Data Management in Heterogeneous Memory Systems

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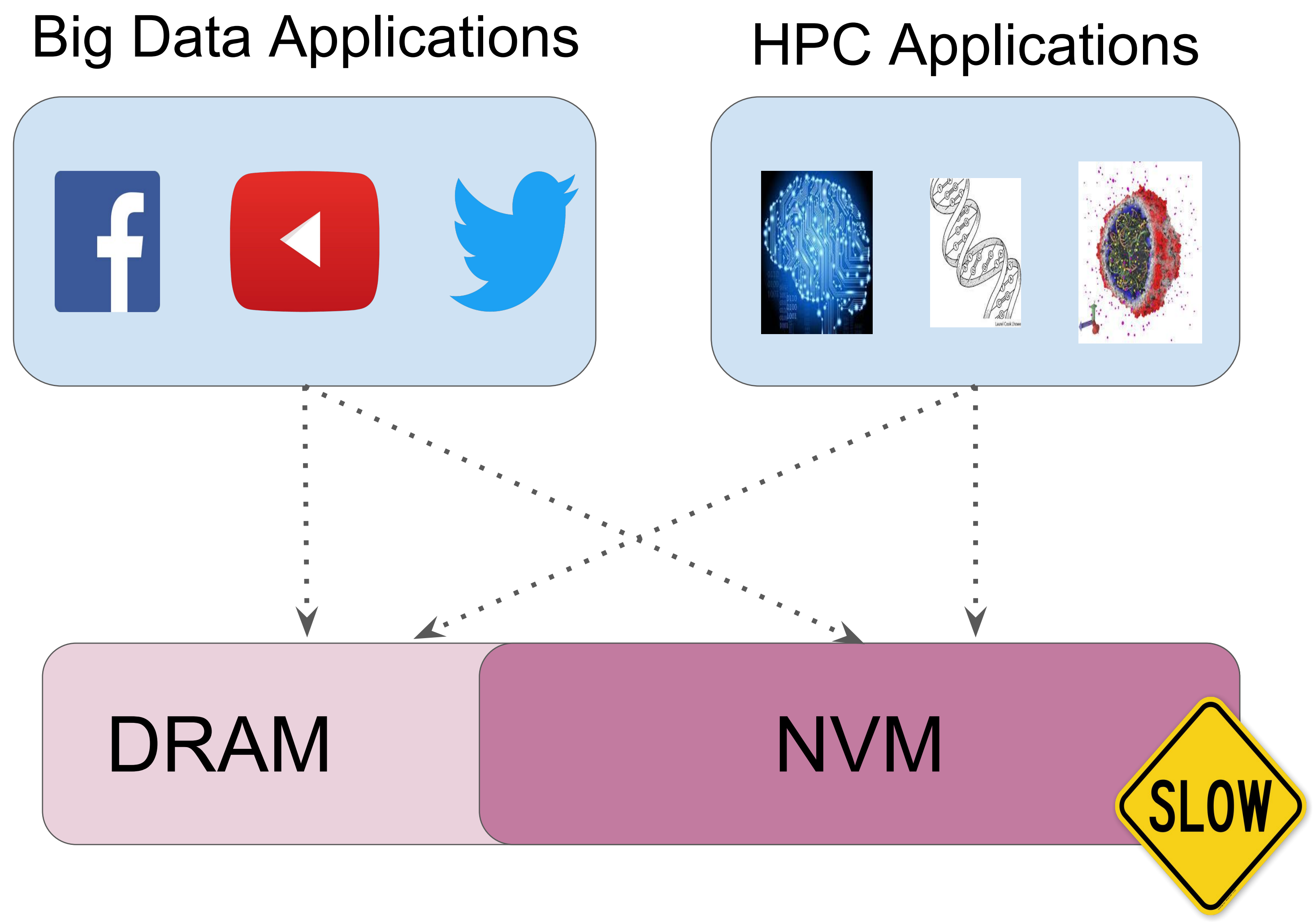
1. Motivation

- ❖ High Performance Computing and Big Data applications have dataset sizes that often exceed the available DRAM capacities.
- ❖ Emerging memory technologies that are much cheaper, such as Non Volatile Memory, are used to extend the memory space creating a ***heterogeneous memory subsystem*.**
- ❖ Data in Non Volatile Memory will incur higher access latencies, affecting the application performance, slowing it down compared to an ideal case when all data could fit in DRAM.
- ❖ Existing solutions **reduce the performance slowdown** by prioritizing allocations of the most frequently accessed objects in DRAM. However, they assume fixed hardware capacities.

2. Problem Statement



Big Data Applications

HPC Applications

DRAM

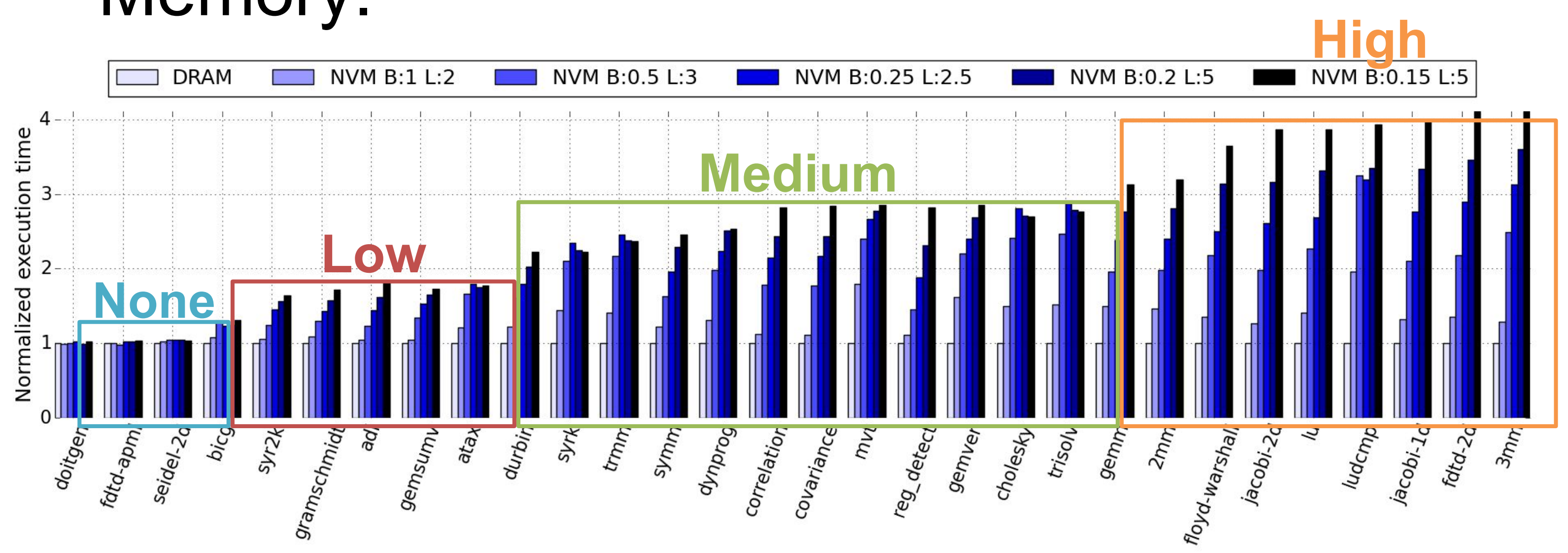
NVM

SLOW

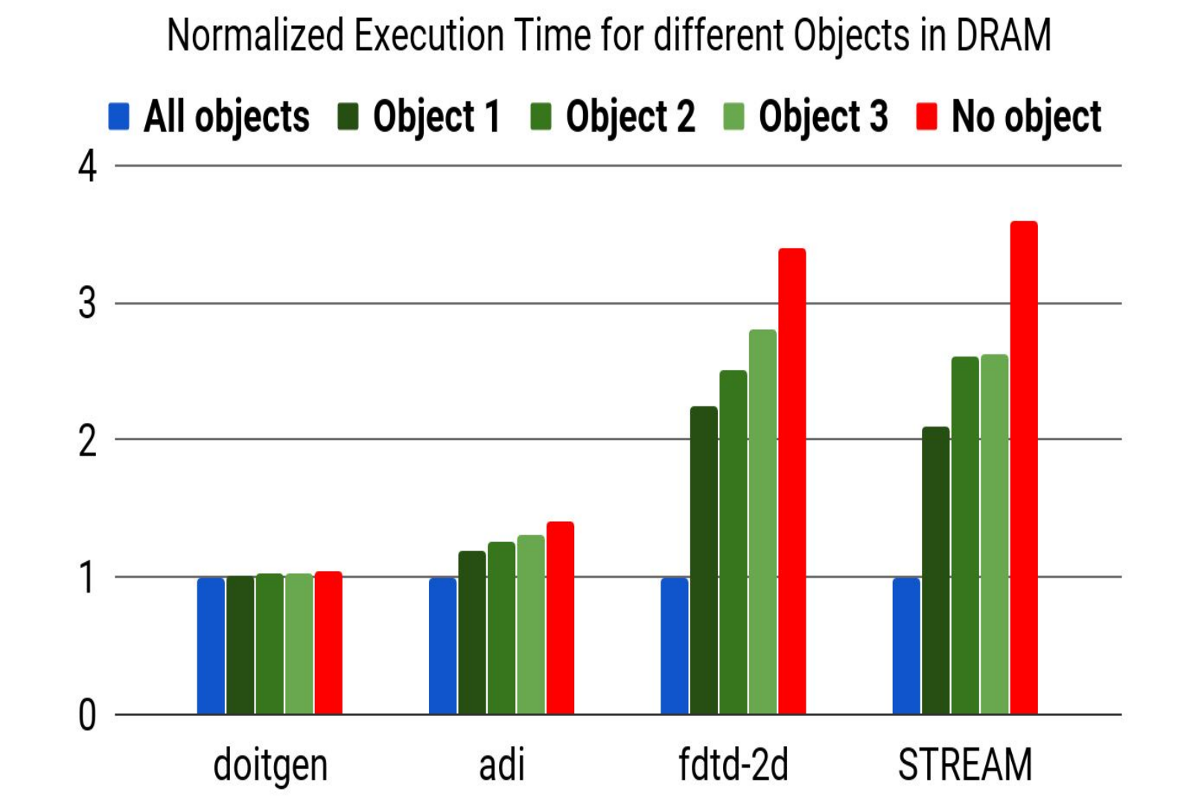
Problem: How do we _size_ the memory components and _manage_ data over the heterogeneous memory system, so as to _minimize_ the application performance slowdown?

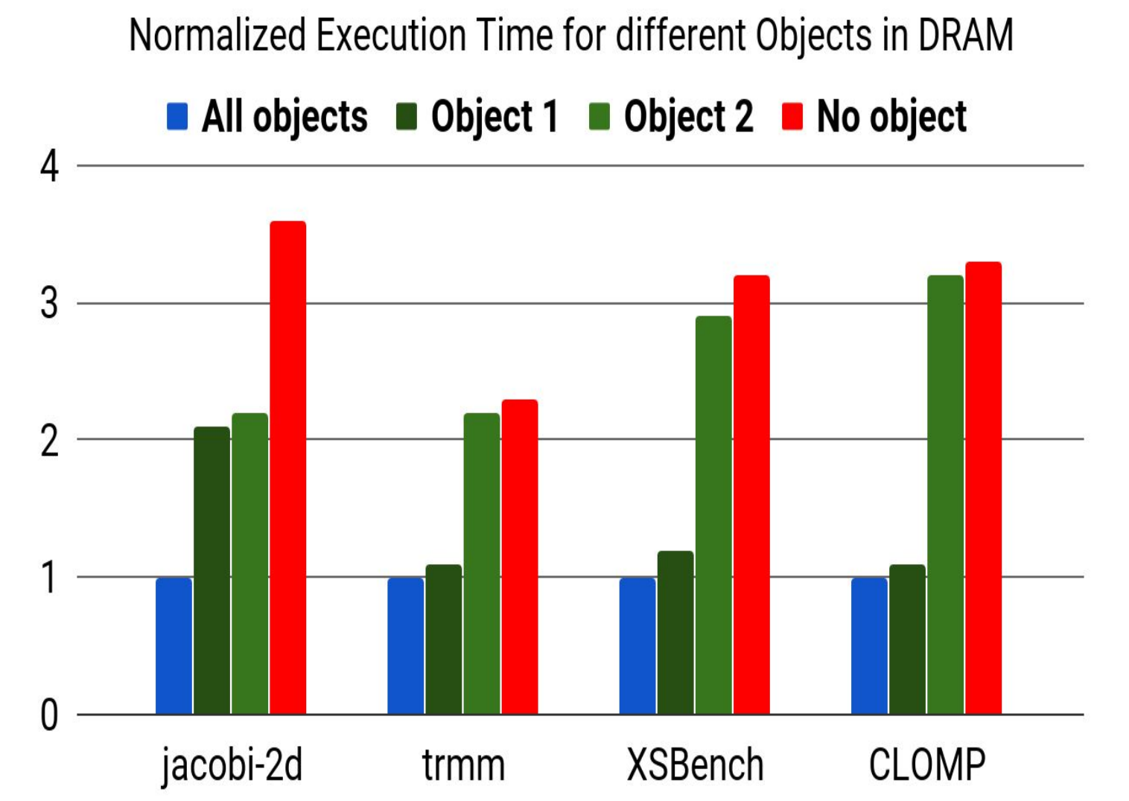
3. Observations

- ❖ Not all applications are slowed down in the same degree when accessing Non Volatile Memory.



- ❖ Not all data objects of an application help reduce the performance slowdown when allocated in DRAM.

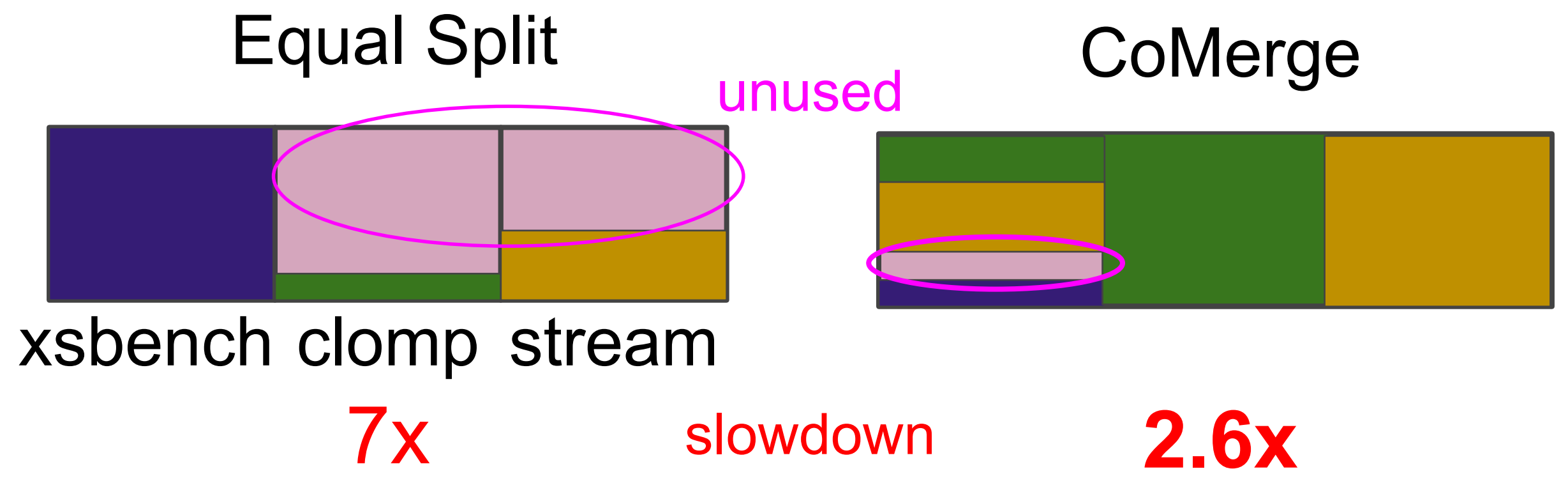




4. CoMerge Solution

CoMerge: Memory sharing policy that prioritizes DRAM allocations for critical data objects. Achieves:

- Lower runtime across all collocated applications.
- Higher DRAM utilization.



Equal Split

unused

CoMerge

xsbench clomp stream

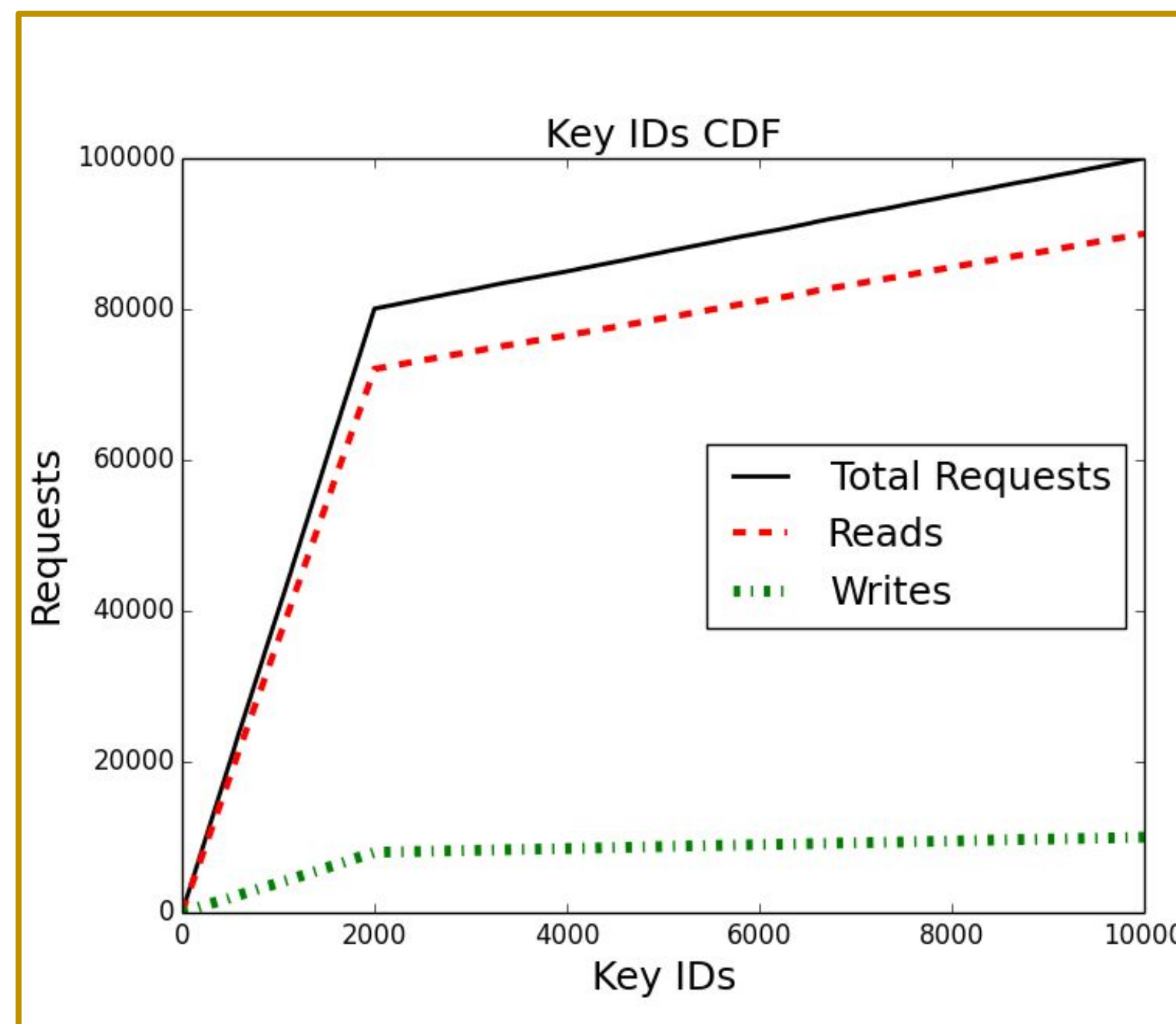
7x

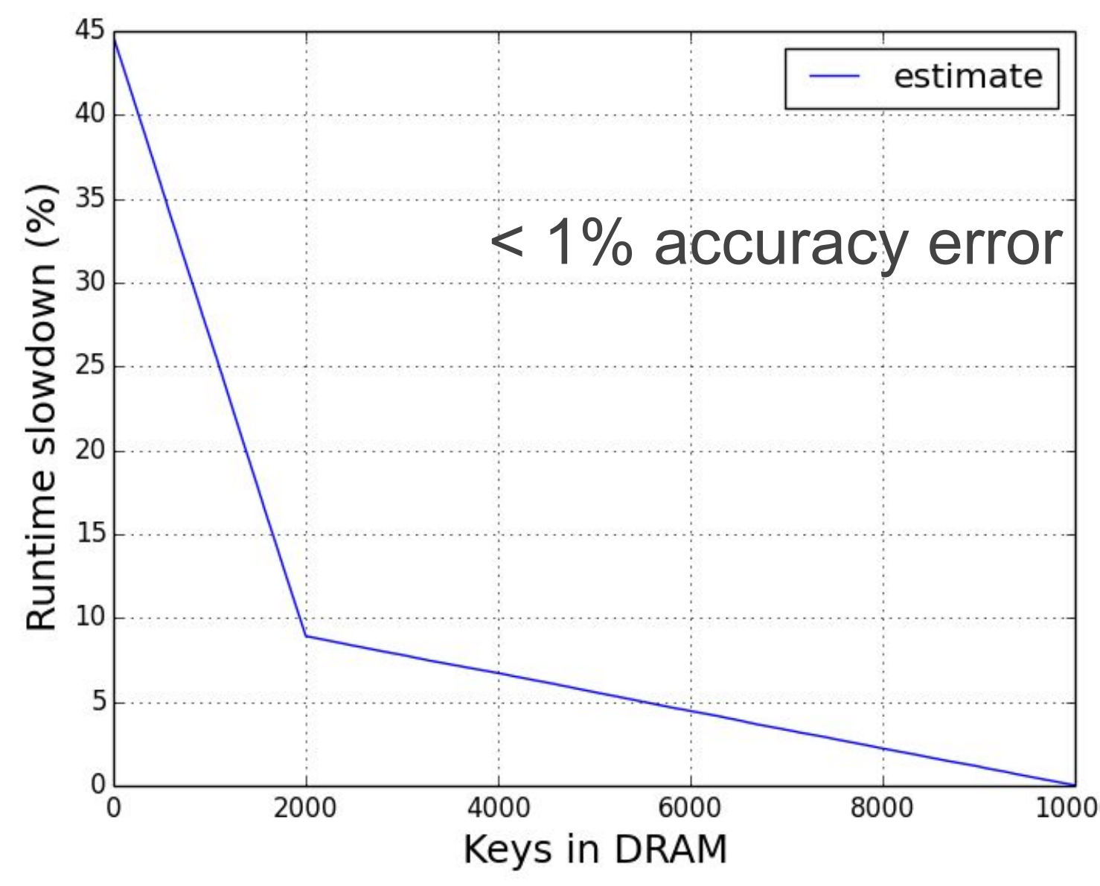
slowdown

2.6x

Thaleia Dimitra Doudali and Ada Gavrilovska. 2017. CoMerge: Toward Efficient Data Placement in Shared Heterogeneous Memory Systems. In Proceedings of MEMSYS 2017, Alexandria, VA, USA, October 2–5, 2017, 11 pages.

5. Mnemo Solution

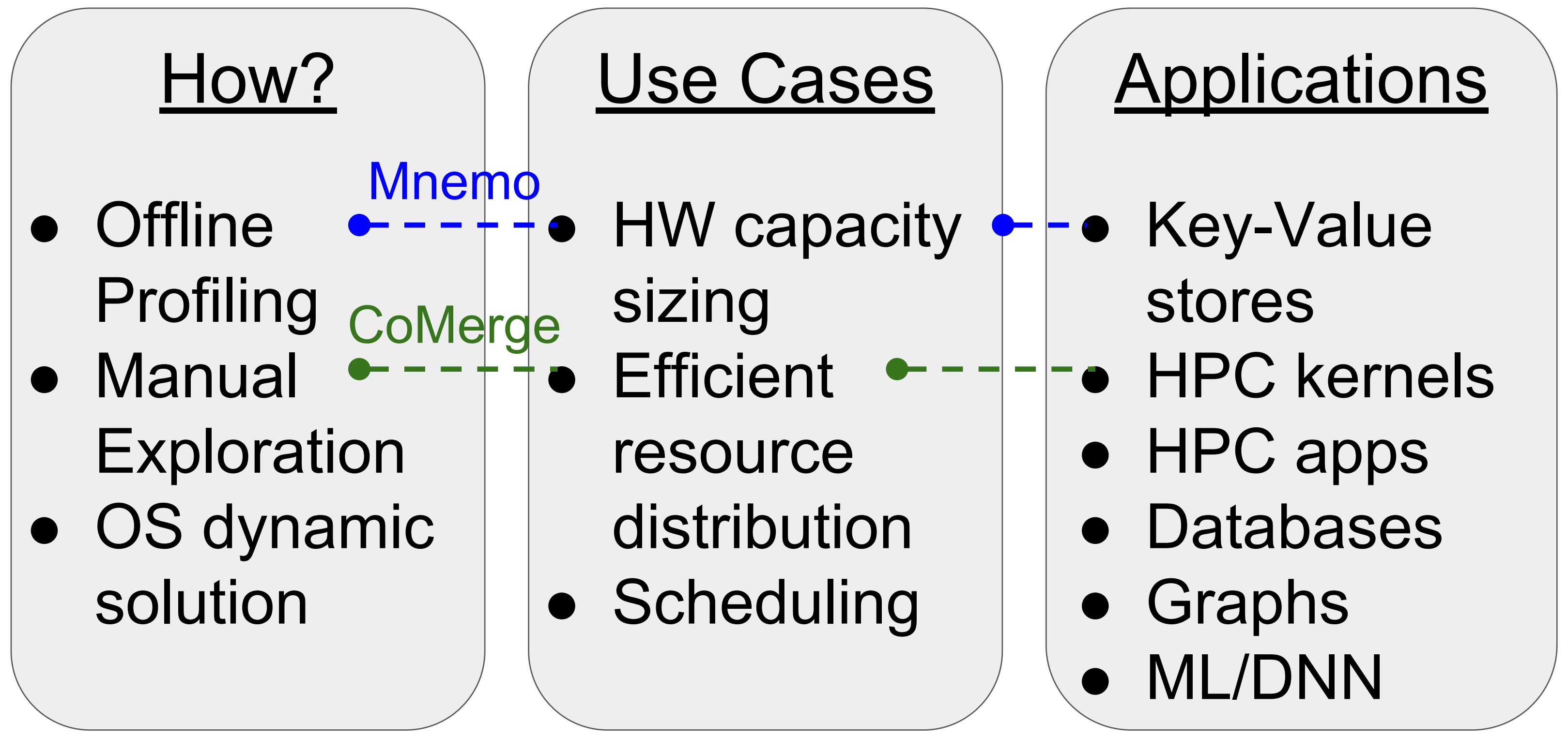




Mnemo: Profiling tool that estimates the application performance slowdown for incremental DRAM capacity on a heterogeneous memory system.

under submission

6. Future Directions



How?

- Offline Profiling
- Manual Exploration
- OS dynamic solution

Use Cases

- HW capacity sizing
- Efficient resource distribution
- Scheduling

Applications

- Key-Value stores
- HPC kernels
- HPC apps
- Databases
- Graphs
- ML/DNN

Mnemo

CoMerge

Goal: connect the rest of the dots.

All work is part of the projects:
ECP SICM (Software Interface to Complex Memories)
SSIO Unity (Unified Memory and Storage Space)