



CE Workgroup

Embedded Linux Community Update

June 2022

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Nature of this talk...

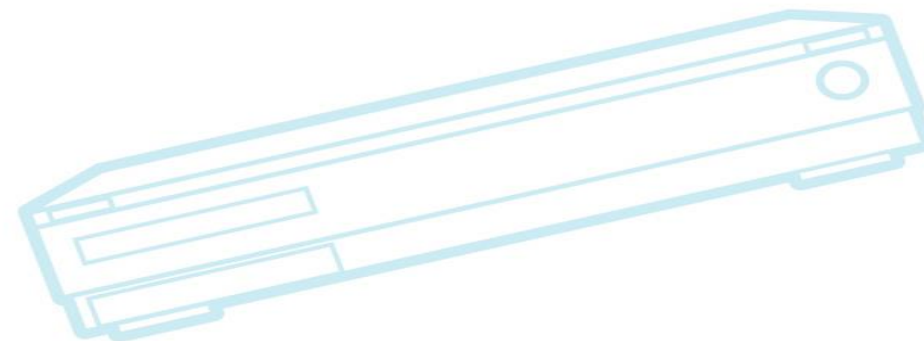
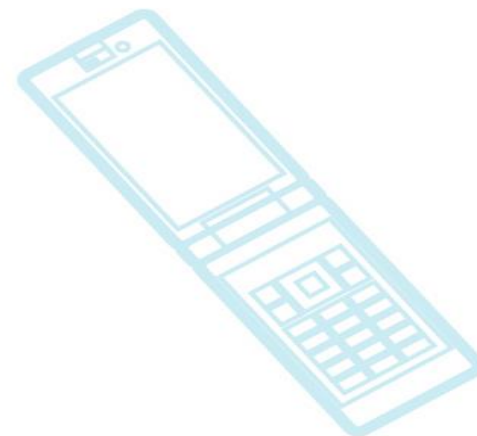
- Quick overview of lots of embedded topics
- A springboard for further research
 - If you see something interesting, you have a link or something to search for
- Some overlap with material given previously
 - I may go quickly over some older slides
- Not comprehensive!
 - Just stuff that I saw



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Outline

Linux Kernel
Technology Areas
Conferences
Industry News
Resources





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Outline

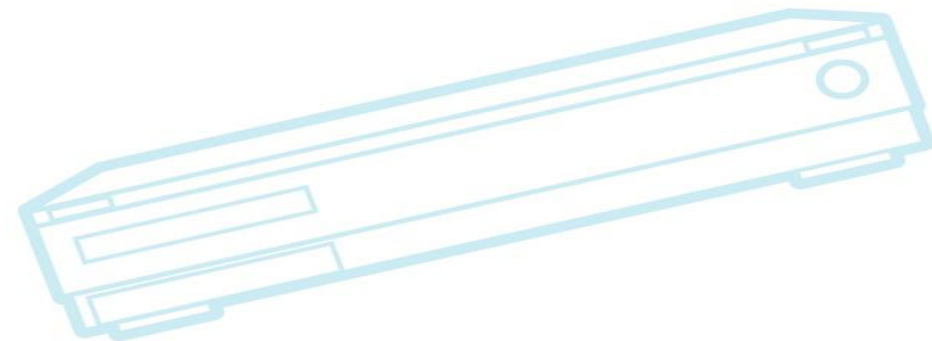
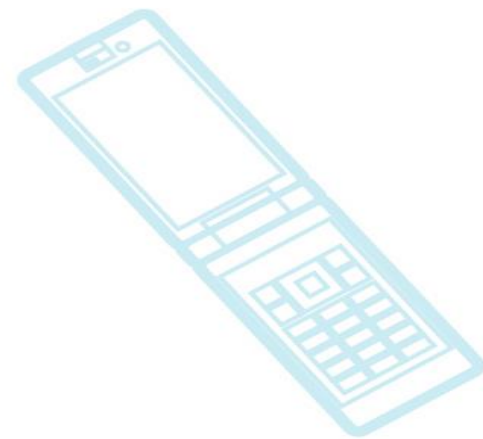
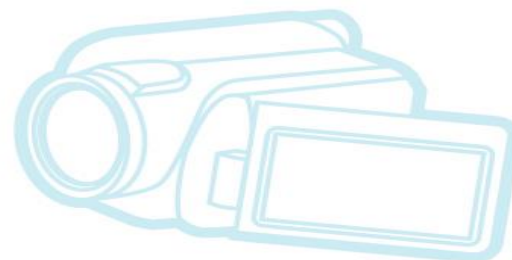
Linux Kernel

Technology Areas

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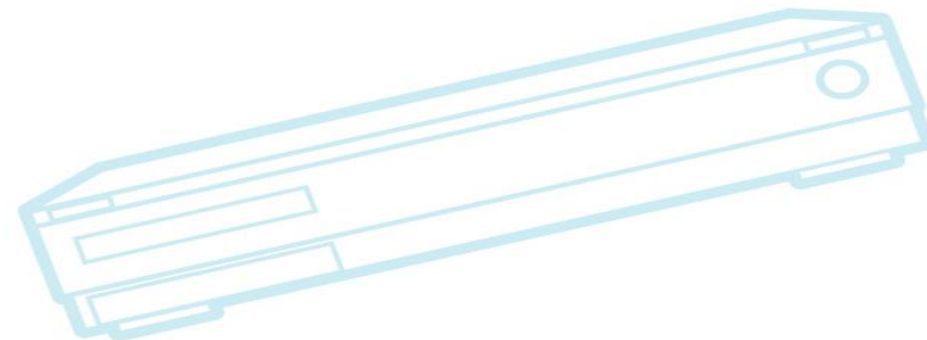
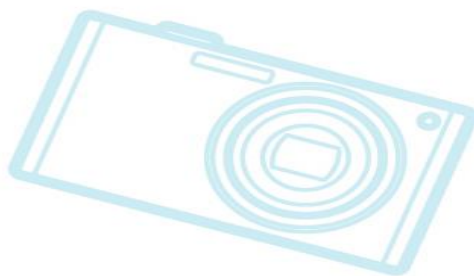
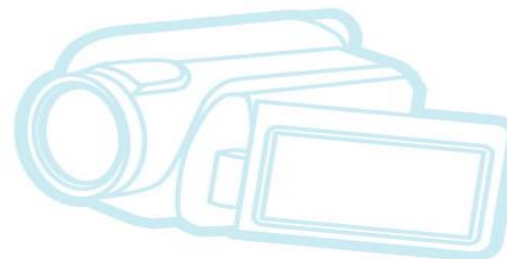
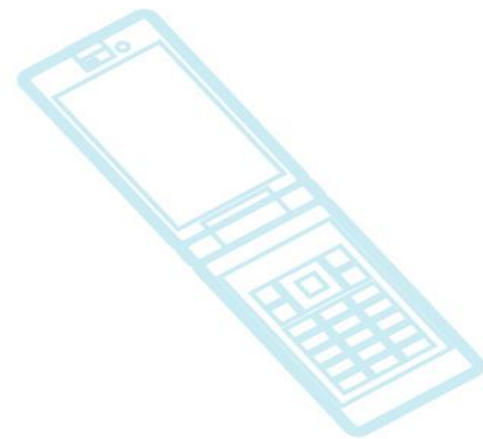




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Linux Kernel

- Versions
- Stuff In Progress
- Development Stats





Kernel Versions

- Linux v5.14 – 29 Aug 2021 – 63 days
- Linux v5.15 – 31 Oct 2021 – 63 days
 - “Trick or Treat” release
- Linux v5.16 – 9 Jan 2022 – 70 days
- Linux v5.17 – 20 Mar 2022 – 70 days
- Linux v5.18 – 22 May 2022 – 63 days
- Linux v5.19-rc1 – Just finished the merge window
 - Expect 5.19 release by end of July



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Linux v5.14 (August 2021)

- memfd_secret system call was added
 - Details on next slide
- new tracers
 - osnoise - show application delays caused by kernel activity
 - timerlat – detailed info about timer-based wakeups
- A fair amount of Qualcomm and MediaTek driver code
 - clocks, pin controllers, sound
- “simplifiedrm” driver
 - direct-rendering interface for simple framebuffer devices
- Kunit can run tests under QEMU (in addition to native and UML)



memfd_secret system call

- Creates a region of memory that even the kernel cannot directly access
 - Pages are removed from the kernel's direct map
 - Intended to be used for cryptographic info (e.g. keys)
- Makes it difficult for other processes or even the kernel to unintentionally (or even intentionally) access the memory
 - See <https://lwn.net/Articles/835342/>
 - For many more details, see <https://git.kernel.org/pub/scm/linux/kernel/git/torvalds/linux.git/commit/?id=1507f51255c9>



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Linux v5.15 (October 2021)

- Realtime preemption locking code – “Sleeping spinlocks”
 - It’s a big deal - More on this later
- More io_uring performance enhancements
 - “BIO recycling”
- Core scheduler support for asymmetric systems
 - Cores on the same chip that can run either 64-bit or 32-bit
 - How to deal with scheduling when the processor can’t even execute some code
 - See <https://lwn.net/Articles/838339/>
- ksmbd – in-kernel SMB server (!!)
 - Not a replacement for Samba, but provides better optimization for Linux in some situations



Linux v5.15 (cont.)

- printk indexing
 - Can extract all printk messages from kernel
 - Is used to detect changes that could break log-parsing tools
- DAMON system merged (Data Access Monitor)
 - See next page
- kernel now uses `-Werror` flag during build, by default
 - A compiler warning will cause the build to fail
- If `LLVM=1` (env var), you don't need to specify `CROSS_COMPILE`
- Minimum gcc version is now 5.1



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DAMON system

- DAMON = Data Access Monitoring tool
- Provides tools to record data access and show visualizations of access patterns
- Different visualizations available
 - A heatmap of memory access for your workload
 - Graphs showing information about working set size
- See <https://damonitor.github.io/doc/html/v17/admin-guide/mm/damon/index.html>
- *Nice diagnostic tool... but is it actually more?*



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Linux v5.16 (January 2022)

- EROFS (Enhanced Read-Only FS) continues to get new features
 - Multiple-device support
- io_uring operations can now have security policies enforced by SELinux or Smack
- First set of patches for folios
 - New memory data type (described later)
- DAMON operation schemes added
 - DAMON can perform pro-active page reclaim, and monitor the physical address space
 - See <https://lwn.net/Articles/863753/>



Linux v5.17 (March 2022)

- Random number generator replaced SHA1 with BLAKE2 hash function
 - Results in 370% increase in RNG performance
- Kernel can decompress kernel modules within itself (instead of relying on user space)
 - This helps the LoadPin security module
- RTLA – realtime analysis tools have been added
 - osnoise and timerlat (not sure how these are different from the tracers added in 5.4)
- Some changes to flags fields used in FUSE_INIT call
 - Check your FUSE filesystems and tools for compatibility



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Linux v5.18 (May 2022)

- Support for older ARM (ARMv4, ARMv5) MMU-less systems has been removed.
 - Support for MMU-less ARMv7-M remains
- Lots of RISC-V stuff
- Tracing system supports “user events”, to allow dynamic tracepoints in user-space applications
- Added guidelines for research on the kernel community
 - Response to the UMN kernel security research episode
 - See [Documentation/process/researcher-guidelines.rst](#)
- Kernel compiles against C11 language standard (instead of C89)
 - See <https://lwn.net/Articles/885941/>



Linux v5.19-rc1 (in progress)

- printk in per-console threads is finally finished
 - See <https://lwn.net/Articles/800946/>
 - printk indexing is now documented
- ARM multi-platform work completed (mostly)
- Initial support for LoongArch CPU architecture
 - new RISC instruction set architecture - similar to MIPS or RISC-V
 - By Loongson (Chinese chip manufacturer)
- New hardware timestamp engine subsystem
 - Devices that can record timestamps



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Stuff In Progress

- A few things being worked on
 - Page folios
 - Multi-generational LRU
 - Rust for the kernel
 - Zero-copy network transmissions with io_uring
 - See <https://lwn.net/Articles/881675/>
- BPF special memory allocator problems
 - Made it into 5.18, then was disabled
 - See <https://lwn.net/Articles/892743/>



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Folios

- Folio = New data type to indicate a pointer to a page that is NOT the tail of a compound page
 - Basically, it's an internal typing improvement to memory management
- To avoid issues with passing a pointer to a page (part of a compound page) with wrong attributes
 - Sometimes, a routine doesn't work properly with a tail page
- Some kernel devs like them, and some don't
- See <https://lwn.net/Articles/849538/>
- Some parts of folio code adopted in 5.16 and 5.17
 - Still not actually used yet



Multi-generational LRU (MGLRU)

- Currently have 2 queues for managing page eviction
 - Active and inactive
- MGLRU propose multiple queues and a more complex algorithm
 - Less CPU overhead
 - Better working set estimation
 - Proactive reclaim (which lowers memory pressure)
- Big debate about whether it could be merged in 5.17
 - It wasn't merged, but it has supporters
 - Google says they're already using it and it's working well
 - See https://www.phoronix.com/scan.php?page=news_item&px=Multigen-LRU-v5



Rust for the Linux kernel

- Some people want to support Rust code in the Linux kernel
- Third version of the Rust support patch was posted in January
- Is a difficult problem because Rust programs don't normally have to deal with memory allocation failures
 - Requires a modified memory allocator that can handle failures
- Lots of features are still unstable
- Has not been accepted into kernel yet, but work is proceeding
- A bit more on this later...



Zero-copy networking with io_uring

- RFC patch by Pavel Begunkov
 - Not sure when it would be ready for upstreaming
- About 1.5 to 2 times faster than current (socket-based) zero-copy networking
- See <https://lwn.net/Articles/879724/>



Linux 5.18 developer stats

- 14,954 change sets, by 2024 developers (289 new devs.)
- Most active 5.18 developers, by changesets:

Person	Changesets	Percent	Subsystem Area
Krzysztof Kozlowski	214	1.4%	device tree updates
Matthew Wilcox	164	1.1%	folio patches
Christoph Hellwig	154	1.0%	refactoring of block and fs layers
Geert Uytterhoeven	140	0.9%	Renesas pin control
Ville Syrjälä	135	0.9%	i915 graphics driver



Linux 5.18 developer stats

- Most active 5.18 developers
- By lines of code:

Person	Lines changed	Percent	Subsystem area
Leo Li	227676	19.4%	AMD graphics driver
Quinquin Zhuo	197757	16.9%	AMD graphics driver
Ian Rogers	72008	6.1%	perf tool
Alan Kao	15814	1.3%	removed nds32 architecture
Ming Qian	12176	1.0%	Amphion media drivers



Most active employers for 5.18

- Most active active employers for the 5.18 kernel:

Company	Changsets	Percent
Intel	1708	11.4%
(Unknown)	1155	7.7%
Red Hat	958	6.4%
Google	886	5.9%
(None)	818	5.5%
AMD	781	5.2%
Linaro	560	3.7%



Kernel commit log entries

- Number of commit log entries (including merges), per kernel version

Company	git log count	developer count
5.14	15871	1982
5.15	13473	1853
5.16	15385	2074
5.17	14199	1978
5.18	16205	2116
5.19-rc1	13973*	1846*

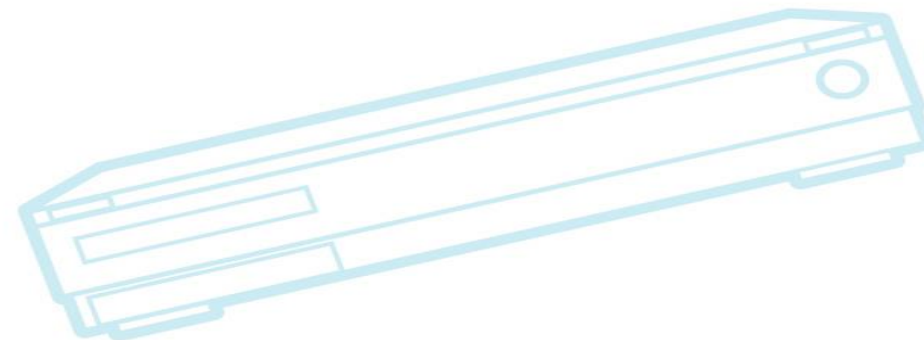
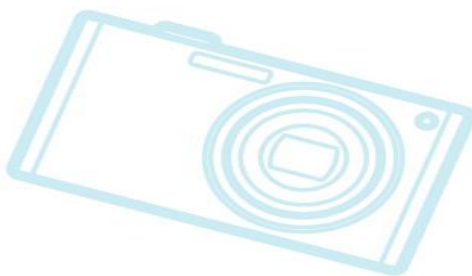
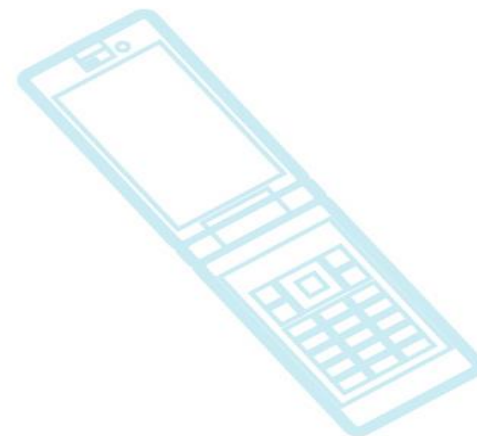
- *we're not done with the 5.19 release cycle yet
- Extracted using 'git log v5.yy..v5.zz --oneline | wc -l' and 'author-stats v5.yy..v5.zz | wc -l'



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Kernel Development

- Kernel code sign-offs
- Maintainer issues





Kernel code sign-offs

- Most maintainers are pushing code directly to Linus
 - But there are exceptions for big sub-systems:
 - Networking, graphics, system-on-chip, character drivers
- Progress is being made to cryptographically sign tags so that the patch source can be validated
 - Only 714 patches in 5.18 did not come from a signed tag
 - Have been working on improving this for 11 years, and are almost done
- See <https://lwn.net/Articles/880599/>

Table data:



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Maintainer issues

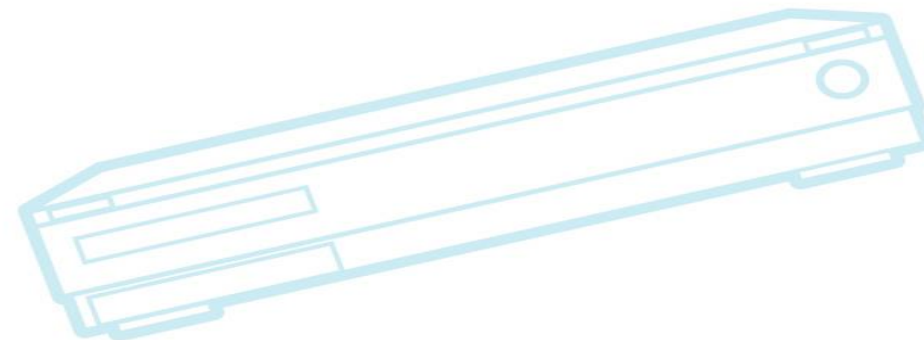
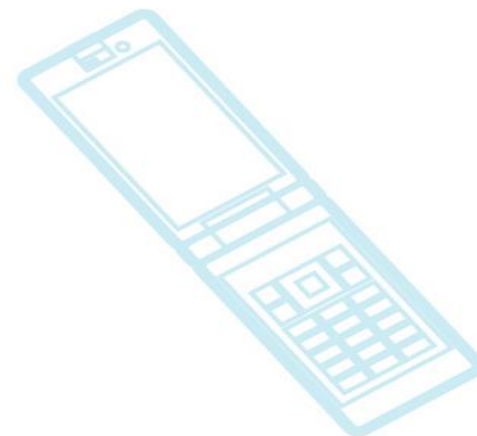
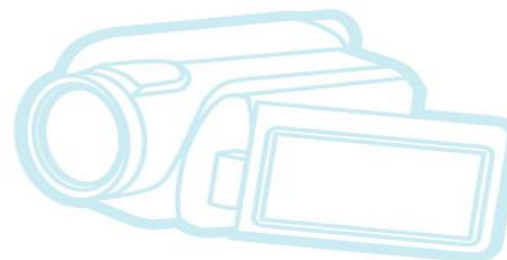
- Discussion at 2022 Linux Storage, Filesystem and Memory-management summit
- Still have a shortage of kernel maintainers
 - Sometimes see conflict, people are overworked
 - Always too much to do:
 - Example: handle CVE reports for issues found by fuzzed filesystem tests
 - Should not be considered a bug. A hardened system will not allow users to mount arbitrary (e.g. USB) filesystems
- Maintainers sometimes wear too many “hats”
- More automated testing would help
 - Volunteers for testing ops would help a lot
- See <https://lwn.net/Articles/896918/>



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Resources





CE Workgroup

Technology Areas

- Audio
- Core Kernel
- Filesystems
- Graphics
- Languages
- Networking
- Security
- Testing
- Toolchains
- Tracing



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Audio

- PipeWire continues to gain ground
 - Intended to replace PulseAudio and JACK
 - Is higher performance
 - WirePlumber is a new session manager for PipeWire
 - Scriptable in LUA
 - See Talk by Geoge Kiagiadakis (Collabora) from ELC 2021
 - https://elinux.org/images/f/fb/Master_your_pipewire_streams_with_wireplumber.pdf
- PulseAudio 16.0 Released in May
 - Lots of fixes and improvements
 - One item: pactl can outoput info in JSON
 - See <https://www.freedesktop.org/wiki/Software/PulseAudio/Notes/16.0/>



Core Kernel

- memfd_secret (v5.14)
- printk_indexing (v5.15)
- scheduling for asymmetric processors (v5.15)
- RNG speedups (using BLAKE2 hash) (v5.17)
- Kernel compiles against C11 spec. (v5.18)
 - Mostly has to do with where variables can be declared
 - Want to declare iterator variable in loop itself, so macros like 'list_for_each_entry' can avoid leaking the iterator value
 - Which can result in a speculative execution vulnerability
 - See <https://lwn.net/Articles/886516/>



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Filesystems

- io_uring continues to mature
 - As a reminder: see <https://lwn.net/Articles/810414/>
 - Performance enhancements (v5.15)
 - Can be security-regulated by SELinux or Smack (v5.16)
 - Support for zero-copy networking (coming)
- EROFS and F2FS continue to mature
 - Better compression support
 - Better xattr support
- FUSE_INIT flag changes (v5.17)



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Filesystem Testing

- Developers use different testing tools and methodologies for testing Linux filesystems
 - Different testers have different priorities
- fstests and blktests are non-deterministic
 - Some failures occur infrequently (only 1 in 300 times)
 - Josef Bacik has been working to improve the reliability of fstests
 - Would be good to share test exclusion lists
- Want to identify things that broke with a patch, versus long-lived, lurking bugs that are rare
- Not enough follow-up on test failure reports
- See <https://lwn.net/Articles/896670/> and <https://lwn.net/Articles/897061>



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Graphics

- “simplifiedrm” driver merged in 5.14
- legacy fbdev sub-system got a new maintainer (Jan, 2022)
 - But there was some initial friction
 - See <https://lwn.net/Articles/881827/>
- MALI GPUS now have an fully-conformant OpenGL ES 3.1 (Panfrost) driver
 - Supportd the new Valhall GPU architecture
 - Patches are queued for upstream
 - See <https://www.collabora.com/news-and-blog/news-and-events/conformant-open-source-support-for-mali-g57.html>



Graphics – NVIDIA GPU Code

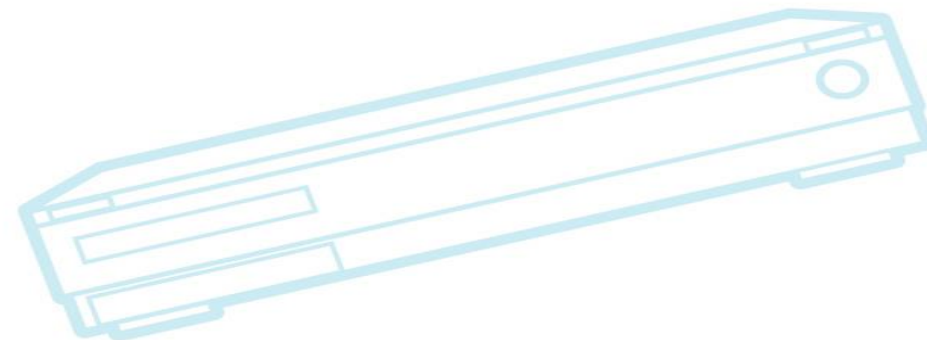
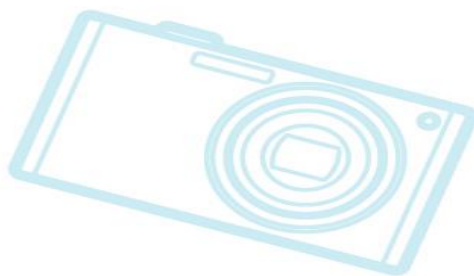
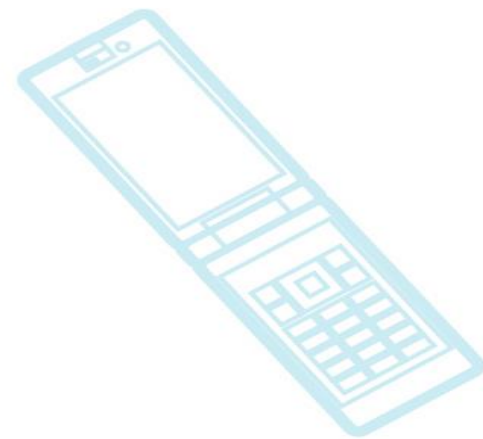
- NVIDIA transitionaing to open source driver!
 - Marks a big shift in open source policy by company
 - Code is not upstream yet
 - Kernel portion of GPU driver is available, but ABI/API not stabalized yet
 - Some proprietary code still in user-space
 - e.g. OpenGL / Vulkan / OpenCL / CUDA drivers
 - Published driver code is under dual MIT/GPLv2 license
 - Not sure effect on Nouveau driver yet
 - They can use the published code
- See <https://www.phoronix.com/scan.php?page=article&item=nvidia-open-kernel&num=1>



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Languages

- Rust
- Python





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Rust

- Rust being applied to security-sensitive tools
 - Rust version of GNU coreutils
 - Work is progressing
 - See https://www.phoronix.com/scan.php?page=news_item&px=Rust-Coreutils-Jan-2022
 - MIT license (!)
- Rust in the kernel



Rust in the Linux kernel

- Work to support Rust code in the Linux kernel continues
 - Patches are still considered experimental
- Support moved to version 1.59.0 of the Rust language
- Patch series is about 35,000 lines of code
- Have been recent discussions about what library code from Rust might be useful in kernel context
 - There is no apparent plan to support auto-loading of Rust code from Rust's dynamic package repository (crates.io)
- Most kernel developers still in “wait-and-see” mode
- See <https://lwn.net/Articles/889924>



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Python

- Some distros have disabled python2 by default (SUSE)
- Python 3.10.5 released June 5, 2022
 - Better error messages (including suggestions!)
 - See <https://lwn.net/Articles/895587/>
 - Better debugging
 - e.g. Better messages in backtraces
 - Structural pattern matching (case statements with matches)
- Having issues with removal of deprecated functions
 - Breaks backwards compatibility
 - Developers can't seem to leave the language alone
 - See <https://lwn.net/Articles/883391/>



Python Performance

- Work continues to make Python faster
- Interpreter overhead is only about 10%
- Rest of slowness relative to a compiled language is due to dynamic nature of python
 - Lots of runtime lookups for functions, methods, variables, etc.
- Several projects, by different companies and groups, are working on different aspects of performance:
 - Pyston, Faster Cpython, Cinder – caching runtime lookups
 - PyPY, Pyjion - JITS
- See <https://lwn.net/Articles/893686/>



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Networking

- Always a stream of oddball networking features and enhancements:
 - Custom configuration of hash policies for multipath IP traffic
 - Support for Management Component Transport Protocol (MCTP)
 - Unix-domain sockets now support out-of-band data
 - `SO_RESERVE_MEM` can reserve kernel memory and speed up some operations
 - New `sysctl` knobs for tuning the ARP cache behavior
 - And so on...
- New internal function to provide reason for a packet drop (5.17)
 - Helps administrators determine reason for networking issues
 - But only 63 of 4000 `kfree_skb` calls converted so far
 - See <https://lwn.net/Articles/885729/>



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Real-Time

- **rtla – real-time Linux analysis tool (5.17)**
 - See https://www.phoronix.com/scan.php?page=news_item&px=Linux-5.17-RTLA
- **PREEMPT_RT status**
 - Sleeping locks was mainlined (v5.16)



RT preemption locking code

- Provides “sleeping spinlocks” (and sleeping rwlocks)
 - Allows for process switch (schedule) while a lock is held, which is the core feature of PREEMPT_RT
- Must turn on CONFIG_PREEMPT_RT config option
 - Extensively tested to verify that non-RT kernels are not affected
 - See also CONFIG_RT_MUTEXES
- See the commit for details:
<https://git.kernel.org/pub/scm/linux/kernel/git/torvalds/linux.git/commit/?id=e5e726f7bb9f>
- Merged in kernel v5.15
 - After 17 years of development effort and many reworks and refactorings



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What's left

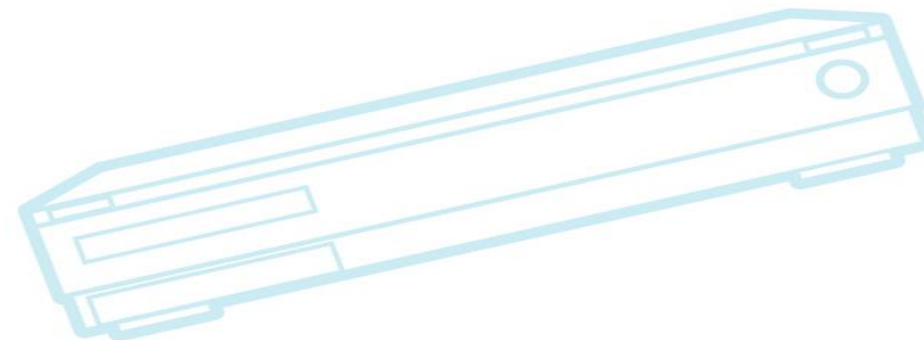
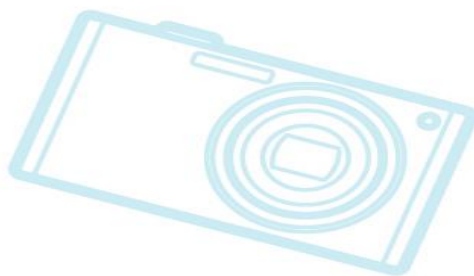
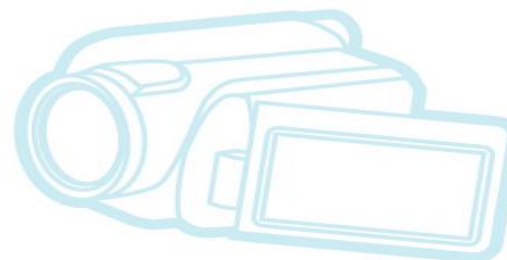
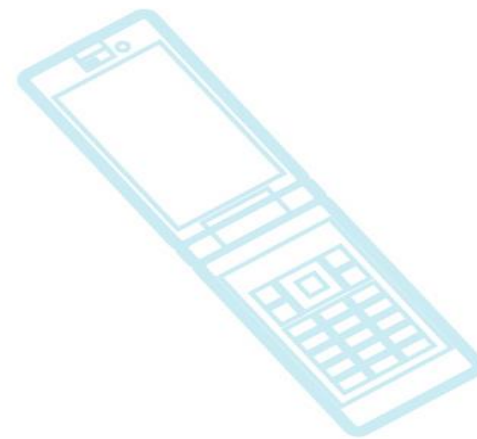
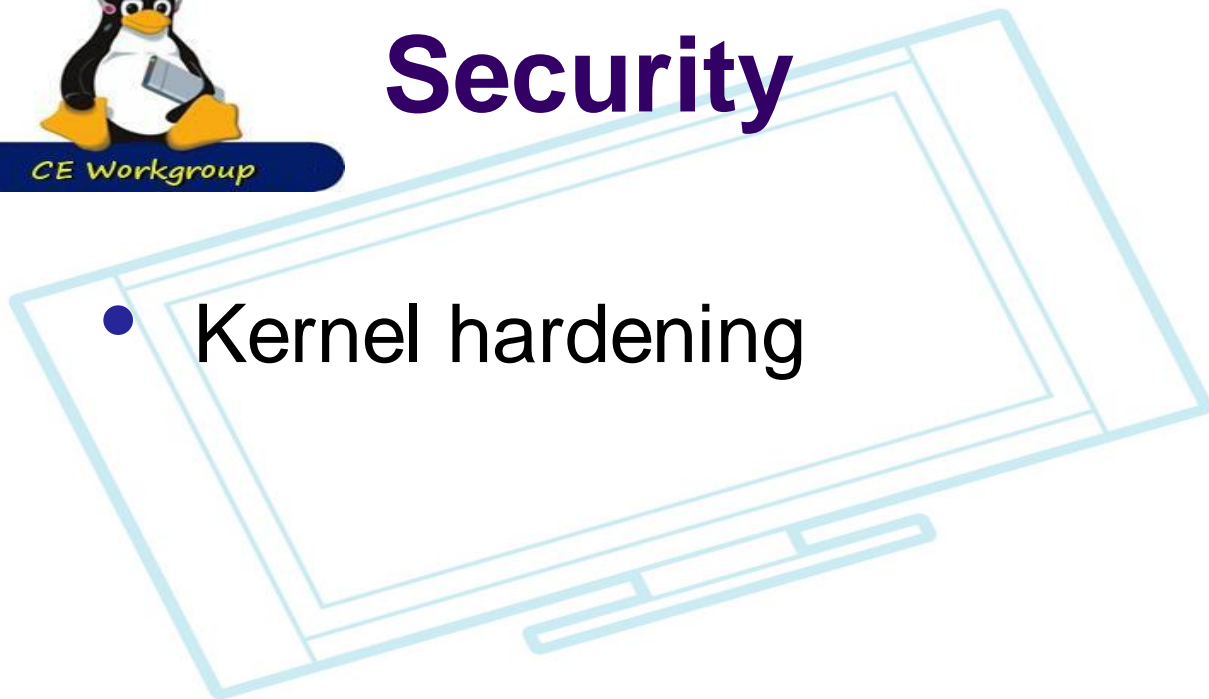
- What's left in PREEMPT_RT patches out of mainline:
 - About 1300 lines of code, affecting 92 files (in 51 patches) (!!)
 - Improved by about 1700 lines of code, 40 files and 50 patches since Feb.
 - Some big changes to printk
 - Some changes to the zram driver, 8250 serial driver, and the core scheduler (and other places)
 - People are anxious for Linux RT without having to apply a patch
- See <https://mirrors.edge.kernel.org/pub/linux/kernel/projects/rt/5.19/patches-5.19-rc1-rt1.tar.gz>



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Security

- Kernel hardening





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Kernel hardening

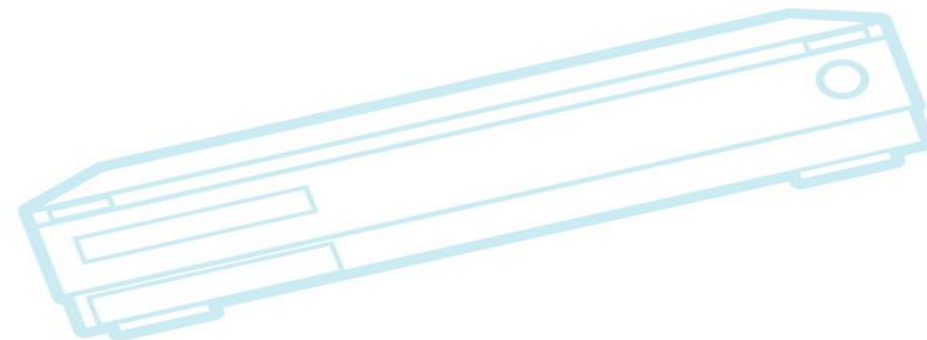
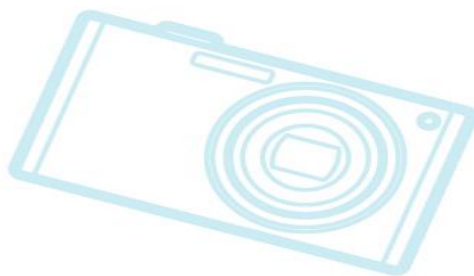
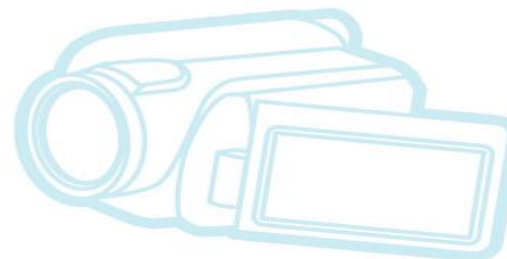
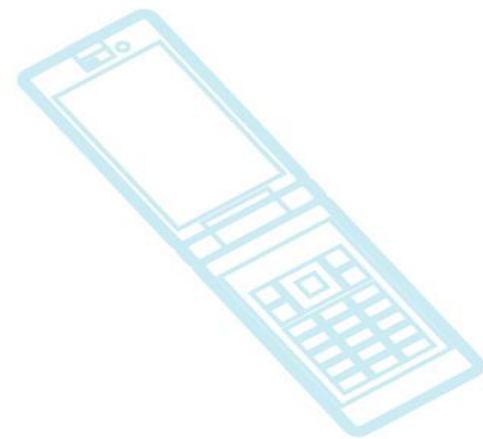
- strict memcpy() bounds checking (v5.16)
 - <https://lwn.net/Articles/864521/>
- Spectre mitigations
 - There always seem to be new speculative execution vulnerability mitigations
 - Interestingly, v5.16 removed some Spectre-mitigation behavior for seccomp()
 - Devs decided that the extra mitigations weren't really buying more security



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Testing

- Systems
- Suites of tests





Test Systems

- Systems:
 - KernelCI – has added kselftest git repo to list of trees it tests
 - Syzbot – always producing more fuzzing failure cases
 - CKI – providing many reports to upstream
 - Fuego
 - CompassCI
 - LKFT – providing many reports to upstream



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Test Suites

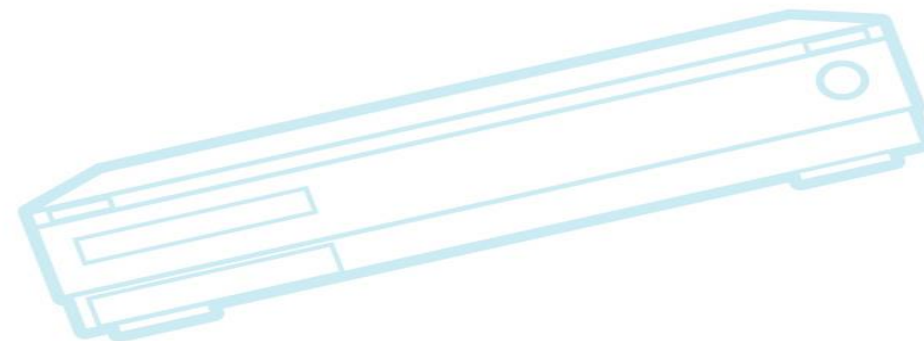
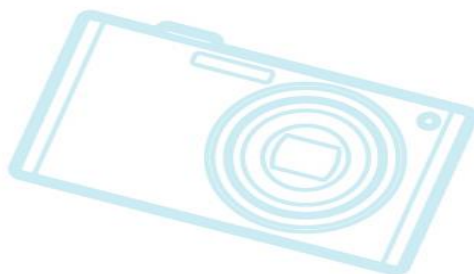
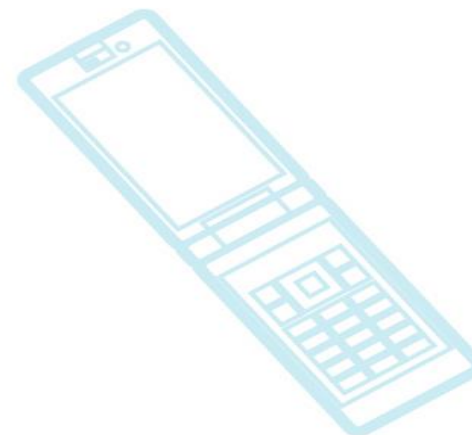
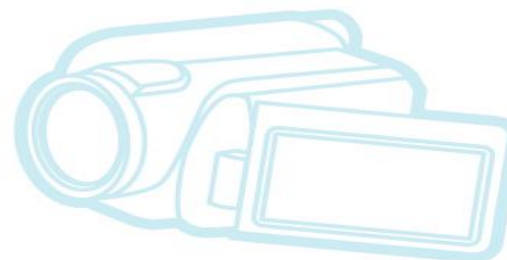
- LTP
 - Latest release: 20220527 (May 27, 2022)
 - New test and fixes to tests
 - Added 'test max runtime' concept to replace test timeout
 - <https://people.kernel.org/metan/test-timeout-and-runtime>
 - See <https://github.com/linux-test-project/ltp/releases>
- kselftest
 - New tests for arm64 (fp, signal), BPF, network drivers, kvm, network forwarding, netfilter, powerpc, ftrace user_events, vm
 - Patch submitted to taint the kernel if testing modules loaded
- Kunit
 - Some documentation improvements



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Toolchains

- GCC
- LLVM





Toolchains - GCC

- Kernel now requires gcc 5.1 to build
- GCC 12.1 released May 6, 2022
 - GCC can now initialize all stack variables implicitly
 - Intended to eliminate flaws related to uninitialized stack variables
 - Use '`--ftrivial-auto-var-init=pattern`'
 - Can fill variables with repeated 0xFE pattern, which tends to show bugs
 - Can fill variables with 0, which tends to provide safer state
 - The experimental static analyzer now has uninitialized variable use detection
 - See <https://gcc.gnu.org/gcc-12/changes.html>



Toolchains - LLVM

- For kernel builds, use of LLVM does not require CROSS_COMPILE environment variable (or make variable)
- LLVM 14.0.4 released May 24, 2022
 - See <https://releases.llvm.org/14.0.0/docs/ReleaseNotes.html>
- “Experiences of OS distributions using LLVM as their main toolchain”
 - By Bernhard Rosenkranzer at 2022 European LLVM Dev. meeting
 - See <https://youtu.be/h9xg8Y8bylg>



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Tracing

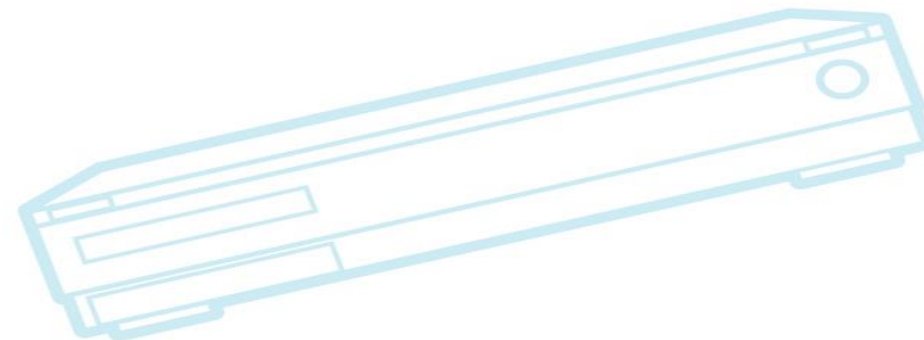
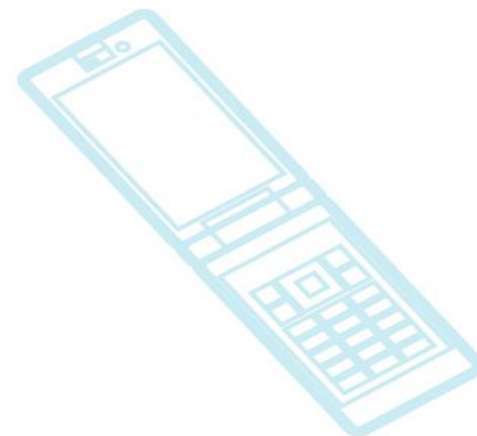
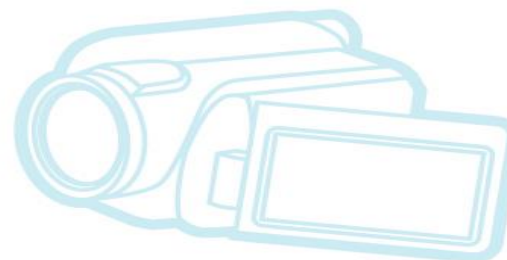
- New perf features in v5.18:
 - <https://git.kernel.org/pub/scm/linux/kernel/git/torvalds/linux.git/commit/?id=7b58b82b86c8>
- SystemTap 4.17 released
 - tracing toolkit for Linux kernel
 - See <https://lwn.net/Articles/893682/>
- Hardware Timestamping Engine system added (v5.18)
 - Can use hardware to grab timestamps for hardware events
 - See <https://docs.kernel.org/hte/hte.html>



CE Workgroup

Outline

Linux Kernel
Technology Areas
Conferences
Industry News
Resources

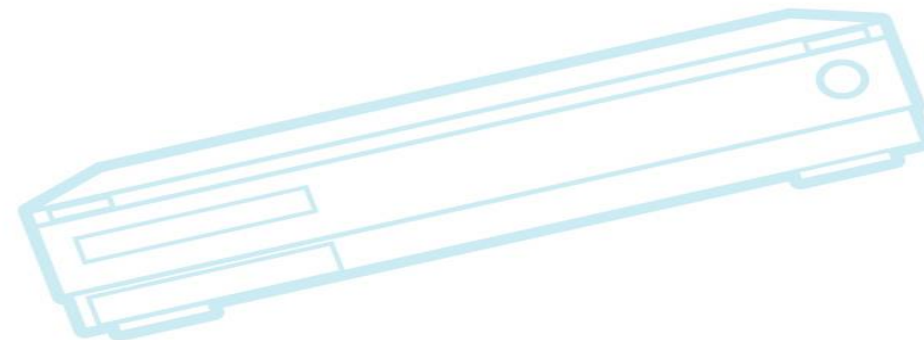
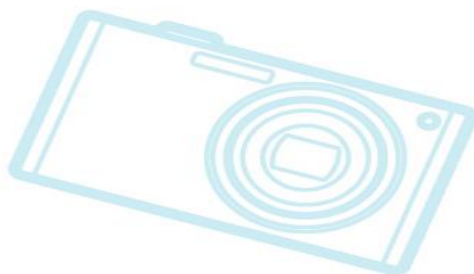
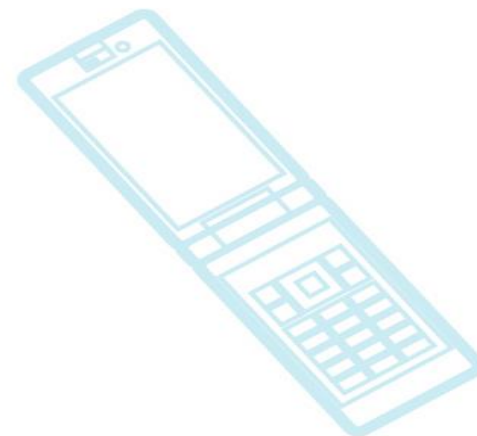
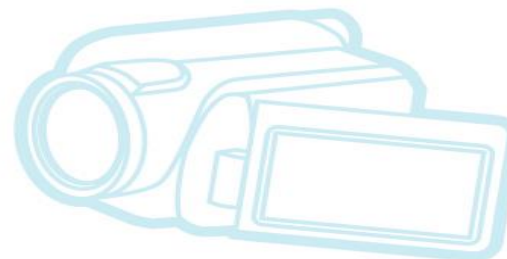




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Conferences – 2022

- ELC 2022
- ELC Europe 2022
- Open Source Summit Japan, 2022





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Embedded Linux Conference 2022

- Hybrid (Austin and virtual), June 2022
- ELC 2021 was challenging:
 - Many people could not attend ELC in-person
 - Only a few talks on-site
- In-person registration for Austin is not great (but not terrible either)
 - Appears to be less in-person international travelers (which is understandable given the pandemic overhang)
 - Not sure about registration for virtual attendees
- But the program looks good (IMHO)



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ELC Europe, 2022

- Embedded Linux Conference Europe
 - Sept 13-16, Dublin, Ireland
 - Hybrid event – in-person and virtual
- Just closed the Call for Sessions
- Conflict with Plumbers (Sept. 12-14, Dublin, Ireland)
- First in-person event in Europe after COVID-19 pandemic
- I expect better numbers than ELC North America
 - But probably still not a lot of people from Asia in person???



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Open Source Summit Japan 2022

- Open Source Summit Japan, 2022
 - Dec 5-6, Yokohama, Japan
 - Hybrid event – in-person and virtual
- CFP is open now; closes September 18, 2022
- Is a mega-event:
 - Automotive Linux Summit, CloudOpen Japan, Community Leadership Conference, ContainerCon, Critical Software Summit, Embedded IoT Summit, Emerging OS Forum, LinuxCon, Open AI + Data Forum, Open Source Summit, OSPOCon, Open Compliance Summit
- Maybe I'll be there in person?
 - I haven't been to Japan since 2019



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Lingering Pandemic issues?

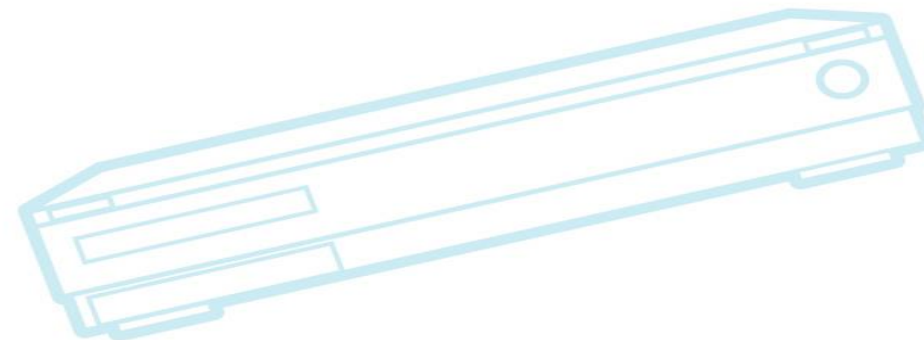
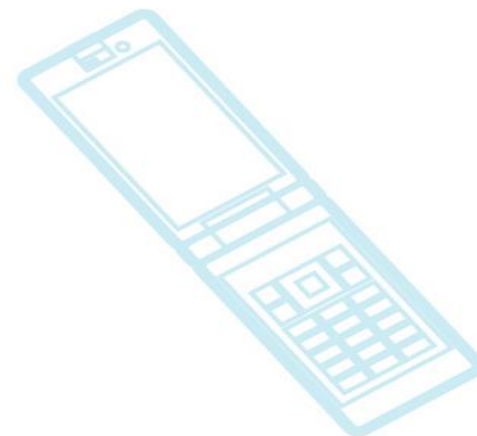
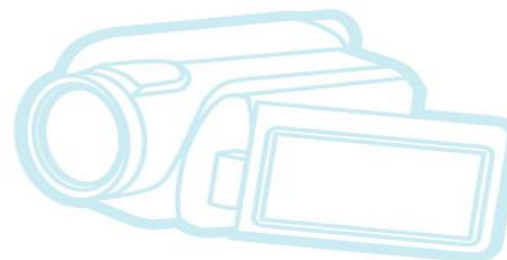
- ELC 2021 was first in-person event by Linux Foundation
 - (well, Open Source Summit 2021, in Seattle)
 - Had some attendance issues, and some issues related to hybrid-style events
- Events will continue with hybrid style through at least 2022
 - Recovery to fully in-person has been slower than expected
- We are still learning how to handle hybrid events
 - Are applying some lessons learned in 2021 events to 2022
 - Eg. recorded talks will get a dedicated room
 - Hope to try some new stuff with jitsi at ELC in a few weeks



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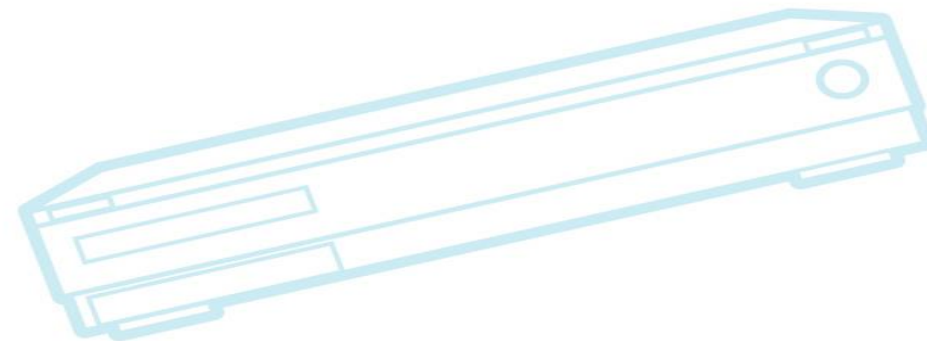
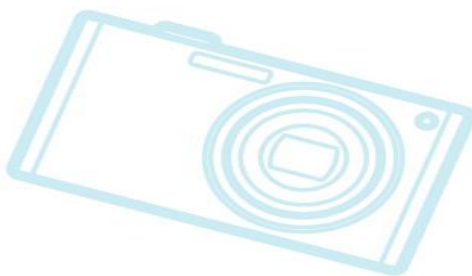
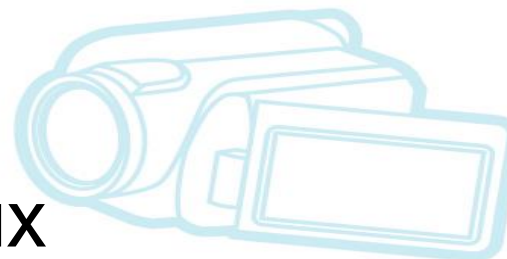
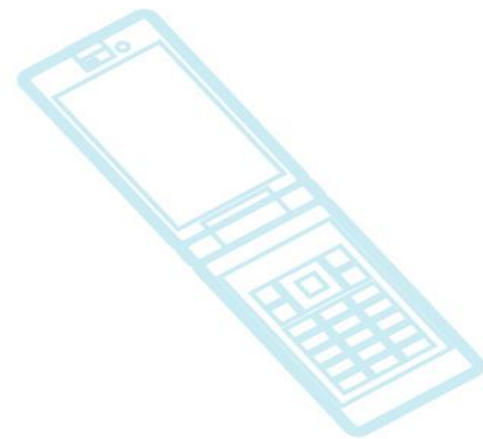




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Industry News

- Trade associations
 - Linux Foundation
 - OpenAtom
- Security news
- Interesting cases of embedded Linux
- Miscellaneous





Linux Foundation

- Training and mentorship has really ramped up:
 - 2M trainings and exams delivered as of Jan 2022
- LFX tools for managing projects
 - Project insights, security, mentorship, crowdfunding, events, training, control center
 - See <https://lfx.dev/>
- 2021 Annual Report at:
 - https://linuxfoundation.org/wp-content/uploads/2021_LF_Annual_Report_010222.pdf



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Linux Foundation stats (as of 2022)

(from LFX dashboard)

739,010

Contributing Developers

11,169

Contributing Companies

30.6M

Lines of Code Added Weekly

14.6M

Lines of Code Deleted Weekly

2.1M

Project Builds

963,390

Logged Issues

13,055

Repositories

263,499

Vulnerabilities Detected

13,802

Vulnerabilities Fixed

200,000

Free Course Enrollments

67,661

Event Attendees in Last 12 Months

2.7M

Email Messages Sent

2.1M

Chat Messages Sent

35,158

CLAs Signed

10,511

Mentees Applied

26,998

2020 Community Meetings



LF Projects

- Initiatives with recent interesting activities:
 - Linux Foundation Research
 - Open Source Security Foundation
 - Internet Security Research Group
- Projects relevant to embedded
 - Yocto Project, Zephyr, Linux kernel, KernelCI, Automotive Grade Linux, Automated Compliance Toolkit



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Linux Foundation Research

- New(ish) initiative to measure, analyze and describe the impact of open source collaborations
- Will use data from LF projects and tools (e.g. LFX), as well as other sources, to prepare reports
- Recent reports:
 - The state of SBOM and Cybersecurity Readiness
 - Hyperledger Brand Study
 - Diversity, Equity, and Inclusion in Open Source
 - Data and Storage Trends
 - The State of Open Source in Financial Services Report



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New LF Report!

“LF Research Guide to Enterprise Open Source”

- Includes:
 - The business case for open source software
 - How to develop an open source strategy
 - Creating an open source program office
 - Implementing an open source strategy
 - Measuring success with open source
 - Best practices for organizational involvement in open source projects
- Report is available at: <https://linuxfoundation.org/featured/a-guide-to-enterprise-open-source-why-your-organization-needs-it-now/>



Open Source Security Foundation

- Initiatives:
 - Security Scorecard
 - Security Reviews
 - Security Metrics Dashboard
 - Package Feeds / Package Analysis
 - CII Best Practices Badge Program
- Standards:
 - Open Source Vulnerability Schema
 - Supply-Chain Levels for Software Artifacts
- Guides and Training:
 - OSS Vulnerability Guide
 - Free Security Software Development courses: see <https://openssf.org/training/courses/>



OpenSSF Testimony before US Congress

- “Security the Digital Commons: Open-Source Software Cybersecurity”
 - Hosted by:
 - Subcommittee on Investigations and Oversight
 - Subcommittee on Research and Technology
 - May 11, 2022
- OpenSSF participated, along with other groups to discuss US Federal government role in OSS Cybersecurity
- Brian Behlendorf, General Manager of OpenSSF testified
- See <https://science.house.gov/hearings/securing-the-digital-commons-open-source-software-cybersecurity>



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Alpha-Omega Project

- Effort to systematically search for new vulnerabilities in open source code
- Alpha = highest priority (most-used, most-critical) projects
 - Will directly assist projects with security (ie with developer resources)
- Omega = long tail of open source projects (10,000 projects)
 - Plan to provide training, and apply automated security analysis, scoring and remediation
- See <https://openssf.org/community/alpha-omega/>



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OpenAtom

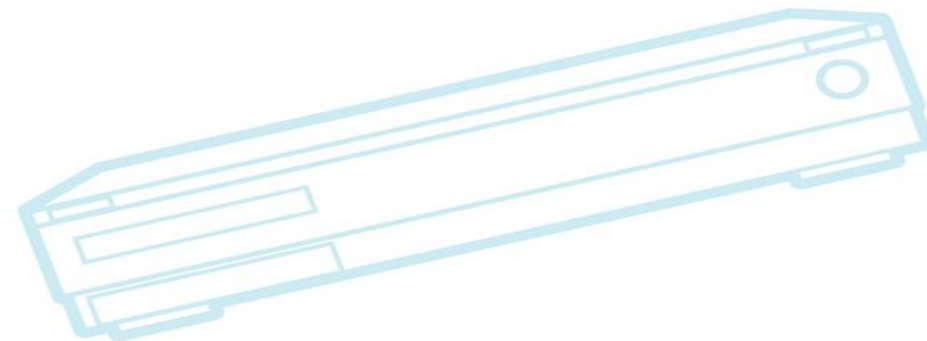
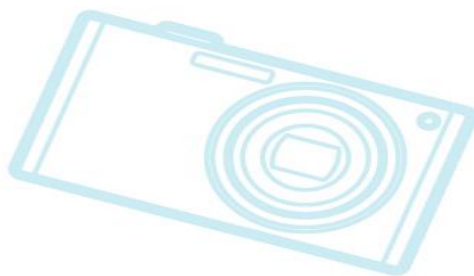
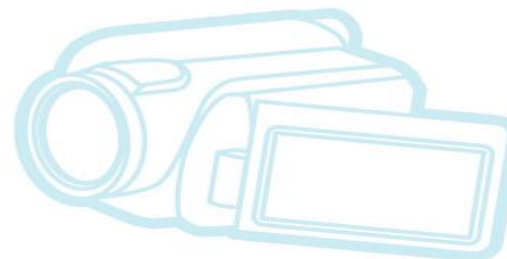
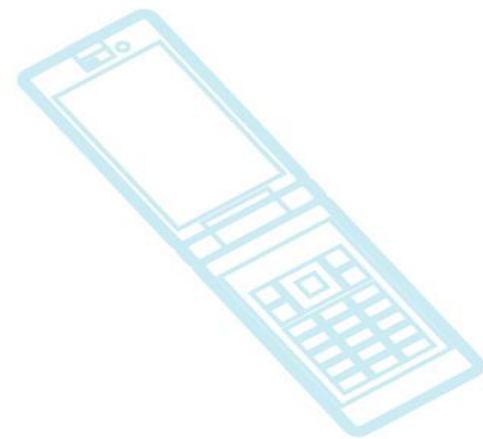
- Chinese Open Source foundation
 - Founded in June 2020 (I just noticed it) by a number of large Chinese companies
- Has a number of projects, including:
 - OpenHarmony – Operating system (distribution?)
 - Can use Linux or LiteOS as kernel
 - OpenEuler – Linux distribution for embedded systems?
 - Donated by Huawei
- Not sure if this indicates a regional shift in OSS development
 - Fragmentation of communities?



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Industry Security news

- Census II of Free and Open Source Software
- log4j
- Software Bill of Materials (SBOMs)





Census II of FOSS Application Libraries

- Conducted by:
 - Harvard Laboratory for Innovation Science
 - Open Source Security Foundation
- Data includes over 500,000 FOSS libraries used in production applications
 - Data was from package systems (npm, maven, nuget, pypi, go)
 - I found it to be of limited use
 - I'm more interested libraries and dependencies for C/C++ programs
- Available at <https://www.linuxfoundation.org/tools/census-ii-of-free-and-open-source-software--application-libraries/>



log4j (Dec. 2021)

- Is a java logging library used by over 30,000 projects
- Vulnerability was due to calling an external service as part of interpolating the logging string
 - The login string included elements provided by the user
- Fix to log4j itself was actually pretty fast and easy
- However, the way log4j was embedded in projects made it difficult for server administrators to detect if they were affected, and fix it
- Need better methods to track component dependencies
 - And also, better security audits and practices for widely-use modules



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Software Bill of Materials

- Is the new buzzword for supply chain security
- SBOMs = way to track and validate source of software as it moves through supply chain
 - Intended to detect and prevent a “Solar Winds” style attack
- LF research did a survey on SBOM and Cybersecurity readiness
 - See <https://www.linuxfoundation.org/tools/the-state-of-software-bill-of-materials-sbom-and-cybersecurity-readiness>
- See Automating Compliance Tooling (ACT)
<https://github.com/act-project/TAC>
 - Umbrella project including: Fossology, OSS Review Toolkit, SPDX Tools and Tern (SBOMS for containers)



Miscellaneous

- Intel acquired Linutronix
 - Linuxtronix is Thomas Gleixner's Linux company
 - See <https://community.intel.com/t5/Blogs/Products-and-Solutions/Software/Intel-Acquires-Linutronix/post/1362692>
- Oniro – Eclipse Foundation IoT operation system
 - Distributed IoT OS??
 - Can sit on top of Linux, Zephyr, FreeRTOS or LiteOS kernel
 - Has blueprints to build end-user ready products (e.g. vending machine)
 - Yocto-based
 - Builds entire system at one time



SFC vs. Vizio lawsuit

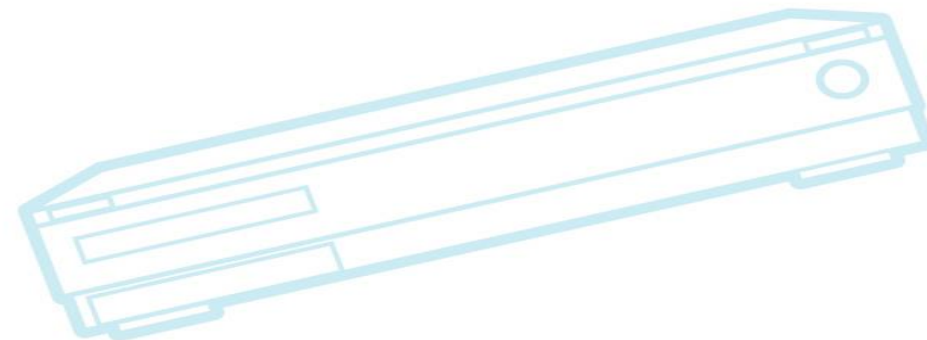
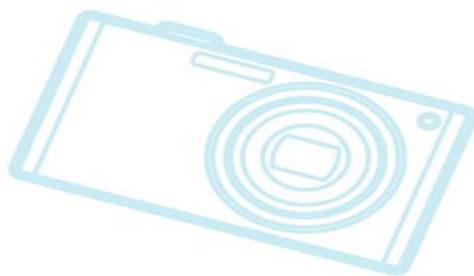
- SFC sued Vizio in California, as a third-party beneficiary of the GPL license
- Vizio tried to move the case to Federal court
 - Federal judge sent it back to California
 - Didn't like Vizio's lawyers arguments
- May indicate that the court accepts SFC claim that this is a contract issue (not just a copyright license issue)
- Nothing decided yet
 - Still waiting for resolution on some issues:
 - third-party beneficiary claim of SFC (whether SFC has standing)



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Interesting embedded Linux uses

- Mars Ingenuity helicopter (update)





Mars Helicopter - Ingenuity





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Mars Helicopter

- Mars Ingenuity Helicopter landed in February, 2021 on Mars
- Performed tests and demonstrations in April & May (2021)
 - First 5 flights were part of “Technology Demonstration”
- After demo, NASA created a plan for continued flights
- Is still flying...
 - Has performed 28 flights so far
- Updates:
 - Recent flight to lander backshell
 - Recent hardware/software issues





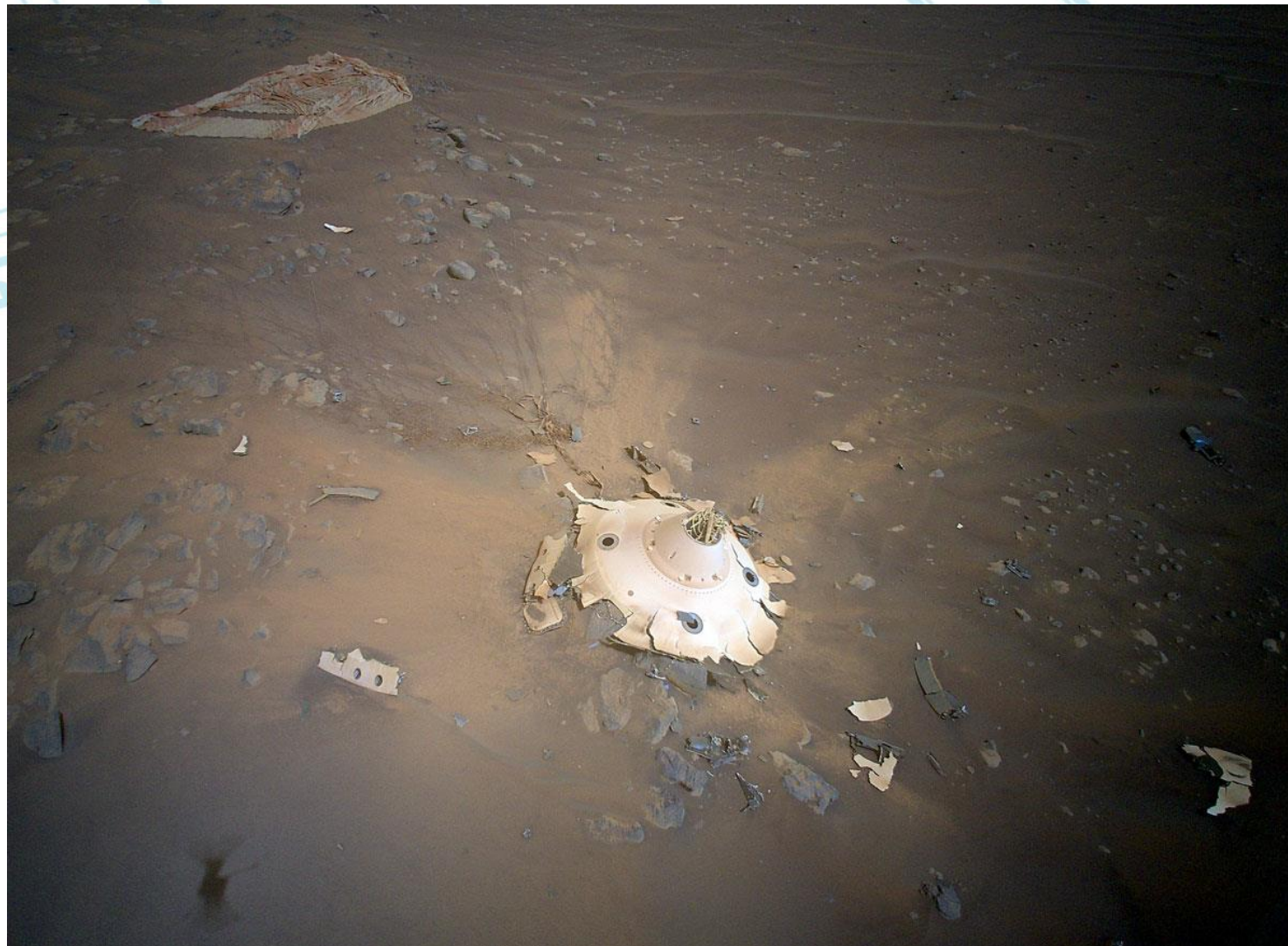
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Picture of Lander backshell (crash site)

The Rover and Helicopter were near the Lander backshell crash site in April.

The helicopter was diverted to take pictures of the area. (Flight 26)

This is the first time that crash debris has been recorded in such detail (from low air vantage point) on another planet



Source: <https://mars.nasa.gov/resources/26694/rovers-backshell-seen-from-the-air/>



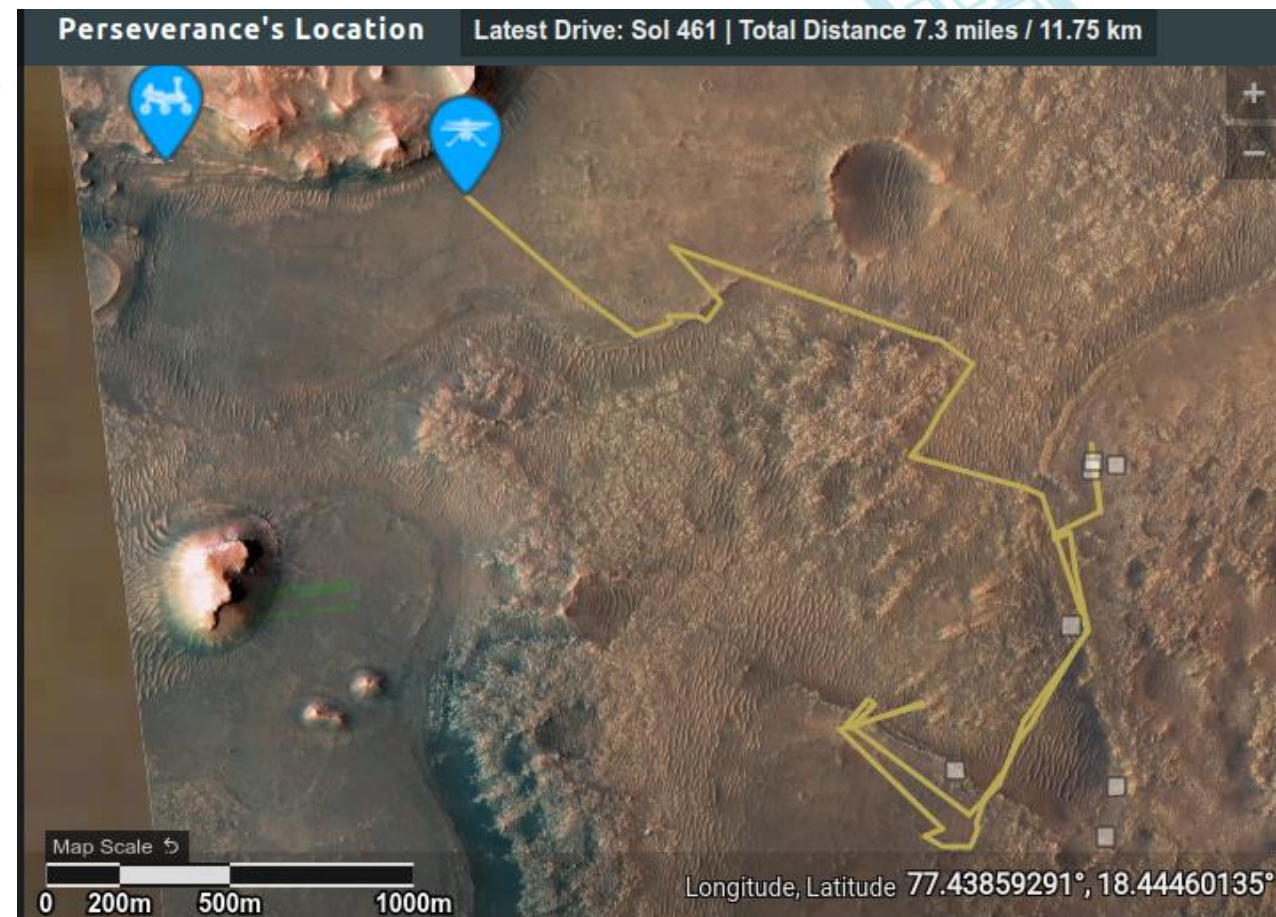
Ingenuity Helicopter Update (June 2022)

- Recent issues:
 - Loss of communications (due to a clock reset due to insufficient charge)
 - Colder weather and increased dust (due to Martian winter) has required changes to thermal management
 - Dust has reduced solar panel charging
 - NASA changed the helicopter's system shutdown threshold
 - Helicopter shuts down at night, and allows lower core temperature
 - Inclinometer is now broken
 - NASA is sending a patch to use information from other sensors in place of inclinometer data
 - Will perform a software update on Mars!!
 - Note: patch was already written!
 - See <https://phys.org/news/2022-06-nasa-mars-helicopter-ingenuity-patch.html> and <https://mars.nasa.gov/technology/helicopter/status/385/keeping-our-sense-of-direction-dealing-with-a-dead-sensor/>



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Ingenuity flights on Mars





Sources for Mars helicopter

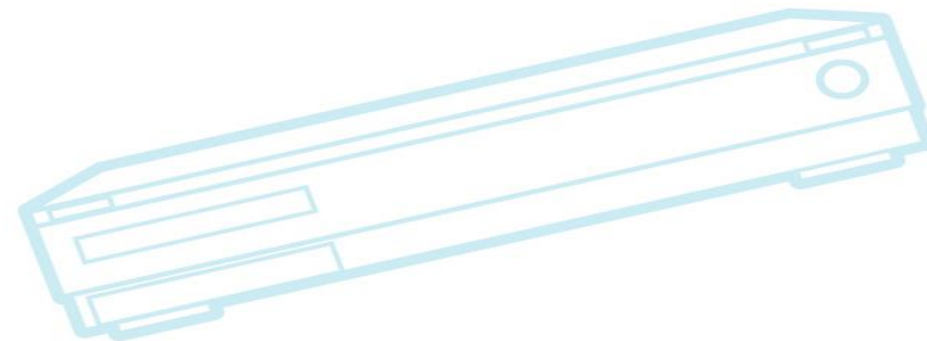
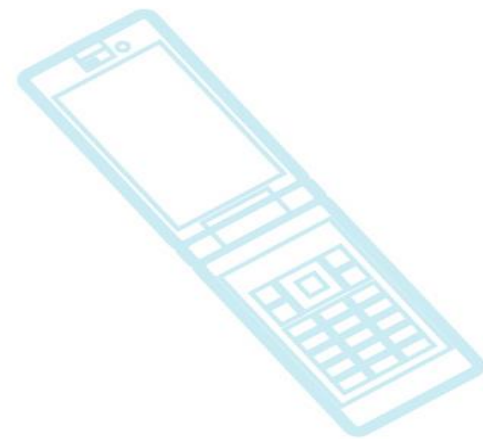
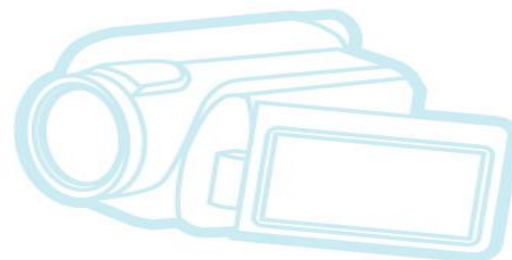
- Talk by Tim Canham at ELC 2021
 - Slides: https://elinux.org/images/5/5a/1._TIMOTHY_CANHAM.pdf
 - Video: https://youtu.be/0_GfMcBmbCg
- <https://mars.nasa.gov/technology/helicopter/>
- [https://en.wikipedia.org/wiki/Ingenuity_\(helicopter\)](https://en.wikipedia.org/wiki/Ingenuity_(helicopter))
- <https://thenewstack.io/how-the-first-helicopter-on-mars-uses-off-the-shelf-hardware-and-linux/>
- <https://www.pcmag.com/news/4-android-smartphones-with-as-much-power-as-nasas-mars-helicopter>



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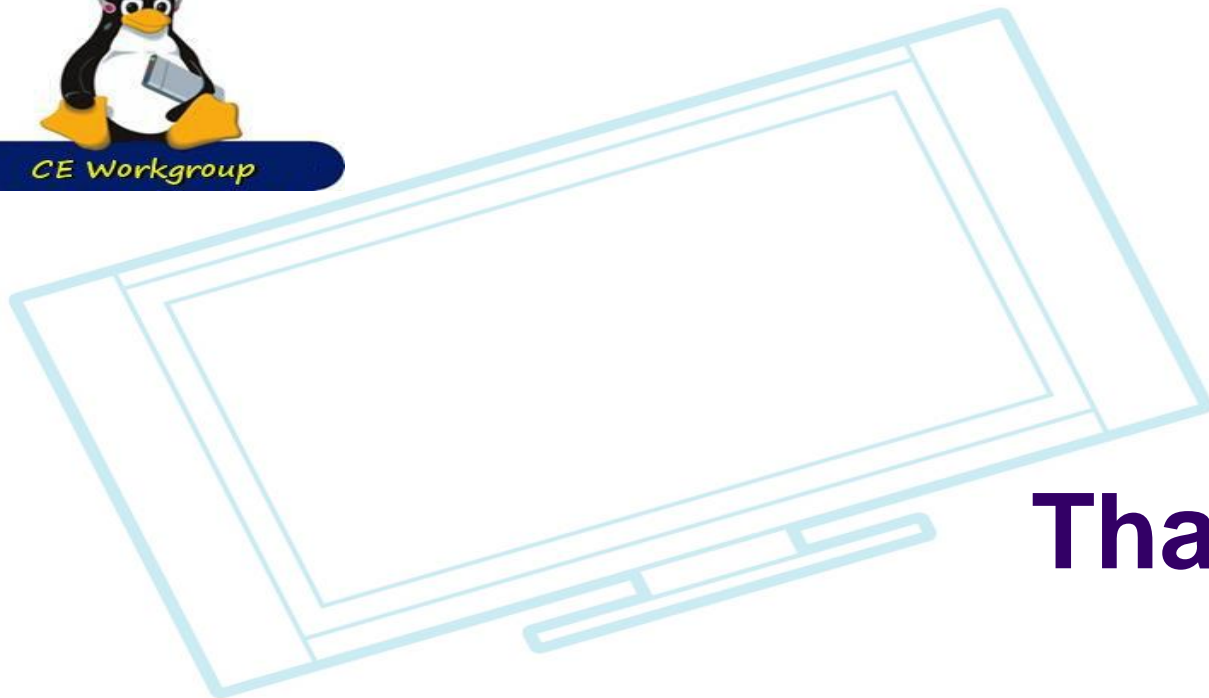
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Resources

- 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)
- Phoronix - <https://www.phoronix.com/>
- eLinux wiki – elinux.org
 - Especially: https://elinux.org/ELC_2021_Presentations
- Google



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Thanks!

