Status of Embedded Linux
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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
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)
• 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 timeout
  - Automatically coalesces longer timeouts
  - Long timeouts have reduced resolution
Linux 4.9

- Virtually mapped kernel stacks
  - [http://lwn.net/Articles/692953/](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/](https://lwn.net/Articles/715955/)
- Timed samples for eBPF
- Modversions deprecated
  - See [https://lwn.net/Articles/707520/](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**
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!
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

  - 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
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
  - 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/](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](http://kernelci.org)
- Presentations:
  - ELC and ELCE 2016 – by Kevin Hilman
  - Linaro Connect:
    - Kernelci and lava update - See [https://lwn.net/Articles/716600/](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
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
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/
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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](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](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/](http://lwn.net/)
  - If you are not subscribed, please do so
- Kernel Newbies
  - [http://kernelnewbies.org/Linux_[34].?](http://kernelnewbies.org/Linux_[34].?)
  - Especially [http://elinux.org/Events](http://elinux.org/Events) for slides
- Celinux-dev mailing list
Thanks!