Micro-Benchmarking MPI Partitioned Point-to-Point Communication

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  - Provides multiple communication APIs
    - Point-to-point
    - Partitioned point-to-point
    - RMA
    - Collective Communication (MPI_Allreduce, MPI_Bcast, etc.)

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- The Message Passing Interface (MPI)
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  - Provides multiple communication APIs
    - Point-to-point
    - Partitioned point-to-point
    - RMA
    - Collective Communication (MPI_Allreduce, MPI_Bcast, etc.)
- MPI Threading Modes:
  - `MPI_THREAD_SINGLE`
  - `MPI_THREAD_FUNNELLED`
  - `MPI_THREAD_SERIALIZED`
  - `MPI_THREAD_MULTIPLE`

Multi-Threaded MPI Point-to-Point Communication

- MPI_THREAD_SERIALIZED

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for(int i=1; i<100; ++i)
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    /* Do Work */
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- Multi-threaded communication usually has issues with MPI's message matching queues.

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- A good implementation does not have the serialization issues of MPI Point-to-Point.

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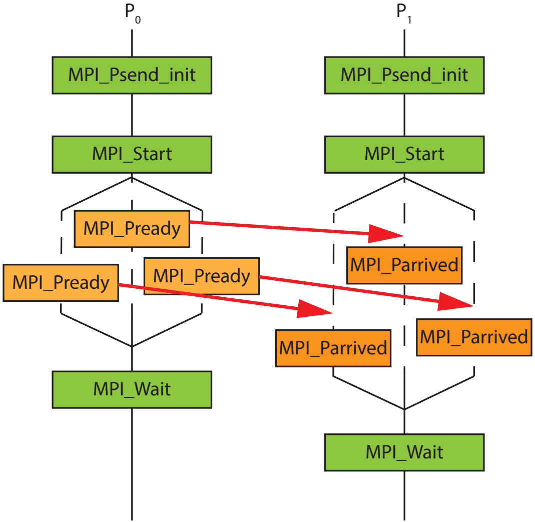

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Can we design an MPI Partitioned Micro-benchmark to address the following:

- How can we understand the behaviour and performance of MPI Partitioned?
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- What are appropriate partition sizes for application developers to use?

Micro-Benchmark Design

- Point-to-Point Metrics
  - Overhead
  - Perceived Bandwidth
  - Early Bird Communication
  - Availability

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  - Uniform Distribution
  - Gaussian Distribution
- Hot vs. Cold Cache

Experiment Setup

- Niagara Supercomputer at SciNet[1]
  - 2x 20 Core Intel Skylake at 2.4GHz
  - EDR InfiniBand Network
  - GNU/Linux - CentOS 7.6
  - Open MPI (master branch)
  - UCX v1.11.0
  - MPIPCL

[1] SciNet is funded by: the Canada Foundation for Innovation; the Government of Ontario; Ontario Research Fund - Research Excellence; and the University of Toronto. This research was enabled in part by support provided by the Digital Research Alliance of Canada

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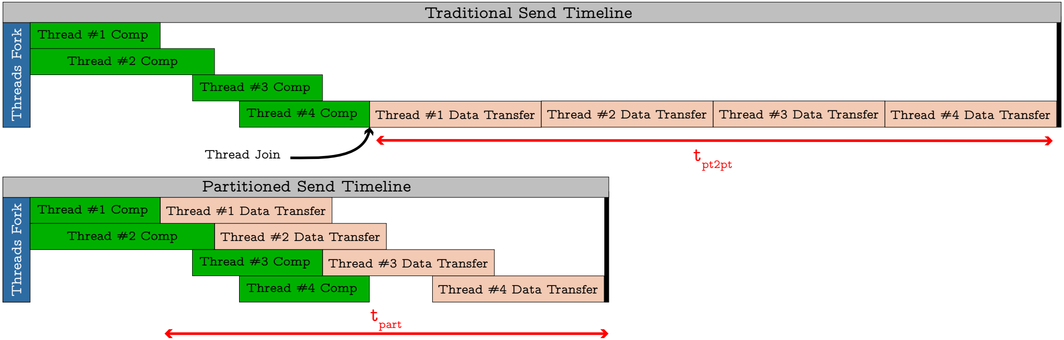
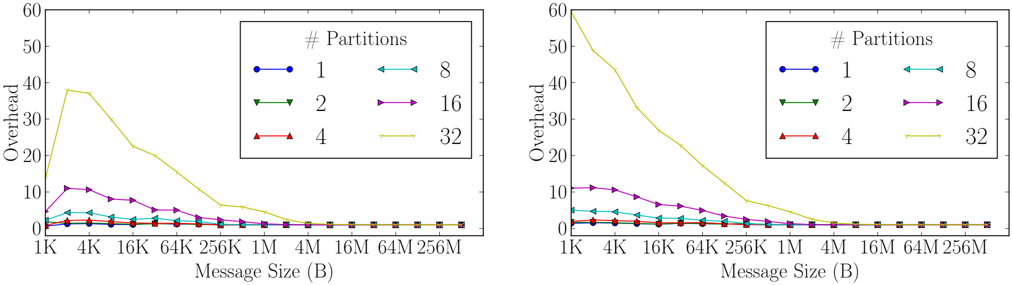


Overhead Results



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(b) Hot Cache

Overhead of Partitioned Point-to-Point Communication Relative to Point-to-Point Communication for 10ms of Compute

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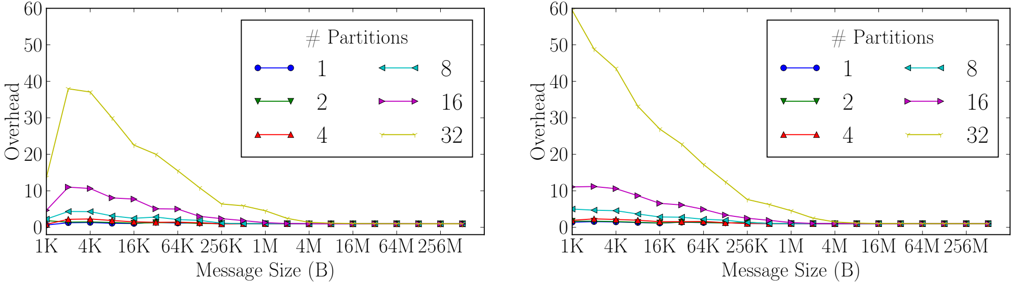
- Partition count correlates with overhead.



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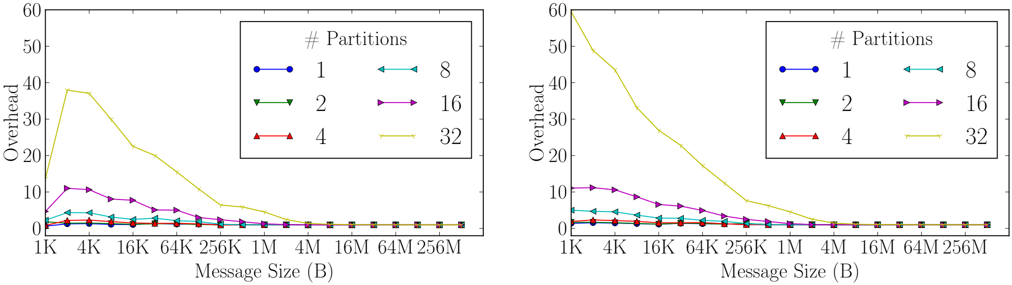

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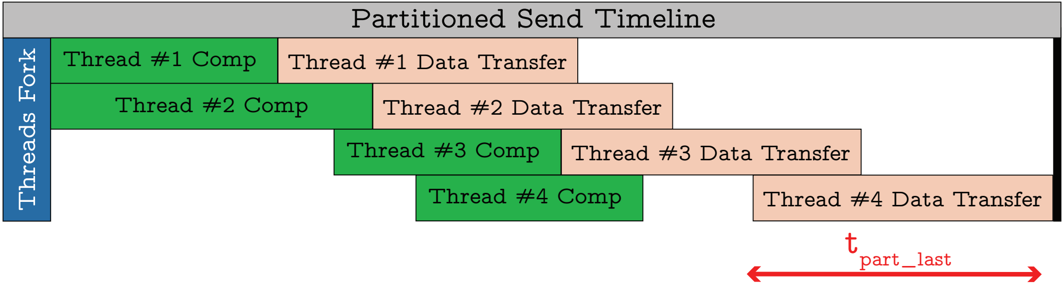

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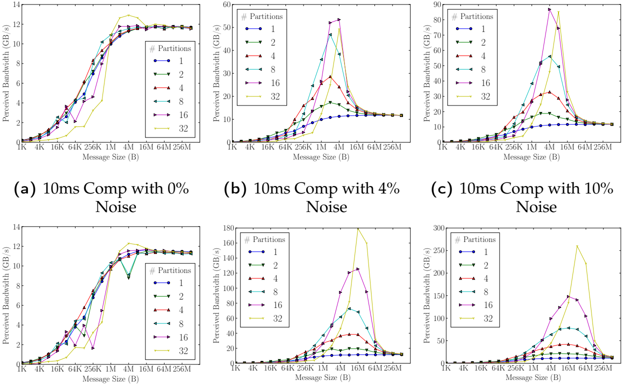

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Perceived Bandwidth of MPI Partitioned Point-to-Point Communication with Uniform Noise and a Hot Cache for Different Noise and Compute Amounts

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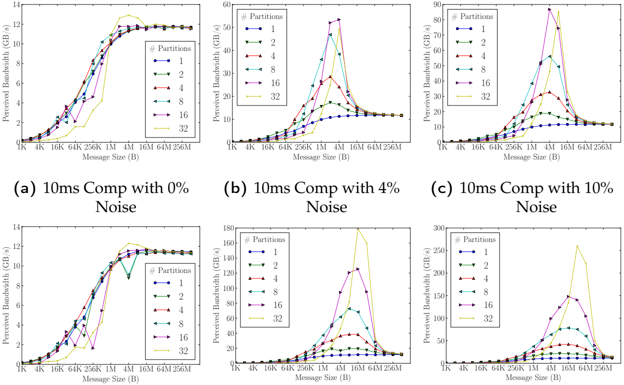

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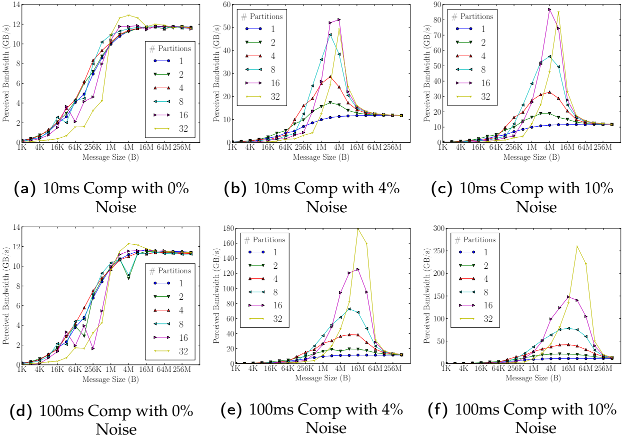

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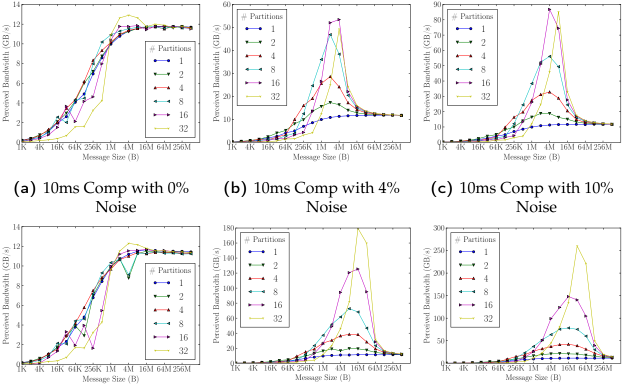
- Peak bandwidth is obtained for medium sized messages.
- Actual network bandwidth is saturated for large messages, thus perceived bandwidth drops.



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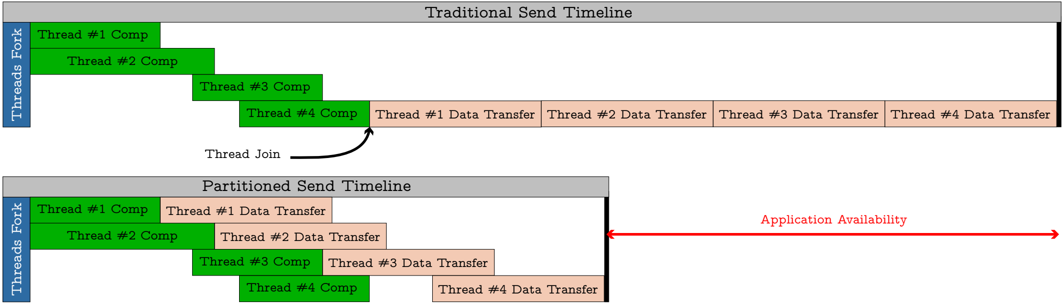

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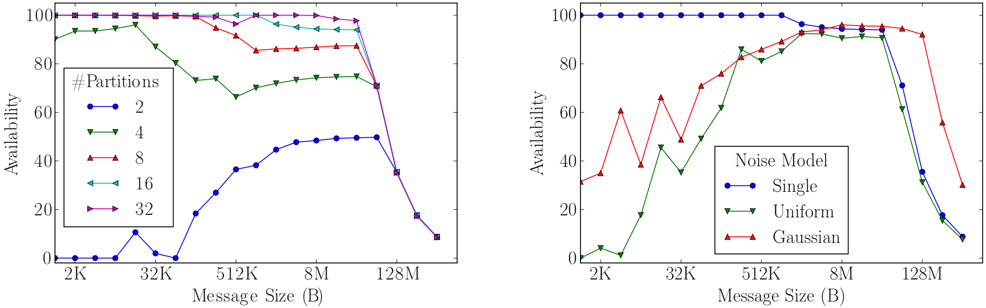

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(b) Noise Distributions (16P)

Application Availability with 100ms Compute and 4% Noise

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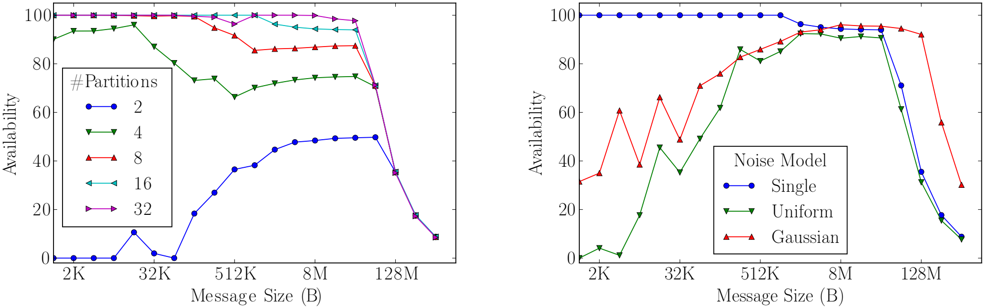

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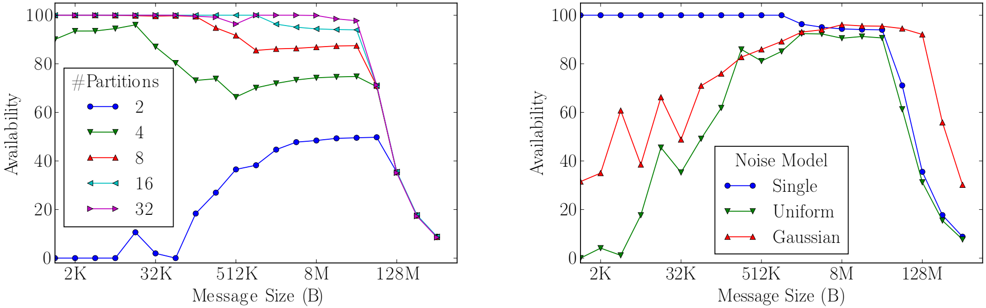

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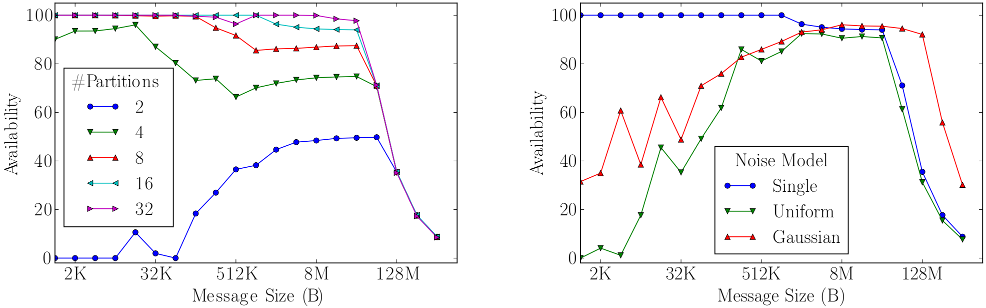
- Less beneficial for very large messages.



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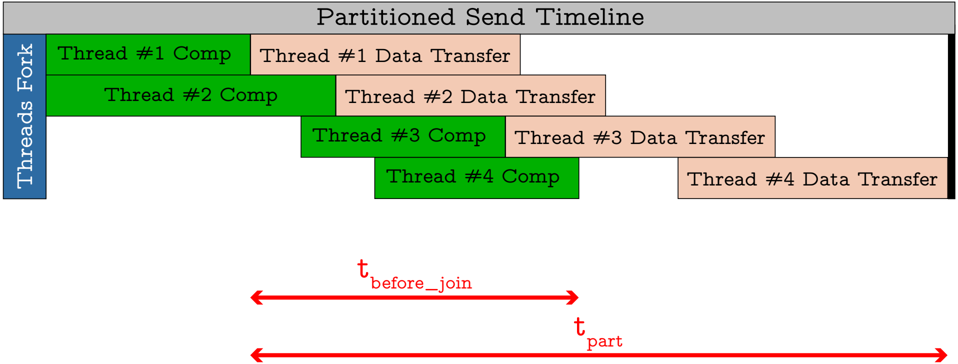

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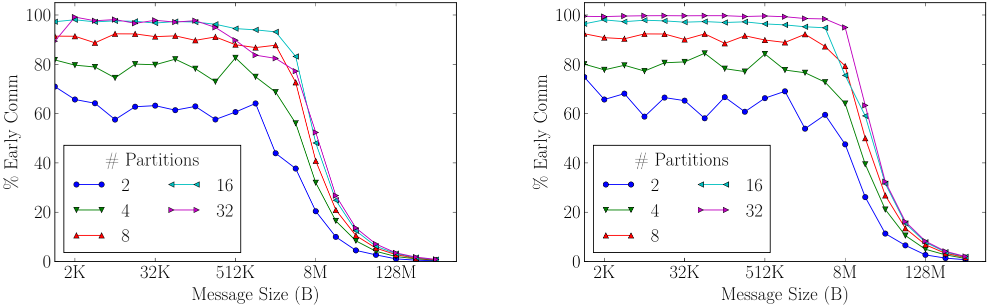

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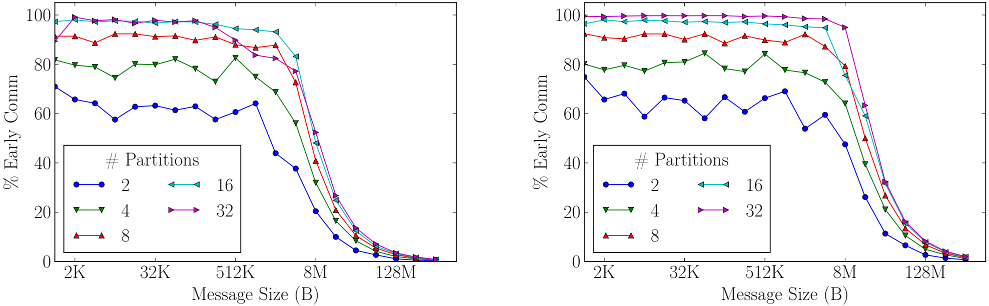

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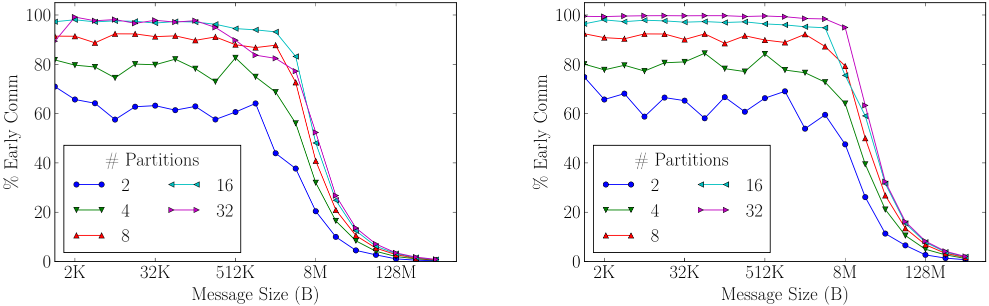
Early Bird Communication

- Better overlap with more partitions for small message sizes.



(a) 4% Noise

(b) 10% Noise

Early Bird Communication with 10ms Compute and Uniform Noise

Early Bird Communication

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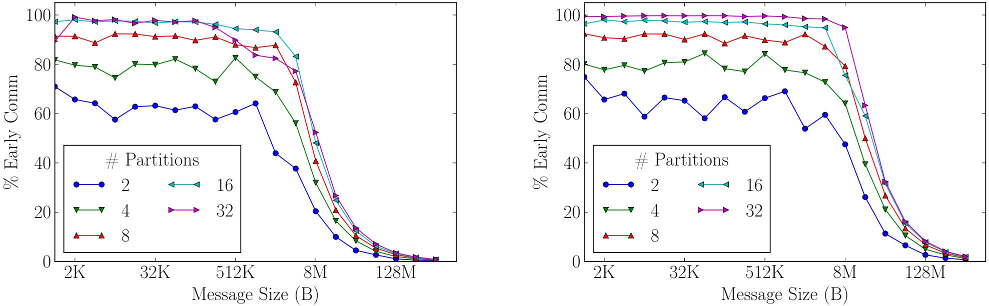
- More allows for more overlap for large messages.



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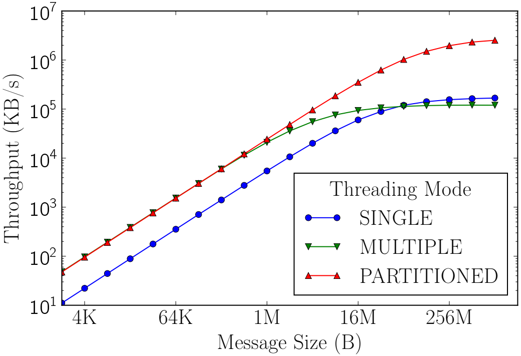
Sweep3D Communication Pattern



Sweep3D communication throughput for 16 partitions, 10ms compute, and 4% Single Noise with a Hot Cache

Sweep3D Communication Pattern

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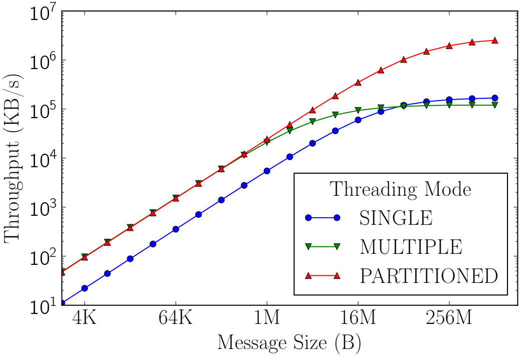

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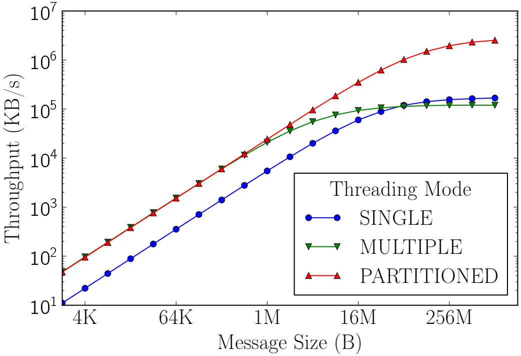

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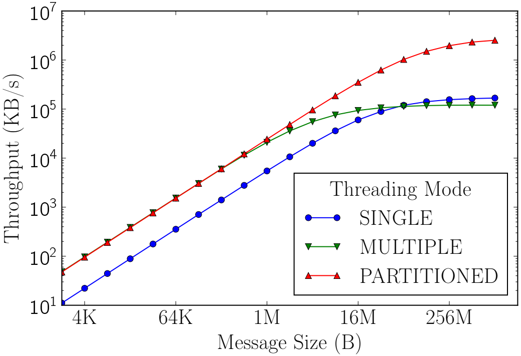

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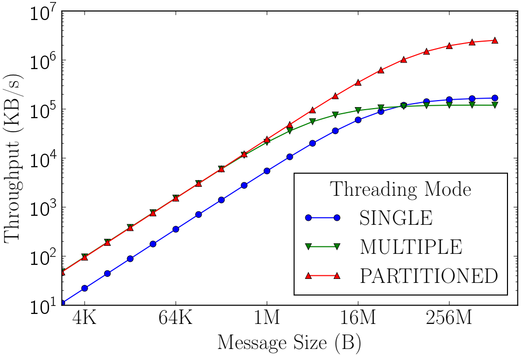

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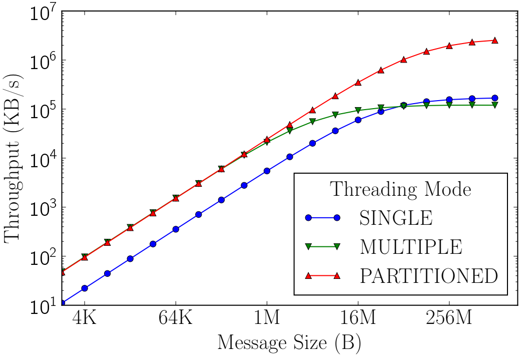

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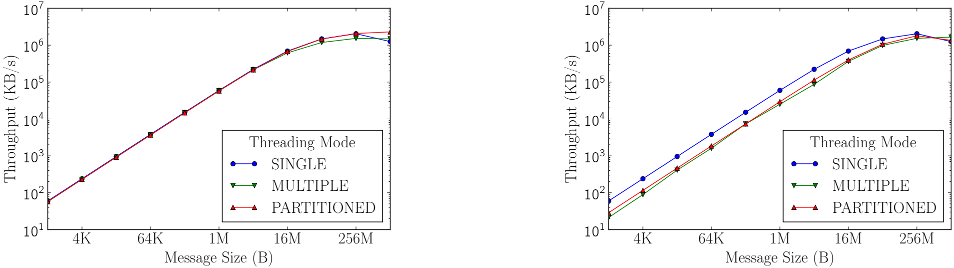

(a) 4 Partitions - 8 Threads

(b) 8 Partitions - 64 Threads (Oversubscribed)

Halo3D Communication Throughput For 10ms, 4% Single Noise with a Hot Cache

Halo3D Communication Pattern

- Halo exchange has lots of synchronization.
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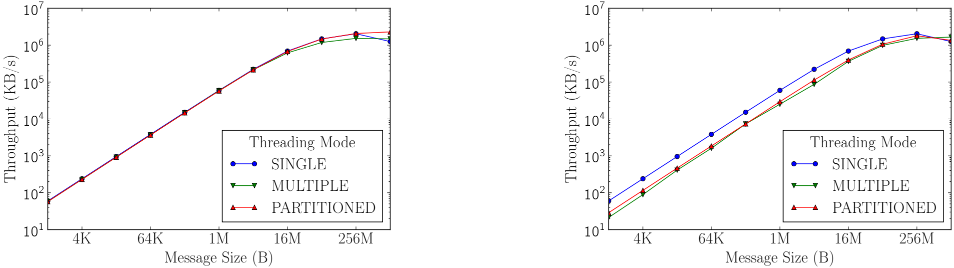

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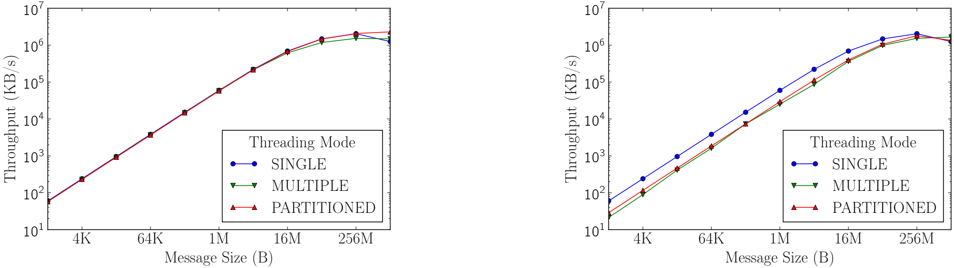
Halo3D Communication Throughput For 10ms, 4% Single Noise with a Hot Cache

Halo3D Communication Pattern

- Halo exchange has lots of synchronization.
  - Minimal difference in our different implementations.
- Additional work could be beneficial to Halo3D using MPI Partitioned
  - 64x increase in total computation with only a 16.8% decrease in throughput.
  - Could benefit from work stealing schemes.



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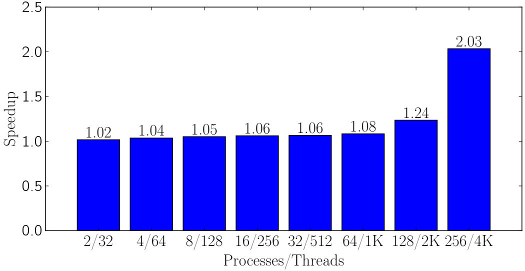

Expected Speedup From Porting SNAP-C to MPI Partitioned.

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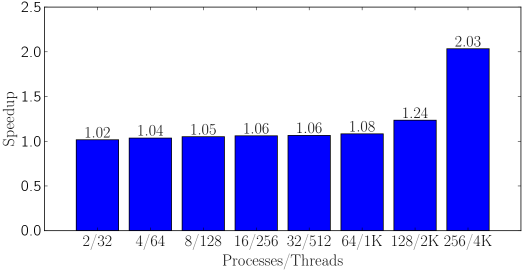

Expected Speedup From Porting SNAP-C to MPI Partitioned.

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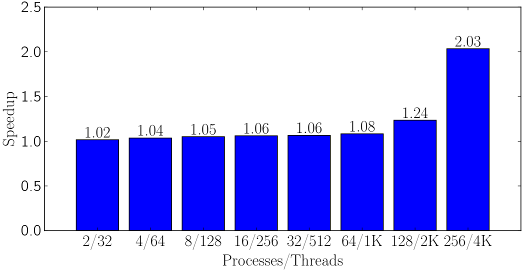
- SNAP uses a Sweep3D communication.
  - We profiled SNAP's communication.
  - Projected the potential speedup.



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Conclusion And Future Work

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- MPI Partitioned Collectives

Acknowledgements

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