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No Forking Way: Detecting Cloning Attacks on Intel SGX Applications

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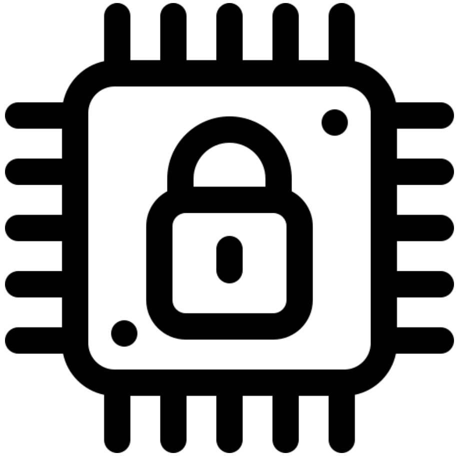
Motivation: Intel SGX

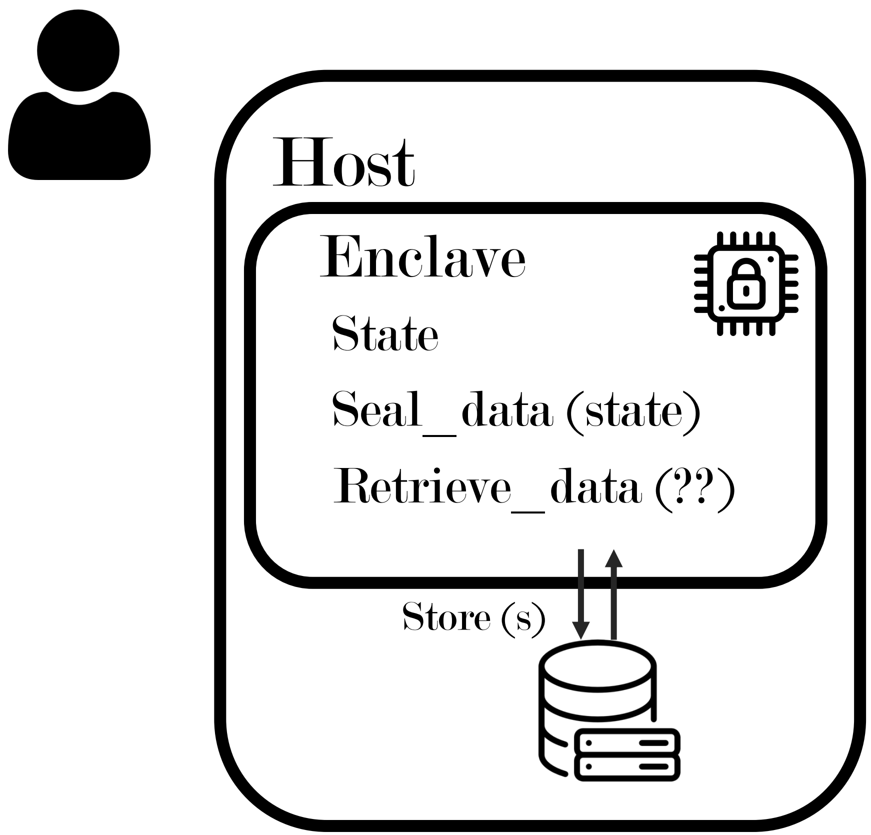
- Intel SGX is a set of extensions that provide runtime hardware protection to both code and data even if other code components are malicious

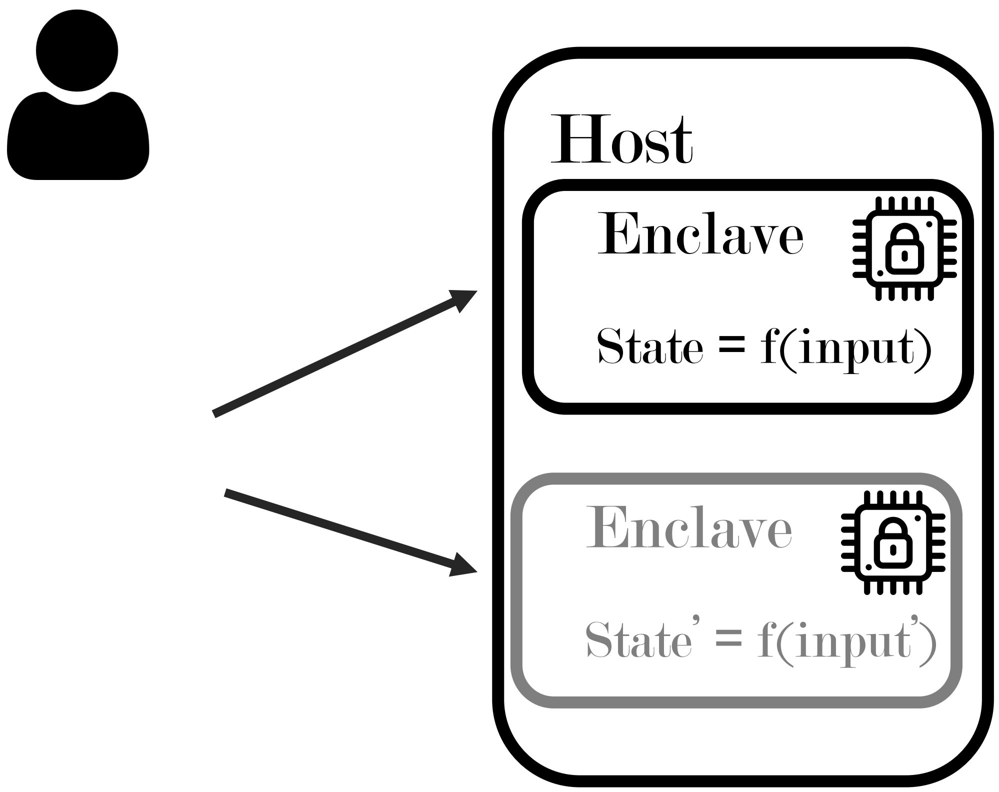


- Vulnerable to different attacks: transient execution attacks, microarchitectural attacks, rollback attacks, forking attacks…

Motivation: Rollback and Forking attacks

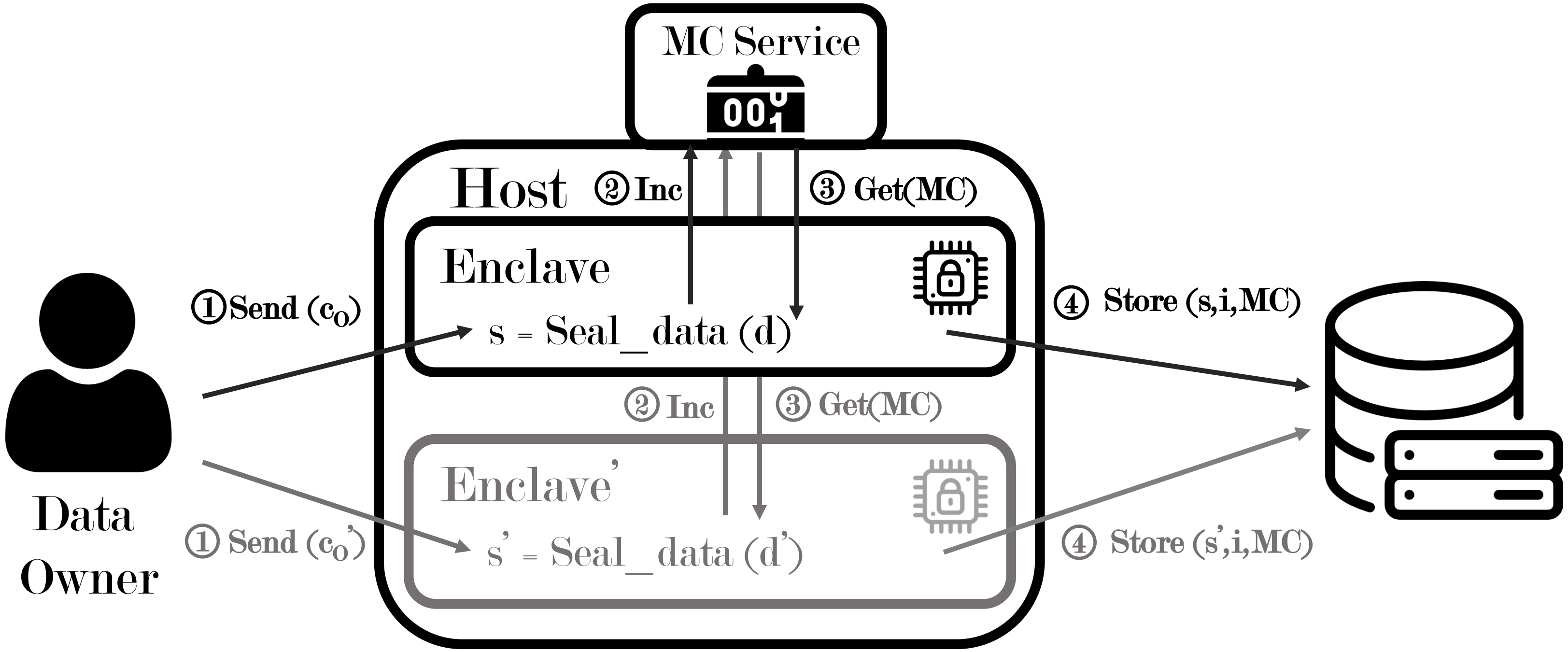
- Rollback attacks: the enclave state can be reverted to a previous one
- Forking attacks: multiple clones of an enclave lead to an inconsistent state





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)



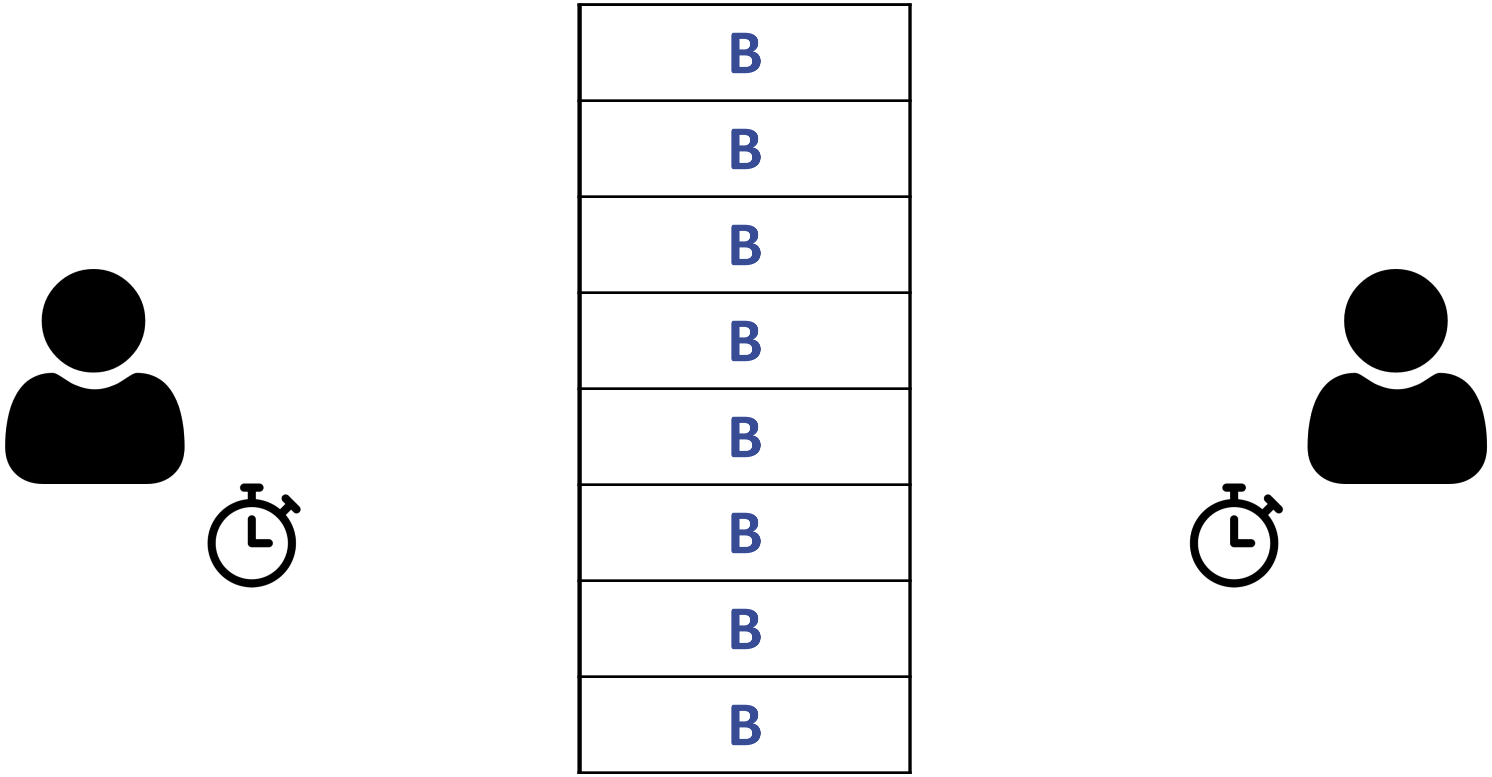
Research questions

- 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 to processes running on the same machine
  - Cache memories.

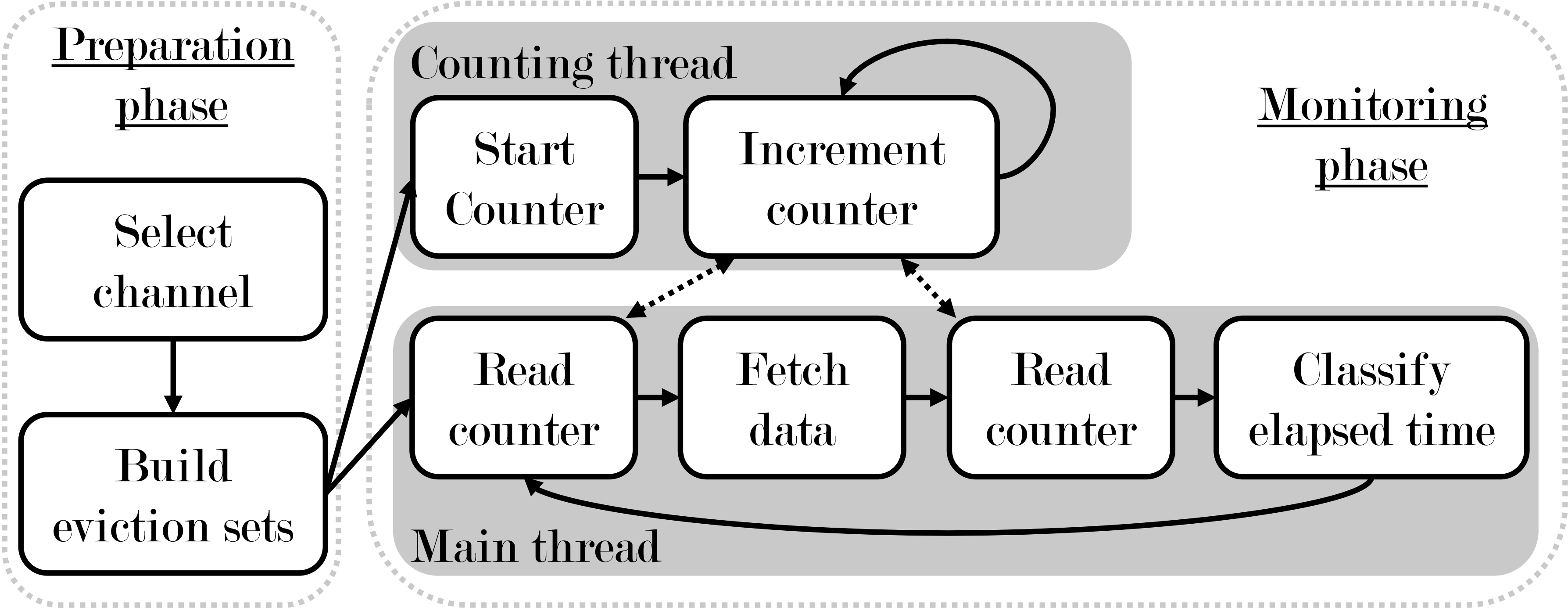


CloneBuster

- 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

- Proposal



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

Artifacts Evaluated
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Thank you very much for your Attention

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

Artifacts Evaluated Functional V1.1

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