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American Megatrends

Tailoring TrustZone as SMM Equivalent

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Agenda

- Introduction
- ARM TrustZone
- SMM-Like Services in TrustZone
- Summary

Introduction

Introduction

- System Management Mode (SMM) was introduced on IA over 20 years ago
- Initially developed to handle power management and system critical events, it has evolved
  - SMM is used as a OS agnostic runtime firmware execution environment
  - Many OEM proprietary features require SMM
  - SMM is required to implement UEFI SecureBoot and NIST 800-147 secure flash on IA
  - SMM is even isolated from operating system access

Moving to New Architectures

- As OEMs look to move to other architectures like ARMv8-A, how do they create a secure platform feature set?
- Solution needs to be as flexible as SMM and offer the same or higher level of security
  - When possible, solution should leverage high-level PI SMM interfaces to simplify porting to new architectures
- A working solution can be built on top of ARM TrustZone

ARM TrustZone

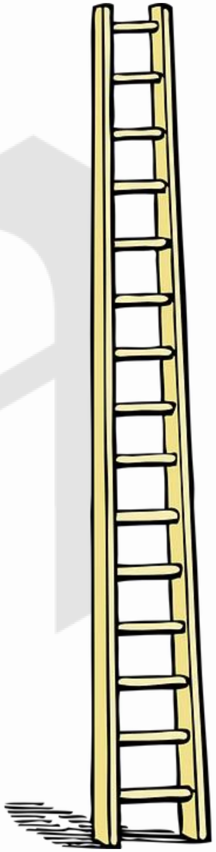
ARM TRUSTZONE

System Security

- ARM TrustZone technology is available for many years.
- Various security applications on top of it:
  - Key protection
  - DRM
  - Electronic Payment
  - PIN Code Verification
- The ARM TrustZone architecture provides a hardware based security isolation enabling a secure world for
  - Trusted Code
  - Secure Interrupts
  - Secure Peripherals

Exception Levels Definitions

- **EL0:** The lowest exception level. Used to execute user application in Non-secure state.
- **EL1:** Privileged exception level. Used to execute operating systems, in Non-secure state.
- **EL2:** Hypervisor exception level. Used to execute hypervisor code, in Non-secure state.
- **EL3:** Secure Monitor exception level. Used to execute secure monitor code, which handles the transitions between Non-secure and Secure states. EL3 is in Secure state.
- **S-EL0:** Used to execute trusted application code in Secure state.
- **S-EL1:** Used to execute Trusted OS code in Secure state.



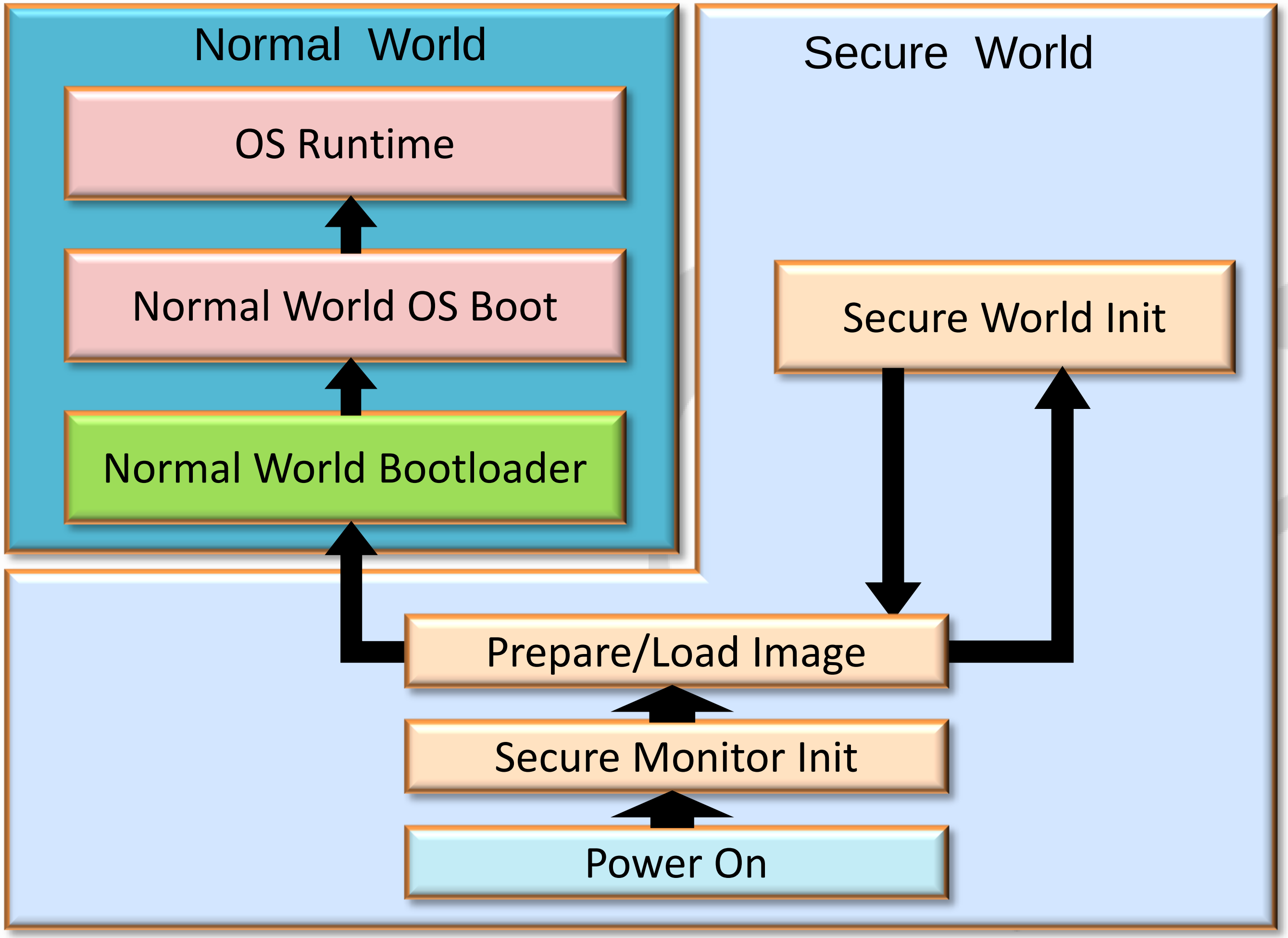
TrustZone Software

- ARM Trusted Firmware (ARM TF) is an open source reference implementation for EL3 software
- ARM TF intends to reduce duplicate effort by providing a single framework with:
  - EL3 Software
  - Multi Stage Authenticated Boot
  - PSCI (Power State Coordination Interface)
  - Trusted OS Interface

OP-TEE
(Open Source Portable - TEE)

- OP-TEE is an open source TrustZone based TEE solution
- OP-TEE act as one Secure Operating System which provides various API in secure world for trusted applications
- Available on GitHub

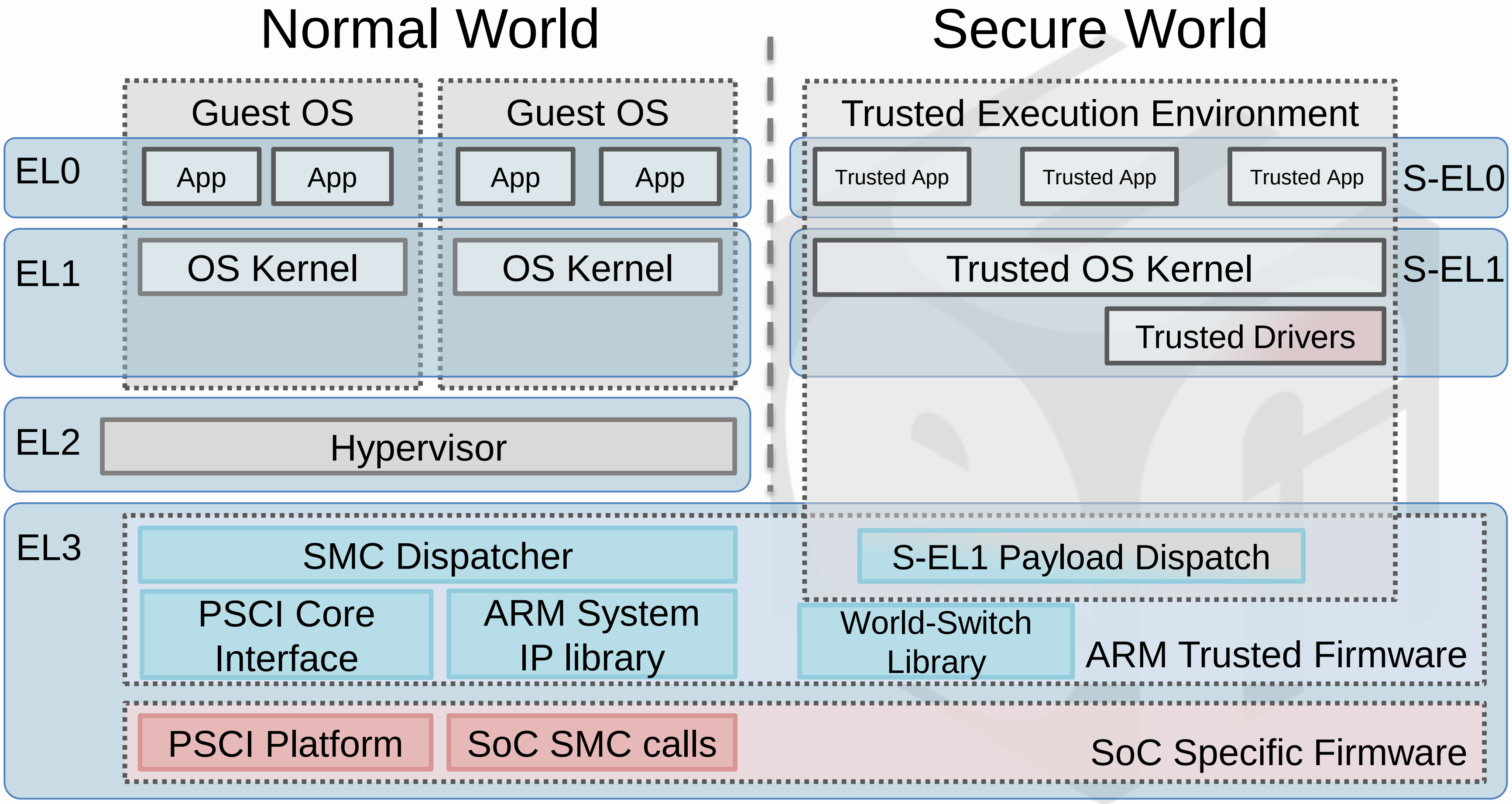
Typical Boot Sequence



Exception Levels

- Similar to IA, ARM provides different execution privilege levels
  - Traditional IA offers Ring 0 (Most Privileged) to Ring 3 (Least privileged)
  - ARMv8-A provides EL0 (Least Privileged) to EL3 (Most Privileged)
- Firmware and OS designers should make use of these ELs to isolate critical code from attacks by malicious software

Typical System Block Diagram



Normal/Secure World Communication

- Normal world applications need a way to communicate with the secure world in certain cases
- Normal world application can generate exceptions to transfer control to monitor mode software, which performs context switching to switch to secure world
- The exceptions can be hardware or software based
  - SMC (Secure Monitor Call) is a software based exception

UEFI Security Implementation Samples

- UEFI NVRAM Services are a runtime service that are trusted and secure services
  - TrustZone offers the opportunity for firmware developers to protect services like NVRAM
  - TrustZone offers the opportunity for hardware developers to limit access to critical hardware like SPI controllers by non TrustZone code
- To further secure platforms, each TrustZone piece of code should be developed to work at the lowest possible Exception Level
  - Only use EL3 when necessary, try to keep all code as S-EL1 or lower

SMM-Like Services in TrustZone

ARM vs IA

	TrustZone	SMM
Secure Memory Blocks	Secure Memory Region	SMRAM
Secure Mode	EL3/S-EL1/S-EL0	SMM
Enter Secure Mode via	SMC or Secure Interrupt	SMI

- Secure Memory Region: Can be one or multiple blocks.
- SMC: Secure Monitor Call
- Secure State: Exception Level of CPU

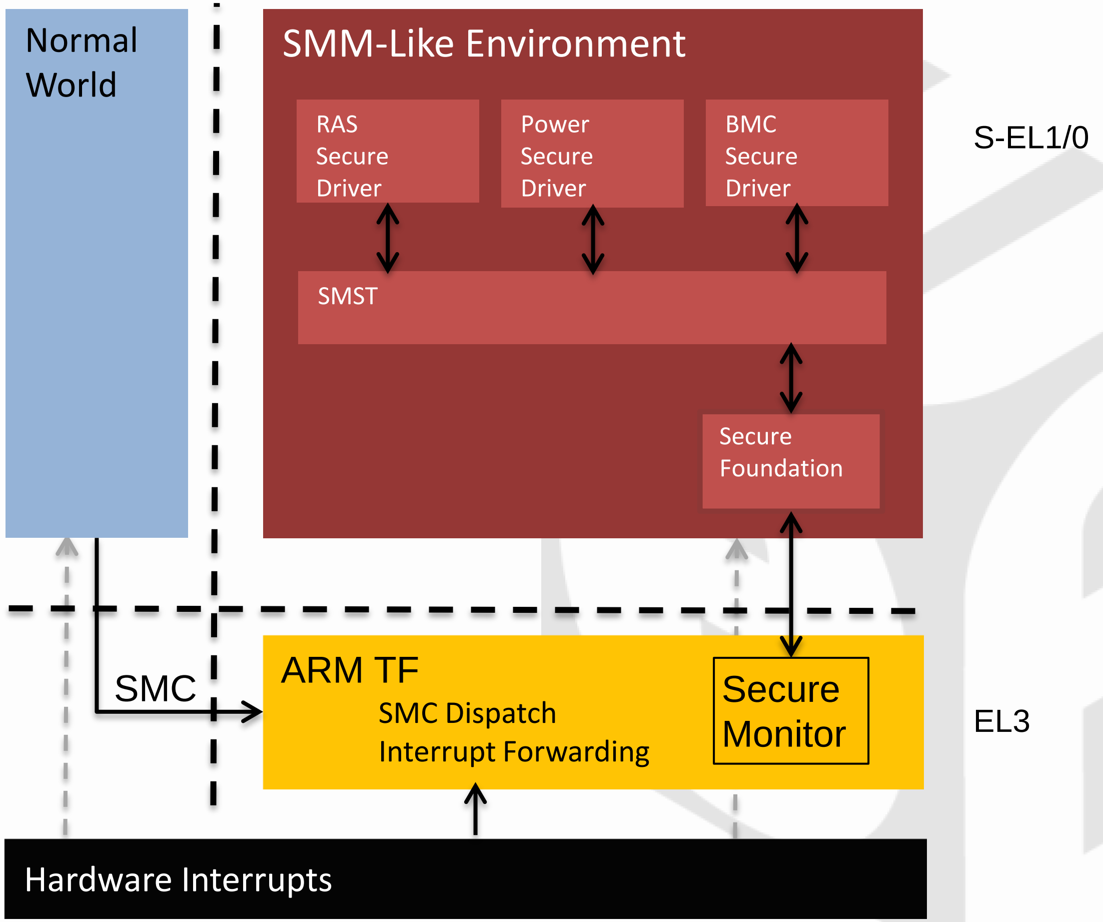
SMM Core/Services Integration

- On IA, once SMM is initialized, there needs to be a way to add code to this region
  - Many different OEM methods exist that make use of SW SMIs
- On ARM we need an equivalent!
  - Add SW provisioning interface within ARM TF to load SMM-like core/services

UEFI SMM Drivers/Protocols

- UEFI SMM Drivers/Protocols need TrustZone approaches:
  - UEFI SMM Drivers
    - SMM Core
    - SMM IPL
  - UEFI SMM Protocols
    - SMM Access
    - SMM Control

SMM as a Secure Payload

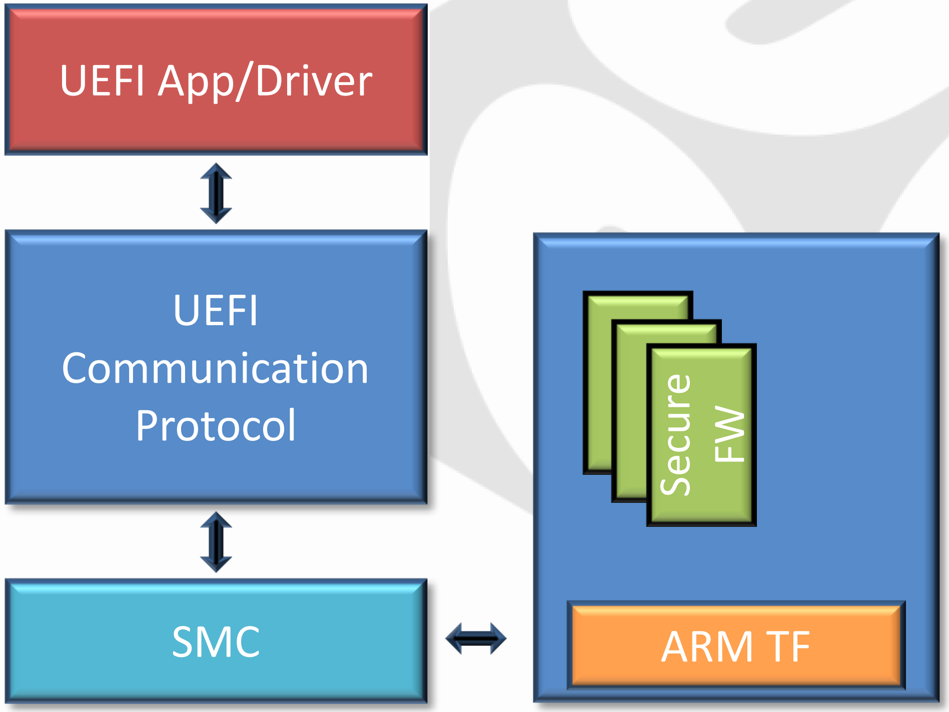


Requirements

- UEFI SMI Services should be registered through ‘SmiHandleRegister’ function of SMST (System Management System Table)
- Secure memory region of TrustZone is protected before giving control to UEFI
  - The only way to access the secure memory region during UEFI is by switching to Secure World

UEFI SMM Services Invocation

- UEFI SMM Communication Protocol provides a way for UEFI drivers to invoke secure services in TrustZone.

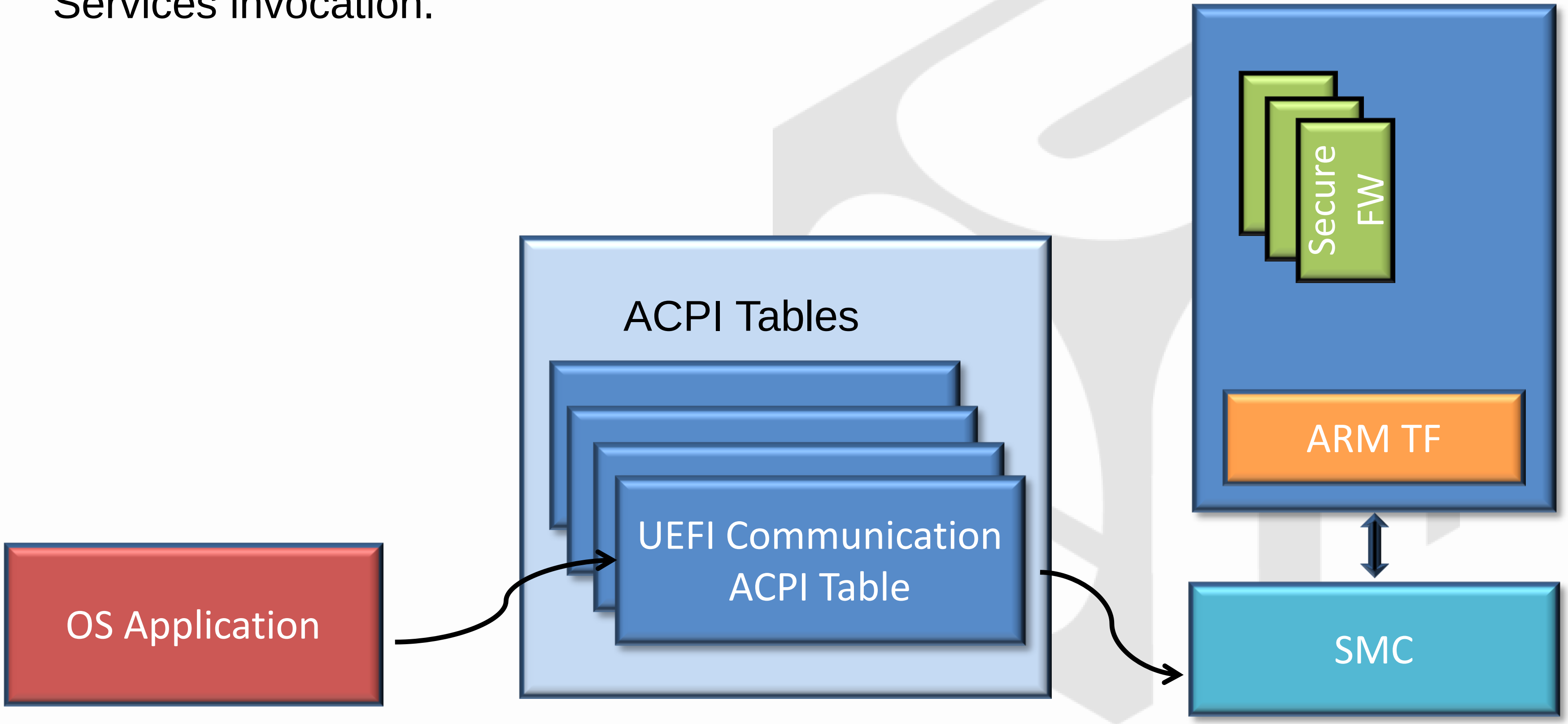


OS Interface

- On IA systems, SMM is invoked by writing to an IO port
  - On some ARM based systems, an MMIO location can be used to invoke TrustZone services
- The UEFI specification was extended in 2.6 to include support non-IO based invocation of secure services
  - On ARM, SMM-like TrustZone Services can be invoked by OS agent

Invocation Path

UEFI ACPI Table adds one new field ‘Invocation register ’ for Secure Services invocation.



Summary

Summary

- Despite the differences between SMM and TrustZone architectures, similarities allow TrustZone to be used as PI secure environment
- PIWG and ABST are the main groups that work on specifications regarding these topics
  - **Interested parties are encouraged to join the conversation in PIWG and ABST!**
- OEMs should pay attention to make sure their features easily migrate to new architectures

Join us!

References

- UEFI Specification 2.6
- UEFI Platform Initialization Specification 1.4
- ARM Trusted Firmware
- ARM Security Technology – Building a Secure System using TrustZone Technology
- Trusted Base System Architecture (TBSA)
  Trusted Board Boot Requirements (TBBR)
  TrustZone Media Protection Architecture (TZMP)

Q&A

Thanks for attending the UEFI Spring Plugfest 2016

For more information on the Unified EFI Forum and UEFI Specifications, visit http://www.uefi.org

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