ELECTRICAL & COMPUTER ENGINEERING
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Optimizing Post-Copy Live Migration with System-Level Checkpoint Using Fabric-Attached Memory

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Outline

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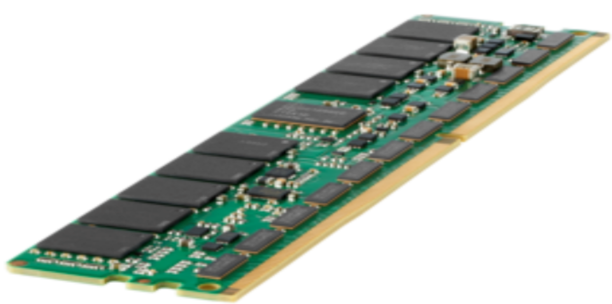
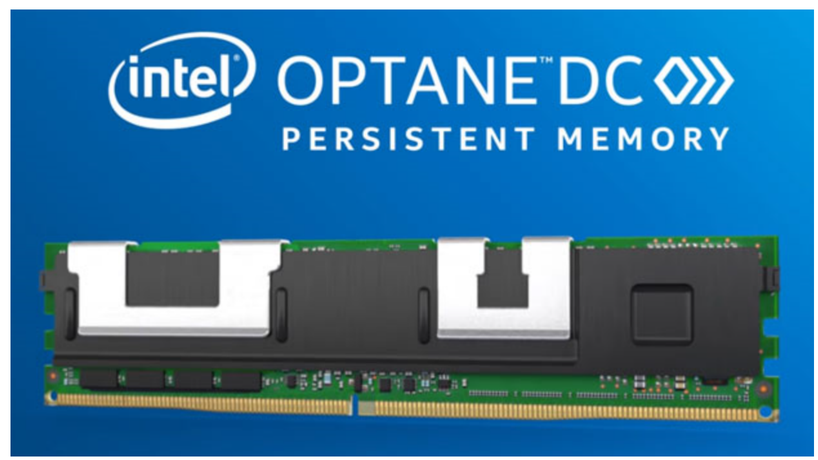
- Introduction
- Motivation and Goal
- Our Approach
- Conclusions
- Acknowledgements

Introduction

- Emerging non-volatile memory (NVM) has becomes promising storage devices due to:
  - Byte-addressability
  - Non-volatility
  - Low latency
  - Low idle power (except for NVDIMM)



HPE 8GB NVDIMM single Rank x4 DDR4-2133 Module



Introduction (cont.)

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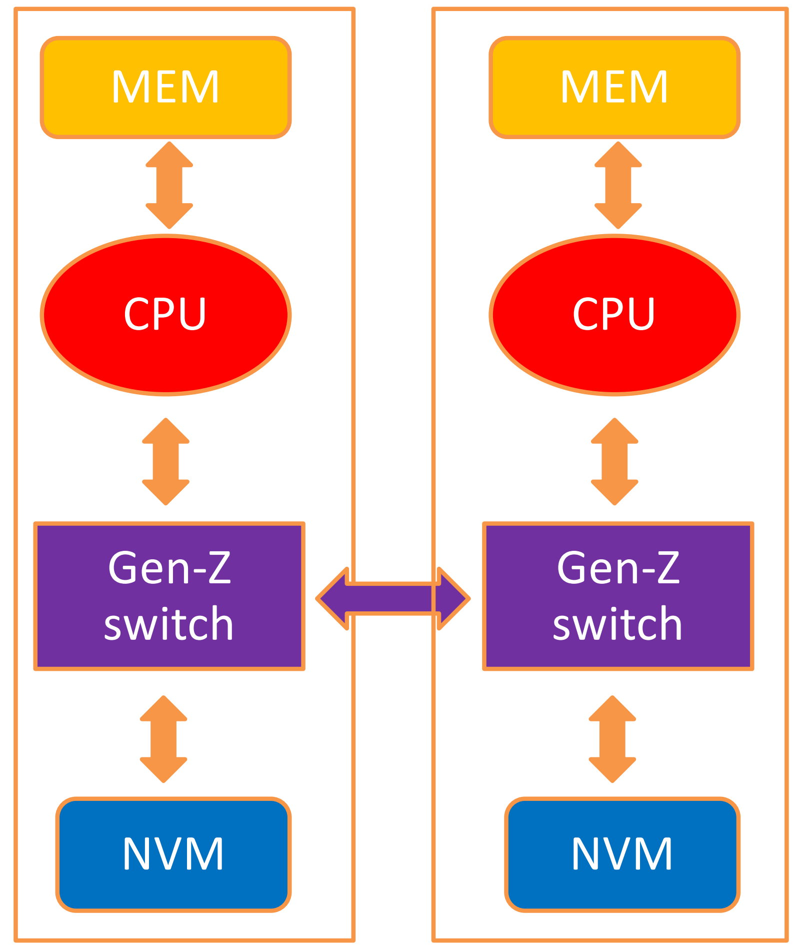
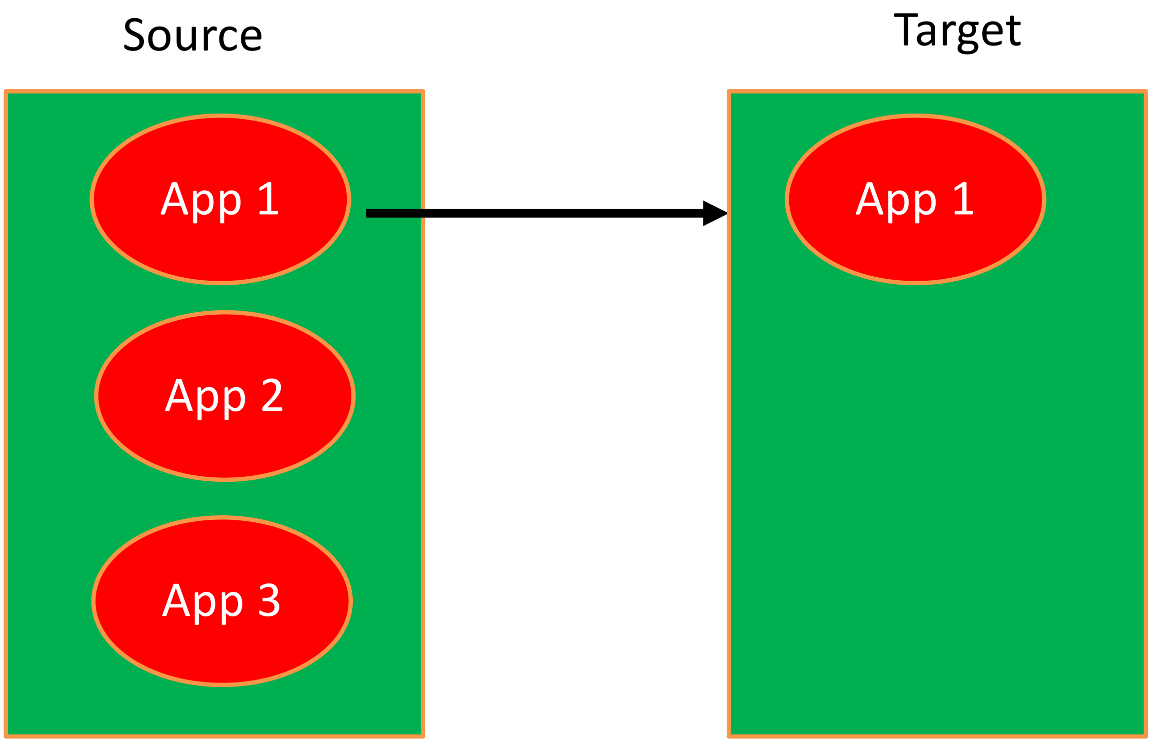
- Fabric-Attached Memory (FAM), which can be accessed by memory semantics, provides high bandwidth, low latency, and shared memory pool across machines in a rack scale.



Introduction of migrations



Introduction of migrations

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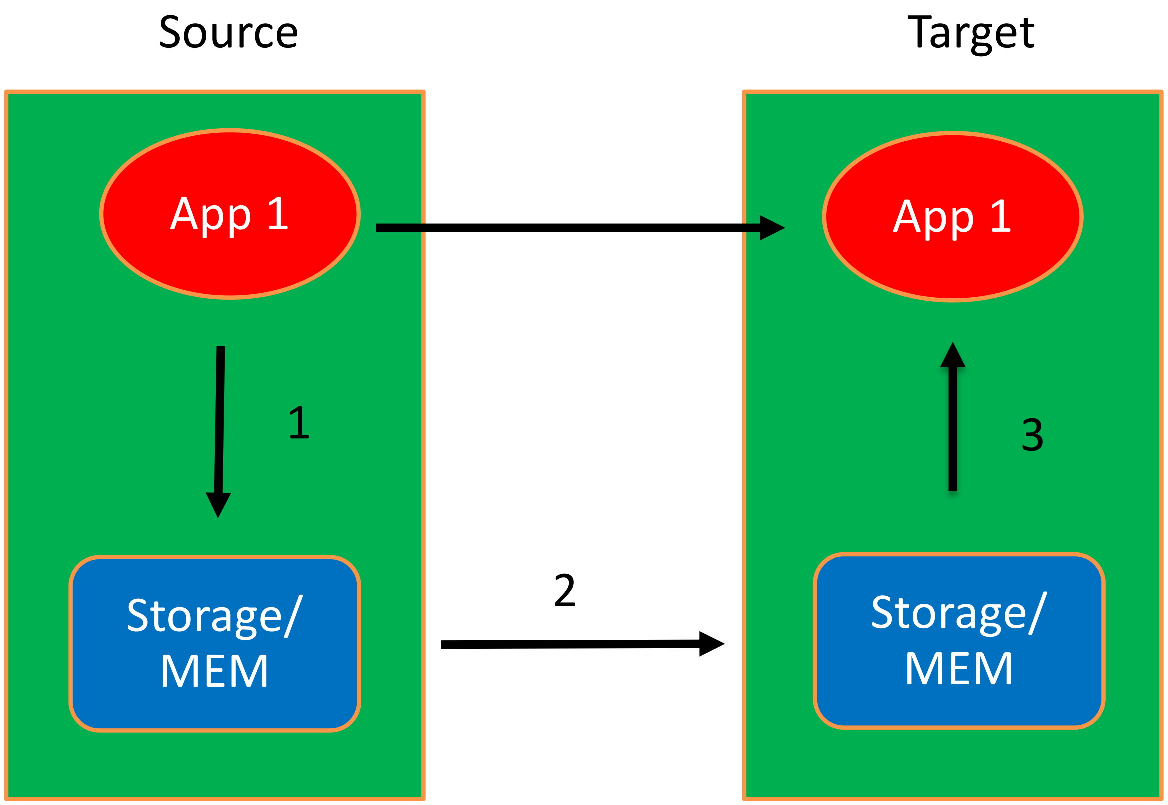
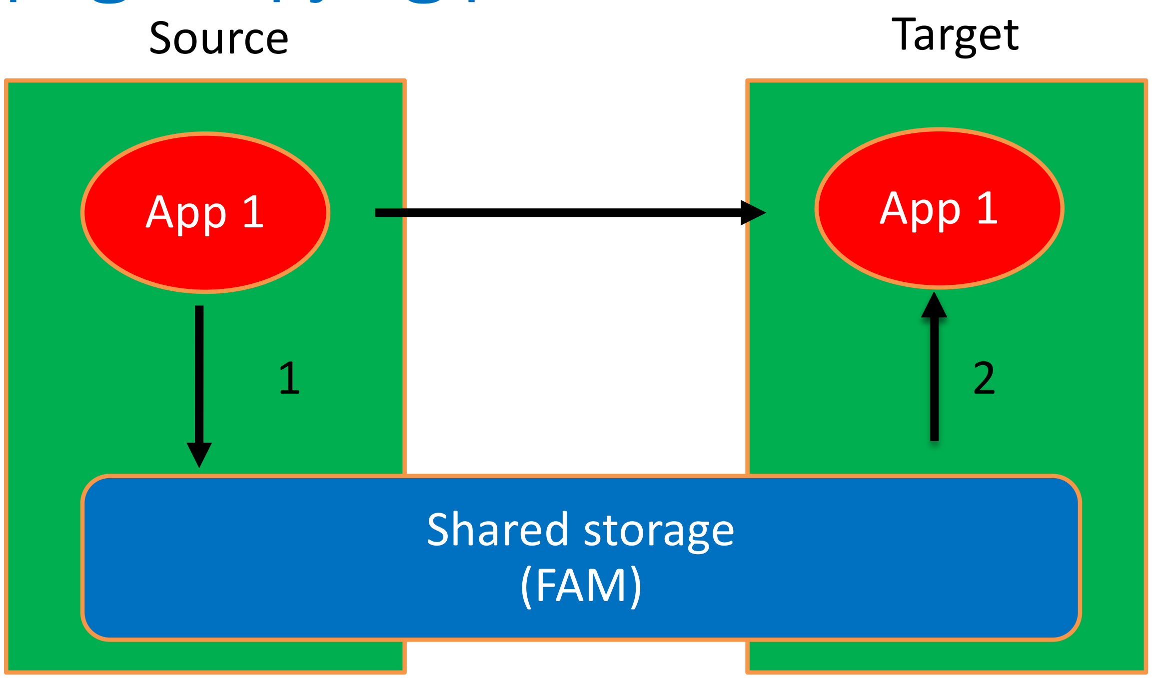
- Non-live migration: the state of application is checkpointed entirely to storage devices, copied to target, and resumed at target.
- Post-copy live migration: Processor state, registers, etc., are transferred first, then application is resumed at target. When pages are accessed at target, a page fault is triggered to acquire faulty pages

Migrations



Motivations

- Non-live migration can benefit from FAM directly by avoiding page-copying phase.



- What about post-copy migration? Can we do more by using FAM?

Goal

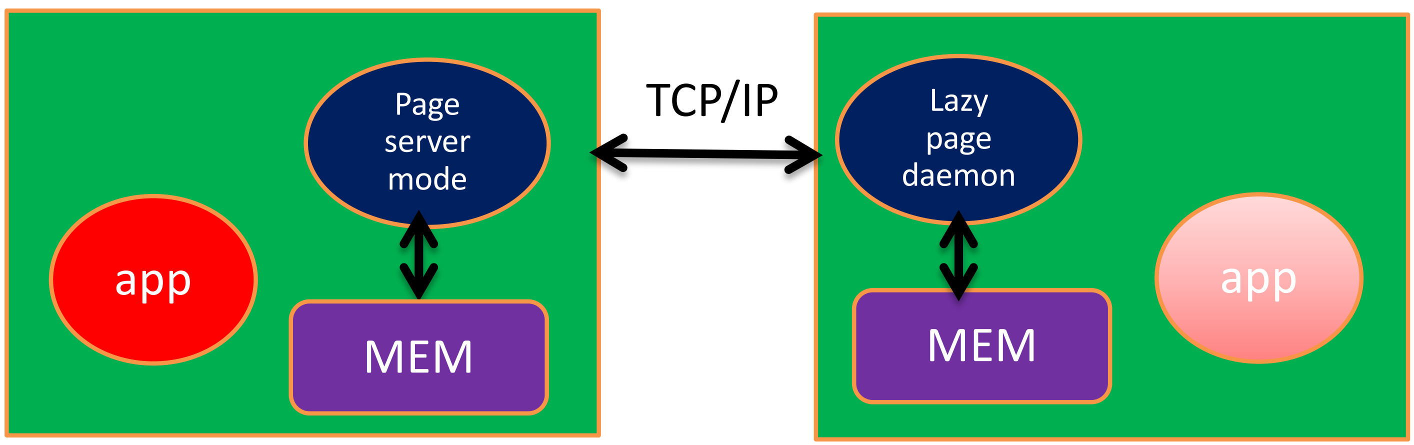
- Almost all previous work focus on total migration time of "victim" application
  - If we can predict the working set correctly, an approach with longer migration time might be better in terms of overall system performance
- Instead, we propose "busy time" (of source node): **the time from the start of migration to the time "victim" can be killed at source node**
  - Meaning how long the remaining applications at source having to wait for the resources, such as CPU and memory, occupied by "victim" to be released
  - Non-live migration has the optimal busy time

Our approach

- Like non-live migration, we propose our post-copy with FAM by first checkpointing the "victim" into FAM
  - Checkpointed-based post-copy migration
  - Therefore, "victim" can be killed after checkpoint immediately
    - Almost the same busy time as non-live migration
  - Due to the nature of FAM, the checkpointed pages can be accessed by target node directly
    - Achieve shorter latency of the page fault
- We have implemented our approach at CRIU (Checkpoint/Restart in Userspace), a Linux open source tool

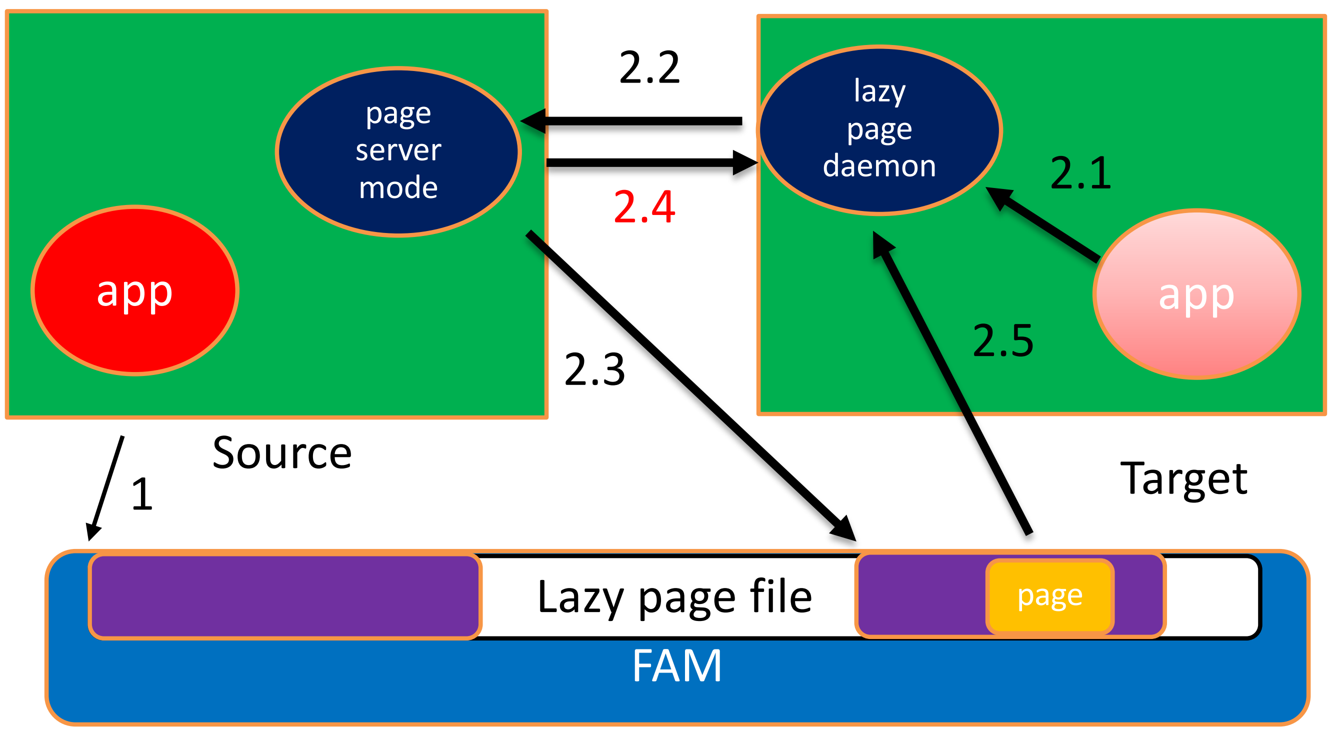
Existing CRIU post-copy migration

- All Pages are stored in memory at source.
- Faulting pages transferred via socket interface to memory at target.



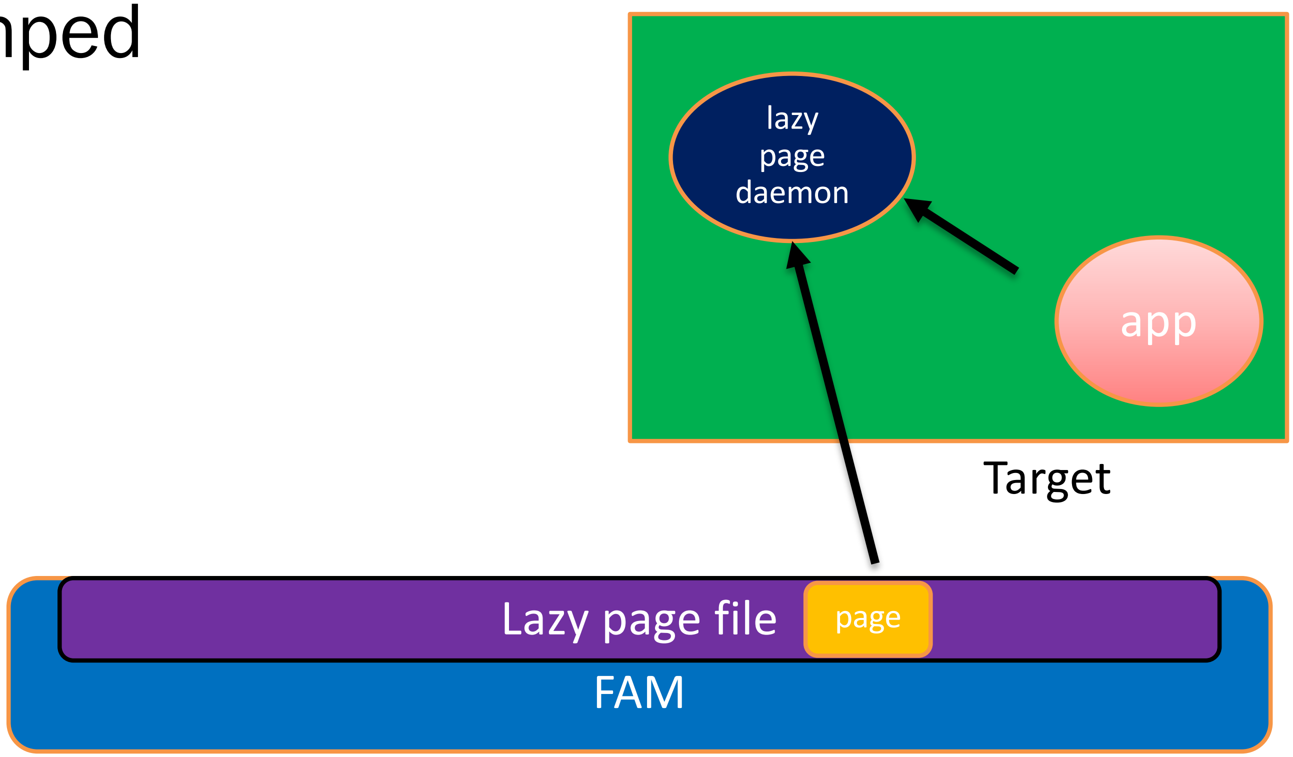
Our implementation

- On background, checkpoint "victim" into FAM
- Asynchronous accessed pages fault if pages are not ensured to be dumped

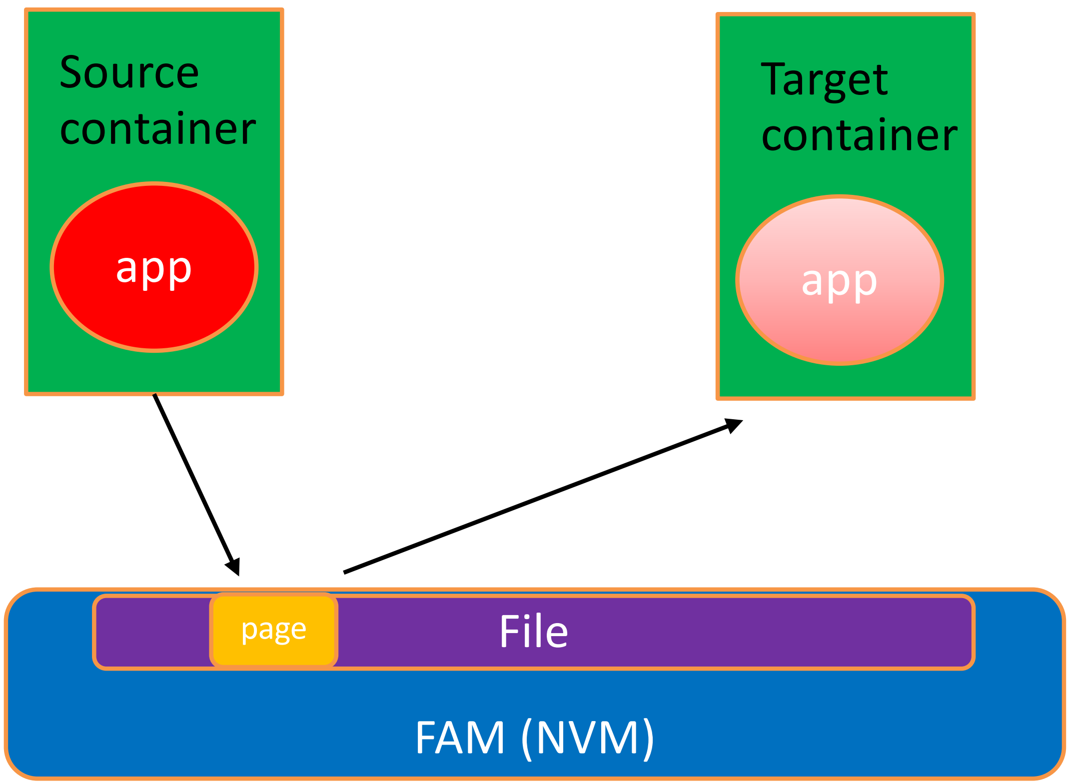


Our implementation (cont.)

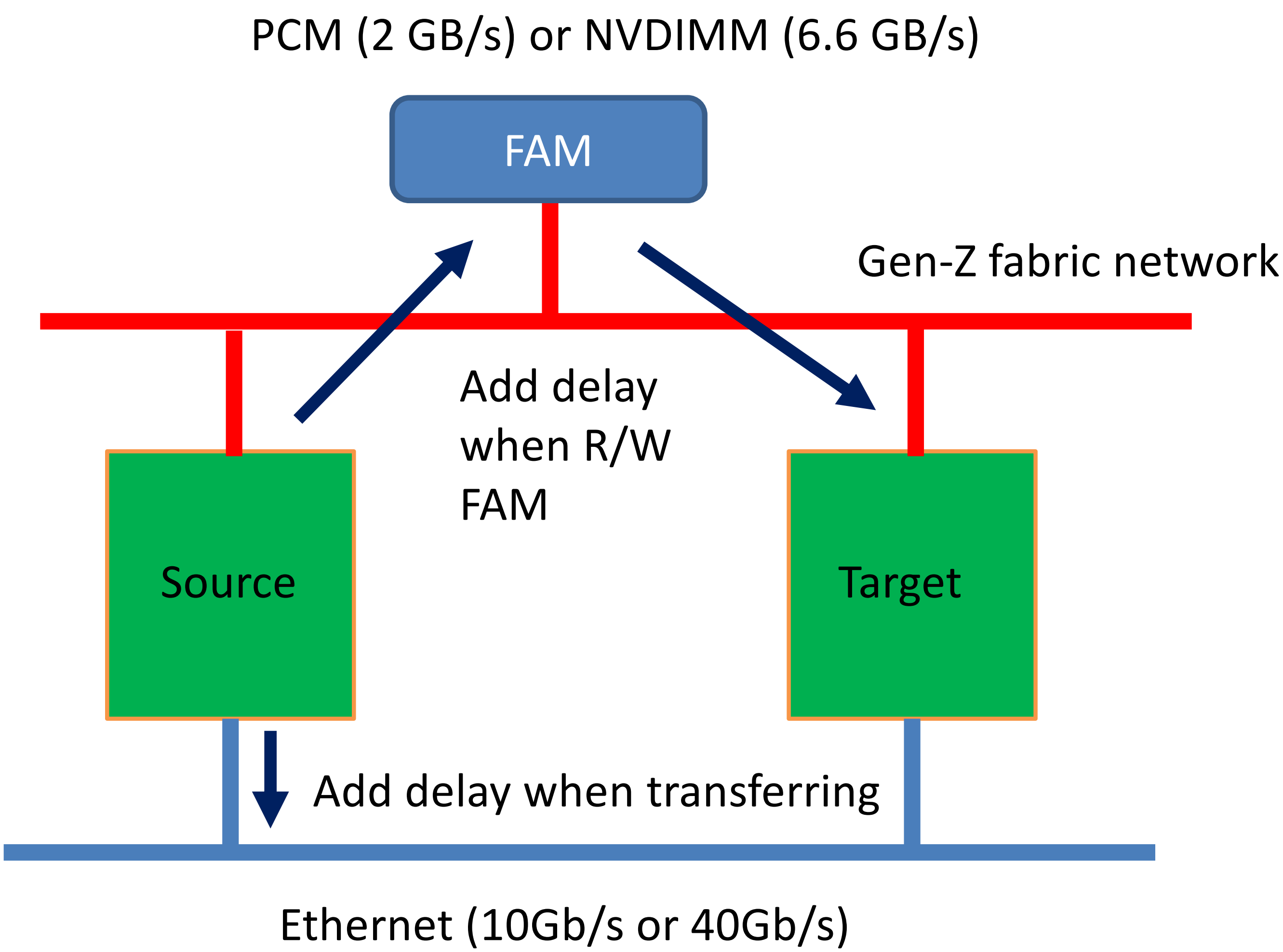
- Synchronously accessed if pages have known to be dumped



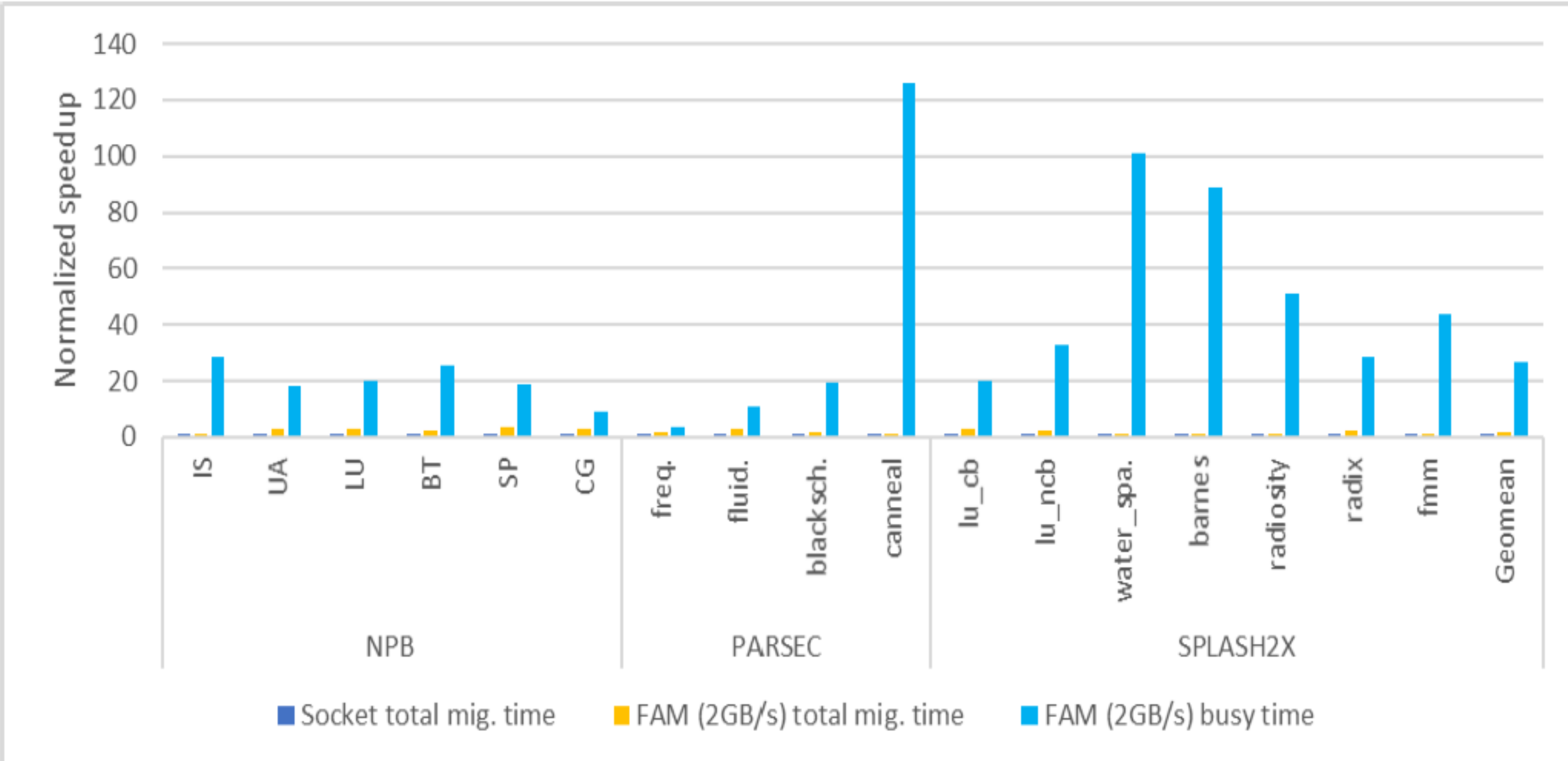
Evaluation of benchmarks



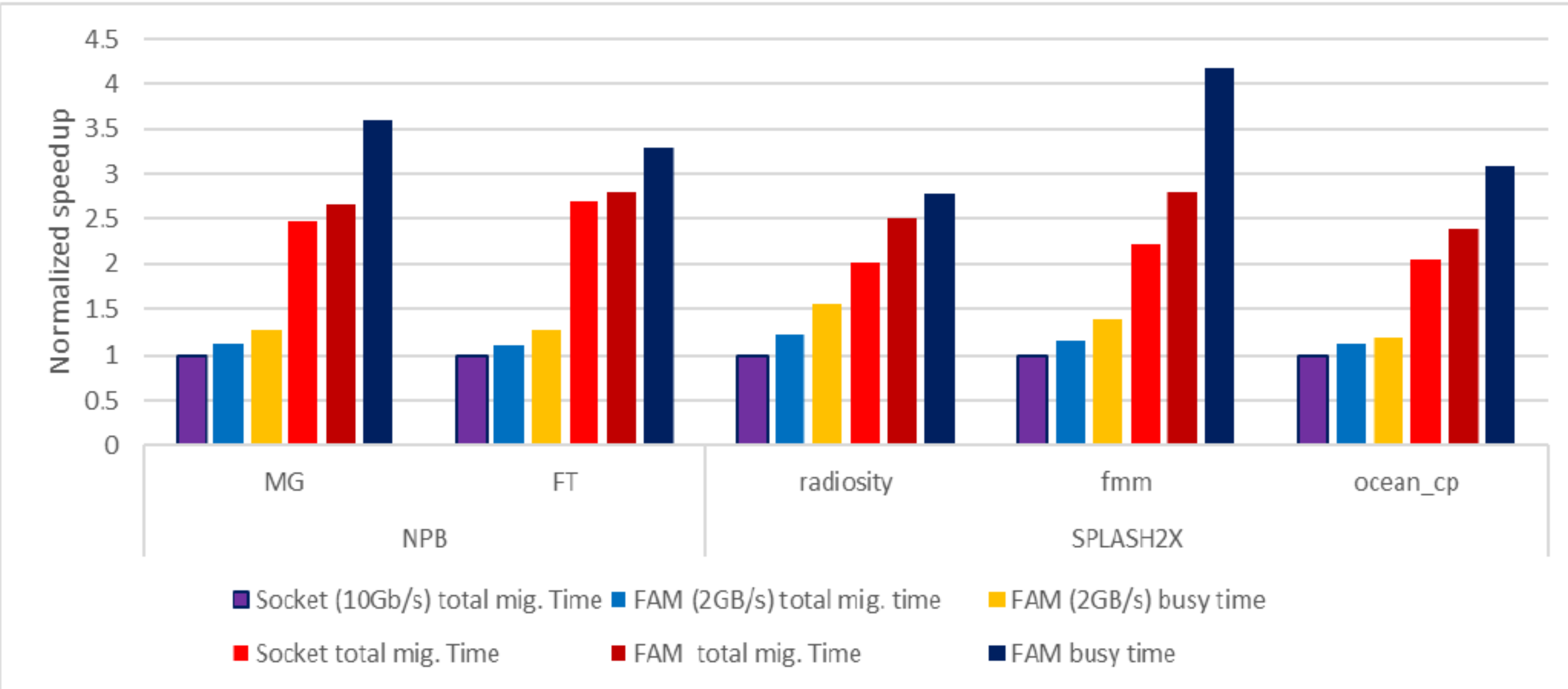
System model



Demanding paging



Active pushing



Evaluation: Redis + YCSB

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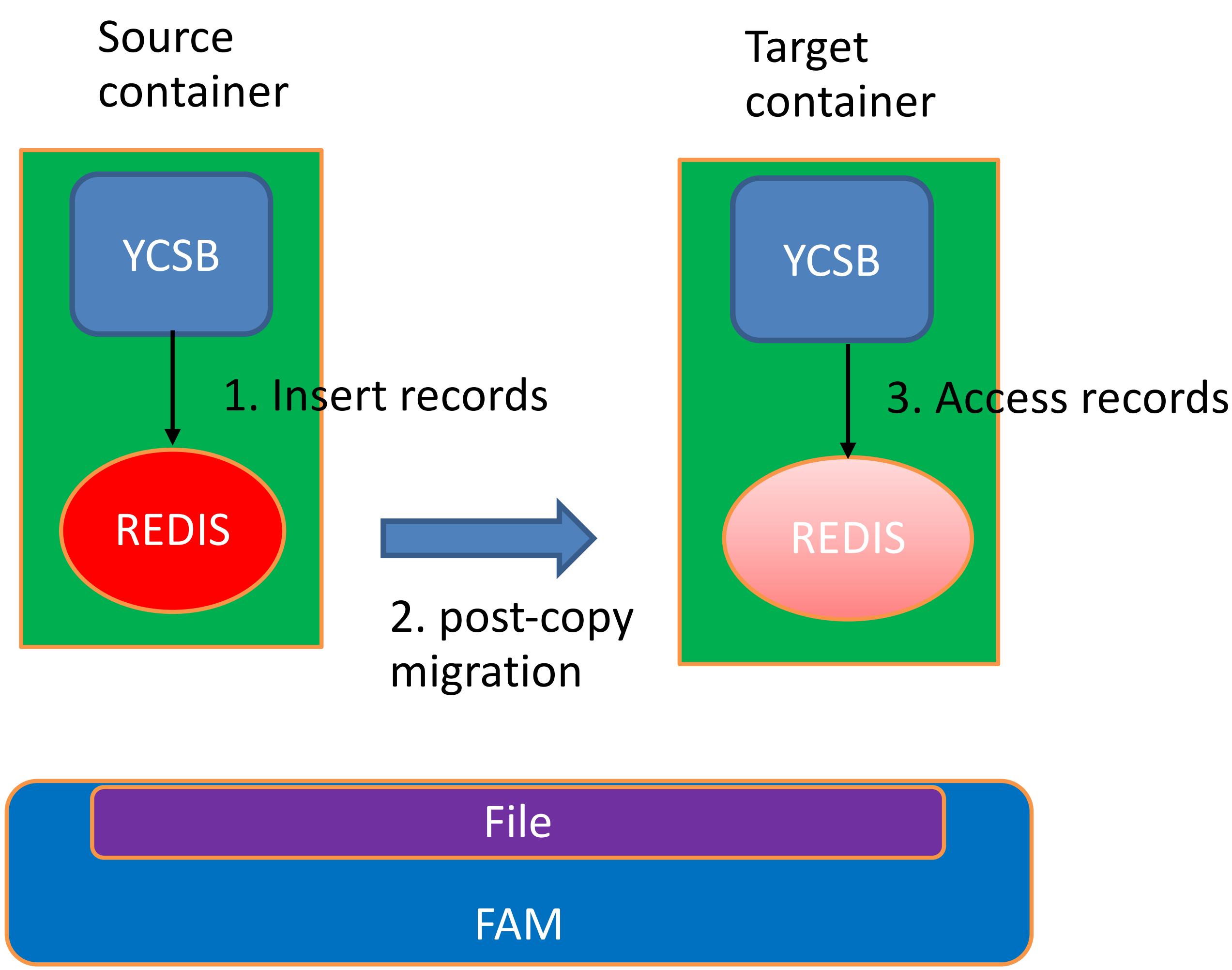

Results of YCSB throughput

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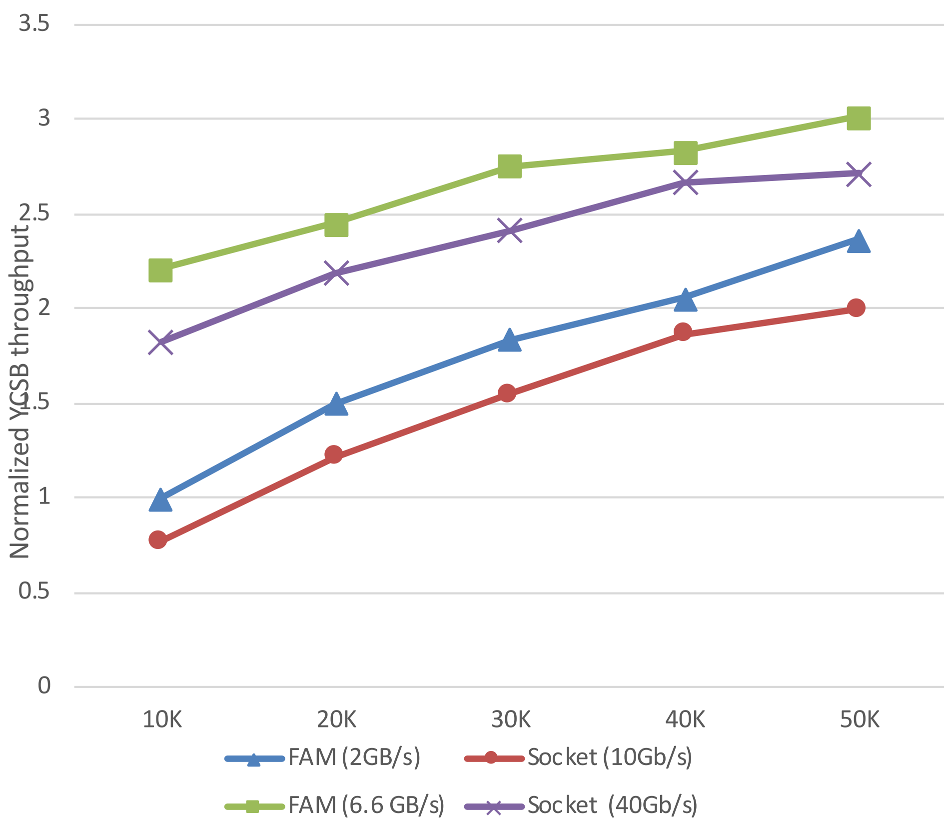
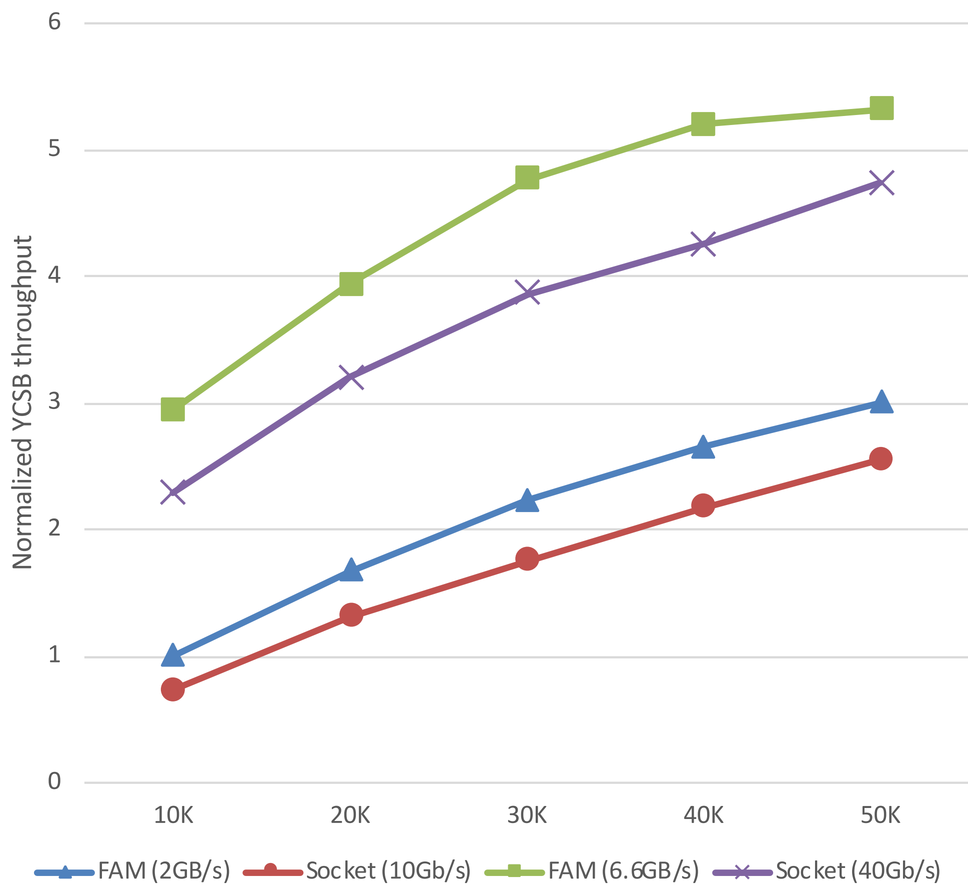


One thread



four threads

Results of speedup

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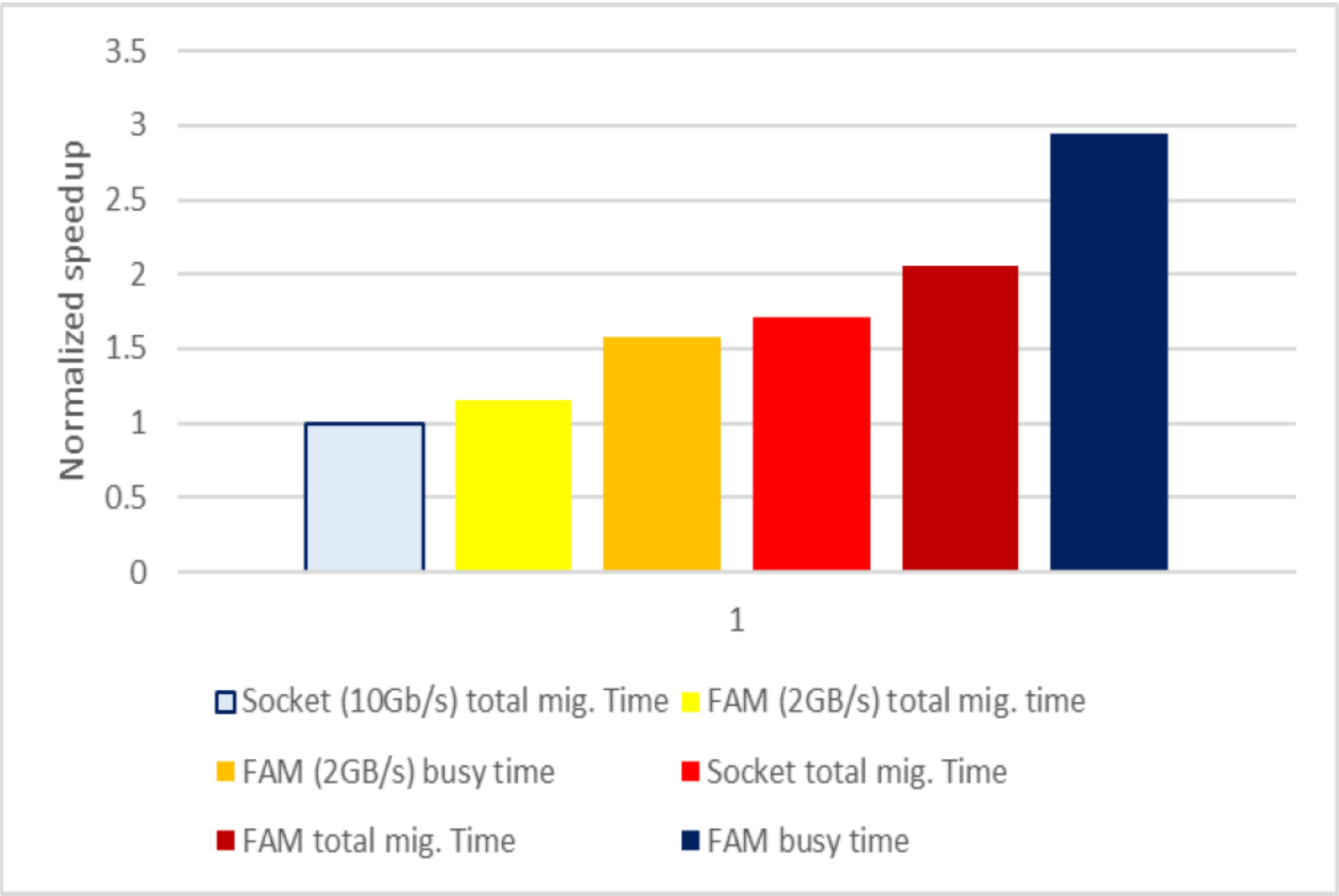

Acknowledgements

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Gen-Z DDR interface

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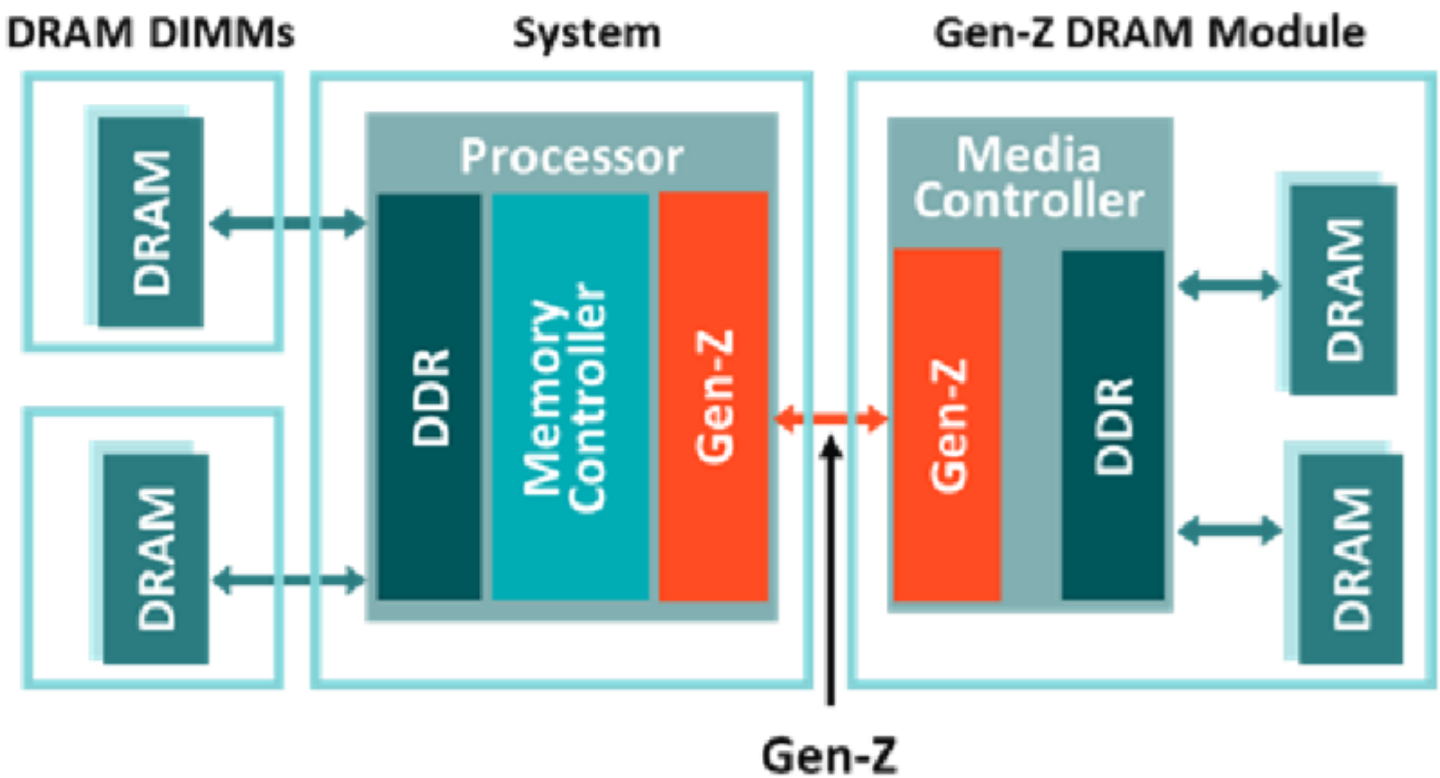

- Ref: Gen-Z white paper: DRAM and Storage-Class Memory (SCM) Overview

Gen-Z memory interfaces

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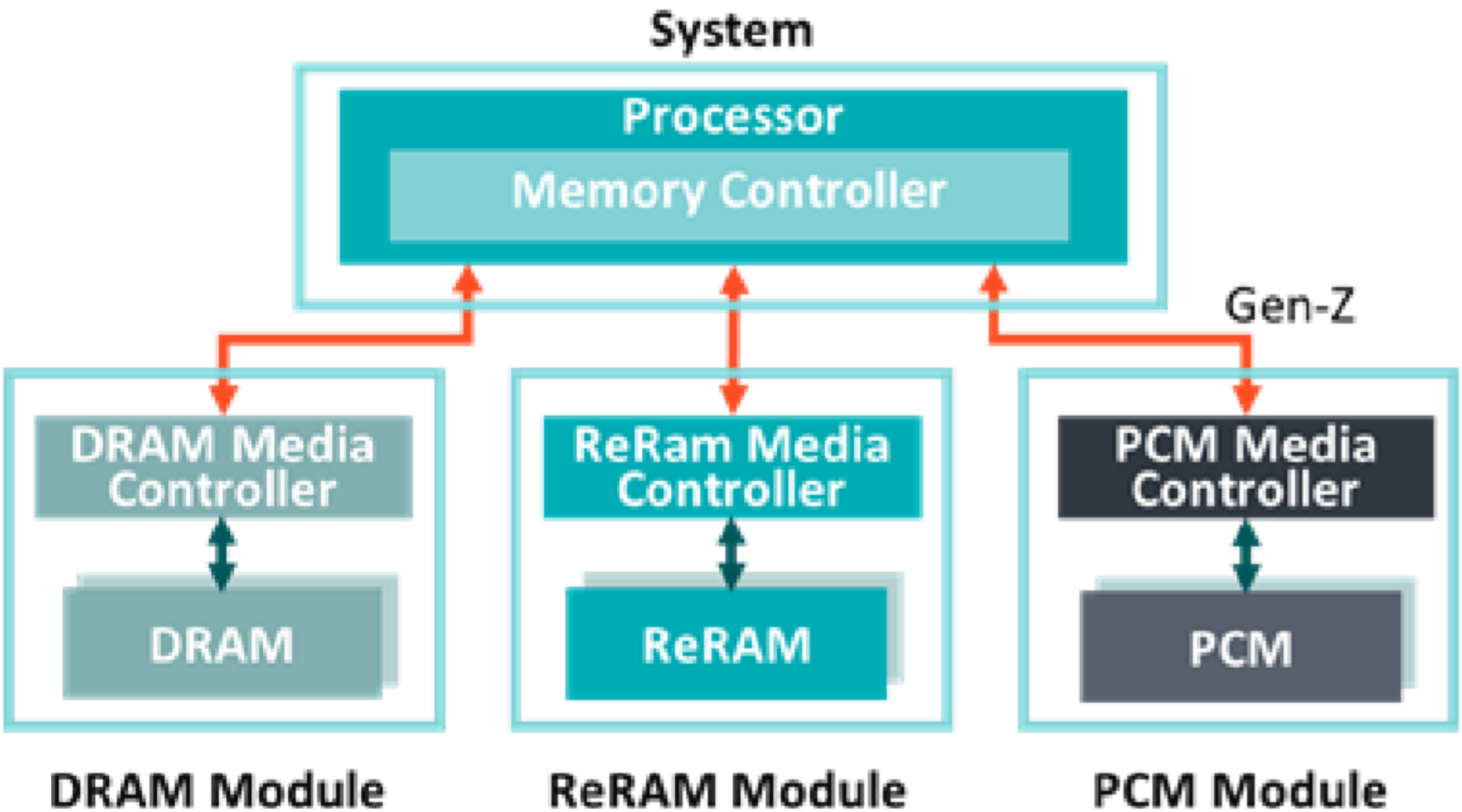

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