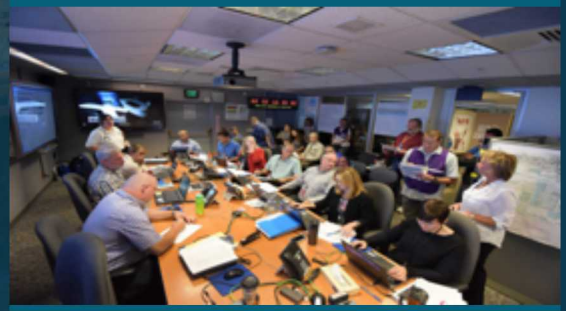
Sandia National Laboratories

SAND2020-7998PE

Similarity between Real and Proxy Applications



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Motivation for Examining Representativeness

Proxy applications used for

- Long term vendor collaboration projects (e.g., PathForward)
- Procurements (benchmarking/performance estimation)
- Testing new systems/architectures

Incentive to limit the number of proxy codes

- Constrained on staff and time (labs & vendors)
- Vendors have limited time & staff to respond to RFPs

Qualitatively down-select number of project codes

- Debate among team of SMEs about perceived relevance
- Choices often advocated based on familiarity, ease, etc

Strategy: Add quantitative support to balance qualitative inputs

What are the Resource Domains?

Basic Node
- Host processors and memory

Communication
- MPI
- Cluster interconnect

Accelerator
- GPU, et al.

Storage I/O
- Filesystem

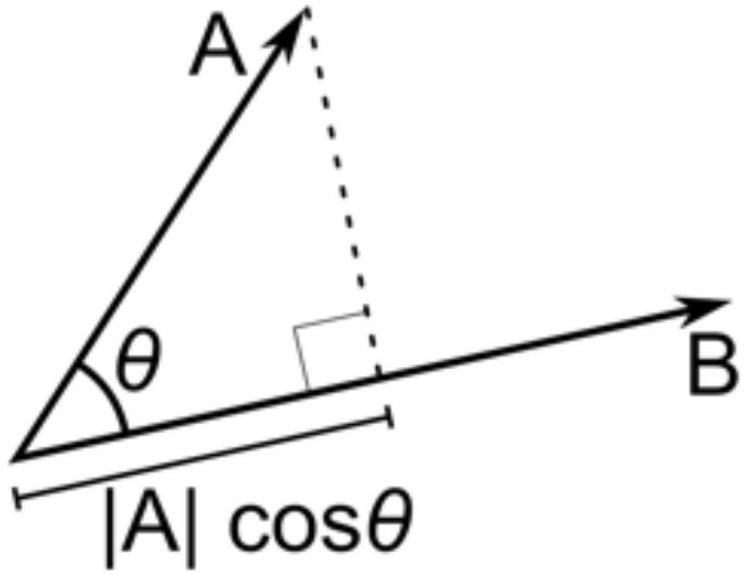
Cosine Similarity

A property of the inner (dot) product in vector spaces of two or more dimensions

- Think: "Projection of **A** in the direction of **B**"

Uses cosθ as an angular distance metric

- Quantifies the distance between A and B independent of their magnitude



$$\boldsymbol{A} \cdot \boldsymbol{B} \equiv \sum_{i=1}^{n} a_i b_i = \| \boldsymbol{A} \| \| \boldsymbol{B} \| \cos\theta$$

$$\therefore \cos\theta = \frac{\left(\sum_{i=1}^{n} a_i b_i\right)}{\left(\| \boldsymbol{A} \| \| \boldsymbol{B} \|\right)}$$

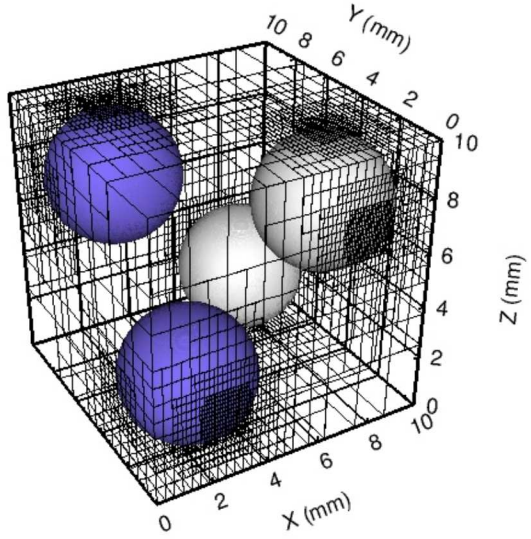
What Parent/Proxy Pairs?

List of the Proxy and real applications used in this work:

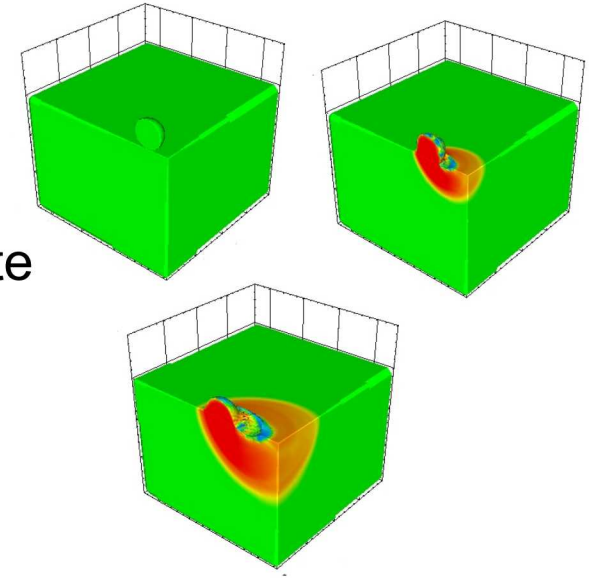
Proxy	Parent	
miniAMR	CTH	Shock Hydrodynamics
miniAMRZ	CTH	Shock Hydrodynamics
SWFFT	HACC	Cosmology/FFT
ExaMiniMD	LAMMPS	Molecular dynamics
sw4lite	sw4	Geo dynamics

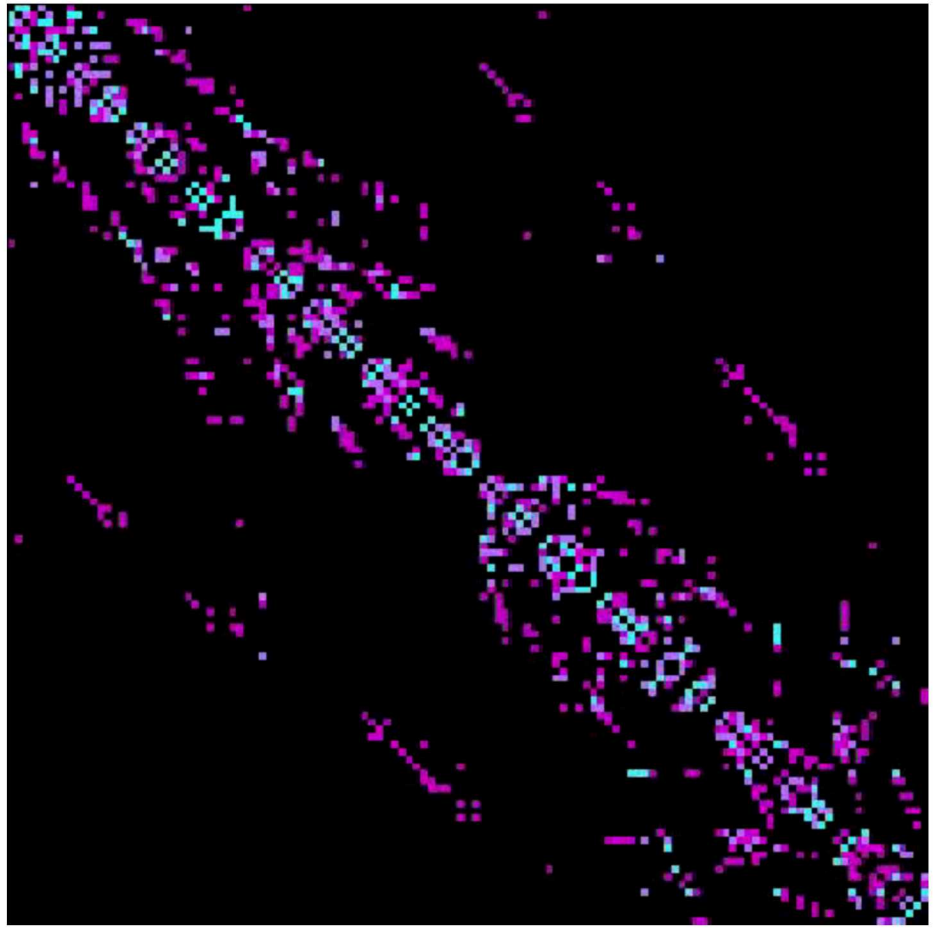
CTH/miniAMR(Z)

4 Sphere



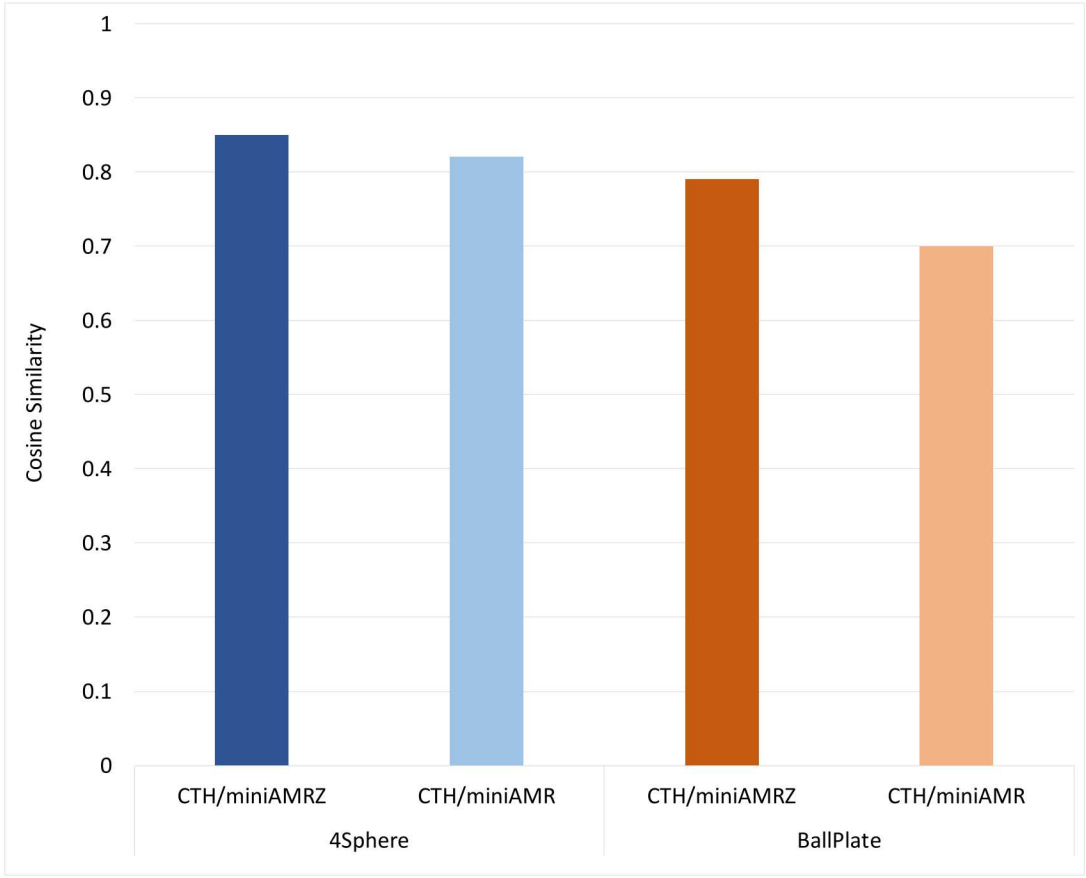
Ball & Plate

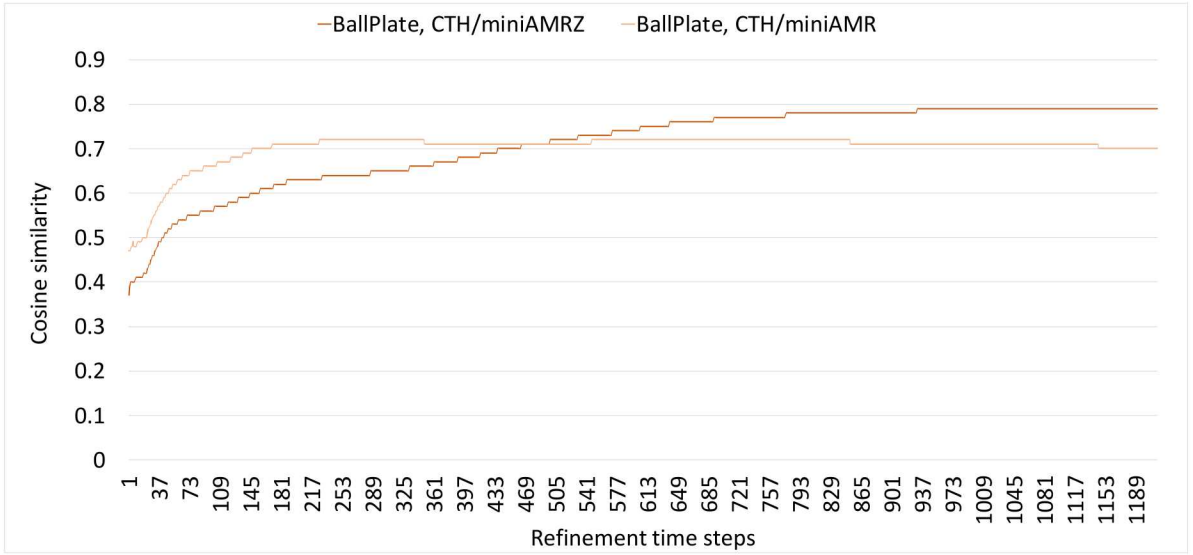


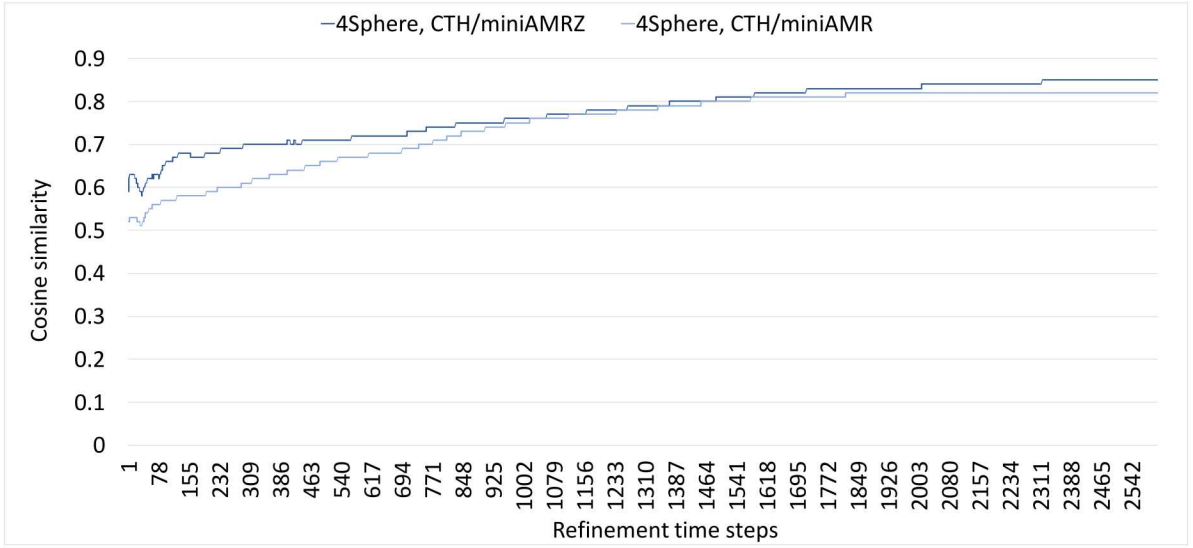


CTH Communication Time-Varying Patterns

MPI Communication Cosine Similarity







LDMS - Aries Performance Counters

Latency

- Report, in microseconds, the latency measured across request-response packet-pairs
- latency helps to find what?

Bandwidth

- Measure of the raw bandwidth consumed (Flit rate)
  - Each NIC network packet is between one and five flits long.

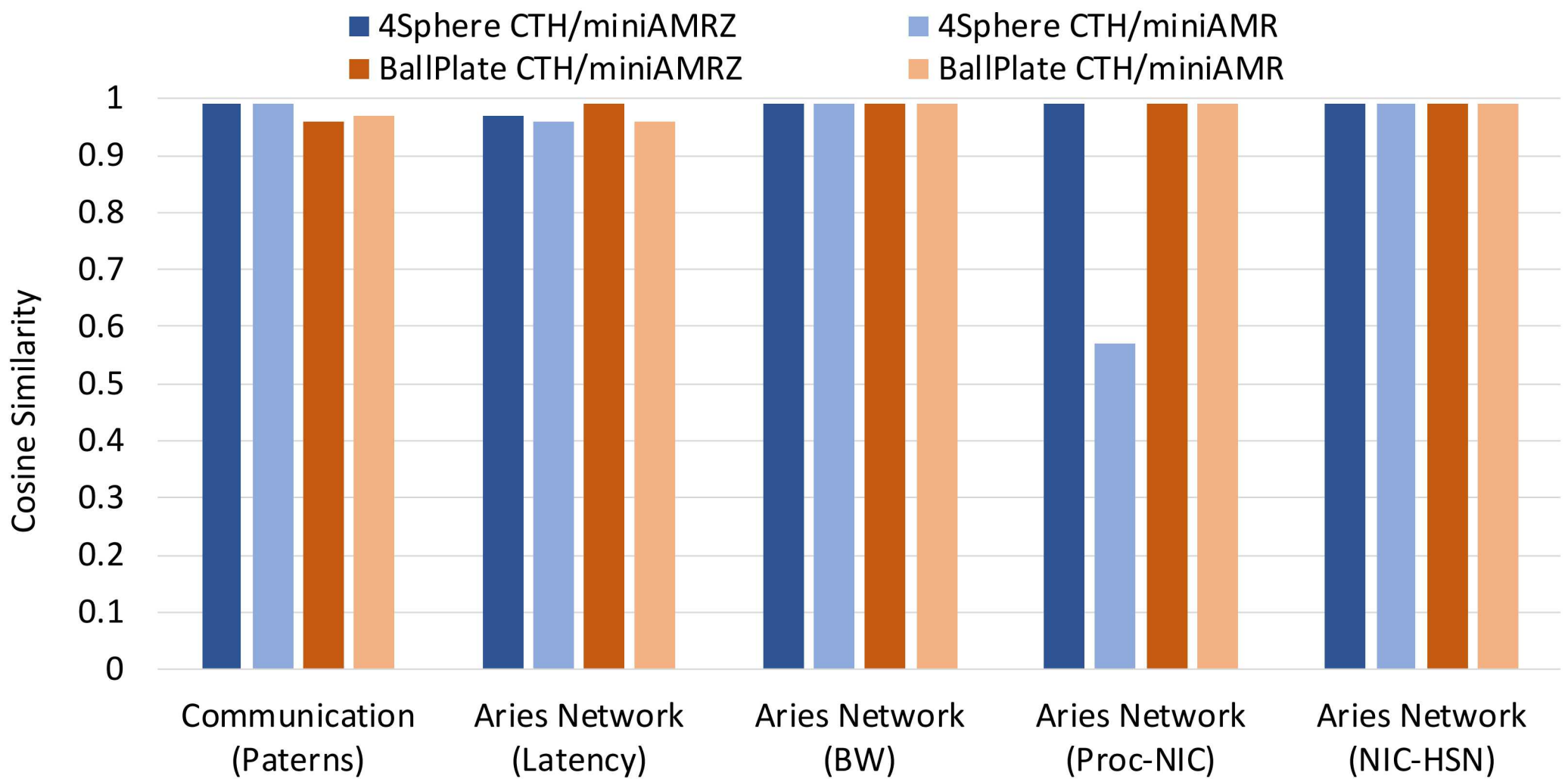
Measurement of Traffic Between the NIC and the Processor

- A high ratio of stalls to flits

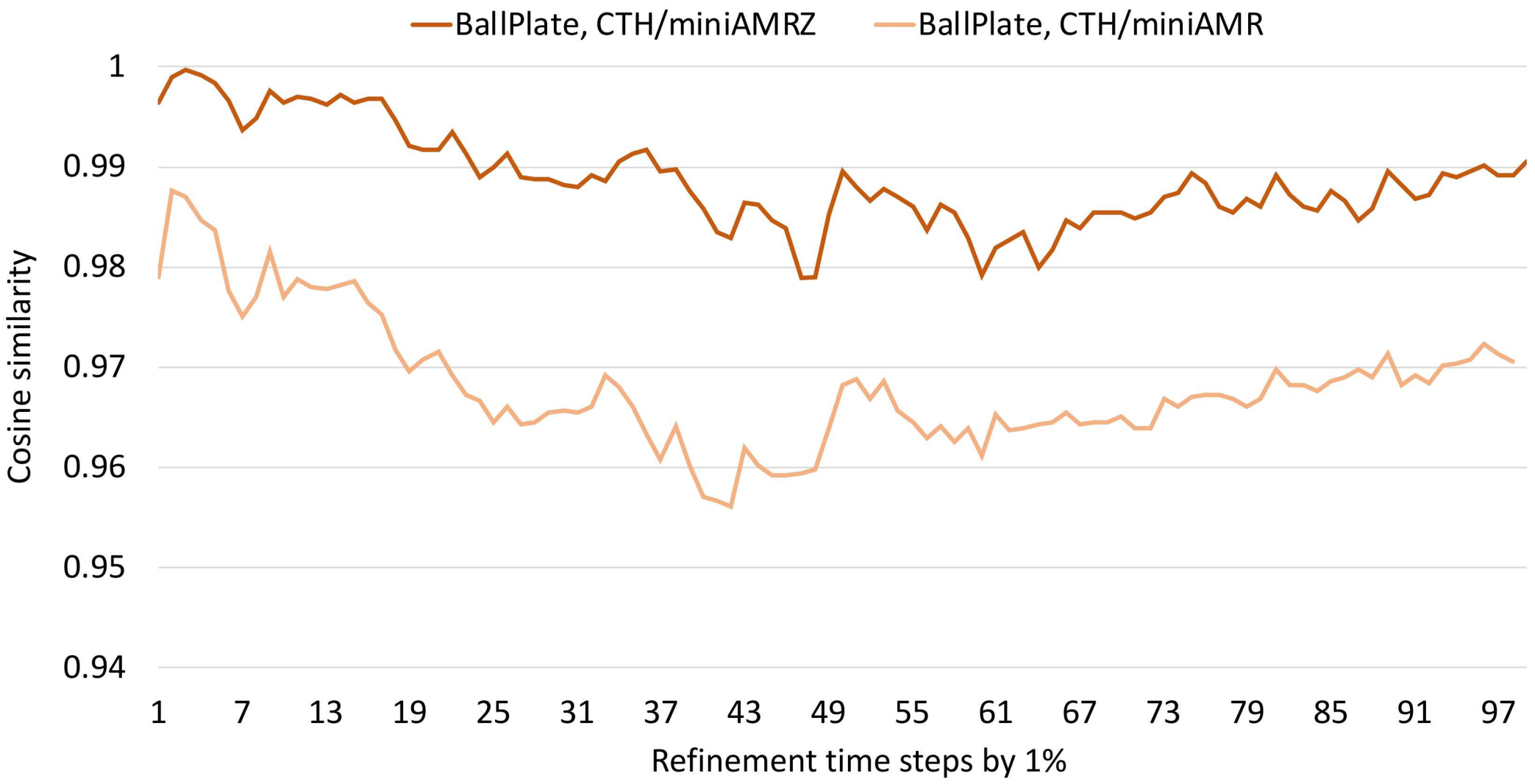
Measurement of Traffic Between the NIC and the HSN

- A high ratio of stalls to flits

Similarity – Aries vs MPI patterns (Averaged Data)



Latency
Similarity Metrics over Detailed Time Series Data, Ball & Plate



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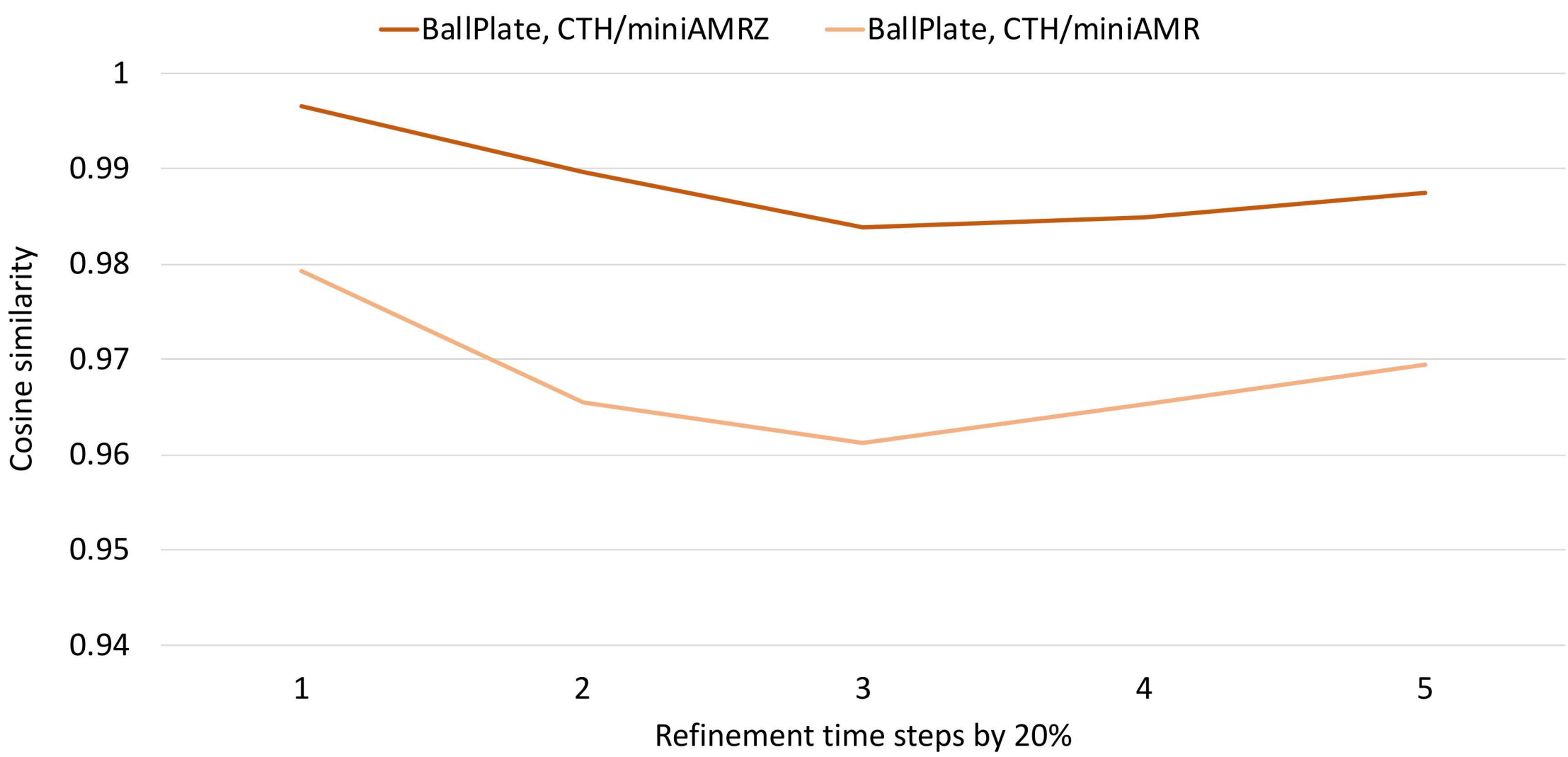
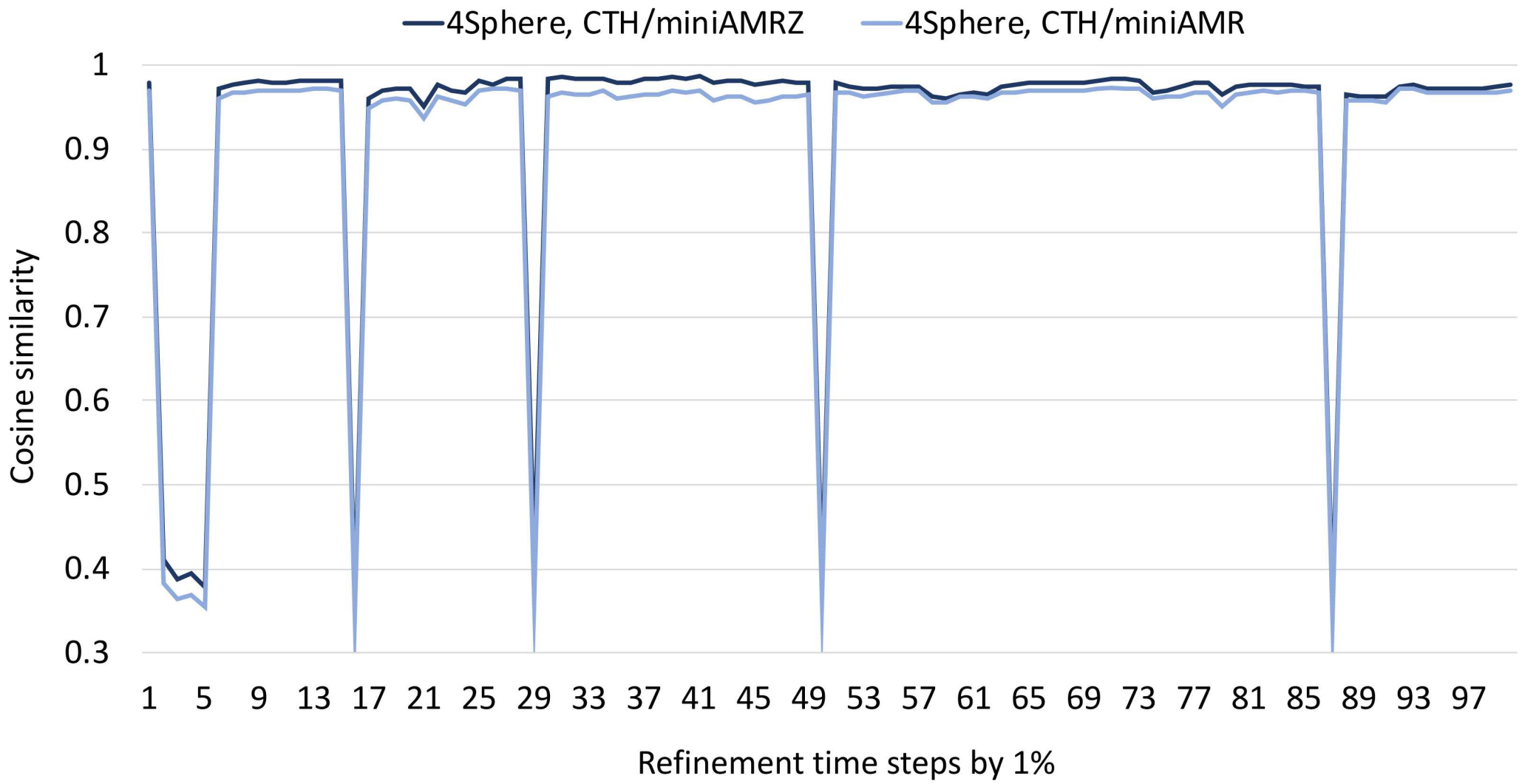
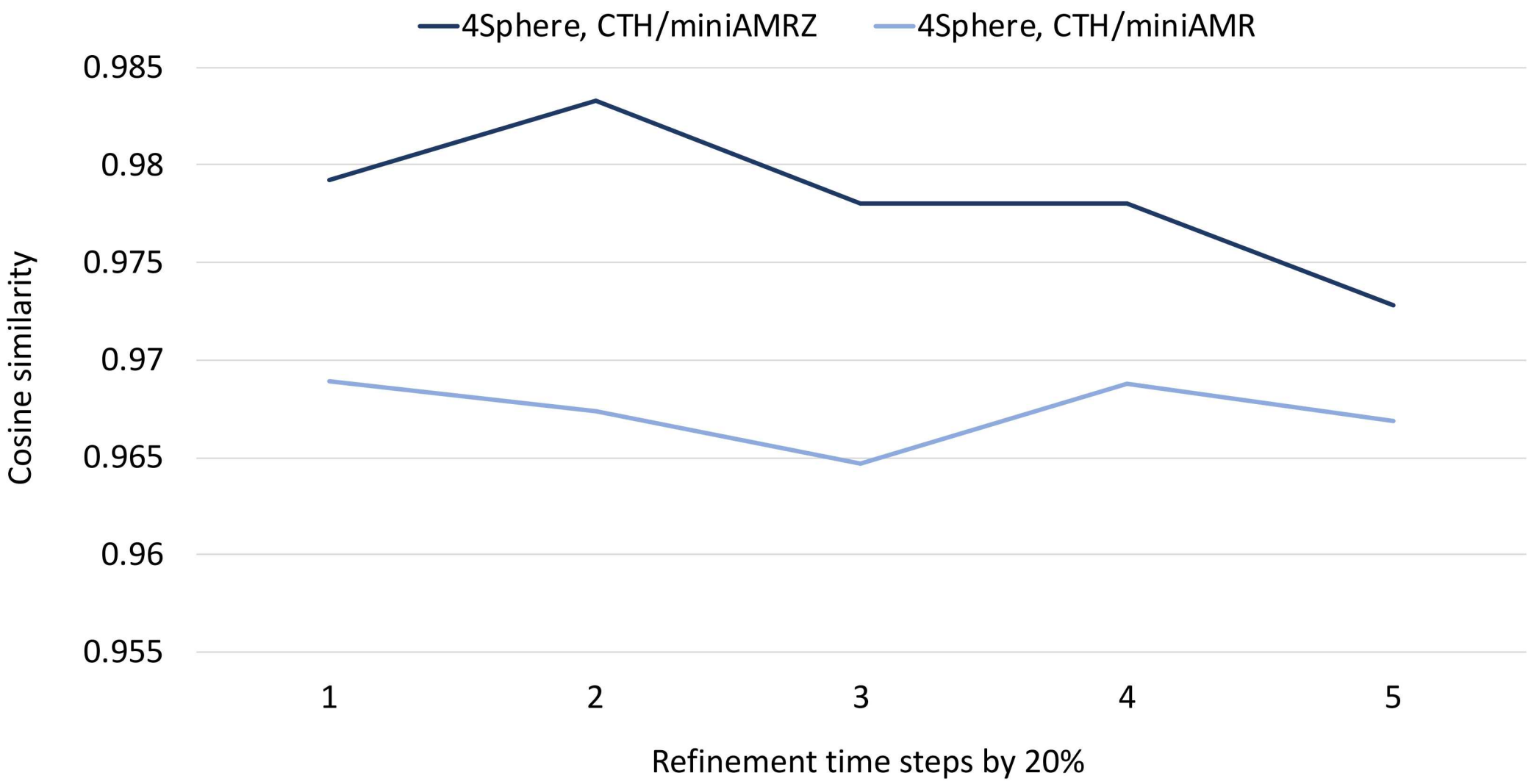


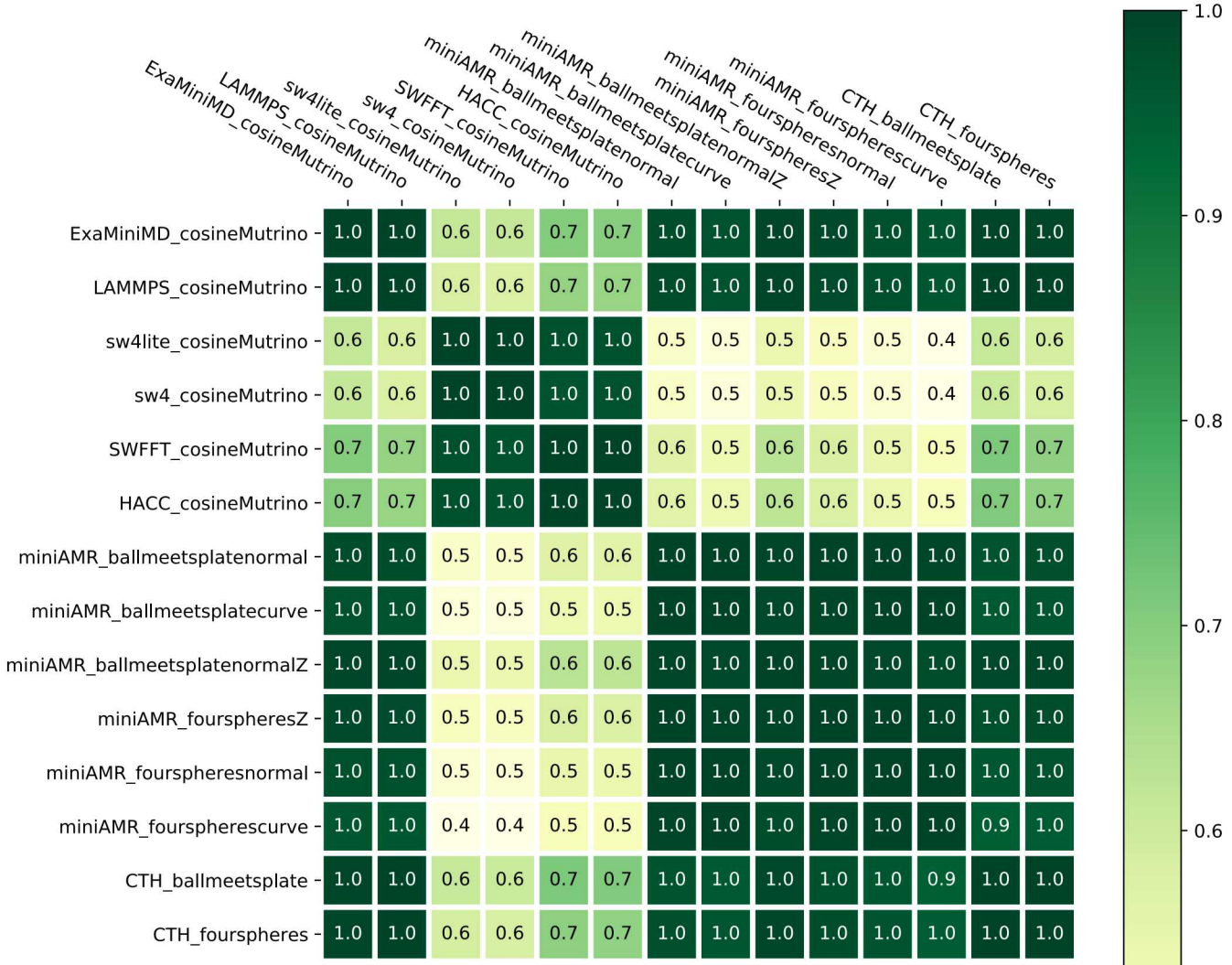
Latency
Similarity Metrics over Detailed Time Series Data, 4 Sphere



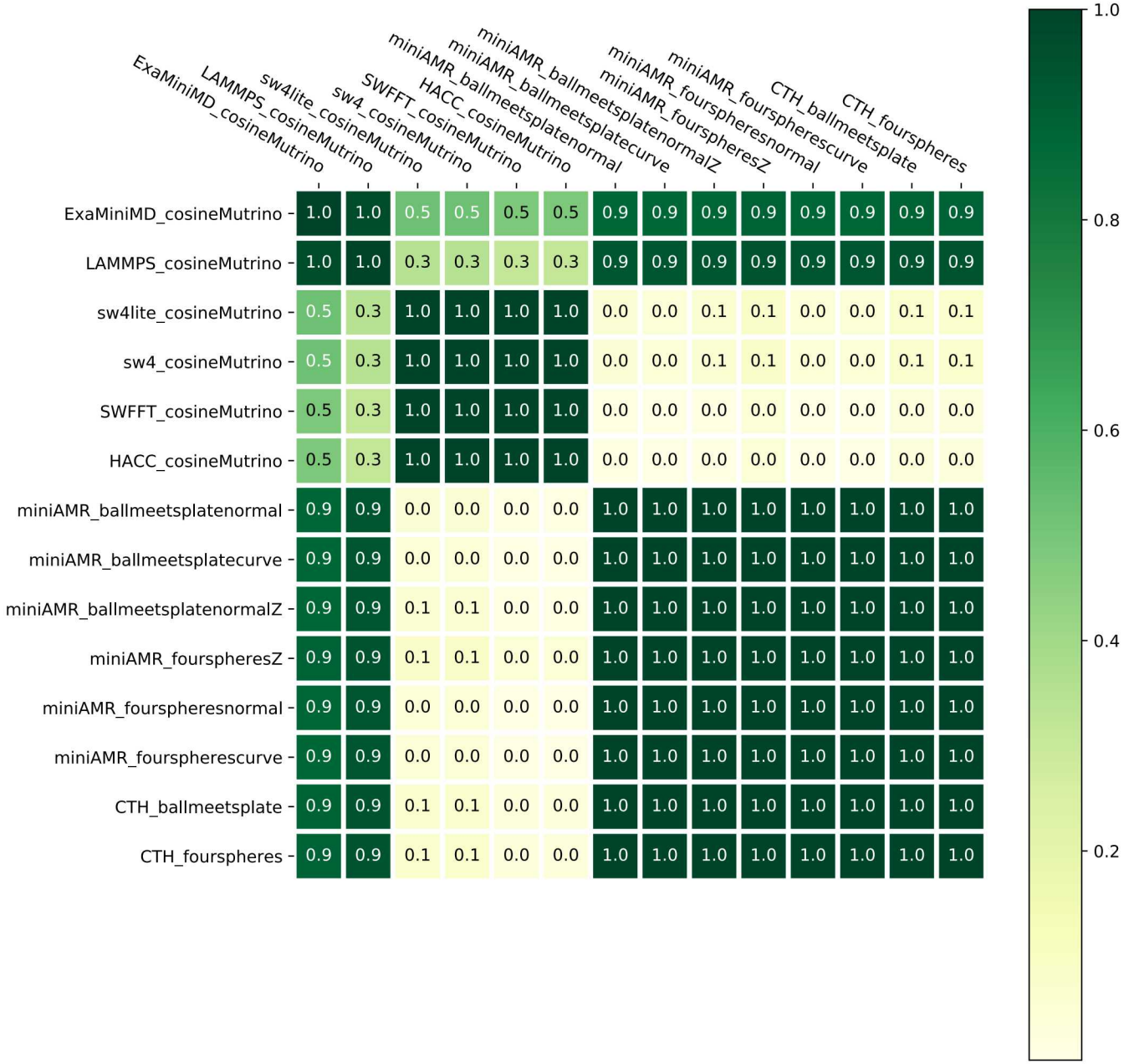
Latency
Similarity Metrics over Detailed Time Series Data, 4 Sphere



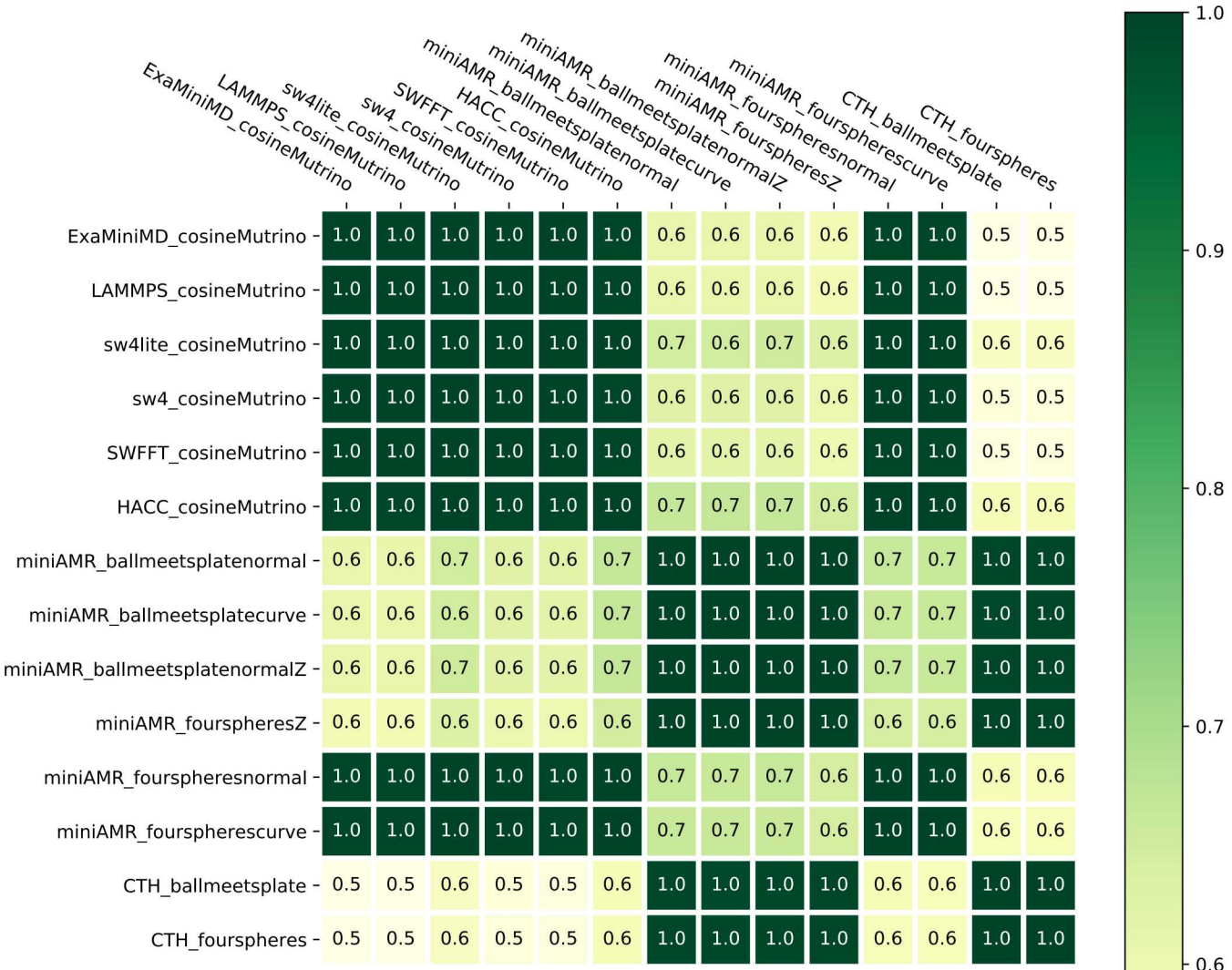
Cosine Between Applications - Latency



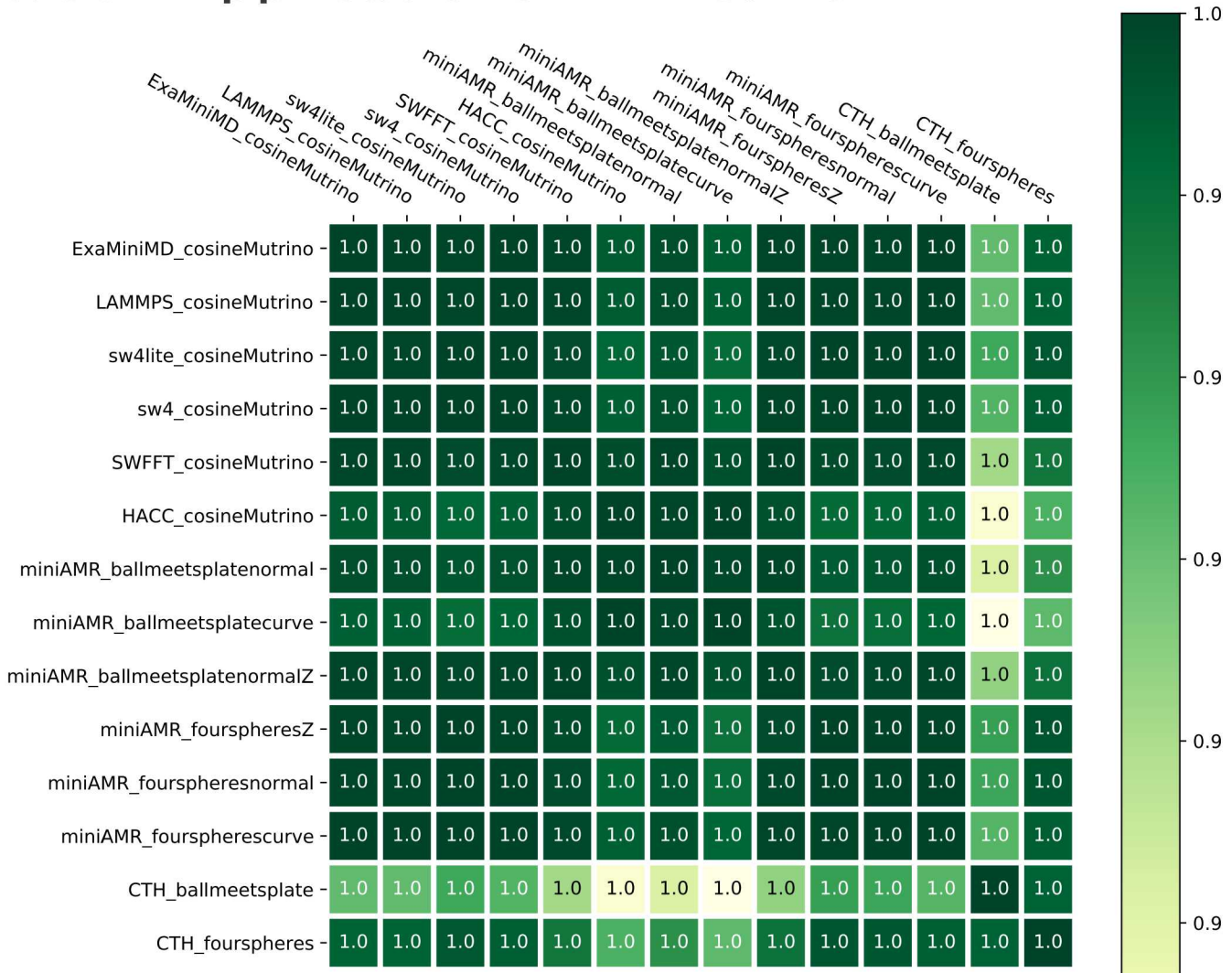
Cosine Between Applications - BW



Cosine Between Applications – Proc/NIC



Cosine Between Applications – NIC/HSN



Conclusion

We showed how LDMS data was used for work beyond monitoring the system health!

Explored how the underlying network performance of a proxy application relates to its parent application

- Network congestion
- Traffic at the NIC

Presented a time-varying quantification method:

- A time-varying network performance quantification method that captures how much of one application matches the other

Future Work

Study the similarity in terms of GPU performance (we just had the GPU sampler!)

Examine alternative similarity methods

Investigation of underlying network performance for networks other than Aries.

- Do the differences in observed similarity matter in other type of networks?
  - Network congestion

Acknowledgment

This research was supported by the **Exascale Computing Project (ECP)**, Project Number 17-SC-20-SC, a collaborative effort of two DOE organizations, the Office of Science and the National Nuclear Security Administration, responsible for the planning and preparation of a capable exascale ecosystem including software, applications, hardware, advanced system engineering, and early testbed platforms, to support the nation's exascale computing imperative.

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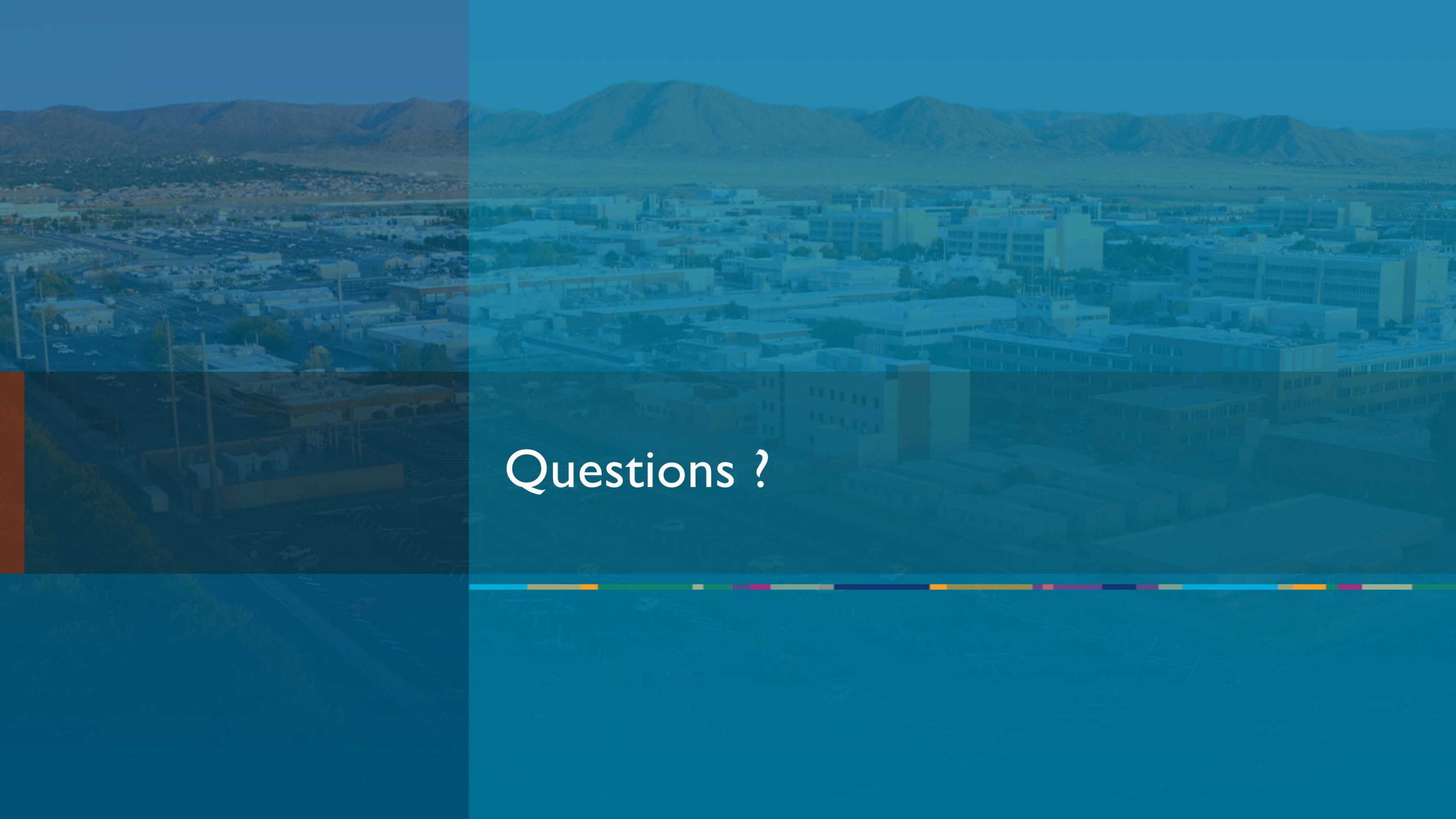

Questions ?