CE Workgroup

Status of Embedded Linux

September 2015

Tim Bird
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LF CE Workgroup
Outline

Kernel Versions
Technology Areas
CE Workgroup Projects
Other Stuff
Resources
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Kernel Versions

- Linux v3.16 – 3 Aug 2014 – 57 days
- Linux v3.17 – 5 Oct 2014 – 63 days
- Linux v3.18 – 7 Dec 2014 – 63 days
- Linux v3.19 – 8 Feb 2015 – 63 days
- Linux v4.0 – 12 Apr 2015 – 63 days
- Linux v4.1 – 21 Jun 2015 – 70 days
- Linux v4.2 – 30 Aug 2015 – 70 days
- Currently at Linux v4.3-rc1
  - Prediction for v4.3: 8 Nov 2015
Linux v3.16

- Power-aware scheduling
- decode_stacktrace.sh
  - Converts offsets in a stack trace to filenames and line numbers
- F2FS large volume support
Linux v3.17

- Lots of ARM hardware support
  - Newly enabled ARM hardware
    - Rockchip RK3288 SoC
    - Allwinner A23 SoC
    - Allwinner A31 Hummingbird
    - Tegra30 Apalis board support
    - Gumstix Pepper AM335x
    - AM437x TI evaluation board
  - Other ARM boards with existing support also saw improvements with Linux 3.17
  - Rework of "config-bisect" mode in ktest
Linux v3.18

- OverlayFS introduced
- Size reduction patch:
  - madvise and fadvise syscalls can be configured out
- More LLVM support
- New SOC support:
  - Hisilicon HiP04
  - Amlogic Meson6 (8726MX)
  - Renesas R-Car E2 (R8A77940)
  - Broadcom BCM63xx DSL
  - Atmel SAMA5D4
Linux v3.19

- F2FS now has a "fastboot" option
- Device tree overlay support
- Squashfs supports LZ4 compression
- Android "binder" code has been moved from the staging tree
Linux v4.0

- This version is not v3.20
  - Linus conducted a survey on Google+
    - 56% of respondents preferred 4.0
- Android binder has security hooks
  - Can use SELinux security with it
- Non-volatile memory support patches
  - Can use filesystem in persistent memory
  - [http://lwn.net/Articles/610174/](http://lwn.net/Articles/610174/)
- UBIFS performance improvements
Linux v4.1

- New tracefs filesystem
- Kernel self-test ‘install’ target
- Ability to attach BPF programs to kernel probes
- I2C subsystem can function in slave mode
- Can configure kernel for single-user operation
Linux v4.2

- Linux security module stacking
  - See https://lwn.net/Articles/635771/
- F2FS supports per-file encryption
- Support for AMD GPUs
- Lots of pin control drivers:
  - Freescale, Mediatek, Allwinner, Qualcomm, Renesas
- Libnvdimm – non-volatile memory (NVM) management
Linux v4.3 (preview)

- MOST (Media Oriented Systems Transport) support is in staging
  - MOST is a framework in automotive market for multimedia networking
- Ext3 removed (but ext4 code supports that FS)
Things to watch

- Kdbus
  - Has hit some stumbling blocks getting merged
- Kernel tinification!
- RT-preempt (again)
- Persistent memory
- SoC mainlining progress
Kernel process improvements

- Kernel merge process is getting better.
- The percent of changes that are accepted after the merge window closes is trending down over time
  - In the 3.0 release, 19% of commits were after the merge window closed
  - In the 4.1 release, 10.5% of commits were after the merge window closed
- See https://lwn.net/Articles/650299/
Bootup Time

- F2FS filesystem has a new "fastboot" option
  - Skips some boot-time checks to reduce mount time
  - Sacrifices a little bit of normal performance
    - Due to more synching during normal filesystem operation

- Good talks:
  - ELCE 2014 - 12 Lessons Learnt in Boot Time Reduction by Andrew Murray
  - ELC 2015 - Fastboot Tools and Techniques by John Mehaffey
Bootup Time

• Kernel speedups
  • Deferred initcalls (patch still out-of-tree)
    • http://elinux.org/Deferred_Initcalls
  • Kernel tinification project helps
    • smaller size means shorter load times
  • XIP on x86
    • See https://lwn.net/Articles/637532/

• User-space speedups
  • Systemd in embedded
    • ELC 2015 - Tuning systemd for Embedded by Alison Chaiken
Device Tree

- Device Tree is causing delays getting stuff upstream
  - DT maintainers are overloaded
  - Backwards compatibility is a problem
  - See “The Device Tree as a Stable ABI: A Fairy Tale?” – Thomas Petazzoni

- Device Tree Overlays
  - Useful for boards that have daughterboards (e.g. capes or shields) that need DTS changes at boot time.
  - “Transactional Device Tree & Overlays: Making Reconfigurable Hardware Work” - Pantelis Antoniou
  - Also see: http://lwn.net/Articles/616859/
Device Tree validation

• New work on validating device tree
  • Matt Porter is creating a formal binding document standard (schema for binding docs)
  • Frank Rowand implementing DTS parser (to be used with validator)
  • Tim Bird worked on a binding doc validator

• How it would work:
  • Binding docs are compared with binding schema
  • DTS entries are compared against binding doc and any errors are reported
  • Maybe add to checkpatch.pl

• To be discussed next week at Linaro connect
• Frank Rowand is a new devicetree maintainer
  • Has been updating http://elinux.org/Device_Tree
  • Working on devicetree debugging
    • LCNA 2015 - *Solving Device Tree Issues* by Frank Rowand (see presentations page for link)

• Big session at plumbers this year
  • http://elinux.org/Device_Tree_presentations_papers_articles
Graphics

- Vulkan API from Khronos Group
  - Alternative to Direct3D or OpenGL
  - Intent is to reduce CPU overhead for CPU/GPU operations
  - AMD announced plans to open source the driver (but Intel and Valve already working on an open source driver)

- GPU support
  - Freedreno – for Adreno
  - Nouveau – for Nvidia
  - Lima – for Mali
  - ??? – for PowerVR
Freedreno

• GPL driver for Adreno GPU on Qualcomm chips
• 3xx supports OpenGL ES 3.0
• 4xx supports OpenGL ES 3.1
• There are still some pieces that need work
  • Bug reports are appreciated
  • Some interesting reverse-engineering tools developed for the project
    • https://github.com/freedreno/freedreno/wiki/Reverse-engineering-tools
    • http://lwn.net/Articles/638908/
PowerVR

- PowerVR SGX code leaked in November
- In June: Imagination Executive blogged:

Q: Is there plans to make/help/fund open PowerVR driver for Linux?
A: Yes, there is a plan and it is one of the things I’ve been working on for the past few months. Hopefully I’ll have something more to share soon(-ish?).

Other OSS GPU drivers

• Nouveau – for Nvidia
  • Nvidia published some GPU details to help open projects write driver (2013)
  • See https://en.wikipedia.org/wiki/Nouveau_(software)
  • See also http://nouveau.freedesktop.org/wiki/

• Lima – for Mali
  • Seems stalled – recent discussion of putting Mali DRM/KMS code into staging indicated that there needs to be an active user-space (but Lima appears to not be active)
File Systems

• SquashFS supports LZ4 compression
• OverlayFS
  • Support for read/write filesystem over the top of a read-only filesystem
  • Most common use-case is live CDs, but it can be useful for some embedded scenarios
• Proposals for UBIFS handling of MLC NAND
  • Lots of complexity due to MLC characteristics
  • See “NAND Support: (New?) Challenges for the MTD/NAND Subsystem” – Boris Brezillon (at ELC)
• EXT3 removed from kernel (4.3-rc1)
ELC talks:
- “Filesystem Considerations for Embedded Devices” – Tristan Lelong
  - Great talk with performance and robustness results for different file systems
  - Ext4, BTRFS, F2FS, XFS, NILFS2
  - Summary: F2FS is faster in many cases, EXT4 is mature
Power Management

- **PM domains**
  - See “Last One Out, Turn Off The Lights” - Geert Uytterhoeven (at ELC)
    - Good talk showing how to use this with device tree

- **Idle and suspend to Idle**
  - “The Art of Doing Nothing: Linux Low Power Idle” – Kristen Accardi (at LCJ)
  - “What is Suspend-to-Idle and How to Make It Work” – Rafael Wysocki (at LCJ)

- **PowerTop/tuning**
  - “Power Tuning Linux: A Case Study” – Alexandra Yates (at LCJ)
    - Was about tuning a laptop distro
Real Time

- RT-preempt patch set got a sponsor
  - That’s good!
- Still have Xenomai (using Cobalt RT core)
- Good overview of existing RT solutions, and a new alternative
  - ELCE 2014 - “rtmux: A thin multiplexer to provide hard realtime applications for Linux”
    - by Jim Huang
- Lots of people using PRUs (programmable real-time units)
  - See http://lwn.net/Articles/639258/
Security

• IOT raises lots of security issues
• See “Kernel security hacking for the Internet of Things” – Daniel Sangorrin (at LCJ)
  • Reduce attack surface
  • Use variation from pre-determined behavior to detect attacks
  • Isolate critical software
• Security module stacking
  • Added in kernel 4.2
  • See https://lwn.net/Articles/635771/
System Size

- Size project keeps nibbling away at items
- Single-user patches
  - Gets rid of users and groups
  - Saves about 25K
  - [http://lwn.net/Articles/631853/](http://lwn.net/Articles/631853/)
  - Mainlined in kernel v4.1
- Removal of kernel command-line parsing
  - Ability to make any command-line option static
  - Example for initcall_debug = saves 385 bytes
    - A lot of the savings are due to GCC constant folding
- Intel X86 XIP patches
  - See [https://lwn.net/Articles/637532/](https://lwn.net/Articles/637532/)
System Size (cont.)

- Some recent talks:
  - Optimize uClinux for ARM Cortex-M4 – Jim Huang (at ELC)
    - Target = STM32F4xx
  - Linux for Microcontrollers: From Marginal to Mainstream – Vitaly Wool (at ELC)
    - Target = STM32F2x
    - 840K .text, 132k .rodata, 86k .data (BT, no TCP/IP)
  - Pushing the limits of Linux on ARM – Andreas Färber (at LCJ)
    - Target = STM32F429
Testing

- Kselftest
- LTSI Test Project
- Kernelci.org
kselftest

- Inside kernel source tree
  - Makefile target: ‘make kselftest’
- Ability to install tests mainlined in kernel v4.1
  - Cross-build should be worked on
  - http://lwn.net/Articles/628625/
- See “Linux Kernel Selftest Framework BoFs – Quality Control for New Releases” – Shuah Khan (at ELC)
- See http://lwn.net/Articles/608959/
LTSI test project

- Jenkins-based Test Automation (JTA)
- Available now
  - https://bitbucket.org/cogentembedded/jta-public/
- Several companies provided feedback at LTSI workshop meeting in Tokyo
  - CogentEmbedded will fix issues in next few months
- Please use JTA
  - Please send feedback to LTSI mailing list
    - https://lists.linuxfoundation.org/mailman/listinfo/ltsi-dev
Kernelci.org

- Place to get free build/boot testing for your board
  - “ci” = continuous integration
  - Builds 126 trees continuously, then reports any errors
- http://kernelci.org
- ELC 2015 - *Upstream Kernel Testing* – by Kevin Hilman
- Sony Mobile has a phone in this farm
Tracing

- eBPF to be used for dynamic tracing
  - Ktap will not be merged (frowny-face)
- new tracefs filesystem
  - No longer part of debugfs
  - But all (psuedo) dirs and files the same
- Histograms (not mainlined yet)
- See “New (and Exciting!) Development in Linux Tracing – Elena Zannoni (at LCJ 2015)
Miscellaneous

- Greybus
- J2
- Next LTS kernel version:
  - 4.1
Greybus

- New fast bus for mobile device hotplugging
  - For project ARA (Google’s modular phone)
  - Being worked on by Greg Kroah-Hartman
- https://lwn.net/Articles/648400/
- Work still needed in Android for support of dynamic hotplugging
Open hardware processor
Formerly SH2, but patents have expired
See http://lwn.net/Articles/647636/ “Resurrecting the SuperH architecture”
Resurgence of nommu Linux
Someday might run Linux on 3-cent processors
See the next presentation by Rob Landley
Outline

Kernel Versions
Technology Areas
CE Workgroup Projects
Other Stuff
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CEWG Projects

- Contract work
- Projects and initiatives
- (conferences covered later)
CEWG Contract Work

- Kernel string refactoring
- Device tree documentation
- LTSI test framework
Kernel string refactoring

- **Description**
  - Refactor kernel strings to enable compiler optimizations which reduce the space used for statically-defined strings
  - [http://elinux.org/Refactor_kernel_strings](http://elinux.org/Refactor_kernel_strings)
- **Contractor**: Wolfram Sang
- **Based on results from last year’s compressed printk investigation**
  - Expect at least 20K of savings, depending on kernel config
- **Project is just starting**
DT documentation

- Are proceeding with “guide” documentation
- Frank Rowand has been collecting data and giving talks
  - LinuxCon NA, ELCE, ELC and LCJ
- Goal is to release by ELC Europe 2015
- Will be put on elinux wiki at:
  - http://elinux.org/Linux_Drivers_Device_Tree_Guide
LTSI test framework

• (Discussed previously)
Projects and initiatives

- Civil Infrastructure
- Shared Embedded Distribution
- Device Mainlining
- LTSI
- eLinux wiki
Civil Infrastructure

- **Goals**
  - Solve problems with Linux for use in social infrastructure systems

- **Status**
  - **Recent Activity**
    - BOFS at ELCE 2014 and ELC2015 and LCJ2015
    - Private meetings to discuss goals with interested companies
  - Working to define requirements in areas of functional safety and maintenance longevity

- **Next steps:**
  - Hold additional meetings to define requirements
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**
  - Get more companies collaborating on the project
Device Mainlining

- http://elinux.org/CE_Workgroup_Device_Mainlining_Project
- Goal is to study obstacles to mainlining, and work to reduce obstacles
- Previous Activity
  - Developer survey in September 2014
  - SIG meetings at ELCE and ELC
  - Presentations about overcoming obstacles at ELCE 2014, ELC 2015, and LCJ 2015
    - See http://lwn.net/Articles/647524/
  - White paper (published at LCJ – June 2015)
Device Mainlining (cont.)

- Mobile phone source analysis
  - Phone kernels have between 1.1 and 3.1 million lines of code out-of-tree
  - Working to identify problem areas
- Published tools:
  - https://github.com/tbird20d/upstream-analysis-tools
## Big problem areas

<table>
<thead>
<tr>
<th>Area</th>
<th>Insertions range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mach-msm</td>
<td>347K – 417K</td>
</tr>
<tr>
<td>Media</td>
<td>120K – 360K</td>
</tr>
<tr>
<td>Video</td>
<td>37K – 346K</td>
</tr>
<tr>
<td>Wireless</td>
<td>80K – 250K</td>
</tr>
<tr>
<td>Sound</td>
<td>74K – 240K</td>
</tr>
<tr>
<td>Input</td>
<td>51K – 238K</td>
</tr>
<tr>
<td>Camera</td>
<td>50K – 210K</td>
</tr>
<tr>
<td>GPU</td>
<td>36K – 172K</td>
</tr>
<tr>
<td>Power</td>
<td>44K – 94K</td>
</tr>
</tbody>
</table>
• Technical Projects:
  • USB OTG charger integration
  • Broadcom wireless driver
  • http://elinux.org/Kernel_areas_of_focus_for_mainlining

• Non-technical:
  • Easy patch submission tool (no special mail settings required)

• Engage with more companies and individuals
  • Targets: Google and MediaTek
  • Meetings at Linaro Connect, ELC and kernel summit
Long Term Support Initiative

• LTSI 3.14 is latest kernel
• Many presentations available on status
• Latest project push is testing facility
  • See previous page on JTA test framework
• Considering multiple merge windows
• Will base next LTSI on 4.1 (LTS)
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
eLinux wiki

- I’m looking for people to take over specific sections (portals)
  - Boot time
  - Power management
  - Security
  - Etc.
- Main job is just to link to talks and articles on that topic
  - Should be 1 or 2 hours a week
- Contact me if you are interested
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Other Stuff

- Projects and Consortia
- Distros and Build Systems
- Events
Projects and Consortia

- PRPL Foundation – Multi-company MIPS non-profit
  - Projects: PRPL OpenWRT, MIPS QEMU
- DroneCode – Open source UAV software group
  - http://www.dronecode.org/
  - First Linux Drone summit at ELC
  - Andrew Tridgell on ELC program committee
Distros

- Android
  - Getting ready for Marshmallow (6.0) release
    - App permissions
    - Fingerprint
    - Mobile payments
    - “Doze” mode to decrease power usage in standby
- Tizen
  - Lots of security work
- AGL
  - Announced it will do it’s own distro
- CEWG Shared embedded distribution
  - (see previous slides)
Build Systems

- OpenEmbedded/Yocto Project
- Buildroot

(nothing new to discuss this time)
Events

• LinuxCon Japan
  • June 3-5, 2015 – Tokyo, Japan
  • Slides at:
• Embedded Linux Conference Europe 2015
  • October 5-7, 2015 - Dublin, Ireland
• Embedded Linux Conference 2016
  • April 4-6, 2016 - San Diego
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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
- Celinux-dev mailing list
Thanks!