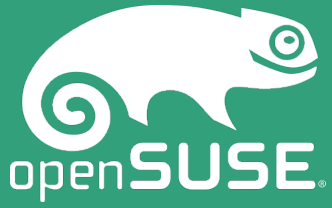

Kexec/Kdump under the hood

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Me...

- Software developer at SUSE
- Working on ARM64
- Maintainer of Mediatek SoCs in the Linux kernel
- … and much more.
- Twitter @bruggems

Outline

- Use cases
- User-space internals
- Kernel internals
- Support in openSUSE
- Q&A

Use cases

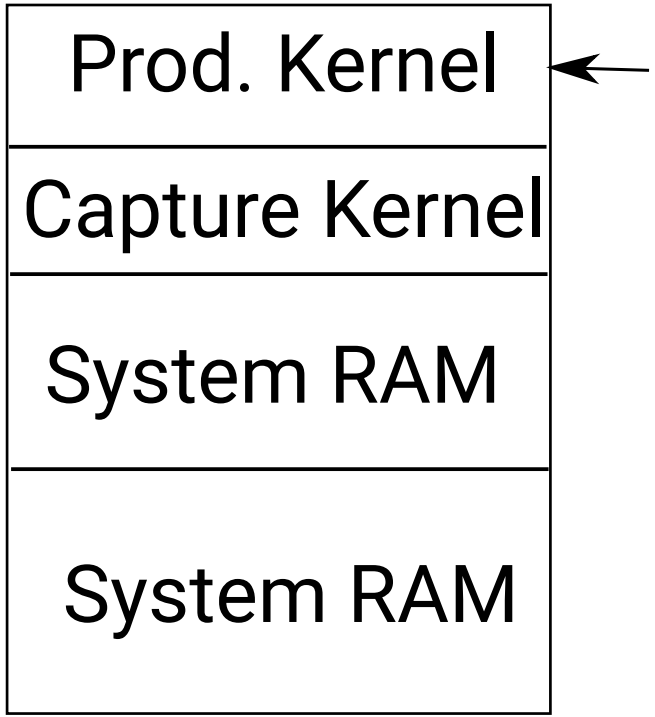
Use cases

- Debug a system
  - No serial console
  - No reproducer inhouse
  - No good logs
- Boot a new kernel without rebooting machine
  - Faster machines have slower firmware
- Boot your system
  - That must be s390!

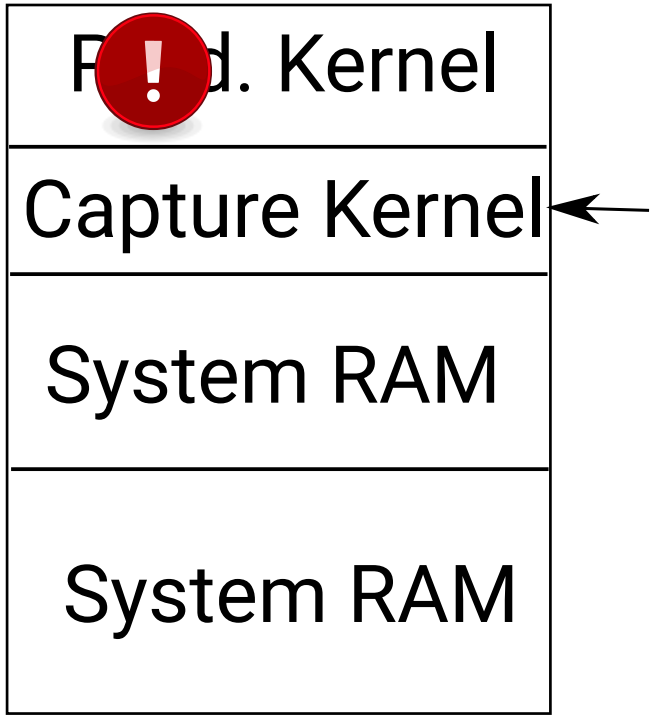
Some comments

- Production- vs Capture-Kernel
- Capture kernel gets loaded when production kernel crashes
  - Creates a dump of memory
  - Save memory dump
  - The dump can later be inspected

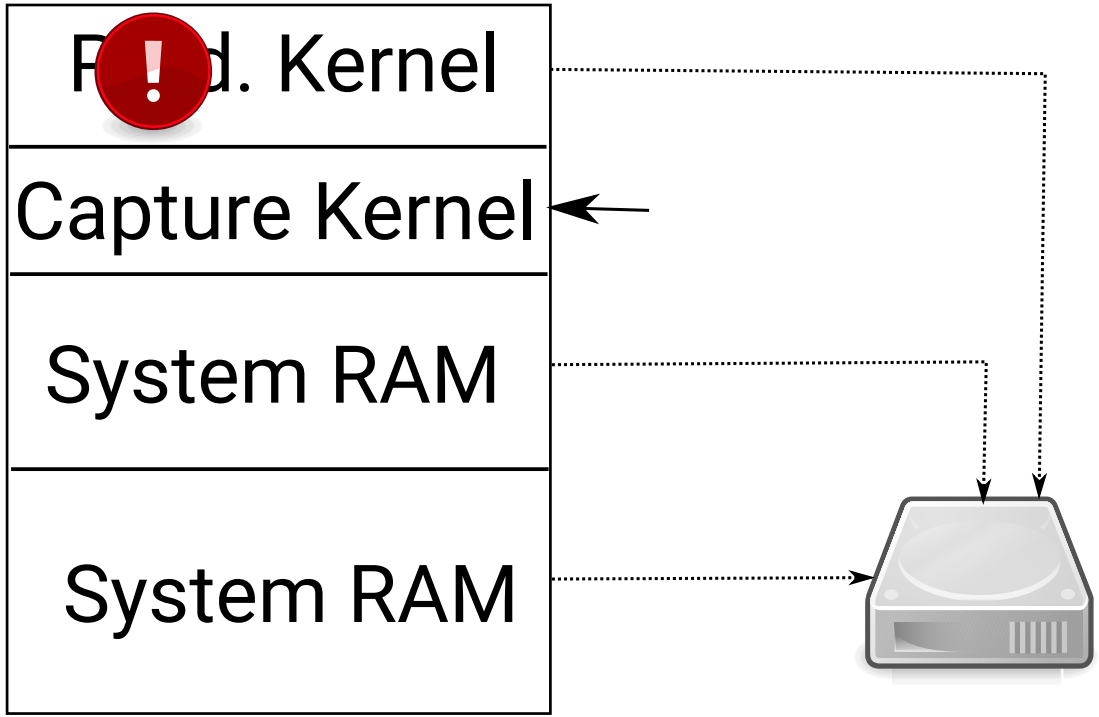
Use cases



Use cases



Use cases



Parts involved

Parts involved

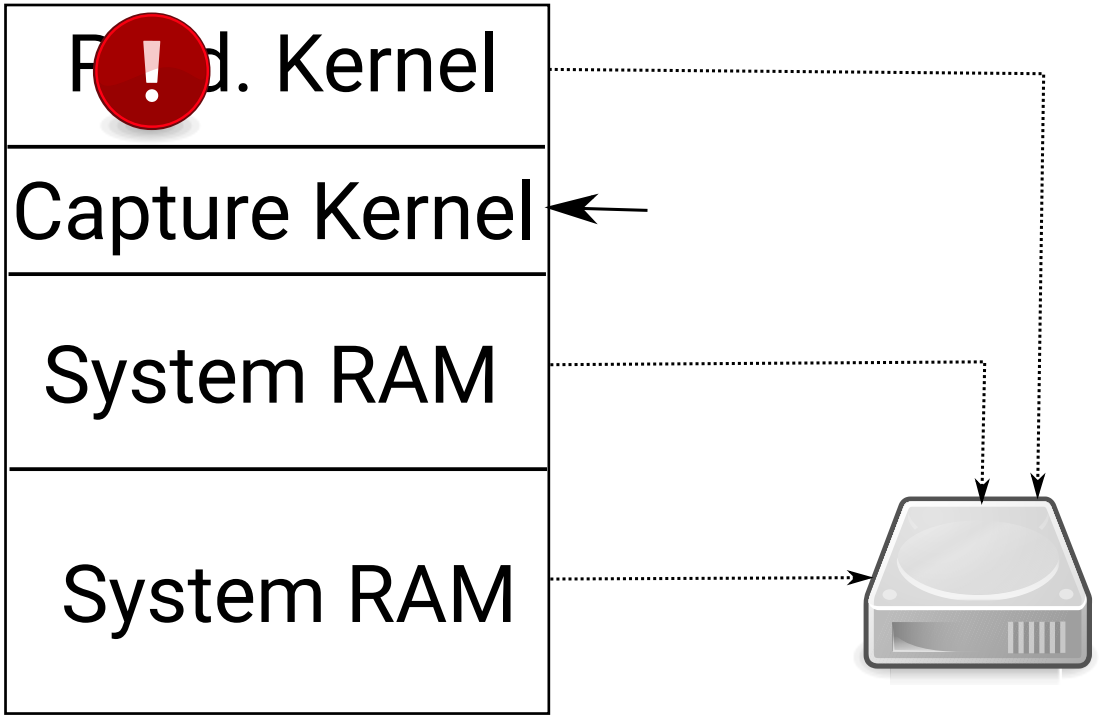
- kexec-tools (user-space) – prepare capture system
- Kernel itself – executes capture kernel on crash
- Other userpsace tools to inspect the dump
  - makedumpfile, crash and crash-python
- Distro programs to easier set things up
  - Kdump on openSUSE

kexec-tools

- kexec -l /boot/vmlinux –initrd=/boot/initrd --reuse-cmdline
  - -e → execute (!) - reboot with magic value
  - -p → load capture kernel
  - -l → load kernel
  - -u -up → unload
  - Arch specific options
    - e.g. --dtb

kexec-tools...
under the hood

Remeber...

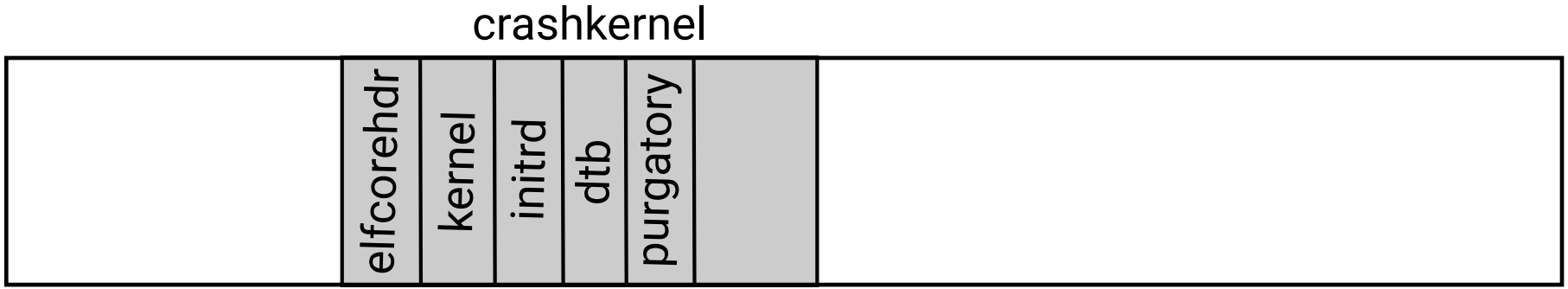


Questions

- When system crashes we need to know where is
  - Capture kernel
  - Usable memory for capture kernel
  - Capture kernel’s initrd
  - Production kernel and memory (for the dump)

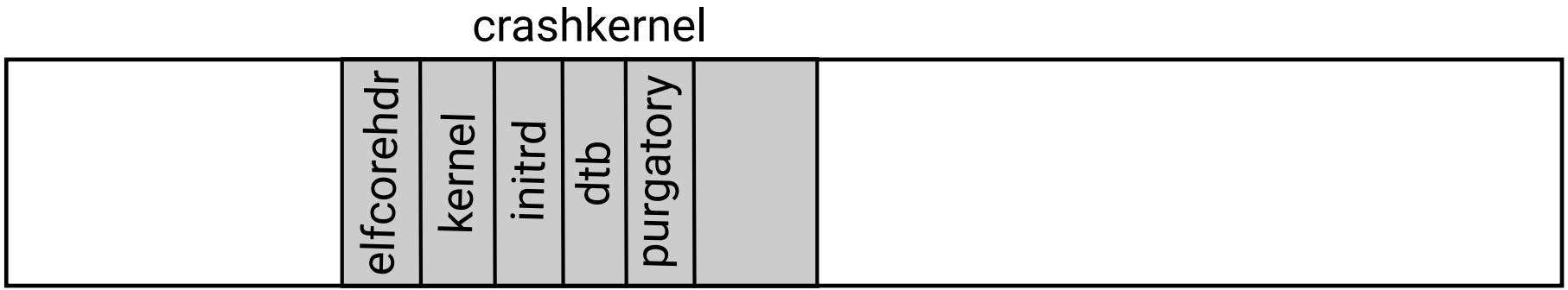
Memory in the production kernel

- Reserve memory for the capture kernel et. al.
- Production-Kernel boot parameter crashkernel=
  - Can be tricky to do



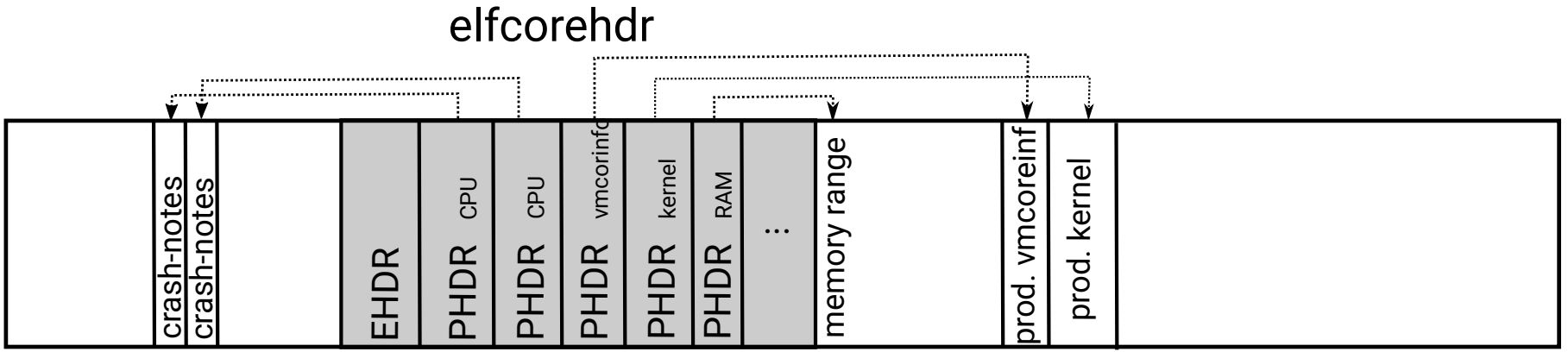
Memory in the production kernel

```
struct kexec_segment {
        const void *buf;
        size_t bufsz;
        const void *mem;
        size_t memsz;
};
```



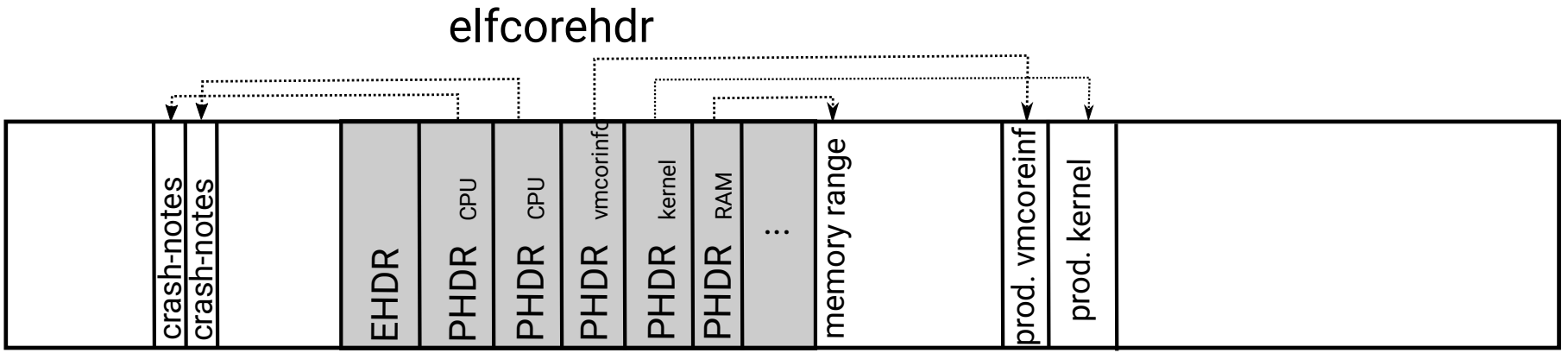
elfcorehdr

- Elf header information about production memory
- Capture kernel creates /proc/vmcore out of it
- Information is collected by kexec-tools



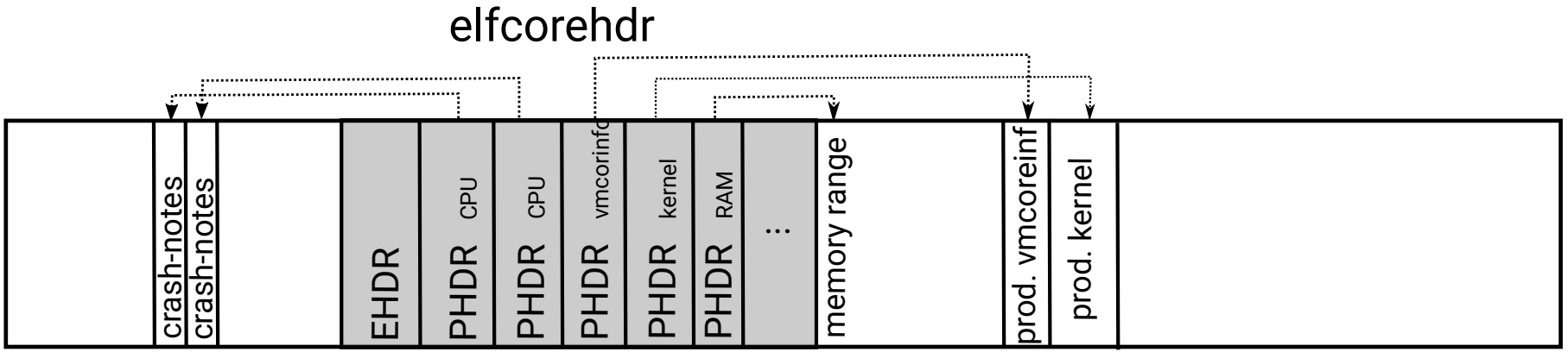
elfcorehdr

- Crashnotes
  - per-CPU area for storing CPU states, PID, CPU registers
  - /sys/devices/system/cpu/cpu%d/crash_note



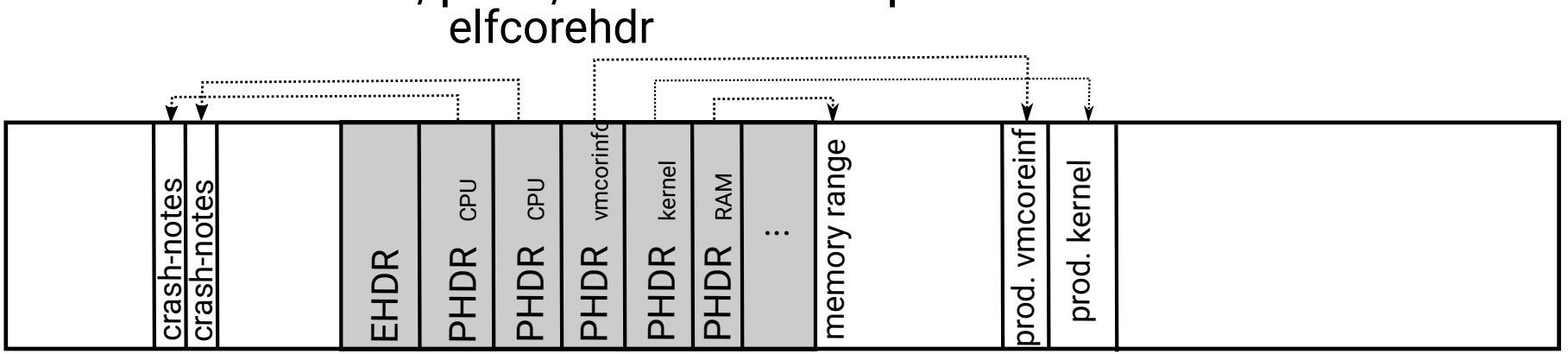
elfcorehdr

- vmcoreinfo
  - Kernel debug information
    - Size of a page, offset of flags in struct page
  - /sys/kernel/vmcoreinfo



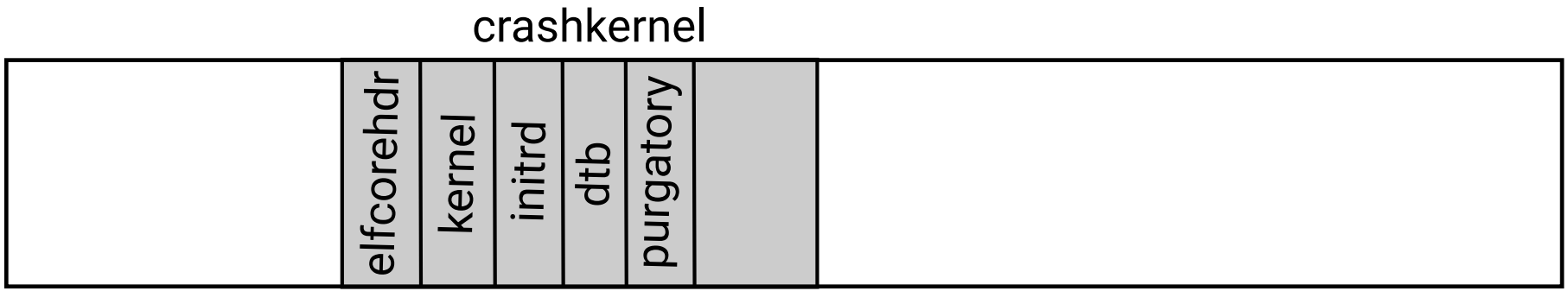
elfcorehdr

- Memory ranges
  - PT_LOAD
  - /proc/iomem
- Used to create /proc/vmcore dump file



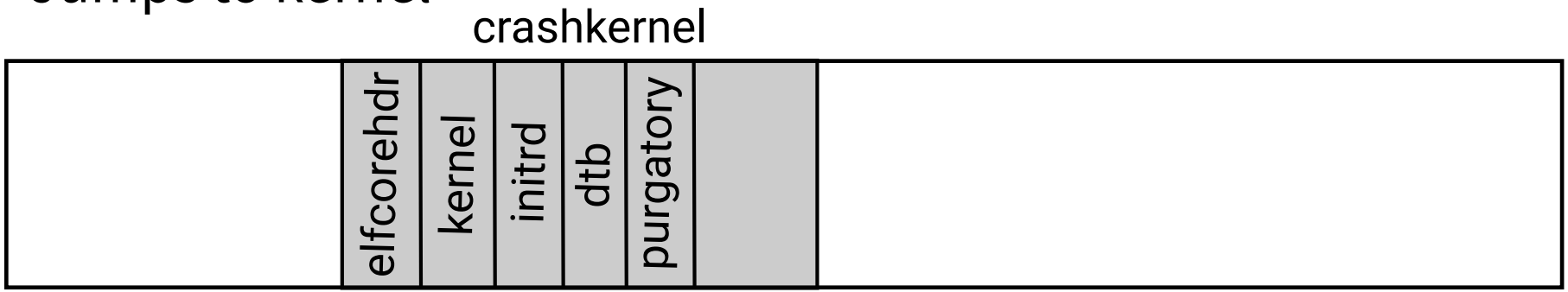
Device tree

- Created from /sys/firmware/fdt (even on ACPI only)
- Updated with information about
  - initrd, elfcorehdr, usable-memory-range



Purgatory

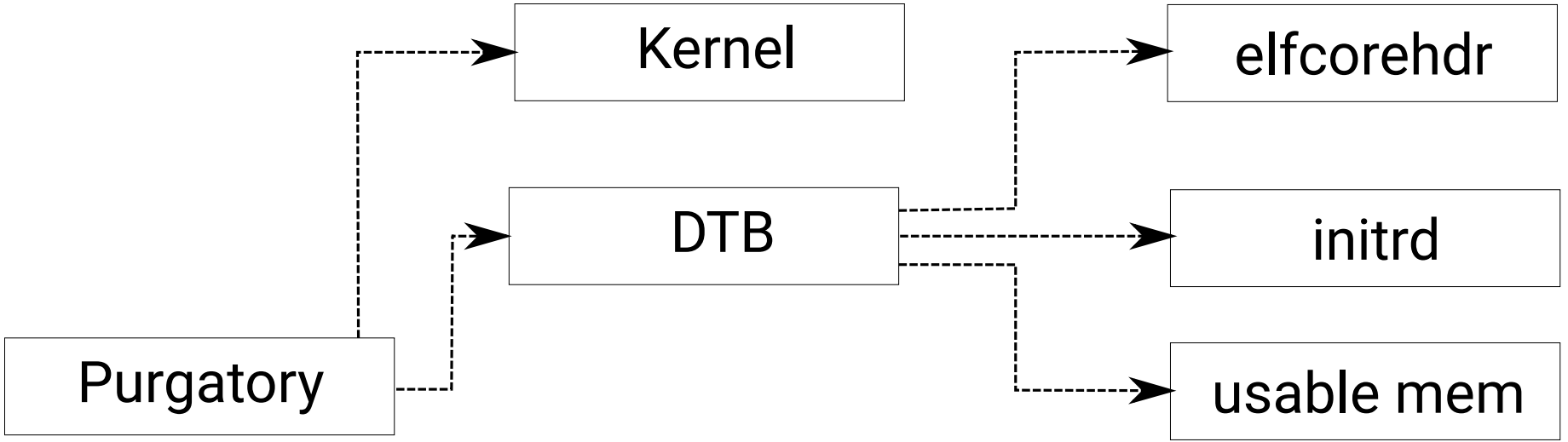
- He decides over heaven and hell
- Checks SHA265 of all segments but itself
- Loads kernel and device tree into registers
- Jumps to kernel



Purgatory - arm64

```
.globl purgatory_start
purgatory_start:

        adr     x19, .Lstack
        mov     sp, x19

        bl      purgatory

        /* Start new image. */
        ldr     x17, arm64_kernel_entry
        ldr     x0, arm64_dtb_addr
        mov     x1, xzr
        mov     x2, xzr
        mov     x3, xzr
        br      x17

.data

.globl arm64_kernel_entry

.globl arm64_dtb_addr

.end
```

Overview - arm64



kexec-tools

- kexec_load and kexec_file_load
- In kexec_load case information passed to the kernel
  - Purgatory entry point
  - Number and address of the segments

```
struct kexec_segment {
        const void *buf;
        size_t bufsz;
        const void *mem;
        size_t memsz;
};
```

Kernel part...
under the hood

Kernel internals

- Production kernel prepares capture kernel
  - kexec_load syscall
- Production kernel crashes
- Capture kernel boots up

Loading capture system

- Check we are root, flags and segment number
- Create kimage which holds
  - kexec_segments info from userspace
  - Purgatory entry point (image->start)
  - Memory for control page, allocated from reserved memory
  - Memory for data copy of vmcoreinfo

Checks (no one told you about...)

- Check sanity of segements
  - No overlap, page aligned, are in reserved memory area
  - segment.memsz >= segment.bufsz
- But also:
  - nr. pages of all segments.mem <= totalram_pages/2

```
struct kexec_segment {
        const void *buf;
        size_t bufsz;
        const void *mem;
        size_t memsz;
};
```

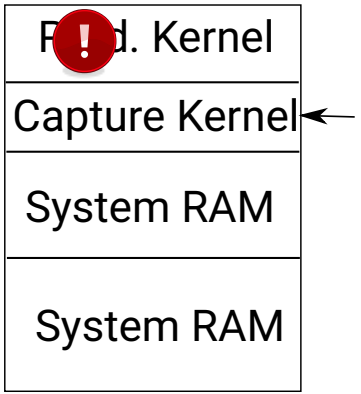
Loading capture system

- copy_from_user:
  - segment.buf to segment.mem (= reservered memory area)
- Protect segment.mem pages
  - Clear PTE_VALID bit for segment pages

```
struct kexec_segment {
        const void *buf;
        size_t bufsz;
        const void *mem;
        size_t memsz;
};
```

Kernel crashes

- Disable local IRQs, save CPU registers
- Write time of crash to (restored) vmcoreinfo
- Stop all other CPUs (IPI_CPU_CRASH_STOP)
  - Save CPU registers (crash_notes), disable local IRQs
  - Call PSCI cpu_die
- Check if all CPUs down
- Copy relocation code to control page

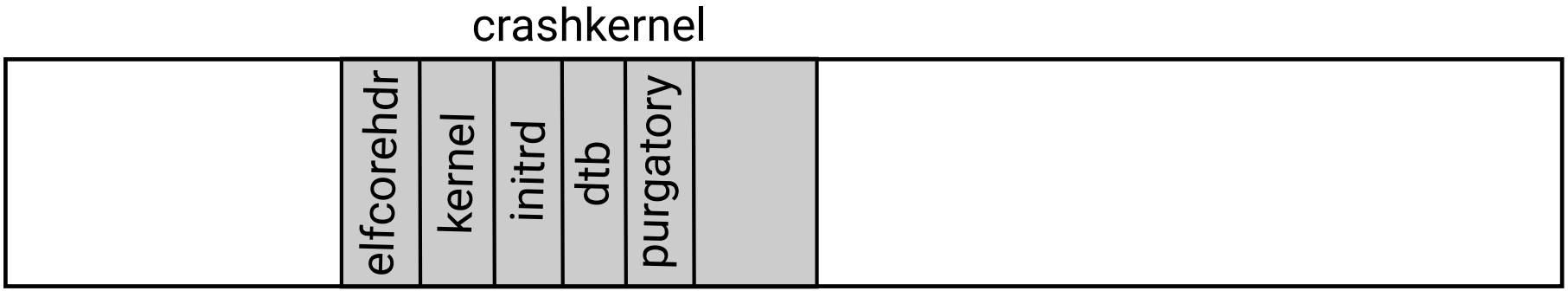


Kernel crashes

- Shutdown MMU, disable caches
- arm64_reloacte_new_kernel
  - Check if relocation needed
  - Jumps to purgatory (directly or through EL2)

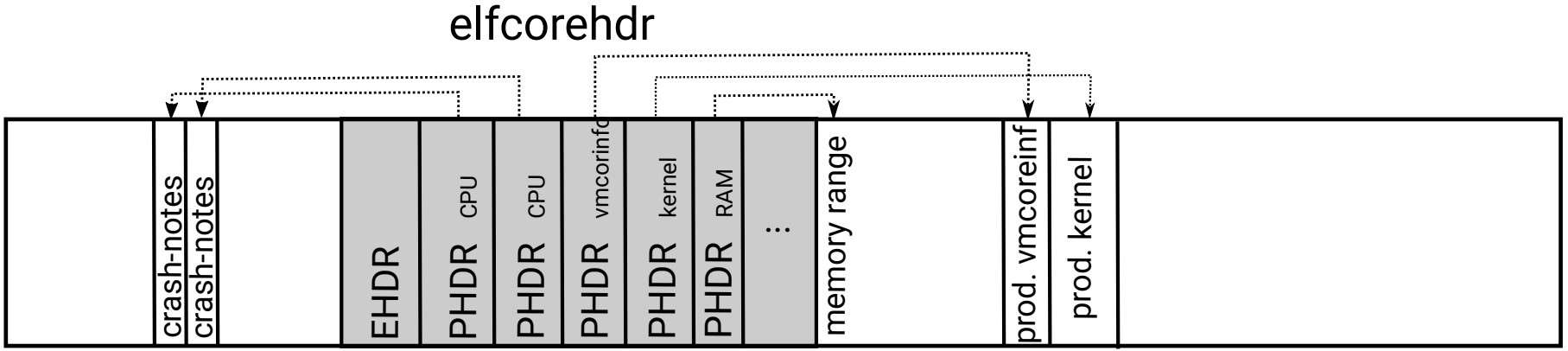
Capture kernel boot

- Special device tree includes
  - linux,elfcorehdr
  - linux,usable-memory-range
  - linux,initrd-start, linux,initrd-end



Capture kernel boot

- Reserves memory and copys content from elfcorehdr into elfcorehdr_buf (from capture kernel)
- When reading /proc/vmcore copy production kernel memory



Distribution parts

Distribution parts

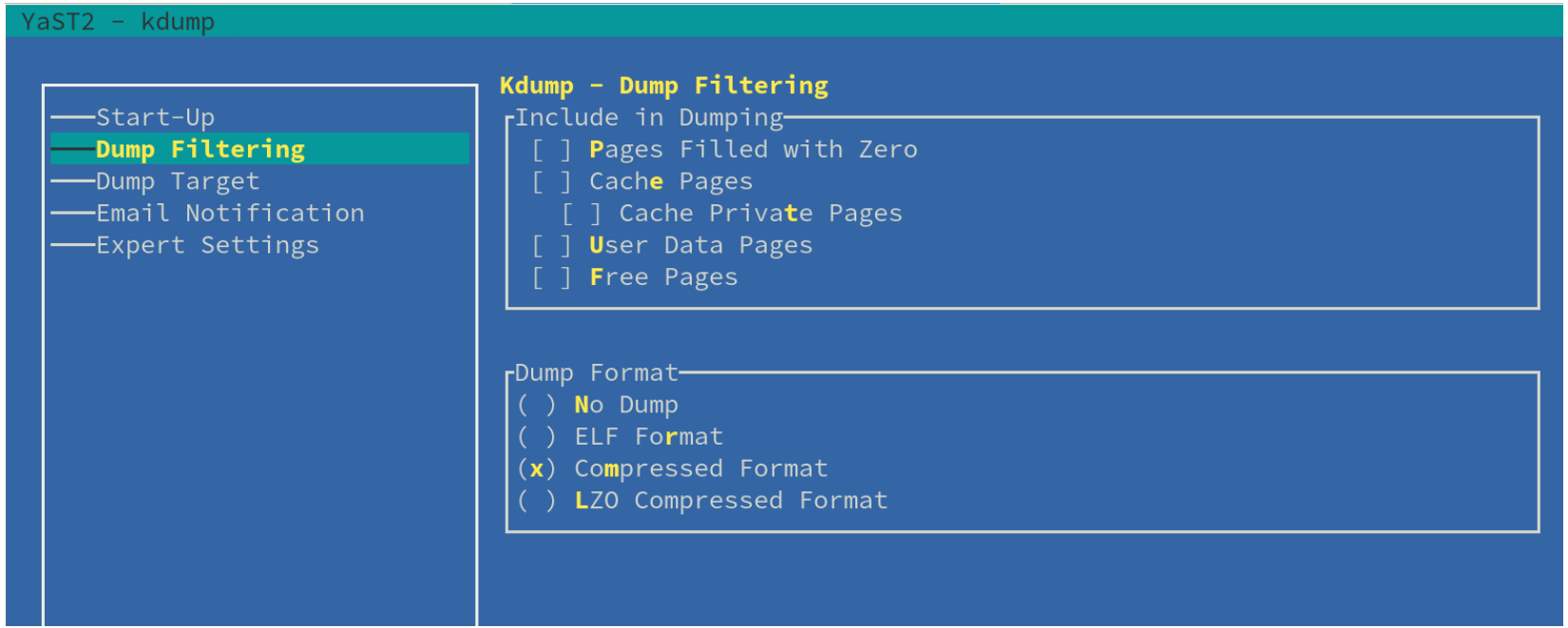
- Set up can be difficult
  - Reserved memory needed depends on system RAM + initrd size
  - Capture initrd should not be to big
  - ...but should have all the tools
  - Automatic storage of dump
  - Want to reboot to production system after crash?

Distribution parts

- SUSE Kdump – swissarmy knife for setting up kdump
  - Production system
    - Dracut scripts to create initrd
    - Bash scripts to load capture system
    - Tool to approximate size of reserved memory
  - Capture system
    - Configuration of dump creation
    - Where the dump gets stored

Distribution parts

- yast2 kdump is your friend!



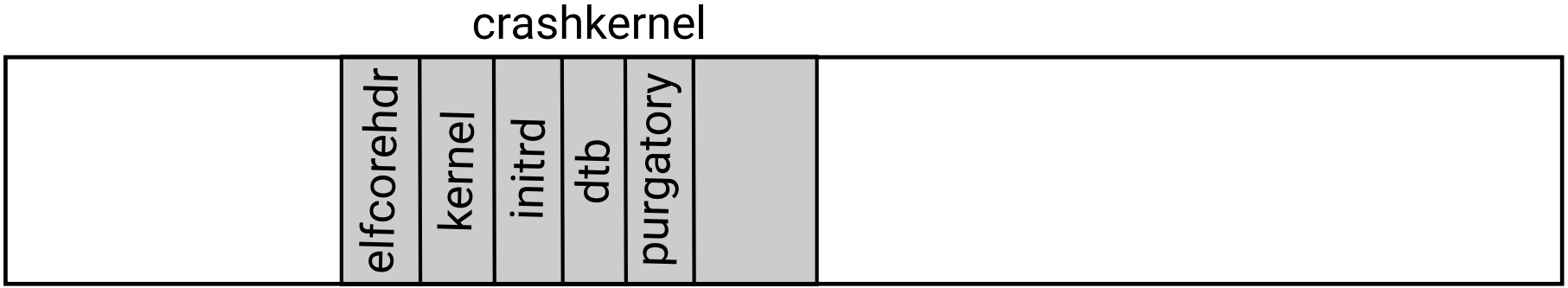
Quick demo

References

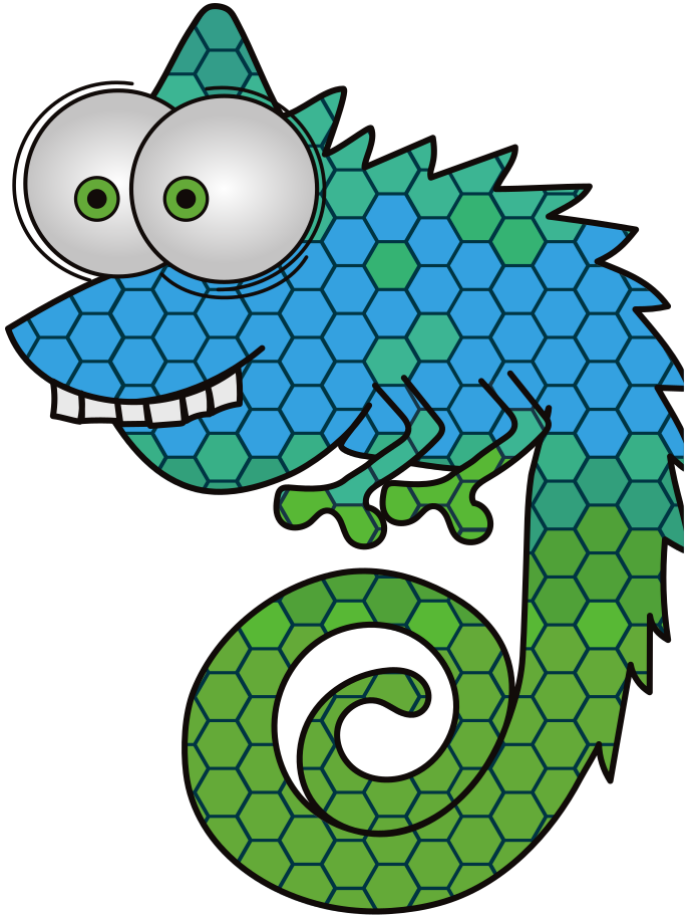
- kexec-tools source code
  - https://git.kernel.org/pub/scm/utils/kernel/kexec/kexec-tools.git/
- SUSE documentation
  - https://doc.opensuse.org/documentation/leap/tuning/html/book.sle.tuning/cha.tuning.kexec.html
- openSUSE Kdump
  - https://github.com/openSUSE/kdump/
- Blog explaining kexec/kdump
  - https://opensource.com/article/17/6/kdump-usage-and-internals

Take aways

- Production system has reserved memory area
- Capture system gets saved in this area
- Segment elfcoreheader points to the different physical memory location of the production system
- Capture system uses this information to create a dump



Questions?!



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