Discover UEFI with U-Boot

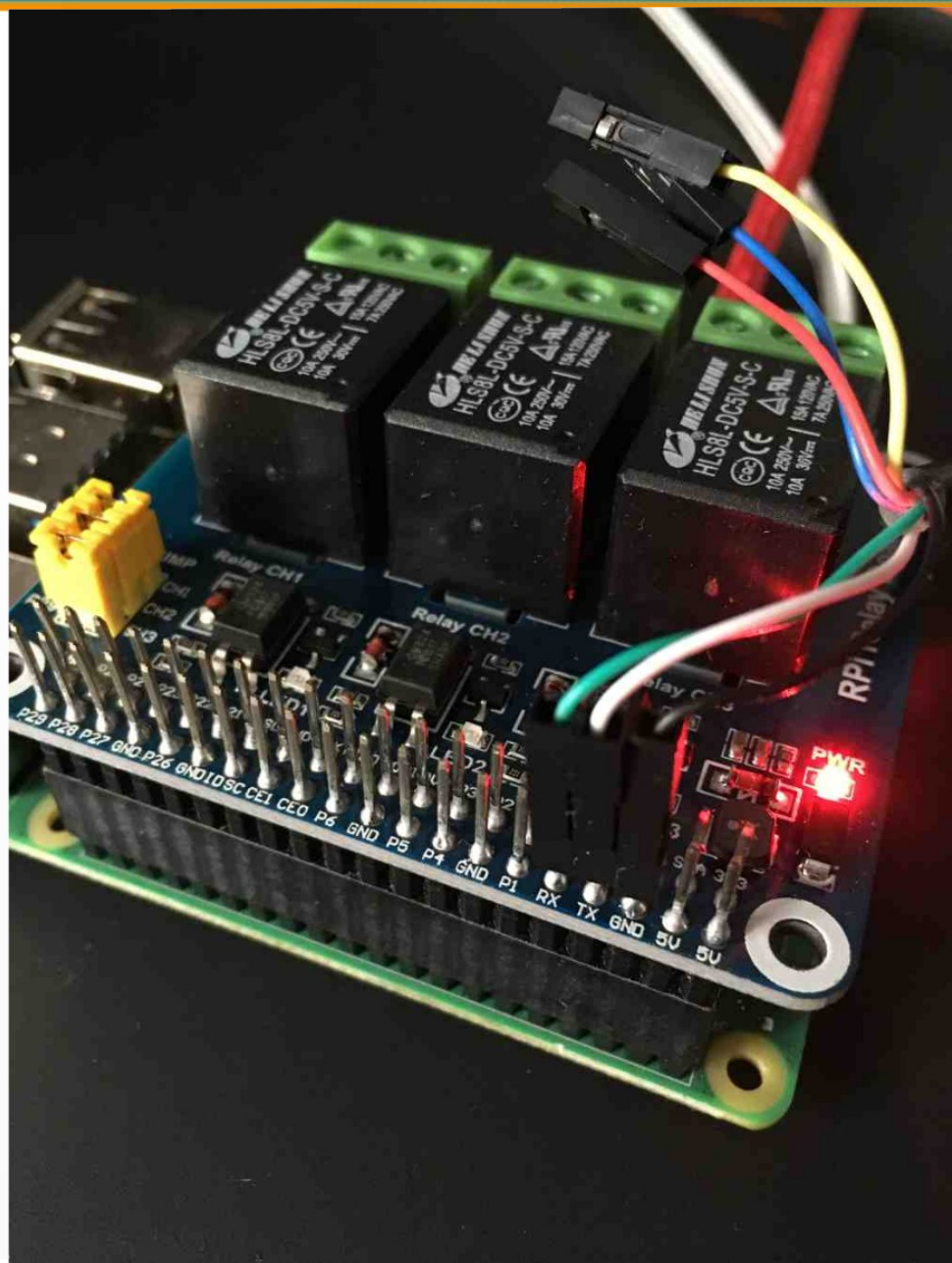
2020-02-01, Heinrich Schuchardt

About Me

- Software-Consultant ERP, Supply Chain
- Contributor to U-Boot since 2017
- Maintainer of the UEFI sub-system since 02/2019

I Want a Network Drive

- Many single board computers have neither SATA nor PCIe.
- For many boards Ethernet is the fastest connector.
- An SSD drive costs more than most SBCs.



Network Booting in U-Boot

BOOTP

tFTP

NFSv3

- BOOTP server provides tFTP server address and name of boot script
- Boot script loads kernel via tFTP or NFSv3 (UDP)
- **No authentication at all**

iSCSI

- SCSI protocol transported via TCP
- Offers entire data stores (LUNs) to iSCSI client
- Mutual authentication of client and server with CHAP: MD5(ID + secret + challenge)
- Further security via VLAN separation and IPsec

iPXE

Swiss army knife of network booting:

- Boot from HTTP(s) server
- Boot via iSCSI
- Boot via FcoE
  (Fibre Channel over Ethernet)
- Boot via AoE (ATA over Ethernet)
- Scriptable
- Can be built as **UEFI** payload

See https://ipxe.org,

Developer Michael Brown <mcb30@ipxe.org>

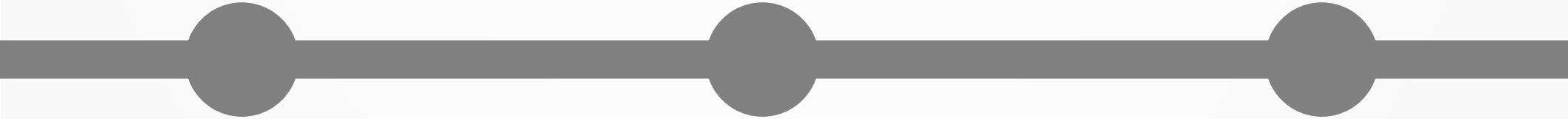
UEFI in U-Boot Started 2016

First Try

```
=> load mmc 0:2 $fdt_addr_r dtb
19600 bytes read in 303 ms (62.5 KiB/s)
=> load mmc 0:1 $kernel_addr_r snp.efi
reading snp.efi
149280 bytes read in 31 ms (4.6 MiB/s)
=> bootefi $kernel_addr_r $fdt_addr_r
## Starting EFI application at 42000000 ...
Scanning disks on usb...
Scanning disks on mmc...
MMC Device 1 not found
MMC Device 2 not found
MMC Device 3 not found
Found 5 disks
## Application terminated, r = -2147483639
=>
```

-2147483639 = 0x80000009 = EFI_OUT_OF_RESOURCES

My U-Boot Journey Begins

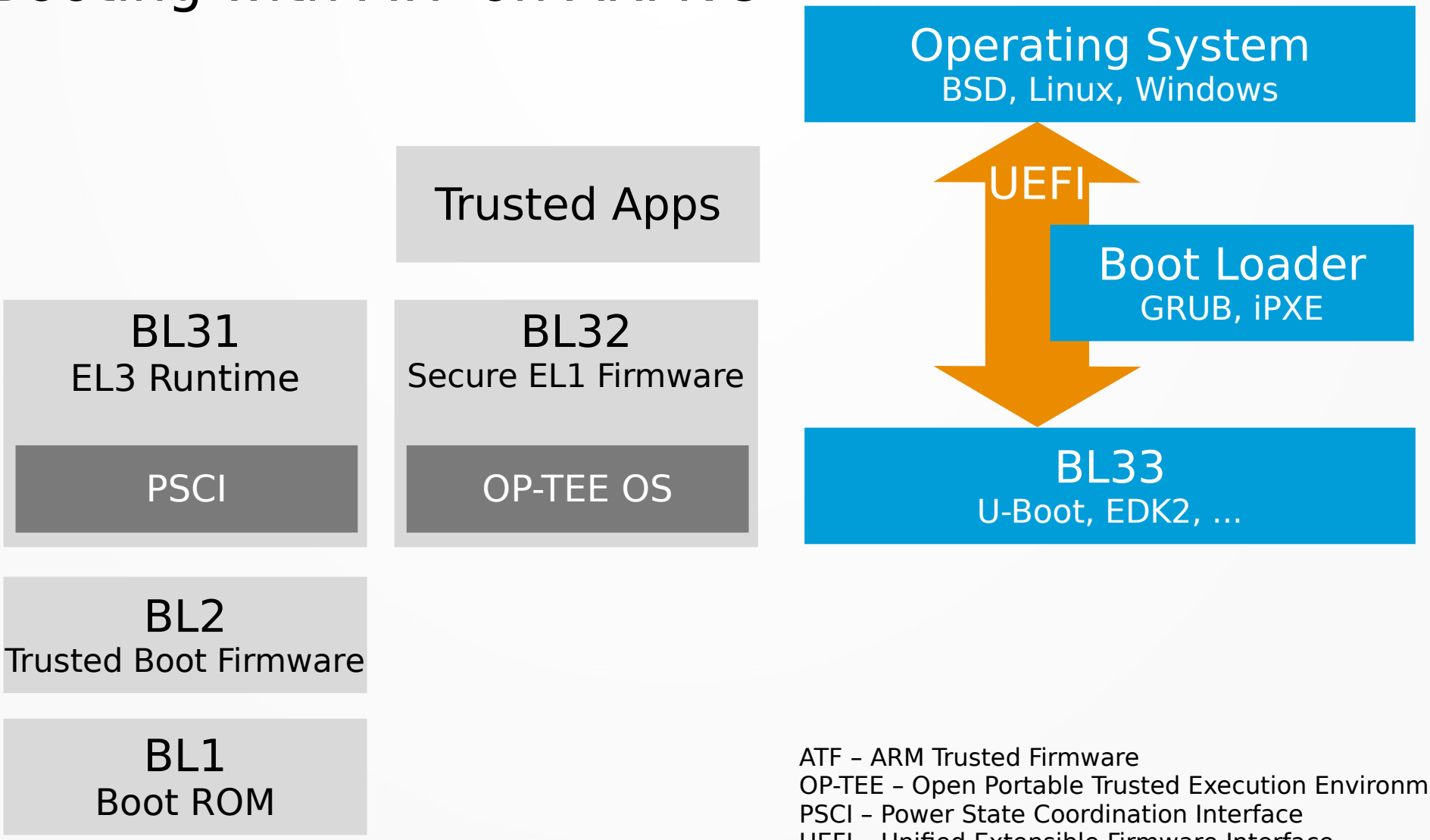


2016/17	2018	2019
Bare Minimum to start GRUB	iSCSI boot with iPXE	Run EFI Shell and EDK II SCT

together with 40 UEFI sub-system contributors

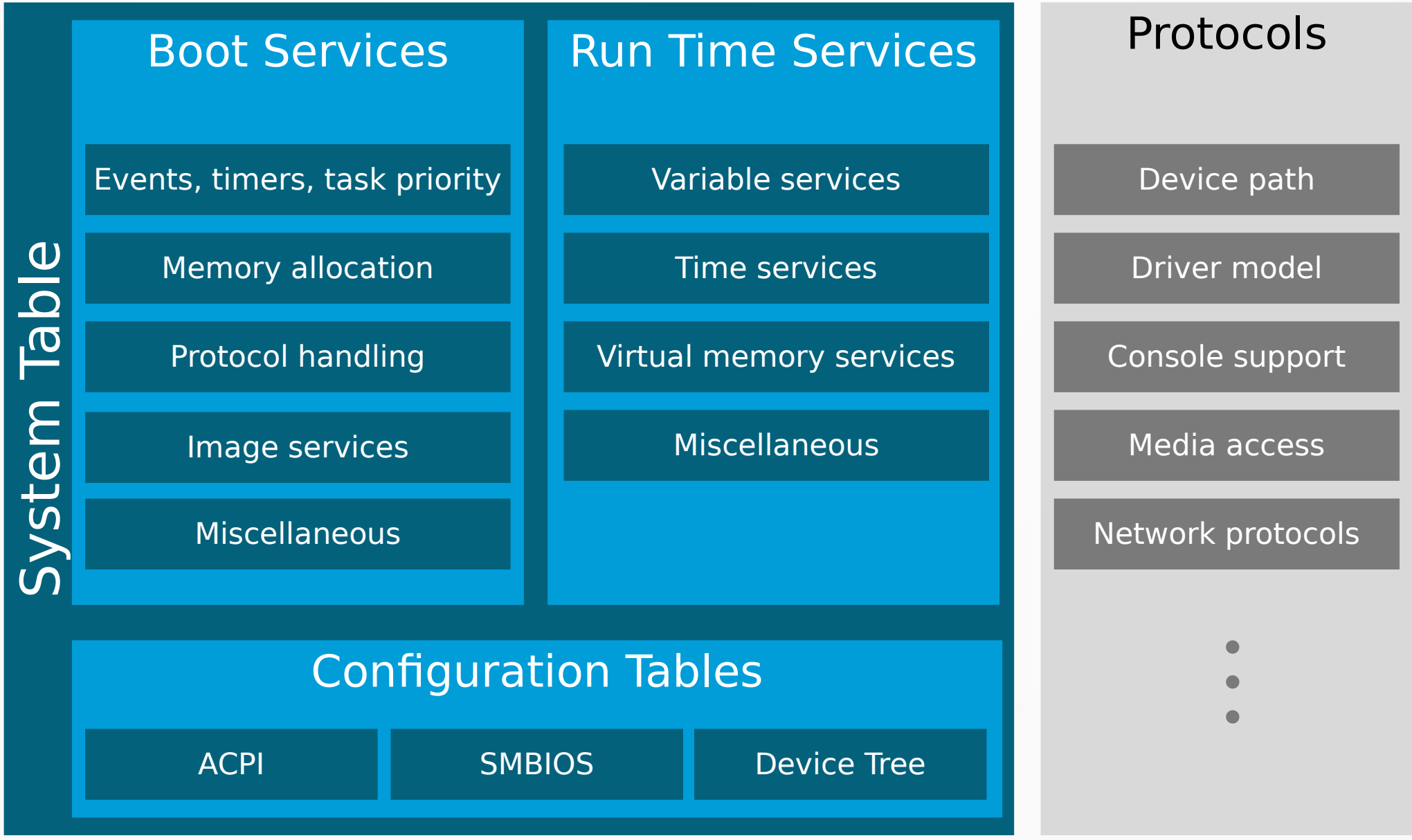
Where Sits UEFI?

Booting with ATF on ARMv8



ATF – ARM Trusted Firmware
OP-TEE – Open Portable Trusted Execution Environment
PSCI – Power State Coordination Interface
UEFI – Unified Extensible Firmware Interface

UEFI


System Table
Boot Services
Events, timers, task priority
Memory allocation
Protocol handling
Image services
Miscellaneous
Run Time Services
Variable services
Time services
Virtual memory services
Miscellaneous
Configuration Tables
ACPI
SMBIOS
Device Tree
Protocols
Device path
Driver model
Console support
Media access
Network protocols

“Atoms” of UEFI

- Handles
  - void* pointer
  - Protocols are installed on handles
- Events
  - Triggered by timer or service call
  - Callback function

Lifetime of a Handle

Creation by
installing first protocol

Deletion by
removing last protocol

InstallProtocolInterface
InstallMultipleProtocolInterfaces

UninstallProtocolInterface
UninstallMultipleProtocolInterfaces

Driver

- Handle with EFI_DRIVER_BINDING_PROTOCOL
  - GUID
    {0x18A031AB, 0xB443, 0x4D1A, {0xA5, 0xC0, 0x0C, 0x09, 0x26, 0x1E, 0x9F, 0x71}}
  - Protocol Interface Structure
    - Supported()
    - Start()
    - Stop()
    - Version
    - ImageHandle
    - DriverBindingHandle

Device (aka Controller)

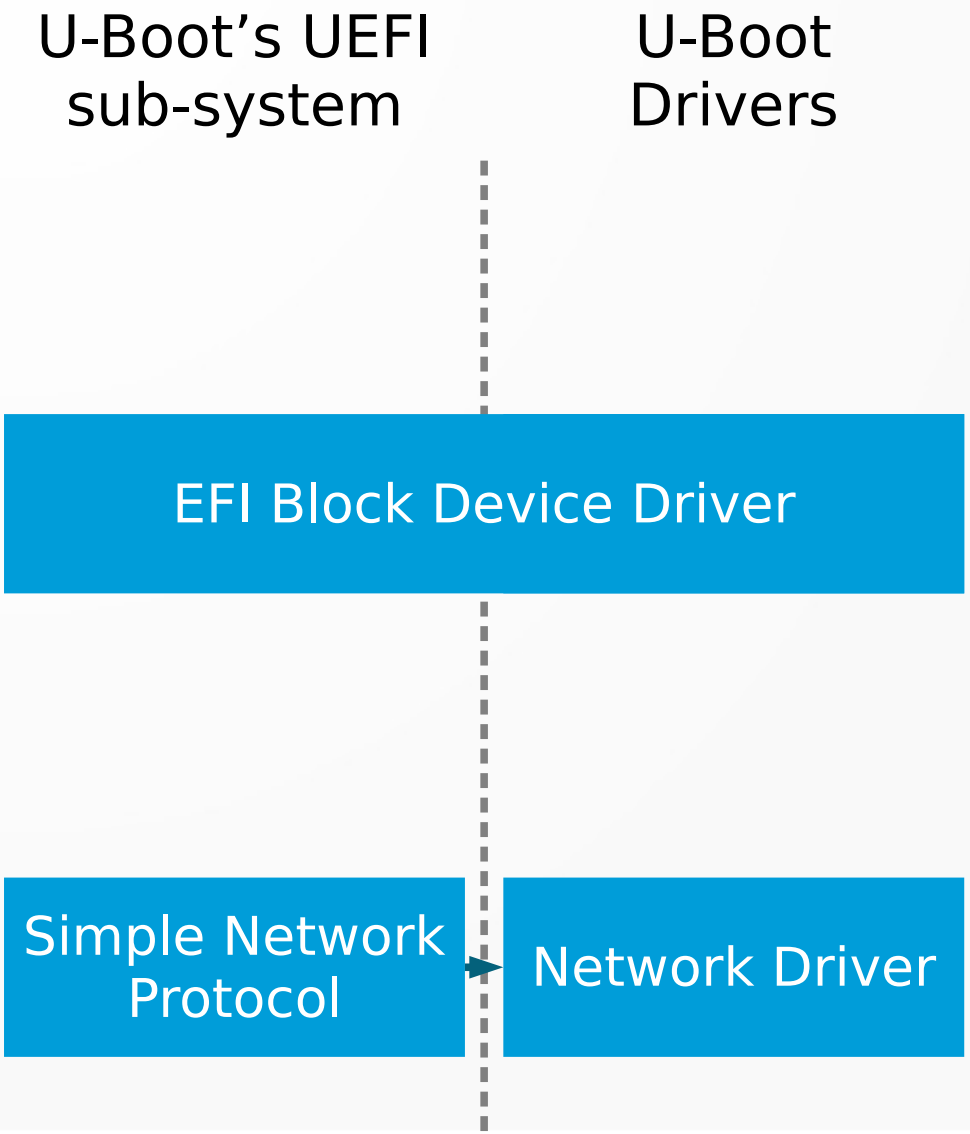
- Handle with the EFI_DEVICE_PATH_PROTOCOL
  - Sequence of device path nodes
  - Arranges devices in a tree

- PciRoot(0x0)
- PciRoot(0x0)/Pci(0x1,0x1)
- PciRoot(0x0)/Pci(0x1,0x1)/Pci(0x0,0x0)/NVMe(0x1,AD-A9-B1-73-55-38-24-00)
- PciRoot(0x0)/Pci(0x1,0x1)/Pci(0x0,0x0)/NVMe(0x1,AD-A9-B1-73-55-38-24-00)
  /HD(1,GPT,F24494A4-585B-4E34-A367-4DC70CFFC93D,0x800,0x1DC800)
- PciRoot(0x0)/Pci(0x8,0x2)
- PciRoot(0x0)/Pci(0x8,0x2)/Pci(0x0,0x0)/Sata(0x0,0x0,0x0)
  /HD(1,GPT,11C3D446-F6E4-4C67-937E-992AFC6F454F,0x800,0x108800)

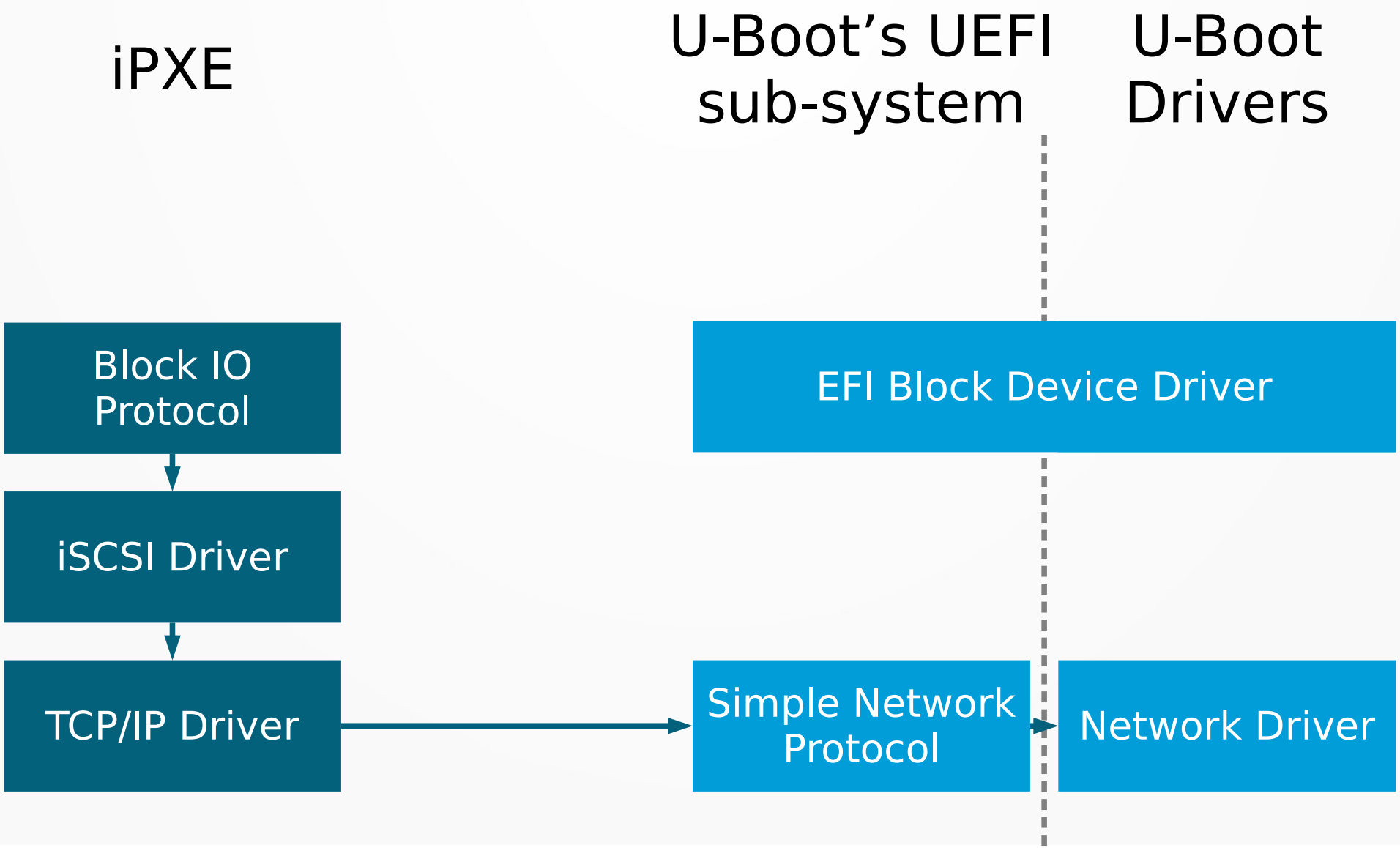
Attaching Drivers

- ConnectController() boot service
  - calls Supported() methods of all drivers to find matches for controller
  - calls Start() method of the matching drivers
- Driver
  - installs protocols on controller
  - may create child controllers

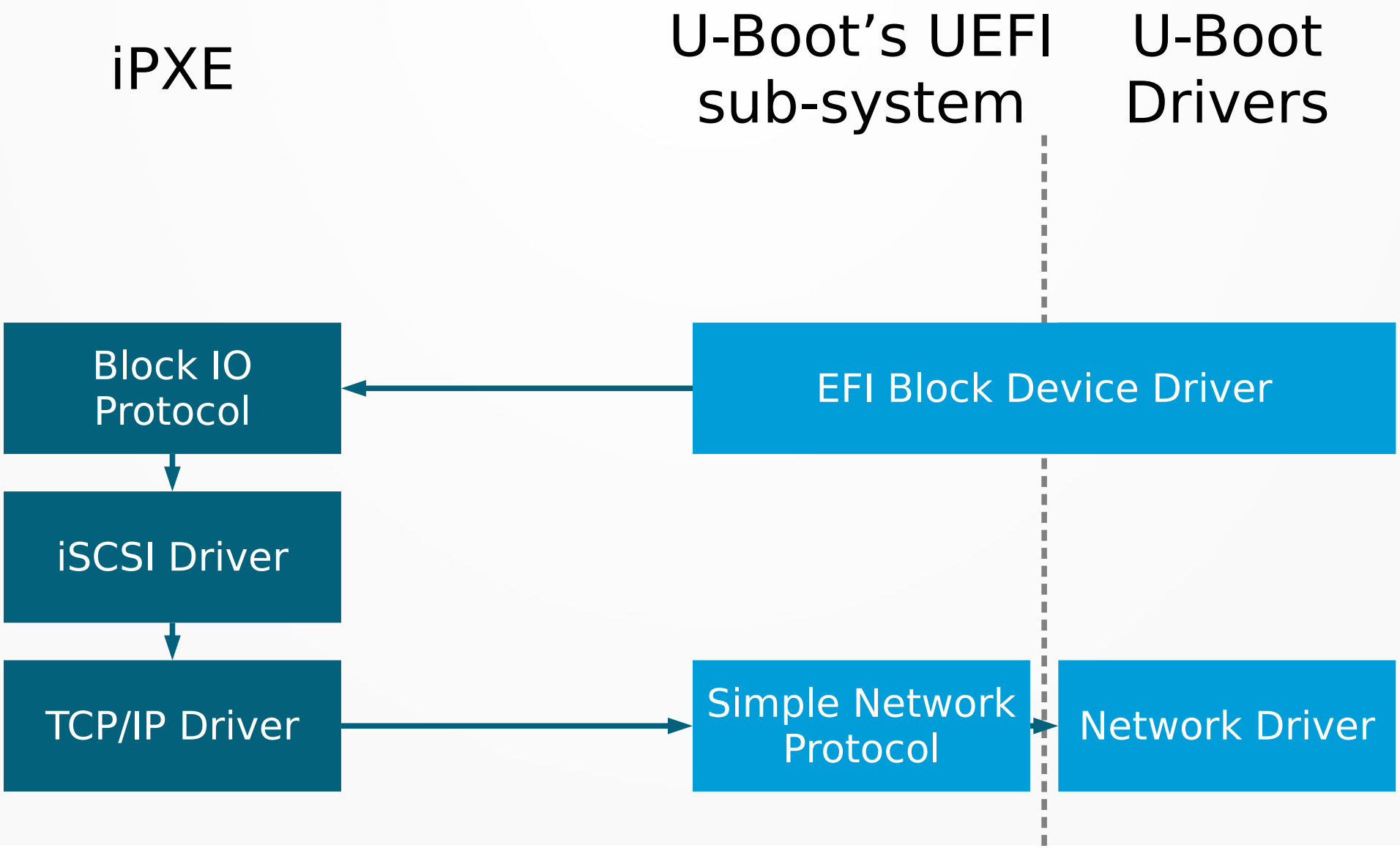
U-Boot Exposes Ethernet



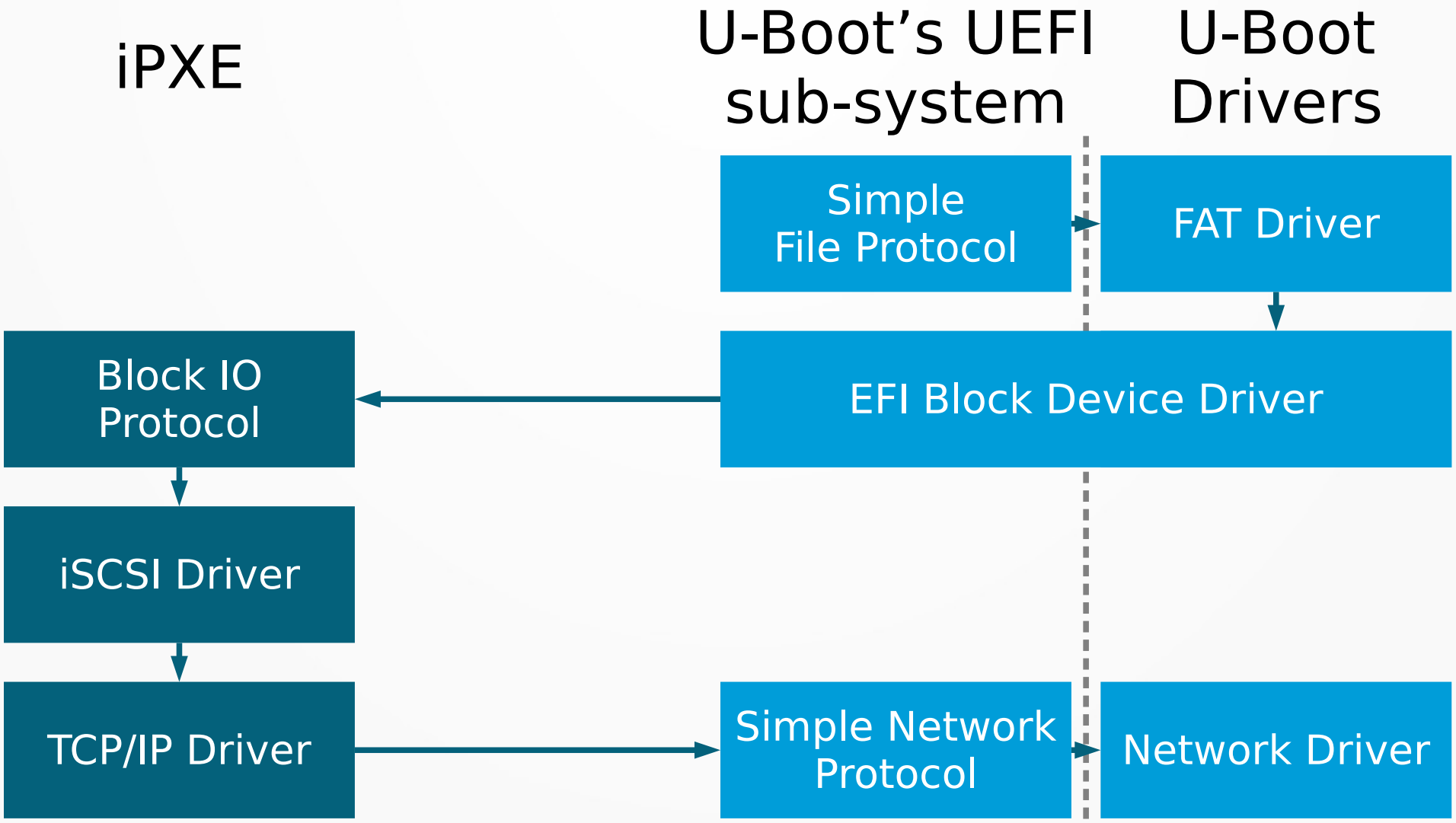
iPXE Exposes Block IO Protocol



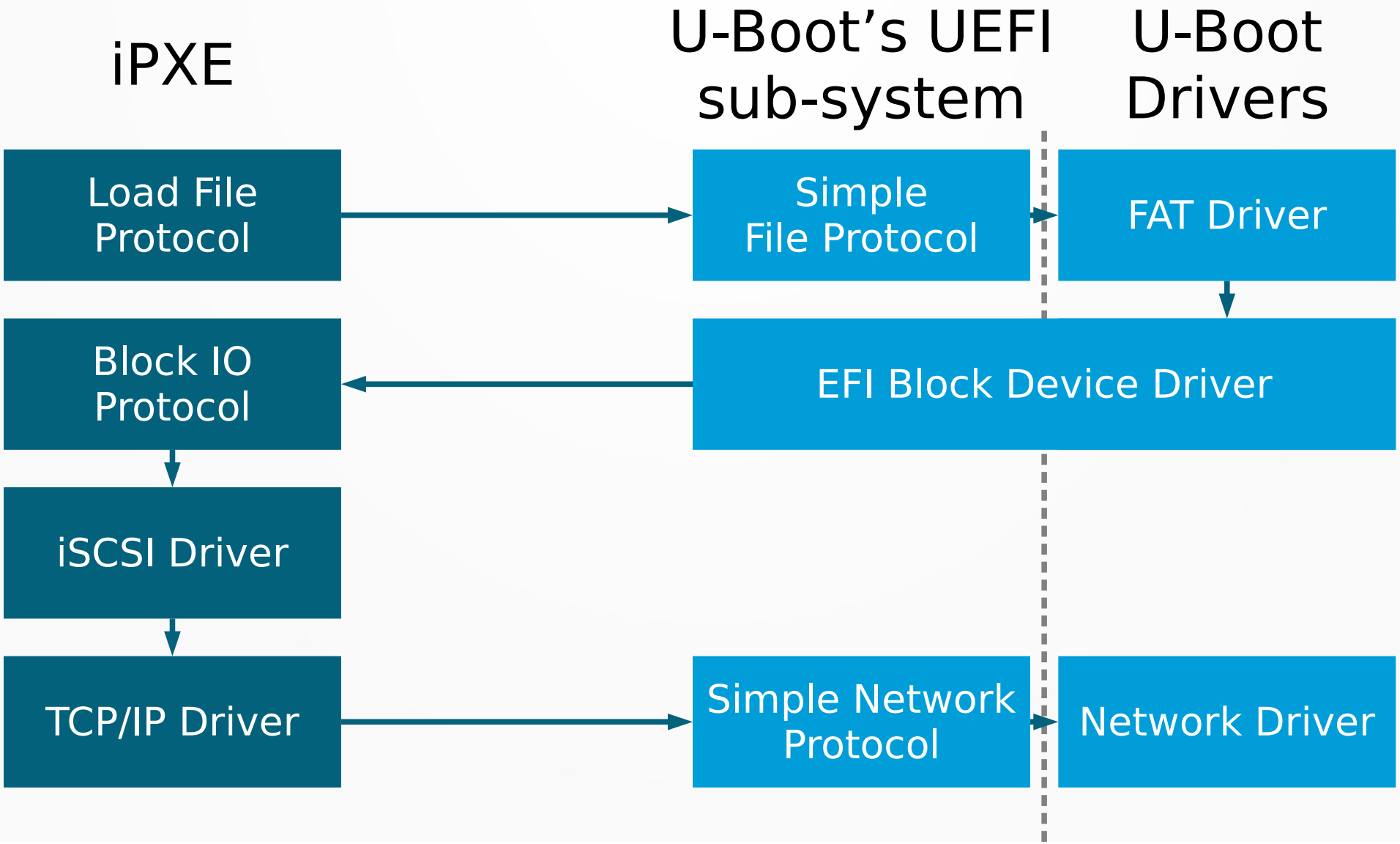
iPXE Connects Controller



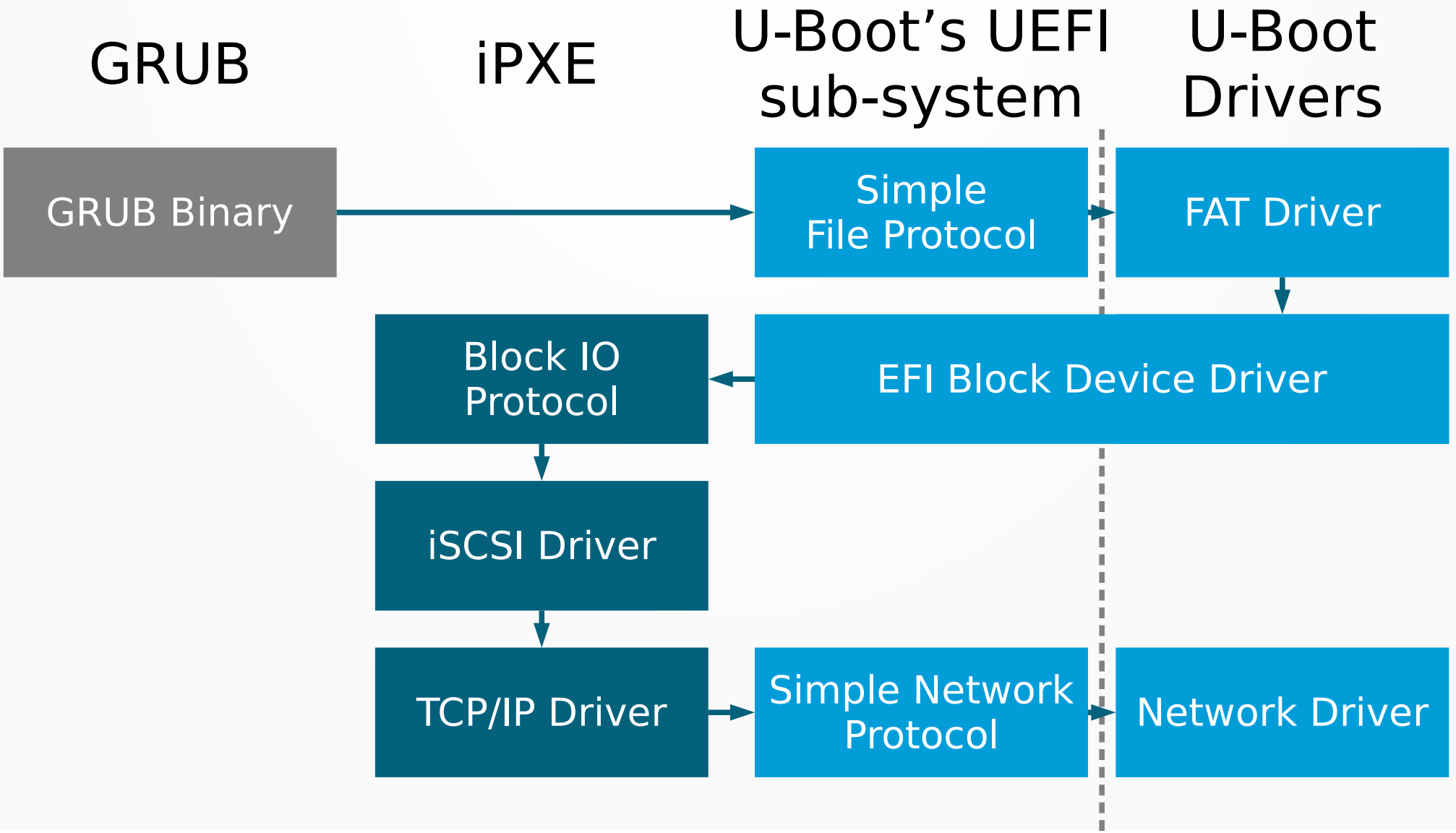
U-Boot Discovers Partitions



iPXE and U-Boot Loading File

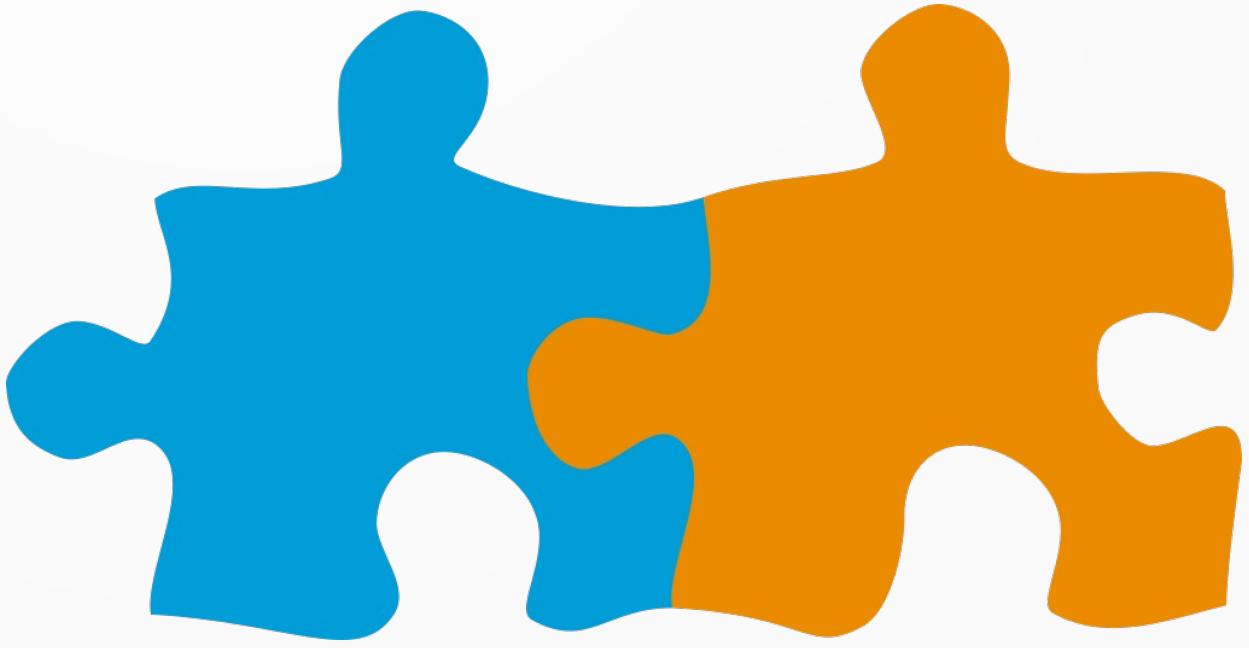


GRUB Loading Kernel



Take Away

- Providing UEFI in U-Boot as a standardized API allows for easy integration with other software



Implementation Events

- U-Boot is single threaded
- No interrupts supporting networking, timers
- ➔ Call event handling routines in
  - console routines
  - network routines
  - CheckEvent(), WaitForEvent(), RestoreTPL(), Stall()

Integration of UEFI sub-system

- U-Boot is in the middle of moving from legacy drivers to a device tree based driver model
- UEFI sub-system sits on top of U-Boot rather than being integrated into U-Boot driver model

Development Targets

- Support subset of UEFI specification
  - Embedded Base Boot Requirements (EBBR)
    - Boot services
    - Run time services
    - Required elements according to UEFI 2.8, chapter 2.6
- Stay small
  - 31000 lines, ca. 70 kiB in U-Boot binary

Achievements in 2019

- Missing boot services added
- Major improvements in UEFI standard compliance
  https://github.com/U-Boot-EFI/u-boot-sct-results
- U-Boot runs EFI shell on ARM, x86, x86_64
- U-Boot runs EDK II SCT on ARM, x86

Work in Progress

- Verified UEFI Boot via FIT images
  Cristian Ciocâltea
- UEFI Secure Boot
  Takahiro Akashi (Linaro)
- EFI_RNG_PROTOCOL based on hardware RNG
  Sugosh Gani (Linaro)