CE Workgroup

Status of Embedded Linux
September 2016

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Architecture Group Chair

LF Core Embedded Linux Project

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Outline

Kernel Versions
Technology Areas
CE Workgroup Projects
Other Stuff
Resources

Outline

Kernel Versions

Technology Areas

Special:
Kernel Summit Discussion
Review

CE Workgroup Projects

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Ksummit-discuss issues

- Some of the most interesting discussions occur on ksummit-discuss mailing list
- A few big areas of discussion:
  - Stable workflow
  - Kernel testing
  - Git-series
  - GPL defense issues
  - Backport trees (and SoC mainlining issues)

KDSL: Stable workflow

- Some vendors don't trust the stable trees, and developers want to improve the quality of them
  - Some patches in stable caused regressions
  - Some users cherry-pick patches instead of basing product on whole tree
- Suggestions to improve quality:
  - Have more review of stable patches
    - But sub-system maintainers are already overworked
  - Have more testing of stable patches
    - This became a long thread about kernel testing
  - Identify commit that patch fixes
    - To allow for easier back-porting to multiple stable trees

KSDL: Kernel testing

- Would like to see new kernel code submitted with unit tests
  - Recommendation only – not required
- Kselftests is a good start, but needs more features
  - Examples, documentation, test interface, standard logging and reporting
- Need to declare test requirements
  - Test should return "not supported" instead of failure, if hardware is missing or requirements are not met
- Important to measure actual bugs caught

KSDL: Git-series

- Lots of discussions (in different threads) about how to use git to manage patches
- Josh Triplett introduced git-series, to maintain a set of patches in git
  - Similarities to quilt or stgit
    - Maintain patches as first-class objects, with meta-data and versioning for each patch

KSDL: GPL defense issues

- Big thread about when to enforce the GPL with lawsuit
  - See http://lwn.net/Articles/698452/
- Linus and Greg KH very reluctant to use lawsuits
  - It drives companies away instead of helping them join the community
- Busybox cited as example of legal enforcement that damaged the project
- Lots of disagreement on some issues

GPL defense issues (cont.)

- When to sue?
  - Can the threat make companies behave better?
  - If you never sue, is there any threat?
- What is objective?
  - Getting useful code (good for developers)
    - Bad actors don't have good code
  - Allowing end-users to get code for their devices (good for users)
    - End users don't have copyrights, and have no standing to sue
- Who can decide to sue?
  - Small group of copyright holders, or the SFC, or an individual?
    - Problem is if other stakeholders don't want to sue

KSDL: Backport trees (and SoC mainlining)

- Long thread about value of trees with backported features
  - LSTI and LSK (Linaro Stable Kernel)
- Some people don't like these trees
  - Reduces incentive to work with upstream
  - Loses shared testing with upstream
- Industry reality is that backporting is inevitable
  - Mobile vendors are not on upstream due to product cycle issues and legacy out-of-tree code
- Backport trees try to find balance in quality between back-porting to in-house tree and forward-porting patches to upstream

Ksummit-discuss issues

- And much more…
  - See https://lists.linuxfoundation.org/pipermail/ksummit-discuss/
- Many topics were put onto the kernel summit agenda
- Kernel summit planned for end of October, in Santa Fe, New Mexico
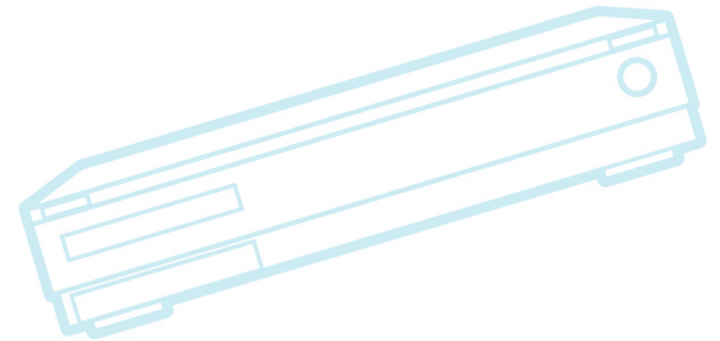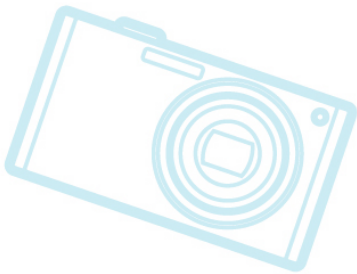
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Kernel Versions

- Linux v4.3 – 1 Nov 2015   – 63 days
- Linux v4.4 – 10 Jan 2016   – 70 days
- Linux v4.5 – 13 Mar 2016   – 63 days
- Linux v4.6 – 15 May 2016   – 63 days
- Linux v4.7 – 24 July 2016   – 70 days
  - By the way, my prediction was correct
- Linux v4.8-rc5
  - I predict 4.8 on 25 Sep 2016 (63 days)
- Greg KH already announced 4.9 as next LTS

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
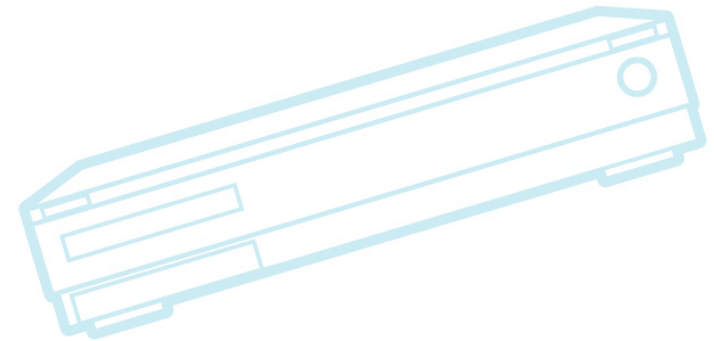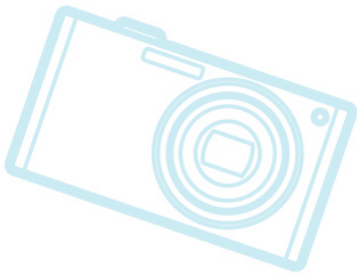
Linux v4.4

- 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
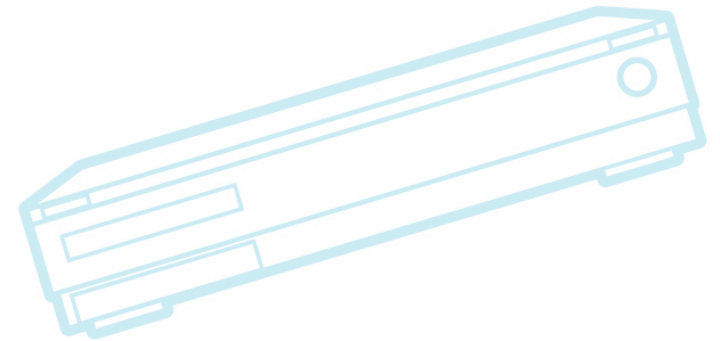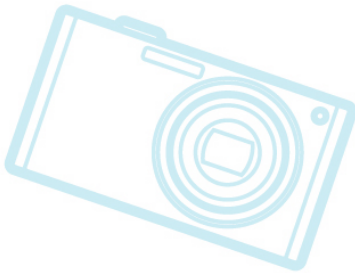
Linux 4.6

- 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)
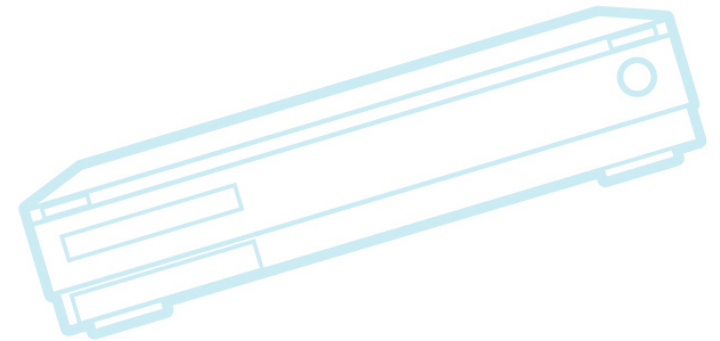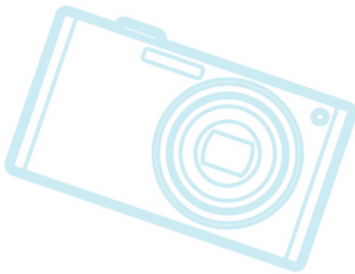
Linux 4.7

- Schedutil frequency governor
  - See http://lwn.net/Articles/682391/
- VFS layer can iterate 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
- Android sync_file feature moved from staging

Sync_file

- Allows for explicit fencing for buffers by userspace
- How it works:
  - Producer driver sends the fence related to the buffer to userspace via a sync_file
  - An intermediary (e.g. a compositor) passes these fenced fds to DRM in an atomic commit
  - Consumer will not use the buffer for anything before the fence(s) signals
- This avoids a lot of waiting
- See Documentation/sync_file.txt

Linux 4.8 (predictions)

- New kernel documentation system
- New pseudo-random number generator
  - See https://lwn.net/Articles/686033/
- ARM64 support for kexec and kprobes
- New timer wheel implementation
  - https://lwn.net/Articles/646950/
  - Better performance:
    - No more cascade operations
    - Quick determination of next timout
  - Long timeouts have reduced resolution
 - Automatically coalesces longer timeouts

Observations

- No embedded-specific features lately
  - Nothing for:
    - Boot-up time
    - System size
    - Embedded filesystems (are these done now?)
    - Embedded security
    - Realtime (well, maybe the timer wheel stuff)
    - Power management
- There is lots of processor support, and lots of device drivers for embedded
- I worry that people are using non-Linux
  - More on this later

Things to watch (from past)

- Kernel tinification!
- RT-preempt
- Persistent memory
  - (NVM = Non-Volatile Memory)
- SoC mainlining progress
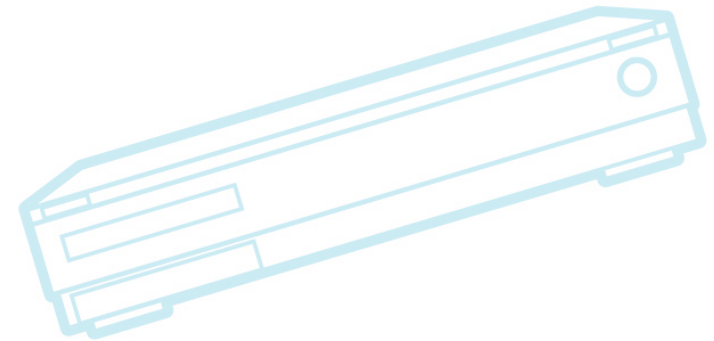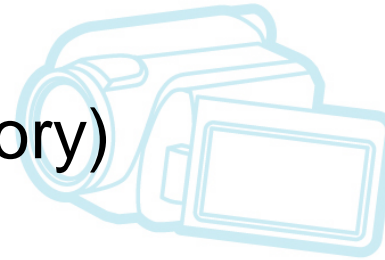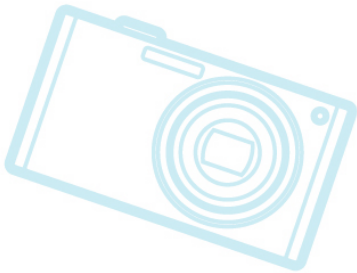
Things to watch (status)

- Kernel tinification! (stalled)
- RT-preempt (only 10K lines left!)
- Persistent memory (in progress)
  - Good talk on about issues:
    - "Making use of persistent memory"
      - http://lwn.net/Articles/674752/
- SoC mainlining progress (stalled)

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Bootup Time

- Mostly old news…
- XIP on x86
  - See https://lwn.net/Articles/637532/
- Asynchronous probing
  - Discussed at last 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
- Device dependencies
  - May be discussed at next kernel summit

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
  - 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
- 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 specification is in progress
  - 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

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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/

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)
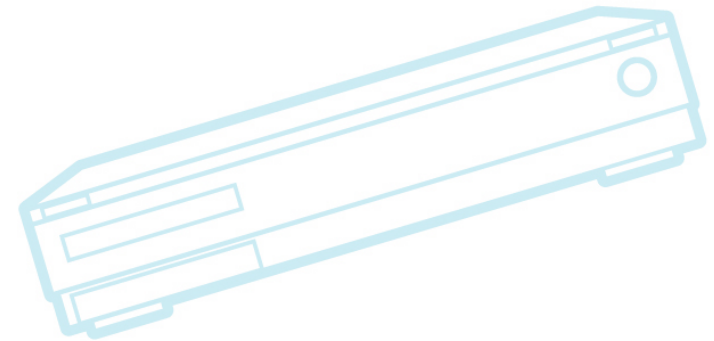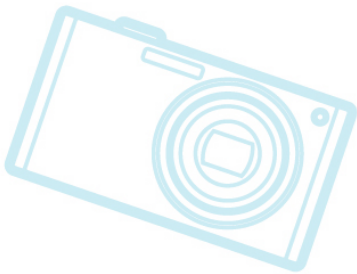
(new) LightNVM

- 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.)
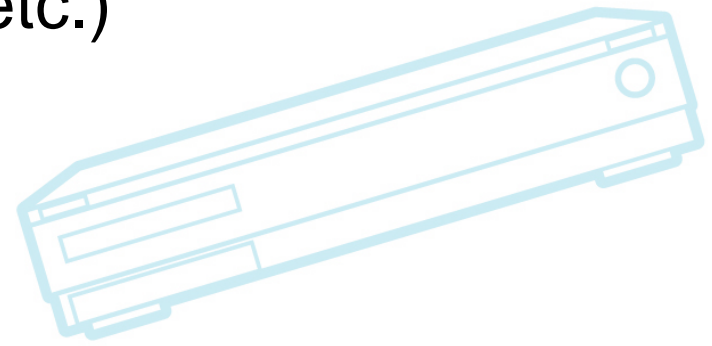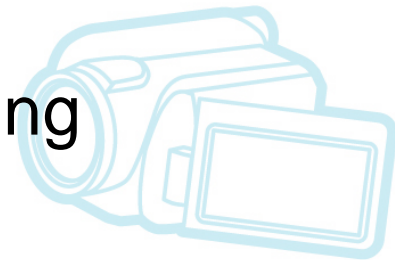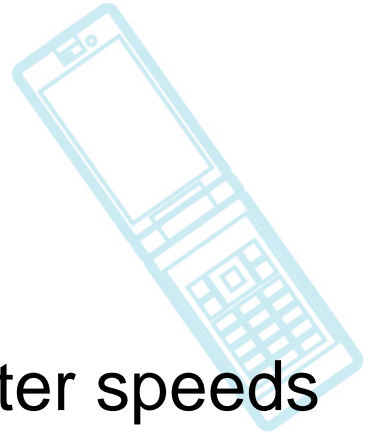
Real Time – RT-preempt

- 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
  - Tends to follow LTS releases
  - See https://www.kernel.org/pub/linux/kernel/projects/rt/

Real Time - other

- Xenomai 3.0.1
  - Uses Cobalt RT core
  - 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
- 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 "Securing Embedded Linux" – Mike Anderson at ELC 2016
  - Who are attackers?
  - Secure boot techniques
  - Encryption
  - Physical security
  - Data Security
  - Network Security
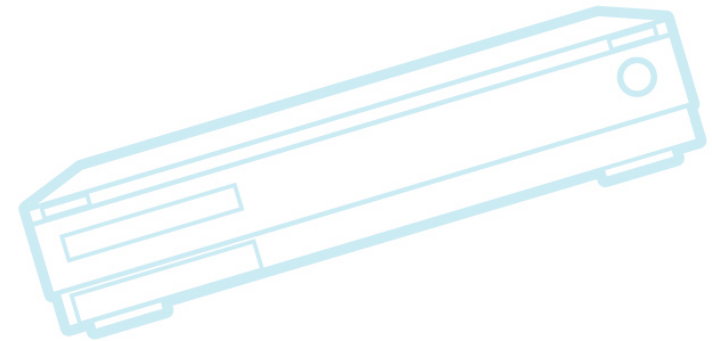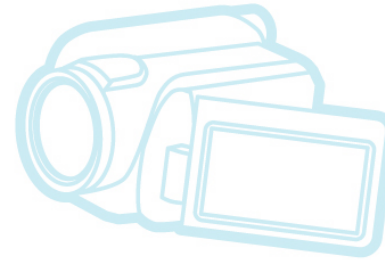
System Size

- 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
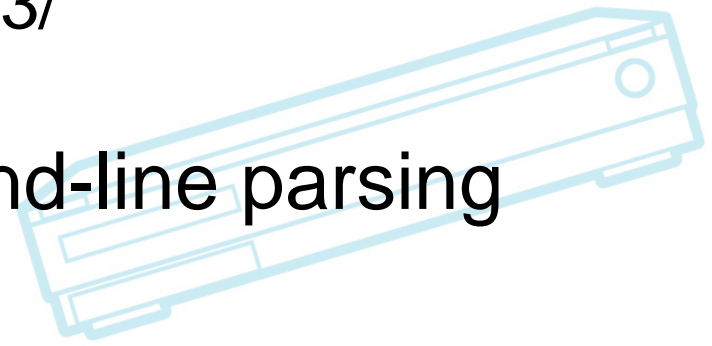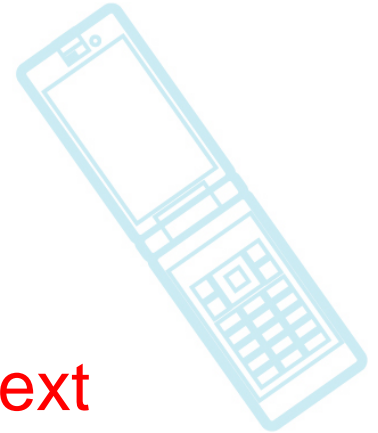
System Size (cont.)

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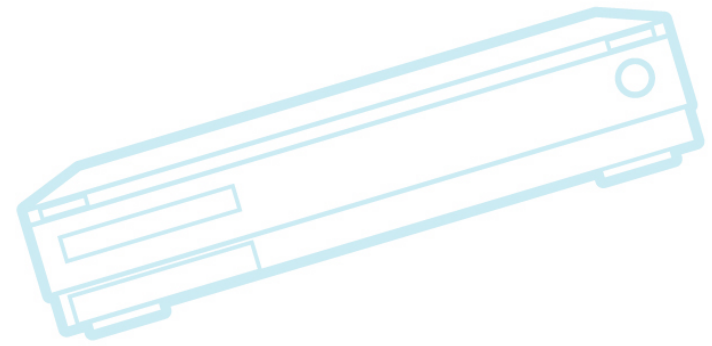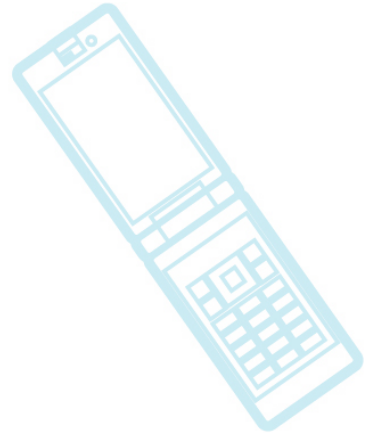
kselftest

- 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/

Fuego - LTSI test project

- Available now
  - https://bitbucket.org/tbird20d/fuego/
- Lots of work recently on wiki (documentation)
- Working on lots of issues in parallel
- Should be ready for demonstrations at ELCE (October)

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
  - Presentation at ELC 2016

Tracing
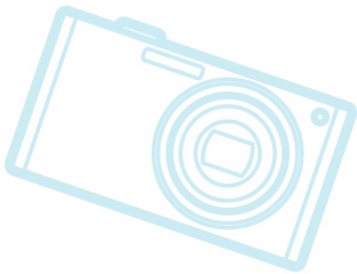
- eBPF to be used for dynamic tracing
  - Perf supports eBPF (in 4.4)
    - eBPF = extended Berkeley Packet Filter
- New tracefs filesystem
  - No longer part of debugfs
  - But all (psuedo) dirs and files the same
- Histograms (not mainlined yet)

Miscellaneous

- Next LTS kernel version:
  - 4.9
  - This is the earliest it's been announced!
    - We haven't even opened the 4.9 merge window
- Non-Linux announcements
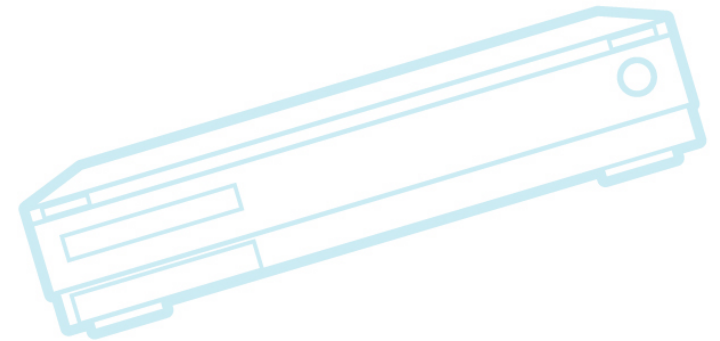
Lots of non-Linux in IOT

- Zephyr – RTOS from Wind River
  - Apache 2 license
  - Minimal size – as small as 8K
    - Highly configurable
  - NoMMU
  - Networking: WiFi, Bluetooth, NFC
- Magenta – RTOS by Google
  - Fuchsia OS - Some attributes of Android
  - Based on LK
  - BSD license

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Kernel Versions

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CEWG Projects

- Contract work
- Projects and initiatives
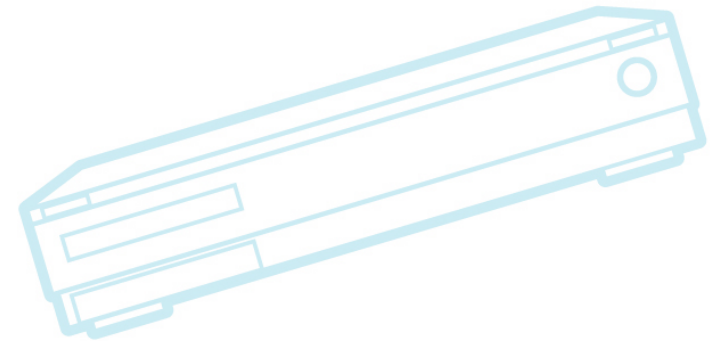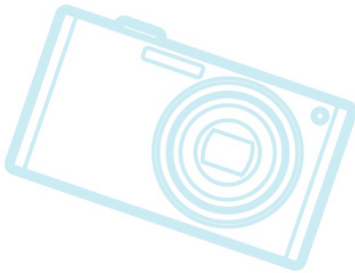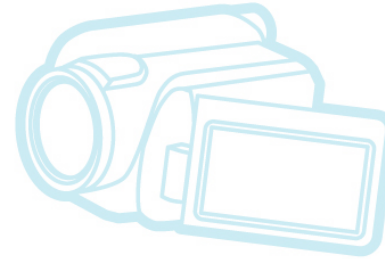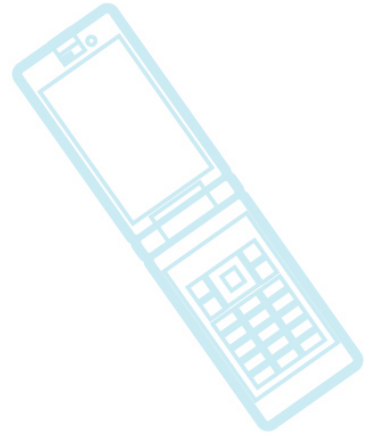
CEWG Contract Work

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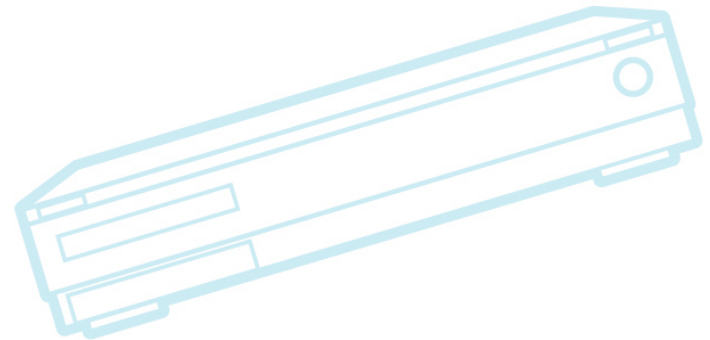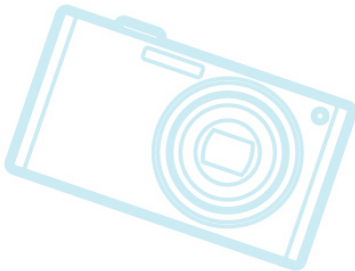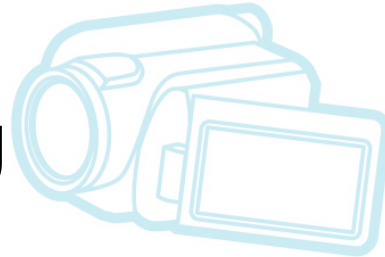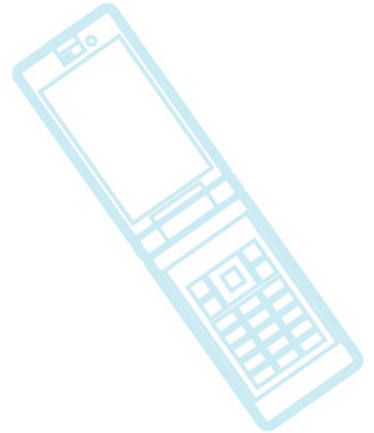
Kernel string refactoring

- 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 provided at LinuxCon Japan

DT documentation

- Finished "guide" documentation
- Frank Rowand has been collecting data and giving talks
  - LinuxCon NA, ELCE, ELC and LCJ
- Is on elinux wiki at:
  - http://elinux.org/Linux_Drivers_Device_Tree_Guide
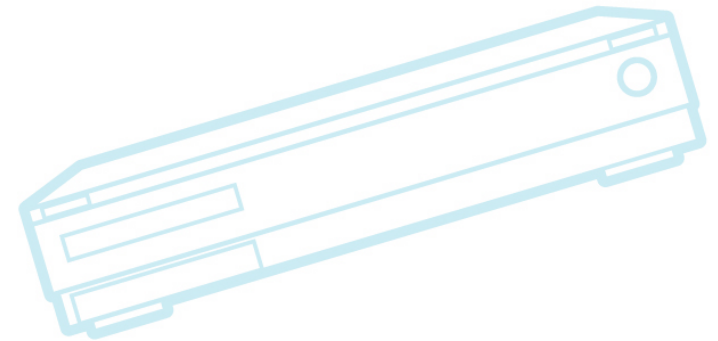
LTSI test framework

- (Discussed previously)
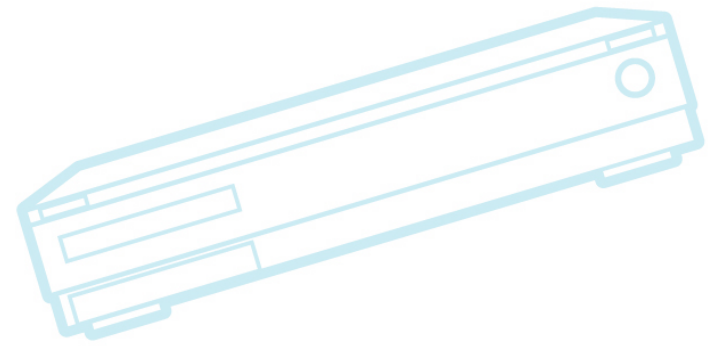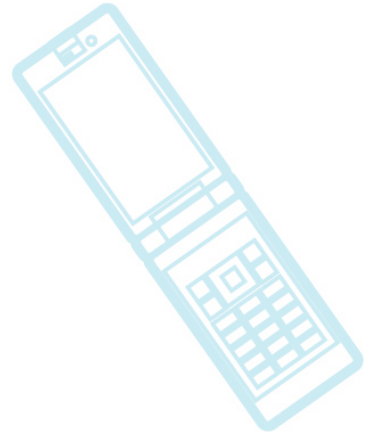
Shared Distribution Testing

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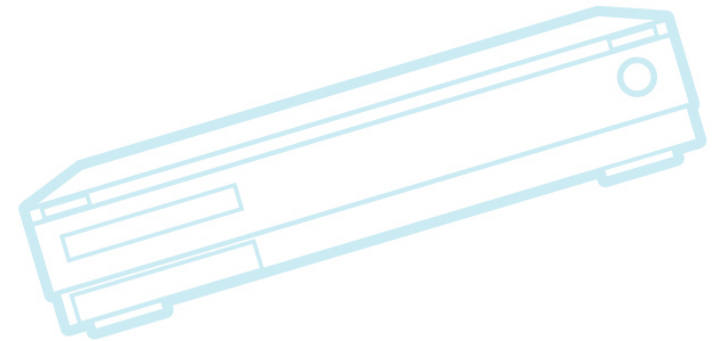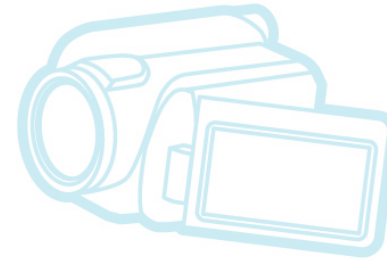- Project to test distribution on a few different hardware platforms
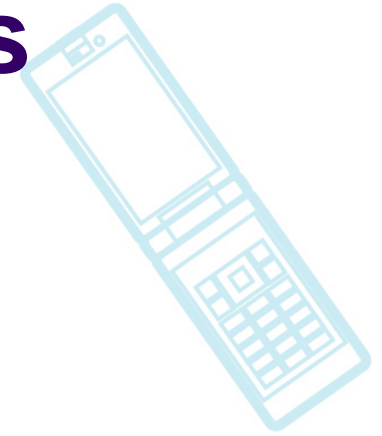- Contractor: Tuan Hoang
- Status: Just starting
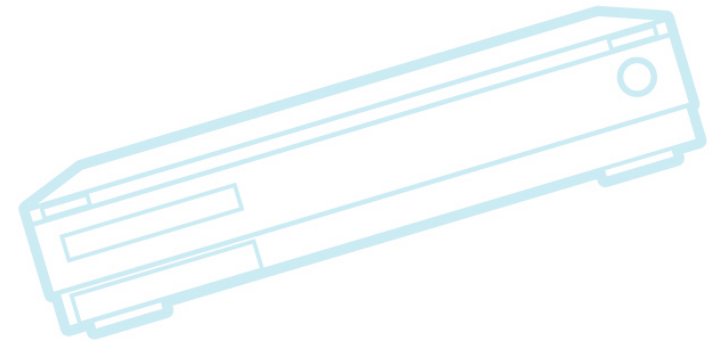
Projects and initiatives

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

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
- Published tools:
  - https://github.com/tbird20d/upstream-analysis-tools
- Ongoing Projects:
  - Create tools for easier mainlining
    - Patch submission tool

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
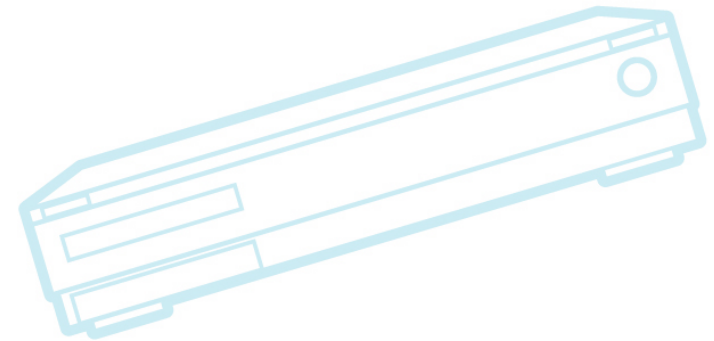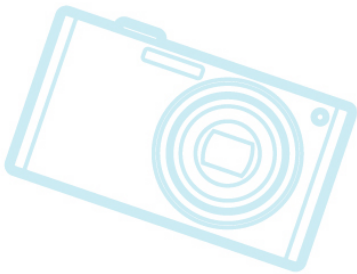
eLinux wiki

- 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

Kernel Versions
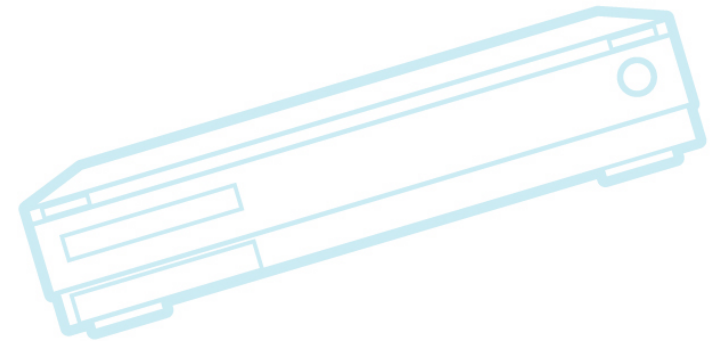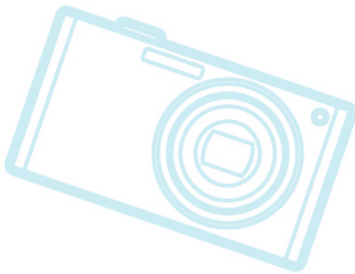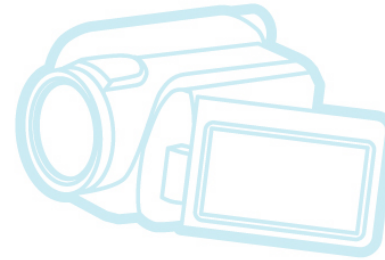
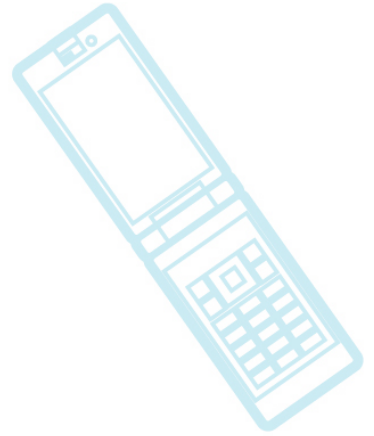Technology Areas

CE Workgroup Projects

Other Stuff

Resources

Other Stuff

- Distros and Build Systems
- Events

Distros

- Android
  - "Nougat" version released in August
  - 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 2016
  - October 6-7, 2016 - Berlin, Germany
- Embedded Linux Conference
  - February 21-23, 2017 – Portland, Oregon
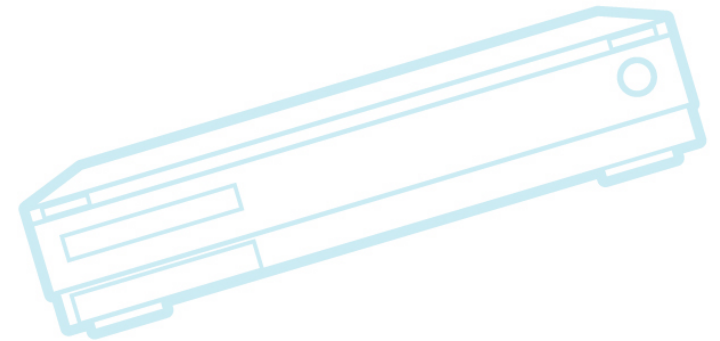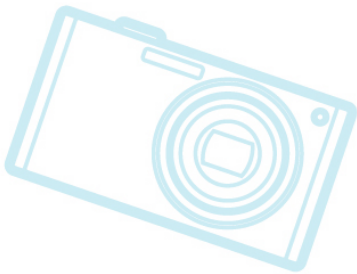
Outline

Kernel Versions
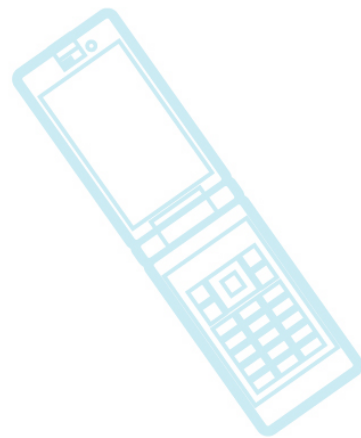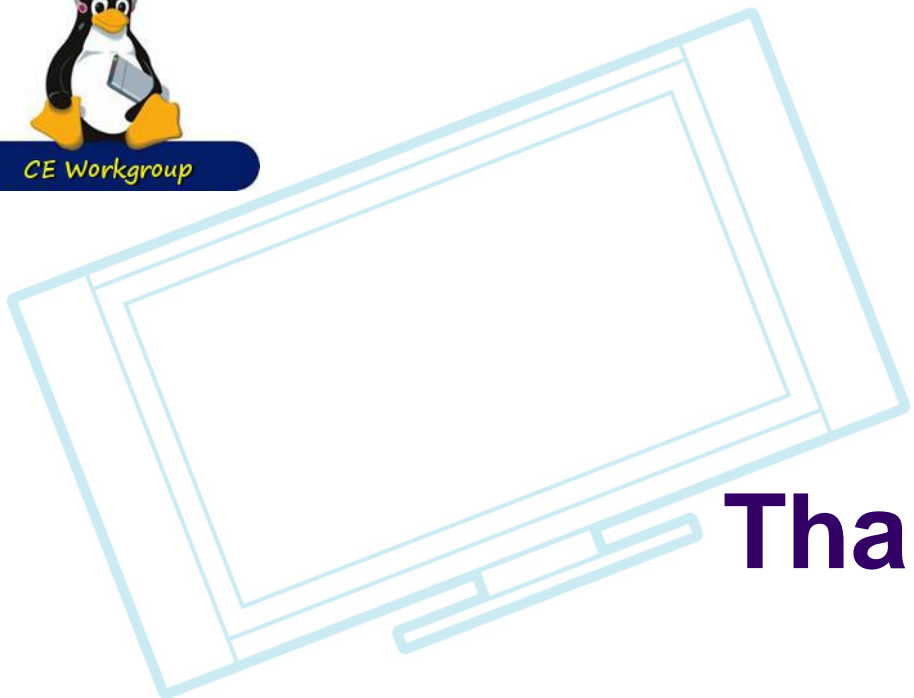Technology Areas
CE Workgroup Projects
Other Stuff
Resources

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!