RSA 2022

UEFI Vulnerabilities Coordination

Handling UEFI vulnerabilities disclosure and improving UEFI patch lifecycle

Vijay Sarvepalli

Carnegie Mellon University
Software Engineering Institute

This material is based upon work funded and supported by the Department of Defense under Contract No. FA8702-15-D-0002 with Carnegie Mellon University for the operation of the Software Engineering Institute, a federally funded research and development center.

DM22-0496

Carnegie Mellon University (CMU)

Pioneering discoveries that enrich the lives of people on a global scale

- Turning disruptive ideas into success through leading-edge research
- 2021 *U.S. News and World Report* rankings:
  - #1 in computer engineering, AI, cybersecurity, and software engineering
  - #2 in overall computer science
  - #3 in data analytics/science

CMU Software Engineering Institute (SEI)

Bringing innovation to the U.S. government

- A Federally Funded Research and Development Center (FFRDC) chartered in 1984 and sponsored by the DoD
- Leader in researching complex software engineering, cyber security, and artificial intelligence (AI) engineering solutions
- Critical to the U.S. government's ability to acquire, develop, operate, and sustain software systems that are innovative, affordable, trustworthy, and enduring

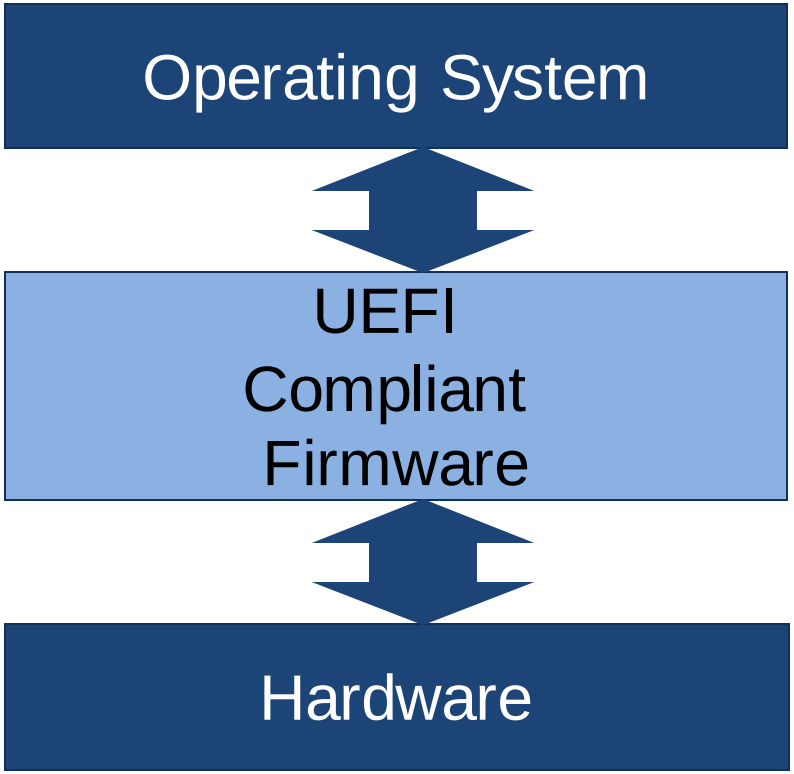
CERT Division: Birthplace of Cybersecurity

Trusted
Conducting research for the U.S. Government in a non-profit, public-private partnership

Valued
Collaborating with military, industry, and academia globally to innovate solutions

Relevant
Achieving technology and talent results for our mission partners

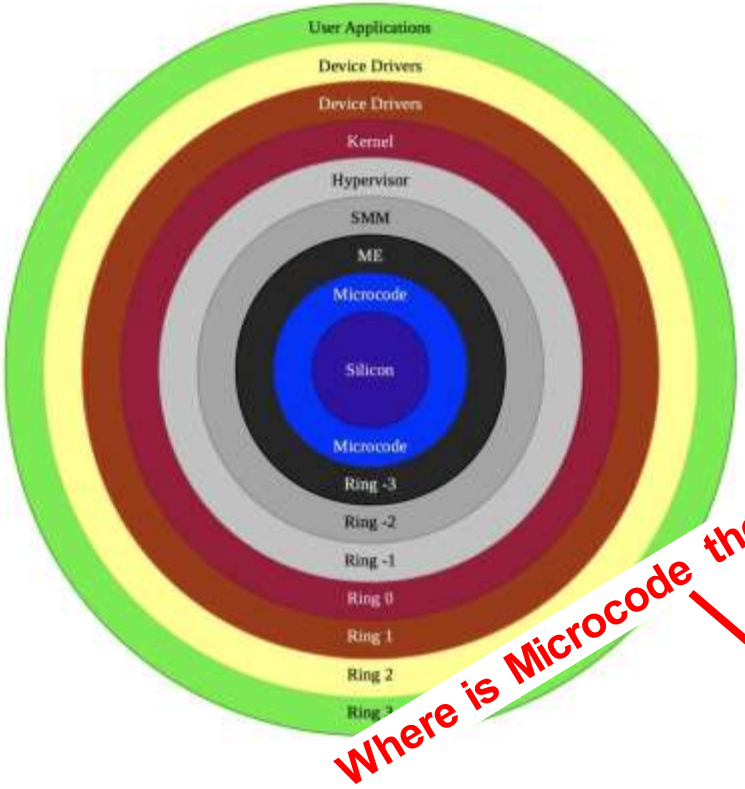
Unified Extensible Firmware Interface (UEFI)



The UEFI standard defines interface between the operating system and the firmware, which controls the hardware. This standard supersedes the legacy BIOS.

UEFI is widely used to boot and in some ways manage modern hardware.

UEFI ring of fire has many subduction zones for attacks



But in recent years there are more!

Hypervisor mode creates a new mode called Ring –1, utilized by Intel VT-x and AMD-V virtualization instructions.

System Management Mode (SMM) adds another Ring –2.

Below that there's Intel Management Engine (ME), called Ring –3 that runs even when the computer is sleeping.

What could possibly go wrong?

- Attacker gets maximum control
- Attacker gets permenance/persistence
- OS has no visibility

Where is Firmware anyway on a modern computer?

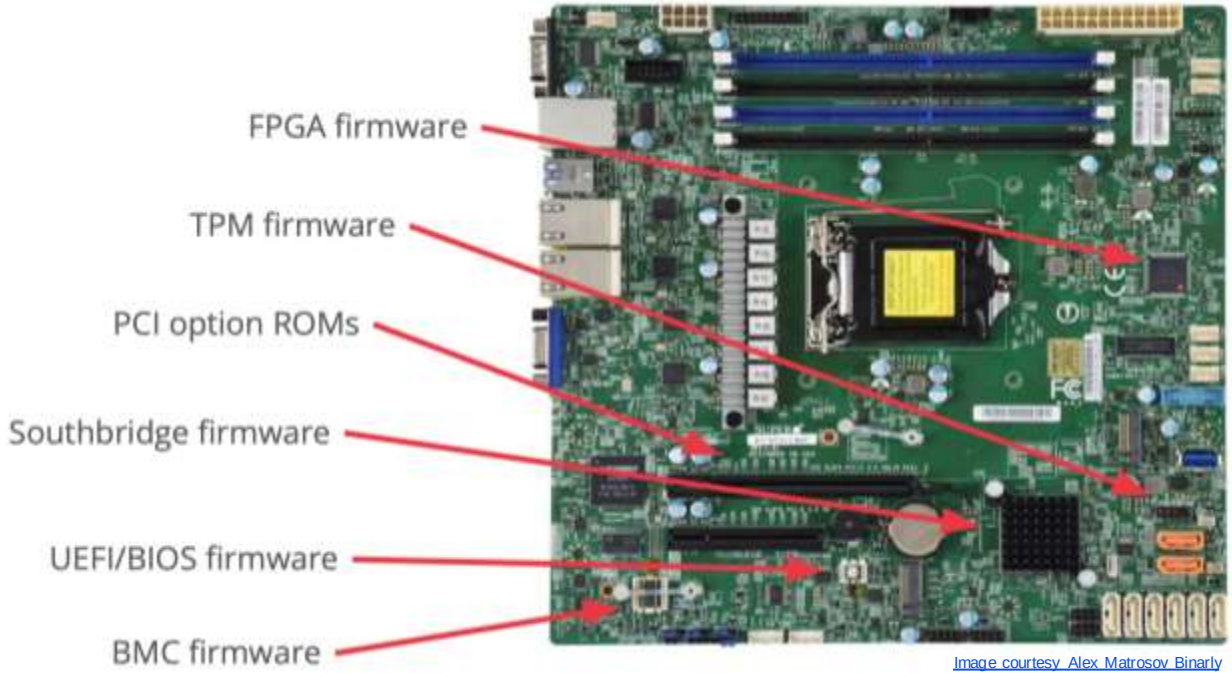
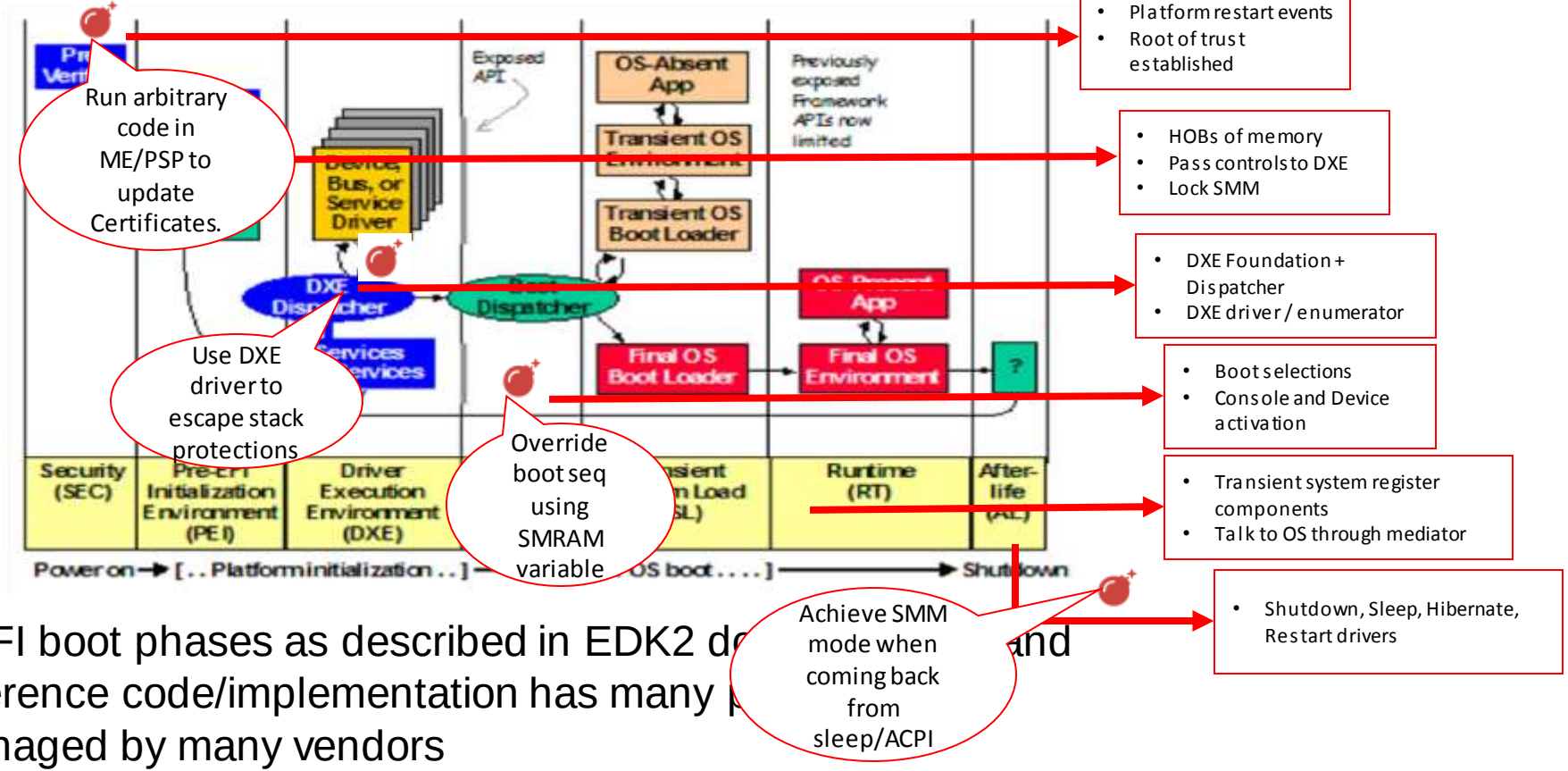


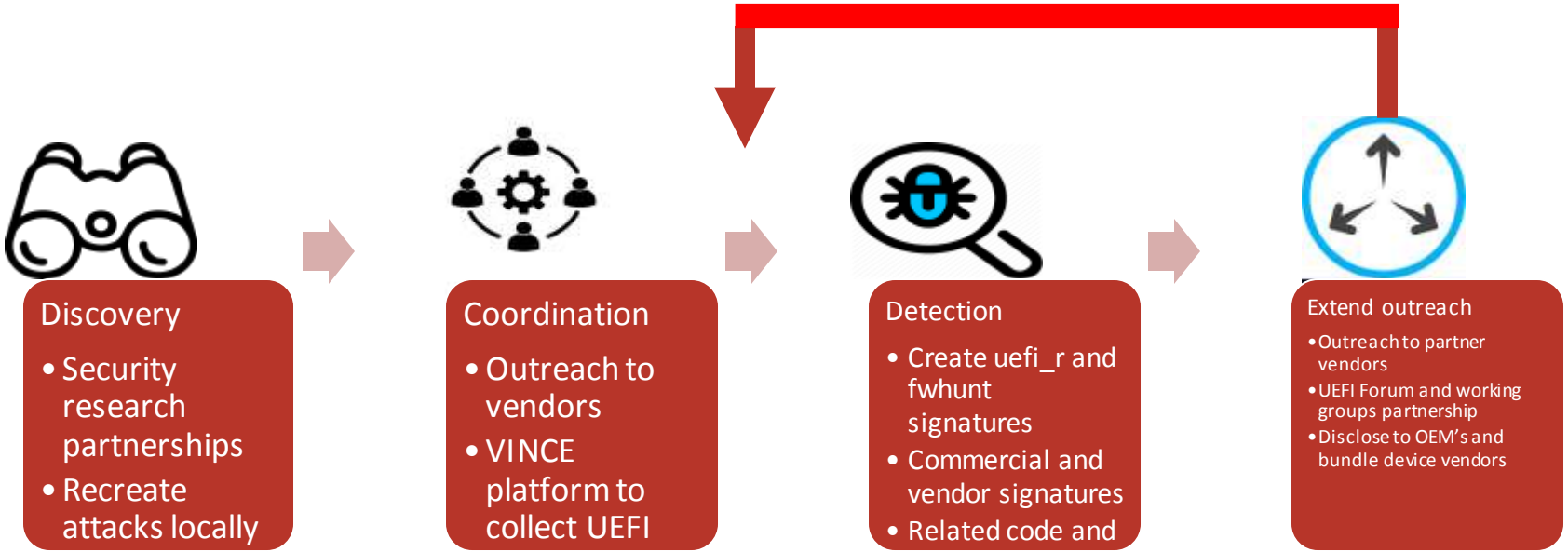
Image courtesy Alex Matrosov Binarly

UEFI phases of danger – even AfterLife is not safe



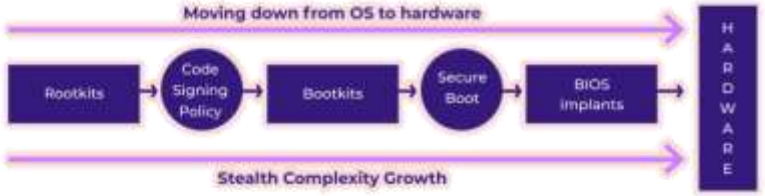
UEFI boot phases as described in EDK2 do and reference code/implementation has many p managed by many vendors

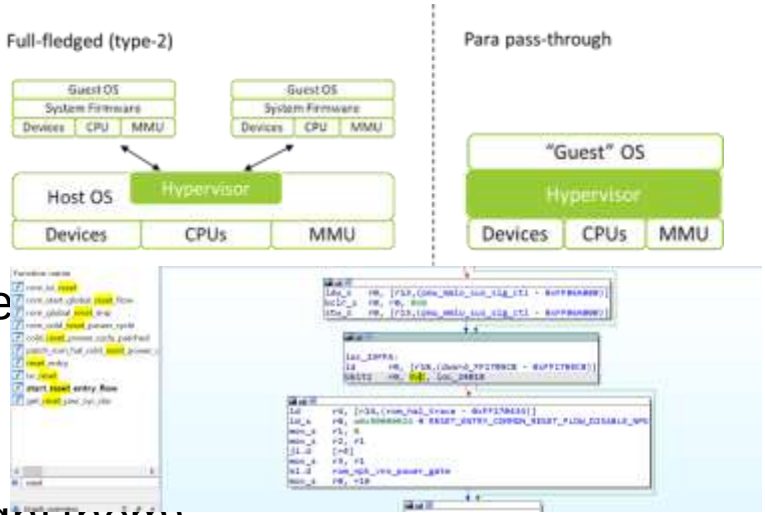
Desired approach for UEFI vulnerability lifecycle



Vulnerability discovery approaches and key players as partners

- Binary analysis and UEFI SMM attacks m
  - Binarly Extended Threat modeling – Al
  - Eclypsium focused on bootkits/rootkits
- Attacking Virtualization and peripherals
  - CrowdStrike focused on Virtualization Tanda
  - Google Project Zero – Diane Dubois
- Attacking microcode and PCH hardware
  - Gorychev and Mark Ermolov
- Intel ME attacks modeling
  - Looking for partners (iStare Intel bought them)





Coordination - the Supply Chain players – reference names

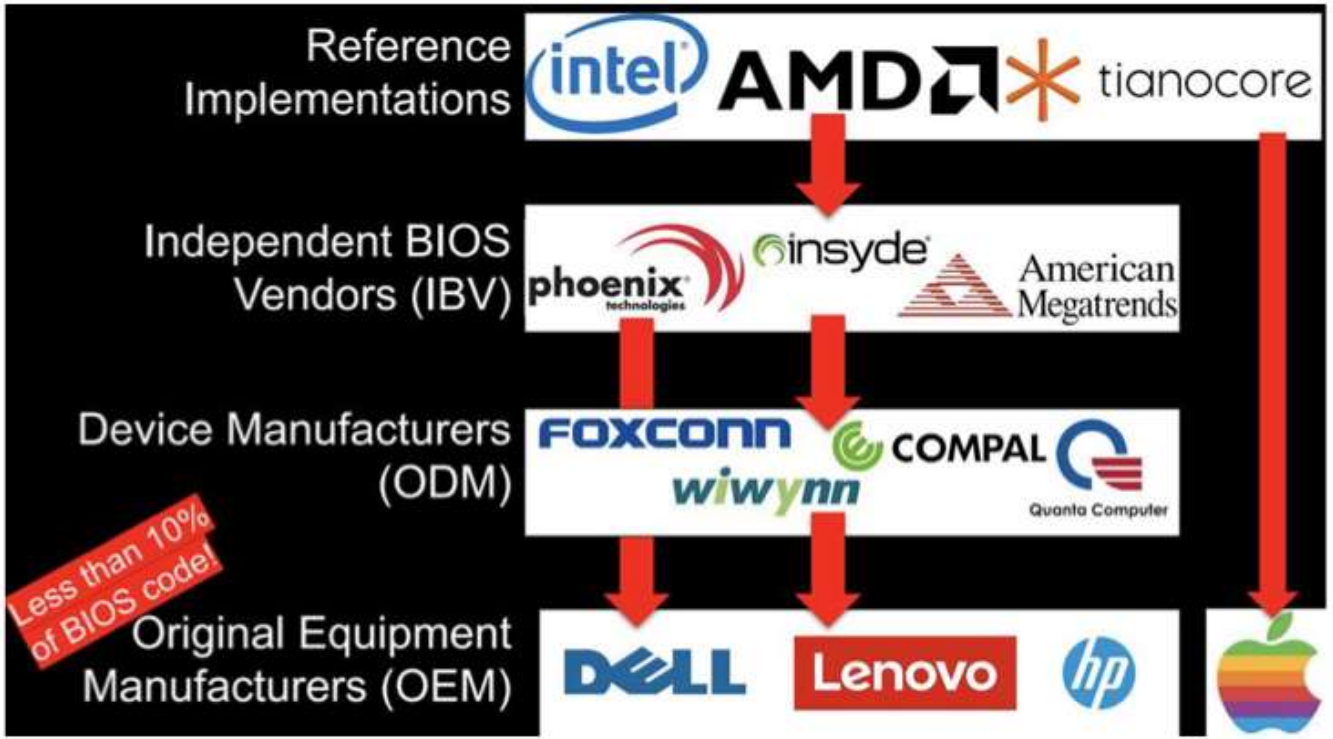


Image courtesy Alex Matrosov Binarly

UEFI Capsule updates and LVFS repository

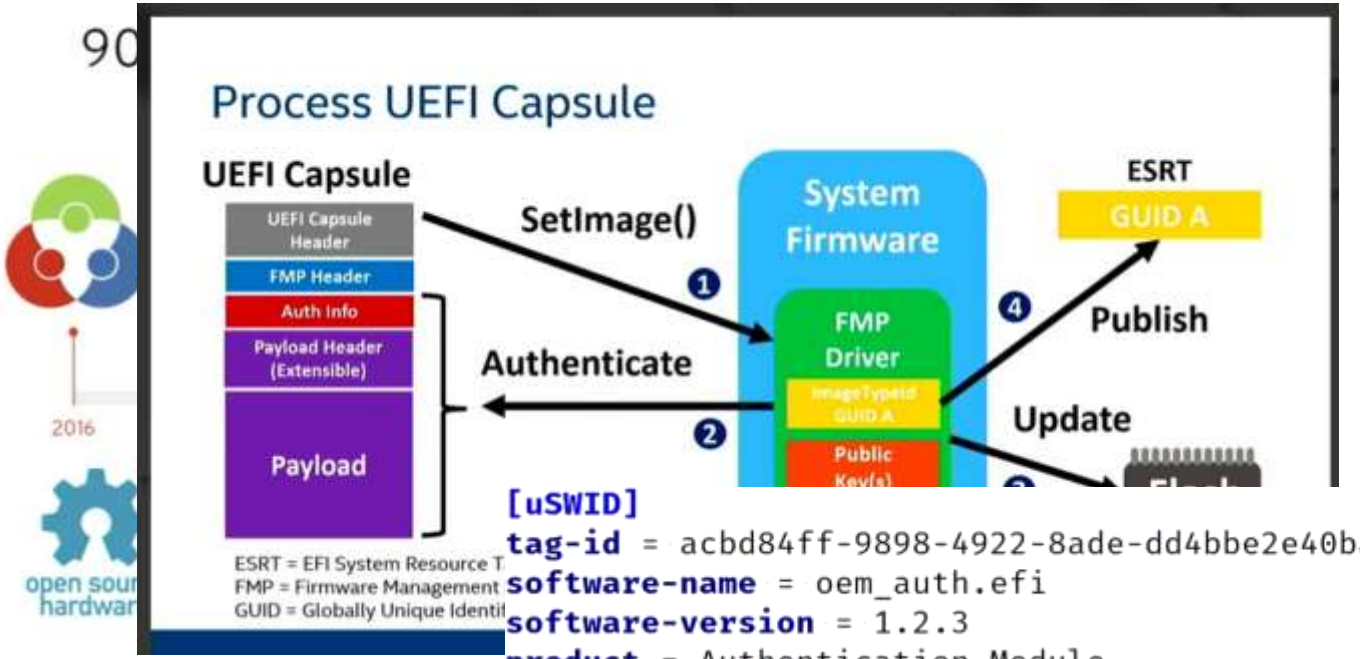
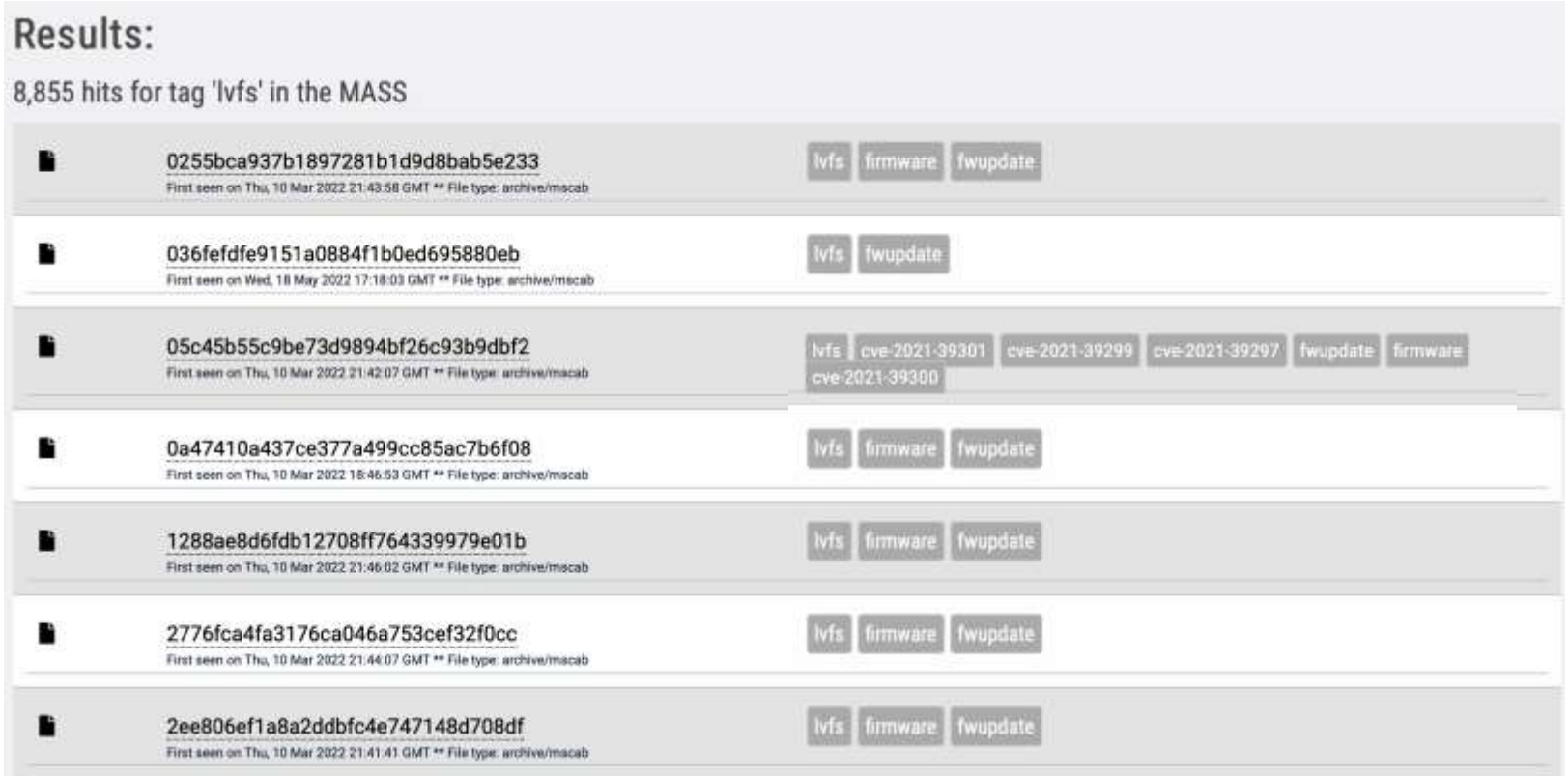


Image from Richard Hughes

```
[uSWID]
tag-id = acbd84ff-9898-4922-8ade-dd4bbe2e40ba
software-name = oem_auth.efi
software-version = 1.2.3
product = Authentication Module
summary = Hughski Super-Secret-Sauce Authentication Module
colloquial-version = b2ed6f1ed8587bf01a2951d74512a70f1a512d38
revision = 2
```

Currently only fwhunt rules are opensource. We are looking for more help and partnership – Eclypsium, CrowdStrike potential researchers

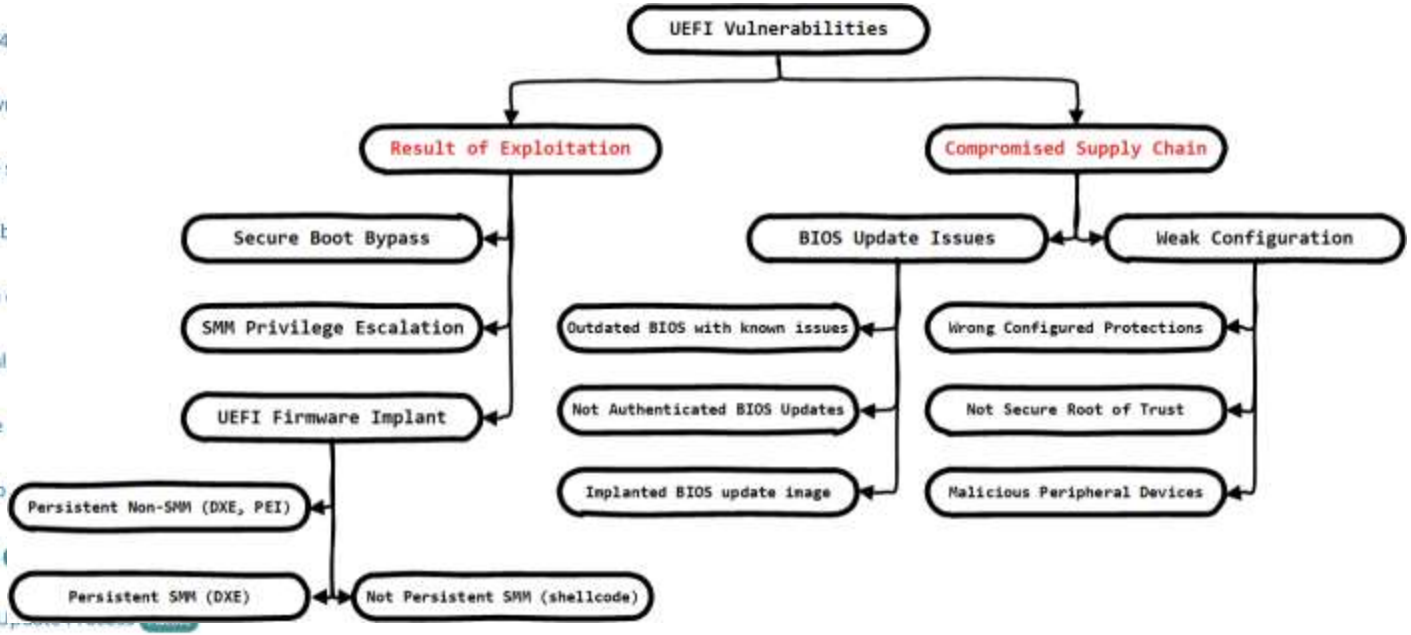
Collecting, tagging and maintaining UEFI capsules in MASS



UEFI vulnerabilities all flavors now in VINCE

UEFI Vulnerability types and methods are growing

VU#434994: TOCTOU Race Conditions in UEFI Vulnerability OS and Firmware DMA Timing Active CERT/CC
Last updated 2022-05-18 (3 hours ago)
VU#796611: InsydeH2O UEFI BIOS impacted by multiple vulnerabilities Active Published CERT/CC
Last updated 2022-04-26 (3 weeks, 1 day ago)
VU#917518: HP UEFI System Firmware (S74
Last updated 2022-03-23 (1 month, 3 weeks ago)
VU#683814: Multiple memory corruption v
Last updated 2022-03-08 (2 months, 1 week ago)
VU#109929: Insyde UEFI software on Edge
Last updated 2022-03-02 (2 months, 2 weeks ago)
VU#174059: GRUB2 boot loader is vulnerab
Last updated 2020-08-25 (1 year, 8 months ago)
VU#766164: Intel BIOS locking mechanism
Last updated 2020-05-22 (1 year, 12 months ago)
VU#552286: UEFI EDK2 Capsule Update vul
Last updated 2020-05-22 (1 year, 12 months ago)
VU#507496: GIGABYTE BRIX UEFI firmware
Last updated 2020-05-22 (1 year, 12 months ago)
VU#533140: Tianocore UEFI implementatio
Last updated 2020-05-22 (1 year, 12 months ago)
VU#316011: Malicious UEFI Bios Firmware
Last updated 2020-05-22 (1 year, 12 months ago)
VU#354550: Vulnerability in UEFI Capsule U
Last updated 2020-05-22 (1 year, 12 months ago)
VU#329192: UEFI contains a shell vulnerability that allows a modified microupdate file to load upon bootup of all uefi systems
Inactive



FwHunt detection and analysis of vulnerable capsules.

R

Richard Hughes
Coordinator
Principal Engineer

2021-12-10 (5 months, 1 week ago)

Affected machines on the LVFS:

- Lenovo ThinkPad L13
- Lenovo ThinkPad L14 Gen 1 / L15 Gen 1
- Lenovo ThinkPad L14 Gen 2 / L15 Gen 2
- Lenovo ThinkPad P1 Gen 3/X1 Extreme 3rd
- Lenovo ThinkPad P1 Gen 4/X1 Extreme Gen 4
- Lenovo ThinkPad P15 Gen 1/ P17 Gen 1/ P15g Gen 1/ T15p Gen 1/ P15v Gen 1
- Lenovo ThinkPad P15 Gen 2i/ P17 Gen 2i/ T15g Gen 2i
- Lenovo ThinkPad T14 Gen 1/ P14s Gen 1 / T15 Gen 1 / P15s Gen 1 / T14 Gen 1 Healthcare Edition
- Lenovo ThinkPad T14 Gen 2 / P14s Gen 2 / T15 Gen 2 / P15s Gen 2
- Lenovo ThinkPad T14s Gen 1 / ThinkPad X13 Gen 1
- Lenovo ThinkPad T14s Gen 2 / X13 Gen 2
- Lenovo ThinkPad T490
- Lenovo ThinkPad X1 Carbon 7th / X1 Yoga 4th
- Lenovo ThinkPad X1 Carbon 9th / X1 Yoga 6th
- Lenovo ThinkPad X1 Carbon Gen 8 /X1 Yoga Gen 5
- Lenovo ThinkPad X13YogaGen1
- Lenovo ThinkPad X13YogaGen2
- Lenovo ThinkPad X390
- Lenovo ThinkStation M70A
- Star Labs StarBook MkV

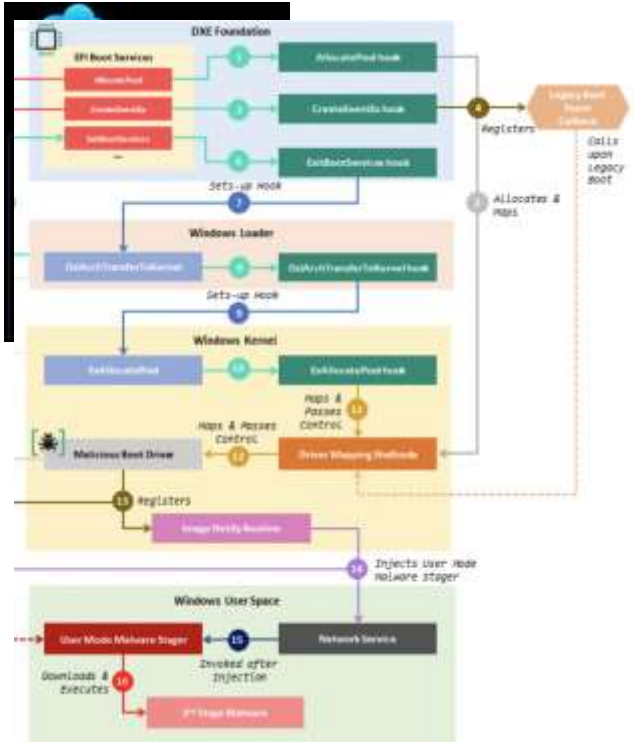
Reply

Intel NUC laptop is vulnerable to SMM memory corruption

Reported by Alex Matrosov – September 2021
Denied by Intel and unacknowledged by vendors – October 2021
Richard Hughes scans using fwhunt – Found 20 models of Lenovo, StarLabs impacted
About 40 vendors have the code
Unknown number of models impacted that is outside of LVFS.

Forward looking research areas and security concerns

- Microsoft Pluton will make it difficult to write implants and self-updating malware. Persistence will become most difficult.
- Chip-to-Cloud approach expected from all vendors like HPE, Lenovo, Dell, Apple and some chip vendors AMD.
- Intel ME and AMD PSP expected to give more capability to access hardware and even in some cases overwrite microcode.
- Attackers have to look at other places for persistence
- Moonbounce is the latest one in the news, but MosaicRegressor, BootHole are early but less sophisticated.



Ongoing work and next steps

- Continue our own exploit research for discovering vulnerabilities and reproducing attacks against UEFI. Enhance work such as parsers, code detection techniques specifically for UEFI.
- Extend partnership with some large researchers and vendors to highlight UEFI security concerns – Sentinel, Intel iStare division.
- Bring more transparency into the UEFI ecosystem - addition of SBOM coSWID, automated detection of reuse of code, fingerprinting and auditing of valid UEFI code (inside capsules).
- Outreach to UEFI Forum about creating a security working group and look into ways to bring transparency.
- Explore other projects like Coreboot and Libreboot bringing transparency and reducing –ve Rings in Protection Ring of modern OS (less likely).

Engage with Us

Download software and tools

Participate in education offerings

Attend an event

Search the digital library

Read the SEI Year in Review

Explore our research and capabilities

Collaborate with the SEI on a new project

Contact Us

Carnegie Mellon University
Software Engineering Institute
4500 Fifth Avenue
Pittsburgh, PA 15213
888-201-4479

info@sei.cmu.edu
www.sei.cmu.edu