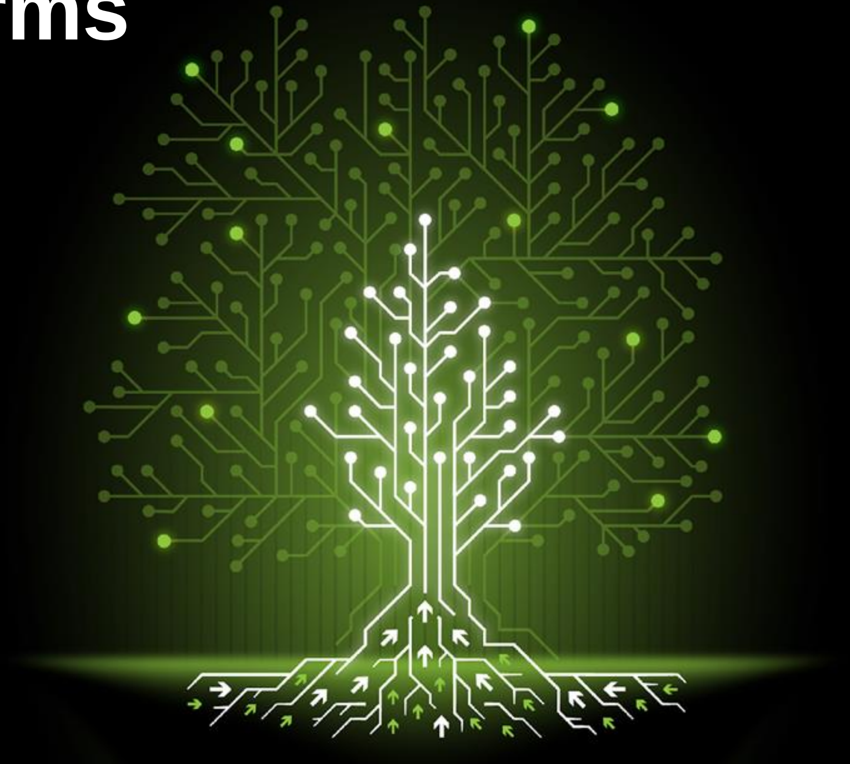
Universal Payload for Optimized Firmware Handoff in Server Platforms

Lean Sheng Tan, Lead, 9elements
Vincent Zimmer, Senior Principal Engineer, Intel



Scaling Innovation Through Collaboration

OCP GLOBAL SUMMIT

OCTOBER 17-19, 2023
SAN JOSE, CA

Open System Firmware (OSF)

OPEN SYS FW

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The paradox of choice with OCP OSF

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- Challenges of firmware development
- Growing customer demand with various open source platform code solutions and boot environments/payloads
- Closely coupled platform firmware design & code for some solutions

- Higher effort/cost + low reuse + longer Time-to-Market
- Porting effort from platform to platform
- Re-development effort from different bootloaders

How to address the paradox?

Overview

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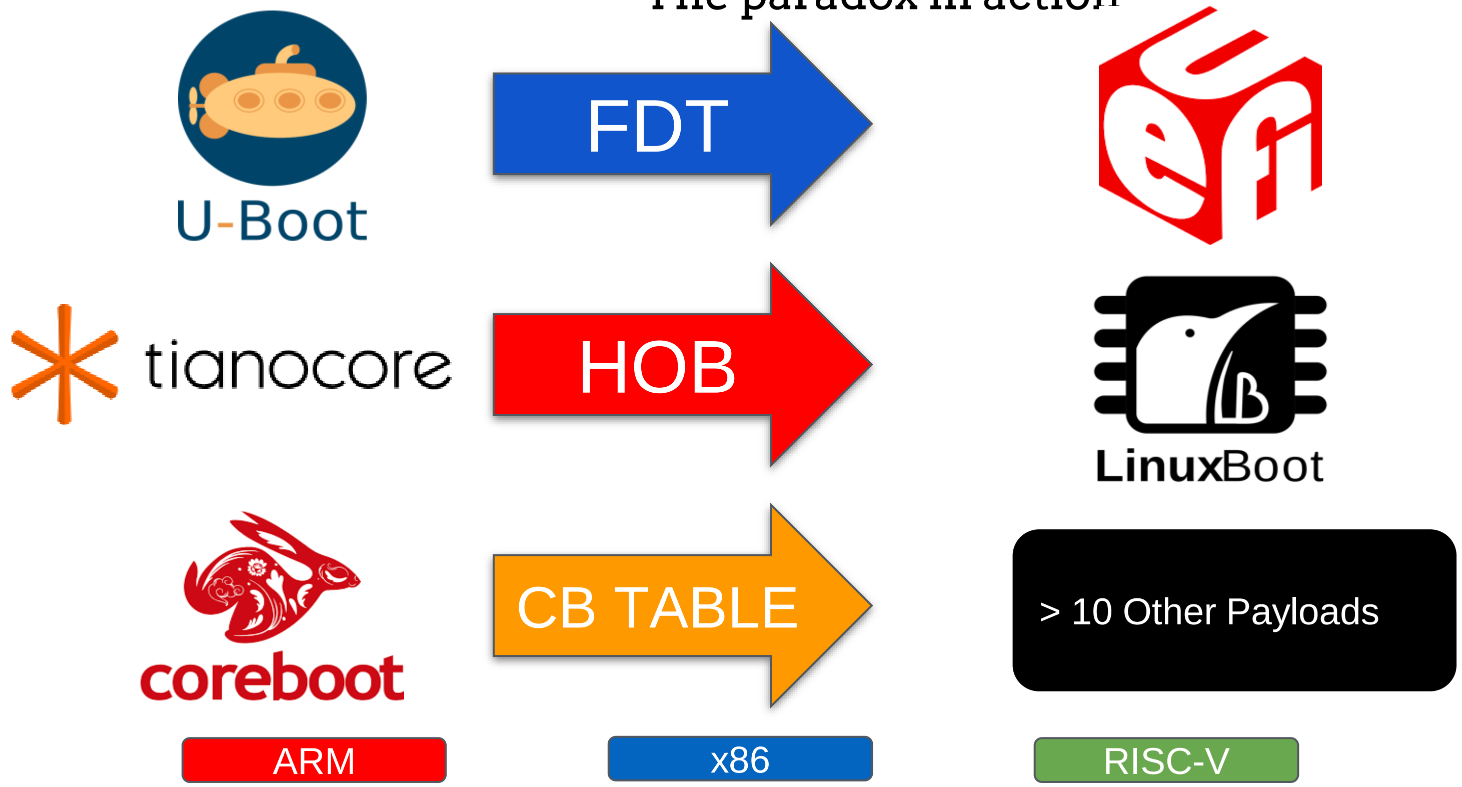
The paradox in action



Make firmware ~~great~~ SIMPLE again

U-Boot

tianocore

coreboot

UPL

LinuxBoot

> 10 Other Payloads

ARM

x86

RISC-V

Universal Payload = the "USB" of OSF world

Solutions?

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- Aspects of a payload - how to encapsulate and how to invoke
- On the latter, what information to pass in to decouple platform init from the payload phase
- Options for information/data to pass in evaluated include:
- Use coreboot tables
- Use HOB
- Protobufs, CBOR https://www.youtube.com/@universalscalablefirmwarec534/videos
- Invent a new mechanism that
  overcomes the limitations
  of HOB & coreboot tables
- …

Problem statement on data passing

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coreboot tables

- Very old (LinuxBIOS): LB_TAG_xxx
- Payload handoff of data that cannot be probed from the hardware
- GPL v2

UEFI HOB

- Some HOB structs contain fields which are specific for Edk2 DXE
- 64K limit - 2 byte size entry
- 16 byte GUID instead of tag number

Not self describing!

Expectations of a Universal Payload Handoff Design

1. **self-describing**
2. **Not bounded by any single language**
3. example of data:
   - memory map
   - buildtime information like tooling, version,
   - pointer to memory console
   - uart to use for debug
   - framebuffer
4. Smooth transition/ **lightweight** introduction
   - edkII, coreboot, U-Boot, Linuxboot, SeaBIOS, etc

Broaden the scope & !reinvent the wheel

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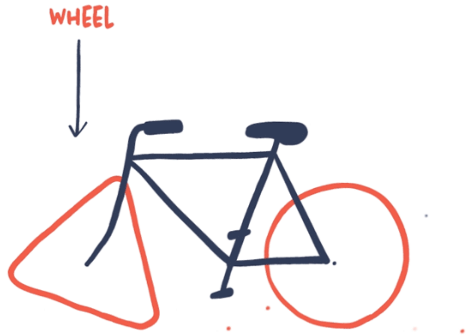
- This is not just limited to payload
  - Other binary interfaces (e.g. OpenSBI, FSP)
- This is not a new issue and has already been solved

Whats the best ‘wheel’ for this firmware usage?



Flattened devicetree (FDT)

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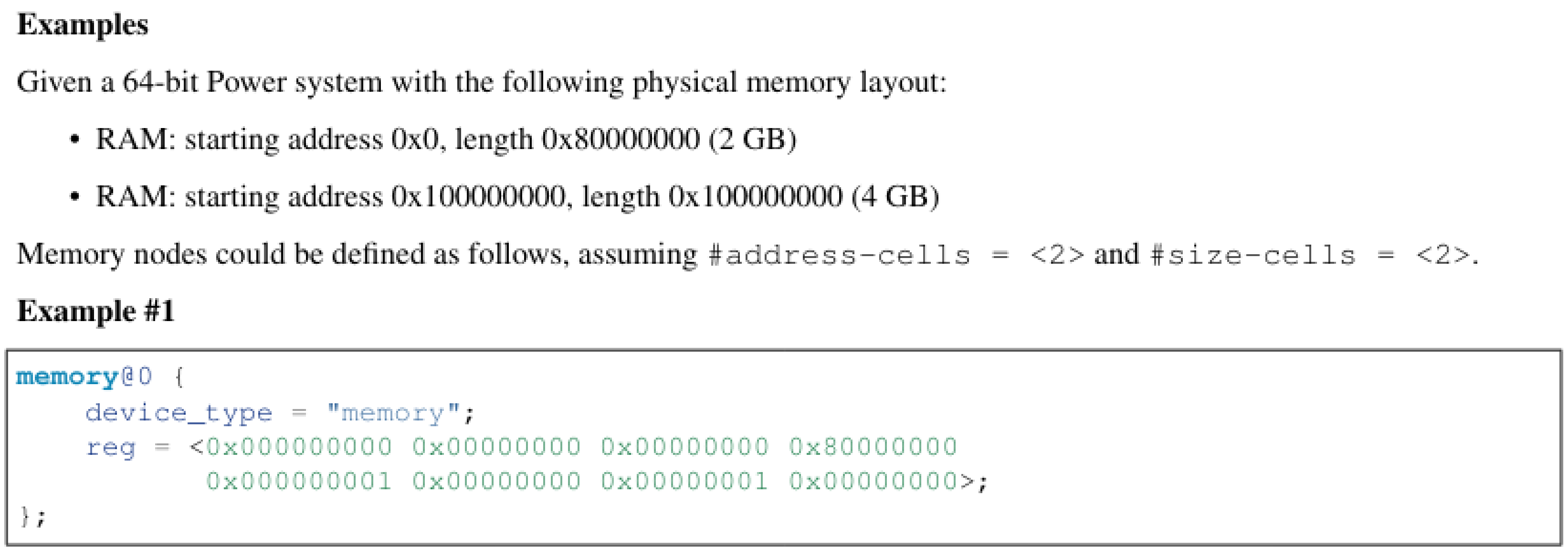
- devicetree.org
- Library exists in EDKII, coreboot, U-Boot
- Describe the hardware and pass control
- Libraries available in a lot of languages
- Binary & plain text format
- Rich usage across embedded firmware, RTOS, OS
- Live binding document

Flattened devicetree (FDT) example



Examples

Given a 64-bit Power system with the following physical memory layout:

- RAM: starting address 0x0, length 0x80000000 (2 GB)
- RAM: starting address 0x100000000, length 0x100000000 (4 GB)

Memory nodes could be defined as follows, assuming `#address-cells = <2>` and `#size-cells = <2>`.

Example #1

```
memory@0 {
    device_type = "memory";
    reg = <0x000000000 0x00000000 0x00000000 0x80000000
           0x000000001 0x00000000 0x00000001 0x00000000>;
};
```

POC

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- Flow
  - Buildtime create of devicetree structure
  - Unpack devicetree
  - Apply fixup on nodes
  - Pack it again
  - Pass a pointer to the payload
  - Payload parses devicetree using existing libraries

- Fields definition for FDT: reuse Zhiguang's work

- Patches
  - https://github.com/ArthurHeymans/coreboot/tree/coreboot_fit_for_edk2
  - https://github.com/ArthurHeymans/edk2/tree/POC_FDT

Example UPL? EDKII payload

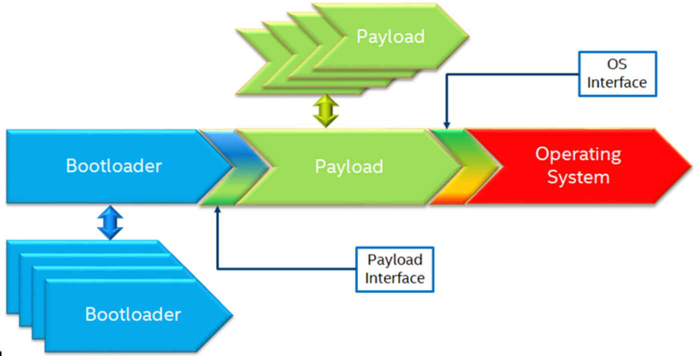
Tianocore: Support FDT library. · tianocore/edk2@10416bf (github.com)

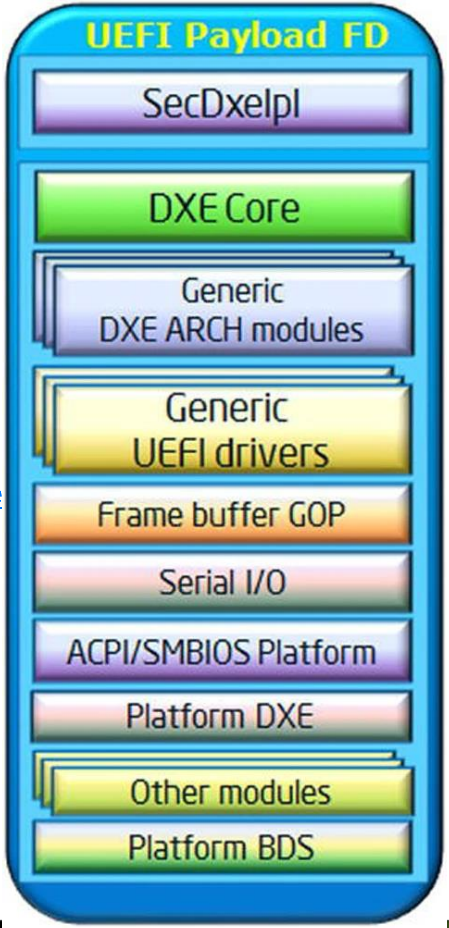
MdePkg: Support FDT library. · tianocore/edk2@5d58660 (github.com)

History for UefiPayloadPkg - tianocore/edk2 (github.com)

….

images from Intel FSP and UEFI Integration | SpringerLink &
An evolutionary approach to system firmware :: Open Source Firmware Conference 2021 :: pre





Future, replace UPDs in FSP?

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```
/** Offset 0x0B26 - Frequency Limit for Mixed 2DPC DDR5 1 Rank 8GB and 8GB
  Frequency Limit for 2DPC Mixed or non-POR Config. 0: Auto, otherwise a frequency
  in MT/s, default is 2000
**/
  UINT16                                    FreqLimitMixedConfig_1R1R_8GB;
```

- Not Flexible: Header mismatch?
- Not Scalable: 1 struct for all IPs/ configurations
- Not Reusable: each FSP has a new UPD

FSP usage with FDT

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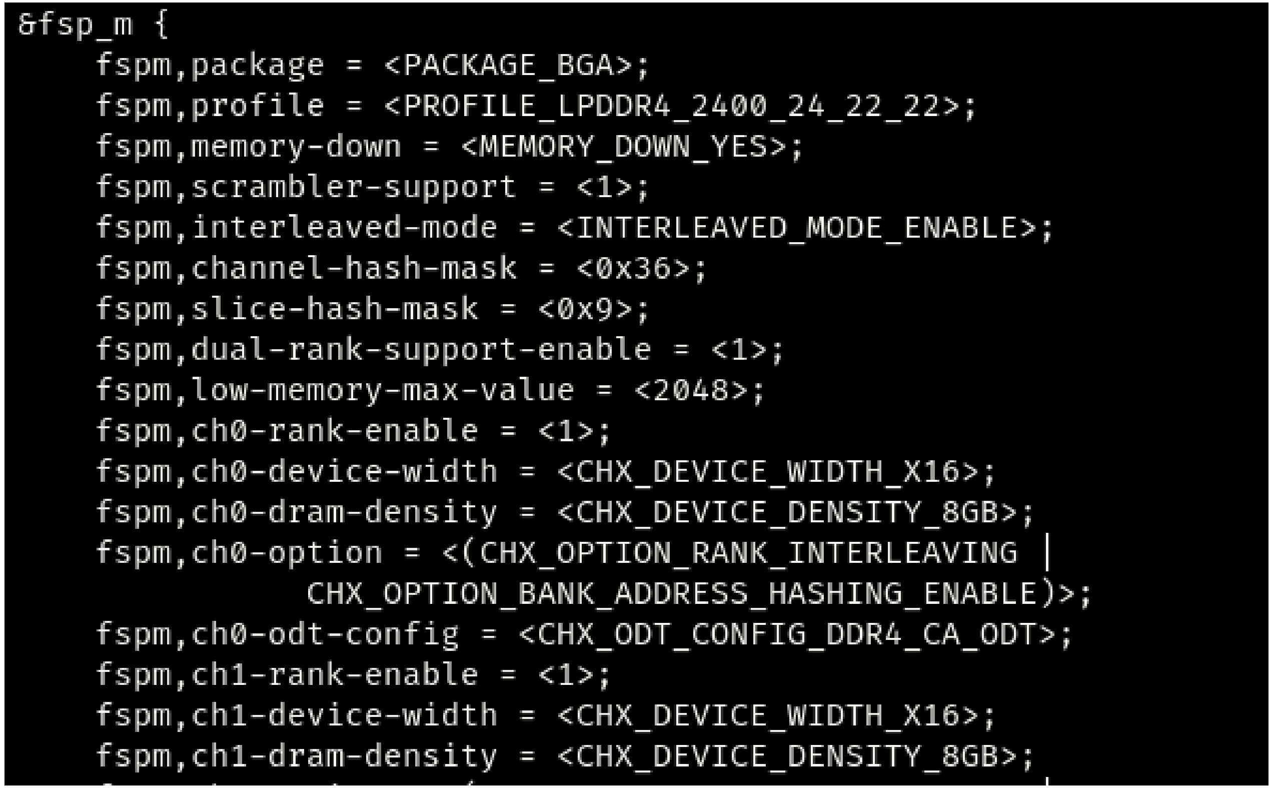

```
&fsp_m {
    fspm,package = <PACKAGE_BGA>;
    fspm,profile = <PROFILE_LPDDR4_2400_24_22_22>;
    fspm,memory-down = <MEMORY_DOWN_YES>;
    fspm,scrambler-support = <1>;
    fspm,interleaved-mode = <INTERLEAVED_MODE_ENABLE>;
    fspm,channel-hash-mask = <0x36>;
    fspm,slice-hash-mask = <0x9>;
    fspm,dual-rank-support-enable = <1>;
    fspm,low-memory-max-value = <2048>;
    fspm,ch0-rank-enable = <1>;
    fspm,ch0-device-width = <CHX_DEVICE_WIDTH_X16>;
    fspm,ch0-dram-density = <CHX_DEVICE_DENSITY_8GB>;
    fspm,ch0-option = <(CHX_OPTION_RANK_INTERLEAVING |
               CHX_OPTION_BANK_ADDRESS_HASHING_ENABLE)>;
    fspm,ch0-odt-config = <CHX_ODT_CONFIG_DDR4_CA_ODT>;
    fspm,ch1-rank-enable = <1>;
    fspm,ch1-device-width = <CHX_DEVICE_WIDTH_X16>;
    fspm,ch1-dram-density = <CHX_DEVICE_DENSITY_8GB>;
```

Future Aspect

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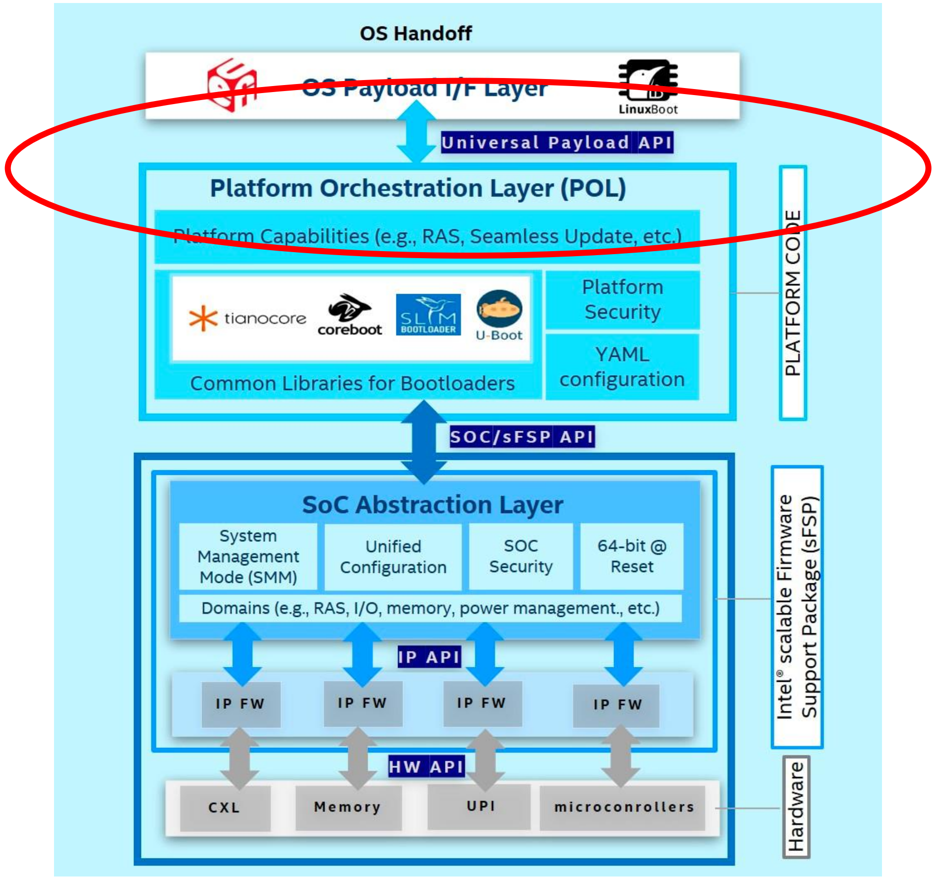
one full firmware stack example with UPL in practice

- OS Handoff Interface
- SoC Universal API design for Silicon code



Timeline - where are we now

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Time	Agenda
March '22	Initial Discussion with community members (EDK2, coreboot, oreboot, etc)
April' 22	Meetings with different communities & industries exploring CBOR, collect feedbacks
July '22	Exploring FDT as a better solution
Aug '22	Consensus reached among key contributors from each communities to proceed with FDT
Sep '22	OSFC presentation for broader feedback
Aug '23	Initial spec draft for feedback; planning for code patches land on edk2, coreboot, LinuxBoot
Nov '23	Finalize Handoff Spec 1.0

Conclusion

- Open development!

- cross communities collaboration
  - good willing people, gesture of trust
  - u-boot, edkII, coreboot
  - By community, for community

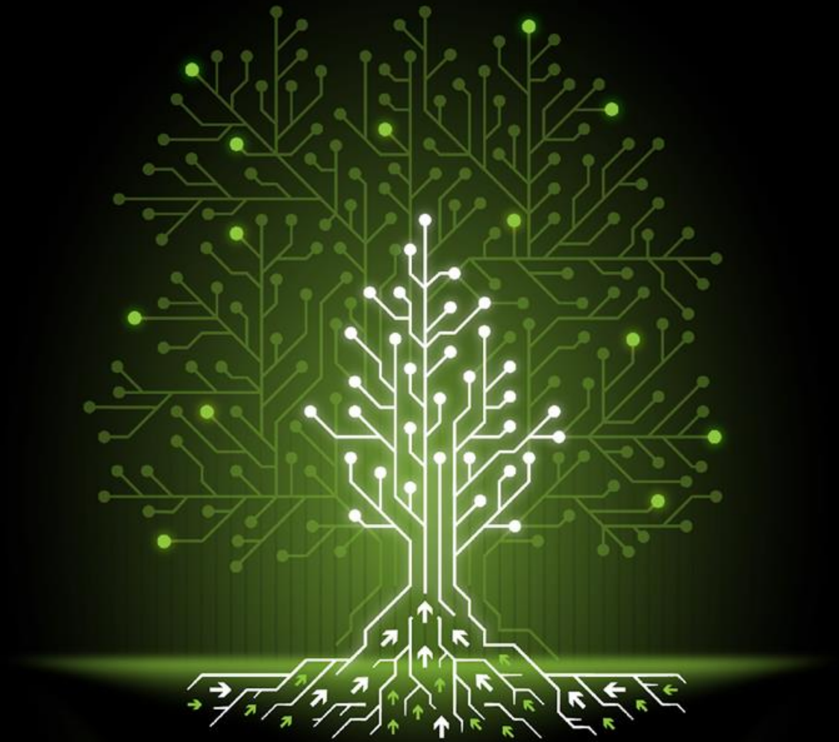
- light-weight industrial wide solution
  - small integration ‘fees’
  - reusable & adoptable
  - self-describing!

Call to Action

- Join upcoming OSF OCP call on this topic

- Check out and contribute to the specification
  - Latest specification link: https://github.com/UniversalPayload/spec

Open Discussion



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