Using the TPM to Solve Today's Most Urgent Cybersecurity Problems

May 20, 2014 10:00AM PDT

Webinar Logistics

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Today's Presenters

Stacy Cannady, Technical Marketing – Trustworthy Computing, Cisco

Stacy Cannady, CISSP, is technical marketing - Trustworthy Computing TRIAD (Threat Response, Intelligence, and Development) for Cisco and a member of the Trusted Computing Group's Embedded Systems Work Group. He also serves as the primary board member representing Cisco.

Stacy has worked in the field of trusted computing for a number of years. As a subject matter expert in trusted computing, his responsibilities require an in-depth understanding of the trusted computing market, including advances in hardware and software security as well as vendor and customer market dynamics.

Monty Wiseman, Security Architect, Intel Corporation

Monty is a Security Architect for Intel's Data Center Group (DCG). His current projects include architecture for TCG, Intel's TXT(R) Technologies, Boot Guard(R) and other security initiatives.

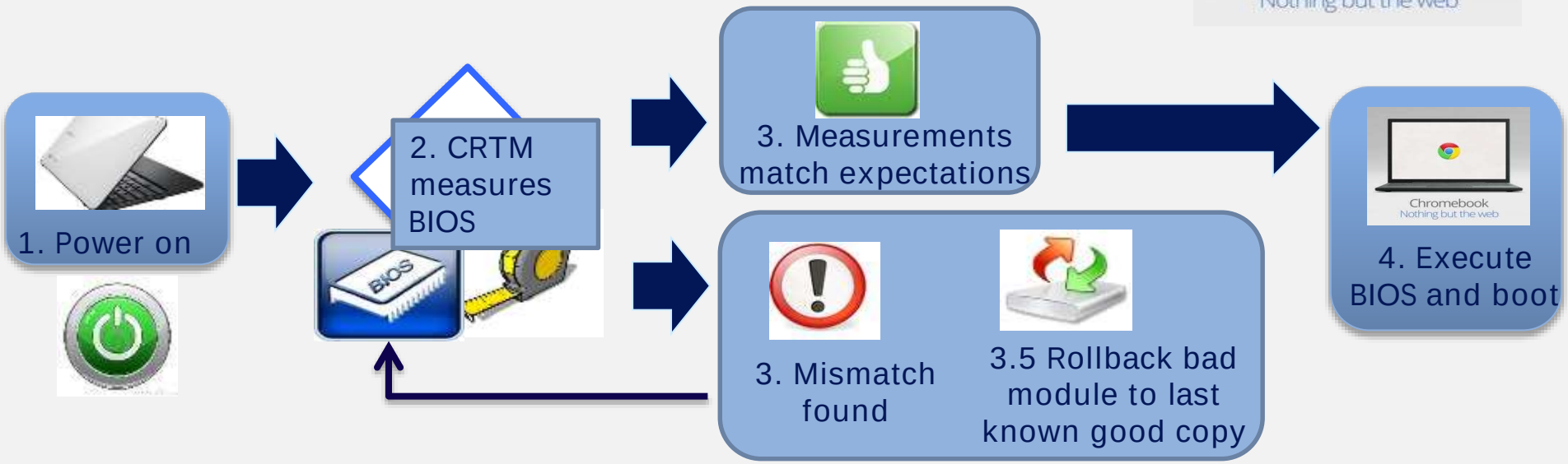
Monty has participated (for chair of) the TCG PC Client working group, Security Evaluation working group and is Intel's representative in the TCG Technical Committee. Monty has 20 years' experience in Desktop, Network and Mainframe environments holding security related and other engineering positions at Novell, Fujitsu, and Control Data. Monty has been developing hardware and software for computers ranging from mainframe to microcomputers since 1975.

Use Cases

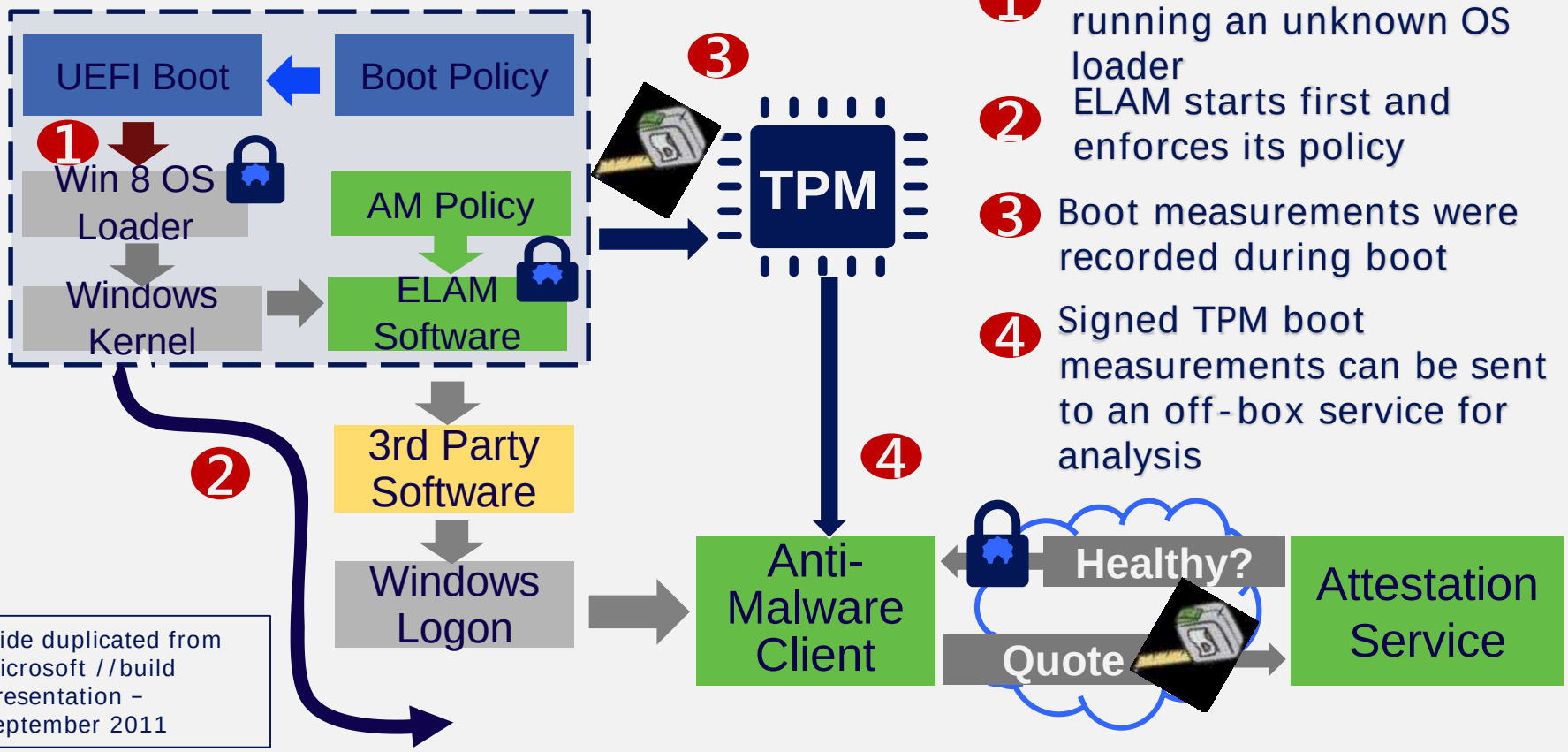
Show Me! Who uses a TPM and how do they use it?

Google's Chromebook – Using TPMs to Self-Correct

- TPM and Core Root of Trust for Measurement (CRTM) measure BIOS at boot
- Measurements are internally verified
- If a mismatch is found, the offending module is rolled back to the Last Known Good
- Then boot continues



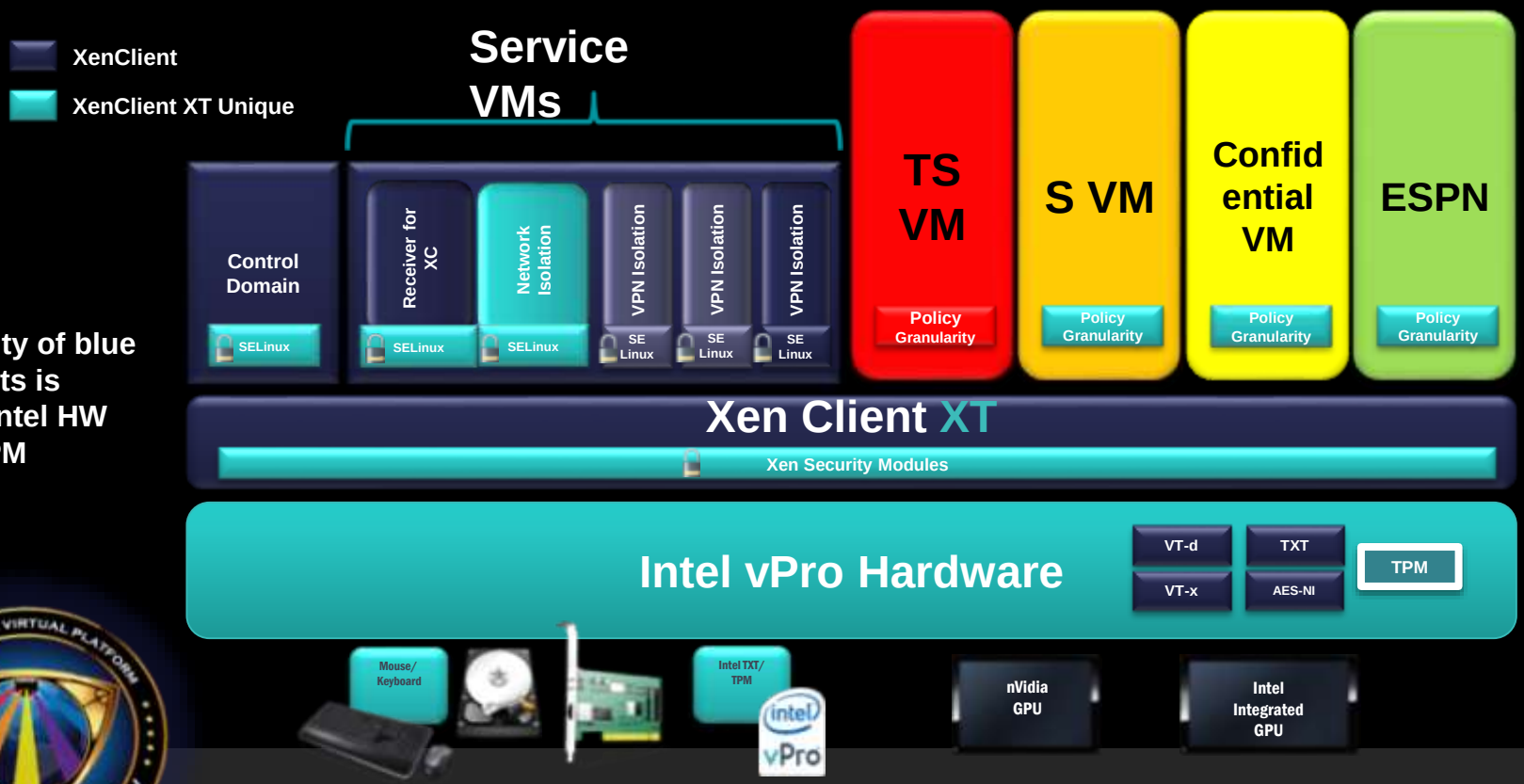
Windows 8 TPM Usage



1. Secure boot prevents running an unknown OS loader
2. ELAM starts first and enforces its policy
3. Boot measurements were recorded during boot
4. Signed TPM boot measurements can be sent to an off-box service for analysis

Slide duplicated from Microsoft //build presentation – September 2011

AFRL's SecureView 1.2 Architecture



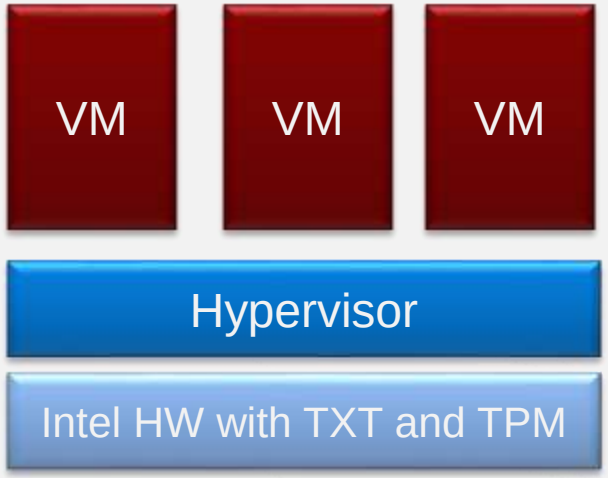
The integrity of blue components is validated Intel HW and the TPM

TPMs and the Cloud

Applying the SecureView Model to Cloud Servers

- **SecureView uses Intel TXT and the TPM to validate BIOS and the Hypervisor at start**
  - You always know you started a trusted Hypervisor and all of its services
  - If one of those services continuously validates runtime integrity, you know the hypervisor remains trusted
- **If VMs are also integrity checked at start, then the VM is also trusted**
  - Same deal – if one of the services in a VM validates runtime integrity, you know the VM remains trusted
- **Defense against zero-day attack: Integrity validation is focused only on detecting ANY uncontrolled change – not any specific change**

Example Cloud Stack at System Start

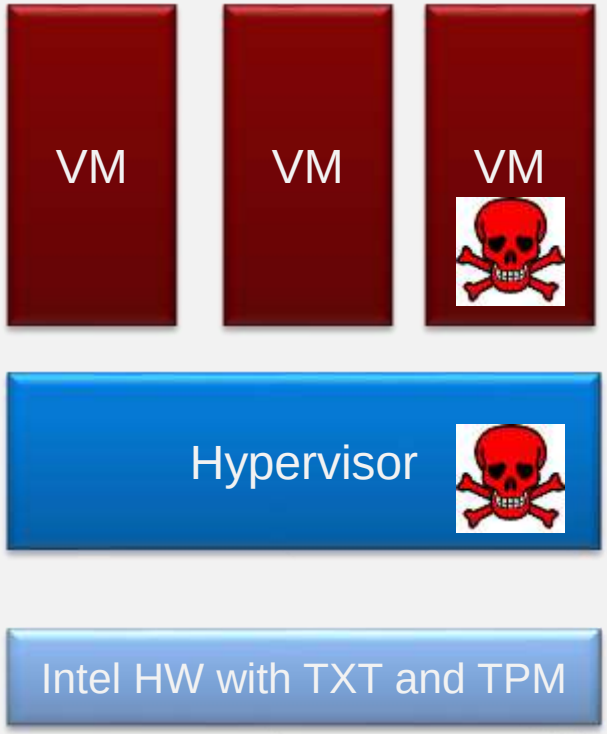


Integrity of VM measured at start and runtime integrity validated as for hypervisor

Runtime integrity validated by Trapezoid or the like

TXT and TPM validate integrity of Hypervisor

Protection of the Cloud Stack in Execution



Runtime integrity validation monitors uncontrolled changes to processes in execution – any change is seen, therefore we have (limited) Zero-Day defense

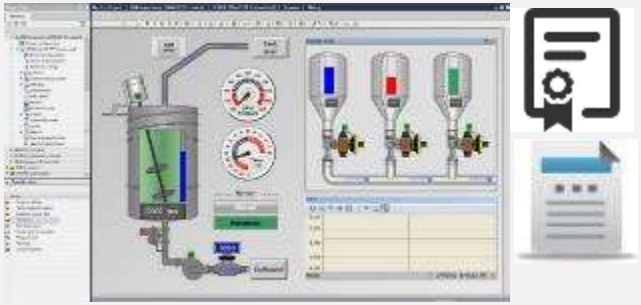
- Continuous integrity validation gives no insight into the nature of the change.
- Operationally, that is generally unimportant.
- The rapid discovery that uncontrolled change occurred, IS important.

The HW is <u>mostly</u> out of the loop during **runtime (until TCG's DRTM spec is implemented**

Teaching Embedded Systems About Stranger Danger

GPU includes a TPM

Central ICS console



No key and no valid integrity report

Unknown operator

Design:

- Authentication protocol enhanced to require
  - Certificate exchange
  - Integrity report exchange
- At session start, each side
  - Signs a nonce and their integrity report using a HW protected key
  - Validates the provided report
- No match, no session
  - No session, no hack

Rationale

A Brief History of BIOS Flash Security

- **BIOS resides in privileged space: Invisible to Anti-Virus SW**
  - Malware in BIOS is "persistent": Does not go away by rebooting or reinstalling the OS
- **CIH/Chernobyl – 1998 – killed between 1M and 2M machines**
- **Increase in security research…**

John Heasman – Rootkit in BIOS via ACPI - 2007 Hijacked ACPI to inject Rootkit into system BIOS Sherry Sparks – SMM rootkit with covert packet exfiltration – 2008 Undetectable Key Logger Alfredo Ortega/Anibal Sacco – persistent BIOS attack – 2009 Hijacked "Lo Jack" security SW to flash malicious BIOS onto system	Butterworth/Kallenberg/Herzog/Kovah– Problems with the Static Root of Trust for Measurement – 2013 51 byte patch to SCRTM to subvert TPM measurements Bulygin/Furtak/Bazhaniuk – 2013 A Tale of One Software Bypass of Windows 8 Secure Boot

- **NIST SP 800-155**
  - http://csrc.nist.gov/publications/drafts/800-155/draft-SP800-155_Dec2011.pdf
- **BIOS Flashing Trojan "in the wild"**
  - Trojan.Mebromi – Sept 2011

Research is a leading indicator of future exploits.
Secure boot bypass provides motivation.

Definitions

Components: Hardware + Firmware

Outside World's view of the **Component**.

FW Component

HW Component

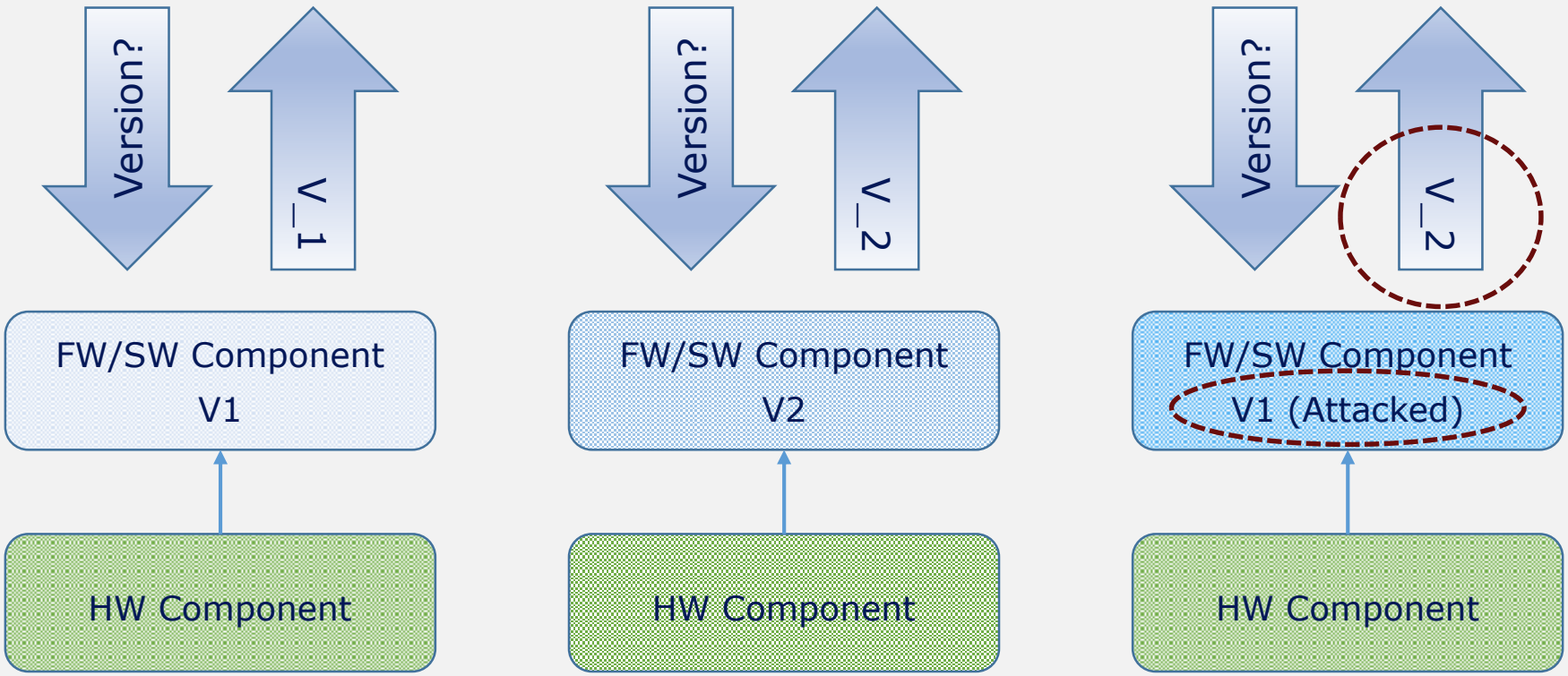
Mutable Components

e.g., Firmware, software, configuration settings

Immutable Components

i.e., hardware

Issue with Trusting Firmware / Software



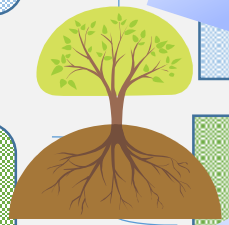
Adding a Root to an Immutable Component

Outside World's view of a ***Trusted* Component**.

FW Component

Root

HW Component



Visible & measureable

table Components

rirmware, software, configuration settings

Immutable Components

i.e., hardware

Undetectable behavior

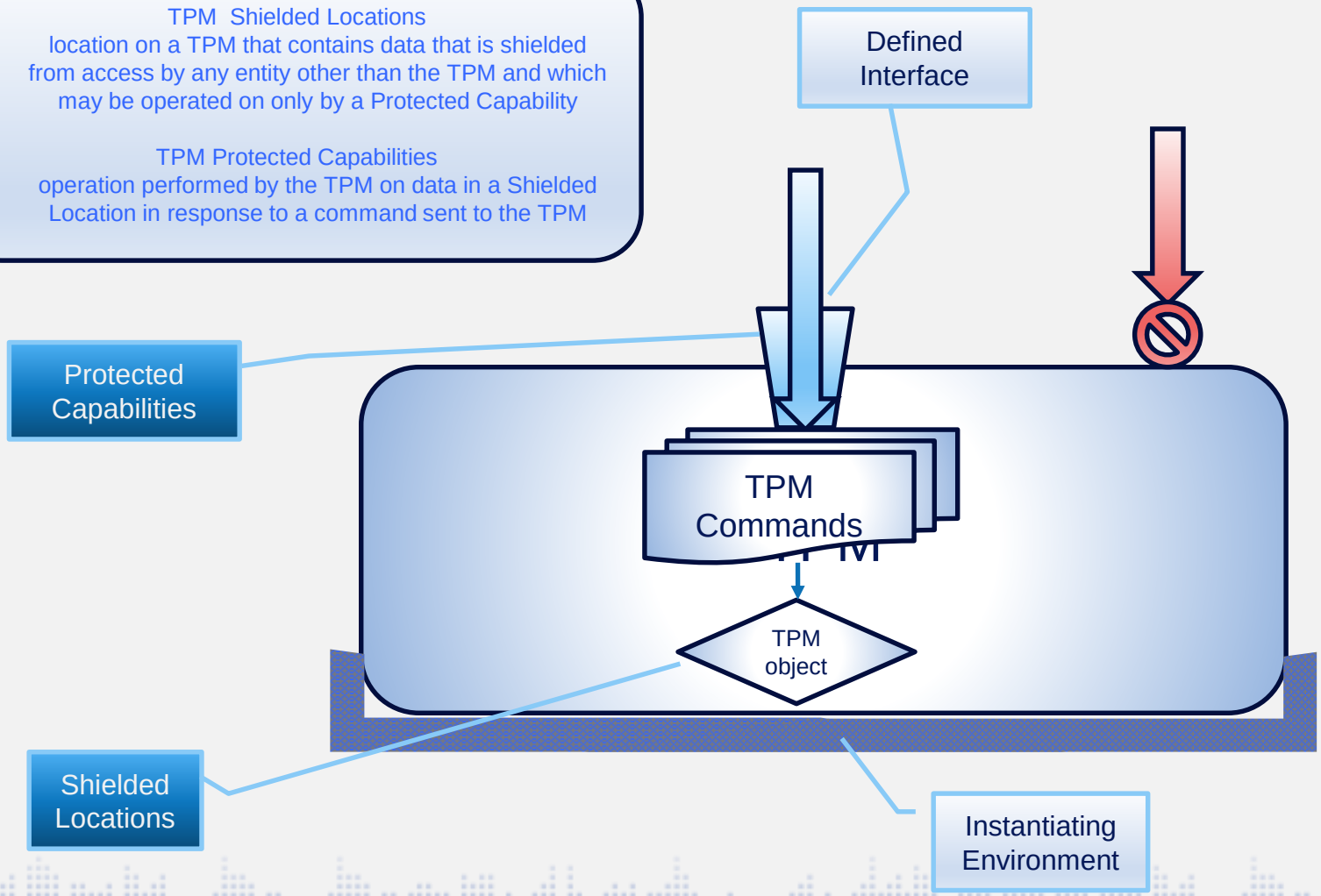
Definition: Root of Trust

- **Glossary:**
  - A component that performs one or more security-specific functions, such as measurement, storage, reporting, verification, and/or update. It is trusted always to behave in the expected manner, because its misbehavior cannot be detected under normal operation.
- **Explanation:**
  - Must begin by trusting a set of components to perform necessary functions to support Trusted Computing in the expected manner.
  - Misbehavior of these components is not detectable by the evidence and protocols provided by Trusted Computing.
  - For example: A root fails to properly initialize a platform and measurements begin incorrectly. While this misbehavior might be detectable by physical inspection (e.g., in a lab) this misbehavior cannot be detected using Trusted Computing methods (i.e., attestation).

Basic TPM Description

TPM Shielded Locations
location on a TPM that contains data that is shielded from access by any entity other than the TPM and which may be operated on only by a Protected Capability

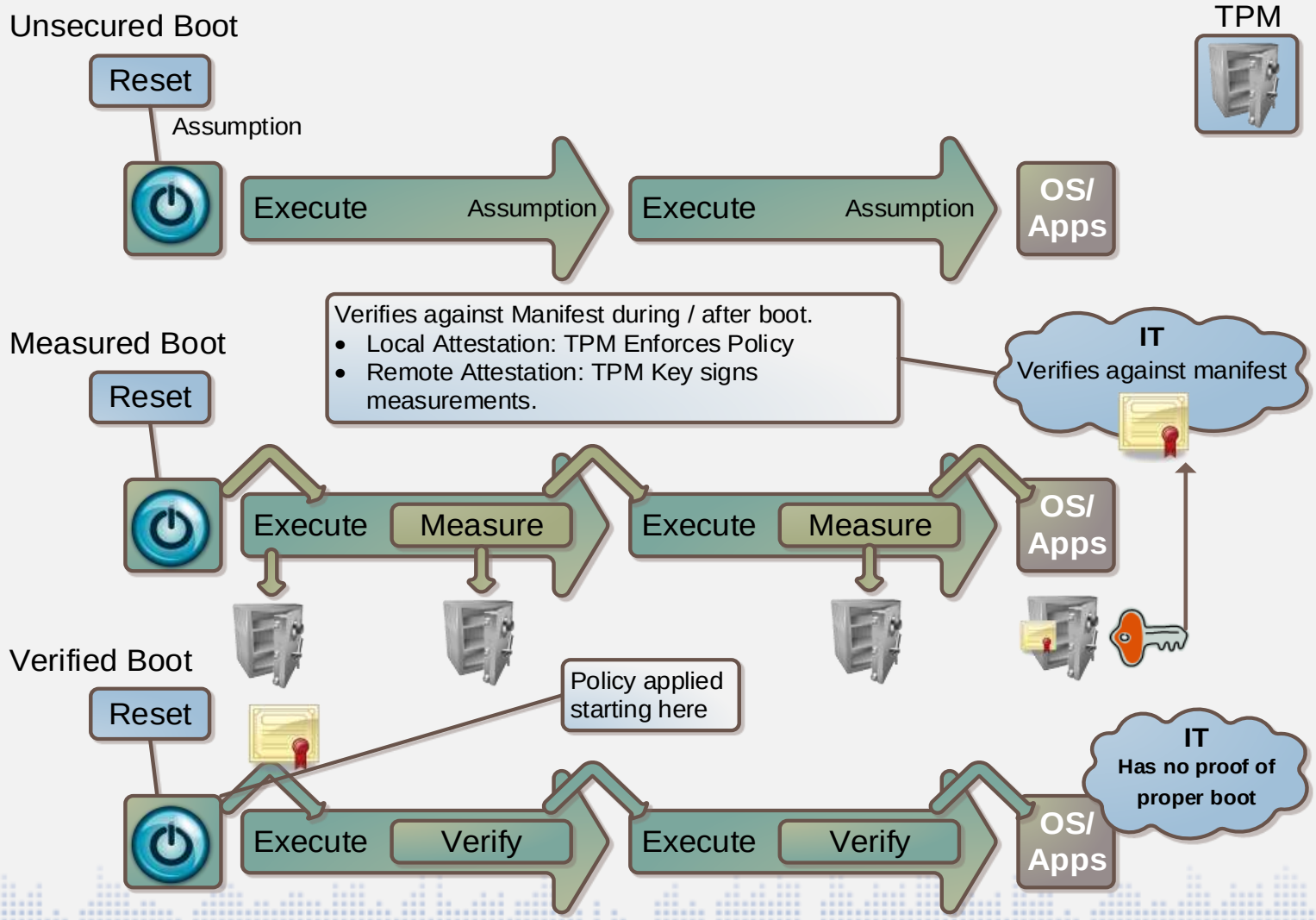
TPM Protected Capabilities
operation performed by the TPM on data in a Shielded Location in response to a command sent to the TPM



Measured & Verified Boot

- **Verified Boot:**
  - Boot policies are enforced during the boot process. Starting with the Root of Trust for Verification the currently executing module verifies the next module against a policy (i.e., manifest).
- **Measured Boot:**
  - Integrity Measurement are placed into the TPM. Starting with the Root of Trust for Measurement the currently executing module places the Integrity Measurement of the next module into the TPM.
- **Secure Boot:**
  - A boot process which implements either Verified Boot or Measured Boot or both..
- **Clarification:**
  - Verified Boot is often referred to as Secure Boot. Measured Boot is often referred to as Trusted Boot. Verified Boot (i.e., Secure Boot), however, only provides assurance that the boot policy was enforced and does not provide any assurance or evidence that the components are “secure”. Therefore, the moniker “secure” in this context is misleading.

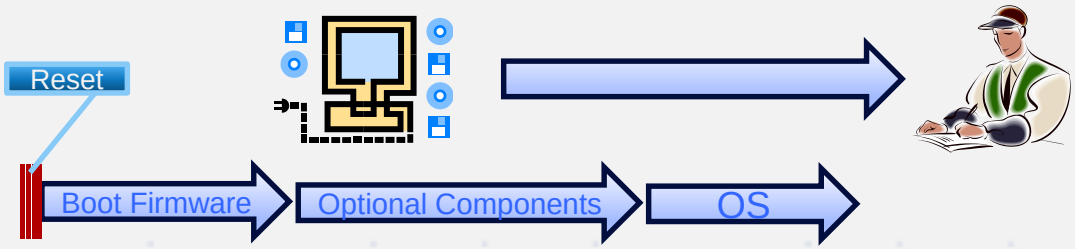
Measured & Verified Boot



Attestation

- **Proof of a Device's Identity**
  - Proof (e.g., Authentication) of a platform's identity
    - TPM adds a cryptographic binding between the platform and a key

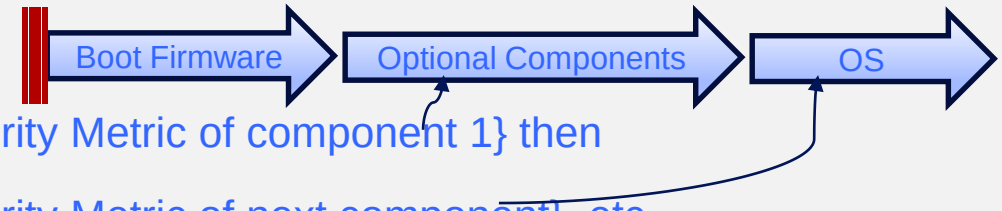
- **Proof of a Device's [boot-time] Integrity**
  - Proof of the identity of the platform's firmware, software components and configuration

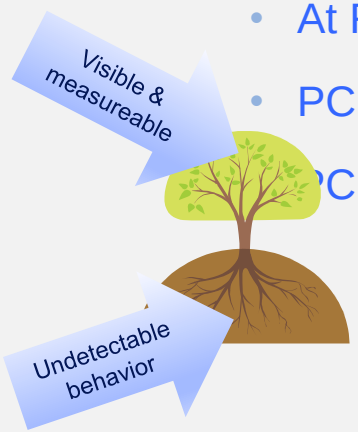


Components of Attestation

Measurement
At Reset PCR := 0
PCR := hash{ [PCR] | “Integrity Metric”}

- **Integrity Measurement**
  - Recorded metrics of the platform’s characteristics
  - Typically done using a series of cryptographic recordings
    - At Reset PCR[X]:=0 then
    - PCR[X] = hash{PCR[X] | Integrity Metric of component 1} then
    - PCR[X] = hash{PCR[X] | Integrity Metric of next component}, etc.



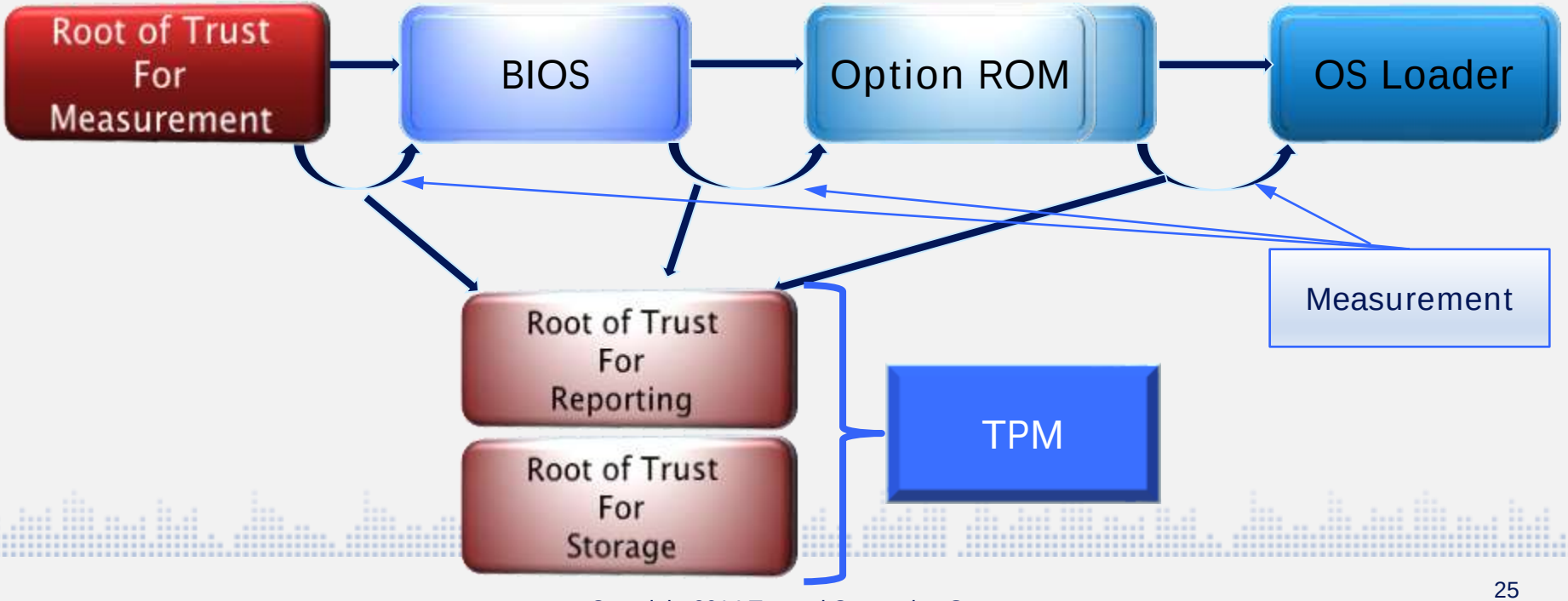


- **Roots**
  - Elements which must be trusted
  - Misbehavior is not detectable
  - Objective: Keep these small

Specifications

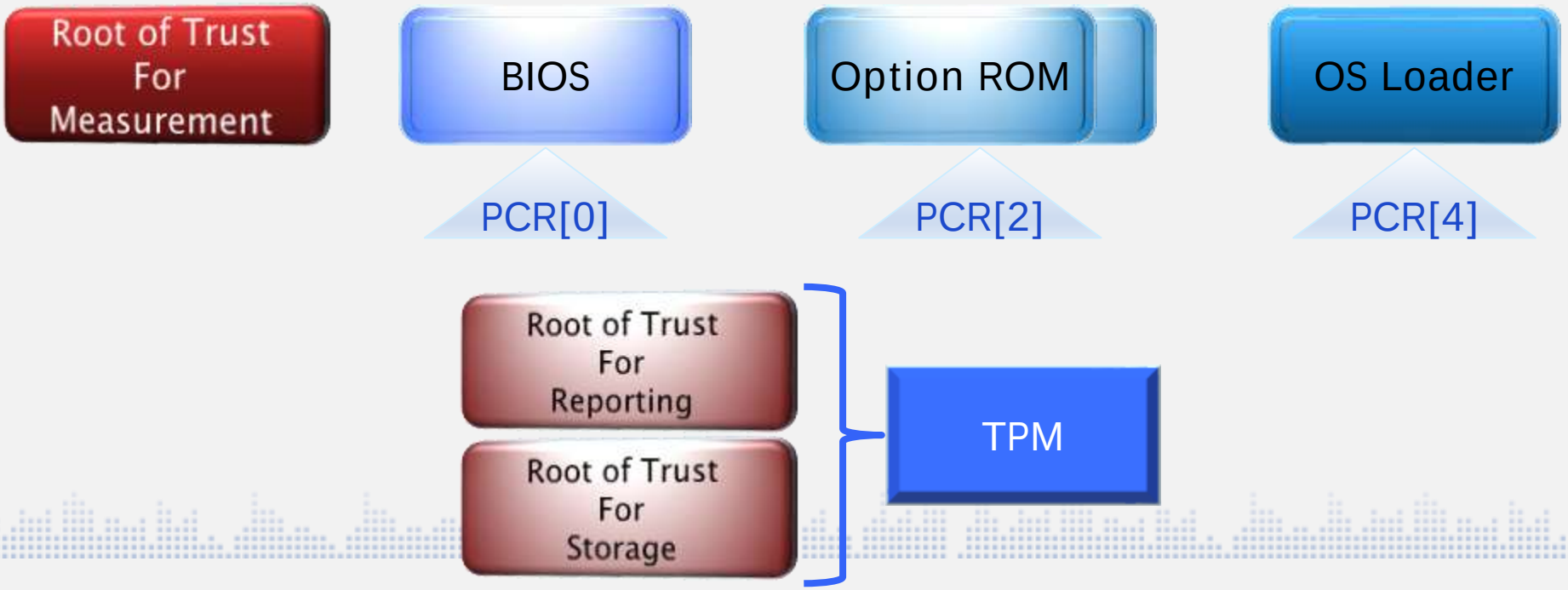
Chain of Trust

- A cohesive set of measurement started by RTM
- Provides an "audit" of boot sequence

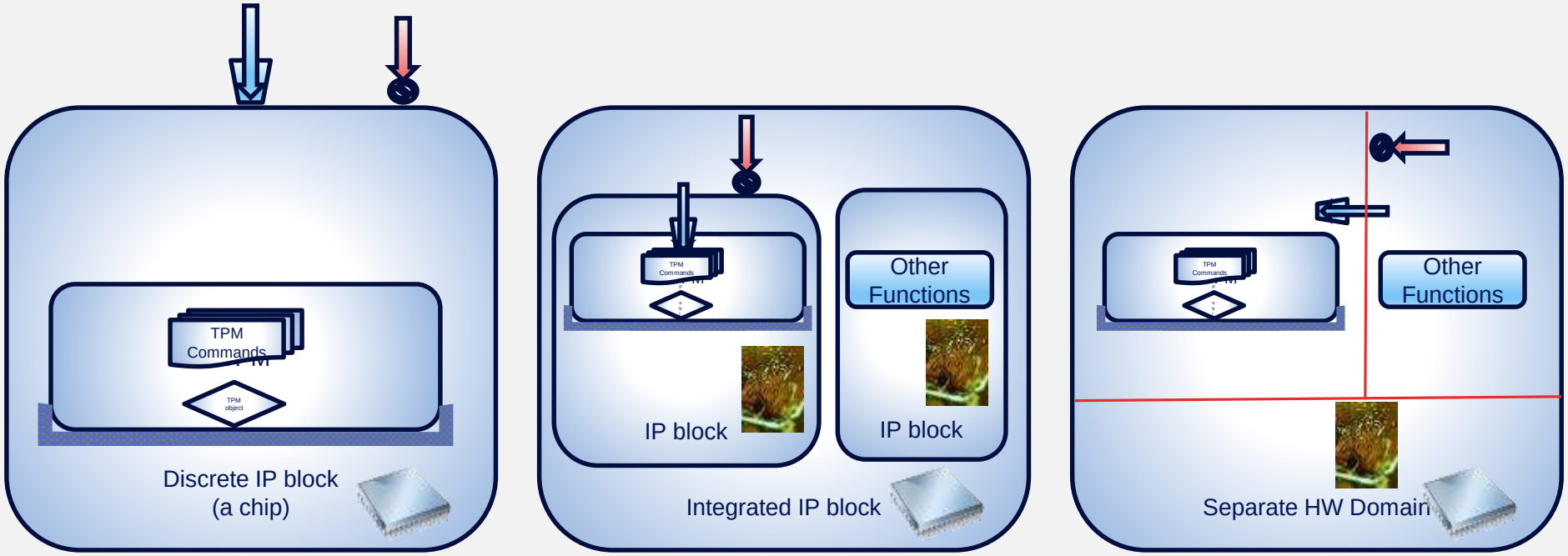


Platform Firmware Specifications

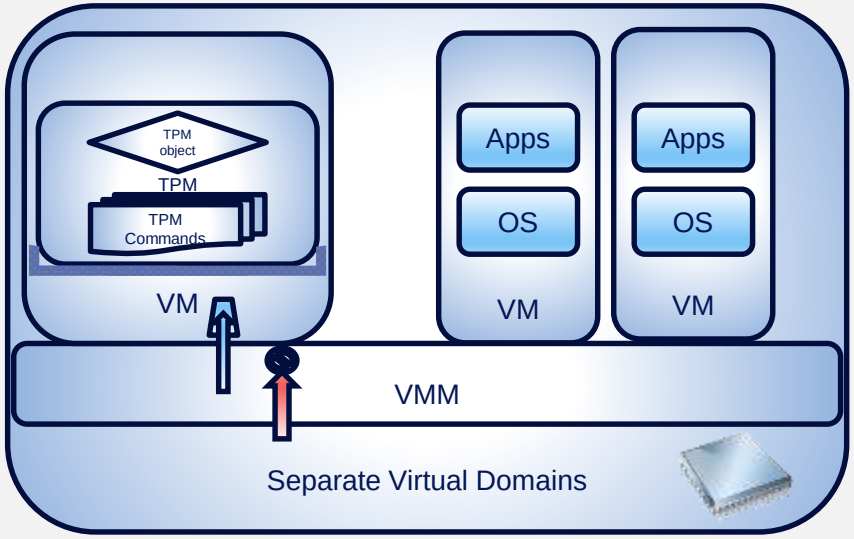
- **Maps the BIOS components to PCRs**
  - E.g., PC Client Specification for UEFI



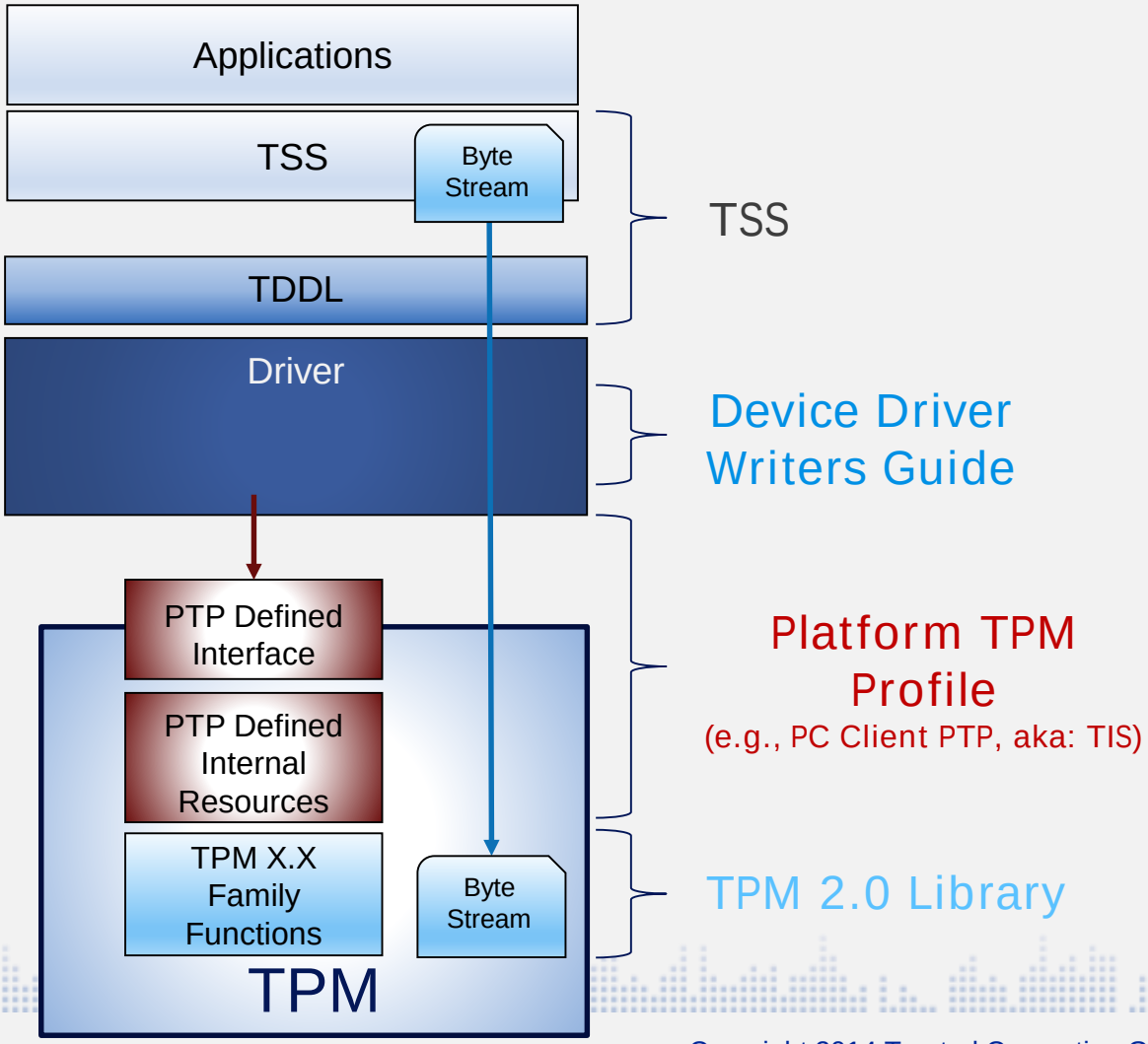
Implementation Options (1 of 2)

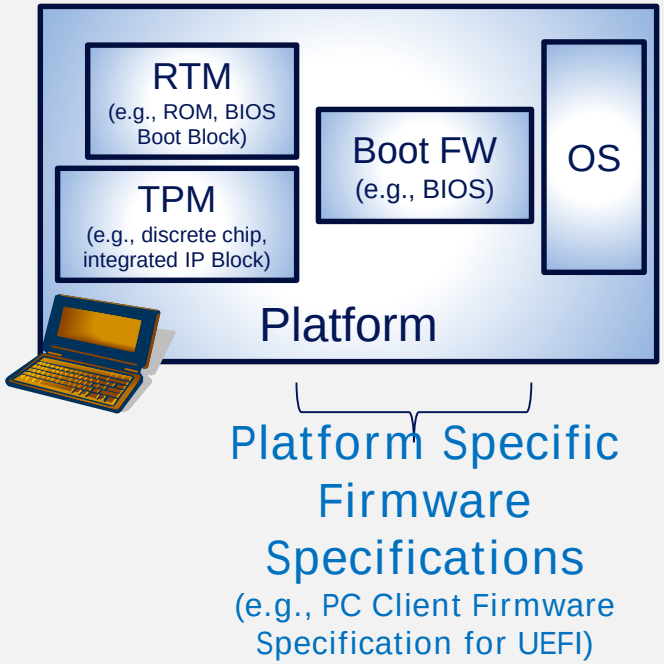


Implementation Options (2 of 2)

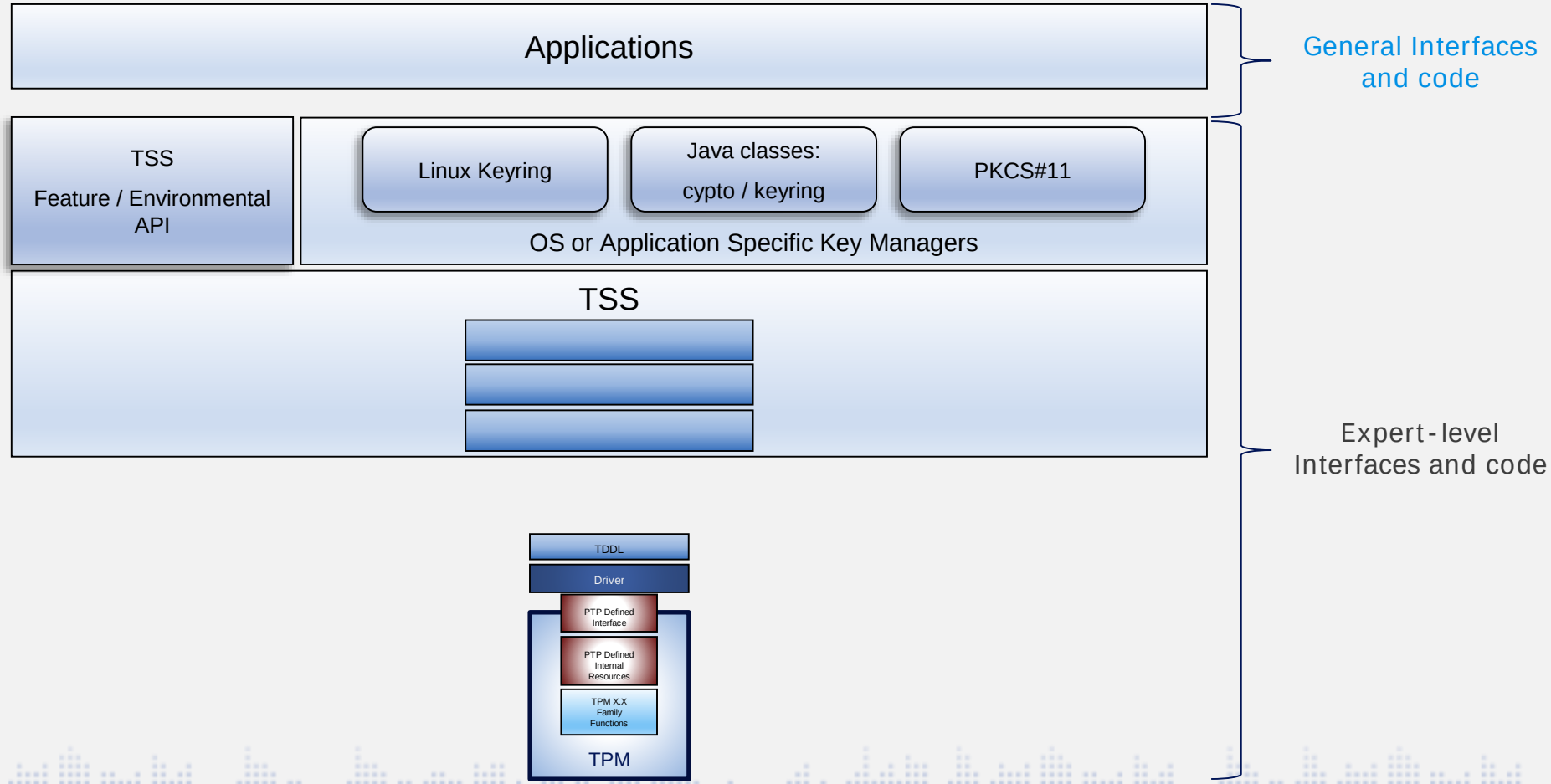


Specifications Layers





Software Stack (Anticipated)



Usages

Sample Usages

Usage	Description	Problem	Solution

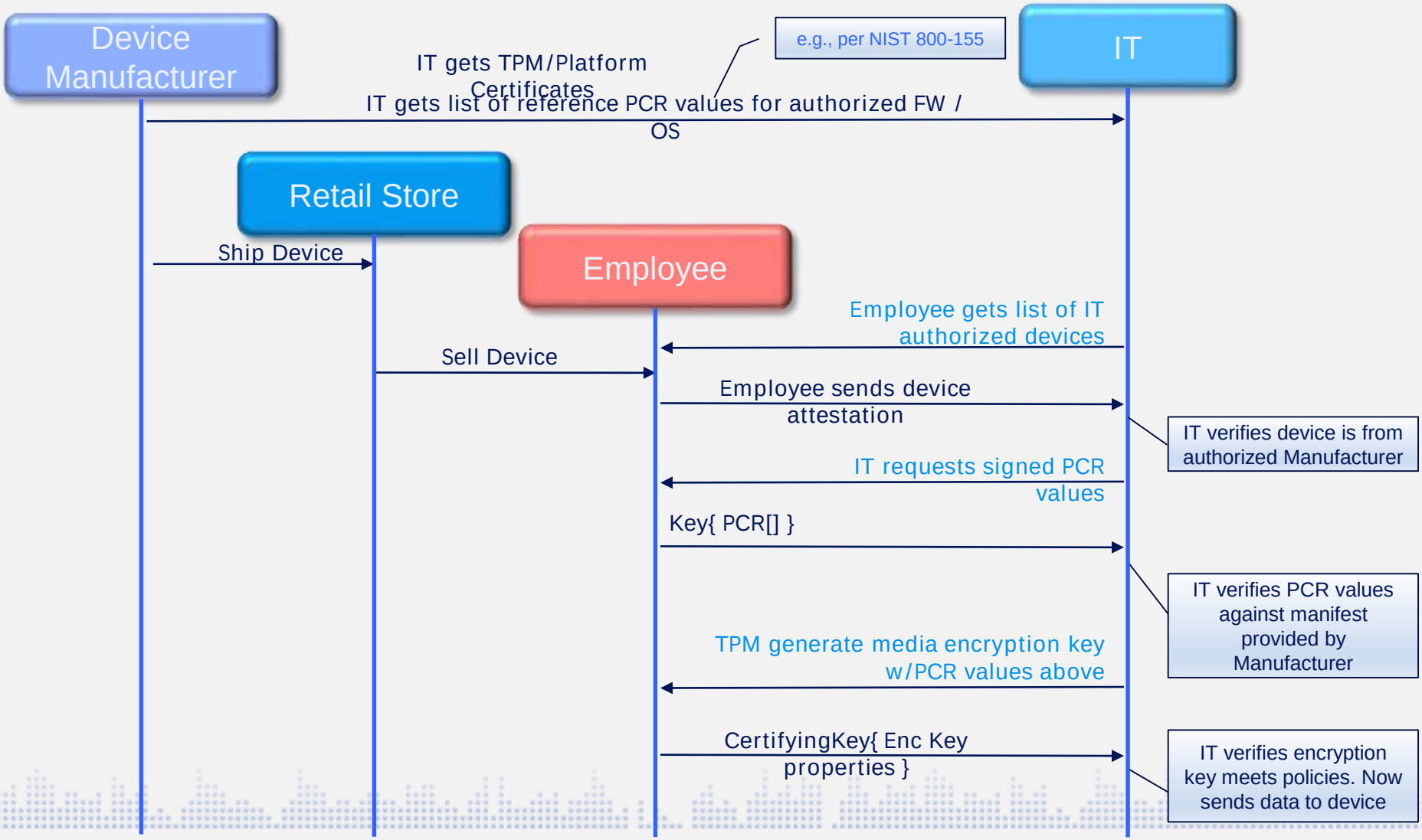
Device Attestation
(Remote Attestation)
	IT wants data is sent only to authorized device. Assume user only executes authorized FW and OS.	Prevent sending data to unauthorized devices. Need to determine the authenticity of an endpoint's claimed identity when:
		• Device is outside IT's physical control
		• Connected via untrusted connection
			• Protect key authenticating device using a TPM key
			• Use a signing key with Properties:
			  • Non-duplicateable
			  • HMAC authorization
			  • Assume FW and OS installed by user will protect assets at runtime

Device & Software Attestation
(Remote Attestation)
	IT wants data is sent only to authorized device. Do not assume user only executes authorized FW and OS. Enforce authorized FW and OS was executed before sending data.	Above +
		
		Enforce device executing authorized firmware / OS.
			• Use a signing key with Properties:
			  • Above +
			  • PCR Policy
			  • Enforce FW and OS installed by user to protect assets at runtime

Device Asset Protection
(Local Attestation)
	Device lost or stolen. Attacker can mount and read device's media. *Assume* device executes only authorized FW and OS which provides runtime asset protection.	Protect data from access when in the physical possession of attacker. Protect data with key but attacker can break user's low entry PIN protecting key using offline methods. Users will not use high-entropy PINs.
		
		Assume device executes only authorized FW and OS which provides runtime protection of key.
			• Protect device encryption key using a TPM key
			• Use a signing key with Properties:
			  • Duplicateable (For recovery)
			  • HMAC authorization
			  • TPM's anti-dictionary attack mechanisms allow low-entropy, user-friendly(er) "PINs"
			
			  • Note: Above protections come into play when attacker attempts to reboot device. Runtime protections are provided by OS.

Device & Software Asset Protection
(Local Attestation)
	Device lost or stolen. Attacker can mount and read device's media. *Enforce* device executes only authorized FW and OS which provides runtime asset protection.	Above +
		
		Enforce device executes only authorized FW and OS which provides runtime asset protection.
			• Protect device encryption key using a TPM key
			• Use a signing key with Properties:
			  • Above +
			  • PCR Policy
			
			  • Note: As above, but now PCR Policy enforces FW and OS.

Simplified Protocol



Features

TPM Features: Summary

- **An open, defined set of building block protocols providing platform-level attestation and storage protections**
  - Discussed previously
- **Flexible set of Policies**
  - Policies are applied to objects when they are created
  - Many policies types supported
  - Can combine with AND and OR operations
- **Algorithm Agility**
  - Protocols provide selectable (at implementation or use time) algorithms
    - Symmetric keys (DEC, AES, etc.)
    - Asymmetric keys (RSA, ECC, etc.)
    - Hash algorithms (SHA-1, SHA-256, SHA-384, etc.)
- **Enhanced Provisioning**
  - Separation of assets for the platform and user

Flexible set of Policies

- **Examples**
  - Password: Simple and in the clear – used for trusted environments
  - HMAC: A shared key using HMAC to protect secret in transit
  - PCR: Platform must match expected configuration (measured firmware and software)
  - Time: Can restrict a key to be used only for a certain period of time
  - Count: Can restrict a key to be used only one time (or a set number)
  - Signed: Verifies a signature from an external private key (e.g., SmartCard)
    - This allows stronger two factor authorization (i.e., authorization is: Using the authorized device (TPM) AND have possession of the SmartCard + PIN.
- **ANDs and ORs**
  - Can create a policy such as:
    - (PCR) AND (Secret) : Normal user access TPM protected data. Only authorized if authorized software and user are present

    OR

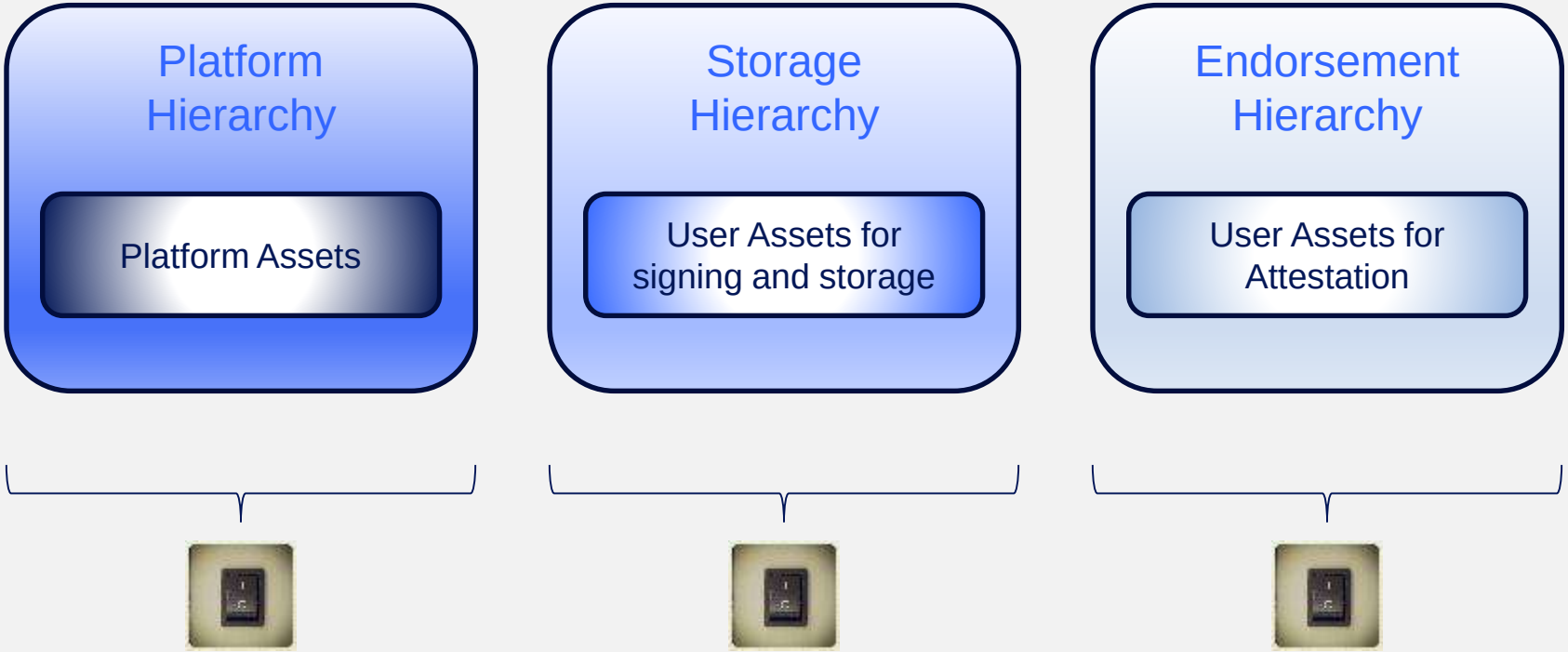
    - (Signed) : An IT admin uses a SmartCard (even remotely) in case user forgets Secret

Algorithm Agility

- **TPM 2's library structures are not hard-coded to a particular algorithm**
  - TPM may support more than one
    - Protocols provide fields for selecting algorithms for each function
  - TPM vendor implement selected algorithms
    - Platform TPM Profile specifies minimum sets of algorithms
      - TPM vendor may implement more than minimum set
- **Supports types such as**
  - Symmetric keys (DEC, AES, etc.)
  - Asymmetric keys (RSA, ECC, etc.)
  - Hash algorithms (SHA-1, SHA-256, SHA-384, etc.)
- **Extensible**
  - TCG Registry published identifying each TCG enumerated algorithm

Structure type
Algorithm Type
Crypto Data

Enhanced Provisioning



Independent Controls for each hierarchy

Questions?

Post your question now.

More Information

- **TPM 2.0 Library Specification:**
  http://www.trustedcomputinggroup.org/resources/tpm_library_specification
- **Infographic - Protect Your Data and Enhance Security:**
  http://www.trustedcomputinggroup.org/resources/protect_your_data_and_enhance_security
- **SANS Institute: Implementing Hardware Roots of Trust White Paper & Webcast:**
  http://www.trustedcomputinggroup.org/resources/implementing_hardware_roots_of_trust
- **Root of Trust: Foundation for IT Security Article:**
  http://www.trustedcomputinggroup.org/resources/root_of_trust_foundation_for_it_security
- **Become a TCG Member – Join Now!:**
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