KVSEV:
A Secure In-Memory Key-Value Store with Secure Encrypted Virtualization

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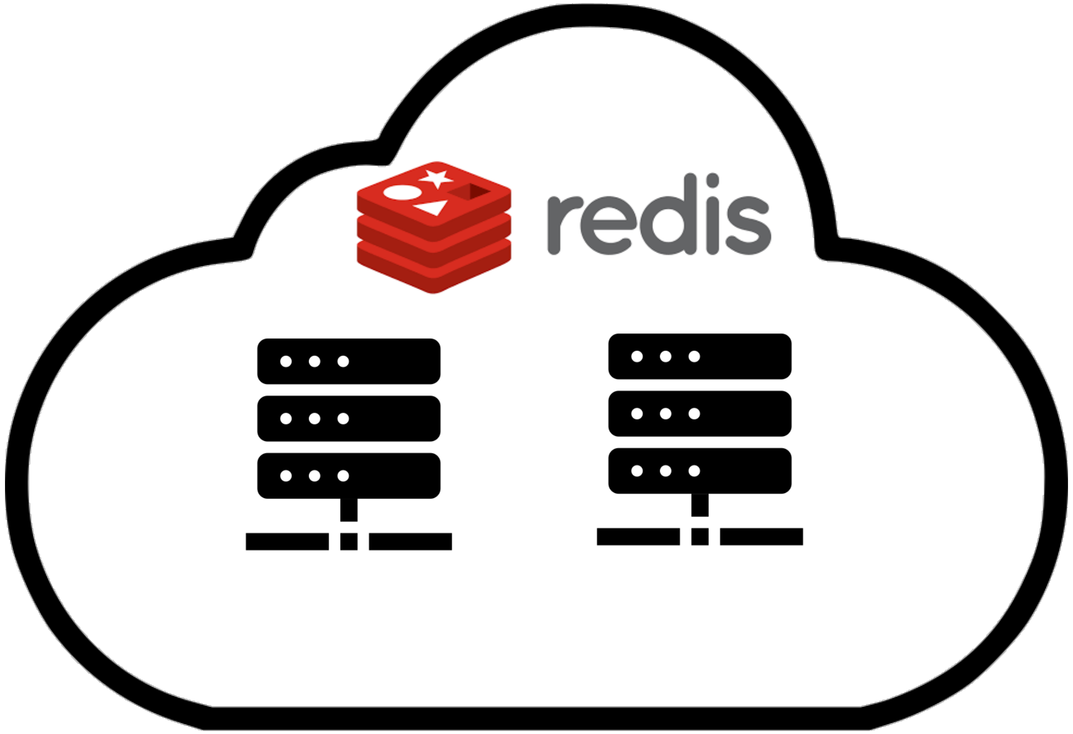
Yeongpil Cho, Yunheung Paek

Santa Cruz, USA
October 31-November 1, 2023

Trusted Key-Value Stores

- User data is exposed to adversarial insiders in cloud



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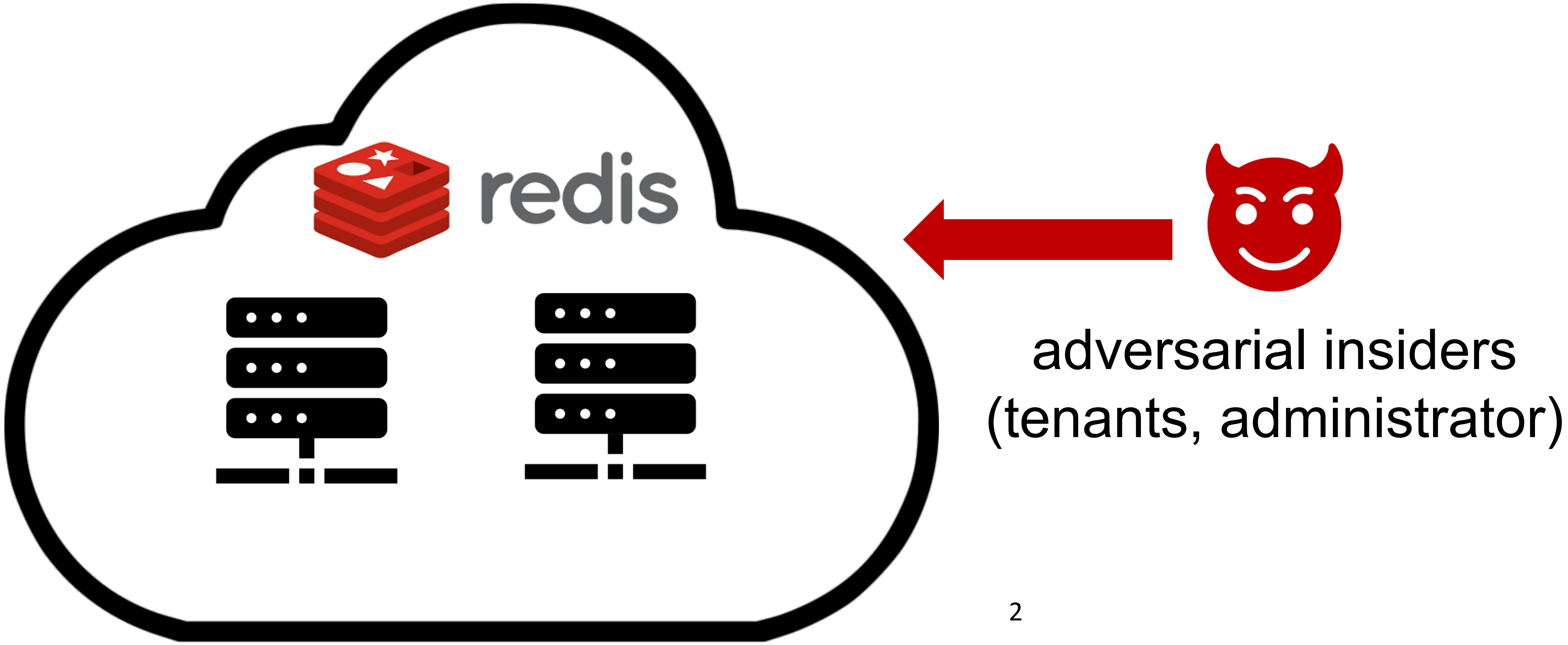

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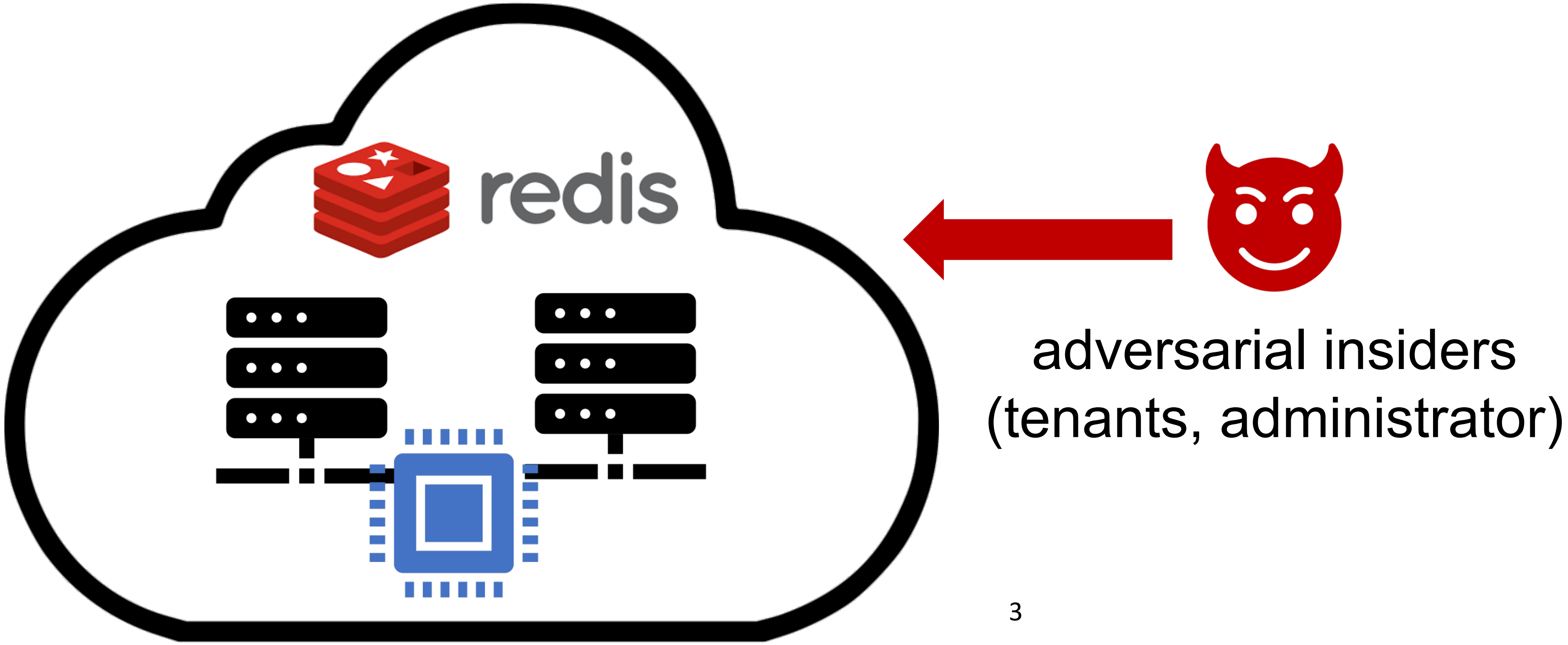

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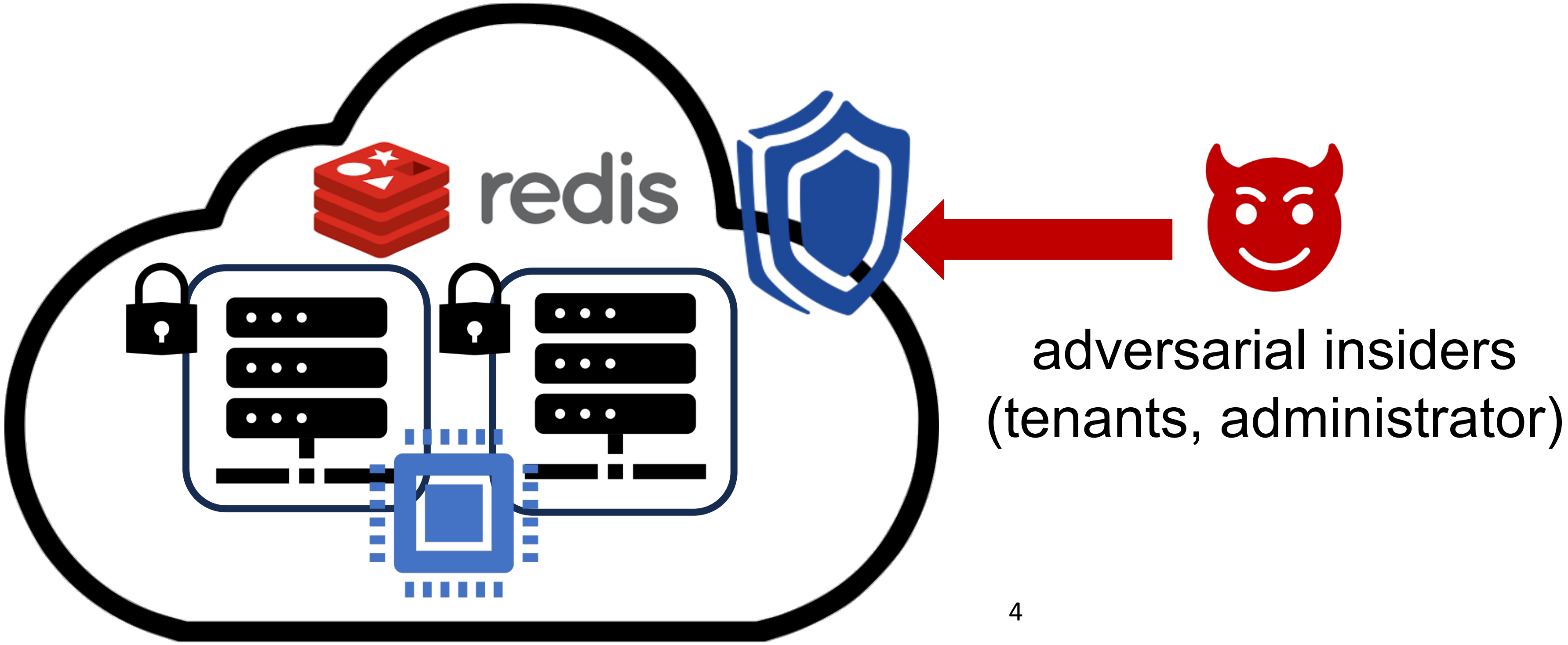

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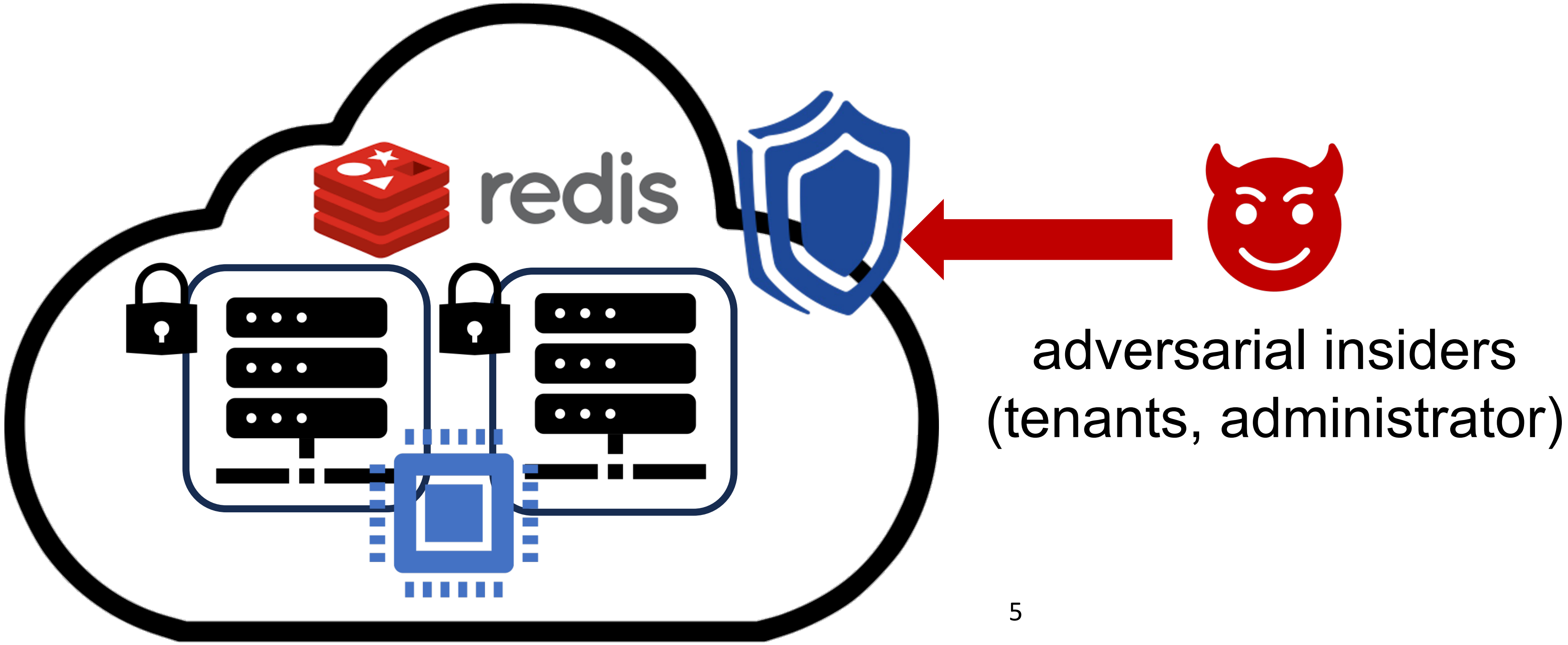
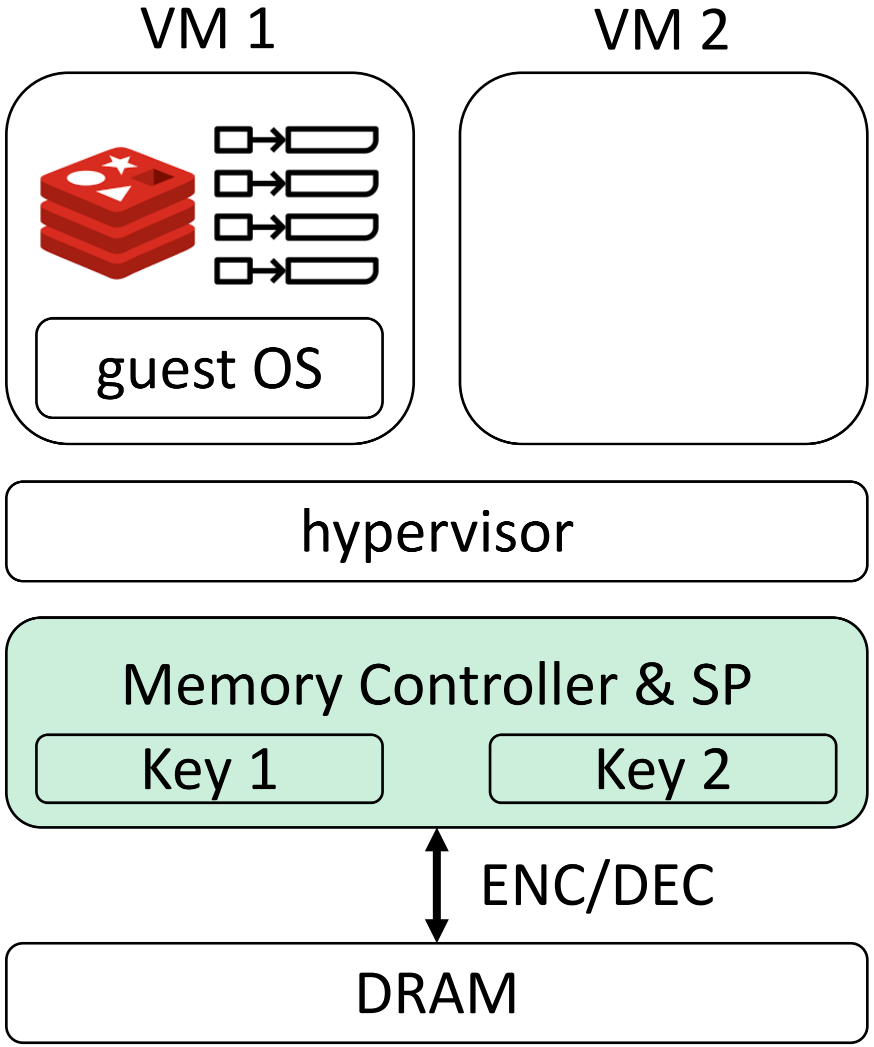


Intel SGX

AMD SEV

Trusted Key-Value Stores with SEV



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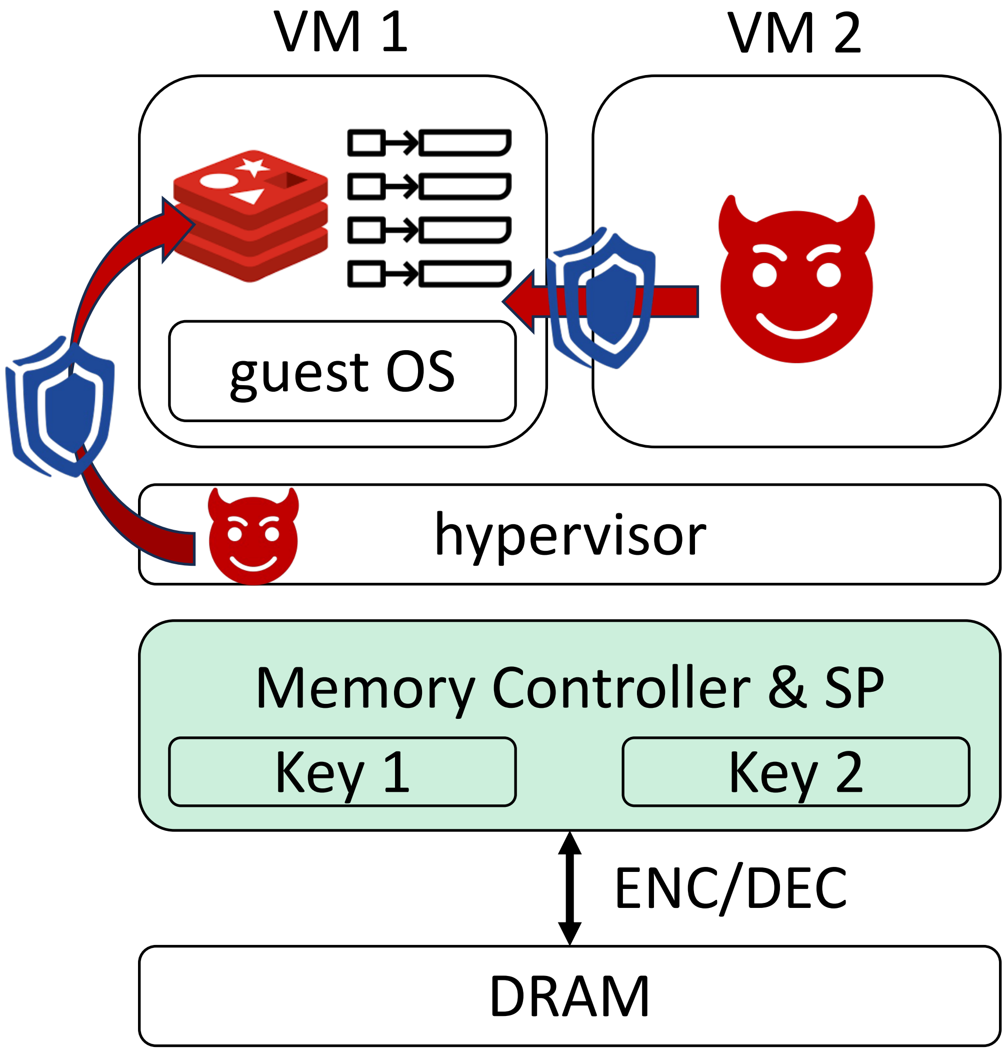

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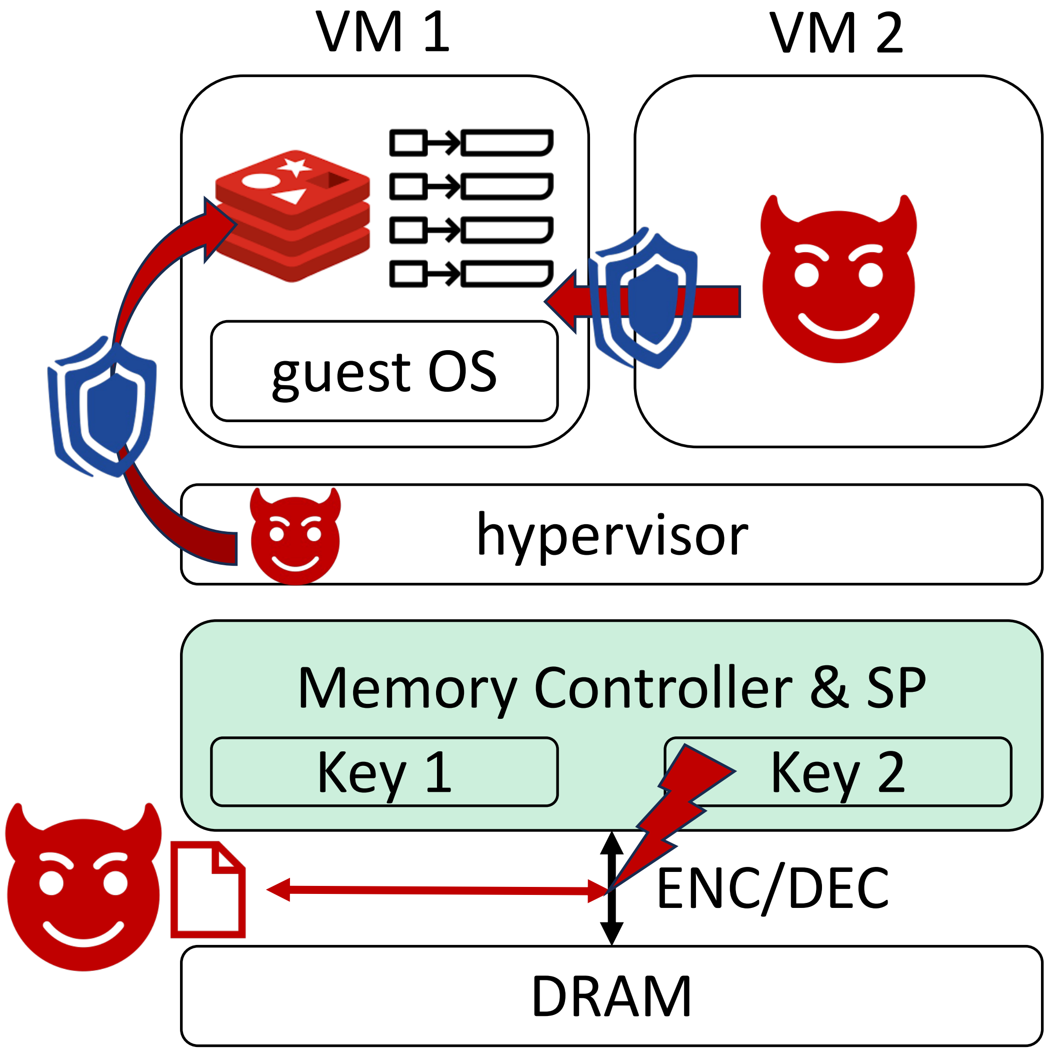

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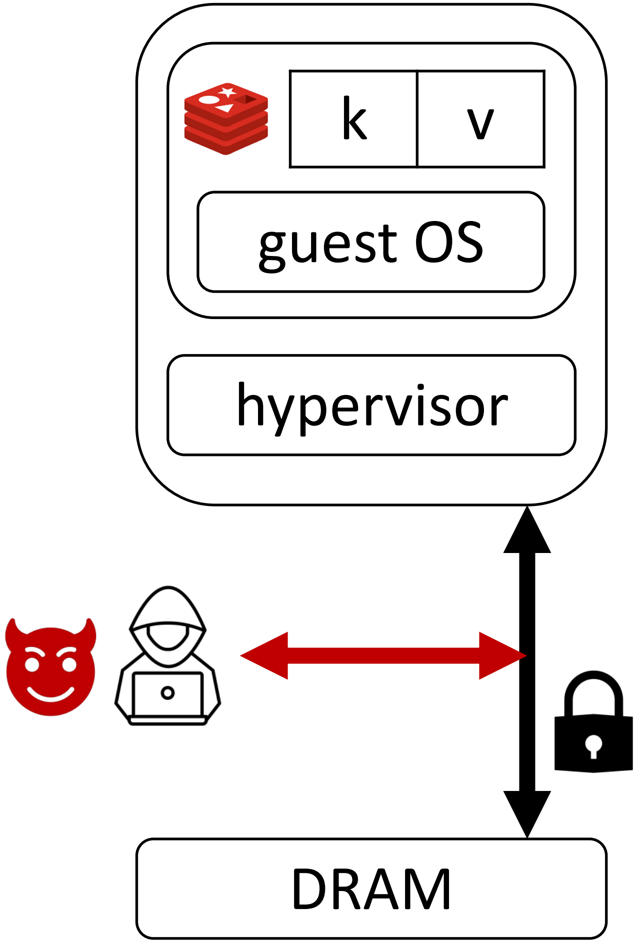
No integrity protection from physical adversaries

Physical Attacks on Key-Value Stores



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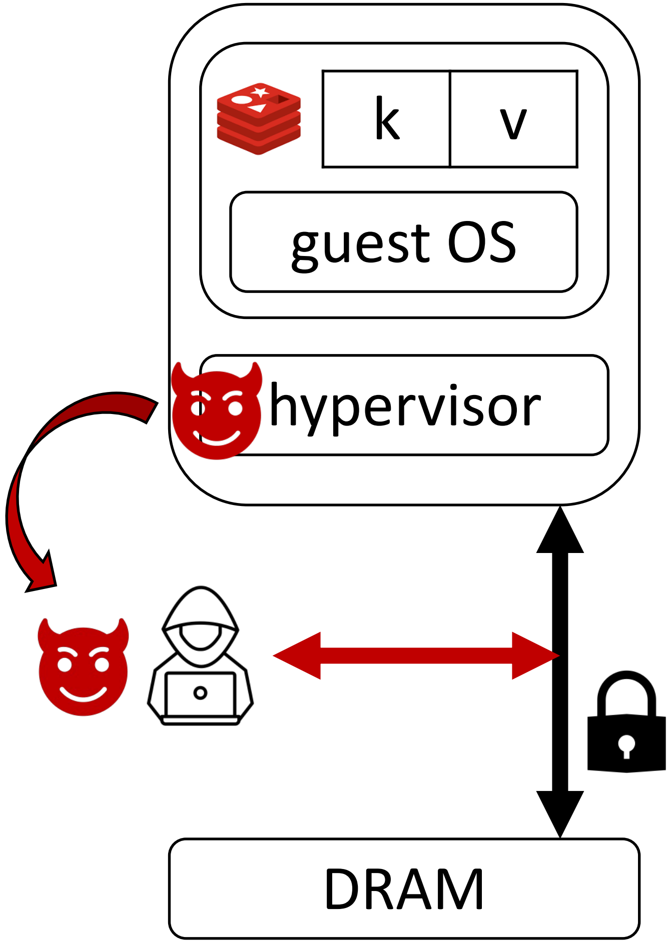

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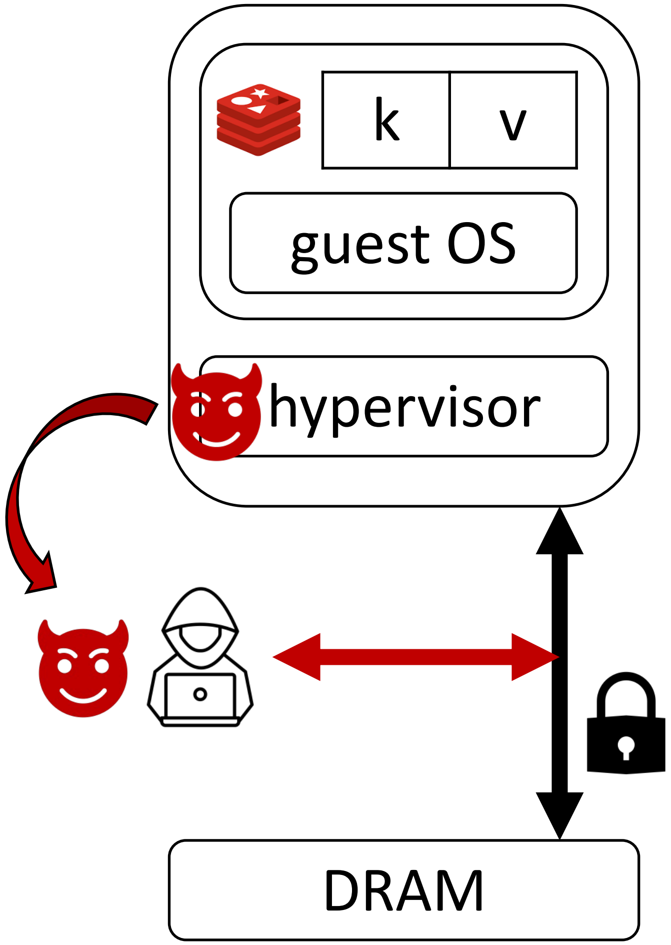

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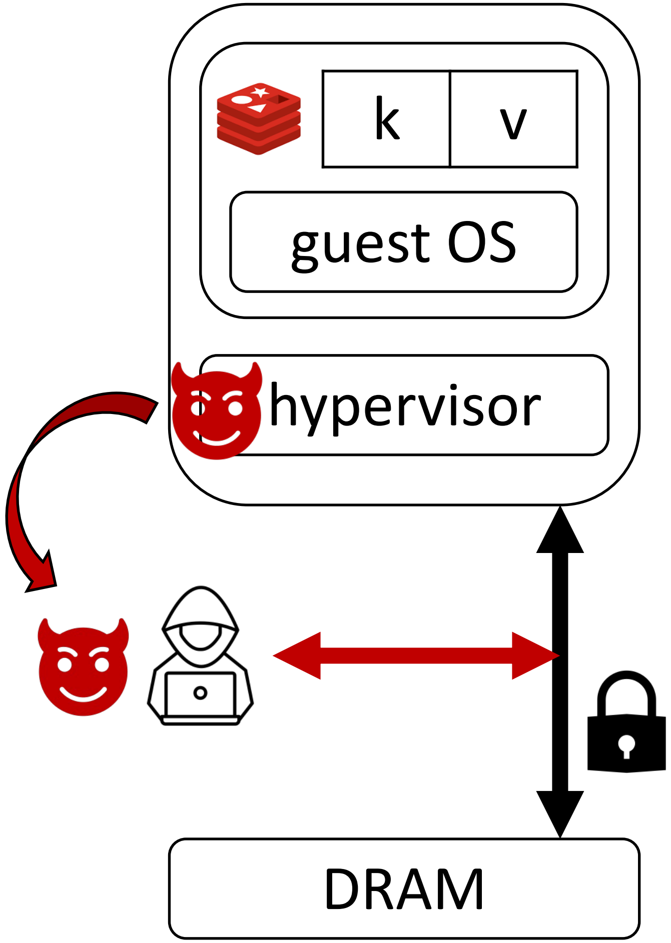

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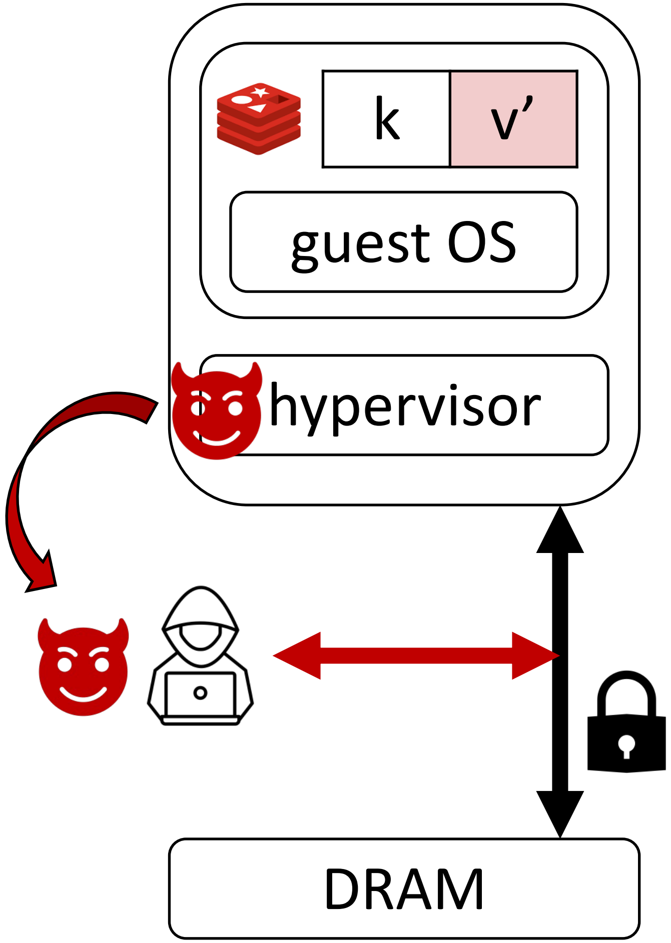

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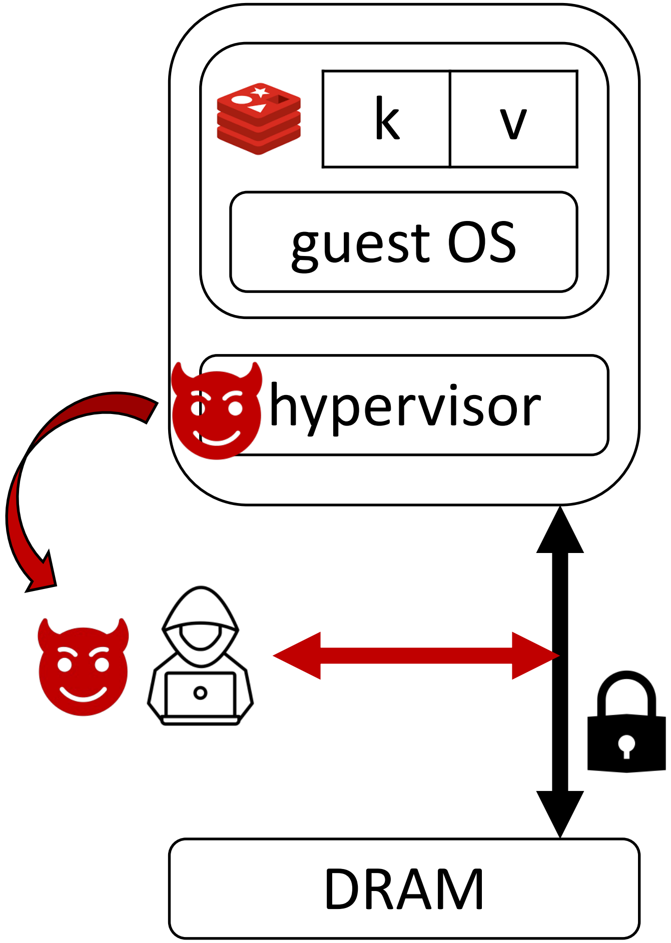

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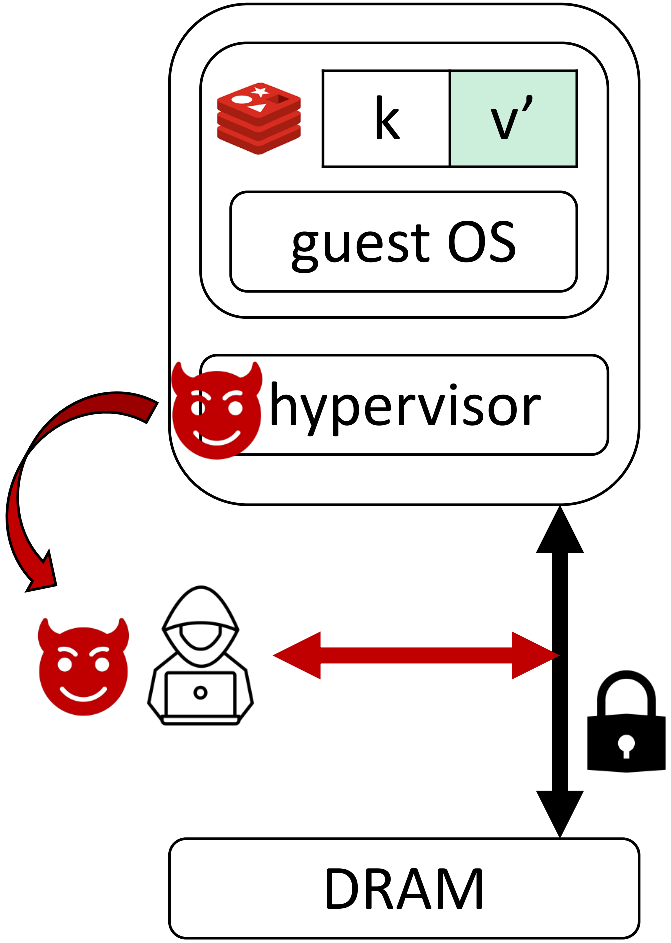

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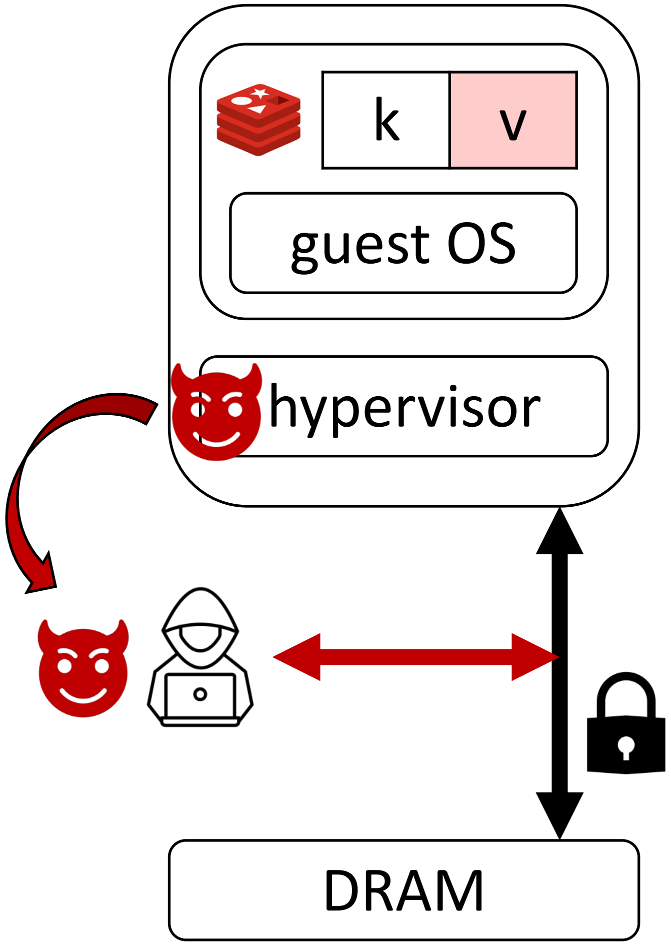

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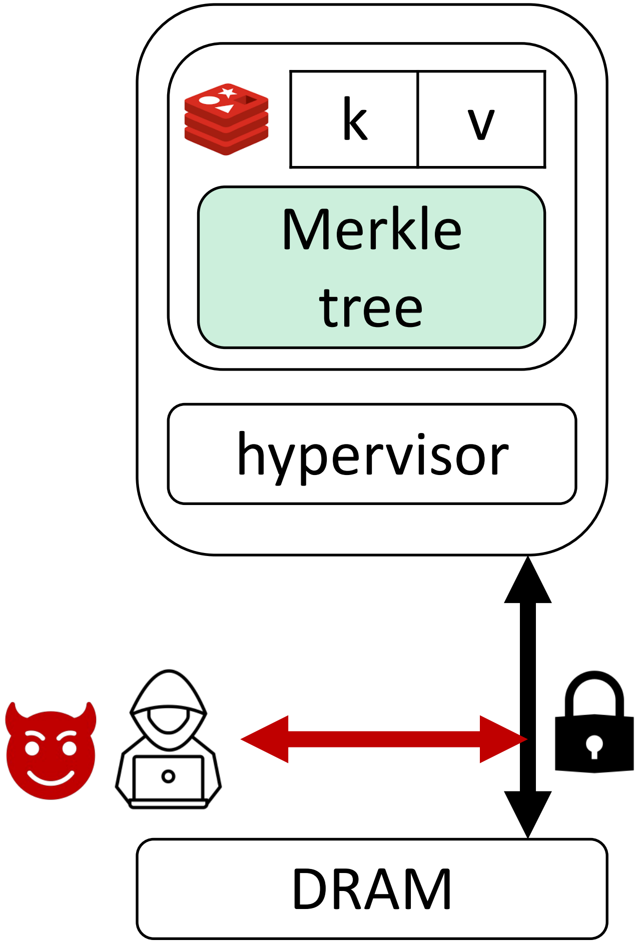

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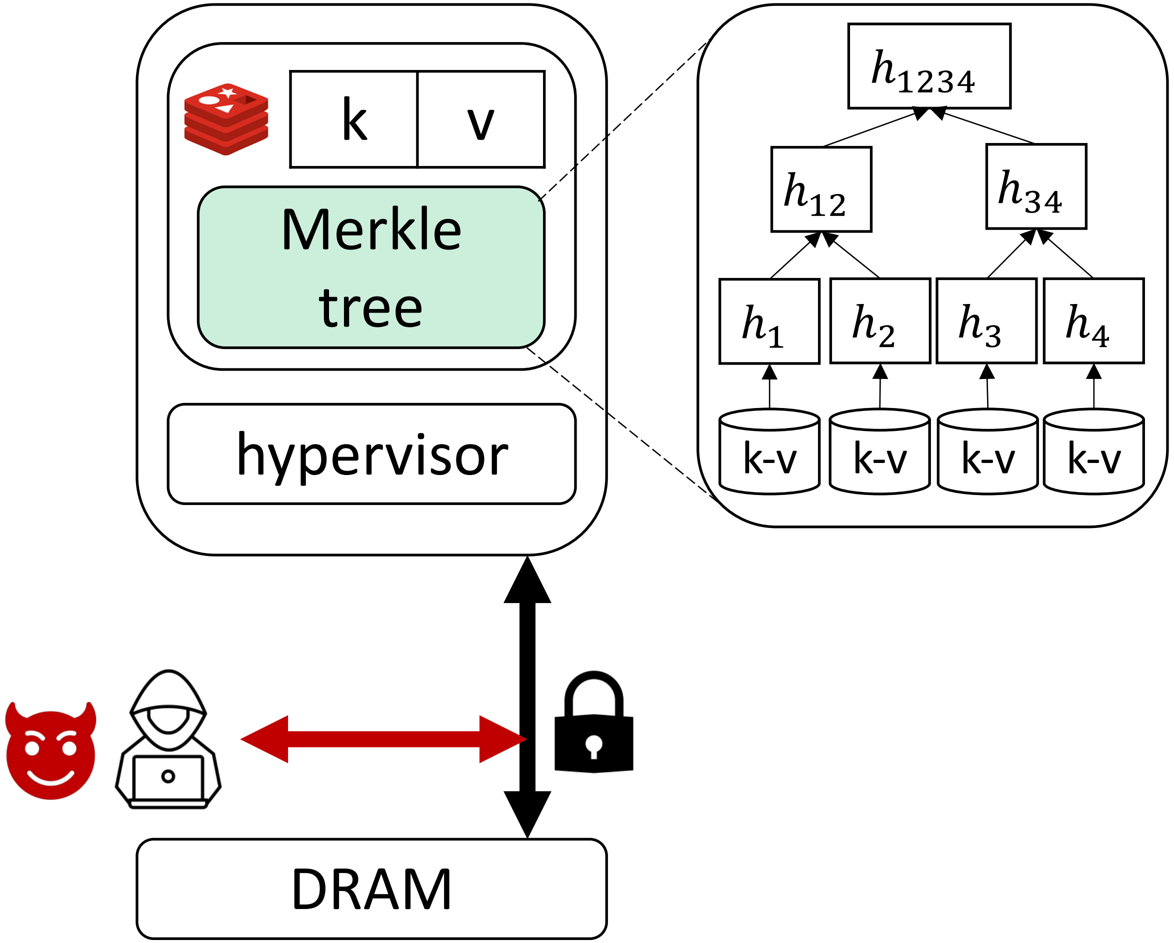

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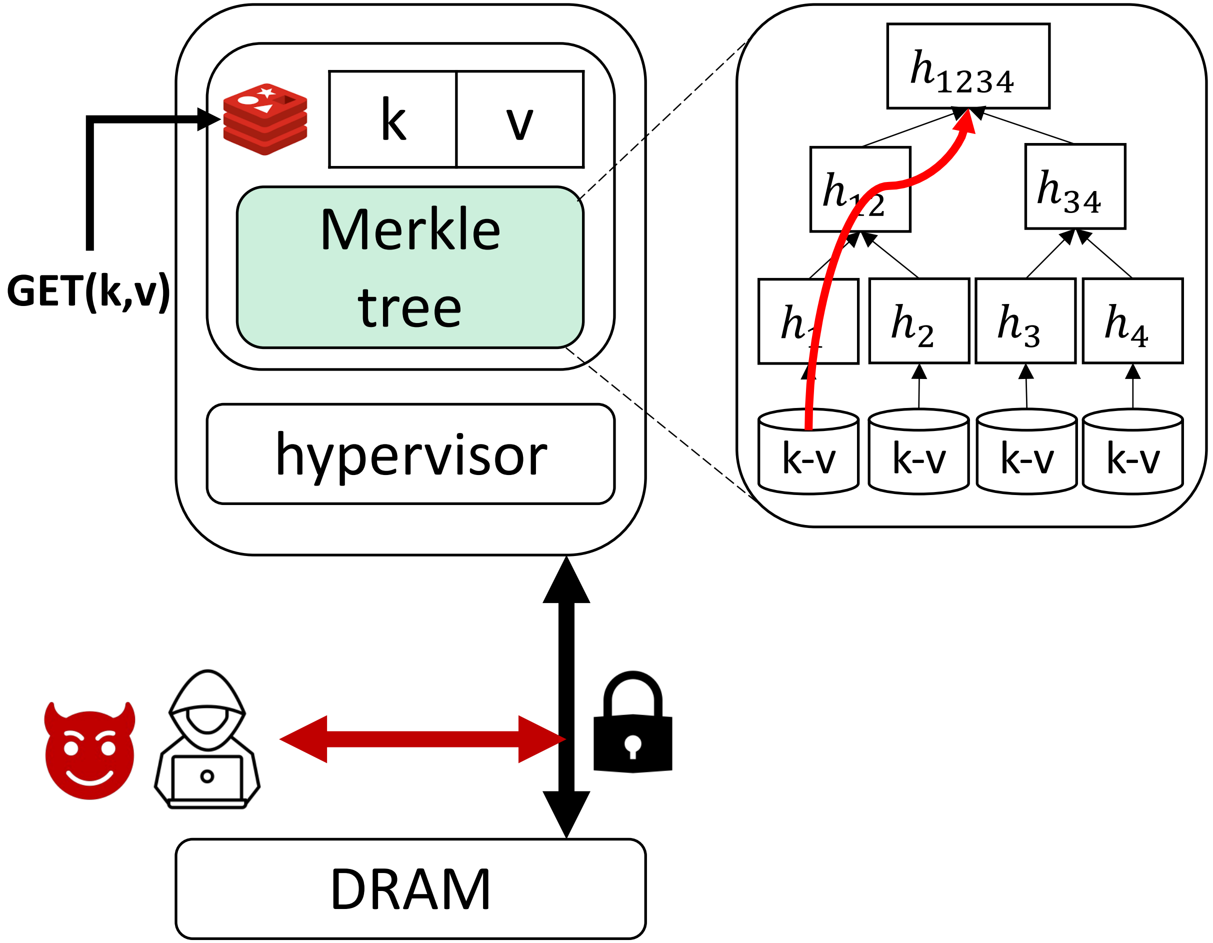

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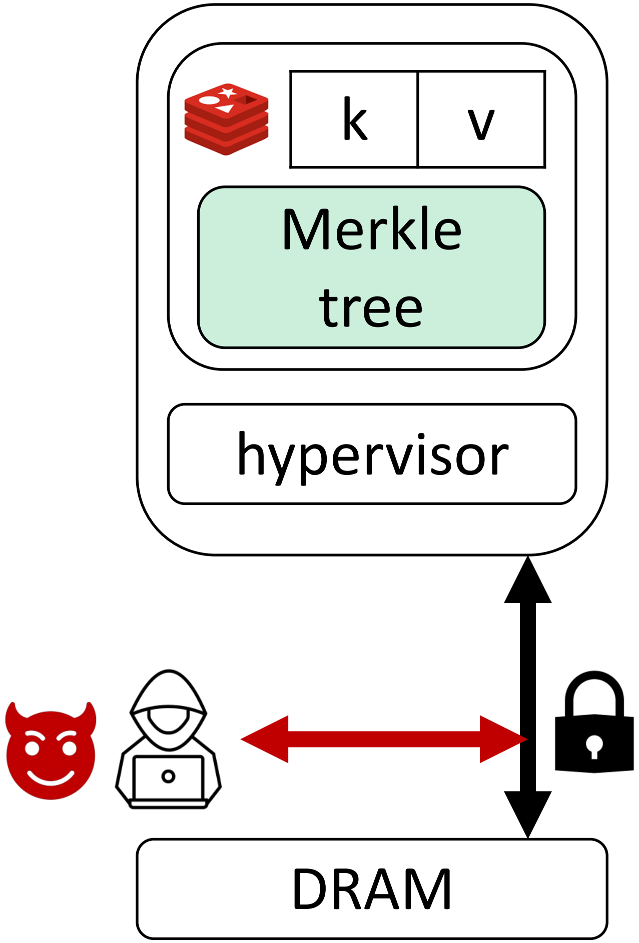

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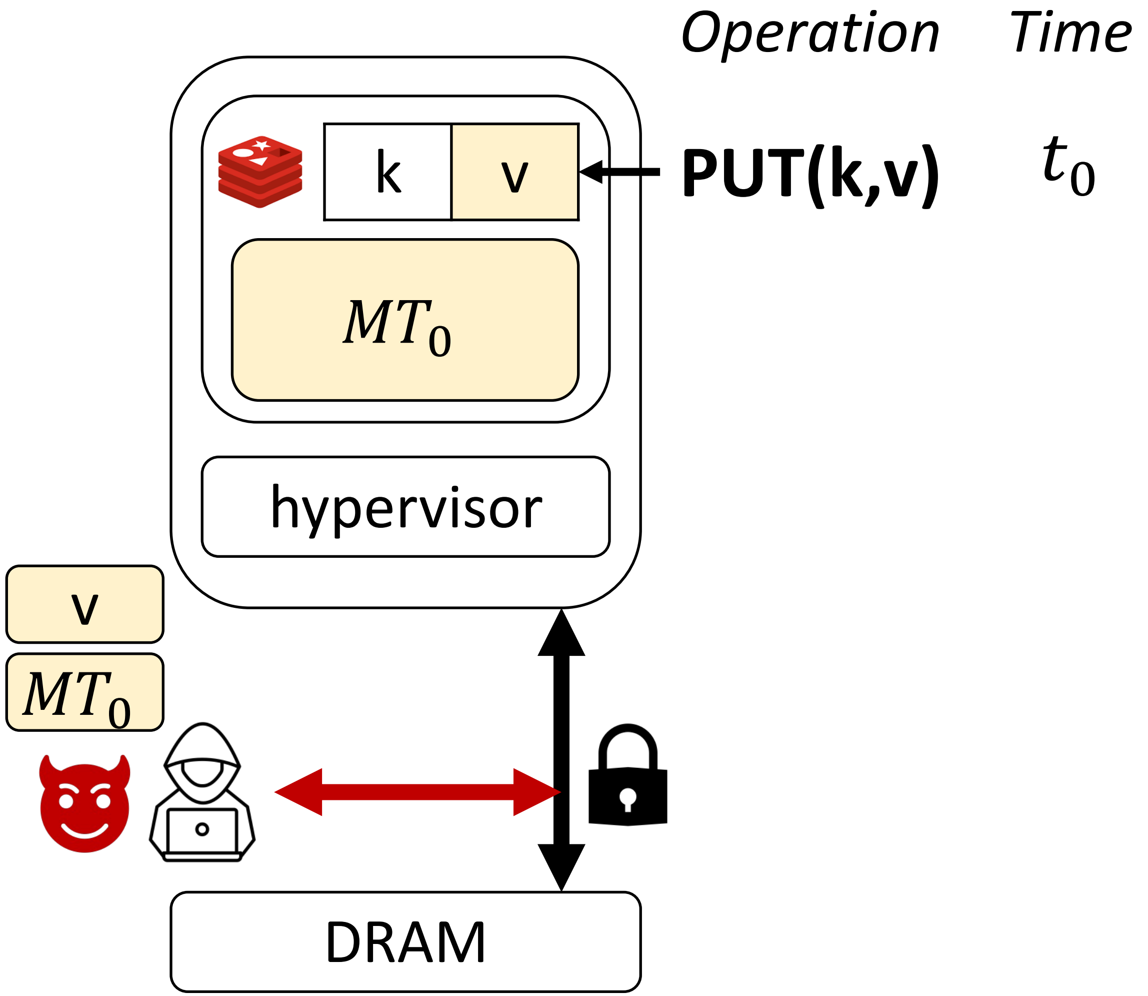

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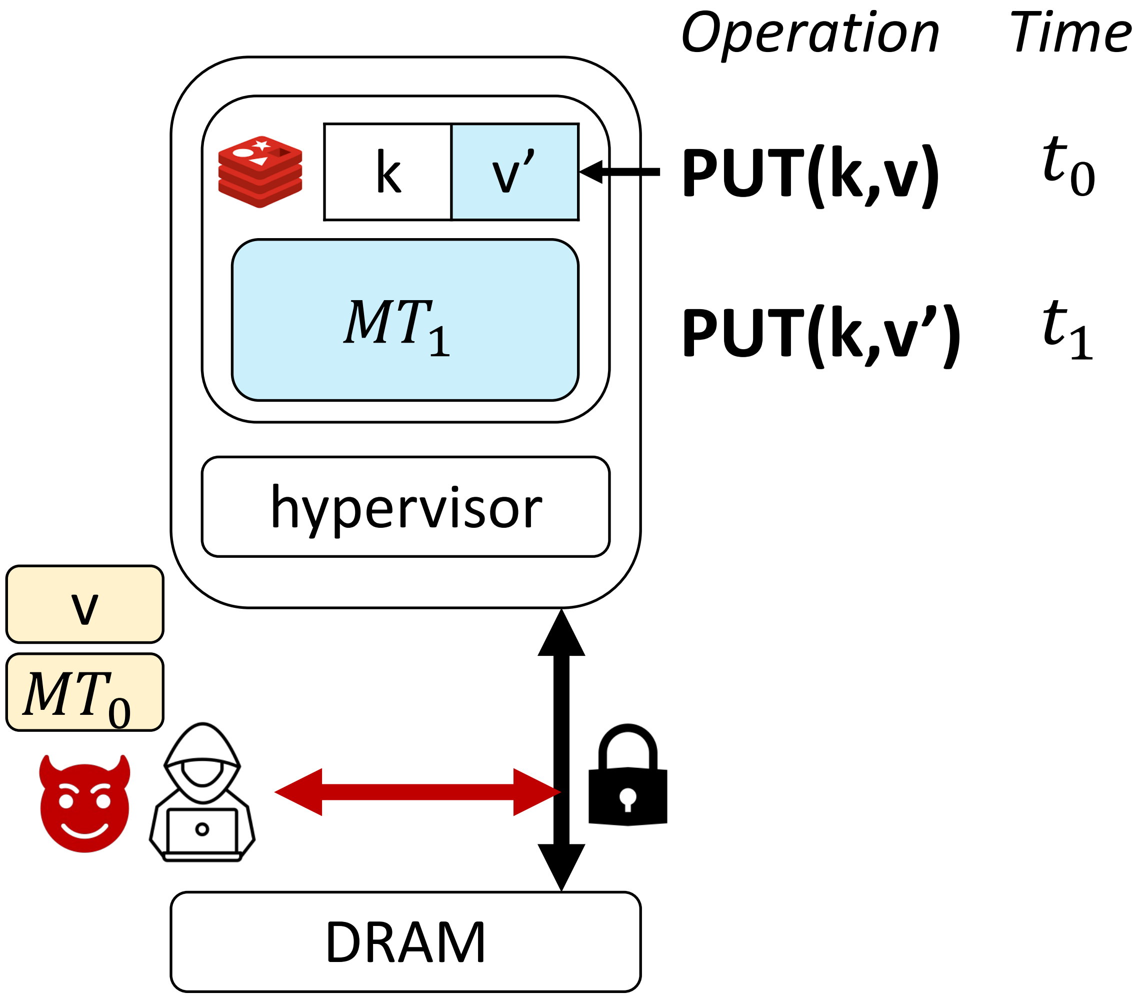

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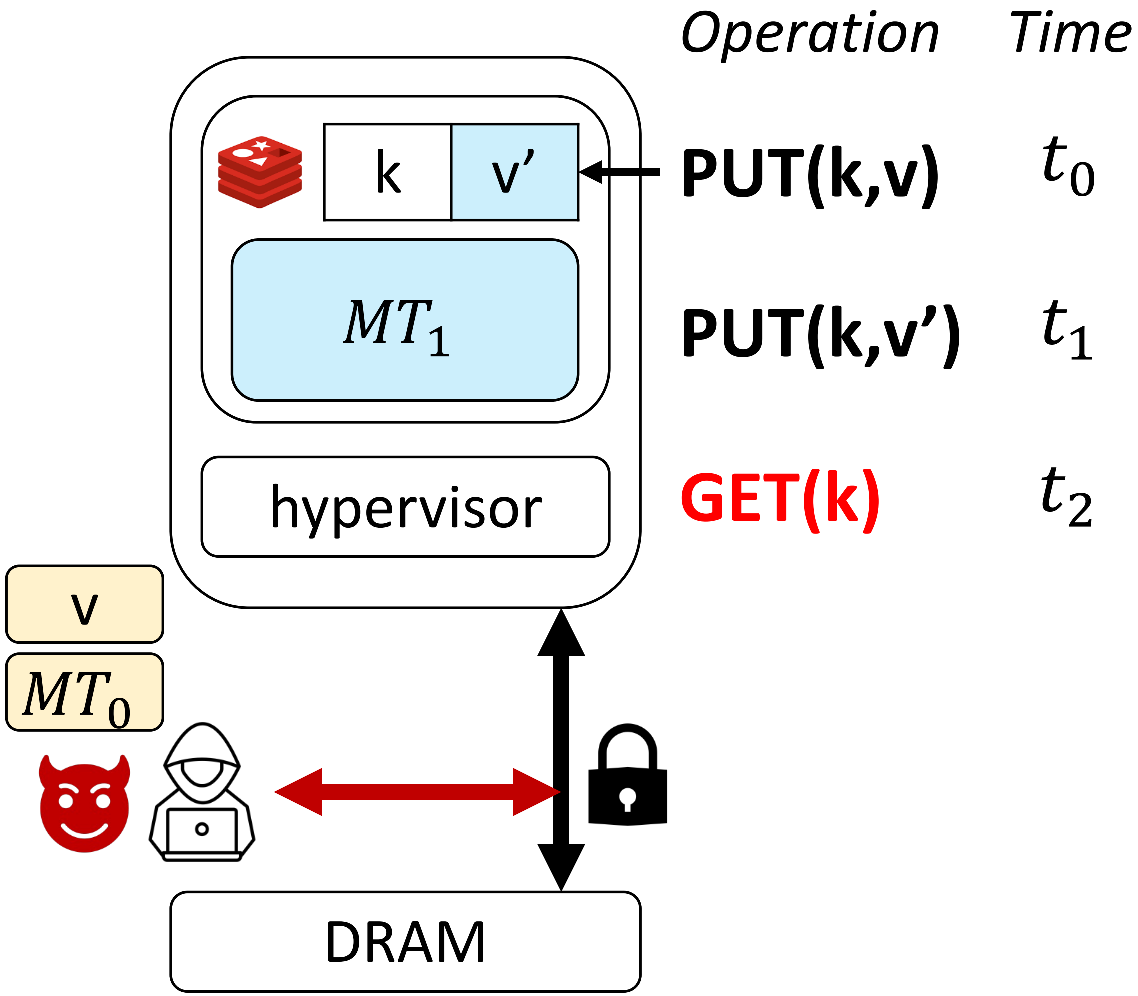

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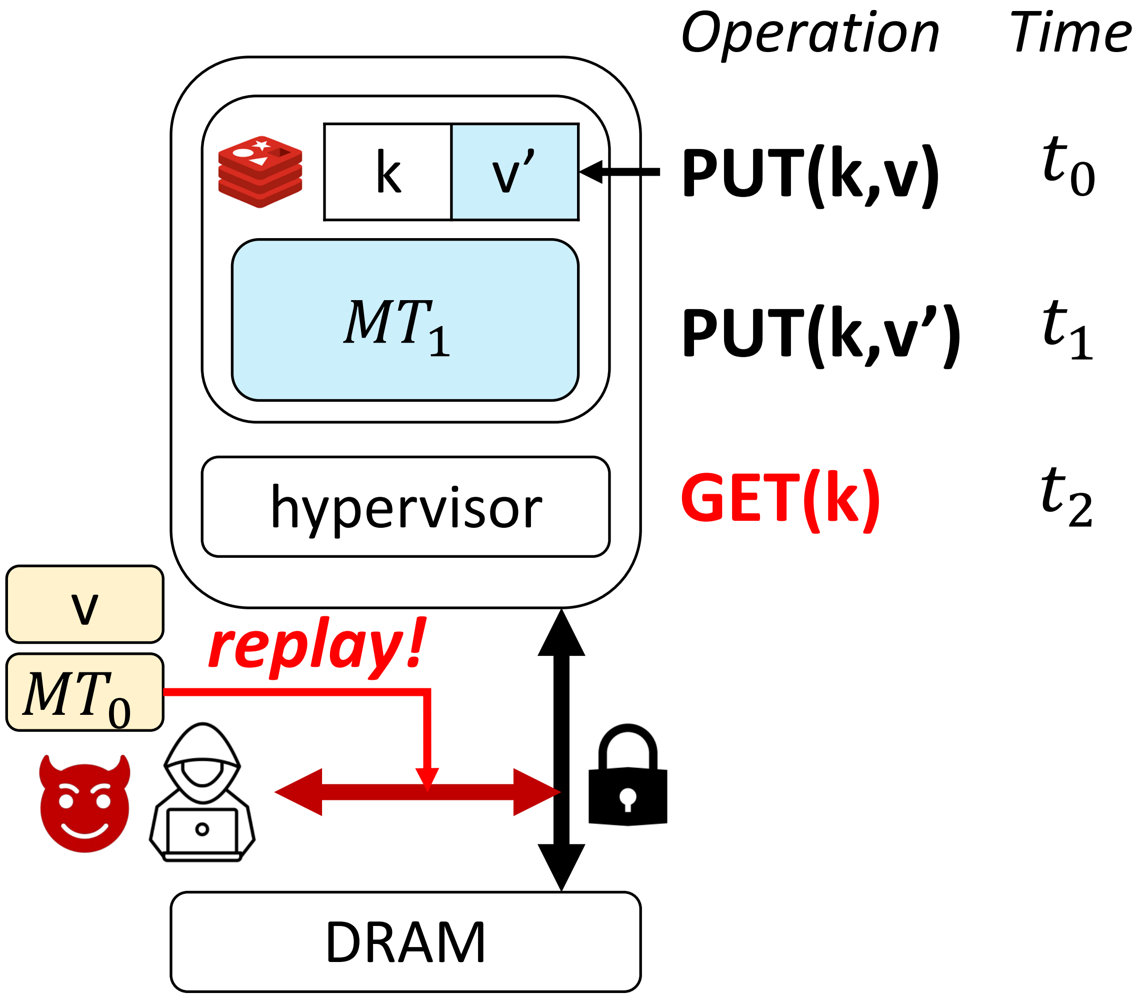

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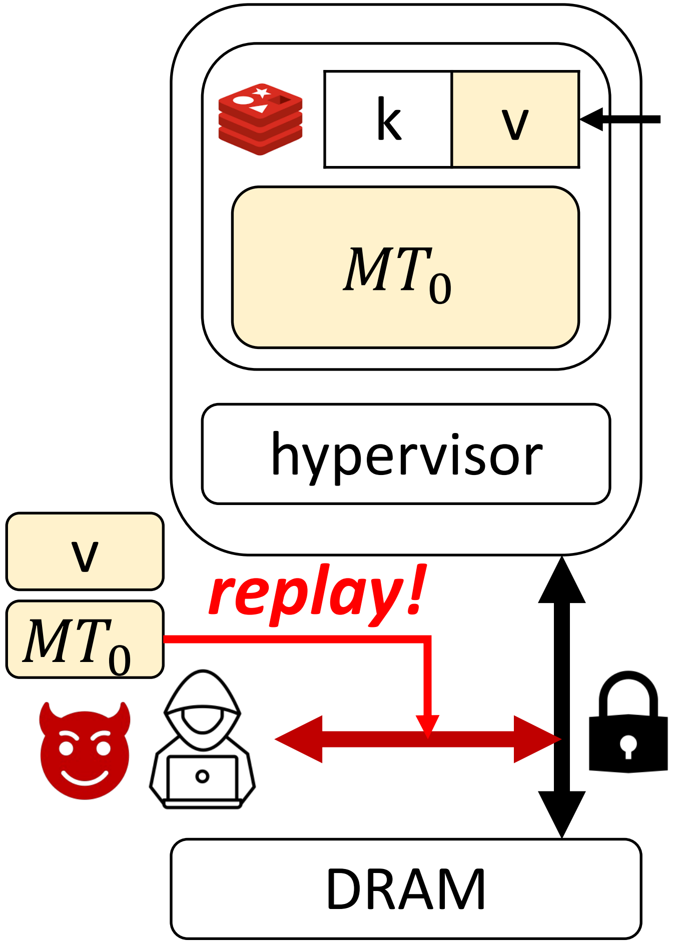

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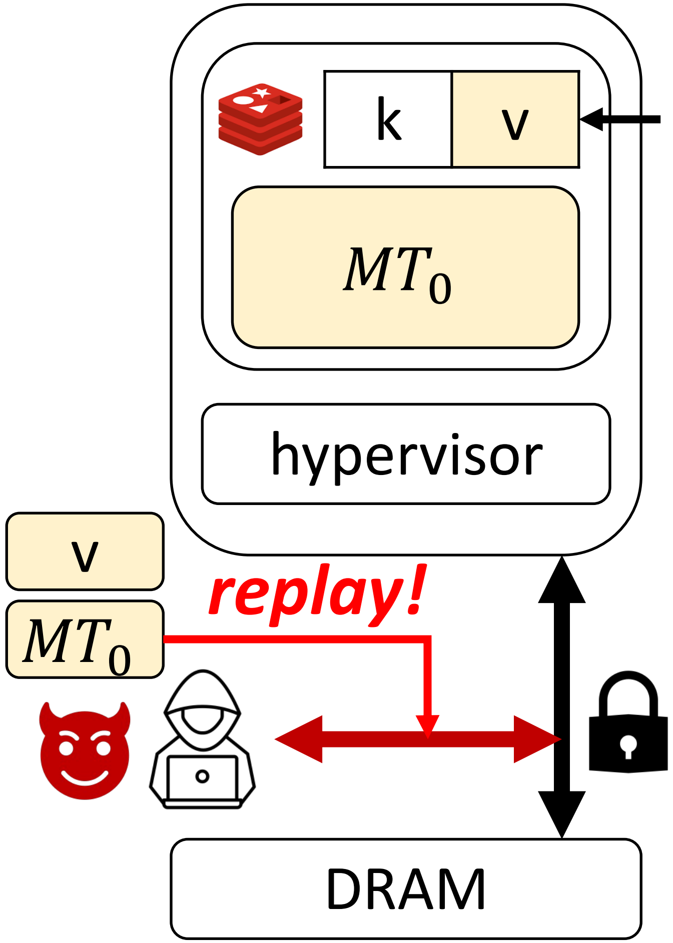

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Returns outdated value ‘v’ passing Merkle tree verification

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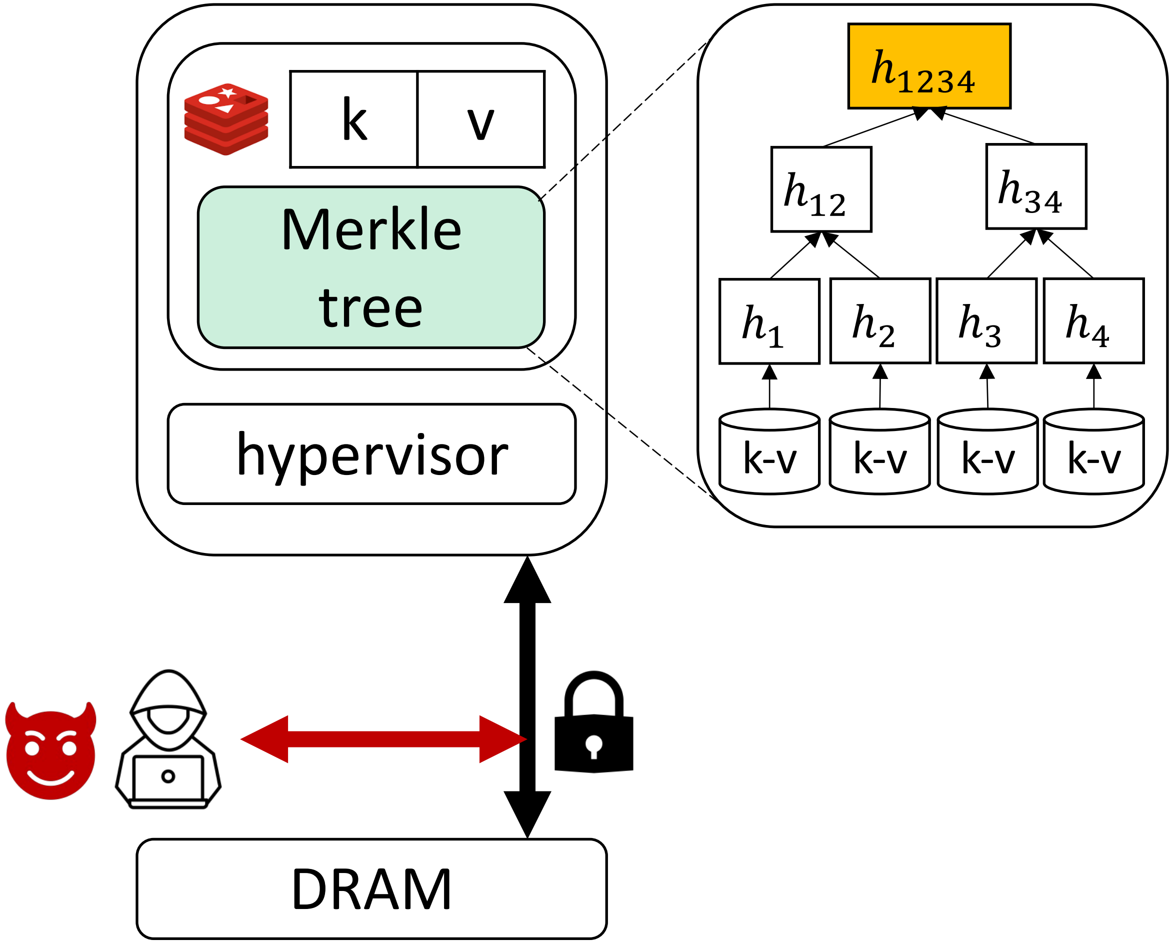

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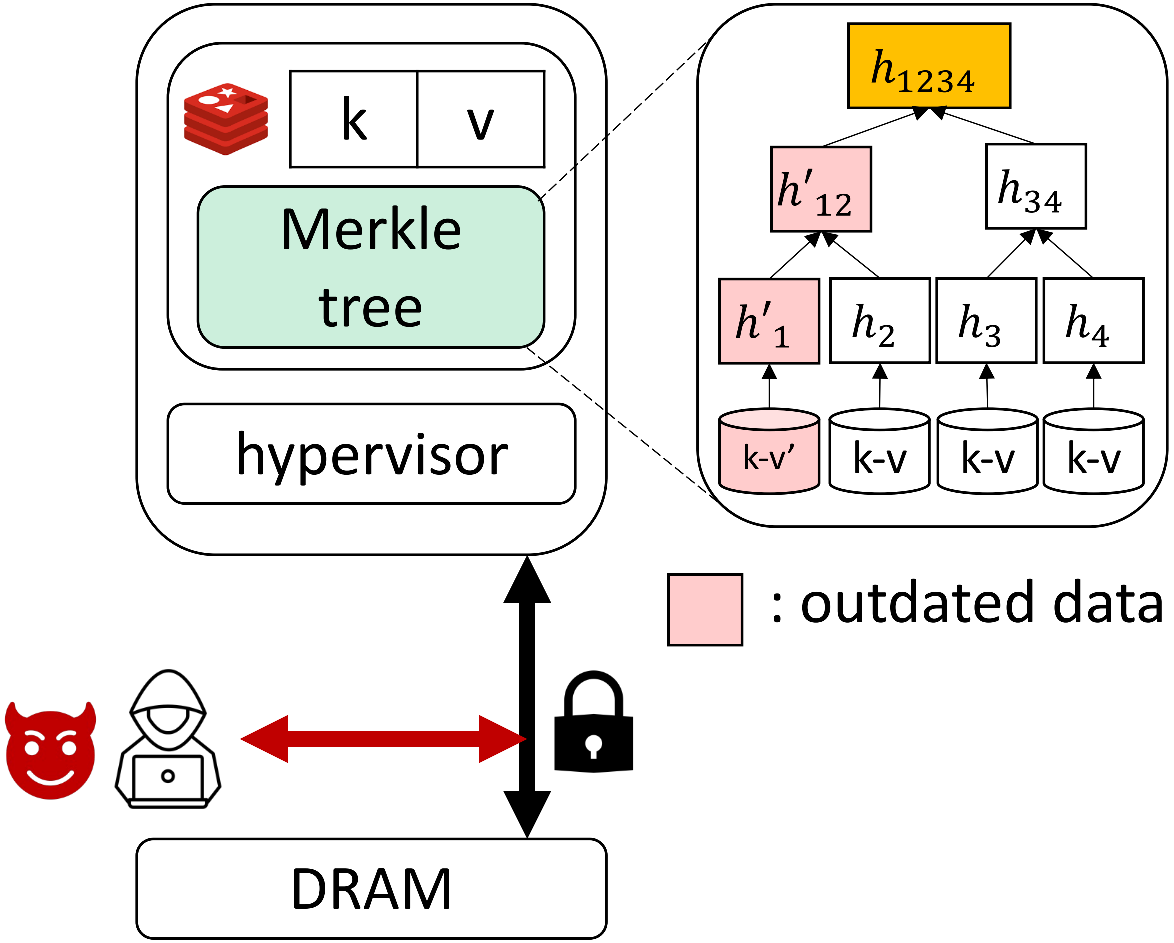

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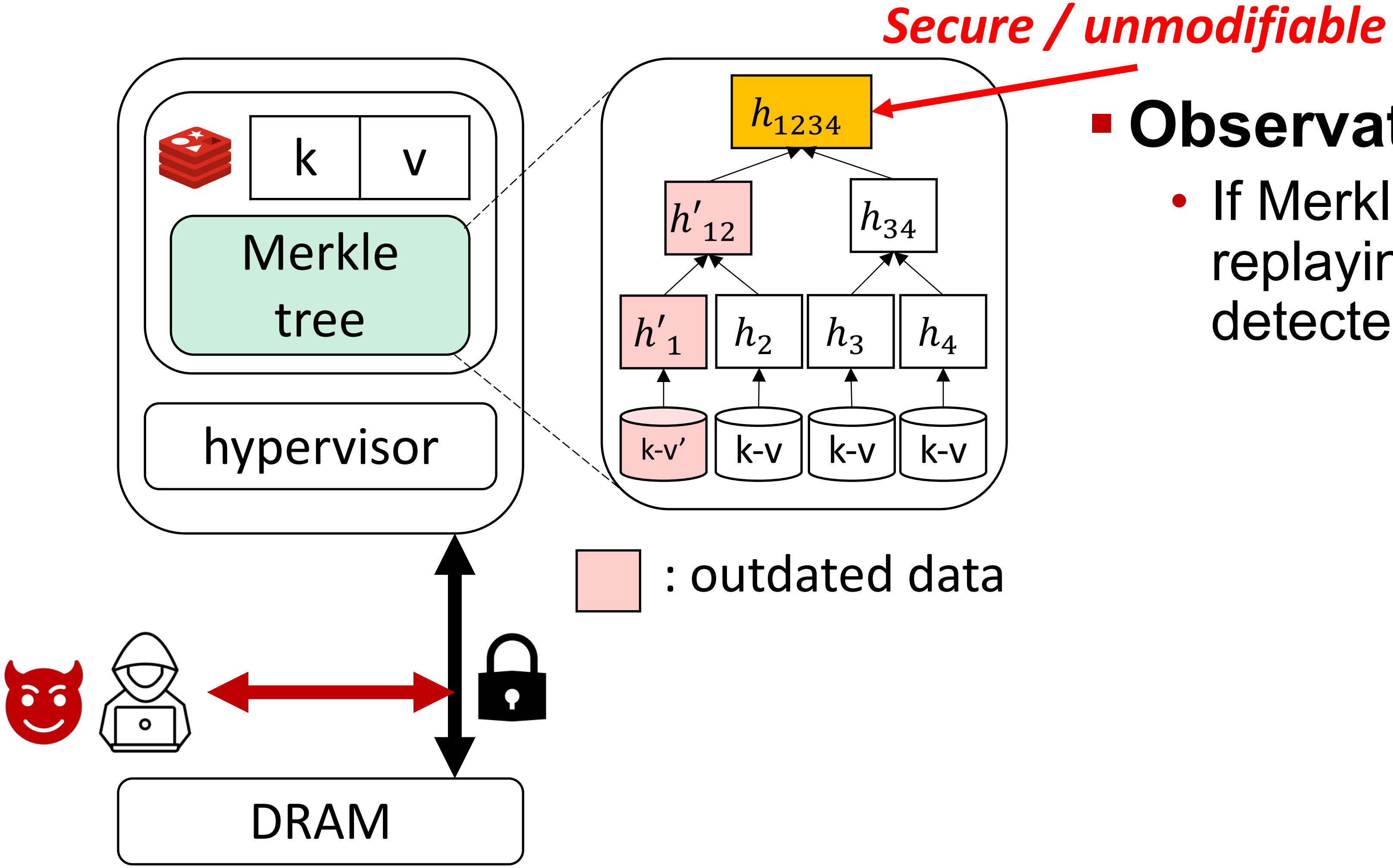

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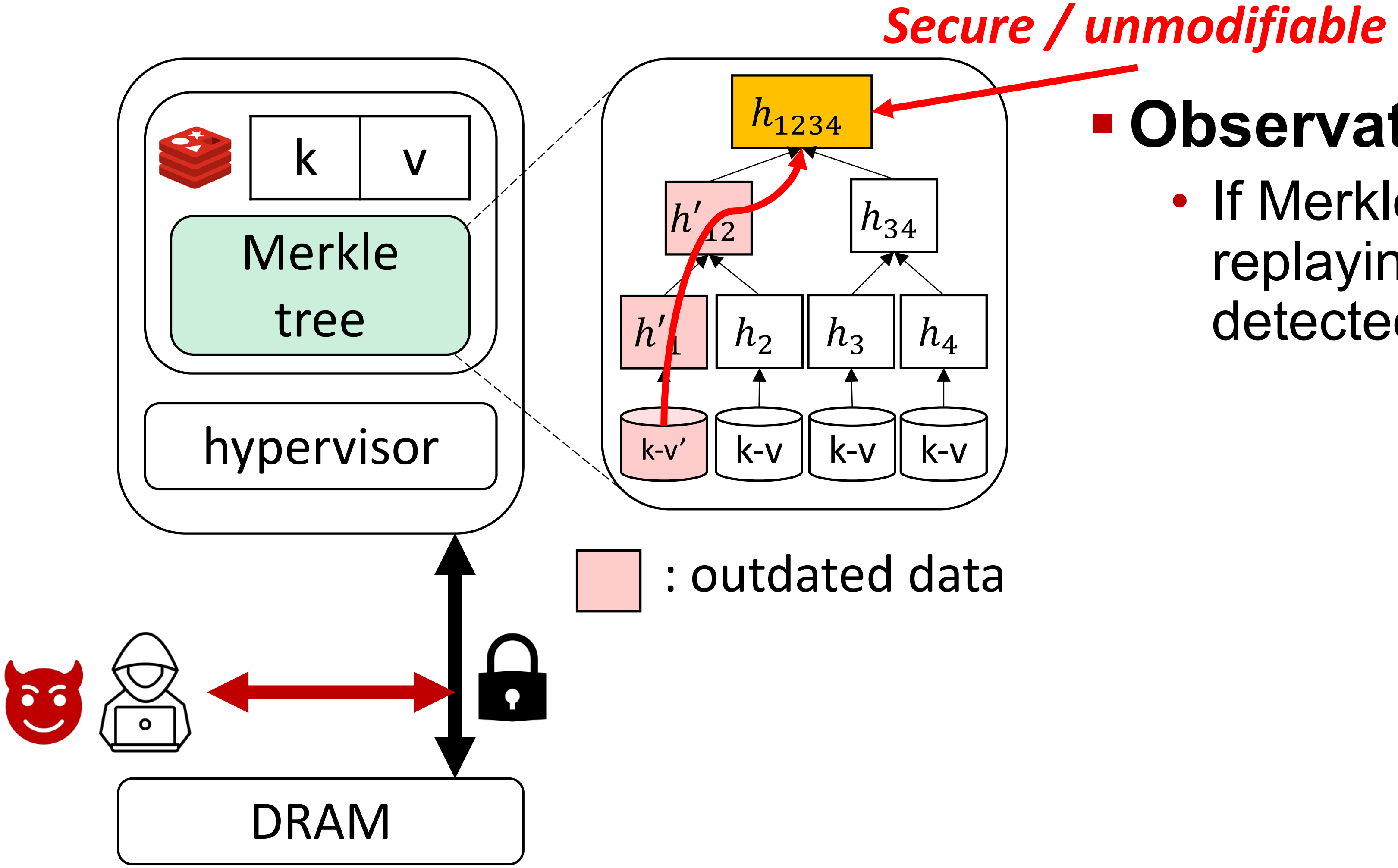

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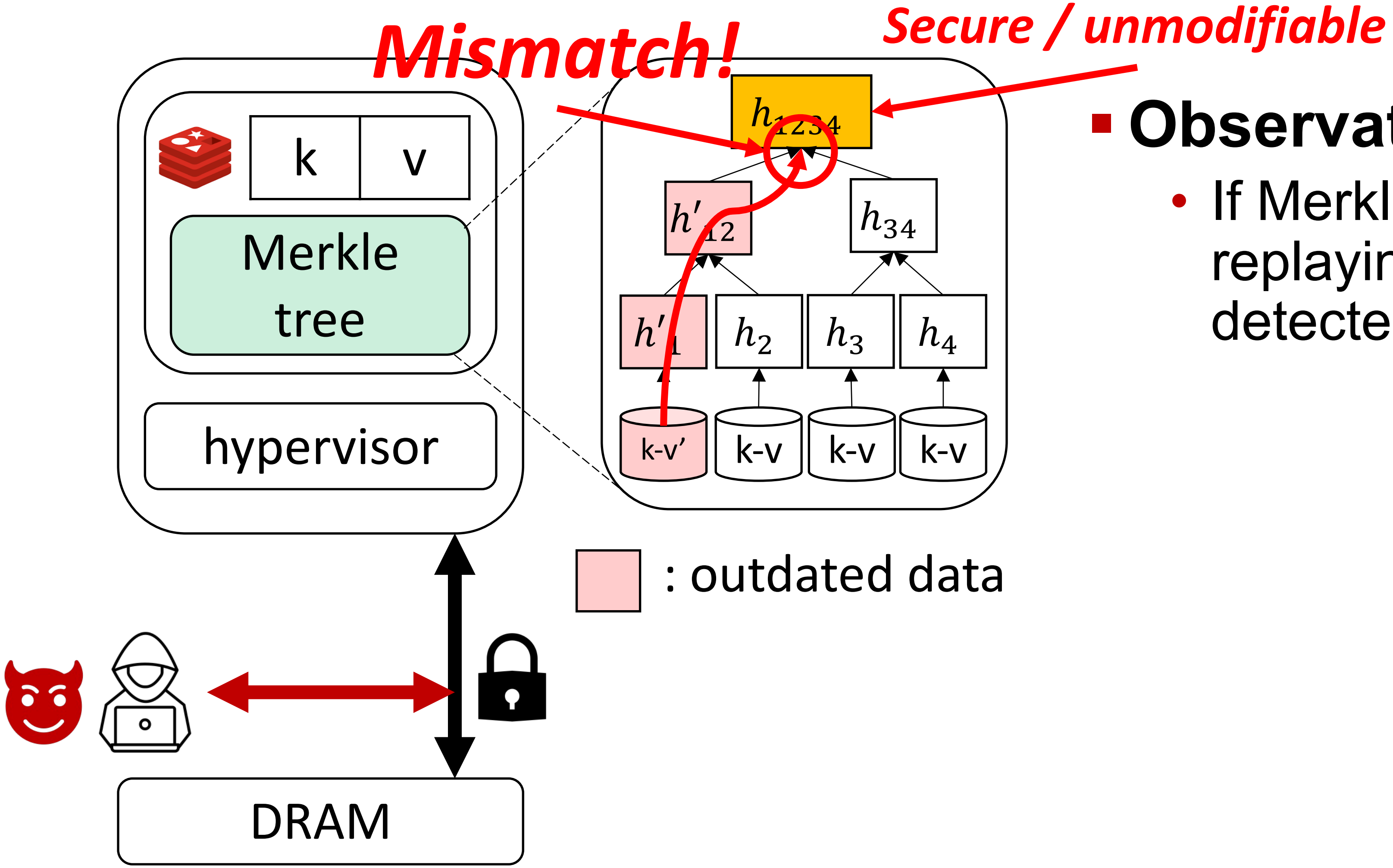

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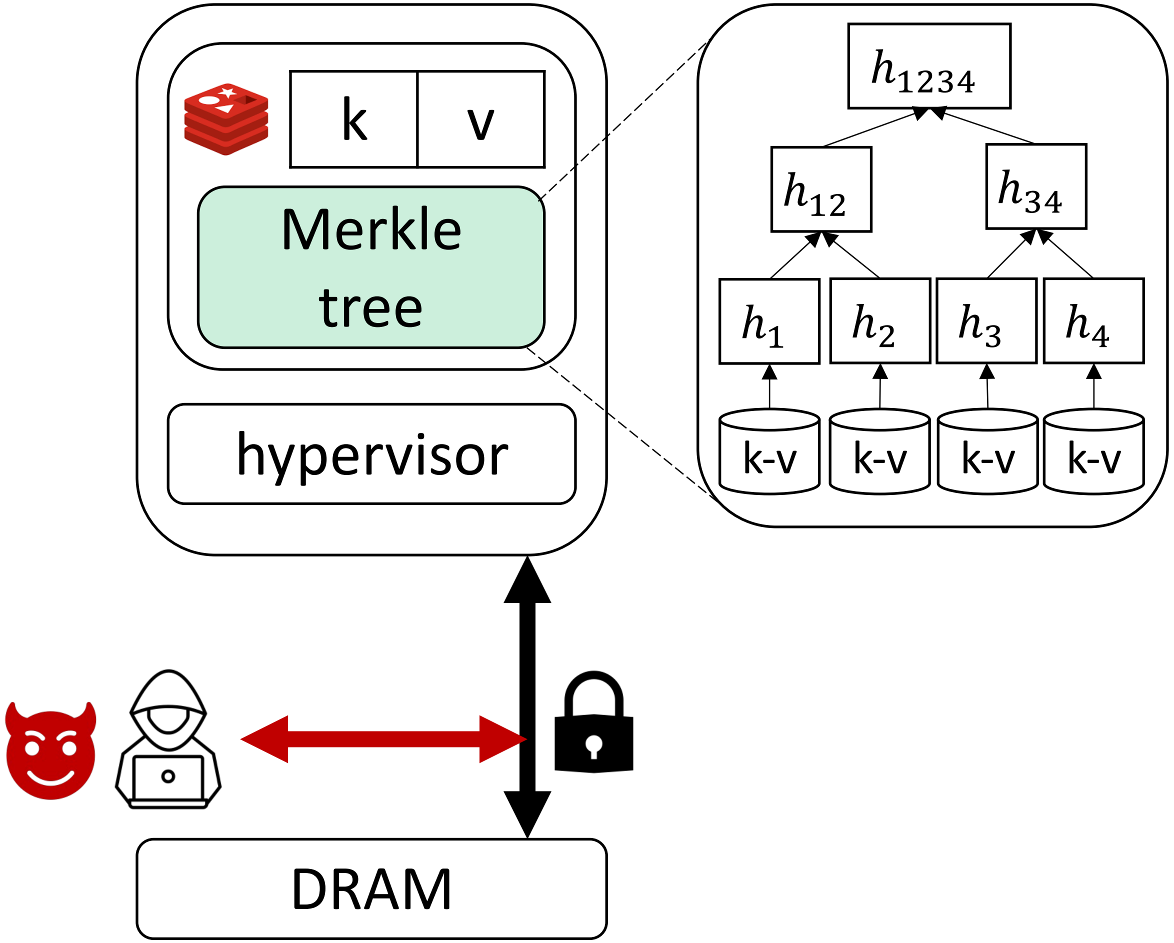

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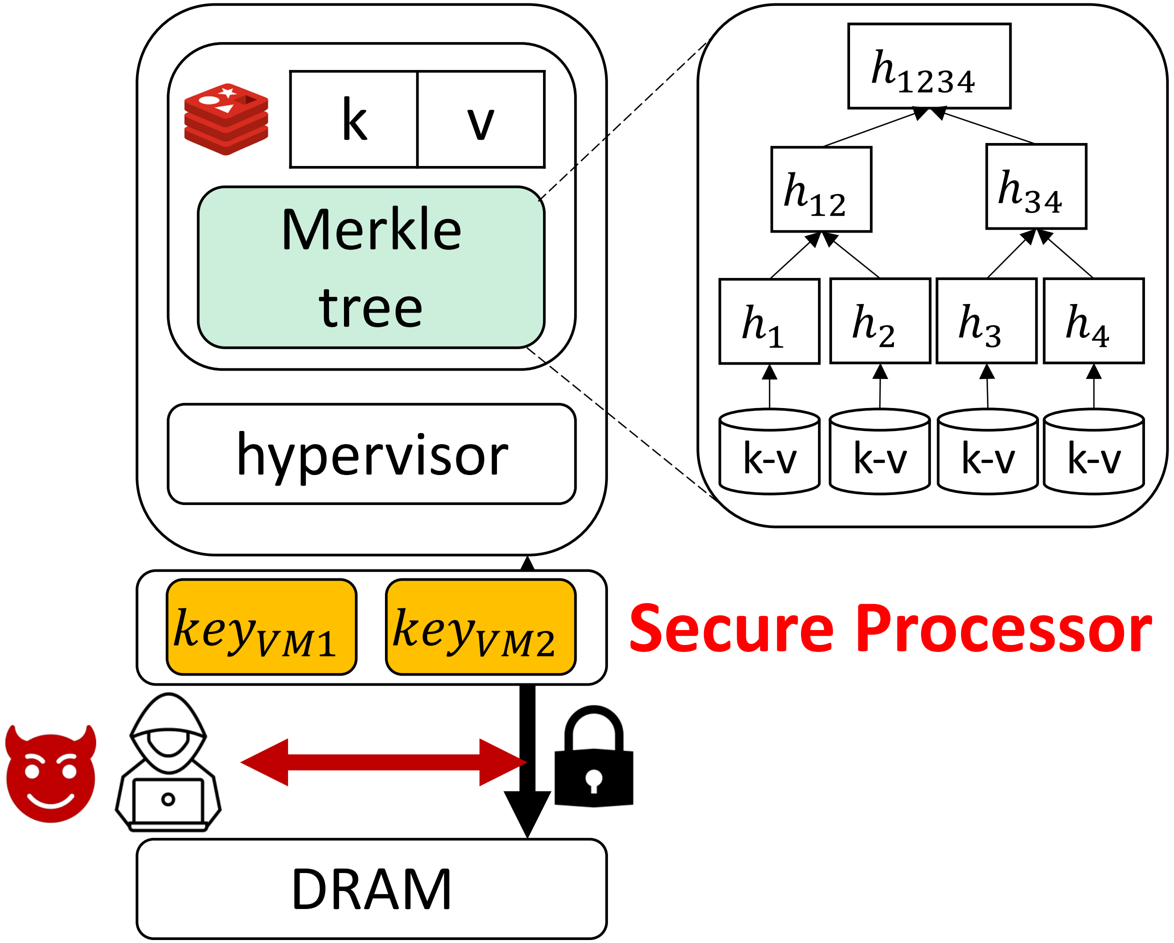

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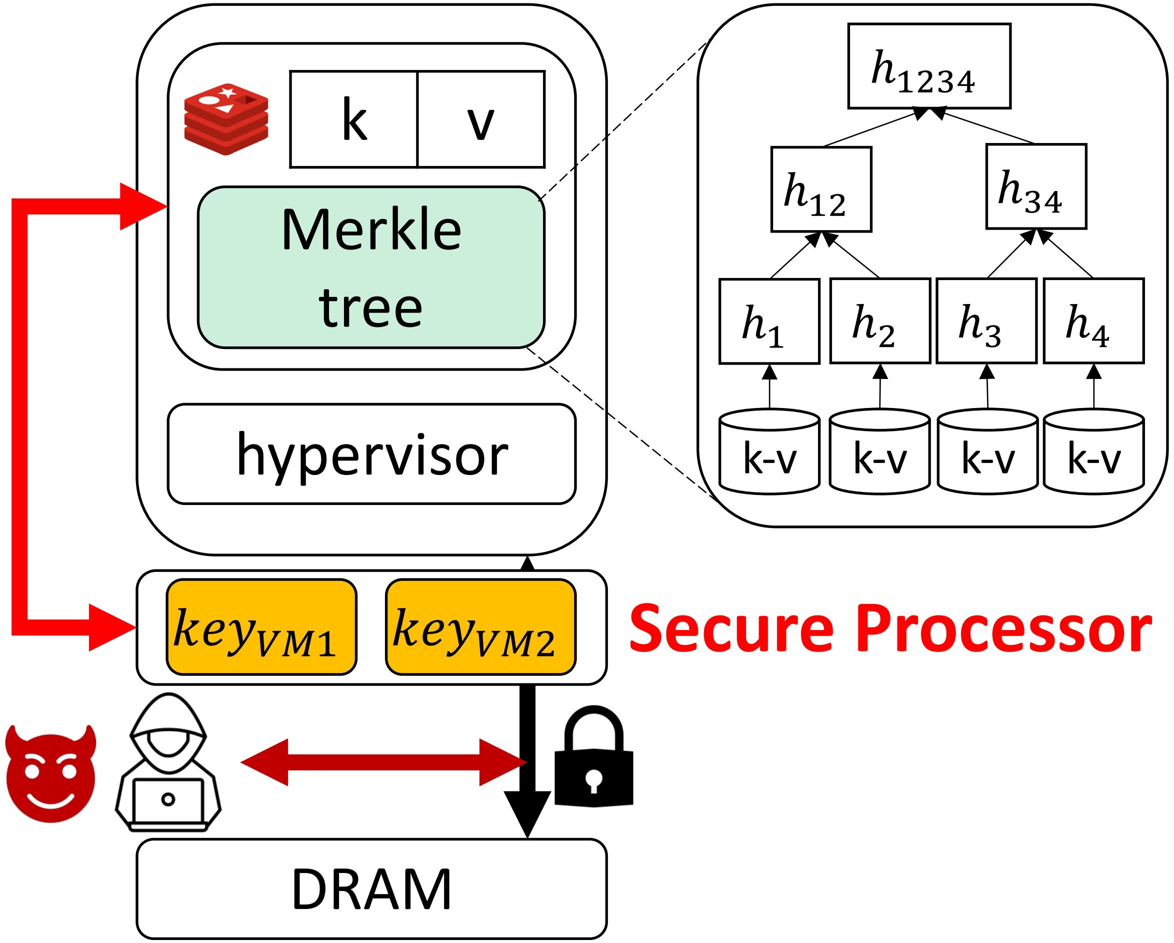

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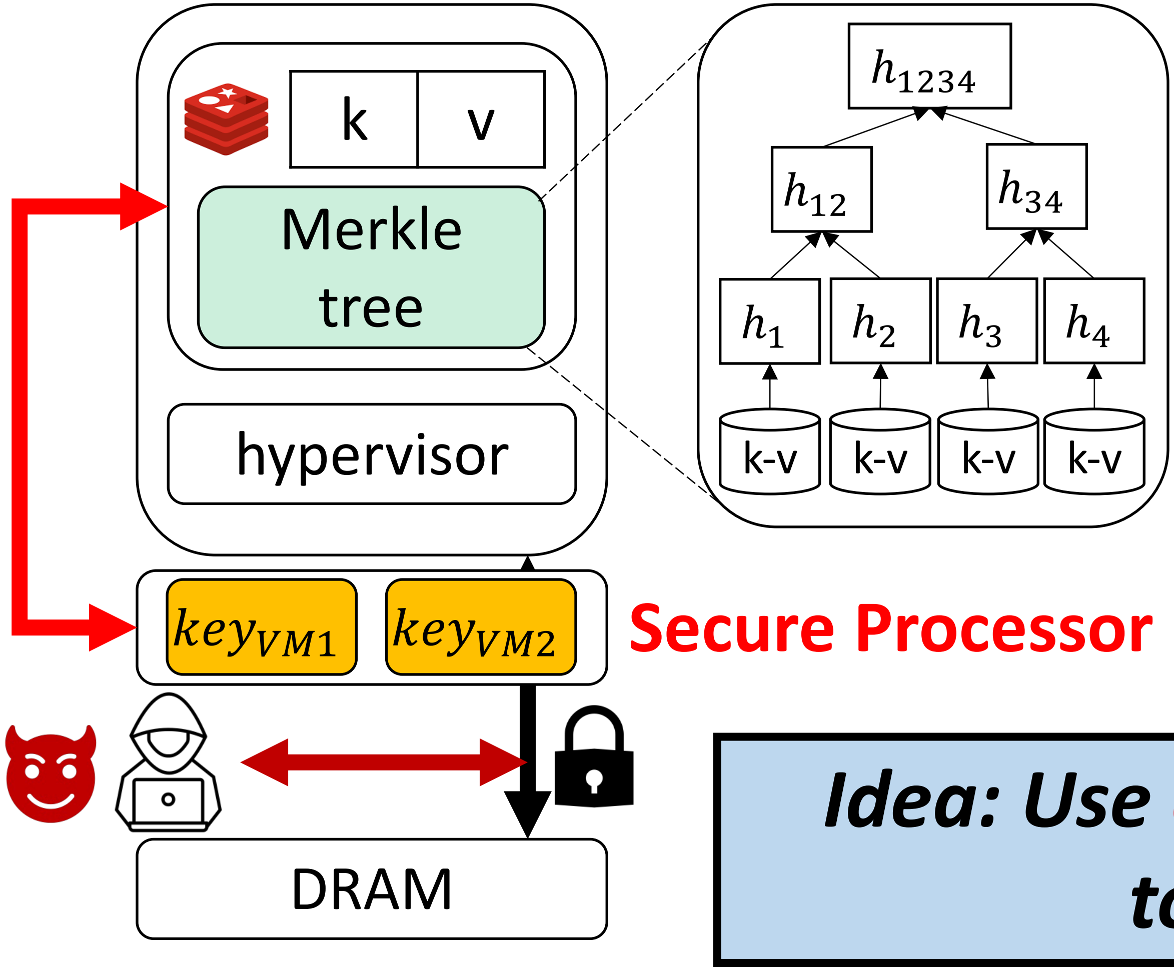

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Idea: Use different VM encryption keys to secure Merkle root

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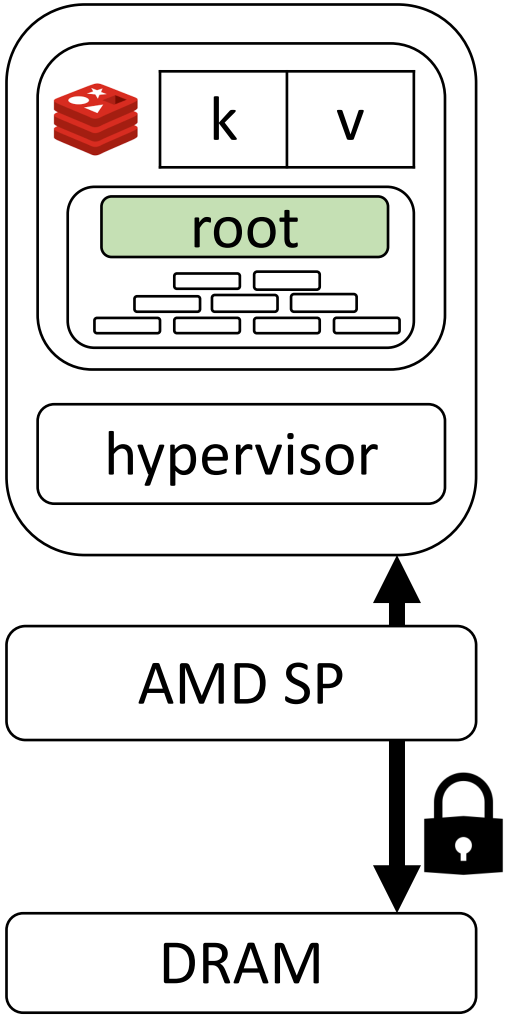

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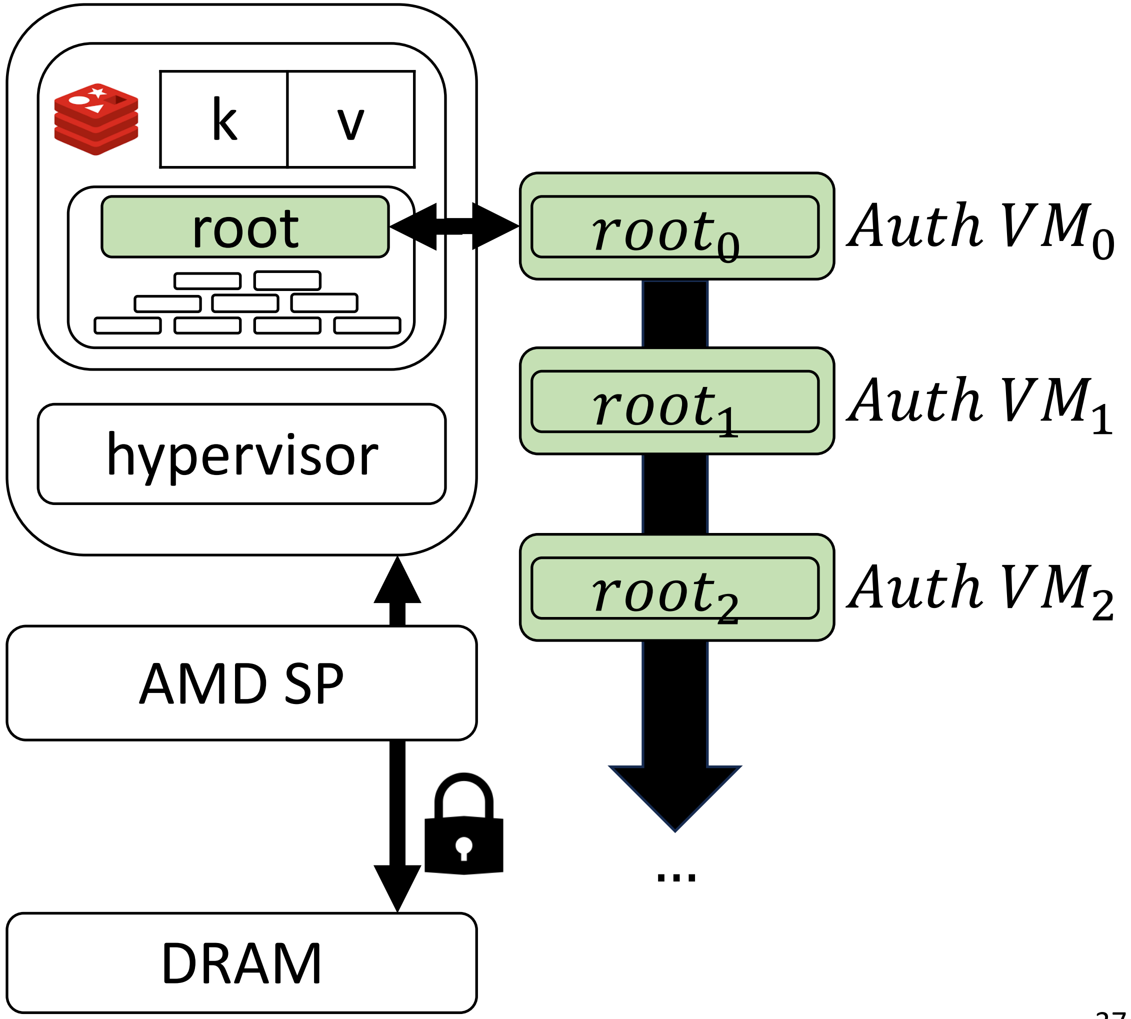

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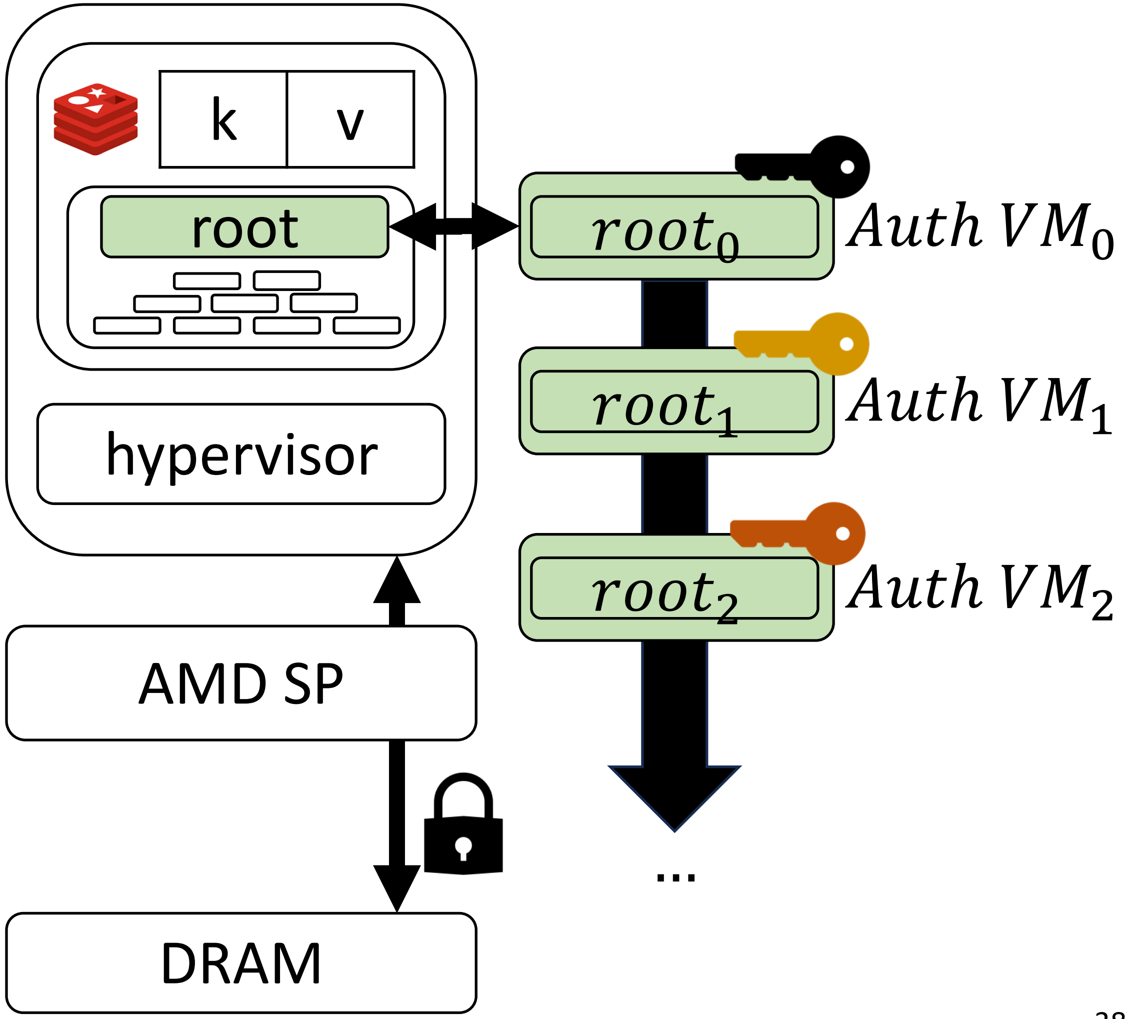

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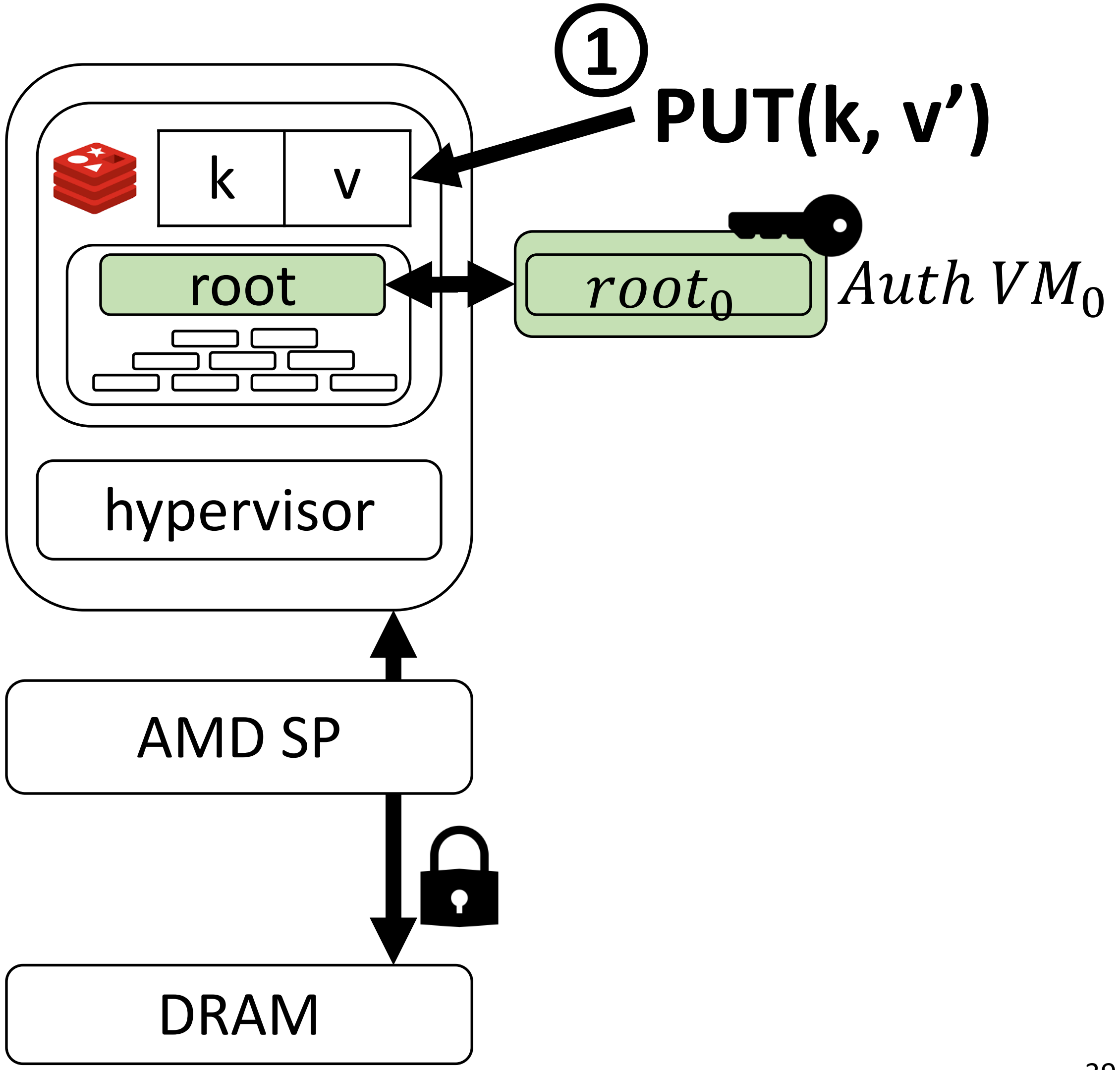

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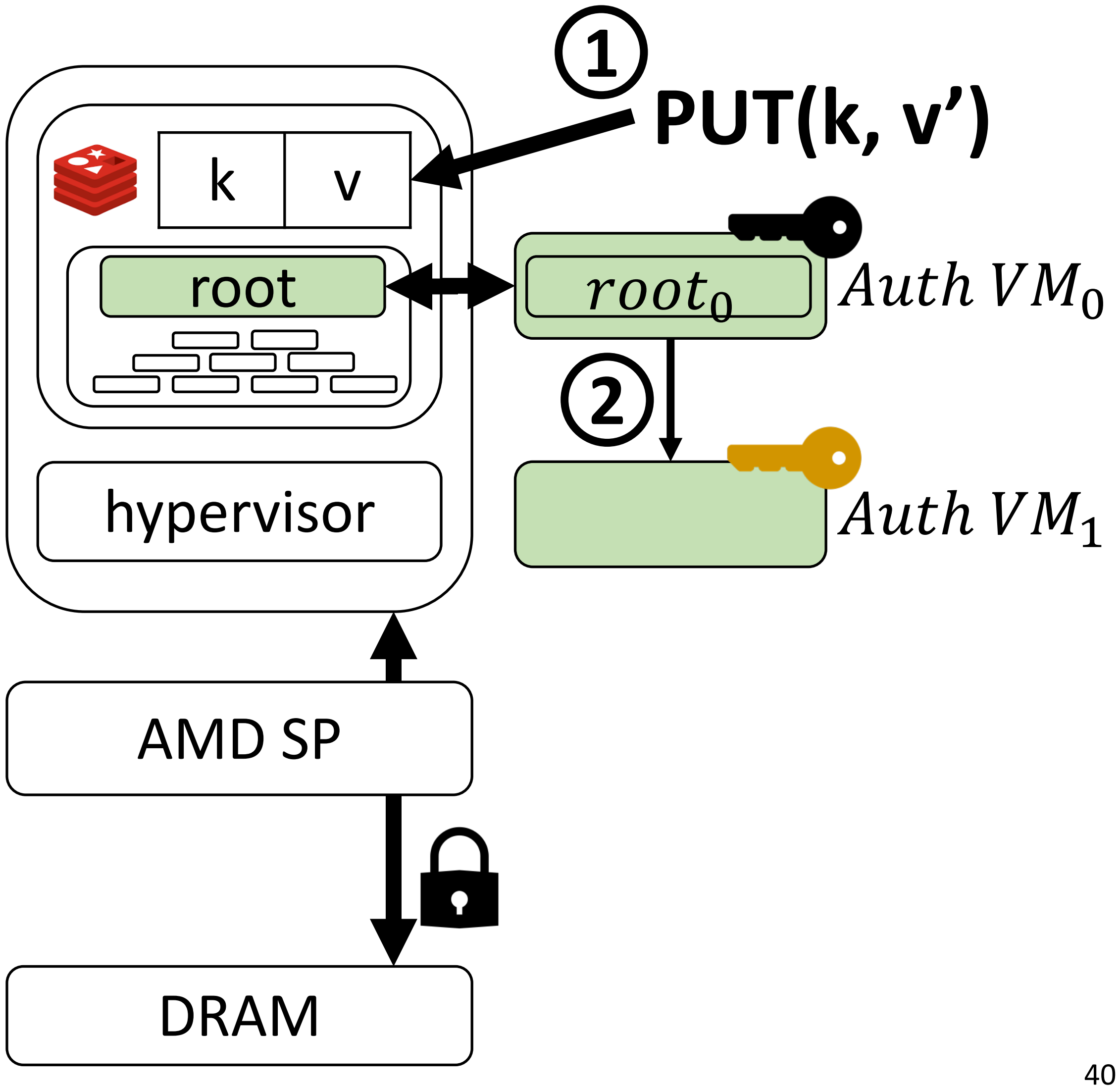

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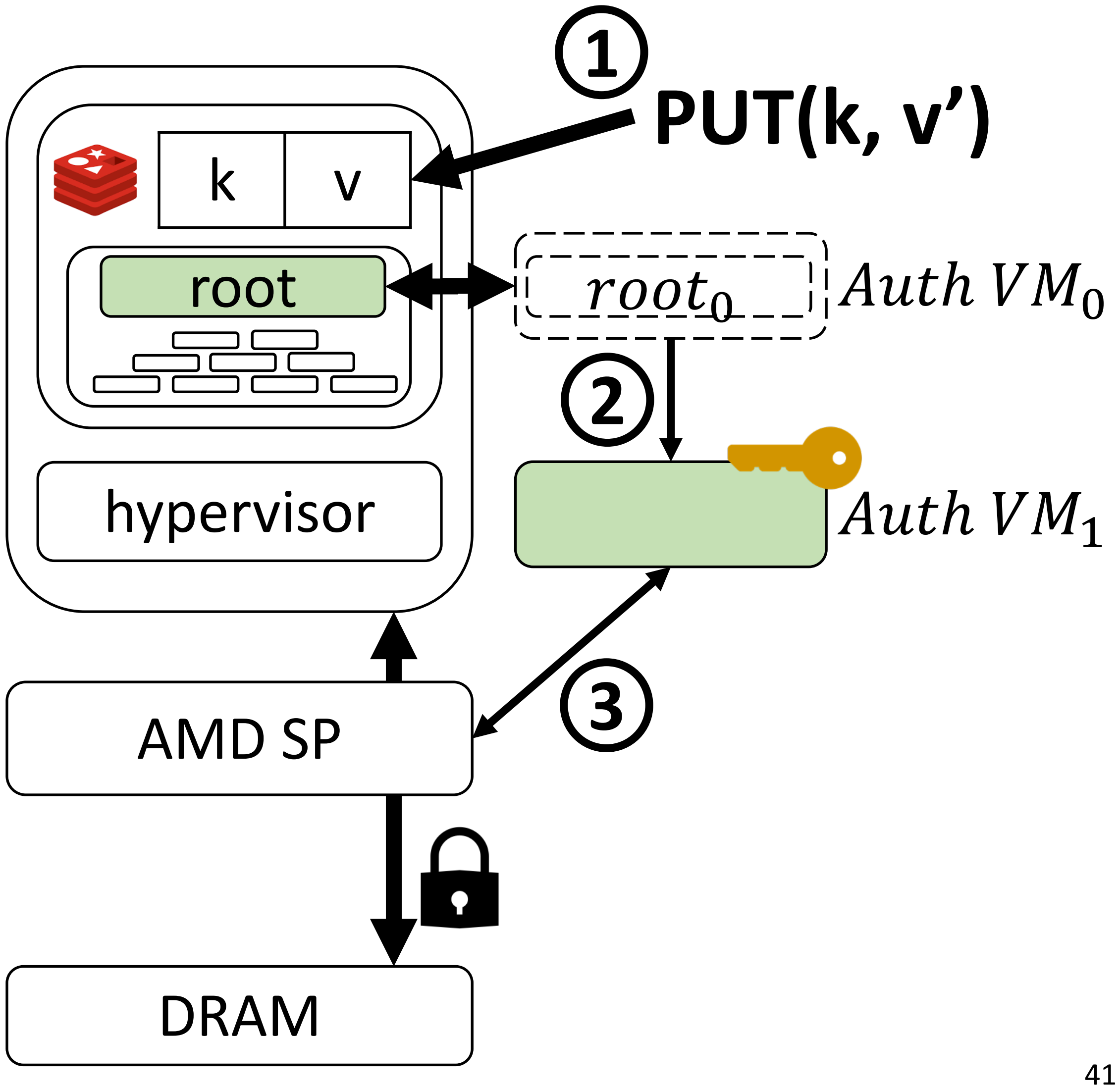

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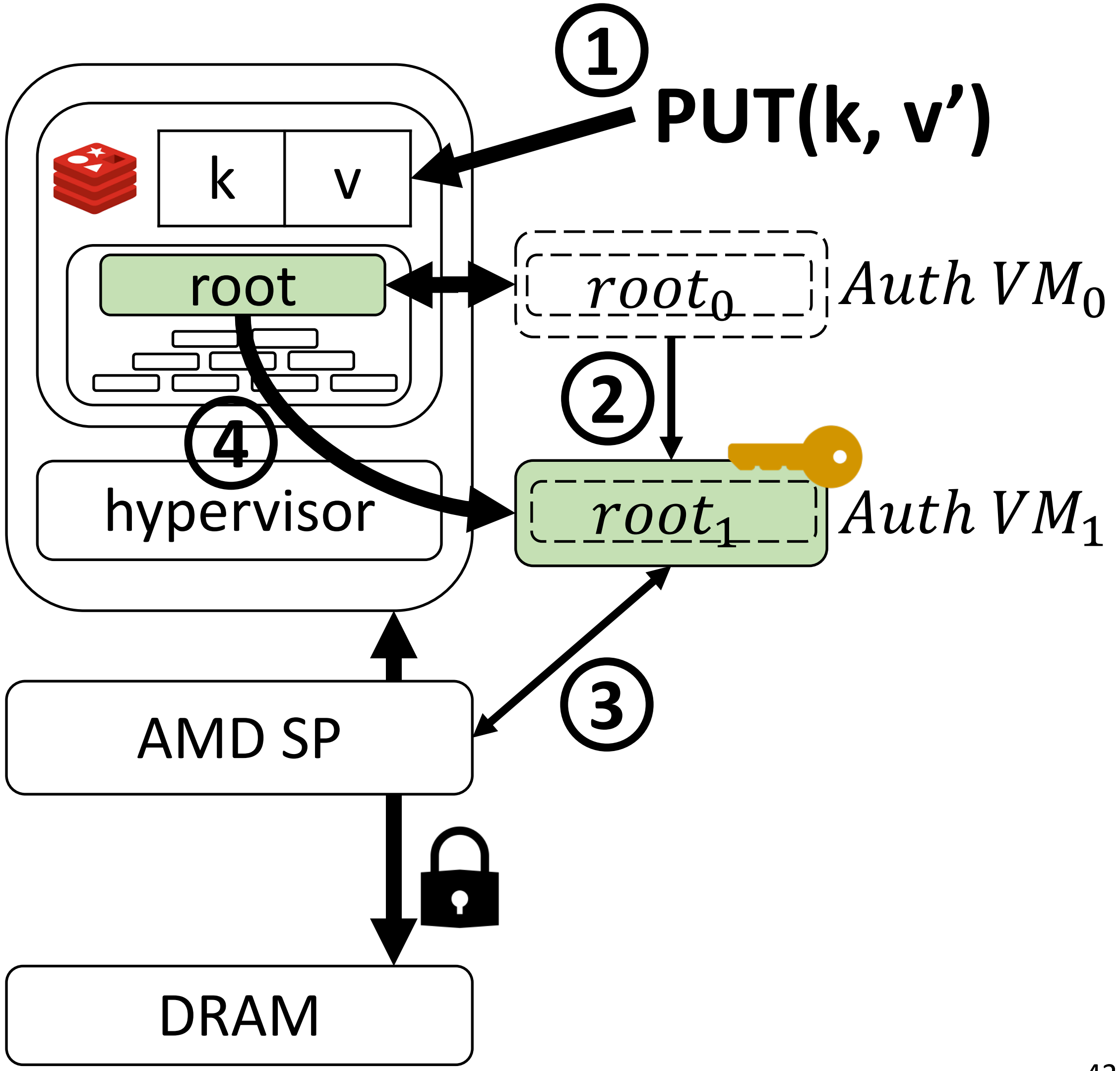

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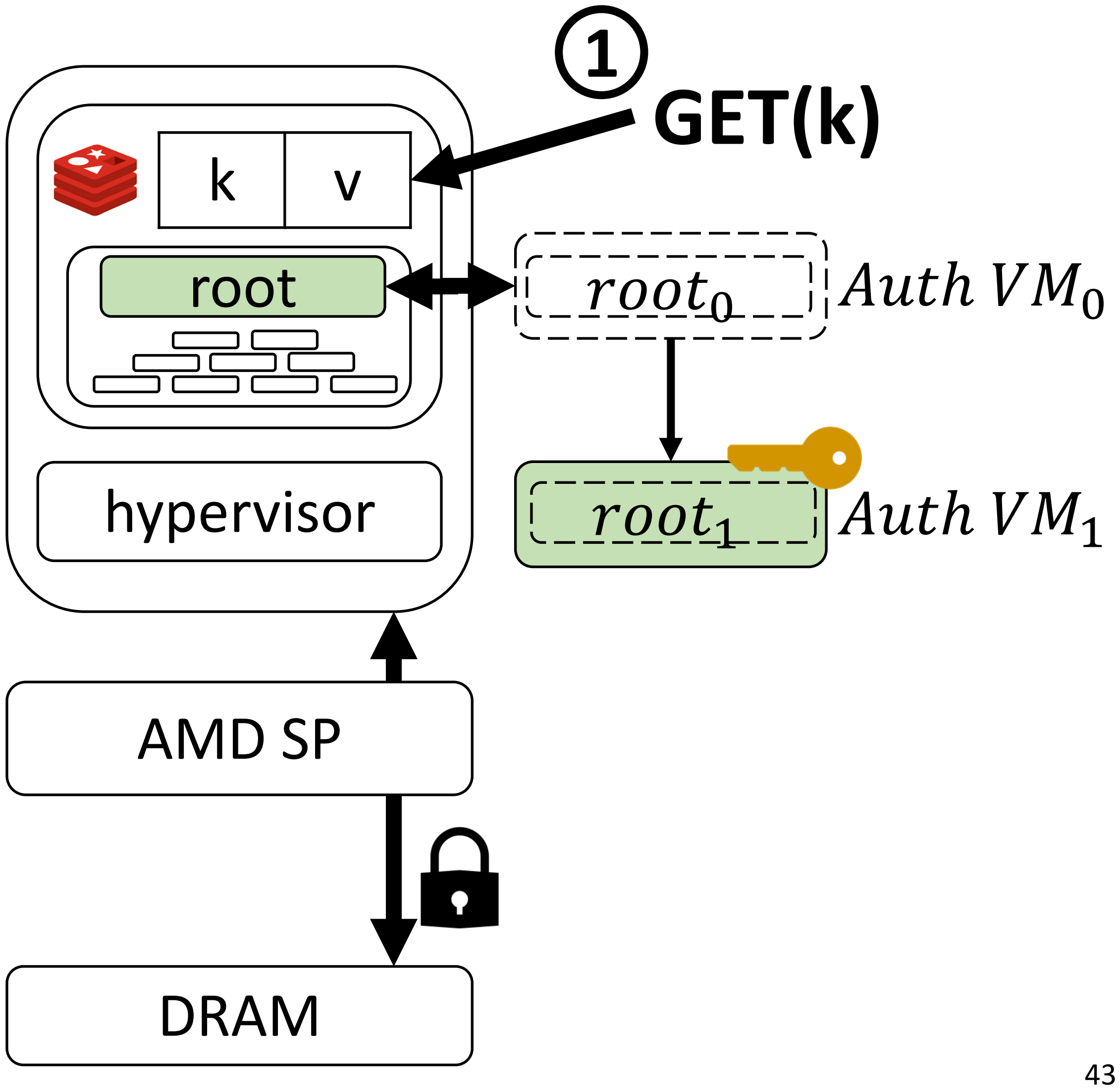

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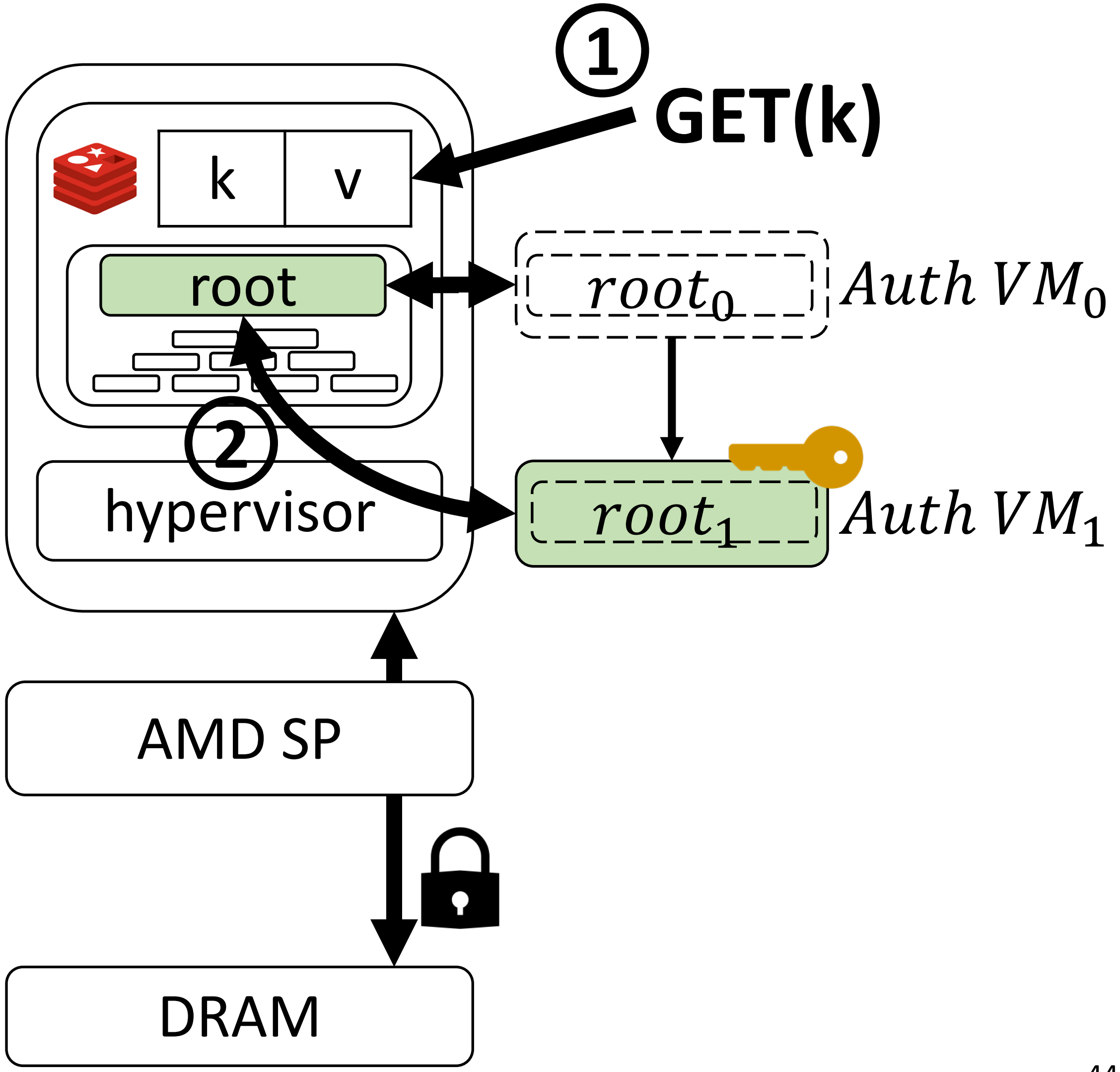

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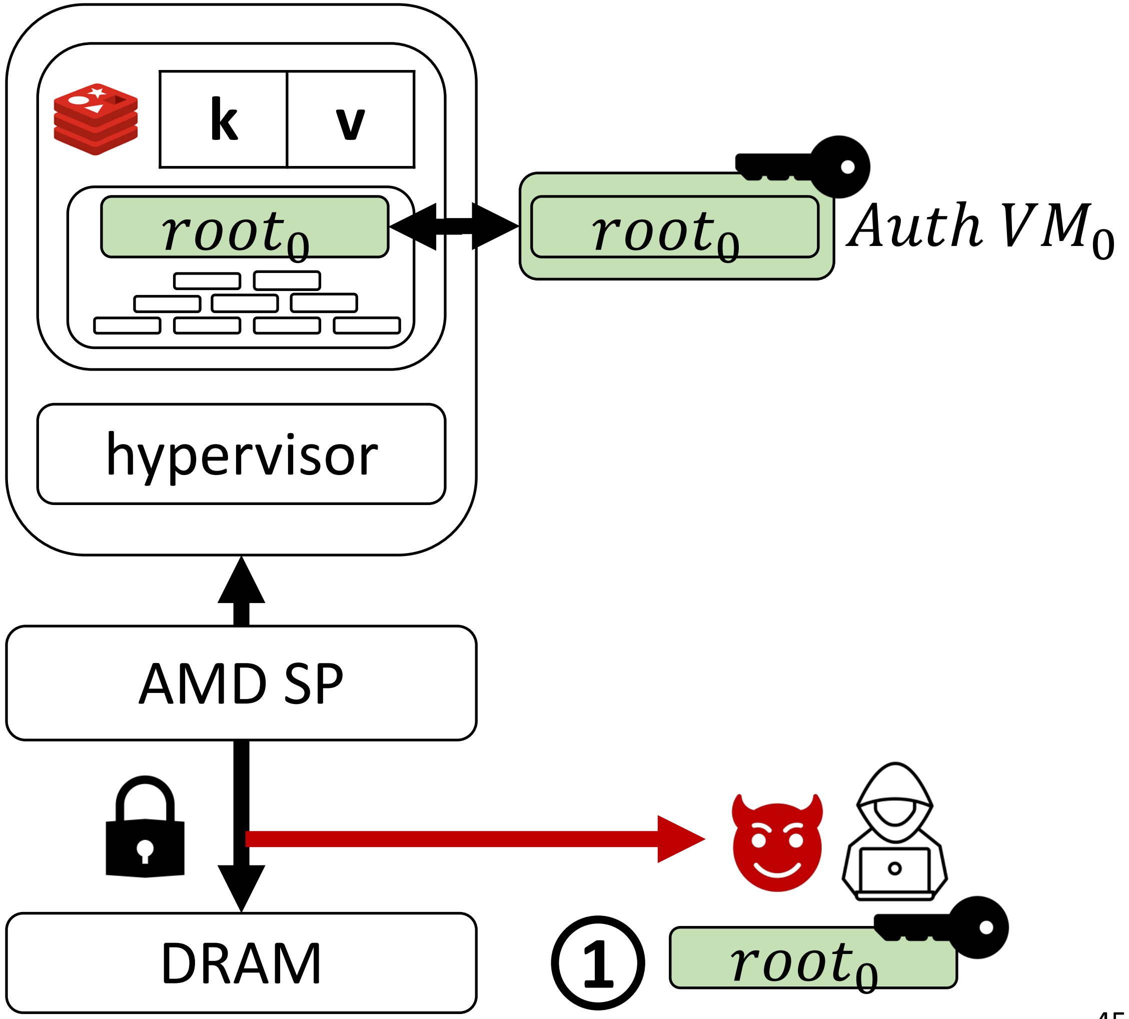

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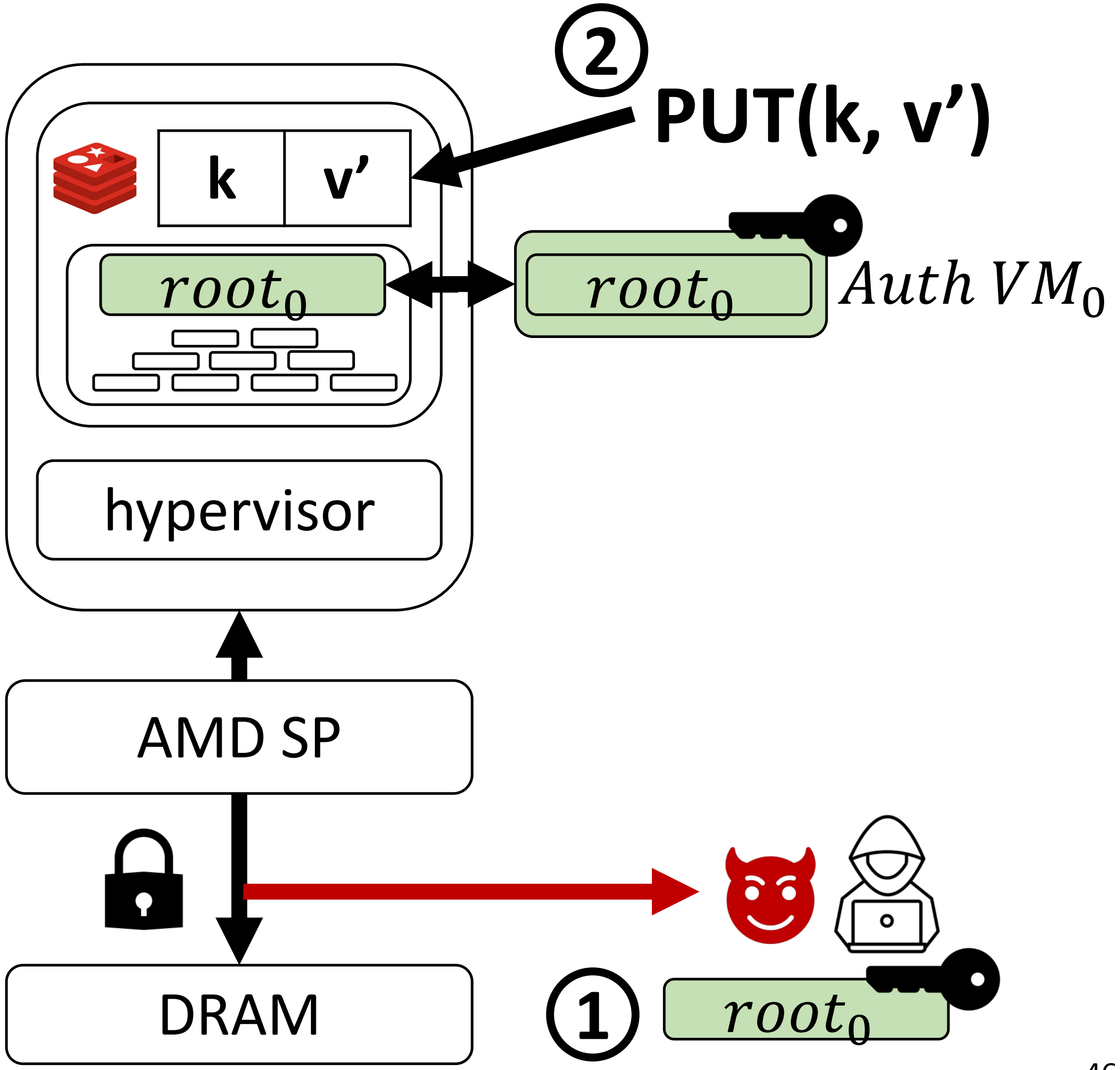

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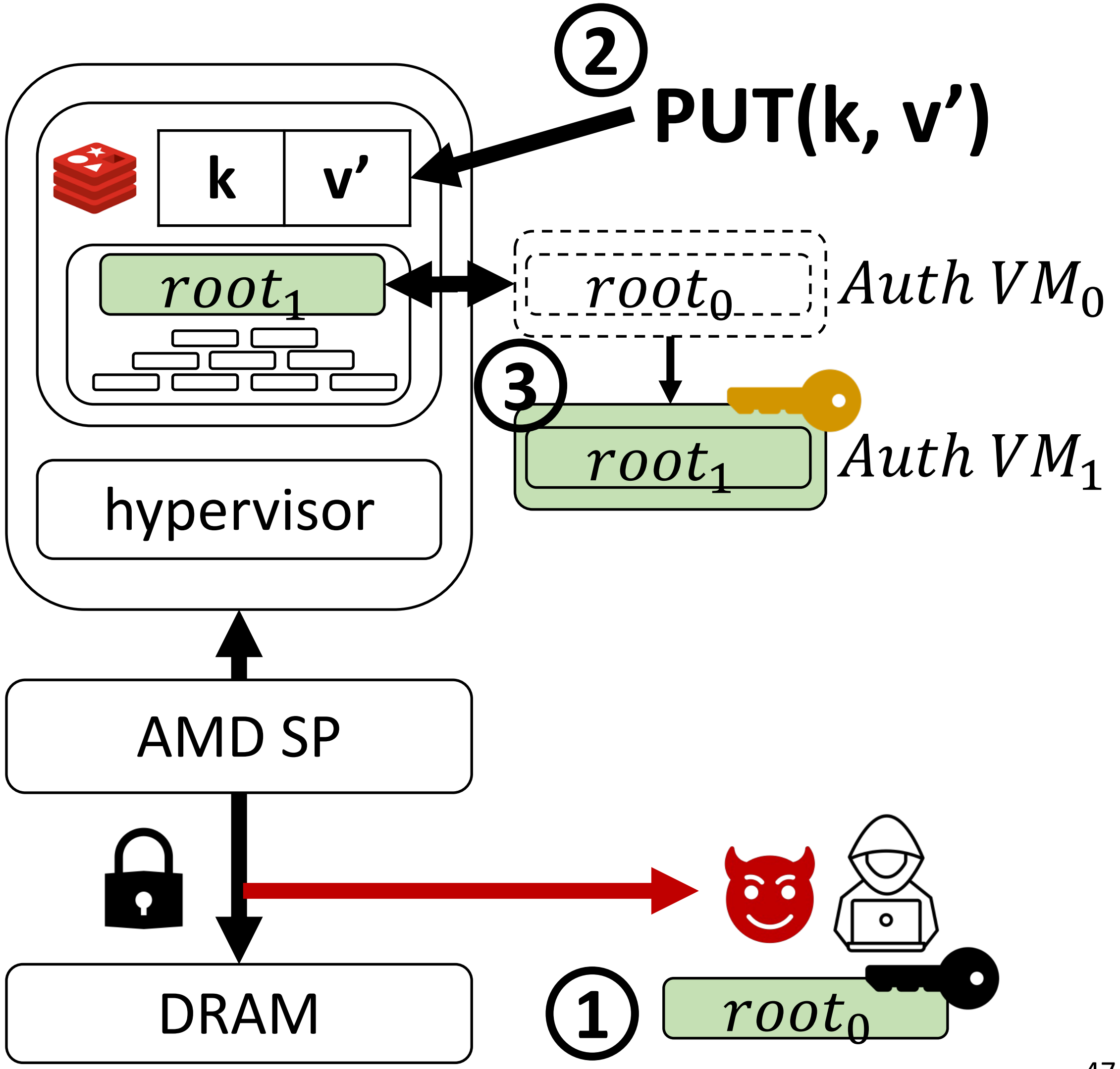

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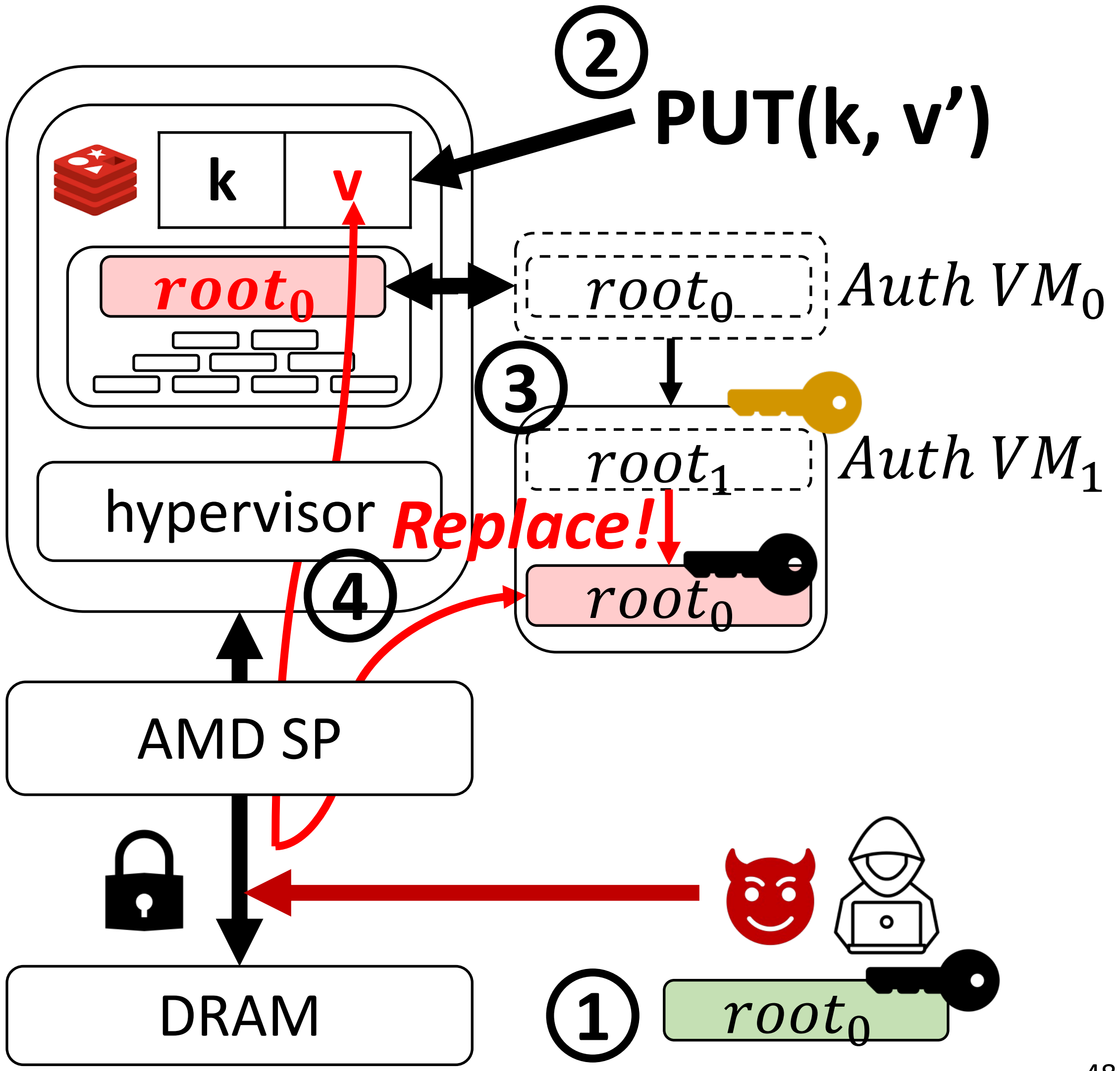

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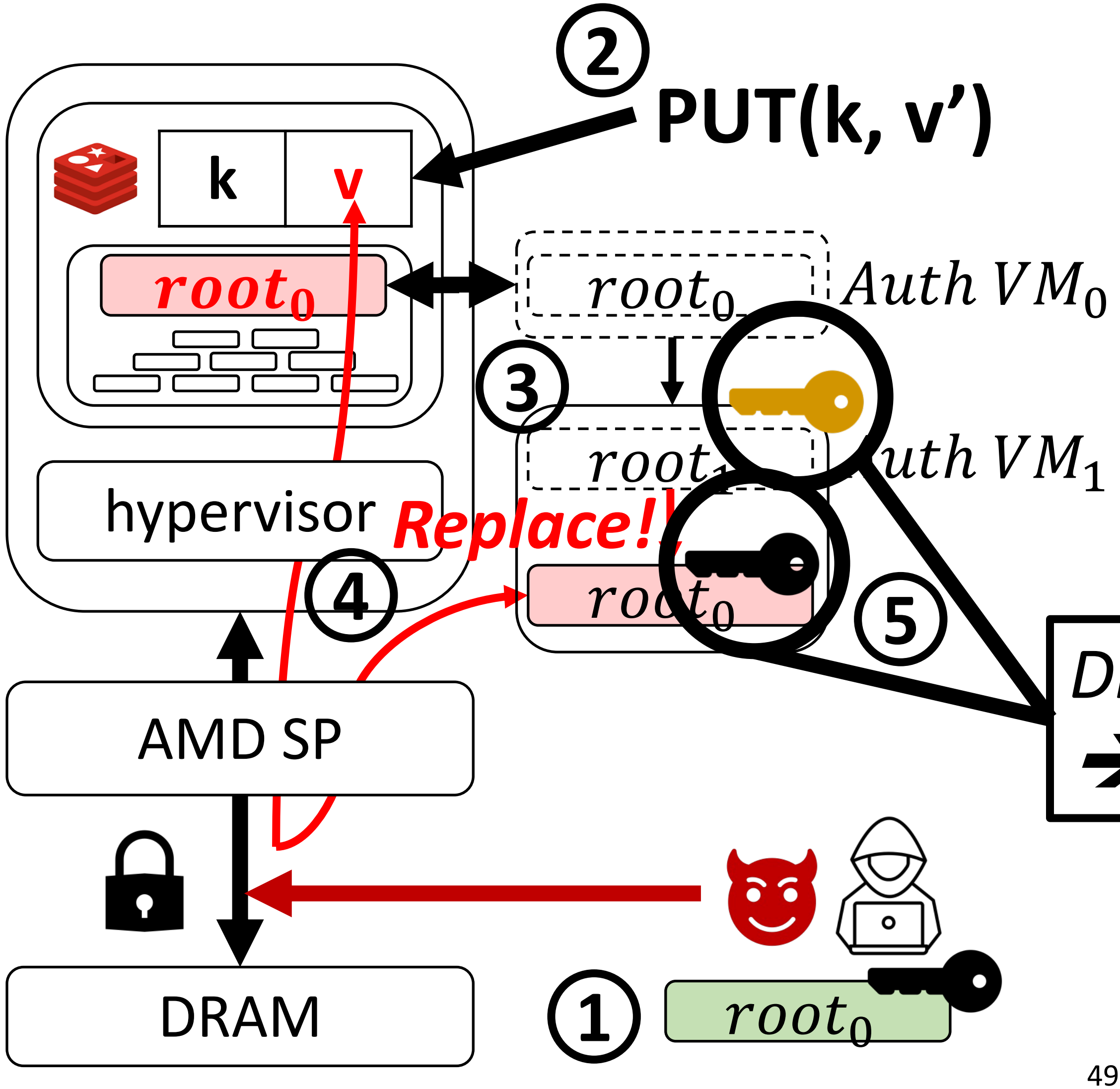

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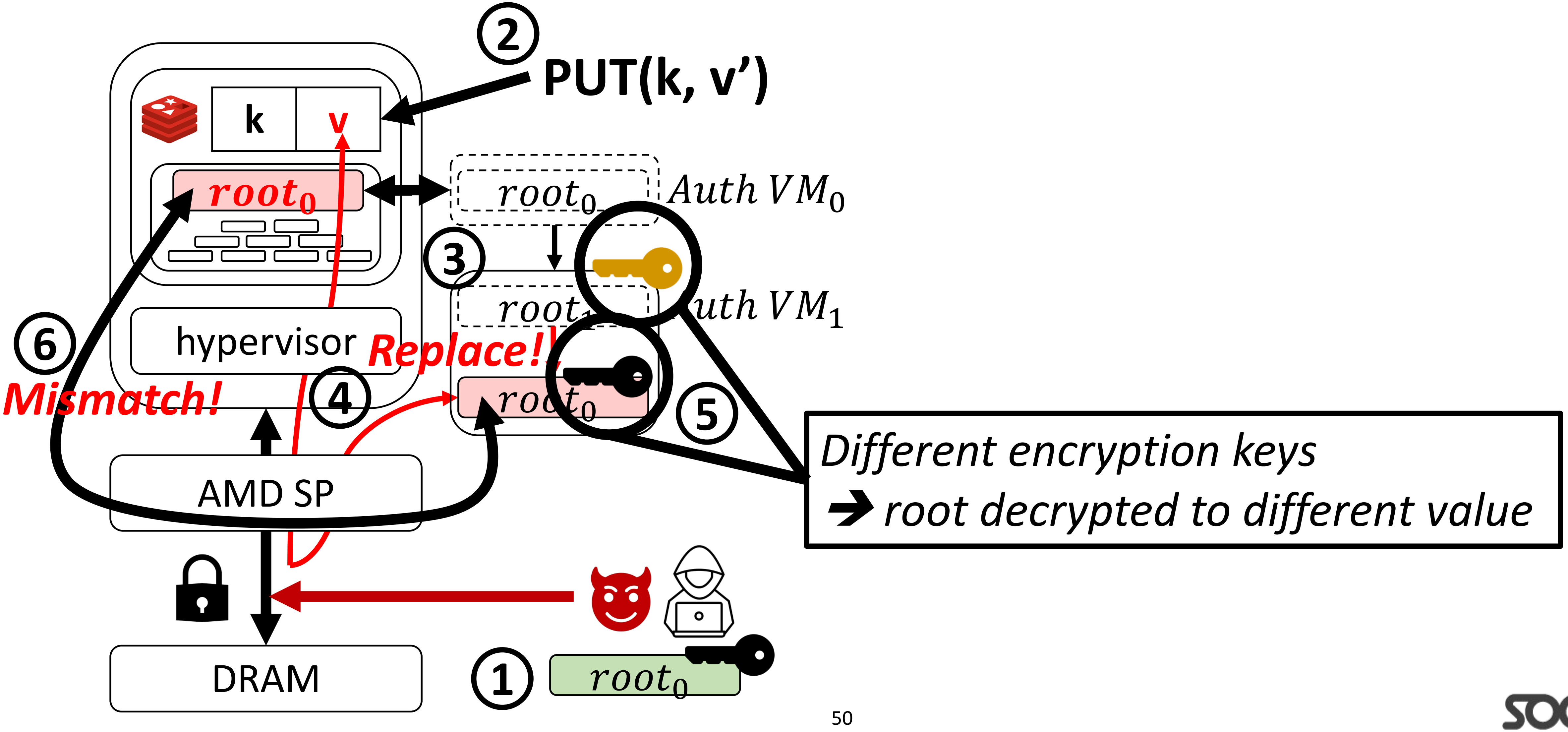

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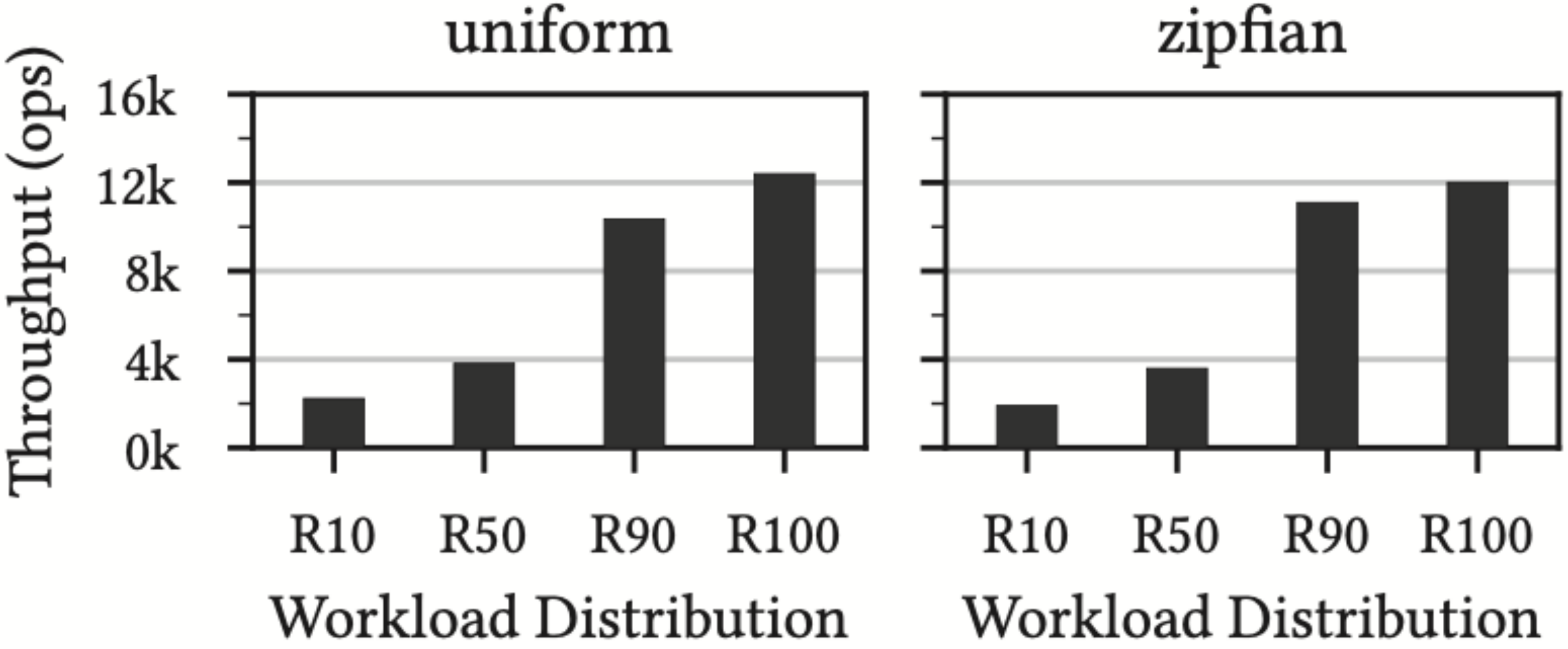
Please refer to the paper for details

Standalone Evaluation

- **KVSEV performs**
  - (Baseline) **13.38x – 64.23x** slower than native KVS
  - Similar numbers across varying number of threads, value size, KVS size



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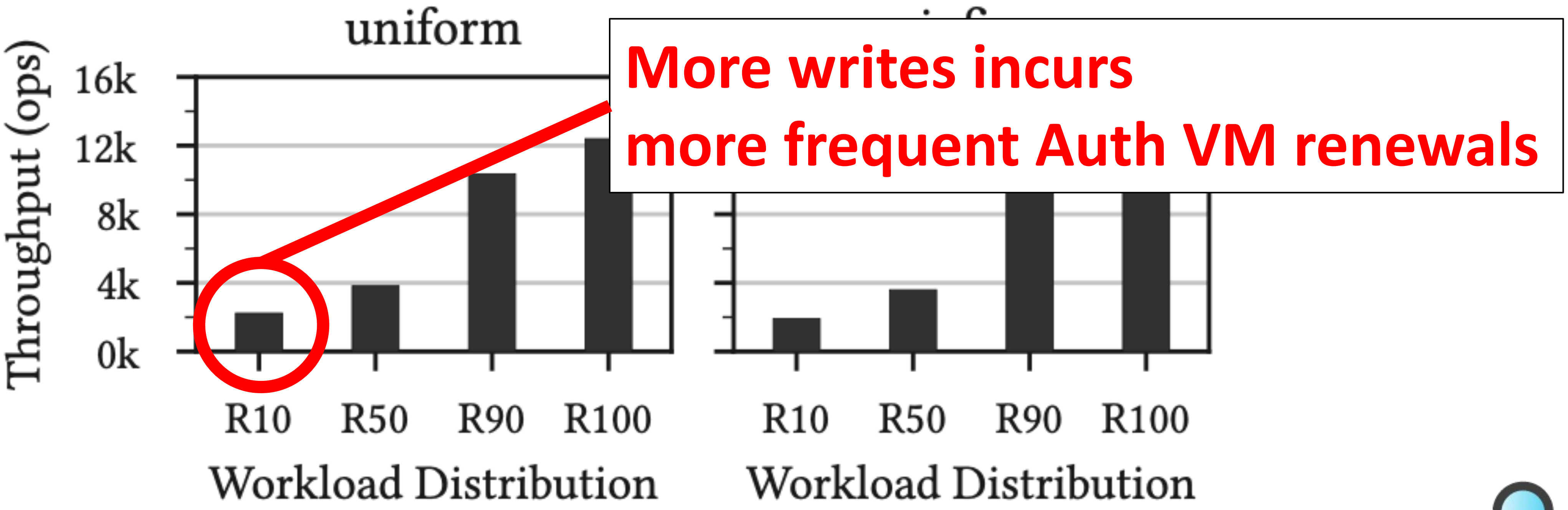
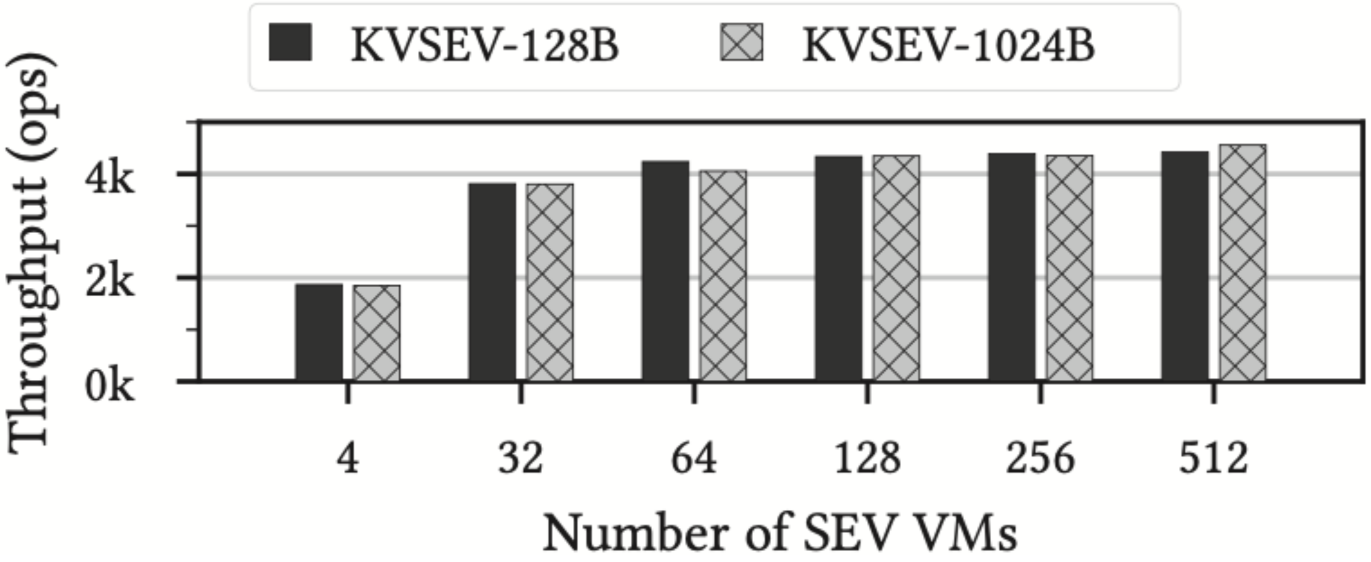
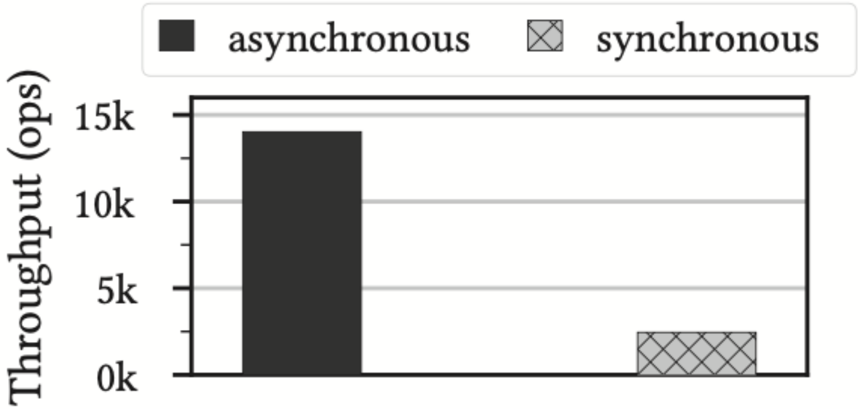


More writes incurs
more frequent Auth VM renewals

Impact of Optimizations

- **KVSEV improves performance by**
  - **2.3x** with *eager VM creation*
  - **5.7x** with *asynchronous verification*
  - **14x** with *Auth VM debloating* (151.1 VMs/s ➔ 2156.3 VMs/s)





Comparison to SGX-based Secure KVS

- **KVSEV performs better than ShieldStore by**
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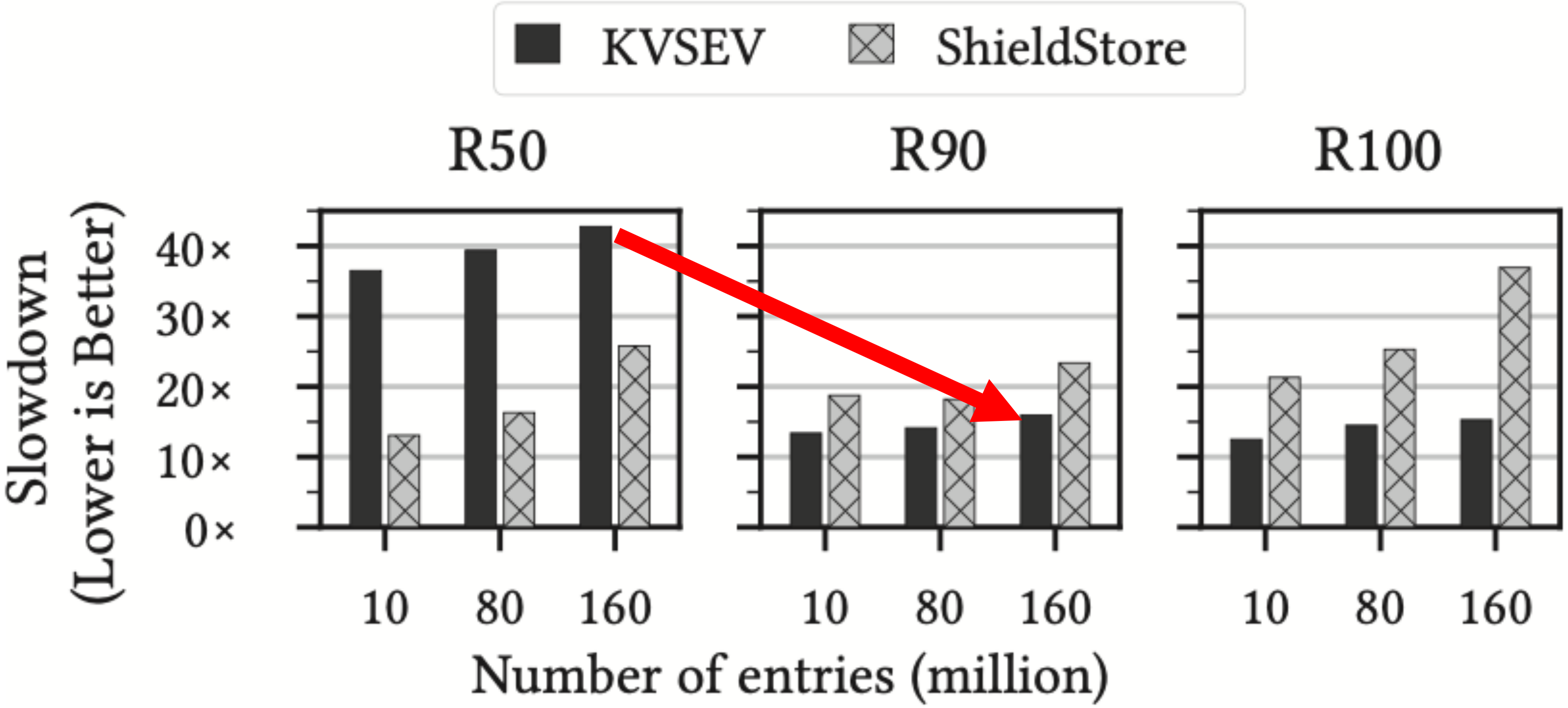

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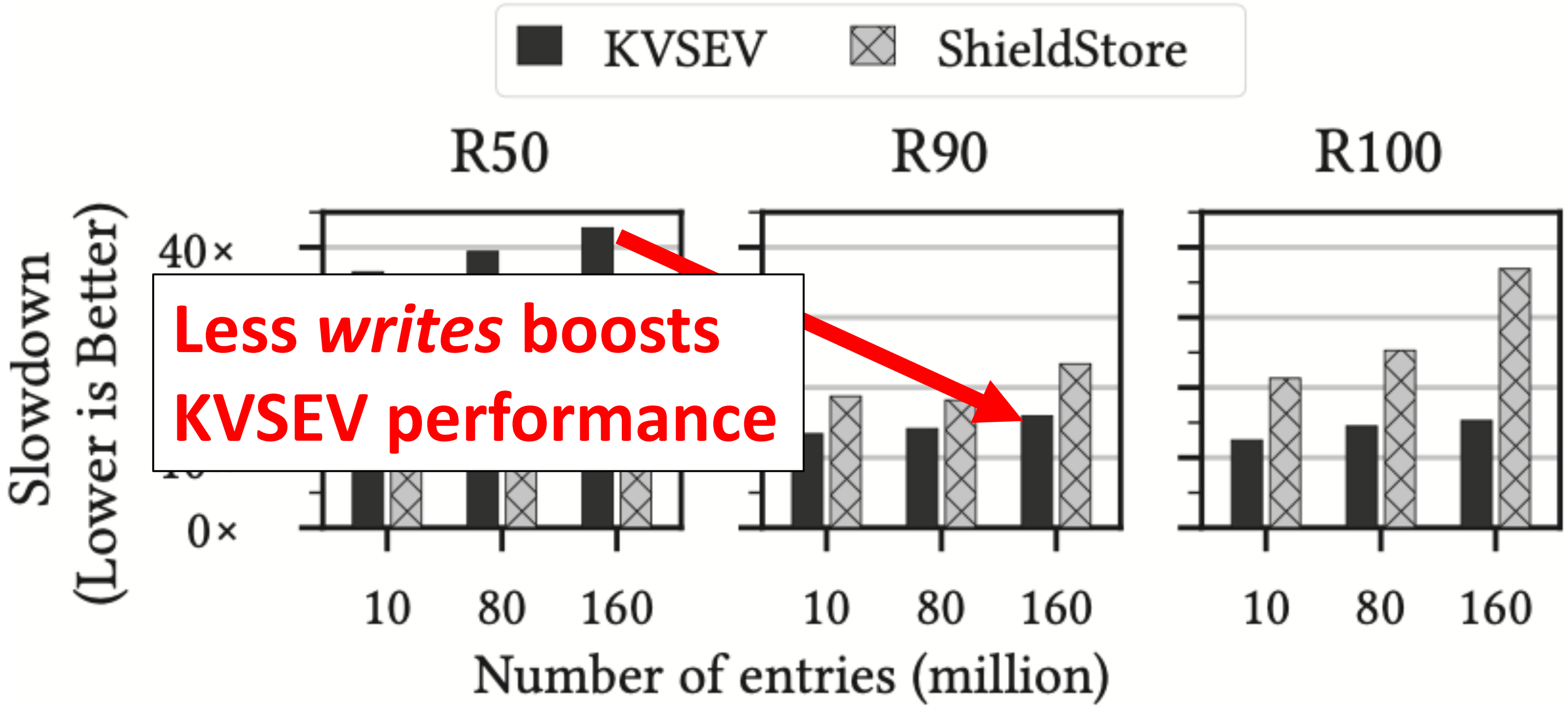

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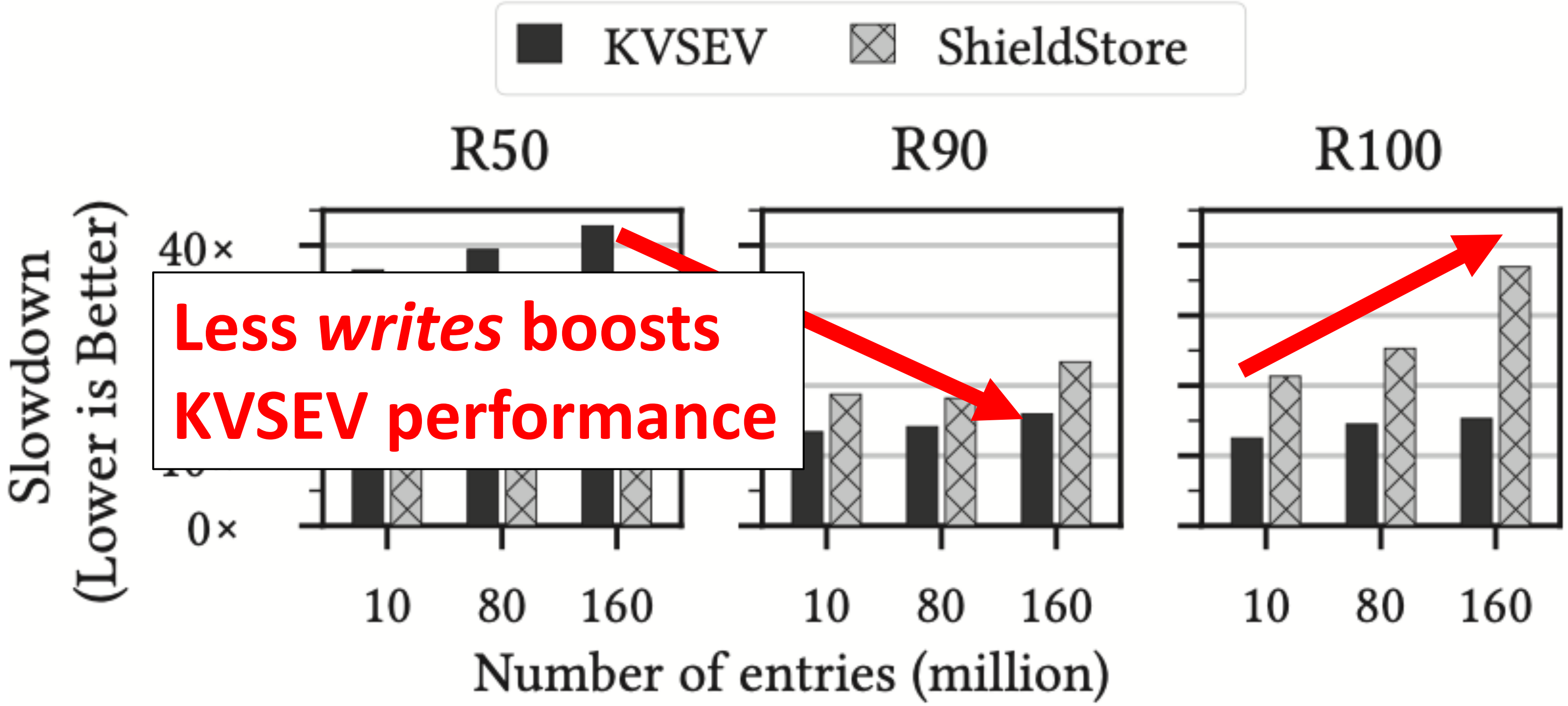

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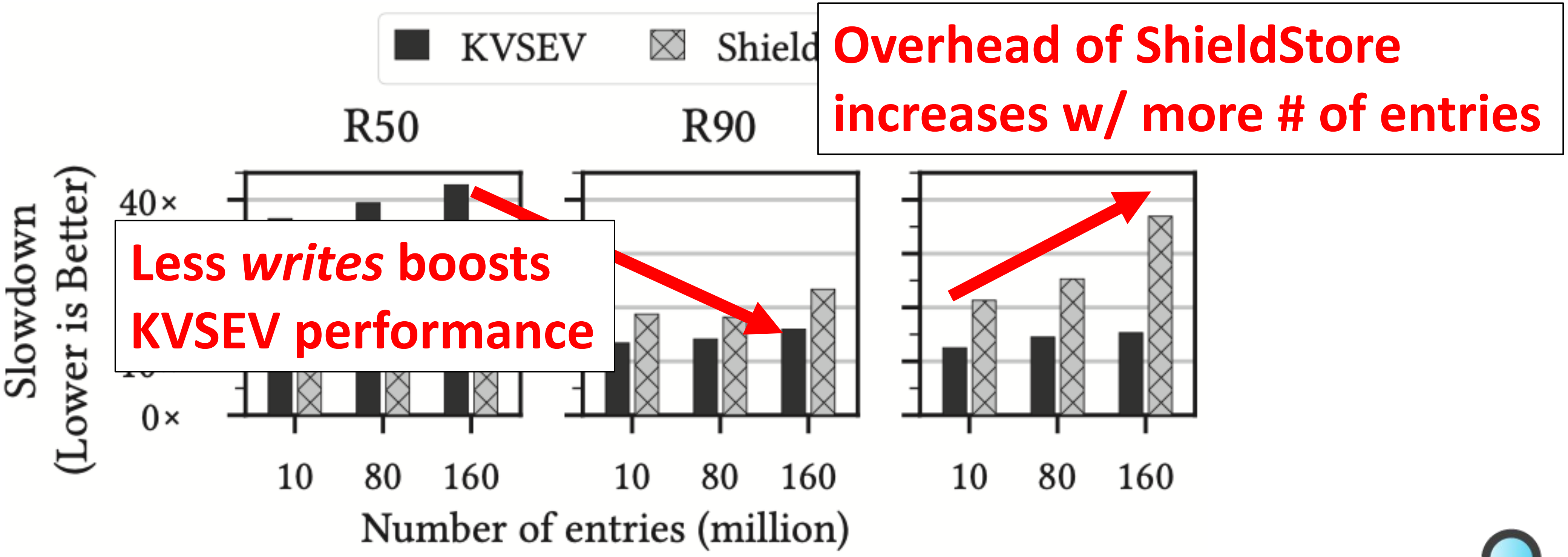

Overhead of ShieldStore increases w/ more # of entries

Less *writes* boosts KVSEV performance

Summary

- KVSEV is a **secure** in-memory KVS with AMD **SEV**
- KVSEV protects KVS from **physical adversaries** by using **ephemeral VMs** as safe storage for SW-only Merkle tree roots

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Santa Cruz, USA
October 31-November 1, 2023