ARM TrustZone for Secure Image Processing on the Cloud

Tiago Brito
IST / INESC-ID

Nuno O. Duarte
IST / INESC-ID

Nuno Santos
IST / INESC-ID

1. Problem

- **Cloud services process sensitive image content**
  Ex.: Facebook, Instagram, Google…
- **Image processing requires access to raw image data on the cloud**
  Ex.: Rescaling for thumbnail generation, image filters…
- **Outstanding server vulnerabilities may lead to sensitive image data disclosure**
  Hackers or malware may exploit application bugs or OS misconfiguration

2. Challenges

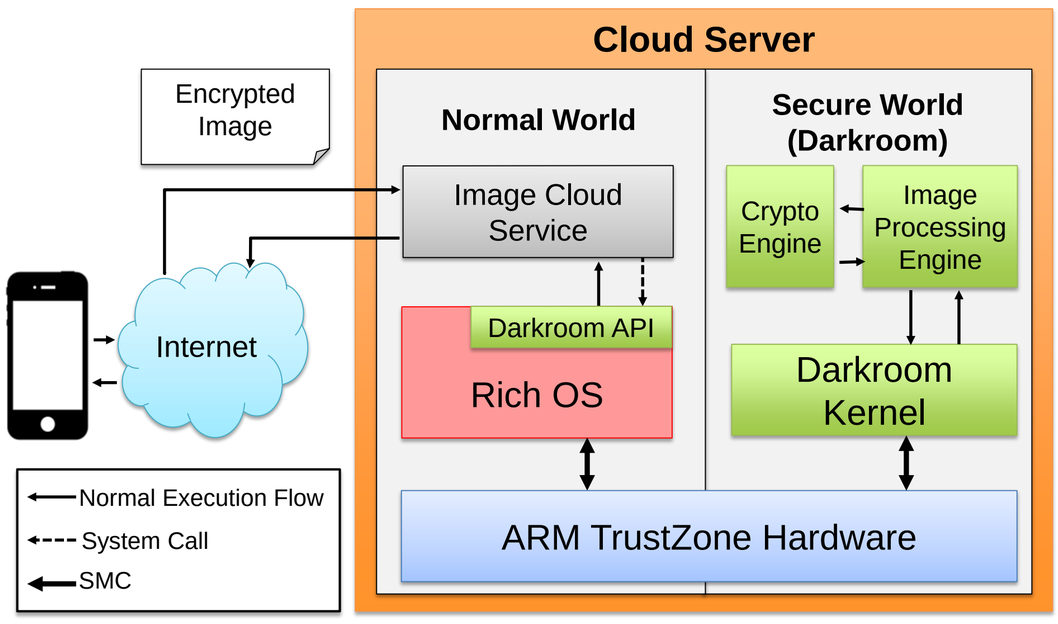
1. **Basic end-to-end encryption is too inflexible**
   - Image content becomes exposed to the OS when unencrypted
   - Hard to securely maintain encryption keys
2. **OS-based sandboxing requires large TCB**
   - Image transformations inside an OS service
   - Secure channel between client and OS
   - Solves exposure of content to the server app
   - But depends on large Trusted Computing Base

3. Darkroom

Our approach: develop a Trusted Execution Environment for the cloud based on ARM TrustZone

- ARM is an alternative architecture for the cloud (less energy consumption)
- A conceptually similar approach can be implemented using Intel SGX (secure enclaves)

1. **Image upload (envelope):**
   - Service key generated by client
   - Image encrypted with service key
   - Service key encrypted with server's private key
2. **Send image transformation request**
3. **Normal world server sends the request via the Darkroom API**

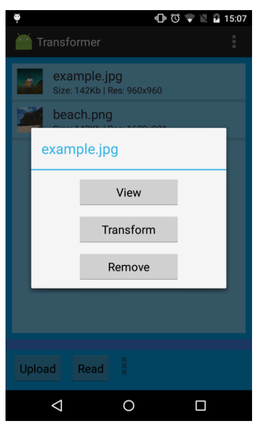


4. **Darkroom API prepares the data to be sent to the secure world and invokes SMC**
5. **Darkroom kernel processes the data**
   - Decrypt image data with service key
   - Transform image
   - Encrypt new image data with service key
6. **Resulting data sent to NW and, in turn, to the client**

4. Implementation

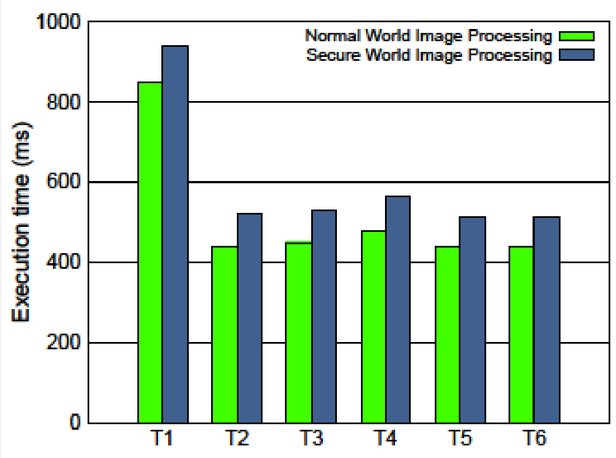
- **Hardware:**
  NXP (Freescale) i.MX53 QSB
- **Darkroom Kernel:**
  - Adapted Genode's micro-kernel
  - Shared memory for data communication between normal and secure worlds

- **Cryptographic engine**: adapted RSA and AES implementation from the mbed_TLS library
- **Image Processing Engine**: small set of simple transformation functions

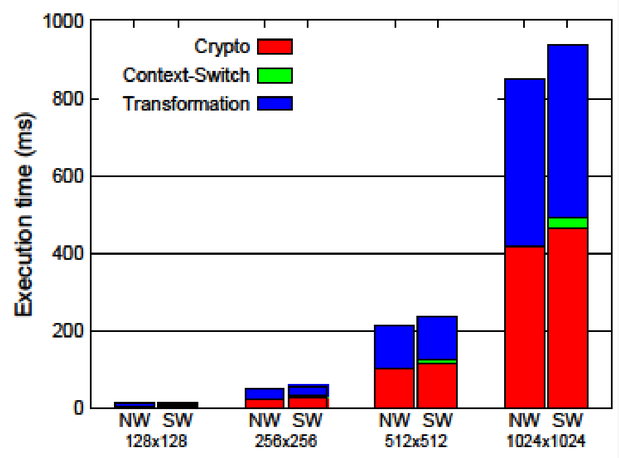


5. Preliminary Evaluation

Compare Darkroom performance running in NW and SW



Constant penalty for using Darkroom across all transformations



Negligible overhead from the context-switch between worlds

So… Small overhead by Darkroom for image processing

5. Conclusions

- **Darkroom: an ARM TrustZone based system for secure image processing on the cloud**
- **Provides isolation between potentially compromised rich OS and the Darkroom image processing engine**
- **Image processing using Darkroom adds reduced overhead**