CE Workgroup

Status of Embedded Linux

March 2017

Tim Bird

Architecture Group Chair
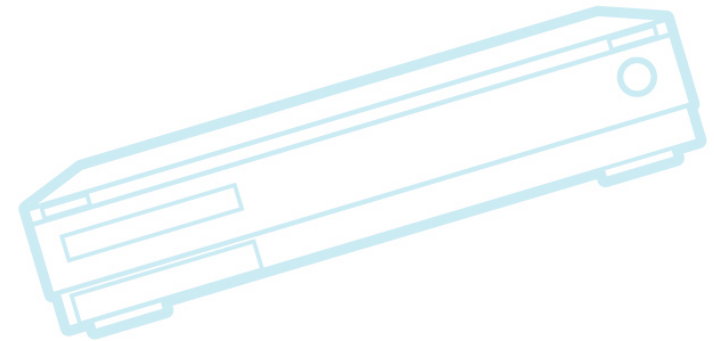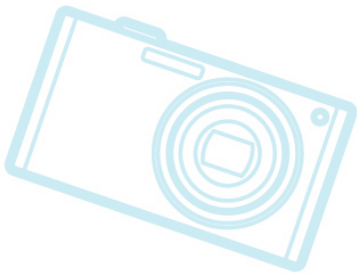
LF Core Embedded Linux Project

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

Outline

Kernel Versions
Technology Areas
CE Workgroup Projects
Other Stuff
Resources

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Kernel Versions

- Linux v4.6 – 15 May 2016 – 63 days
- 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
- Currently at Linux v4.11-rc2
  - v4.11 expected on April 30, 2017

Linux 4.6

- GPIO subsystem rework
- scripts/dtc/dtx_diff
  - Compare device trees in a number of formats
- Improved page-poisoning
  - Separate from debug, can set poison value to 0 (to clear pages after free for security reasons)
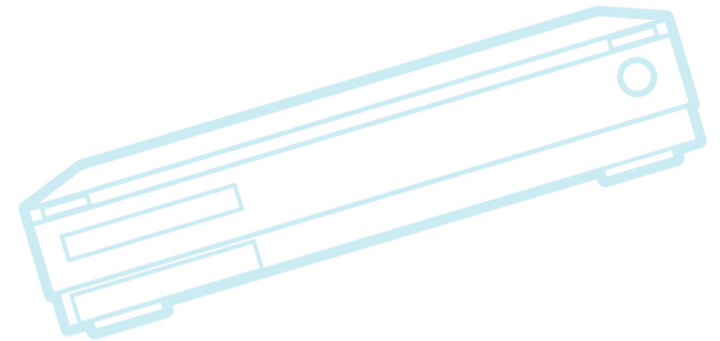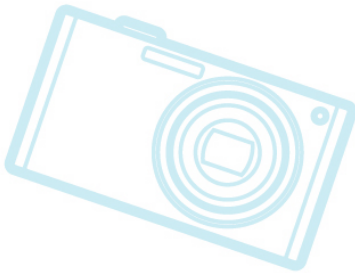
Linux 4.7

- 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 histogram triggers
  - Can tell tracer to accumulate events into buckets and give results, via the sysfs interface
- Android sync_file feature moved from staging
  - Support for explicit buffer fencing

Linux 4.8

- New kernel documentation system
- 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 timout
  - Automatically coalesces longer timeouts
  - Long timeouts have reduced resolution

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/

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!
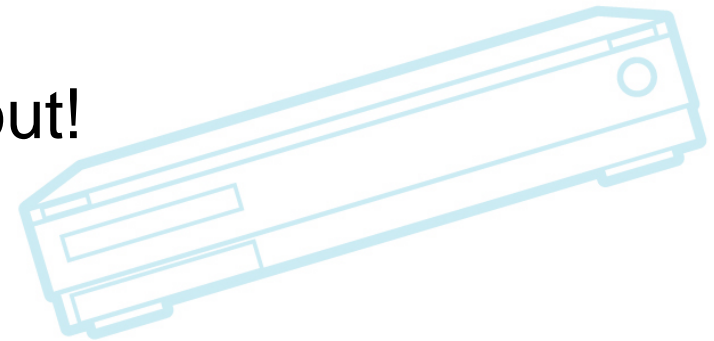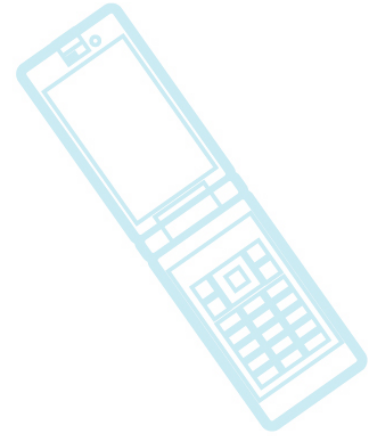
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Bootup Time

- No new work in kernel, that I'm aware of
- 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

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
- Updated Device Tree specification
  - Being discussed
  - 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

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
- GPU support:
  - ARM mali drivers status update
    - https://lwn.net/Articles/716600/
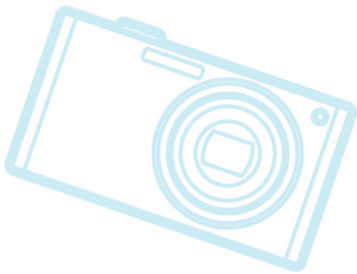- Presentation
 - ELC 2017 *What Can Vulkan do for You*? - by Jason Ekstrand

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

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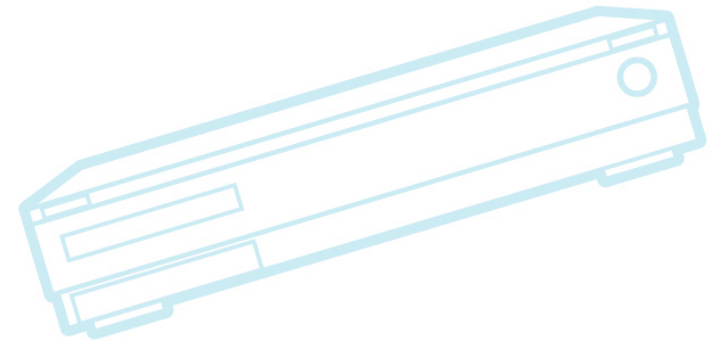
Networking

- 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
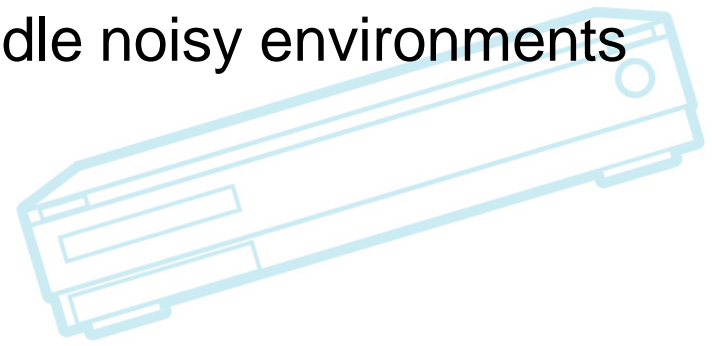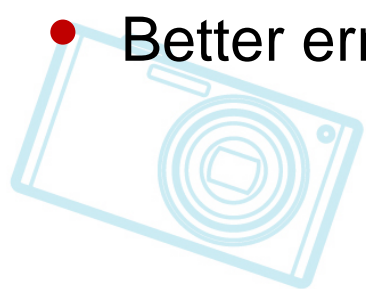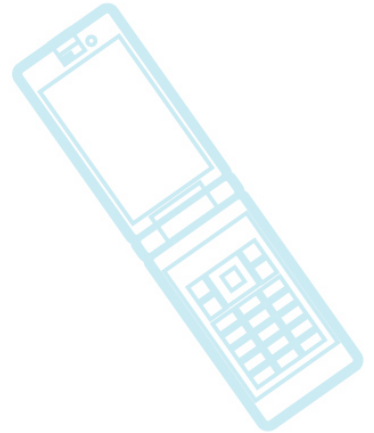
Real Time

- 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

Security

- Kernel hardening
  - http://kernsec.org/wiki/index.php/Kernel_Self_Protection_Project
  - 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/
- Presentations
  - ELC 2017 *Securing Embedded Linux Systems with TPM 2.0* – by Philip Tricca

System Size

- Initramfs compression method is selectable
- Configurable POSIX timers – in v4.10
- 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

Testing

- Kselftest
- Fuego
- Kernelci.org
- LAVA V2
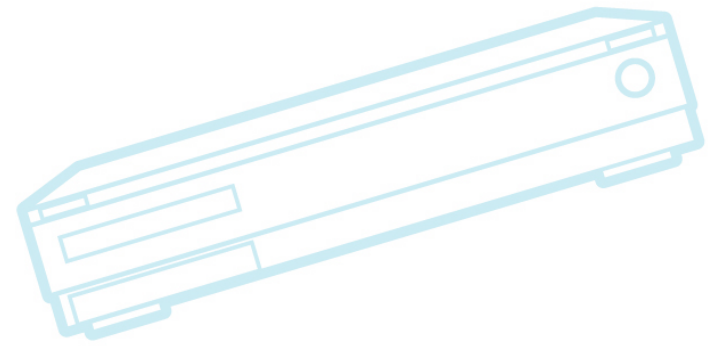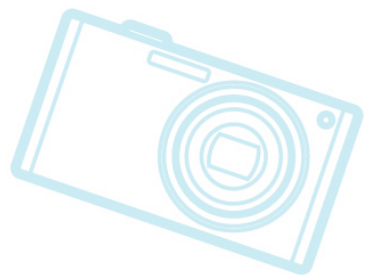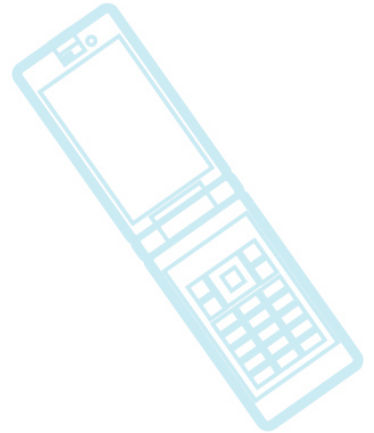
Kernelci.org

- 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!

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
    - Stay until 3:00 pm

Miscellaneous

- Year 2038 status:
  - 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
  - See https://lwn.net/Articles/717076/

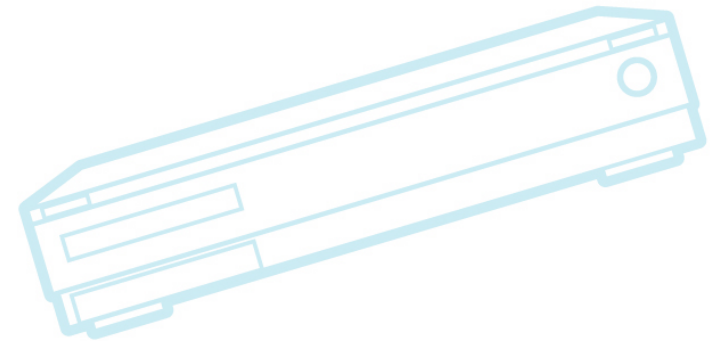# **Outline**

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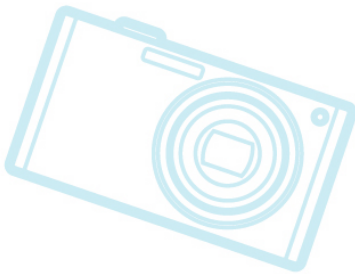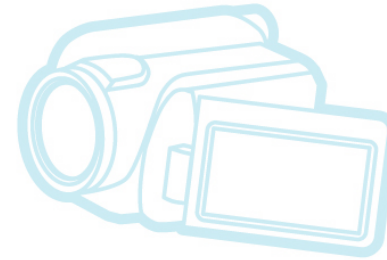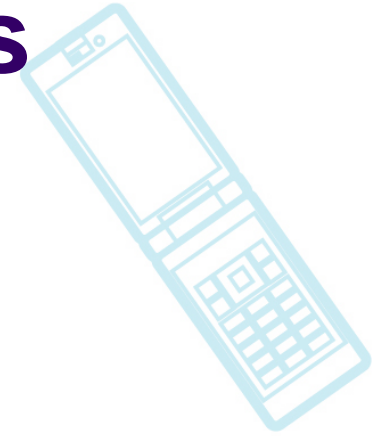
Resources

Projects and initiatives

- Shared Embedded Distribution
- LTSI
- Fuego
- eLinux wiki

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

Long Term Support Initiative

- LTSI 4.9 will be next LTSI kernel
  - Work is in progress on next release
  - 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

Fuego - Linux Test Framework

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

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
- Lots of pages in last few years about low-cost development boards
- 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
  - Microsoft has joined the Linux Foundation as a platinum member
  - CE Workgroup officially changed its name to "Core Embedded Linux Project"

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
  - March 12-14, Portland, Oregon, USA
- Japan Jamborees
  - Continuing

ELC 2017 thoughts

- Linus and Dirk fireside chat
  - 4.10 release was calm
    - 4.9 was a bit bigger due to LTS pre-announcement
    - Linus thinks is healthier to not push things based on a deadline, but 4.9 wasn't too bad
  - Even after all these years, we see changes to core files
  - Linus said that Linux is general-purpose, so may not be appropriate for the lowest-footprint device
    - I feel vindicated

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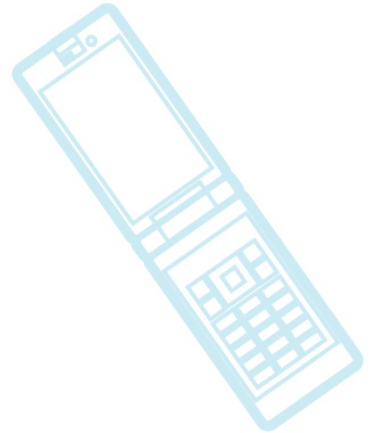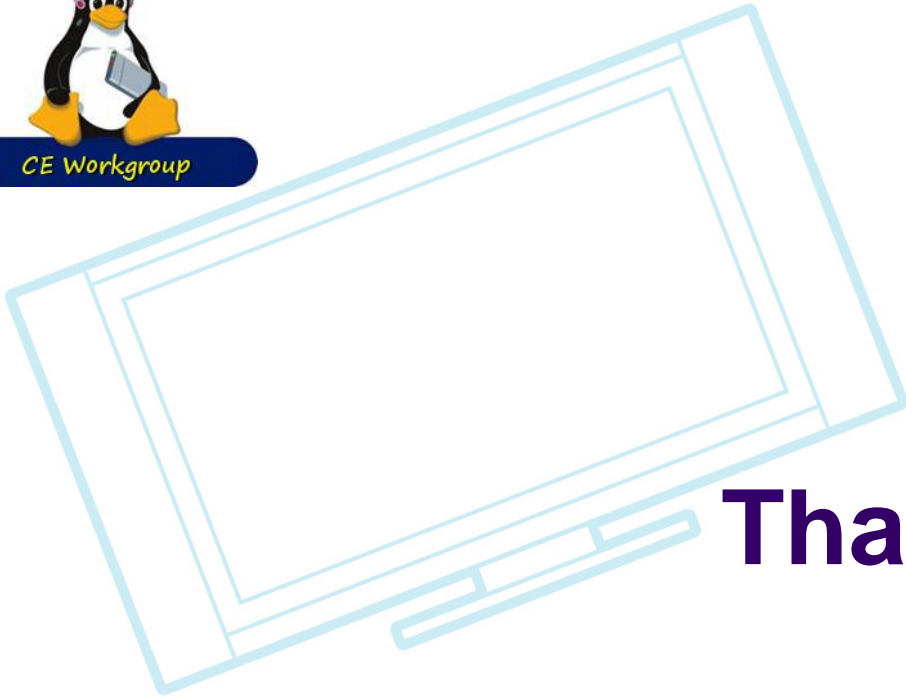
- LWN.net
  - http://lwn.net/
  - If you are not subscribed, please do so
- Kernel Newbies
  - http://kernelnewbies.org/Linux_[34].?
- eLinux wiki - http://elinux.org/
  - Especially http://elinux.org/Events for slides
- Celinux-dev mailing list

Thanks!