CE Workgroup

Status of Embedded Linux

March 2016

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LF CE Workgroup

Outline

Kernel Versions
Technology Areas
CE Workgroup Projects
Other Stuff
Resources

Outline

Kernel Versions

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Kernel Versions

- 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
- Linux v4.4 – 10 Jan 2016 – 70 days
- Linux v4.5-rc7 – currently at 60 days
  - Should see Linux v4.5 on March 13

Linux v4.0

- This version is not v3.20
- 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 ext3 filesystems

Linux v4.4

- LightNVM feature
  - Take control of low-level SSD features
    - Will talk about this later
- Perf can build and load eBPF files
- Arm64 can have 16K pages
- Broadcom VC4 GPU (raspberry pi)
- Devfreq cooling – thermal management
- Various PWM drivers

Linux v4.5

- ARM multiplatform hits an important milestone
  - Major patch including lots of minor plaforms
  - Many v6 and v7 platforms are now supported
- Not much else specific to embedded
  - Well, continued mainlining of drivers for SoC features

Things to watch (from past)

- Kdbus
  - Has hit some stumbling blocks getting merged
- Kernel tinification!
- RT-preempt
- Persistent memory
  - (NVM = Non-Volatile Memory)
- SoC mainlining progress

Things to watch (status)

- Kdbus (stalled)
  - Has hit some stumbling blocks getting merged
- Kernel tinification! (stalled)
- RT-preempt (in progress)
- Persistent memory (in progress)
  - Good talk on about issues:
    - “Making use of persistent memory”
      - http://lwn.net/Articles/674752/
- SoC mainlining progress (in progress)

Kernel process analysis

- Does kernel development scale
  - Does the kernel patch acceptance process scale?
- “How 4.4’s patches got to the mainline”
  - http://lwn.net/Articles/670209/
  - Has an interesting graph
- Tree is very flat
  - Only a few areas where patch flows through more than one maintainer tree
    - Networking is a good example

Kernel process analysis (cont.)

- Some conclusions:
  - Most maintainers push directly to Linus
    - Patch path is shorter than expected
    - Linus trusts his sub-maintainers
  - Linux pulls about 300 trees each release
  - Adding a little depth could scale the process even more, with no slow-down
  - Currently at about 1500 developers and 11,000 commits per release, but should be able to scale to many more
- Linus has pushed for “maintainer groups”
- There’s much more automated testing

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Bootup Time

- Mostly old news…
- XIP on x86
  - See https://lwn.net/Articles/637532/
- Asynchronous probing
  - Discussed at kernel summit
- Reduction in probe deferral
  - Explicit probe ordering can be used to get a specific subsystem (like display) up sooner
  - The “On-demand probing” patches were NAKed
  - Need to measure effect on overall boot time

Bootup Time (cont.)

- No talks at ELC this year
  - But boot time is NOT a solved problem
  - Boot time issues are unique per platform, and reductions tend not to be mainlinable
    - e.g. remove stuff not needed
- Some good previous 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 Overlays
  - Seems to be working as intended
  - Will be session at ELC 2016 by Pantellis on making overlays independent of the base board
    - Should allow add-on boards to be used with different platforms
- New Maintainer – Frank Rowand
- Device Tree validation
  - Project by Matt Porter and others
  - Schema for binding language, validator for bindings and for device tree data
  - Work is stalled
- Updated Device Tree spec possibly in works
  - Want to update material and make it more available

Graphics

- Vulkan API from Khronos Group
  - Alternative to Direct3D or OpenGL
  - Reduce CPU overhead for CPU/GPU operations
  - AMD announced plans to open source the driver (but Intel and Valve already working it)
  - Version 1.0 is now available
  - Nvidia now supports it
- Qt license change
  - From LGPL 2.0 to LGPL 3.0
  - Companies scrambling to find alternative
    - GPL/LGPL 3.0 is undesirable for CE products

GPUs and OSS support

- Integrated GPUs
  - AMD, Intel, Nvidea, Qualcomm:Adreno
- GPU IP suppliers
  - ARM:Mali, Imagination:PowerVR, Vivante
- GPU support
  - Freedreno – Adreno (good progress)
  - ??? – for PowerVR (no progress)
  - Etnaviv – for Vivante (good progress)
  - Nouveau – for Nvidia (not sure of status)
  - Lima – for Mali (no progress)

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

- In June 2015: 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

- No word since then…

Etnaviv

- Etnaviv – for Vivante
  - 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 now available for this talk
  - Also see See http://lwn.net/Articles/659391/
- Stuff hit mainline in January:
  - https://git.kernel.org/cgit/linux/kernel/git/torvalds/linux.git/commit/drivers/gpu/drm/etnaviv?id=a8c21a5451d831e67b7a6fb910f9ca8bc7b43554
  - From “the etnaviv authors”

File Systems

- 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

(new) LightNVM

- Framework for holding SSD parameters
- Allows kernel to manage flash translation layer
- SSDs have weird (black-box) FTL implementations
  - Are often optimized for FAT filesystems
  - Recent drives allow direct access to blocks
- See http://lwn.net/Articles/641247/
  - “The host primarily handles data placement, I/O scheduling, and garbage collection and leaves everything else to the SSD controller”

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

- “Dynamic Audio Power Management”
  - ELCE 2015 talk by Lars Peter Clausen
  - New system that manages a graph of relationships between IP blocks on the system
  - Turns on/off power, or scales it, according to needs
    - Lots of graph traversal
  - Could be used for other systems (e.g. video)

Hardware power reduction

- Passive WiFi
  - Modulate reflected WiFi instead of broadcasting
  - 10,000x less power for mobile device
  - Research by University of Washington
  - Still in research, but promising
  - http://www.networkworld.com/article/3037088/mobile-wireless/researchers-make-low-power-wi-fi-breakthrough.html

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
    - Thomas will have keynote session at ELC 2016
- Latest RT-preempt is for 4.4 kernel
  - Just released on this week!
  - Tends to follow LTS releases
  - See https://www.kernel.org/pub/linux/kernel/projects/rt/

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
  - Presentation on Xenomai at ELC 2016

Security

- “Making your own security modules” – Casey Schaufler
  - http://lwn.net/Articles/674949/
  - Promote experimentation by giving tips on how to write your own security modules
- Security module stacking
  - Added in kernel 4.2
  - See https://lwn.net/Articles/635771/
- New project for kernel security issues:
  - http://kernsec.org/wiki/index.php/Kernel_Self_Protection_Project

Security and IOT

- 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

System Size

- Kernel tinification project is stalled
  - Tiny repository removed from linux-next
  - No activity in one year!
- 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
  - Not mainlined

System Size (cont.)

- Intel X86 XIP patches
  - See https://lwn.net/Articles/637532/
- Nicolas Pitre has done work recently on supporting gcc --gc-sections
  - Lighter-weight option similar to LTO
- Linux Foundation announces IOT RTOS
  - Zephyr
  - Does this mean that we're giving up on Linux size reductions??
    - (maybe)

Testing

- Kselftest
- LTSI Test Project
- Kernelci.org
- Lots of automated testing talks at ELC 2016

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)
  - I've asked to rename it Fuego
    - Waiting for my patch to be applied
- Available now
  - https://bitbucket.org/cogentembedded/jta-public/
- Hard to tell what adoption rate is
- Want to identify some specific verticals, and build tests for them
  - Otherwise, it's a solution in search of a problem

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 and ELCE 2015 - *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
  - Will have presentation at ELC 2016

Tracing

- eBPF to be used for dynamic tracing
  - Perf supports eBPF (in 4.4)
    - eBPF = extended Berkeley Packet Filter
- 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

- J2
- Current LTS kernel version:
  - 4.4
- IOT news

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
- “Linux” Foundation announces non-Linux RTOS for Internet of Things
- Google Brillo is available (by invitation)
  - Java-less, headless, Android

LF RTOS for IOT

- Zephyr – RTOS from Wind River
- Idea is to target devices that Linux will never support
  - E.g. sensors
- Attributes:
  - Apache 2 license
  - Minimal size – as small as 8K
    - Highly configurable
  - NoMMU
  - Networking: WiFi, Bluetooth, NFC
- Governed by committee

Short rant

- I’m not sure why this is called an RTOS
  - There’s no RealTime requirement
- It should be called IoTOS

- (rant over)

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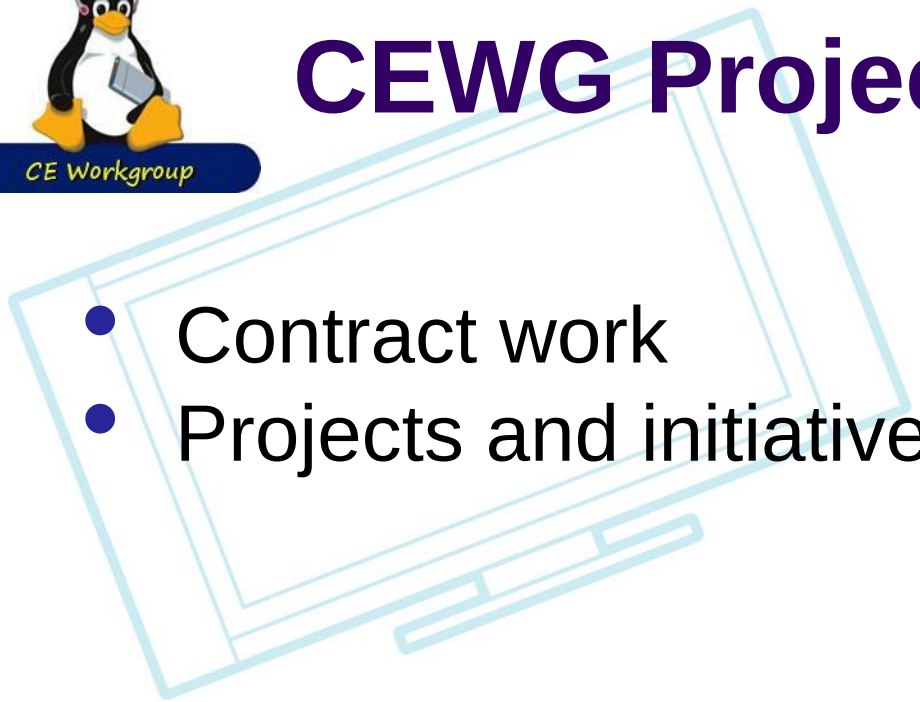
CEWG Projects

- Contract work
- Projects and initiatives



CEWG Contract Work

- Kernel string refactoring
- Device tree documentation
- LTSI test framework
- Shared distribution testing

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 in progress
  - Report expected at LinuxCon Japan

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)

Shared Distribution Testing

- See “Shared Embedded Distribution” project (later in these slides)
- Project to test distribution on a few different hardware platforms
- Contractor: Tuan Hoang
- Status: Just starting

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 many recent events
    - Private meetings to discuss goals with interested companies
  - Have organized some companies to work on the project
- Next steps:
  - Activities are being planned
  - Presentation at ELC 2016

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
  - Presentation at ELC 2016

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
- Published tools:
  - https://github.com/tbird20d/upstream-analysis-tools
- Ongoing Projects:
  - Presentation at Collab Summit 2016
  - Possibly create some training materials
  - Qualcomm report on mainline status at ELC 2016
  - Create tools for easier mainlining

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
- Kernel diversion measurement tool
  - Presentation at ELC 2016

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 Connectivity Foundation (OCF)
  - Adopted OIC/Iotivity technology, along with UPnP stuff
  - I think there's some kind of OCF/Allseen collaboration, but I'm not sure
- DroneCode – Open source UAV software
  - http://www.dronecode.org/
  - Have a good drone track at ELC 2016

Projects and Consortia

- Linaro
  - Linaro IoT and Embedded initiative (LITE)
    - Waiting to see their proposal
    - Run Linux on Cortex A and mbedOS on Cortex M
      - Unsure about licensing for Cortex M
- PRPL Foundation
  - Multi-company MIPS non-profit
  - Projects: PRPL OpenWRT, MIPS QEMU

Distros

- Android
  - Working on “N” version
  - New build system under development, using ‘go’ language and something called blueprints
  - Google switching to OpenJDK
    - Eliminates those troublesome Oracle Java libraries
- Tizen
  - Lots of security work
- CEWG Shared embedded distribution
  - (see previous slides)

Build Systems

- OpenEmbedded/Yocto Project
  - 2.0 (Jethro) released
  - 1.8 allowed builds and runs with Toaster (web interface)
    - HOB is gone
    - Presentation on Toaster at ELC 2016
- Buildroot
  - Configurable support for static linking
  - Improved support for package hashes
  - Better warnings about toolchain header safety issues
  - License reporting?

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
  - Please come if you can make it
    - Should be lots of fun
- Embedded Linux Conference Europe 2016
  - October 6-7, 2016 - Berlin, Germany

Hardware

- Samsung ARTIK 1 processor
  - 1MB RAM, 4MB Flash, BLE 4.0
  - 12x12mm
  - Running Nucleus (frowny face)
- Raspberry Pi Zero
  - $5 computer
    - It came for free with the December issue of MagPI magazine
  - 1GHz, 512M RAM, faster than Pi 1
  - Good review at:
    - https://www.youtube.com/watch?v=NFFQmdUc5Vg

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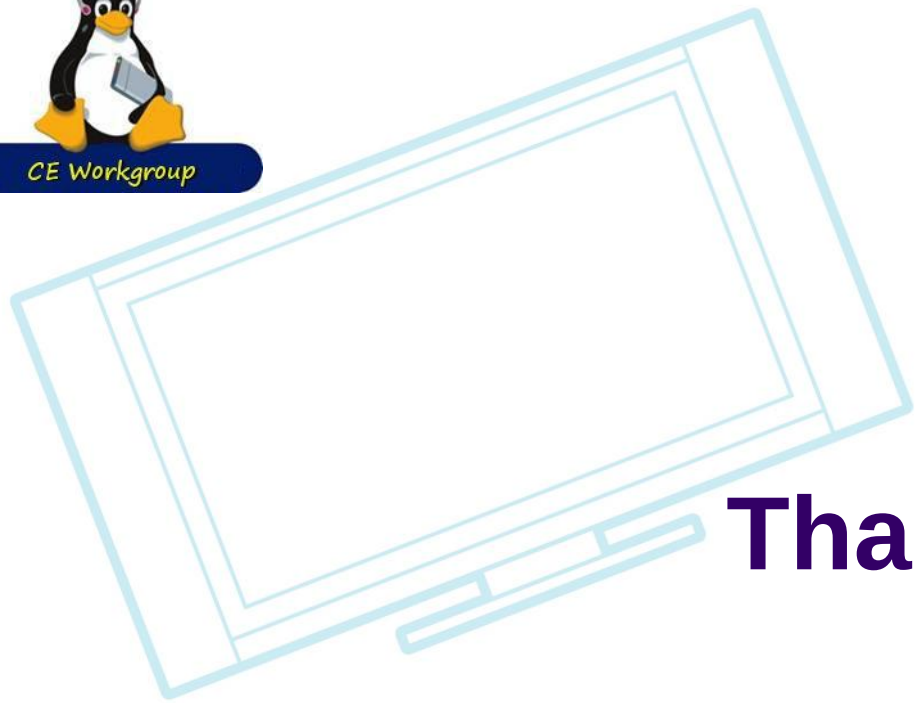
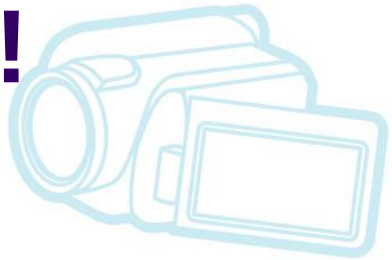
Resources

- 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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