The Kernel Report

Jonathan Corbet
corbet@lwn.net

The Plan

A quick review of the kernel development process

- How it works
- Current issues of interest

Recent history review

- What has happened over the last year

Looking forward

- Wild predictions about future kernels

The kernel release process

- Major kernel releases about every 3 months
  - Named 2.6.x
  - 2.6.x.y releases for important fixes
    - Security problems
    - System crashes

- Every 2.6.x is a major release
  - New features
  - Internal API changes

- Where's 2.7?
  - The old even/odd scheme is no more

The kernel release lifecycle

Week 0: the merge window opens

- All new features and major changes merged
- Can be several thousand patches

Week 2: 2.6.x-rc1 is released

- Merge window closes – no new features (usually)
- Patch rate remains high – but should all be fixes

Weeks 3-8: additional -rc releases

- Patch rate slows as bugs get fixed

Week 8: 2.6.x is released

- 2.6.x.y bug fix releases come later

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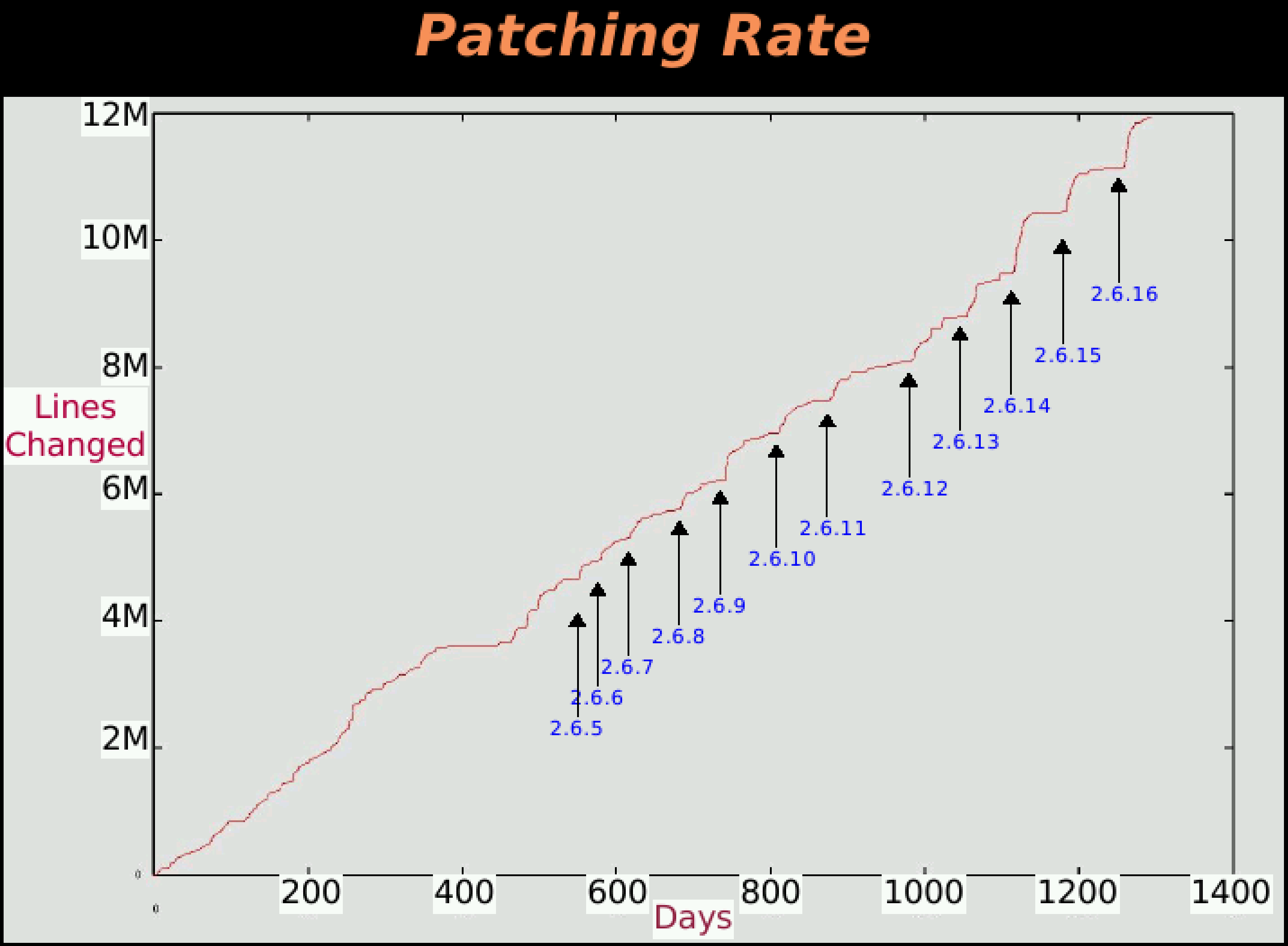
The patch rate



9,200 lines changed per day

Some statistics

Since 2.6.16 (just over 1 year ago):

- 30182 changesets merged
- 2074 developers contributed to the kernel
  - 10 contributed >= 1% of changes
- 766,000 lines added to the kernel

Who do they work for?

Unknown	25%	SANPeople	1%
Red Hat	14%	SteelEye	1%
Volunteer	12%	Freescale	1%
IBM	8%	Simtec	1%
Novell	4%	Astaro	1%
Qlogic	4%	Linux Foundation	1%
Intel	3%	Atmel	1%
MIPS Tech.	2%	Oracle	1%
MontaVista	2%	HP	1%
Nokia	2%	SGI	1%

The results

The patch flow rate is high

- New features get to users more quickly
- Distributor kernels stay closer to the mainline

Relatively predictable kernel releases

Happy distributors, developers, and users

- ...most of the time

Kernel Quality

> “I believe the 2.6 kernel is slowly getting buggier. It seems we're adding bugs at a higher rate than we're fixing them.”
>
> -- Andrew Morton, May, 2006

- Some fear that kernel quality is declining
  - Bugs not getting fixed
  - Too many features added too quickly
  - Too little stabilization time

- Kernel developers tend not to agree
  - But everybody agrees fewer bugs would be better

A quick review of the last year

2.6.16 (March 19, 2006)

- Mutexes replace semaphores
- High-resolution timer code
- OCFS2 cluster filesystem
- SCHED_BATCH

2.6.17 (June 17, 2006)

- SPARC Niagara support
- Lightweight robust futexes
- User-space software suspend
- Broadcom 43xx wireless support
- splice()

Still reviewing last year

2.6.18 (September 19, 2006)

- Priority inheritance
- Generic IRQ layer
- New core time subsystem
- Kernel locking validator
- Devfs gone

2.6.19 (November 29, 2006)

- Parallel ATA driver subsystem
- GFS2 cluster filesystem
- ext4 development filesystem
- eCryptfs

The current kernel

2.6.20 (February 4, 2007)

- Fault injection framework
- Many big internal API changes
- UDP-Lite protocol
- paravirt_ops
- Kernel virtual machine (KVM)
- Playstation 3 support

Looking forward

Predicting the kernel's future is hard

- No five-year roadmaps
- No ability to force work from anybody
- No limits on what people might come up with

I won't let that stop me

- I can handwave with the best

How does one proceed?

- Look at work in progress now
- Look at pressures from the outside world
- Make some wild guesses

Woe to anybody who actually believes what follows...

The next kernel

2.6.21 (any day now)

What's going in?

- Dynamic tick and clockevents
- Major ACPI update
- Sysfs shadow directories
- ALSA system-on-chip layer
- Device resource management API
- VMI virtualization interface
- KVM improvements (live migration)

Virtualization

- Still an area of high interest
  - Server consolidation
  - High-reliability systems
  - Isolation and security

- The big players
  - Xen
    - Full paravirtualization
    - Path into the kernel has been slow
  - User-mode Linux
    - Run Linux as a user-mode process
    - Longstanding Linux project
  - Various commercial offerings

- The biggest development issue:
  - A common hypervisor interface

Virtualization developments

paravirt_ops

- The common hypervisor interface
- Isolates low-level operations
- Run-time substitution via “hypervisor ROM”
- Remains a highly volatile interface

VMI

- Higher-level hypervisor interface

Kernel Virtual Machine

- Support for hardware virtualization
- Open /dev/kvm, create CPUs with ioctl(), launch systems
- A full virtualization solution
  - ...but paravirtualization being done too

Lguest (aka Rustyvisor)

- A simple native Linux virtualization mechanism

Containers

A lighter-weight approach to virtualization

No full emulation of the processor

- Containers run as process groups on host
- All containers run on the host kernel

Containers are isolated from each other

- Can't see other processes

Containers

There are a number of container projects
- Linux-VServer
- OpenVZ
- Various proprietary offerings

All have the same needs
- Multiple views of global resources
- Per-container resource usage control

Most of them want into the kernel
- But multiple implementations are unwelcome

The projects are talking to each other
- Some early code bits have been merged
- Big issues: resource management, networking, ...

CPU schedulers

Scheduling has been quiet for some time

- Worst problems solved in early 2.6.x

The issue has come back

- Better interactive response wanted
- Dump complex heuristics for simple fairness

Three contenders

- Staircase Deadline
- Completely Fair Scheduler
- Nicksched

CFS looks to be the likely winner

- ...but expect some debate first

Fibrils / syslets / threadlets / ...

Asynchronous I/O is a perennial pain

- State-machine approach difficult to implement, maintain

Fibrils: a new approach

- If something blocks, keep running in a new process
- Makes *any* system call asynchronous

Syslets

- Variant of fibrils
- Applications can load code into the kernel

Threadlets

- On-demand threading
- Simple API

Filesystems

Pressures

- Disks are getting bigger – quickly
- They are getting faster much less quickly
  - The time to read the entire disk is growing
- They are not getting more reliable
- Some filesystem limits are being reached

How long does it take to run fsck?

- Kernel.org RAID: over 1 week

Current filesystems have a long history

> “We're continuing to nurse along a few basically-15-year-old filesystems while we do have the brains, manpower, and processes to implement a new, really great one.”
>
> --Andrew Morton

Filesystems – what's coming

ext4

- Currently a development-only filesystem
- Extents
- 48-bit block numbers (break the 8TB limit)

Reiser4

- A number of interesting new ideas
- Still stalled – won't be in 2.6.22 either
- Future is now in serious doubt

Hardware support

Hardware support is better than ever

- Most hardware Just Works
- No driver disks, no hassles
- Linux supports more hardware than any other system, ever

There are exceptions

- Wireless networking
- Video adapters

The problem

- Vendors will not release free drivers
- ...or programming information

Why not release information?

> “It's so hard to write a graphics driver that open-sourcing it would not help.”
>
> -- Andrew Fear, Nvidia software product manager

Other issues

- Patent problems
- Regulatory issues
- They just plain don't get it

Wireless networking

- Wireless has traditionally been poorly supported
  - Few drivers
  - Suboptimal network stack design

- The mac80211 (formerly Devicescape) stack
  - A proper 802.11 networking stack
  - Slowly making its way toward the mainline

- New drivers
  - Broadcom 43xx
  - Atheros
    - Now cleared of legal clouds
  - Intel
    - Well supported by the vendor

Video adapters

Video vendors remain stubborn

Intel the biggest exception

- Still short on programming information
- Integrated controllers only – for now

Nvidia

- The Nouveau project is moving forward
  - nouveau.freedesktop.org
  - Some ground to cover yet

ATI

- R300 driver is getting good
- Little hope for newer chipsets

Binary-only drivers

Some vendors do provide proprietary drivers

Some problems:

- Only work with specific kernel versions
- Unknown security problems
- No hope for fixing bugs
- No support for other architectures
- Long-term support is dubious
- Can impede development
- Questionable legality

Linux cannot give in to binary-only drivers

- That way leads to the end of our free system

Networking

- Network channels
  - Presented by Van Jacobson at lca 2006
  - Push network processing to the end points
    - ...even into user space
  - Progress is slow

- Needed: an event reporting API
  - Unify application event loops
  - Improve high-bandwidth application performance

- The new eventfd system calls:
  - Get a file descriptor for interesting events
    - Timers, signals, etc.
  - Wait for them in the poll() loop

- The kevent mechanism
  - Seemingly superseded by eventfd

Security

SELinux: The one true security framework?

- Becoming more comprehensive (packet labeling)
- Higher-level admin tools

AppArmor

- Pushed by Novell/SUSE
- Much simpler administration
- Unpopular with developers – use of pathnames
- New patch set posted (finally)

SLIM, EVM, and friends

- Use the TPM for integrity management
- Can be used for high security – or lockdown
- Slow path into kernel

Real time

- The realtime preemption patch set
  - Claims 20 μsec deterministic response time
  - Large invasive patch set
- Much of it has already been merged
  - Robust futexes, priority inheritance, mutexes
  - core timekeeping, high-resolution timers, ...
- Some pieces remain
  - Sleeping spinlocks
  - Interrupt handlers in kernel threads
  - Dynamic tick

Small and embedded systems

Much is happening in small systems
- Telephones
- Tablet systems
- OLPC

Running Linux there presents different challenges
- Minimal resource use
- Real-time response
- Fast boot

Lots of people are working in this area
- But cooperation is often lacking
- Little participation in the development process
  - Proprietary hardware
- Things are getting better – maybe

Licensing and GPLv3

Version 3 of the GPL is still in draft form
- Final version due in June

Relatively unpopular in kernel circles
- The anti-DRM provisions in particular

The kernel is explicitly licensed under GPLv2
- The “or any later version” language is missing

Changing the license would be hard
- Hundreds of copyright holders
- Achieving a consensus is unlikely
- Even finding them all would be hard

Thus:
- A GPLv3-licensed kernel is unlikely

Questions?

Slides at http://lwn.net/talks/elc2007/

The user-space API

The user-space API used to be simple

- System calls

Now it is more complicated

- *Lots* of system calls
- /proc (100's of files)
- /sys (1000's of files)
- Netlink

Breaking this API is against the rules

But it is happening anyway

- Such a wide interface is easy to break
- Sysfs directly mirrors internal data structures
- These APIs are still evolving

Scalability

Today's big iron is tomorrow's laptop
- Supporting 1GB of memory was once a big deal

The current state of the art
- 512-processor NUMA systems work well
  - Getting larger
- Getting to 4K will take some work

The scalability effort continues
- Shrinking data structures
- Lockless algorithms
- ...

Questions to ask

Is there really a problem?

If so, what is to be done about it?

What to do about it?

Regardless of whether kernel bugs are getting worse

- ...it would be nice to have fewer of them

More testing is needed

- By users!

Better bug tracking

- Special tracking for regressions

Better bug fixing

- Fixing bugs can be hard work
  - No access to the hardware – unable to reproduce the problem
- Developer discipline can be lacking
- Known bugs often remain unfixed.

What to do about it?

- Make bugs harder to introduce
    - Better internal APIs
    - Better automated tools
        - Locking validator
        - Sparse
        - Fault injection framework
        - Memory leak tracker

- Stabilization releases
    - Reserve occasional 2.6.x releases for bug fixes
    - Seems to be a hard sell