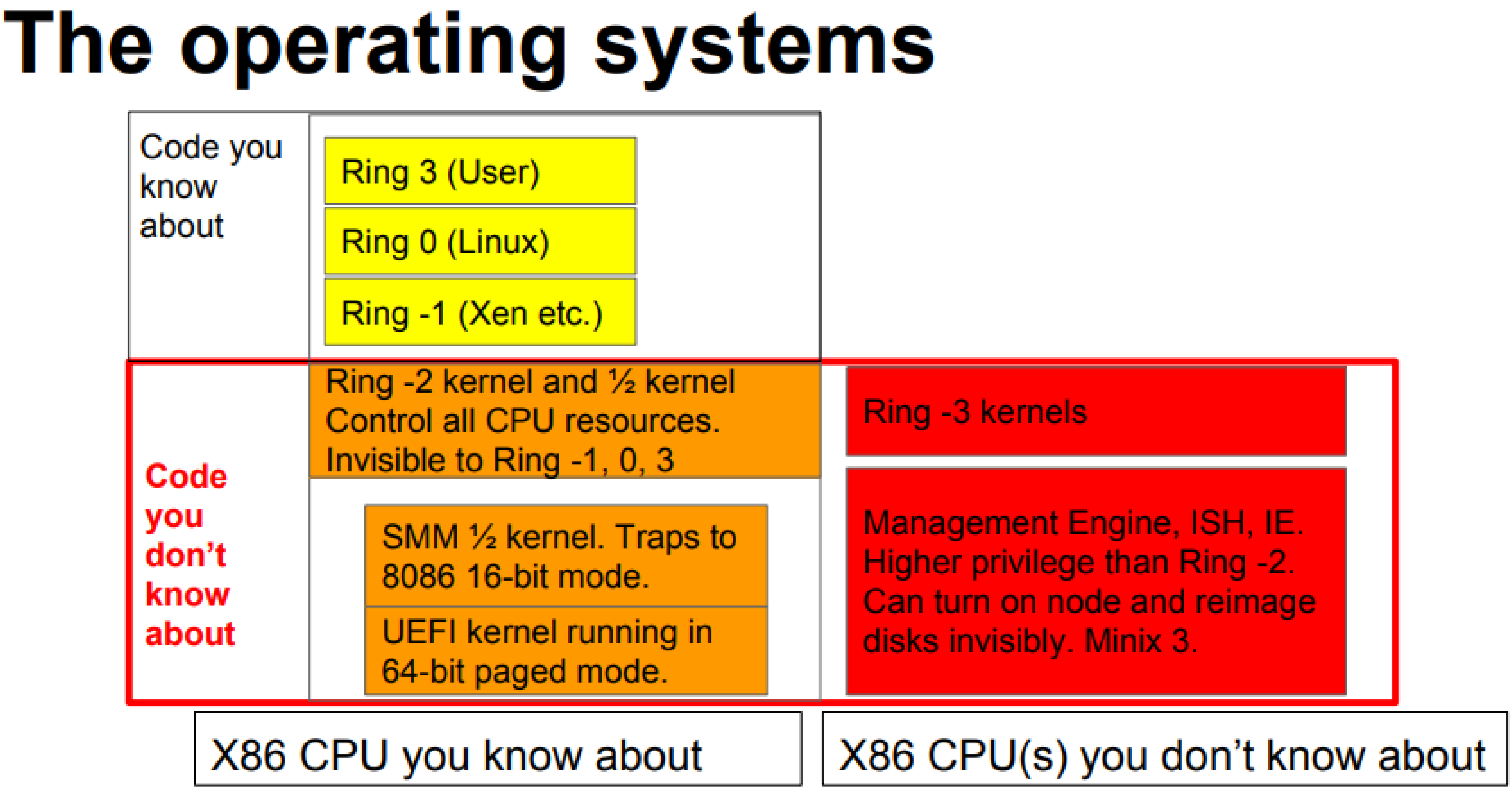
Hardware Exploitation

Ring -1, -2, -3

Exploiting Ring <0

“Replace Your Exploit-Ridden Firmware with Linux - Ronald Minnich, Google”



The operating systems

Code you know about

Ring 3 (User)

Ring 0 (Linux)

Ring -1 (Xen etc.)

Code you don’t know about

Ring -2 kernel and ½ kernel Control all CPU resources. Invisible to Ring -1, 0, 3

SMM ½ kernel. Traps to 8086 16-bit mode.

UEFI kernel running in 64-bit paged mode.

Ring -3 kernels

Management Engine, ISH, IE. Higher privilege than Ring -2. Can turn on node and reimage disks invisibly. Minix 3.

X86 CPU you know about

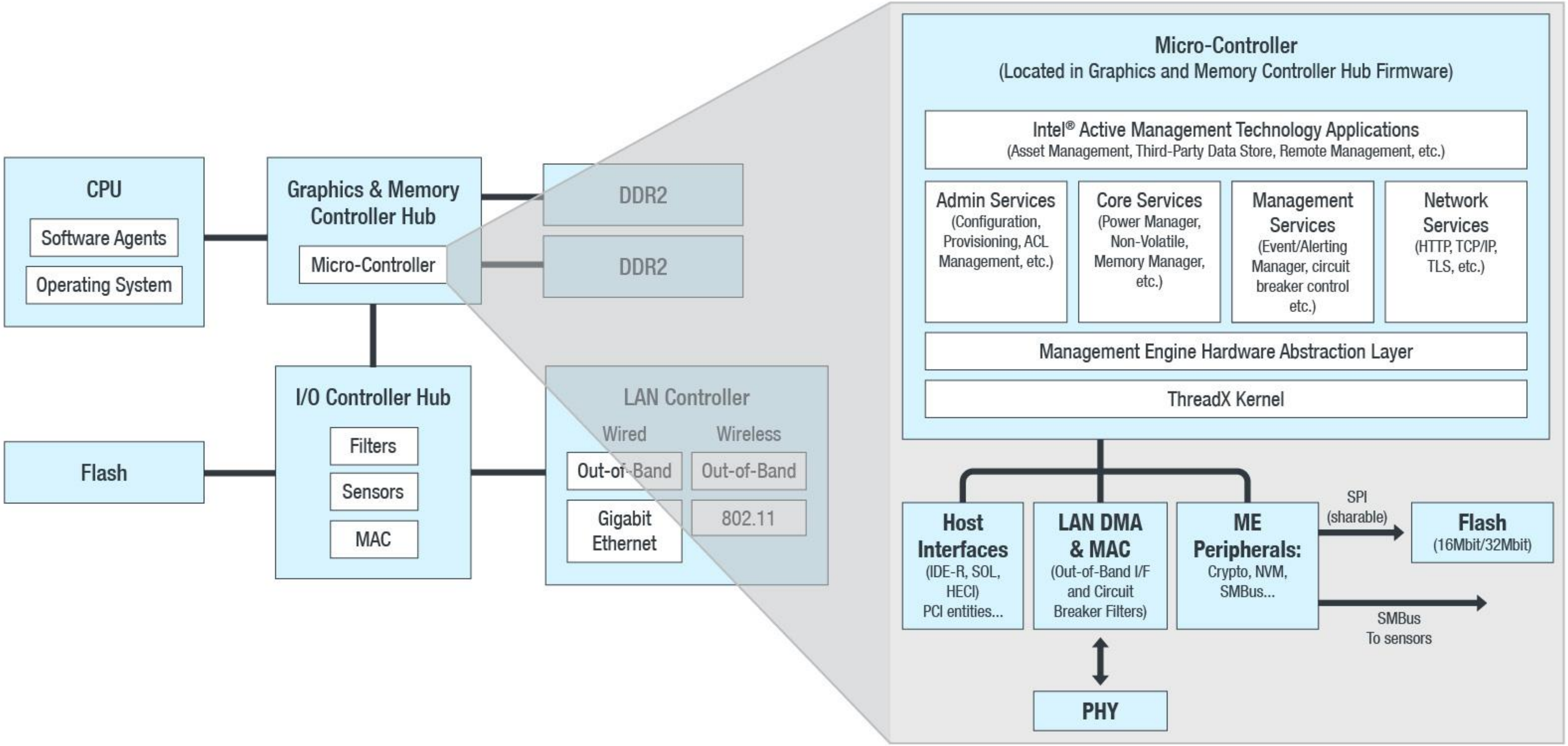
X86 CPU(s) you don’t know about

Ring -1, -2, -3

- Ring -1: Hypervisor
  - ESX, HyperV, Xen etc
  - Makes it possible to run multiple kernels (VM’s) at the same time
- Ring -2: SMM
  - System Management Mode
  - 16 bit mode
  - Handling of interrupts
- Ring -3: Intel ME
  - Management Engine
  - Separate Microprocessor (!)
  - Works if your computer is off
  - Has TCP/IP stack
  - Minix OS
  - Access to Screen (KVM)
  - Intel AMT

Intel ME

https://blog.trendmicro.com/trendlabs-security-intelligence/mitigating-cve-2017-5689-intel-management-engine-vulnerability/

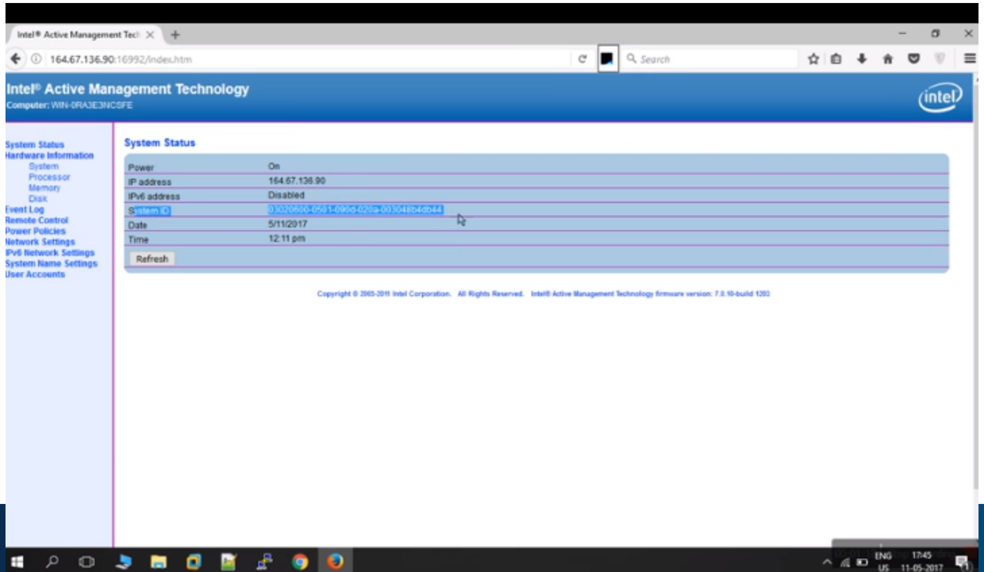

CPU
Software Agents
Operating System
Graphics & Memory Controller Hub
Micro-Controller
DDR2
DDR2
I/O Controller Hub
Filters
Sensors
MAC
Flash
LAN Controller
Wired
Wireless
Out-of-Band
Out-of-Band
Gigabit Ethernet
802.11
Micro-Controller
(Located in Graphics and Memory Controller Hub Firmware)
Intel® Active Management Technology Applications
(Asset Management, Third-Party Data Store, Remote Management, etc.)
Admin Services
(Configuration, Provisioning, ACL Management, etc.)
Core Services
(Power Manager, Non-Volatile, Memory Manager, etc.)
Management Services
(Event/Alerting Manager, circuit breaker control etc.)
Network Services
(HTTP, TCP/IP, TLS, etc.)
Management Engine Hardware Abstraction Layer
ThreadX Kernel
Host Interfaces
(IDE-R, SOL, HECI)
PCI entities...
LAN DMA & MAC
(Out-of-Band I/F and Circuit Breaker Filters)
ME Peripherals:
Crypto, NVM, SMBus...
SPI
(sharable)
Flash
(16Mbit/32Mbit)
SMBus
To sensors
PHY

Intel ME / AMT Bug

Using a web-based control panel, accessible from **port 16992 and 16993**, which comes pre-installed on the chipset, an administrator can remotely manage a system.

The **Intel AMT Web Interface works even when the system is turned off**, as long as the platform is connected to a line power and a network cable, as it operates independently of the operating system.

To exploit this logical flaw in Intel AMT Web Interface, **all an unauthorized attacker needs to do is send nothing (null)** into user_response to the server.



Intel® Active Management Tech

164.67.136.90:16992/index.htm

Intel® Active Management Technology

Computer: WIN-0RA3E3NCSFE

System Status

Power	On
IP address	164.67.136.90
IPv6 address	Disabled
System ID	03020600-0501-090d-020a-003048b4db44
Date	5/11/2017
Time	12:11 pm

Refresh

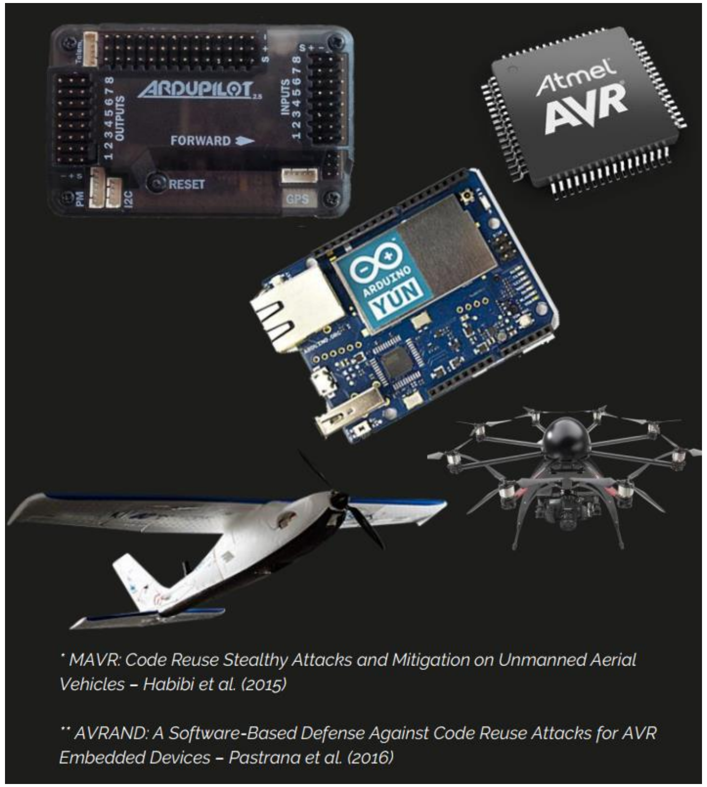
Copyright © 2005-2011 Intel Corporation. All Rights Reserved. Intel® Active Management Technology firmware version: 7.0.10-build 1203

Embedded Systems

Non Intel/AMD/ARM

Embedded Systems

- Non Linux/Windows Systems
- ESP8266, ROTS, ESP32, Zephyr, Fuchsia OS (Google), …
- Reference:
  - Jos Wetzels
  - http://samvartaka.github.io/work



* MAVR: Code Reuse Stealthy Attacks and Mitigation on Unmanned Aerial Vehicles – Habibi et al. (2015)

** AVRAND: A Software-Based Defense Against Code Reuse Attacks for AVR Embedded Devices – Pastrana et al. (2016)

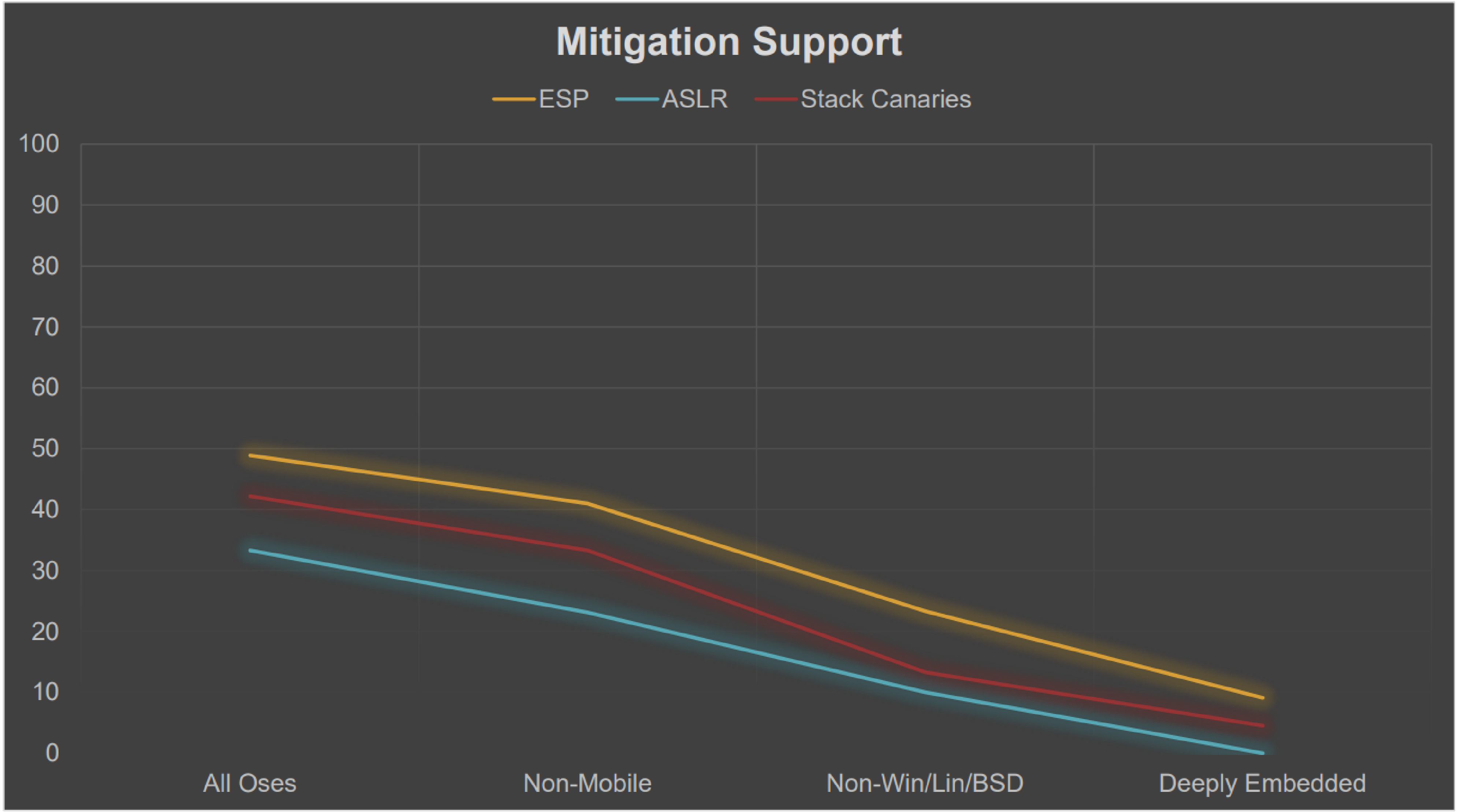
ARM
MIPS TECHNOLOGIES
ti
AVR
NXP
MICROCHIP
infineon
ST
RENESAS
MOTOROLA
PowerPC
ANALOG DEVICES
Atmel
intel

Hardware Selection

- Selected 78 Popular Embedded '*Core Families*'
- Evaluated for Hardware Dependency Support

https://hardwear.io/document/rtos-exploit-mitigation-blues-hardwear-io.pdf

Embedded Systems



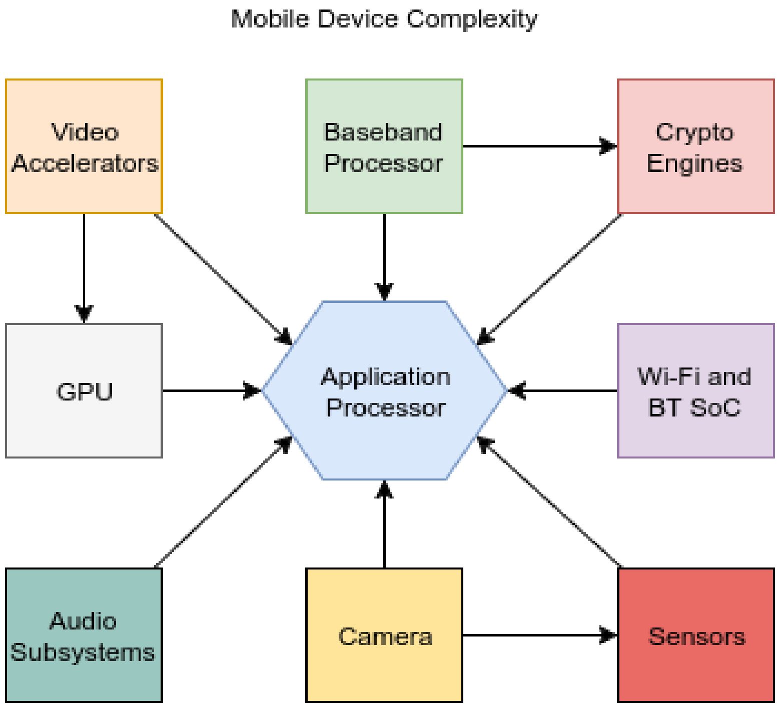
https://hardwear.io/document/rtos-exploit-mitigation-blues-hardwear-io.pdf

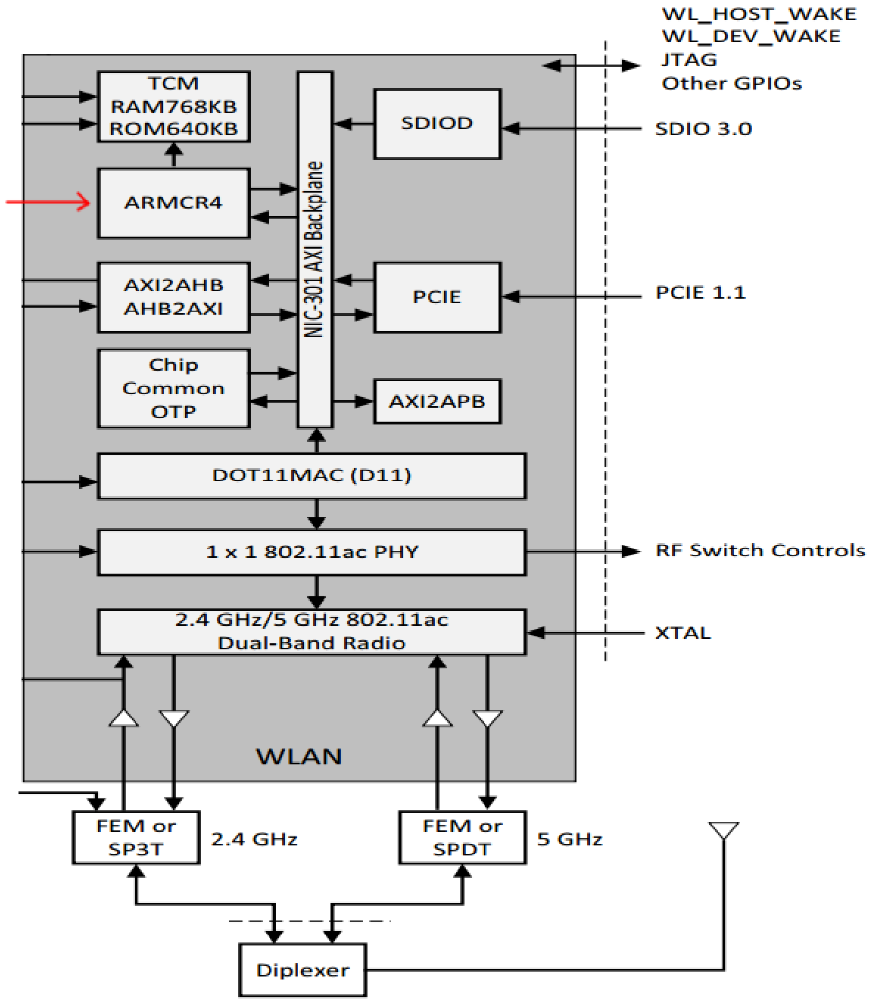
Embedded Systems

- Have their own CPU implementation, instruction set
- May or may not have Exploit Mitigation
    - DEP (CPU+OS)
    - ASLR (OS)
    - Stack Canaries (compiler)
- May or may not enable them by default
- May or may not have to create your own ROP technique (JOP, SOP,…)
- Have to create your own shellcode

Exploiting Broadcom’s Wi-Fi Stack

https://googleprojectzero.blogspot.ch/2017/04/over-air-exploiting-broadcoms-wi-fi_4.html





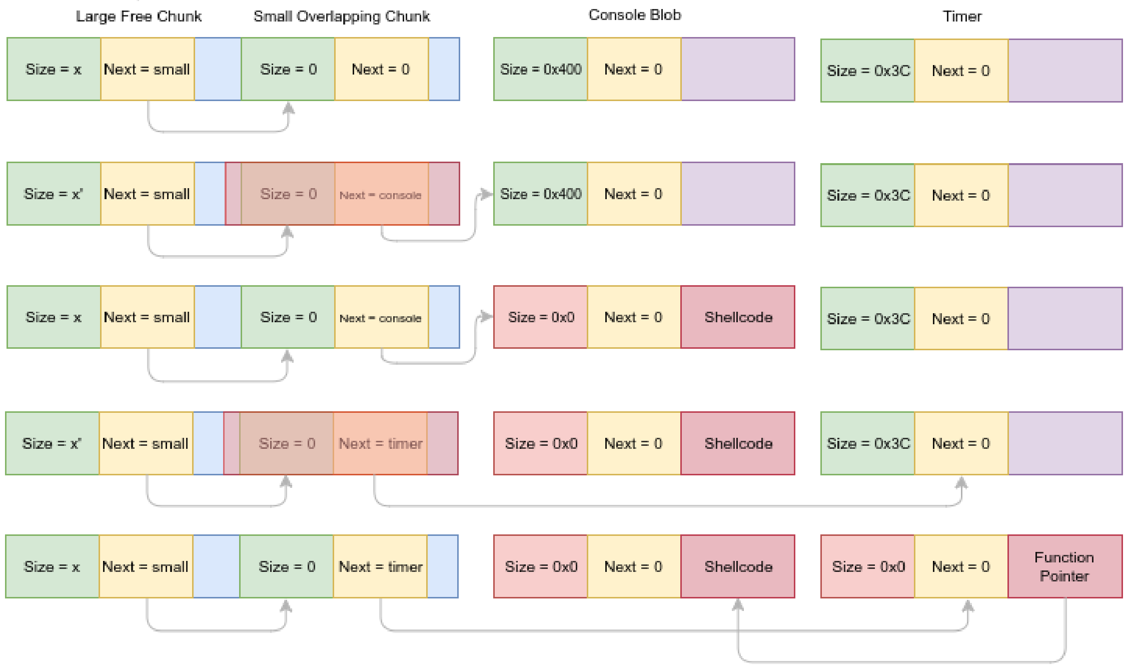
ARM Cortex R4 Running Firmware Logic

Exploiting Broadcom’s Wi-Fi Stack

https://googleprojectzero.blogspot.ch/2017/04/over-air-exploiting-broadcoms-wi-fi_4.html

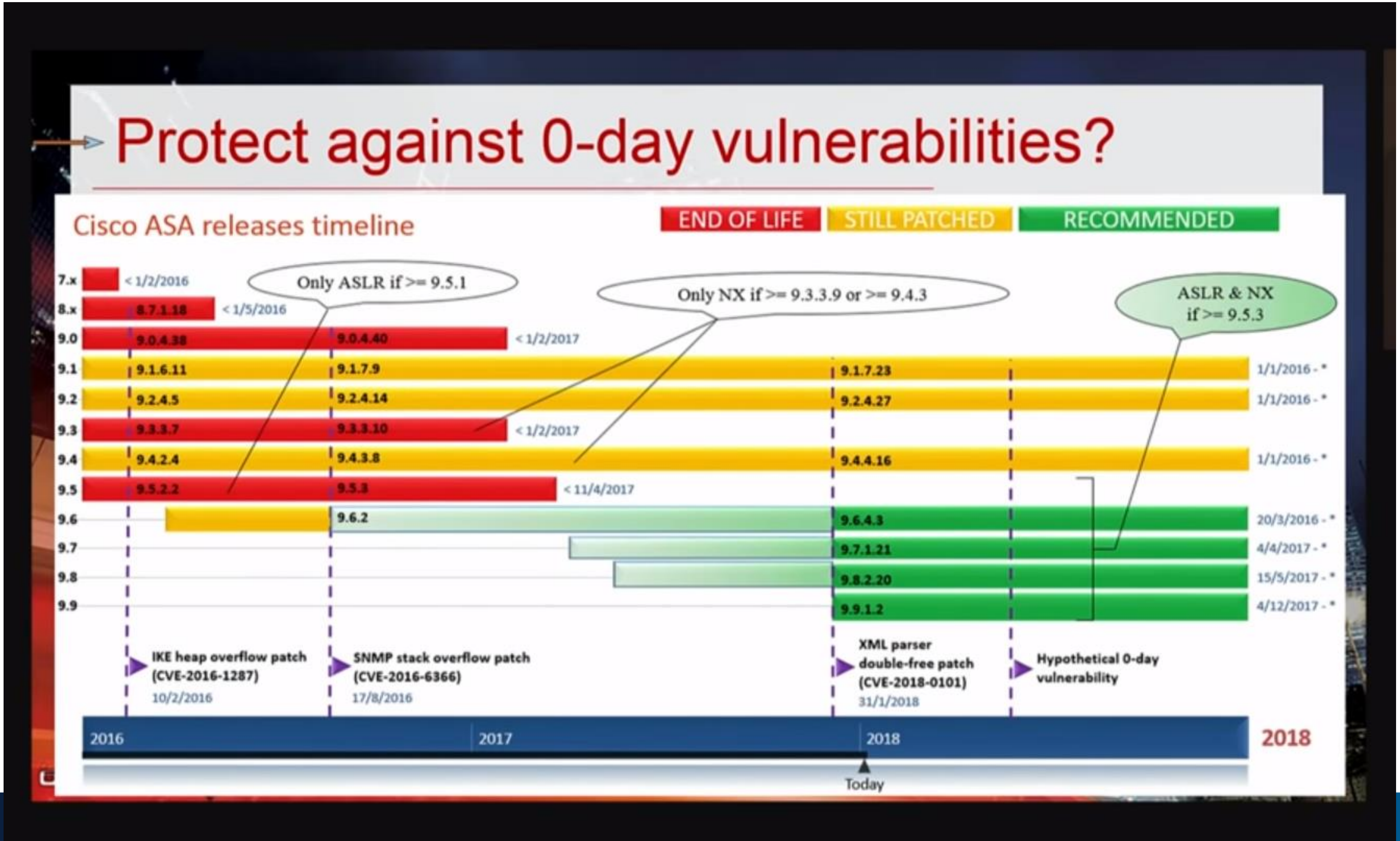
- Exploit for WiFi Chip Broadcom (Nexus 5, 6, 6P, Samsung, iPhones, …)
- Via WiFi frames
- Heap overflow (heap massage)
- After RCE: Escalate to Host OS

We’ve seen that while the firmware implementation on the Wi-Fi SoC is incredibly complex, it still lags behind in terms of security. Specifically, **it lacks all basic exploit mitigations – including stack cookies, safe unlinking and access permission protection**



What about ASA (Cisco)

https://www.youtube.com/watch?v=eDyxBgIUaR8



Protect against 0-day vulnerabilities?

Cisco ASA releases timeline

Attacking Hardware

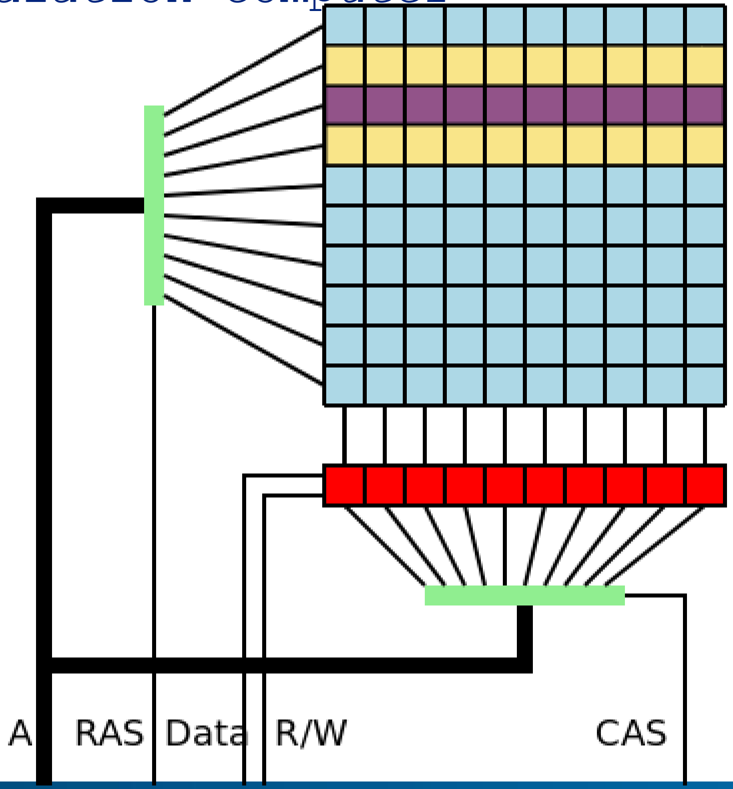
Local Kernel Exploits - Hardware

RAM Attack: Rowhammer

Row hammer is an unintended side effect in (DRAM) that causes memory cells to leak their charges and interact electrically between themselves, possibly **altering the contents of nearby memory rows** that were not addressed in the original memory access.

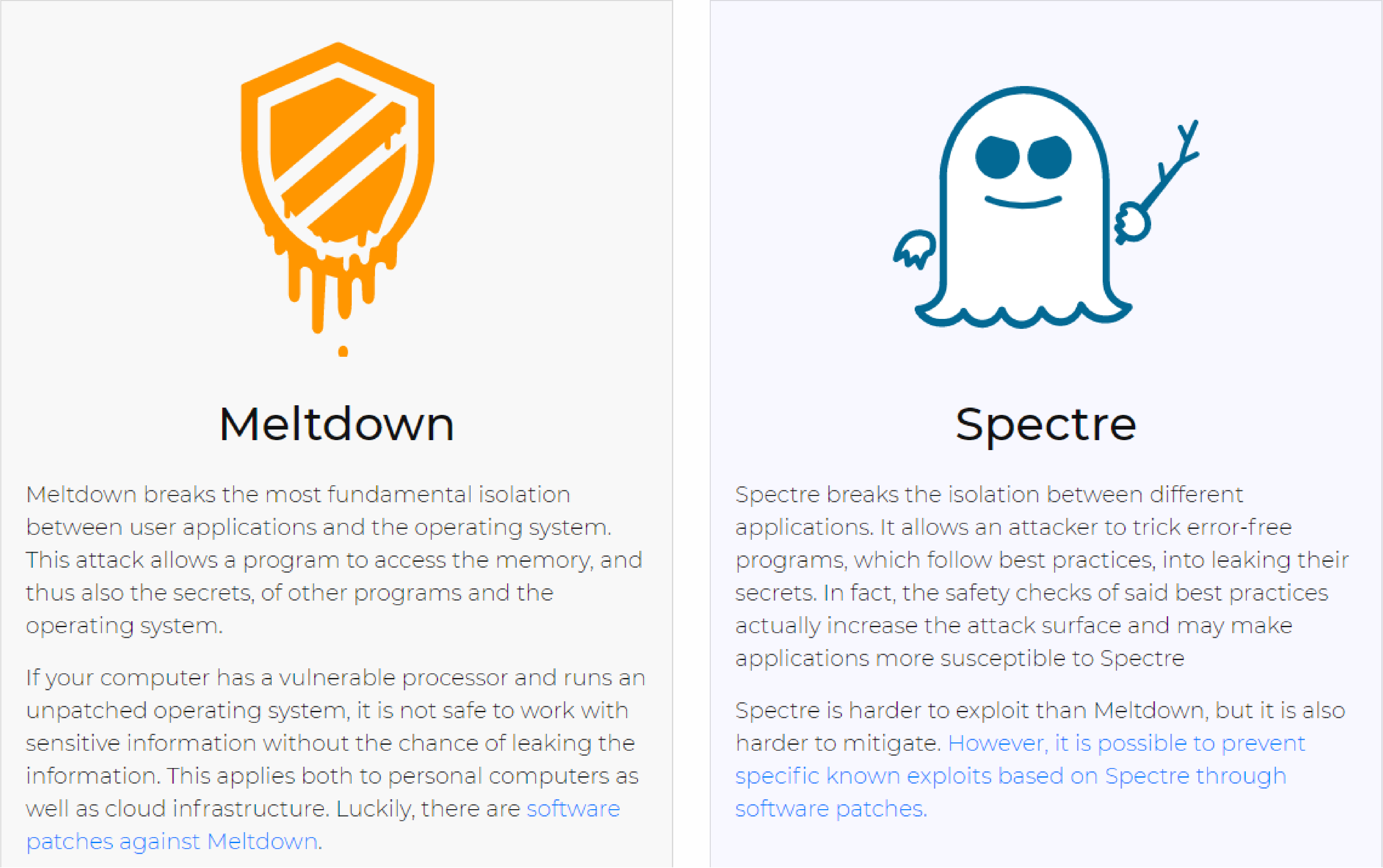
The row hammer effect has been used in some privilege escalation computer security exploits

- Write into other memory cells in RAM (bypass OS/CPU protection)
- Integrity of data not guaranteed
- Who is affected? Everyone!



Local Kernel Exploits - Hardware

- Meltdown / Spectre
  - Read memory of kernel or other userspace processes
  - Confidentially of “protected” memory pages not guaranteed
    - Stealing keys
    - Bypass kASLR
  - Can be exploited via Browser (JavaScript)
  - Who is affected? Everyone! (Intel, ~AMD, ARM, …)



Meltdown

Meltdown breaks the most fundamental isolation between user applications and the operating system. This attack allows a program to access the memory, and thus also the secrets, of other programs and the operating system.

If your computer has a vulnerable processor and runs an unpatched operating system, it is not safe to work with sensitive information without the chance of leaking the information. This applies both to personal computers as well as cloud infrastructure. Luckily, there are software patches against Meltdown.

Spectre

Spectre breaks the isolation between different applications. It allows an attacker to trick error-free programs, which follow best practices, into leaking their secrets. In fact, the safety checks of said best practices actually increase the attack surface and may make applications more susceptible to Spectre

Spectre is harder to exploit than Meltdown, but it is also harder to mitigate. However, it is possible to prevent specific known exploits based on Spectre through software patches.

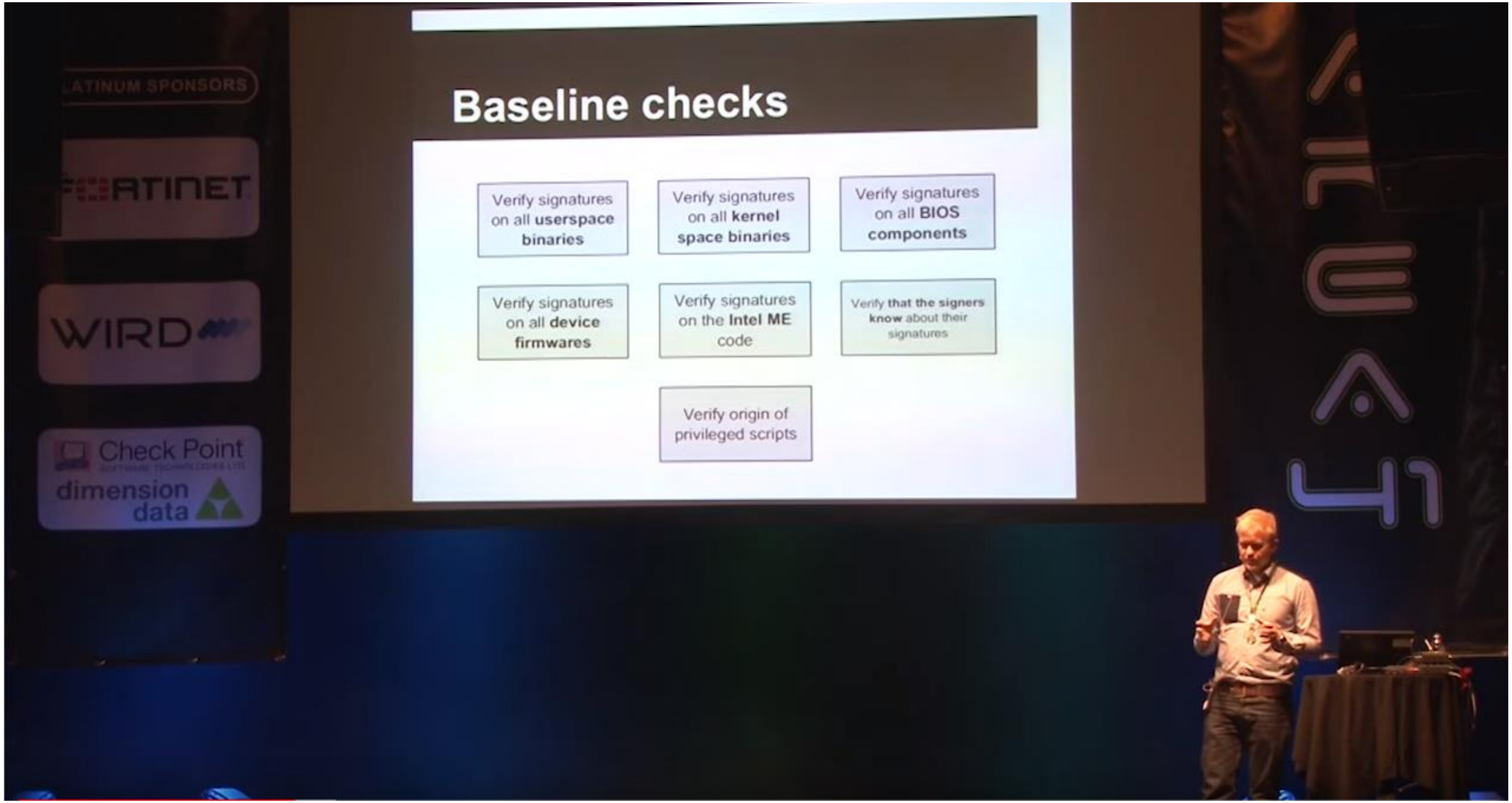
Conclusion

Hardware Attacks - Conclusion

- X86 hardware has layer we cannot control, and which are insecure
- Most embedded platforms are very insecure
- Our hardware itself is insecure
- Nothing can be trusted

Trusting our computers

Area41 2014: Halvar Flake: Keynote

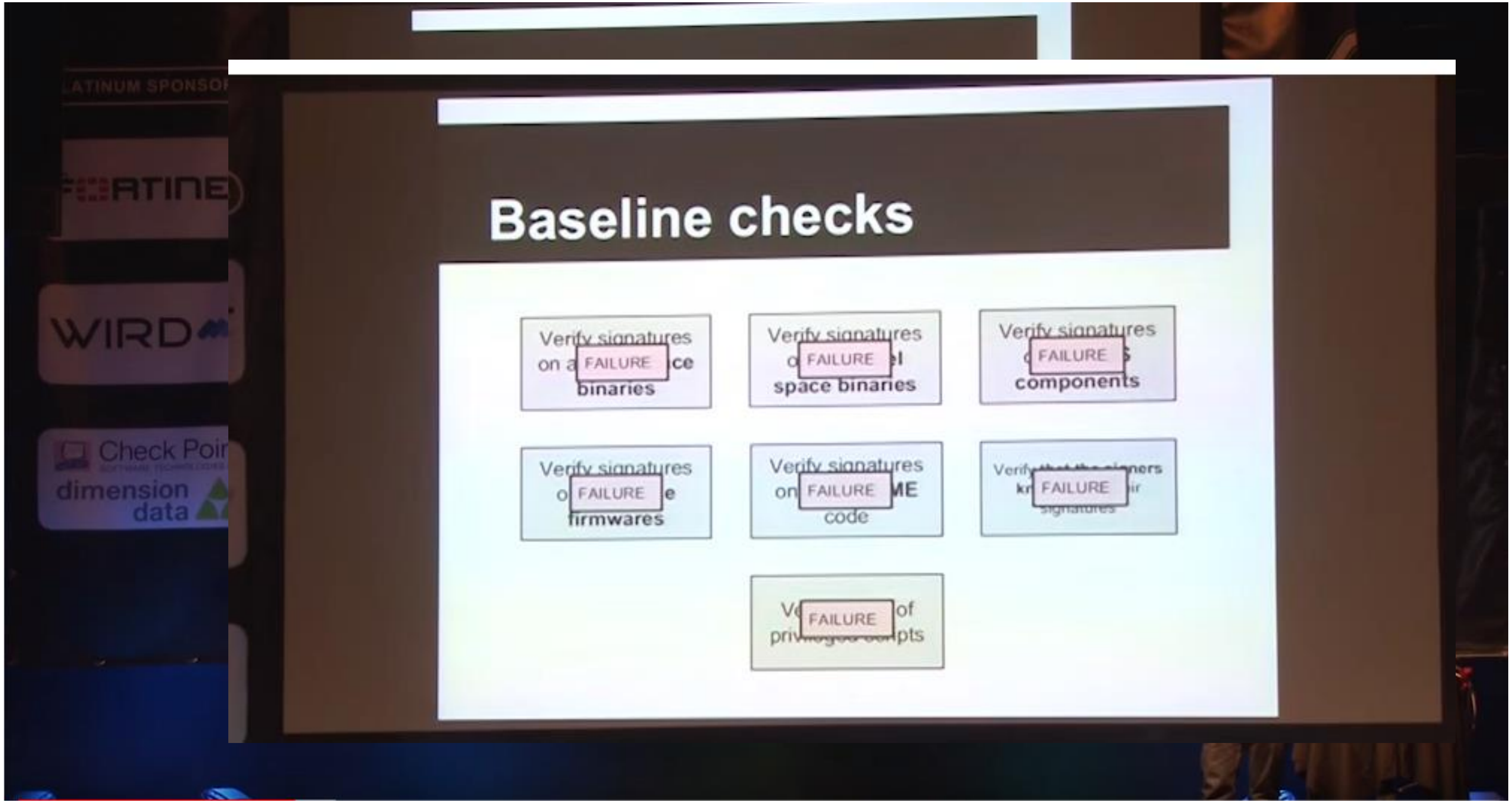


Baseline checks

- Verify signatures on all **userspace binaries**
- Verify signatures on all **kernel space binaries**
- Verify signatures on all **BIOS components**
- Verify signatures on all **device firmwares**
- Verify signatures on the **Intel ME** code
- Verify **that the signers know** about their signatures
- Verify origin of privileged scripts

Trusting our computers

Area41 2014: Halvar Flake: Keynote



Baseline checks

Verify signatures on a FAILURE ce binaries

Verify signatures o FAILURE el space binaries

Verify signatures o FAILURE S components

Verify signatures o FAILURE e firmwares

Verify signatures on FAILURE ME code

Verify ~~that the signers~~ kn FAILURE ir ~~signatures~~

Ve FAILURE of pri~~vileged scr~~ipts