



CE Workgroup

Status of Embedded Linux

May 2018

Tim Bird

Architecture Group Chair

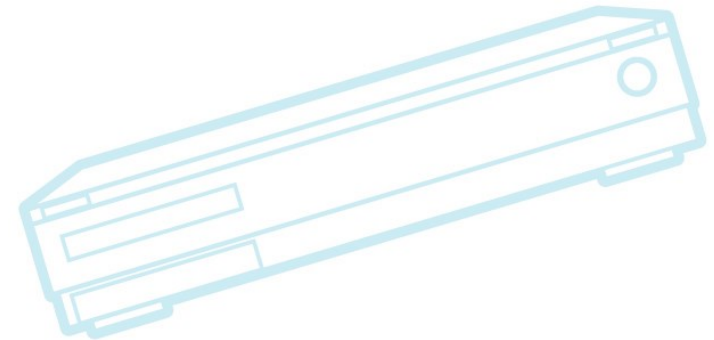
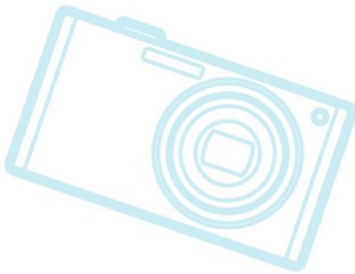
LF Core Embedded Linux Project



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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





CE Workgroup

Outline

Kernel Versions
Technology Areas
CE Workgroup Projects
Other Stuff
Resources



CE Workgroup

Outline

Kernel Versions

Technology Areas

CE Workgroup Projects

Other Stuff

Resources



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Kernel Versions

- Linux v4.12 – 2 Jul 2017 – 63 days
- Linux v4.13 – 3 Sep 2017 – 63 days
- Linux v4.14 – 12 Nov 2017 – 70 days
- Linux v4.15 – 28 Jan 2018 – 77 days
 - Included Spectre and Meltdown fixes
- Linux v4.16 – 1 Apr 2018 – 63 days
- We're on 4.17-rc6 now
 - Expect 4.17 on June 3



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Linux 4.12

- BFQ and Kyber block I/O schedulers
- Mini-tty prep work
 - Not full mini-tty implementation yet
- Proper support for USB type-C connectors
- AnalyzeBoot tool
 - Reads dmesg (and possibly ftrace log) and produces html graph of boot events
 - Part of Intel pm-graph tools project
 - <https://github.com/01org/pm-graph>
 - See `tools/power/pm-graph/analyze_boot.py`



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Linux 4.13

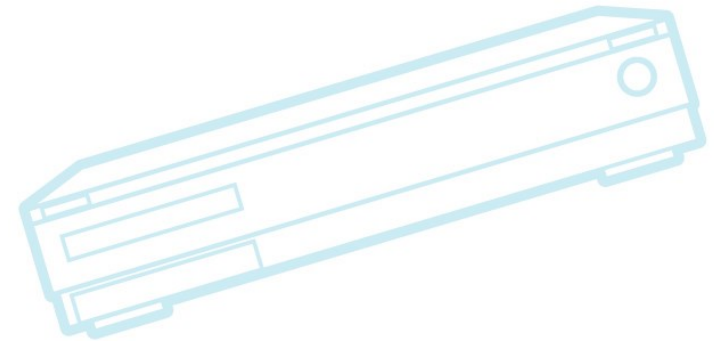
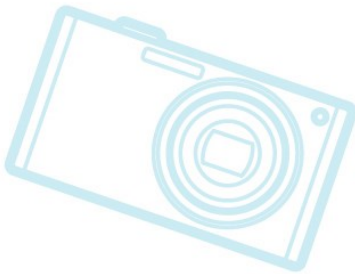
- TLS implementation in the kernel
 - Should help with HTTPS performance
 - See <https://lwn.net/Articles/666509/>
- Next-interrupt prediction
- F2FS support for disk quotas
- Kselftest transitioning to TAP13 protocol



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Linux 4.14

- New kernel stack unwinder (ORC) for x86_64
 - Better unwinding via kernel-specific out-of-band structure (for every kernel PC address)
 - See <https://lwn.net/Articles/728339/>
- zstd compression for btrfs and squashfs
- Better cpufreq coordination with SMP





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Linux 4.15

- Cramfs supports mapping persistent memory
 - Can use for XIP
- AMD display core system accepted
- Device tree compiler has support for overlays
- RISC-V support
- Spectre/Meltdown mitigations
 - KPTI
 - retpolines



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Linux 4.16

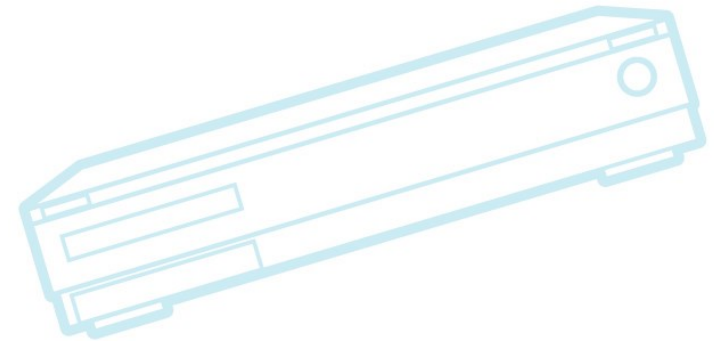
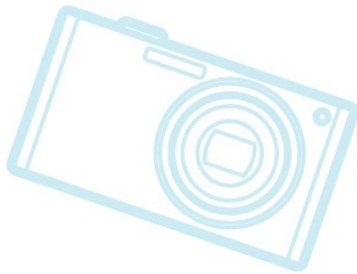
- Initial support for the Jailhouse hypervisor
- eBPF support for functions
- arm64 mitigations for Spectre and Meltdown
- More Spectre mitigations (general)
 - `array_index_nospec()`
- High resolution timers now have two modes, to allow them to be run in software interrupt context



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Linux 4.16 – cont.

- F2FS miscellaneous improvements
- Slimbus and Soundwire sub-systems added
 - These are MIPI audio bus standards
- Flex and Bison are required for kernel build





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Linux 4.17

- 8 old architectures dropped
 - Blackfin, CRIS, FRV, M32R, Metag, MN10300, Score, Tile
 - Removes about 460K lines of code
 - Only 3rd time ever that a kernel release has shrunk
- Rework of kernel idle loop
- Finished full in-kernel TLS protocol support
- Improved CPU load estimation



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Improved CPU load estimation

- Is a modification of the per-entity load-tracking (PELT) mechanism
 - PELT decays the load information about processes too quickly
 - New estimator avoids this
- Load estimation can clamp more quickly
- Good for mobile and embedded
- Adds 1% scheduling overhead
 - Requires setting SCHED_UTILEST scheduler feature bit
- See <https://lwn.net/Articles/741171/>



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Linux 4.17 – cont.

- A formal kernel memory-ordering model
 - With tests for formal proofs of adherence
 - See <https://lwn.net/Articles/718628/>
- Kernel build now requires gcc 4.5 or later on x86
- Changes to system call implementation on x86



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Bootup Time

- Nothing new, here is older stuff...
- Analyze_boot tool – new in in 4.12
- Some good previous talks:
 - ELCE 2017 - *A Pragmatic Guide to Boot-Time Optimization* by Chris Simmonds
 - ELCE 2014 - *12 Lessons Learnt in Boot Time Reduction* by Andrew Murray



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Device Tree

- **Nothing new, here is older stuff...**
- **Device Tree validation**
 - Schema for binding language, validator for bindings and for device tree data
 - New proposal for device tree validation by Pantellis and Grant Likely
- **Updated Device Tree specification**
 - Want to update material and make it more available
- **Overlays**
 - Device tree compiler has support for overlays



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File Systems

- **F2FS**
 - Miscellaneous fixups (4.17)
 - Lost & Found support
 - Better tuning for low_end devices
 - See https://www.phoronix.com/scan.php?page=news_item&px=F2FS-Lost-Found
 - Support for disk quotes (4.13, 4.15)
- **BTRFS and Squashfs support for zstd compression (4.14)**
 - Faster and smaller compression/decompression
 - <https://clearlinux.org/blogs/linux-os-data-compression-options-comparing-behavior>
 - See https://www.phoronix.com/scan.php?page=news_item&px=Linux-4.14-Zstd-Pull



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Graphics

- Working on support for virtual reality
 - LCA 2018 *Driving Virtual Reality from Linux* - Keith Packard



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GPU drivers

- ELC 2018 *Progress in the Embedded GPU Ecosystem* – by Robert Foss
 - *Watch the video – the slides don't have enough text*
 - Nvidia, Intel, AMD, Broadcom, Qualcomm, Vivante have upstream support
 - Of varying quality
 - ARM – some stuff happening recently with Mali T series, but not upstreamed yet.



Networking

- Time Sensitive Networking
 - ELC 2018 *The Road Towards a Linux TSN Infrastructure* – Jesus Sanchez-Palencia
 - ELCE 2017 *Deterministic Networking for Real-Time Systems (Using TSN)* – by Henrik Austad
 - so_txtime option for high-resolution transmit time
 - IEEE deterministic networking (DetNet) working group
 - Lots of standards
- Bluetooth 5 – supported



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Power management

- Rework kernel idle loop (in 4.17)
 - Prevent CPUs from spending too much time in shallow idle states
 - Reduces idle power on some systems by 10% or more
 - May increase performance of some workloads
 - See <https://www.phoronix.com/scan.php?page=article&item=linux-417-power>
 - Also: <https://lkml.org/lkml/2018/4/11/337>



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Power Management

- Presentations:
 - ELC 2018 *An Unbiased Look at the Energy Aware Scheduler (EAS)* – by Vital Wool
 - Qualcomm has their own big.LITTLE scheduler (QHMP)
 - QHMP does better than EAS in some regards
 - But cannot be mainlined (code is messy)
 - Want to use features of QHMP in EAS, which still has shortcomings



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Real Time

- RT-Preempt patches give good real-time performance
- RT-Preempt patch still out of tree
 - What's left:
 - Hotplug locking
 - Timer wheel rework
 - dentry cache locking
 - Lots work goes into maintaining RT trees out-of-mainline
 - Don't support every kernel release
 - Focused on supporting kernel LTS releases



Real Time (cont.)

- Presentations
 - ELC 2018 *Steering Xenomai into the Real-Time Linux Future* – Jan Kiska
 - ELC 2018 *Not Really, but Kind of Real Time Linux* – Sandra Capri
 - Discusses how much RT performance you can get, without Preempt-RT patches
 - ELC 2018 *Preempt-RT Raspberry Pi Linux* – Tiejun Chen
 - Demonstrates the Preempt-RT is very effective on Raspberry Pi
 - ELC 2018 *Maintaining a Real Time Stable Kernel* – by Steven Rostedt



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Security (review)

- Spectre and Meltdown
 - Break security via side-channel timing attacks using speculative execution
 - Variants 1, 2 (Spectre), and 3 (Meltdown)
- Is a family of vulnerabilities related to speculative execution
 - Many modern processors vulnerable
 - Many embedded processors not affected
- Very severe problem:
 - Can read data you're not supposed to
 - Vulnerability has existed for 20 years!
 - Cannot be fixed with CPU firmware updates
 - Mitigations are expensive



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Security

- New Spectre variants
 - Variant 3a – Rogue System Register Read
 - Variant 4 – Speculative Store Bypass
- No surprise
 - We were expecting new variations of speculative execution vulnerabilities to be discovered
- Fixes are:
 - More microcode updates for Intel processors
 - Kernel patches to use new speculative execution control flags
- See <https://lwn.net/Articles/755114/>



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Security Presentations

- ELC 2018 *Secure Boot from A to Z* – by Quentin Schulz and Mylune Josserand
 - Overview of secure boot techniques and issues
- ELCE 2017 *Security Features for UBIFS* – by Richard Weinberger



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System Size

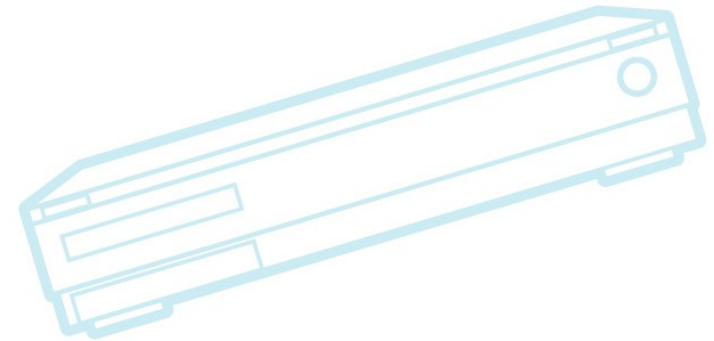
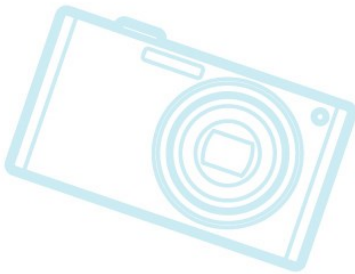
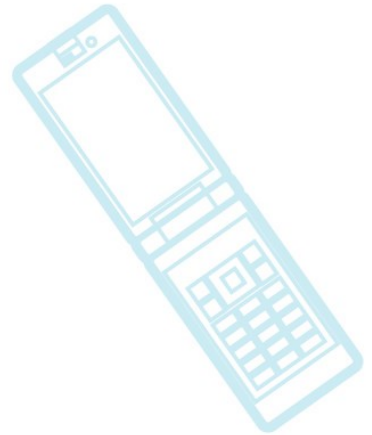
- No new kernel features
- Presentations
 - ELC 2018 *Poky-tiny and Beyond, or Trying to the put Yocto in Yocto Project* – by Scott Murray
 - Gives status of poky-tiny project, available for Yocto Project
 - ELC 2018 BoF: *Embedded Linux Size* – By Michael Opdenacker
 - Great overview of reduction techniques and status
 - Toybox and musl (smaller libc) are worth looking at
 - Long list of things that can be worked on



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Testing

- Kselftest
- Fuego
- Kernelci.org
- LKFT
- Work to make 'next' more testable





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Kselftest

- Nothing new, here is older stuff...
- Unit test system inside kernel source tree
- Recent work:
 - -silent option, to reduce output clutter
 - Support for O= option, to build outside source directory
 - Lots more regression tests (preferred place for syscall compatibility/regression tests (over LTP))
 - Converting to TAP (Test Anything Protocol) for test output (started in 4.13)
- See <https://lwn.net/Articles/737893/>



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Fuego

- Test Framework for collaborating on tests and test infrastructure for Linux
- v1.3 released May 2018
 - More report output formats (rst, csv, excel, html, pdf)
 - Hardware board control
 - Test phase execution
- Tests being added on a consistent basis
 - 18 new tests in 1.3 release (some are self-tests)
 - 7 are realtime tests
- Presentation:
 - Japan Jamboree 63: *Fuego Status and Roadmap* December 2017 – by Tim Bird
 - upcoming: ALS 2018 by Tim



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Kernelci.org

- Does continuous build/boot testing of kernel
 - Builds 126 trees continuously, then reports any errors
- Working on creating a project in Linux Foundation (more later)



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LKFT

- Linux Kernel Functional Testing
 - Relatively new Linaro kernel testing effort
 - Focused on Functional testing (as opposed to build/boot testing)
 - Focused on embedded devices
- Presentation:
 - ELC 2018 *Keeping Up With LTS: Linux Kernel Functional Testing (LKFT) on Devices* – Thomas Gall



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Making 'next' more testable

- Linux-next is the integration tree used during the kernel release cycle
- It's hard to test, because things break a lot
 - Automated testing doesn't work
- Stephen Rothwell (the 'next' maintainer) created a 'fixes' branch
- Isolates fixes intended for next release, from other code being integrated into 'next'
 - Should not break automated testing rigs as much
- Result: fixes will get more testing in 'next'



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Toolchains

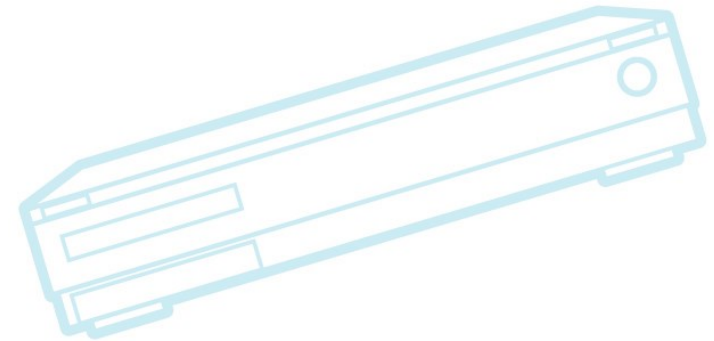
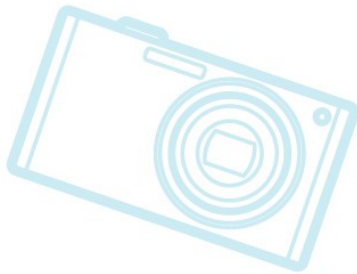
- gcc 8
 - Major effort on usability improvements
 - Provides much better messages for some errors
 - Shows fix-it hints
 - Shows what to change to fix the error
 - Can be automatically processed
 - Detects missing include files, saying which files are needed
 - See <https://lwn.net/Articles/749450/>, and
 - <https://developers.redhat.com/blog/2018/03/15/gcc-8-usability-improvements/>



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Toolchains (cont.)

- Support for Linux-based ARM systems by “Arduino Create” developer tool
 - Arduino sketches can be deployed to Linux devices like BeagleBone and Raspberry Pi, through the cloud
 - See ELC 2018 Keynote *Arduino & Linux: A Love Story* - by Massimo Banzi





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Tracing

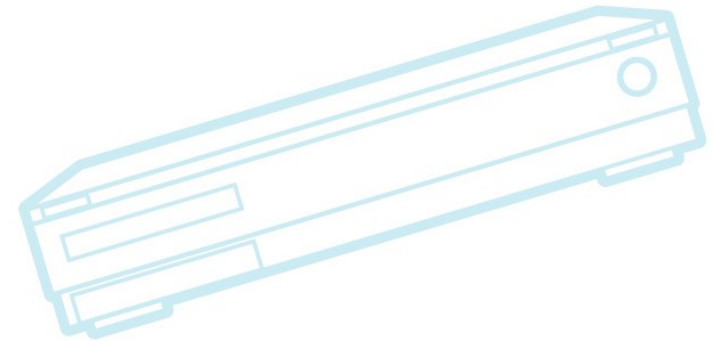
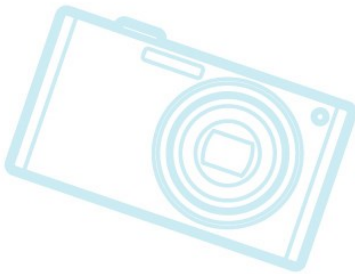
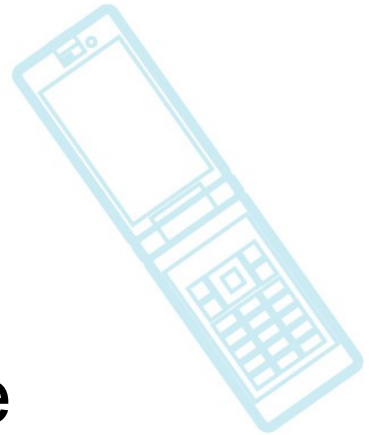
- Nothing new, here is older stuff...
- Dynamic function tracing events
 - Ability to create a tracepoint for a function at runtime
 - Goal is to avoid having a tracepoint become part of kernel ABI
 - Is work-in-progress
 - See <https://lwn.net/Articles/747256>
- Presentations:
 - ELC 2017 *Dynamic Tracing Tools on ARM/AArch64 Platform: Updates and Challenges* - by Hiroyuki Ishii
 - Great overview of Linux tracing capabilities and programs



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Miscellaneous

- Year 2038 work
- FreeRTOS switched to MIT license
- Git protocol version 2
- Android kernel status





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Year 2038 work

- Status update:
 - Lots of small driver fixes in 4.16
 - Changes to system call entry points for timekeeping related syscalls
 - Patches for structures with new 64-bit timestamps have been submitted
 - Still need more work converting the VFS layer
 - Lots of stuff intended to land in 4.18
- See <https://www.mail-archive.com/linux-kernel@vger.kernel.org/msg1674216.html>



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FreeRTOS license change

- FreeRTOS switch to MIT license
 - Richard Barry started working for Amazon last year
 - Amazon released FreeRTOS version 10 with MIT license
 - Removed GPL v2 (with extra clauses)
 - Added branding “fair use” clause to MIT
 - See <https://lwn.net/Articles/740372>



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New git protocol (version 2)

- 3x performance improvement for no-op fetches on repositories containing 500k references.
- 8x reduction of overhead bytes sent from server
 - Due to filtering references to those the client expressed interest in
- Worked on by Google
 - See <https://opensource.googleblog.com/2018/05/introducing-git-protocol-version-2.html>



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Android kernel status

- Progress being made
- diff from 4.14 Android and LTS
 - 432 files, 41K changes
 - sdcard, netfilter, Energy Aware Scheduling, USB gadgets
- Linaro doing android mainline tracking
 - Test Android-common patches on latest mainline Linux
- ELC 2018 *Android Common Kernel and Out of Mainline Patchset Status* – by Amil Pundar



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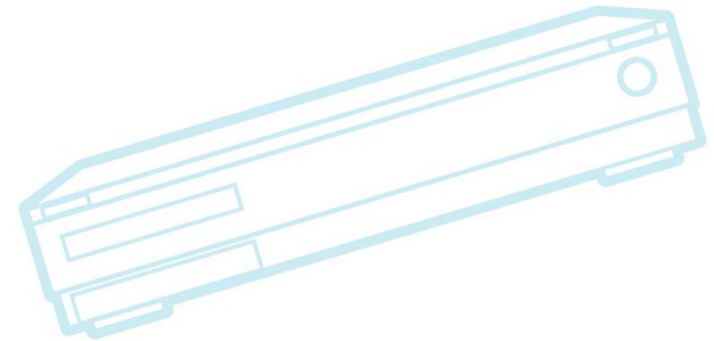
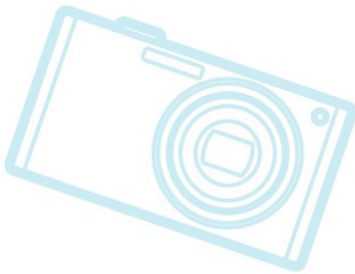
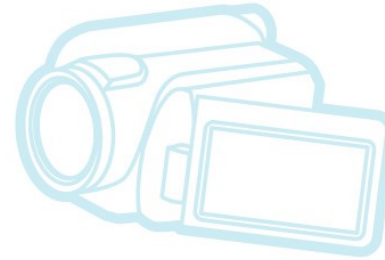
Resources



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Projects and initiatives

- Shared Embedded Distribution
- LTSI
- Fuego
- eLinux wiki





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Shared Embedded Distribution

- **Goals**
 - Create an industry-supported distribution of embedded Linux
 - Main goal is very long term support (15 years)
- **Status**
 - Working on building Debian with Yocto Project
 - 3 projects - meta-debian, isar and elbe wish to collaborate and combine their yocto recipes into a single layer.
- **Next steps**
 - Continued integration of Debian-based build and packaging systems



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Long Term Support Initiative

- LTSI 4.9 is current LTSI kernel
 - Work is in progress on next release 4.14
- Most of industry is using LTS or LTSI
- Using upstream-first policy for patches
- Security fixes are very important
- Presentation:
 - ELCE 2017 *Using Long Term Stable Kernel for the Embedded Products* – by Tsugikazu Shibata



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Long Term Stable Releases

Version	Maintainer	Released	Projected EOL
3.16	Ben Hutchings	2014-08-03	Apr, 2020
4.1	Sash Levin	2015-06-21	May, 2018
4.4	Greg Kroah-Hartman	2016-01-10	Feb, 2022
4.9	Greg Kroah-Hartman	2016-12-11	Jan, 2019
4.14	Greg Kroah-Hartman	2017-11-12	Jan, 2020



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Fuego - Linux Test Framework

- CELP funding for Fuego self-test project
- Fuego now has an integrated release test
 - A Fuego job to build the Fuego docker container from scratch, and test it
 - Includes tests of user interface using Selenium and Chromium
 - This adds packages to base Fuego distribution for doing this type of web-based and image-based testing
- Work completed by ProFusion Embedded Systems



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eLinux wiki

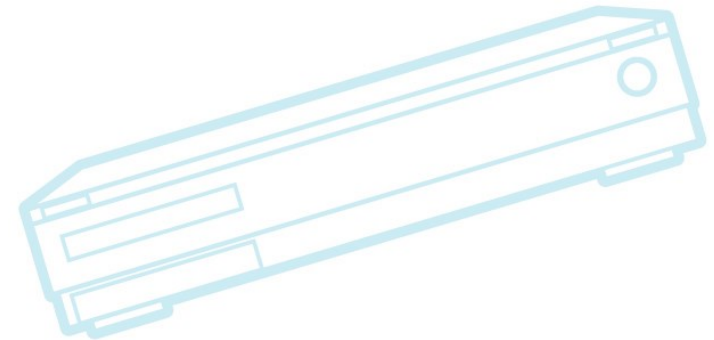
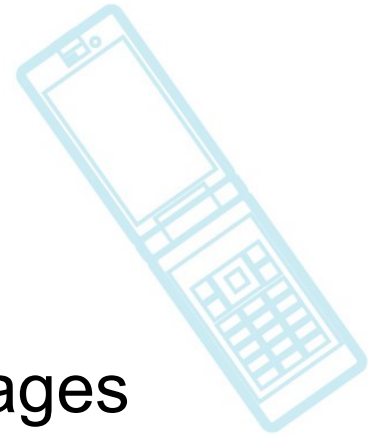
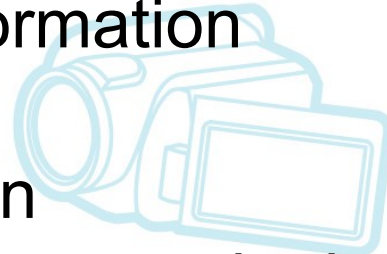
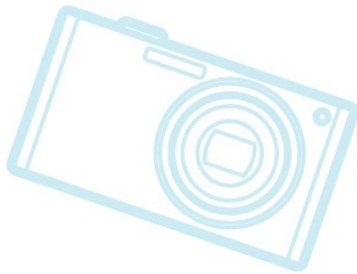
- <http://elinux.org>
 - Web site dedicated to information for embedded Linux developers
 - The wikipedia of embedded linux!
- Hundreds of pages covering numerous topic areas: bootup time, realtime, security, power management, flash filesystem, toolchain, editors
- **Slides and Videos for 12 years of ELC!!**
- Please use and add to site



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eLinux wiki

- Recent topics
 - Board farm and automated testing pages
 - Lots of Renesas board information
 - Developer guidelines
 - Community Doc Translation
 - Event pages (ELC, Jamboree, and others)

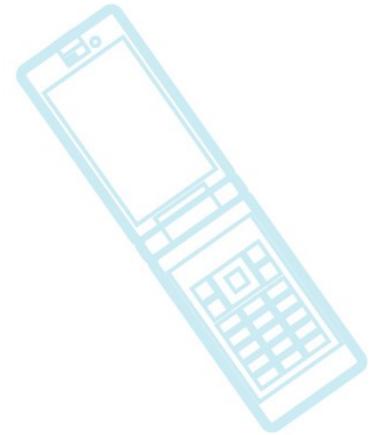
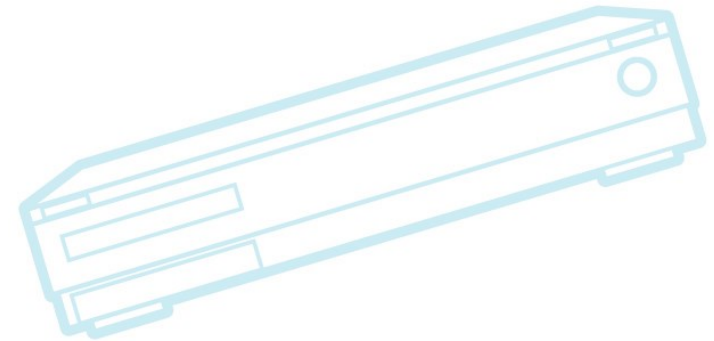




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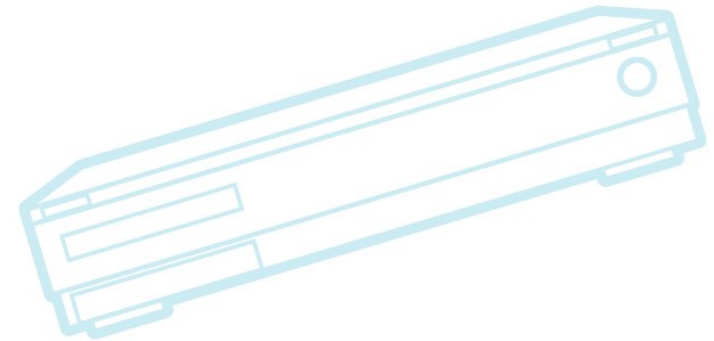
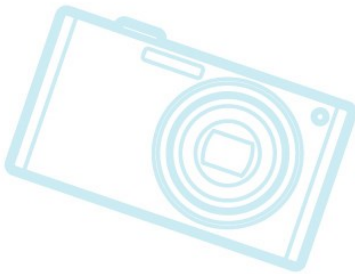
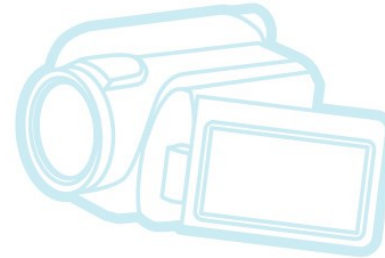
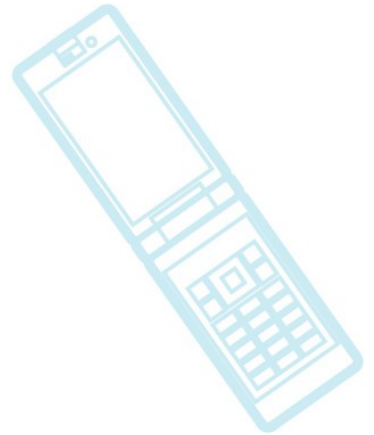




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Other Stuff

- Trade associations
- Conferences
- Legal issues
- Community issues
- Industry changes





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Trade associations

- Linux Foundation
 - Possible creation of Kernel Testing project
 - KernelCI developers working on getting new hosting
 - Project is underfunded by Linaro
 - Project may expand scope (remains to be seen)



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Conferences

- Embedded Linux Conference 2018
 - March 12-14, Portland, Oregon, USA
 - See https://elinux.org/ELC_2018_Presentations
 - Did really good at collecting slides and videos
- Japan Jamborees
 - Continuing
- Open Source Summit Japan/Automotive Linux Summit
 - June 20-22, Tokyo, Japan
- Fuego Jamboree #2
 - June 23, Tokyo, Japan
- ELC Europe 2018
 - October 22-24, Edinburgh, Scotland
- Automated Testing Summit
 - October 25, Edinburgh, Scotland



Legal issues

- McHardy withdraws suit against Geniatech in Germany
- Geniatech fought back, with arguments:
 - Suit scope is too broad (covered all kernel versions, not just ones McHardy had contributed to)
 - Did not show that his commits fulfilled requirements for copyright protection
 - Did not show which of his commits were used by Geniatech
 - McHardy is not following community norms, with regard to GPL revocation terms
 - McHardy is approaching multiple companies for monetary gain



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Legal issues (cont.)

- McHardy withdrawal – lessons learned:
 - Don't sign the cease-and-desist declaration
 - Ensure GPL compliance
 - Prepare a legal defense strategy
 - Geniatech arguments seem sound, and can be used elsewhere
- Community wants to fight McHardy, but still allow for proper legal enforcement of GPL
- See <https://lwn.net/Articles/752485/>
- Details: <http://laforge.gnumonks.org/blog/20180307-mchardy-gpl/>



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Community issues

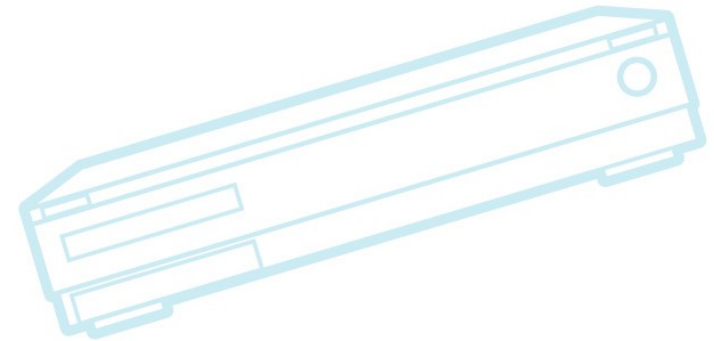
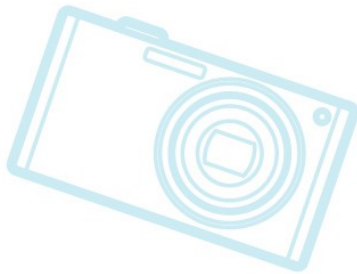
- Complaints about abusive maintainers in the Linux Community
 - Tim gave talk at ELC about maintainers, and handling negative communication
 - ELC 2018 *The Maintainer's Paradox* – by Tim Bird
- Linux Foundation TAB is looking at issue
 - Working on Kernel developers guide, covering some social issues



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Industry changes

- Intel selling Wind River
 - <https://www.windriver.com/news/press/pr.html?ID=20982>
 - Not sure what this means for Yocto Project
 - Intel has discontinued Edison, Galileo and Joule





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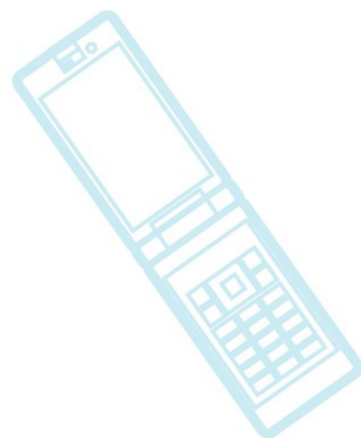
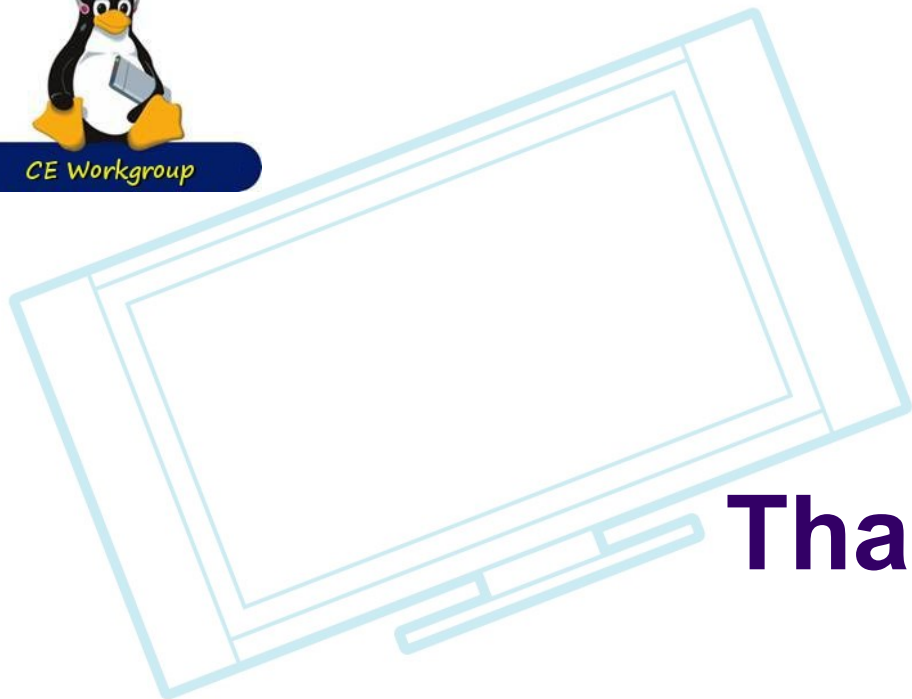
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Resources

- LWN.net
 - <http://lwn.net/>
 - If you are not subscribed, please do so
- Kernel Newbies
 - http://kernelnewbies.org/Linux_4.??
- Phoronix
 - <https://www.phoronix.com/>
- eLinux wiki - <http://elinux.org/>
 - Especially <http://elinux.org/Events> for slides and videos



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Thanks!

