Fobnail: Attestation in Your Pocket

Linux Secure Launch - TrenchBoot Summit 2021

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whoami

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- OSF and OSHW promoter interested in Trusted Computing
- Conference speaker and organizer
- TrenchBoot Steering Committee Core Member

- 13yrs in business
- 7yrs in Open Source Firmware and Trusted Computing integration
- C-level positions in

About us

- coreboot licensed service providers since 2016 and leadership participants
- UEFI Adopters since 2018
- Yocto Participants and Embedded Linux experts since 2019
- Official consultants for Linux Foundation fwupd/LVFS project
- IBM OpenPOWER Foundation members

Kudos

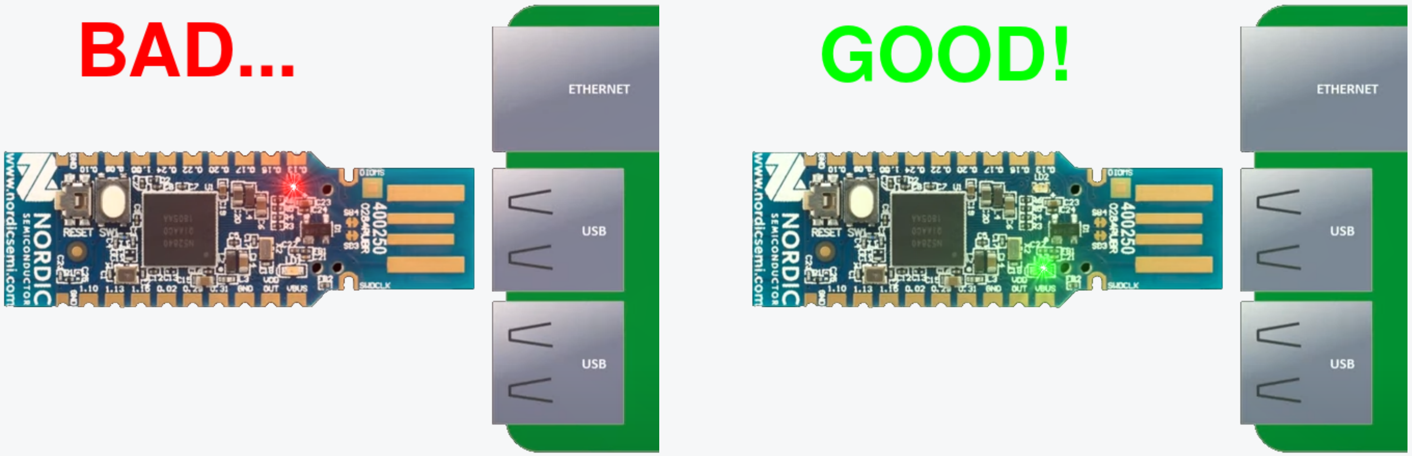
- Michał Żygowski, Firmware Engineer @ 3mdeb, as main contributor this presentation
- Artur Kowalski, Junior Embedded Firmware Engineer @ 3mdeb, as main contributor this presentation
- Maciej Pijanowski, Engineering Manager @ 3mdeb

What is Fobnail?

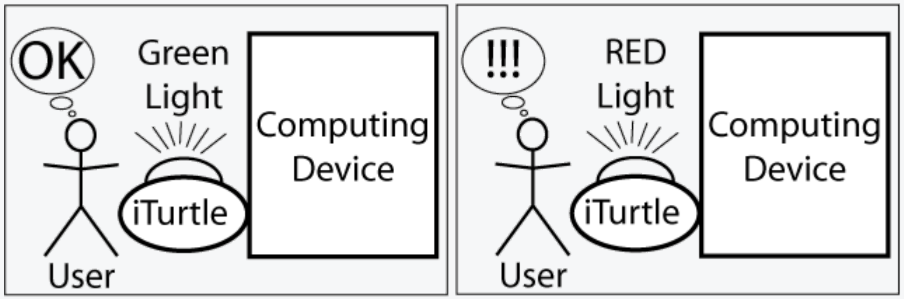
- NLNet Foundation granted project
- Reference OSF for OSHW USB token enabling a user/administrator for a user/administrator/enterprise to determine the integrity of a system.
- Fobnail improve trustworthiness of integrity checks by leveraging D-RTM effectively attesting Dynamically Launched Measured Environments (DLME), locally, over USB.

Fobnail use case

Provide axiomatically trustworthy device[1] and simple user interface to attest platform state



This not new concept



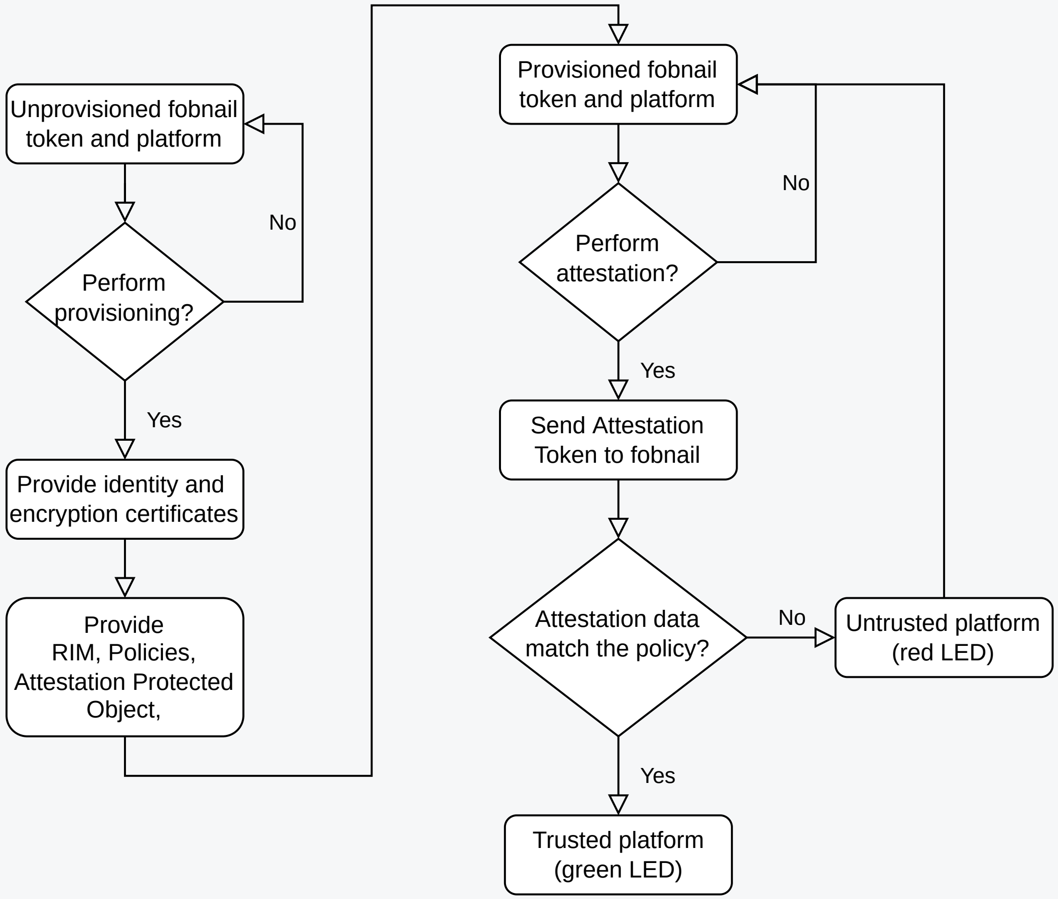
- The Fobnail project aims to provide a reference architecture for building offline integrity measurement servers on the USB device and clients running in Dynamically Launched Measured Environments (DLME)
  - In short it would be attestation server on USB token capable of attesting D-RTM payload
  - this is not new concept in principle, it was already announced by Jonathan McCune (Flicker author) at HotSec07 with the name iTurtle
- Project website: https://fobnail.3mdeb.com

iTurtle: https://www.usenix.org/legacy/event/hotsec07/tech/full_papers/mccune/mccune_html/index.html

Fobnail features

- open-source implementation of the iTurtle security architecture concept [1]
- compliance with IETF RATS (Remote ATtestation procedureS) [2]
- based on Reference Interaction Model for Challenge-Response-based Remote Attestation (CHARRA) [3]
- attest platform integrity in the early launch but also runtime
- sophisticated attestation policies
- multiple RIMs (Reference Integrity Measurements) to support attestation of multiple devices
- offline remote attestation

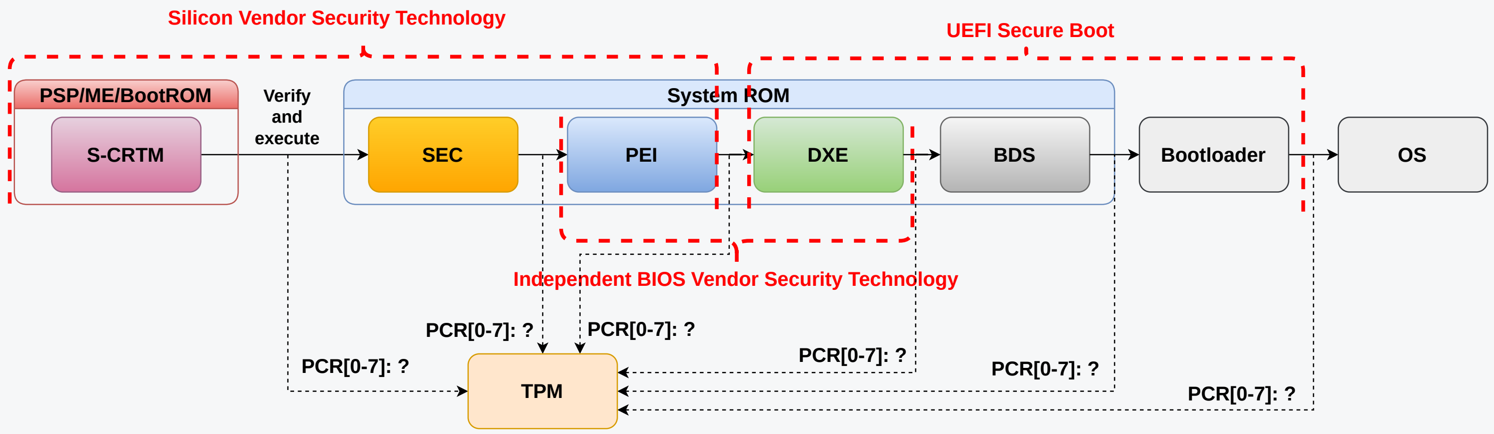
Fobnail usage

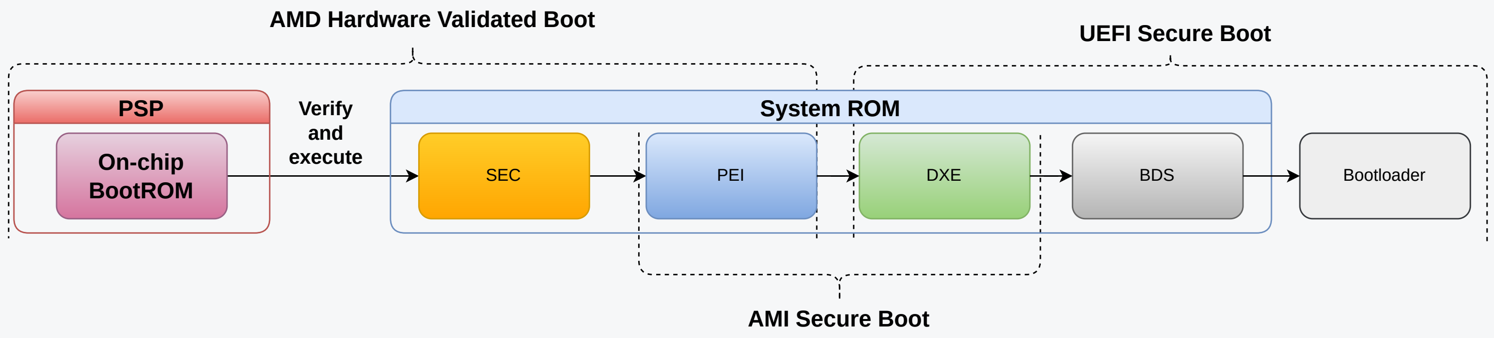

Unprovisioned fobnail token and platform
Perform provisioning?
No
Yes
Provide identity and encryption certificates
Provide RIM, Policies, Attestation Protected Object,
Provisioned fobnail token and platform
Perform attestation?
No
Yes
Send Attestation Token to fobnail
Attestation data match the policy?
No
Untrusted platform (red LED)
Yes
Trusted platform (green LED)

S-RTM vs D-RTM "holy war": S-RTM

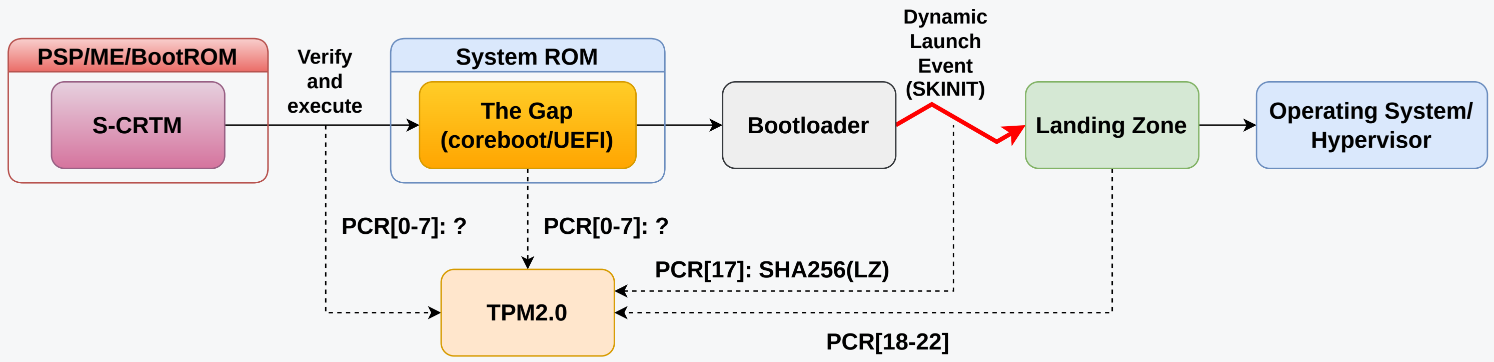
- as good as code making initial measurement
- vendor specific and closed technologies (NXP HAB, Intel Secure Boot/Boot Guard, AMD HVB) to protect S-CRTM implementation implies NDAs and proprietary tool chain
- S-CRTM protection is hard to establish and maintain properly (more then 20 keys and certificates involved)
- well-established in oligopolistic SV+IBV environment
- lack of standardization around measurement reporting and event log transparency
- requires platform reset to establish trusted state
- lack of firmware supply chain transparency makes it hard to update (re-evaluation of PCR values, forward sealing)
- above issues leads to very slow adoption, complexity and mistakes while provisioning security features
- there are open implementations based on coreboot, vboot (Chromebook, PC Engines) and SPI NOR flash OTP features

S-RTM vs D-RTM "holy war": S-RTM



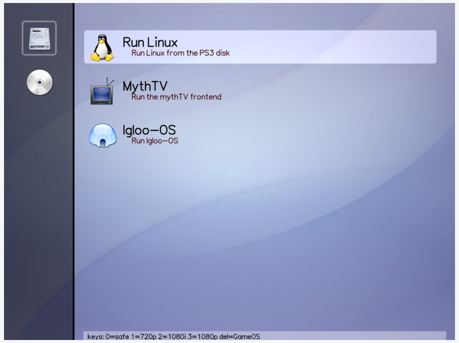


S-RTM vs D-RTM "holy war": D-RTM

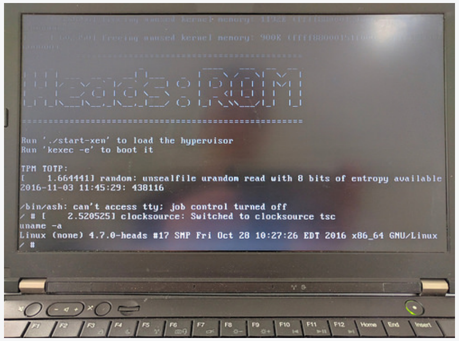


- establish root of trust even in environment for which S-CRTM and its protection is questionable
- does not require platform reset
- depending on vendor can be fully open source (AMD, IBM, Arm)
- used with OSF and TrenchBoot provide transparent software supply chain
- small enough to pass common criteria certification
- patches already submitted to GRUB, Linux kernel and iPXE

Modern OSF boot flow



Run Linux
Run Linux from the PS3 disk
MythTV
Run the mythTV frontend
Igloo–OS
Run Igloo–OS
keys: 0=safe 1=720p 2=1080i 3=1080p del=GameOS



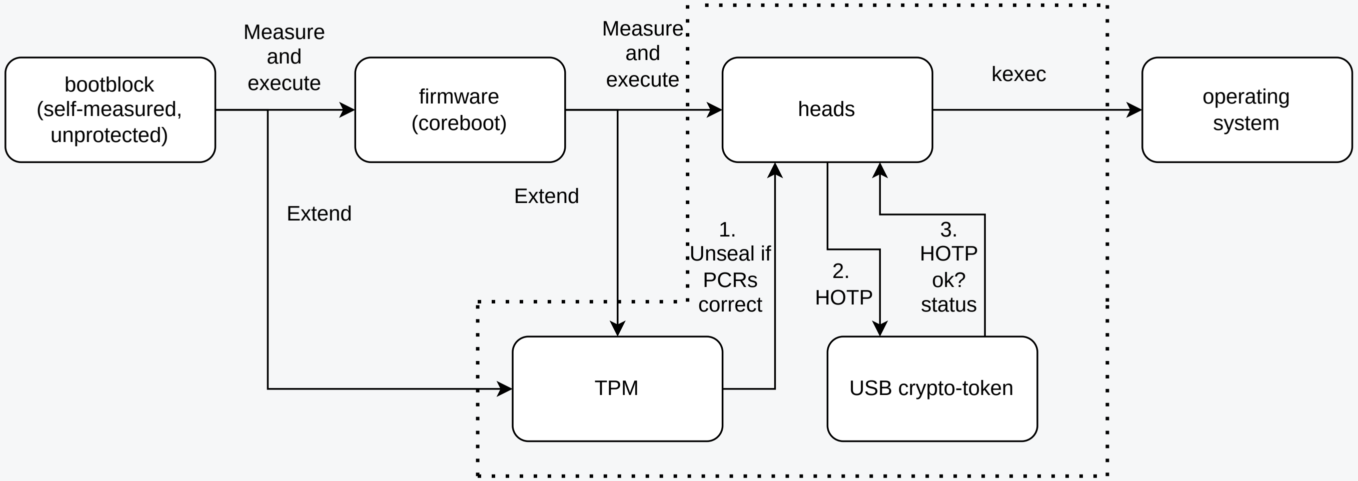
```
Run './start-xen' to load the hypervisor
Run 'kexec -e' to boot it

TPM TOTP:
[    1.664441] random: unsealfile urandom read with 8 bits of entropy available
2016-11-03 11:45:29: 438116

/bin/ash: can't access tty: job control turned off
/ # [    2.520525] clocksource: Switched to clocksource tsc
uname -a
Linux (none) 4.7.0-heads #17 SMP Fri Oct 28 10:27:26 EDT 2016 x86_64 GNU/Linux
/ #
```

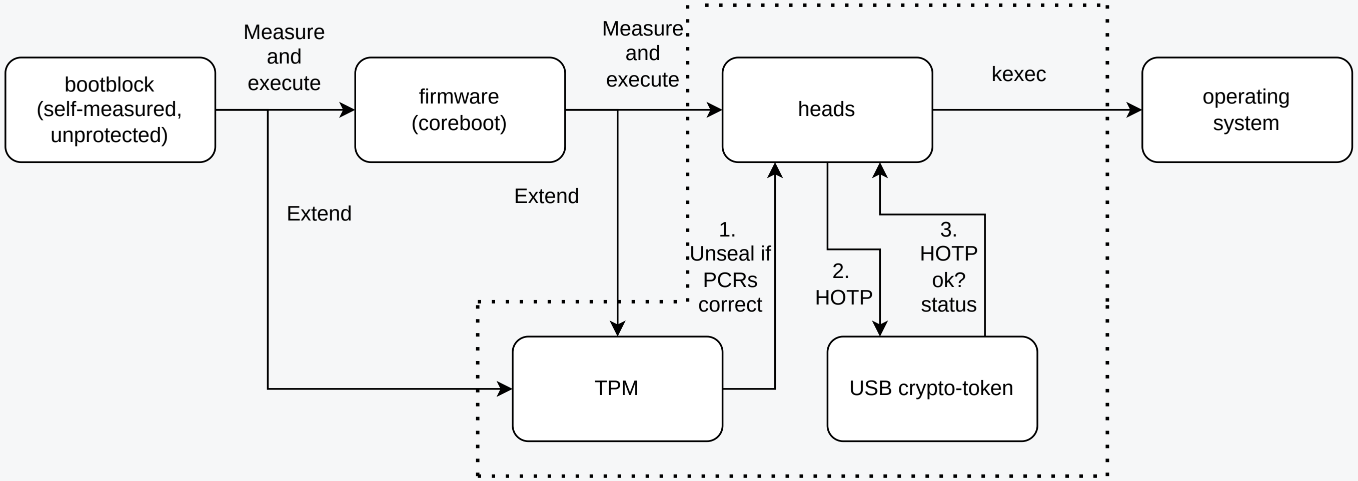
- **kexec everything** - for couple last years we see trend of using kexec as ultimate boot loader
- This is proved by existence of project such Petitboot, LinuxBoot, Heads
- kexec successfully boostrapped: Linux, Windows, VMware, FreeBSD, Xen hypervisor and other kernels.
- kexec has ability to verify signatures and we believe it will gain D-RTM capabilities

Modern OSF boot flow - security properties



- Measured boot
- Platform open source firmware self-attestation
- Visual indicator of platform attestation state through USB crypto-token
- Signed updates of firmware and OS
- Re-ownership of boot process
- LVFS/fwupd support

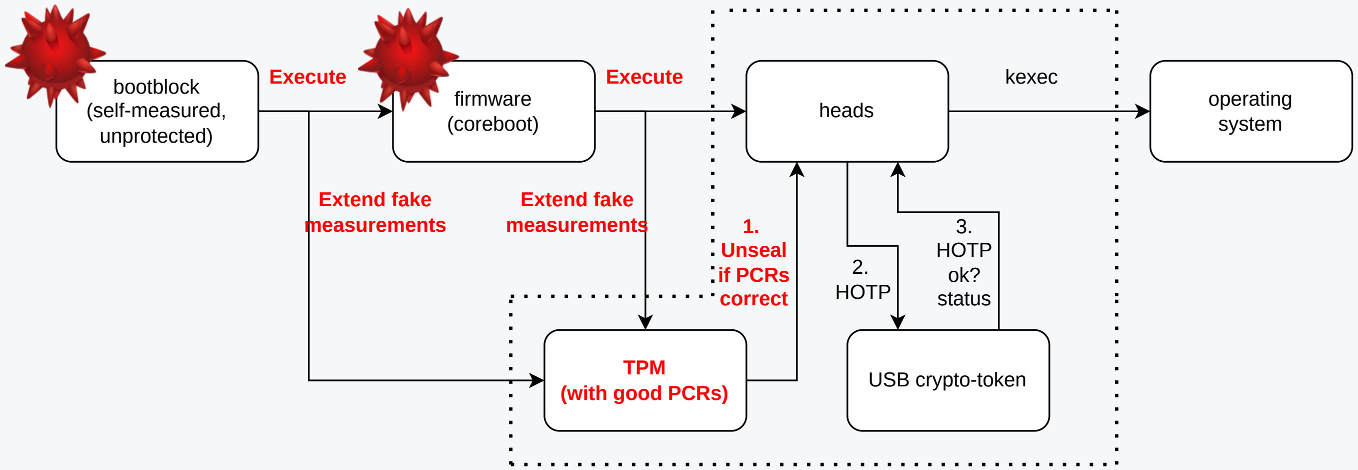
Modern OSF boot flow - issues



- bootblock unprotected by any RoT (SPI WP, Boot Guard, etc.)
- possible firmware replacement attack
- USB crypto-token verifies only the secret presence which is provided by the platform (**platform "attests" itself**)

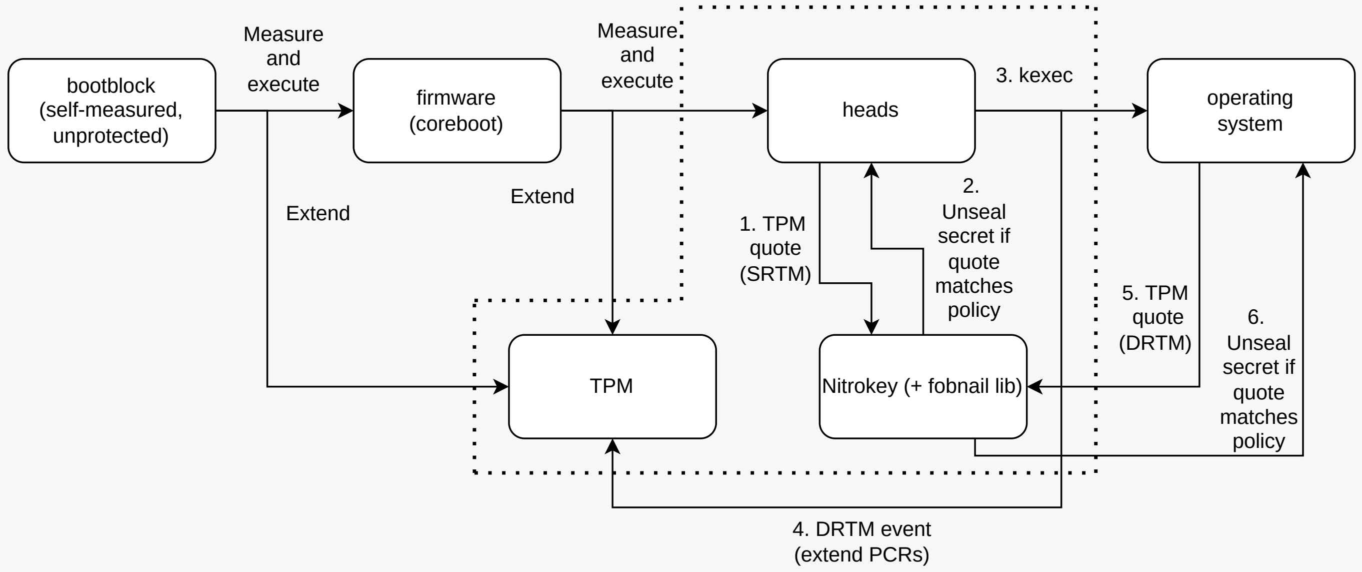
"If an attacker can control this shared secret (such as by directly sending PCR values into the TPM) they can install malicious firmware in the SPI flash and generate valid TOTP codes. [1]"

USB crypto-token kexec boot flow



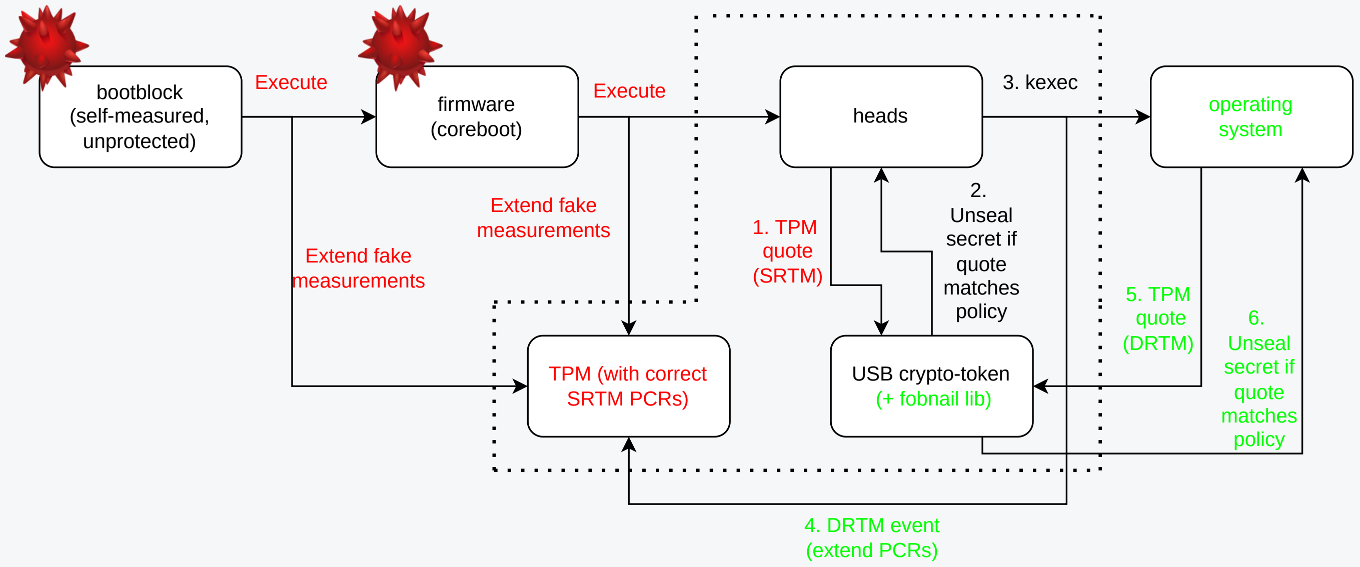
- firmware is replaced
- TPM PCR measurements are faked and replayed
- secret is still unsealed and USB crypto-token is giving a false platform state

Fobnail enabled boot flow



- bootblock unprotected by any RoT (SPI WP, Boot Guard, etc.)
- possible firmware replacement attack
- **USB crypto-token performs the attestation** based on securely stored policies and received TPM quote and unseals the secret if quote matches the policy

Fobnail enabled boot flow


bootblock (self-measured, unprotected)
Execute
firmware (coreboot)
Execute
heads
3. kexec
operating system
Extend fake measurements
Extend fake measurements
1. TPM quote (SRTM)
2. Unseal secret if quote matches policy
5. TPM quote (DRTM)
6. Unseal secret if quote matches policy
TPM (with correct SRTM PCRs)
USB crypto-token (+ fobnail lib)
4. DRTM event (extend PCRs)

- firmware is replaced + TPM SRTM PCR measurements are faked and replayed
- Secret unsealed from the USB crypto-token and a false platform state is reported
- USB crypto-token performs second attestation after DRTM event using TPM DRTM quote which cannot be faked - this give trustworthy OS

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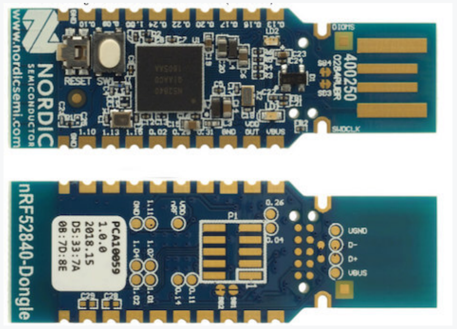
Other use cases

- Previous slides show end-user scenario, but there are more use cases available after Fobanail features implementation
- Proprietary UEFI-based hardware with D-RTM capability
- Network appliance runtime attestation
    - Linux appliance running long time may use Linux Runtime Guard running as D-RTM paylaod for runtime threat detection
    - Network boot (iPXE) attestation
    - Hypervisor ealry lanunch (boot time) and late launch (runtime) attestation
- Cloud hardened VMs attestation (eg. Google Shielded VMs)
- The most secure cryptocurrency cold wallet with offline wallet in DLME and secure transaction file transfer

Who support us

- Early Adopters - companies which will include Fobnail firmware features on their hardware-capable USB tokens
    - Nitrokey considers becoming an early adopter of Fobnail
- Supporting parties
    - Michael Eckel - Cyber Security Researcher in Fraunhofer Institute for Secure Information Technology - CHARRA the Maintainer
    - Daniel P. Smith - TrenchBoot Project Founder
    - Thierry Laurion - Insurgo's Founder & CEO
    - Marek Zmuda - Ph.D. Cyber Security Researcher and System Security Architect at Intel, IEEE Member
    - F-Secure USB Armory project would be glad to see Fobnail features integrated in TamaGo and related projects

Fobnail - hw and sw stack



- HW and SW selection is at early stage
- We started development on Nordic nRF52840 development kit
    - future iterations will consider RISC-V FPGA implementation maybe even from European Processor Initiative
- Firmware will be written in Rust
    - Proffered HAL: nRF Rust/nrf-hal
    - Crypto library: Trussed
- We hope to create unified software stack on both Fobnail and DLME side

Current status

[DONE] Phase 1: Implementation of the build infrastructure

The Fobnail device needs build infrastructure and bootloader to provide software upgrade methods. We chose the nRF52840 UBS dongle as Fobnail development device. Also we need the external debugging method.

[IN PROGRESS] Phase 2: Communication between Attester and Fobnail Token

The attested platform must communicate with the Fobnail Token. Fobnail is the USB device so we need to develop the communication method that will meet CHARRA requirements.

Future work

Phase 3: Local platform provisioning development

In the case of local provisioning the Fobnail Token receives platform metadata (CPU serial, MAC, and EK cert hash). The Fobnail Token counts metadata hash and uses this information for platform verification during the attestation.

Phase 4: The Fobnail Token provisioning development

In the case of the Fobnail Token provisioning, the platform owner generates Fobnail Identity Certificate, which is used by the attested platform during the attestation process.

Phase 5: The attestation development

Attestation process provides the information if the attested platform is trustworthy. In this case the Fobnail takes the role of the Verifier.

Future work

Phase 6: Fobnail Token service implementation

The Fobnail Token service will run the attestation after the device is plugged.

Phase 7: Creating the Fobnail Research Paper

The strength of the Fobnail solution is in the details. To make Fobnail solutions accepted and supported by community, applied in various areas, we need clearly articulate our assumptions and threats that we are mitigating. Additionally, we want to involve top-talented security researchers to get their feedback and commitment for future development. We believe that the best way to get their interest is to publish research paper.

Future work

Phase 8: Development of the minimal operating system RTOS for the DLME

Our goal is to provide support for running minimal operating system in DLME.

Phase 9: Development of the boot time measurement verification

During the boot the minimal operating system must communicate its state to the Fobnail Token and Fobnail Token must decide if the platform is trustworthy

Q&A