CE Workgroup

Status of Embedded Linux
April 2015

Tim Bird
Architecture Group Chair
LF CE Workgroup
Outline

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

- Linux v3.14 – 30 Mar 2014 – 70 days
- Linux v3.15 – 8 Jun 2014 – 70 days
- 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 day
- Linux v4.0-rc7 – (60 days so far)
  - Linus said probably this weekend or next
Linux v3.14

- Last long-term stable (LTS) kernel
  - LTS is at 3.14.37 (as of March 2015)
  - Will be supported until August of 2016
- Current LTSI is based on 3.14.28
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
    - The name of this kernel is “hurr durr I’m a sheep”
  - 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/
- UBIFS performance improvements
Things to watch

- Kdbus
- Kernel tinification!
- Systemd in embedded
- RT-preempt (again…)
## Kernel contribution notes

### Contributions by different companies

<table>
<thead>
<tr>
<th>Author email domain</th>
<th>commits</th>
<th>Commiters (since 3.4)</th>
</tr>
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<tbody>
<tr>
<td>Sony[me] (sonymobile)</td>
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Results from: `git log v3.4.. --author=<expr> --format=%ae | sort | uniq | wc -l`
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Other Stuff
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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
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/
Graphics

- Freedreno graphics driver
  - 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
    - http://lwn.net/Articles/638908/
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
File Systems (cont.)

- 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

- At ELCE
  - Power management measurement devices
- At Plumbers
  - Energy management vs. power management
    - Performance vs. battery life
    - Want performance hinting from apps
- At ELC
  - PM domains
    - See “Last One Out, Turn Off The Lights” - Geert Uytterhoeven
      - Good talk showing how to use this with device tree
Power Management (cont.)

- Energy-aware Scheduling
- Idle time prediction
  - Permits better choice of idle state
  - http://lwn.net/Articles/618074/
- CPUFREQ
  - Changing clock frequency according to demand
  - Continuing integration into scheduler
- PM domains
  - Sets of devices to be treated similarly with regard to power management
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 at ELCE:
  - “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/
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/
- 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
System Size (cont.)

• Some ELC talks:
  • Optimize uClinux for ARM Cortex-M4 – Jim Huang
    • Target = STM32F4xx
  • Linux for Microcontrollers: From Marginal to Mainstream – Vitaly Wool
    • Target = STM32F2x
    • 840K .text, 132k .rodata, 86k .data (BT, no TCP/IP)

• Both have good descriptions of additional kernel areas that can be reduced
Toolchains

- LLVM being used for more and more
  - Including Linux kernel
    - ELCE talk by Behan Webster with latest update
  - More fixes for LLVM support in 3.18
  - Building Android with Clang (next slide)
Building Android with Clang

• Nexus 7 and 10 are booting and can run many apps
• Nexus 4 and 5 still problematic
• 112 patches submitted
  • 74 accepted
  • 34 waiting
• GCC performance is slightly better
• Clang is finding real bugs
Testing

- Kselftest
- LTSI Test Project
- Kernelci.org
kselftest

- Inside kernel source tree
  - Makefile target: ‘make kselftest’
- Currently supports host-mode selftest
  - Ability to install tests is in linux-next
  - Cross-build now being worked on
- New size test:
  - “make TARGETS=size kselftest”
    - Really needs cross-build and deploy-to-target support
- See http://lwn.net/Articles/608959/
- See “Linux Kernel Sefltest Framework BoFs – Quality Control for New Releases” – Shuah Khan
LTSI test project

- Jenkins-based Test Automation (JTA)
  - We need a new name!!
- Available now
- Fujitsu has tested the test framework, and contributed ethtool tests
- Officially would like to encourage:
  - Please use JTA
  - Please send feedback to LTSI mailing list
    - https://lists.linuxfoundation.org/mailman/listinfo/ltsi-dev
  - Or add to elinux wiki page
Kernelci.org

- Place to get free build/boot testing for your board
- Sony Mobile has a phone in this farm
- http://kernelci.org
- Don’t know many details
  - But I can see kernel build/boot failures online for my platform
  - I missed this ELC session, but the site looks interesting
Outline

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CEWG Projects

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

- Compressed printk
- Device tree documentation
- LTSI test framework
  - Funded by Renesas
Compressed printk

- Project completed
- Contractor: Wolfram Sang
- Results are on elinux wiki
  - http://elinux.org/Compressed_printk_messages_-_Results
- Wolfram delivered reports at LinuxCon North America and ELC Europe 2014
- Result of investigation: it’s not worth doing
  - But some interesting size optimizations were found
DT documentation

- Still want to proceed with documentation
- Frank Rowand has been collecting data and giving talks
  - LinuxCon North America and ELC Europe
- Not sure when this will be released
LTSI test framework

(Discussed previously)
Projects and initiatives

- Social infrastructure
- Standard Embedded Distribution
- Device mainlining
- Possibly a “size” project
- LTSI
- eLinux wiki
Social Infrastructure

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

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

- **Next steps:**
  - Hold additional meetings to define requirements
  - Initiate project with goal of starting in Fall 2015
Goals
• Create an industry-supported distribution of embedded Linux

Status
• Toshiba reported results of Poky-Debian project
• Lots of results to be described in presentation later today

Next steps
• Write up more detail on project, to solicit Linux Foundation funding or involvement of more parties
• Approach individual companies about collaborating on the project
Device Mainlining

- **Goals**
  - Study obstacles to mainlining, and work to reduce obstacles

- **Status**
  - Recent Activity
    - Survey in September 2014
    - Talk about overcoming obstacles at ELCE 2014 and ELC 2015
    - BOF in October 2014 in Dusseldorf
    - Mobile phone source code analysis
    - SIG meeting in March 2015 in San Jose
Device Mainlining (cont.)

- Review of source analysis
  - Phone kernels have between 1.1 and 3.1 million lines of code out-of-tree
  - Tried to identify problem areas
  - Next few slides show results of source analysis for 9 phones with 5 different processors
    - Based on 3.4 of 3.0 kernels
# SOC overview

<table>
<thead>
<tr>
<th>Company</th>
<th>SOC</th>
<th>Files</th>
<th>Insertions</th>
<th>Deletions</th>
</tr>
</thead>
<tbody>
<tr>
<td>LG</td>
<td>Msm</td>
<td>5775</td>
<td>2.616M</td>
<td>40K</td>
</tr>
<tr>
<td>Motorola</td>
<td>Msm</td>
<td>4490</td>
<td>1.795M</td>
<td>40K</td>
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<tr>
<td>Samsung</td>
<td>Exynos</td>
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<td>Hisilicon</td>
<td>5082</td>
<td>2.659M</td>
<td>43K</td>
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</table>
### Big problem areas

<table>
<thead>
<tr>
<th>Area</th>
<th>Insertions range</th>
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</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>
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<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>
SIG meeting notes

- Attendees included several maintainers and companies interested in mainlining patches
- Some obstacles mentioned:
  - Lack of business incentive for companies to mainline code
  - Obsolescence of SoC before code can be mainlined
  - Device tree bottleneck
  - Unresponsive maintainers
- Some ideas mentioned:
  - Assist maintainers with paid help
  - Educate companies on benefits
  - Create SoC staging area (particularly for unstable device-tree bindings)
Device mainlining - Next steps

- Need to process input from SIG meeting
- Most promising ideas:
  - Fund projects (possibly with Linaro) in certain key kernel areas
    - Need to dig deeper to find common problem areas
  - Fund a developer to be co-maintainer for certain overloaded maintainers
    - Need method to find overloaded maintainers
- LF white paper on overcoming obstacles
Possible size project

- Separate people and companies are working on kernel size reduction patches
- Josh Triplett now manages a linux-tiny tree
- CEWG may contribute to that effort
Long Term Support Initiative

- LTSI 3.14 is latest kernel
- Many presentations available on status
  - Including this Jamboree
- Latest project push is testing facility
  - Test framework (JTA) is now available!!
- Currently considering multiple merge windows
- See the presentation later in this jamboree
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
  - Working on new wiki projects:
    - Video transcription project
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Other Stuff

- Projects and Consortia
- Distros and Build Systems
  - Android
  - Tizen
  - Poky-Debian
  - Yocto Project
  - Buildroot
- Events
Projects and Consortia

• Allseen Alliance – Peer-to-peer ad-hoc networking
  • http://allseenalliance.org
  • AllJoyn is the name of the implementation
• 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

- Lollipop now shipping
- Lots of changes in upper portions of stack
- Some kernel level changes
  - Android no longer uses logger kernel driver
- Toybox now included in AOSP!!
  - Should be in default builds for the “M” release
Distros - Tizen

- Doing lots of security work with SMACK
  - Have new access-control broker: Cynara
    - See https://lwn.net/Articles/602060/
- Have proposed security modules for use with Yocto Project
  - “Ready made Recipes to add Security and Data Protection to a Yocto based Project reusing Tizen-Meta” – Dominiq Ar Fol
Distros – Poky Debian

(See Kobayashi-san’s presentation later today)
Build System – Yocto Project

• Promoting “Toaster” - web interface to the Yocto Project
• New Features in 1.8:
  • Import and build your own custom layers
  • Set configuration variables (in toaster)
  • Add packages to core images
  • Select target and build them
  • Download artifacts
• Lots of projects making meta-layers for YP
• Need to get slides for YP sessions at ELC from presenters
Build System - Buildroot

- Is continuing, as the simpler alternative to Yocto Project/OpenEmbedded
- 600+ packages
- New features:
  - Allow defconfig and recipes from external tree
  - Check integrity of downloaded archives
  - Better report licensing information
- See “Buildroot: Embedded Linux for Small Devices and Makefile Enthusiasts” - Stephanie Lockwood-Childs
Events

• Embedded Linux Conference 2015
  • March 23-25, 2015 – San Jose
  • Many presentations online at:
    • http://elinux.org/ELC_2015_Presentations

• LinuxCon Japan
  • June 3-5, 2015 – Tokyo, Japan

• Embedded Linux Conference Europe 2015
  • October 5-7, 2015 - Dublin, Ireland

• Embedded Linux Conference 2016
  • April 4-6, 2016 - San Diego
ELC overall impressions

• Was our biggest ELC yet
  • Over 600 attendees

• Theme: Drones, Things and Automobiles

• Drones = exciting area (one vertical)
  • They need RT-preempt – it’s good someone picked it up
  • Otherwise, they are using standard Linux features – just need board support and drivers for hardware
  • Lots of interesting technology and features in their space (see Andrew Tridgell’s slides)

• Automotive = seems to be going along
  • I worry about whether we’re getting sufficient traction – but I’m not in that space
ELC impressions (cont.)

• IOT – Internet of Things
  • Linux has “won” the cloud and the gateway
  • It will only “win” (some) sensors if it is smaller
    • Renewed interest in size reductions is welcome
  • Other areas that could be improved:
    • Security improvements
    • In-field upgrades (this is not a Linux problem, per se, but some Linux features can help with this)
  • Other problems are infrastructure, social, etc.
  • We have plenty of IOT stacks
    • Including mature but newly released OpenDOF from Panasonic
Final Thoughts

- We can still improve, especially in mainlining
- But overall, Embedded Linux is doing very well!!
Resources

- LWN.net
  - http://lwn.net/
  - If you are not subscribed, please do so
- Kernel Newbies
  - http://kernelnewbies.org/Linux_3.?
- eLinux wiki - http://elinux.org/
  - Especially http://elinux.org/Events for slides
- Celinux-dev mailing list
Thanks!