Our LBL Visit: Accomplishments and Future Work

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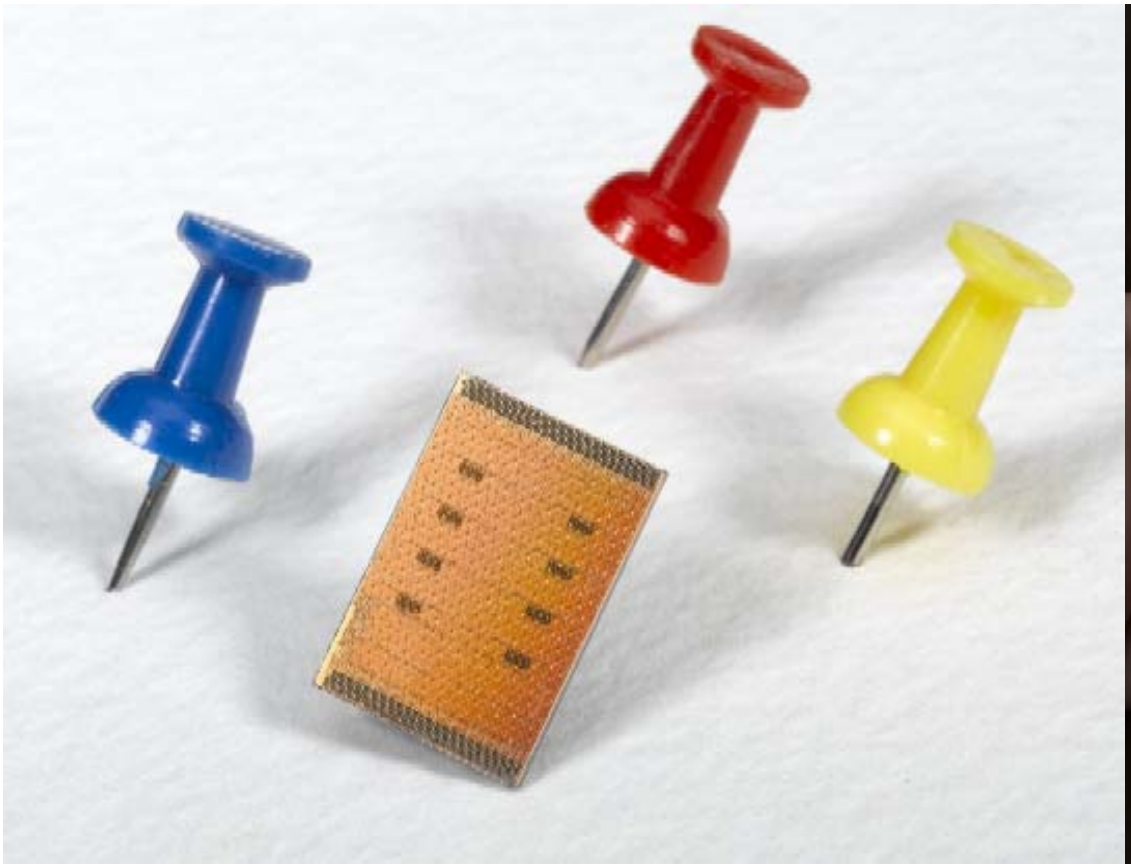
[1]ETH Zürich

[2]Institut für Theoretische Physik, Universität Zürich

August 5, 2007

Outline

Introduction to the Cell Processor



Dr. Michael Perrone, IBM. MIT Lecture Slides

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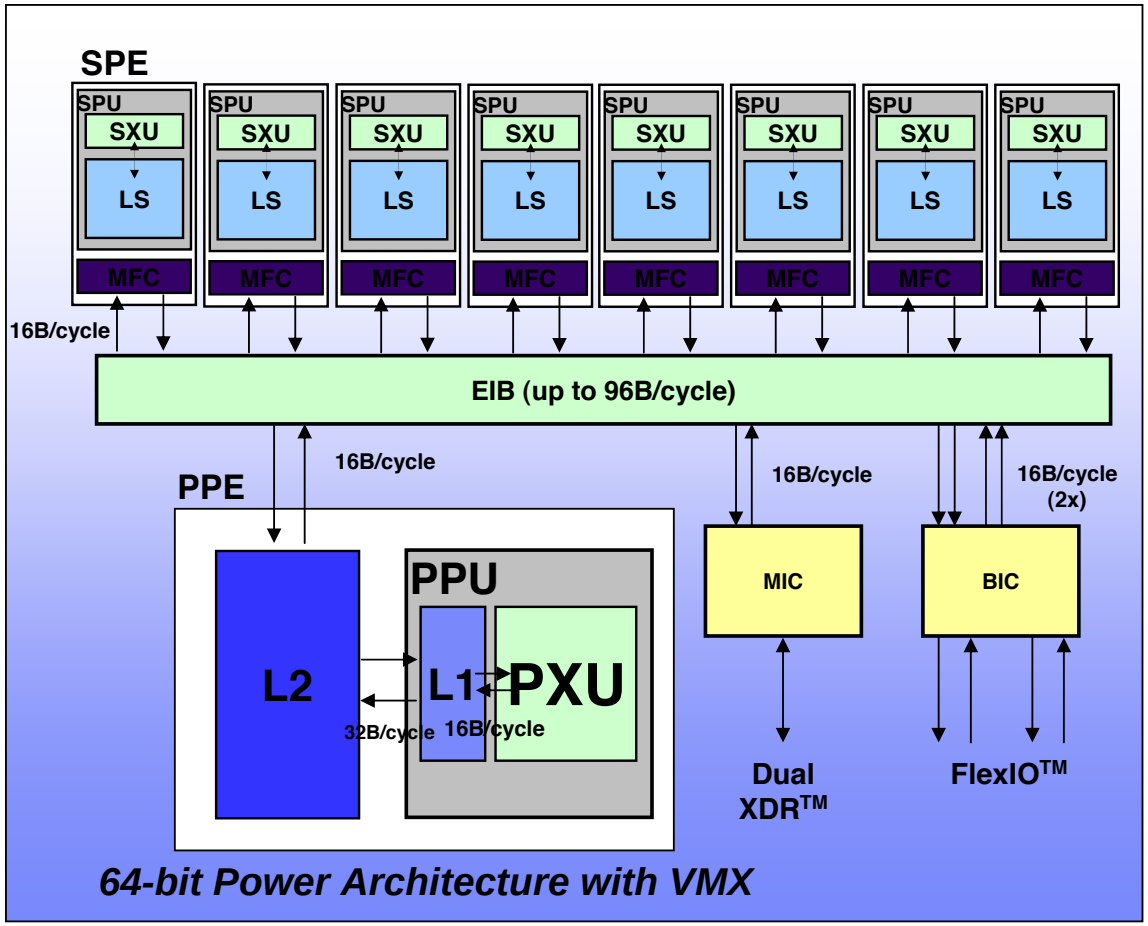

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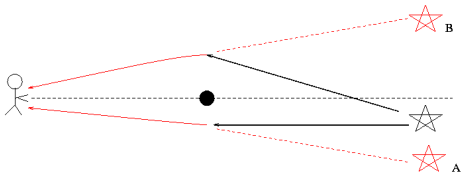
What can we do with the Cell?

Applications

- Gravitational Lens Modeling 

[1]
- Solar System Integration 

[2]
- 3D FFTs
- MHD 

The future of these fields require higher precision calculations than current hardware provides.

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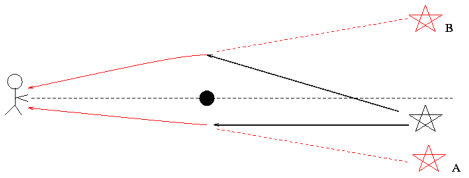
- Gravitational Lens Modeling 

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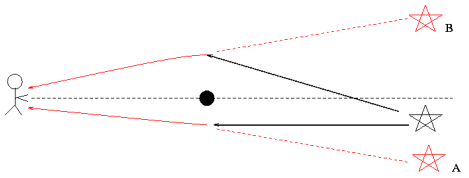
- Gravitational Lens Modeling 

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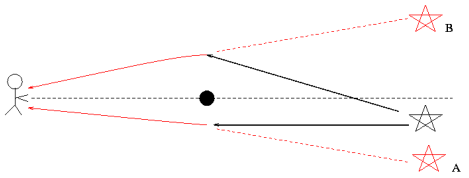
- Gravitational Lens Modeling 

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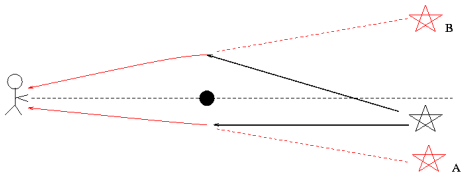
- Gravitational Lens Modeling 

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High-Precision Library

Many high precision or arbitrary precision libraries already exist:

- qd/dd
- arprec

These are yet tailored to take advantage of the vector capabilities of the Cell processor.

Our High-precision Floating-point Numbers (HFNs):

- Use 11-bit exponents and 117-bit mantissa (with hidden bit)
- Fit completely into a single SPU register
- Can be easily adjusted to support IEEE quad-precision format.

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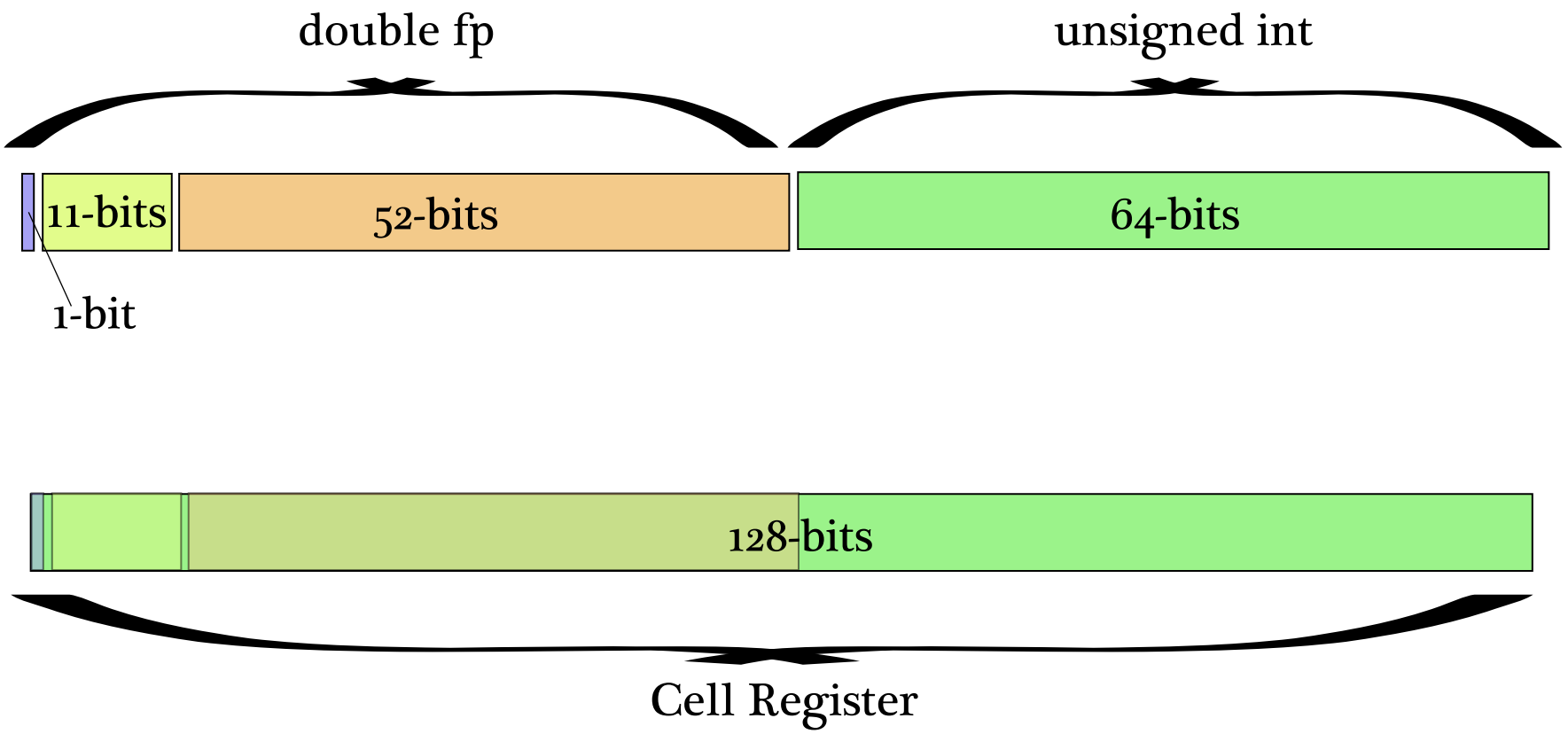
HFN Layout


double fp
unsigned int
11-bits
52-bits
64-bits
1-bit
128-bits
Cell Register

Multiplication

Basic idea:

- split the mantissa
- multiply the parts of the mantissa
- add the products
- (compute the exponent and the sign)

Many possible implementations:

- floating-point + integer vs integers only
- size of the parts of the mantissa

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Plan

Finished

$+ \; - \; \times$

$\div$

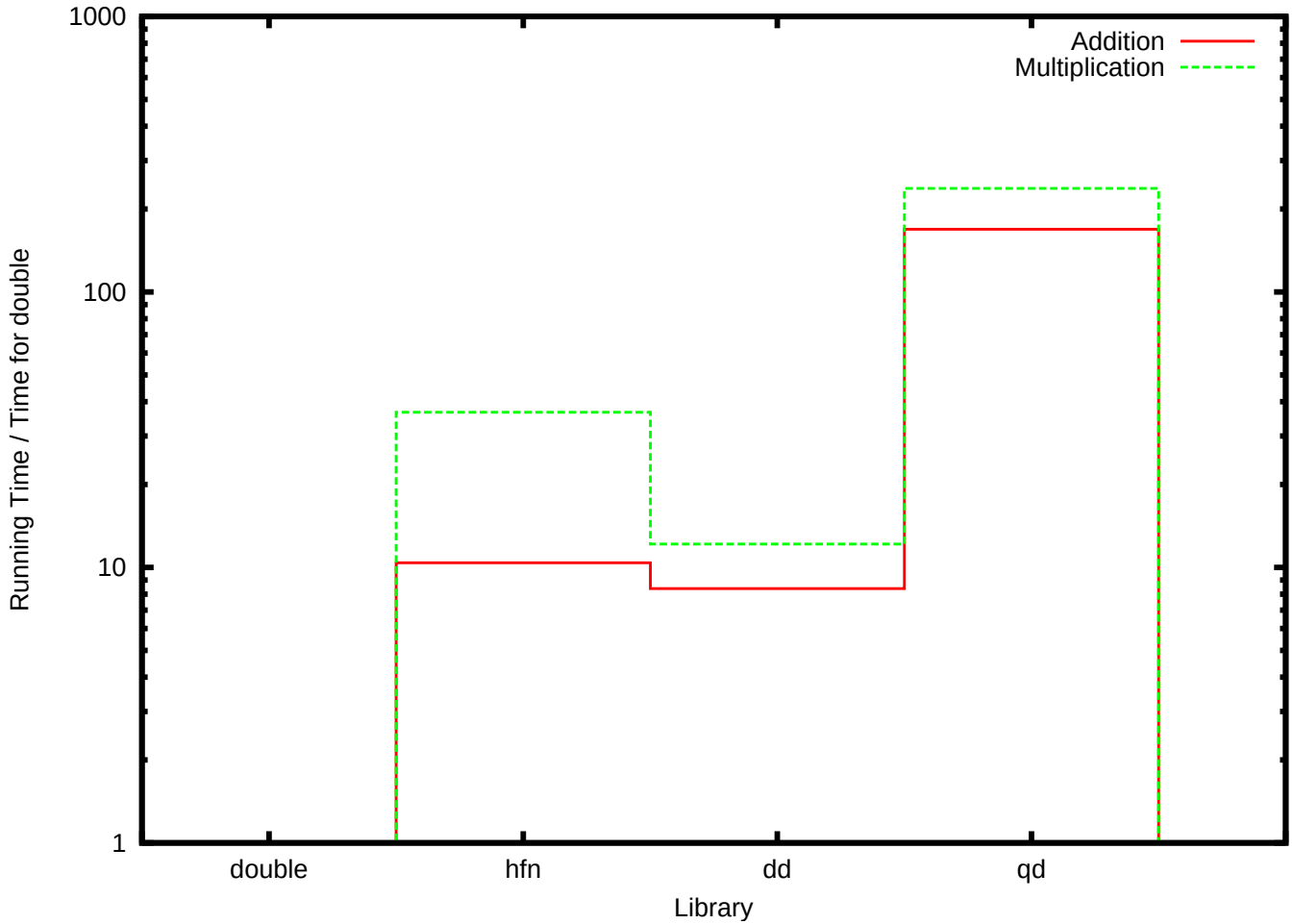
$\sqrt{}$

exp log

$\sin^{(-1)}$ $\cos^{(-1)}$ $\tan^{(-1)}$

Gamma Function
Quadrature

Performance



MPI: Single Transfer BM

PingPong Classical pattern, measures startup and throughput of single messages between two processes.

PingPing Similar to PingPong, message passing is obstructed by oncoming messages (crucial). Processes wait for each other and send simultaneously.

MPI: Parallel Transfer BM

Sendrecv Processes form a periodic communication chain, sending to the "righthand" and recieving from the "lefthand" neighbour.

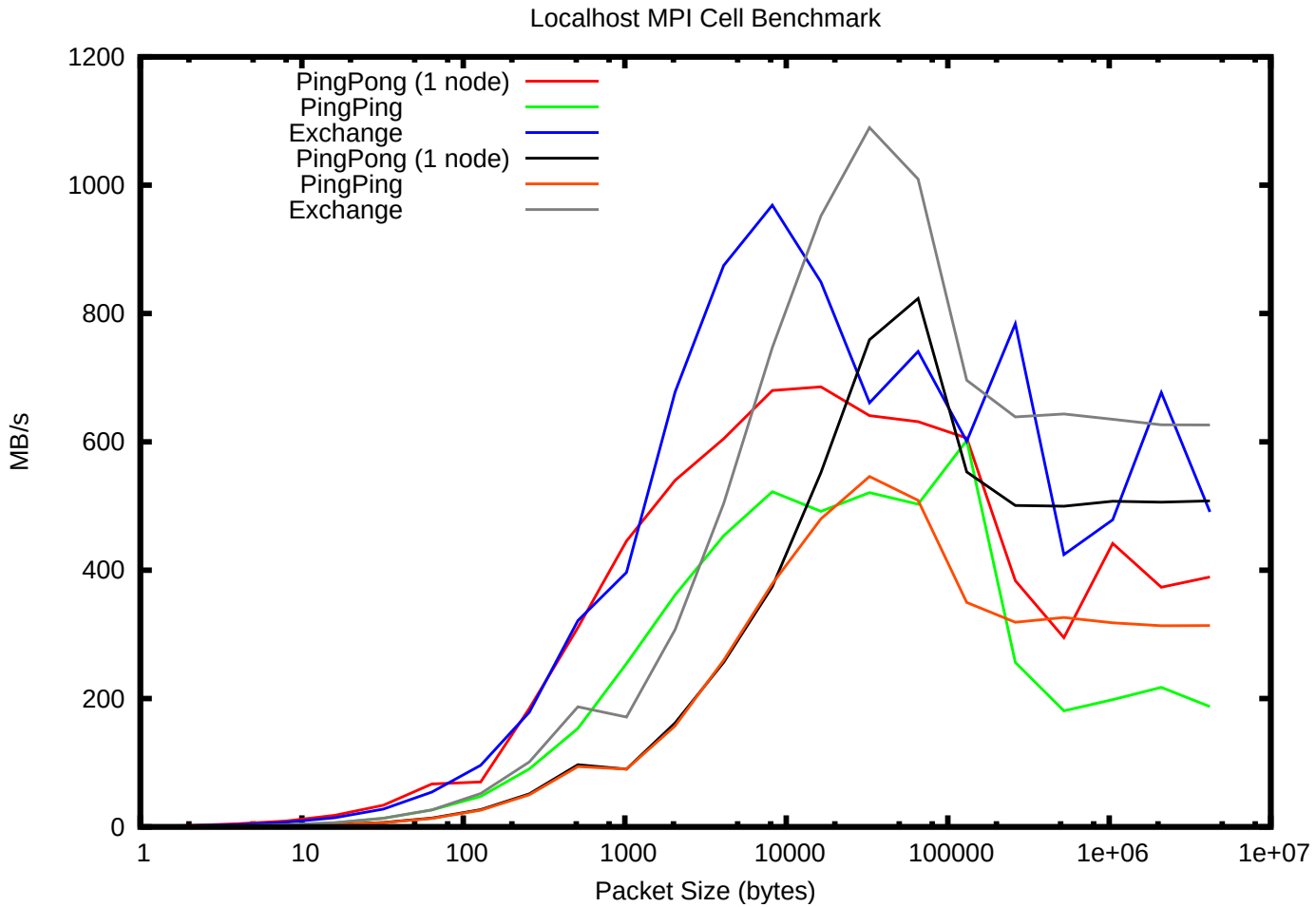
Exchange A pattern often seen in grid splitting algorithms (Cactus?), forming a 1D communication chain similar to Sendrecv but sending and recieving towards both sides.

MPI: Collective BM (i.e. other benchmarks)

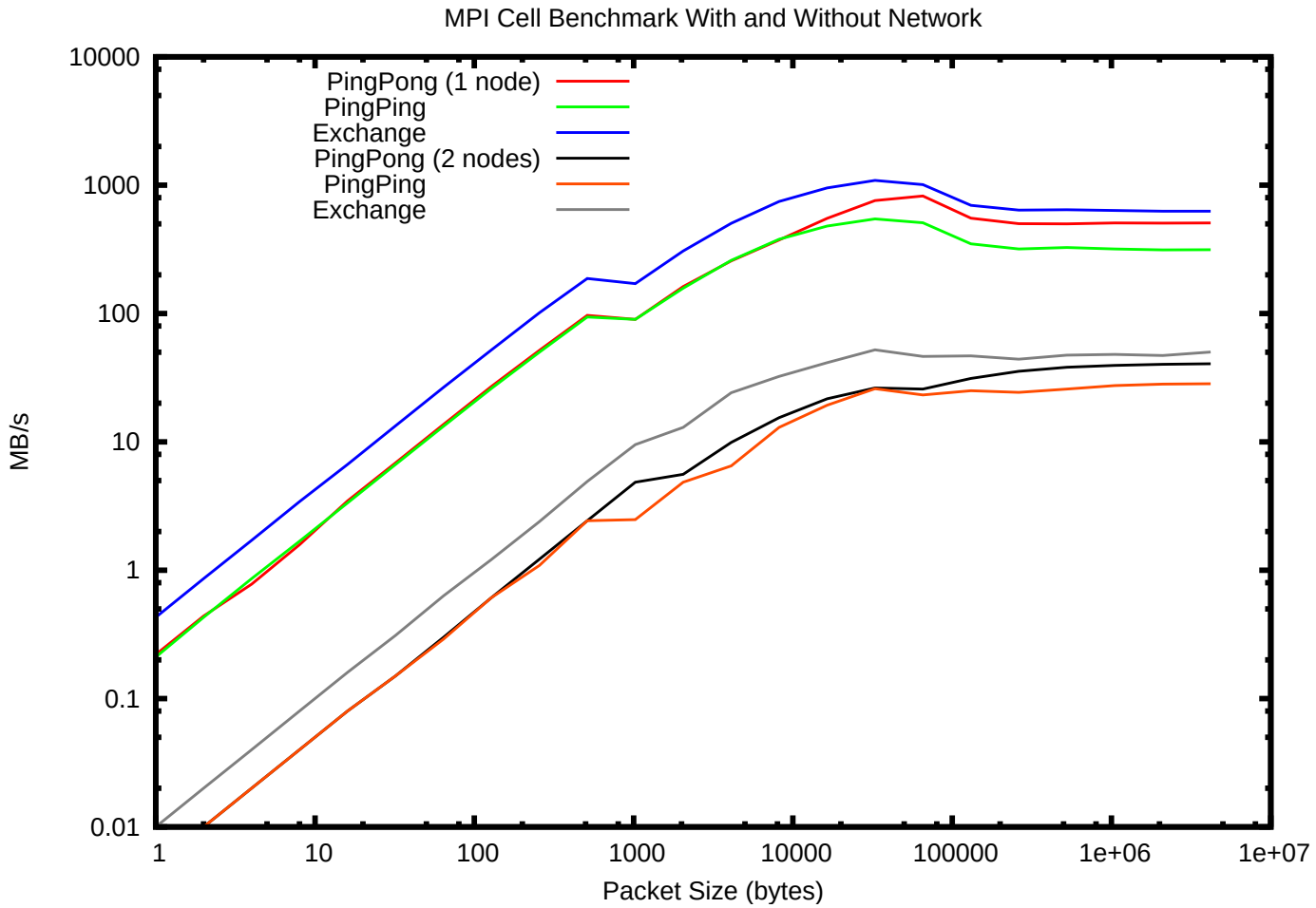
- Reduce
- Reduce_scatter
- Allreduce
- Allgather
- Allgatherv
- Alltoall
- Alltoallv
- Bcast
- Barrier

Source: Intel MPI Benchmark Handbook (v3.0)

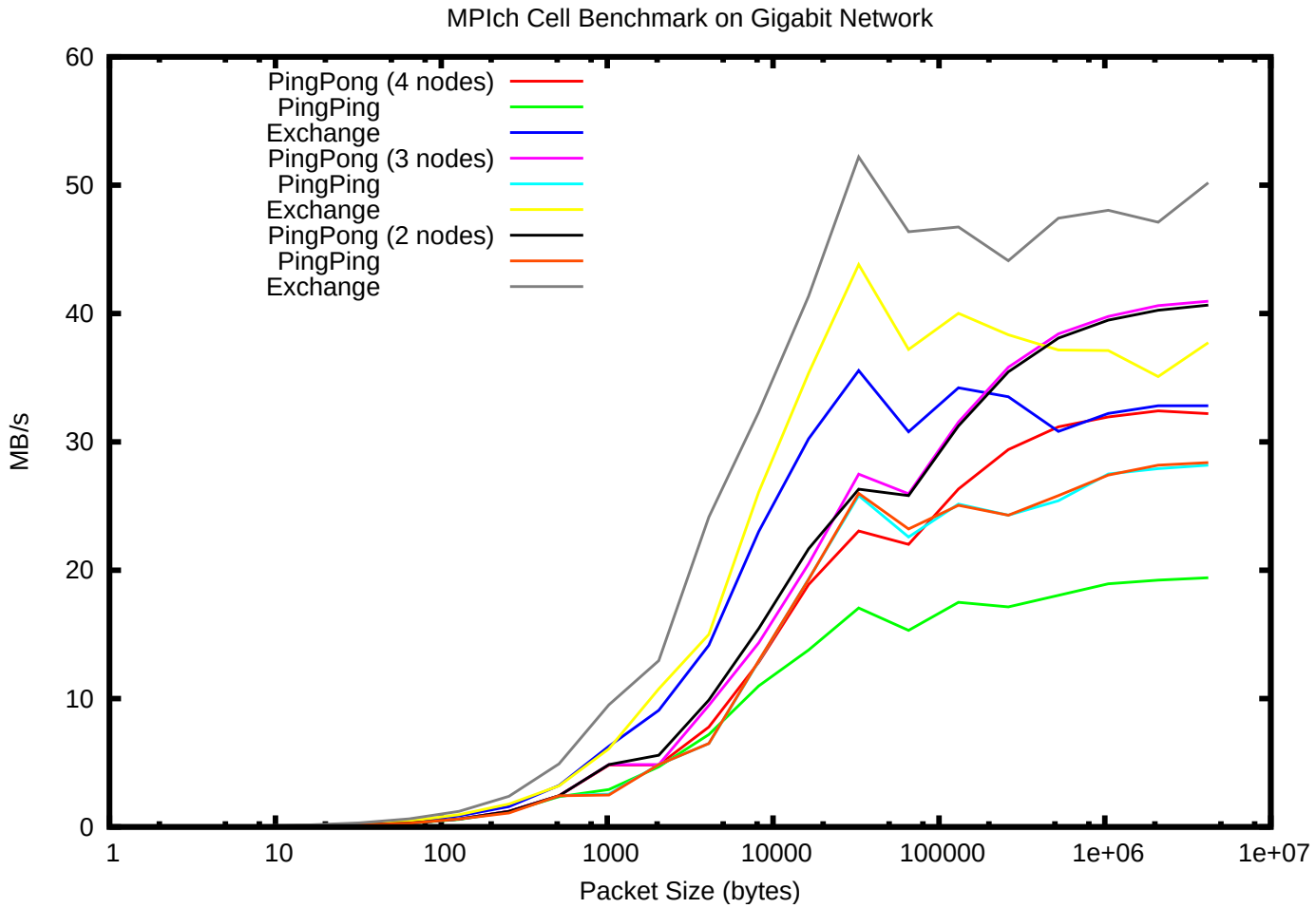
MPI


Localhost MPI Cell Benchmark
PingPong (1 node)
PingPing
Exchange
PingPong (1 node)
PingPing
Exchange
MB/s
Packet Size (bytes)
0
200
400
600
800
1000
1200
1
10
100
1000
10000
100000
1e+06
1e+07

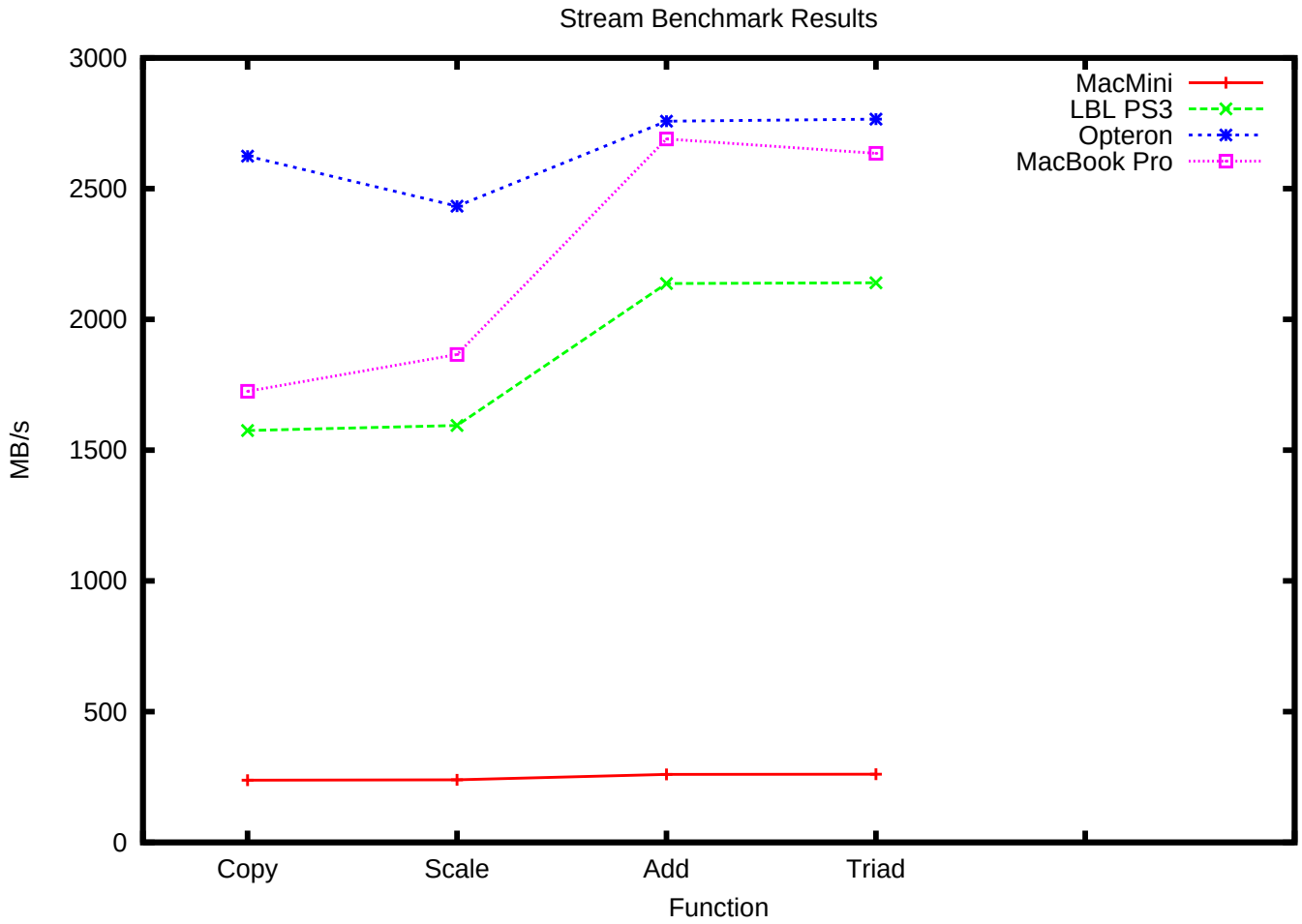
MPI


MPI Cell Benchmark With and Without Network
PingPong (1 node)
PingPing
Exchange
PingPong (2 nodes)
PingPing
Exchange
MB/s
Packet Size (bytes)
10000
1000
100
10
1
0.1
0.01
1
10
100
1000
10000
100000
1e+06
1e+07

MPI


MPIch Cell Benchmark on Gigabit Network
PingPong (4 nodes)
PingPing
Exchange
PingPong (3 nodes)
PingPing
Exchange
PingPong (2 nodes)
PingPing
Exchange
MB/s
Packet Size (bytes)
0
10
20
30
40
50
60
1
10
100
1000
10000
100000
1e+06
1e+07

Stream Benchmark



Future Work

- MPI (Lenny and John)
- FastBit (Kurt Stockinger)
- Cactus Kernels (John)
- Supernovae Simulations (Peter Nugent)

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Future HFN Plans

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Who, What, Where Next?

- Us
- Future students: Master's and undergrad projects
- Great potential for further collaboration

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Thank You

Thank you very much for your generosity, hospitality, and help!