

# Linux Kernel Development

Greg Kroah-Hartman  
[gregkh@linuxfoundation.org](mailto:gregkh@linuxfoundation.org)

[github.com/gregkh/kernel-development](https://github.com/gregkh/kernel-development)

**47,000 files**  
**18,900,000 lines**

3,483 developers  
439 companies

8,300 lines added  
4,650 lines removed  
1,900 lines modified

8,300 lines added

4,650 lines removed

1,900 lines modified

Every day

# 7.8 changes per hour

Kernel releases 3.12.0 – 3.17.0  
November 2013 – October 2014

9.5 changes per hour

3.16 release

# How we stay sane

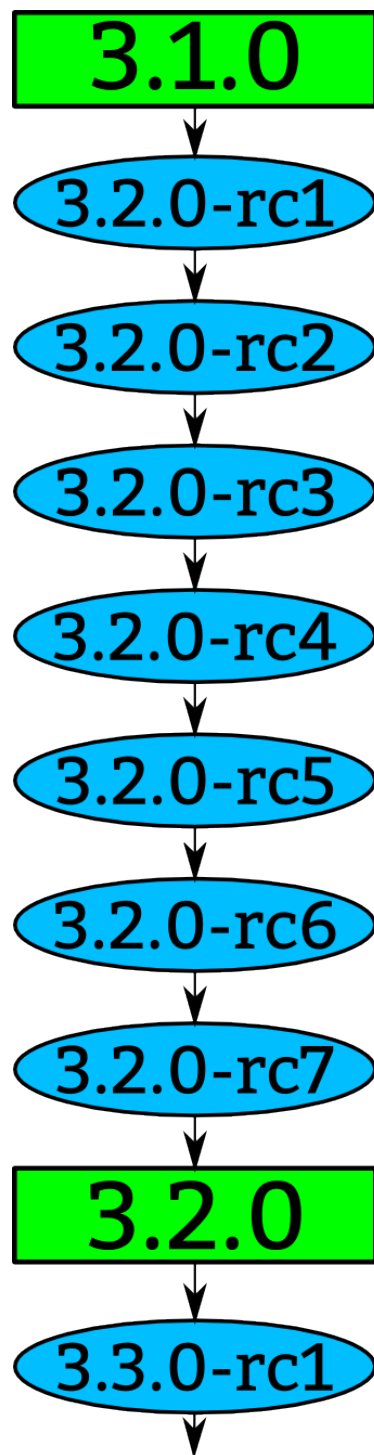
## Time based releases

## Incremental changes





**New release every  
2½ months**





# “Longterm kernels”

One picked per year

Maintained for two years

3.10    3.14

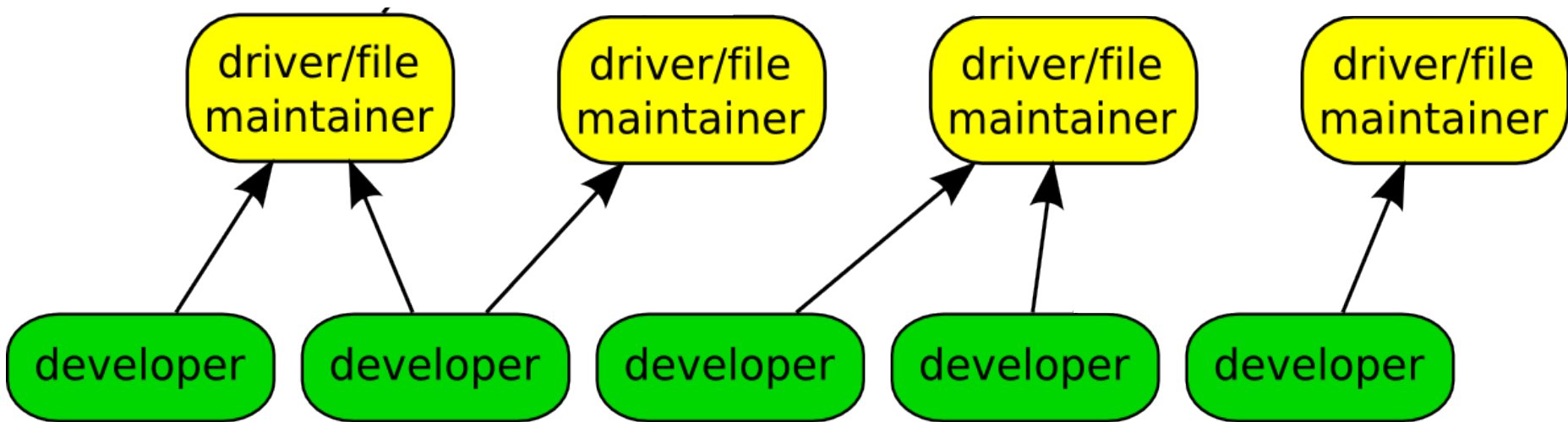
developer

developer

developer

developer

developer



commit ecf85e481a716cfe07406439fdc7ba9526bbfaeb  
Author: Robert Jarzmik <robert.jarzmik@free.fr>  
AuthorDate: Tue Apr 21 20:33:10 2009 -0700  
Commit: Greg Kroah-Hartman <gregkh@suse.de>  
CommitDate: Thu Apr 23 14:15:31 2009 -0700

USB: otg: Fix bug on remove path without transceiver

In the case where a gadget driver is removed while no transceiver was found at probe time, a bug in otg\_put\_transceiver() will trigger.

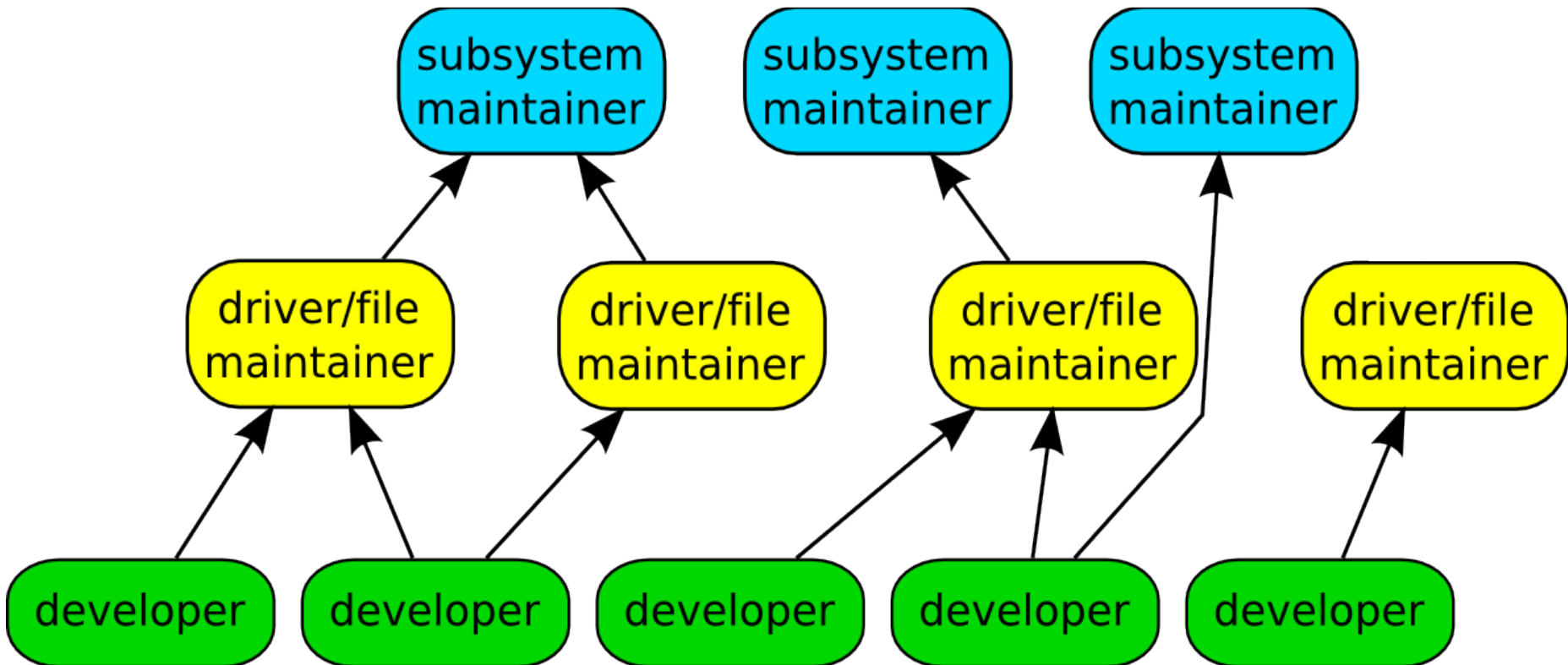
Signed-off-by: Robert Jarzmik <robert.jarzmik@free.fr>  
Acked-by: David Brownell <dbrownell@users.sourceforge.net>  
Signed-off-by: Greg Kroah-Hartman <gregkh@suse.de>

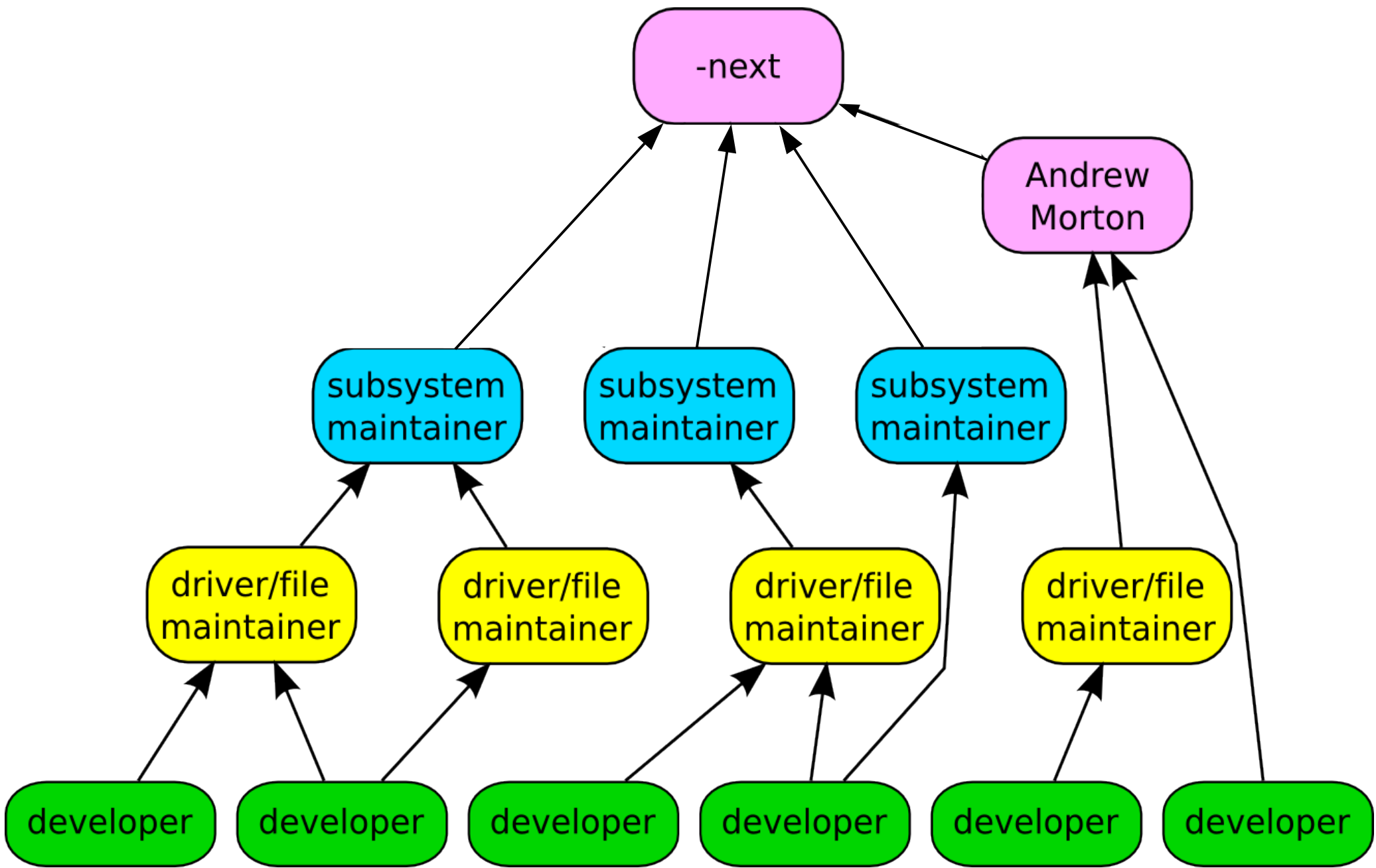
```
--- a/drivers/usb/otg/otg.c
+++ b/drivers/usb/otg/otg.c
@@ -43,7 +43,8 @@ EXPORT_SYMBOL(otg_get_transceiver);
 void otg_put_transceiver(struct otg_transceiver *x)
 {
-    put_device(x->dev);
+    if (x)
+        put_device(x->dev);
 }
```

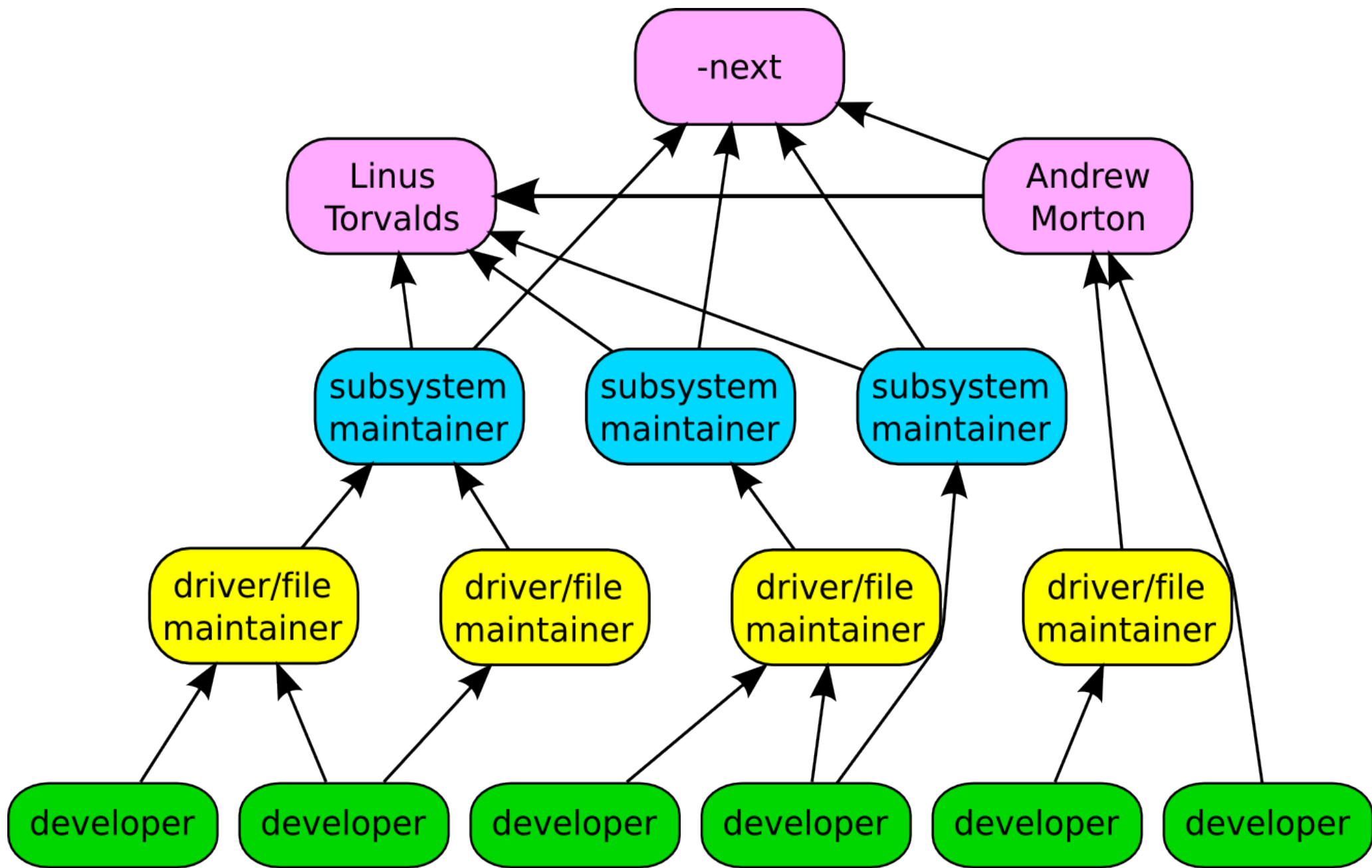
# Developer's Certificate of Origin

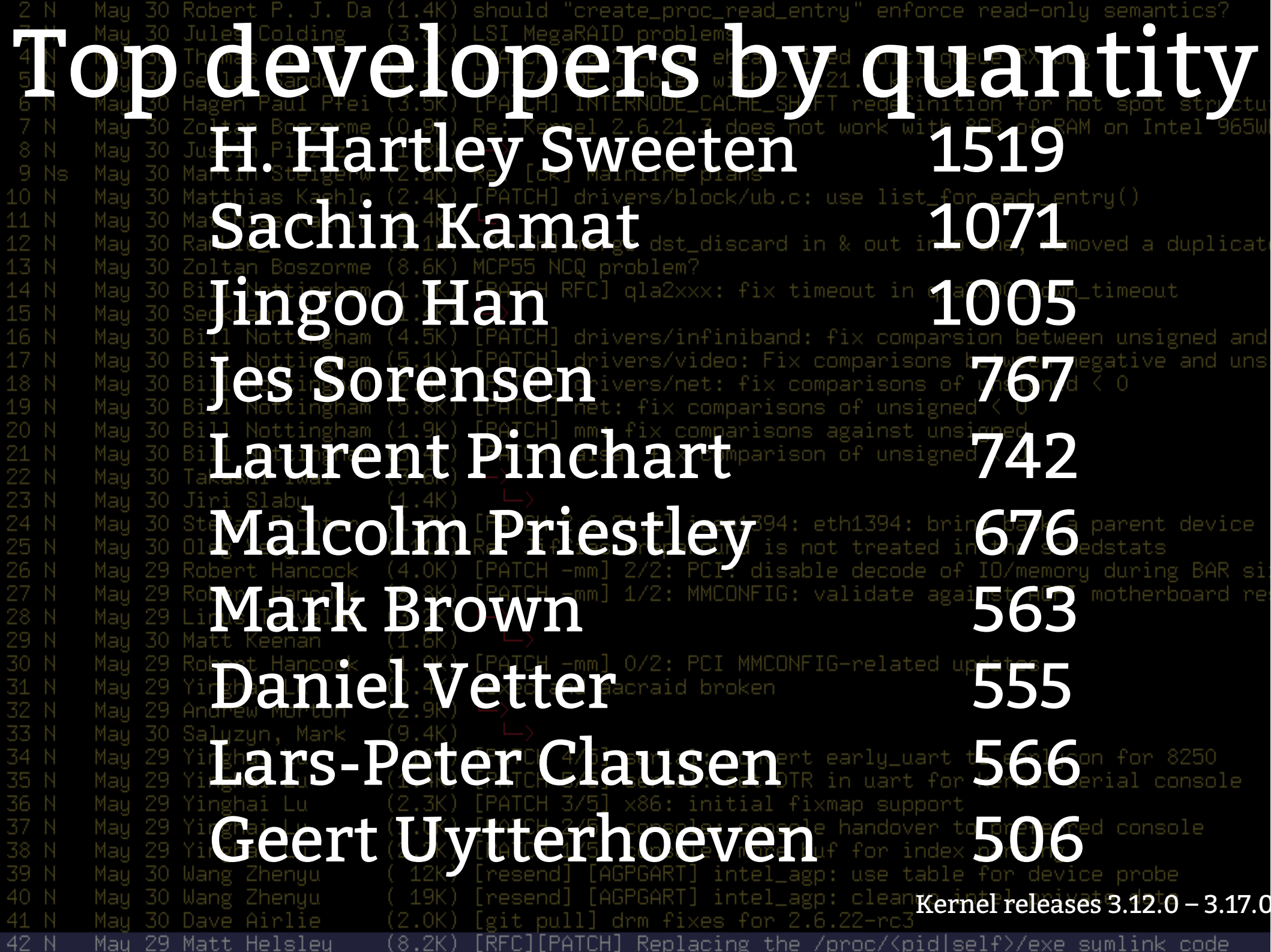
- (a) I created this change; or
- (b) Based this on a previous work with a compatible license; or
- (c) Provided to me by (a), (b), or (c) and not modified
- (d) This contribution is public.











# Top Signed-off-by:

Greg Kroah-Hartman 10483

David S. Miller 5978

Mark Brown 3655

Linus Torvalds 2977

Andrew Morton 2807

Daniel Vetter 2558

Mauro Carvalho Chehab 2277

John Linville 1706

Rafael Wysocki 1608

H Hartley Sweeten 1519

Kernel releases 3.12.0 – 3.17.0

# Who is funding this work?



1. Intel	10.6%
2. “Amateurs”	10.3%
3. Red Hat	8.4%
4. Unknown Individuals	7.3%
5. Linaro	5.6%
6. Samsung	4.4%
7. IBM	3.0%
8. SuSE	3.0%
9. Consultants	2.6%
10. Texas Instruments	2.4%

# Who is funding this work?



11. Vision Engraving	2.0%
12. Google	2.0%
13. Renesas	2.0%
14. Freescale	1.8%
15. Free Electrons	1.6%
16. Nvidia	1.2%
17. FOSS OPFW	1.2%
18. Oracle	1.2%
19. AMD	1.0%
20. Huawei	0.9%

# “Working upstream saves time and money”

Dan Frye – VP Open Systems, IBM

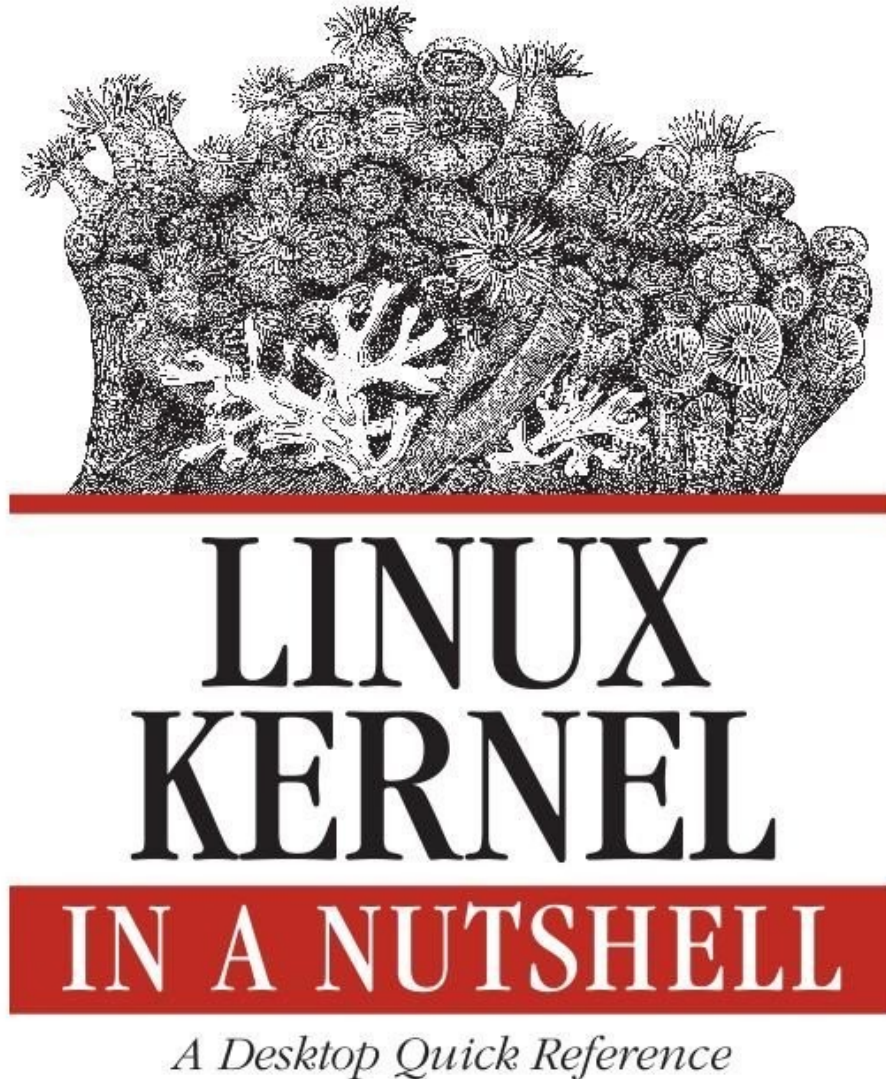
Dirk Hohndel – Chief Technologist, Intel



# Getting involved

Run the kernel.org release on your machine

# Getting involved



# Getting involved

**Documentation/HOWTO**

**Documentation/development-process**

# Getting involved

[kernelnewbies.org](http://kernelnewbies.org)



# Getting involved

Google “write your first kernel patch”

# Getting involved

[kernelnewbies.org/KernelJanitors/ToDo](https://kernelnewbies.org/KernelJanitors/ToDo)

# Getting involved

Eudiptula Challenge  
(little penguin)

<http://eudiptula-challenge.org/>

# Getting involved

Linux Driver Project

`drivers/staging/*/TODO`





[github.com/gregkh/kernel-development](https://github.com/gregkh/kernel-development)



# Linux Kernel Development

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I'm going to discuss the how fast the kernel is moving, how we do it all, and how you can get involved.

**47,000 files**  
**18,900,000 lines**

Kernel release 3.17.0

This was for the 3.17 kernel release, which happened October 5, 2014.

The 3.17 kernel is the only release we have had in the past 4 years that we went down in size, this has only happened twice in the past 10 years.

# 3,483 developers 439 companies

Kernel releases 3.12.0 – 3.17.0  
November 2013 – October 2014

This makes the Linux kernel the largest contributed body of software out there that we know of.

This is just the number of companies that we know about, there are more that we do not, and as the responses to our inquiries come in, this number will go up.

Have surpassed 400 companies for 2 years now.

**8,300 lines added**  
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**1,900 lines modified**

Kernel releases 3.12.0 – 3.17.0  
November 2013 – October 2014

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Every day

Kernel releases 3.12.0 – 3.17.0  
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# 7.8 changes per hour

Kernel releases 3.12.0 – 3.17.0  
November 2013 – October 2014

This is 24 hours a day, 7 days a week, for a full year.

We went this fast the year before this as well, this is an amazing rate of change.

Interesting note, all of these changes are all through the whole kernel.

For example, the core kernel is only 5% of the code, and 5% of the change was to the core kernel. Drivers are 55%, and 55% was done to them, it's completely proportional all across the whole kernel.



# 9.5 changes per hour

## 3.16 release

This past 3.16 release was the fastest we have ever created. That number shows just how well the Linux kernel development model is working. We are growing in developers and in how fast we are developing overall.

Now this is just the patches we accepted, not all of the patches that have been submitted, lots of patches are rejected, as anyone who has ever tried to submit a patch can attest to.

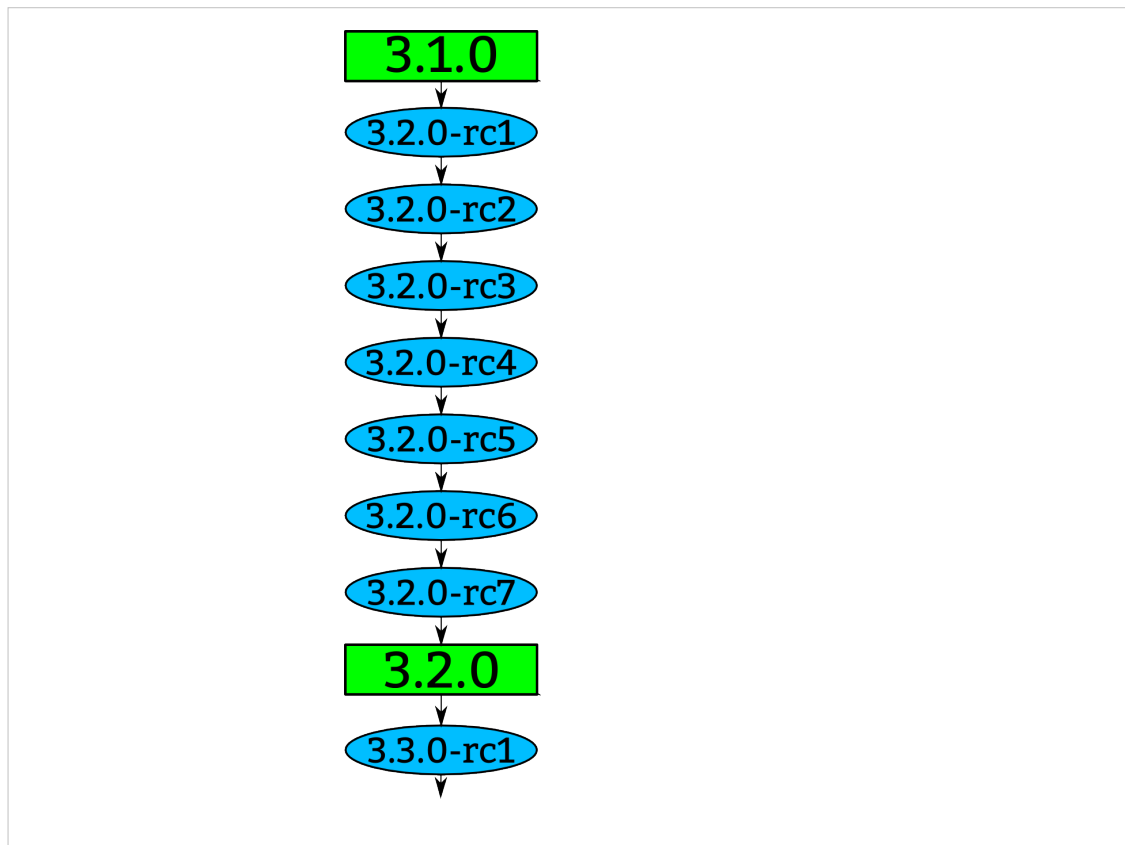
# How we stay sane

## Time based releases

## Incremental changes



67 days to be exact, very regular experience.



How a kernel is developed.

Linus releases a stable kernel

- 2 week merge window from subsystem maintainers

- rc1 is released

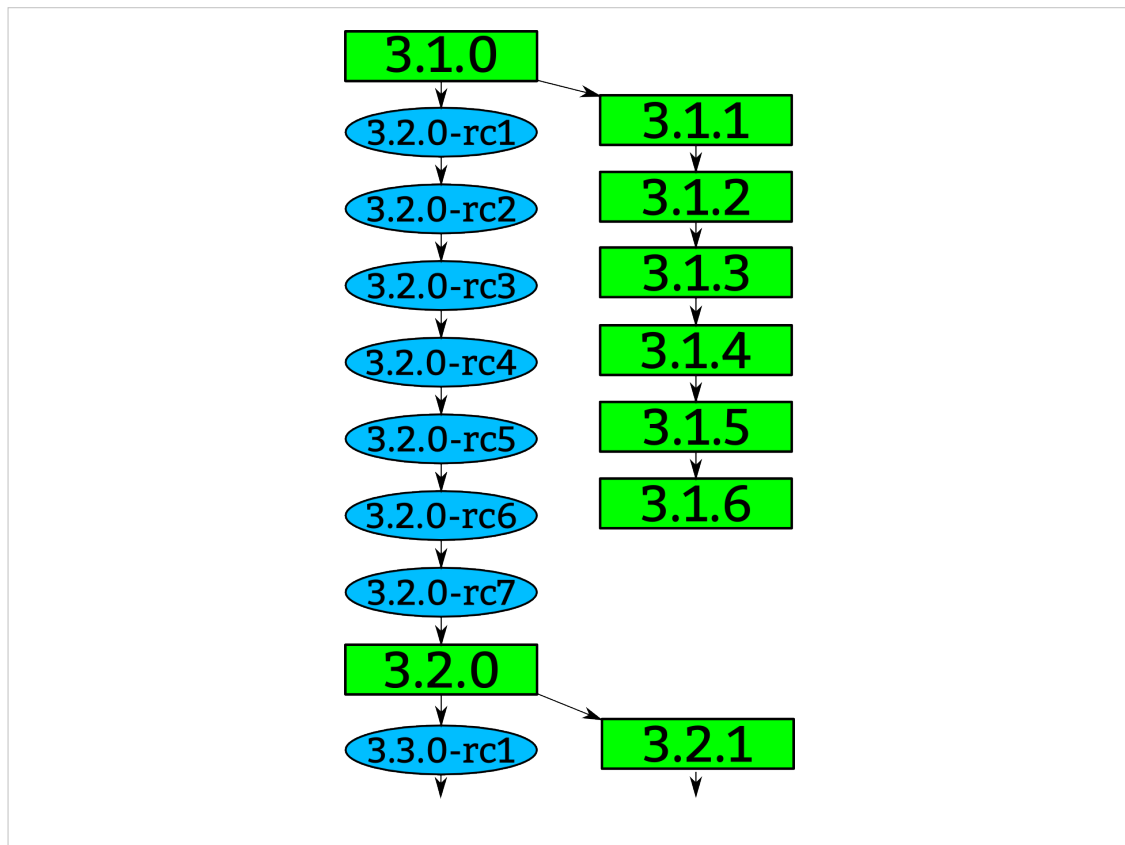
- bugfixes only now

- 2 weeks later, rc2

- bugfixes and regressions

- 2 weeks later, rc3

And so on until all major bugfixes and regressions are resolved and then the cycle starts over again.



Greg takes the stable releases from Linus, and does stable releases with them, applying only fixes that are already in Linus's tree.

Requiring fixes to be in Linus's tree first ensures that there is no divergence in the development model.

After Linus releases a new stable release, the old stable series is dropped.

With the exception of “longterm” stable releases, those are special, the stick around for much longer...

# “Longterm kernels”

One picked per year  
Maintained for two years

3.10 3.14

I pick one kernel release per year to maintain for longer than one release cycle. This kernel I will maintain for at least 2 years.

This means there are 2 longterm kernels being maintained at the same time.

3.4 and 3.10 are the longterm kernel releases I am maintaining.

3.4 will stop being maintained in October.

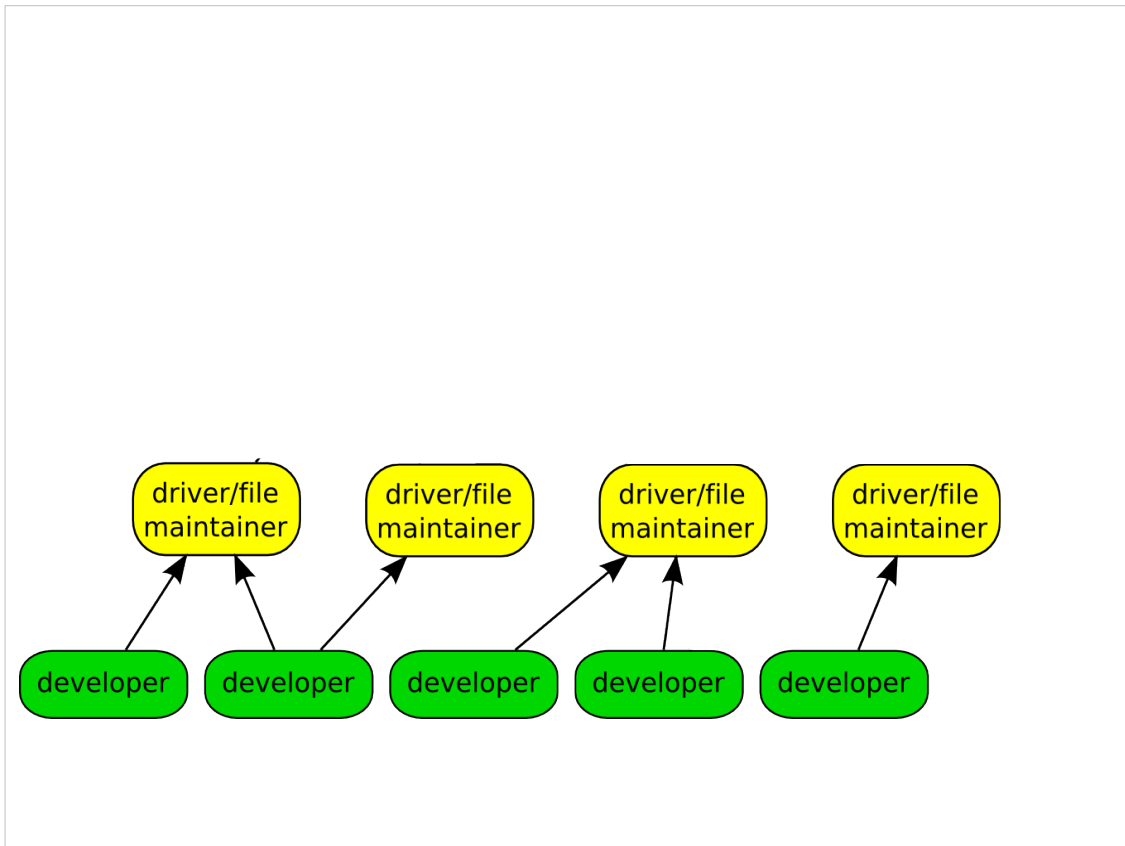
Ben Hutchings is maintaining the 3.2 kernel as a longterm kernel for the Debian project.

The LTSI project is based on the longterm kernels.



Like mentioned before, we have almost 3000 individual contributors. They all create a patch, a single change to the Linux kernel. This change could be something small, like a spelling correction, or something larger, like a whole new driver.

Every patch that is created only does one thing, and it can not break the build, complex changes to the kernel get broken up into smaller pieces.



The developers send their patch to the maintainer of the file(s) that they have modified.

We have about 700 different driver/file/subsystem maintainers



```
commit ecf85e481a716cfe07406439fdc7ba9526bbfaeb
Author:      Robert Jarzmik <robert.jarzmik@free.fr>
AuthorDate:  Tue Apr 21 20:33:10 2009 -0700
Commit:      Greg Kroah-Hartman <gregkh@suse.de>
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    USB: otg: Fix bug on remove path without transceiver

    In the case where a gadget driver is removed while no
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    Signed-off-by: Robert Jarzmik <robert.jarzmik@free.fr>
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--- a/drivers/usb/otg/otg.c
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@@ -43,7 +43,8 @@ EXPORT_SYMBOL(otg_get_transceiver);
 void otg_put_transceiver(struct otg_transceiver *x)
 {
-    put_device(x->dev);
+    if (x)
+        put_device(x->dev);
 }
```

This is an example of a patch.

It came from Robert, was acked by David, the maintainer at the time of the usb on-the-go subsystem, and then signed off by by me before it was committed to the kernel tree.

The change did one thing, it checked the value of the pointer before it was dereferenced, fixing a bug that would have crashed the kernel if it had been hit.

This is also a “blame” trail, showing who changed each line in the kernel, and who agreed with that change.

If a problem is found, these are the developers that you can ask about it.

Because of this, every line in the Linux kernel can be traced back to at least two developers who are responsible for it.

This is better than any other body of code.

## Developer's Certificate of Origin

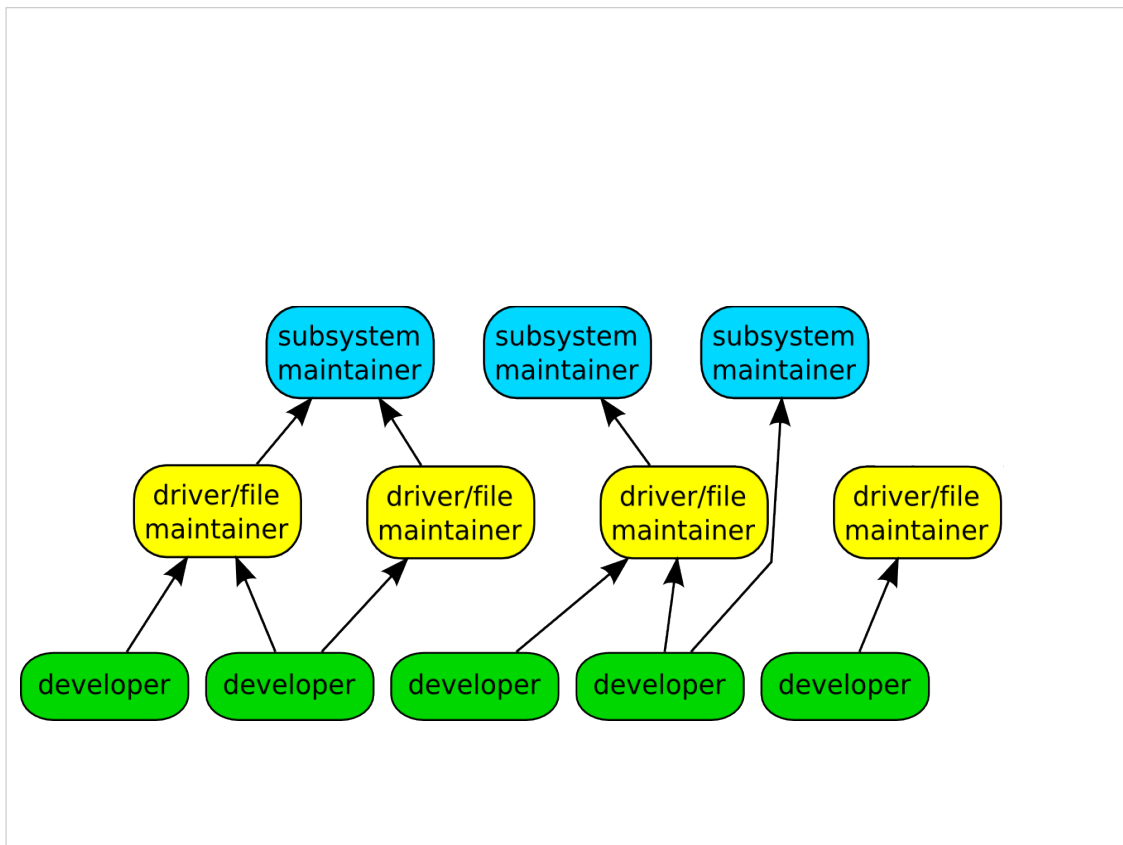
- (a) I created this change; or
- (b) Based this on a previous work with a compatible license; or
- (c) Provided to me by (a), (b), or (c) and not modified
- (d) This contribution is public.

This is what “Signed-off-by:” means. All contributions to the Linux kernel have to agree to this, and every single patch has at least one signed-off-by line, usually all have at least two.

This is also a “blame” trail, showing who changed each line in the kernel, and who agreed with that change.

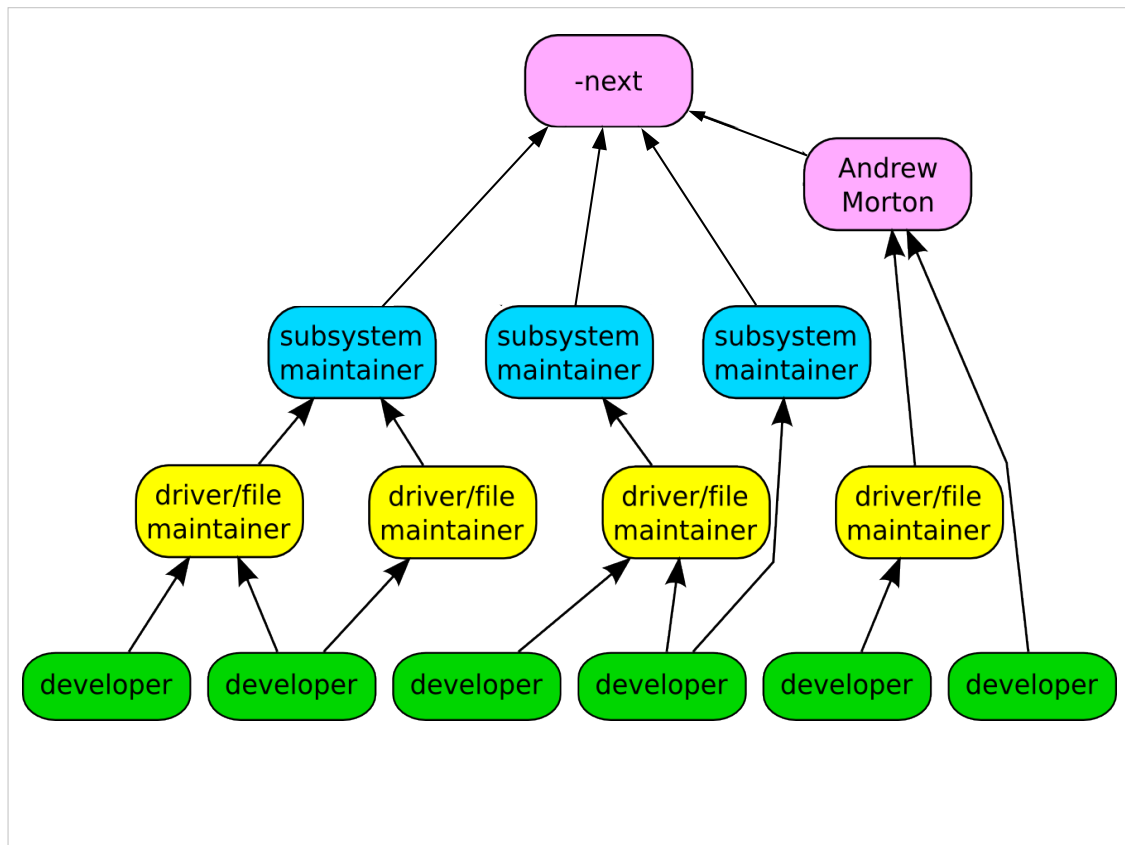
If a problem is found, this is the developers that you can ask about it.

Because of this, every line in the Linux kernel can be traced back to at least two developers who are responsible for it. This is better than any other body of code.



After reviewing the code, and adding their own signed-off-by to the patch, the file/driver maintainer sends the patch to the subsystem maintainer responsible for that portion of the kernel.

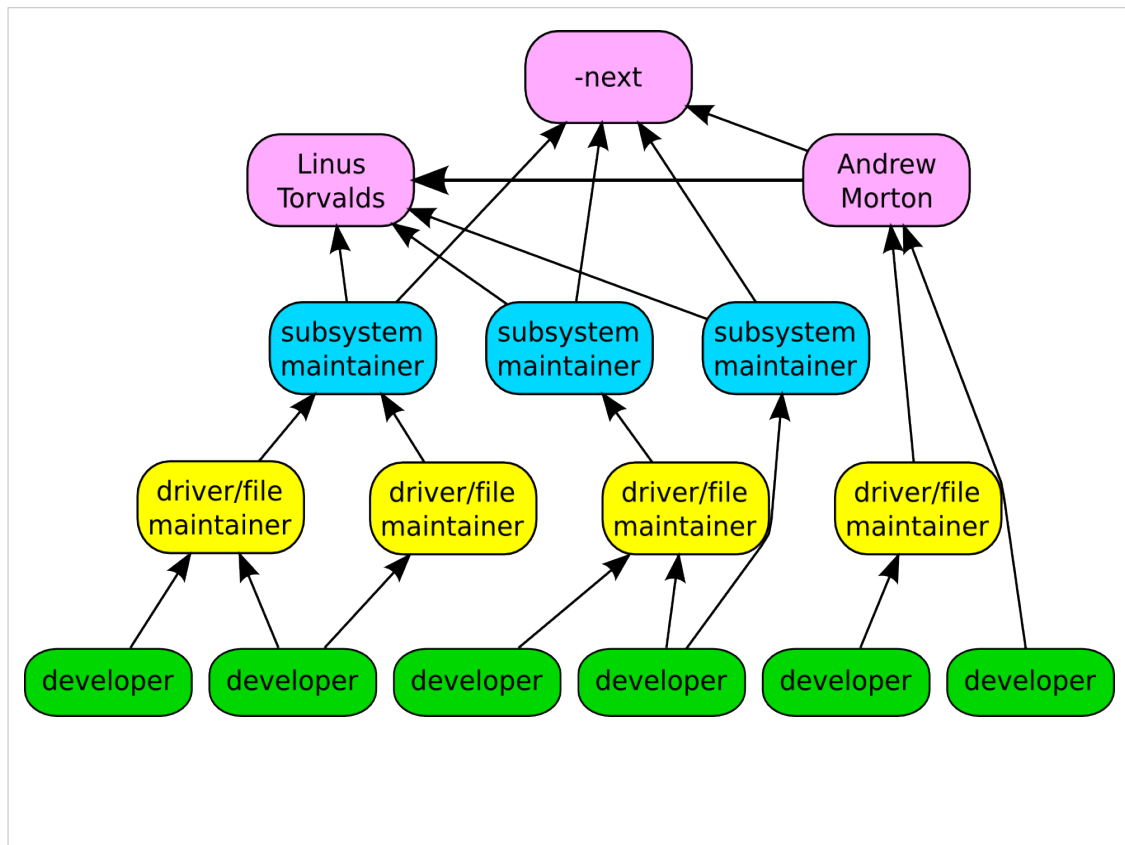
We have around 150 subsystem maintainers



Linux-next gets created every night from all of the different subsystem trees and build tested on a wide range of different platforms.

We have about 150 different trees in the linux-next release.

Andrew Morton picks up patches that cross subsystems, or are missed by others, and releases his -mm kernels every few weeks. This includes the linux-next release at that time.



Every 3 months, when the merge window opens up, everything gets sent to Linus from the subsystem maintainers and Andrew Morton.

The merge window is 2 weeks long, and thousands of patches get merged in that short time.

All of the patches merged to Linus should have been in the linux-next release, but that isn't always the case for various reasons.

Linux-next can not just be sent to Linus as there are things in there that sometimes are not good enough to be merged just yet, it is up to the individual subsystem maintainer to decide what to merge.

Top developers by quantity		
2 N	May 30 Robert P. J. Da	(1.4K) should "create_proc_read_entry" enforce read-only semantics?
4 N	May 30 Jules Colding	(3.1K) LSI MegaRAID problem
5 N	May 30 Thomas	(1.7K) [PATCH] ethernet: add support for 1000base-t
6 N	May 30 Hagen Paul Pfei	(3.5K) [PATCH] INTERNUDE_CACHE_SHIFT red definition for hot spot stratu
7 N	May 30 Zoltan Boszorm	(0.5K) Re: Kernel 2.6.21.5 does not work with 256M of RAM on Intel 965W
8 N	May 30 Justin P	(1.1K) [PATCH] net: fix comparisons of unsigned < 0
9 Ns	May 30 Martin Steigelm	(2.8K) [PATCH] mainline plane
10 N	May 30 Matthias Kahl	(2.4K) [PATCH] drivers/block/ub.c: use list_for_each_entry()
11 N	May 30	(1.4K) [PATCH] net: fix comparisons of unsigned < 0
12 N	May 30	(1.4K) [PATCH] net: fix comparisons of unsigned < 0
13 N	May 30 Zoltan Boszorm	(8.6K) MCP55 NCQ problem?
14 N	May 30 Bill Nottingham	(1.9K) [PATCH] RFC] qla2xxx: fix timeout in qla2xxx_timeout
15 N	May 30	(1.4K) [PATCH] net: fix comparisons of unsigned < 0
16 N	May 30 Bill Nottingham	(4.5K) [PATCH] drivers/infiniband: fix comparison between unsigned and
17 N	May 30 Bill Nottingham	(5.1K) [PATCH] drivers/video: Fix comparisons of unsigned < 0
18 N	May 30 Bill Nottingham	(5.1K) [PATCH] drivers/net: fix comparisons of unsigned < 0
19 N	May 30 Bill Nottingham	(3.8K) [PATCH] net: fix comparisons of unsigned < 0
20 N	May 30 Bill Nottingham	(1.9K) [PATCH] mm: fix comparisons against unsigned
21 N	May 30 Bill Nottingham	(1.9K) [PATCH] mm: fix comparisons against unsigned
22 N	May 30 Takashi	(1.3K) [PATCH] net: fix comparisons of unsigned < 0
23 N	May 30 Jiri Slaby	(1.4K) [PATCH] net: fix comparisons of unsigned < 0
24 N	May 30	(1.4K) [PATCH] net: fix comparisons of unsigned < 0
25 N	May 30	(1.4K) [PATCH] net: fix comparisons of unsigned < 0
26 N	May 29 Robert Hancock	(4.0K) [PATCH -mm] 2/2: PCI: disable decode of IO/memory during BAR si
27 N	May 29 Robert Hancock	(4.0K) [PATCH -mm] 1/2: MMCONFIF: validate against motherboard re
28 N	May 29	(1.9K) [PATCH] net: fix comparisons of unsigned < 0
29 N	May 30 Matt Keenan	(1.9K) [PATCH] net: fix comparisons of unsigned < 0
30 N	May 29 Robert Hancock	(1.9K) [PATCH -mm] 0/2: PCI MMCONFIF-related updat
31 N	May 29 Yinghai	(0.4K) [PATCH] net: fix comparisons of unsigned < 0
32 N	May 29 Andrew	(1.9K) [PATCH] net: fix comparisons of unsigned < 0
33 N	May 30 Saluzyn, Mark	(8.4K) [PATCH] net: fix comparisons of unsigned < 0
34 N	May 29 Yinghai	(1.9K) [PATCH] net: fix comparisons of unsigned < 0
35 N	May 29 Yinghai	(1.9K) [PATCH] net: fix comparisons of unsigned < 0
36 N	May 29 Yinghai Lu	(2.3K) [PATCH 3/5] x86: initial fixmap support
37 N	May 29 Yinghai	(1.9K) [PATCH] net: fix comparisons of unsigned < 0
38 N	May 29 Yinghai	(1.9K) [PATCH] net: fix comparisons of unsigned < 0
39 N	May 30 Wang Zhenyu	(1.2K) [resend] [AGPGART] intel_agp: use table for device probe
40 N	May 30 Wang Zhenyu	(1.9K) [resend] [AGPGART] intel_agp: clean up intel_agp
41 N	May 30 Dave Airlie	(2.0K) [git pull] drm fixes for 2.6.22-rc3
42 N	May 29 Matt Helsley	(8.2K) [RFC][PATCH] Replacing the /proc/<pid/>/exe symlink code

Kernel releases 3.12.0 – 3.17.0

Hartley – comedi

Sachin – exynos ARM platform

Jingoo – backlight / framebuffer

Jes – a wireless driver

Laurent – video camera drivers

Malcolm – wireless driver work

Mark – embedded sound

Daniel – Intel graphics driver

Lars – sound

Geert – janitorial

Top Signed-off-by:		
Greg Kroah-Hartman	10483	
David S. Miller	5978	
Mark Brown	3655	
Linus Torvalds	2977	
Andrew Morton	2807	
Daniel Vetter	2558	
Mauro Carvalho Chehab	2277	
John Linville	1706	
Rafael Wysocki	1608	
H Hartley Sweeten	1519	

Kernel releases 3.12.0 – 3.17.0

Greg – driver core, usb, staging

David – networking, isa

Mark – embedded sound

Linus – everything

Andrew – everything

Daniel – Intel graphics

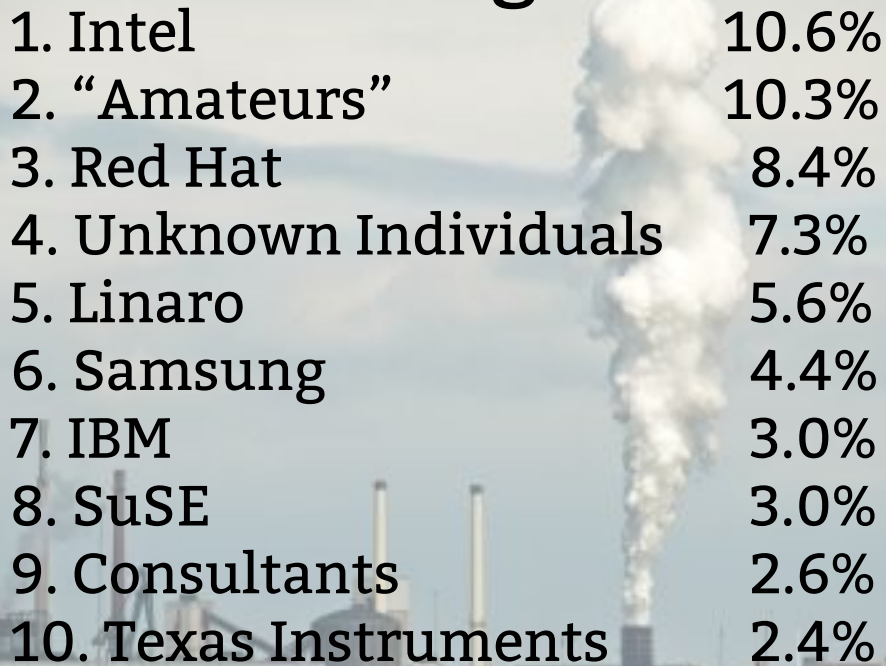
Mauro – v4l

John – wireless networking

Rafael – ACPI / power management

Hartley – comedi data acquisition

# Who is funding this work?



1. Intel	10.6%
2. "Amateurs"	10.3%
3. Red Hat	8.4%
4. Unknown Individuals	7.3%
5. Linaro	5.6%
6. Samsung	4.4%
7. IBM	3.0%
8. SuSE	3.0%
9. Consultants	2.6%
10. Texas Instruments	2.4%

Kernel releases 3.12.0 – 3.17.0

So you can view this as either 17% is done by non-affiliated people, or 83% is done by companies.

Now to be fair, if you show any skill in kernel development you are instantly hired.

Why this all matters: If your company relies on Linux, and it depends on the future of Linux supporting your needs, then you either trust these other companies are developing Linux in ways that will benefit you, or you need to get involved to make sure Linux works properly for your workloads and needs.



# Who is funding this work?



11. Vision Engraving	2.0%
12. Google	2.0%
13. Renesas	2.0%
14. Freescale	1.8%
15. Free Electrons	1.6%
16. Nvidia	1.2%
17. FOSS OPFW	1.2%
18. Oracle	1.2%
19. AMD	1.0%
20. Huawei	0.9%

Kernel releases 3.12.0 – 3.17.0

Vision Engraving (Hartley 1519 patches)  
Google, 1493 patches

FOSS Outreach Program for Women 900  
patches  
20 women interns / students

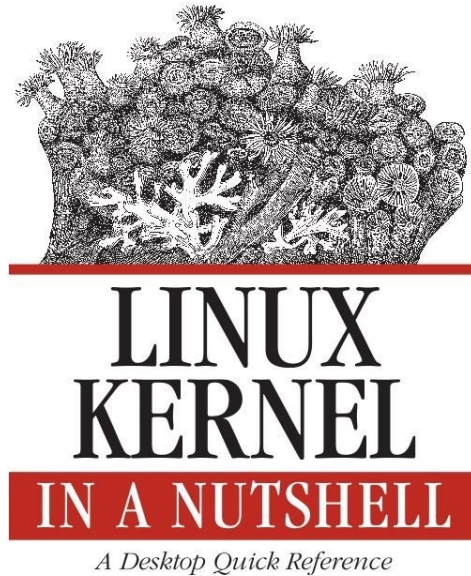
# “Working upstream saves time and money”

Dan Frye – VP Open Systems, IBM  
Dirk Hohndel – Chief Technologist, Intel

# Getting involved

Run the kernel.org release on your machine

# Getting involved



This book tells you how to build and install a kernel on your machine.

Free online

# Getting involved

`Documentation/HOWTO`

`Documentation/development-process`

These documents in the kernel source directory are the best place to start if you want to understand how the development process works, and how to get involved.

The HOWTO file has links to almost everything else you ever wanted..

# Getting involved

kernelnewbies.org



<http://www.kernelnewbies.org>

# Getting involved

Google “write your first kernel patch”

This is a video of a talk I gave at FOSDEM, going through the steps, showing exactly how to create, build, and send a kernel patch.

# Getting involved

[kernelnewbies.org/KernelJanitors/ToDo](https://kernelnewbies.org/KernelJanitors/ToDo)

So you know how to create a patch, but what should you do? The kernel janitors has a great list of tasks to start with in cleaning up the kernel and making easy patches to be accepted.



# Getting involved

Eudryptula Challenge  
(little penguin)

<http://eudryptula-challenge.org/>

Google “Linux kernel challenge” to find the site, if you can't remember Eudryptula.

It is a series of programming challenges, all run through email that starts out with a “Hello World” kernel module, and gets more complex from there. Over 4000 people are currently taking the challenge, and is a lot of fun if you don't know where to start out.

You need knowledge of C, but that's about it.

# Getting involved

## Linux Driver Project

`drivers/staging/*/TODO`

The staging tree also needs a lot of help, here are lists of things to do in the kernel for the drivers to be able to move out of the staging area.

Please always work off of the linux-next tree if you want to do these tasks, as sometimes they are already done by others by the time you see them in Linus's tree.



[github.com/gregkh/kernel-development](https://github.com/gregkh/kernel-development)

Obligatory Penguin Picture

