Status of Embedded Linux
July 2014

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LF CE Workgroup
Outline

Kernel Versions
Technology Areas
CE Workgroup Projects
Other Stuff
Resources
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Kernel Versions
Technology Areas
CE Workgroup Projects
Other Stuff
Best of ...
Resources
Kernel Versions

- Pace of versions is consistent and good
- Kernel processes are working well
Kernel Versions

• Linux v3.11 – 2 Sep 2013 – 64 days
• Linux v3.12 – 3 Nov 2013 – 62 days
• Linux v3.13 – 19 Jan 2014 – 77 days
• Linux v3.14 – 30 Mar 2014 – 70 days
• Linux v3.15 – 8 Jun 2014 – 70 days
• Linux v3.16-rc6
Kernel Versions

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- Linux v3.12 – 3 Nov 2013 – 62 days
- Linux v3.13 – 19 Jan 2014 – 77 days
- Linux v3.14 – 30 Mar 2014 – 70 days
- Linux v3.15 – 8 Jun 2014 – 70 days
- Linux v3.16-rc6
  - I predict 3.16 on Aug 16 – 69 days
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Bootup Time

• Kernel can be quick (under 1 second)
  • But it takes a lot of work, per product
• Lots of resources available for tuning
  • See http://elinux.org/Boot_Time
  • Good recent presentation:
  • Michael Opdenacker – ELC 2014
  • Update on Boot Time Reduction Techniques with Figures
• More focus recently on user-space
  • Lots of people looking at systemd in embedded
Bootup Time

- Make sure UBI fastmap feature is on, if using UBIFS (available from 3.7 on)
  - Focus on firmware
  - Lots of U-boot optimizations in Michael's talk
  - Avoid copies, use best compression method, simplify scripting, trim down u-boot size, modularize u-boot, etc.

- Really looking forward to ELCE 2014
  - Have several good talks lined up for boot time reduction

- Long-term problem:
  - No automation for boot-time ye
File Systems

- Asynchronous startup helps a lot with resume on spinning media (SATA)
  - 10x reduction in resume speed
- Block layer on UBI flash translation layer
  - Read-only for now
  - Optimizations in IO scheduler for SSDs
  - Can now handle millions of IOPs
Memory Management

• ION memory allocator
• Now in staging
Power Management

• Evolution of power management in Linux
  • Suspend/resume, voltage and frequency scaling, longer sleep (tick reduction), runtime device power management, race-to-sleep (wakelocks/autosleep)

• New stuff starting to get crazy
Power Management

- Autosleep
- Power-aware scheduling
  - Big.LITTLE scheduling
  - Some products now shipping with this
  - Support is now mainlined for some processors
  - Baseline power-aware patches seem stalled
- Memory power management
- Full tickless
Power-aware scheduling:

• Small-task packing
  • Try to migrate tasks to allow more CPUs to go idle
• Task placement on mixed cpu_power systems
  • Move large tasks to faster CPUs
• Resources:
  • [http://lwn.net/Articles/546664](http://lwn.net/Articles/546664) - overview
  • [http://lwn.net/Articles/552885](http://lwn.net/Articles/552885) - some resistance
  • Ingo Molnar wants to consolidate this power stuff in the scheduler – rather than spread out into power/cpufreq/cpuidle/scheduler systems
This is big.LITTLE
System Size

- Renewed interest due to IOT
- Projects
  - MicroYocto
  - Linux for microcontrollers
- Kernel size
- Shared Library size
Renewed Interest due to IOT

• Is desirable to run Linux in very constrained devices
• Need to eliminate DRAM for power savings
  ▪ Conversion to SRAM or STMRAM means no current draw when idle
• Can possibly work with on-die RAM
• Back to wanting 2M or less RAM
Projects

• Micro-Yocto project
   by Tom Zanussi at Intel
   1.6MB SRAM, 8MB flash
   Lots of kernel, user-space reductions
   NET Diet patches, CONFIG_PROC_MIN
   Link Time Optimization
   LWIP in extreme case (lightweight IP – user-space IP stack)
   Their own tracing system (microYocto hash triggers)

• Details in ELC 2014 presentation
Projects

- Linux for Microcontrollers
  - By Vitaly Wool at Softprise Consulting
  - 256K SRAM, 2MB NOR flash
  - 2.6.33 kernel, using XIP
- Flash usage:
  - 64K bootloader
  - 900K kernel text
  - 800K root filesystem (RO)
  - 196K config filesystem (RW)
Kernel Size

• Recent work on several different patches
  ▪ NET Diet patches – Andi Kleen
  ▪ Link Time Optimization – Andi Kleen
  ▪ Min proc
  ▪ Configurable syscalls and kernel features
    ▪ sys_sendfile, X86_IOPORT, CONFIG_PTRACE, CONFIG_SIGNALS
  ▪ Resistance to NET Diet patches when they tried to mainline them
  ▪ To be discussed at kernel summit in August
  ▪ Maybe a new “linux-tiny” effort???
Shared Library reduction

• mklibs
  - http://packages.debian.org/sid/mklibs
• Cuts down shared libraries to match a specific set of executables
• Useful for large libraries like OpenGL and Qt
• Does not require source
• Warning: May miss dlopened libraries
• Available in Yocto but not Buildroot (as of 2013)
Security

• Kernel features
  • Kernel address space layout randomization
  • See https://lwn.net/Articles/569635/

• Heartbleed bug
  • Big problem caused by very old bug
  • http://lwn.net/Articles/593809/

• Linux Foundation creates fund for critical projects
  • See http://lwn.net/Articles/595959/
Tracing

- **Ktap**
  - Dynamic tracing, without the overhead of compiling into a module
  - Adds an interpreter to the kernel
  - Temporarily added to mainline in 3.13 (but subsequently removed)
  - Ingo Molnar objected – needs more work
  - See https://lwn.net/Articles/572788/
Device Tree
Device Tree

- Continues its inexorable march
- All new SoC and most driver code needs to be DT-compatible
- New work on DT schemas and validators
  - By Tomasz Figa
  - See ELC 2014 talk “Trees need care: a solution to the device tree validation problem”
- More talks on device tree coming at ELCE 2014
  - Security, dynamic trees, tutorials, under-the-hood documentation
Device tree (cont.)

• Change in maintainership
  • Grant Likely transferred maintainership to others
  • Not enough review of bindings
• Discussion about having device tree be long-lived ABI to kernel
  • Should be usable by other operating systems
  • Maybe move out of kernel repository
• Lots of discussions planned at ARM mini-summit/Kernel Summit
  • Lots of presentations at ELC Europe this year
• See http://elinux.org/Device_Tree
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CEWG Contract Work 2014

- Compressed printk messages
- LTSI test framework
- Device-tree documentation
- ARM RO text and data overwrite detection
- Android boot time reduction
- CPU Shielding capability
- Config_numa support for ARM
- More robust UBIFS support
Contract Work Details

- Compressed printk messages
  - Size reduction while retaining messages
  - Contractor: Wolfrom Sang
  - Status: Will report preliminary results at LinuxCon North America in August

- LTSI test framework
  - Enhance Cogent test framework, in Jenkins, for use with LTSI kernel
  - Support board-independent deployment and control system, based on ttc
  - Contractor: Cogent
  - Status: not started
Contract Work (cont.)

- Device-tree documentation
  - Better docs needed for developers, sub-system maintainers, and binding reviewers
  - Contractor: Frank Rowand
  - Status: not started

- Overwrite detection for kernel text and read-only data
  - Something similar mainlined in 3.14
  - May not be needed

- Android boot time improvements
  - Work to bring up side stack (such as back-up camera) before rest of Android initializes
  - Contractor: Cogent
  - Status: not started
Contract Work (cont.)

- CPU Shielding capability
  - Ability to isolate a CPU at runtime for realtime work
- Add support for CONFIG_NUMA to ARM
  - To allow for handling some memory regions in a special way - even if memory appears uniform to kernel.
- More robust UBIFS support
  - Try to fix some robustness problems when power is lost or bits flip.
CEWG New Projects

- New projects for CE Workgroup, with focused areas
  - Based on Steering Committee meetings in May
- New project areas:
  - Internet of Things
  - Standard Distribution
  - Linux in Social Infrastructure
  - SoC Mainlining
  - Others...
CEWG New Projects

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  - Based on Steering Committee meetings in May
- New project areas:
  - Internet of Things
  - Standard Distribution
  - Linux in Social Infrastructure
  - SoC Mainlining
  - Others...
Project: Internet of Things

- Identify barriers to Linux use in IOT, and fix issues found
  - Focus on size, at the moment
  - May also focus on security
  - Supporting revival of Linux-tiny project may be part of this effort
Project: Standard Distribution

- Goal is to share maintenance burden for a standard embedded distribution
- Already discussed previously
Project: Linux in Social Infrastructure

- Identify issues with using Linux-based system for societal infrastructure projects
  - Includes security, upgradability, long-term support
Project: SoC Mainlining

- Help companies collaborate on upstreaming support for their SoCs
- Identify barriers and overcome with training, best-practices documents, etc.
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- Tools
- Testing Frameworks
- Build Systems
- Distributions
- Wiki
Tools

- LLVM
  - Kernel is close to supporting LLVM without patches
Testing frameworks

• Kernel interest in automated testing increasing
  ▫ Ktest.pl
  ▫ Kevin Hillman automated test lab
• Linaro Lava
• Autotest
Build Systems

• Yocto project
  • Toaster project – big push to web-based interface
  • Micro-yocto
  • Tizen

• Buildroot
  • New: license compliance, rootfs overlays, eclipse plugin for toolchains and sdk
  • Defconfigs for lots of popular dev boards
  • Package dependency graphing
  • Build-time graphing
Distributions

- Poky
- Ångström
- MicroYocto
- Tizen
- Android
- Possible standard embedded distribution
Poky

- Default distribution used by Yocto Project
- YP keeps trying to avoid shipping a distribution
- Poky should be considered a sample distro, but not suitable for production (?)
Ångström

- Mature package-feed based embedded distro
  - Originally focused on handheld devices (e.g. Sharp Zaurus)
- Developed originally under OpenEmbedded
- Is shipped with a number of development boards
MicroYocto

- Focused on IOT requirements
  - Has special features for tiny systems
  - Kernel patches
  - Special tracing for dynamic memory usage monitoring
  - Currently focused on size and networking aspects of IOT
Tizen

- Descended from Meego, which descended from Maemo and Moblin
- Getting more widespread usage
  - Replacing Bada at Samsung
  - Shipping in TVs, phones and increasingly targeted at automotive
- Can be built with Yocto Project
- May be a serious competitor as general embedded distribution
Android

- Is increasingly used in non-mobile devices
  - See ABS 2014 talk by Gary Bisson
  - Google “cyborgstack” and “headless android”
- KitKat focused on size issues
  - Target devices with 512MB of space, to drop Android into low-end phones
- “L” release has lots of changes:
  - Project Volta – for power reduction
  - “Material Design” - 3d look with “floating” widgets
  - ART – Android Runtime
  - Ahead-of-time compiler
    - Goodbye Dalvik
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Possible standard embedded distribution

- CEWG project to create and maintain a standard distribution for the embedded industry
- Just getting started with requirements definition
- May select an existing distribution
- If you are interested, please contact
  - Yoshitake Kobayashi
eLinux wiki

- [http://elinux.org](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 wiki projects:
  - 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!
Extra Slides

- The following slides are just for reference, for embedded-related features introduced in recent kernel versions
Linux 3.12

• Full-system idle detection
  • Tricky rcu-based implementation to allow for fast indication of individual CPU idleness (using per-cpu variable), AND fast detection of global CPU idleness (single global variable)

• New cpu-idle driver that builds on multi-cluster power management
  • Ie. Getting closer to support for “big.LITTLE” CPU scheduling

• Lots of device drivers converting over to device tree
  • More on this later
Linux 3.13

- ARM big.LITTLE switcher support
- Scalable block layer for better SSD performance
- Power capping framework
- Ktap was put in, then taken out
Linux 3.14

- Kernel Address space layout randomization
- ION memory allocator in staging
- ARM text and RODATA protection
- 6lowpan emulation for BLE
- Zram compressed swap moved out of staging
  - Reports are that it is used in TVs and some Android devices
  - See http://git.kernel.org/cgit/linux/kernel/git/torvalds/linux.git/commit/?id=cd67e10ac6997c6d1e1504e3c111b693bfdbc148
Linux 3.15

- UBI flash translation now has block device layer support
  - Read-only for now
- More support for LLVM compiler suite
  - Not finished yet, but getting closer
Linux 3.16

- Power-aware scheduling
- decode_stacktrace.sh – convert offsets in a stack trace to filenames and line numbers