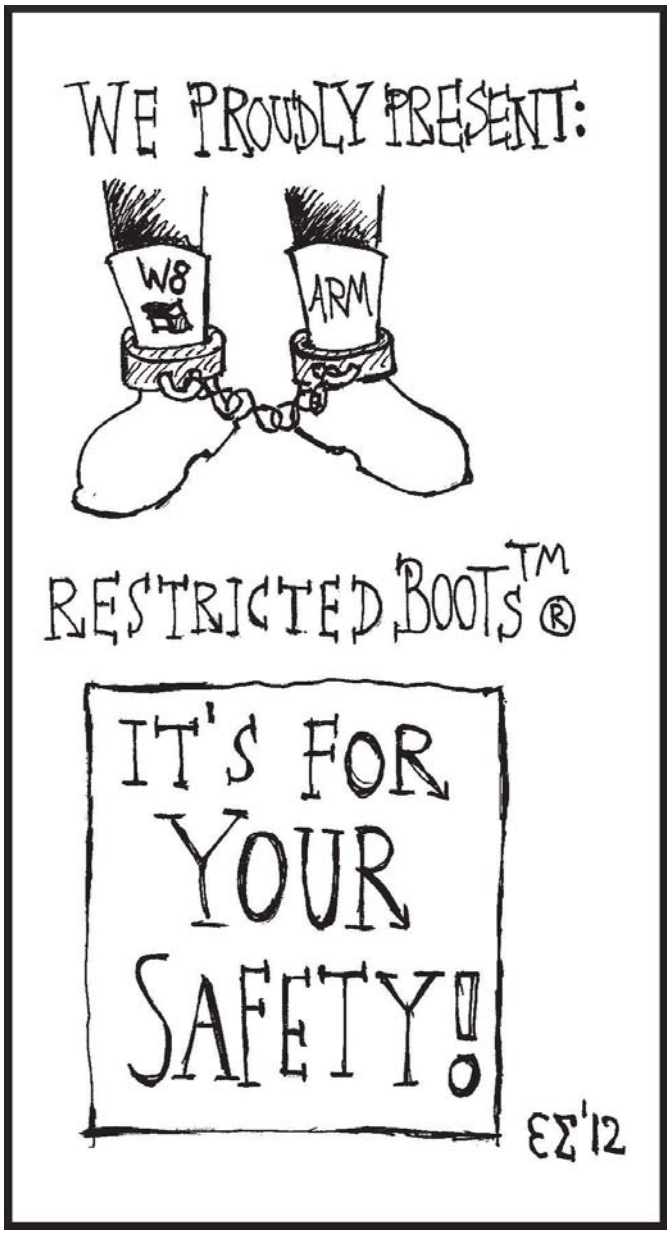
Portland Linux
User Group
October 4, 2012

Secure Boot Ecosystem Challenges

Vincent Zimmer

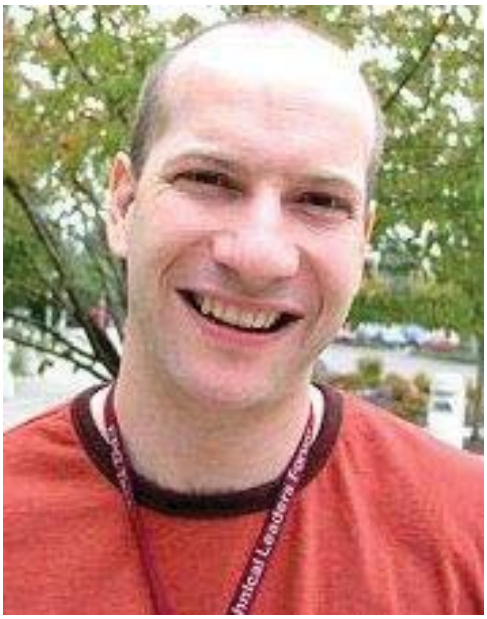
Usual disclaimer-
These foils and opinions are mine and not necessarily those of my employer

Really?



http://www.fsf.org/news/fsf-announces-winner-of-restricted-boot-webcomic-contest

Who am I? I'm 'not' Mark Doran

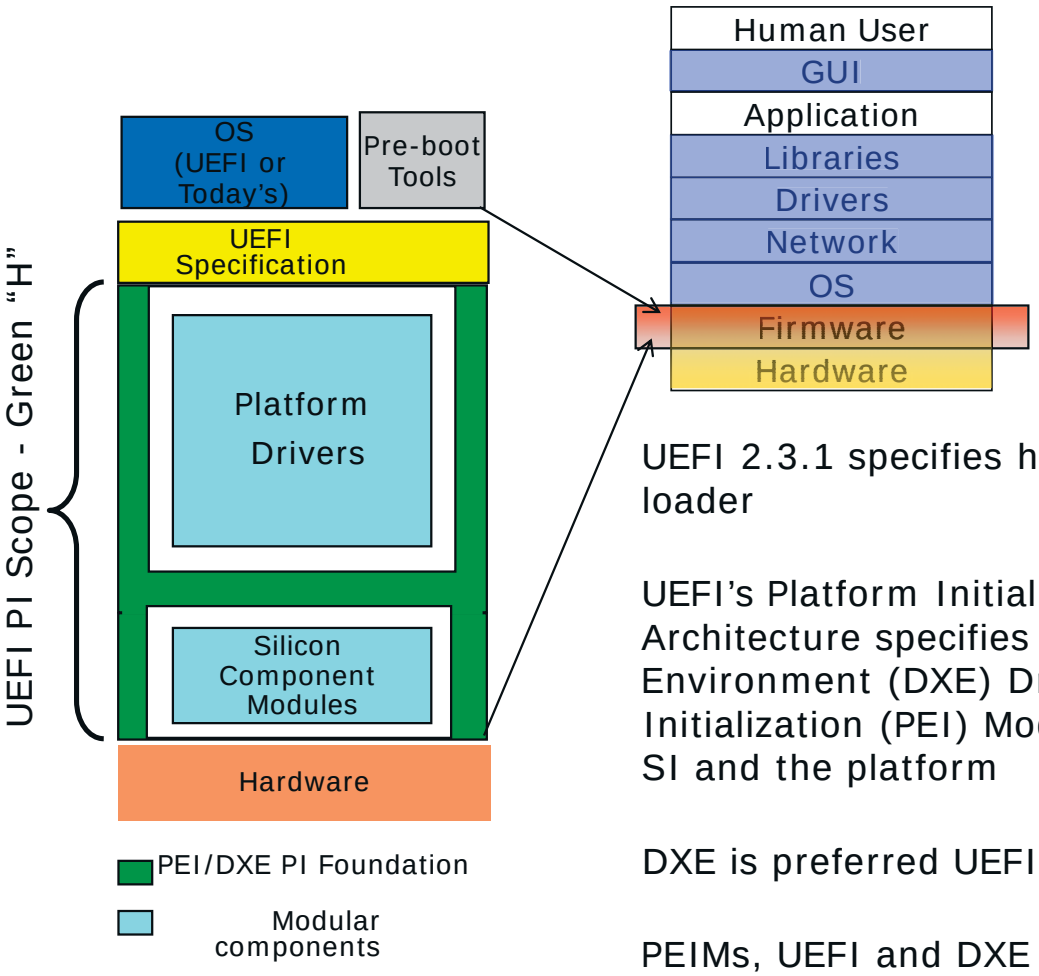


Original person tapped for this talk
Lead Intel UEFI architect
Pres of UEFI Forum
USWG chair
PIWG chair
Mark stuck in jury duty this week, so…..

Who am I? Vincent Zimmer

Principal Engineer at Intel
Industry since 1992
Intel since 1997
Chair of UEFI network subteam
Chair of UEFI PI security subteam
More –
sites.google.com/site/vincentzimmer/

What is UEFI? UEFI Platform Initialization Overview



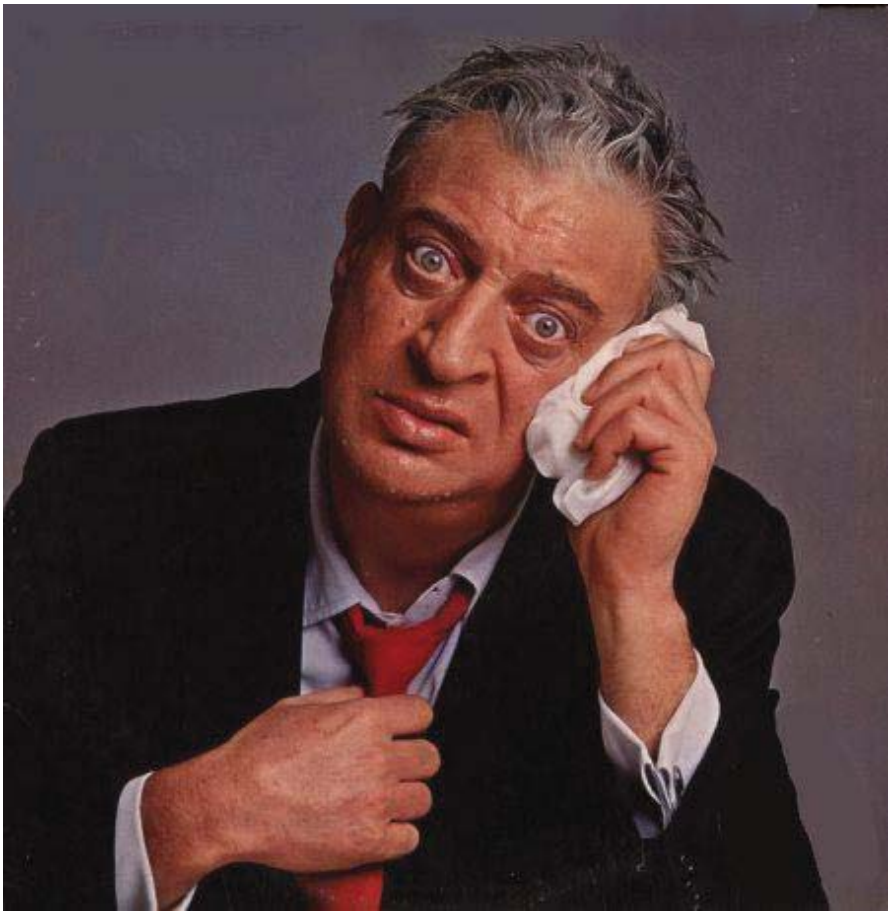
UEFI 2.3.1 specifies how firmware boots OS loader

UEFI's Platform Initialization (PI) 1.2 Architecture specifies how Driver Execution Environment (DXE) Drivers and Pre-EFI Initialization (PEI) Modules (PEIMs) initialize SI and the platform

DXE is preferred UEFI Implementation

PEIMs, UEFI and DXE drivers implements networking, Update, other security features

UEFI / PI is a type of BIOS
BIOS– aka. the Rodney Dangerfield of Software



“No respect”

http://www.noethics.net/News/index.php?option=com_content&view=article&id=1923:todays-rodney-dangerfield-award-winner-is-newt-gingrich&catid=121:rodney-dangerfield-award-winners&Itemid=96

How to build it? UDK2010

Industry Standards Compliance
- UEFI 2.0, UEFI 2.1, UEFI 2.2, UEFI 2.3; PI 1.0, PI 1.1, PI 1.2

Extensible Foundation for Advanced Capabilities
- Pre-OS Security
- Rich Networking
- Manageability

Support for UEFI Packages
- Import/export modules source/binaries to many build systems

Maximize Re-use of Source Code**
- Platform Configuration Database (PCD) provides "knobs" for binaries
- ECP provides for reuse of EDK1117 (EDK I) modules
- Improved modularity, library classes and instances
- Optimize for size or speed

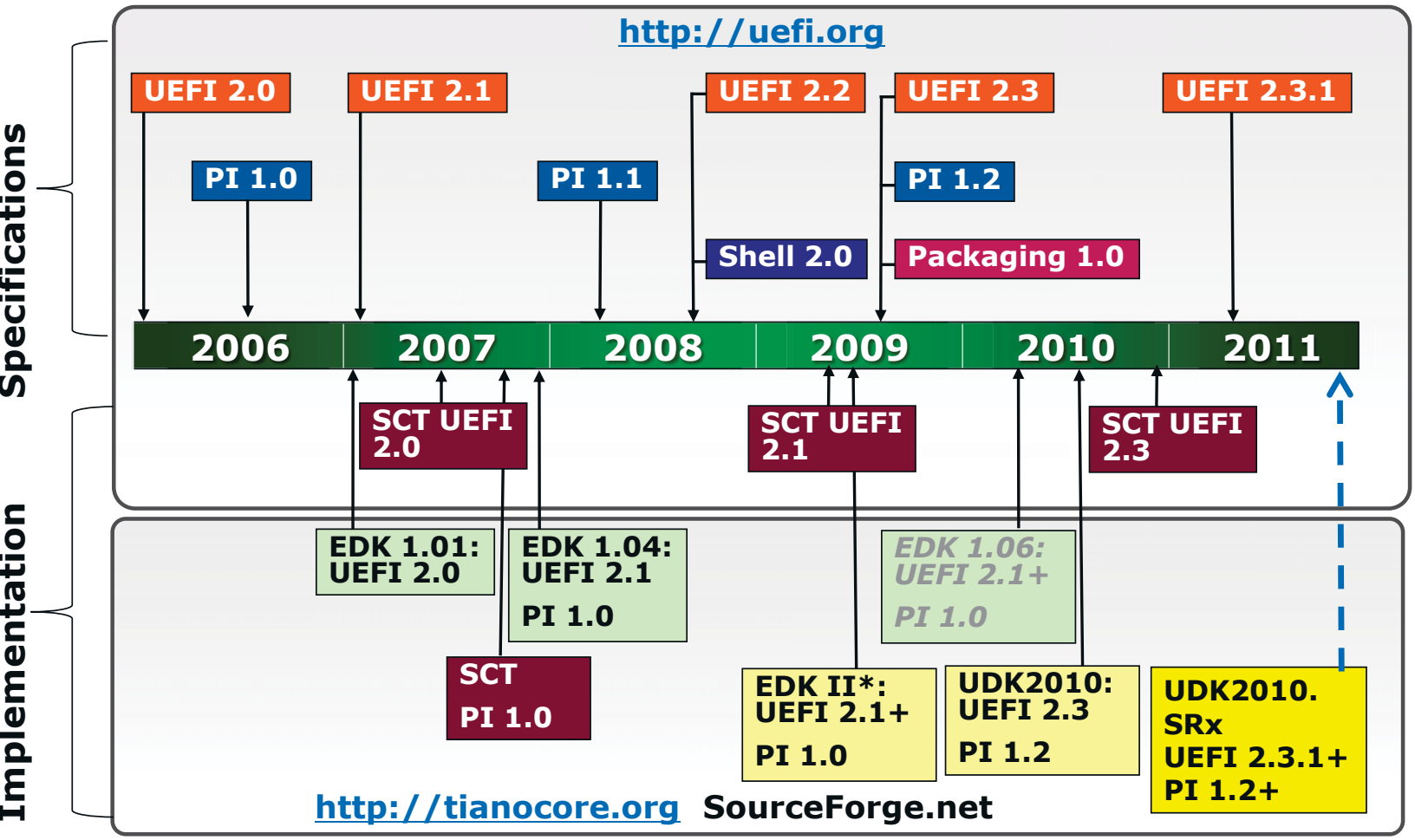
Multiple Development Environments and Tool Chains**
- Windows, Linux, OSX
- VS2003, VS2005, WinDDK, Intel, GCC

Fast and Flexible Build Infrastructure**
- 4X+ Build Performance Improvement (vs EDKI)
- Targeted Module Build Flexibility

** *benefit of EDK II codebase*

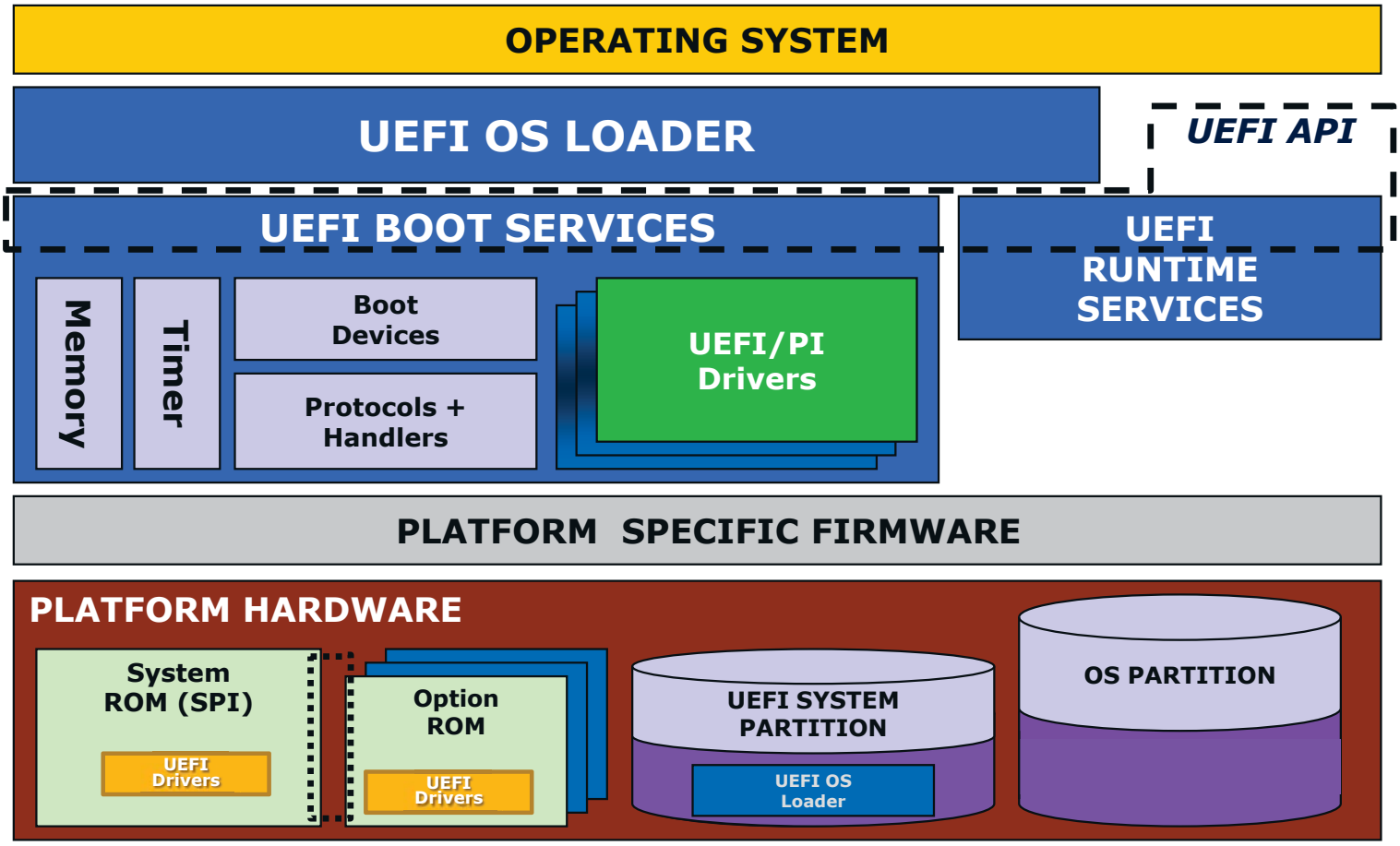
Maximize the open source at www.tianocore.org

Specification & Tianocore.org Timeline



All products, dates, and programs are based on current expectations and subject to change without notice.

Overview of the UEFI Boot Process



Typical OS Loader Scenario for UEFI

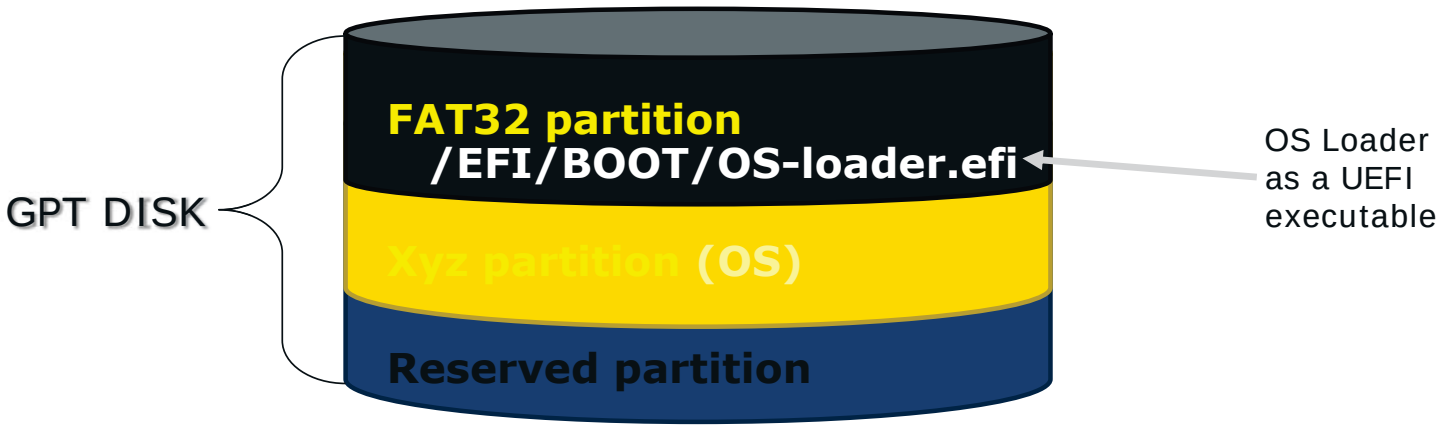
One GPT disk partition is FAT32 (service partition)

OS installer puts the loader on the service partition

- Under `/EFI/BOOT` or `/EFI/osname` directory
- Ex: **`/efi/boot/bootx64.efi`**, **`/efi/ubuntu/grubx64.efi`**

NVRAM `(Bootxxxx)` has a device path to OS loader

- Maps to specific device, GUID partition & filename



Advantages of UEFI Boot Process

Extensible across multiple boot devices

- SATA, SAS, USB, PXE/iSCSI (IPv4/IPv6), ...

Supports multi-boot operations

- Multi-boot loaders w/o MBR chain-loading
- UEFI Forum reserves directories to avoid collisions
- Use `/efi/boot` directory for removable media

Device path stored in boot options (NVRAM)

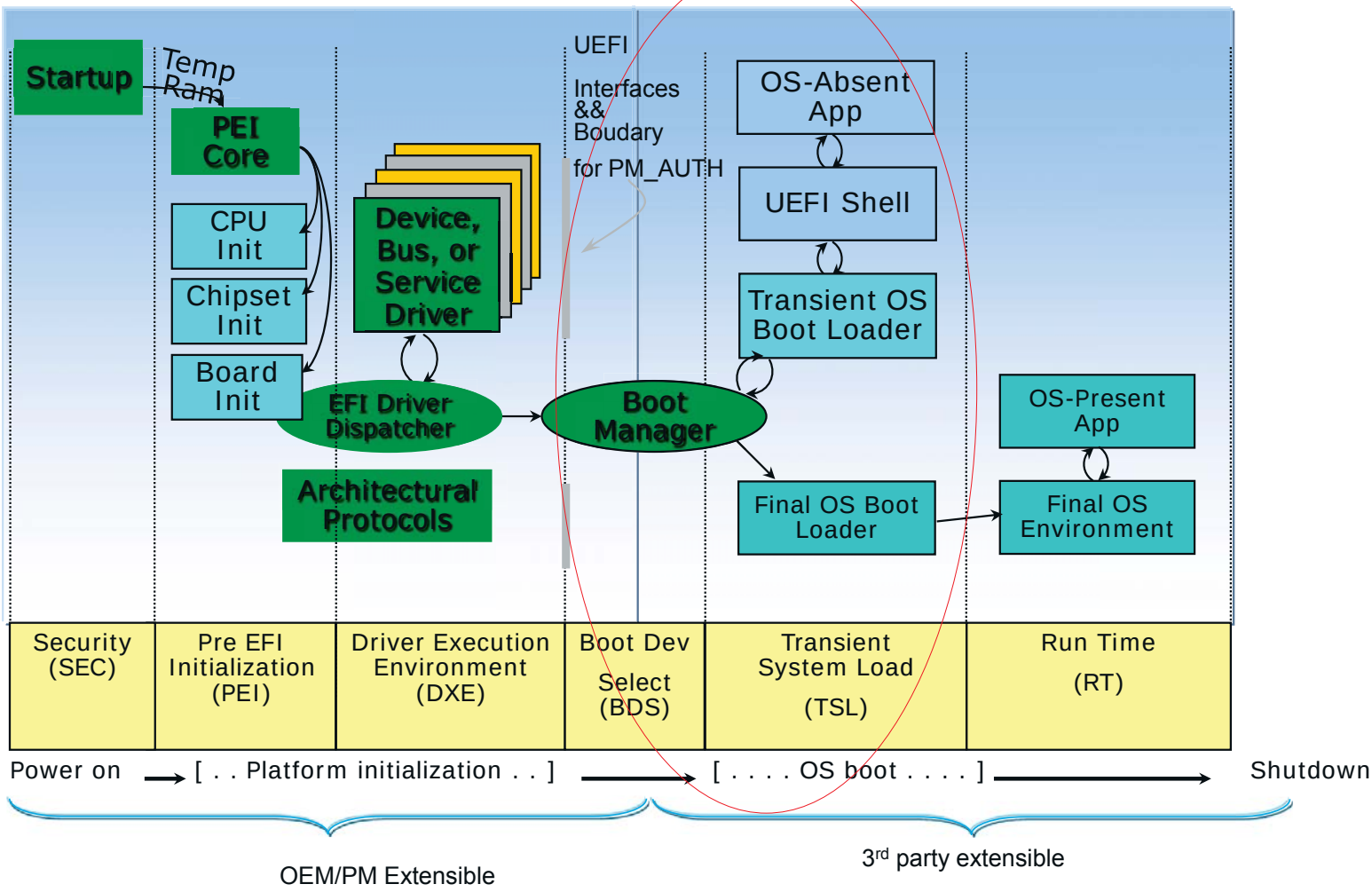
- Pointer to specific boot device

Boot image can be validated when loaded

- Allows firmware loader to perform security checks

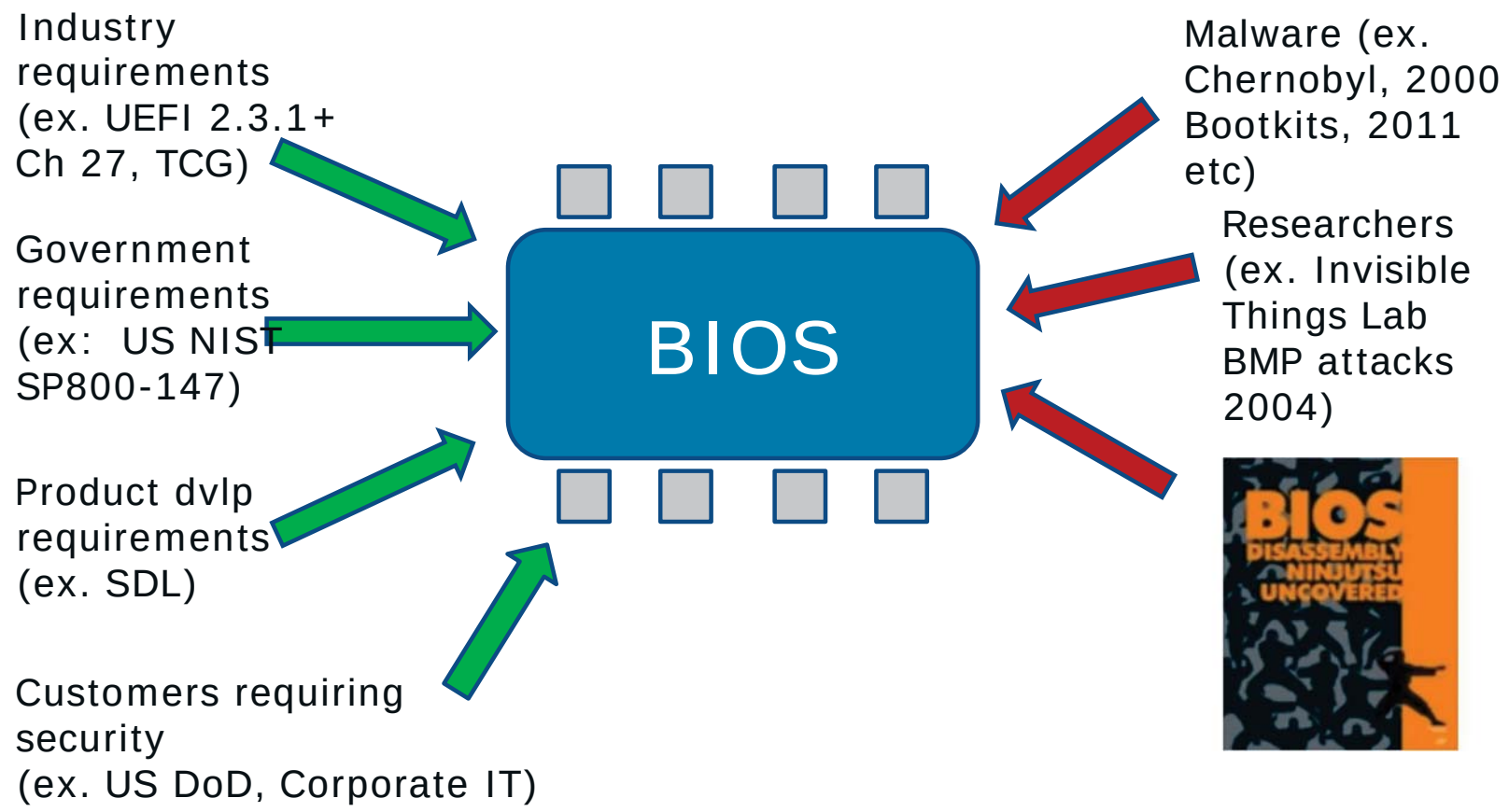
What problem are we solving?

(more importantly, what problems we are not solving w/ this technology)

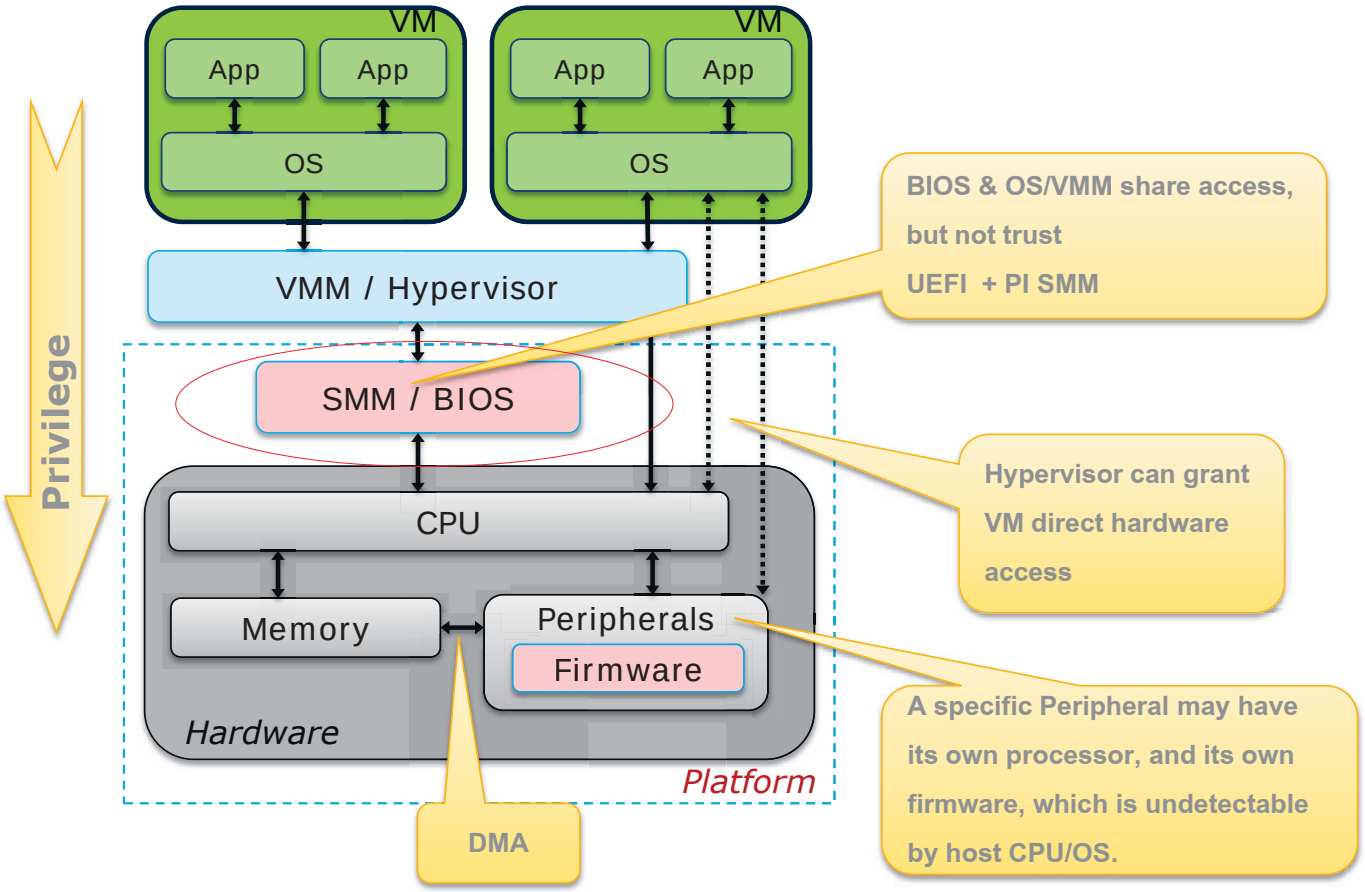


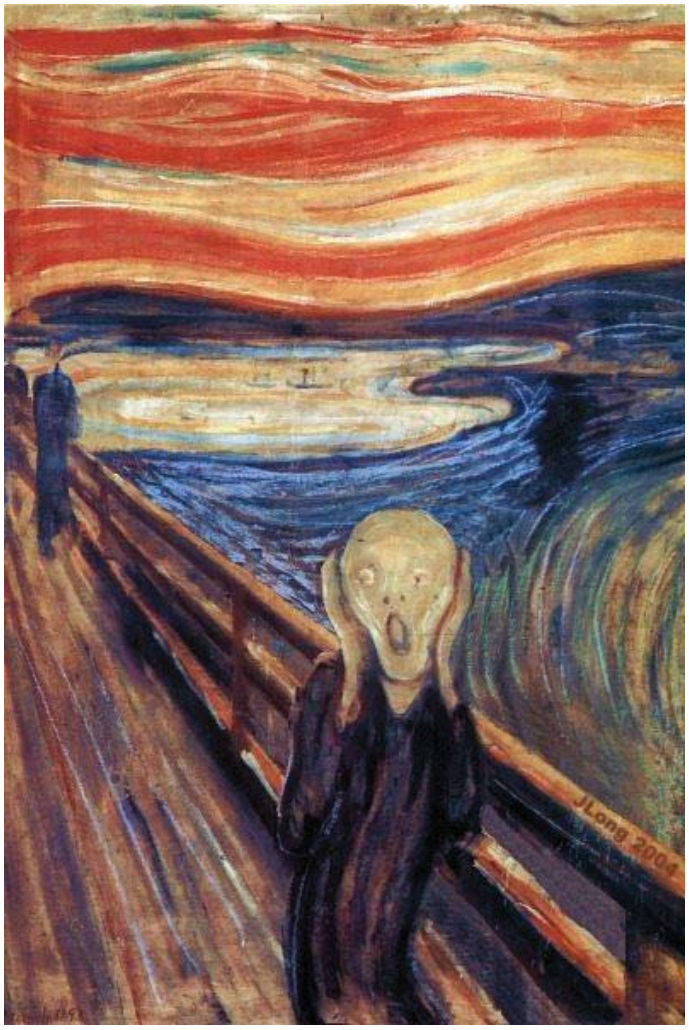
Why

Pressure on BIOS



Where are we (BIOS / UEFI firmware)?




JLong 2004

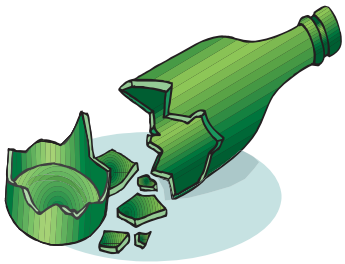
Why

Why use UEFI Secure Boot

Without

Possible corrupted or destroyed data

- BootKit virus – MBR Rootkits
- Network boot attacks e.g. PXESPOILT
- Code Injection Attacks



With

Data integrity

- Trusted boot to OS
- Trusted drivers
- Trusted Applications

a

*

What

What is Security from BIOS Perspective

Secure Boot - UEFI

- Defined a policy for Image loading
- Cryptographically signed
  - Private key at signing server
  - Public key in platform

Measured Boot -Trusted Computing Group (TCG)

- Trusted Platform Module (TPM)
  - Isolated storage and execution for Logging changes, attestation

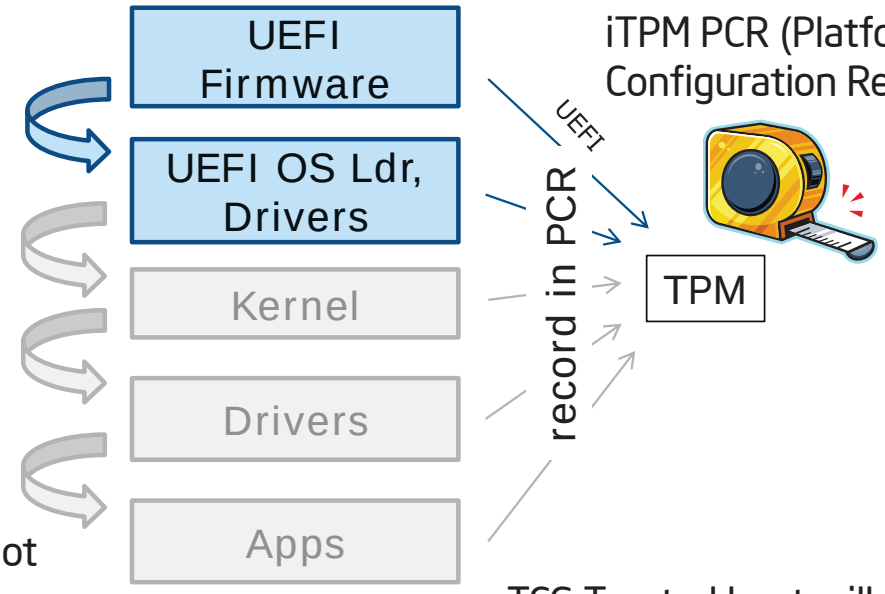
NIST 800-147 -Security Guidelines for System BIOS Implementations

What

UEFI Secure Boot VS TCG Trusted Boot

UEFI authenticate OS loader
(pub key and policy)

Check signature of before loading



UEFI PI will measure OS loader & UEFI drivers into iTPM PCR (Platform Configuration Register)

- UEFI Secure boot will stop platform boot if signature not valid (OEM to provide remediation capability)
- UEFI will require remediation mechanisms if boot fails

- TCG Trusted boot will never fail
- Incumbent upon other SW to make security decision using attestation

What

NIST Implementation Requirements

Make sure UEFI PI code is protected

The NIST BIOS Protection Guidelines break down to three basic requirements...

1. The BIOS must be protected
2. BIOS updates must be signed
3. BIOS protection cannot be bypassed

What

UEFI Secure Boot Goals

Local verification. Complements measured boot

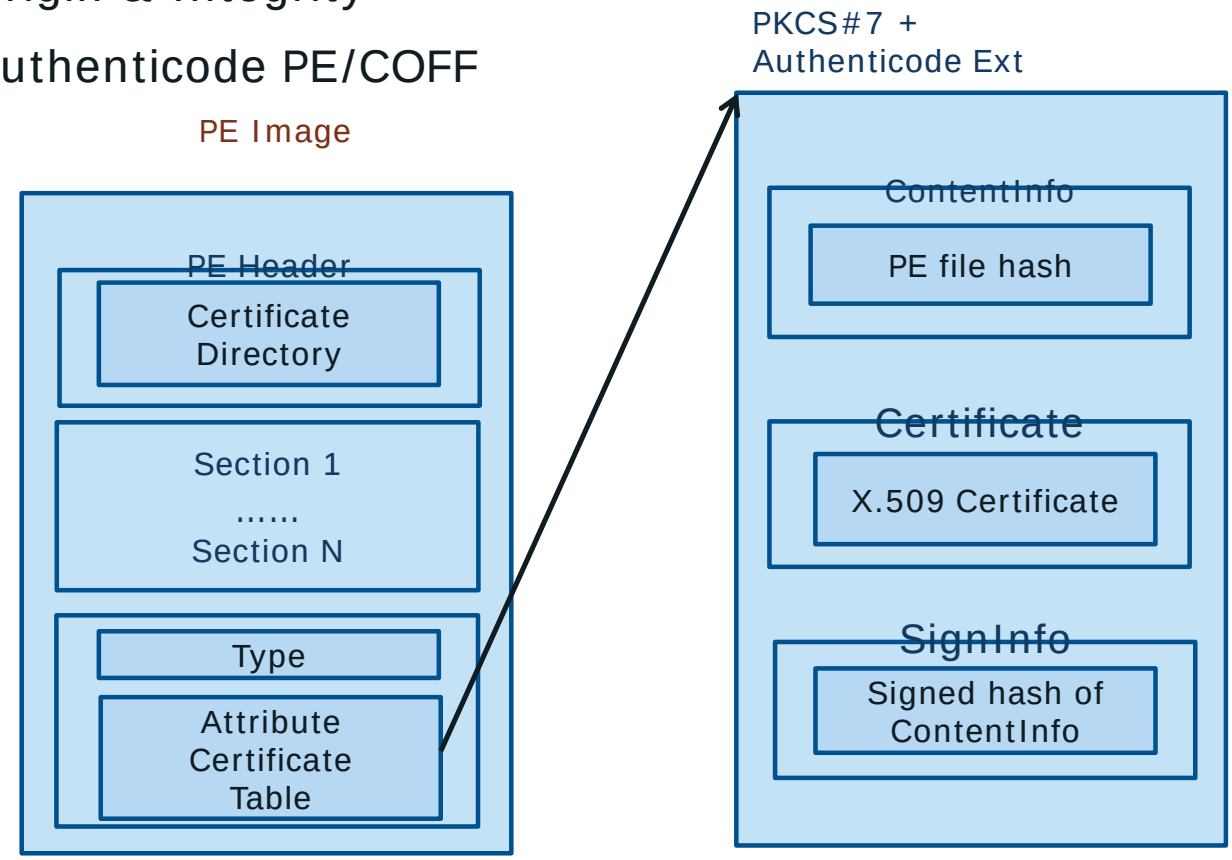
Allow the platform owner to check the integrity and security of a given UEFI image ensuring that the image is only loaded in an approved manner.

Allow the platform owner to manage the platform's security policy as defined by the UEFI Secure Boot authenticated variables

UEFI Image (driver & application/OS loader) Signing

Why? – Origin & Integrity

How? – Authenticode PE/COFF

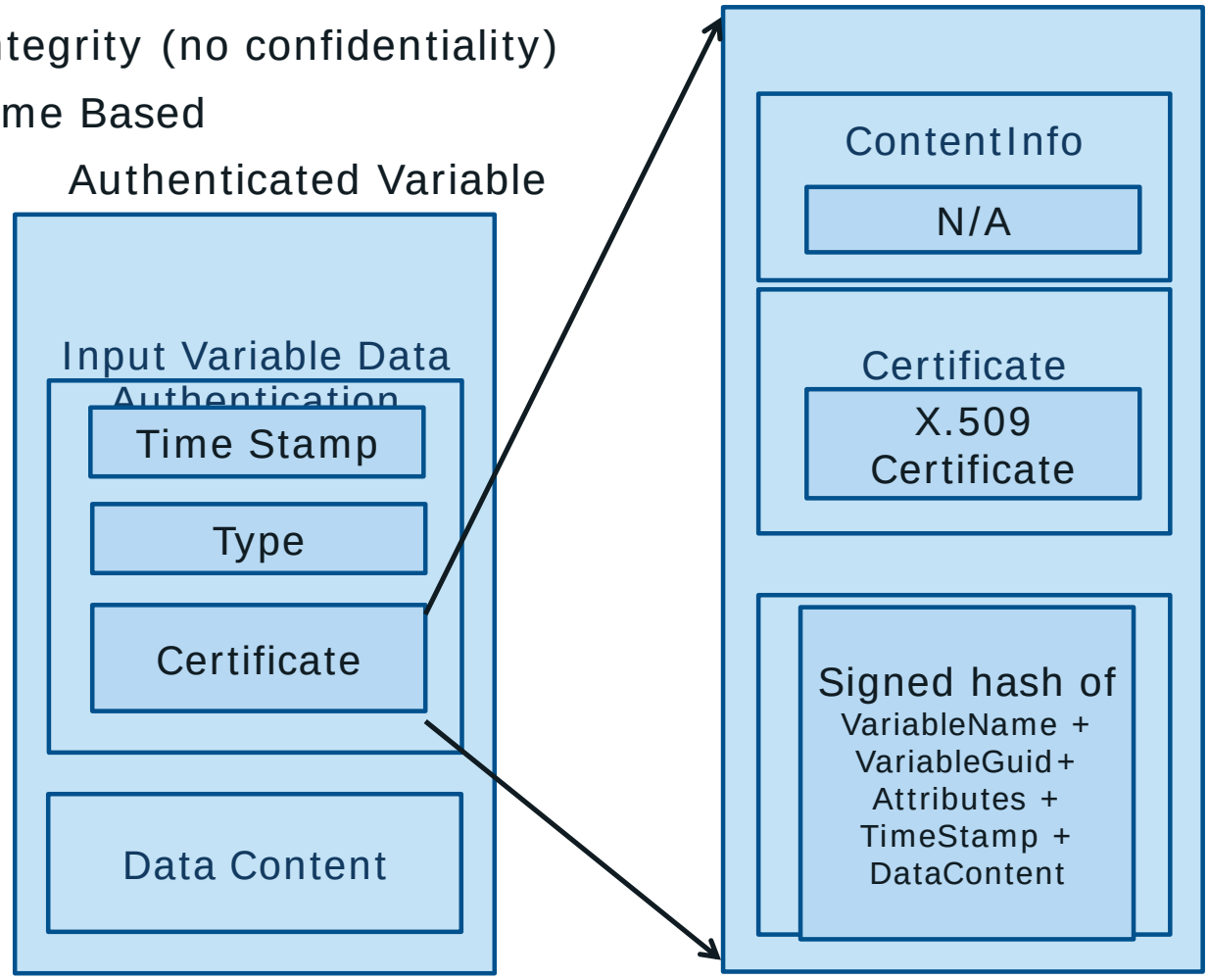


UEFI Authenticated Variable

Why? – Integrity (no confidentiality)

How? – Time Based

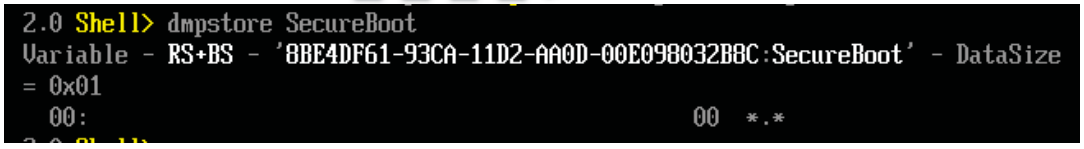
Authenticated Variable



Authenticated Variables

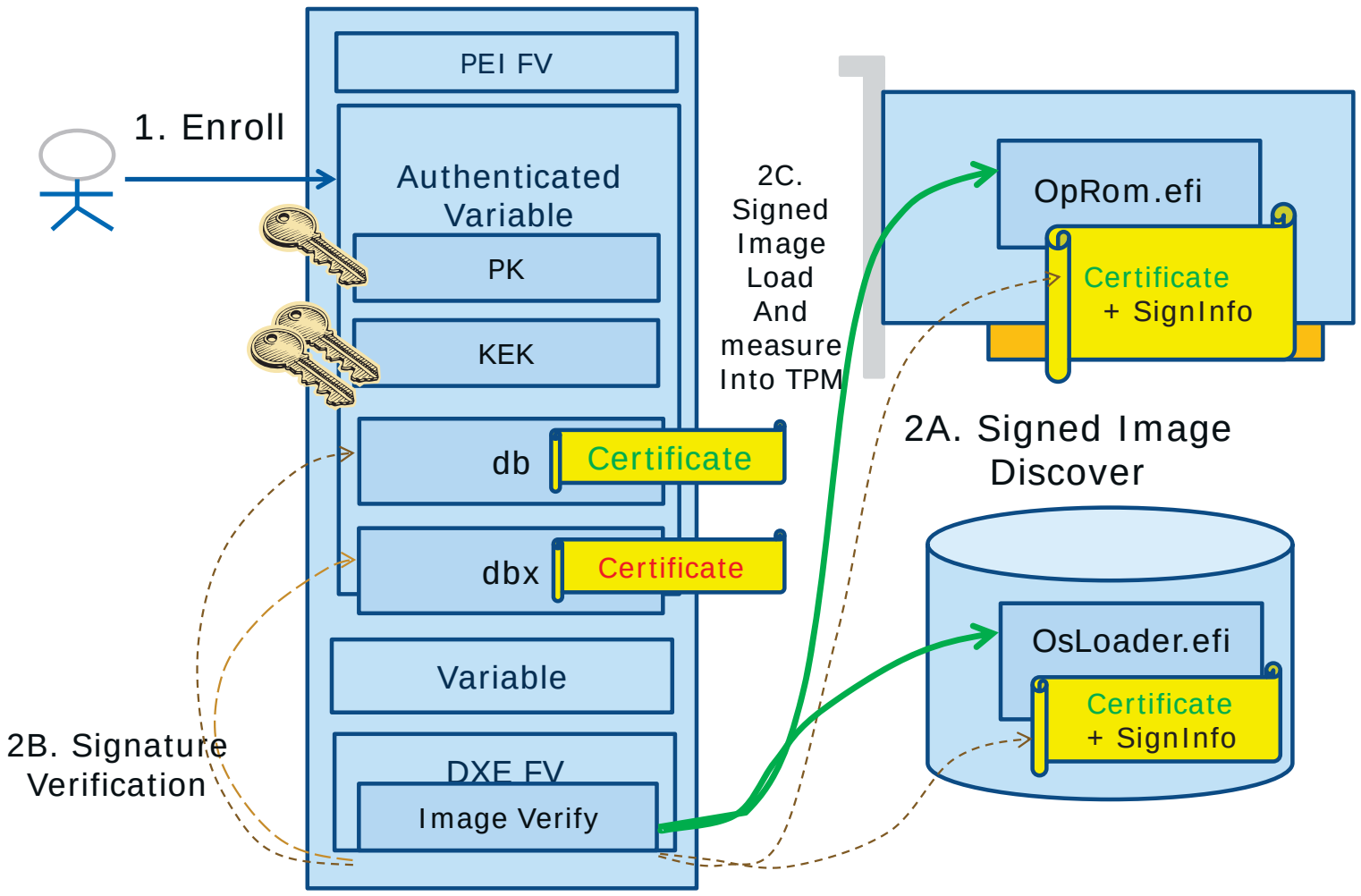
Secure Boot's Authenticated Variables

Key/ DB Name	Variable	Details
PkPub	PK	OEM and Platform FW- format is RSA-2048
Key Exchange Key	KEK	Platform FW and OS - format is RSA-2048
Authorized Signature DB	DB	Authorized Signing certificates - white list
Forbidden Signature DB	DBX	Unauthorized Signing certificates - Black list
Setup Mode	SetupMode	NULL - Secure Boot not supported 0 - PK is enrolled - in user mode User mode requires authentication 1 – Platform is in Setup mode – no PK enrolled
Secure Boot	SecureBoot	1-Platform in Secure boot mode

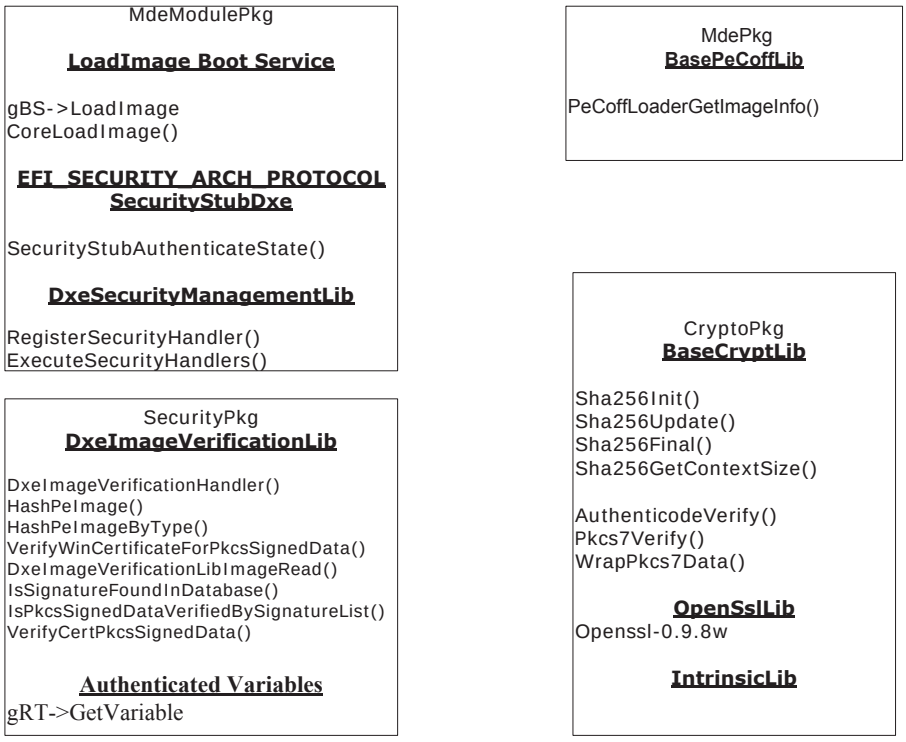


Authorization Flow

UEFI Secure Boot Flow

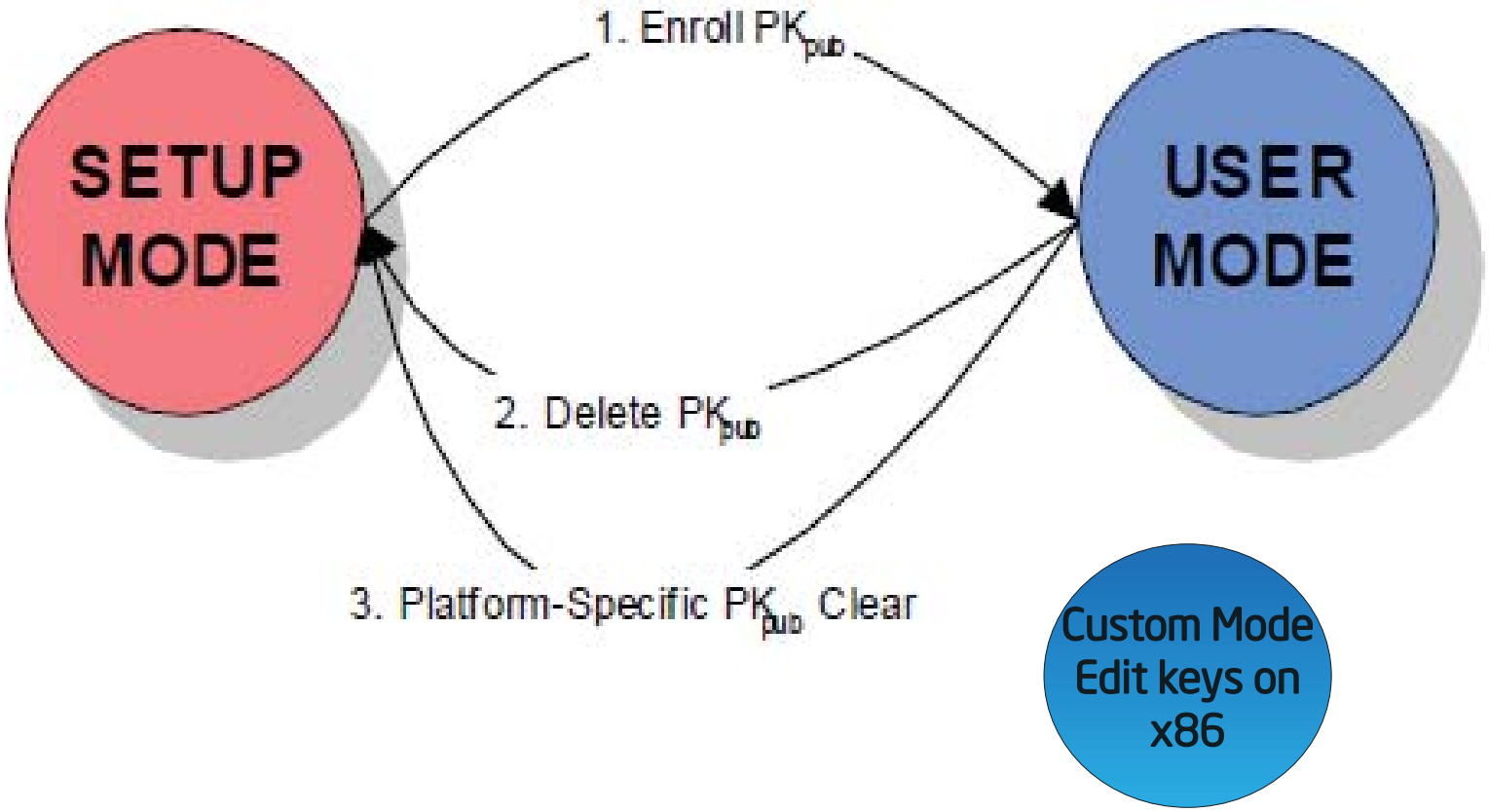


Relevant open source software packages/routines for Authorization flow



See *Rosenbaum, Zimmer, "A Tour Beyond BIOS into UEFI Secure Boot,"* for more details

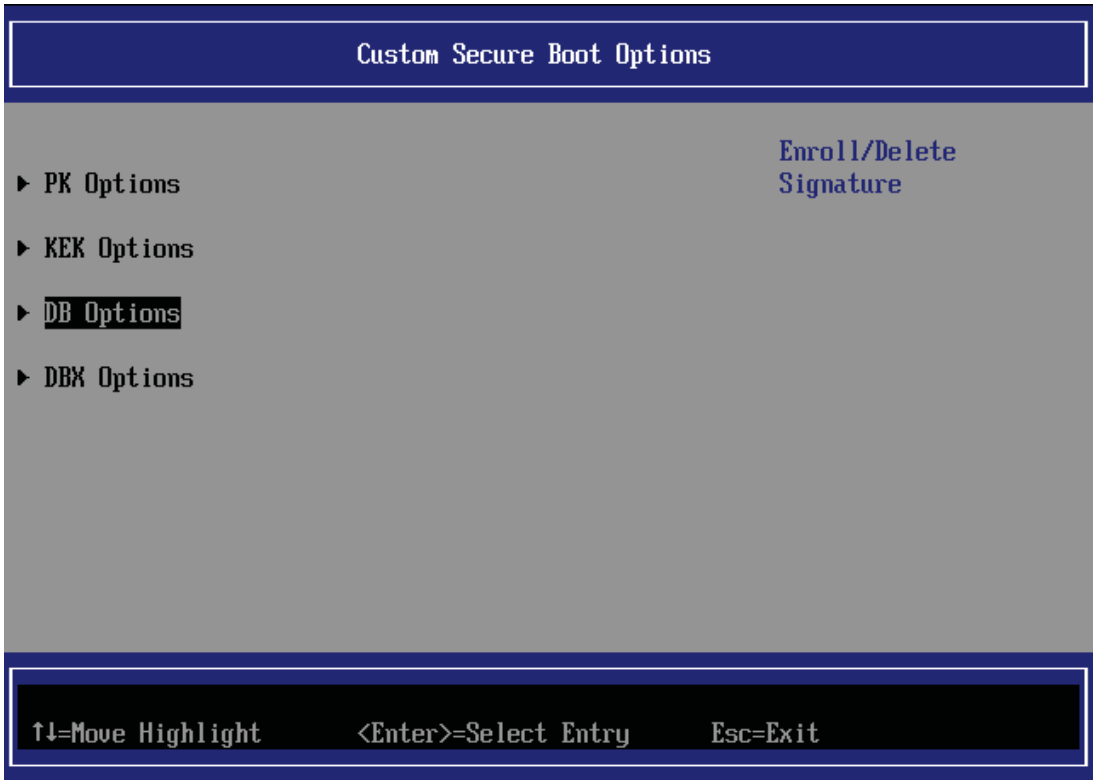
Put them altogether: UEFI Secure Boot



Enable Secure Boot

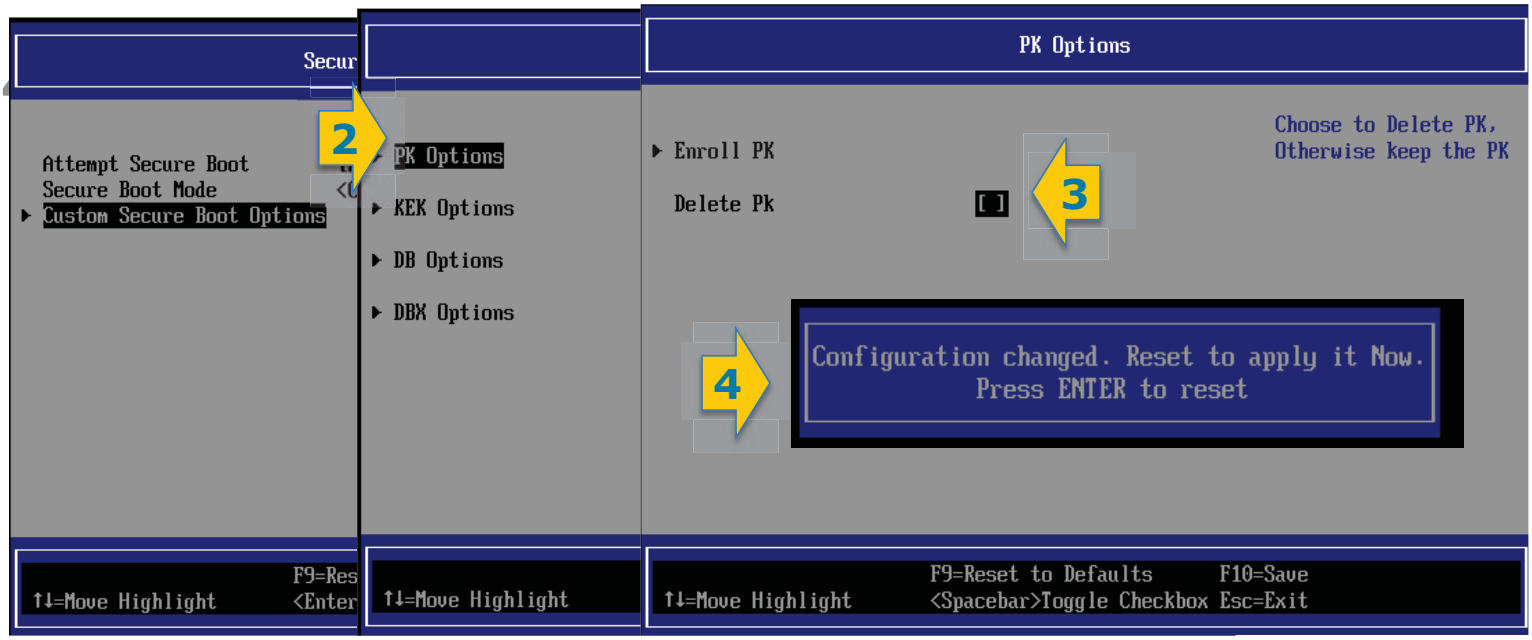
End user controls -Custom Secure Boot Options

Enrolling DB and/or DBX for physically present user



Disable Secure Boot

1. Select Custom Secure Boot Options
2. Select PK Options
3. Delete Pk (space bar)

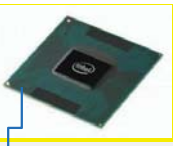


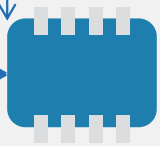
Technologies – putting it together

Reset

TCG Measurements into PCRs 0...7

Assets	Threats	
BIOS Flash	ROM Swap Bit rot	H/W Spec
System BIOS NIST SP800-147. Recovery. DXE SMM, UEFI Core	Erase flash part Overwrite flash part	SP800 -147
Option ROMs BIOS device drivers	Erase op ROM Overwrite op ROM	UEFI 2.3.1
Network Boot IPv6 for the cloud	Network attacks	
OS Boot loader BIOS loads the OS To BIOS, Hv/VMM is an OS	Spoof boot loader	



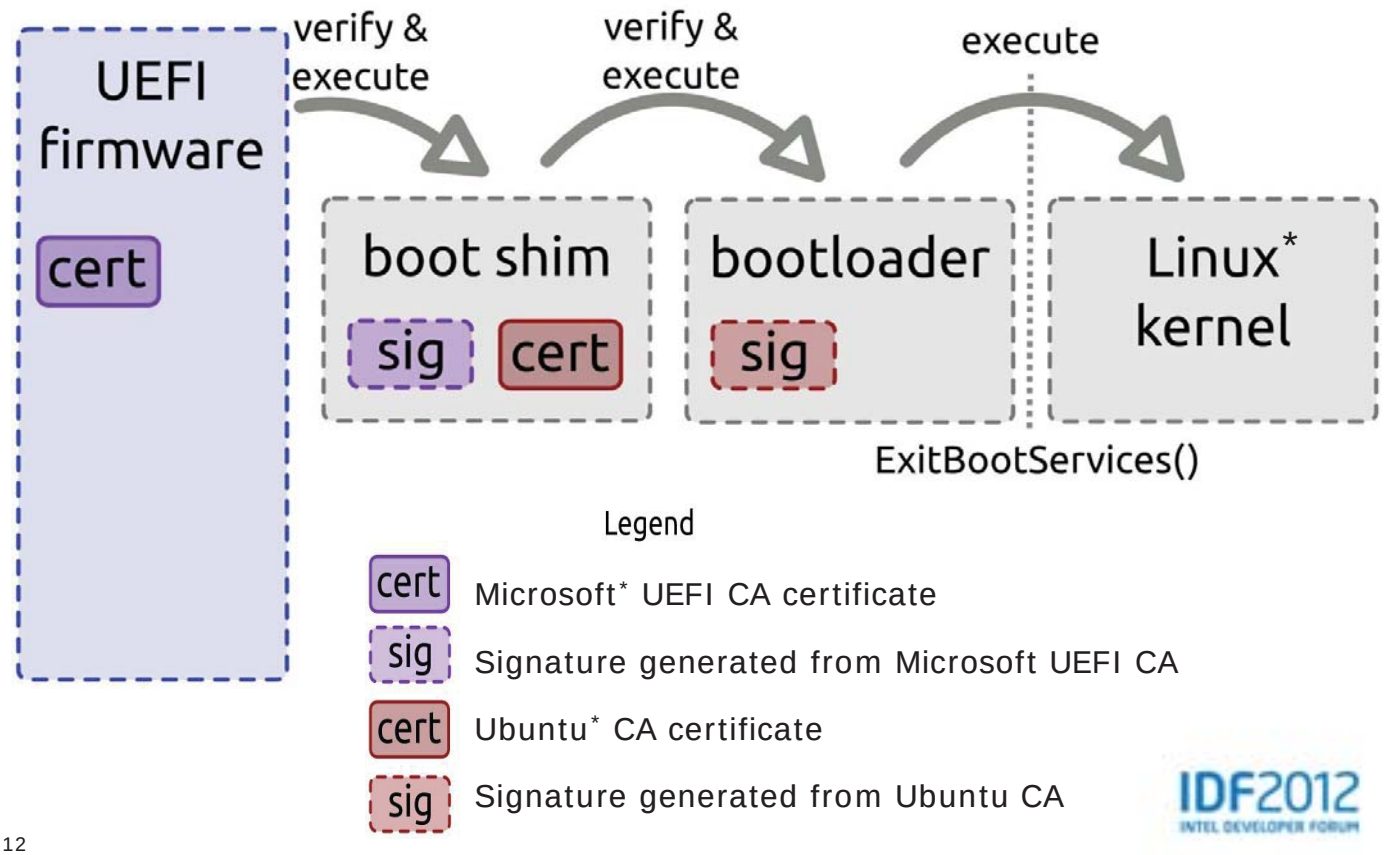


Different colors for different vendors

Linux solutions – from Sept Intel Dev Forum

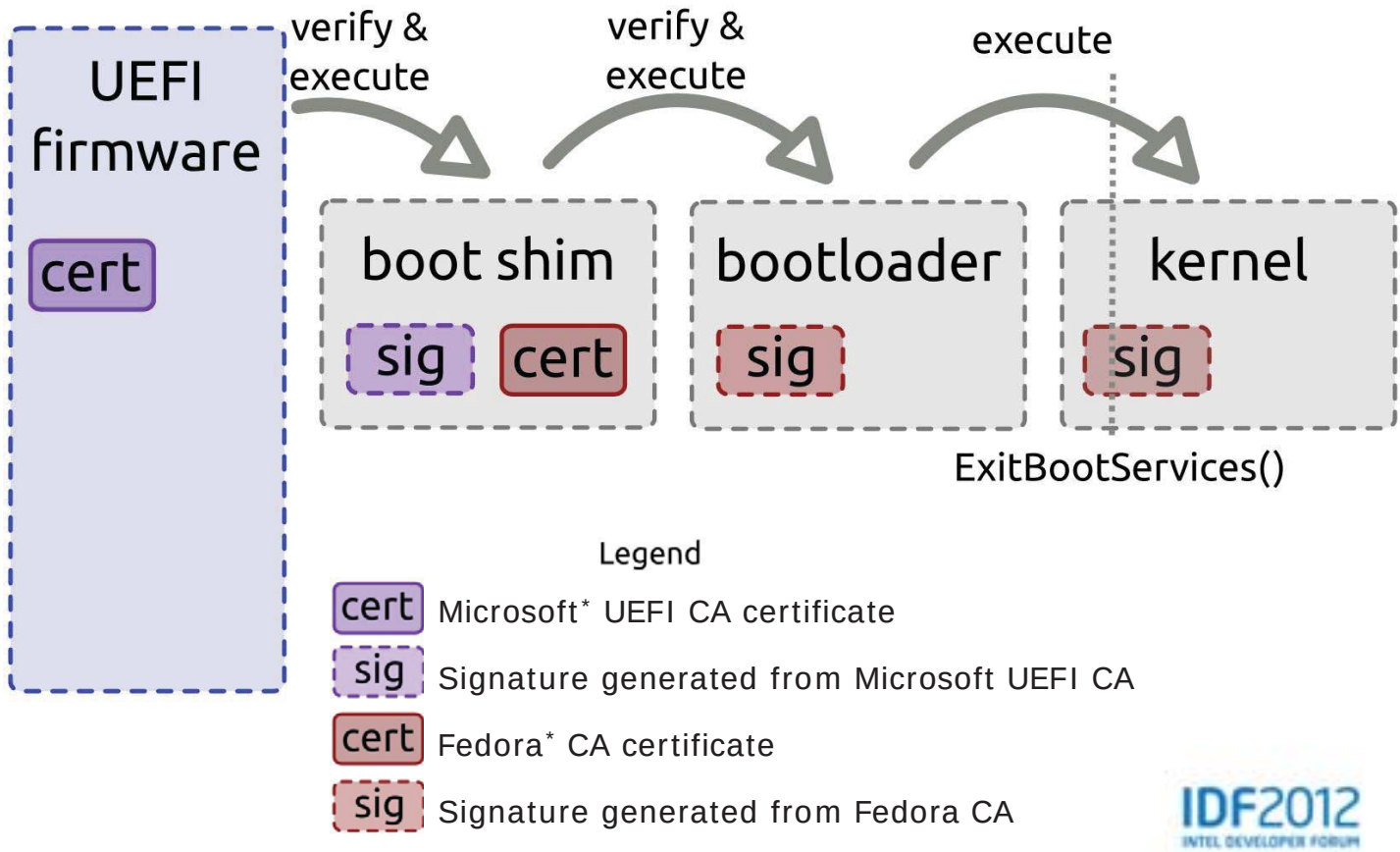
Ubuntu – Jeremy Kerr

Ubuntu* Implementation



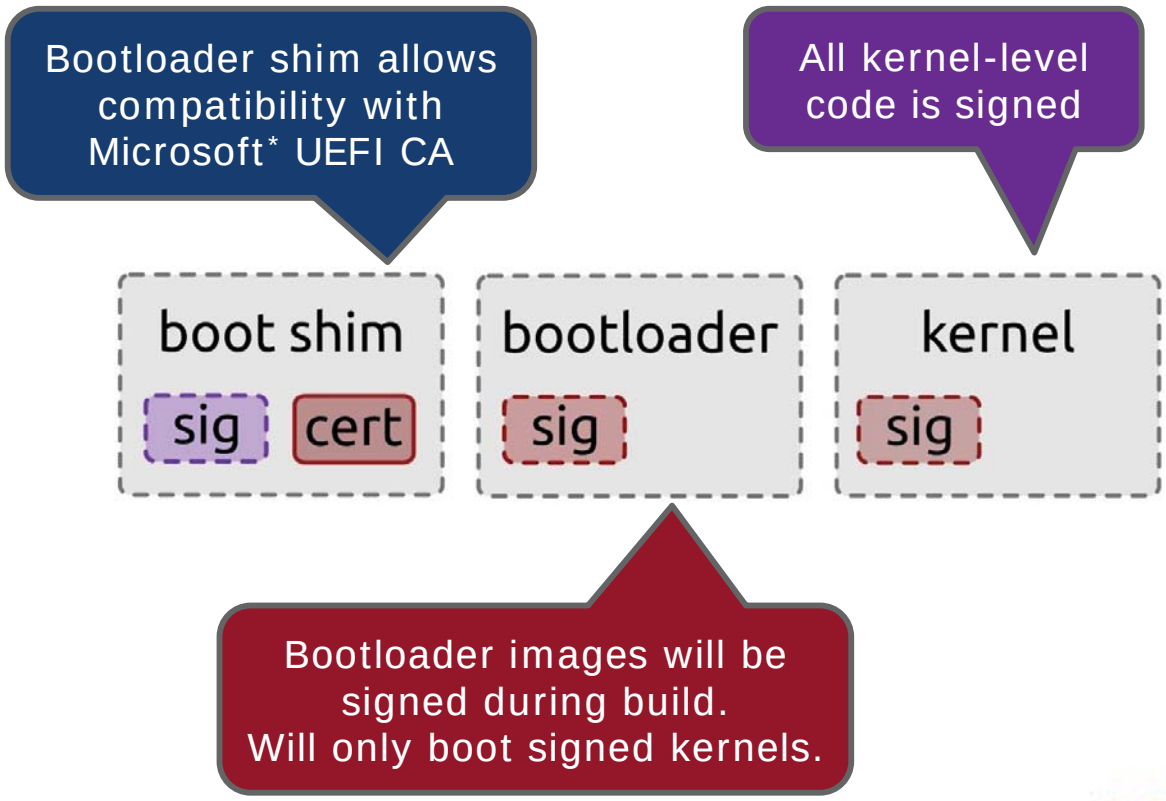
Fedora – Matthew Garrett

Fedora* Implementation



Fedora - cont.

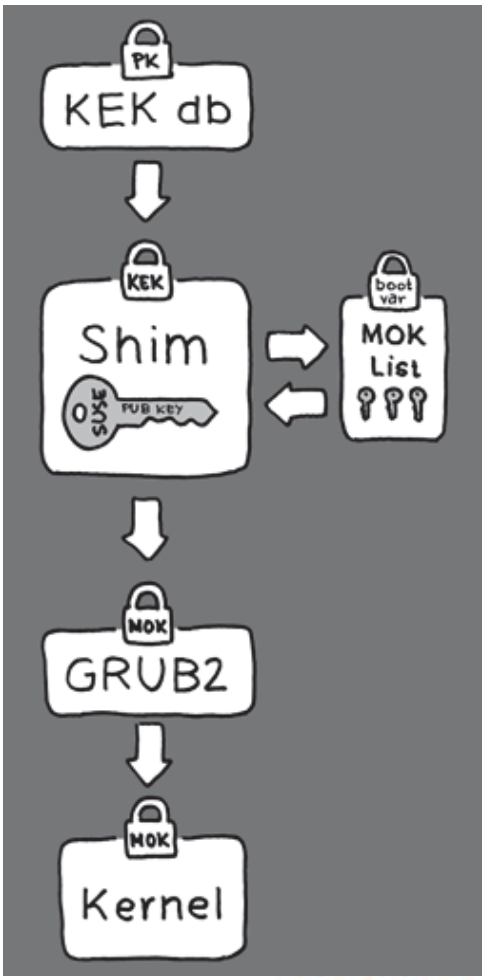
Fedora* Implementation



SuSE

SUSE* Approach to UEFI Secure Boot

- We need to balance two goals
  - Improving Enterprise security by adopting Secure Boot
  - Reconcile Secure Boot with Linux developer community need to run own boot loader/kernel
- Aiming to support Secure Boot in SLE11 SP3* and openSUSE *
- Working with Linux* community and other vendors
  - Building on the shim loader created by Matthew Garrett
  - Extending it to allow machine owner to securely boot other kernels



Challenges

- Multi-OS support, GPL3 & Open source
- Firmware size – open source & crypto libs
- Speed impacts
- Consistency w/ other ‘security’ technologies in platform
- Robustness
  - Coding practice
  - Protected updates
  - Recovery
- Validation
  - Negative testing
  - Fuzzing
- Interoperability of different implementations

Summary

- Threats of UEFI extensibility are real
- Address w/ open standards and open source
- Secure boot is coming w/ next OS wave (and like longevity of any shrinkwrap OS release, will continue for 10 yrs)
- Challenges in ecosystem enabling

For more information - UEFI Secure Boot

Intel Technology Journal, Volume 15, Issue 1, 2011, UEFI Today: Bootstrapping the Continuum, UEFI Networking and Pre-OS Security, page 80 at
http://www.intel.com/technology/itj/2011/v15i1/pdfs/Intel-Technology-Journal-Volume-15-Issue-1-2011.pdf

Rosenbaum, Zimmer, "A Tour Beyond BIOS into UEFI Secure Boot," Intel Corporation, July 2012
http://sourceforge.net/projects/edk2/files/General%20Documentation/A_Tour_Beyond_BIOS_into_UEFI_Secure_Boot_White_Paper.pdf/download

UEFI 2.3.1 specification: Sections 7.2 (Variable Services) and Sections 27.2 through 27.8 (Secure Boot) of the at www.uefi.org

Beyond BIOS: Developing with the Unified Extensible Firmware Interface, 2nd Edition, Zimmer, et al, ISBN 13 978-1-934053-29-4, Chapter 10 – Platform Security and Trust,
http://www.intel.com/intelpress

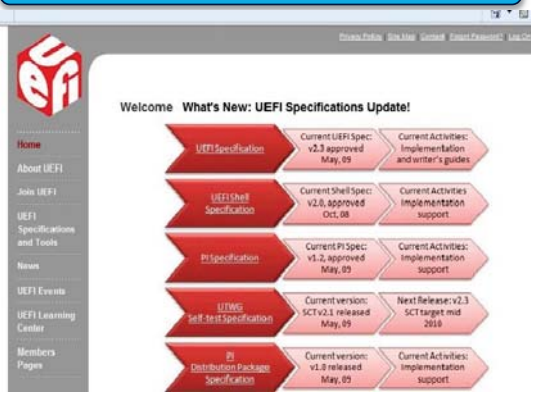
"Hardening the Attack Surfaces," MSFT 2012 UEFI Plugfest
http://www.uefi.org/learning_center/UEFI_Plugfest_2012Q1_Microsoft_AttackSurface.pdf

"Building hardware-based security with a TPM" MSFT BUILD
http://channel9.msdn.com/Events/BUILD/BUILD2011/HW-462T

Matthew Garrett's various blogs http://mjg59.livejournal.com/

UEFI Industry Resources

UEFI Forum



www.uefi.org

UEFI Open Source

www.tianocore.org

Intel UEFI Resources

www.intel.com/UDK

Intel EBC Compiler

http://software.intel.com/en-us/articles/intel-c-compiler-for-efi-byte-code-purchase/

UEFI Books/ Collateral

www.intel.com/intelpress

http://www.intel.com/technology/itj/2011/v15i1/index.htm

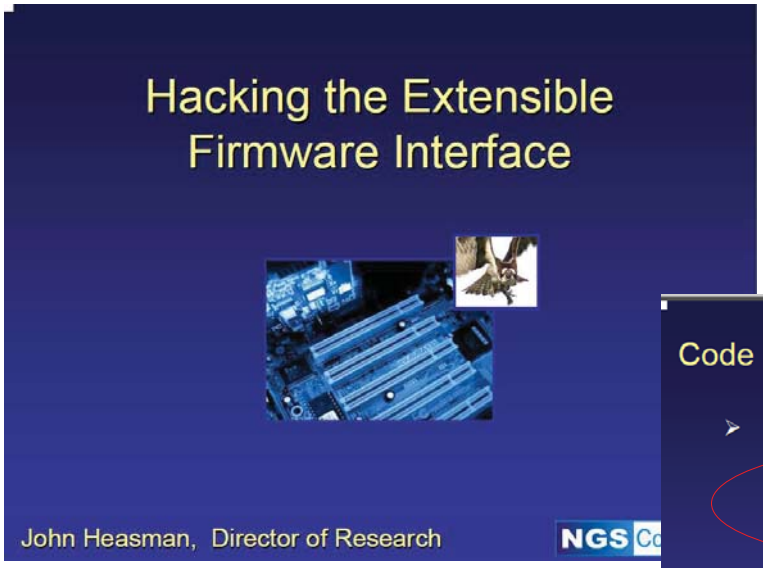
PLUG

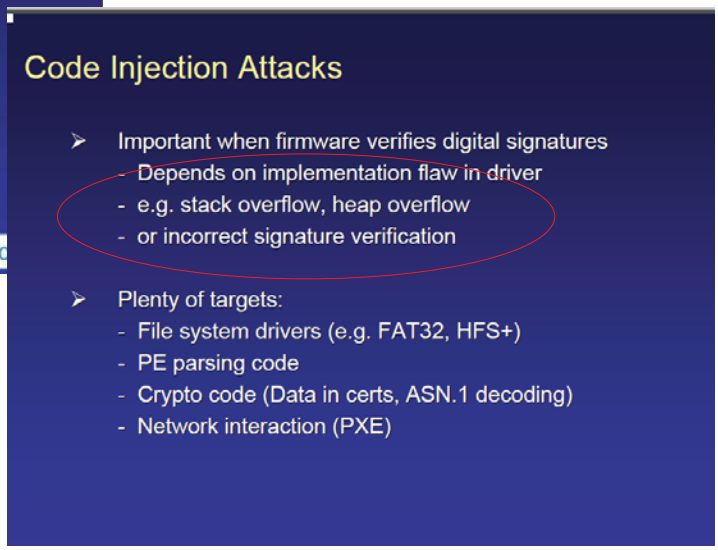
Thank You

Contact:
vincent.zimmer@gmail.com

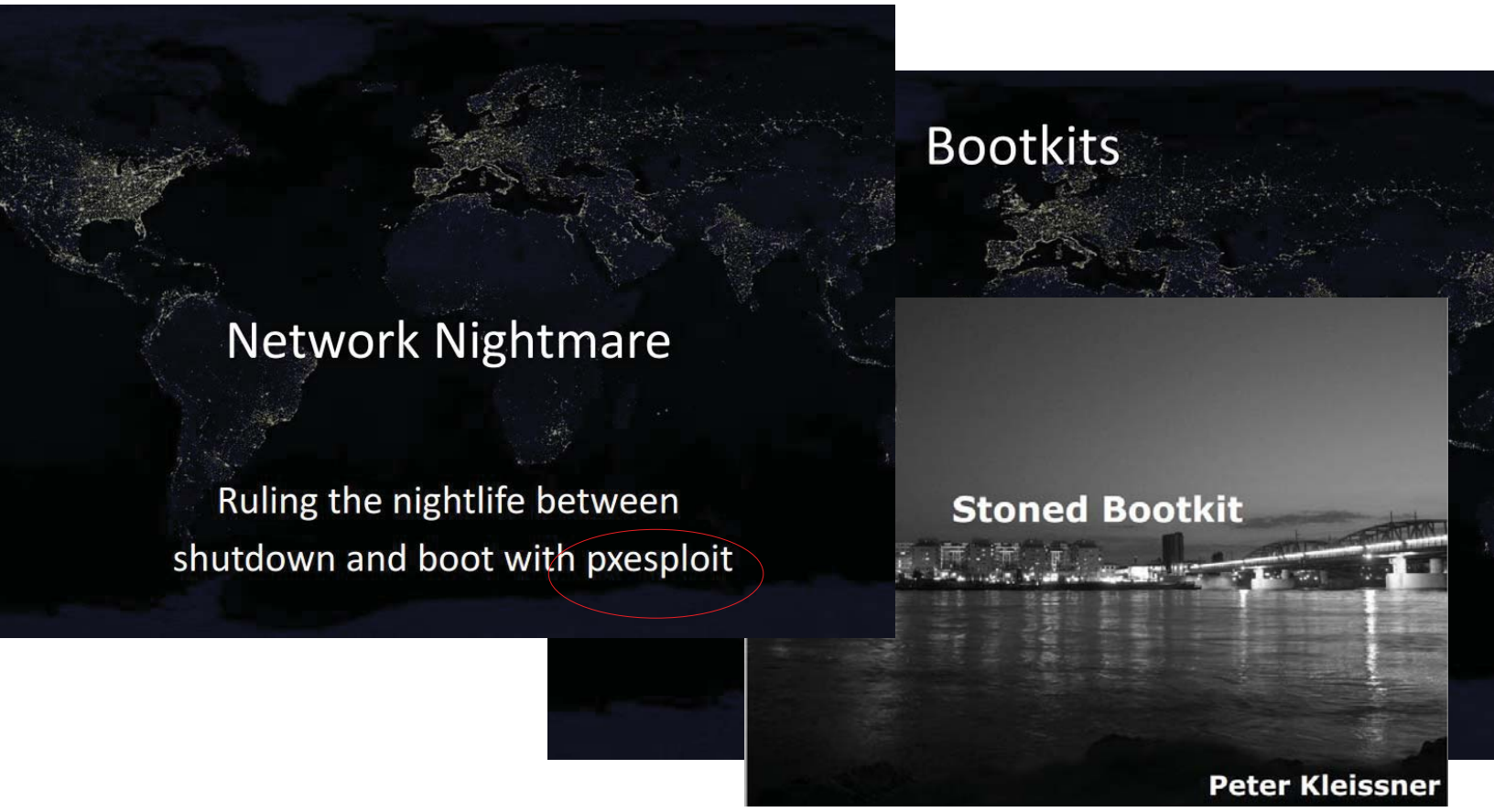
Backup

History of attacks – 2007 – Blackhat Las Vegas

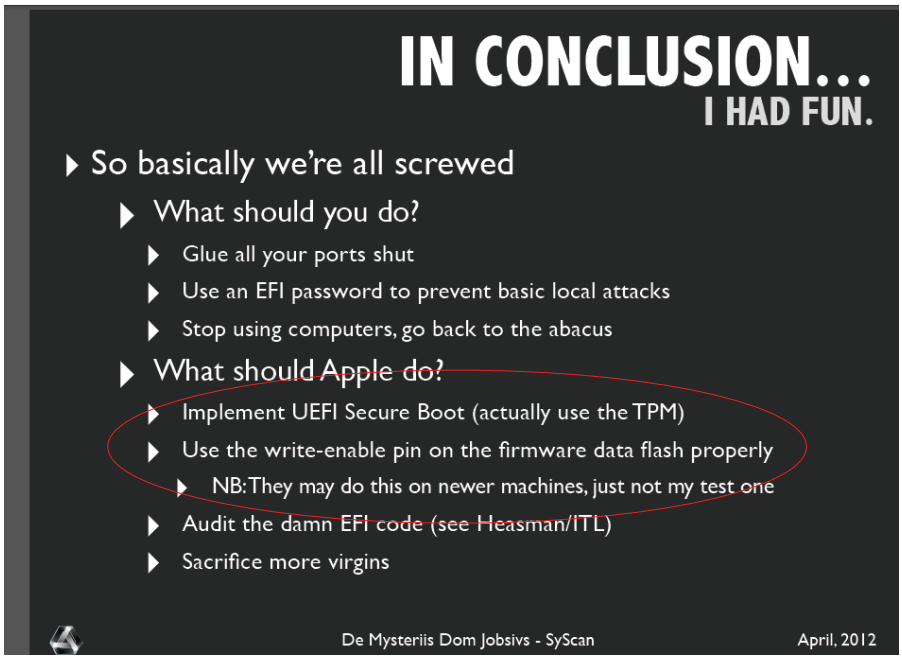




Defcon 19 – Bootkits and network boot attacks



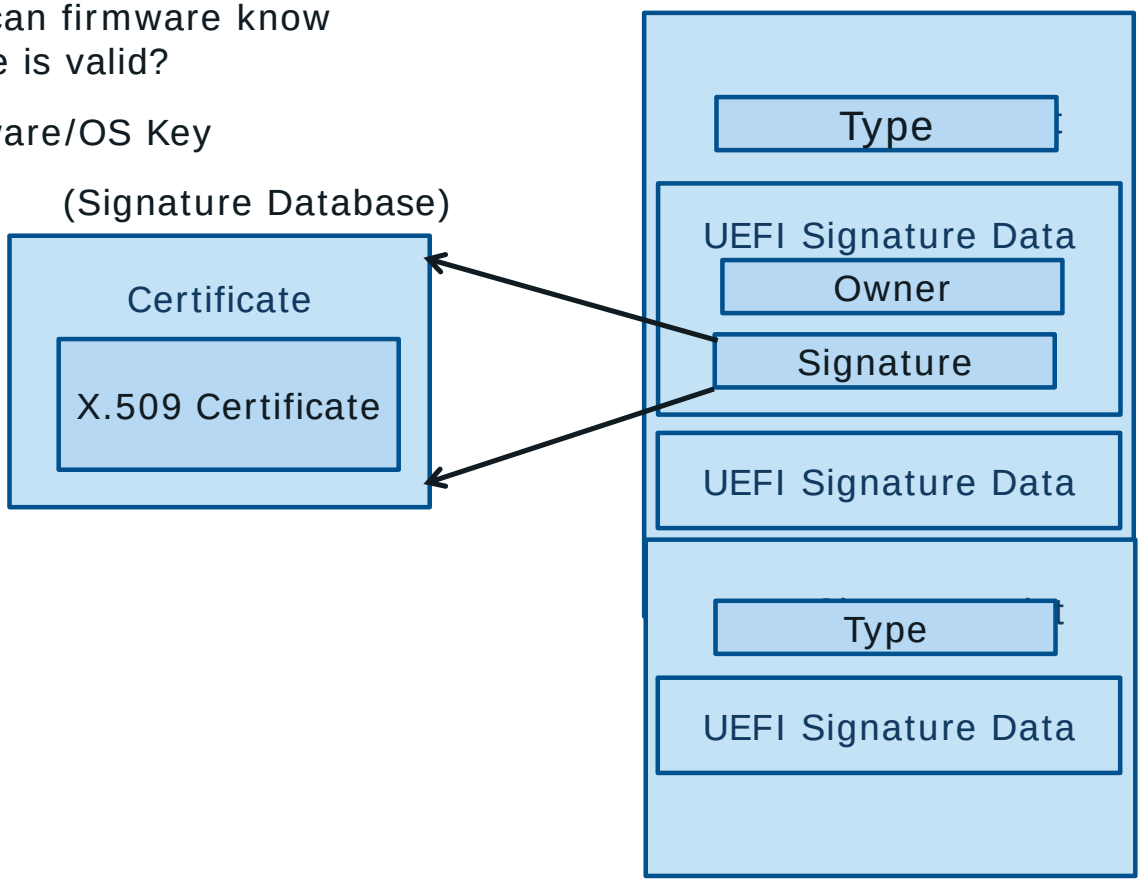
SYSCAN Singapore – April 2012



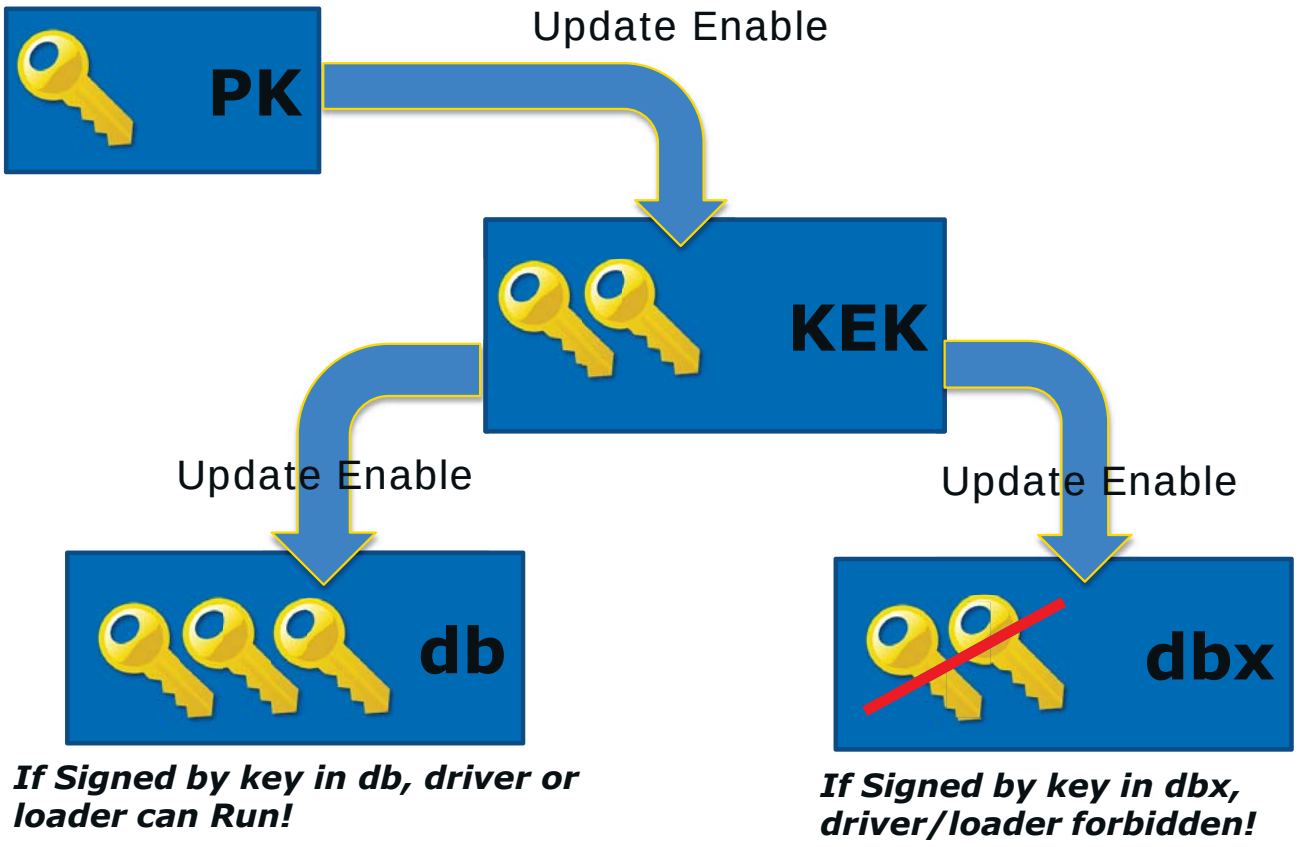
Firmware/OS Key

Why? – How can firmware know if certificate is valid?

How? – Firmware/OS Key



UEFI Secure Boot Database Review



Who "Owns" The System Security Keys?

PK – Key pair is created by Platform Manufacturer

Typically one PK pair used for a model or model Line

KEK – Key supplied by OS Partner,

Optional: Include 2nd key created by OEM

db – OS vendor supplies Key,

CA supplies Key,

Optional: OEM App Signing Key

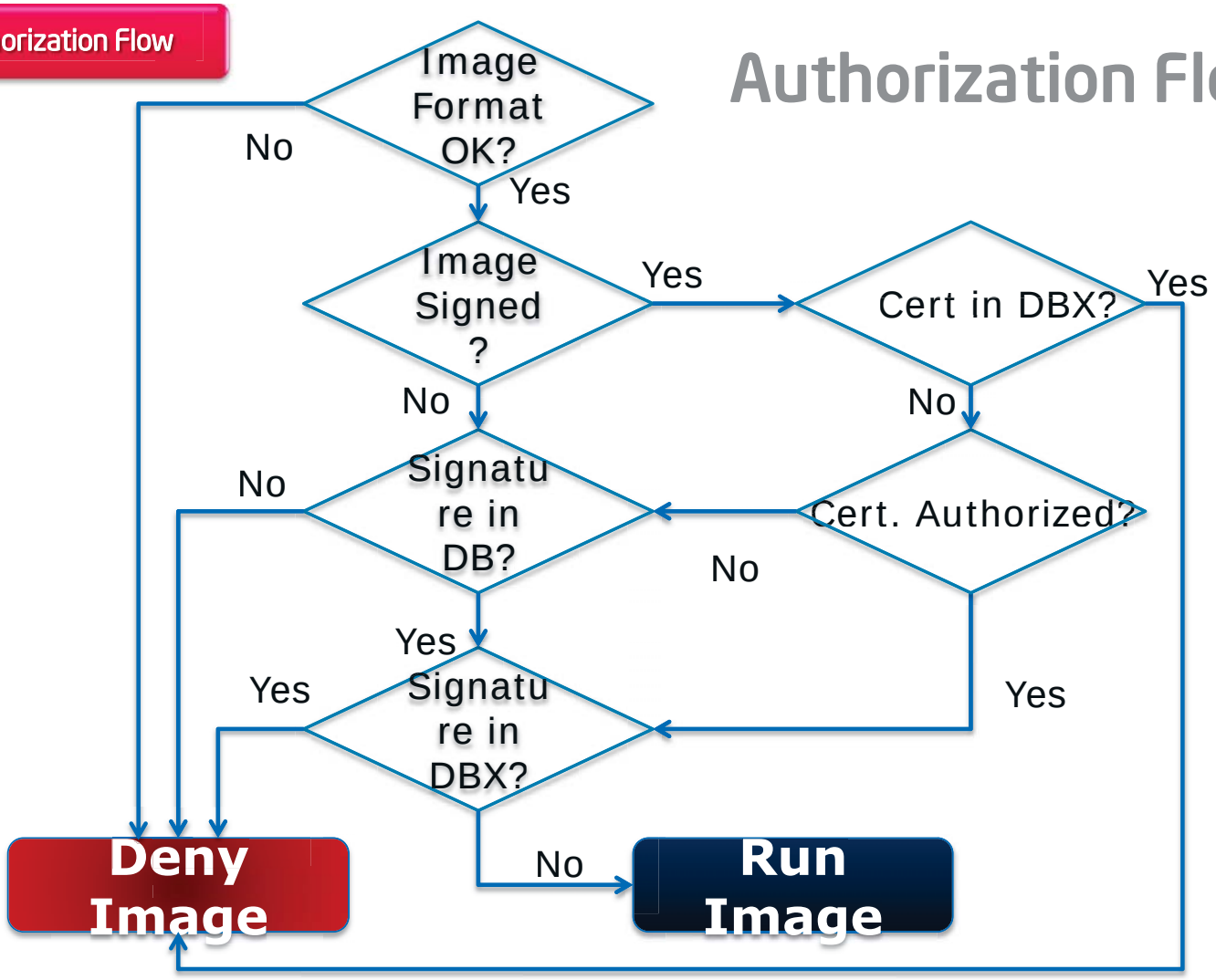
dbx – list of revoked keys

- Signing authority issues revoked keys

Signature Tests using db Keys Block Rogue S/W!

Authorization Flow

Authorization Flow



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