SCONE: **S**ecure Linux **Con**tainer **E**nvironments with Intel SGX

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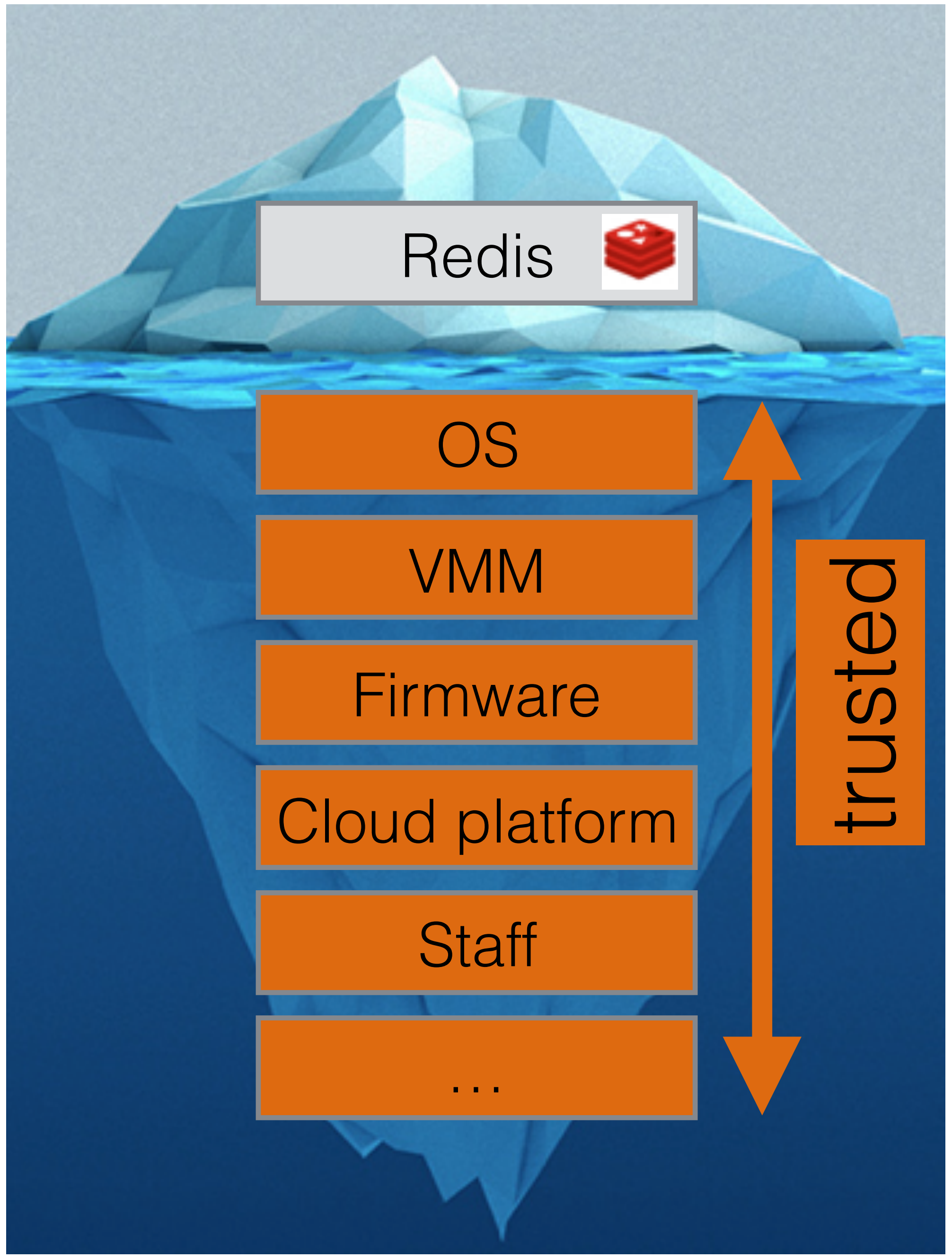
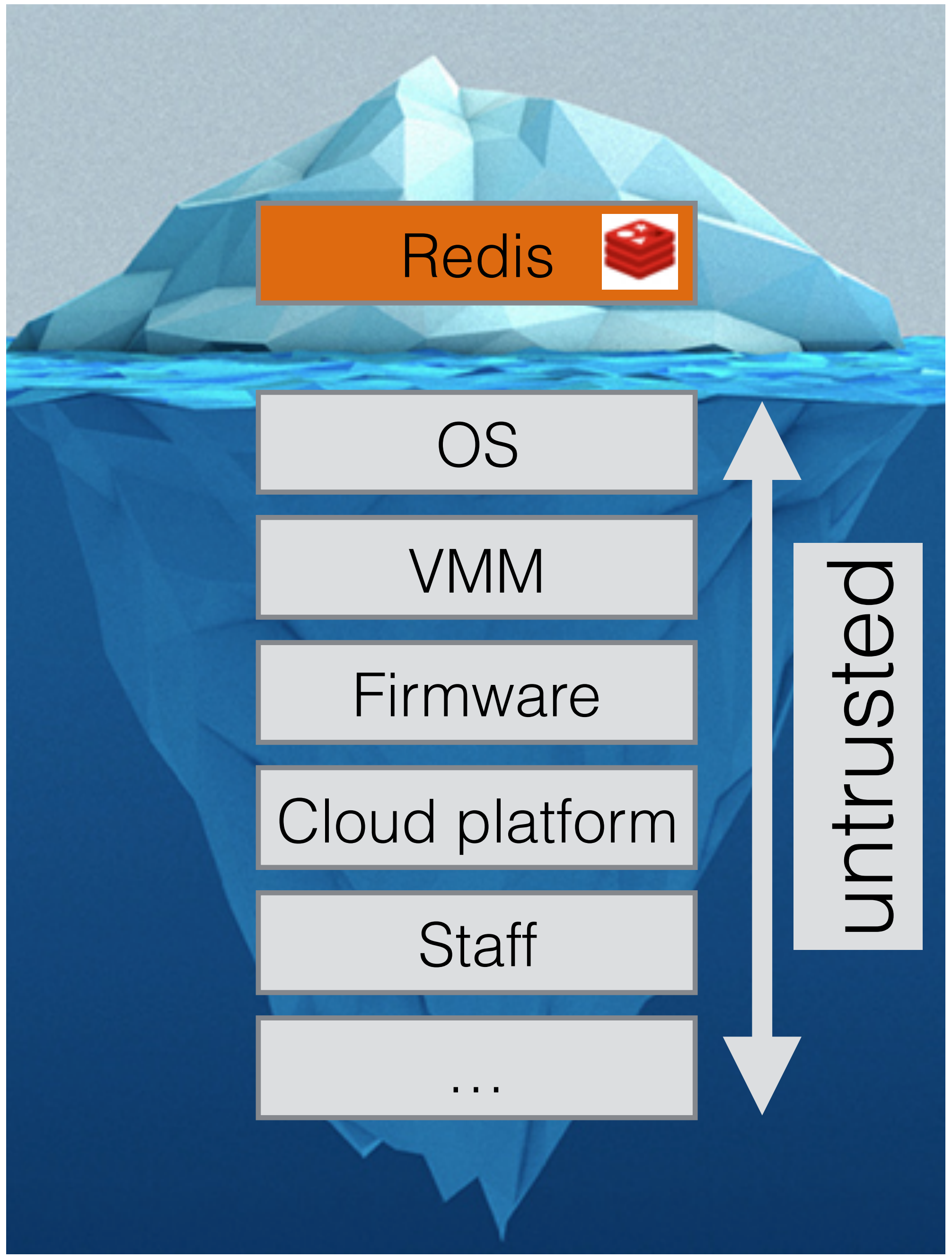
Trust Issues: The Provider's Perspective

- Cloud provider does not trust users
- Use virtual machines to isolate users from each other and the host
- VMs only provide one way protection



Trust Issues: The User's Perspective

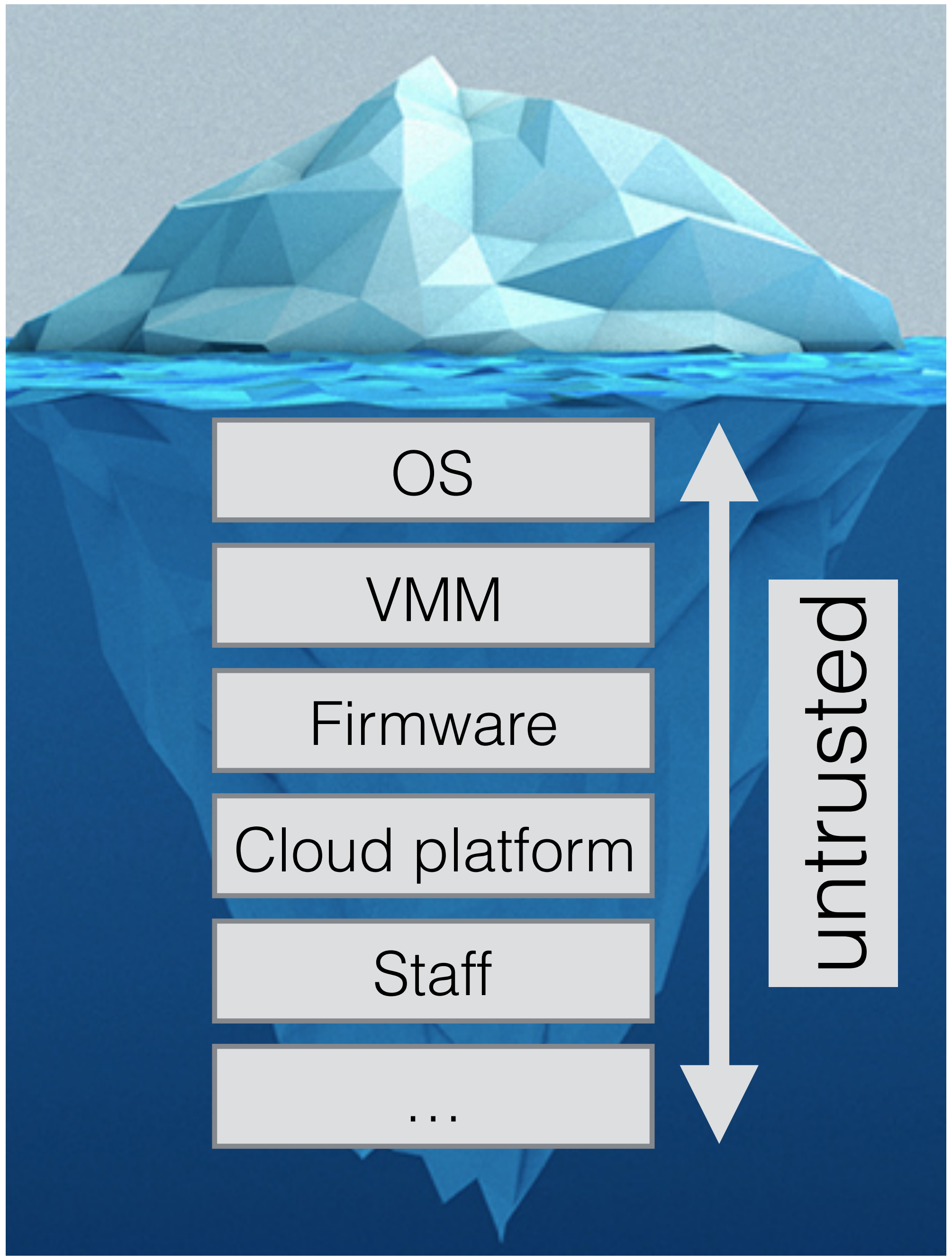
- Users trust their application
- Users must implicitly trust the cloud provider
- Existing applications implicitly assume trusted operating system

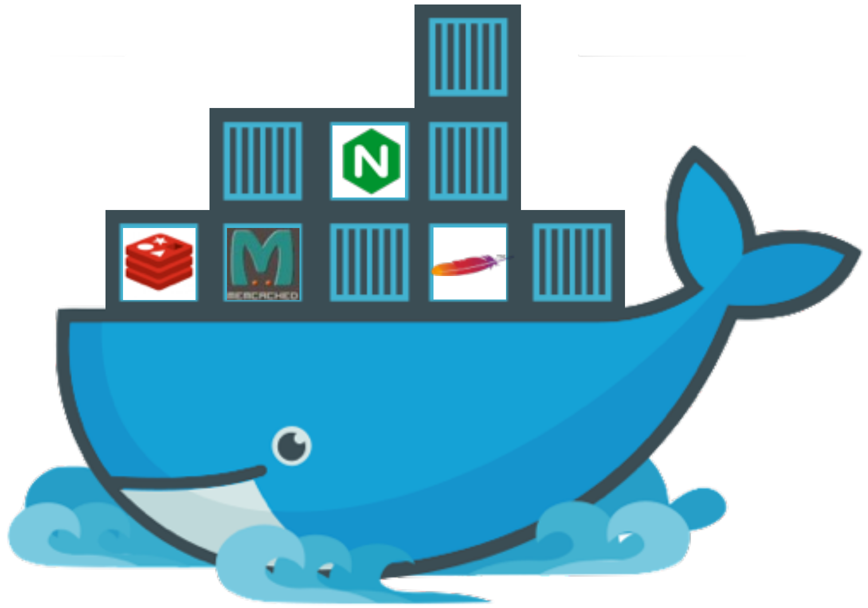


Containers are the new VMs

- Containers provide resource isolation and bundling
- Smaller resource overhead than virtual machines
- Convenient tooling to create and deploy applications in the cloud

Disaster!





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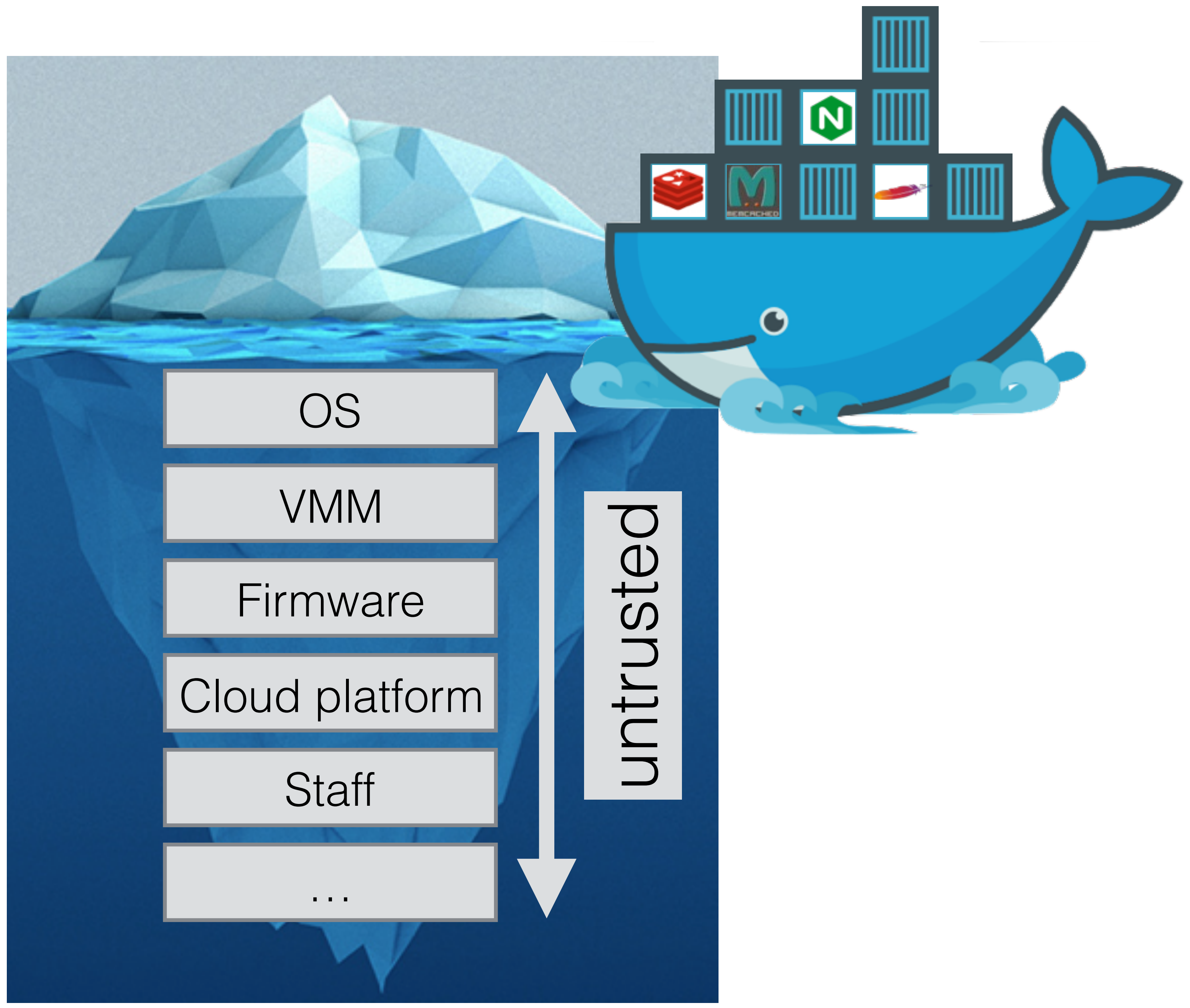

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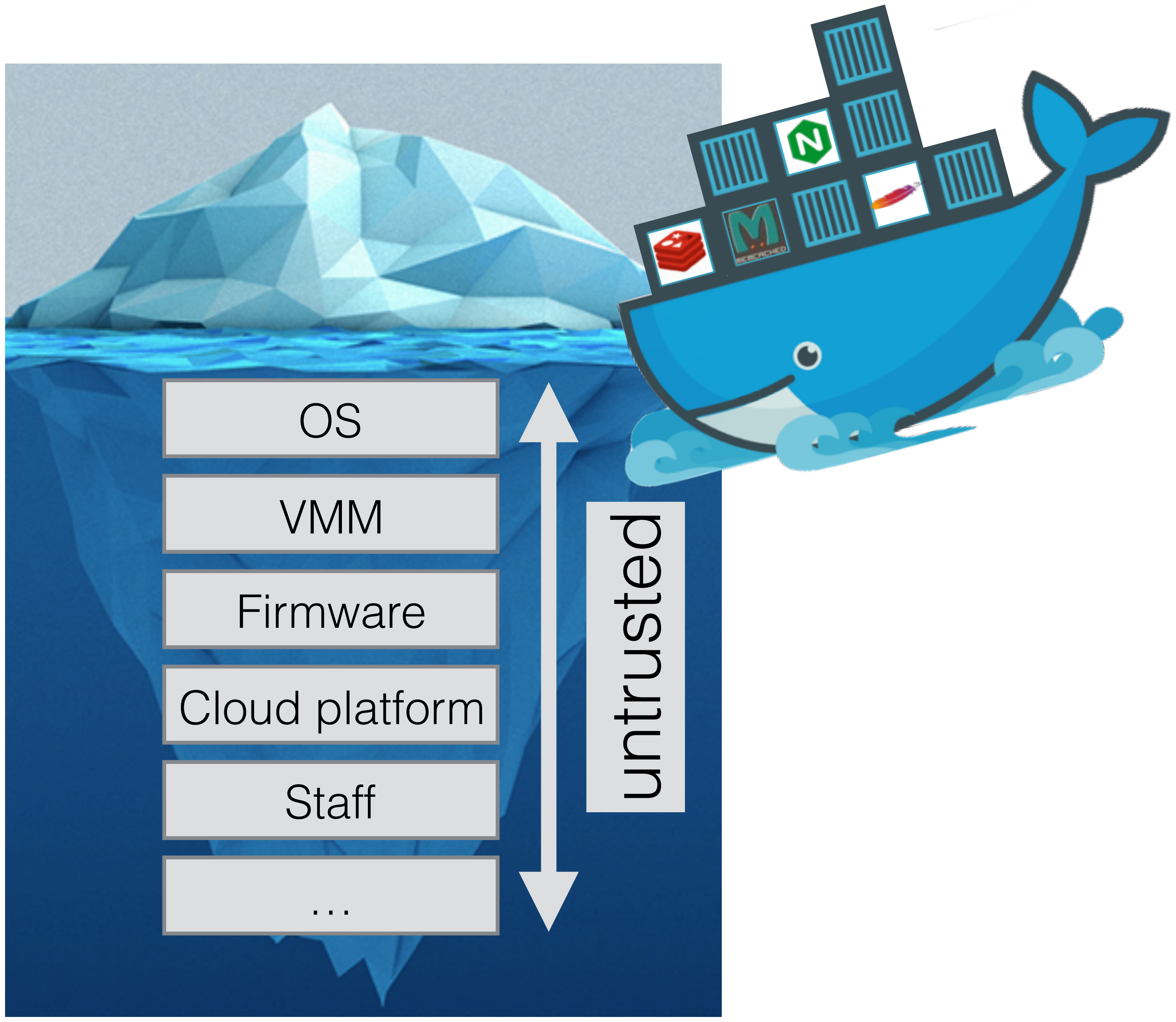

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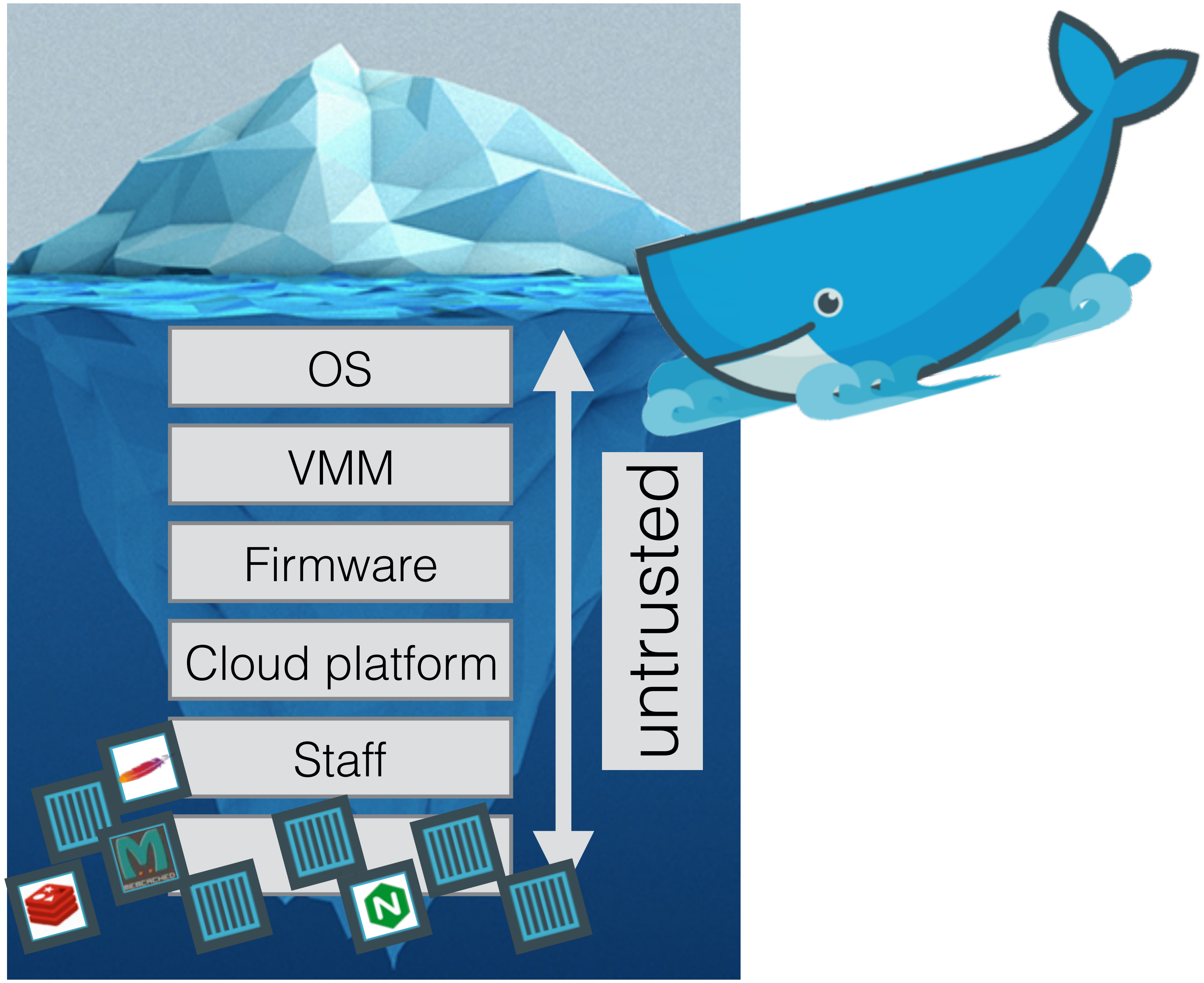
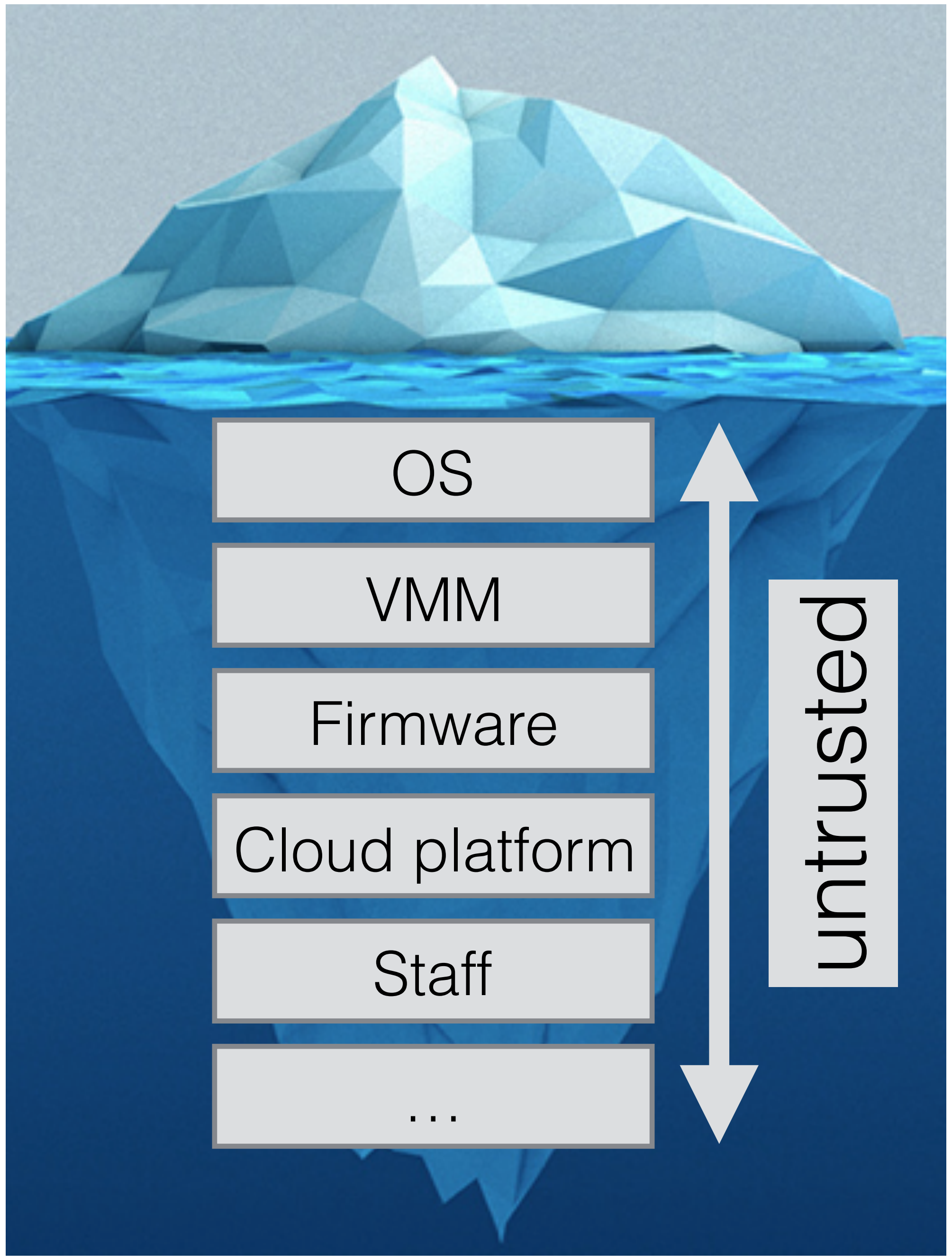


We want to …



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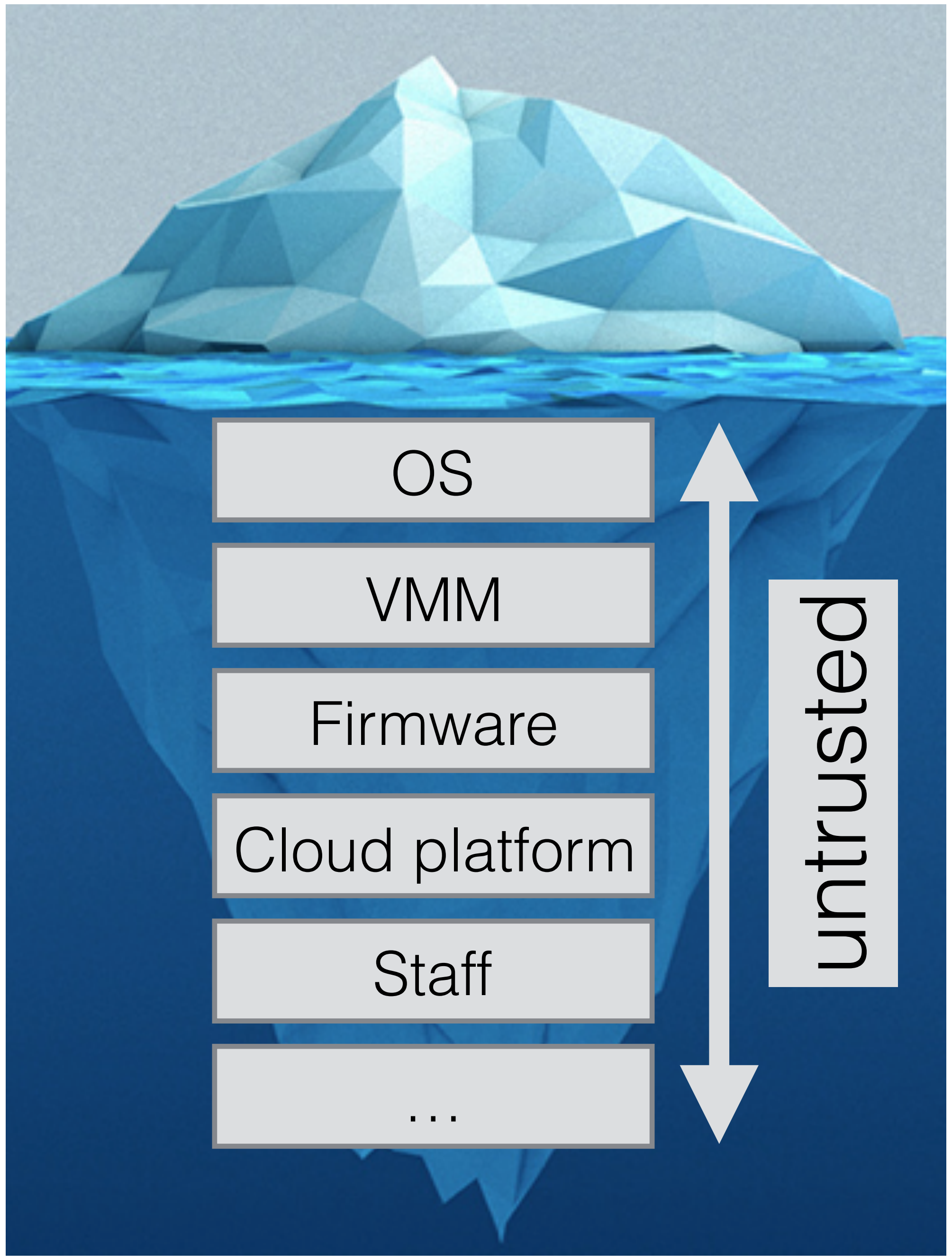

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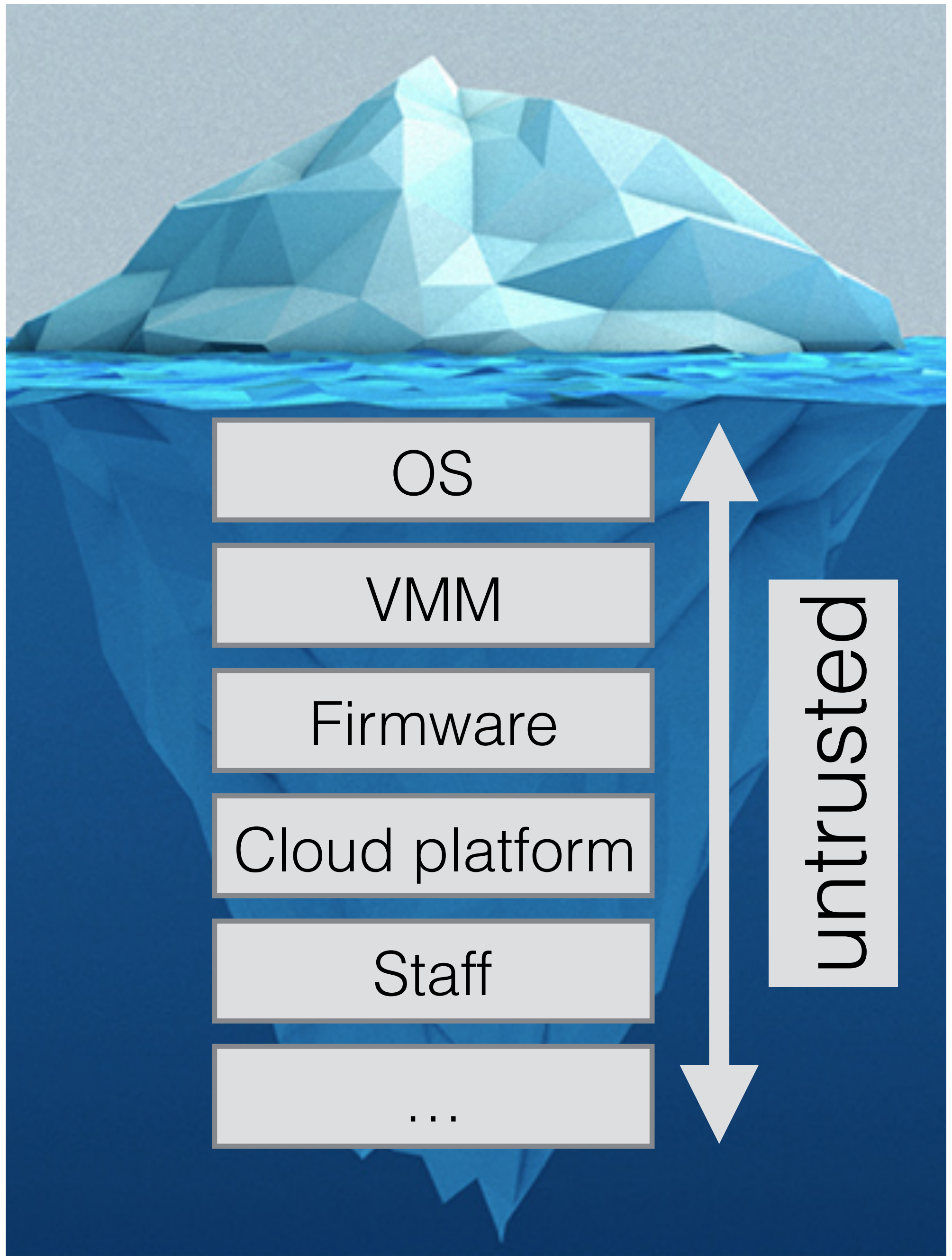

- run unmodified Linux applications …
- in containers …

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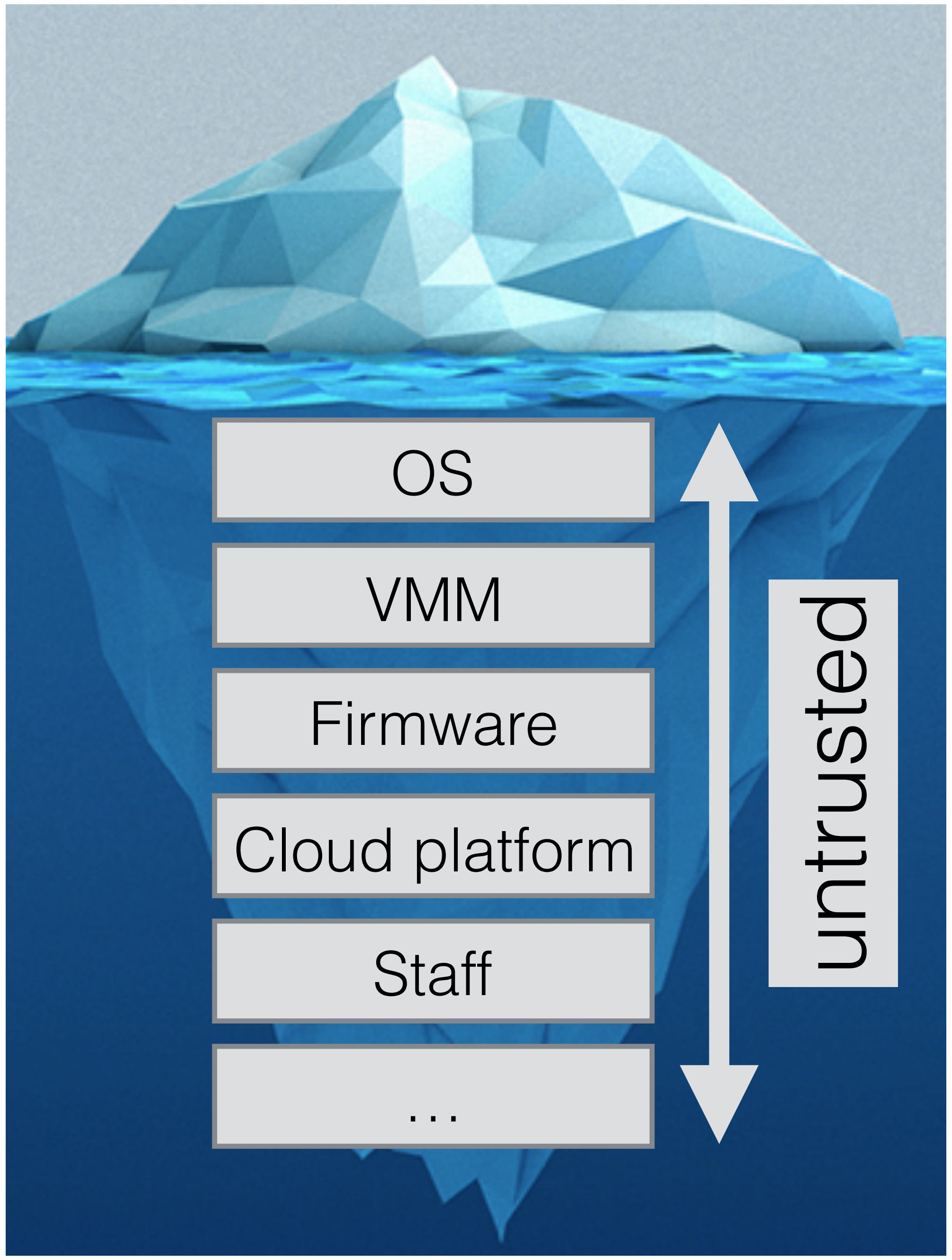

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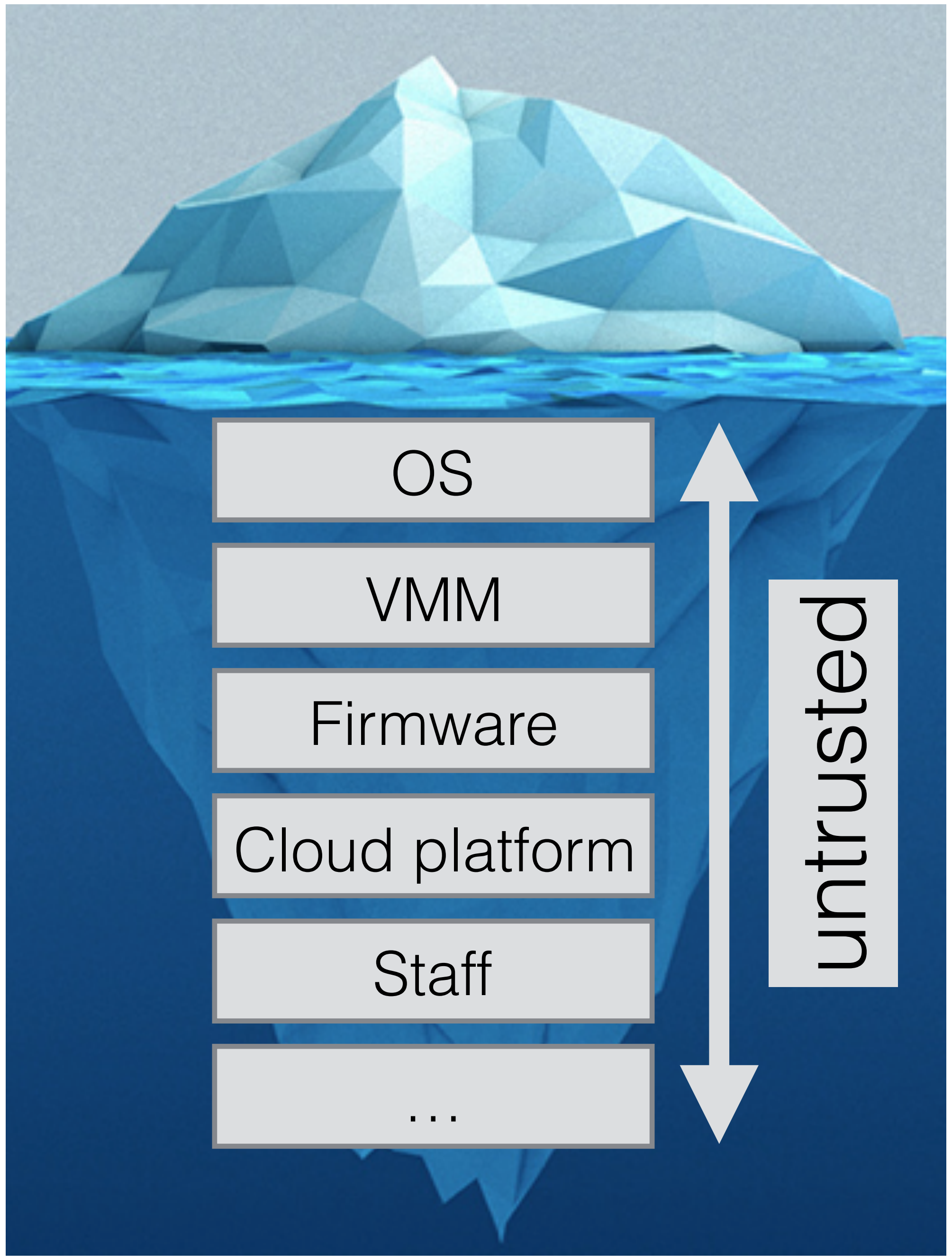

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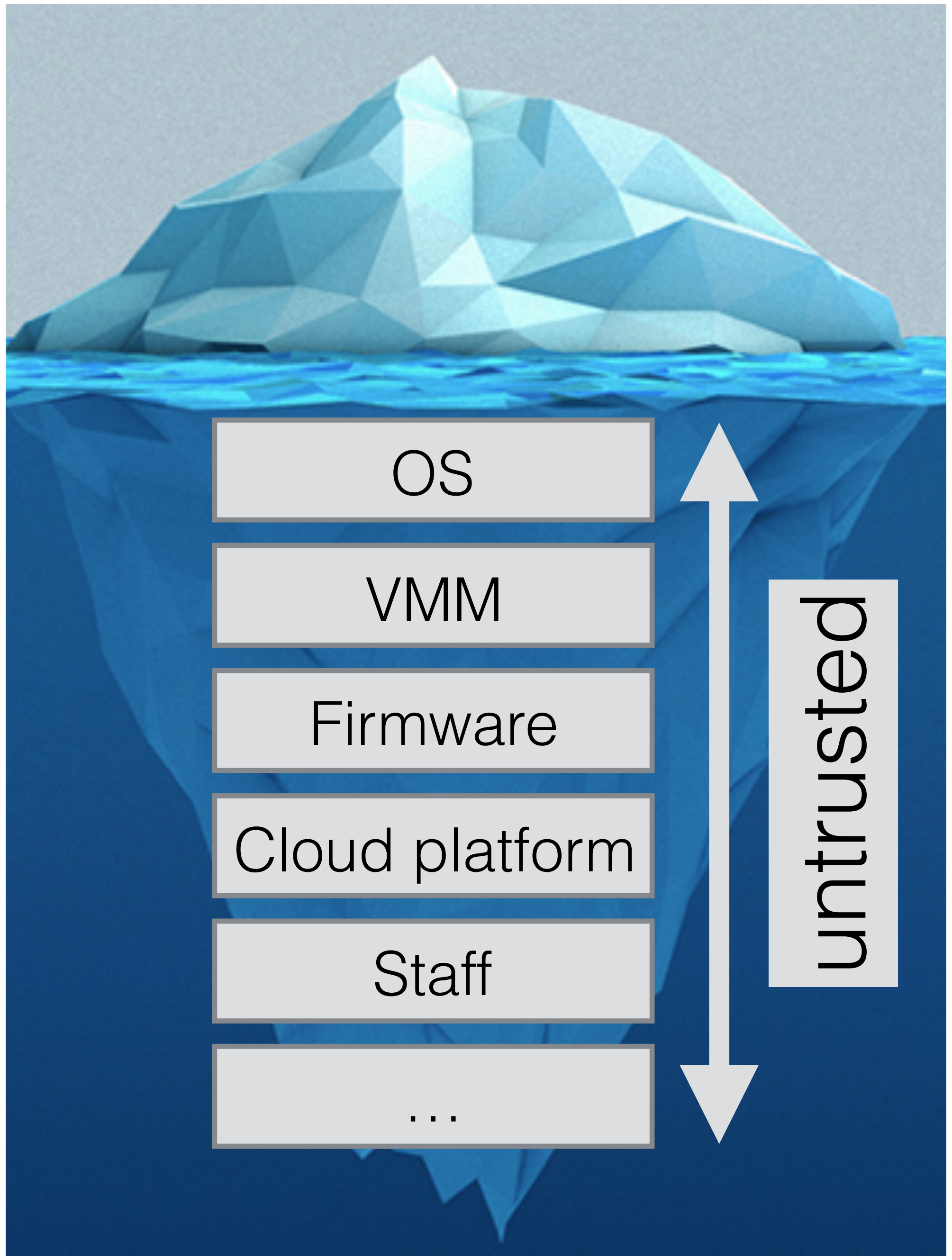
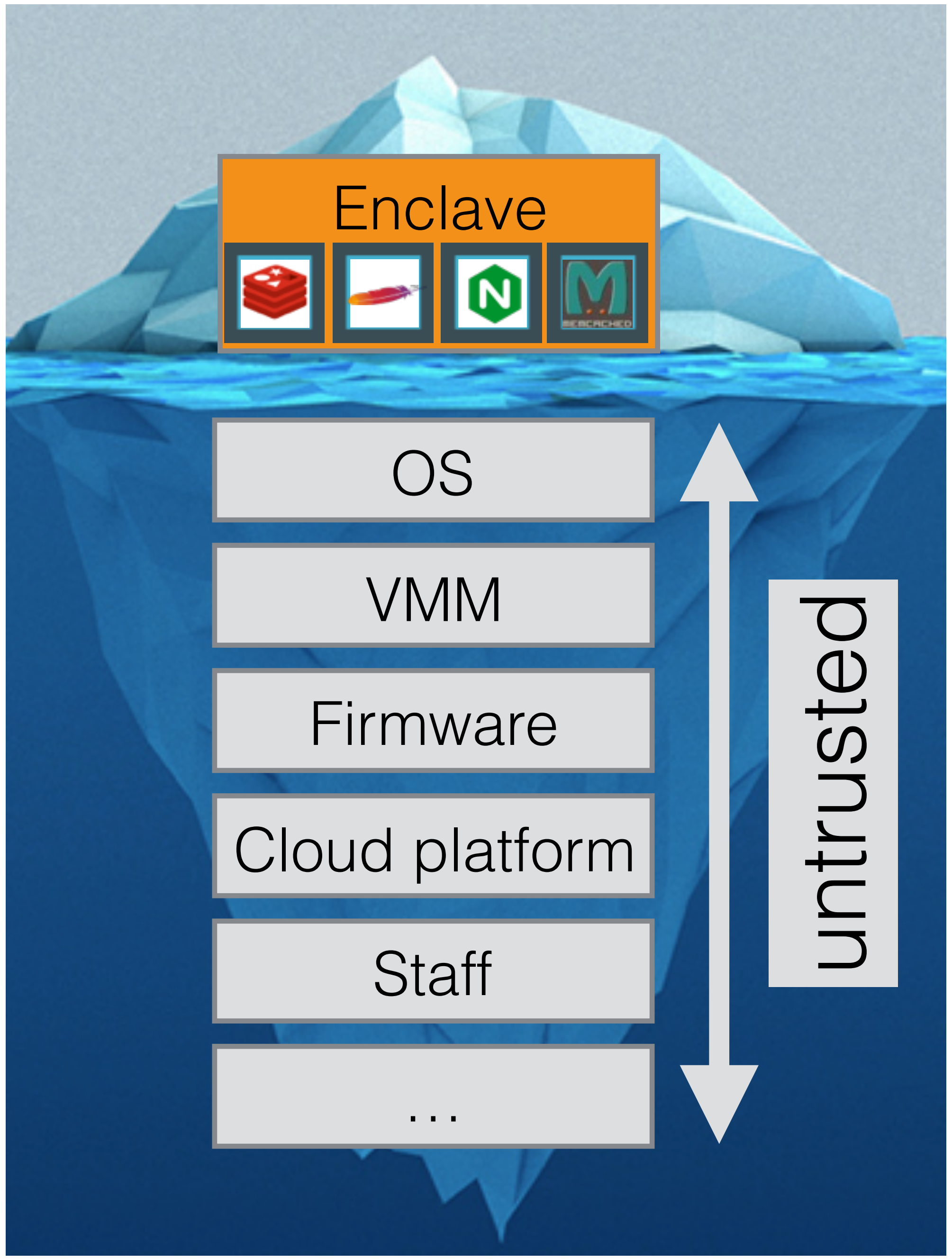


- run unmodified Linux applications …
- in containers …
- in an untrusted cloud …
- securely and …
- with acceptable performance

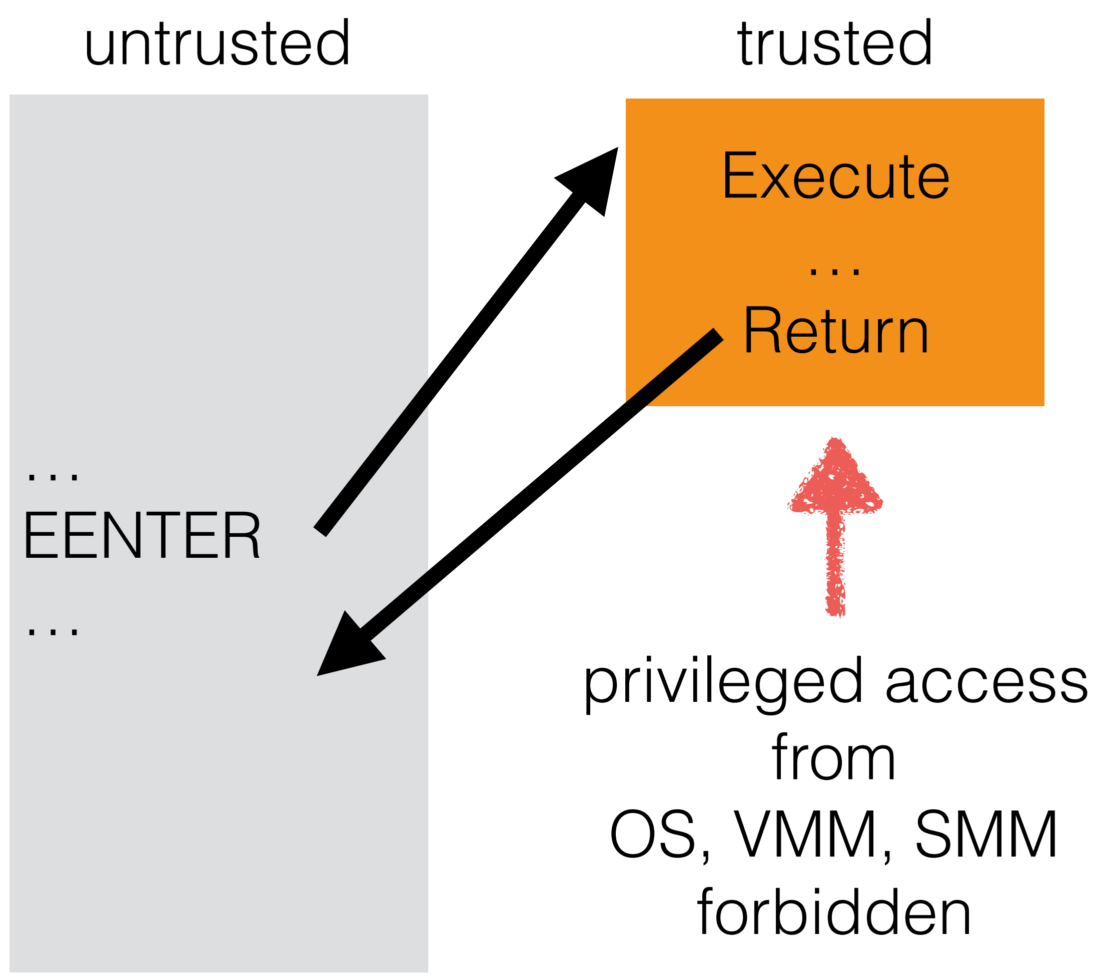
Secure Guard Extensions



- New **enclave** processor **mode**
- Users can create a HW-enforced trusted environment
- Only trust Intel and Secure Guard Extensions (SGX) implementation

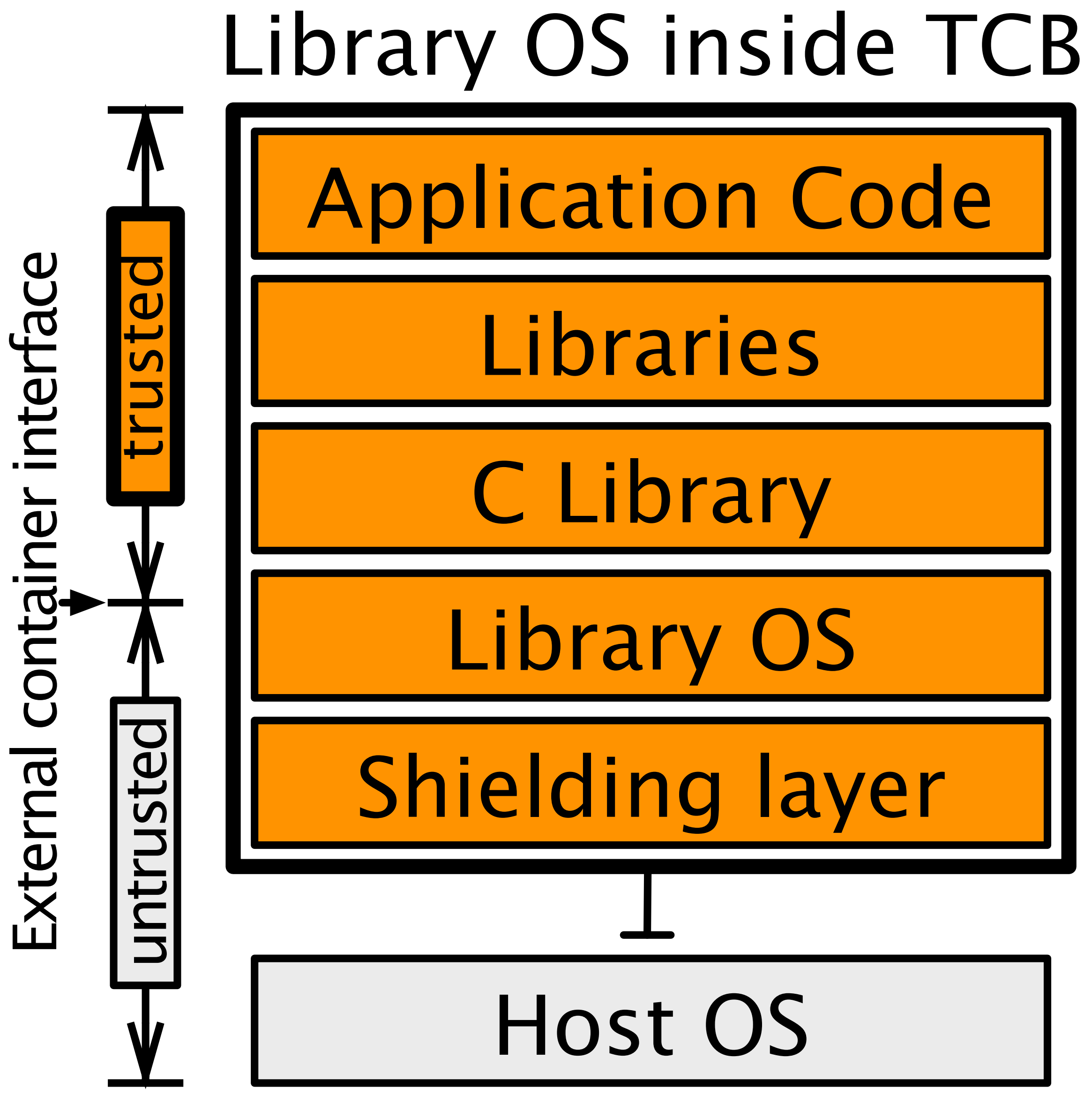
SGX: HW-enforced Security

- 18 new instructions to manage enclave life cycle
- **Enclave memory** only accessible from enclave
- Certain instructions disallowed, e.g., `syscall`



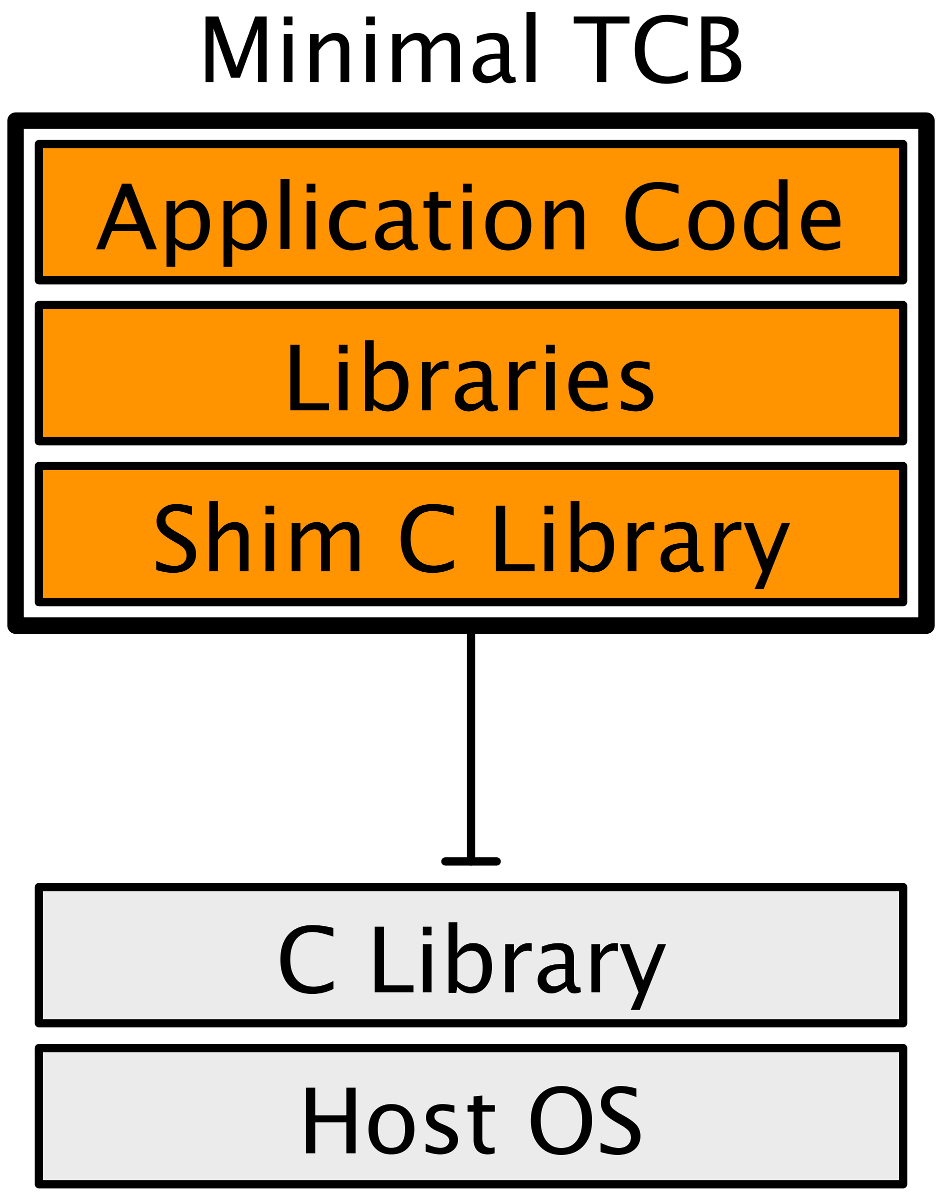
Challenge 1: Interface

- Haven (OSDI'14): library operating system in enclave
- Large TCB → more vulnerable
- Small interface (22 system calls)
- Shields protect the interface

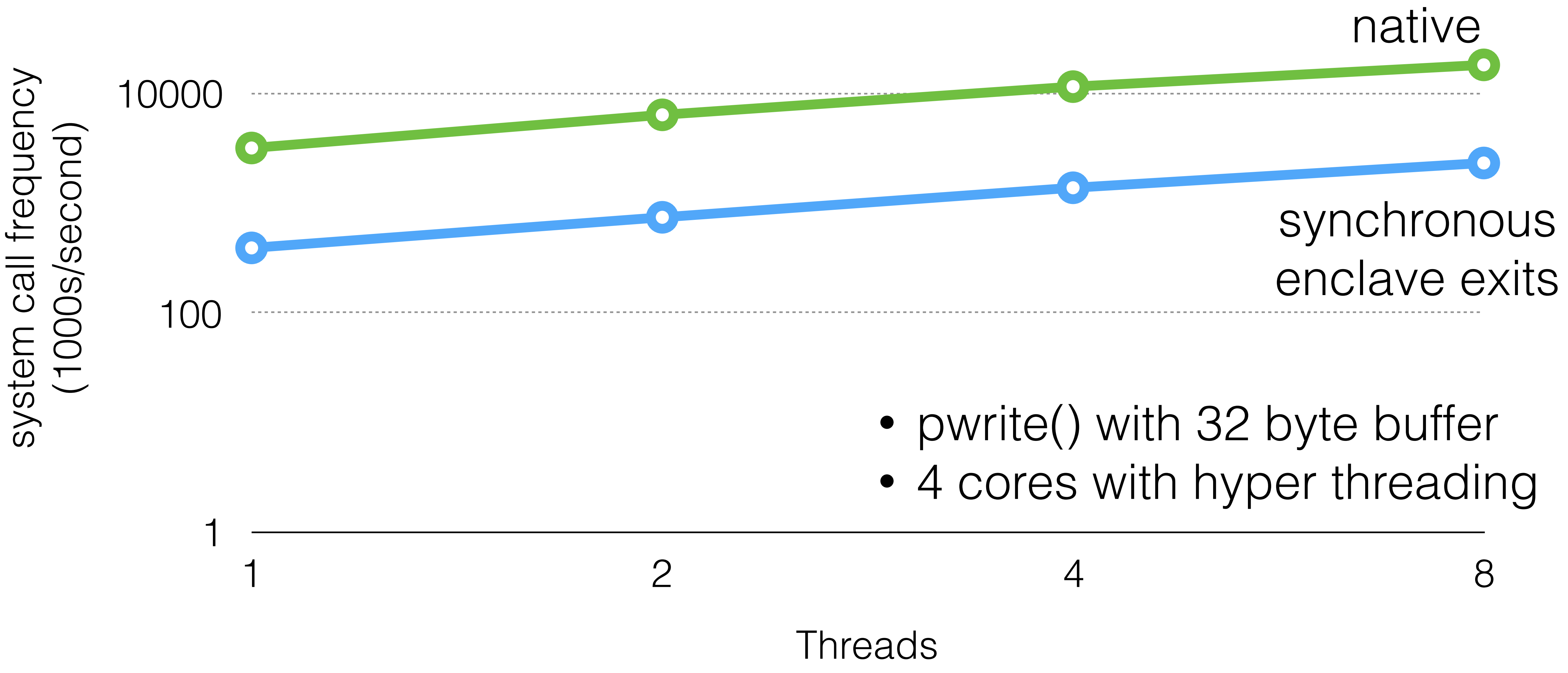


Challenge 1: Interface

- Small TCB
- C library interface is complex
- Harder to protect



Challenge 2: Performance



- pwrite() with 32 byte buffer
- 4 cores with hyper threading

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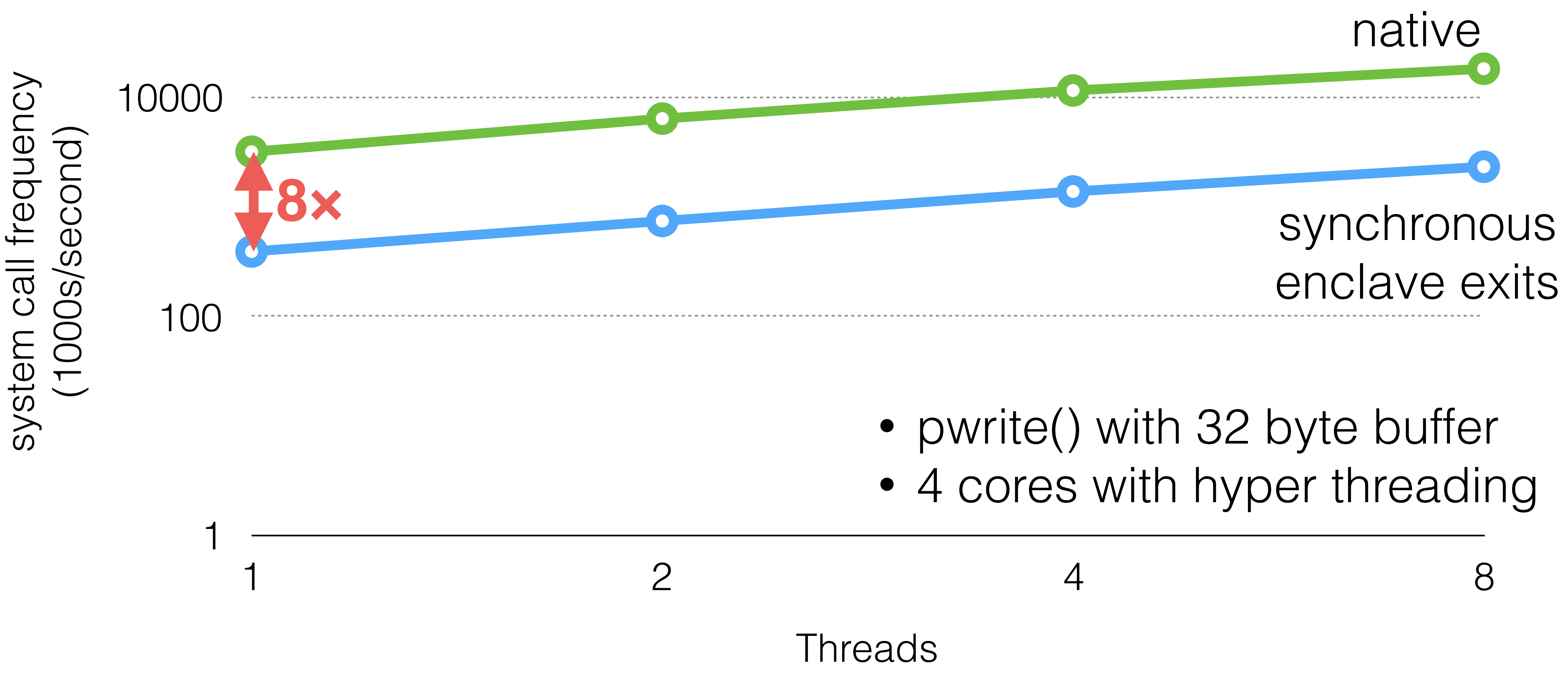

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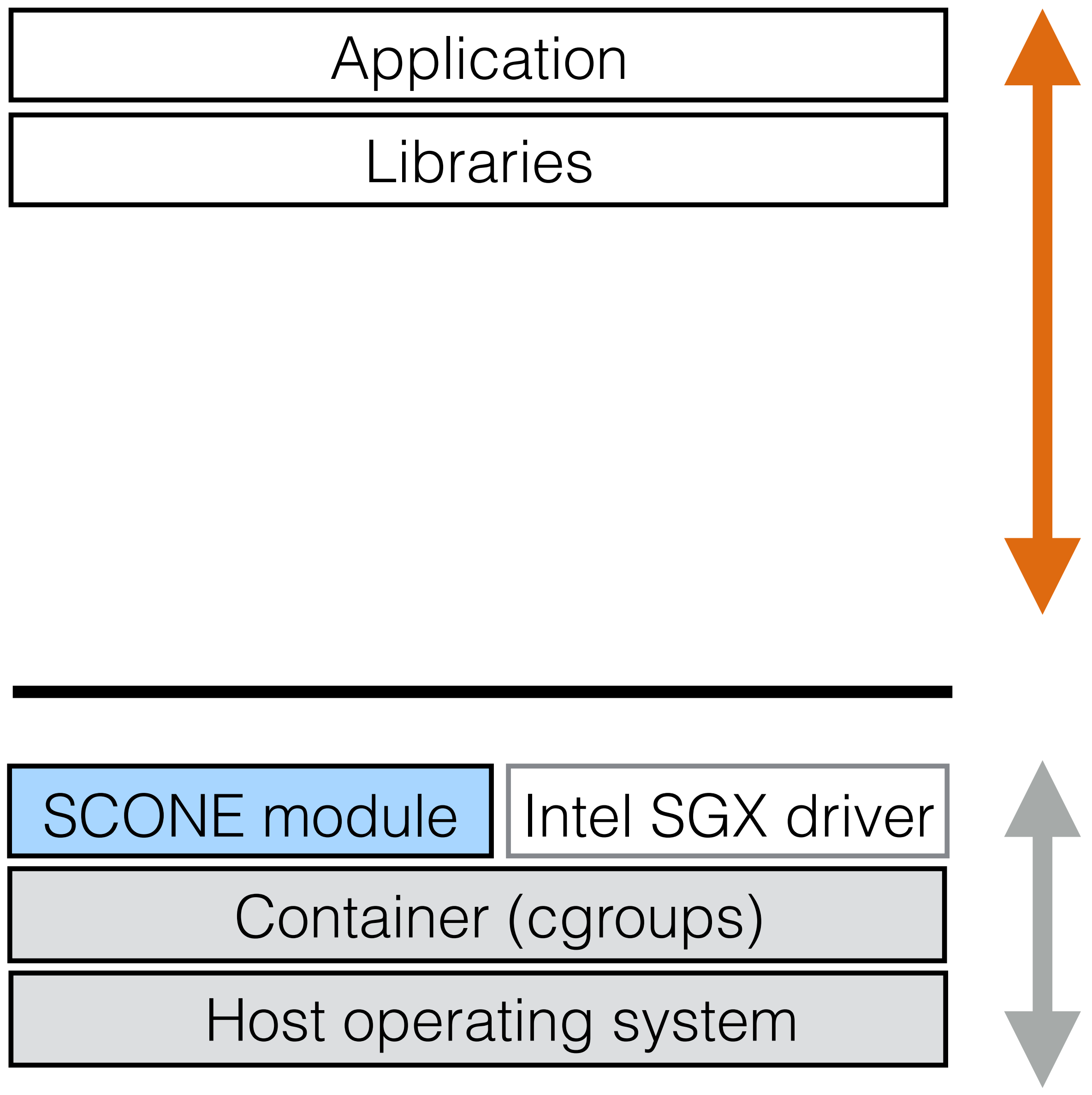
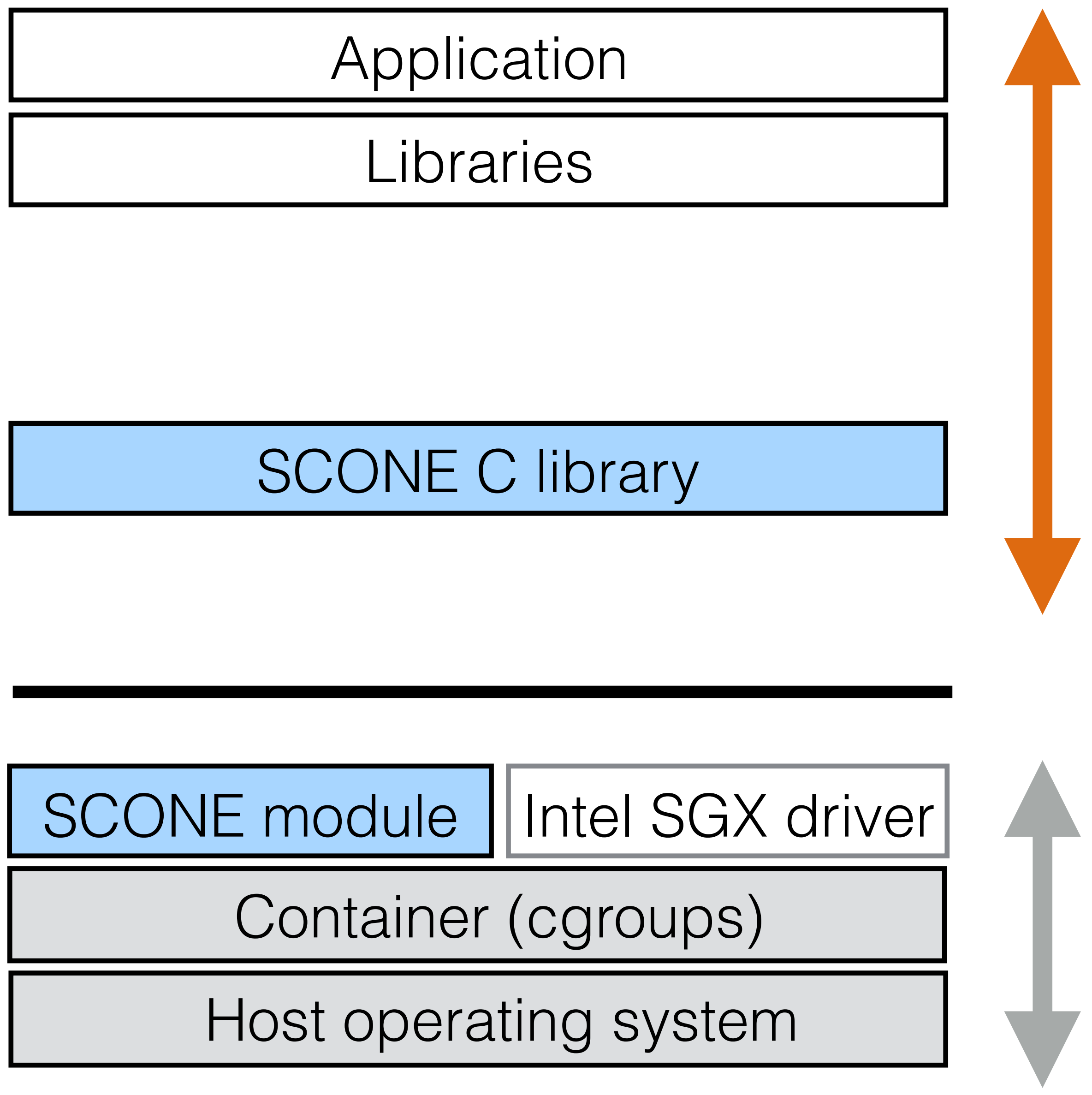
SCONE Architecture



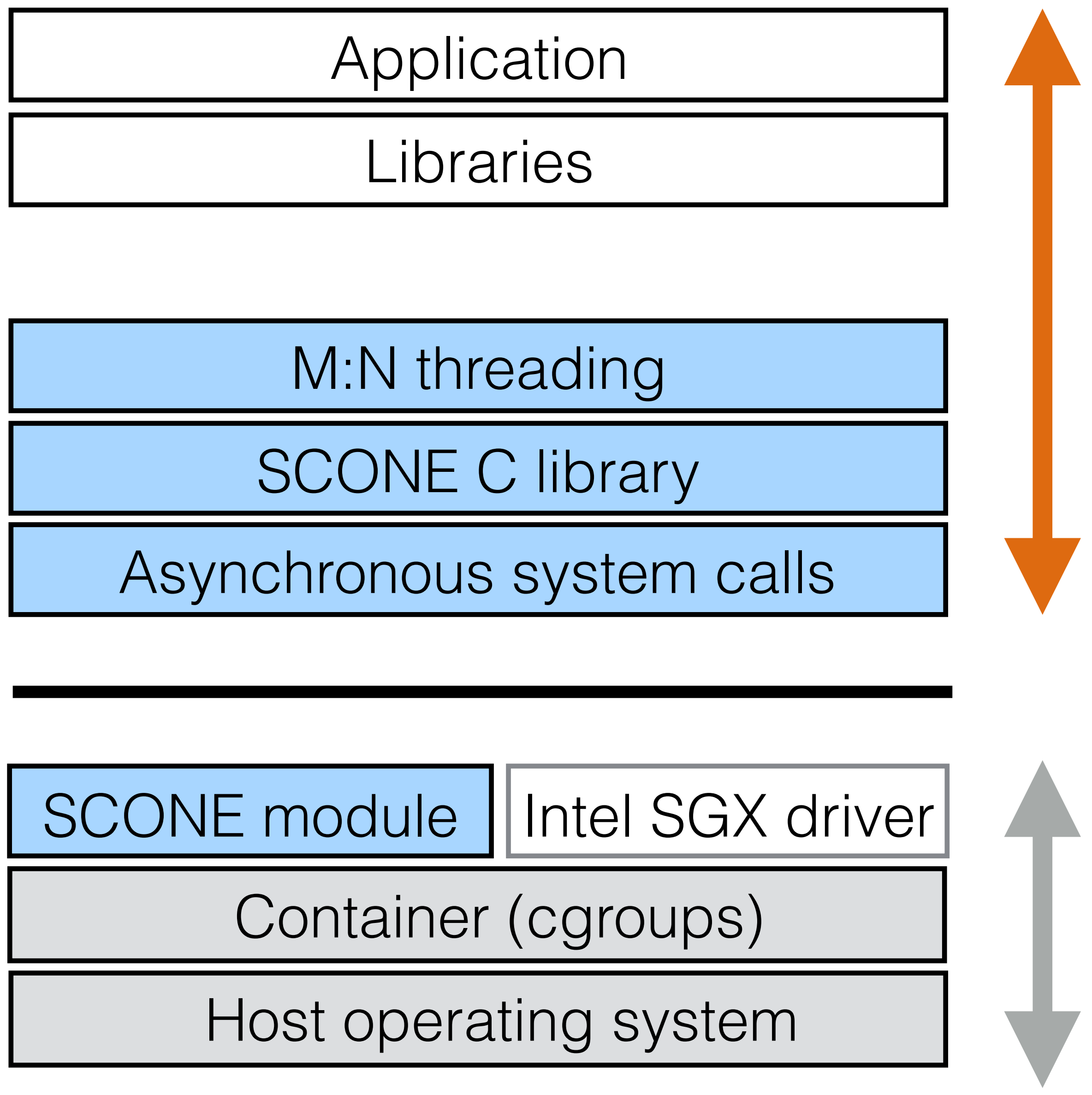
SCONE Architecture

- Enhanced C library → small TCB (Challenge 1)



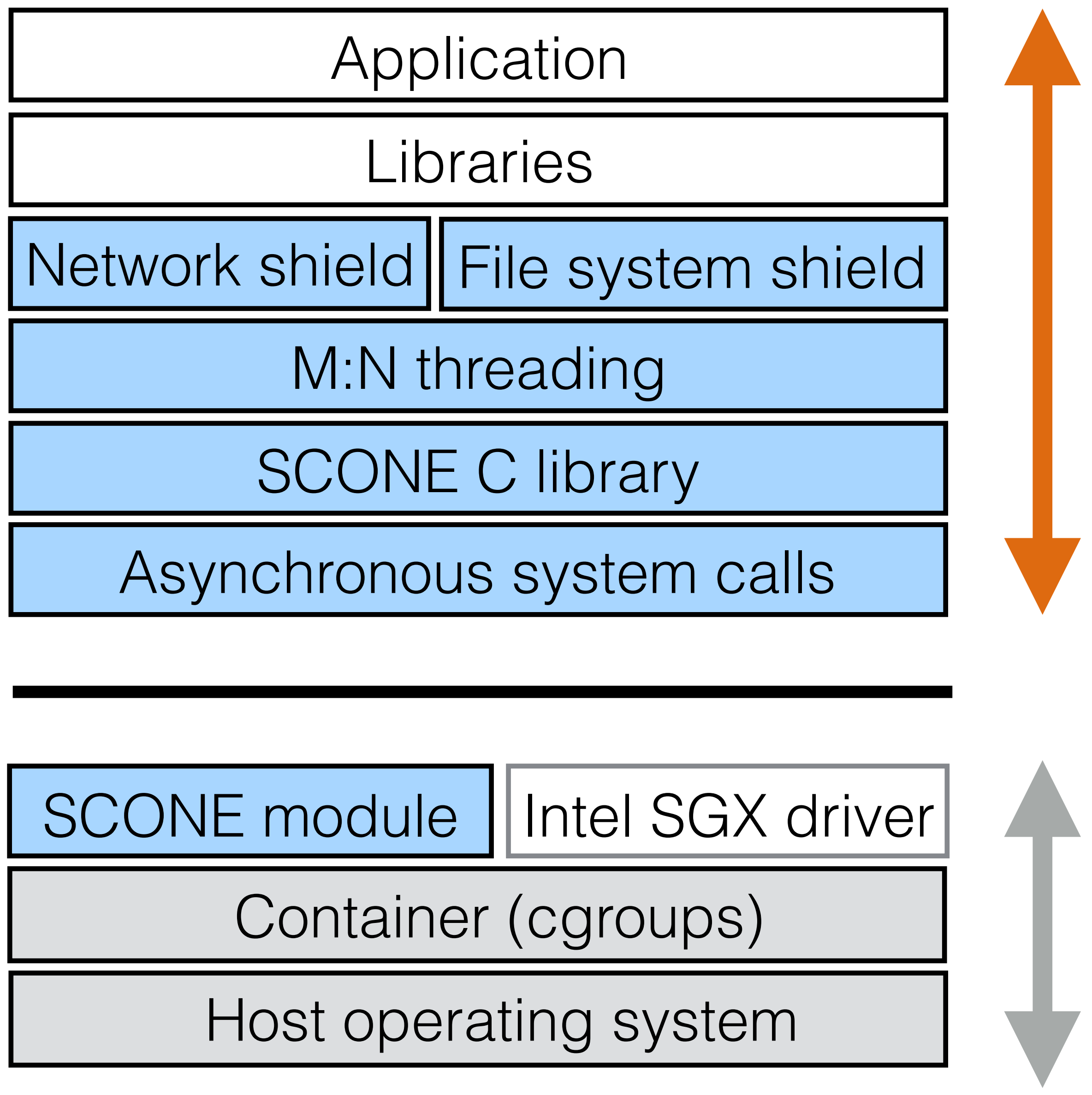
SCONE Architecture

- Enhanced C library → small TCB (Challenge 1)
- Asynchronous system calls and user space threading **reduce** number of **enclave exits** (Challenge 2)



SCONE Architecture

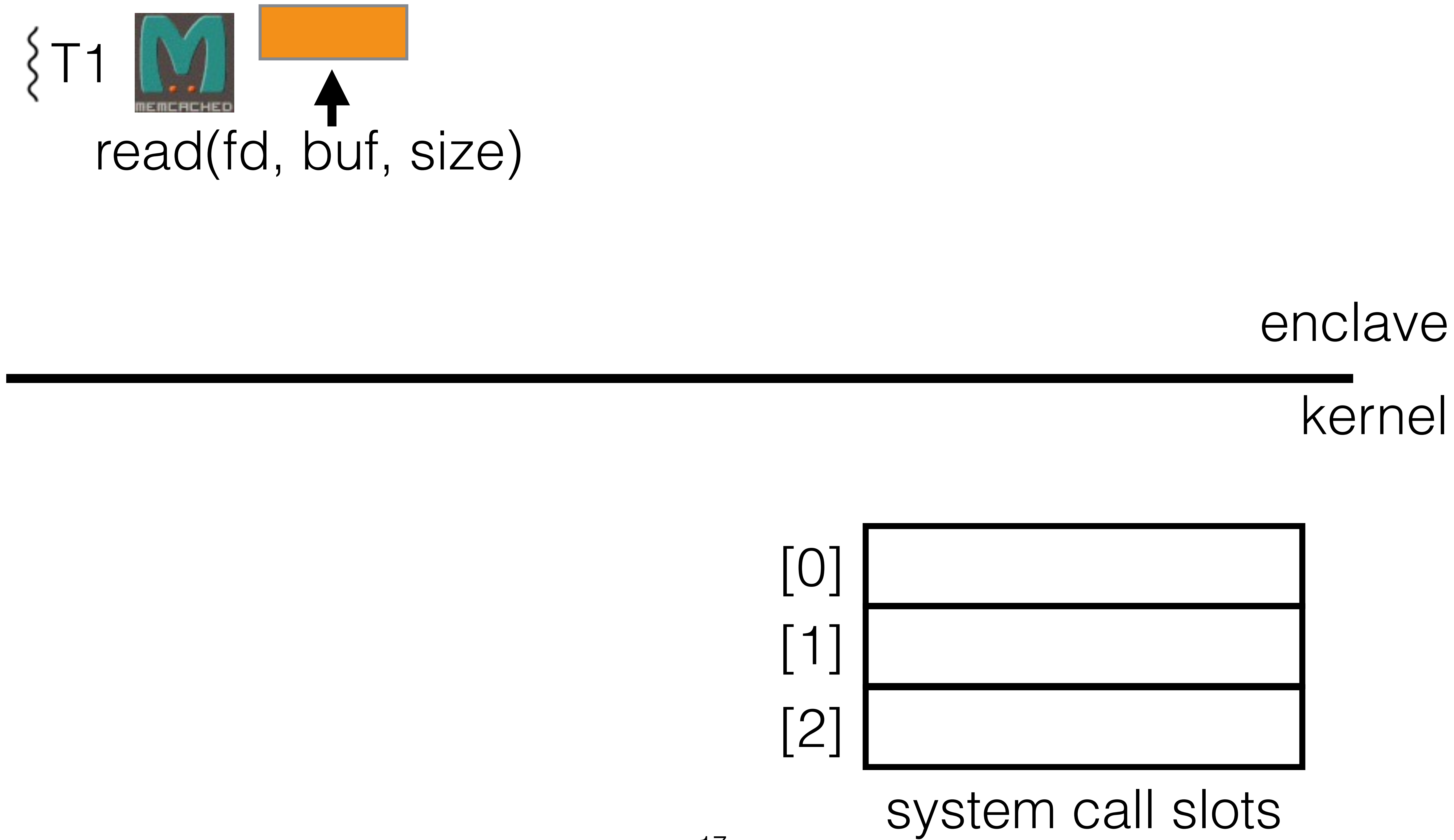
- Enhanced C library → small TCB (Challenge 1)
- Asynchronous system calls and user space threading **reduce** number of **enclave exits** (Challenge 2)
- Network and file system shields **actively** protect user data



Anatomy of a System Call

enclave
kernel

Anatomy of a System Call



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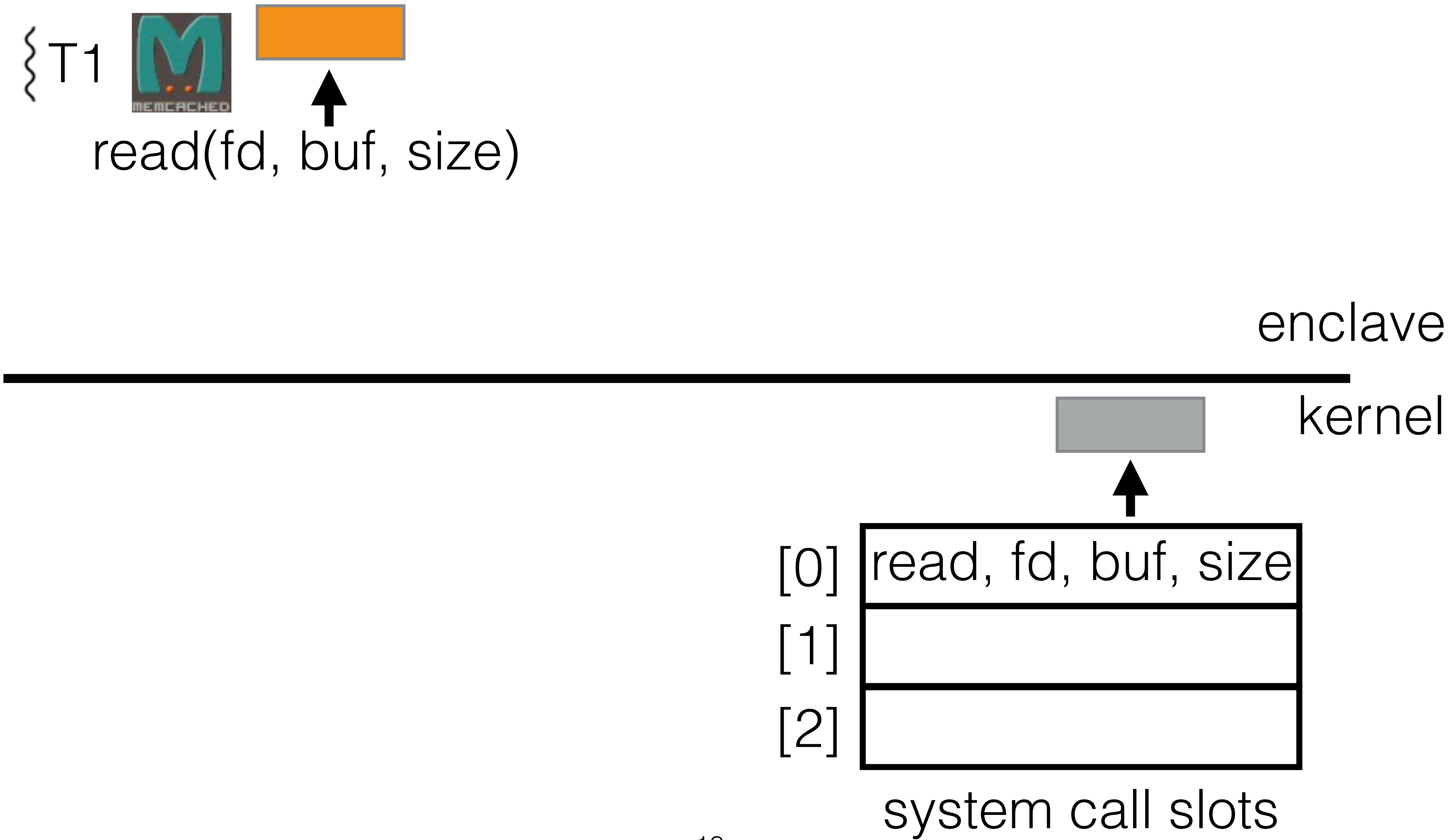

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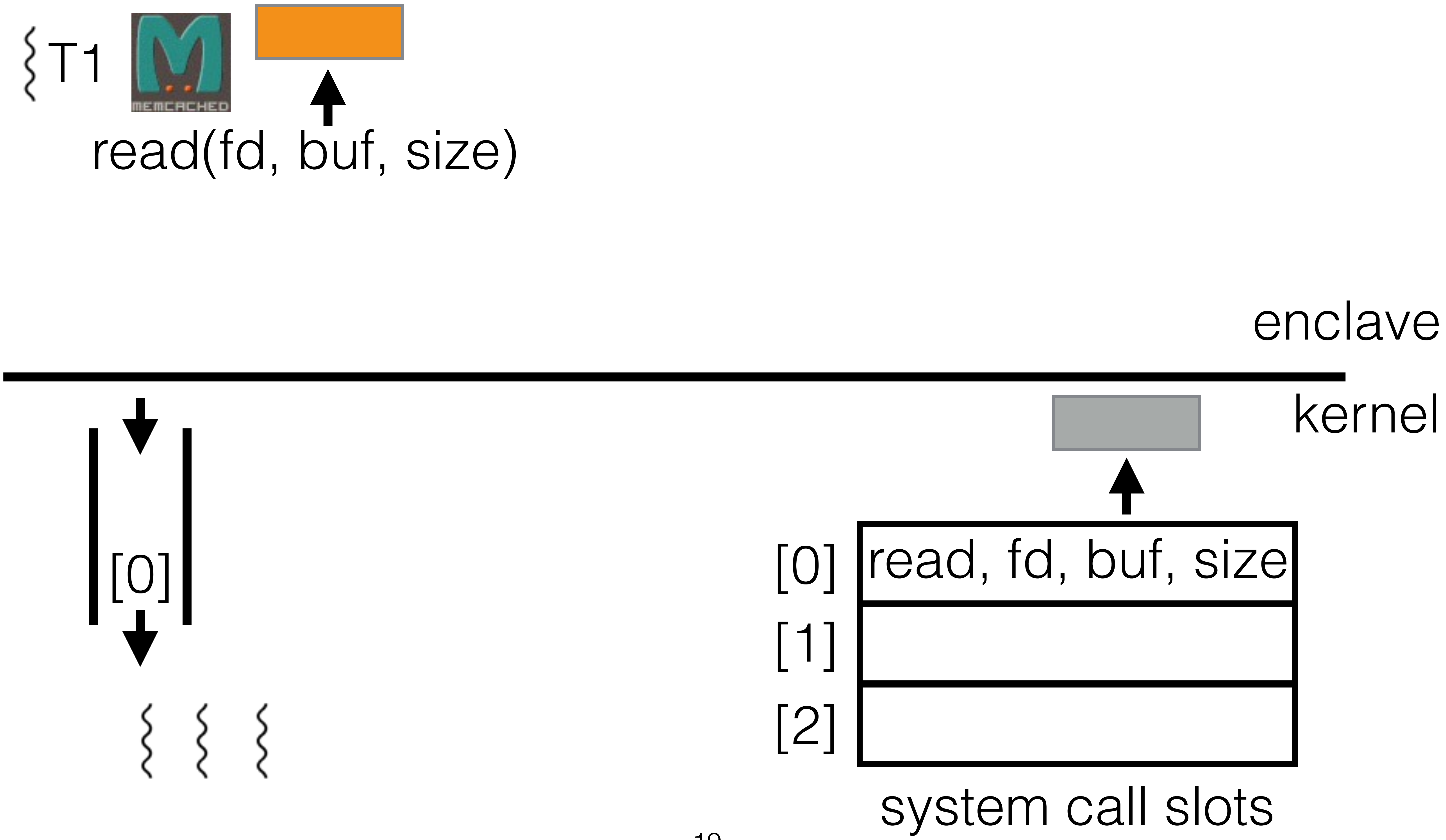

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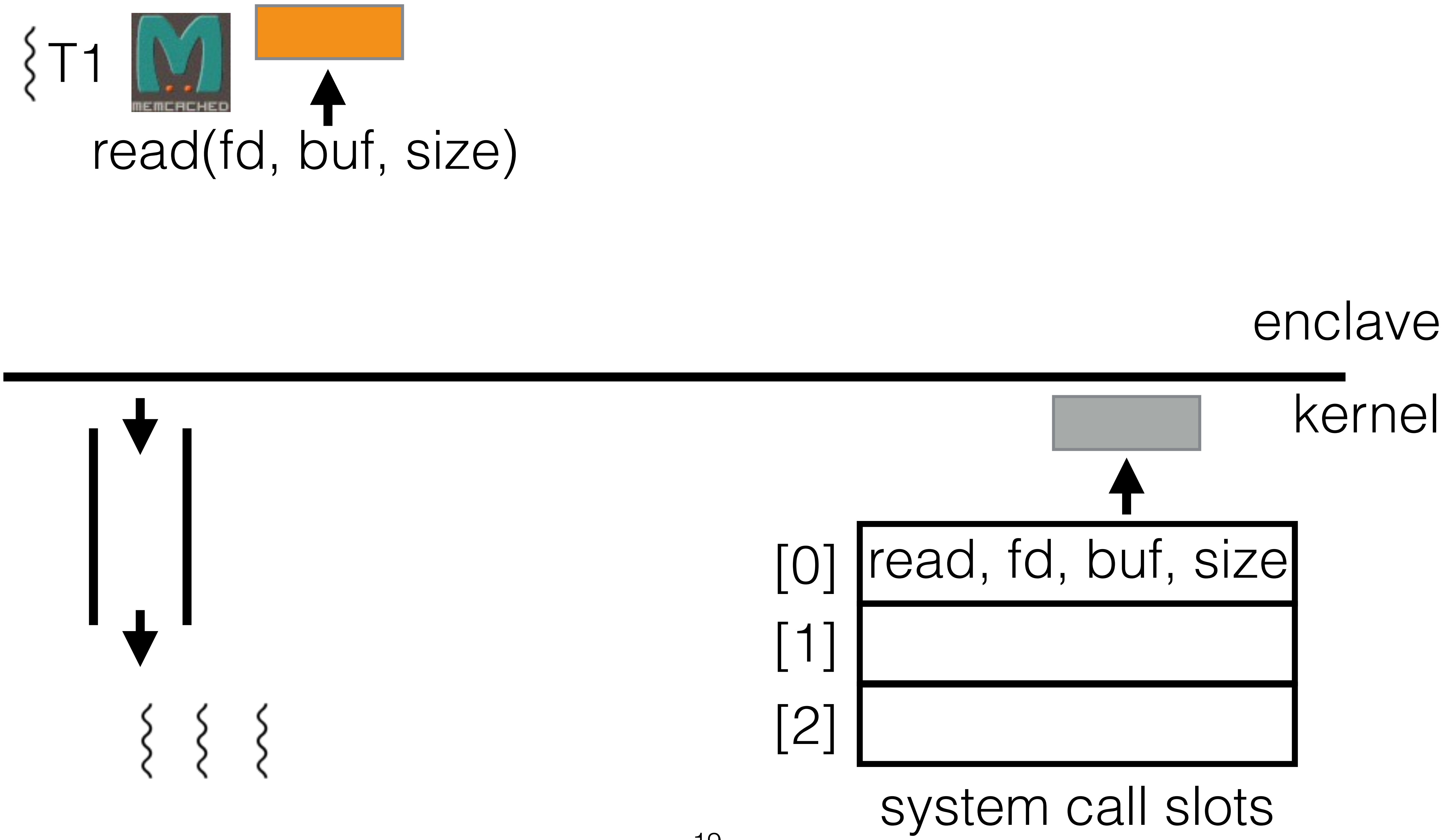

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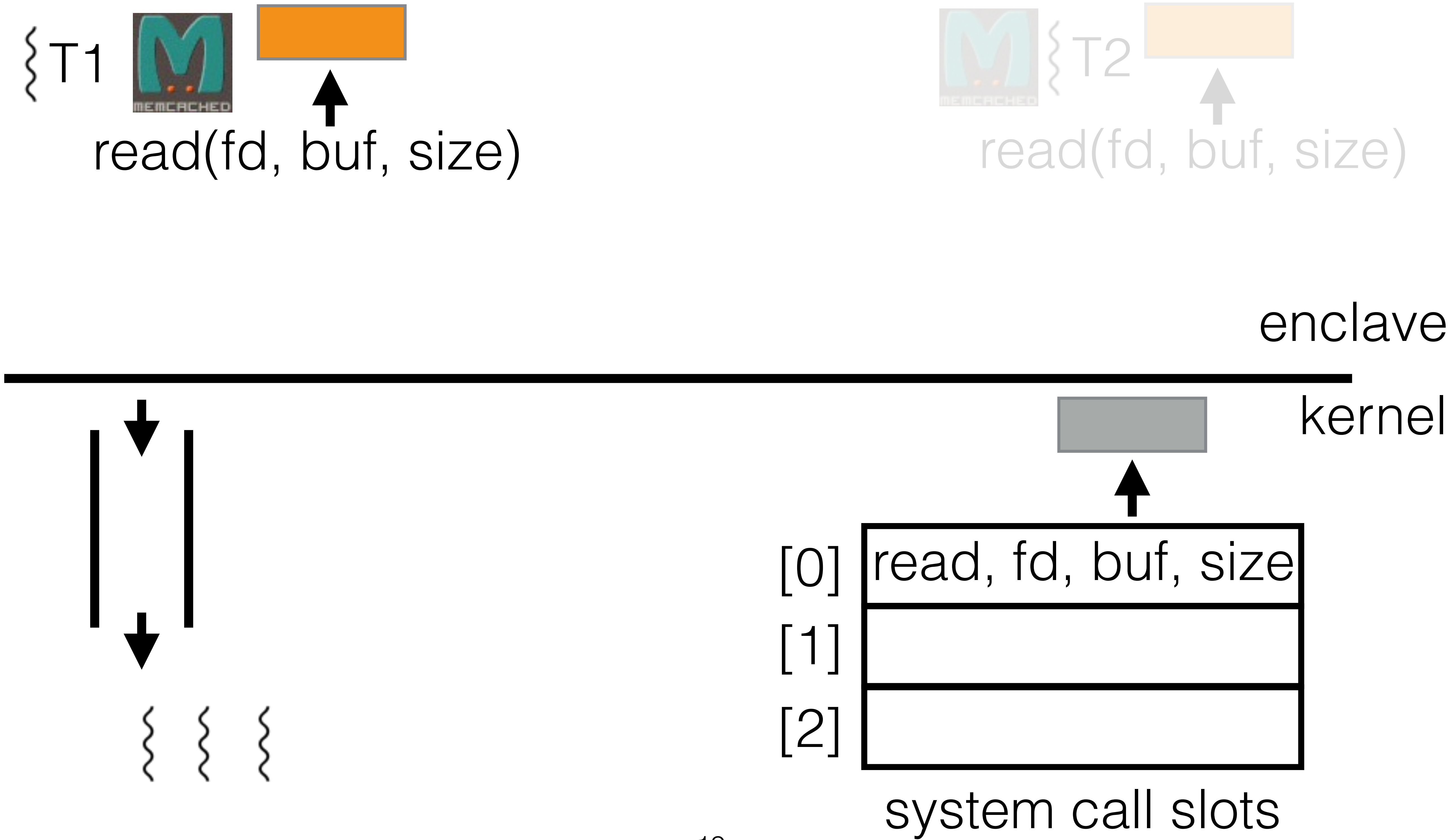

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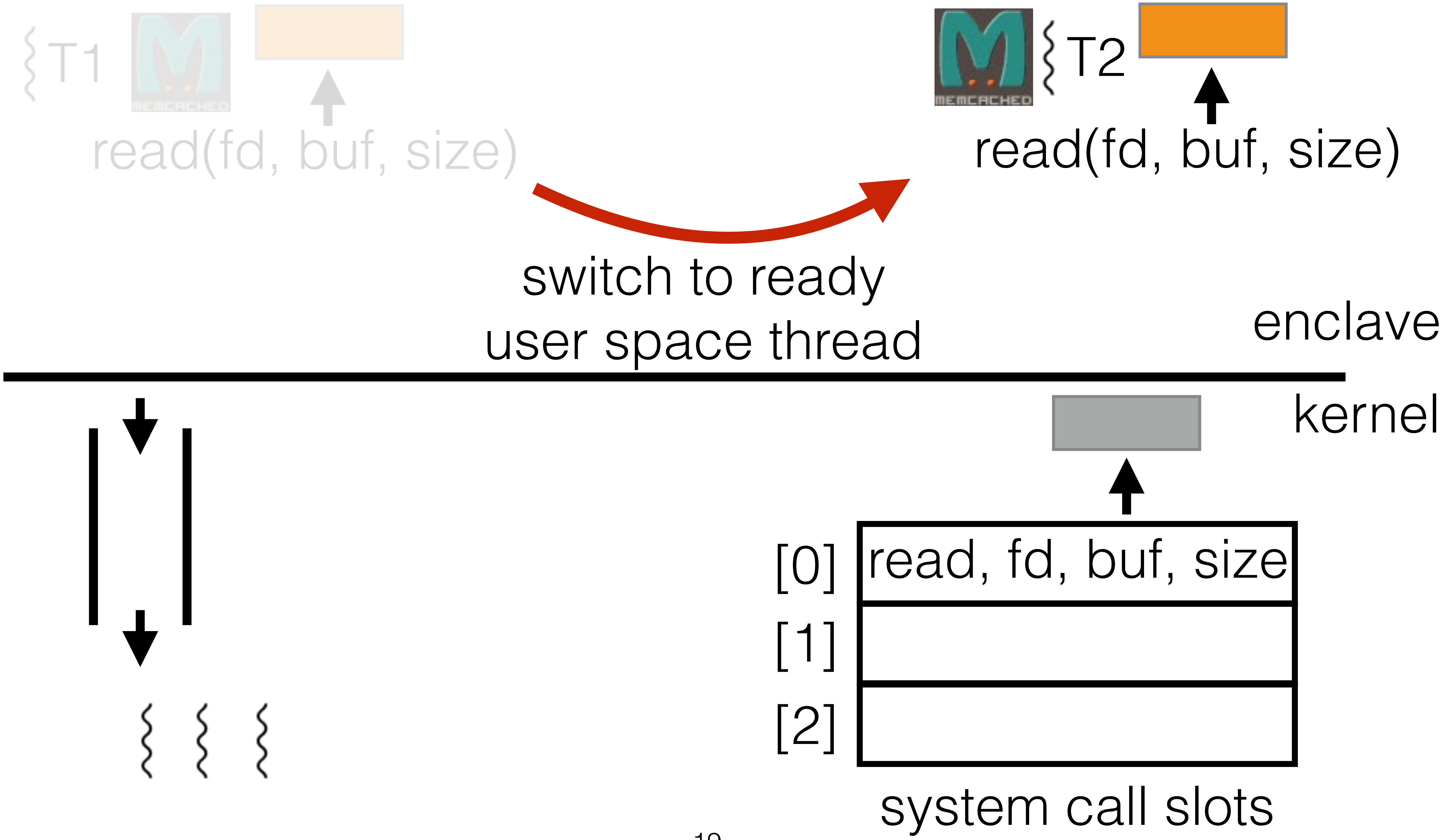

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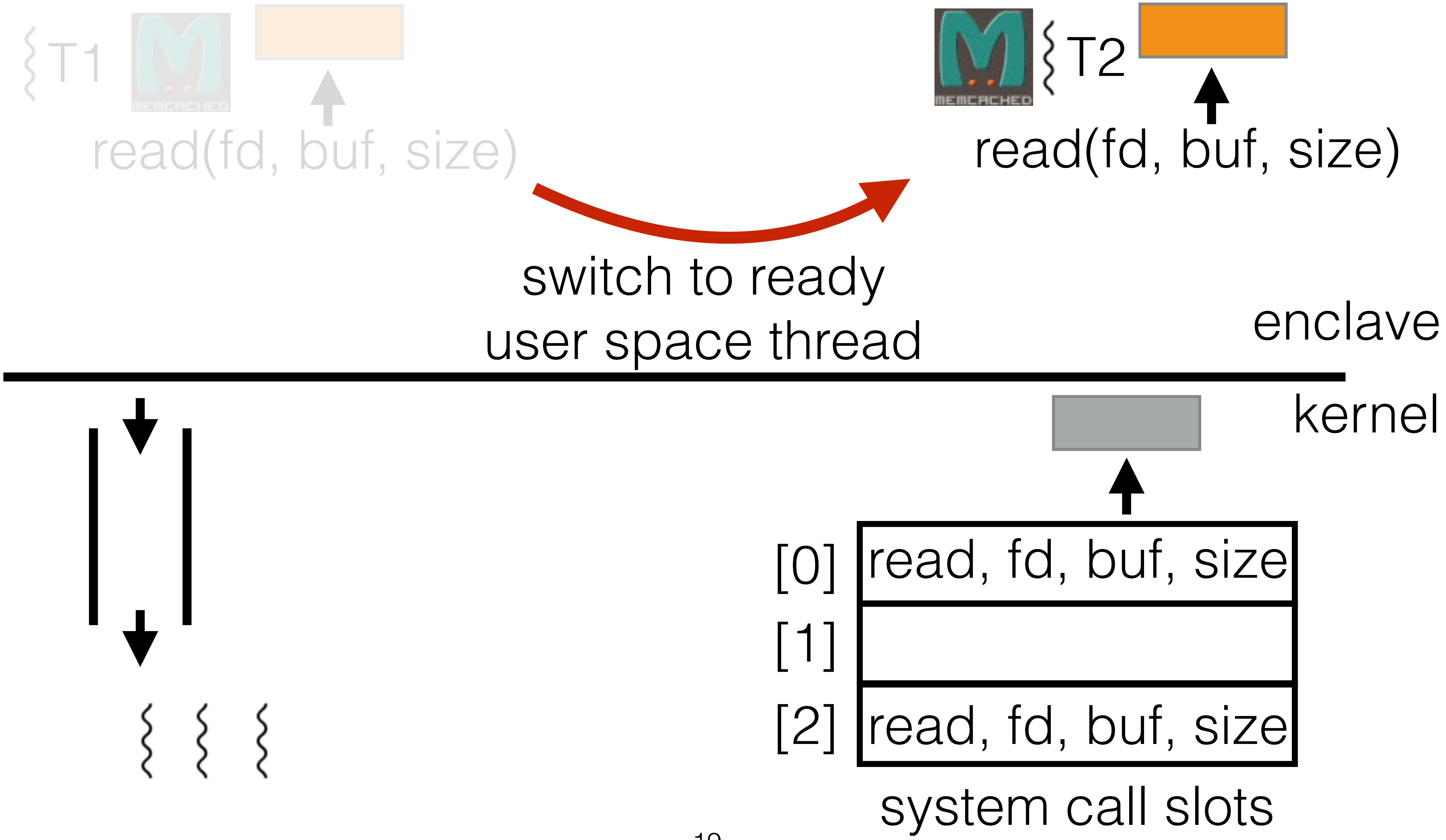

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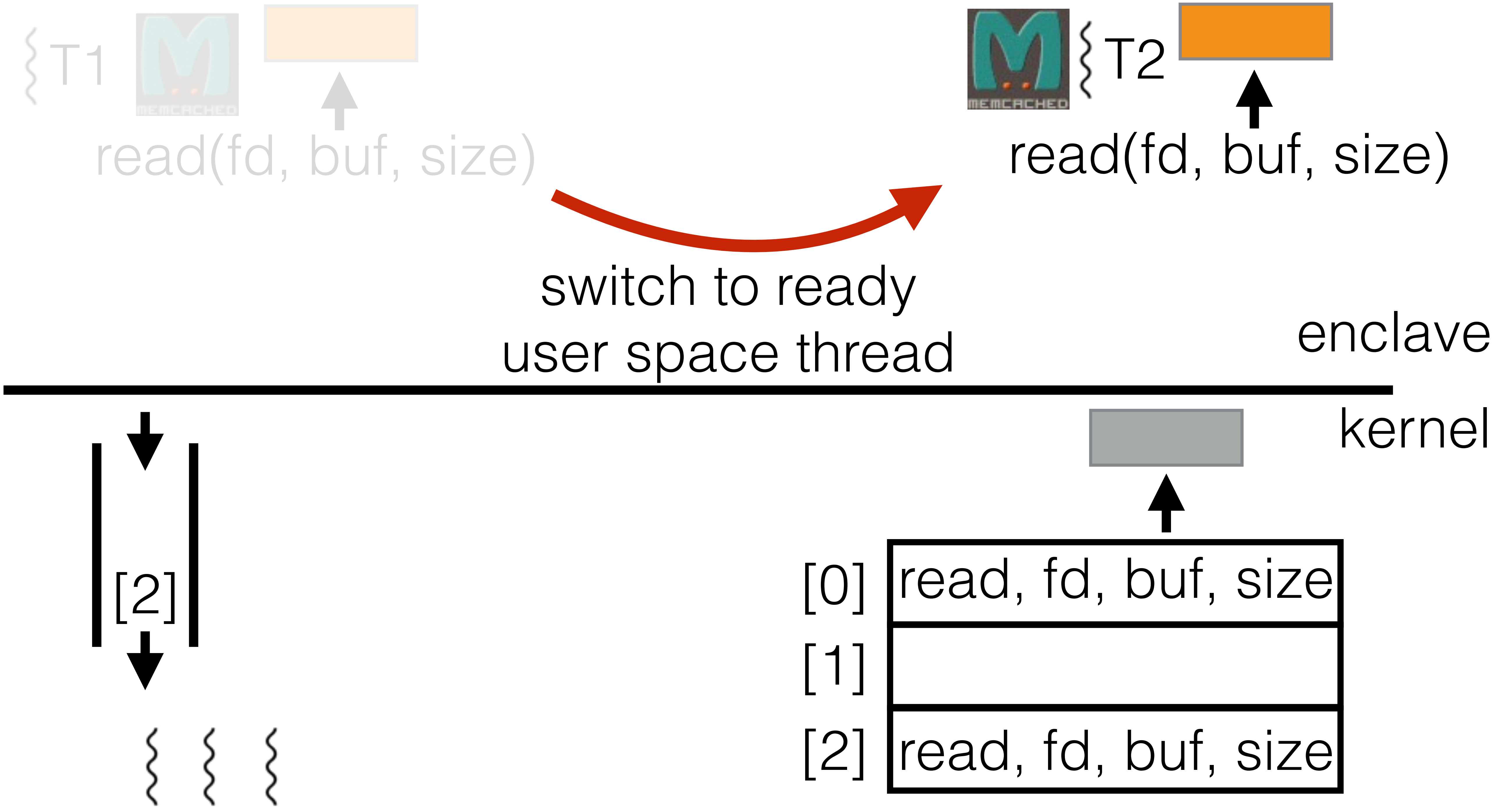

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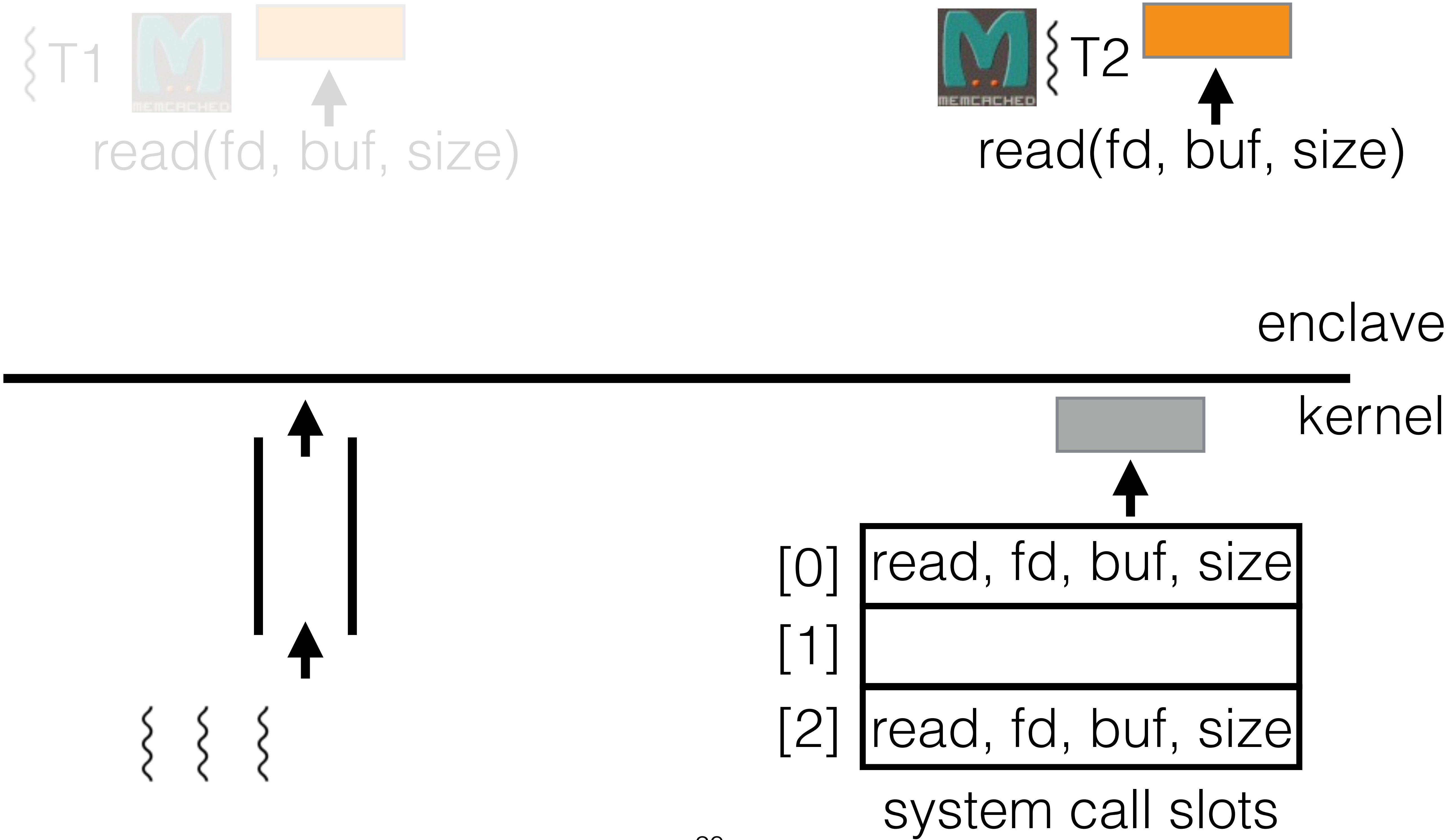

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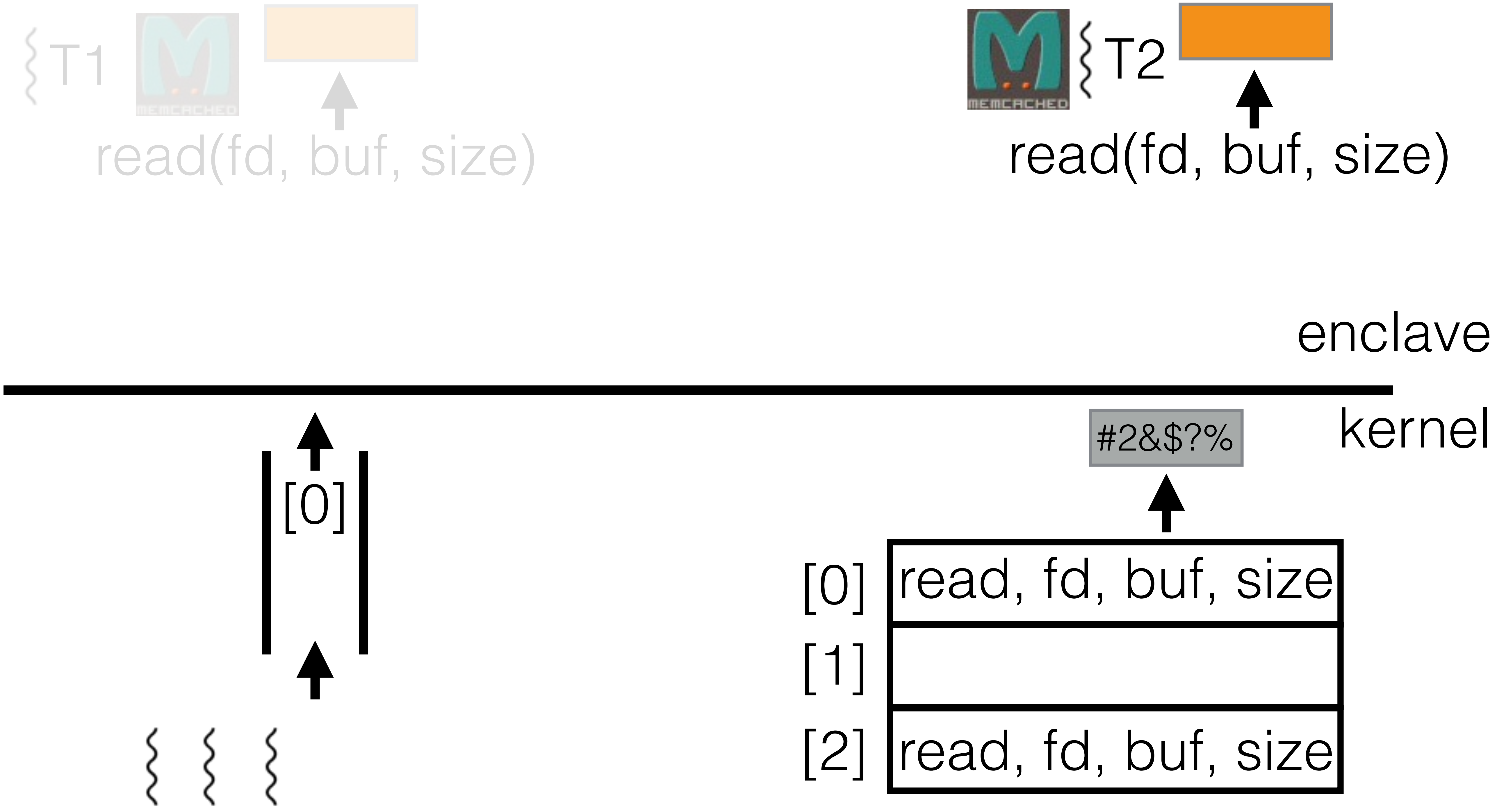

system call slots

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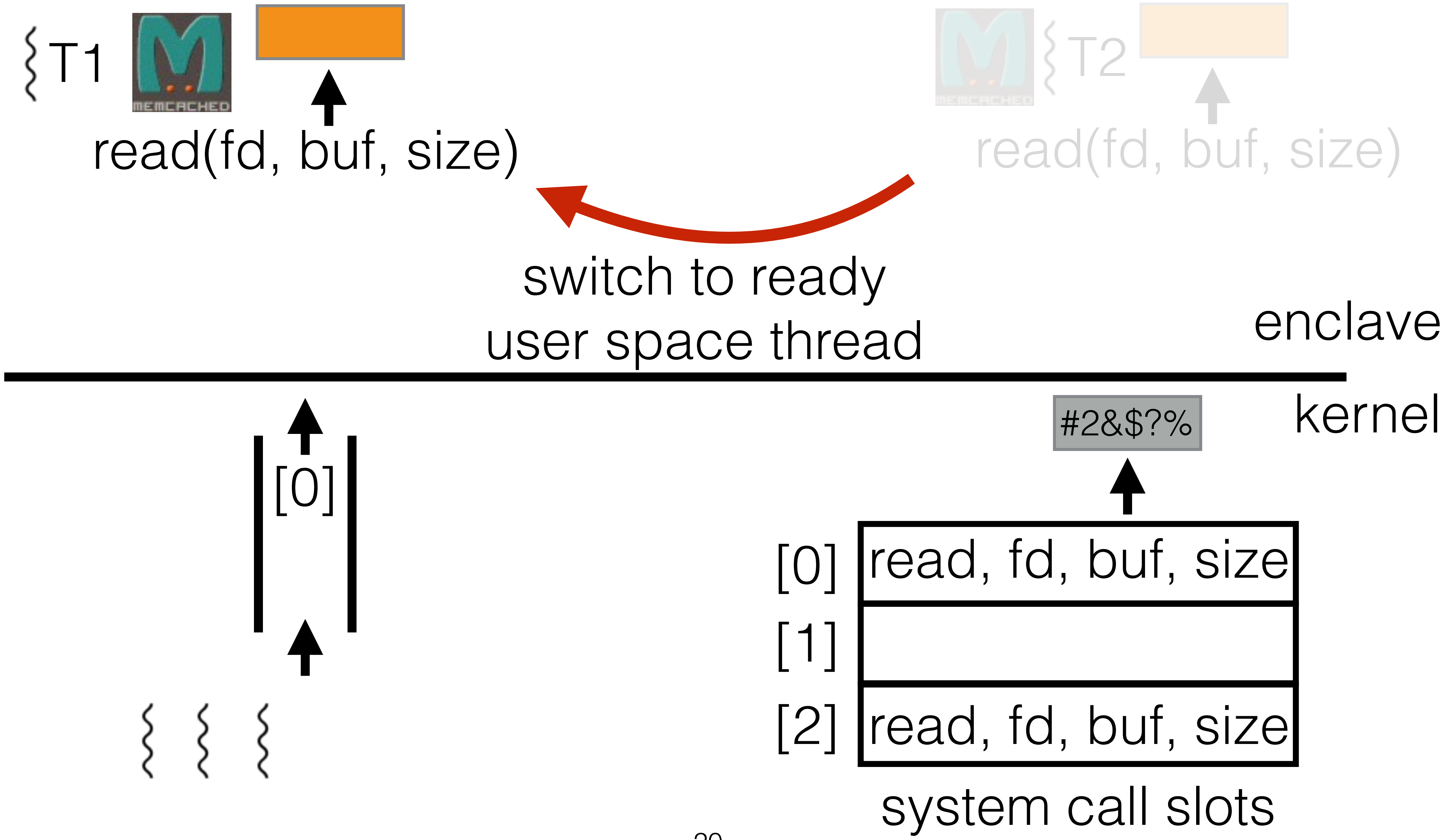

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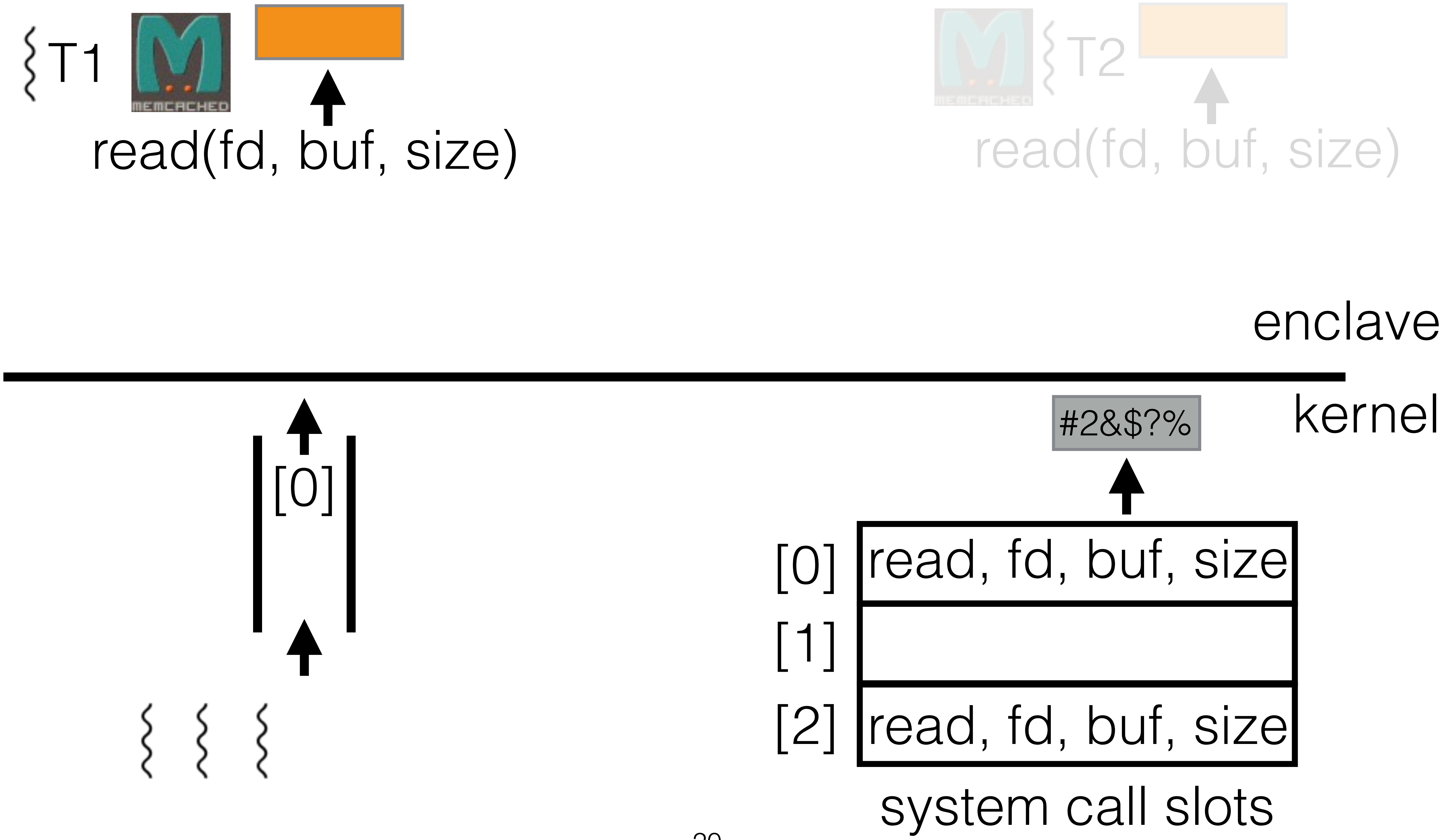

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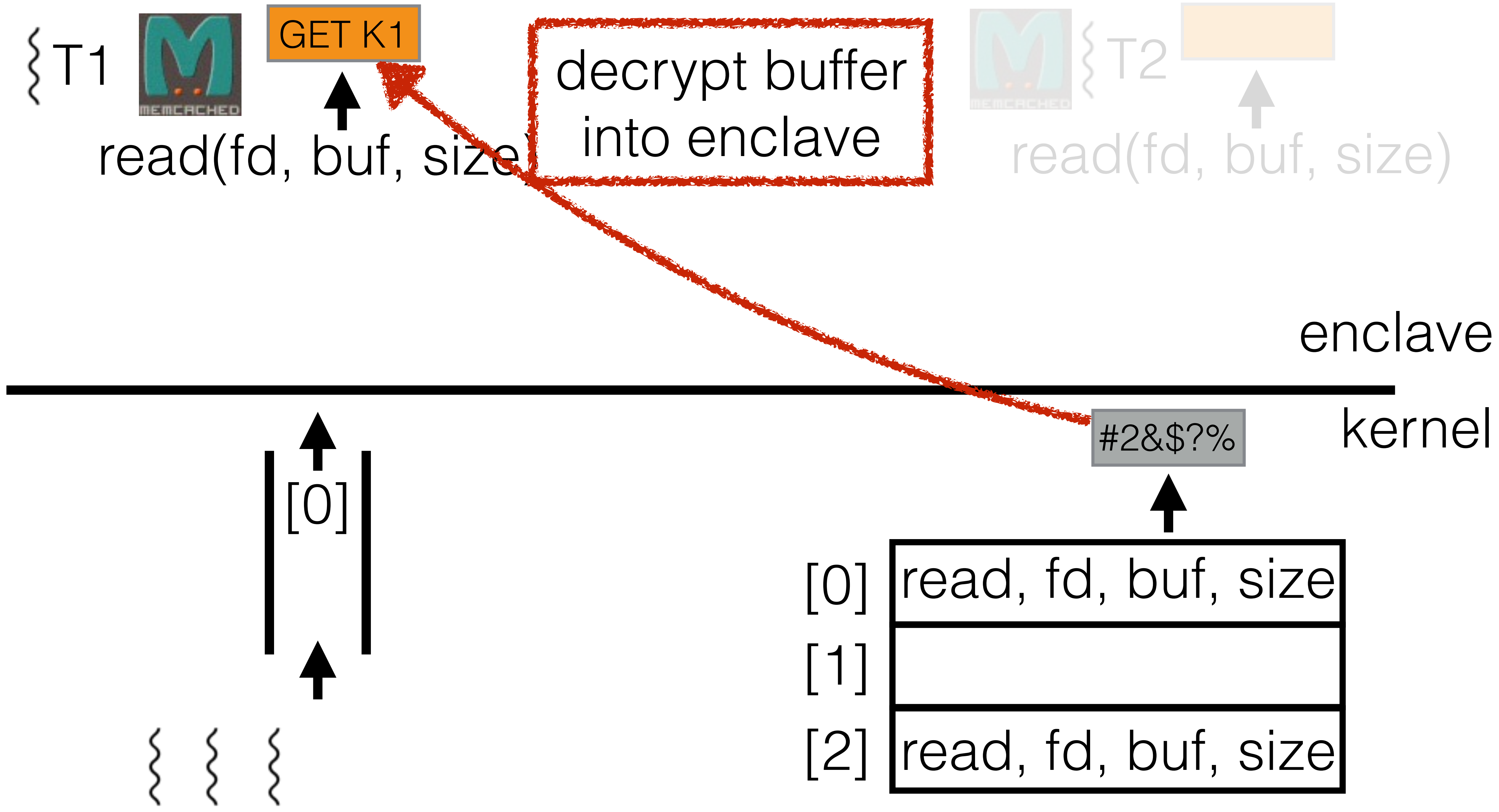
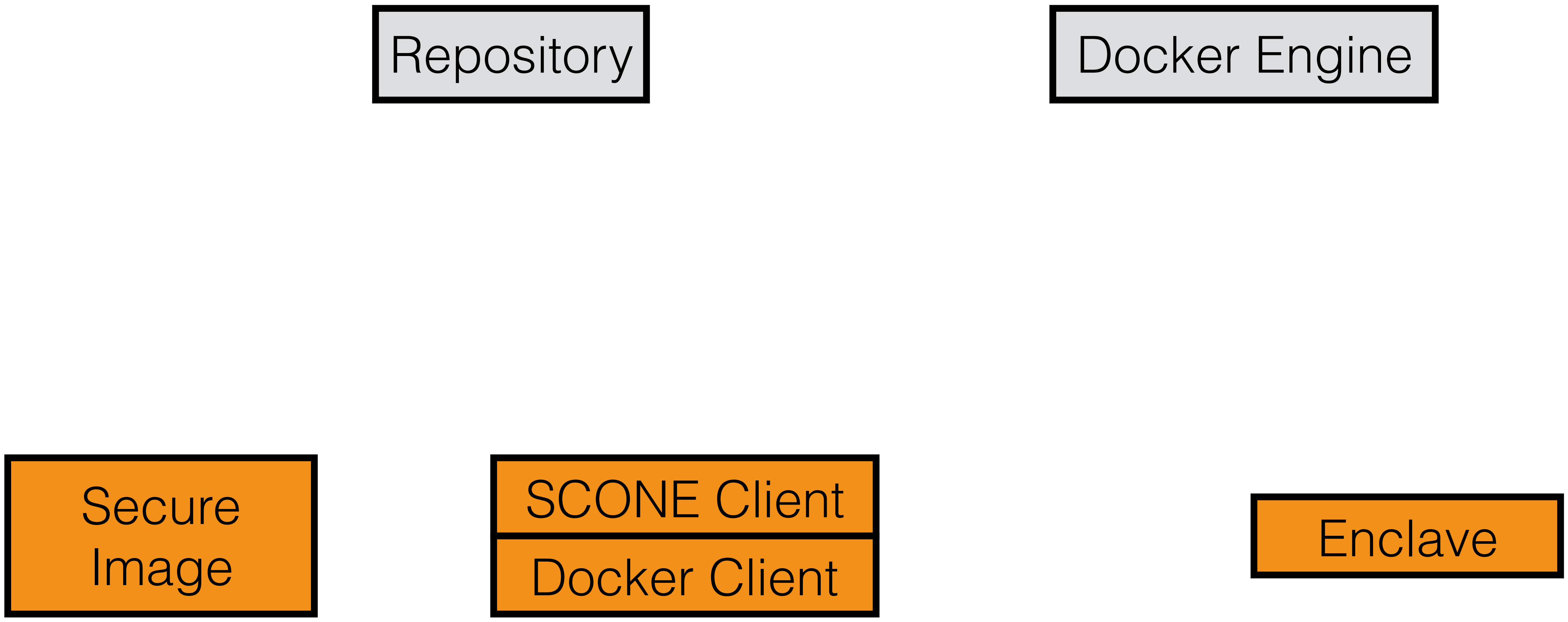


Container Integration



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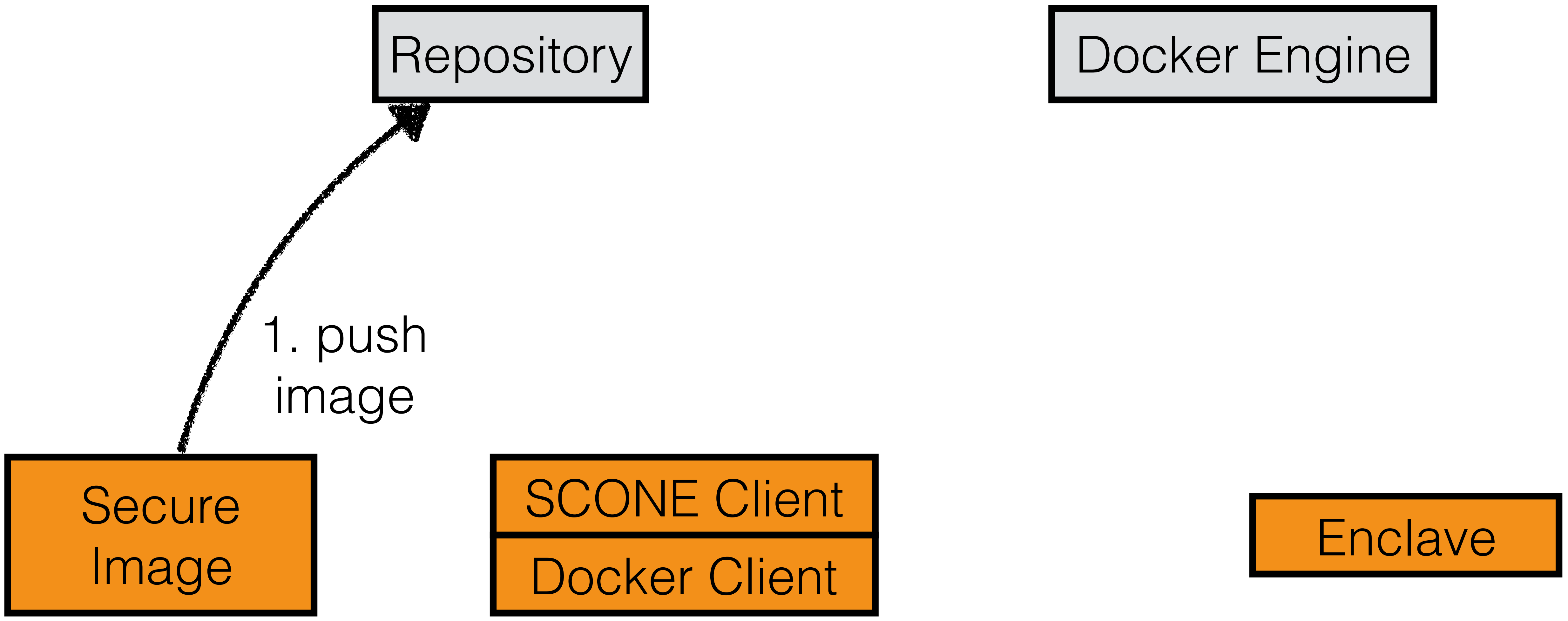

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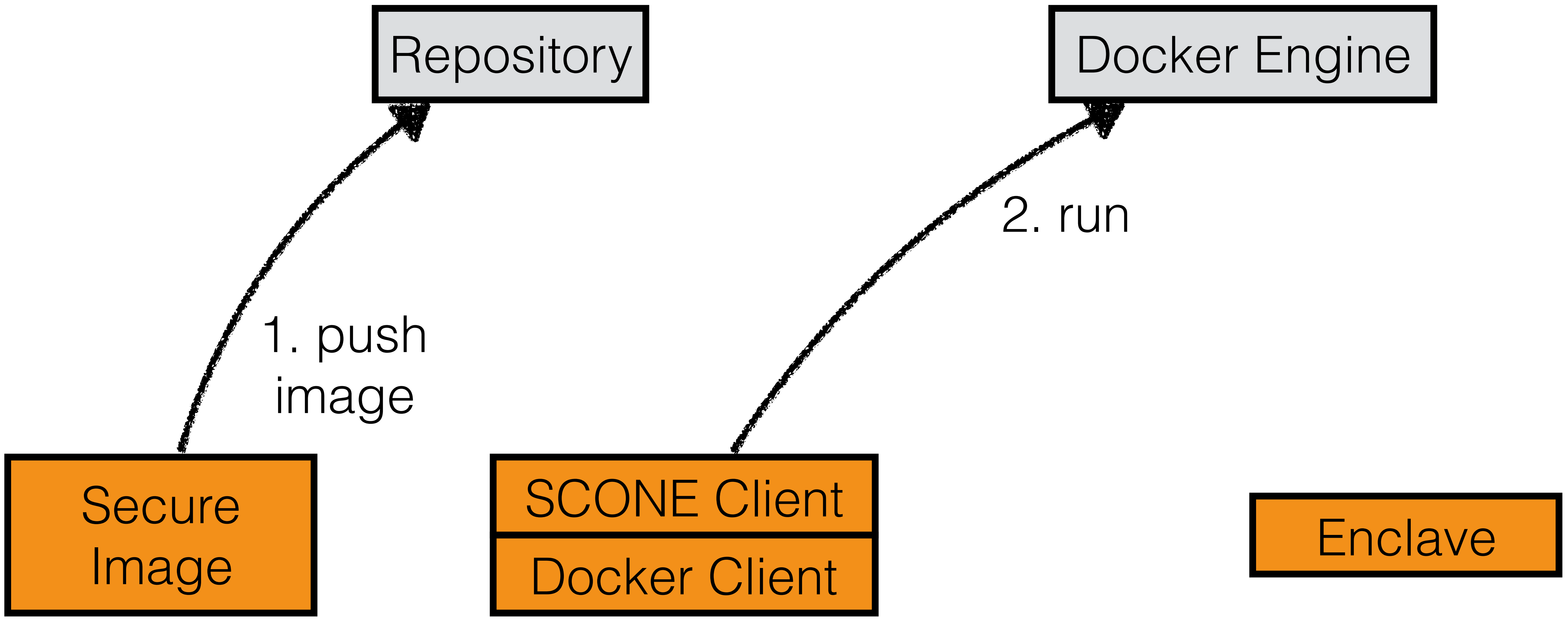

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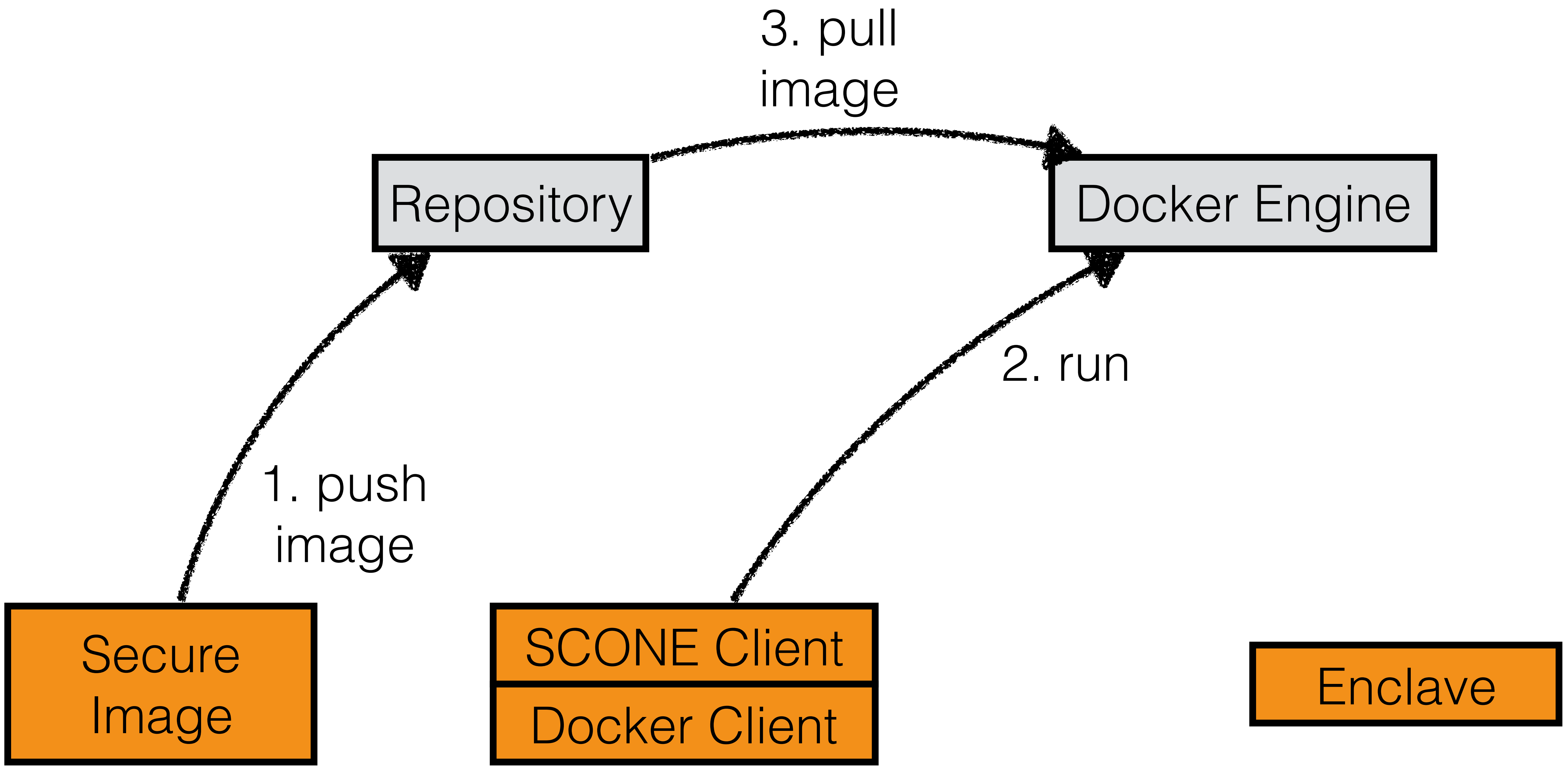

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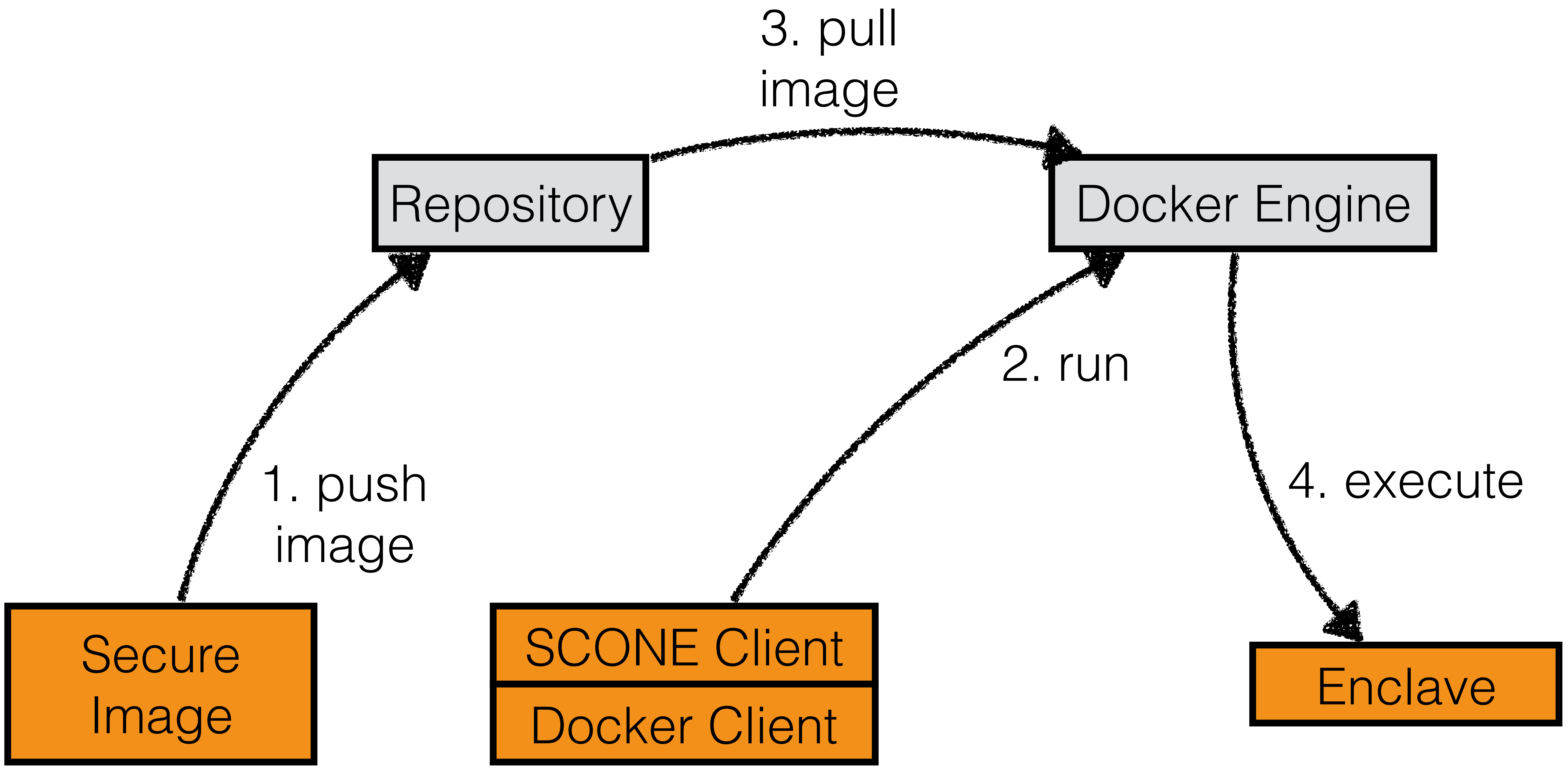

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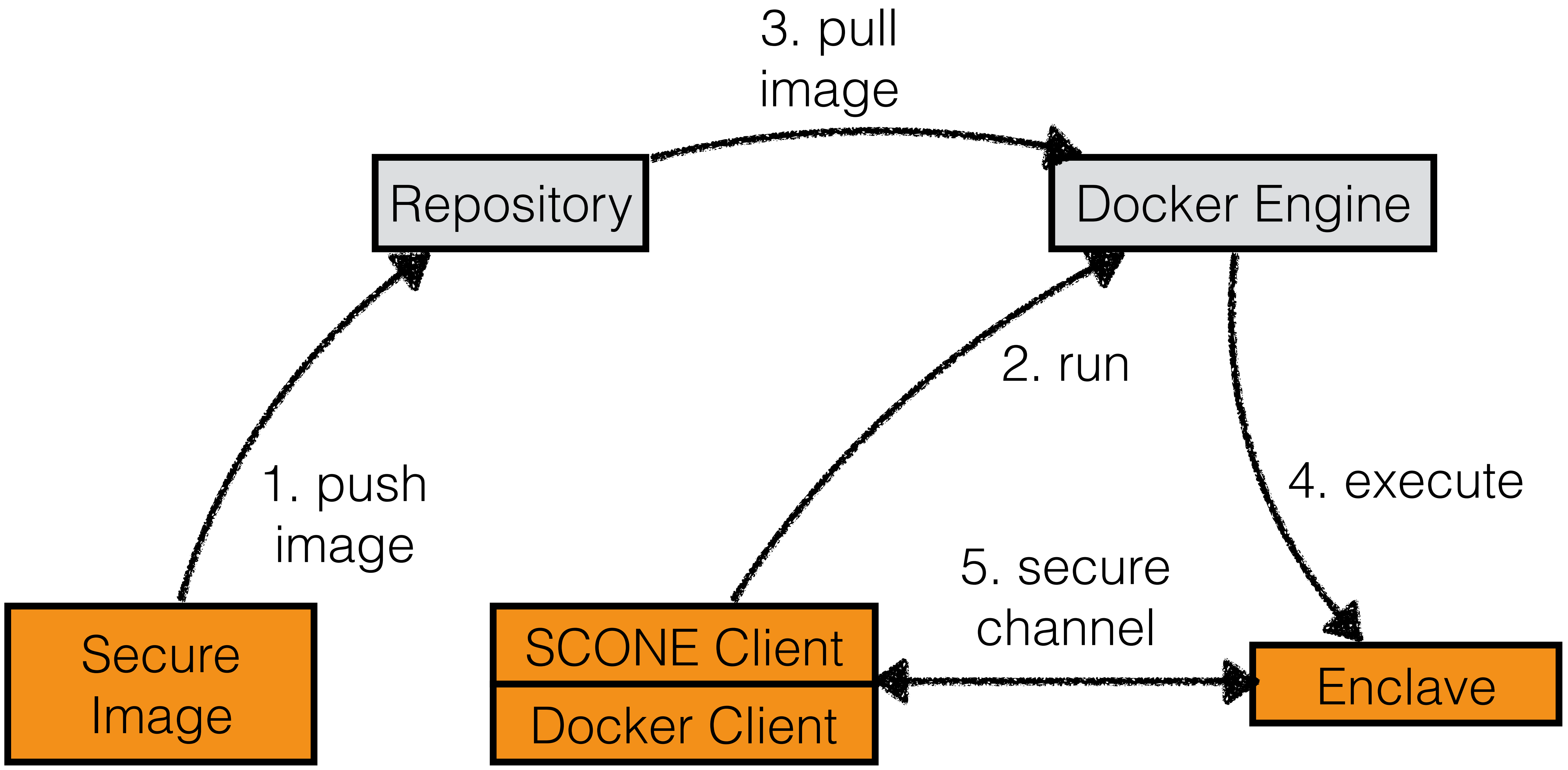
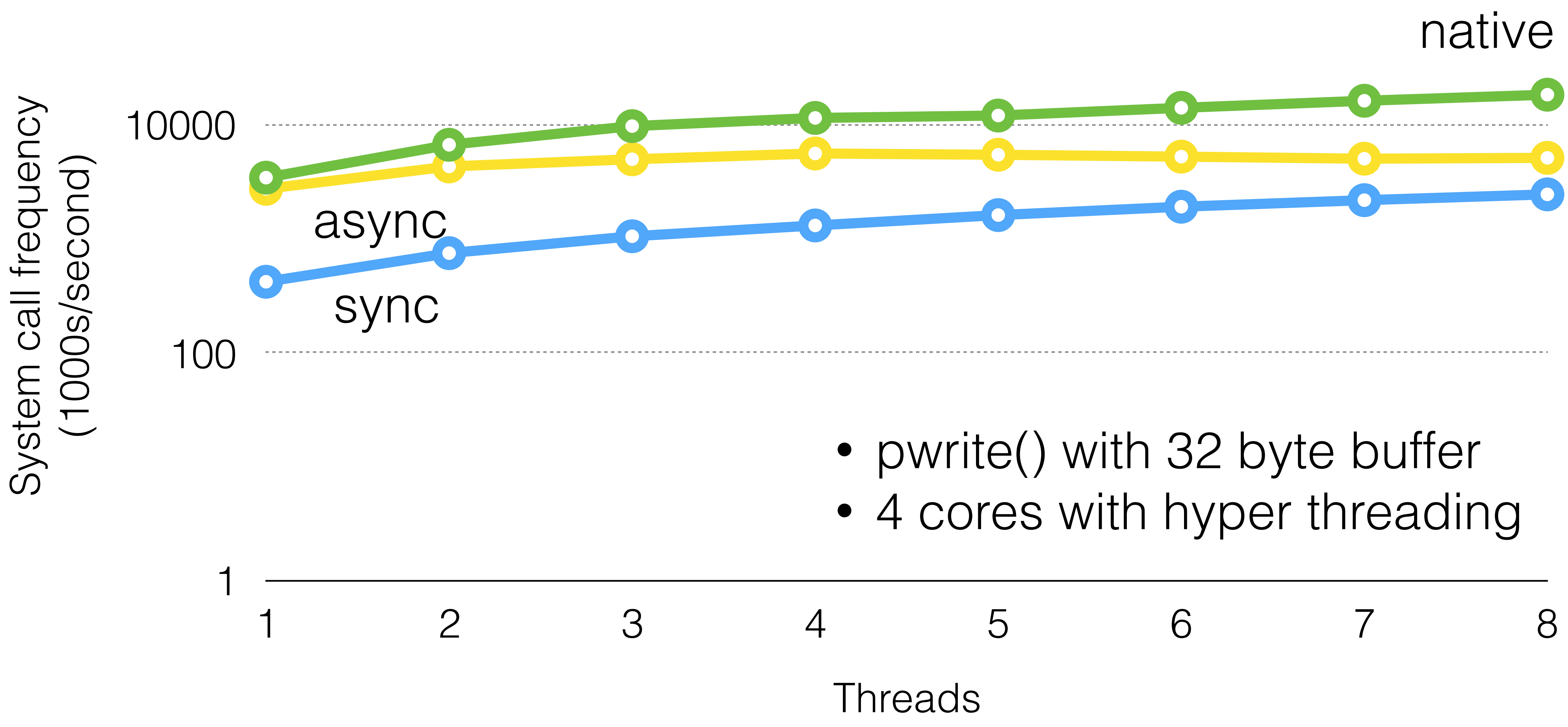


System Call Performance



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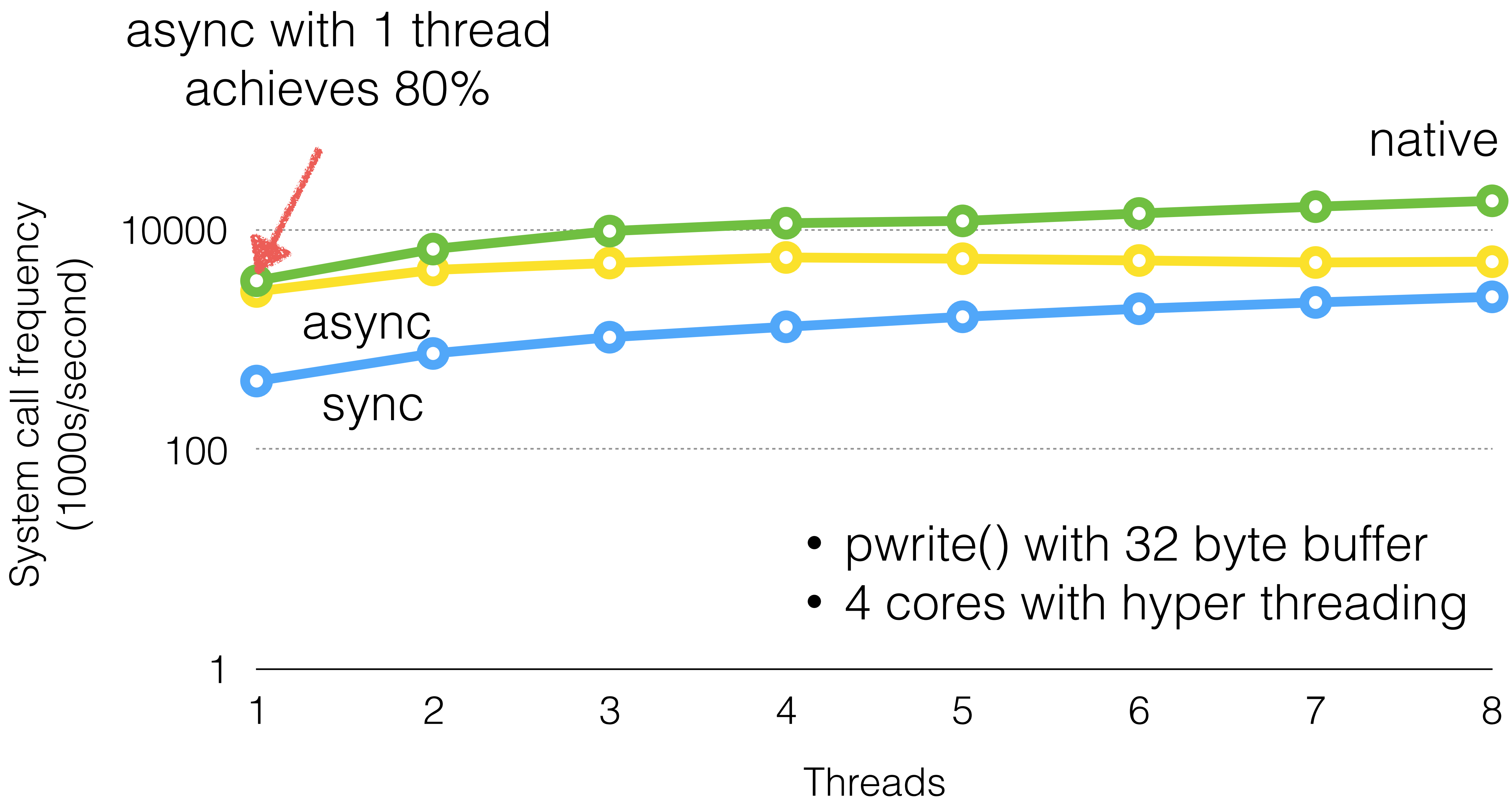

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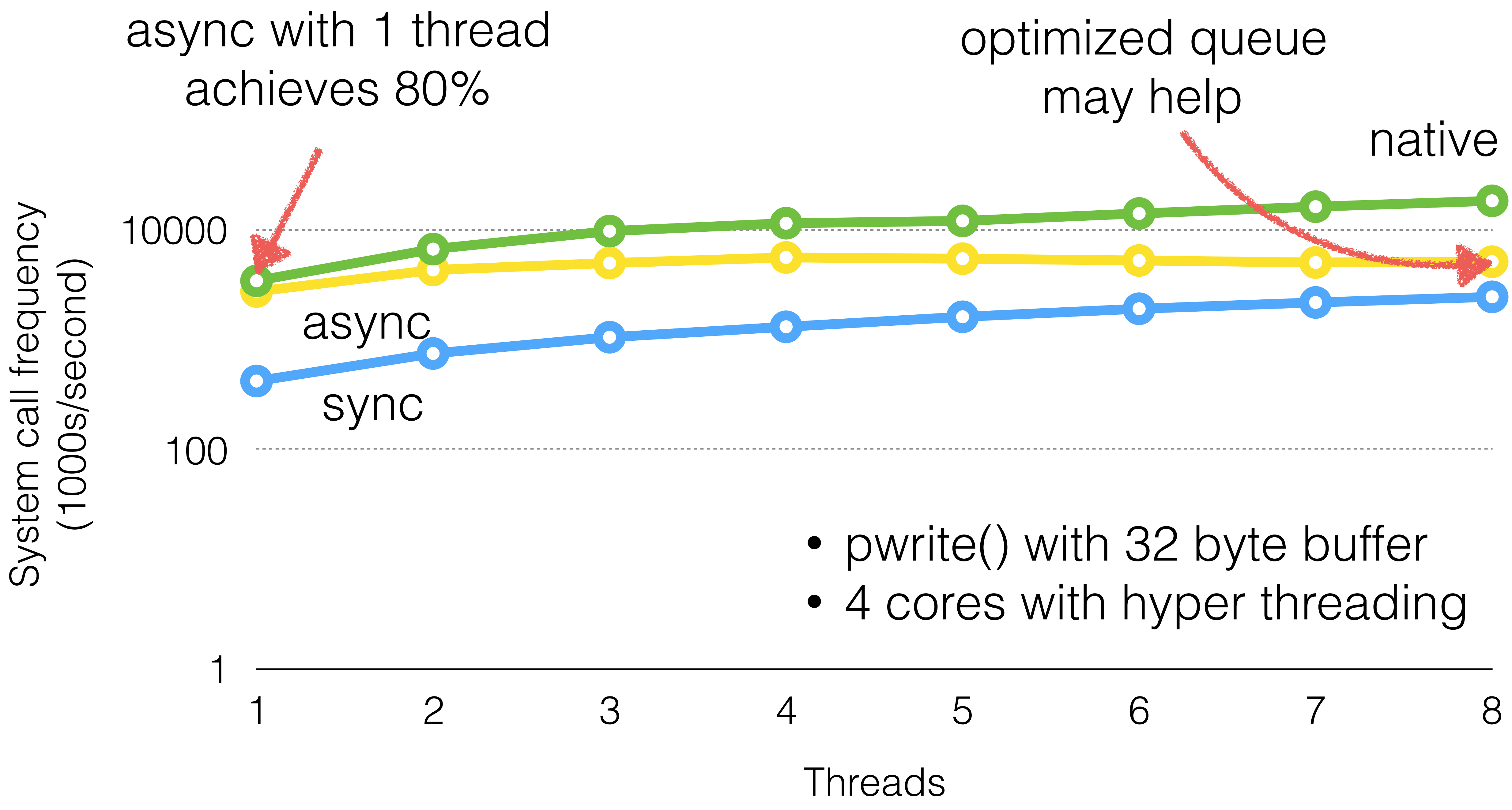

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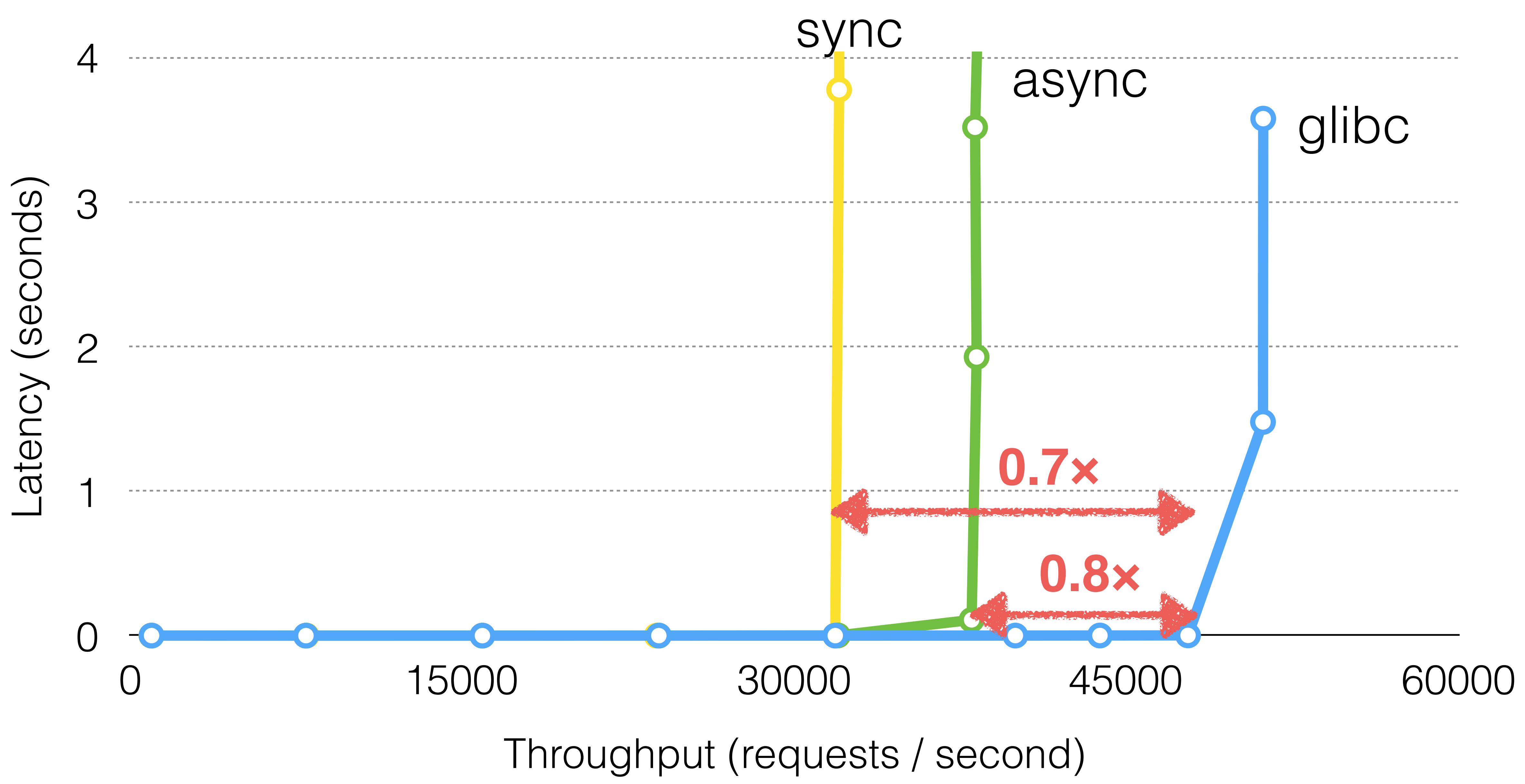
Apache Throughput



Performance Overview

Application	Throughput w.r.t. native	
	async (%)	sync (%)
Memcached	120	113
Apache	80	70
NGINX	80	36
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inline encryption has less overhead

inline encryption hurts performance with single thread

Summary

- Small trusted computing base (0.6× – 2.0× of native binary size)
- Low runtime overhead (0.6× – 1.2× of native throughput)
- Transparent to the container engine (e.g. Docker)