Evaluating the Efficacy of the Cloud for Cluster Computation

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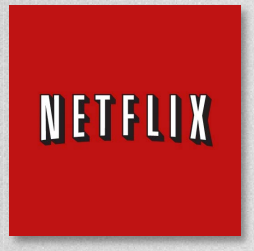
George Chang, Tom Soderstrom

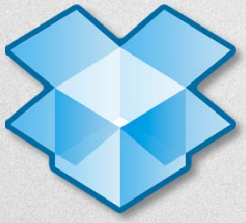
JPL / Caltech

To the cloud!

Different Things to Different People

Consumers





Developers

Infrastructure

Platforms

Acronyms

Different Things to Different People

Consumers

Developers

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Acronyms

What about scientists and engineers?

Traditional Science Problems

Linear algebra calculations

Large input data set

Many iterations with varying parameters

Data locality challenges

Traditional Science Cluster

Many CPU Cores

Lots of RAM per Core

Super-Fast Interconnects
(i.e. InfiniBand)

Prior Works

Lackluster Network Performance

Amazon EC2 (non-HPC) vs. NCSA Abe Cluster

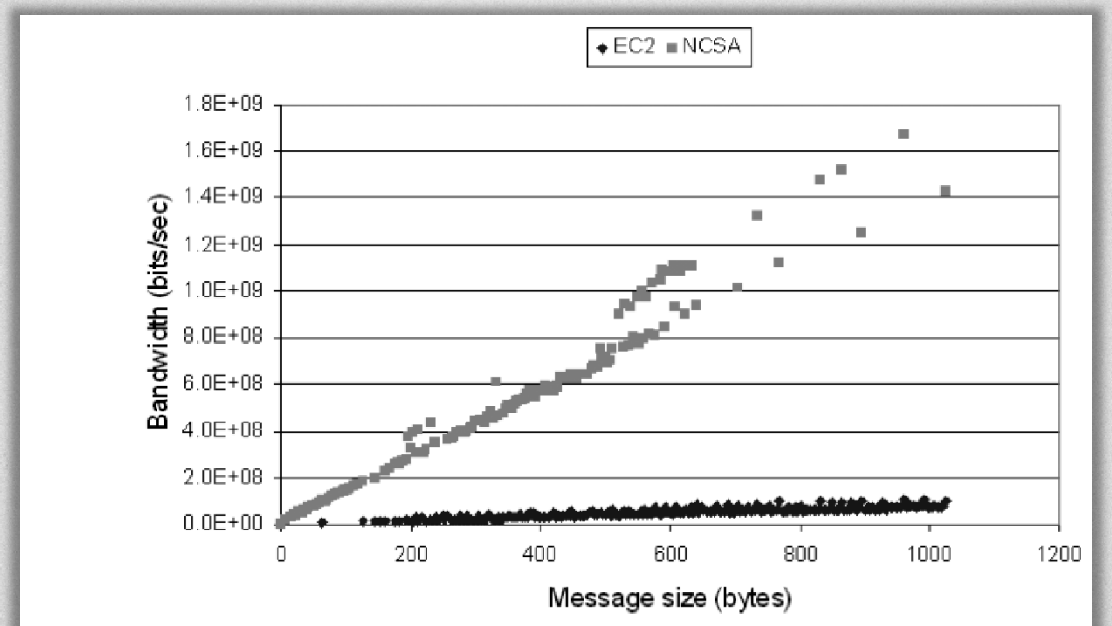

FIGURE 3. MPI BANDWIDTH PERFORMANCE IN THE MPPTEST BENCHMARK ON THE NCSA AND EC2 CLUSTERS

E. Walker, *Benchmarking Amazon EC2 for High-Performance Scientific Computing*, USENIX ;login: October 2008.

Lackluster Network Performance

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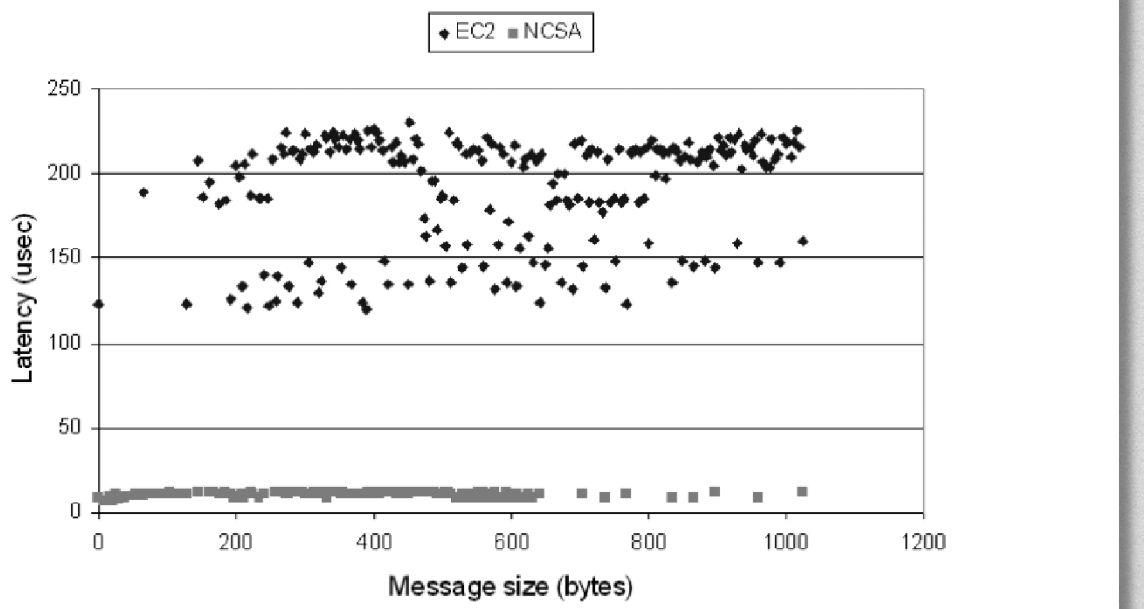

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Lackluster Scalability

LINPACK Scalability on Amazon EC2 (non-HPC)

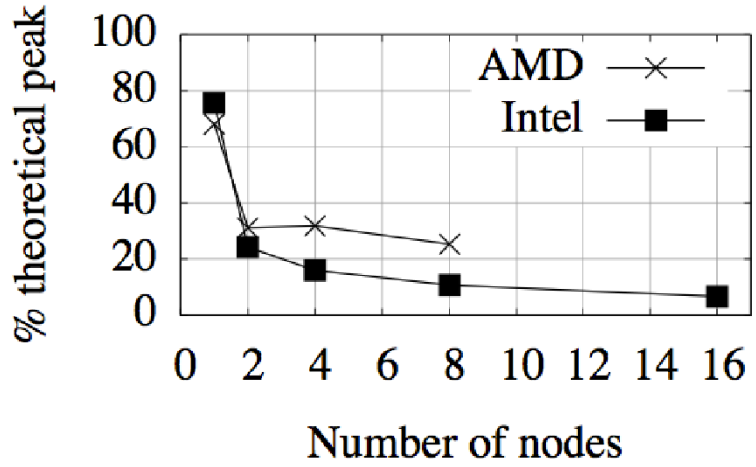


Figure 1: Efficiency as percentage of optimal GFLOP/sec on clusters of AMD or Intel EC2 instances.

J. Napper and P. Bientinesi, *Can Cloud Computing Reach the TOP500?*, UCHPC-MAW 2009.

A Turning Point

Amazon HPC

cc1.4xlarge instance type with HVM

10 GigE interconnects
(full bi-section bandwidth)

Amazon reached the Top500

The Numbers

HPCC LINPACK

Cluster Compute Quadruple Extra Large Instance

23 GB of memory
33.5 EC2 Compute Units (2 x Intel Xeon X5570,
1690 GB of instance storage
64-bit platform
I/O Performance: Very High (10 Gigabit Ethernet)
API name: cc1.4xlarge

30 of These

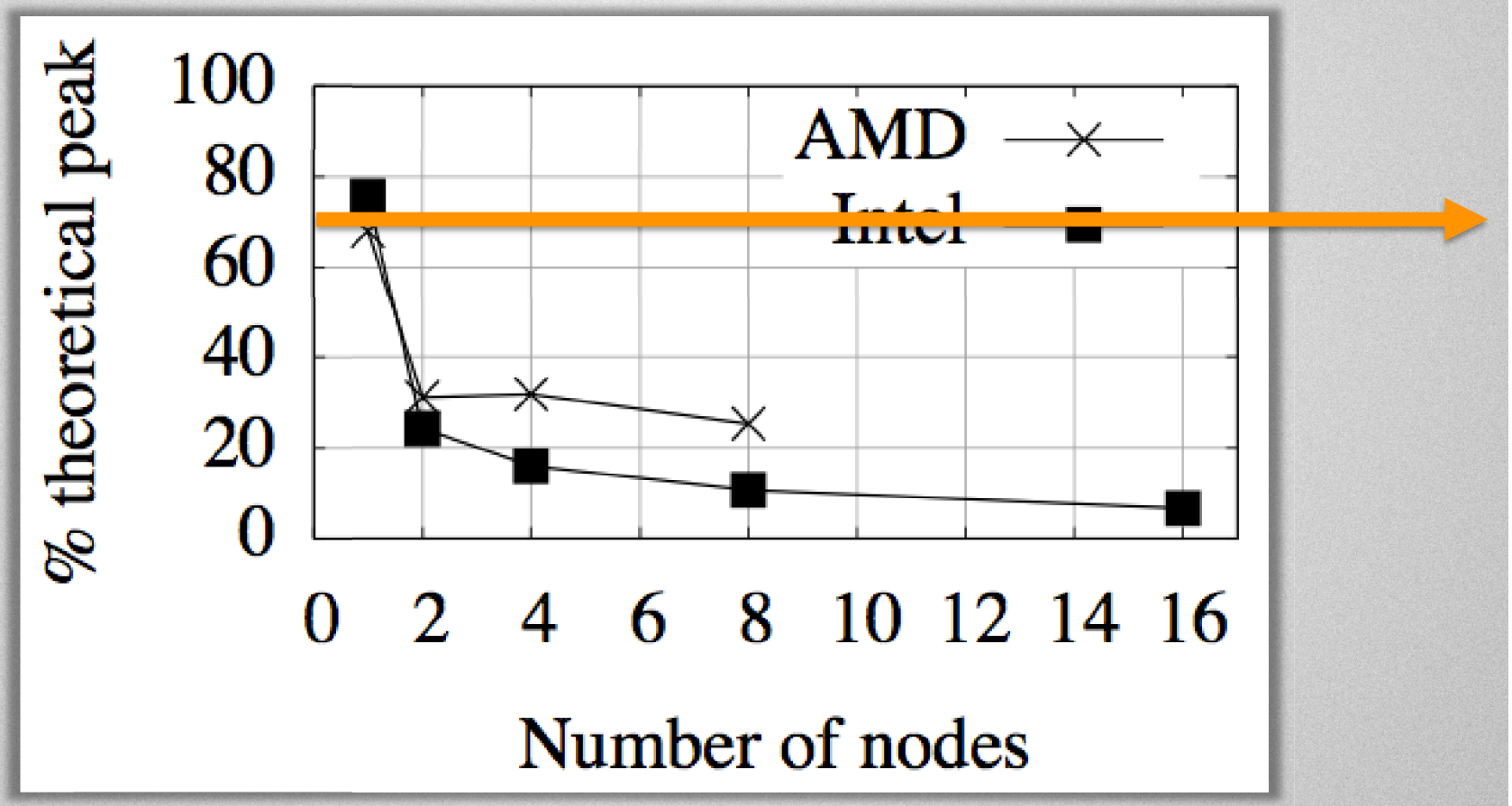
Problem Size

5	1	# of
6	221760	Ns
7	1	# of

2.0 TFLOPS
(71% Efficiency)

HPCC LINPACK

30 Nodes, 71% Efficiency



HPCC MPI Ping-Pong Tests

97 us max. latency

(8 byte messages)

331 MBps min. throughput

(2 MB messages)

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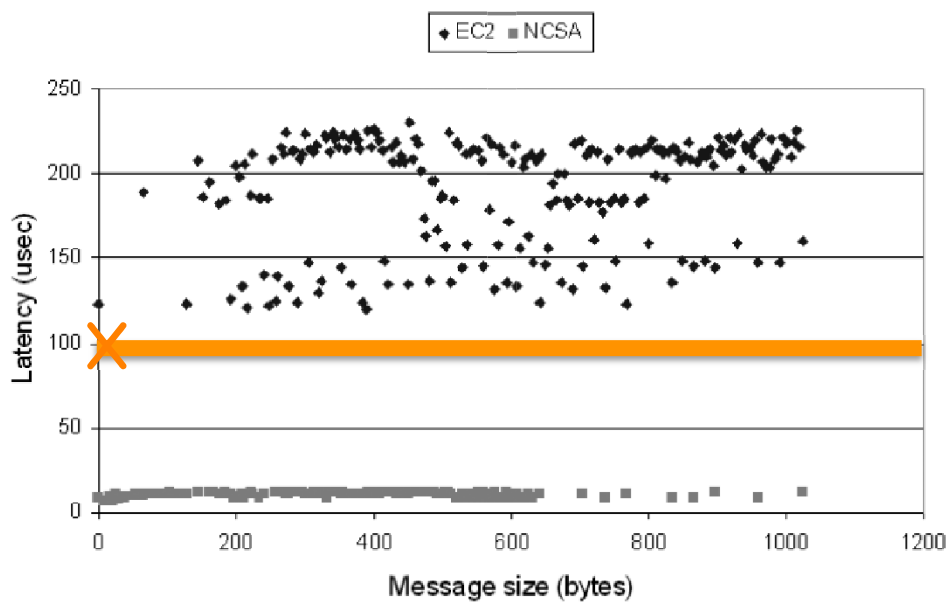

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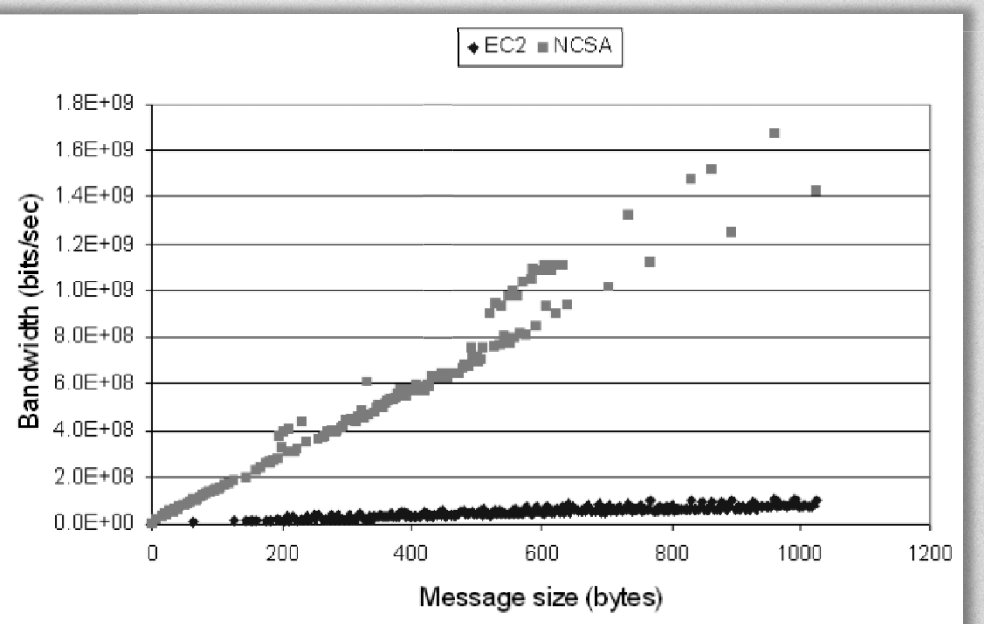

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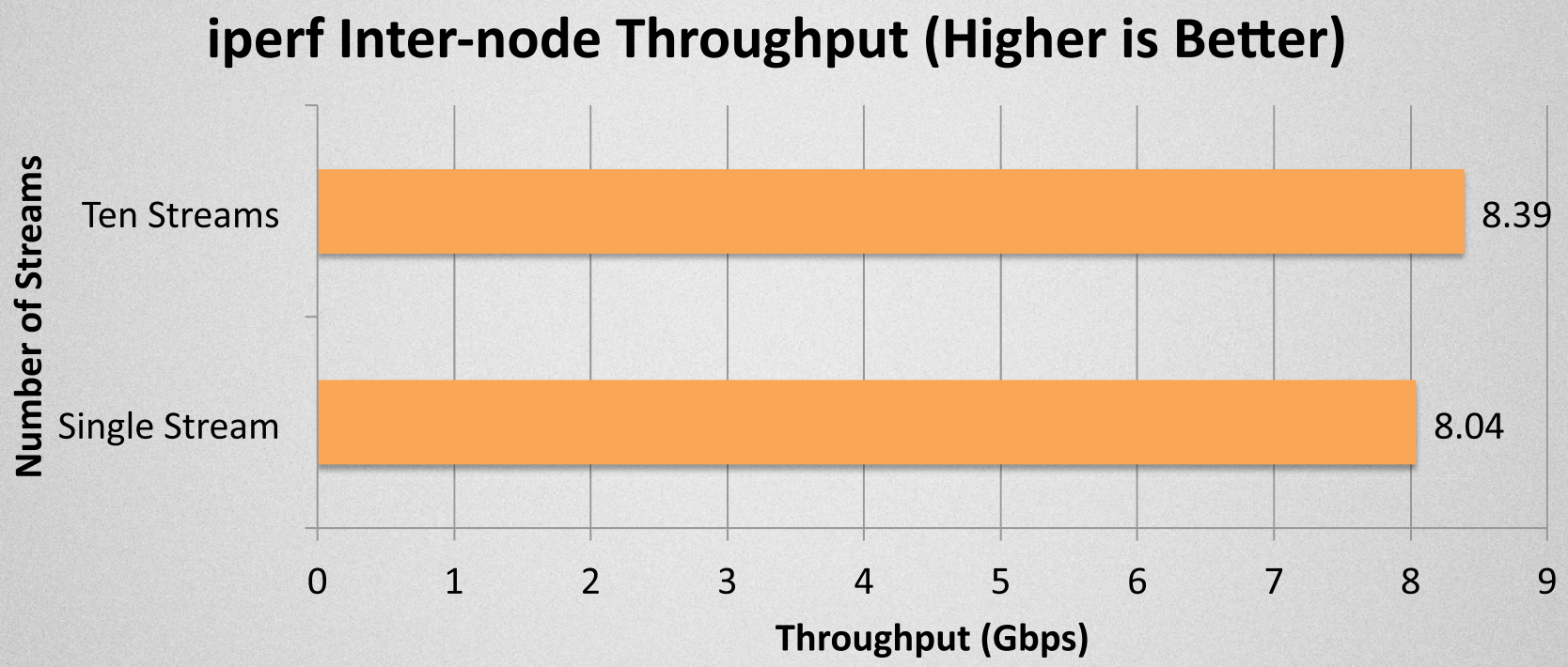
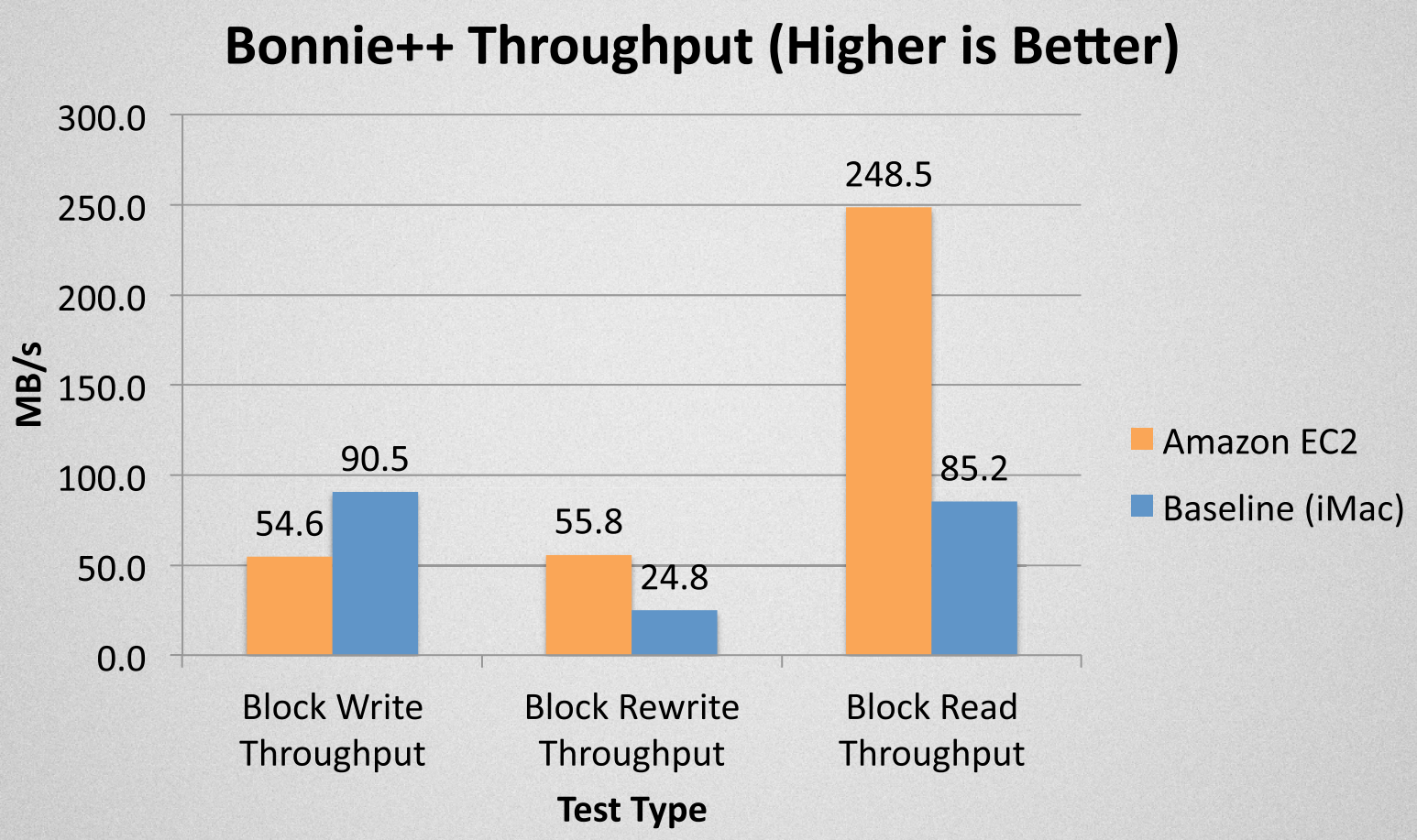
Iperf Throughput



Mass Storage Performance



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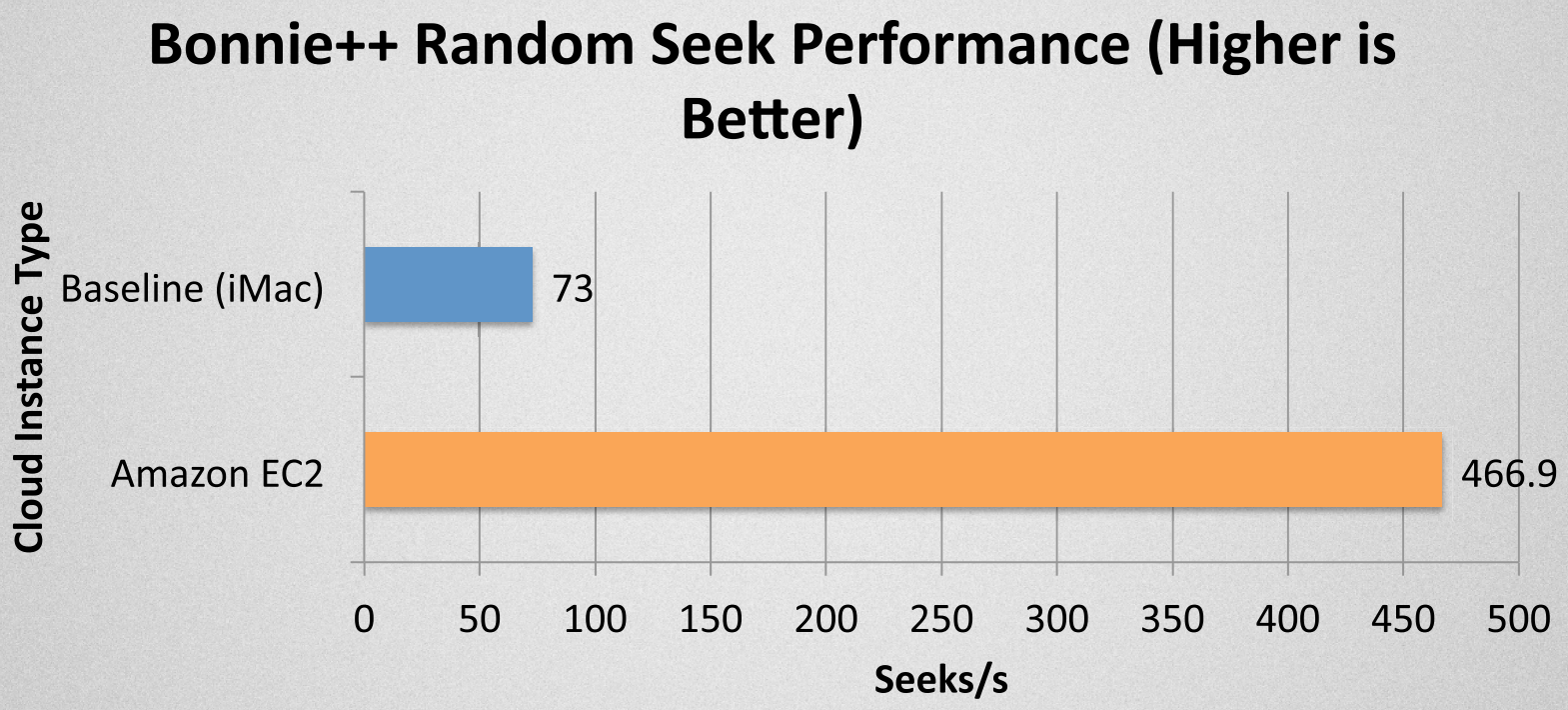


Other Results in the Paper

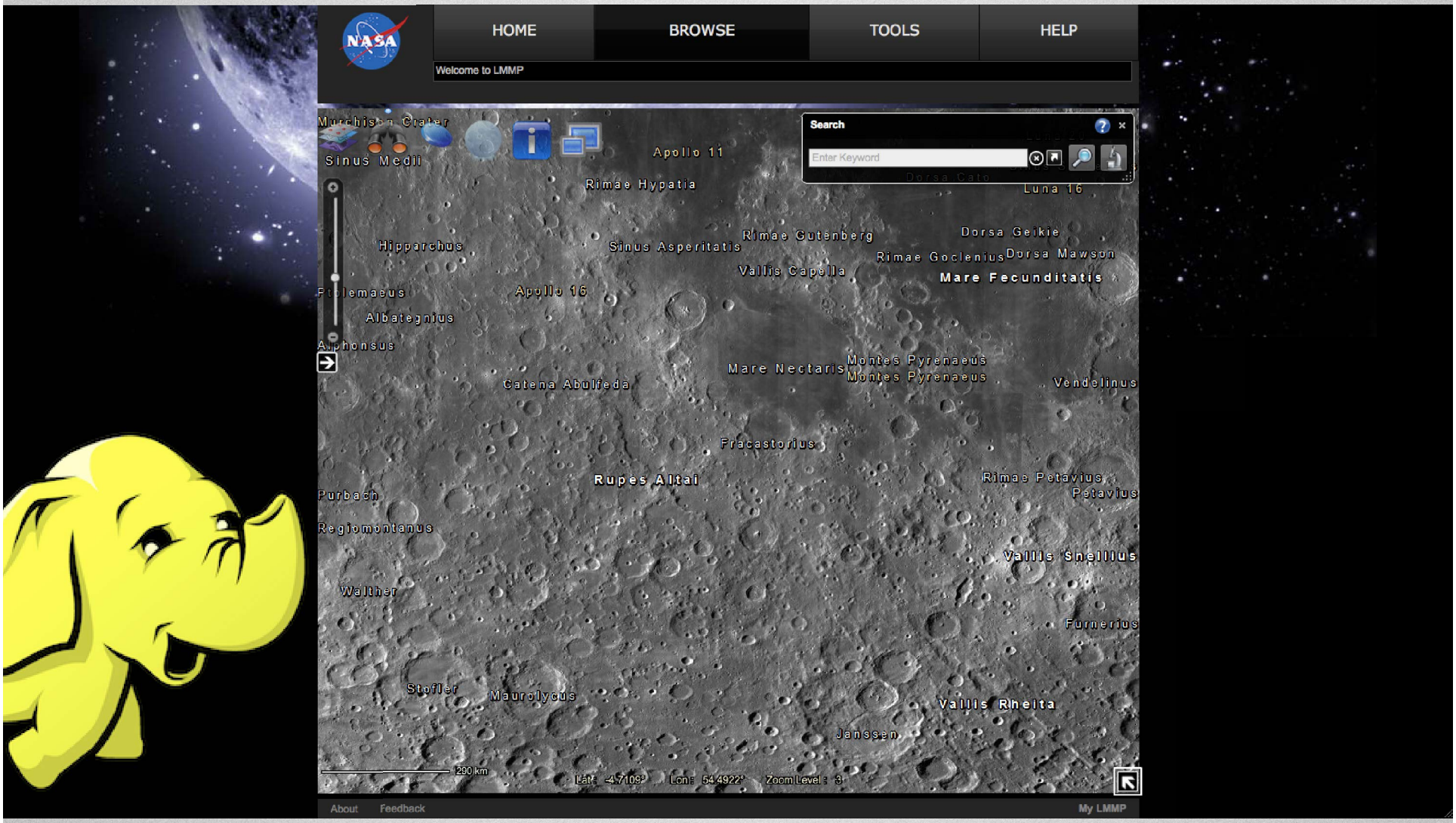
JPL-AWS latency and throughput

CPU cache throughput results

RAM throughput results

A Real-World Case

Gigapixel Image Tiling



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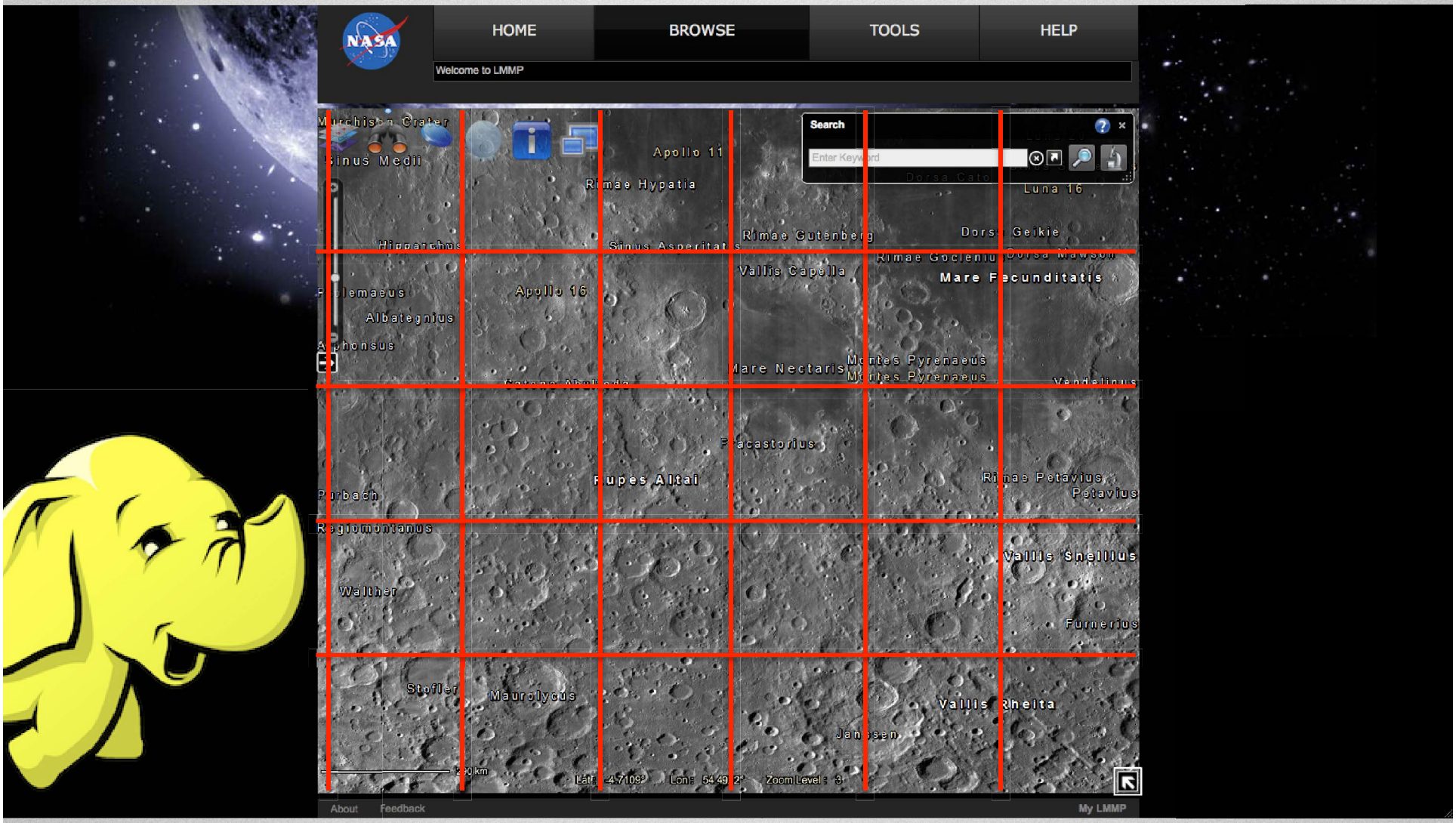

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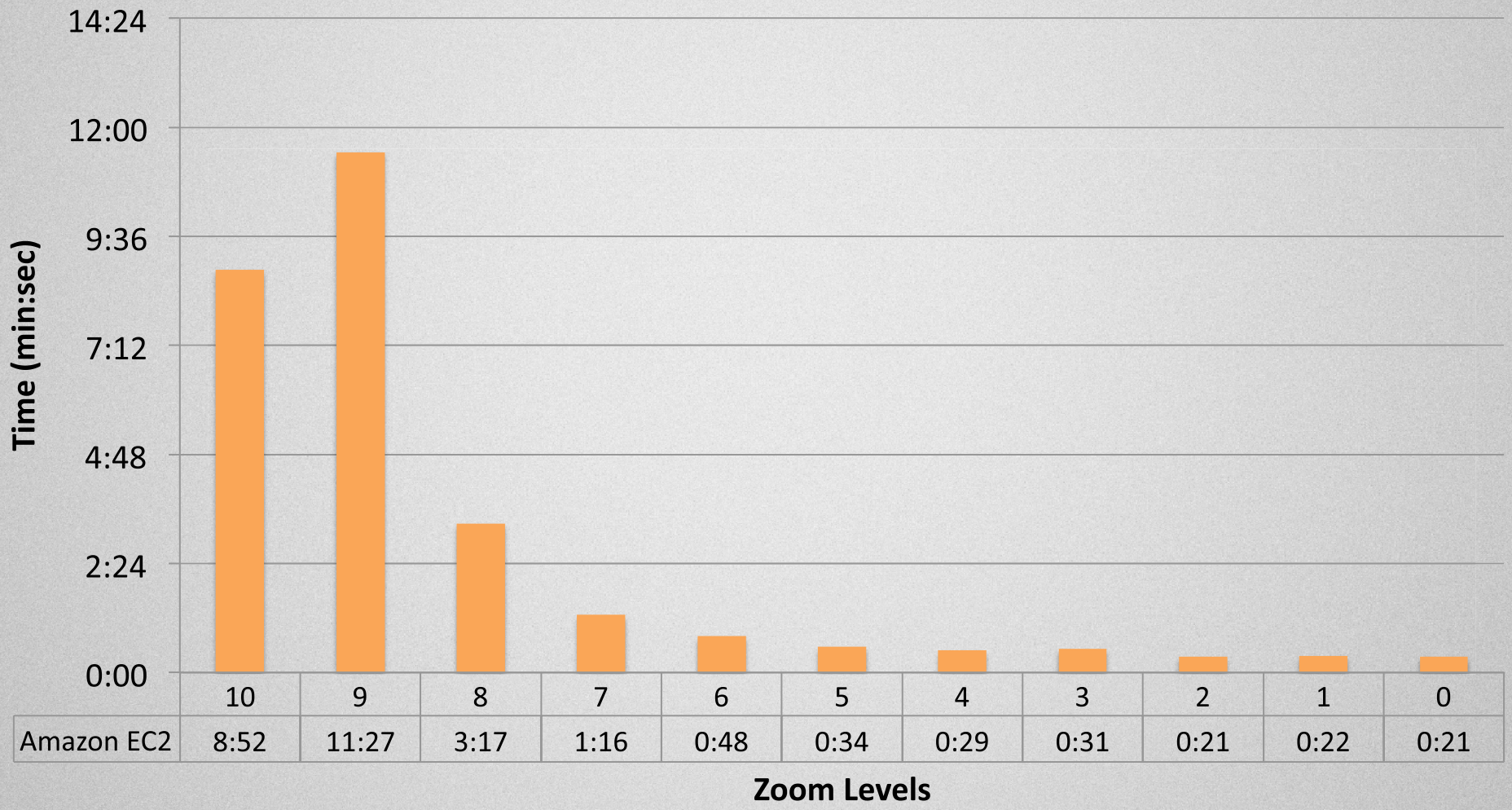

	10	9	8	7	6	5	4	3	2	1	0
Amazon EC2	8:52	11:27	3:17	1:16	0:48	0:34	0:29	0:31	0:21	0:22	0:21

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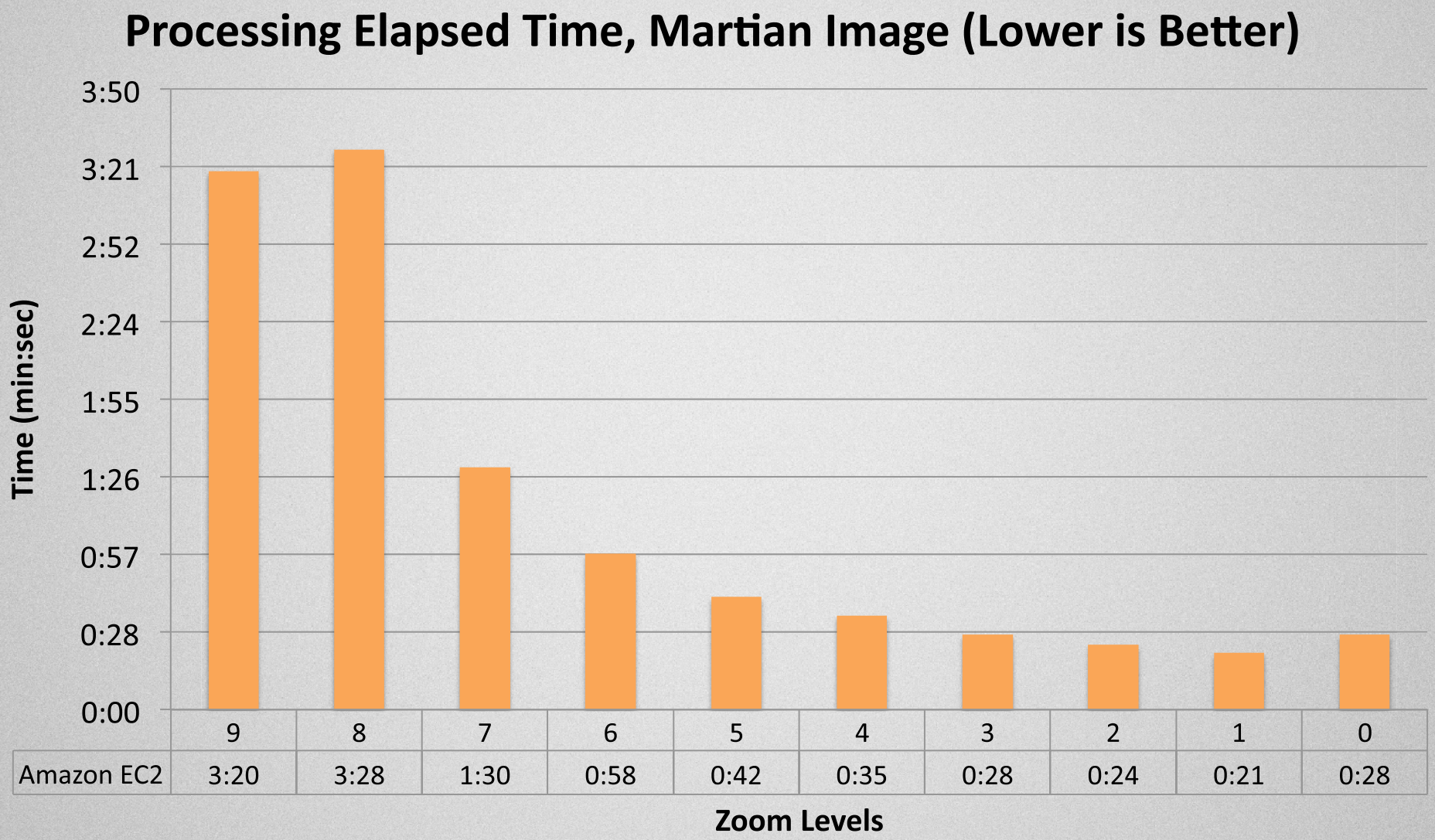

	9	8	7	6	5	4	3	2	1	0
Amazon EC2	3:20	3:28	1:30	0:58	0:42	0:35	0:28	0:24	0:21	0:28

Possibilities

Cloud Can't…

Not a replacement for dedicated, InfiniBand connected clusters

Cloud Can…

Network infrastructure and cluster scalability have improved

Rapidly provision a compute cluster without hardware investment

Easier, faster to explore the problem space

Something New…

Intel LINPACK

12.7 TFLOPS

(60% efficiency)

64 cc2.8xlarge nodes

(1024 cores)

N = 600,000

Questions?