CE Workgroup

Status of Embedded Linux

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Tim Bird

Architecture Group Chair

LF CE Workgroup

Outline

Kernel Versions
Technology Areas
CE Workgroup Projects
Other Stuff
Resources

Outline

Kernel Versions

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Kernel Versions

- Linux v3.1 – 24 Oct 2011 – 95 days
  - Larger due to kernel.org breakin
- Linux v3.2 – 4 Jan 2012 – 72 days
- Linux v3.3 – 18 Mar 2012 – 74 days
- Linux v3.4 – 20 May 2012 – 63 days
- Linux v3.5 – 21 July 2012 – 62 days
- Linux v3.6-rc6 – 16 Sep 2012
  - Expect v3.6 ANY DAY NOW

Linux v3.1

- Watchdog timer core
- New framework for handling power management domains was added
  - See driver/base/power/domain.c
- Multiple ARM SoCs now have device tree support

Linux v3.2

- New pin control subsystem
  - Allows control of multiple pins as named groups, with multiplexing
  - See Documentation/pinctrlt.xt
  - See ELC 2012 talk by Linus Walleij
- devfreq – DVFS for non-cpu devices
- PM QOS now supports per-device constraints
  - See Documentation/power/pm_qos_interface.txt
  - See http://lwn.net/Articles/466230

Linux v3.3

- ARM large physcial address extensions
  - See Catalin Marinas talk at ELC Europe 2011
- ALSA support for compressed audio
- New “charger manager” subsystem
  - Can partially resume to poll battery and re-suspend
- Android patches in staging
  - This is really cool

Linux v3.4

- Universal Flash Storage host controller drivers
  - See Documentation/scsi/ufs.txt
- Common clock framework
  - Unifies handling of subsystem clocks
  - See Documentation/clk.txt
- HSI (High-speed synchronous serial interface) framework
  - Used for communication between CPU and cellular modem engines

Linux v3.4 (continued)

- DMA buffer sharing API
- Remoteproc subsystem
  - Allows for control of other CPUs through shared memory
  - Rpmsg is a new mechanism for communicating with other CPUs (running non-Linux)
  - See Documentation/remoteproc.txt and rpmsg.txt

Linux v3.5

- Kernel log rework
  - Structured printk (new format), with tags
  - http://lwn.net/Articles/492125/
- Support for writing NFC drivers
- Integration of ramoops and pstore
  - Part of work to support Android ram_console
- Uprobes
  - User-space probes
  - https://lwn.net/Articles/499190/
- Autosleep

Linux v3.6 (probable)

- Android RAM console functionality integrated into pstore
- Haven’t found much else yet…

Things to watch

- Device trees
- Android features
  - Volatile ranges
  - ARM FIQ -> KDB glue
- big.LITTLE
- Single kernel image for ARM
  - Result of lots of device tree and ARM refactoring work
  - See LinuxCon Japan talk by Deepak Saxena

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Bootup Time

- Free-electrons presentation
  - Great overview of known techniques
  - http://free-electrons.com/pub/conferences/2011/genivi/boot-time.pdf
  - Free-electons service:
    - Audit, Report, Knowledge transfer
- Systemd in embedded
  - Systemd starts services and daemons on-demand
  - Saw first demo of systemd on Angstrom at ELCE 2011

Bootup Time technologies

- Snapshot boot
  - Old topic, but still very popular
  - Requires work both inside and outside kernel
    - Not much mainlined
  - See ELC 2011 presentation by Kang Dongwook
- Suspend-to-both
  - Suspend to both RAM and disk
  - If RAM loses power, can unhibernate from disk

Graphics

- Nothing new here at the API layer (?)
- 3D
  - OpenGL ES is de-facto standard everywhere
- 2D
  - Android had Skia, but is moving to HWUI
  - Other platforms can use Clutter, Qt, and X
  - Framebuffer is going away, with acceleration required for larger screens

Graphics (cont.)

- Lots of work around memory management between kernel, user-space and GPU
- Android has /dev/ion
  - A unified approach to buffer management and sharing between display, GPU, camera, codecs, etc, new in Ice Cream Sandwich
  - Replacement for pmem
- Mainline has Contiguous Memory Allocator (CMA) and dma-buf
  - http://lwn.net/Articles/468044/ - CMA
  - http://lwn.net/Articles/470339/ - dma-buf

File Systems

- Traditional flash-based:
  - UBIFS
    - Replacing JFFS2 as default raw flash FS of choice
    - Still needs some boot time improvements
  - AXFS
    - Advanced XIP File system – developed by Intel/Numonyx but never mainlined
    - Sony uses this, we've been preparing it for a mainlining effort

File Systems (cont.)

- Lots of companies using EXT4 on eMMC
- Want to optimize Linux block filesystem layers for flash
  - See Arnd Bergmann's talk at ELC Europe 2011 on filesystem performance on cheap flash media
  - See Ken Tough's ELC 2012 talk
- CE WG project to analyze filesystem performance on eMMC

Power Management

- Runtime Power Management
  - Relatively new ability to suspend and resume individual system components
  - See http://lwn.net/Articles/347573/
- See Magnus Damm's slides at: http://elinux.org/ELC_2011_Presentations
- Device power domains
  - Set of devices sharing power resources (clocks, power planes, etc.)
  - See Rafael Wysocki's talks at LinuxCon Japan 2011 and ELC Europe 2011

Power Management

- Autosleep
  - Wakelock-compatible solution by Rafael Wysocki
    - http://lwn.net/Articles/479841/
  - Rafael: "*This series tests the theory that the easiest way to sell a once rejected feature is to advertise it under a different name*"
  - Mainlined in v3.5
- Power-aware scheduling:
  - http://lwn.net/Articles/512487/

System Size

- Good talks recently:
  - Darren Hart at ELCE 2011 – poky-tiny
- Kernel size
  - Andi Kleen's Link-Time Optimization patches
  - CE WG project for kernel dynamic memory analysis
  - LLVM compilation of the kernel
- User space is memory problem area now
  - OOM killer or OOM avoidance is big issue
    - Application lifecycle
    - Application hinting
  - Volatile Ranges = the new hotness

Link Time Optimization

- See http://lwn.net/Articles/512548/
- Newer gcc (4.7) supports adding extra meta-data about routines (gimple) at compile time
- Linker can now do whole-program optimization at link time
- Andi Kleen has 74 patches that add support to the Linux kernel for LTO feature
  - Mark functions as 'visible' to avoid dead-code elimination
  - Adjust compilation flags to be consistent
  - Add dependencies to avoid conflicts for features which can't conform to LTO requirements (ftrace)

LTO (cont.)

- Cost:
  - Longer kernel builds (4x)
  - More memory during build (up to 9G required for allyesconfig)
  - Subtle bugs from optimizations
    - E.g. duplicate code elimination caused a pointer comparison failure
- Benefits:
  - Right now - NO size benefit
  - Performance: (very preliminary)
    - Hackbench – 5%, network benchmark – up to 18%

LTO (cont. 2)

- Why am I so excited about this?
- I have recently been studying automatic kernel reduction techniques
  - It is not tractable to reduce kernel manually
  - Whole system optimization is a critical part of automatic reduction
  - LTO and LLVM represent first systematic approach to problem
- Note: This work obsoletes -ffunction-sections
- Takes Linux-tiny in a whole new direction

Possible LTO benefits

- Can automatically drop unused global functions and variables
  - Could cut down on ifdefs
- Partial inlining
  - Inline only parts of a function like a test at the beginning.
- Optimize arguments to global functions
  - Drop unnecessary args, optimize input/output, etc.
- Detect function side effects and optimize caller
  - e.g. Caller can keep some globals in registers over calls.
- Detect read only variables and optimize them
- Replace indirect calls with direct calls, enabling other optimizations.
- Do constant propagation and specialization for functions.
  - If a function is called commonly with a constant it can generate a special variant of this function optimized for that
    - e.g. kmalloc_GFP_KERNEL()

Volatile Ranges

- Work by John Stultz
  - Inspired by Android feature in ashmem
    - http://lwn.net/Articles/468896/
    - http://lwn.net/Articles/500382/
- Allows cooperation between the kernel and applications on "volatile" memory usage
- Overview:
  - Application notifies kernel about re-claimable memory areas
  - Not mainlined yet

Volatile Ranges Use Example

- Application allocates memory and uses it
- Kernel notifies app that memory is running low
- Application marks areas that can be re-created (like image caches or layout areas) as volatile
  - Kernel can free those areas if needed
- If application wants to use the data, it tries to unmark it as volatile
  - If area was freed, the call fails – the application must regenerate the data
  - If area was not freed, the call succeeds – the application can use the data as is

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CE Workgroup Projects

Other Stuff

Resources

CEWG Contract Work 2012

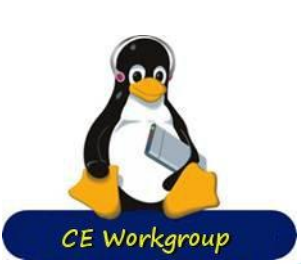
- eMMC tuning
- Dynamic memory reduction
- Mainline FIQ debugger
- ConnMan support for WiFi direct
- Improve kexecboot
- Measure systemd and udev
- UBIFS robustness work
- U-boot log buffer sharing

eMMC tuning guide

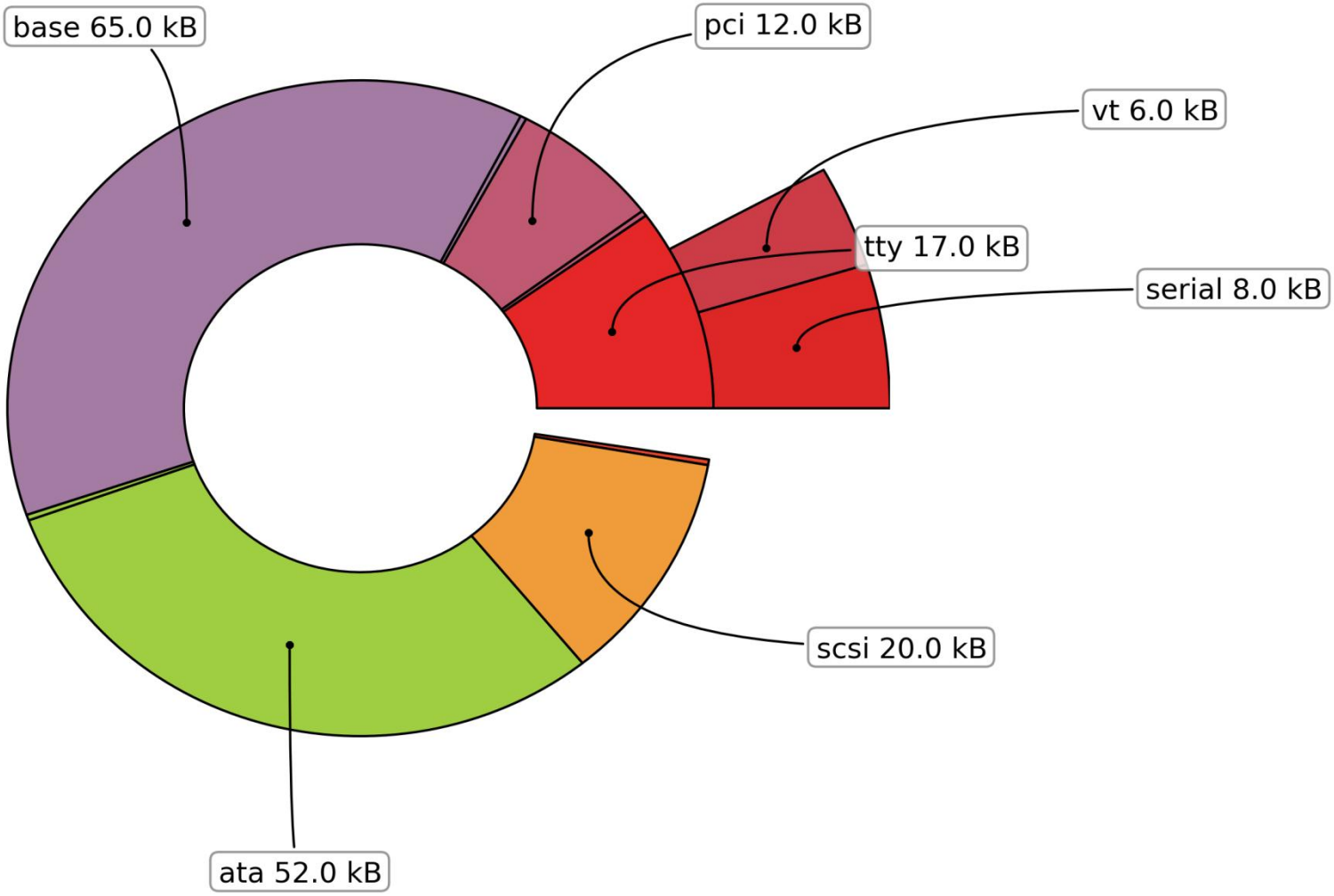
- Description:
  - This project will analyse EXT3, EXT4 and BTRFS on a variety of block-based flash parts on a few different development boards
  - Output will be a document describing best practices for tuning Linux block-based filesystems for block-based flash filesystems
- Contractor: Cogent Embedded
- Status: work has just begun

Dynamic memory reduction

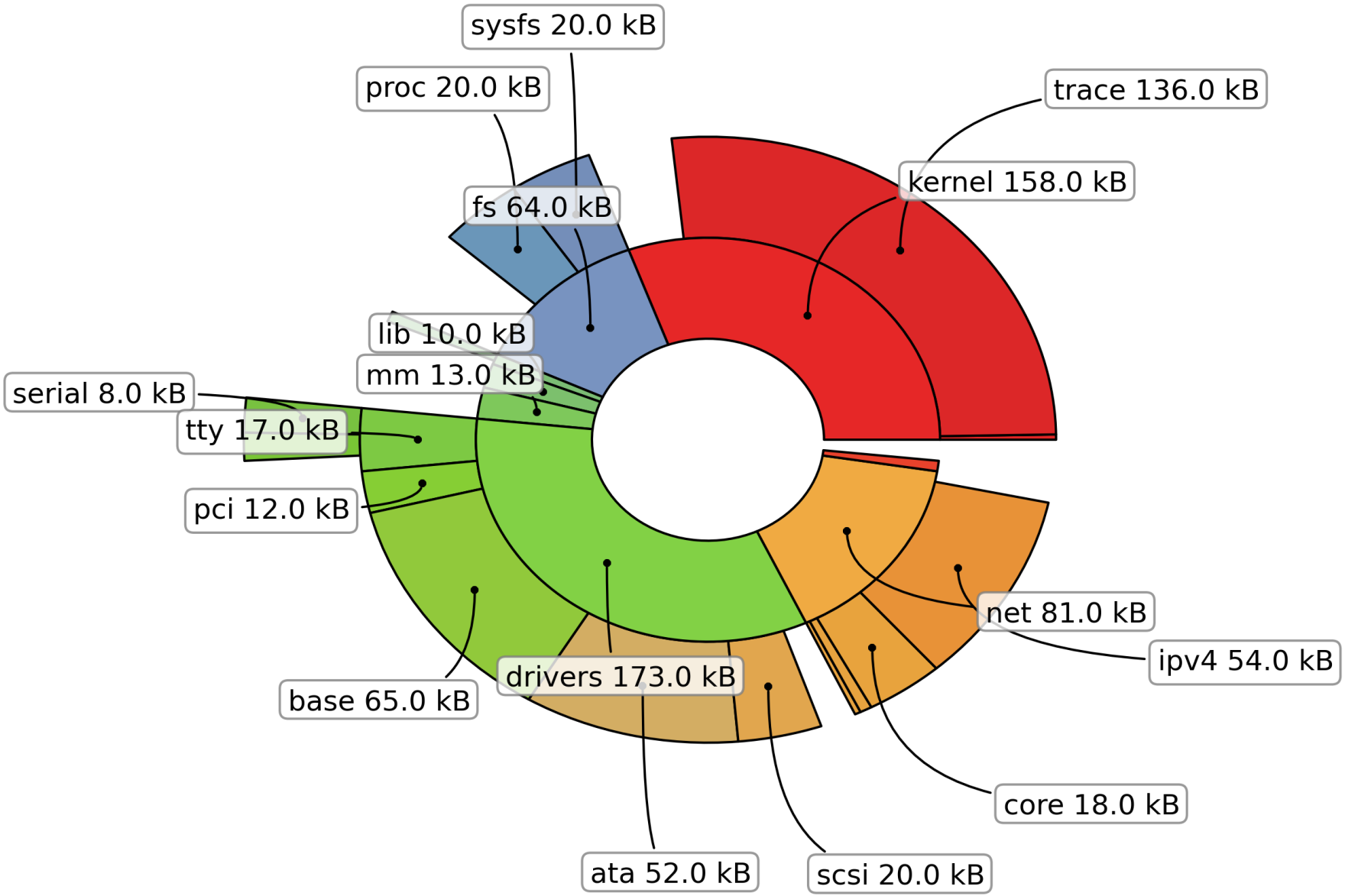
- Description:
  - Instrument and collect data on kernel dynamic memory allocations
  - Make recommendations for areas where dynamic kernel memory usage could be reduced
- Contractor: Ezequiel Garcia
- Status:
  - Work is under way to use existing kmem_events (ftrace) infrastructure to report dynamic memory usage in the kernel
  - Some patches already accepted upstream to improve memory tracing infrastructure
  - Work is in progress to create tool for visualization of kernel memory usage
  - See http://elinux.org/Kernel_dynamic_memory_analysis



Drivers kmalloc



Linux kmalloc



Mainline FIQ debugger

- Description:
  - Add ARM FIQ glue code and integrate with existing kernel debugger
  - Allows use of ARM FIQ (non maskable interrupt) to activate a kernel debugger
  - Android used it's own debug monitor, and has phones that are configured to trigger this on the earphone jack (also supplying a serial console on the earphone jack)
- Status:
  - Project is on hold because Anton Vorontsov is apparently already doing this work
    - See https://lkml.org/lkml/2012/7/30/124
    - This should show in mainline soon

ConnMann WiFi direct

- Description:
  - Add support for WiFi direct to ConnMann wireless connection manager
- Contractor: ProFusion
- Status: not engaged yet

Improve kexecboot

- Description:
  - Make improvements to kexecboot booloader
  - Support load from network
  - UI improvements
- Contractor: Yuri Bushmelev
- Status: Finalizing contract

Measure systemd and udev

- Description:
  - Measure the overhead and performance of system and udev, as used in embedded systems
- Status: Not started yet

UBIFS robustness work

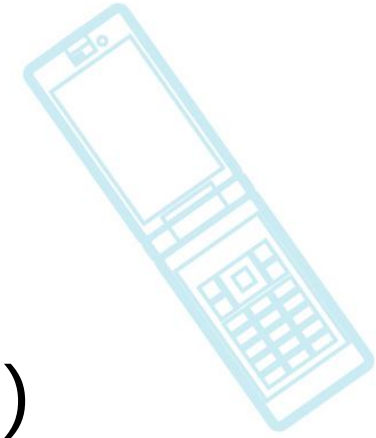
- Description:
  - Add support for "power cut" simulations to UBIFS, to allow for finding and fixing filesystem bugs that occur when power is lots
- Status: Not started yet

U-boot log buffer sharing

- Description:
  - Add support for U-Boot and the Linux kernel to share their log buffer, to allow for easier collection of joint logs
- Status: Not started yet

Long-term Projects

- Android mainline project
- Long Term Support Initiative (LTSI)



Android mainline status

- 3.3 kernel (with 12 lines of patches) boots AOSP
- eLinux status page:
  - http://elinux.org/Android_Mainlining_Project
- Was reported on at Kernel Summit:
  - http://lwn.net/Articles/514901/

Mainline status (cont.)

- Specific pieces:
  - Wakelocks => autosleep
  - Ashmem => (partly) volatile ranges
  - Ram console => persistent RAM
  - Android USB gadget driver
  - Alarm-dev => POSIX alarm timers
  - FIQ glue code (in progress)
  - GPIO timers => LED triggers (??)
  - Low memory killer => vmevents (??) in progress

Mainline status (cont. 2)

- What's not been done?
  - Logger – a few cleanups, but nothing to generalize it for other users
  - Binder – a few people talking about
  - IO memory allocator
    - Work in progress to adopt features into dma-buf
  - Network security – may stay out-of-tree forever

Android Meta-Issues

- Social issues have largely been worked out
  - Colin Cross was at Kernel Summit
  - Nobody complains like they used to
  - Linaro doing lots of "proxy" work on the features
- Android not using a continuous stream of kernels any more
  - Will use selected kernel versions longer
    - Currently plan to use 3.4 in next generation products
- Nobody really worries about "Android fork" anymore
  - Still lots of work left, though

Long Term Support Kernel for Industry

- Ueda-san will have more information later
- Small report from LTSI meeting at LinuxCon US
- Kernel version: 3.4 is the next big thing
  - Wind River supporting LTSI kernel
  - Yocto Project supporting LTSI kernel
    - Officially supported (very big news)
  - Android using 3.4 kernel
  - Next community long-term = 3.4
  - LTSI 3.4 kernel is now open for contributions

LTSI support by Yocto Project

- Plan to support multiple kernels:
  - Latest upstream kernel, 6 weeks prior to release
  - LTSI kernel
- Support qemu and 1 physical board per arch (arm, mips, ppc, x86, x86-64)
  - This means kernel and distribution testing on 10 platforms
- Projected kernels for Yocto Project releases (tentative):

YP release	1.3	1.4	1.5	1.6
Kernels	3.2, 3.4	3.4 LTSI, 3.6	3.4 LTSI, 3.8	3.8 LTSI, 3.10

LTSI release schedule

- Merge window for LTSI 3.4 open for one month
  - Just opened today (Sep 19 in US)
- Should be released by end of year
- Features:
  - Sony working on AXFS patches
  - Samsung working on F2FS patches

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Other Stuff

- Tools
- Build Systems
- Distributions
- Android
- Industry Organizations
- Events
- Miscellaneous

Tools

- QEMU
  - QEMU is being used everywhere, for device emulation (Android, Yocto)
  - Javascript QEMU implementation (!!)
- Eclipse
  - Is now de-facto “umbrella” tool for development
  - Need to pry seasoned developers away from command line
- Tracing
  - Perf, Ftrace and LTTng 2.0
  - Common Trace Format standard

Build Systems

- Yocto project
  - Some new things:
    - "HOB" graphical interface
    - Builder image – created by Yocto Project
      - Finally can test YP with no external dependencies
  - Sony is adopting Yocto Project

Android

- Android 4.1 (Jelly Bean) released July 2012
- Ice Cream Sandwich unifies mobile, tablet and TV platforms in one codebase
- Phone activations at 1,00,000 per day
  - 400 million activations total
- Ubuntu for Android
  - Very interesting – use Android device as PC, when connected to dock (large screen and keyboard)

Events

- ELC/Android Builders Summit – Feb 2012
- LinuxCon Japan – June 2012
- Japan Jamborees
- Kernel Summit/LinuxCon US/Plumbers
  - August 2012
- Embedded Linux Conference Europe 2012
  - November 7-9, 2012 – Barcelona, Spain
- Embedded Linux Conference 2013
  - February 20-22, 2013 – San Francisco

Highlights from recent events

- Plumbers
  - Freeing memory under pressure
    - John Stultz – "Letting Go"
    - http://www.linuxplumbersconf.org/2012/wp-content/uploads/2012/08/LettingGo.pdf
  - Mini coredump (see next slide)
- Kernel summit
  - ARM mini-summit
    - Not enough embedded content
      - All about ARM64, big.LITTLE, single system image, etc

Mini core dumps

- Project to dump sparse core images
- Has a configuration-driven user agent
- Core dumps with only requested information:
  - Can save basic register, backtrace, etc.
  - Saves only part of the process image
- On host, backfills the coredump with text, read-only data, etc.
  - Once the mini-coredump is backfilled on the host you can use standard coredump analysis tools (gdb)
- Project by Thomas Gleixner

Miscellaneous

- Increased use of Stack Overflow
  - Great site for answering detailed development questions
  - See www.youtube.com/watch?v=NWHfY_lvKIQ
  - Google developers answer questions here
  - Search: “site:stackoverflow.com <question>”
- Raspberry Pi
  - Extremely low-cost development board - $25
  - Targeted at students and hobbyists

eLinux wiki

- http://elinux.org
  - Web site dedicated to information for embedded Linux developers
    - The wikipedia of embedded linux!
- Hundreds of page covering numerous topic areas: bootup time, realtime, security, power management, flash filesystem, toolchain, editors
- Working on new wiki projects:
  - Video transcription project
  - Topic-by-topic cleanup

Video Transcription Project

- Plan to ask volunteers to provide written versions of presentations from events
  - Makes it easier to search for information
  - Can make it much faster to review a presentation
  - Volunteers can do as little as one minute of video
    - Idea is to crowd-source the effort
- Not advertised yet
  - Still defining process and creating templates
  - Likely announced at ELC Europe
- See http://elinux.org/Video_transcription_project

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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.?
- eLinux wiki - http://elinux.org/
  - Especially http://elinux.org/Events for slides
- Celinux-dev mailing list

Thanks!