Avocado

A Secure In-Memory Distributed Storage System

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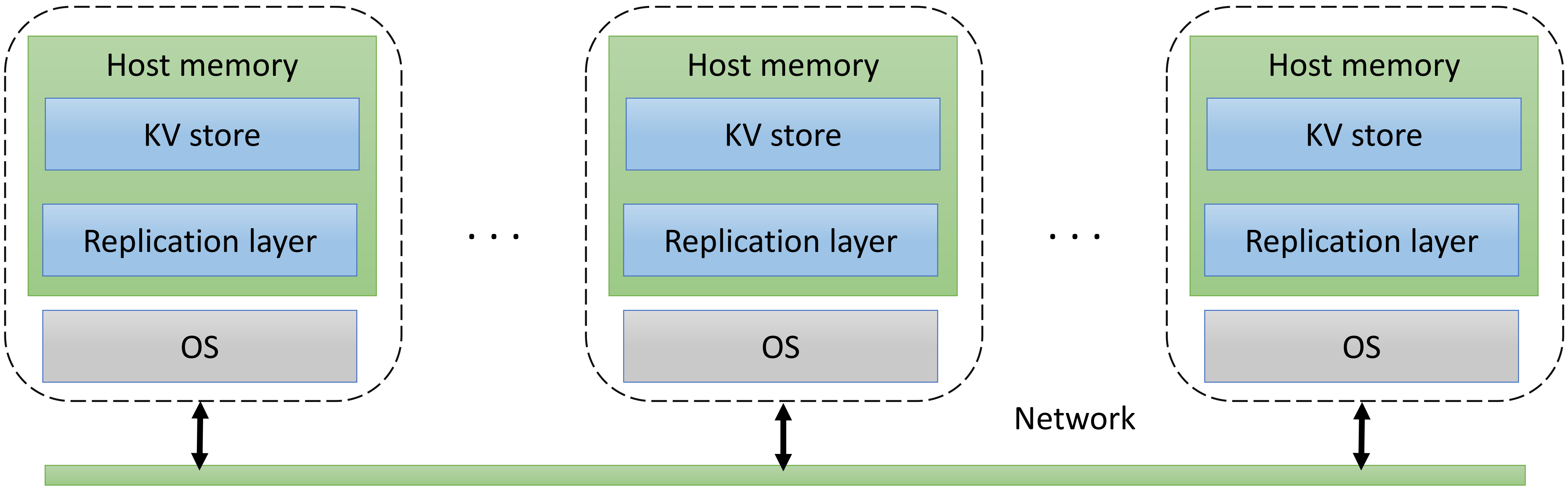
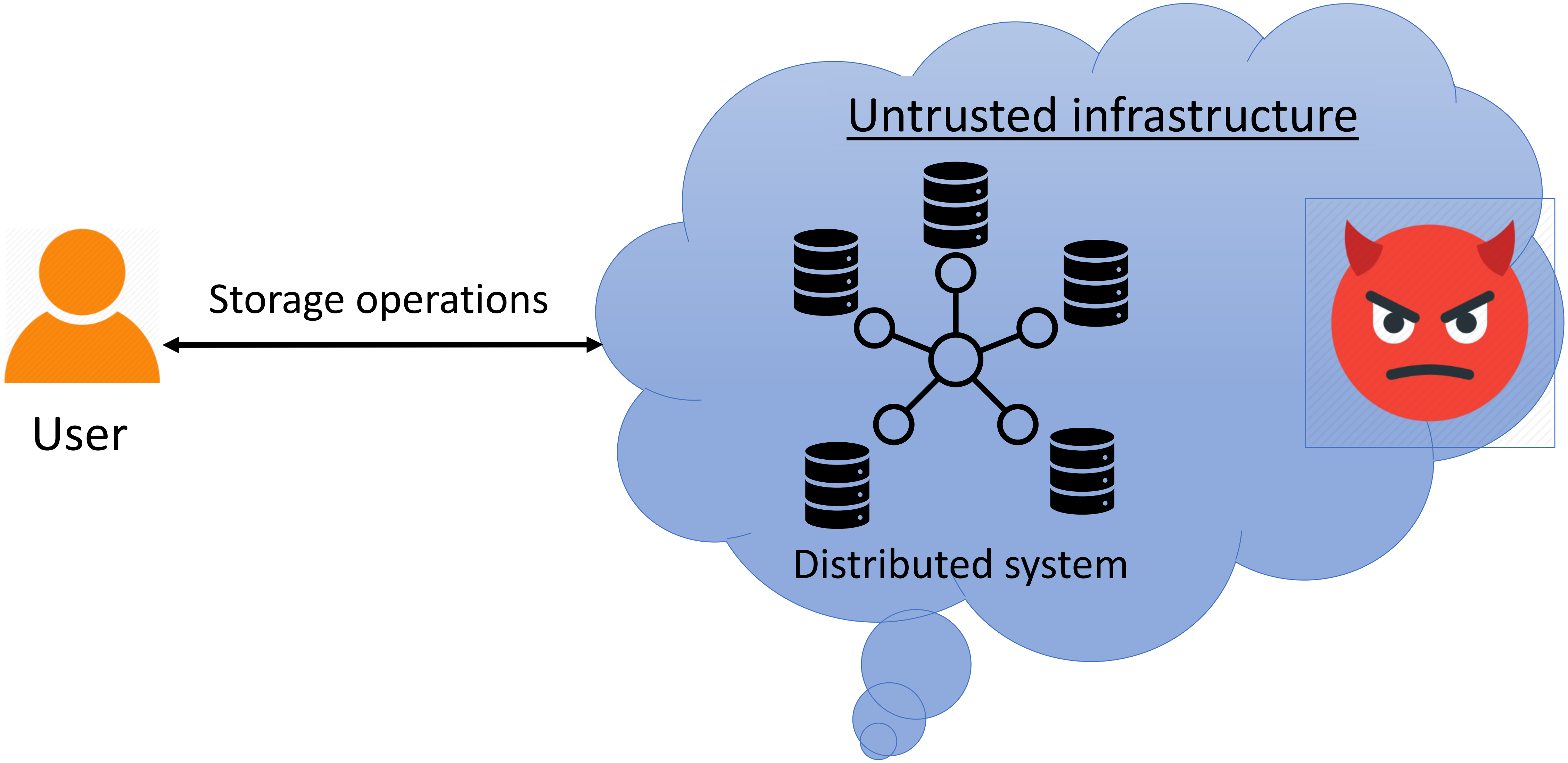
Distributed in-memory KVS



- Provides a high-performance, scalable, & fault-tolerant storage system
- Extensively used as a fundamental building block in modern online services

Trust in cloud storage



Problem statement

How to design a **secure distributed in-memory KV store** for untrusted cloud environments?

Avocado

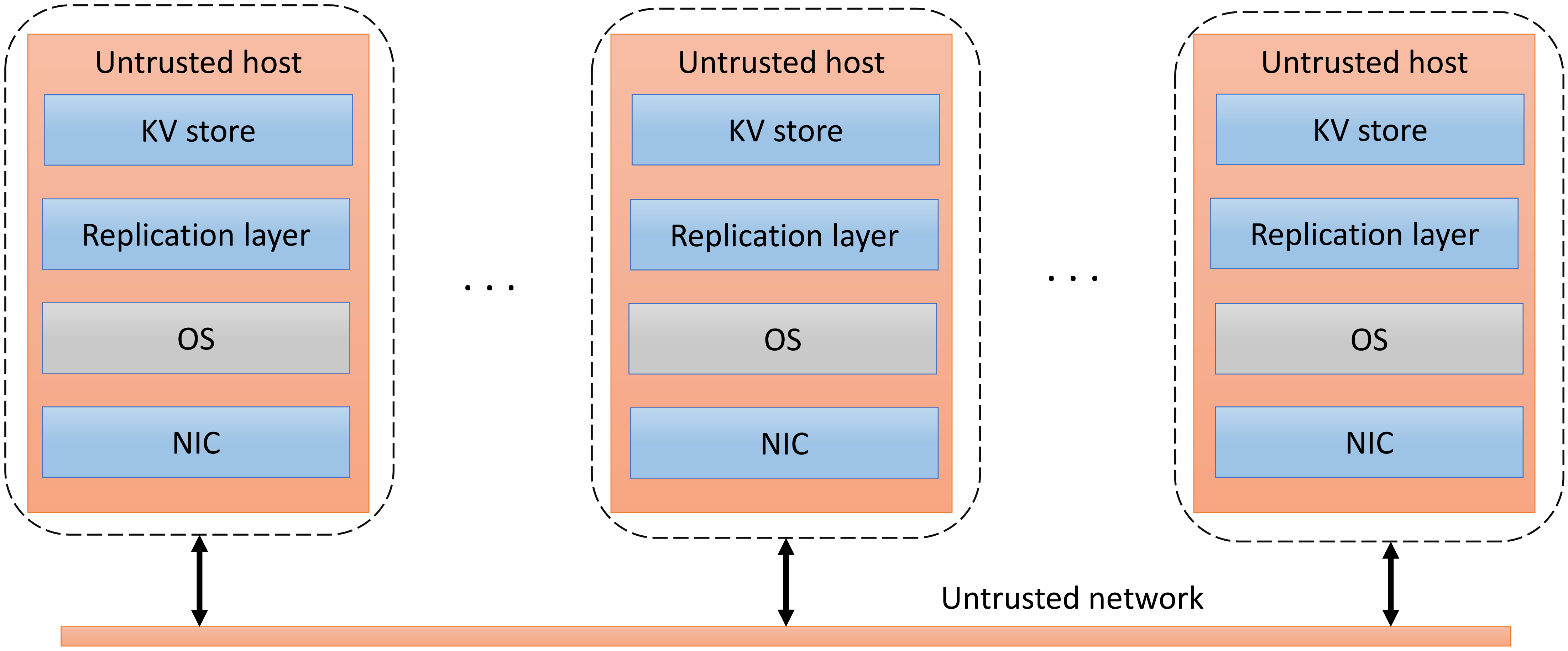
A secure distributed in-memory KVS
for untrusted computing infrastructure

Properties:

- Security: confidentiality + integrity + freshness
- Fault tolerance
- Performance

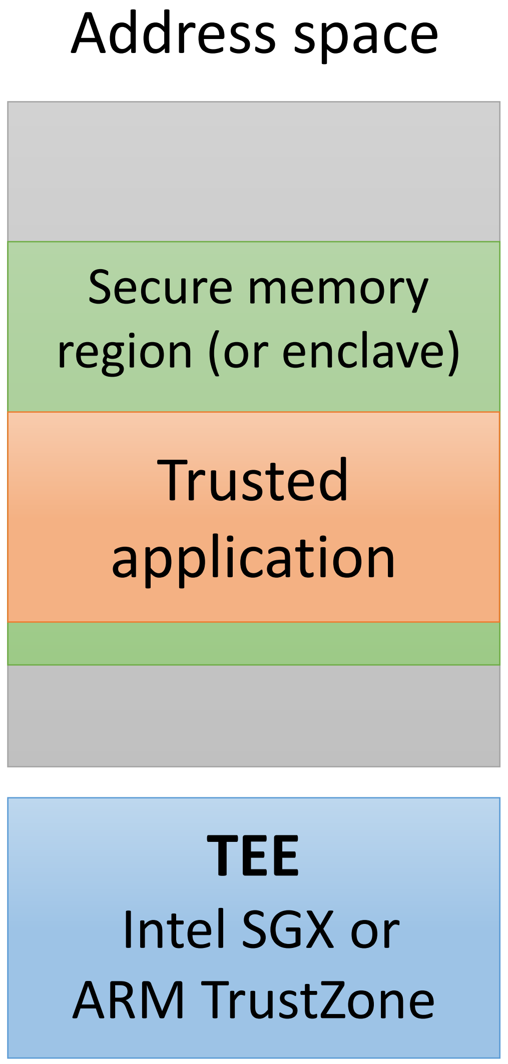
Design

Basic design



Trusted computing

Can we use trusted computing for distributed in-memory KV stores?



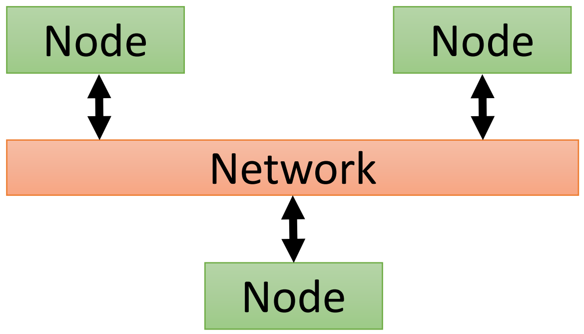
Trusted Execution Environment (TEEs):

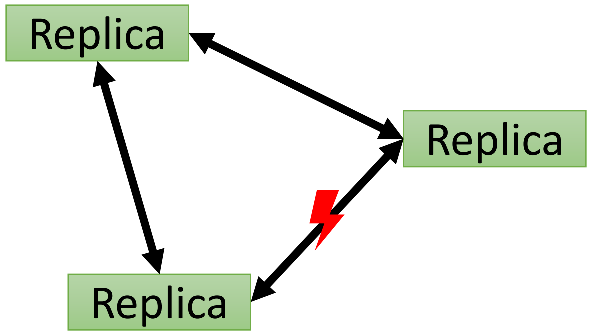
Hardware extensions for trusted computing, e.g., Intel SGX and ARM TrustZone

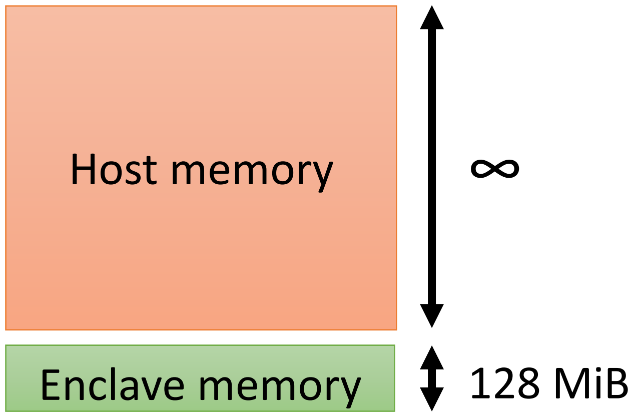
Limitations:

- Untrusted network
- Not well-suited for distributed systems
- Architectural limitations: memory, I/O, and attestation

Design challenges







#1: Networking

How to design a secure network stack?

#2: Fault tolerance

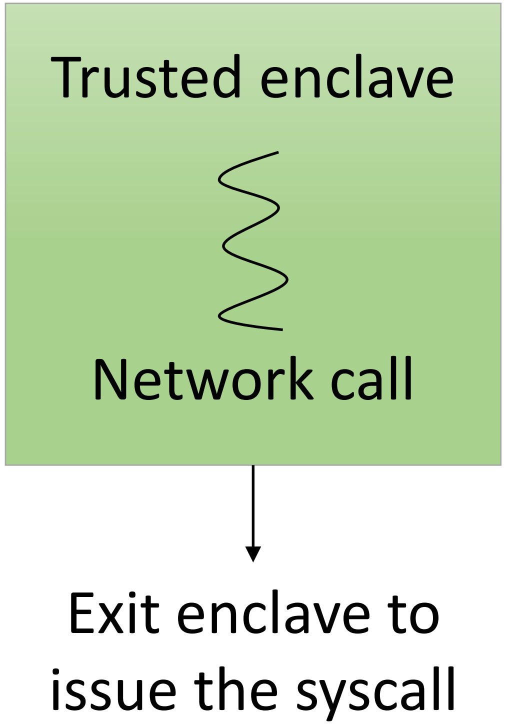
How to tolerant faults in Byzantine settings?

#3: Hardware limitations

How to overcome the architectural limitations of TEEs?

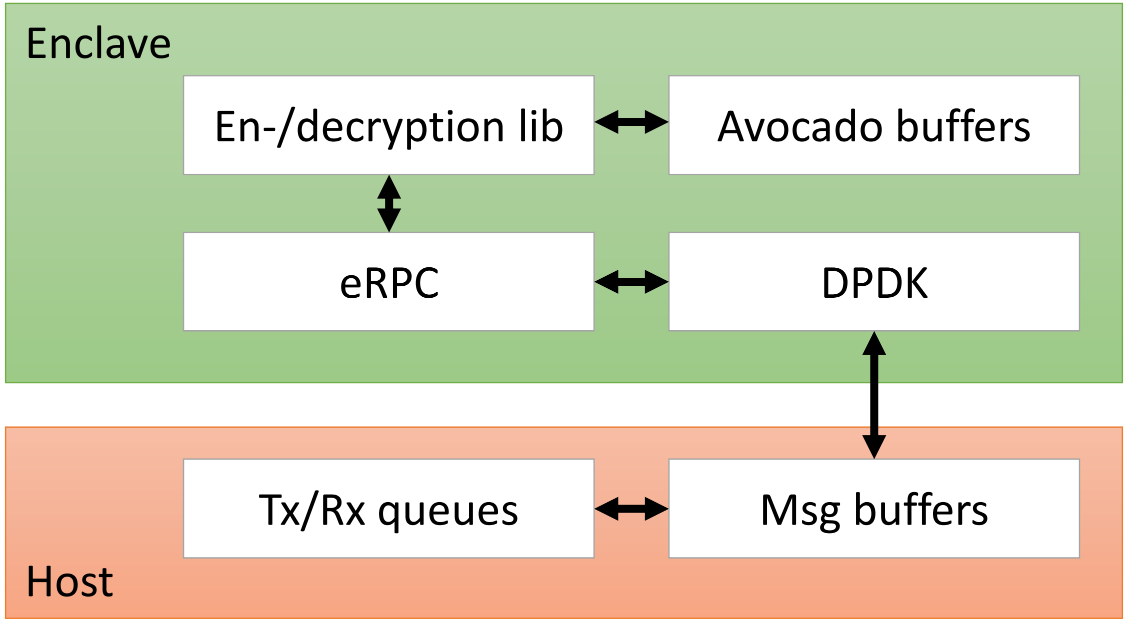
#1: Networking

- Frequent network operations are expensive
- NIC, network and OS are not trusted
- NIC cannot access TEE memory



<u>We designed a network stack for trusted computing</u>
based on eRPC and DPDK for fast networking without exiting enclave

#1: Trusted network stack



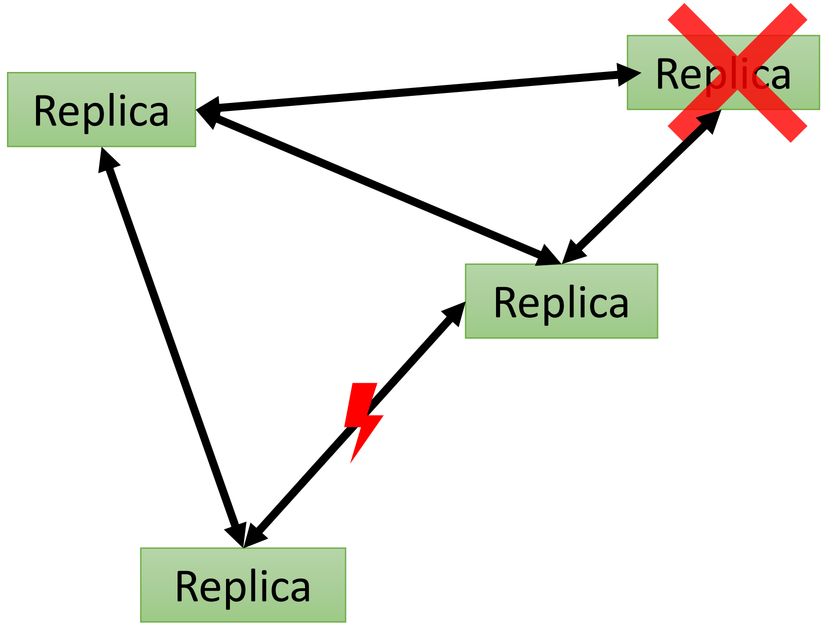
Splits the network stack into:

- Logic in the enclave and buffers in the host

Package format guarantees freshness

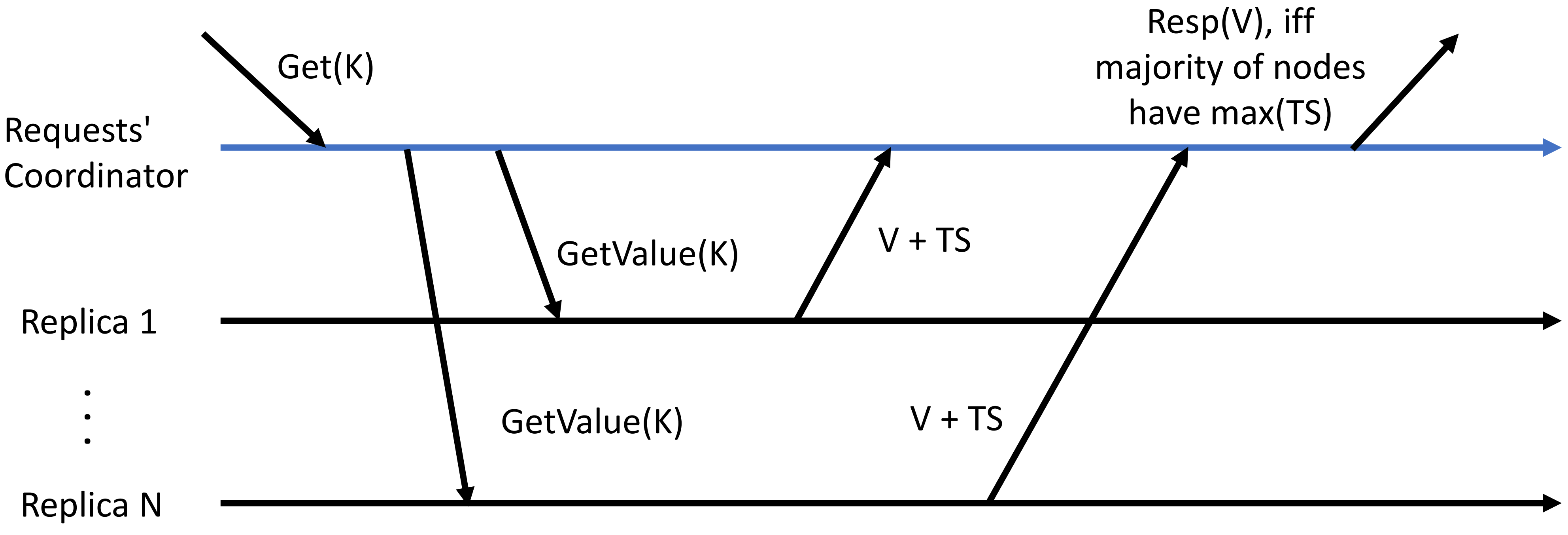
#2: Fault tolerance

- Crash-stop failure
  - Replication
- Network provider can manipulate traffic
  - BFT protocol



<u>We can employ a non-byzantine protocol,</u> due to the trust provided by TEEs and our network layer.

#2: Trusted replication protocol

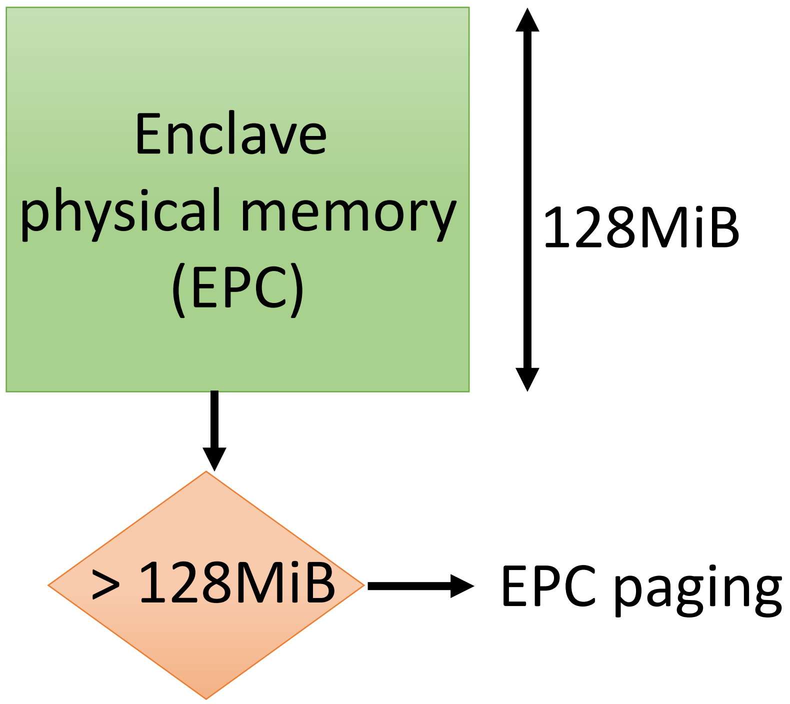


Avocado based on non-Byzantine protocol (ABD):

- It runs inside the enclave to prevent equivocation
- Majority voting guarantees liveness and forking protection

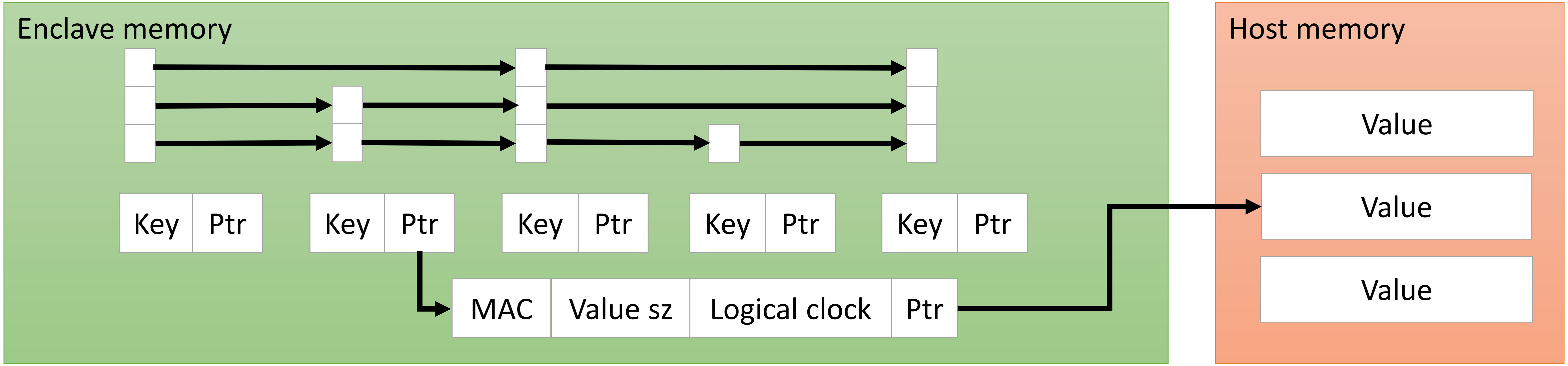
#3: Hardware limitations

- EPC is limited (94 MiB)
- Secure paging for bigger memory area
- EPC paging incurs high overheads



We designed a fast EPC conserving in-memory KV data structure
to overcome the enclave physical memory limitation

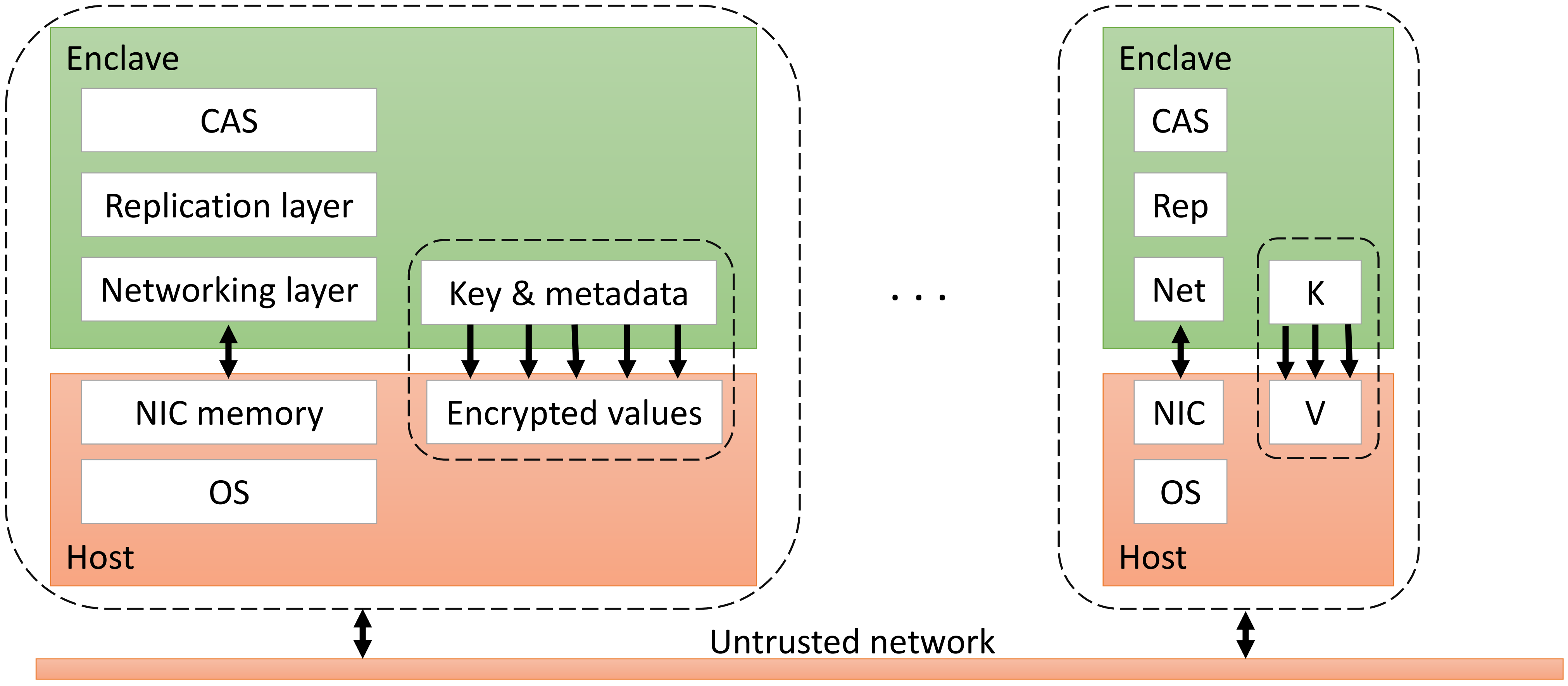
#3: In-memory KV store



Split in Memory KV store into two parts:

- Keys -> stored in enclave for fast lookup
- Meta data -> split from key for atomic updates
- Values -> stored in untrusted memory, reducing EPC pressure

Overall system design



Evaluation

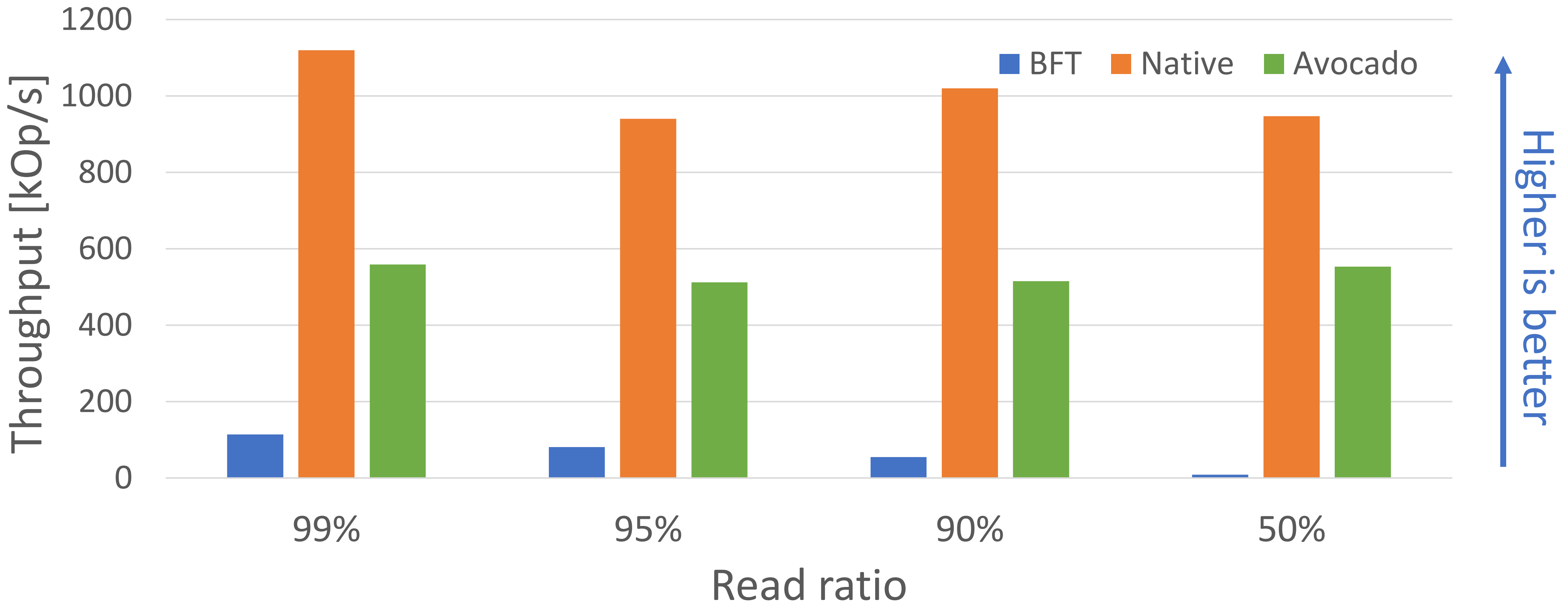
Evaluation

- Questions
  1. What is the overall performance compared to BFT?
  2. How well does Avocado scale?

See the paper for more results

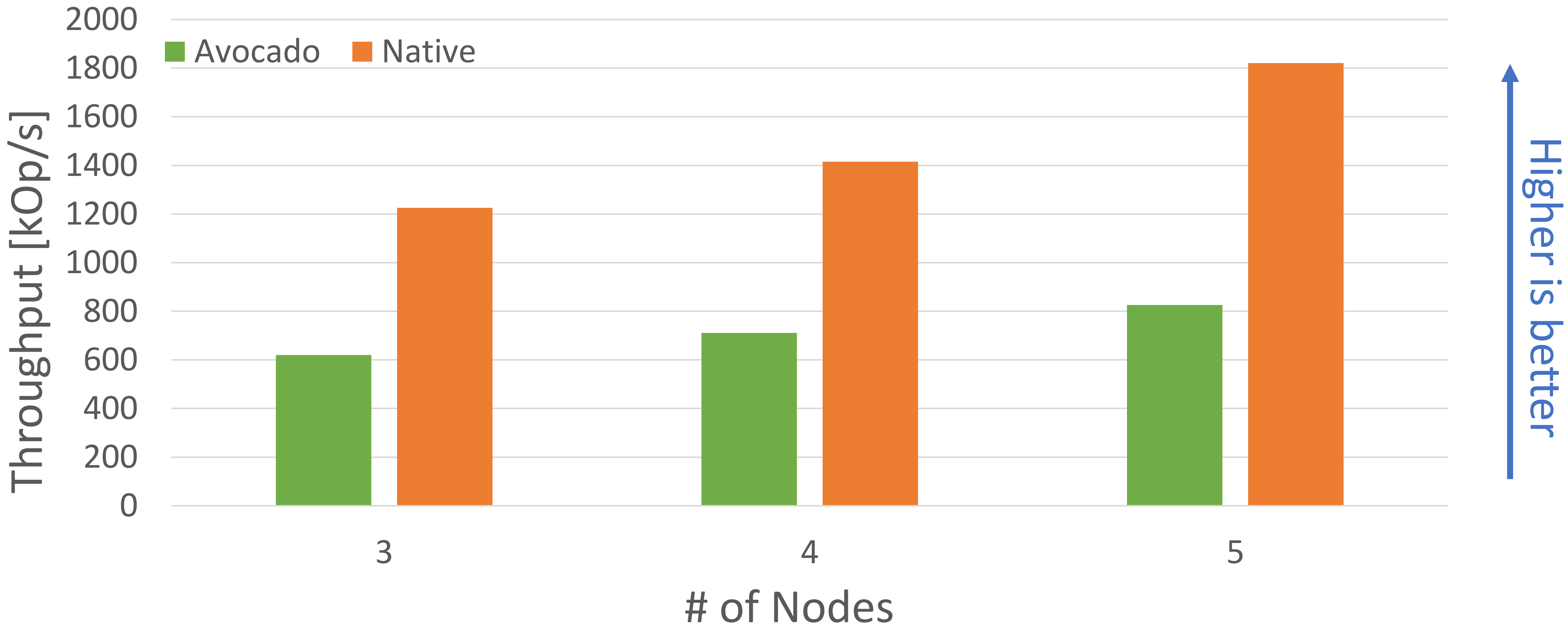
- Experimental setup:
  - 5x Intel i9-9900K (@3.60GHz, 8 cores, 16 HT)
  - Intel NIC XL710 (40Gb/s, QSFP+)

Overall performance



Avocado performs similar in read and write heavy workloads and outperforms BFT

Scalability



Avocado scales with the number of increasing nodes

Avocado:
A secure in-memory distributed storage system

Security properties: confidentiality + integrity + freshness

Challenge: How to leverage TEEs to design a high-performance secure and fault-tolerant in-memory KV store?

Contributions
Trusted network stack
Trusted replication protocol
Trusted in-memory KV store
Configuration and attestation service (see the paper for details)

Thank you!

If you have follow up questions, please contact us:

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