CE Workgroup

Status of Embedded Linux

November 2015

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LF CE Workgroup

Outline

Kernel Versions
Technology Areas
CE Workgroup Projects
Other Stuff
Resources

Outline

Kernel Versions

Technology Areas

CE Workgroup Projects

Other Stuff

Resources

Kernel Versions

- 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
- Linux v4.3 – 1 Nov 2015 – 63 days
- We're in the 4.4 merge window now

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’ma 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

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

- 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 Ext3 filesystems

Things to watch

- Kdbus
  - Has hit some stumbling blocks getting merged
- Kernel tinification!
- RT-preempt
- Persistent memory
  - (NVM = Non-Volatile 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/

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Bootup Time

- XIP on x86
  - See https://lwn.net/Articles/637532/
- Deferred initcalls (patch still out-of-tree)
  - http://elinux.org/Deferred_Initcalls
- Asynchronous probing
- Reduction in probe deferral
  - No one has measured effect on overall boot time
  - Explicit probe ordering can be used to get a specific subsystem (like display) up sooner

Bootup Time (cont.)

- Kernel tinification project helps
  - Smaller size means shorter load times
- User-space speedups
  - Systemd in embedded
    - ELC 2015 - *Tuning systemd for Embedded by* Alison Chaiken
- Some good talks:
  - ELCE 2014 - *12 Lessons Learnt in Boot Time Reduction* by Andrew Murray
  - ELC 2015 - *Fastboot Tools and Techniques* by John Mehaffey

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 working 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 or kernel build
- V2 of spec has been published – still hashing out details

More devicetree stuff

- Frank Rowand is a new devicetree maintainer
  - Has been updating http://elinux.org/Device_Tree
  - Working on devicetree debugging
    - LCNA 2015 (and here) - *Solving Device Tree Issues* by Frank Rowand
- Big DT 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 it)
- GPU support
  - Freedreno – for Adreno
  - ??? – for PowerVR
  - Etnaviv – for Vivante
  - Nouveau – for Nvidia
  - Lima – for Mali

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?).

Read more: http://www.cnx-software.com/2015/06/18/open-source-linux-drivers-for-powervr-gpus-might-be-in-the-works/#ixzz3dSpJ9bhI

Other OSS GPU drivers

- Etnaviv – for Vivante
  - See http://www.x.org/wiki/Events/XDC2015/Program/Stach_etnaviv.pdf
  - Replaced 65K kernel driver with 6.5K driver
  - See ELCE 2015 talk: “Bringing up FOSS GPU Drivers on Freescale i.MX6 Systems” by Lucas Stach
    - Slides not there yet, but I will ping Lucas

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)

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
  - “Current Challenges in UBIFS” – ELCE 2015
    - Richard Weinberger

Networking

- Bluetooth:
  - Bluetooth 4.2 has better security, faster speeds
  - 6lowpan integration
  - Working on mesh networking
- New protocols for IOT
  - Thread – Nest's low-power IP stack
  - Others (Sigfox, LoRaWan, etc.)
- Visible Light Communication (VLC)
  - Disney's Linux Light Bulb
  - Low-bandwidth via LED-to-LED
  - Allows toy to have cheap transmitter/sensor

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

- Linux Foundation Real-Time Linux Collaborative project
  - Thomas Gleixner is a Linux Foundation fellow
  - Should result in more stuff going upstream
  - One interesting note: press release says they'll meet regularly at ELC
- Latest release of RT-preempt is for 4.1 kernel
  - Tends to follow LTS releases

Real Time - other

- Xenomai 3.0 is out !! *(actually, 3.0.1)*
  - Uses Cobalt RT core
  - 3.0 supports both dual-kernel and single-kernel configurations (using RT-preempt)
  - See xenomai.org
- Some RT talks
  - ELCE 2015 – *Practical Real-Time Linux* – by Arnout Vandecappele
  - ELCE 2014 - *"rtmux: A thin multiplexer to provide hard realtime applications for Linux"* - by Jim Huang
    - Good overview of existing RT solutions, and a new alternative

Security

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

Security (cont.)

- Lots of focus on security at kernel summit
  - http://kernsec.org/wiki/index.php/Kernel_Self_Protection_Project

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
- Intel X86 XIP patches
  - See https://lwn.net/Articles/637532/

System Size (cont.)

- Nicolas Pitre has done work recently on supporting gcc --gc-sections
  - Lighter-weight option similar to LTO
- Some recent talks:
  - Optimize uClinux for ARM Cortex-M4 – Jim Huang (at ELC)
  - Linux for Microcontrollers: From Marginal to Mainstream – Vitaly Wool (at ELC)
    - 840K .text, 132k .rodata, 86k .data (BT, no TCP/IP)
  - Pushing the limits of Linux on ARM – Andreas Färber (at LCJ)

Testing

- Kselftest
- LTSI Test Project (JTA)
- Kernelci.org

kselftest

- Inside kernel source tree
  - Makefile target: ‘make kselftest’
- Ability to install tests mainlined in kernel v4.1
  - Cross-build now supported?
    - I didn’t have time to test this myself
  - 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
- 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 (also here) - *Upstream Kernel Testing* – by Kevin Hilman
- Sony Mobile has a phone in this farm

Toolchains

- Khem Raj has added support to the Yocto Project for Clang (LLVM)
  - Builds all but about 45 packages
  - He has a mini-distro with kernel, musl, toybox, built with clang (non-GNU)
    - Call it LinuxNG?

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
- Weird IOT news

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

Weird IOT news

- Microsoft released Windows 10 IoT kit for Raspberry PI
- Google is making Brillo preview available (upon request and approval)

Outline

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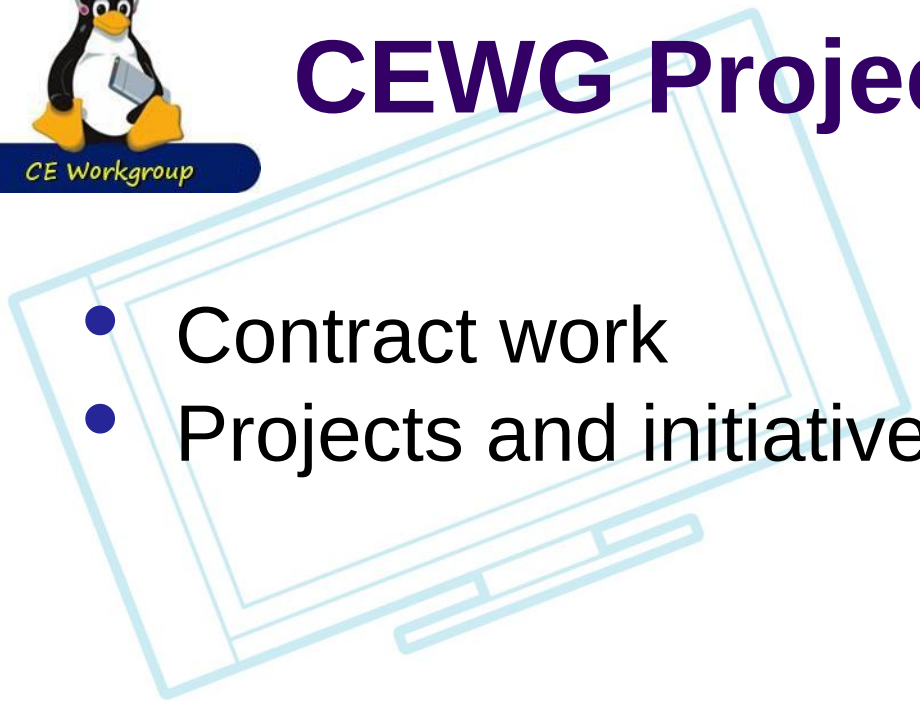
CEWG Projects

- Contract work
- Projects and initiatives



CEWG Contract Work

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

Kernel string refactoring

- Description
  - Refactor kernel strings to reduce the space used for statically-defined strings
  - http://elinux.org/Refactor_kernel_strings
- Contractor: Wolfram Sang
- Based on results from last year's compressed printk investigation
  - Aiming for at least 50K of savings, depending on kernel config
- Project is just starting

DT documentation

- Working on “guide” documentation
- Frank Rowand has been collecting data and giving talks
  - LinuxCon NA, ELCE, ELC and LCJ
- 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 civil 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 2014
  - SIG/BOF meetings at ELCE, ELC, LCNA and Linaro Connect
  - Presentations about overcoming obstacles
    - 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
- Projects:

Big problem areas

Area	Insertions range
Mach-msm	347K – 417K
Media	120K – 360K
Video	37K – 346K
Wireless	80K – 250K
Sound	74K – 240K
Input	51K – 238K
Camera	50K – 210K
GPU	36K – 172K
Power	44K – 94K

Active technical projects

- Wireless drivers
  - Mainline Broadcom wireless driver has never been run on production phone hardware
  - Want to improve/mature the mainline driver
  - Sony has tested a backport of the driver
  - Recently got latest kernel running on phone hardware, and we now run the mainline driver
- USB
  - No one has ever charged their mobile device using only mainline code
  - Working on USB charger framework

Additional projects

- Technical Projects:
  - Gathering more project ideas at:
    - http://elinux.org/Kernel_areas_of_focus_for_mainlining
  - UART bus
- Non-technical:
  - Easy patch submission tool (no special mail settings required)
- Metrics for in-tree code size and maintenance reduction benefits (for managers)
  - Real data instead of hand-waving

Long Term Support Initiative

- LTSI 4.1 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

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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Other Stuff

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

Projects and Consortia

- Allseen Alliance – Peer-to-peer ad-hoc networking
  - AllJoyn is the name of the implementation
- Open Interconnect Consortium
  - Iotivity is the technology
- DroneCode – Open source UAV software
  - http://www.dronecode.org/

Projects and Consortia

- Linaro
  - Just celebrated 5th anniversary
  - Linaro IoT and Embedded initiative (LITE)
    - Run Linux on Cortex A and mbedOS on Cortex M
      - Unsure about licensing for Cortex M
- PRPL Foundation (Multi-company MIPS non-profit)
  - Announced at ELCE 2014
  - Projects: PRPL OpenWRT, MIPS QEMU
  - OpenWRT summit tomorrow, here

Distros

- Android
  - Just released “M” version
  - New build system under development, using ‘go’ language and something called blueprints
- 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
  - 1.8 released
    - Can now do builds and runs with Toaster (web interface)
- Buildroot
  - Configurable support for static linking
  - Improved support for package hashes
  - Better warnings about toolchain header safety issues

Events

- Embedded Linux Conference Europe 2015
  - October 5-7, 2015 - Dublin, Ireland
  - Lots of content - check for slides on elinux wiki
- Embedded Linux Conference 2016
  - April 4-6, 2016 - San Diego, USA
- Embedded Linux Conference Europe 2016
  - October 6-7, 2016 - Berlin, Germany

Hardware

- Intel and Micron 3D Xpoint memory
  - Non-volatile
  - Read/Write, Random access, Faster than NAND, Cheaper than flash
  - Not many details yet
- Is this the persistent memory we've been waiting for?

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Final Impressions

Resources

- 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

Impressions – hardware price

- Steady decline in price of silicon
  - Cheapest Android phone = $29
    - Lenovo A288t (Russian)
  - The Chip - $9 computer board
  - Estimate that cheapest Linux-capable SoC (with MMU) currently about $3
- Still want to see Linux on cereal boxes
  - Less than $1 for SoC, display, battery, input

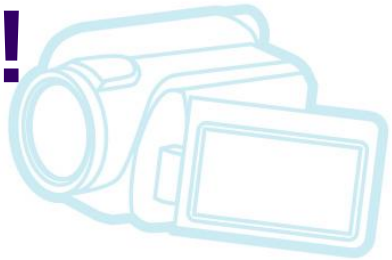
Impressions – markets

- I worry that Linux will not be in the “things” part of IOT
  - Linux on IOT gateway is a no-brainer
  - Linux is too big for sensors
  - Rate of adoption of tinification patches is slow
  - Need a concerted, collaborative effort here
- In other areas Linux is already penetrating:
  - Drones, Industrial automation, Robotics
  - Automotive, Automated vehicles
  - Gateways, Civil infrastructure

Impressions

- Embedded Linux is doing fine….

Thanks!



Kernel Summit Report

- See http://lwn.net/Articles/662628/
- Running mainline on a cellphone
  - (see previous slides about device mainlining project)
- Power management knobs
  - How to make sure existing PM features of Linux are actually used
  - Lots of tunable (“knobs”), but are often
- Device dependencies and deferred probing
  - Rafael Wysocki has a proposal to build a dependency graph
- Realtime mainlining

Kernel Summit Report (cont.)

- Security – fixing exploitation classes
  - Big focus on kernel security issues
- Developer recruitment
- Kernel testing
  - 0-day now sends patch fixes for patches seen on mailing lists
- Kernel tinification
  - 0-day test now reports size
- Stable kernels:
  - Things going pretty well
  - Next LTS kernel is 4.4 (different time of year)