



CE Workgroup

Status of Embedded Linux September 2017

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



CE Workgroup

Outline

Kernel Versions
Technology Areas
CE Workgroup Projects
Other Stuff
Resources



CE Workgroup

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Kernel Versions

- Linux v4.7 – 24 July 2016 – 70 days
- Linux v4.8 – 2 Oct 2016 – 70 days
- Linux v4.9 – 11 Dec 2016 – 70 days
- Linux v4.10 – 19 Feb 2017 – 70 days
- Linux v4.11 – 30 Apr 2017 – 70 days
- Linux v4.12 – 2 Jul 2017 – 63 days
- Linux v4.13-rc7
 - v4.13 expected on 3 Sep, 2017 (*would be 63 days*)



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Linux 4.7

- Schedutil frequency governor
 - Use the load calculated by the scheduler instead of the average load over past little while
 - See <http://lwn.net/Articles/682391/>
- VFS layer can iterate through directories in parallel
- Ability to attach BPF programs to tracepoints
- Ftrace histograms
 - Can tell tracer to accumulate events into buckets and give results, via the sysfs interface



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Linux 4.8

- New kernel documentation system
 - Based on Sphynx
 - See <https://lwn.net/Articles/692704/>
- New pseudo-random number generator
 - See <https://lwn.net/Articles/686033/>
- ARM64 support for kexec and kprobes
- New timer wheel implementation
 - <https://lwn.net/Articles/646950/>
 - Better performance:
 - No more cascade operations
 - Quick determination of next timeout
 - Automatically coalesces longer timeouts
 - Long timeouts have reduced resolution



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Linux 4.9

- Virtually mapped kernel stacks
 - <http://lwn.net/Articles/692953/>
 - Allows to detect stack overruns
 - Cleans up kernel code, faster process creation
 - Only on x86, for now
- **Greybus** - <https://lwn.net/Articles/715955/>
- Timed samples for eBPF
- Modversions deprecated
 - See <https://lwn.net/Articles/707520/>



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Linux 4.10

- Perf sched timehist
- Hybrid block polling
 - Supports polling for block I/O, but with a short delay (estimated) before the polling starts
 - Improves performance by queuing blocks as soon as device is ready (via polling)
 - Uses less CPU than full polling
- Support for ARM SoCs:
 - Huawei, Allwinner, Marvel, Renesas
- Posix timers are configurable
- Initramfs compression method is selectable
- New interface for system sleep state selection
 - `/sys/power/mem_sleep`
- UBIFS support for encryption



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Linux 4.11

- New kernel refcount API
- TinyDRM subsystem added
- New statx() system call
 - <https://lwn.net/Articles/707602/>
 - 2038-safe time values
 - Mask of fields to obtain (for efficiency)
- Sched.h refactoring
 - Non-mainline code: watch out!



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Linux 4.12

- BFQ and Kyber block I/O schedulers
- Minitty prep work
 - Not full minitty 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 (expected)

- 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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Bootup Time

- Analyze_boot tool – new in 4.12
- Some good previous talks:
 - ELCE 2014 - *12 Lessons Learnt in Boot Time Reduction* by Andrew Murray
 - ELC 2015 - *Fastboot Tools and Techniques* by John Mehaffey
- Android boot time ideas
 - ELC 2017 – *Improving the bootup speed of AOSP* – Bernhard Rosenkranzer



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Bootup ideas from Bernhard

- Two approaches:
 - Improve cold boot
 - Enhance suspend/resume
- Areas analyzed for cold boot:
 - Package Manager scanning
 - Java class preloading
 - PM: force high CPU frequency during boot
 - IO: read-ahead, kernel compression, squashfs
 - Kernel modules – defer modules until later
 - Library and compiler optimizations



Device Tree

- Device Tree Overlays
 - Allow plugin-boards to be configured at runtime
 - Session at ELC 2016 by Pantellis
 - **Not mainlined yet? – expected in 4.11?**
- Device Tree validation
 - Schema for binding language, validator for bindings and for device tree data
 - **This work stalled**
 - **New proposal for device tree in YAML format**
 - <https://lwn.net/Articles/730217/>
- Updated Device Tree specification
 - Want to update material and make it more available
- See http://elinux.org/Device_tree_plumbers_2016_etherpad
 - And ELC 2017 Device Tree BOF – Frank Rowand



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Graphics

- TinyDRM
 - Provides graphic support for small simple displays (eg displays over i2C or SPI)
 - Hope to replace framebuffer drivers over time
 - See https://www.phoronix.com/scan.php?page=news_item&px=TinyDRM-Patches-Posted
- Presentation
 - ELC 2017 *What Can Vulkan do for You?* - by Jason Ekstrand



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GPU drivers

- Nvidia, Vivante and Broadcom GPUs have open drivers
 - Nouveau, Etnaviv, and VideoCore 4
- Qualcomm Adreno
 - Freedreno continues to be developed (June 2017)
 - See <https://www.xda-developers.com/open-source-adreno-project-freedreno-receives-new-update/>
- Imagination PowerVR – no public driver, although one was teased in 2015
 - Apple dropping Imagination (April 2017)
- ARM Mali – Some work (Lima project) on earlier chip versions, nothing lately
 - Status update: <https://lwn.net/Articles/716600/>
 - No open source drivers likely



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File Systems

- UBIFS support for encryption (in 4.11)
- IO scheduling for solid state storage
- LightNVM
 - Software control of flash-translation layer
 - <https://lwn.net/Articles/641247>
- F2FS support for disk quotas (in 4.13)



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Networking

- Bluetooth:
 - Bluetooth 5.0
 - Most features are on BLE codebase
 - Only 1 for “BL classic”
 - 800% data throughput increase
 - 4 times the range
 - Coexistence with wireless
 - Better error correction to handle noisy environments



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Power Management

- New interface for system sleep state (in 4.10)
 - `/sys/power/mem_sleep`
- Power-efficient workqueues
 - More efficient work scheduling
 - Results in about 15% better energy consumption
 - See <https://lwn.net/Articles/731052/>
- Operating-System-Directed Power-Management Summit
 - <https://lwn.net/Articles/721573/>
 - Energy-aware scheduling
 - A collection of scheduling talks that will make your head spin



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Real Time

- **SCHED_DEADLINE**
 - ELC 2017 - *SCHED_DEADLINE: It's Alive* - by Juri Lelli
 - Energy Aware Scheduler support
 - Bandwidth reclaiming
 - Temporarily allow a task to exceed it's bandwidth, if no other process' deadline suffers
 - Support for Frequency scaling
 - Group scheduling
- **Presentations:**
 - ELC 2017 *Effectively Measure and Reduce Kernel Latencies for Real-time Constraints* – By Jim Huang
 - ELC 2017 *Real-Time Linux on Embedded Multicore Processors* – by Andres Ehmanns



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Security

- Kernel hardening
 - http://kernsec.org/wiki/index.php/Kernel_Self_Protection_Project
 - Rare_write infrastructure
 - Keep some code and data read-only most of the time
 - <https://lwn.net/Articles/724319/>
 - GCC plugins for kernel security
 - Kernexec
 - Prevent kernel from executing user-space code
 - Structleak (mainlined in 4.11)
 - Zero out kernel structures passed to user space, under some conditions
 - See <https://lwn.net/Articles/712161/>
 - Randstruct
 - Randomize C structure layout
 - See <https://lwn.net/Articles/722293/>



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Security Presentations

- ELC 2017 *Securing Embedded Linux Systems with TPM 2.0* – by Philip Tricca



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System Size

- Initramfs compression method is selectable
- Nicolas Pitre work
 - Configurable POSIX timers – in v4.10
 - <https://lwn.net/Articles/701095/>
 - Mini TTY
 - Smaller implementation of TTY subsystem, for embedded
 - Saves about 38K
 - <https://lwn.net/Articles/721074/>
 - People wanted refactoring of full-size TTY instead of new small implementation, but Nicolas said that wasn't feasible



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System Size (cont.)

- Shrinking the scheduler
 - Drops features and eliminates realtime and deadline scheduler classes
 - Saves about 20k
 - <https://lwn.net/Articles/725376/>
 - Lots of resistance to this
 - Code complexity increase is not worth saving 20k (according to Ingo Molnar)
 - Disagreement on whether Linux should support computers with sub-1MB memory



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Size Presentations

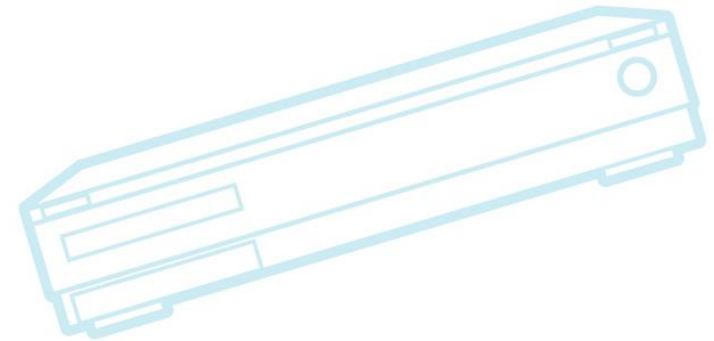
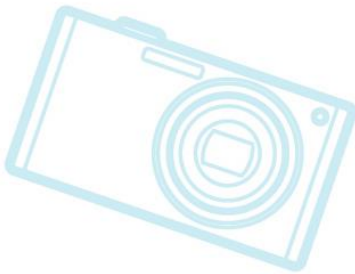
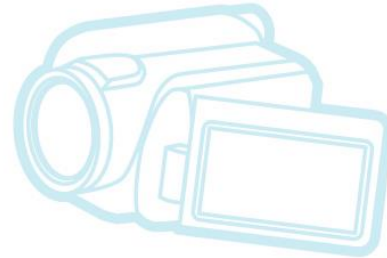
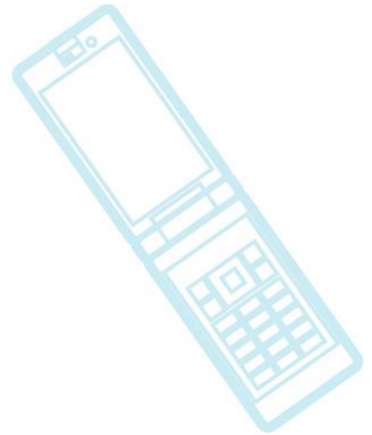
- LinuxCon North America: *Running Linux on Tiny Peripherals* – by Marcel Holtmann
 - Got Linux to around 1MB for IOT sensor project
- ELC 2017 *Embedded Linux Size Reduction Techniques* – By Michael Opdenacker
 - Very good overview of existing reduction techniques and status
 - Formal Tinification project is stalled
 - Toybox and musl (smaller libc) are worth looking at



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Testing

- Kselftest
- Fuego
- Kernelci.org
- LAVA V2





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Kselftest

- Unit test system inside kernel source tree
- Recent work:
 - 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)



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Fuego

- New Test Framework for collaborating on tests and test infrastructure for Linux
- V1.1 features (April 2017)
 - Upgrade to latest Jenkins
 - Test script refactoring
 - Fuego container directory layout change
 - About 40 new tests
- V1.2 plans (RC very soon (Sep 2017))
 - Unified output format
 - Convert all test results to JSON, in a format compatible with Kernel CI
 - New pass criteria system
 - Test dependency system
 - Board dynamic variables



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Kernelci.org

- Place to get free build/boot testing for your board
 - Builds 126 trees continuously, then reports any errors
- <http://kernelci.org>
- Presentations:
 - ELC and ELCE 2016 – by Kevin Hilman
 - Linaro Connect:
 - Kernelci and lava update - See <https://lwn.net/Articles/716600/>
- The most successful public, distributed build and test system for Linux, in the world!



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LAVA

- Linaro Automation and Validation Architecture
- V2
 - Job files now use Jinja2 templates
 - Was previously hand-written JSON
 - Jobs are run asynchronously, without polling,
 - ZeroMQ is used for communications.
 - ReactOBus is used to run jobs from messages.
 - Requires more explicit board configuration



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Toolchains

- LLVM 4.0.0 is released
 - Some code size improvements from optimizations (GVNHoist)
 - Experimental support for LLVM coroutines
 - <https://lwn.net/Articles/716979/>
- Presentations:
 - ELC 2017 - *GCC/Clang Optimizations for Embedded Linux* – by Khem Raj



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Tracing

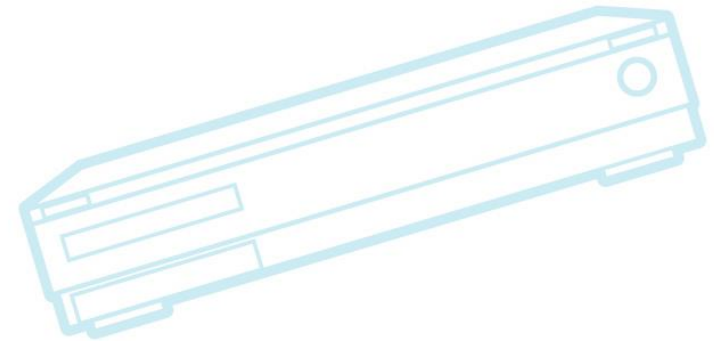
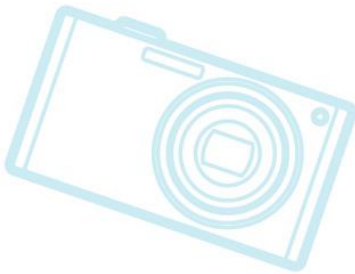
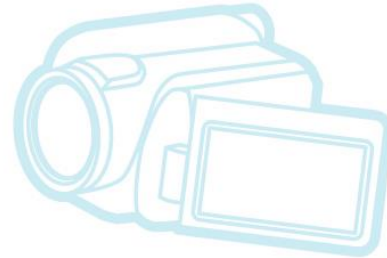
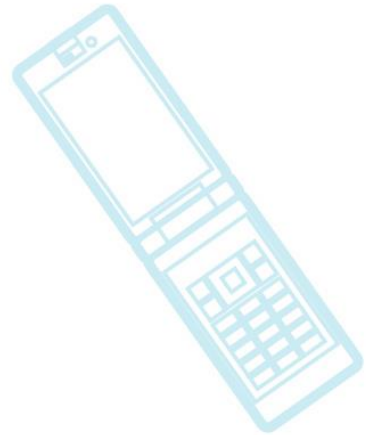
- More perf tools (both in 4.10):
 - perf sched timehist
 - Analysis of scheduling events
 - perf c2c
 - Cacheline contention analysis
- Presentations:
 - ELC 2017 *Dynamic Tracing Tools on ARM/AArch64 Platform: Updates and Challenges*
 - by Hiroyuki Ishii
 - Great overview



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Miscellaneous

- Printk issues
- Year 2038 work
- Linus issues with Kconfig
- AGL making inroads





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Printk issues

- Discussion on kernel summit mailing list
 - Lots of issues with printk
 - It's not per-CPU, console lock held too long, it has complicated code paths, and lots more
 - See thread start at:
 - <https://lists.linuxfoundation.org/pipermail/ksummit-discuss/2017-June/004358.html>
- Recent discussions about KERN_CONT
 - KERN_CONT is unreliable for SMP kernels
 - Latest kernelput '\n' between lines that don't have KERN_CONT
 - Eventual removal of KERN_CONT
 - Maybe use of seq_buf for outputting serialized data atomically
 - <https://lwn.net/Articles/732420/>



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Year 2017 work

- 3 areas of work
 - Converting all 32-bit timestamps to 64-bit in the kernel
 - e.g. New statx() system call
 - Many patches are in-progress (vfs layer, v4l, device-mapper, input subsystem)
 - C libraries
 - Lots of work in glibc to make everything backwards compatible
 - Even programs built with 32-bit timestamps should work
 - Distribution builds – fixing up individual packages
- See <https://lwn.net/Articles/717076/>



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Linus issues with Kconfig

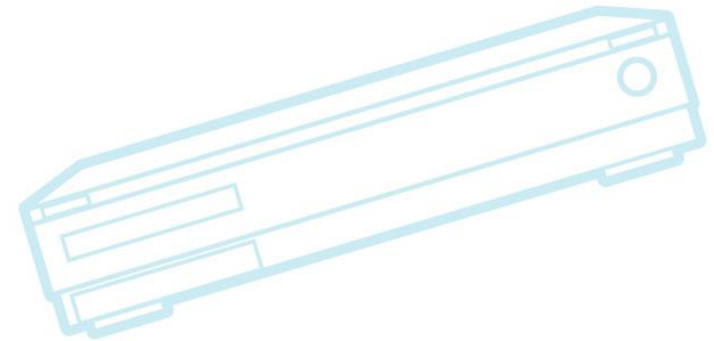
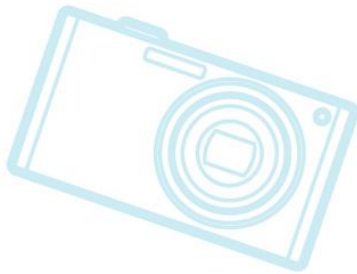
- Discussion on kernel summit mailing list
 - Kconfig is too hard for end users
 - What can be done?
 - Linus' complaint:
 - <https://lists.linuxfoundation.org/pipermail/ksummit-discuss/2017-June/004504.html>
- Ideas:
 - Config fragments
 - Higher level options
 - Better dependencies
 - From distro feature to kernel config



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AGL status

- First car in US with Entune (AGL-based infotainment OS) will be 2018 Toyota Camry
 - Announced at Open Source Summit Japan by Toyota
- Mazda and Toyota collaborating on Entune
 - https://www.theregister.co.uk/2017/08/29/mazda_toyota_linux_entune_car_infotainment/





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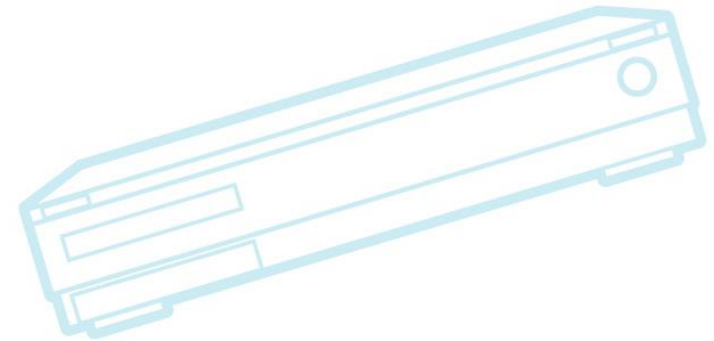
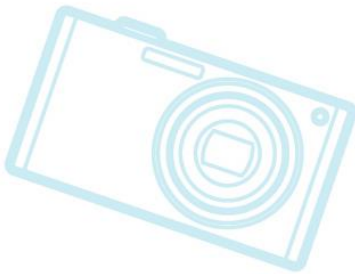
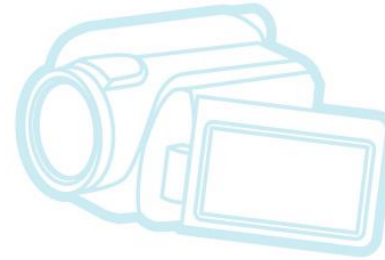
Resources



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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**
 - Toshiba has created Yocto layer meta-Debian
 - Presented at ELCE, ELC, and LCJ
- **Next steps**
 - Improve coordination with Debian community



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Long Term Support Initiative

- LTSI 4.9 is current LTSI kernel
 - Work is in progress on next release
- GregKH said
 - Expected delivery date: Sep 2017
 - Converting to upstream-first policy
- Presentation:
 - ELC 2017 *Using Linux as Long Term Working with the Community* – by Tsugikazu Shibata



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Fuego - Linux Test Framework

- Working on lots of issues:
 - Command line tool
 - Test packaging
 - LAVA integration
 - Serial console transport
- Presentation:
 - ELC 2017 *BoF: Fuego Status and Roadmap* – by Tim Bird



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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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Trade Associations

- Linaro still doing lots of great work
 - Lava v2 and kernelci
 - Now promoting Zephyr
 - Linaro Connect consistently has useful material
- Linux Foundation
 - Continuing to grow
 - First event in China sold out in 2 weeks (1200 attendees)
 - Over 100 conferences, 67 projects
 - Not just Linux
 - More than 500 members



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Conferences

- ELC 2017
 - Lots of great sessions
 - See: http://elinux.org/ELC_2017_Presentations
- Open Source Summit Japan
 - May 31-June 2, Tokyo
- Embedded Linux Conference Europe
 - October 23-25, Prague, Czech Republic
- Embedded Linux Conference 2018
 - March 12-14, Portland, Oregon, USA
- Japan Jamborees
 - Continuing



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Closing thoughts

- Google search oddity
- How is Linux doing in embedded
 - AspenCore/EETimes/embedded survey of embedded market 2017



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Google search “linux kernel”

- Tux seems a bit off...

The screenshot shows a Google search for "linux kernel". The search bar contains "linux kernel" and the results show "About 1,440,000 results (0.64 seconds)". The top results include "The Linux Kernel Archives", "Linux kernel - Wikipedia", and "GitHub - torvalds/linux: Linux kernel source tree". A knowledge panel on the right side of the page provides detailed information about the Linux kernel, including its developer, release history, and OS family.

Search results for "linux kernel":

- The Linux Kernel Archives**
<https://www.kernel.org/>
GIT · <https://git.kernel.org/> · RSYNC, [rsync://rsync.kernel.org/pub/](https://rsync.kernel.org/pub/). Latest Stable Kernel: ... [browse], [changelog]. linux-next: next-20170831, 2017-08-31, [browse] ...
[Releases](#) · [Index of /pub](#) · [About](#) · [The Linux Kernel Archives - FAQ](#)
- Linux kernel - Wikipedia**
https://en.wikipedia.org/wiki/Linux_kernel
The Linux kernel was conceived and created in 1991 by Linus Torvalds for his personal computer and with no cross-platform intentions, but has since expanded to support a huge array of computer architectures, many more than other operating systems or kernels.
[Operating system](#) · [Comparison of operating ...](#) · [List of Linux kernel names](#)
- GitHub - torvalds/linux: Linux kernel source tree**
<https://github.com/torvalds/linux>
Merge git://git.kernel.org/pub/scm/linux/kernel/git/davem/net. 10 days ago. arch. Merge branch 'for-linux-4.13-rc7' of git://git.kernel.org/pub/scm/lin... 17 hours ago.
- Commits · torvalds/linux · GitHub**
<https://github.com/torvalds/linux/commits/master>
Linux kernel source tree. Contribute to linux development by creating an account on GitHub.

Knowledge panel for "Linux kernel":

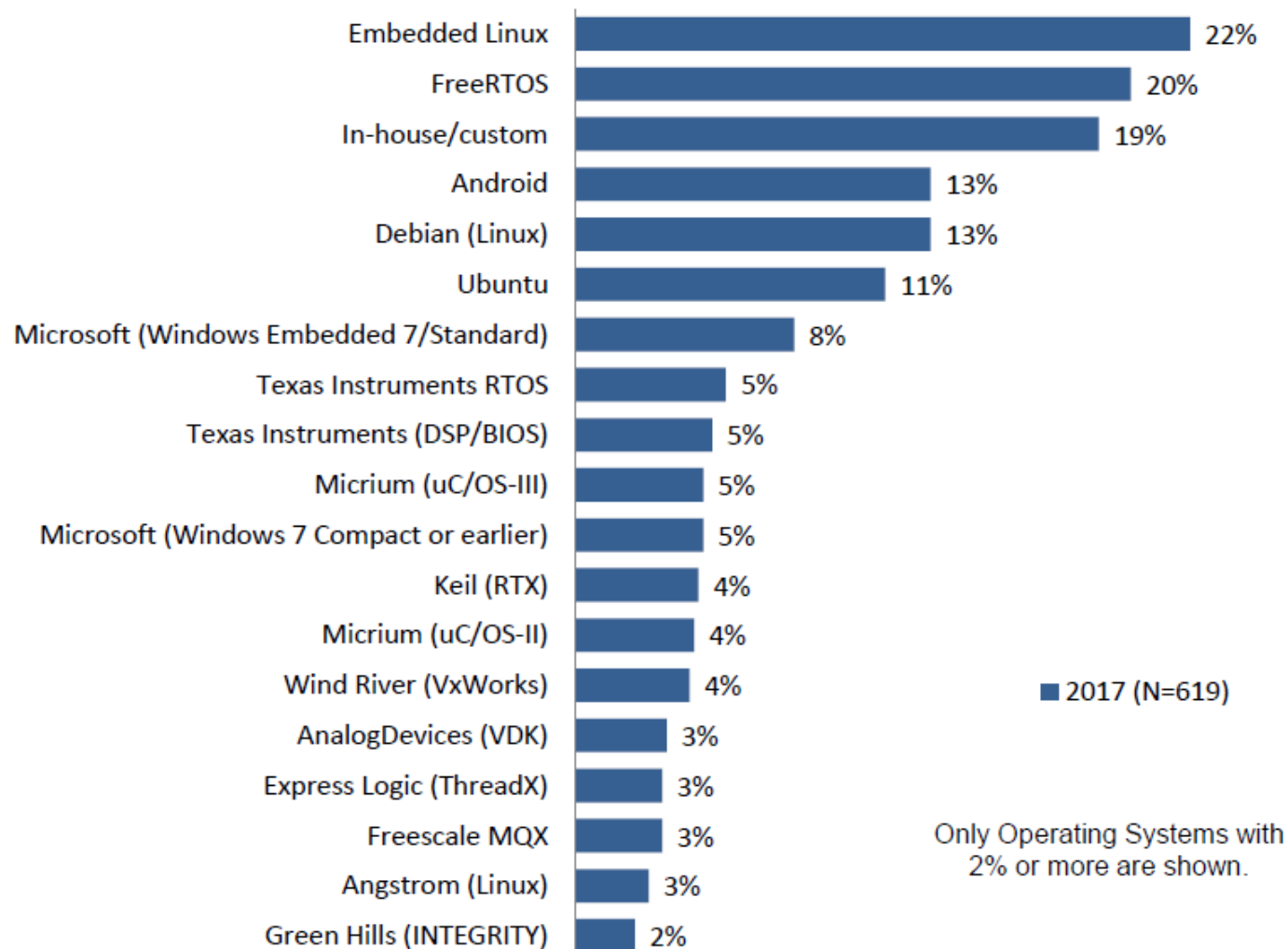
- Linux kernel**
Operating system
-
- The Linux kernel is a monolithic Unix-like computer operating system kernel. The Linux family of operating systems is based on this kernel and deployed on both traditional computer systems such as ... [Wikipedia](#)
- Developer:** Linus Torvalds and thousands of collaborators
- Written in:** C and assembly
- Latest release:** 4.12.8 (16 August 2017; 7 days ago)
- Initial release:** 0.01 (17 September 1991; 25 years ago)
- Latest preview:** 4.13-rc6 (20 August 2017; 3 days ago)
- OS family:** Unix-like

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ASPENCORE

Please select **ALL** of the operating systems you are currently using.



Base: Currently using an operating system



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Survey notes

- Embedded Linux at 22 percent
 - But if you include Android, Debian, Ubuntu and Angstrom – it's 61%
 - If you can add them – which is unclear
- Article:
<https://www.linux.com/news/event/elce/2017/linux-and-open-source-move-embedded-says-survey>
- Source:
<http://m.eet.com/media/1246048/2017-embedded-market-study.pdf>



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Despite goofy Tux,
world domination is proceeding
as planned...



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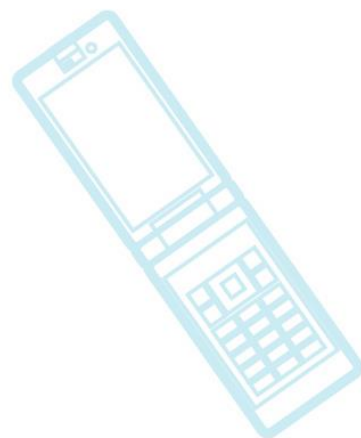
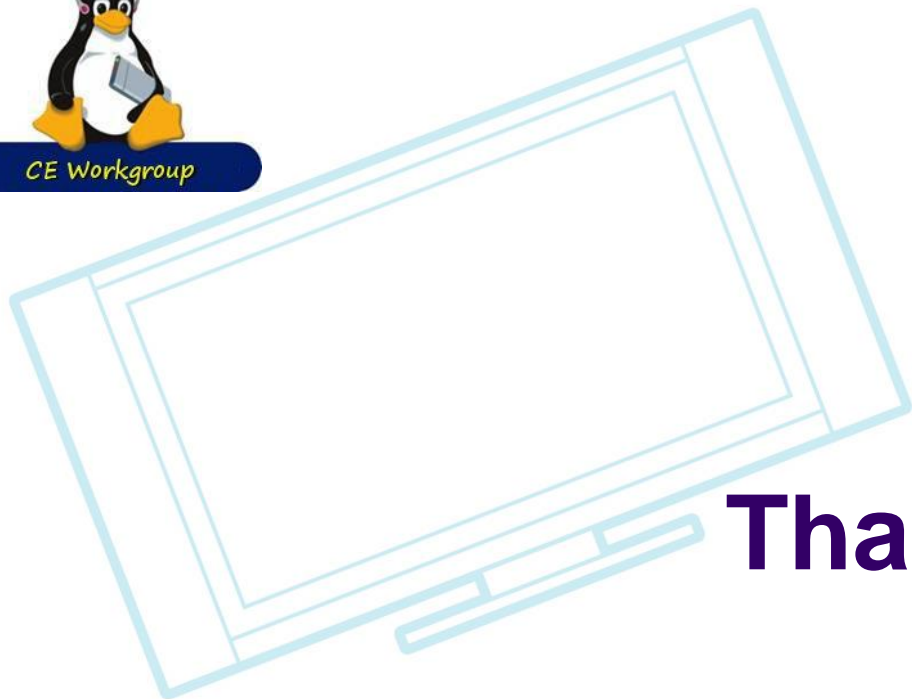
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Resources

- LWN.net
 - <http://lwn.net/>
 - If you are not subscribed, please do so
- Kernel Newbies
 - http://kernelnewbies.org/Linux_4.??
- eLinux wiki - <http://elinux.org/>
 - Especially <http://elinux.org/Events> for slides
- Celinix-dev mailing list



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Thanks!

