How to Avoid #ifdef Bugs in The Linux Kernel

Valentin Rothberg Daniel Lohmann

valentin.rothberg@lip6.fr dl@cs.fau.de

Inria / LIP6 Paris
and
System Software Group
Friedrich-Alexander University Erlangen-Nürnberg (FAU)

`https://www4.cs.fau.de/Research/CADOS/`

LPC '14

supported by DFG

What could possibly go wrong?

```
--- a/kernel/smp.c
+++ b/kernel/smp.c
@@ -34,8 +39,45 @@
[...]
+#ifdef CONFIG_CPU_HOTPLUG
+       case CPU_UP_CANCELED:
+       case CPU_UP_CANCELED_FROZEN:
+
+       case CPU_DEAD:
+       case CPU_DEAD_FROZEN:
+               free_cpumask_var(cfd->cpumask);
+               break;
+#endif
[...]
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- The kernel leaks memory!
- CONFIG_CPU_HOTPLUG does not exist
- CONFIG_HOTPLUG_CPU is the right option

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```

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```
#ifdef CONFIG_UNDEFINED

    /* I will never see the compiler :( */

#endif
```

- ... and **undead** `#ifdef` blocks

```
#ifdef !CONFIG_UNDEFINED

    /* I will always see the compiler :( */

#endif
```

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if UNDEFINED
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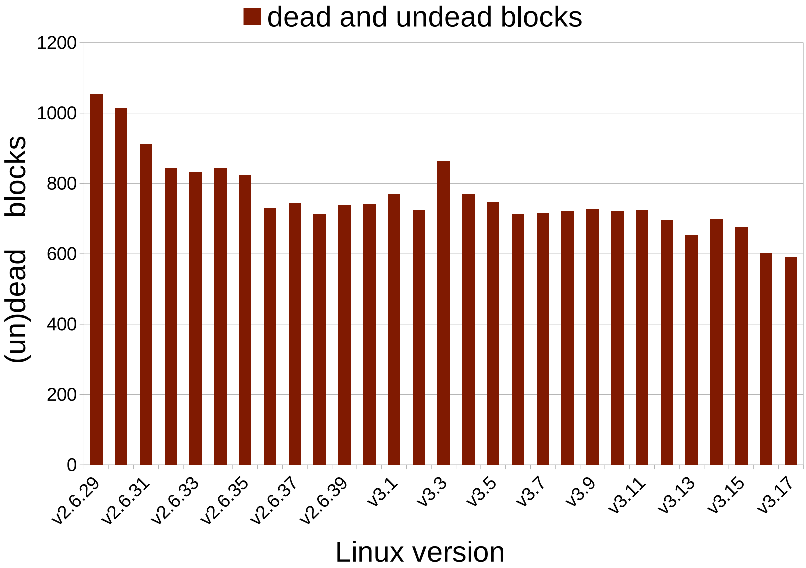
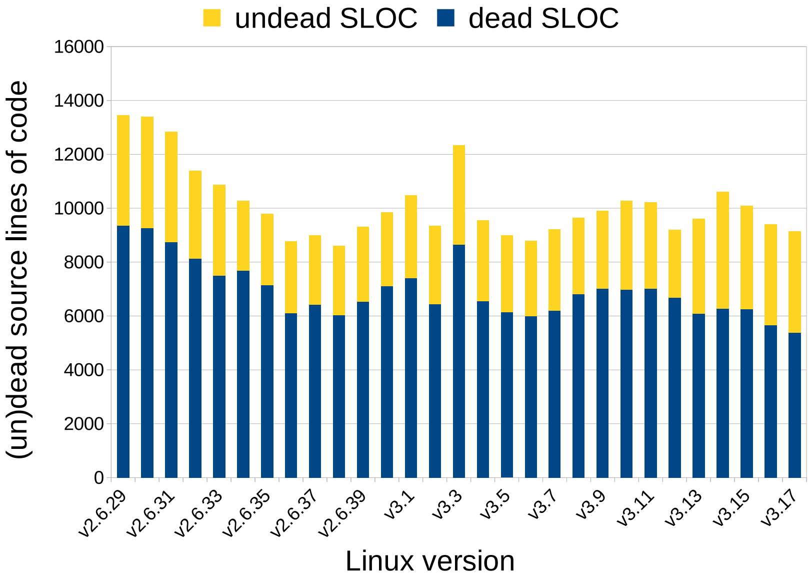
if UNDEFINED
    config HOTPLUG_CPU
        bool
```

- Such issues manifest in **dead** and **undead** `#ifdef` blocks

(Un)Dead `#ifdef` **blocks** per Linux version



(Un)Dead **SLOC** per Linux version



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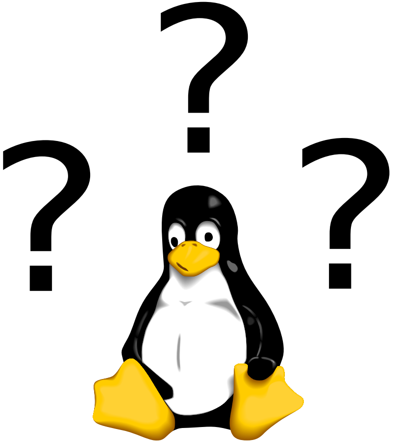
```
    [...]
#ifdef CONFIG_HIGHMEM_START_BOOL
    ioremap_base = CONFIG_HIGHMEM_START;
#else
    ioremap_base = 0xfe000000UL;   /* ... */
#endif /* CONFIG_HIGHMEM_START_BOOL */
    ioremap_bot = ioremap_base;

    /* Initialize the context management stuff */
    mmu_context_init();
}
```

How can we avoid these defects?



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- It reports if such bugs are added or repaired
- It analyzes the bugs and displays the bug-causing identifiers
- It prevents (un)dead blocks by checking Kconfig changes

Example: Is this patch okay?

```
--- a/arch/arm/mach-omap2/board-h4.c
+++ b/arch/arm/mach-omap2/board-h4.c
@@ -379,6 +379,39 @@ ...
         .ctrl_name      = "internal",
 };

+static struct omap_usb_config h4_usb_config ....
+#ifdef CONFIG_MACH_OMAP2_H4_USB1
+       /* NOTE:  usb1 could also be used with 3 ...
+       .pins[1]        = 4,
+#endif
+
+#ifdef CONFIG_MACH_OMAP_H4_OTG
+       /* S1.10 ON -- USB OTG port
...
```

No, it’s broken!

```
user@abc:∼linux$ undertaker-checkpatch patch
```

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New defect: arch/arm/mach-omap2/board-h4.c:
    B0:383:386:missing.globally.dead:
    CONFIG_MACH_OMAP2_H4_USB1 referenced but not defined

New defect: arch/arm/mach-omap2/board-h4.c:
    B1:388:403:missing.globally.dead:
    CONFIG_MACH_OMAP_H4_OTG referenced but not defined
```

Kconfig changes are critical

- Renaming / removing a feature without propagating the change

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```
--- a/arch/arm/mach-ixp23xx/Kconfig
+++ /dev/null
@@ -1,25 +0,0 @@
...
-config MACH_IXDP2351
-       bool "Support Intel IXDP2351 platform"
-       help
```

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...
-config MACH_IXDP2351
-       bool "Support Intel IXDP2351 platform"
-       help
```

- **undertaker-checkpatch** displays leftover references

```
Feature CONFIG_MACH_IXDP2351 is removed
    but still referenced in:
drivers/net/ethernet/cirrus/cs89x0.c:176:
#if defined(CONFIG_MACH_IXDP2351)
```

Example: Logical Constraints

```
#ifdef CONFIG_X86_X2APIC /* depends on INTR_REMAP */

#ifdef CONFIG_INTR_REMAP
    /* I am undead */
#else
    /* I am dead  */
#endif

#endif
```

[1] http://undertaker.cs.fau.de

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```

- **25%** of (un)dead blocks are caused on a logic level
- I use the **Undertaker** [1] toolsuite to detect such logic issues

[1] http://undertaker.cs.fau.de

Conclusion

- **undertaker-checkpatch** detects, and further analyzes `#ifdef` bugs

[2] https://www4.cs.fau.de/Publications/2014/tartler_14_usenix.pdf

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  - Helps to detect and analyze **symbolic** and **logic defects**

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"Frankly, most of the sw configuration ones tend to be annoyances rather than anything hugely fundamental. Compile warnings or failures that developers don't notice because it's not the configuration they use." [Linus Torvalds]

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⇒ We have a tool to do that, the **Vampyr** [2]

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Interested?

- Download and try the tool:

  `http://undertaker.cs.fau.de`

- More information and papers on the project's website:

  `https://cados.cs.fau.de`

- Questions? Contact me directly ...

  valentin.rothberg@lip6.fr

- ... or write to our mailing list!

  cados-dev@lists.cs.fau.de