



# *CE Workgroup*

# Status of Embedded Linux

June 2015

Tim Bird

Architecture Group Chair

LF CE Workgroup



CE Workgroup

# Outline

Kernel Versions  
Technology Areas  
CE Workgroup Projects  
Other Stuff  
Resources



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# Outline

Kernel Versions

Technology Areas

CE Workgroup Projects

Other Stuff

Resources



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# Kernel Versions

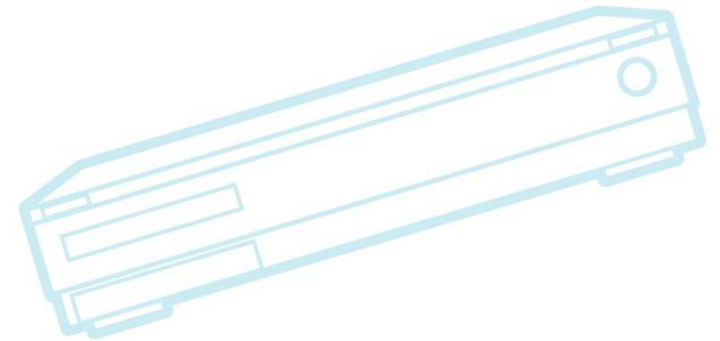
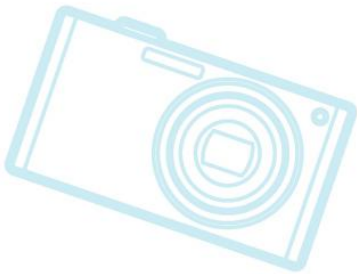
- Linux v3.15 – 8 Jun 2014 – 70 days
- Linux v3.16 – 3 Aug 2014 – 57 days
- Linux v3.17 – 5 Oct 2014 – 63 days
- Linux v3.18 – 7 Dec 2014 – 63 days
- Linux v3.19 – 8 Feb 2015 – 63 days
- Linux v4.0 – 12 Apr 2015 – 63 days
- Linux v4.1-rc8
  - Very close to 4.1 release (already at 67 days)



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# Linux v3.16

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







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# 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



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# Linux v3.18

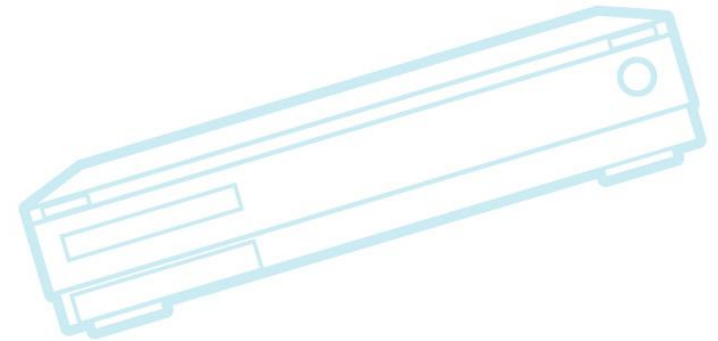
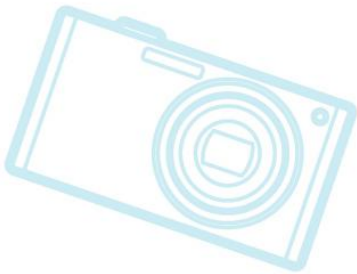
- OverlayFS introduced
- Size reduction patch:
  - madvise and fadvise syscalls can be configured out
- More LLVM support
- New SOC support:
  - Hisilicon HiP04
  - Amlogic Meson6 (8726MX)
  - Renesas R-Car E2 (R8A77940)
  - Broadcom BCM63xx DSL
  - Atmel SAMA5D4



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# 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







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# 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



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# Linux v4.1

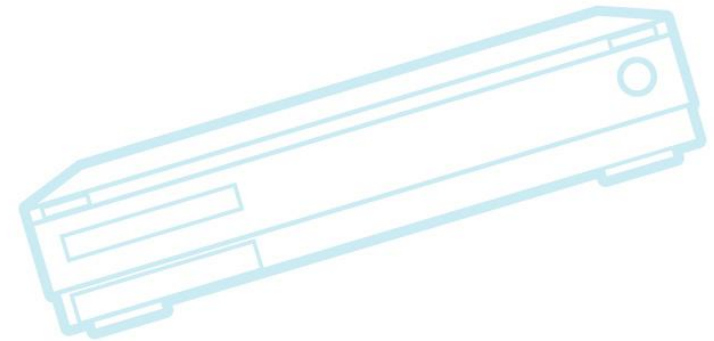
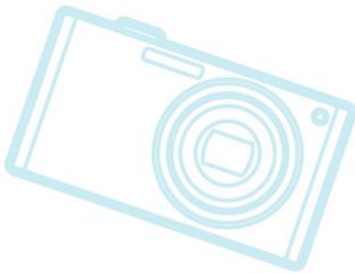
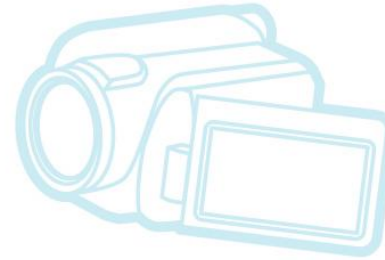
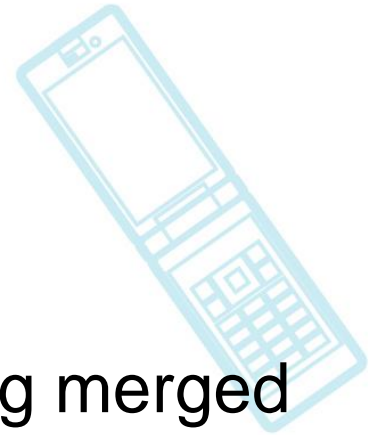
- New tracefs filesystem
- Kernel self-test 'install' target
- Ability to attach BPF programs to kernel probes
- I2C subsystem can function in slave mode
- Can configure kernel for single-user operation



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# 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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# Outline

Kernel Versions

**Technology Areas**

CE Workgroup Projects

Other Stuff

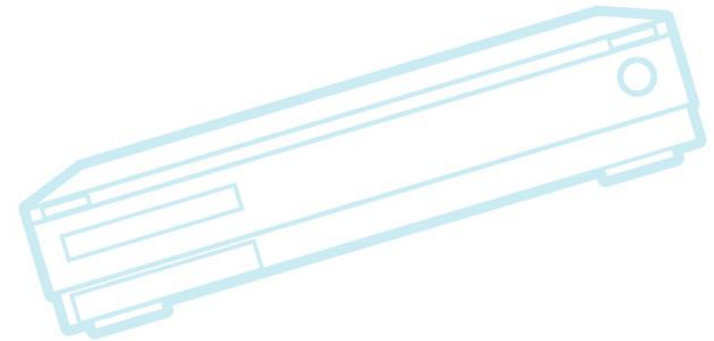
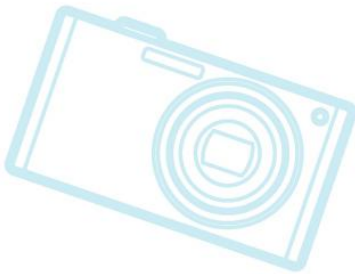
Resources



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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







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# Device Tree

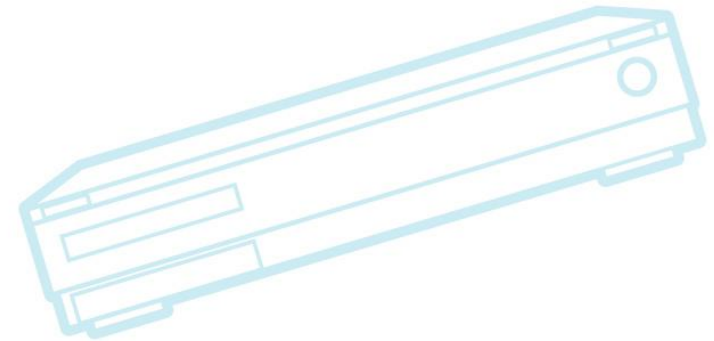
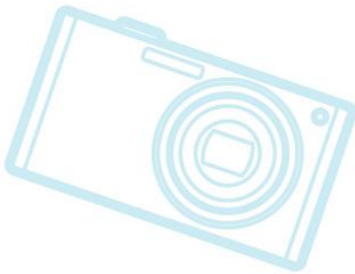
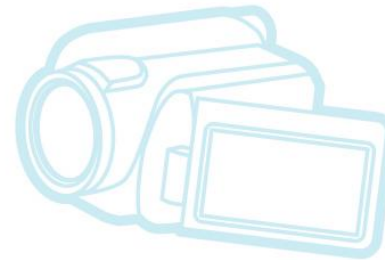
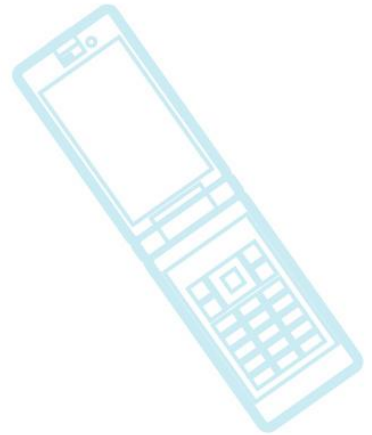
- Device Tree is causing delays getting stuff upstream
  - DT maintainers are overloaded
  - Backwards compatibility is a problem
  - See “The Device Tree as a Stable ABI: A Fairy Tale?” – Thomas Petazzoni
- Device Tree Overlays
  - Useful for boards that have daughterboards (e.g. capes or shields) that need DTS changes at boot time.
  - “Transactional Device Tree & Overlays: Making Reconfigurable Hardware Work” - Pantelis Antoniou
  - Also see: <http://lwn.net/Articles/616859/>



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# Graphics

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





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# 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/>



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# 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?).

Read more: <http://www.cnx-software.com/2015/06/18/open-source-linux-drivers-for-powervr-gpus-might-be-in-the-works/#ixzz3dSpJ9bhl>



# 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 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



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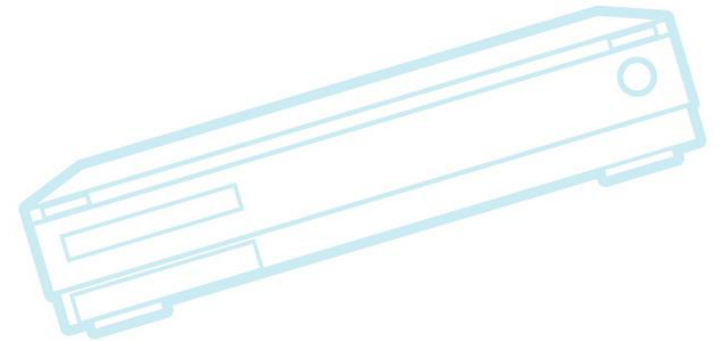
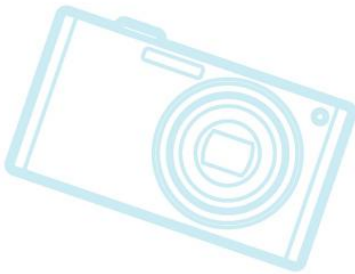
# Real Time

- 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/>



# 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





# System Size (cont.)

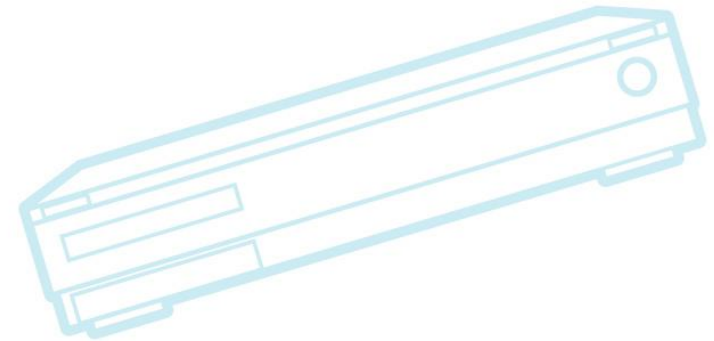
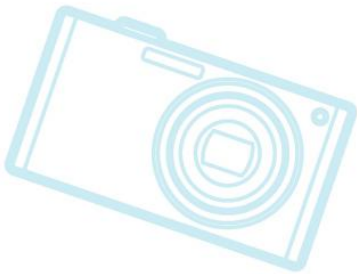
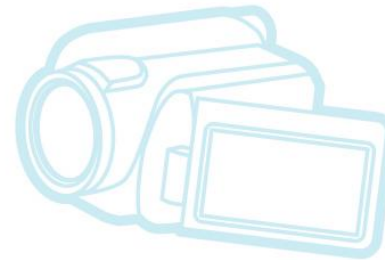
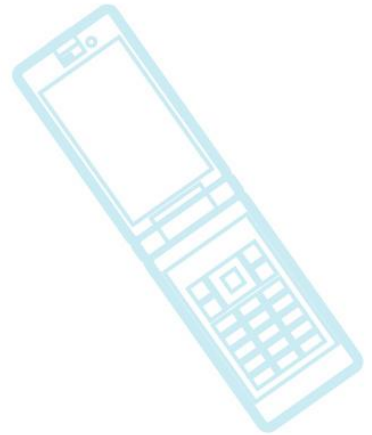
- Some recent talks:
  - Optimize uClinux for ARM Cortex-M4 – Jim Huang (at ELC)
    - Target = STM32F4xx
  - Linux for Microcontrollers: From Marginal to Mainstream – Vitaly Wool (at ELC)
    - Target = STM32F2x
    - 840K .text, 132k .rodata, 86k .data (BT, no TCP/IP)
  - Pushing the limits of Linux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



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# Testing

- Kselftest
- LTSI Test Project
- Kernelci.org





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# 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/>



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# LTSI test project

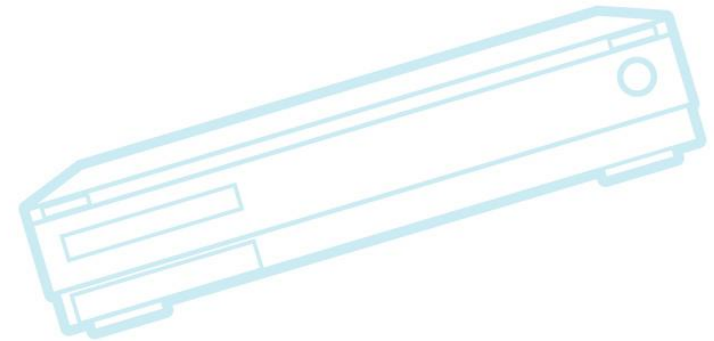
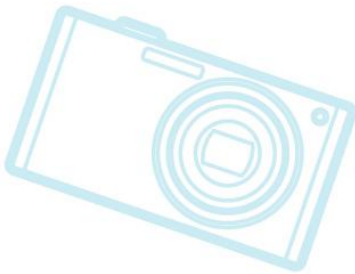
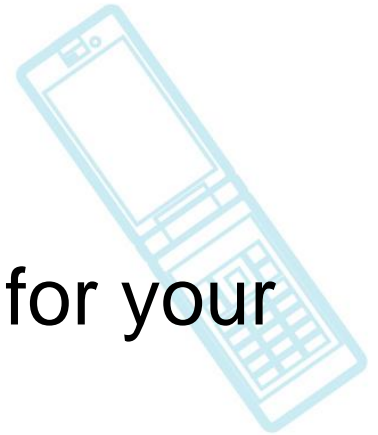
- Jenkins-based Test Automation (JTA)
- Available now
  - <https://bitbucket.org/cogentembedded/jta-public/>
- Several companies provided feedback at LTSI workshop meeting in Tokyo
  - CogentEmbedded will fix issues in next few months
- Please use JTA
  - Please send feedback to LTSI mailing list
  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



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# Kernelci.org

- Place to get free build/boot testing for your board
- Sony Mobile has a phone in this farm
- <http://kernelci.org>







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# Tracing

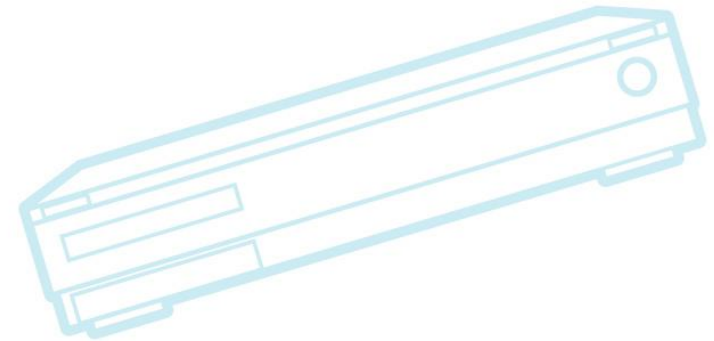
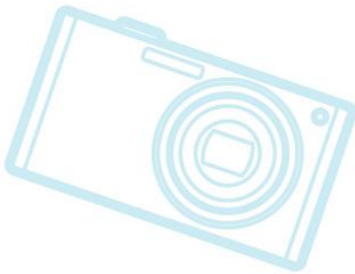
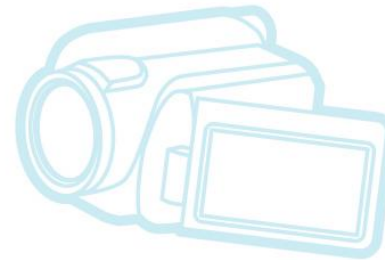
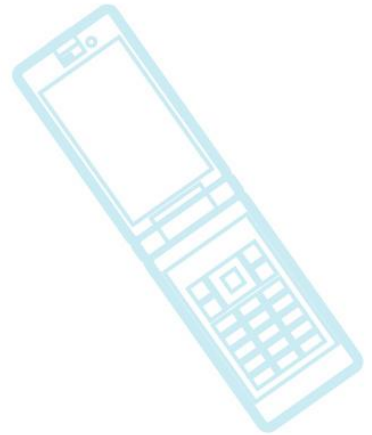
- eBPF to be used for dynamic tracing
  - Ktap will not be merged (frowny-face)
- new tracefs filesystem
  - No longer part of debugfs
  - But all (psuedo) dirs and files the same
- Histograms (not mainlined yet)
- See “New (and Exciting!) Development in Linux Tracing – Elena Zannoni (at LCJ 2015)”



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# Miscellaneous

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

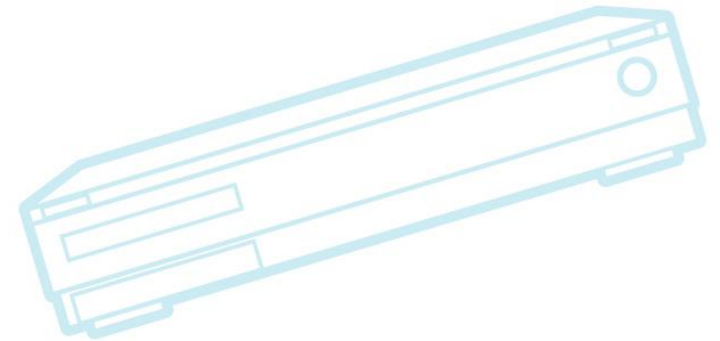
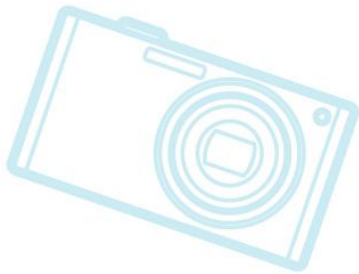




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# Greybus

- 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





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# 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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# Outline

Kernel Versions

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**CE Workgroup Projects**

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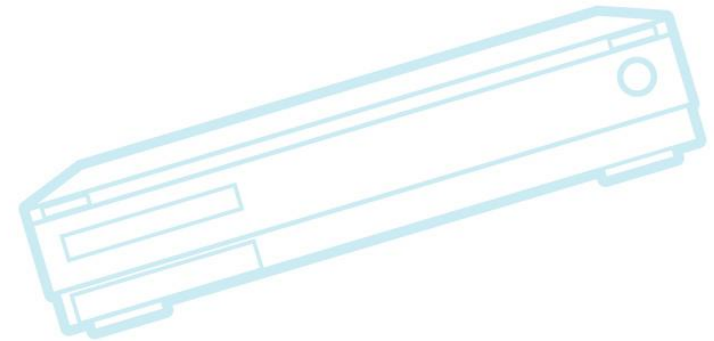
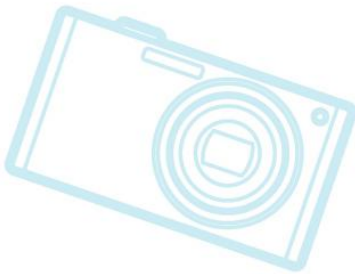
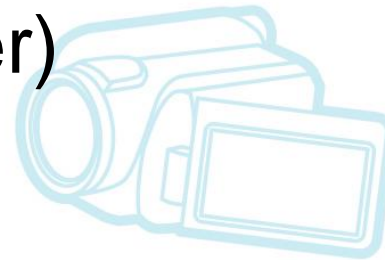
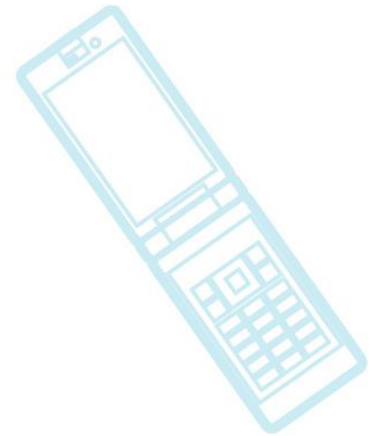




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# CEWG Projects

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

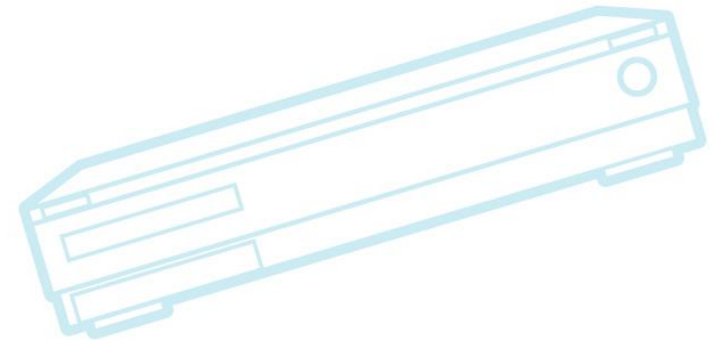
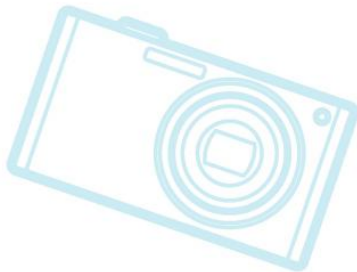
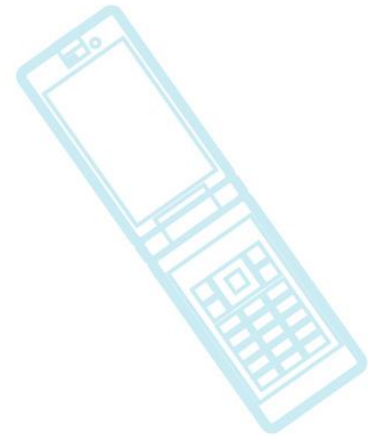




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# CEWG Contract Work

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





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# 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



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# DT documentation

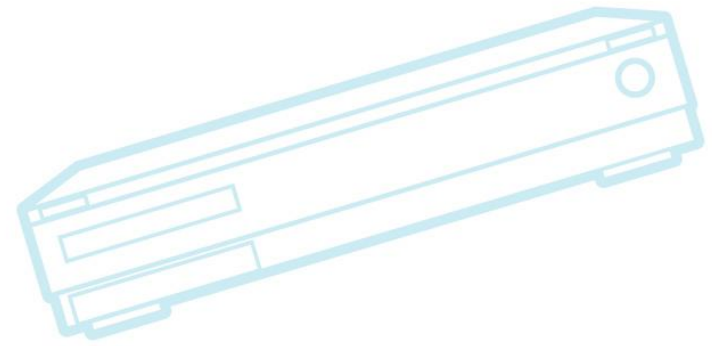
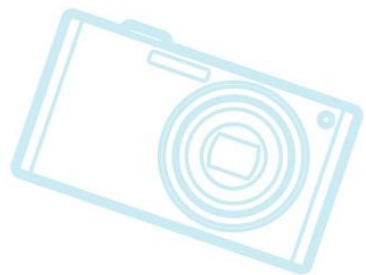
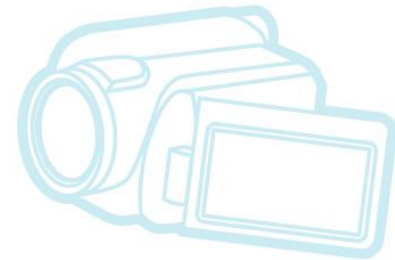
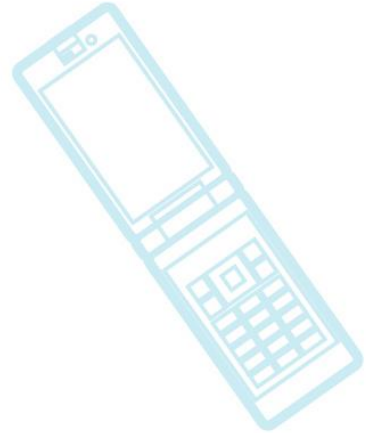
- Are proceeding with “guide” documentation
- Frank Rowand has been collecting data and giving talks
  - LinuxCon NA, ELCE, ELC and LCJ
- Goal is to release by ELC Europe 2015
- Will be put on elinux wiki at:
  - [http://elinux.org/Linux\\_Drivers\\_Device\\_Tree\\_Guide](http://elinux.org/Linux_Drivers_Device_Tree_Guide)



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# LTSI test framework

- (Discussed previously)



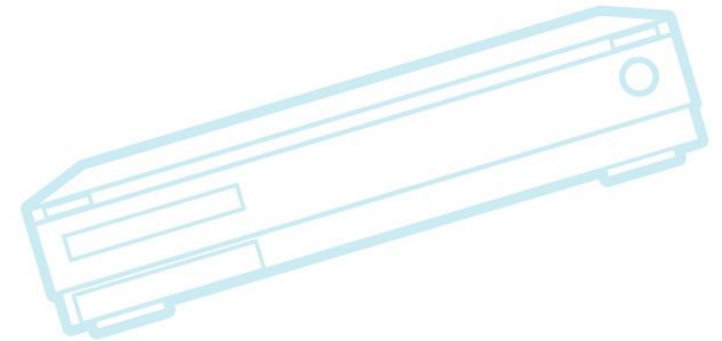
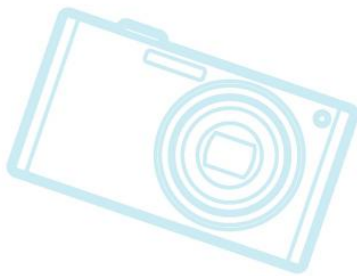
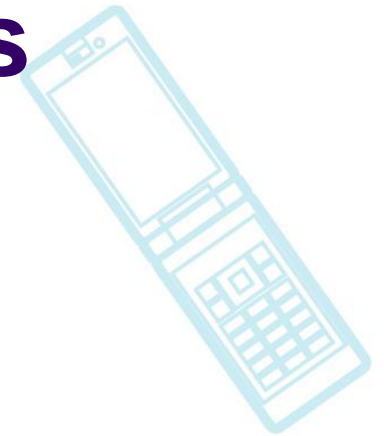




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# Projects and initiatives

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





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# 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



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# 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



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# Device Mainlining

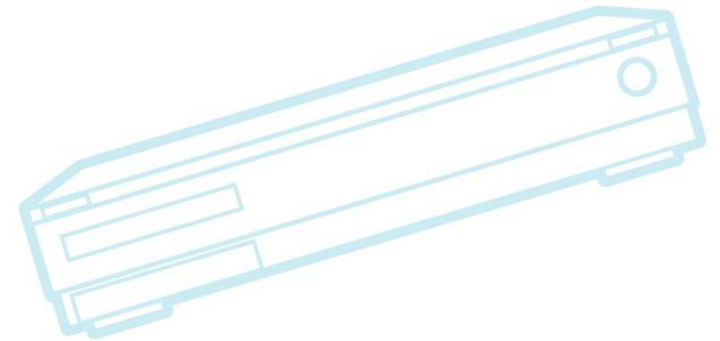
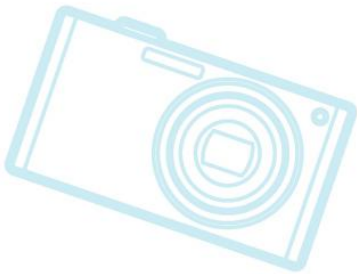
- **Goals**
  - Study obstacles to mainlining, and work to reduce obstacles
- **Status**
  - **Recent Activity**
    - Survey in September 2014
    - SIG meeting in March 2015 in San Jose
    - Talk about overcoming obstacles at ELCE 2014 and ELC 2015 and LCJ 2015
      - See <http://lwn.net/Articles/647524/>
    - Mobile phone source code analysis
    - White paper (published at LCJ)



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# 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>







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# 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



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# Device mainlining (cont.)

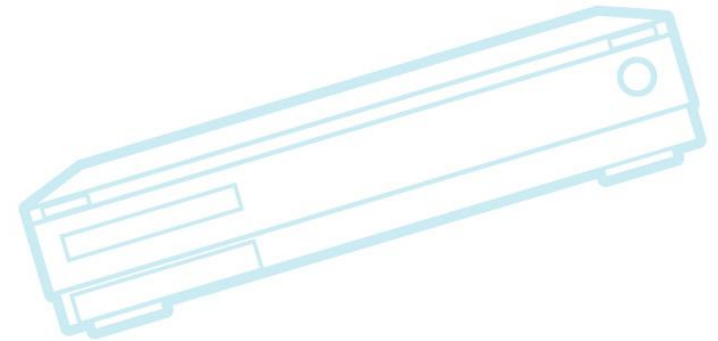
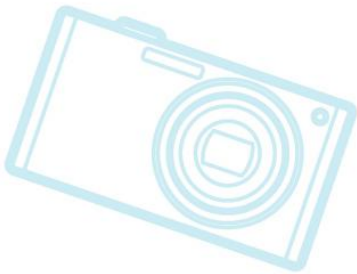
- LF white paper on overcoming obstacles
  - <http://elinux.org/images/e/ed/Overcoming-Obstacles-to-Mainlining-White-Paper-version-0.9.pdf>
  - Need to move from v0.9 to v1.0
- Refine upstream-analysis-tools
  - Make it more automated
- Engage with more companies
  - Targets: Google and MediaTek
- See [http://elinux.org/CE\\_Workgroup\\_Device\\_Mainlining\\_Project](http://elinux.org/CE_Workgroup_Device_Mainlining_Project)



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# 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)





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# 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



CE Workgroup

# Outline

Kernel Versions

Technology Areas

CE Workgroup Projects

**Other Stuff**

Resources

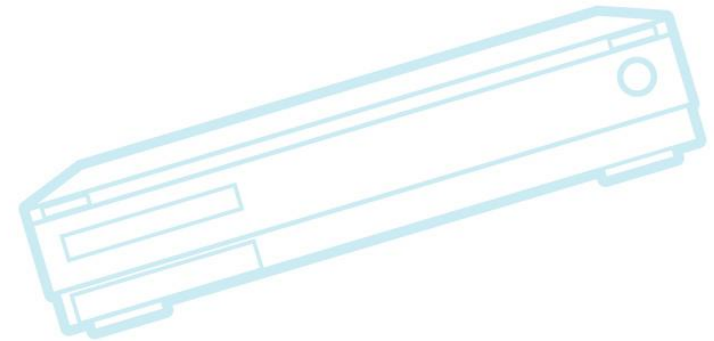
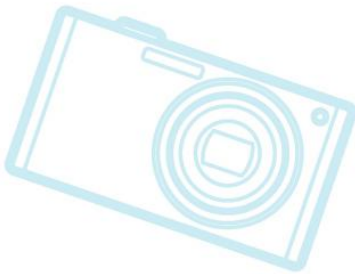
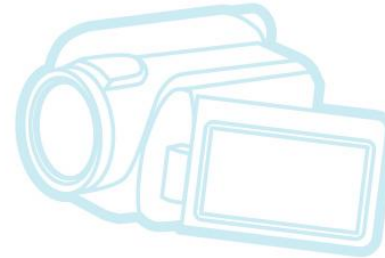
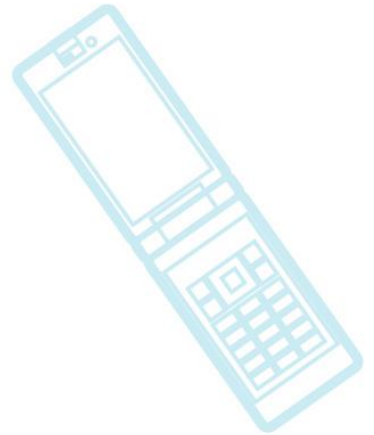




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# Other Stuff

- Projects and Consortia
- Distros and Build Systems
- Events





# Projects and Consortia

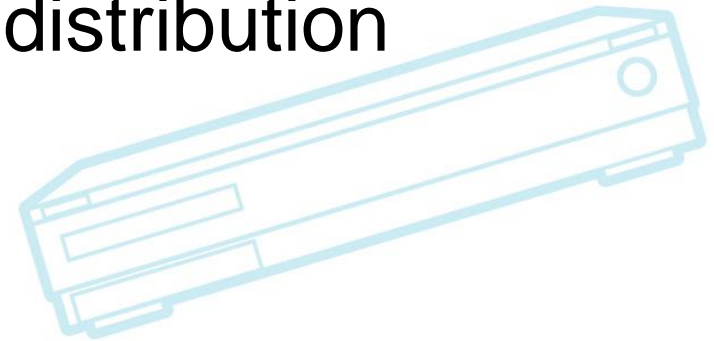
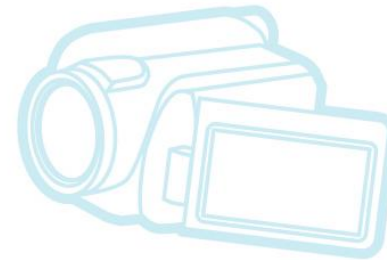
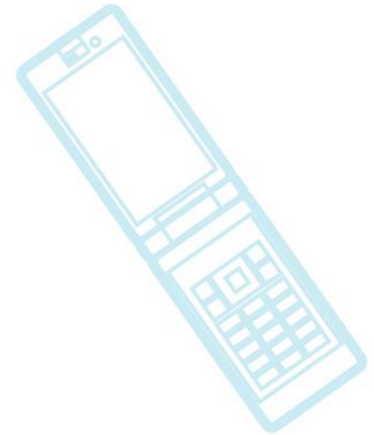
- Allseen Alliance – Peer-to-peer ad-hoc networking
  - <http://allseenalliance.org>
  - AllJoyn is the name of the implementation
- PRPL Foundation – Multi-company MIPS non-profit
  - Projects: PRPL OpenWRT, MIPS QEMU
- DroneCode – Open source UAV software group
  - <http://www.dronecode.org/>
  - First Linux Drone summit at ELC
  - Andrew Tridgell on ELC program committee



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# Distros

- Android
  - Getting ready for “M” release
- Tizen
  - Lots of security work
- AGL
  - Announced it will do it’s own distro
- CEWG Shared embedded distribution
  - (see previous slides)



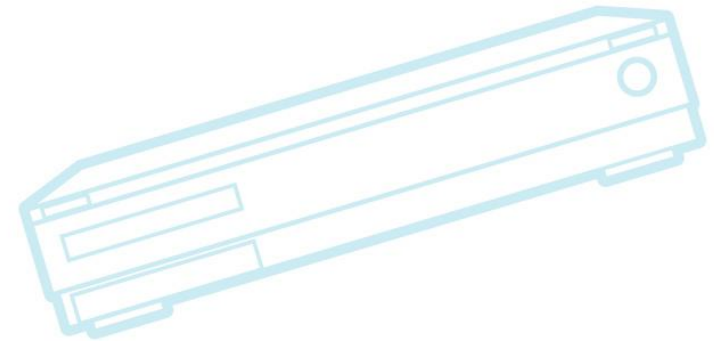
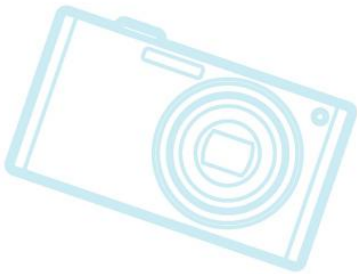
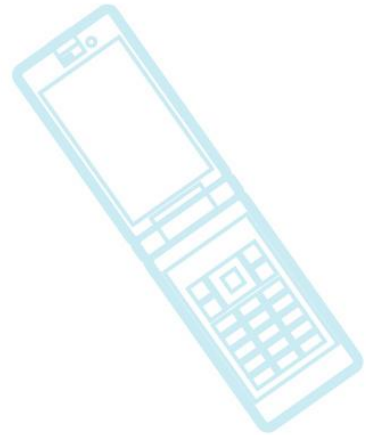


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# Build Systems

- OpenEmbedded/Yocto Project
- Buildroot

(nothing new to discuss this time)





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# 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





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# 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



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# 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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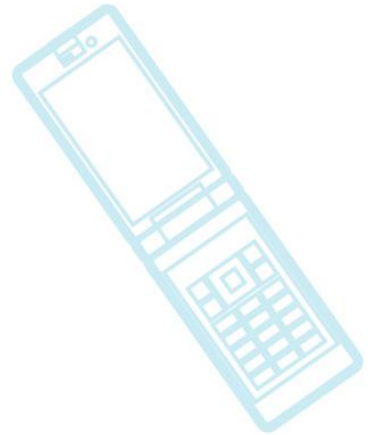
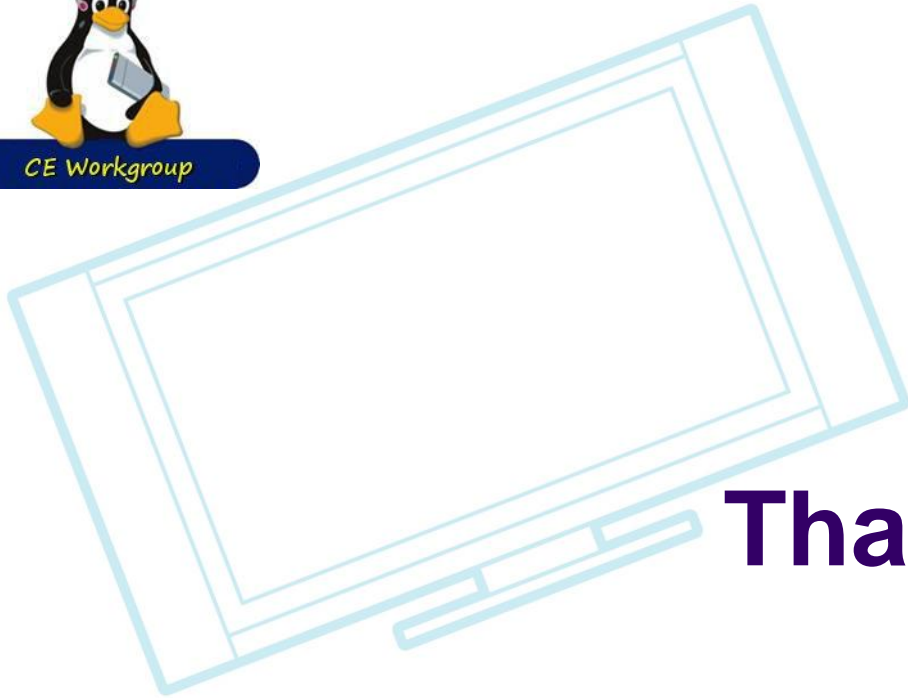
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# Resources

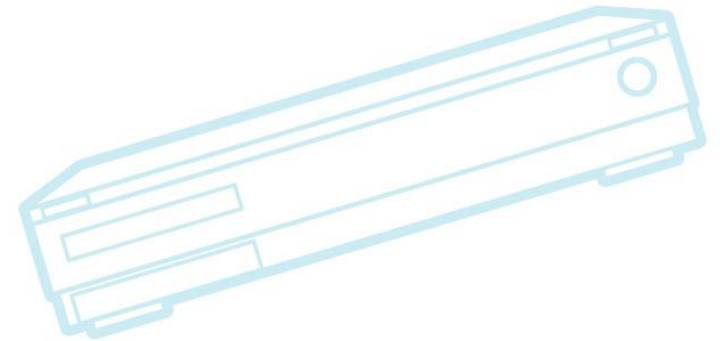
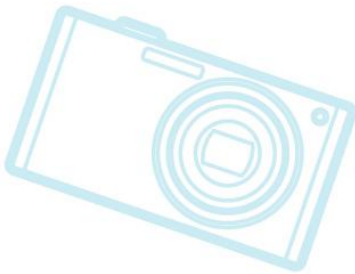
- LWN.net
  - <http://lwn.net/>
  - If you are not subscribed, please do so
- Kernel Newbies
  - [http://kernelnewbies.org/Linux\\_3.?.?](http://kernelnewbies.org/Linux_3.?.?)
- eLinux wiki - <http://elinux.org/>
  - Especially <http://elinux.org/Events> for slides
- Celinux-dev mailing list



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**Thanks!**







# Kernel contribution notes

- Contributions by different companies

Author email domain	commits	Committers (since 3.4)
Sony[me]      ( <i>sonymobile</i> )	53	14
Lge.com	565	11
Huawei	1220	71
Qualcomm Codeaurora	1349	46
Moto	1035	15
Free-electrons	2333	9
Samsung	7031	160
Intel	17374	469

Results from: `git log v3.4.. --author=<expr> --format=%ae | sort | uniq | wc -l`