Status of Embedded Linux
June 2016

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LF CE Workgroup
Outline

ELC 2016 Report
Kernel Versions
Technology Areas
CE Workgroup Projects
Other Stuff
Resources
ELC 2016 report

• Warning: this is NOT a comprehensive report
  • I can’t stay on top of all the sessions
  • 4 tracks of ELC, 4 tracks of IOT = 8 tracks!!
    • Sometimes I missed tracks due to management duties

• Just give my impressions of talks I saw, and overall event
Tim’s notes

• From individual sessions
• Overall impressions
• Resources
My session list

- Digitalization of Kernel Diversion from the upstream
- Kernelci BOF
- Disecting Qualcomm's 1.7M Android Fork
- Would you trust Linux with your Life? Linux for safety critical applications
- Intel Keynote
- Introducing the Civil Infrastructure Platform
- Introduction to the Fuego Test System
- Zephyr Project: an RTOS to Change the Face of IoT
- EFL: A Toolkit for Uis
- Tales of Enforcement
- Interview with Thomas Gleixner – state of RT-preempt
Digitalization of Kernel Diversion from the upstream

- Project to find a metric for difference between vendor kernel and upstream
- Must use automated tools (code is too big)
- Using locality sensitive hashing (TLSH) to determine code distance between files from vendor kernel and it’s upstream version
  - Put code into buckets of divergence level
  - High (dirty), medium (OK) or low (clean)
- Can measure your vendor’s kernel yourself
Kernelci BOF

- Does basic boot testing of kernels, in a continuous integration fashion
  - Builds 55 upstream trees for hundreds of target boards
- Multiple farms contributing to results
  - Anyone can join effort and send results
- Some technical details:
  - All tests run from RAM (ramdisk)
    - Never touches storage, and doesn't use network
    - MMC and network drivers are first to break
    - Scrapes the console for results (doesn't use file transfer)
  - Does virtual targets as well
Dissecting Qualcomm's 1.7M Android Fork

- Discouraging talk about problems upstreaming
  - Progress has been made, but there’s lots left to do
- Long list of items that are hard to push upstream
Some specific issues mentioned:

- Upstream voltage and frequency scaling is not complete for clock framework
  - Internal team use their own drivers instead of upstream drivers because of power issues
- Some drivers have debug code that mainline won't take
  - e.g. USB diagnostic framework
- Internal teams are on a treadmill, and don't have time to contribute
  - In local trees, developers just replace upstream drivers with local versions, rather than fix them
Would you trust Linux with your Life? Linux for safety critical applications

• Unfortunately had problems with the projector
  • Good introduction to topic
• Talk about functional safety, and different standards in the industry
  • Safety Integrity Levels (SIL)
  • Assessment for events:
    • Severity, Exposure and Controllability
• Can use system complexity to provide diversity
  • Which can provide redundancy
Intel Keynote

- Zephyr
  - RTOS for sub-Linux computers
- OSTRO
  - Linux distro targeted to IOT
  - Small footprint
  - Has Iotivity stack integrated
- Yocto Project
  - 2.1 provides an extensible SDK
    - Exposes build flexibility in simpler way
      - YP has too steep of a learning curve
  - Support Windows developers with containers
Introducing the Civil Infrastructure Platform

• New project by Linux Foundation
  • Based on CE WG civil infrastructure project
• Find issues with Linux in civil infrastructure systems, and fix them
• Many developers question if Linux can last long enough for these use cases
  • Good quote during session:
    • “If you don’t use Linux for civil infrastructure, what else are you going to use?”
    • Thus, problems have to be (will be) solved with Linux, whether people think they’re solvable or not
• Collaboration will give better results
Introduction to the Fuego Test System

- Fuego = (Jenkins + abstraction scripts + pre-packed tests) inside a container
- I’ll give this presentation at Linuxcon Japan
  - Please come see it there
- Good feedback from audience
  - Plan to add serial support
  - Working on command-line tool
    - To isolate test framework from continuous integration front-end
Zephyr Project: an RTOS to Change the Face of IoT

- Small RTOS
  - Can be configured for as little as 8K
- Focus is on security and mature networking stacks
- Apache 2.0 license
  - Can’t be GPL because “apps” are statically linked to kernel
- Hallway conversation:
  - Maybe Linaro will use this instead of mbed?
EFL: A Toolkit for UIs

(Will cover this in next slide set)
Tales of Enforcement

• Interesting talk about how the Software Freedom Conservancy works on GPL compliance

• SFC view: If you don't enforce or threaten to, some companies will never comply

• SFC seeks only compliance - does not try to monetize infringement
  • SFC has written principles about enforcement
    • If approached by another actor, ask if they are principled in the same

• Vendors who don't receive source are victims, but won't turn around and work on their supply chain
  • Is frustrating to SFC
Interview with Thomas Gleixner – state of RT-preempt

- Real-time Linux Collaborative Project
  - Is good to get organized funding
    - Brought RT-preempt out of “hobby mode”
- Lots of stuff already upstreamed
  - Things that are left are really hard
  - Often requires re-factoring mainline to support the required change
- About 10,000 lines of code left
- I asked about succession plan
  - As long as there are users of RT-preempt, there will be people with an interest in maintaining it (and the skill to do it)
- Good insights into why single-kernel vs. dual-kernel
Sessions I watched later

- Buildroot vs. Yocto
  - Really good presentation to see differences between the systems
- Autotools demystification tutorial
  - Very handy to (finally!) understand autotools
    - Should hang build diagram on slide 24 on your wall
- Socio-Technical Aspects of Long-term Embedded Systems Maintenance
  - Very interesting tool for analyzing communities
- I still have a list of 15 or so sessions to watch
Overall Impressions

- First year with Open IOT Summit
  - Some complaints about too many IOT keynotes
  - We had good sponsorship from companies on the IOT side
  - Lots of really good IOT content
  - Some overlap with Linux, but a lot of separate content as well
  - We’ll do it again in Europe at ELCE

- Lots of content on old and new technology
  - Good material to learn old systems: USB, gdb, nand, testing, build tools, autotools, etc.
More Impressions

- Excellent hallway track (as usual)
  - I found people who had same problems as me
  - Also saw old friends and colleagues
  - I met new people
  - Got background info from vendors, other trade groups, other developers – useful for Sony
- Some traditional topics were not represented
  - Nothing on boot time or system size
- Some new topics
  - Long-term support is an interesting problem
- Kernel is mature, but still tons of good topics
More impressions

• I had lots of fun
• I’m losing any sense of embarrassment
Resources

  • If a presentation is missing, send me an e-mail
  • I will bug the developer
    • Note: We check for missing presentations from previous events during program review

• [https://lwn.net/Archives/ConferenceByYear/#2016-Embedded_Linux_Conference](https://lwn.net/Archives/ConferenceByYear/#2016-Embedded_Linux_Conference)

• [http://events.linuxfoundation.org/events/emb edded-linux-conference](http://events.linuxfoundation.org/events/embedded-linux-conference)
  • (until next year)
Outline

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

- 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  – 13 Mar 2016  – 63 days
  - By the way, my prediction of Mar 13 was perfect
- Linux v4.6  – 15 May 2016  – 63 days
- Linux v4.7-rc
  - Predict 4.7 release on July 24 (70 days)
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 platforms
  • Many v6 and v7 platforms are now supported

• Not much else specific to embedded
  • Well, continued mainlining of drivers for SoC features
Linux 4.6

- GPIO subsystem rework
- scripts/dtc/dtx_diff
  - Compare device trees in a number of formats
- Improved page-poisoning
  - Separate from debug, can set poison value to 0 (to clear pages after free for security reasons)
Linux 4.7 (predictions)

- Schedutil frequency governor
- VFS layer can interate through directories in parallel
- Ability to attach BPF programs to tracepoints
- Ftrace histogram triggers
  - Can tell tracer to accumulate events into buckets and give results, via the sysfs interface
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/](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
Outline

Kernel Versions
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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 on 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, Nvidia, 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
  - 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?).


• 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
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 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/](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)
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/](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
Outline

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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/lotivity 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
Thanks!