Benefits of User-Controlled Firmware in Production Systems

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Google
Google
ex-Google Intern
ITRenew
Facebook
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Netflix

OCP Taipei Workshop
October 23, 2019

Overview

1. Today’s System Firmware
2. LinuxBoot: Linux as Firmware
3. Firmware Written in Go
4. Bootloader options
5. Case Studies
UEFI Boot

OS-like features:
- Drivers
  - Network
  - Disk
  - USB
- Dispatching / Scheduling
- Filesystem
- Applications
- Events
- ...

Pre Verifier
Processor Init
Chipset Init
Board Init
EFI Driver Dispatcher
Intrinsic Services
Boot Manager
UEFI Interface
OS-Absent App
Transient OS Environment
Transient OS Boot Loader
OS-Present App
Final OS Boot Loader
Final OS Environment

Security (SEC)
Pre EFI Initialization (PEI)
Driver Execution Environment (DXE)
Boot Dev Select (BDS)
Transient System Load (TSL)
Run Time (RT)
After Life (AL)

Power on → [ . . Platform initialization . . ] → [ . . . . OS boot . . . . ] → Shutdown
Today’s System Firmware

- UEFI Implementations
  - are mostly closed source,
  - written in C,
  - share an address space in ring 0.
- Vendors are incentivized to ship it and forget.
- Owners do not own their system.
  - Even when it is open-source
Today’s System Firmware

• 20+ vendors involved in shipping firmware
  - IBVs (BIOS vendors),
  - silicon manufacturers,
  - ODMs, OEMs,
  - NIC, disk, BMC, ... vendors,
  - OS vendors (Windows, RHEL, Debian)
• Black boxes that wrap black boxes.
• What happens with vulnerabilities?
  - Who owns fixing it?
  - How to integrate it?
• Most DXEs are removed.
• The DXECore is kept for ACPI and some device initialization.
• Boot kernel knows how to initialize rest of devices.
• The boot kernel kexec’s the runtime kernel.
What have we gained?

- Linux already has drivers for everything
  - No need to reimplement drivers in firmware
- Some applications and drivers can be written as a userspace program in Linux
- Speed
  - Winterfell boot time: 8 minutes down to 20 seconds
  - Boots faster than iPXE/grub/etc. (measured for 20 years)
- Are we simply replacing GRUB?
  - Remove grub and replace what was used to run GRUB.
- Why have Linux boot another Linux?
  - Can use limited kernel to boot more feature-full kernel
  - Kiosk mode: The firmware linux is the final linux.
Linux + what’s in the initramfs?

- Whatever you want.
  - We provide tools, not policy.
- Busybox?
- Systemd-boot?
- Petiteboot?
- HEADS? trmm.net/Heads
  - Security-focused busybox LinuxBoot runtime
- Stages of firmware we are replacing...
  - Drivers
  - Bootloaders
  - Debugging shells
  - ...

u-root: Why Golang for firmware?

- Use Go static analysis tools
  - go vet, golint, gofmt, ineffassign, ...
- Race detector, memory sanitizer, etc...
  - go test -race
- Continuous Integration (CI) testing
- Open documentation (https://godoc.org/)
- Language is safer than C or shell scripts
- Well designed and secure standard library
  - Easy cross-compilation: GOOS= and GOARCH=
  - Supports amd64, arm, arm64, and ppc64
- Fast compilation (on the order of seconds)
More Bootloader Options

![Diagram showing the boot process flow, including UEFI PEI, coreboot romstage, u-boot SPL, firmware HW init, Memory initialized, LinuxBoot, Linux Kernel, initramfs, and Operating System.]

*Consume. Collaborate. Contribute.*
Booting Multiboot OSes from LinuxBoot

- The work of Max Shegai
- Supports booting OSes using the Multiboot standard
- Open-source and available on GitHub
- Can now boot:
  - Akaros
  - Harvey
  - tboot
  - VMware ESXi
Booting Windows from LinuxBoot

- The work of Ofir Weisse
- Still a proof of concept
- Open-source and available on GitHub
Case Study #1: Google

- Substantial contributions to LinuxBoot open-source projects
  - u-root, fiano, dhclient, ...
- Substantial presence in conferences and communities
- **LinuxBoot is now running on Google’s production servers!**
Case Study #2: ChromeOS

- Chromebooks have been running Coreboot for **almost a decade**
  - Accounts for 50 million machines
- Supports arm32, arm64 and x86
- Coreboot has existed for over **2 decades**!
- Firmware is open-source and user-controlled
  - Some leeway in terms of FSP blobs
- Large open-source community contributing to Coreboot
- Very passionate engineers and active open-source community
Case Study #3: Facebook
Case Study #4+: Others

- Netflix
- HPE
- Wiwynn
- ITRenew
The Future

• More and more vendors are using LinuxBoot
• Shipping more hardware with LinuxBoot
• Modern bootloaders implemented in Go
• Firmware tools in Go (cbfs support, self-flashing capabilities, ...)  
  - cbfs support
  - self-flashing capabilities
  - improved ACPI and device tree support
  - ...
• Documentation  
  - Linuxboot Book, technical writers are onboard
Call to Action

Join Open Source Firmware Slack
https://u-root.slack.com
Join using https://slack.u-root.com

LinuxBoot
https://www.linuxboot.org
https://github.com/linuxboot/linuxboot

u-root
https://github.com/u-root/u-root

Bi-weekly OSF Calls
https://www.opencompute.org/wiki/Open_System_Firmware

LinuxBoot Book
https://github.com/linuxboot/book

New Hardware
We’ll help get LinuxBoot working on your hardware.

Laptop Stickers