Benchmarking Current PC Server Hardware.

Parallel Benchmarks used at DESY

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DESY

- Introduction
- Hardware
  - Nehalem CPU
  - Shanghai CPU
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- FORM Benchmark
- Lattice Quantum Chromodynamics Benchmarks
  - Chroma Benchmark
- Summary
- References

Computing at DESY

Main computing tasks at DESY in Zeuthen:

- Grid (WLCG)
- National Analysis Facility
- Local Batch Farm
- Parallel Computing
  - Special Purpose Computers (APE)
  - Parallel Clusters

Nehalem CPU

- New Intel Xeon quad core generation
- New micro architecture
  - QuickPath Interconnect
  - Simultaneous Multithreading
  - Turbo Boost – overclocking mode
- Available Hardware
  - tick Dell PowerEdge M610, Intel Xeon E5520, 2.27 GHz, 8 MB L3 cache
  - tick2 HP ProLiant BL280c G6, Intel Xeon E5506, 2.13 GHz, 4 MB L3 cache

Shanghai CPU

- AMD quad core Opteron
- New K10 architecture
- Hypertransport Interconnect
- DDR2 memory with 800 MHz clock speed
- Available Hardware: shanghai Dell PowerEdge R805, Opteron 2384, 2.7 GHz, 6 MB L3 cache

Harpertown CPU

Older hardware for reference:

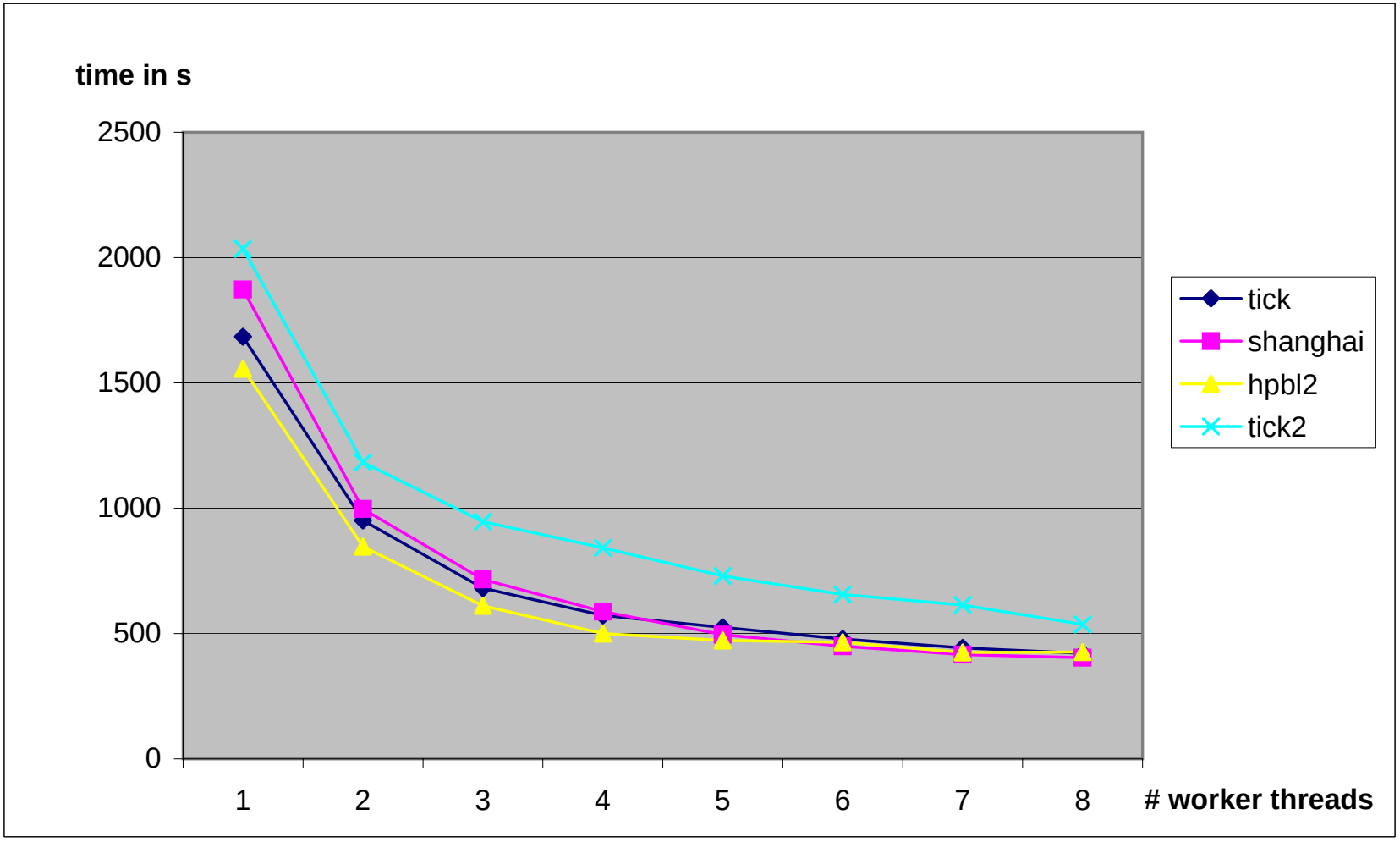
- hpbl2: HP ProLiant BL460c, Intel Harpertown (Xeon E5440 2.83 GHz)
- 2x 6 MB L2 Cache
- 1333 MHz FSB

FORM Benchmark

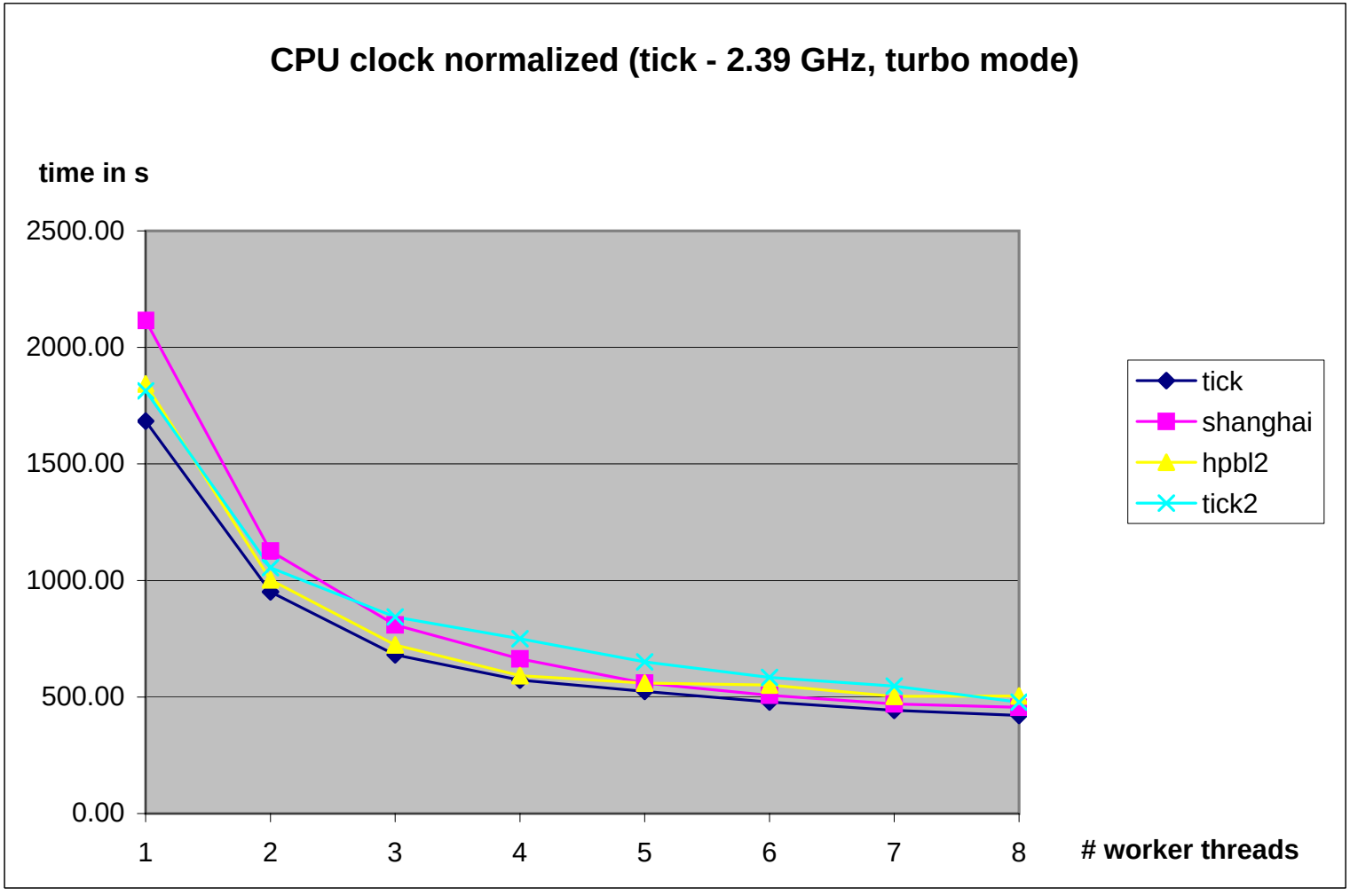
- Symbolic Manipulation System
- Developed by Jos Vermaseren of NIKHEF
- Benchmark based on multi-threaded FORM – TFORM
- Used by theoretical particle physicists

- Benchmark calculates Feynman diagram 8th momentum
- Dependence on disk performance
- Measurements taken by Peter Wegner

FORM Benchmark II



FORM Benchmark III



Lattice Quantum Chromodynamics

- Theory of quarks and gluons formulated on a space-time lattice
- Discrete space-time – simplified model
- Higher accuracy means huge computation costs

- Code small and well parallellised
- Simulation at DESY on APE machines and parallel Linux clusters
- Blue Gene/L
- QPACE (IBM Cell processor)

Lattice Quantum Chromodynamics II

- Overall performance typically dominated by a single kernel
- Mainly (sparse) matrix-vector multiplication:

$$\psi_i = M_{ij}\phi_j$$

- Consider particular version of M: Wilson-Dirac hopping matrix. For each i:
  - 1320 floating point operations
  - 336 loads of floats or doubles
  - 24 stores of floats or doubles

  $\Rightarrow$ 3.7 Flops per load or store of 1 float or double

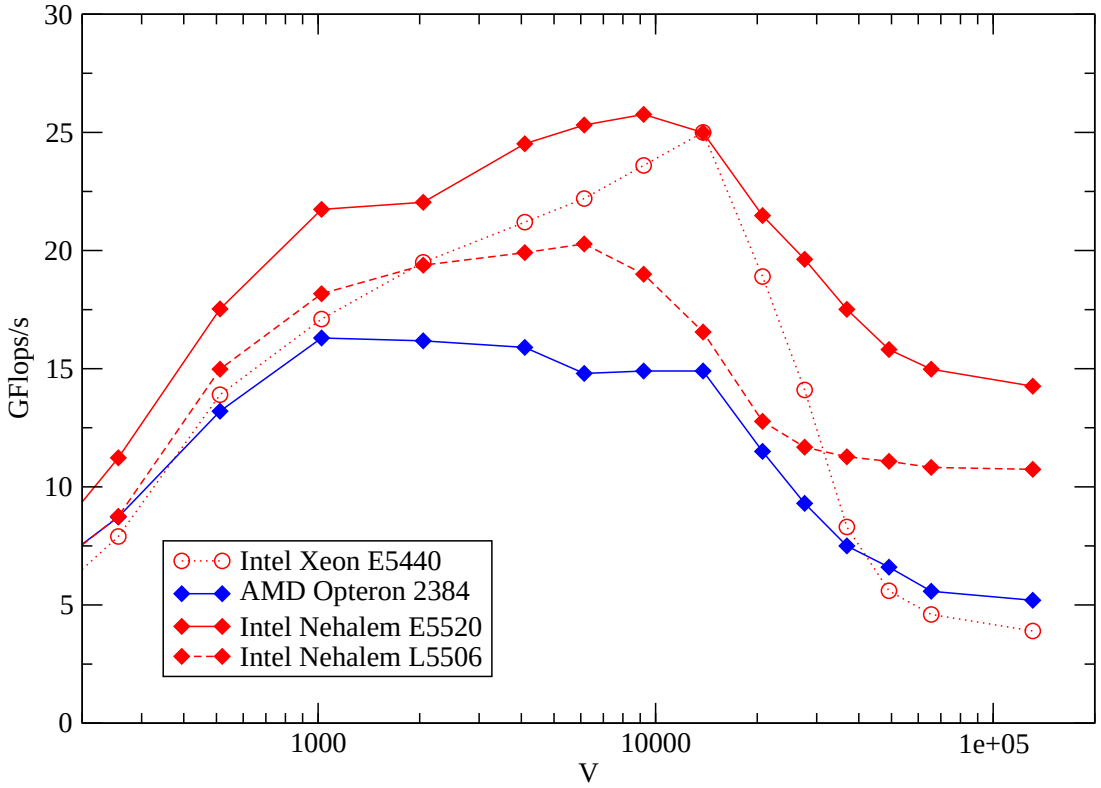
Chroma Benchmark

- Lattice QCD community code called *Chroma*
- Developed and maintained at JLAB
- C++ code with hand-optimized kernel (using SSE)
- Parallel Application using Shared Memory
- Hybrid Monte-Carlo application

- Measurements taken by F.Winter, D.Pleiter and C.Külker

Weak scaling

- Investigate performance for fixed number of cores as function of the problem size
  - Measured performance of Conjugate Gradient inverter:



  - Application parallelized on 2×4 cores using openMPI
  - Disclaimer: No additional optimization done

Observations and comments

- Maximum sustained performance:
  - Nehalem E5520 60% faster than Shanghai 2384
  - Nehalem E5520 27% faster than Nehalem L5506
- Sustained performance for large problem size:
  - Nehalem E5520 2.7 times faster than Shanghai 2384
  - Nehalem E5520 33% faster than Nehalem L5506
- Caveat: Measured performance on single node only
  - Less realistic
  - Smallest lattice: $V = 2 \times 4^3 \Rightarrow$ 16 sites per core
  - Largest lattice: $V = 16^3 \times 32 \Rightarrow$ 16384 sites per core
- More realistic scenario: $V = 32^3 \times 64$ on 16-32 nodes
  - 8192-16384 sites per core
  - Interconnect via XDR IB

$\Rightarrow$ Performance impact not measured (yet)

Summary

- Nehalem shows significant performance increase
- Higher Memory Bandwidth
- Well-suited for QCD simulations

- Outlook
  - Run other QCD benchmarks
  - Run QCD Benchmark on Nehalem Cluster with QDR Infiniband
  - Benchmark 4-Way Nehalem (TFORM)

References

M. Tentyukov, J.A.M. Vermaseren.
The Multithreaded version of FORM
http://arxiv.org/abs/hep-ph/0702279v1

R.G. Edwards (LHPC Collaboration), B. Joó (UKQCD Collaboration).
The Chroma Soft ware System for Lattice QCD
http://arxiv.org/abs/hep-lat/0409003

C. McClendon.
Optimized Lattice QCD Kernels for a Pentium 4 Cluster
http://www.jlab.org/~edwards/qcdapi/reports/dslash_p4.pdf

The End

Questions?