Firmware Use Case

Scope

This document aims to confirm that the SCITT building blocks and threat model satisfy the use case requirements. It is not intended to be all-encompassing across all aspects of the hardware supply chain. Instead, it introduces the topic and highlights unique properties that warrant investigation in the working group and may influence the final architecture document. Ultimately, implementations will make final design decisions (e.g., storage/network architectures, standards/policies, artifacts, signatures, endorsements, claims) based on their mission needs while meeting the interoperability objectives of SCITT.

This use case is scoped to device firmware. Device firmware loads and operates starting at the device's "reset vector", performs dedicated functions such as device initialization, then loads the starts the Operating System (OS). These functions are dedicated to the operational characteristics of the device. They typically perform initialization functions such as memory configuration that are needed prior to the OS and OS Present drivers. Firmware loads and executes outside the scope and visibility of the Host Processor and the Operating System.

Firmware, while serving a specialized function is typically developed and operates as "traditional" software. It is developed and provided by the Device manufacture. Distribution and installation is done using Device Manufacturer specialized operations -- typically call a Firmware Update.

This use case will focus on devices commonly called the "PC Architecture". These are based on the x86 CPU, UEFI Boot architecture, and commonly available Operating Systems such as Windows or Linux. While the term PC implies "Personal Computer" this architecture is common to several device classes such as networking equipment, servers, industrial controller (e.g., a PLC) etc.

Simple Device Firmware:

This use case considers a simple device with only firmware for the device's host (aka Application processor). In this use case, this firmware is called the "Host Firmware". The Host Firmware is responsible for boot strapping the device's host processor, memory, its peripherals and other components needed by the Host Processor. The Host Firmware may also contain runtime components that execute transparently the Host Processor. Examples of runtime executables are SMM drivers on X86 class devices and TrustZone on ARM class processors. Example devices in this use case are Personal Computers, servers, network equipment, etc.

> This distinction is to enable a more detailed or complex Use Case were firmware within individual components of the Device is considered. The more complex use cases will rely, no depend, on this one.

Terminology

Use Case: Simple Device Firmware

Description

As much of the device's hardware components (CPU, memory, IO Hubs, etc.) are now commodity and standard, most device manufacturers start Host Firmware development using commonly available 3rd party libraries, typically from sources outside the manufacturer. These are Independent BIOS Vendors (IBVs). The IBV packages also have common components which IBV's may obtain from their outside sources. For example, firmware may contain cryptographic modules used to verify other components or updates. Another example may be a network stack used to remotely boot the device such as PXE boot. Modules to perform these functions may be bundled into the IBV's larger package when delivered to the device manufacture.

Boot Sequence

The Host Firmware may be comprised of several discrete firmware modules loaded and executed during the various phases of the initial boot cycle. Using a common X86 architecture as an example, the boot phases and firmware modules are:

Ref	Boot Cycle	Firmware Module	Function
1	Initial Boot Vector	Boot Vector Code	Performs simple CPU configuration and load next Firmware modules
2	Memory Configuration	Memory Module	Configures memory. This may be supplied by the memory controller manufacturer
3	Load runtime	Runtime module	Load runtime code such as SMM and UEFI runtime executable
4	Full Boot Mode	PXE module	Main module that finds, loads, and executes other device-specific built-in or plug-in modules
5	Execution of Device-specific modules	built-in or plug-in device modules	Pre-boot configuration of a specific device
6	OS Boot	Boot Loader	Finds, loads and executes the OS
7	OS	Operating System	This is the user visible application processor Operating System

Contrast with OS Present Supply Chain Use Cases

OS and Application Supply Chain use cases provide for verification of software *before* it is executed (or even loaded). As Host Firmware loads and executes prior to the OS having the ability to verify it, these HFW (Host Firmware Components) cannot be verified. HFW is transient and cannot be inspected after it executes. It is opaque to the OS after the OS boots. Even the runtime HFW components (e.g., UEFI runtime protocols) are opaque to the OS as they are in protected memory preventing the OS from access it.

> Secure boot is often cited as solving this. In Secure Boot, the HFW component's are digitally signed by an authority (typically the device manufacturer). These signatures are verified during the device's boot sequence. This only provides proof of the origin of the HFW component, not which HFW. For example, if a HFW Component version 1 were signed by the device manufacturer but later found to have a vulnerability, the device manufacturer can release HFW Component version 1.1 to address it. As updating the verification keys in Host Firmware is difficult and risky, HFW Component version 1.1 will be signed by the same keys. The boot firmware will allow either version 1 or 1.1 to load and execute. This fails to support Supply Chain Assurance.

Boot Measurements to support Supply Chain Assurance

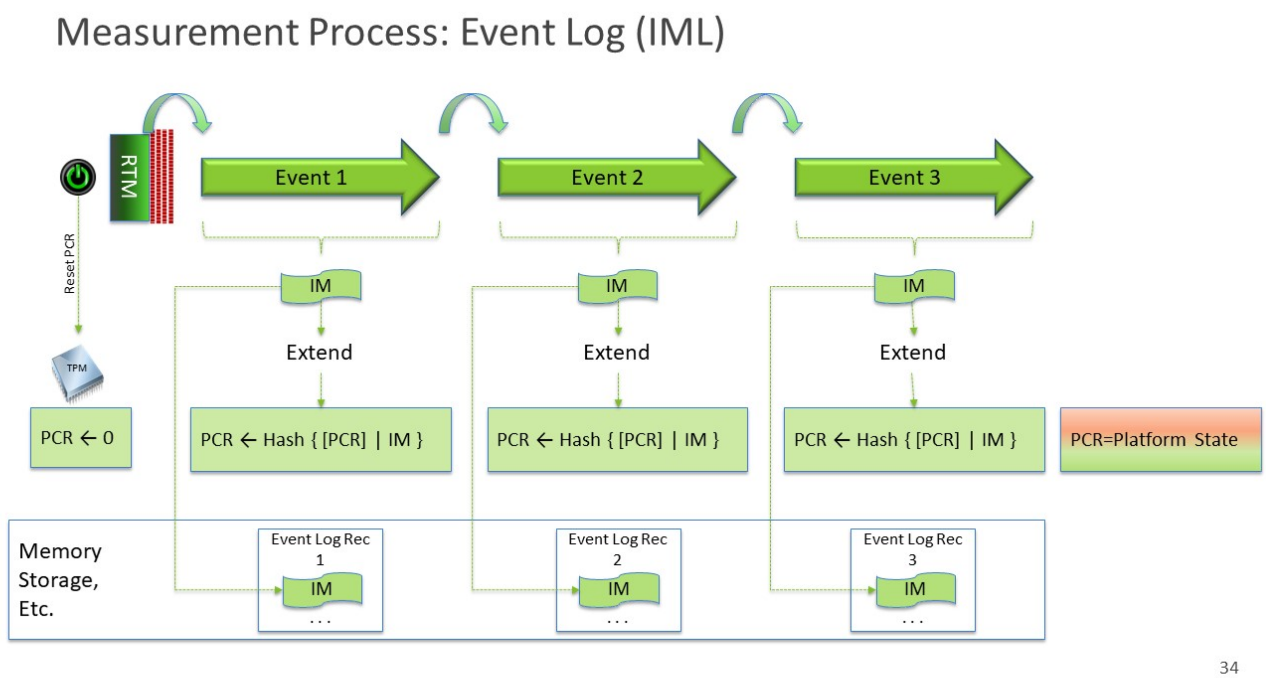
A device equipped with a TPM and HFW supporting measurement using the TPM provides trustable artifacts of the Host Firmware that can be assessed even after they have executed and removed from memory. This is done use Integrity Measurements as depicted in the Figures below.

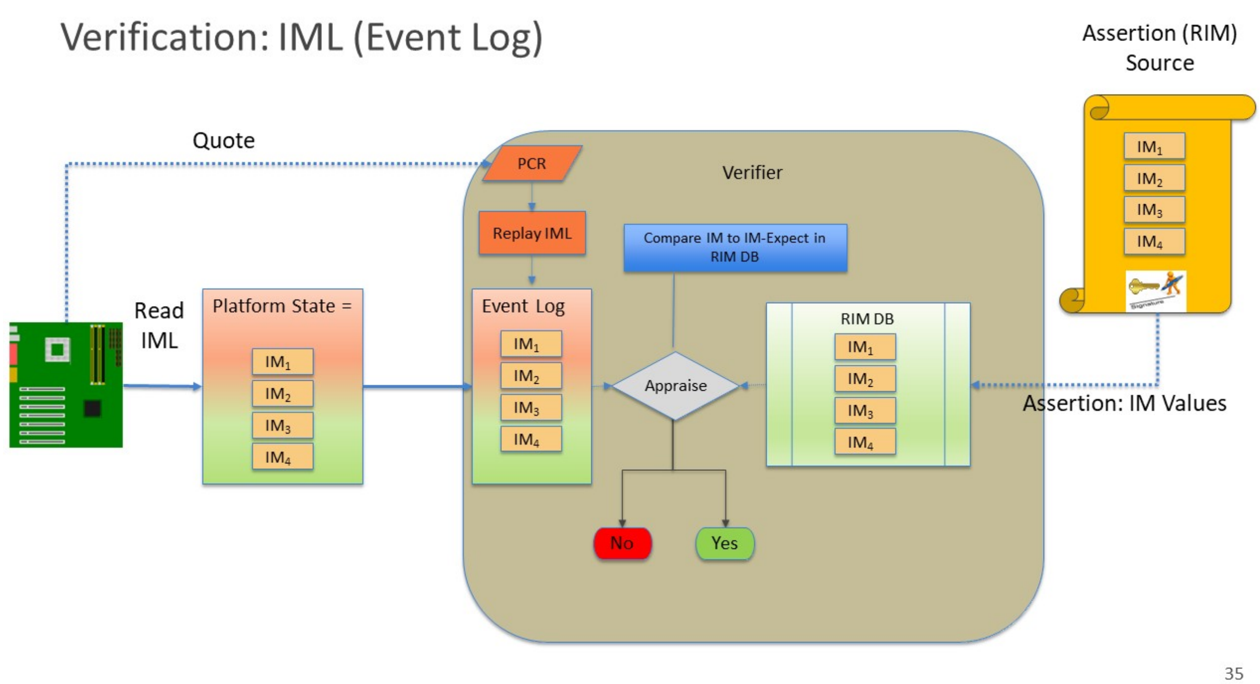
The TPM contains registers called Platform Configuration Registers which have the following properties:

- Each PCR is the size of a hash
- All PCRs are initialized to zero on device initialization
- Starting from the earlies boot component called the Root of Trust for Measurement (RTM) the current component *measures* the next prior to executing it

- A Measurement operation is:
- Hash the next component
- Perform the *Extend* operation on the TPM
    - The TPM, internally, concatenates the current PCR contents with the *Extend* value
    - The new value is hashed
    - The PCR content is replaced with a hash of the new value

> PCR <- Hash{ [PCR] | *Extend* }





This builds a chain of Integrity Measurements representing the all the HFW components executed during the boot sequence.

The PCR is *Evidence* in IETF RATS terminology. For the TPM, it is obtained using a *Quote* operation which digitally signs the PCR using a key trusted by the Verifier.

To provide higher resolution and visibility into the boot sequence, the HFW creates a sequence of each Integrity Measurements. This allows a verifier to examine either the end state or the details of the boot sequence.

> The above is a summary of the PC Client Platform Firmware Profile

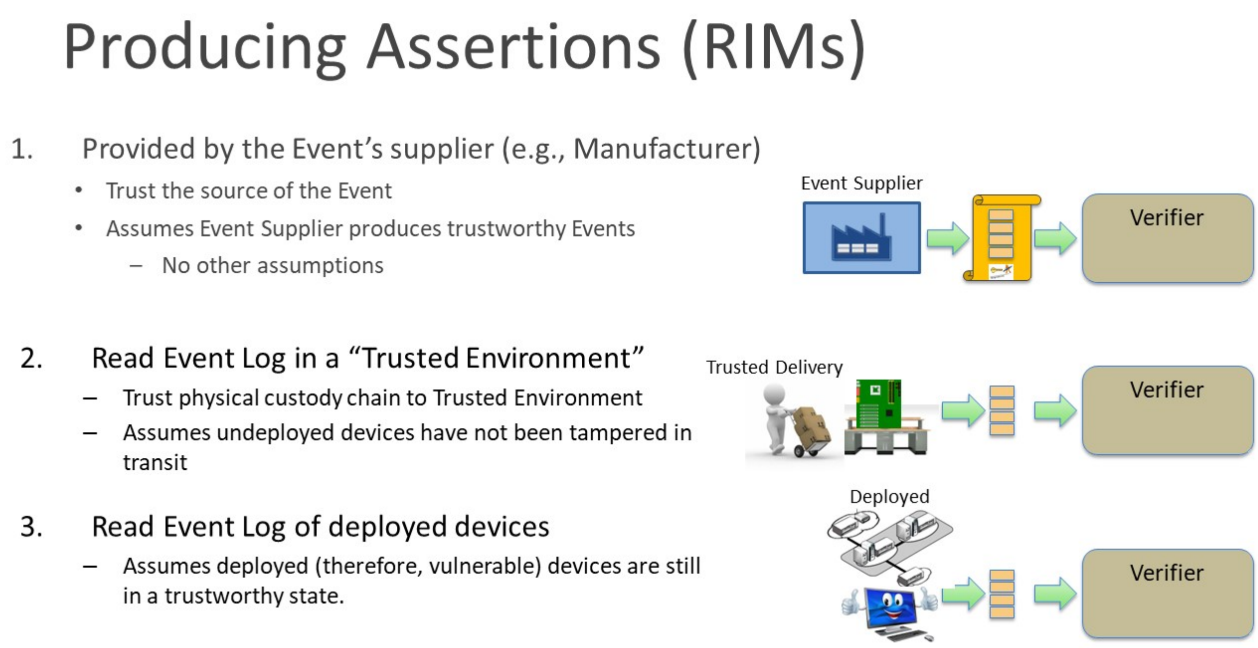
Reference Measurements

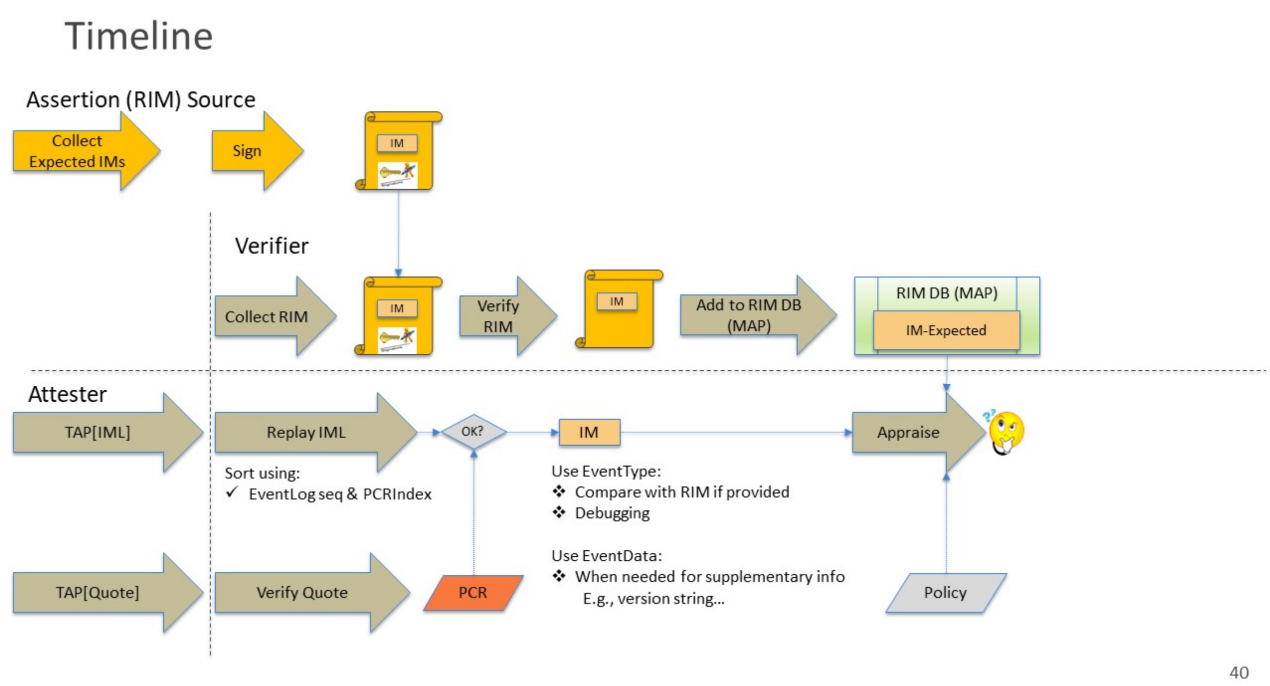
A verifier will need to know the *Expected* values to make an assessment. These are called *Reference Integrity Measurements* or in IETF RATS terminology, *Endorsements*. These are typically provided by the device manufactures in the role of *Endorser* and are digitally signed. The Trusted Computing Group has defined a format for HFW called RIM (Reference Integrity Manifest)

> PC Client Reference Integrity Manifest

The Verifier collects the *Endorsements* (RIMs) then requests the *Evidence* (PCR via a Quote function). The Verifier compares the *Endorsements* against the *Evidence* and makes an assessment.

This is shown in the following Figures.





this is a test

SCITT Use Case

Device Manufacturers often provide several versions of their Firmware to improved functionality, address flaw, or vulnerabilities. Some versions may impact the Device's performance and trustworthiness in different ways in different applications. Using SCITT, consumers can obtain 3rd party assessments of the potential impact of various firmware versions distributed.

SCITT may also provide a means for parties other than the Device Manufacturer to provide RIMs. The information to generate a RIM is obtainable by a standard set of utilities. For example, a 3rd party can make system calls in both Windows and Linux operating systems to read the PCRs and the Event Logs. This can be done using what the 3rd party considered a "trusted environment". A RIM can be built and signed by that 3rd party. This may be an end user or the receiving IT department. This information can be put onto a SCITT-based repository for others to compare and consume.