Embedded Linux Community Update
March 2020
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Nature of this talk…

- Quick overview of lots of embedded topics
- A springboard for further research
  - If you see something interesting, you have a link or something to search for
- Not comprehensive!
  - Just stuff that I saw
Outline

Linux Kernel
Technology Areas
Conferences
Industry News
Resources
Outline

Linux Kernel
Technology Areas
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Industry News
Resources
Kernel Versions

- Linux v5.1  –  5 May 2019  –  63 days
- Linux v5.2  –  7 Jul  2019  –  63 days
- Linux v5.3  –  15 Sep 2019  –  70 days
- Linux v5.4  –  24 Nov 2019  –  70 days
- Linux v5.5  –  26 Jan 2020  –  63 days
- Current kernel = v5.6-rc4
  - Merge window is closed – no new features for 5.6
  - Expect 5.6 kernel on March 29 or April 5
Linux v5.1

- Deprecating support for a.out binaries
  - Use ELF from now on
- Lots of DRM changes
- More Y2038 work
  - More syscalls with 64-bit time values
    - See [https://git.kernel.org/pub/scm/linux/kernel/git/torvalds/linux.git/commit/?id=b1b988a6a035](https://git.kernel.org/pub/scm/linux/kernel/git/torvalds/linux.git/commit/?id=b1b988a6a035) for a list of new syscalls (20 of them)
Linux v5.1 (cont.)

- Energy-Aware scheduling
  - New sysctl knob
    (/sys/kernel/sched_energy_aware)
  - Documentation/scheduler/sched-energy.txt
  - Documentation/power/energy-model.txt

- Improved idle behavior in tickless systems
  - Added timer-events oriented (TEO) CPU-idle governor
    - Uses timer interrupts timing instead of device interrupt timing for predicting next wake-up
  - See [https://lwn.net/Articles/775618/](https://lwn.net/Articles/775618/)
Linux v5.1 (cont1.)

- Modification to memfd for Android use case
  - Add F_SEAL_FUTURE_WRITE operation for memfd regions
    - Caller can continue to write to region, but others can’t
  - Want to eliminate use of ashmem (legacy Android memory manager)

- F2FS has a new mode bit that disables copy-on-write behavior for a file (F2FS_NOCOW_FL)
Linux v5.2

- ext4 supports case-insensitive lookups
- New system calls for filesystem mounting
  - See https://lwn.net/Articles/759499/
- Support for ARM Mali GPUs
- New “mitigations=” command-line option to control speculative execution features
- Improved support for gcc ‘-Wimplicit-fallthrough’
- Lots of BPF improvements
- Pressure stall monitors added
Pressure stall monitors

- Allow user-space to detect and respond quickly to memory pressure
- Monitor writes a stall notification specification to /proc/pressure/memory
  - Indicates to the kernel what frequency to check for stalls (which can be as little as .5 seconds)
- Monitor receives stall notification events (via poll())
- Android can use this to detect memory pressure and kill processes before the device becomes sluggish
  - See https://lwn.net/Articles/775971/
Linux v5.3

- New pidfd feature – to handle pid reuse
- Scheduler utilization clamping
  - (see next slide)
- 0.0.0/8 IPv4 address support
  - Allows 16 million new IPv4 addresses
- Added CONFIG_PREEMPT_RT
  - But not the final code yet
- init_on_alloc and init_on_free boot options
  - pre/post-initialize memory from heap allocations
- See https://kernelnewbies.org/Linux_5.3
Scheduler utilization clamping

- Extension to Energy Aware Scheduling
- Allows specifying minimum or maximum frequency for a process
- Can clamp user-visible (foreground) tasks to high minimum frequency
- Can clamp background tasks to low maximum frequency
- Helps conserve power while still keeping responsiveness
- See [https://lwn.net/Articles/762043/](https://lwn.net/Articles/762043/)
Linux v5.4

- EROFS graduated from staging
- exFAT added to staging
- fs-verity feature added
- boot-time entropy fix
  - Fix for commit that was reverted in late 5.3
  - Prevents get_random() from blocking on boot
  - Implementation based on clock jitter, by Linus himself
- See https://lwn.net/Articles/802360/
Linux v5.5

- ARM64 has full support for ftrace
- MIPS supports kcov – coverage analysis
- KUnit testing framework added
- CPU scheduler’s load-balancing algorithm was replaced
  - Follow-on to PELT (Per Entity Load Tracking) work
  - See https://lwn.net/Articles/732021/ for PELT info
- sysctl() system call was removed
  - Use /proc/sys/... instead
Linux v5.6

- WireGuard VPN feature added to kernel
- Work on 2038 issues for ALSA
  - New 64-bit structure for some operations
- Mechanism to disable SELinux at module load time is deprecated (system runtime)
  - Plan is to add a painful delay (increasing with each kernel release) in order to discourage future use
- Bootconfig tool to add super-long command-linelines arguments to kernel
- F2FS gained support for compression
Interesting stats

- 285 new contributors in 5.5
  - Developers who have never contributed before
- The top 3 “reported-by” lines for bugfixes are for automated testing systems

<table>
<thead>
<tr>
<th>Test system</th>
<th>Reported-bys</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hulk Robot</td>
<td>164</td>
<td>15.7%</td>
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<tr>
<td>Syzbot</td>
<td>125</td>
<td>12.0%</td>
</tr>
<tr>
<td>kbuild test robot</td>
<td>102</td>
<td>9.8%</td>
</tr>
</tbody>
</table>

- At least 14% of commits are fixes for bugs
- See [https://lwn.net/Articles/798505/](https://lwn.net/Articles/798505/)

Table data from: [https://lwn.net/Articles/810639/](https://lwn.net/Articles/810639/)
More stats

- 90% of kernel developers are paid by their employer to work on the kernel
  - But there are areas that no one is paid to work on (dedicated)
  - E.g. There is no paid documentation person or team
  - There’s still a lot of anxiety about unsupported or under-resourced areas of the kernel
Outline

Linux Kernel
Technology Areas
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Industry News
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Technology Areas

- Audio
- BPF
- Documentation
- Filesystems
- Graphics
- Languages
- Memory

- Security
- Testing
- Tracing
- Toolchains
- Tools
- Build Systems
Audio

- Work in ALSA drivers to support new 64-bit structures
  - One benefit is cleanup of fields to avoid year-2038 problems
- New patch proposed for Qualcomm protection domain restart helpers
  - Feature specific to qualcomm SoCs
  - Allows AVS Audio to run in a separate address space
  - Can crash&recover without disrupting other domains
BPF

- Replacing kernel operations structures
  - Ability to replace a structure of function pointers
  - Can load new functions as BPF modules
  - Can create a structure in user-space to override the current in-kernel structure
  - Use a BPF program to replace the in-kernel structure

- Caveats:
  - Must be a structure pre-designated to support this kind of replacement
  - Is only used for TCP congestion-control algorithms (for now)
  - See [https://lwn.net/Articles/811631/](https://lwn.net/Articles/811631/)
BPF (cont.)

• Book Review: BPF Performance Tools
  • Looks like a nice book, and lots of neat tools
  • A sign that BPF should probably be taken seriously
  • See https://lwn.net/Articles/813114/

• Recent discussions about BPF integration with LSM for kernel runtime security instrumentation (KRSI) patch set
  • KRSI needs high performance (wants a special mechanism to replace crypto calls with static jumps)
  • LSM wants general mechanisms (no special cases for BPF)
  • See https://lwn.net/Articles/813261
Good article on how to contribute to kernel documentation:

- [https://lwn.net/Articles/810404/](https://lwn.net/Articles/810404/)

Specific Tasks:

- Remove all warnings
  - Specific tips on how to address changes required in kerneldoc messages
- Add unreferenced kerneldoc info
  - Use scripts/find-unused-docs.sh
- Fix typos
  - This is a good place to start to learn process
  - Leave some typos for other beginners
Documentation Tasks (cont.)

• Specific Tasks (cont.):
  • Remove, fix or tag outdated documentation
    • Lots of old stuff
  • Organize content into better groups
  • Improve HTML look
    • Improve the style-sheet for HTML output
  • Make rst2pdf tool work with kernel docs
  • Write more documentation
    • Still lots of undocumented areas
  • Would be nice to have automated testing to indicated “health status” of kernel docs
  • See this video, from kernel recipes 2019:
    • https://www.youtube.com/watch?v=1LuAlUKqKDk
Side note on Japanese Docs

- Japanese translations of some docs are available
  - See Documentation/translations/ja_JP
- There was an effort in 2007 to do Japanese translation
- I’m not sure what happened to that effort
  - Website http://www.linux.or.jp/JF/ no longer works
- You might ask Tsugikazu Shibata about the status of the docs. He did some work in the Japanese docs in 2017.
Filesystems

- F2FS gets compression (already mentioned)
- New io_uring system for asynchronous I/O
  - Already have AIO system – this one is better
  - A ring buffer is shared between kernel and user-space
    - User-space can stuff opcodes (commands) into the buffer, and the kernel can execute them, without any syscalls
  - More complex operations are envisioned using BPF
    - That’s under heavy discussion
- See https://lwn.net/Articles/810414/
Graphics

- Panfrost driver for ARM Mali GPUs
  - Open Source driver
  - Some support by ARM for development work
  - Support for Mali T720, T820 and T860
  - Support for normal desktops (including Wayland)
  - Currently only support for OpenGL ES <= 2.0
  - Does not support Vulkan yet

- Source: LinuxConfAU talk by Robert Foss
Graphics (cont.)

- “Everything Awesome about GPU Drivers”
  - LinuxConf AU talk by Daniel Vetter
  - Good overview of state of Linux kernel graphics stack
  - Source: https://linux.conf.au/schedule/presentation/86/
Languages

- Python
Python

- Python 2 is now unsupported
  - (since Jan 1, 2020)

**Python 2.7 will retire in...**

<table>
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<tr>
<th>Years</th>
<th>Months</th>
<th>Days</th>
<th>Hours</th>
<th>Minutes</th>
<th>Seconds</th>
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What's all this, then?

Python 2.7 **will not be maintained past 2020**. Originally, there was no official date. Recently, that date has been updated to **January 1, 2020**. This clock has been updated.

- There are lots of resource to help with conversion to Python 3
  - "2to3" tool, online guides, etc.
Python in embedded

- Snek by Keith Packard
  - New language - subset of Python
  - Made to run on Arduinos and other low-end systems
  - Can squeeze down to about 32kB without math functions
  - See [https://lwn.net/Articles/810201/](https://lwn.net/Articles/810201/)
- MicroPython = decent subset of python for embedded
  - 100s of kBs
  - There are variations like CircuitPython
Memory

- Facebook contributing OOMD to systemd
  - Facebook’s OOMD is a replacement for Linux OOM handler
    - Faster and more configurable
  - Plan to contribute to systemd so it’s automatically integrated into most Linux distributions
  - Probably take about 1 year to show up
  - See https://www.phoronix.com/scan.php?page=news_item&px=Systemd-Facebook-OOMD
Security

- Control-flow integrity for the kernel
  - New patch set for kernel hardening
    - Not mainlined yet – it’s in development
  - Reduce ability to redirect code execution
  - Validate function pointer or return address on heap or stack
  - Compiler can collect function pointers into tables that are verified before being used
  - Arm has support for “shadow stacks”
    - Only stores return addresses
    - Shadow stack location is kept secret to prevent tampering
  - Requires Clang (LLVM 10) support for latest features
- See https://lwn.net/Articles/810077/
Security (cont.)

- Kernel Runtime Security Instrumentation (KRSI)
  - Allows to mitigate a security attack while it’s in progress
  - Provides flexible hook for monitoring and mitigation
  - Implemented as LSM that can run eBPF programs
  - See https://lwn.net/Articles/798157/

- Recent news:
  - Disagreements between LSM and BPF developers over ways to enhance performance
    - See BPF section
WireGuard VPN tunnel

- Faster and simpler than Ipsec and OpenVPN
- Aim is to be as easy to use as SSH
  - Simple generation of public/private key pairs
  - Similar mode of distribution for public keys
- Uses Linux ip commands to set up tunnel
- Allows roaming by both sides of tunnel
- Uses state-of-the-art cryptography
  - High-speed cryptography, suitable for embedded
- Amenable to security audits
  - Due to much simpler code base
Testing

- Kselftest
- Kunit test framework
- Linux Test Project
- Update on testing collaboration
Kselftest

- Sub-system test code inside kernel source tree
- Recent work:
  - Working on making sure tests cross-compile and install
    - Bpf is particularly difficult – it often requires the very latest (unreleased) LLVM compiler
  - Goal is to run with KernelCI
  - Also trying to reduce output differences
    - Some tests never adopted TAP format, like they were supposed to
Kunit test framework

• Set of patches for kernel unit testing
  • Accepted in v5.5
• Lots of changes recently
  • Allow tests to run on kernel boot or on module load
    • Originally tests were configured to run on a UML kernel (not on real hardware)
  • Changes to put log output into debugfs
  • Addition of KASAN (kernel address sanitizer) tests to Kunit
Linux Test Project (LTP)

- Adding syzkaller reproducers to LTP
  - Syskaller is a fuzzer that creates C programs to find kernel oopses
  - It saves all the ones what “work”
    - Called ‘reproducers’
    - There are thousands of them
  - LTP and syskaller developers working to add the reproducers to LTP
  - Result will be a nice regression test to make sure that the bug doesn’t come back in
Testing Collaboration

• “The magical fantasy land of Linux kernel testing”
  • Presentation by Russell Currey at LinuxConf AU
• Good overview of kernel testing landscape
  • Test matrix is very large
  • Lots of different stakeholders
    • Developers, maintainer, distros, end-users
• People are starting to work together, but it’s slow progress
• First collaboration=unified results format
• Source
Tracing

- New Bootconfig system
  - Extra boot configuration
  - Allows passing a large set of options to the kernel during boot
    - Was not a good fit for device tree
  - Passes a tree-structured key-value list
  - Data is loaded with initrd
  - Used primarily to pass kernel command line items for ftrace and early tracing
  - Mainlined in 5.6
  - See https://lwn.net/Articles/806002/
Tracing (cont.)

• Babeltrace 2.0 released
  • New version of the babeltrace trace manipulation toolkit
  • For viewing, converting, transforming, and analyzing traces
  • See https://lwn.net/Articles/810395/
  • And https://babeltrace.org
Kernel tracing overview

Commonality

- LTTng
- stap
- trace-cmd
- perf
- bpftrace
- LTTng mod
- SystemTap mod
- perf_open()
- sys_bpf()
- trace events
- perf events
- eBPF (JIT)
- kprobes
- uprobes
- trace points
- function hooks (ftrace)
Toolchains

• Static analysis framework for GCC
  • Analyses intermediate representation of code
  • Uses a plugin architecture, for now
  • 2 facility categories for now:
    • memory allocation errors
    • file handling errors
  • Adds meta-data to the diagnostic message
    • Lots of information about the problem
    • e.g. Can indicate the Common Weakness Enumeration (CWE) entry for a problem
  • See https://lwn.net/Articles/806099/
Tools

• Continuing efforts to create tools for bridging gap between git and e-mail
  • New tool: get-lore-mbox
    • Can download a thread related to message id into a local .mbox format (mail archive)
    • Can download just the patch in the thread
    • Can automatically add tags (from different e-mails in the thread) to the patch
      • E.g. reported-by, acked-by, tested-by, etc.
    • Very handy for retrieving patches that were mangled by your email system
    • See https://lwn.net/Articles/811528/

• More work is going on to make additional tools
  • https://github.com/gitgitgadget/gitgitgadget
    • Converts from github pull request to e-mail patches
Tools (cont.)

- New patch attestation scheme
  - Allows users to sign patch messages sent to email lists
  - New tool: attest-patches
  - Protects against patches coming from unconfirmed sources
  - Some kernel developers are not convinced it’s needed
  - Under development – not deployed yet
- See https://lwn.net/Articles/813646/
Build systems

- Yocto Project
Yocto Project

- Yocto Project 3.0 release
  - Oct 23, 2019
  - Lots of work on build caching
  - Have new “build change equivalence” feature
  - Have hashes of source and binaries
  - Can detect already-built items, and retrieve them from cache
  - Speeds up build
  - Can share build artifacts using a server
- Technology lends itself to reproducible builds
- https://lwn.net/Articles/804640
Conferences (past)

- Embedded Linux Conference 2019
  - August 21-23, San Diego, California, USA
- Linux Plumbers
  - September 9-11, Lisbon, Portugal
- ELC Europe 2019
  - October 28-30, Lyon, France
- Automated Testing Summit 2019
  - October 31, Lyon, France
- LinuxConf Australia 2020
  - January 13-17, Gold Coast
LinuxConf AU videos

- Schedule at: [https://linux.conf.au/schedule/](https://linux.conf.au/schedule/)
  - Videos linked from session pages
    - On YouTube AND their own server
- I watched some:
  - Picolibc
    - Small C library for embedded by SiFIVE
  - OpenWRT for Energy monitoring
  - Everything Awesome about GPU drivers
  - Panfrost: Open Source meets Arm Mali GPUs
  - The magical fantasy land of Linux Kernel testing
LinuxConf AU impressions

- Some embedded topics
  - Whole track on RISC-V
    - Glibc, picolibc, software environments
    - Testing, energy monitoring, trusted boot, snek
  - Not a ton of embedded content, but some worth viewing
- Lots of conferences provide videos now
  - This is a very welcome trend
Conferences - 2020

- Embedded Linux Conference 2020
  - June 22-24, Austin, Texas, USA
- Linux Plumbers
  - August 28, Halifax, Canada
- Open Source Summit Japan
  - September 15-16, Tokyo, Japan
- ELC Europe 2020
  - October 26-28, Dublin, Ireland
COVID-19 issues?

- Will conferences get canceled?
- No one knows what the status of COVID-19 will be this summer
- Everyone hopes that the virus will be under control in the next few weeks
- But it depends on many factors
  - China new infection rate is down this week
  - But South Korea, Italy, Iran are up
- ELC has not been canceled yet
COVID-19 infection rates

- Many of the China province graphs look like this: (this is for Hunan province)

- See https://corona.help/ for good charts
ELC video salvaging

- ELC 2015 and ELCE 2015 videos were lost
  - Due to an error by Linux Foundation staff with LF’s YouTube channel
  - ELC 2016 videos were recovered from original videographer
- I’m backing up all known videos
  - If you downloaded one of the missing videos, let me know
- Trevor Woerner also making a backup of ELC videos and slides
  - Also collecting videos from other events
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- Trade associations
- Update on Gnome Foundation patent lawsuit
  - And patents (and OSS) in general
- FSF launching collaboration site
- New president of IBM
- Guido van Rossum retired
- Raspberry Pi STEM kit
Trade associations

- Linux Foundation
  - Subaru announces adoption of AGL software for infotainment in some cars
  - Uber and Microsoft announce OpenChain conformance
  - LF Core Infrastructure Initiative collaborates with Open Source Technology Improvement Fund (OSTIF)
    - OSTIF committing resources through LF’s Community Bridge project
    - To enhance security audits of Open Source projects
      - LF already spent over $1M to complete 20 audits
  - See https://www.linuxfoundation.org/press-release/
Gnome Foundation sued by patent NPE (troll)

- Rothschild sued Gnome Foundation
  - Claims that “Shotwell” image management app infringes a patent
  - Patent is very generic
    - Uploading images over a wireless network using a filter criteria (e.g. subject identification)
- Gnome foundation is fighting back
  - Established a legal defense fund
- OIN has suggested that they will help
- See https://www.zdnet.com/article/leave-gnome-alone-this-patent-troll-is-asking-for-trouble/
Patent lawsuit update

- Gnome has filed a motion to dismiss

- Gnome fundraiser raised more than needed:
  - $150,199 as of March 4
  - This is more than their goal of $125K

- Good overview of issues at:
OIN update

- Microsoft joined OIN in October
  - Will now provide patents to pool to defend Linux from patent attacks
  - My how times change...
- OIN creates “United Patents Open Source Zone”
  - To defend OSS projects from patent trolls
More on patents: DPL

- Law professors from Berkeley working on new license and pool system:
  - Defensive Patent License
  - Not the same as traditional patent pools
    - Members of DPL contribute 100% of their patents to the pool
    - Patents only used for defense
    - A bunch of rules (e.g. for non-aggression between DPL members)
  - Encourage developers to use patent law like GPL uses copyright law
- See https://www.networkworld.com/article/2230668/the-defensive-patent-license-makes-patents-less-evil-for-open-source.html
New (freer) code collaboration site

- FSF is launching a new code collaboration site in 2020
  - Ostensibly to compete with github and gitlab
  - Want it to meet standards for ethics, freedom, etc.
    - No third party tracking
    - Proper license information
  - Plan to select an existing open source platform and enhance it to meet goals
  - In the planning stages now
  - See https://www.fsf.org/blogs/sysadmin/coming-soon-a-new-site-for-fully-free-collaboration
Jim Whitehurst, former CEO of RedHat will be the new president of IBM
- Effective April 6, 2020
- Current president and CEO Virginia Rometty is retiring
- Indicates that knowledge of open source culture is extremely valuable
- See https://www.forbes.com/sites/jonobacon/2020/01/31/jim-whitehurst-becomes-president-of-ibm-why-he-gets-culture/#1a70802b6394
Guido van Rossum retired

- Guido created the Python language
- Retired from Dropbox in October
- Time marches on...
  - When will Linux people start retiring?
    - John “Maddog” Hall, early Linux pioneer is still active!
Raspberry Pi STEM kit

• New Sania Box embedded computer kit
  • Includes a Raspberry Pi 4 board and custom shield
    • Has multiple sensors, relay, pushbutton, LEDs, 7-segment display
  • Works with Raspberry Pi 4
  • Targeted at STEM education market
    • To teach basics of Python, electronics and IoT
  • Ships in April
• Was designed by 13-year old Sania Jain
  • I feel like I wasted my youth...
• See http://linuxgizmos.com/teen-launches-raspberry-pi-4-based-stem-kit/
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- LWN.net – https://lwn.net
  - If you are not subscribed, please do so
  - Some content is delayed by 2 weeks for non-subscribers (some links in this presentation)
- Linux Gizmos – https://linuxgizmos.com
- Phoronix - https://www.phoronix.com/
- Google
Thanks!