Status of Embedded Linux
June 2013

Tim Bird
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LF CE Workgroup
Outline

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

- Linux v3.5 – 21 July 2012 – 62 days
- Linux v3.6 – 30 Sep 2012 – 71 days
- Linux v3.7 – 10 Dec 2012 – 71 days
- Linux v3.8 – 18 Feb 2013 – 70 days
- Linux v3.9 – 28 Apr 2013 – 69 days
  - I predicted April 30 (only 2 days off)
- Linux v3.10-rc4 – 2 June 2013
  - I predict...
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  - I predict… July 7, 2013
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

- Android RAM console functionality integrated into pstore
- CANFD support for CAN protocol
  - CAN with flexible data rate
- LED oneshot mode
  - Sysfs interface for certain one-time LED/gpio manipulations
- "Suspend to Both"
  - Create resume image both in RAM and on disk
  - If power dies during suspend, disk image can be used to resume
Linux v3.7

- ARM multi-platform support
  - See http://lwn.net/Articles/496400/
- ARM 64-bit support (Aarch64)
- Cryptographically signed kernel modules
  - See https://lwn.net/Articles/470906/
- Perf trace (alternative to strace)
  - Allows intermingling kernel trace events with syscall events
- Runtime power management for audio
- K meltdown system can output in HTML5 format
Linux v3.8

- F2FS – flash-friendly file system
  - See https://lwn.net/Articles/518988/
- New thermal governor subsystem
- Memory control group support for accounting for kernel memory usage
  - Stack and slab accounting and limits
- Cpuidle support for big.LITTLE
Linux v3.9

- Ftrace snapshots
  - Grab a snapshot of a running trace without stopping
- KVM virtualization for Cortex A15 processors
- PowerPC support for transactional memory
- CONFIG_EXPERIMENTAL=y
  - And should be gone soon
- ‘make menuconfig’ now has "save" and "load" buttons
Linux v3.9 (cont.)

- Descriptor-based GPIO
  - Access GPIOs by descriptor (e.g. by name in addition to by number)
  - Allows for grouping GPIOs - for “atomic” operations
    - Possibly useful for handling realtime issues
  - See http://lwn.net/Articles/533632/
Linux v3.10

- Full tickless (more later)
- Single zImage for ARM
  - Lots more platforms support multi-platform kernels
  - Arnd Bergmann shooting for almost-complete coverage by v3.12
- Multi-cluster power management
  - Partial support for big.LITTLE PM
  - https://lwn.net/Articles/539082/
Linux v3.10 (cont.)

- Multiple ftrace buffers
- Memory pressure control group support
  - Allows for notification if memory gets low
  - [http://lwn.net/Articles/531077/](http://lwn.net/Articles/531077/)
Full tickless

• Full tickless (full dynamic tick)
  • Under some circumstance, some processors may run with no periodic ticks at all
  • Previous CONFIG_NO_HZ used dynamic tick, but only when CPU was idle
  • New option is tri-state: periodic, idle, full
  • Boot CPU cannot be ‘full’ tickless
  • CPU cannot be full tickless with more than one process
  • https://lwn.net/Articles/549580/
Things to watch

- Android features
  - Volatile ranges
  - ARM FIQ -> KDB glue
- big.LITTLE MP scheduling
  - See [https://lwn.net/Articles/501501/](https://lwn.net/Articles/501501/)
  - See the In-Kernel-Switcher work
    - [https://lwn.net/Articles/549473/](https://lwn.net/Articles/549473/)
- Single zImage support on ARM
- Support for transactional memory instructions
  - Could be as big a deal (eventually) as locking primitives
Things to watch (longer-term)

- Non-volatile mass memory
  - Interesting remarks by Linus in LinuxCon keynote question and answer
  - Skeptical it will happen “this year” – it’s always within a few years of happening.
  - Won’t change a lot of kernel algorithms
  - Will mostly change filesystems
    - Byte-addressable storage has big implications for long-term storage
  - Applications will still segregate data between persistent and non-persistent groups
  - Things take longer to change than people think
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Bootup Time

- Not much new stuff this time
Graphics

- Not much new stuff this time
File Systems

- **F2FS** – Samsung Flash-friendly filesystem
  - Mainlined in Linux version 3.8
  - Log-structured, with lots of tweaks
    - E.g. hot vs. cold data separation
  - See [http://elinux.org/F2FS](http://elinux.org/F2FS)

- CE WG project to analyze filesystem performance on eMMC
  - More on next slides
Flash Filesystem tuning

- CE Workgroup contracted with Cogent Embedded
- Goal: to test different block-based filesystems on flash media
  - Specifically, want to measure the effect of different kernel tuning options (IO scheduler, flash geometry vs. flash part attributes and workload characteristics)
- Result document is NOW available at:
  - http://elinux.org/File_Systems#Comparison_of_flash_filesystems
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
big.LITTLE scheduling

• Lots of work recently on big.LITTLE scheduling
  • Multi-cluster power scheduling
  • In-kernel-switcher work
  • See talk at LCJ by Nakagawa-san of Renesas
    • One User Space Approach to big.LITTLE MP System on Real Silicon

• Still waiting for real-product results ??
System Size

- Kernel size
- Library size
Kernel size

- Cooperative memory relinquishment
  - Volatile Ranges
  - Lexmark work (membroker and ANR malloc)
    - See talk at ELC 2013 – "SystemWide Memory Management without Swap"
- Tim Bird’s presentation on advanced size optimization of the kernel
  - Notes and slides available at: http://elinux.org/System_Size_Auto-Reduction
  - (more later)
Library reduction

• olibc – bionic libc
  • Has good features from Android, and is smaller and more configurable than glibc

<table>
<thead>
<tr>
<th>Library</th>
<th>File Location</th>
<th>Size Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>glibc 2.11</td>
<td>/lib/libc.so</td>
<td>→ 1,208,224 bytes</td>
</tr>
<tr>
<td>uClibc 0.9.30</td>
<td>/lib/libuClibc.so</td>
<td>→ 424,235 bytes</td>
</tr>
<tr>
<td>bionic 2.1</td>
<td>/system/lib/libc.so</td>
<td>→ 243,948 bytes</td>
</tr>
</tbody>
</table>

• See ELC 2013 talk by Jim Huang

• Kconfig for eglibc
  • Ability to configure parts of libc to use

<table>
<thead>
<tr>
<th>Library</th>
<th>Reduced Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>libc-2.17.so</td>
<td>830K</td>
</tr>
<tr>
<td>ld-2.17.so</td>
<td>120K</td>
</tr>
<tr>
<td>libm-2.17.so</td>
<td>580K</td>
</tr>
</tbody>
</table>

• See ELC 2013 talk by Khem Raj
Advanced Size Optimization of the Linux Kernel

• “Auto-reduce” project
• Find automated ways to reduce the kernel
  • Link-time optimization
  • System call elimination
  • Kernel command-line argument elimination
  • Kernel constraint system
• Additional research
  • Link-time re-writing
  • Cold-code compression
Security

- SMACK
- SE-Linux
SMACK

- SMACK for Tizen
  - Simplified rule set (3 tiers, 40,000 rules)
- See http://lwn.net/Articles/55278
- Published June 5, requires LWN.net subscription
SE-Linux

- **SE-Android**
  - Implementation of SE-Linux for Android systems
- **SE-Linux was previously too big for embedded**
  - Early embedded SE-Linux required 2M
  - Desktop SE ruleset is 900,000 rules
- **However, SE-Android only has 1658 rules and 263 types (71K policy size)**
- **[http://selinuxproject.org/page/SEAndroid](http://selinuxproject.org/page/SEAndroid)**
  - Especially: [http://www.internetsociety.org/sites/default/files/Presentation02_4.pdf](http://www.internetsociety.org/sites/default/files/Presentation02_4.pdf)
Tracing

• Ktap
  • Dynamic tracing, without the overhead of compiling into a module
  • Adds an interpreter to the kernel
  • Single module, that leverages ftrace, kprobes, etc.
  • Prints results in ASCII
  • Good session in LinuxCon Japan by Jovi Zhang
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CEWG Contract Work 2013

- Dynamic memory analysis (2012)
- eMMC tuning guide completed
Dynamic memory analysis

- **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:**
  - Use existing kmem_events (ftrace) infrastructure
  - Some patches already accepted upstream
  - New tool for visualization of kernel memory usage
  - See http://elinux.org/Kernel_dynamic_memory_analysis
  - See ELC 2013 talk
Drivers kmalloc

- base 65.0 kB
- pci 12.0 kB
- tty 17.0 kB
- serial 8.0 kB
- scsi 20.0 kB
- ata 52.0 kB
- vt 6.0 kB
eMMC tuning guide

- **Description:**
  - This project analysed EXT4, BTRFS and F2FS on a variety of block-based flash parts on a few different development boards
  - Output is a document describing best practices for tuning Linux block-based filesystems for block-based flash filesystems
  - Also, methods and scripts for filesystem testing
- **Contractor:** Cogent Embedded
- **Status:** Just completed
Other Projects

- Long Term Support Initiative (LTSI)
Long Term Support Kernel for Industry

- LTSI 3.4 is available now
- Held a workshop at LinuxCon Japan
  - Discussed testing phase of project
  - Discussed promotion of project
- Program for free hardware for LTSI kernel testing
Hardware

• Rise of cheap hardware
  • Lots of < $200 boards
  • Raspberry Pi - $35
  • New BeagleBone - ?? (<$79)
• Lots of people have mobile phones or tablets
• No need for CE WG hardware program
• Anyone can learn embedded Linux
  • FYI – code.org – new site to teach programming
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- Tools
- Build Systems
- Events
- Miscellaneous
Tools

- Cortex
  - Coredump filter
  - Generates sparse coredump
  - See ELC 2013 presentation by Tristan Lelong
    - "Debugging for production systems"

- Debugging techniques
  - Good overview by Kevin Dankwardt at ELC 2013
    - "Survey of Linux Kernel Debugging Techniques"
Testing frameworks

- Autotest
  - Simple framework
  - Not cross-compiler aware?
- LAVA
  - Linaro test framework
- "Kernel Testing Tools and Techniques" BOF by Matt Porter at ELC 2013
- CE workgroup considering reviving test activity for 2013
  - Need input…
Build Systems

- Yocto project
  - Lots of talks at ELC (and previous ELCs)
    - Sean Hudson – good introduction tutorial
    - Saul Wold – current status
  - Tutorials now online
- Buildroot still hanging in there
Distributions

• Tizen – may be a serious competitor in embedded distros
  • Needs to open up a bit more (but it looks like it’s happening)
  • Replacing Bada at Samsung
  • Shipping in phones??
• Android use in non-CE embedded
  • Headless android
• Yocto Project = the new in-house distro
• Angstrom
  • Very common on development boards
Events

- LinuxCon Japan – May 29-31 2013
- Japan Jamborees
- LinuxCon US
  - September 2012 – New Orleans
- Embedded Linux Conference Europe 2013
  - October 21-23, 2013 – Edinburgh, Scotland
- Embedded Linux Conference 2014
  - April, 2013 – San Jose
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
  - Tech Zones
Miscellaneous

• Status of industry = Healthy
  • Over 1.4 billion devices shipped with embedded Linux
• Just had CELF 10\textsuperscript{th} anniversary party
• Still going strong
• Personally, I’m excited about new job
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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
- LinuxCon Japan slides
  - http://events.linuxfoundation.org/events/linuxcon-japan/program/presentations
Thanks!