Secure boot, trusted boot and remote attestation for ARM TrustZone-based IoT Nodes

Zhen Ling, Huaiyu Yan, Xinhui Shao, Junzhou Luo, Yiling Xu, Bryan Pearson, Xinwen Fu
Journal of Systems Architecture 119 (2021)

Oberon Swings

KU Leuven

[Lin+21]

March 30, 2022

Outline

Introduction

Hybrid booting

Process integrity measurement

Evaluation & security analysis

Relevance for thesis

Outline

Introduction

Hybrid booting

Process integrity measurement

Evaluation & security analysis

Relevance for thesis

Goals

- IoT devices
- ARM (TrustZone)
- Assure integrity
- Defend against
  - Hardware attacks
  - OS/Firmware attacks
  - Software attacks

Solutions

- Hybrid booting
  - Secure boot
  - Trusted boot
- Process integrity measurement
  - Pagebased attestation

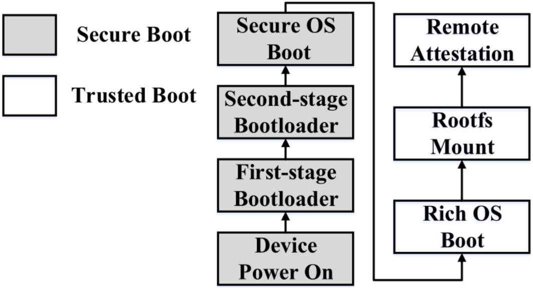


image: [Lin+21]

Outline

Introduction

Hybrid booting

Process integrity measurement

Evaluation & security analysis

Relevance for thesis

Secure boot

- Offline phase
  - Measure image
  - Hash
  - Sign
- Secure boot phase
  - First-stage bootloader trusted base
  - Locate next
  - Verify

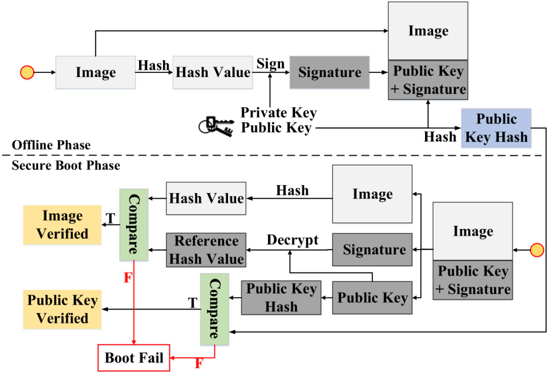
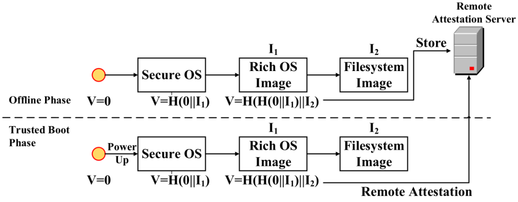
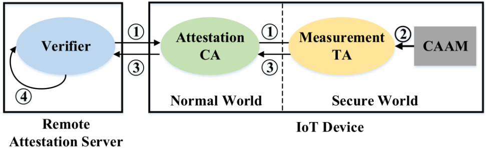


image: [Lin+21]

Trusted boot

- Offline phase
  - Calculate hash
  - Encrypt with symmetric key
  - Store
- Trusted boot phase
  1. TLS connection nonce
  2. Encrypt nonce & hash
  3. Respond
  4. Hash verification (integrity)
     Nonce verification (replay)

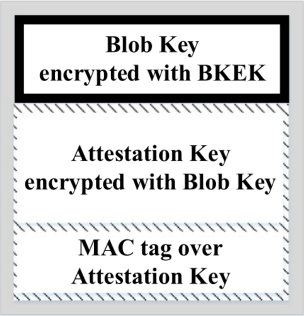




images: [Lin+21]

Trusted boot encryption

- Symmetric key
- Safe at server
- Storage in IoT device
    - Generate blob key (RNG)
    - Encrypt and MAC
    - Derive BKEK using MK
    - Concatenate parts
    - SNVS for Master Key



Blob Key encrypted with BKEK

Attestation Key encrypted with Blob Key

MAC tag over Attestation Key

image: [Lin+21]

Outline

Introduction

Hybrid booting

Process integrity measurement

Evaluation & security analysis

Relevance for thesis

Idea

- Secure boot base
- Runtime integrity
- Measure code pages
- Measurement TA
- Remote Attestation Server

Process integrity measurement

1. Map address of init_task
2. Obtain physical address
3. Transform to virtual address
4. Calculate page boundaries
5. Measure each page

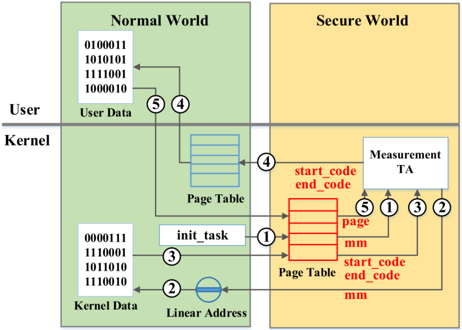


image: [Lin+21]

Process integrity attestation

1. Request nonce
2. Calculate measurement
3. Encrypt attestation info
4. Send cyphertext and repeat 2 or continue
5. Send cyphertext to verifier
6. Verify (new, modified)

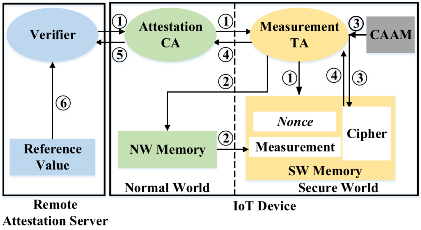


image: [Lin+21]

Outline

Introduction

Hybrid booting

Process integrity measurement

Evaluation & security analysis

Relevance for thesis

Results

Performance

- Secure boot doubles secure OS boot-time
- Trusted boot adds little overhead (0.5%)
- Measurement TA and attestation CA overhead (-0.5% $\approx$ +0.5%)

Security

- Secure boot gives secure base
- Measurement method relies on NW

Outline

Introduction

Hybrid booting

Process integrity measurement

Evaluation & security analysis

Relevance for thesis

Focus shift

- Secure boot (engineering)
- Attestation
  - Informing user
  - Securing NW
- Reproduction
  - Process measurement
  - Process attestation
- Adjustments
  - Remote server
  - Reliance on NW OS

Differences

Paper

- Secure boot
- Trusted boot
- Remote attestation
- IoT devices

Thesis

- Secure boot assumed
- No Trusted boot
- SW attests NW
- Secure Open platform

Questions?

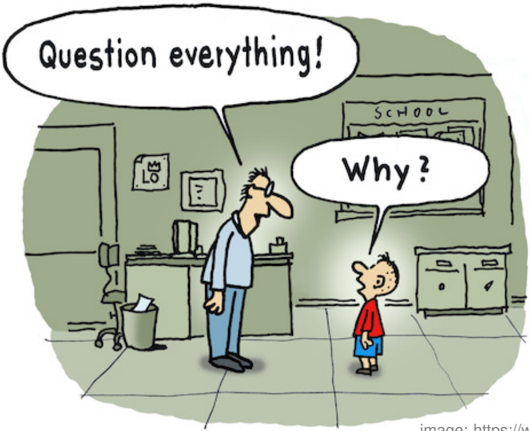


image: https://www.toonpool.com/cartoons/Question_376876

References

Zhen Ling et al. “Secure boot, trusted boot and remote attestation for ARM TrustZone-based IoT Nodes”. In: Journal of Systems Architecture 119 (July 2021), p. 102240. DOI: 10.1016/j.sysarc.2021.102240.