An Analysis of the Impact of MPI Overlap and Independent Progress

Ron Brightwell and Keith Underwood

Scalable Computing Systems

Sandia National Laboratories

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Introduction

- Analyze the impact of MPI overlap, independent progress, and offload from an application perspective
- Network perspective analyzes the ability of the network to provide/offer these features
- Need to understand the ability of applications to take advantage of these features

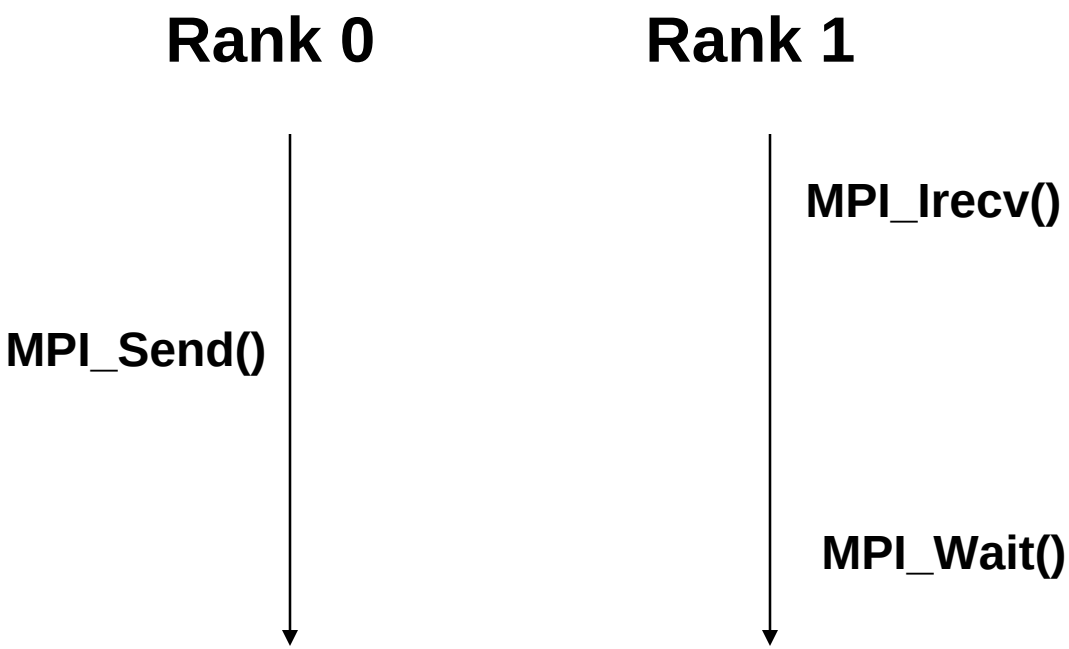
Overlap of Computation and Communication

- Most micro-benchmarks measure the overlap potential of a network and/or MPI implementation
- How much overlap potential is available from the application?
- For applications that cannot benefit, providing overlap may actually decrease performance

MPI Progress Rule

- Determines how a point-to-point communication operation completes once it has been “enabled”
- Room for interpretation
  - Strict: once a communication has been enabled, no subsequent MPI calls are needed to complete it
  - Weak interpretation: application must make library calls in order for an operation to make progress

Example



Impact of Progress

- Important for large messages
- Rendezvous protocol makes performance dependent on how often the application makes MPI library calls
  - Depends on the structure of the code
  - Depends on the OS
- Independent progress
  - Progress is independent of library calls
  - Application is not the MPI progress engine
- Understand the potential of an application to benefit from independent progress

Overlap and Progress Can Be Separate

- OS bypass can overlap data transfer without progress
  - Although potential for application overlap may be much less
- Interrupt-driven networks can provide progress without overlap
  - Although potential for network overlap may be much less

Offload

- MPI matching operations and/or protocol processing are handled by a separate processor

Platforms

- Accelerando cluster at LANL
  - 32 nodes
  - Dual 1 GHz Intel Itanium-2 processors
  - 2 GB main memory
  - 2 Quadrics Elan-3 NICs
  - Linux 2.4.21
- ASCI Red at SNL
  - 4000+ nodes
  - Dual 333 MHz Intel Pentium-2 processors
  - 256 MB main memory
  - CNIC
  - Cougar lightweight kernel

MPI Implementations

- Elan-3 cluster
  - MPI/Tports
    - Vendor-supplied
  - MPI/SHMEM
    - "A New MPI Implementation for Cray SHMEM", EuroPVM/MPI 2004
- ASCI Red
  - Eager / Rendezvous
  - Heater (P0) / Co-processor (P1) modes

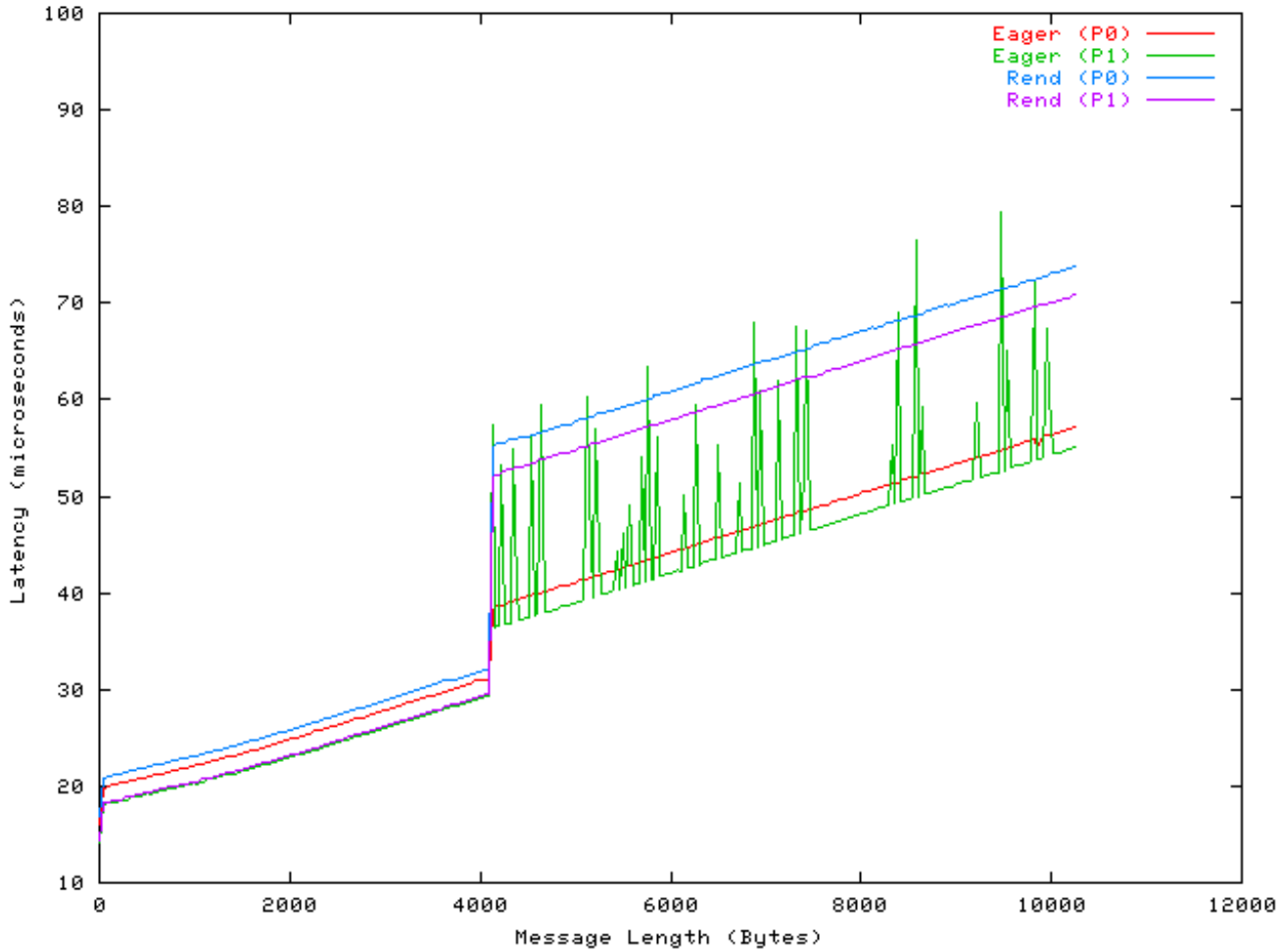
MPI Implementation Characteristics

	ASCI Red				Quadrics	
	Eager		Rendezvous		Tports	SHMEM
	P0	P1	P0	P1		
Progress	✓	✓			✓	✓
Overlap		✓		✓	✓	
Offload		✓		✓	✓	

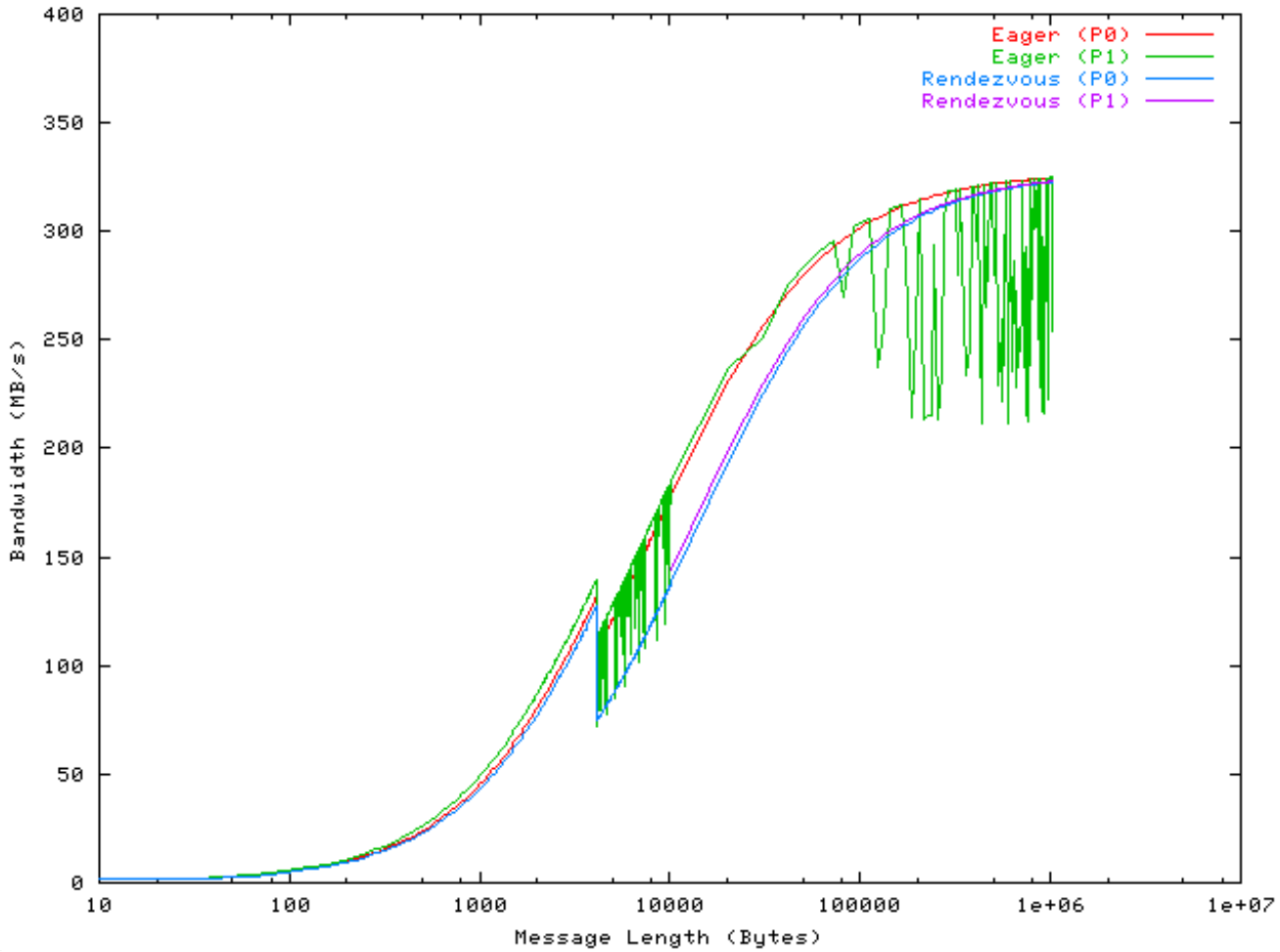
Communication Micro-Benchmarks

- Ping-pong
  - Latency and bandwidth
- Implementations show nearly identical performance
  - Except for Eager/P1 on Red

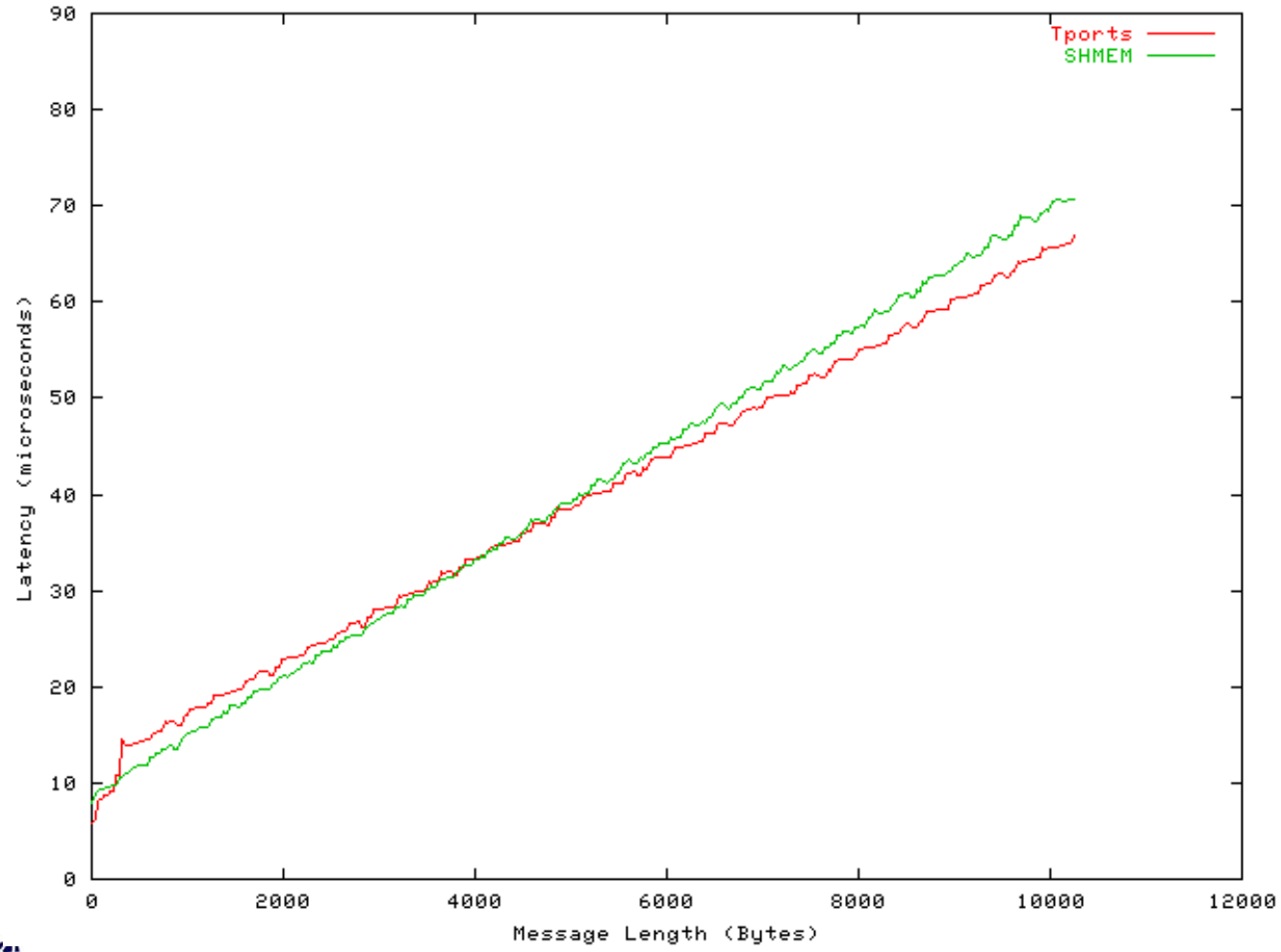
Latency – ASCI Red



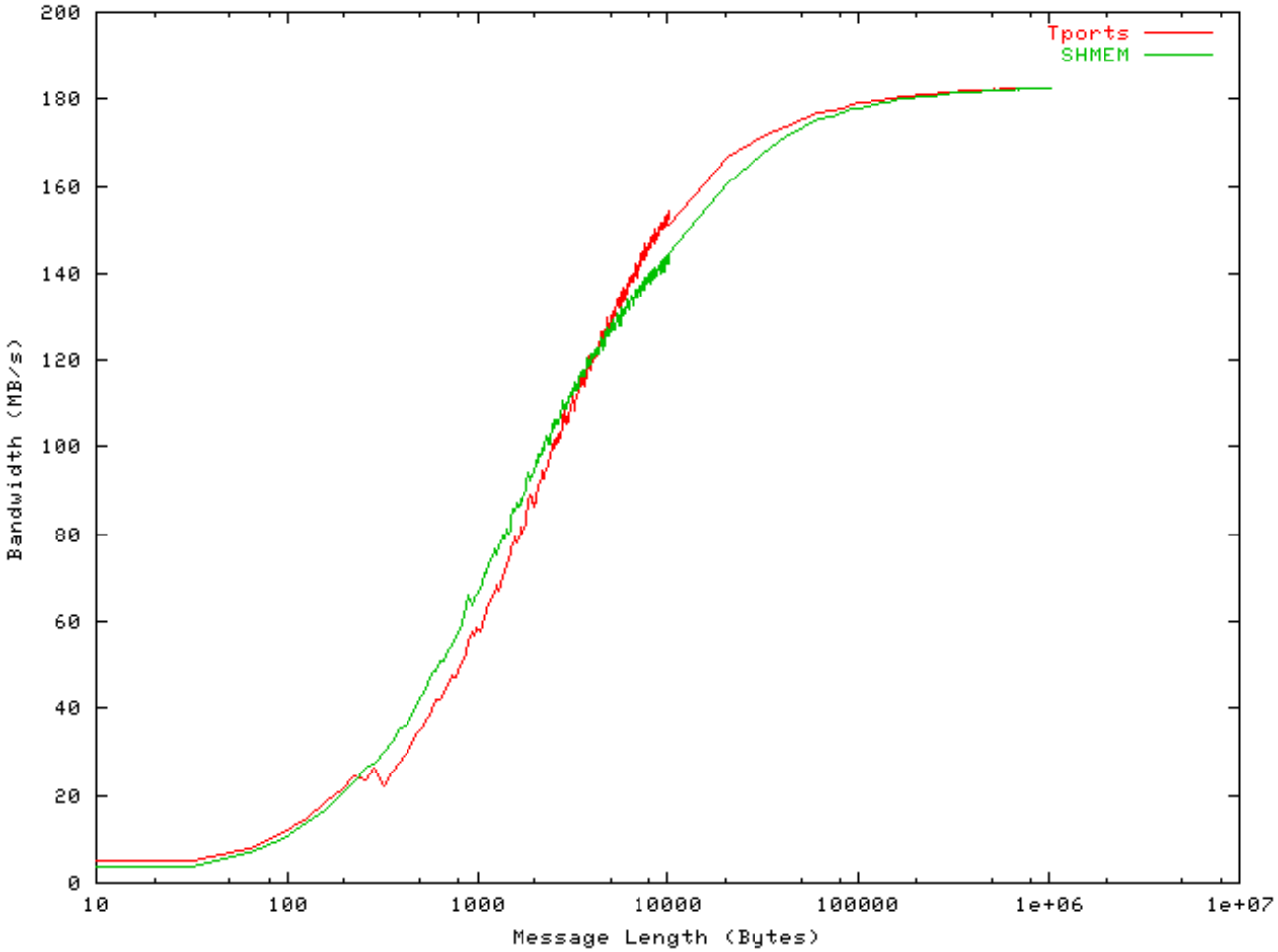
ASCI Red Bandwidth



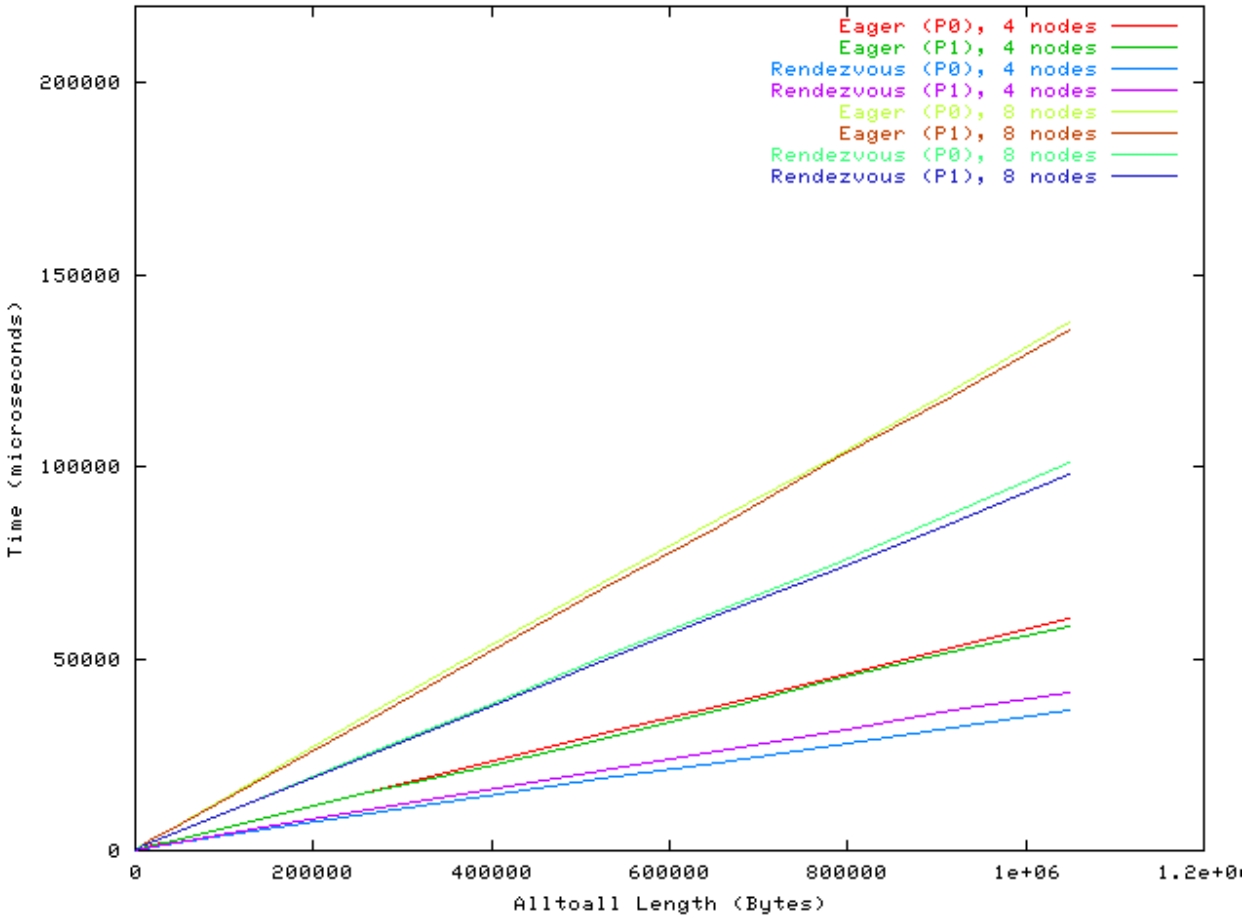
Elan-3 Latency



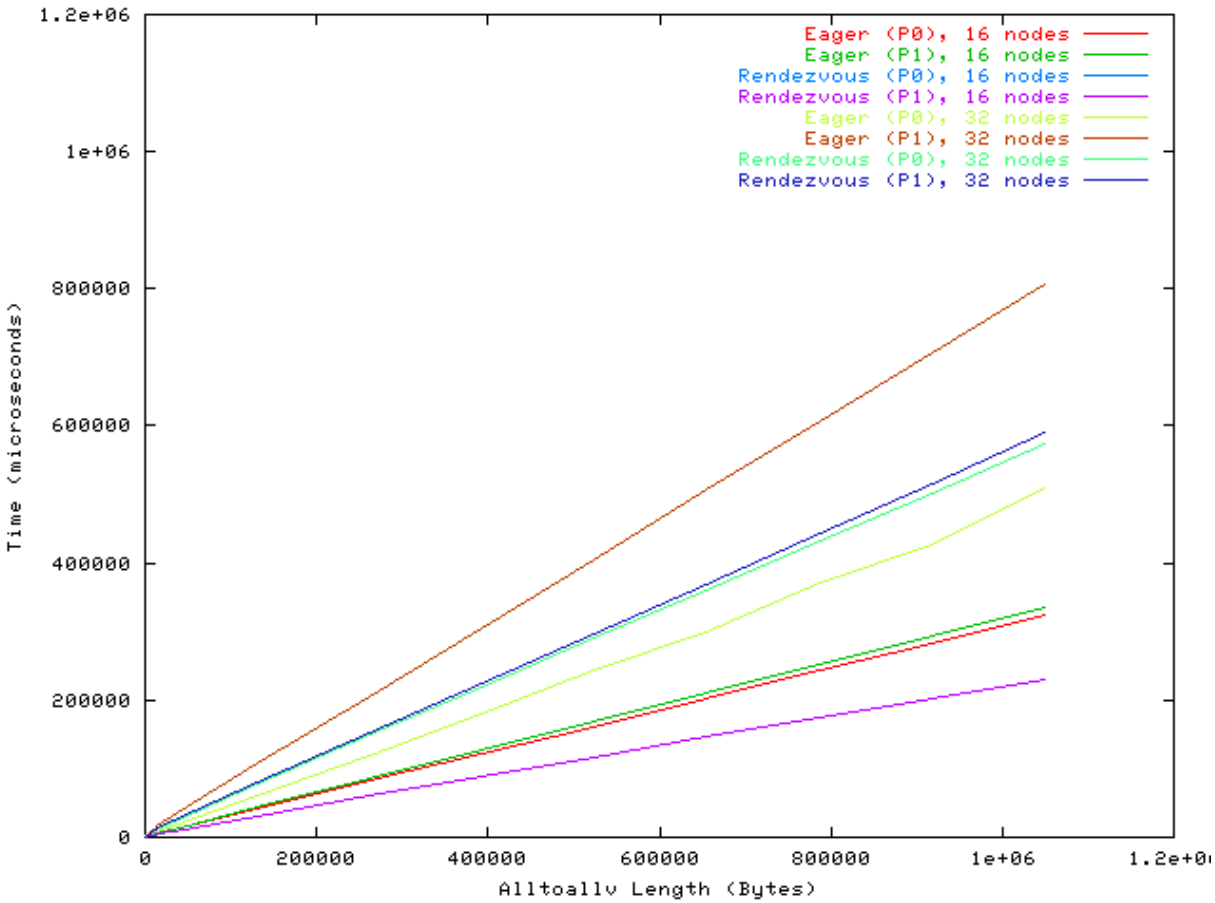
Elan-3 Bandwidth



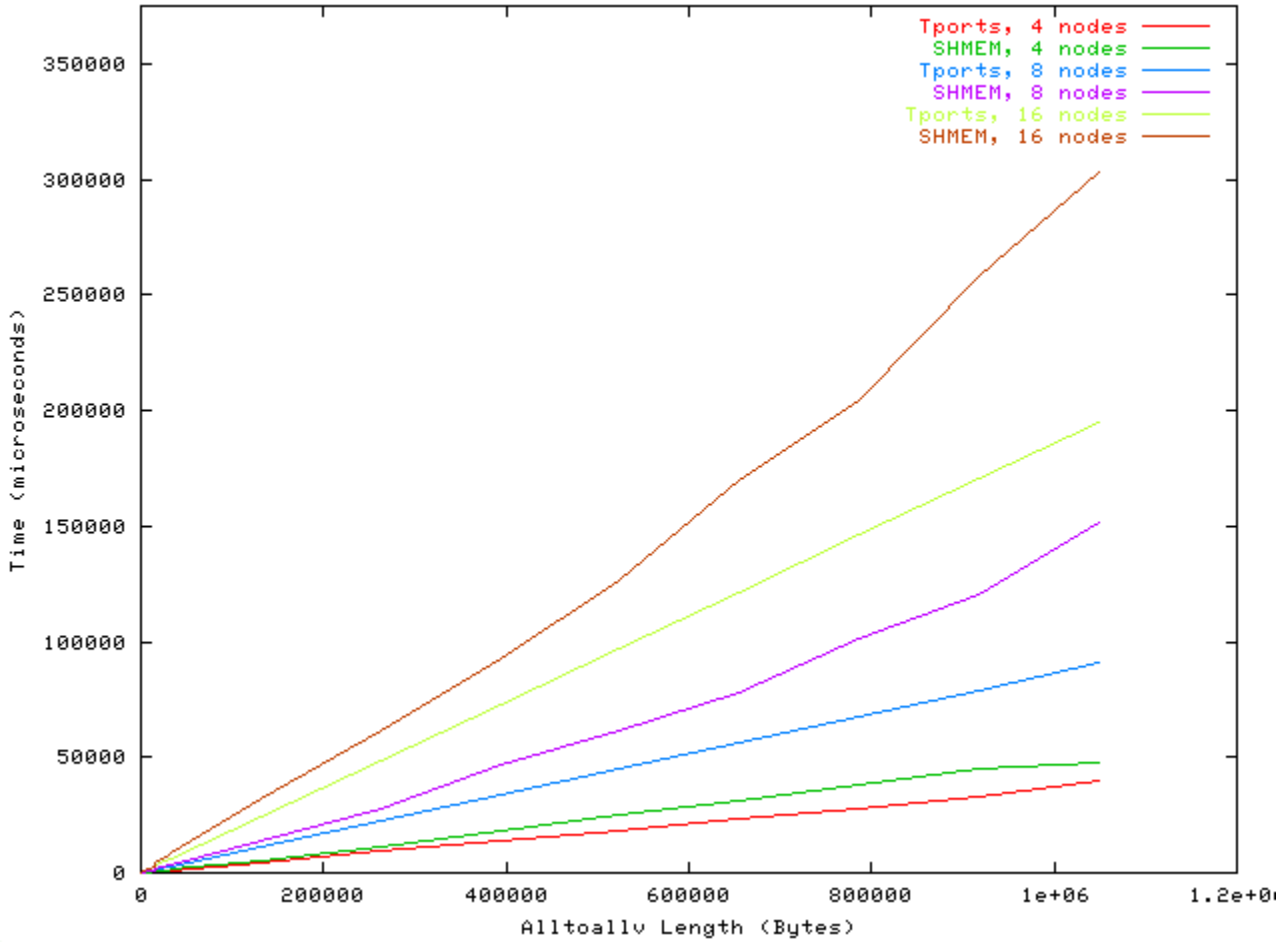
ASCI Red - MPI_Alltoallv() (1)



ASCI Red - MPI_Alltoallv() (2)



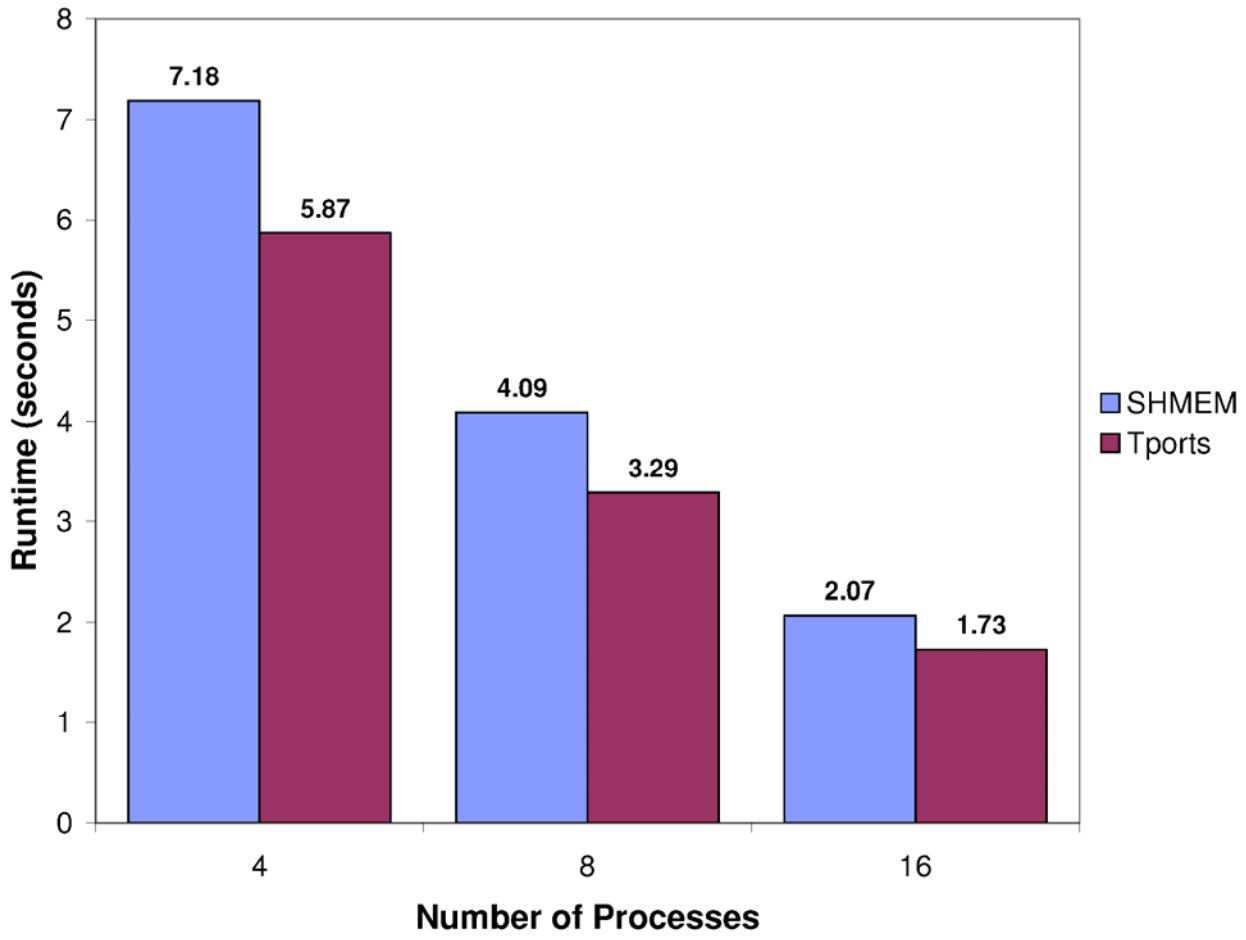
Elan-3 - MPI_Alltoallv()



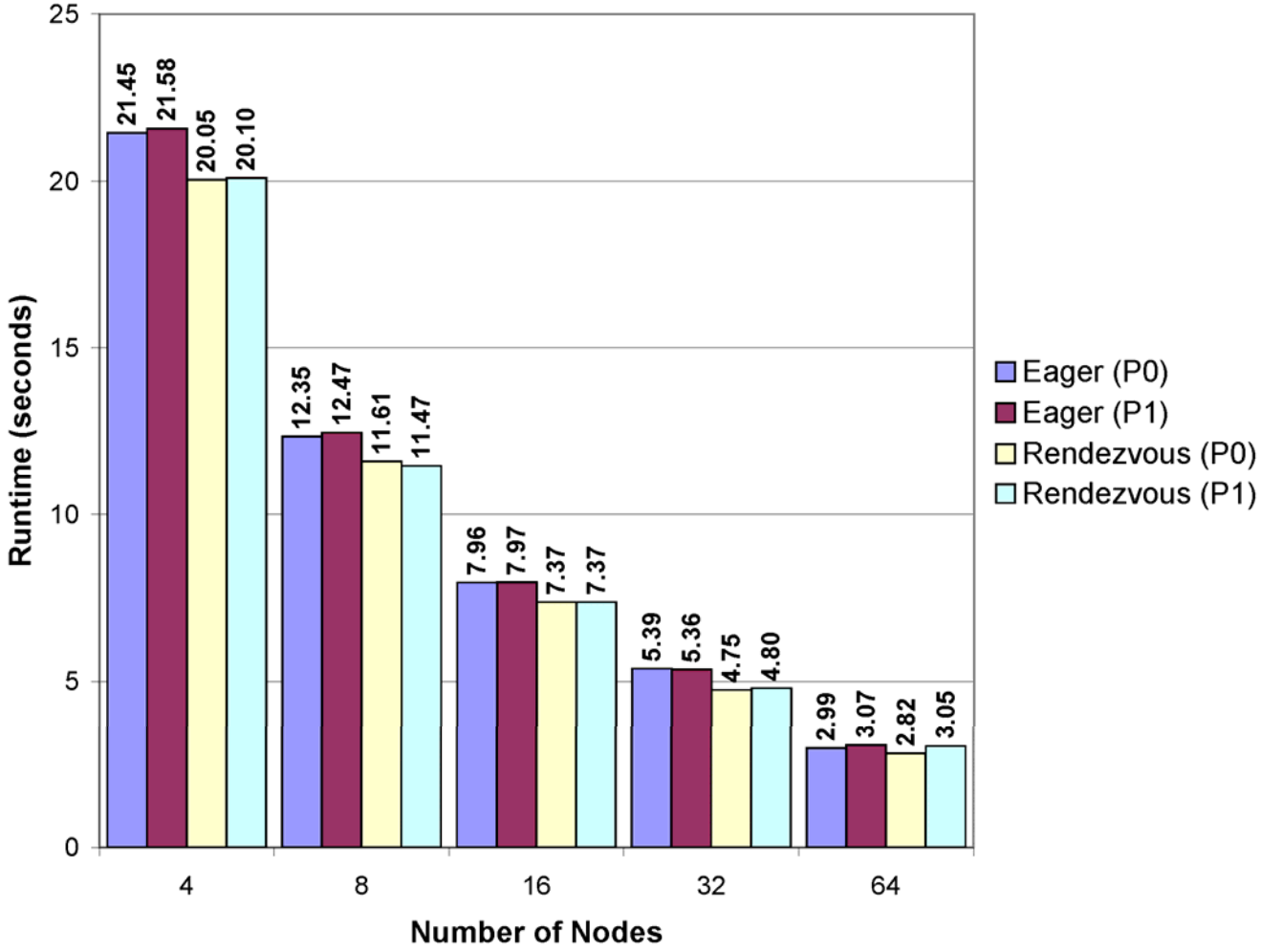
NAS Benchmarks 2.3 Class B

- IS, BT, and SP are the only ones that showed a significant difference in performance
- Times are an average of four runs
- Times from ASCI Red varied by less than 0.5%
- Elan-3 numbers do not use optimized collective operations

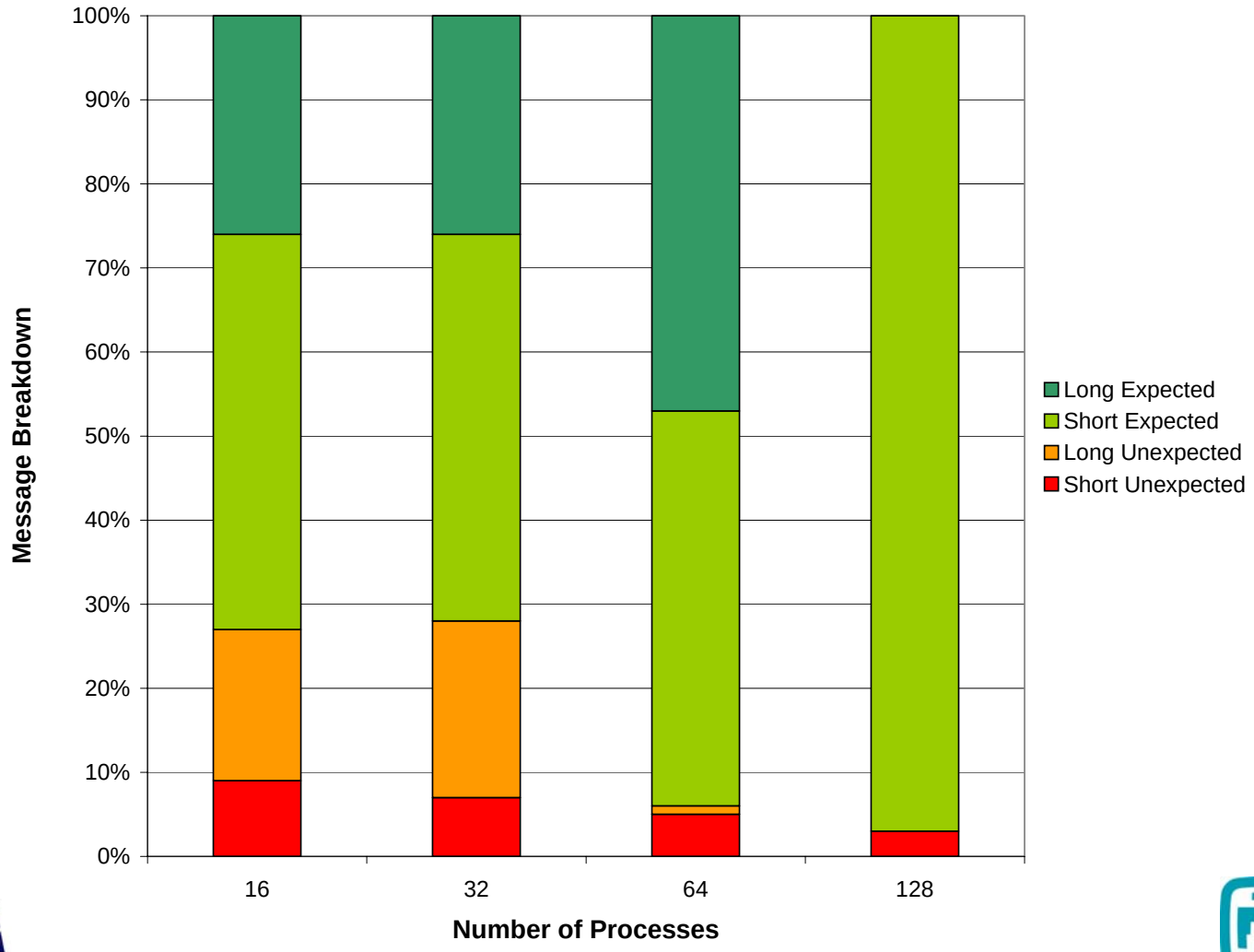
IS – Elan3


8
7
6
5
4
3
2
1
0
Runtime (seconds)
7.18
5.87
4.09
3.29
2.07
1.73
4
8
16
Number of Processes
SHMEM
Tports

IS - Red


25
20
15
10
5
0
Runtime (seconds)
21.45
21.58
20.05
20.10
12.35
12.47
11.61
11.47
7.96
7.97
7.37
7.37
5.39
5.36
4.75
4.80
2.99
3.07
2.82
3.05
4
8
16
32
64
Number of Nodes
Eager (P0)
Eager (P1)
Rendezvous (P0)
Rendezvous (P1)

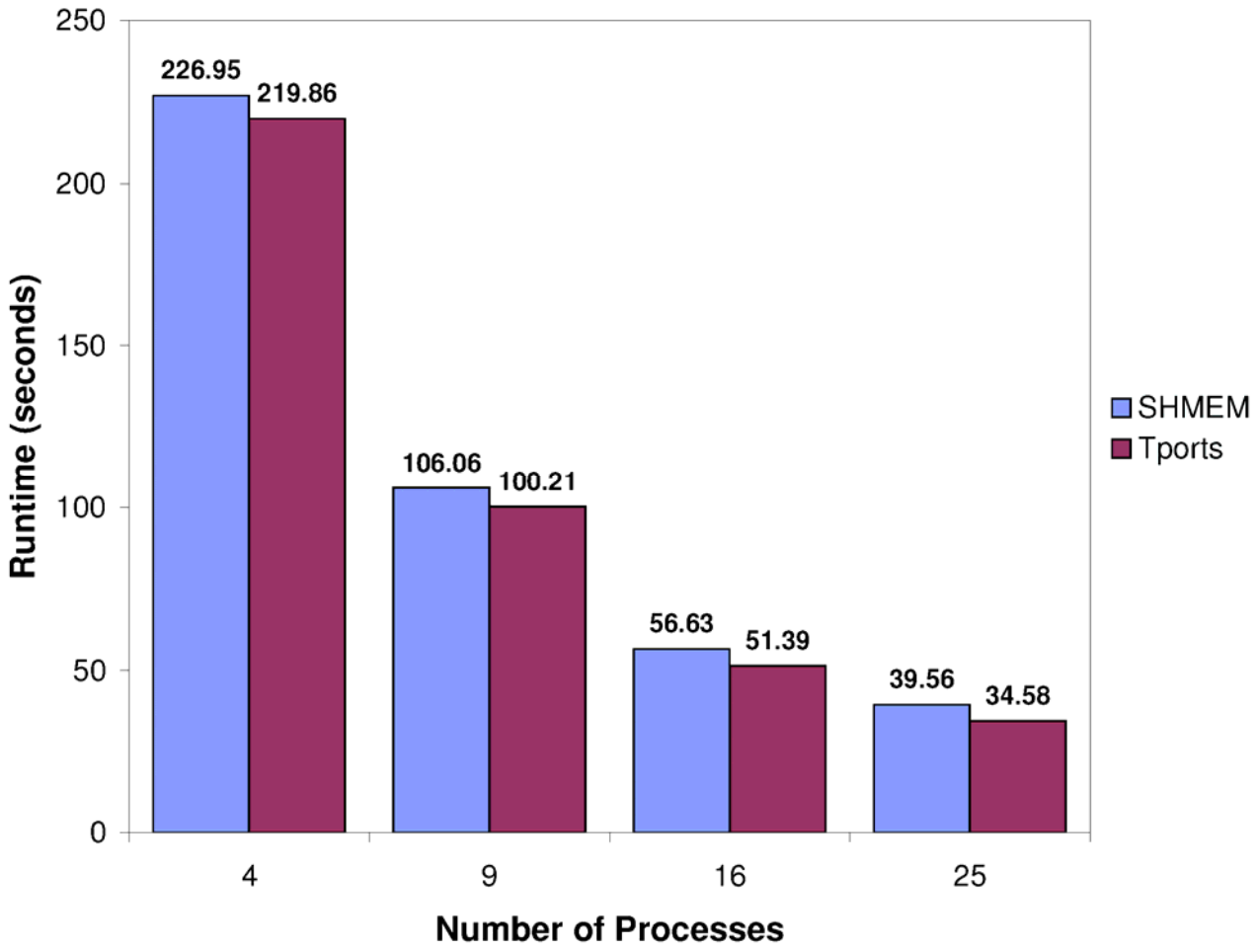
IS – Message Breakdown



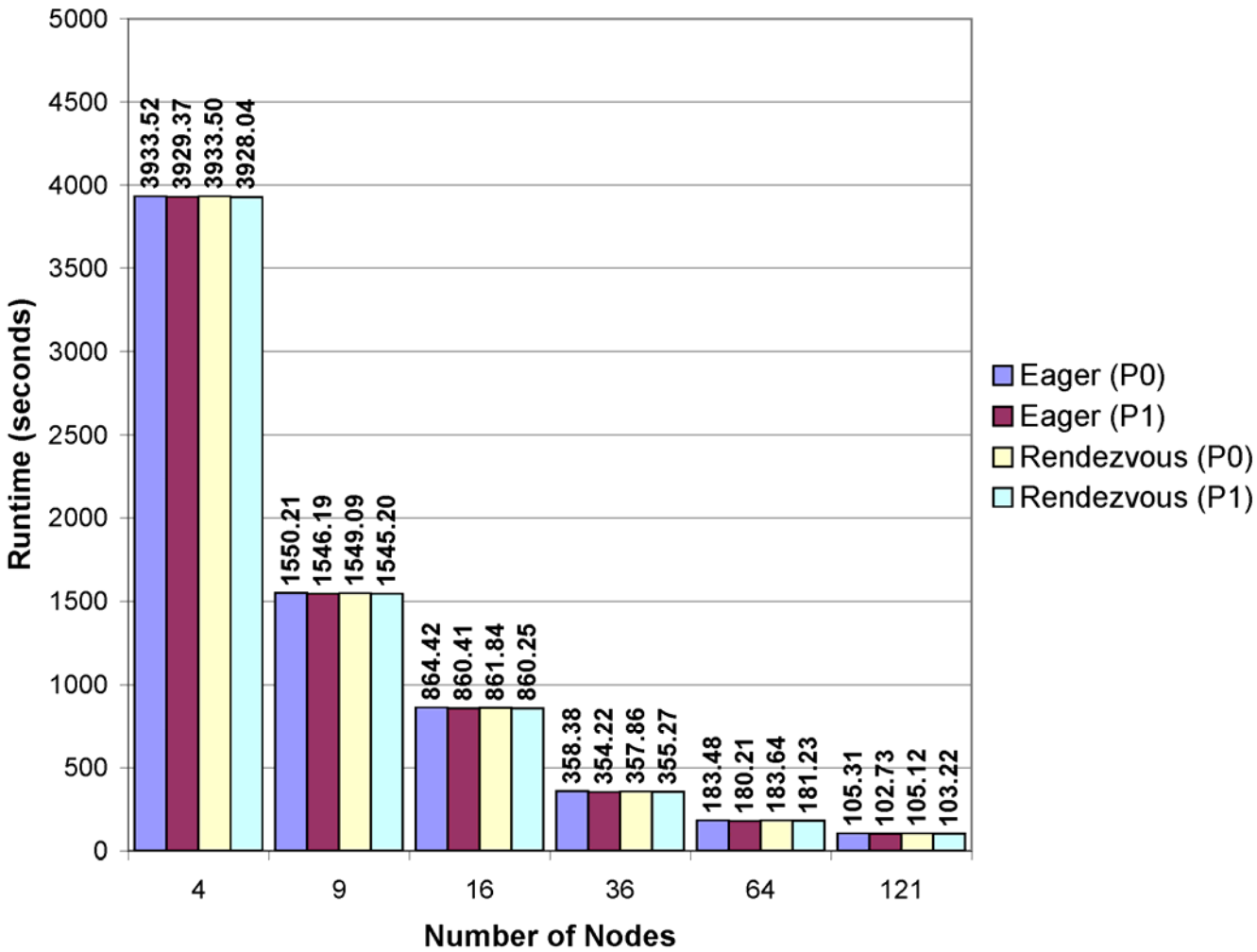
IS

- Performance on Elan-3 can be explained by partially by MPI_Alltoallv() performance
- PO and P1 performance on Red is nearly identical
- Price of independent progress on Red is high for large number of unexpected messages
- Performance is determined by independent progress

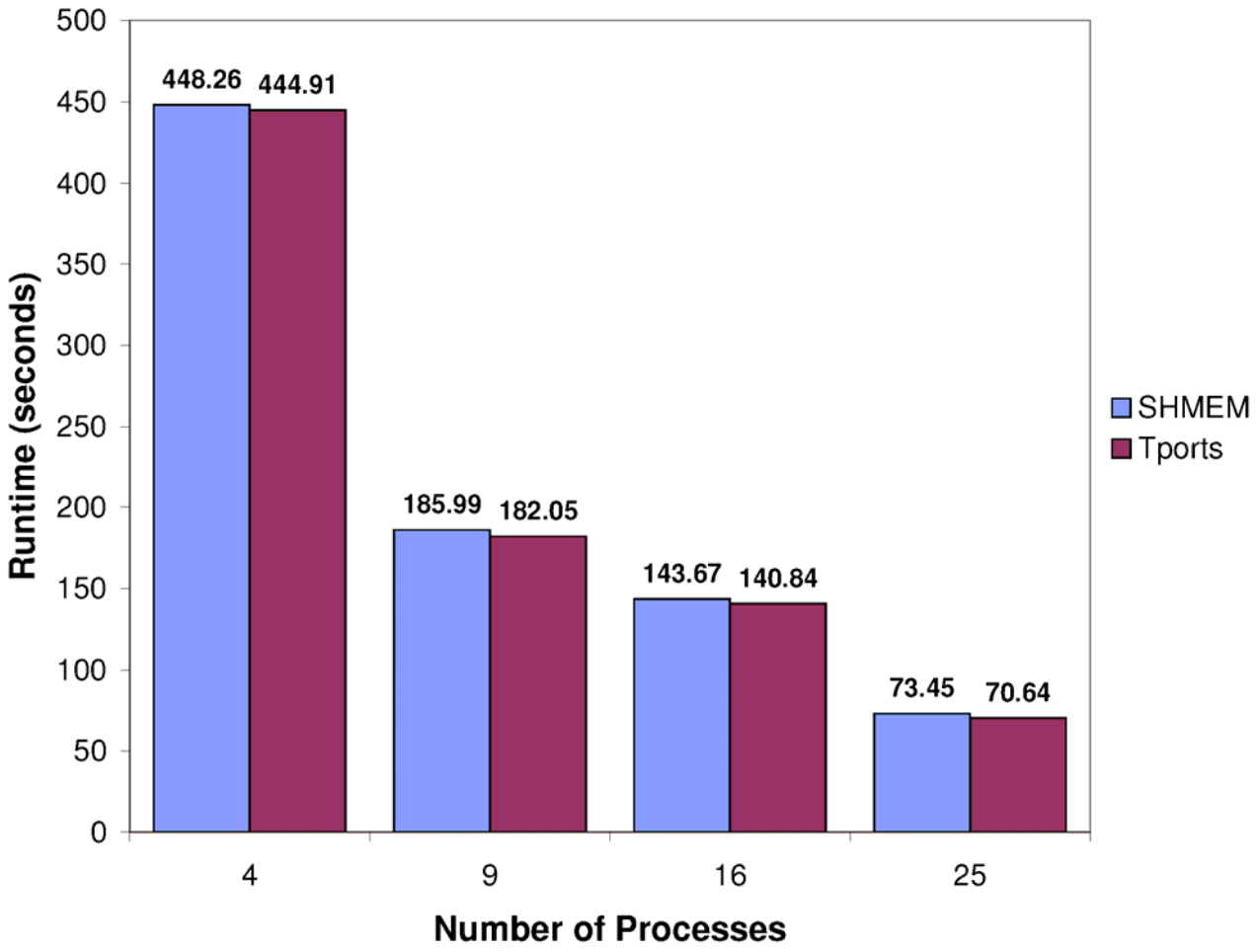
SP – Elan3


250
200
150
100
50
0
Runtime (seconds)
226.95
219.86
106.06
100.21
56.63
51.39
39.56
34.58
4
9
16
25
Number of Processes
SHMEM
Tports

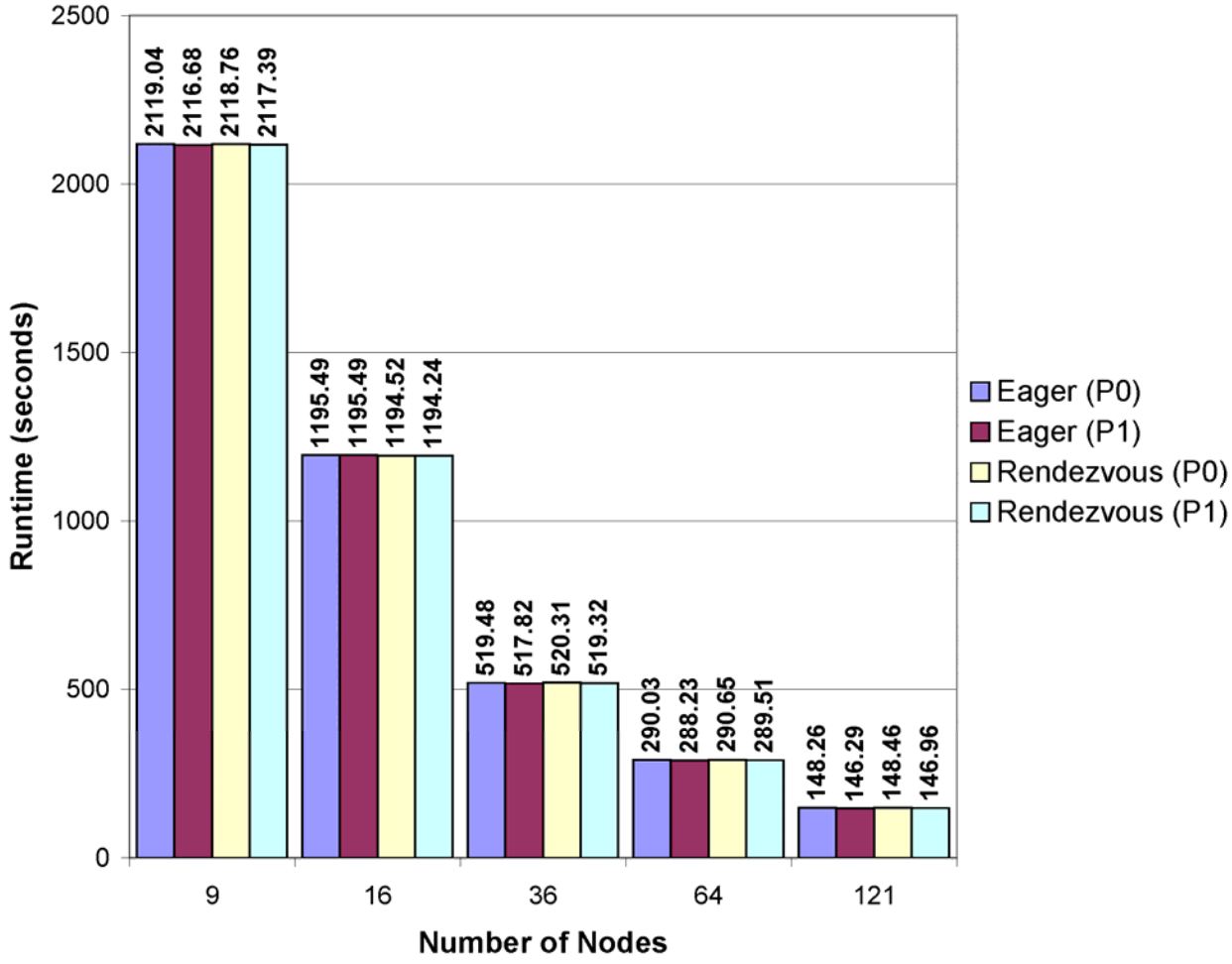
SP – Red


Runtime (seconds)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
3933.52
3929.37
3933.50
3928.04
1550.21
1546.19
1549.09
1545.20
864.42
860.41
861.84
860.25
358.38
354.22
357.86
355.27
183.48
180.21
183.64
181.23
105.31
102.73
105.12
103.22
4
9
16
36
64
121
Number of Nodes
Eager (P0)
Eager (P1)
Rendezvous (P0)
Rendezvous (P1)

BT – Elan3


500
450
400
350
300
250
200
150
100
50
0
Runtime (seconds)
448.26
444.91
185.99
182.05
143.67
140.84
73.45
70.64
4
9
16
25
Number of Processes
SHMEM
Tports

BT - Red


2500
2000
1500
1000
500
0
Runtime (seconds)
2119.04
2116.68
2118.76
2117.39
1195.49
1195.49
1194.52
1194.24
519.48
517.82
520.31
519.32
290.03
288.23
290.65
289.51
148.26
146.29
148.46
146.96
9
16
36
64
121
Number of Nodes
Eager (P0)
Eager (P1)
Rendezvous (P0)
Rendezvous (P1)

Important Points

- Overlap, independent progress, and offload must be combined to achieve the greatest performance benefit
  - The whole is greater than the sum of the parts
- Independent progress is an important factor in performance
  - The way it is implemented is important
  - Interrupts results in a loss in performance for IS on Red
  - Offload results in a significant performance gain for Elan-3

Future Work

- Explore the reasons why independent progress, and overlap improve performance
- Develop further techniques to isolate the benefits of each
  - Be able to identify applications that would benefit from each
- Extend this analysis to applications in Sandia's workload