Monthly Research 2017.3

TrustZone use case and trend

E-Mail: research-feedback[at]ffri.jp
Twitter: @FFRI_Research

FFRI, Inc.
http://www.ffri.jp/en

Table of Contents

About TrustZone

- About ARM TrustZone
  - Security mechanism of ARM processor
  - Cortex-A series and Cortex-M series are different mechanism
  - It makes a trusted world and non-trusted world on memory
    - For payment system, NFC, etc.,

- TEE (Trusted Execution Environment)
  - Secure execution environment realized at hardware level
  - Enactment by Global Platform and Trusted Computing Group
    - Global Platform create and publish specifications for secure chip and more

Use case of TrustZone

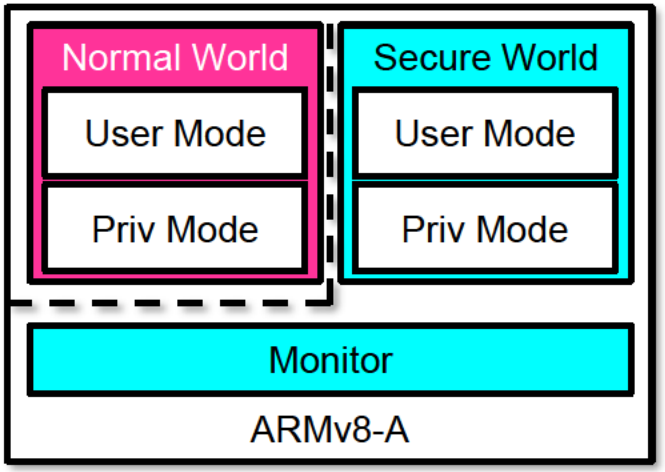
- Android 7.0 requires the implementation of a keystore using TrustZone etc.

- ARM Ltd. proposes the following use cases of TrustZone
  - Mobile payment
    - Credit card information and transaction are protected in a trusted world
  - Digital Rights Management
    - DRM data are protected in a trusted world
  - Credential information
    - Credential information such as fingerprint are protected in a trusted world

Cortex-A TrustZone

- Cortex-A series
  - Used a mobile and network device and more
  - ARMv7-A and ARMv8-A

- TrustZone
  - Memory isolation of Normal World and monitor mode
  - Trusted OS works in the Secure World
    - Switch the monitor mode by the SMC instruction

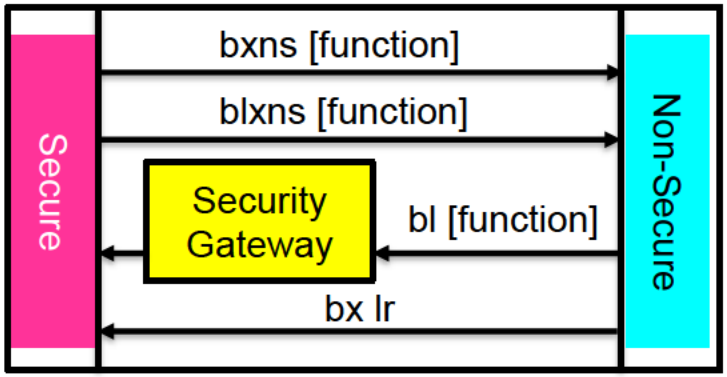


- For more information FFRI Monthly Research 2013.3

Cortex-M TrustZone

- TrustZone for low-power chips
  - ARMv8-M, s Cortex-M23/M33
- Memory isolation mechanism using state
  - Each memory area have state
    - Secure State, Non-Secure State, Non-Secure Callable State

- Non-Secure State call the Secure State
  - Via security gateway by the BL
  - Return to Secure State by the BX



- Secure State call the Non-Secure State
  - Use the BXNS and BLXNS

- For more information FFRI Monthly Research 2016.2

Well-known TEE implementation

- Trusty TEE
  - Developed by Google
  - Third party can't add the trusted application
  - Source code has published in AOSP

- OP-TEE
  - Developed by STMicroelectronics and Linaro Security Working Group
  - Source code has published in GitHub
  - Supports many board using Cortex-A series processor

- ARM mbed
  - An IoT platform developed by ARM Ltd.
  - Source code has published in the bed official site
  - It realizes TEE on board with Cortex-M

Security Research for TEE implementation

- Gal Beniamini (2017) TrustZone TEEs An Attacker's Perspective
  - Lecture at BlueHat IL Security Conference held by Microsoft
  - Analysis target are Qualcomm TEE and Trustonic TEE

- Both TEEs also were pointed out problems
  - ASLR is unused or entropy deficiency
  - Stack cookie is unused or implementation deficit

- The speaker recommends TEE implementation will be open source to get many reviews

- There is a risk that the vulnerability of TA is exploited and TEE breaks down if the security mechanism of the TEE implementation is insufficient

Vulnerability detail

- Qualcomm TEE
  - Insufficient entropy of ASLR
    - Non-Secure World OS can load a Trusted App(TA) into the Secure World user area(QSEE)
    - Trusted OS (QSEOS) load the TA at QSEE, but available memory is very limited
  - Buffer overflow
    - A TA check an overflow using stack cookie, but stack cookie is not random because many TA use BSS buffer
    - TA stack exist immediately after BSS, and a guard page doesn't exist
  - System call
    - QSEOS receives pointers at a system call from QSEE
    - QSEOS kernel memory can destruction because QSEOS don't check pointer value
- Trustonic TEE
  - ASLR and stack cookie are not available for TA

Conclusions

- TrustZone isolates memory for the trusted world and the non-trusted world
  - Security mechanism to realize TEE(Trusted Execution Environment)
    - TrustZone protect the confidentiality code or resource
  - Available in Cortex-A and Cortex-M

- TEE implementation with TrustZone
  - OP-TEE, Trusty TEE, mbed and more

- Vulnerability of TEE implementation
  - ASLR and stack cookie are incomplete
  - TEE implementation should be open sourced and reviewed more
  - Should use TEE implementation with solid ASLR and stack protection

References

- ARM Security Technology
  - http://infocenter.arm.com/help/topic/com.arm.doc.prd29-genc-009492c/PRD29-GENC-009492C_trustzone_security_whitepaper.pdf
- TrustZone TEEs An Attacker's Perspective
  - https://microsoftrnd.co.il/Press%20Kit/BlueHat%20IL%20Decks/GalBeniamini.pdf
- Trusty TEE | Android Open Source Project
  - https://source.android.com/security/trusty/
- mbed OS | mbed
  - https://www.mbed.com/en/platform/mbed-os/
- OP-TEE
  - https://www.op-tee.org/