

# Linux Kernel Development

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

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

**38,566 files**  
**15,384,000 lines**

2,833 developers  
373 companies

7.21 changes per hour

3.4.0 release

10,500 lines added

8,400 lines removed

2,300 lines modified

10,500 lines added


8,400 lines removed

2,300 lines modified

every day

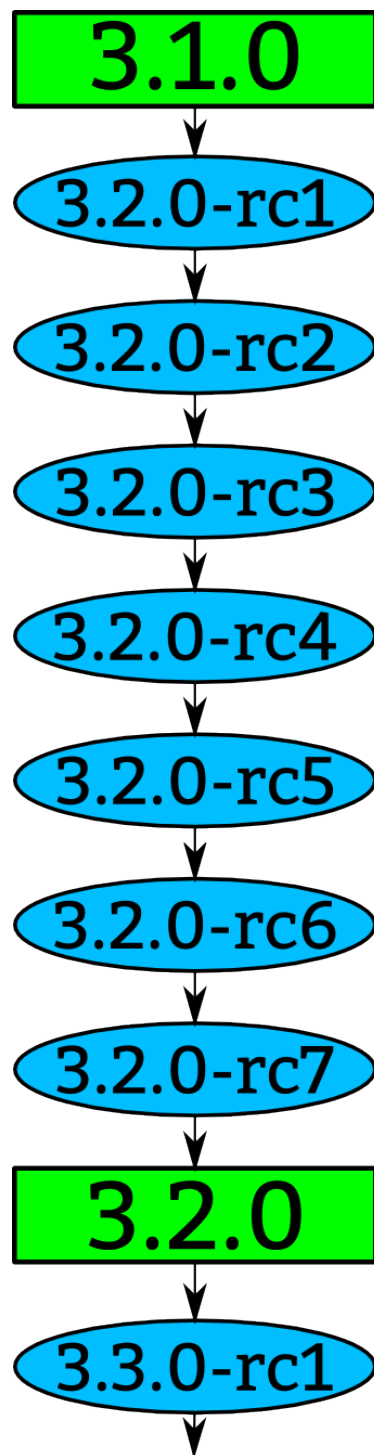
# 5.79 changes per hour

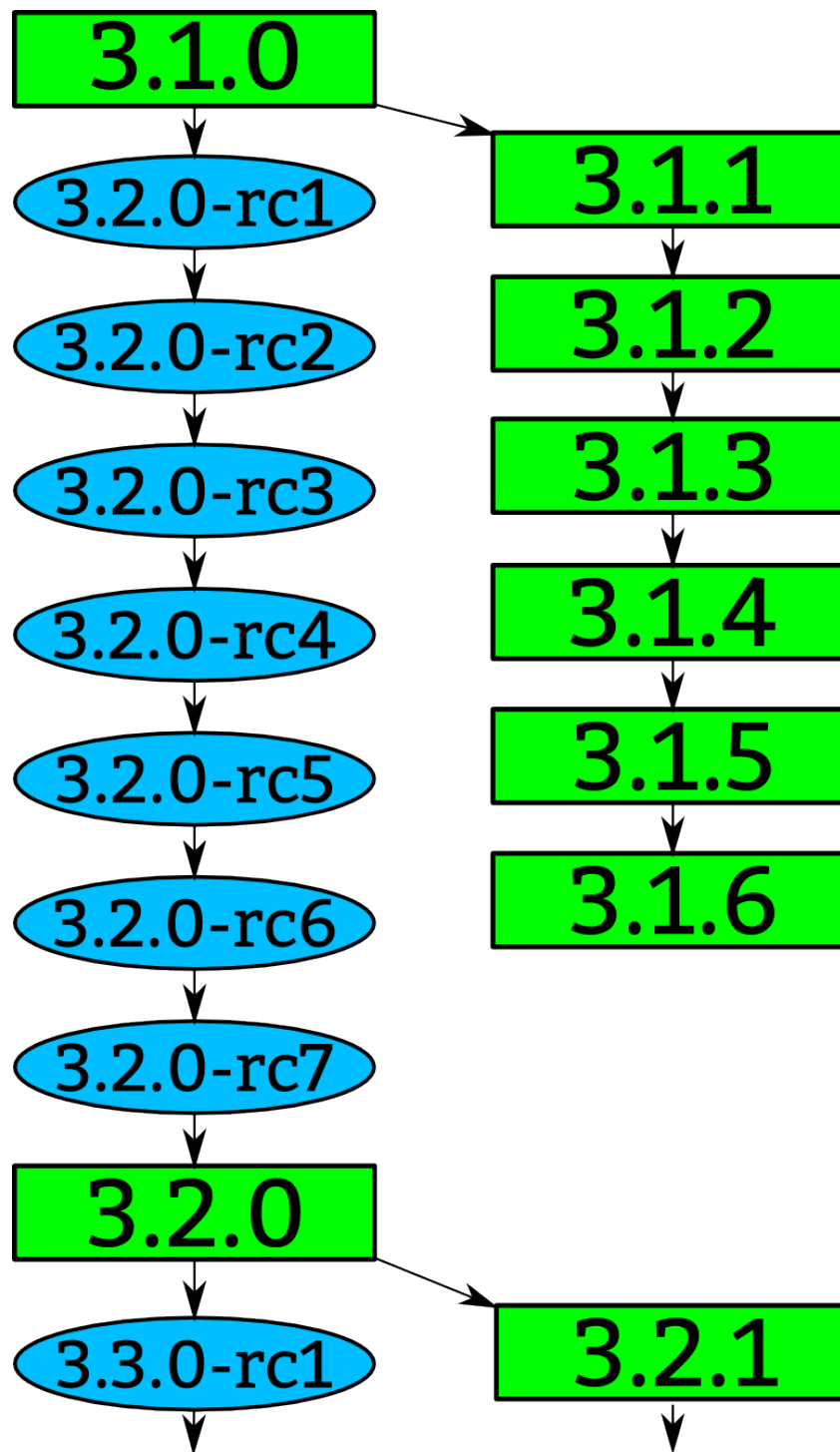
Kernel releases 3.0.0 – 3.4.0  
May 2011 – May 2012



**New release every  
2<sup>3</sup>/<sub>4</sub> months**







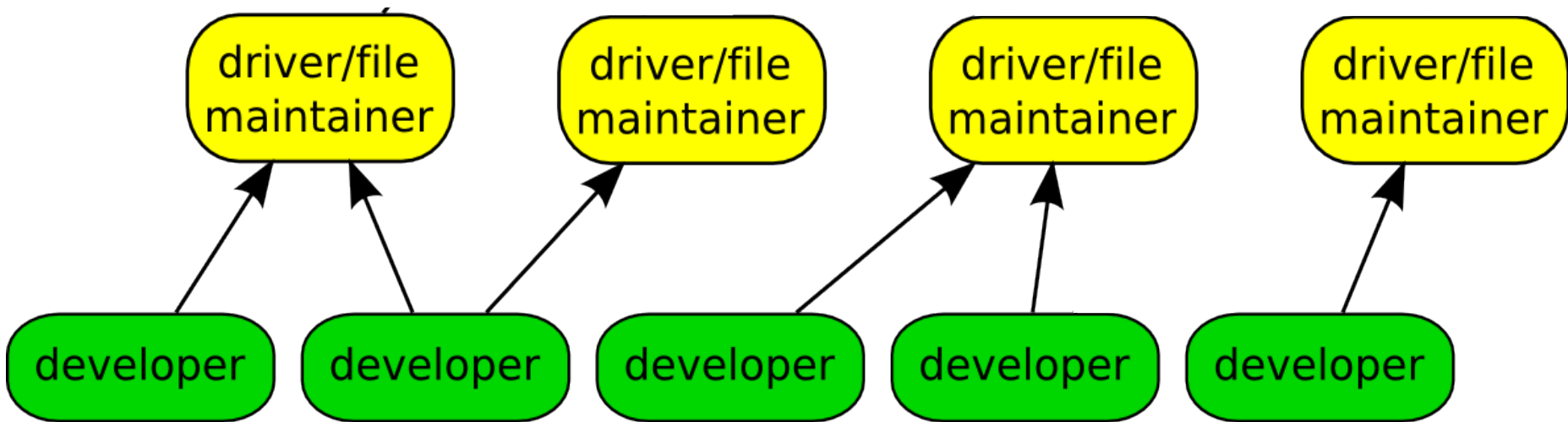
developer

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

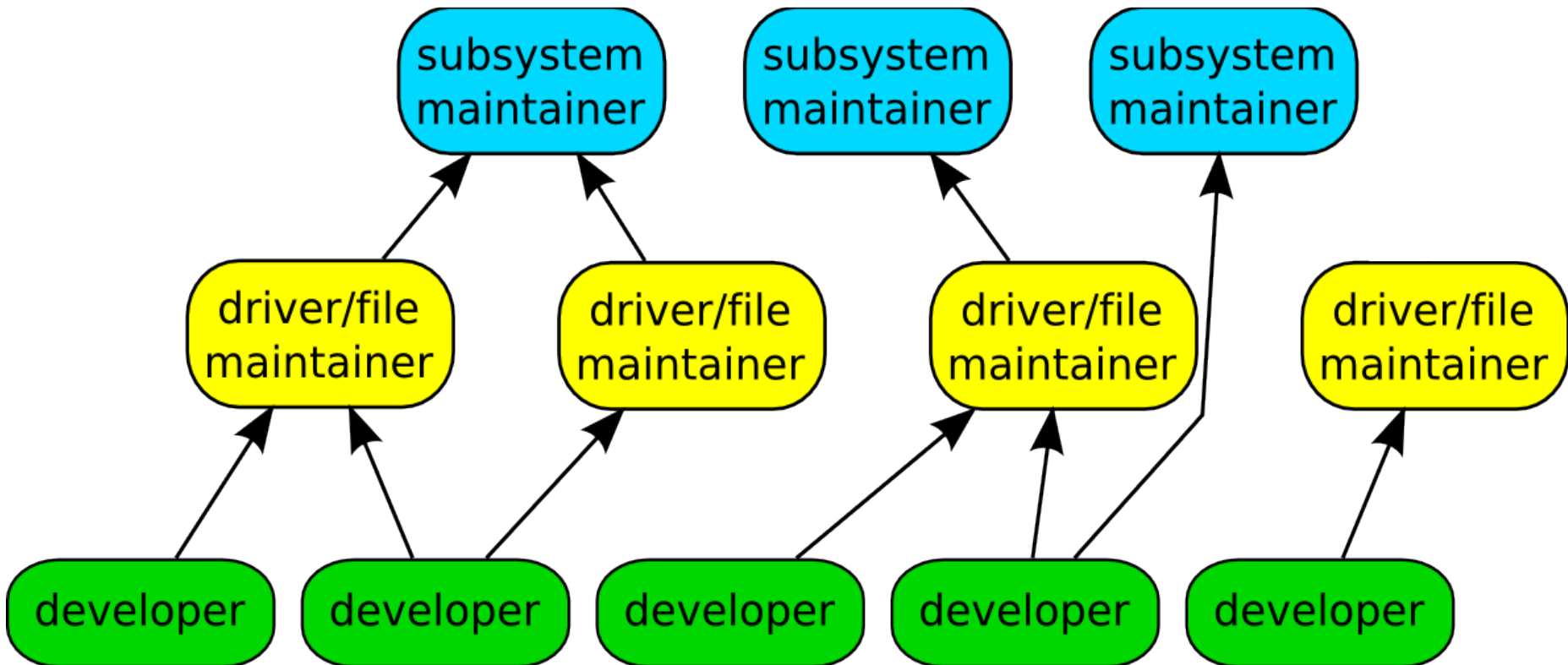
In the case where a gadget driver is removed while no transceiver was found at probe time, a bug in otg\_put\_transceiver() will trigger.

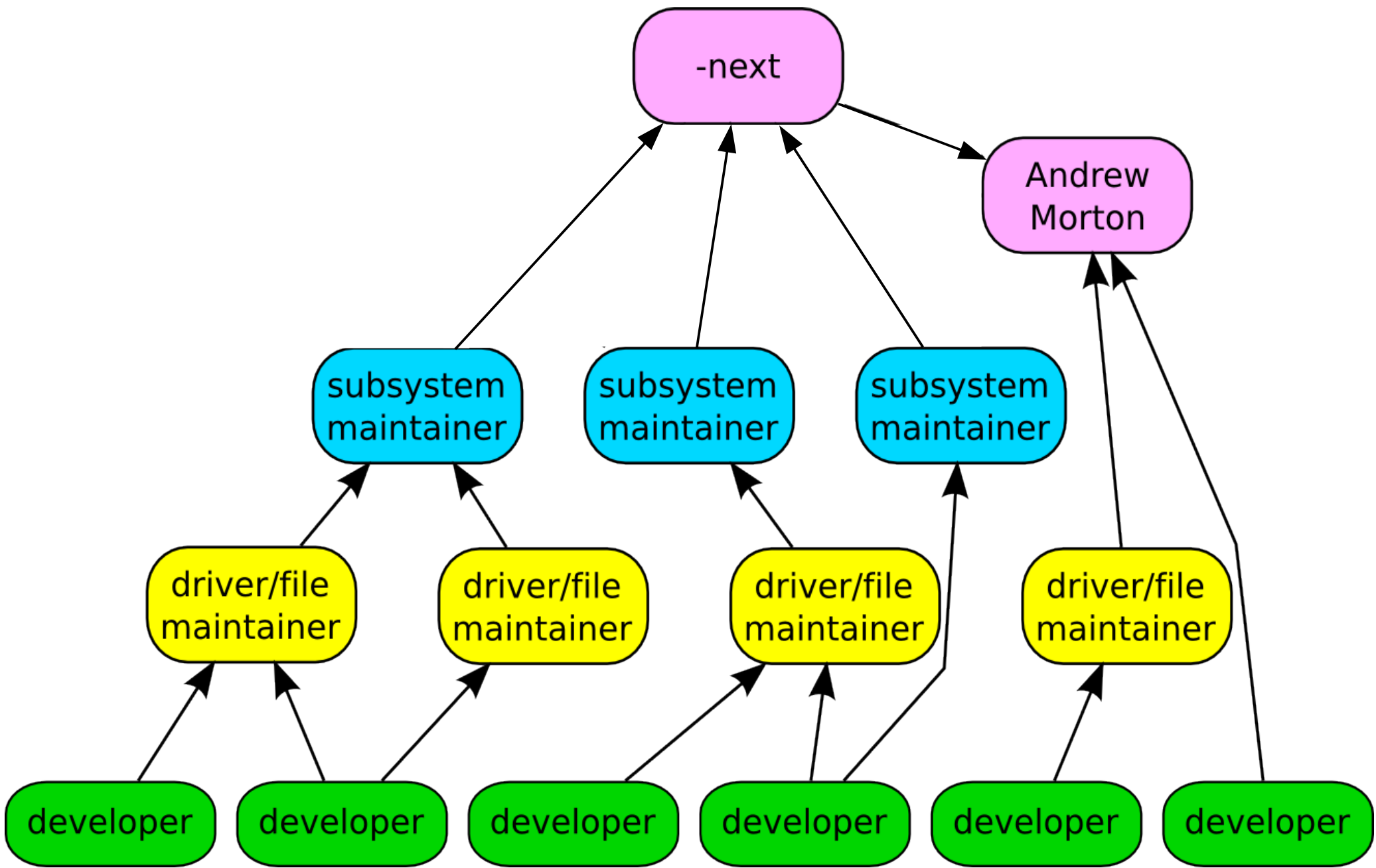
Signed-off-by: Robert Jarzmik <robert.jarzmik@free.fr>  
Acked-by: David Brownell <dbrownell@users.sourceforge.net>  
Signed-off-by: Greg Kroah-Hartman <gregkh@suse.de>

```
--- 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);
 }
```

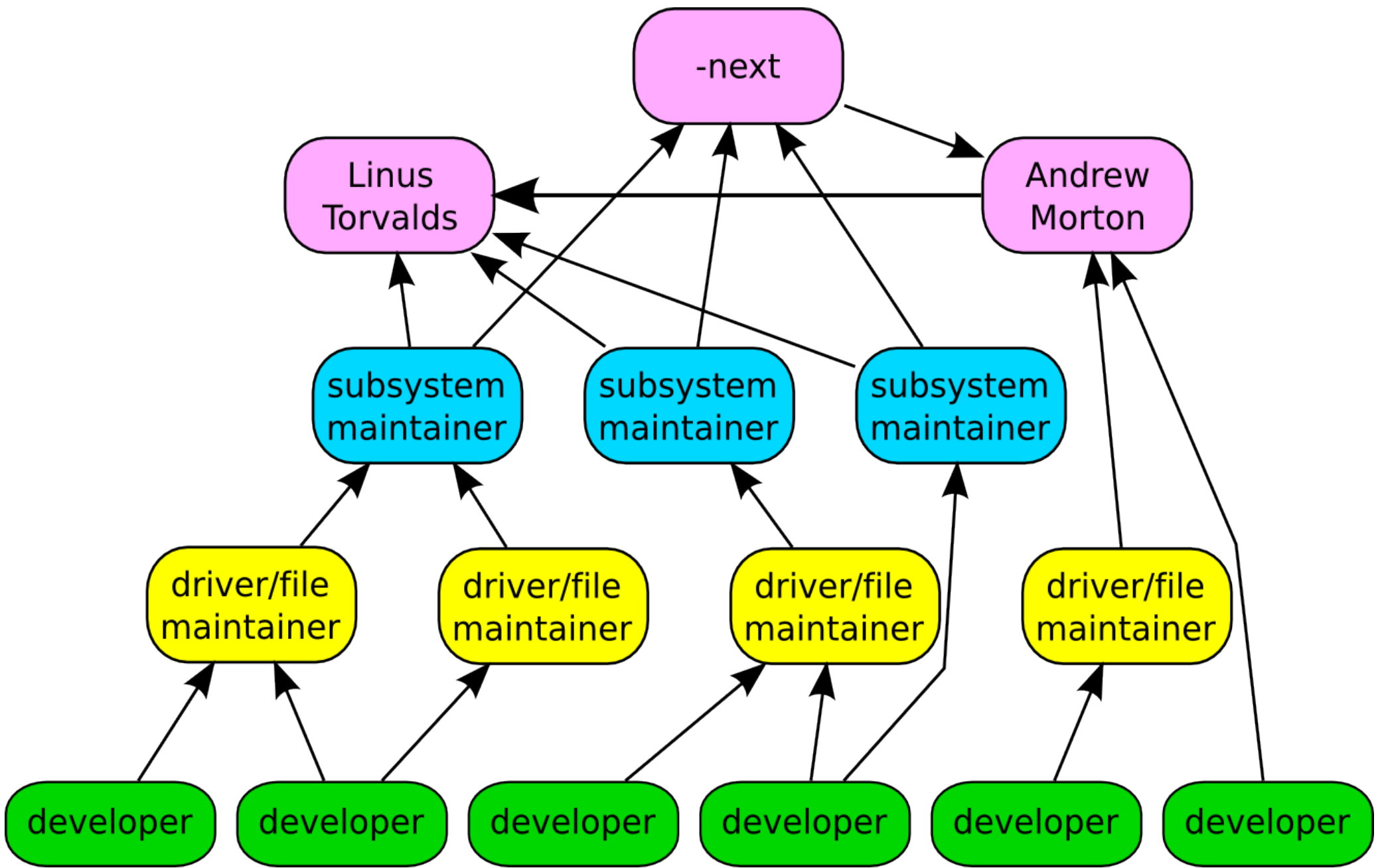
# Developer's Certificate of Origin

- (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 developers by quantity

1026	Mark Brown
723	Alxel Lin
626	K. Y. Srinivasan
607	Al Viro
517	Takashi Iwai
507	Mauro Chehab
419	Russell King
469	Johannes Berg
405	Ben Skeggs
396	Jonathan Cameron

Kernel releases 3.0.0 – 3.4.0

# Top Signed-off-by:

Greg Kroah-Hartman 4767

David S. Miller 3857

John Linville 3252

Mauro Carvalho Chehab 2412

Mark Brown 2230

Linus Torvalds 1984

Andrew Morton 1573

James Bottomley 1089

Takashi Iwai 953

Russell King 930

Kernel releases 3.0.0 – 3.4.0

# Who is funding this work?



1. “Amateurs”	14.2%
2. Red Hat	10.1%
3. Intel	8.6%
4. Unknown Individuals	5.2%
5. Novell	4.0%
6. IBM	3.7%
7. Texas Instruments	3.6%
8. Broadcom	3.0%
9. Consultants	2.3%
10. Wolfson Micro	2.1%

# Who is funding this work?



11. Samsung	1.9%
12. Google	1.8%
13. Oracle	1.7%
14. Freescale	1.5%
15. MiTAC	1.4%
16. Qualcomm	1.4%
17. Microsoft	1.3%
18. Linaro	1.2%
19. Nokia	1.2%
20. AMD	1.1%

# Who is funding this work?

...

23. Fujitsu

448

...

43. Cisco

206

...

59. HP

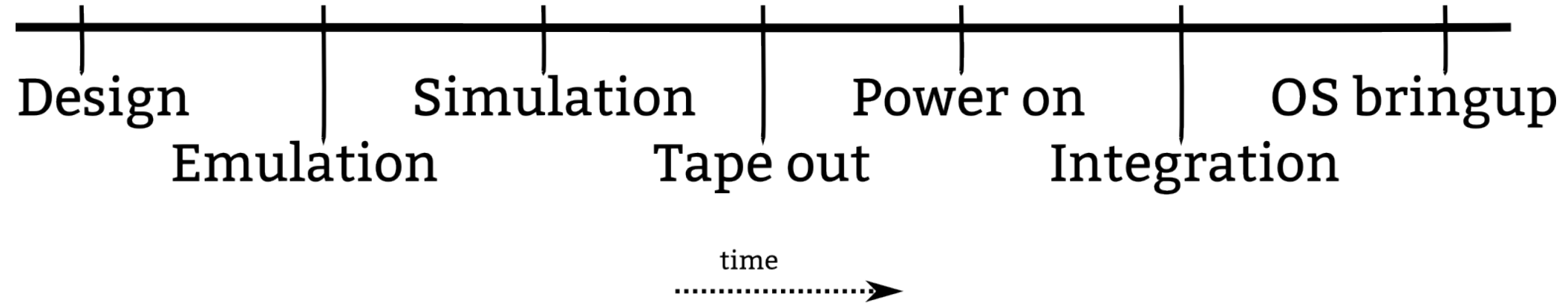
118

...

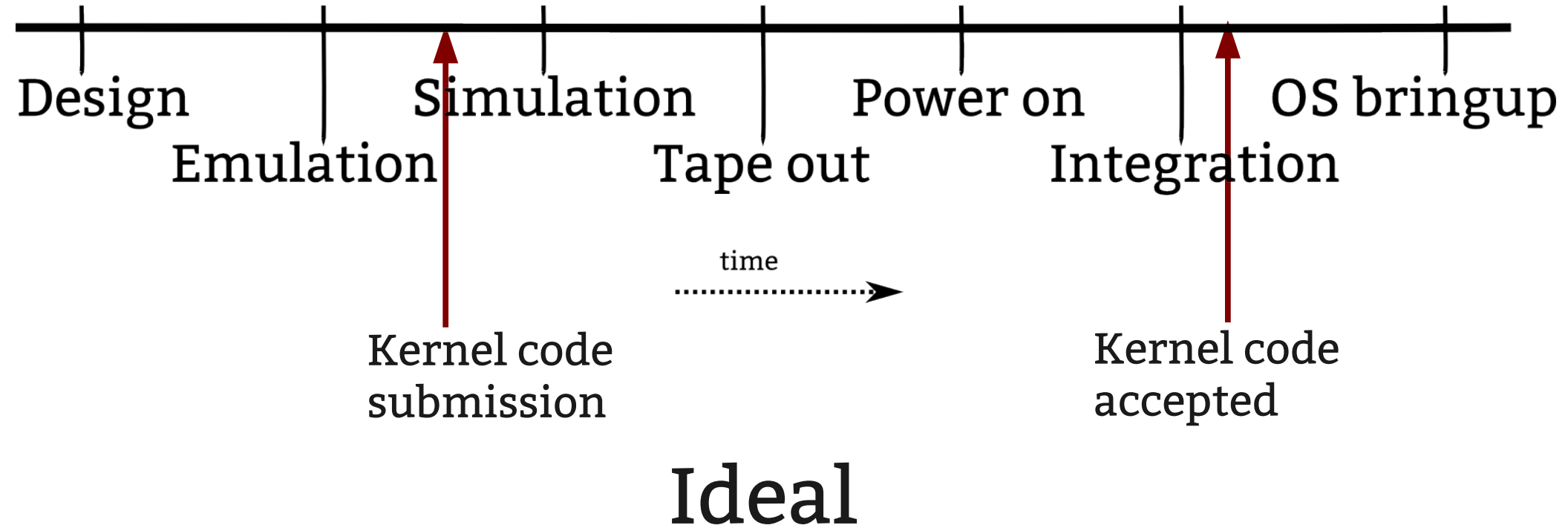
230. Huawei

3

# Development Process



# Development Process





# “Working upstream saves time and money”

Dan Frye – VP Open Systems, IBM

Dirk Hohndel – Chief Technologist, Intel

# How to change

# How to change

Submit code early and often

# How to change

Send small pieces

# How to change

Ask community for feedback

# How to change

Act on it

# How to change

Remove legal hurdles

# How to change

Force them to work in public



# How to change

Allow them to be the community



[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.

**38,566 files**  
**15,384,000 lines**

Kernel release 3.4.0

This was for the 3.4 kernel release, which happened May 20, 2012.

# 2,833 developers 373 companies

Kernel releases 3.0.0 – 3.4.0  
May 2011 – May 2012

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.

**7.21 changes per hour**

**3.4.0 release**

The 3.4 kernel release was the fastest one ever created

**10,500 lines added**  
**8,400 lines removed**  
**2,300 lines modified**

Kernel releases 3.0.0 – 3.4.0  
May 2011 – May 2012



**10,500 lines added**  
**8,400 lines removed**  
**2,300 lines modified**

**every day**

Kernel releases 3.0.0 – 3.4.0  
May 2011 – May 2012

Every single day for a year.

# 5.79 changes per hour

Kernel releases 3.0.0 – 3.4.0  
May 2011 – May 2012

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

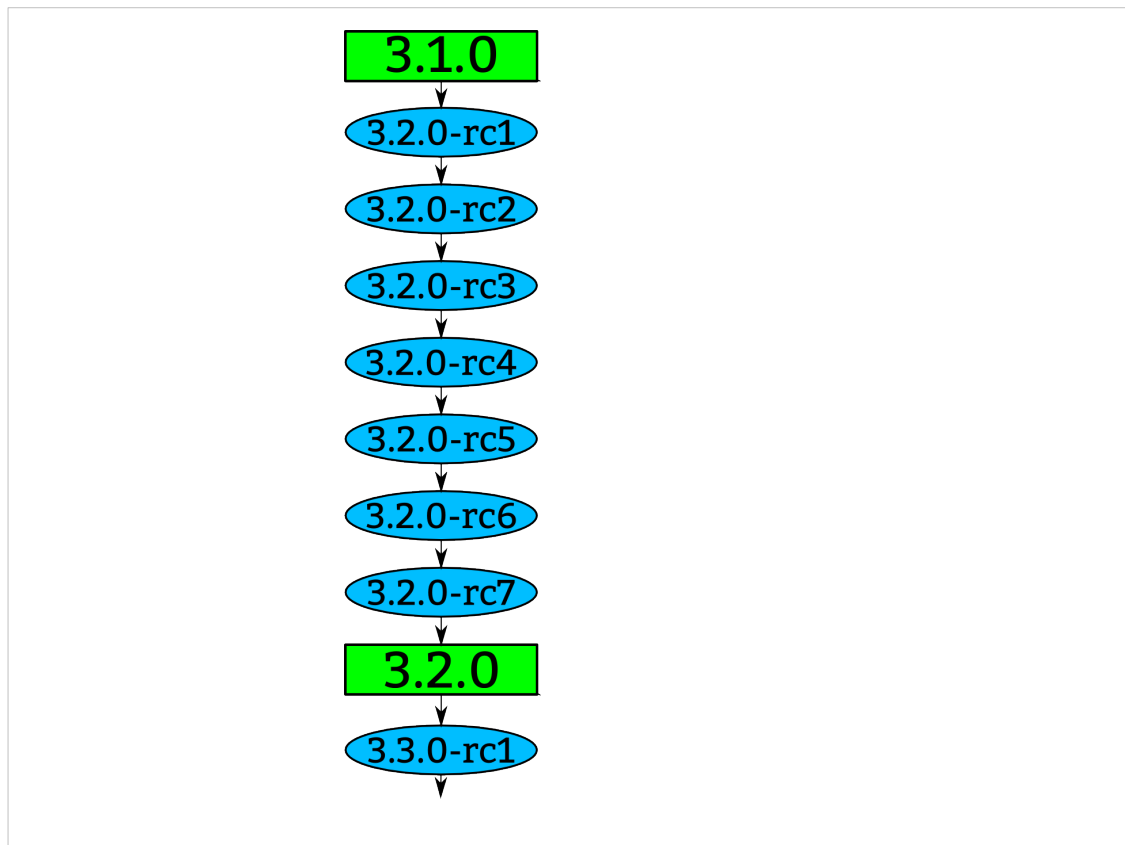
We went this fast the year before this as well, this is an amazing rate of change.

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.



84 days to be exact, very regular experience.

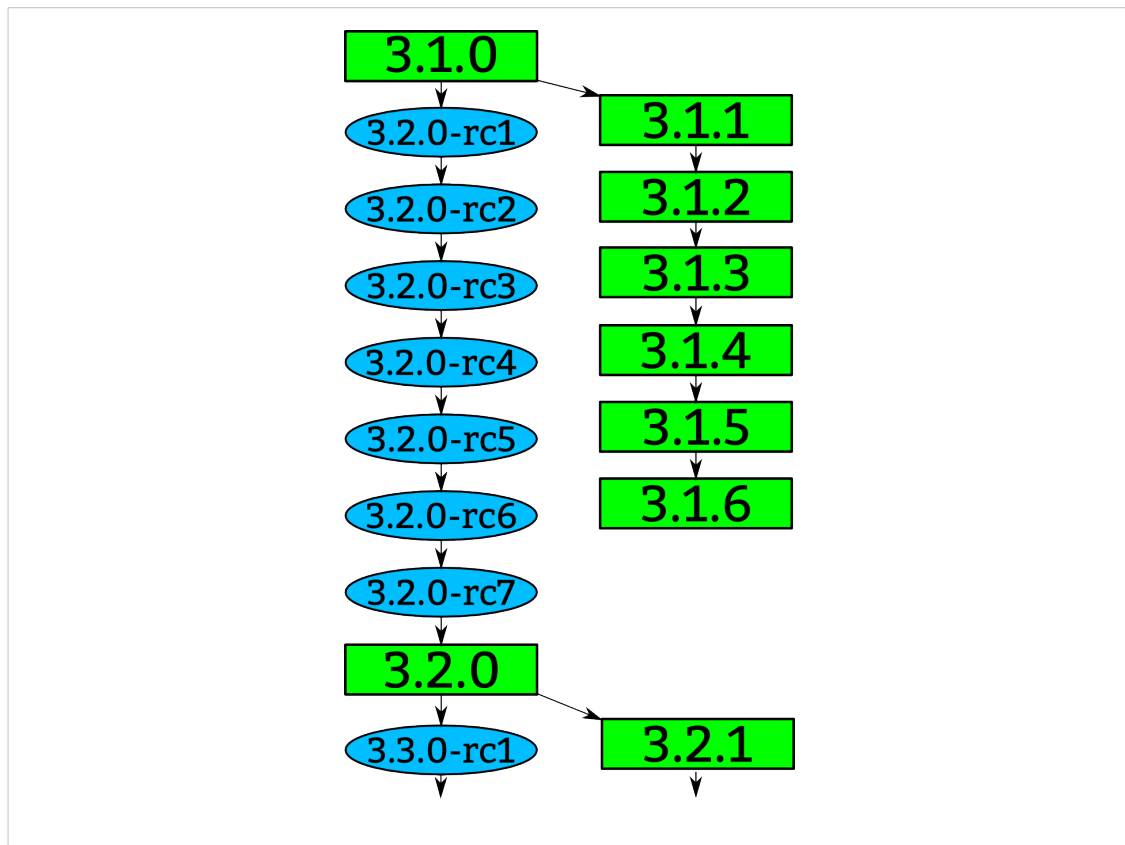


How a kernel is developed.

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.

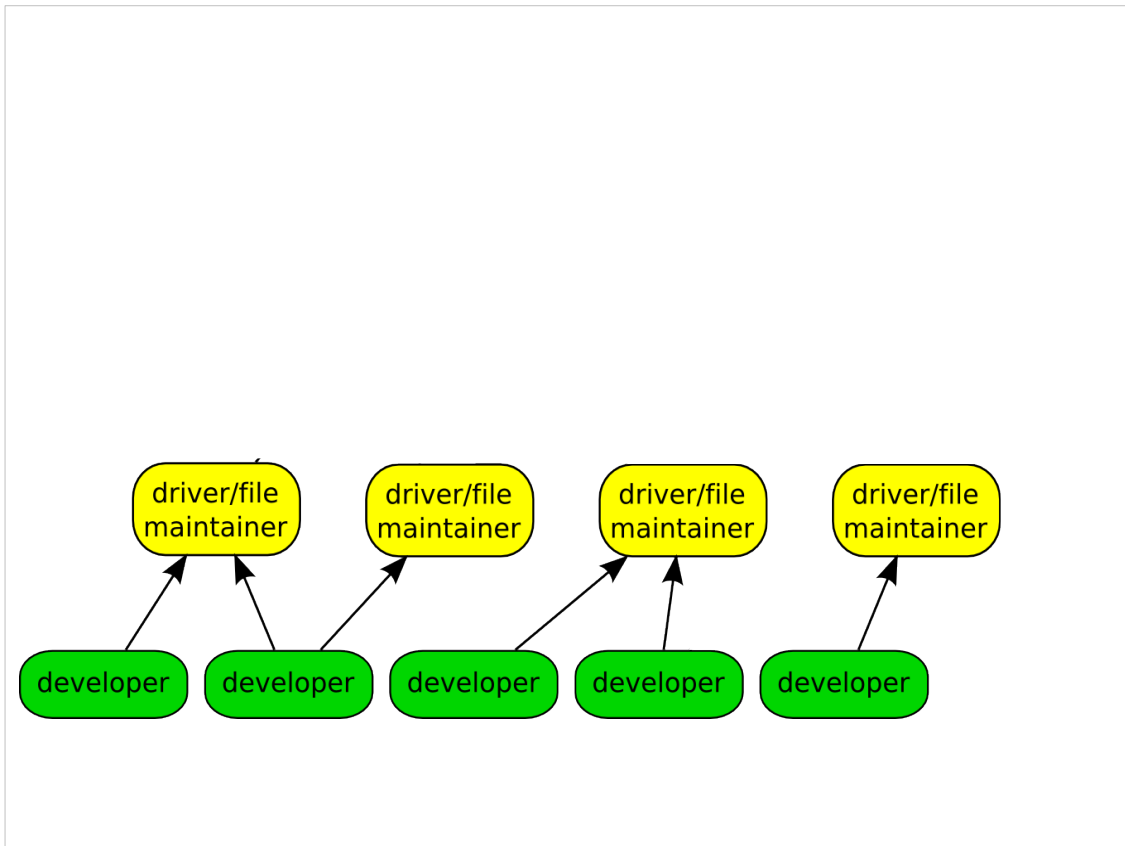
After Linus releases a new stable release, the old stable series is dropped.

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



Like mentioned before, we have almost 2900 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
    transceiver was found at probe time, a bug in
    otg_put_transceiver() will trigger.

    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 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

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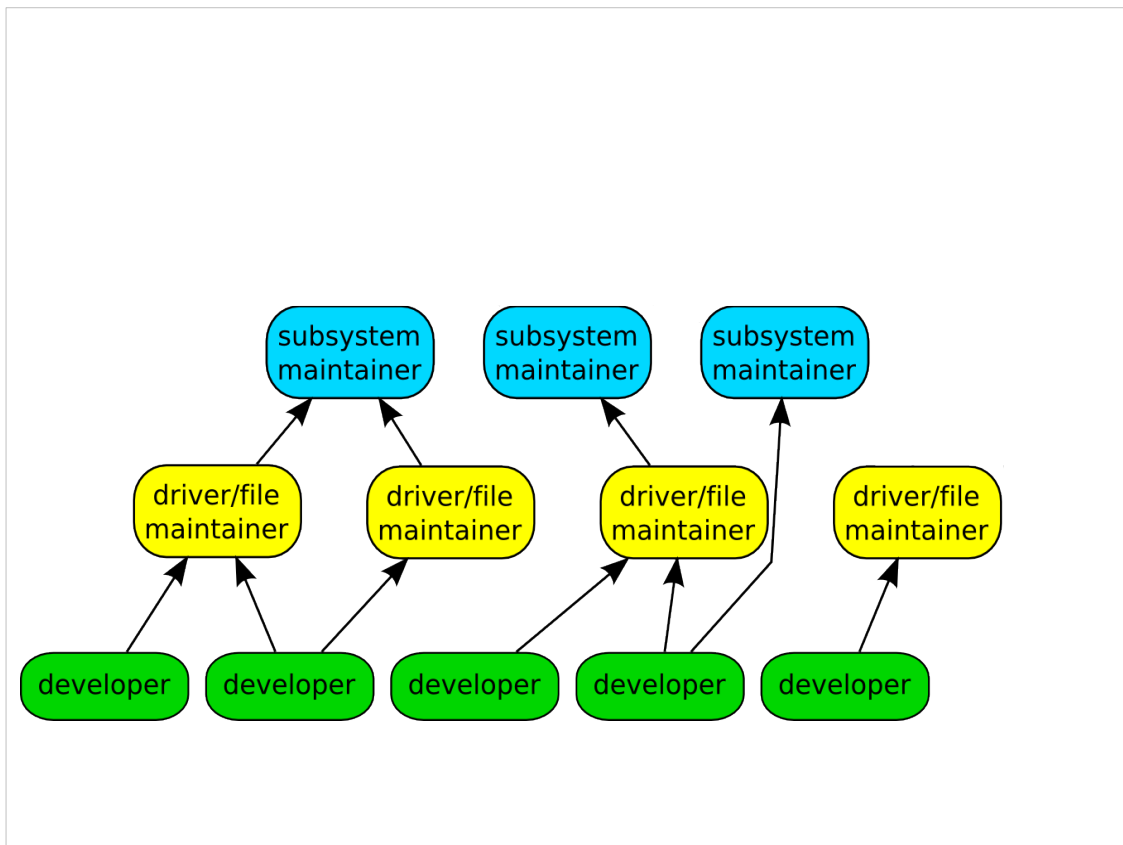
This is what “Signed-off-by:” means.

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.

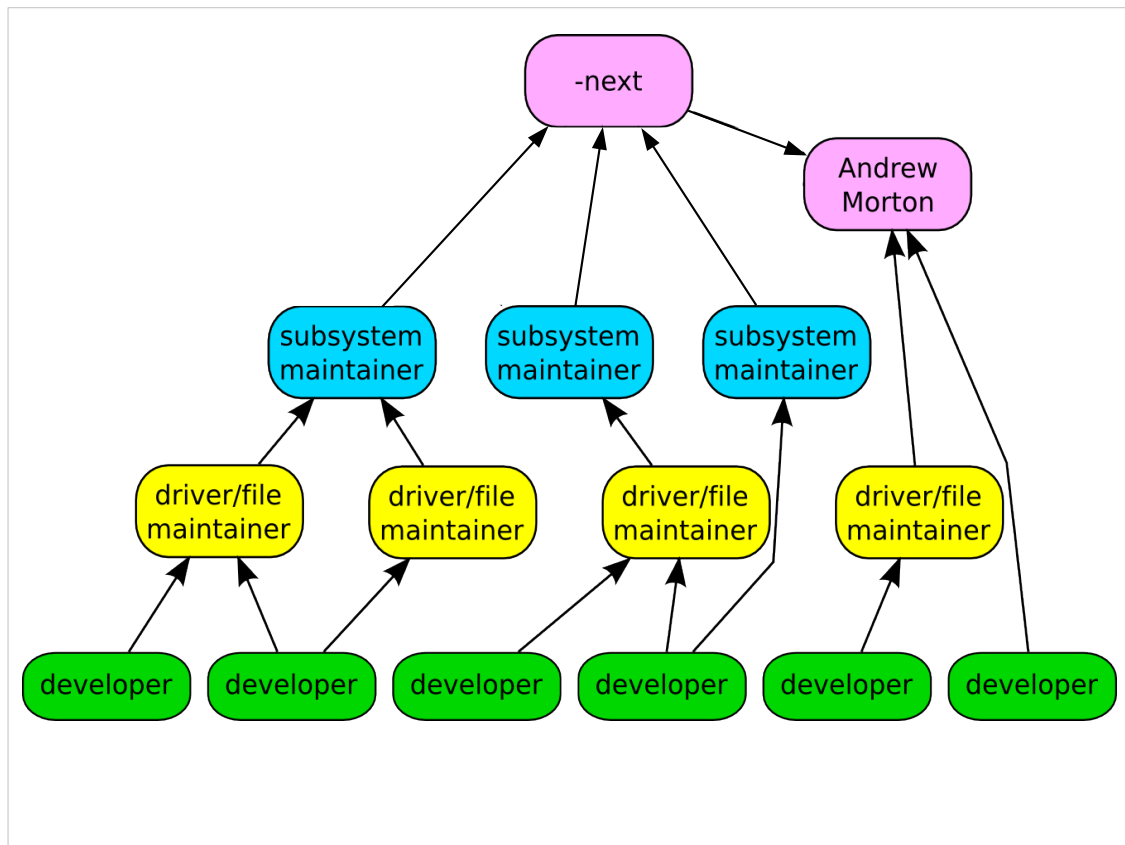
If a problem is found, this is the developers that you can ask about it.

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.

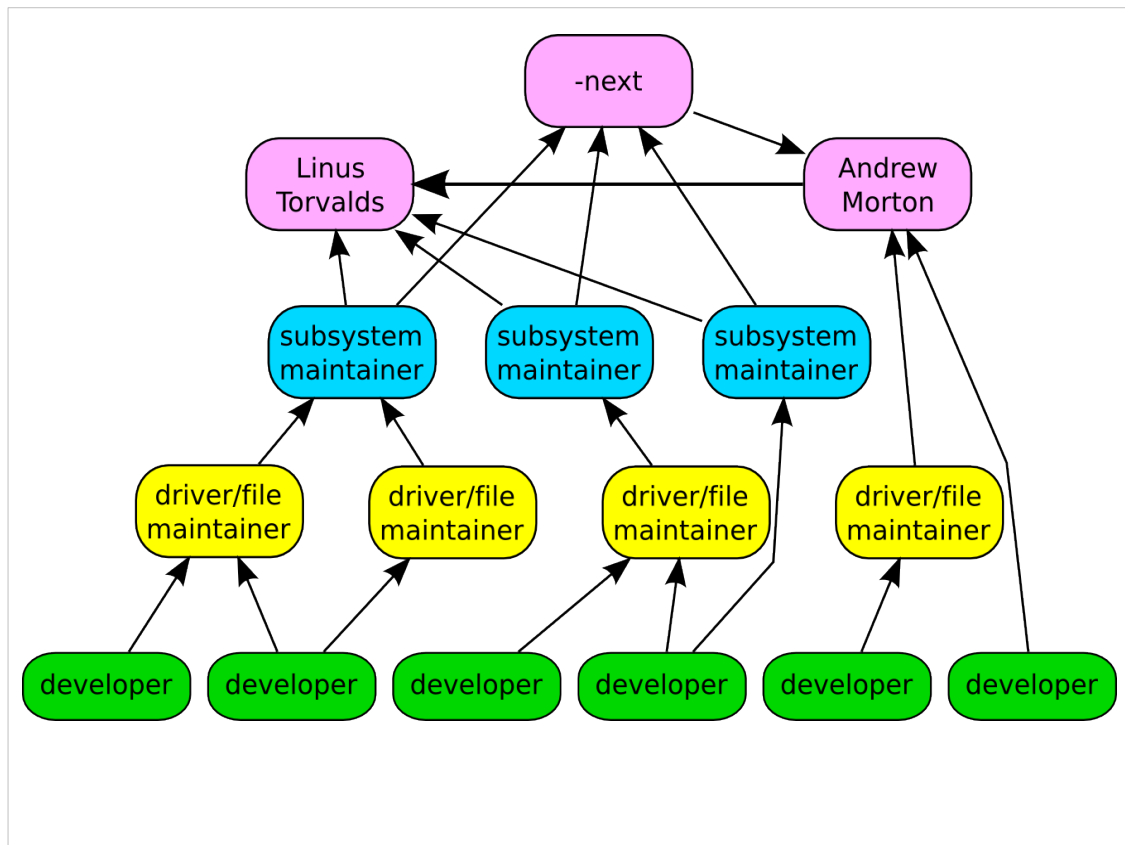
We have around 150 subsystem maintainers



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		
1	Mark Brown	1026
2	Alexel Lin	723
3	K. Y. Srinivasan	626
4	Al Viro	607
5	Takashi Iwai	517
6	Mauro Chehab	507
7	Russell King	419
8	Johannes Berg	469
9	Ben Skeggs	405
10	Jonathan Cameron	396

Kernel releases 3.0.0 – 3.4.0

Mark – embedded sound

Alexl – janitorial

KY – hyperv

Al – vfs and filesystem

Takashi – sound maintainer

Mauro – v4l

Russell – ARM maintainer

Johannes – wireless developer

Ben – nouveau developer

Jonathan – IIO

Top Signed-off-by:		
Greg Kroah-Hartman	4767	
David S. Miller	3857	
John Linville	3252	
Mauro Carvalho Chehab	2412	
Mark Brown	2230	
Linus Torvalds	1984	
Andrew Morton	1573	
James Bottomley	1089	
Takashi Iwai	953	
Russell King	930	
Kernel releases 3.0.0 – 3.4.0		

Greg – driver core, usb, staging

David – networking

John – wireless networking

Mauro - v4l

Linus – everything

Mark - embedded

Andrew – everything

James – SCSI

Takashi – sound

Russell - ARM

# Who is funding this work?

1. "Amateurs"	14.2%
2. Red Hat	10.1%
3. Intel	8.6%
4. Unknown Individuals	5.2%
5. Novell	4.0%
6. IBM	3.7%
7. Texas Instruments	3.6%
8. Broadcom	3.0%
9. Consultants	2.3%
10. Wolfson Micro	2.1%

Kernel releases 3.0.0 – 3.4.0

So you can view this as either 20% is done by non-affiliated people, or 80% 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. Samsung	1.9%
12. Google	1.8%
13. Oracle	1.7%
14. Freescale	1.5%
15. MiTAC	1.4%
16. Qualcomm	1.4%
17. Microsoft	1.3%
18. Linaro	1.2%
19. Nokia	1.2%
20. AMD	1.1%

Kernel releases 3.0.0 – 3.4.0

Samsung 980 patches  
Qualcomm 707 patches



# Who is funding this work?

...

23. Fujitsu	448
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...

43. Cisco	206
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...

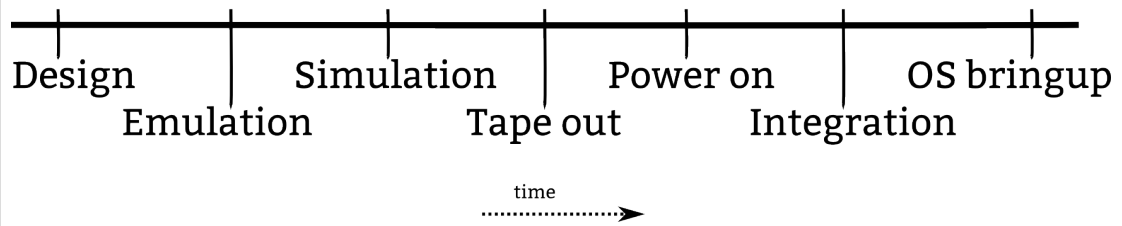
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...

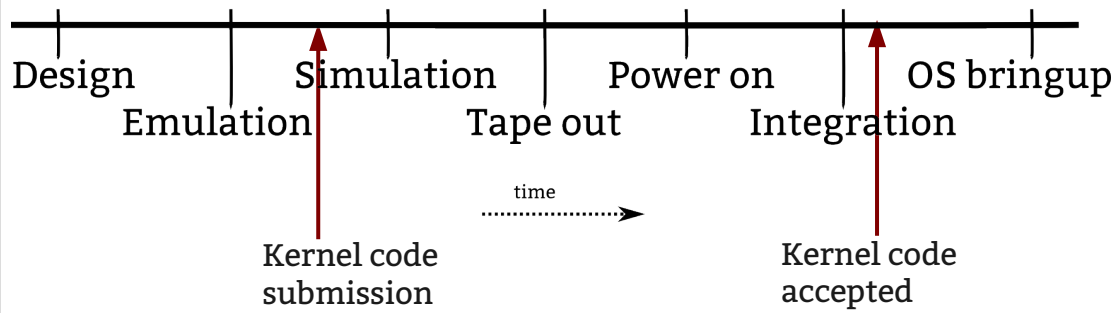
230. Huawei	3
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Kernel releases 3.0.0 – 3.4.0

# Development Process



# Development Process



Ideal

# “Working upstream saves time and money”

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

# How to change

“Change or die”

# How to change

Submit code early and often

No big code dumps.

They are hard to review, and even harder for you to modify and resend, slowing everything down and delaying any potential acceptance.

# How to change

Send small pieces

# How to change

## Ask community for feedback

Some companies get Linux kernel community members together and discuss products and technologies directly with the senior engineers, no managers in the way.

Great feedback circle, the community gets to understand your products better, and no long explanation is needed when showing the code later, and the community gets to tell your engineers what they are doing wrong.



# How to change

Act on it

Change products / roadmaps / features based on feedback. This makes Linux work better on your platforms which makes your platform better.

# How to change

Remove legal hurdles

Let them contribute whatever they want and can.

Legal is to support the business, change the hurdles to be on the legal side, not the developers.

# How to change

Force them to work in public

No internal mailing lists

All communication is done publicly

Let them argue in public

# How to change

Allow them to be the community

Your developers will become the maintainers, driving the future of Linux forward, always keeping your products in mind as things evolve and change.



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

Obligatory Penguin Picture

