Status of Embedded Linux
June 2015

Tim Bird
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LF CE Workgroup
Outline

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

- 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 days
- Linux v4.0 – 12 Apr 2015 – 63 days
- Linux v4.1-rc8
  - Very close to 4.1 release (already at 67 days)
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/](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
Things to watch

- Kdbus
  - Has hit some stumbling blocks getting merged
- Kernel tinification!
- RT-preempt (again…)
- Persistent memory
- SoC mainlining progress
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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 – 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
    - http://lwn.net/Articles/638908/
Other graphic drivers

- PowerVR SGX code leaked in November
- 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?).

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)
File Systems (cont.)

ELC talks:
- “Filesystem Considerations for Embedded Devices” – Tristan Lelongs
  - 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 at ELCE:
  - “rtmux: A thin multiplexerer 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
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/
  - 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
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
- Sony Mobile has a phone in this farm
- http://kernelci.org
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
J2

- 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
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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

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

- **Status**
  - **Recent Activity**
    - Survey in September 2014
    - SIG meeting in March 2015 in San Jose
    - Talk about overcoming obstacles at ELCE 2014 and ELC 2015 and LCJ 2015
      - See http://lwn.net/Articles/647524/
    - Mobile phone source code analysis
    - White paper (published at LCJ)
Device Mainlining (cont.)

- Review of 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

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<thead>
<tr>
<th>Area</th>
<th>Insertions range</th>
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<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>
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<tr>
<td>Input</td>
<td>51K – 238K</td>
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<tr>
<td>Camera</td>
<td>50K – 210K</td>
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<tr>
<td>GPU</td>
<td>36K – 172K</td>
</tr>
<tr>
<td>Power</td>
<td>44K – 94K</td>
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</tbody>
</table>
Device mainlining (cont.)

- LF white paper on overcoming obstacles
  - Need to move from v0.9 to v1.0
- Refine upstream-analysis-tools
  - Make it more automated
- Engage with more companies
  - Targets: Google and MediaTek
  - See http://elinux.org/CE_Workgroup_Device_Mainlining_Project
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
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- Projects and Consortia
- Distros and Build Systems
- 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
  - Getting ready for “M” release
- Tizen
  - Lots of security work
- AGL
  - Announced it will do its 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
  - CFP just closed
- **Embedded Linux Conference 2016**
  - April 4-6, 2016 - San Diego
LCJ overall impressions

- CE Workgroup had a booth
  - It was fun, but hard to tell how productive
- More embedded-related content than I expected
  - Micro-controllers
  - Raspberry PI (x2)
  - Power management (x3)
  - Tracing
  - Open Hardware
  - Civil Infrastructure, Shared distribution, LTSI
- Lots of “Studying Open Source” talks
  - At least 6 talks
Event impressions

- Resurgence in interest in small systems
- IOT is a big deal
  - Lots of proposals for ELCE
  - I still worry about Linux missing out in the sensor market, but we’ll see…
- J2 (open hardware) came out of nowhere
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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!
## Kernel contribution notes

### Contributions by different companies

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