CoMerge

Toward Efficient Data Placement in Shared Heterogeneous Memory Systems

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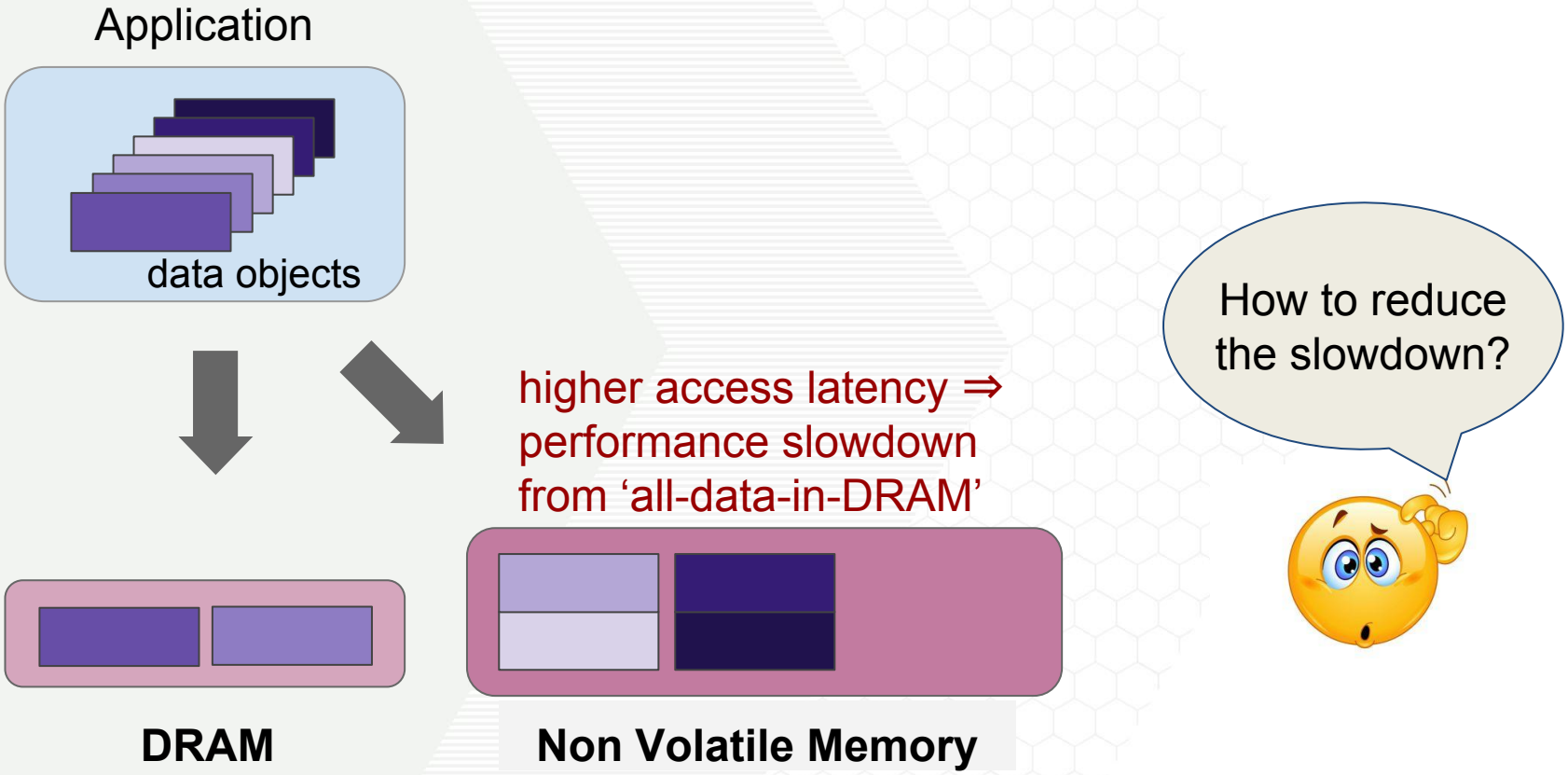
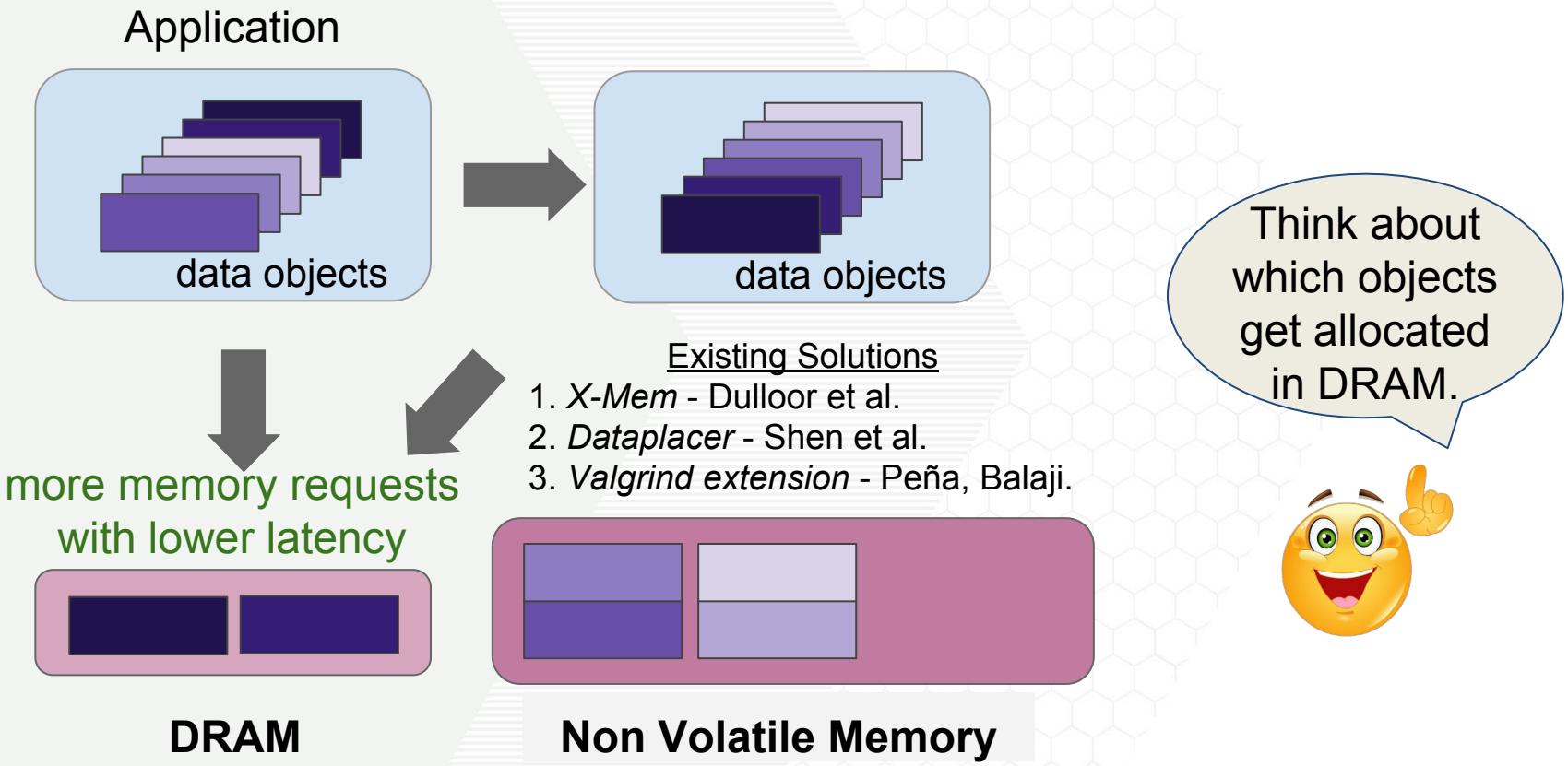
Motivation

Performance slowdown in heterogeneous memory systems.



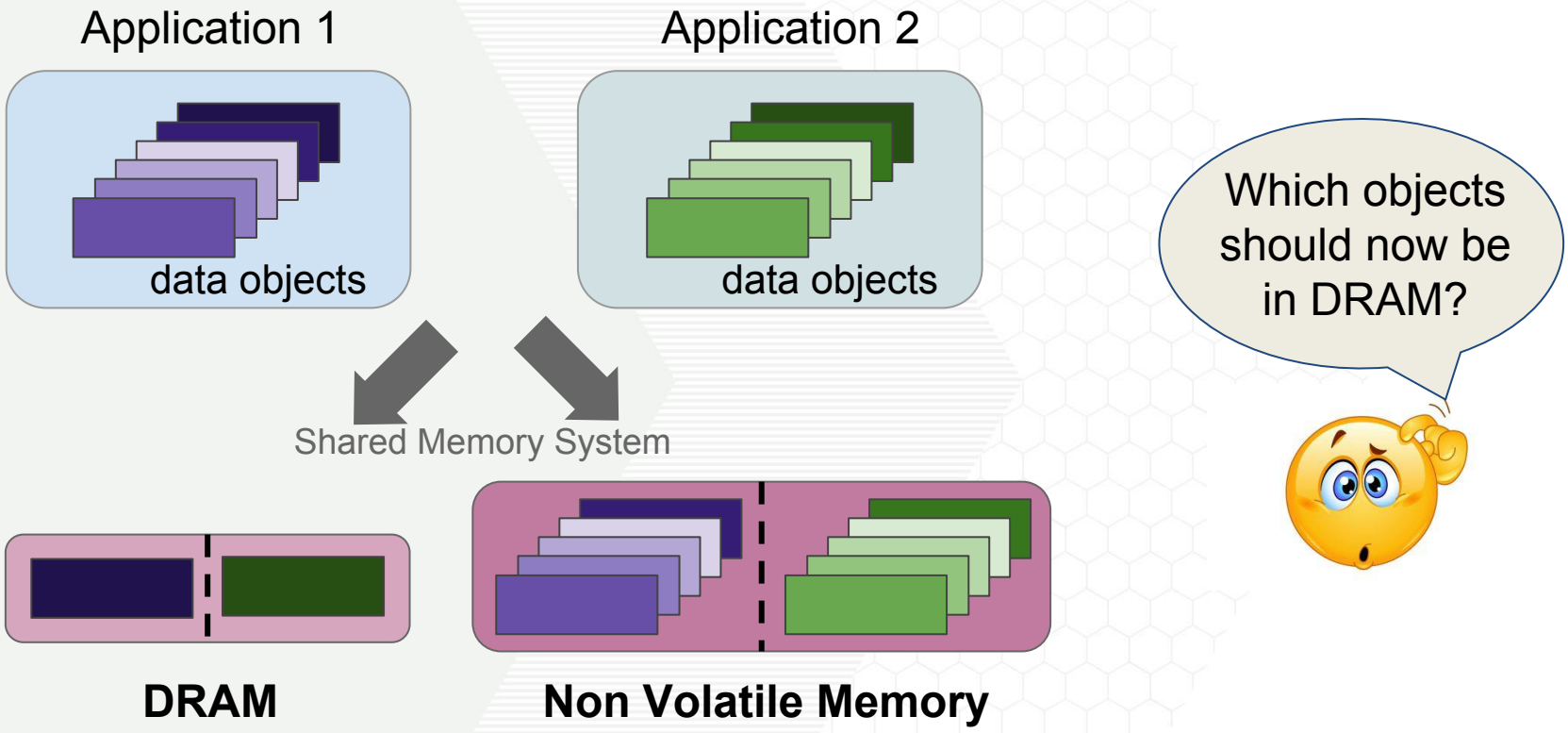
Existing Solutions

Data tiering that maximizes DRAM accesses.



Problem Statement

Limited Utility of Existing Solutions in Shared Systems.



Do the partitioning techniques using existing solutions:

- Reduce the slowdown across all collocated applications?
- Maximize DRAM utilization?

⇒ NO

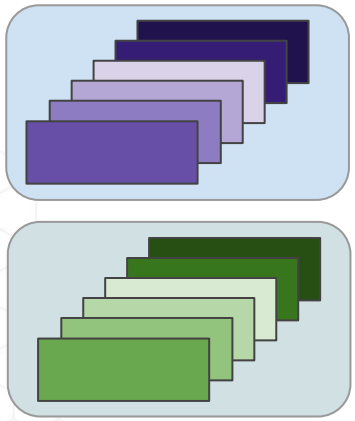
Our Contributions

What do we need to do differently?

1. Sorting objects within one application:

co-benefit metric captures:

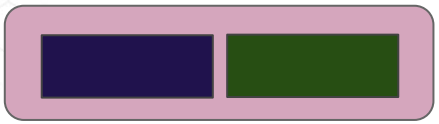
a. Exact contribution of a data object to overall application runtime.
b. Overall application sensitivity to execution over Non-Volatile Memory.



2. Distributing DRAM across applications:

CoMerge memory sharing technique.

a. Mitigates slowdown across all collocated applications.
b. Maximizes the DRAM usage.



Observations

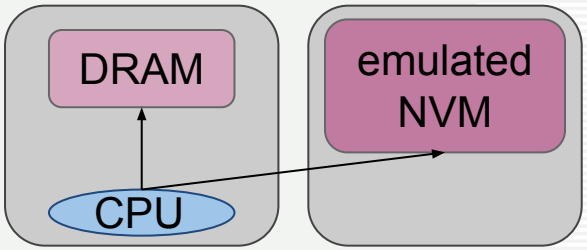
What are we going to see next?

1. Not all applications are slowed down in the same degree when accessing Non Volatile Memory.
2. Not all data objects of an application help reduce the performance slowdown, when placed in DRAM.

Polybench Benchmarks
- 30 simple algebraic kernels.
- Single-threaded.

CORAL Suite of mini-apps
- 3 HPC representative kernels.
- Multi-threaded. OpenMP.

Hardware Testbed



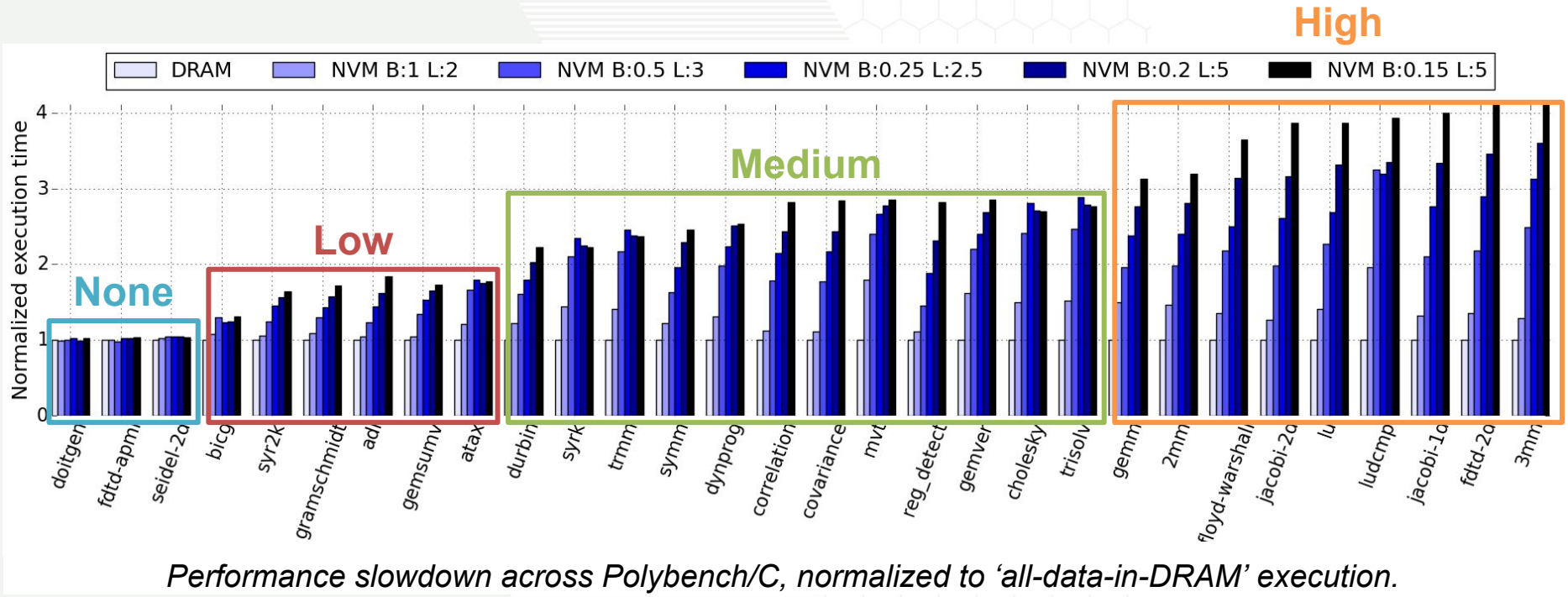
Emulate Non Volatile Memory for various combinations of ***reduced bandwidth*** and ***increased latency***.

e.g. B 0.5 : L 2

0.5 times less bandwidth : 2 times more latency

Overall Application Sensitivity

Do all applications get slowed down in the same way when accessing Non Volatile Memory?



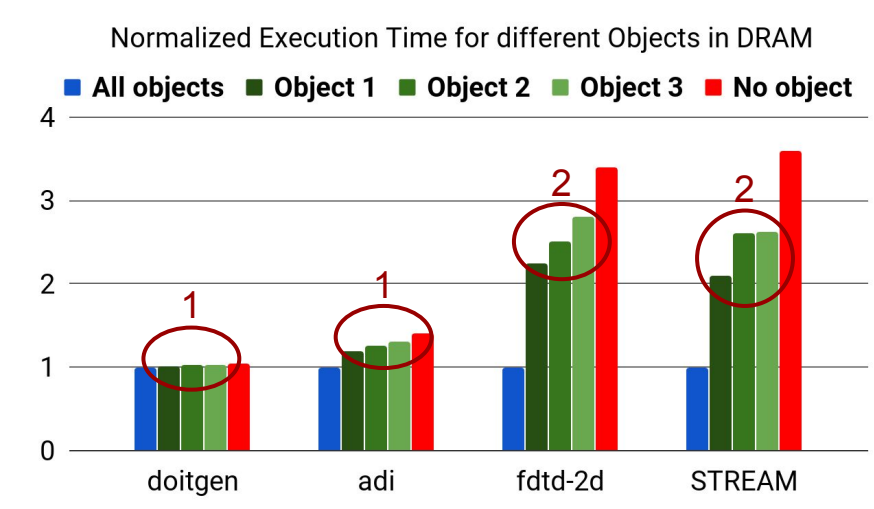
Performance slowdown across Polybench/C, normalized to 'all-data-in-DRAM' execution.

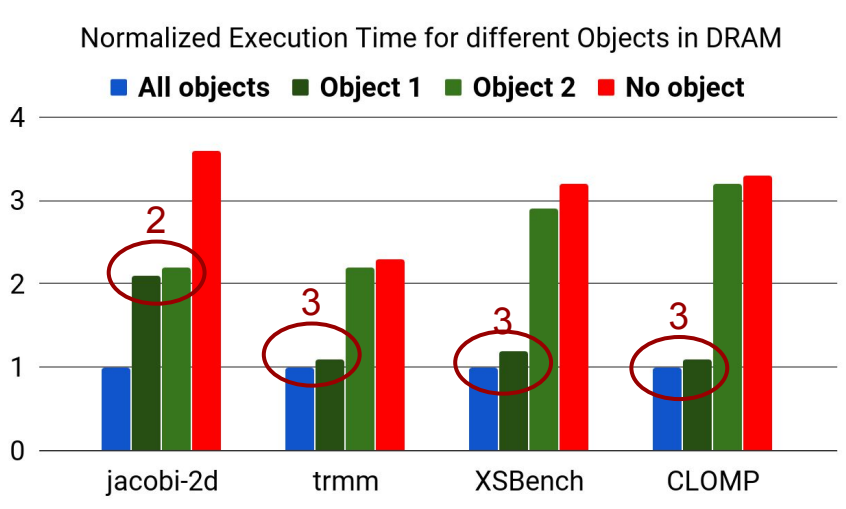
Applications show different levels of sensitivity to execution over slower memory components.

Data Object Sensitivity

Do all data objects help minimize the slowdown, when allocated in DRAM?

fixed NVM at B 0.2 : L 5



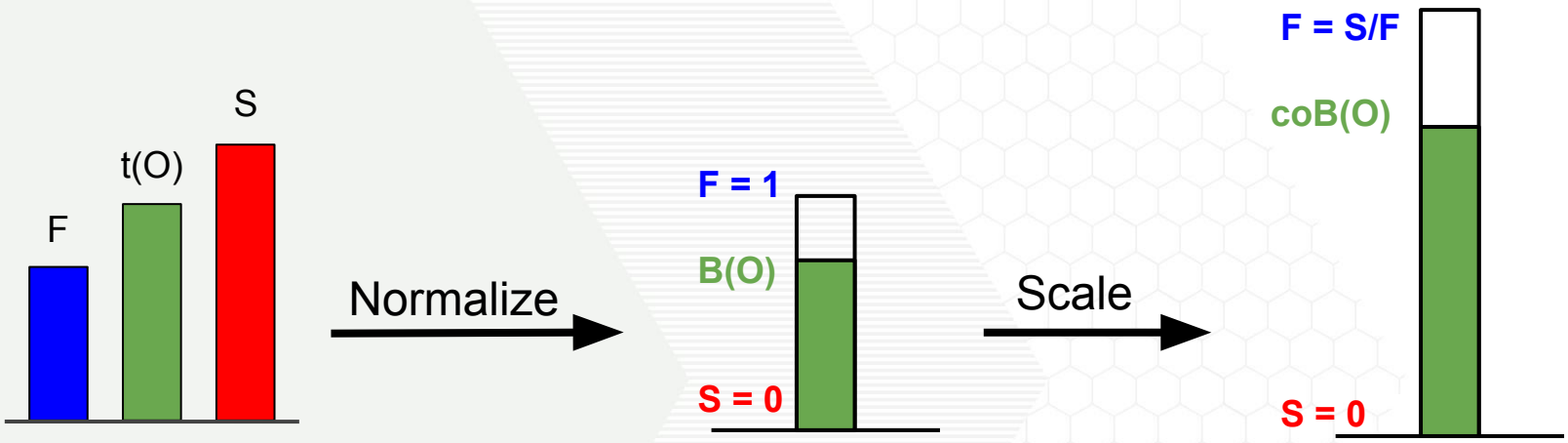


Observations

1. For non or low sensitive apps, doesn't matter which object is in DRAM.
2. Different data objects can contribute equally to the application runtime.
3. There can be objects whose allocation in DRAM is the only way to mitigate slowdown.

Co-Benefit Metric

Can we capture the previous observations?



Run Time	*Objects in DRAM*
F	All
t(O)	object O
S	None

How much does a specific object help reduce the slowdown?

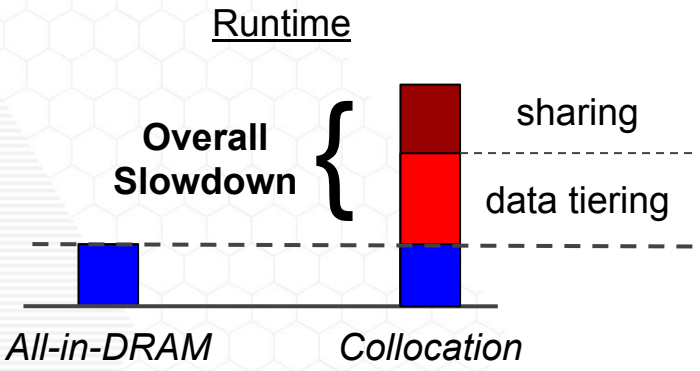
How can we make sure that objects of higher sensitivity kernels are getting prioritized?

e.g. B(O) = 0.9 ⇒ coB(O) = 0.9 * low sensitivity = 0.9
coB(O) = 0.9 * high sensitivity = 3.9

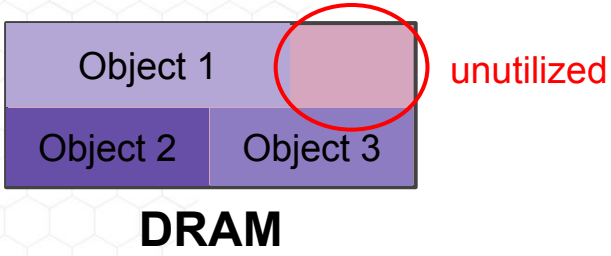
DRAM Distribution

What are the goals of an efficient technique?

1. Minimize overall runtime slowdown across all applications.

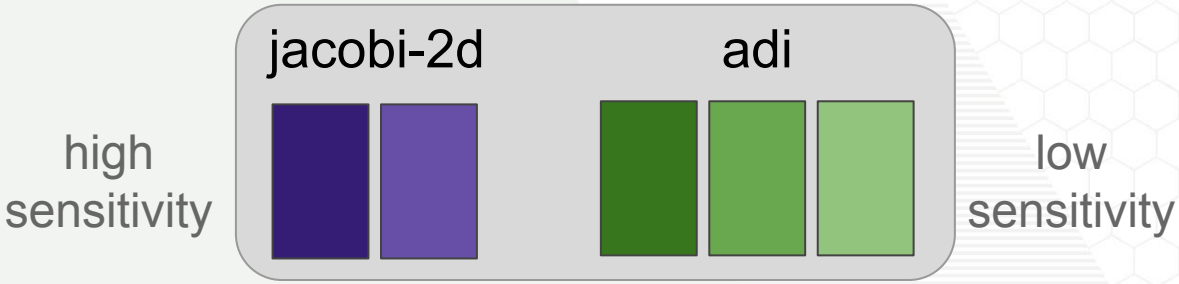


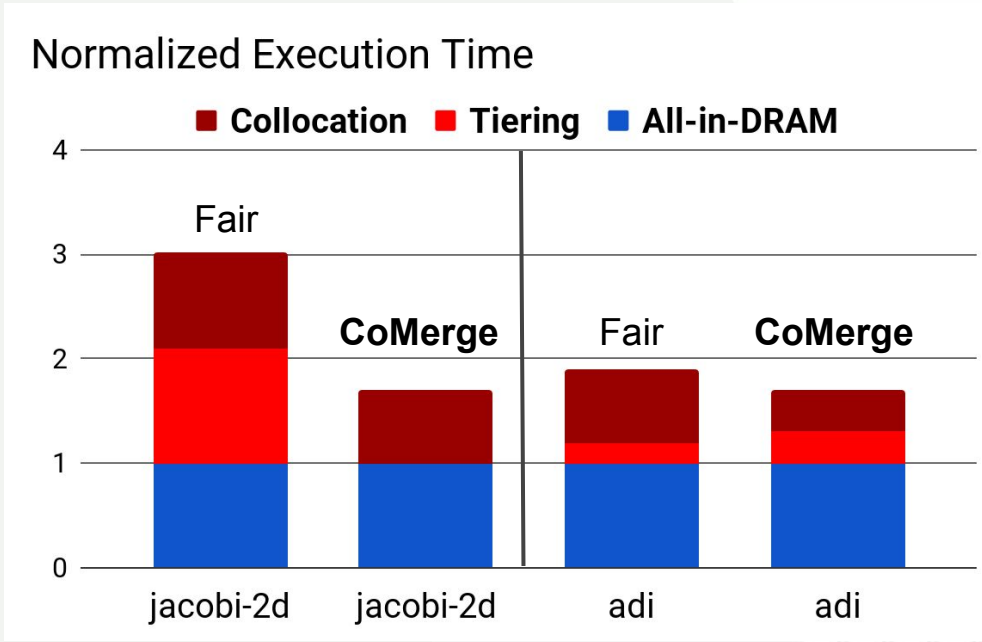
2. Maximize the utilization of DRAM.



Sharing DRAM

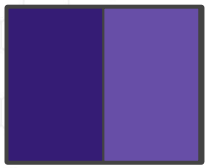
Sorting objects using co-benefit metric.





Fair Merge

CoMerge

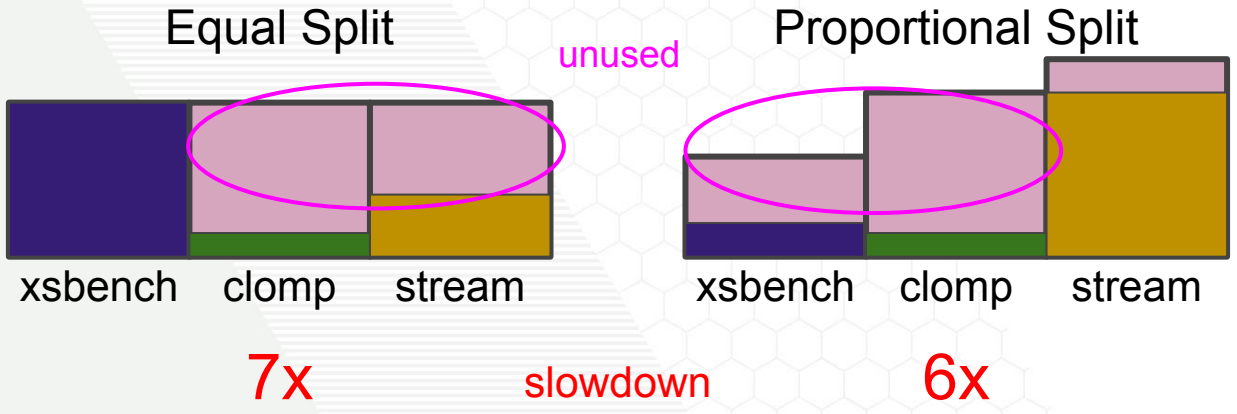


DRAM

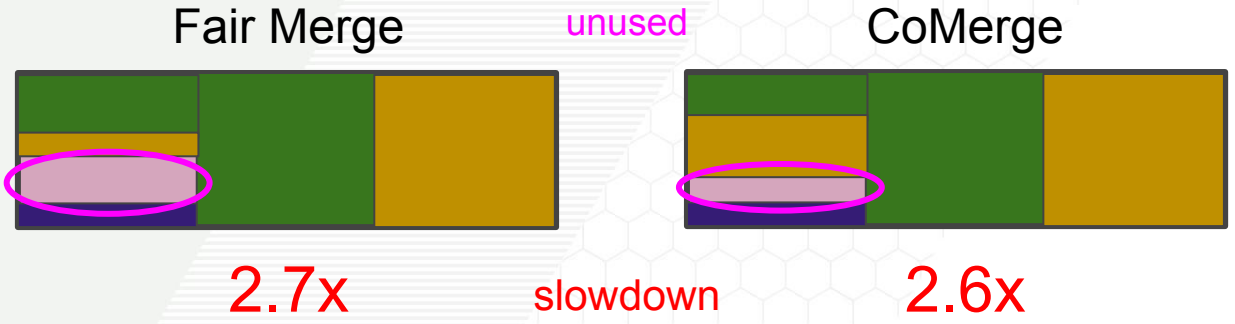
Summary

More detailed analysis in the paper

Partitioning & existing solutions



Sharing & co-benefit metric



Co-Benefit metric allows ***CoMerge*** to achieve:

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