support to new cards;
- Contribution by Ben Skeggs.

Optimus/prime

Optimus/Prime support

- Offloading support added by Dave Airlie in Linux 3.9;
- Synchronisation between drivers, worked on by mlankhorst;

More information + how to

`http://nouveau.freedesktop.org/wiki/Optimus/`

Power Management

Thermal management

- Temperature monitoring support added for most cards;
- Except for the i2c-only temperature probes.

Fan management

- Static fan management added in Linux 3.7;
- Experimental automatic fan management added in Linux 3.9;
- Enabled by default in Linux 3.13;
- Doesn't work on all Keplers...

Contact Martin Peres (mupuf) if you have problems!

Power Management

Reclocking

- Still a work in progress...;
- Will provide much better performance!

Power and clock gating

- Will lower the power consumption (good for laptops);
- Should be released soon for Fermi/Kepler.

Performance and power monitoring

- Some Kepler have i2c power sensors!
- Rough engine-usage indicators (Memory, Graph, Video);
- Will be exposed ASAP.

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- Performance counters
- Libdrm_nouveau2
- Video decoding
- OpenGL
- Direct 3D

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Performance counters

DONE

- MP-counters support for Fermi+;
- Exposed through Gallium-HUD;
- Kepler support by Christoph Bumiller;
- Fermi support by Samuel Pitoiset (GSOC 2013).

WIP

- Performance monitoring from PDAEMON(Mem, VDec, GR);
- Reverse engineering graphics-related signals on W7 (Samuel);
- Export the kernels

Userspace updates - Libdrm_nouveau2

Libdrm_nouveau2

- Expose BOs' VM addresses;
- Support multiple threads per channel;
- Rework the rellocation mechanism;
- Reduce the occurences of -ENOSPC;
- Released in April 2012 by Ben Skeggs.

Libdrm_nouveau2 : Mesa updates

- Mesa drivers updated to use Libdrm_nouveau2;
- Nvfx rewritten and renamed nv30;
- Various fixes to the other drivers.

Userspace updates - Video decoding

Video decoding : Maarten Lankhorst

- Fermi+ support added by Maarten Lankhorst;
- Rely on user-extracted firmwares (mmiotrace).

Video decoding : Ilia Mirkin

- Nv50: Full VP2/3/4 support added by Ilia Mirkin;
- Wrote a script to extract firmwares from the blob;
- Added back support for video planes on (nv04-40);
- PMPEG support for MPEG1/2 on nv40-96.

More information

`http://nouveau.freedesktop.org/wiki/VideoAcceleration`

OpenGL

History: GL version support

- OpenGL 3.0 in Mesa 8.0 (nvc0);
- OpenGL 3.1 in Mesa 9 (nvc0);
- OpenGL 3.3 support in Mesa 10.1 for nv50/nvc0.

Limited support

- GK110;
- GK208.

Nine: a d3d9 state tracker

Nine: a d3d9 state tracker

- Started by Joakim Sindholt;
- Completed by Christoph Bumiller
- Runs Skyrim, Civilization 5, Anno 1404 and StarCraft 2;
- Up to 2 times faster than Wine's d3d implementation.

Announcement

`http://lists.freedesktop.org/archives/mesa-dev/2013-July/041900.html`

Source tree

`https://github.com/chrisbmr/Mesa-3D/tree/gallium-nine`

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- Envytools repo moved
- RESTification of the documentation
- Falcon C Compiler
- Falcon & other NVIDIA ISAs Decompiler!

6 Community

Envytools

Envytools

- is a collection of nvidia-related tools and docs;
- was primarily hosted by Pathscale;
- but was also hosted by mwk & sourceforge;
- moved to one repo with every dev as admins.

More information

`http://lists.freedesktop.org/archives/nouveau/2013-July/013089.html`

Envytools : documentation

hwdocs before

- text-based documentation of NVIDIA hw;
- links written as plain text.

hwdocs after

- text-based documentation of NVIDIA hw;
- can generate pretty html documentations;
- Example: `http://envytools.readthedocs.org`.

hwdocs future

- rnndb generated from the ReST documentation;
- cross referencement of registers and bitfields.

Falcon C compiler

Falcon C compiler

- Started by Shinpei Kato;
- work for PGRAPH firmwares;
- can be extended to support PDAEMON.

Links

- Source: https://github.com/CS005/guc
- Paper: http://hgpu.org/?p=10251

NVIDIA ISAs decompiler

decompiler

- Decompiler project started by Marcin Kościelnicki;
- Works on vp2macro and partial support of Falcon;
- Will support xtensa & possibly vuc;
- Will be released after Marcin's master thesis (soon);
- Example: `http://ng.0x04.net/~mwk/deco.txt`.

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- Bugzilla cleaning
- Wiki portage & rewrite
- New member!?

Community

Bugzilla cleaning

- Started by Ilia Mirkin;
- closed all bugs not updated since 2011;
- asking people to reproduce on current Nouveau;
- Reduced bug reports from 410 to 167;
- Helped fixing some actual bugs along the way.

Community

Wiki portage

- Freedesktop moved to ikiwiki;
- killed a lot of spam along the way;
- but it is now harder to add content.

Wiki clean up & rewrite

- Started by Ilia Mirkin & Martin Peres;
- Rewrote all the main pages to make them helpful;
- deleted the old cruft.

Community - Welcome NVIDIA!

Flash news

- NVIDIA released NDA-free documentation during XDC2013!;
- Offered us a contact email to answer questions;
- Are willing to improve the out-of-the-box experience of users;
- Provided documentation on the DCB-related vbios tables;
- Helped us get MSI IRQs working and fix video decoding;
- Released a GPL Tegra K1 driver with extensive reg dumps;
- Sent an RFC to support the Tegra K1 driver in Nouveau;
- Welcome to the Nouveau community, NVIDIA!