No Forking Way: Detecting Cloning Attacks on Intel SGX Applications

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Contents

1. Motivation
2. Research question
3. CloneBuster
4. Conclusions
Motivation: Intel SGX

- Intel SGX is a set of extensions that provide runtime hardware protection to both code and data even if other code components are malicious.

- Vulnerable to different attacks: transient execution attacks, microarchitectural attacks, rollback attacks, forking attacks...
Motivation: Rollback and Forking attacks

- Rollback attacks: the enclave state can be reverted to a previous one
- Forking attacks: multiple clones of an enclave lead to an inconsistent state
Motivation: Analysis of SGX Applications

- We analyzed 72 SGX-based applications and 14 of them were vulnerable to forking attacks (3 of them included monotonic counters)
Research questions

◆ Can we design an anti-cloning solution that is:
  ■ practical,
  ■ efficient,
  ■ and does not require a TTP?

◆ Recall that clones share the same binaries and the same hardware
CloneBuster

- Idea: it is possible to establish a covert channel between two processes running on the same machine
  - Cache memories.
CloneBuster

◆ Considerations:

◆ Sgx does not provide high accuracy timers (e.g. rdtsc)
  - Previous work suggest a counting thread

◆ Enclaves are not aware of physical addresses of their data
  - Still they can gain some information if the mapping functions of the cache or DRAM are known in advance

◆ The enclave needs to know some details about the HW in advance

◆ The OS might be malicious and try to break the communication
CloneBuster

Proposals
CloneBuster

- We have implemented a prototype for its evaluation:
  - Access pattern that minimizes clone detection time
  - Defines up to 64 channels for monitoring the cache.
- Runs several tests to ensure all the sets in the channel have been built
- Does not allow applications to run until all the eviction sets are created
- Data might be prefetched
- Needs to be running during the whole execution time of the protected application
CloneBuster: Evaluation

- We have evaluated the impact on performance of
  - Observation window size
  - Number or monitored ways per set
  - Classification algorithm
  - Noise (other applications running on the same machine)
  - Overhead (WolfSSL benchmark)
- Less than 5% overhead introduced in protected applications
- F1 score of 0.99 even in the presence of noise
- Further experiments in an extended version of the paper
Conclusions

◆ Providing protection against forking attacks is tricky and SGX applications are still vulnerable to them.
◆ Clones share the same hardware, which can be leveraged to detect the presence of clones.
◆ We have designed CloneBuster
  ■ Does not require a TTP
  ■ Low overhead
  ■ Robust in the presence of noise
◆ Source code is available
Thank you very much for your Attention

Artifacts: https://github.com/nec-research/CloneBuster

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