Challenges and Issues in Benchmarking MPI

a.k.a. Benchmarks Lie

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EuroPVM/MPI 2006

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company,
for the United States Department of Energy's National Nuclear Security Administration
under contract DE-AC04-94AL85000.

Introduction

- Most important applications are a pain
  - Want to wait 3 weeks for an application to build?
  - How long can we wait for the application to run?
  - Have a classified test cluster handy?
- Benchmarks are frequently too simplistic
  - Nominal objective: isolation of network performance
  - How many applications have NO computation?
  - How many applications send messages in the order they are expected?
  - How many benchmarks include load imbalance?

Benchmarks Lie

- Not a new revelation
- Vendors work hard to keep it this way
  - They don't really want you to know how similar their products are
  - They have to optimize to "the same test everyone else does"
- That does not mean it is easy to do benchmarking well
  - Hardware optimizations interact with software optimizations to yield interesting effects
  - Each network has different interactions to make a "fair" comparison hard

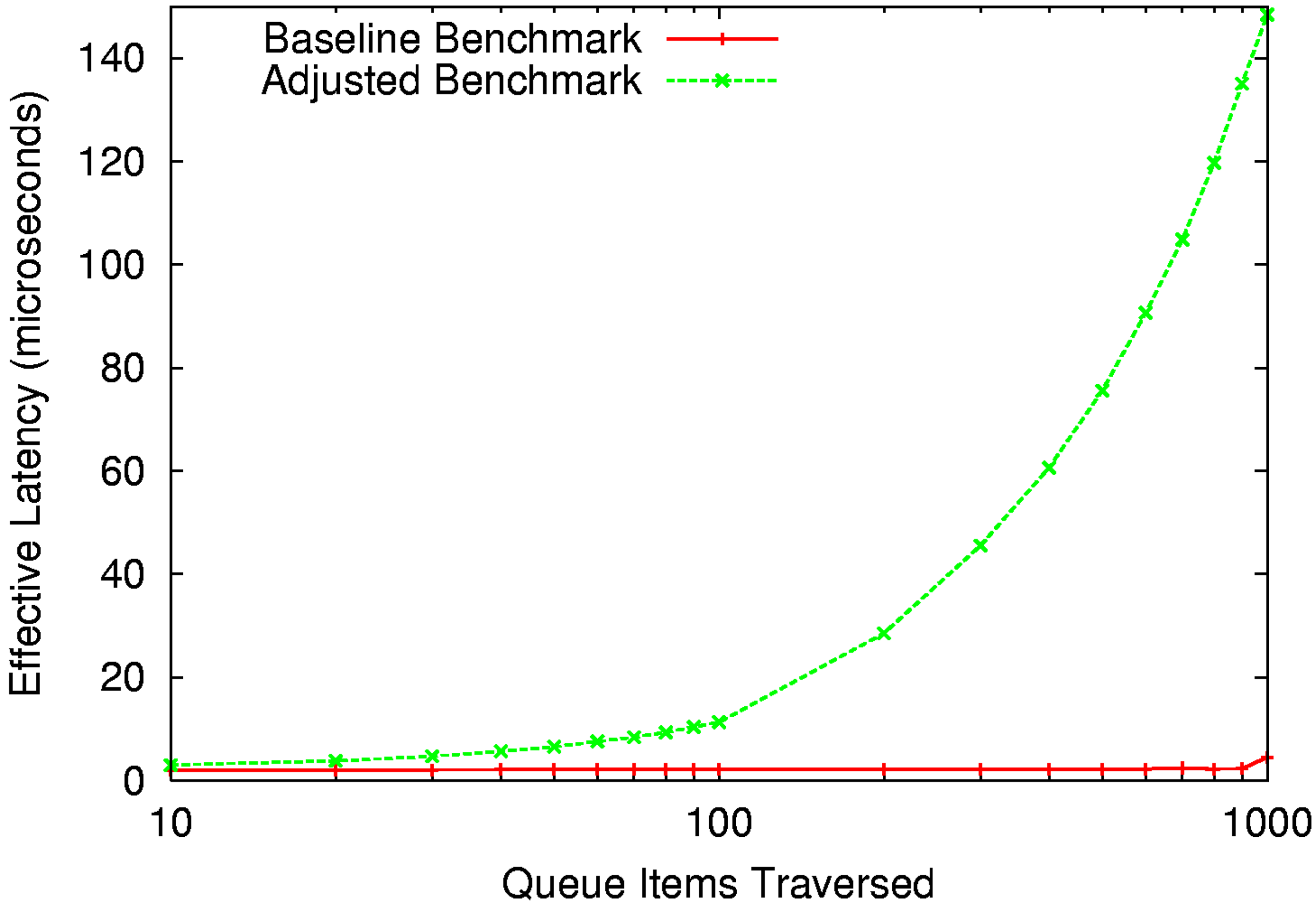
Overview of Issues

- Optimized host processor
  - Big cache (holds all of benchmark)
  - Prefetcher (works unnaturally well on benchmark)
- Unfriendly compilers
  - Tend to create terrible code without optimization
  - Tend to eliminate “dead” code with optimization – all of a benchmark is “dead” code ☺
- “Good” software optimizations
  - The “right thing to do” in the software stack can interact with the hardware to make good benchmarking hard
- No interaction of “computation” with “communication”
  - Load imbalance?
  - RogueOS effect?

Quadrics Elan4

- Connected by PCI-X bus
- Offload of MPI matching semantics to NIC processor
  - Provides low host overhead
  - Provides true “independent progress”
- Primary issue: “good” software optimization
  - Use of PCI-X bus is lousy for “on node” communications
  - The “right thing to do” is to segregate “local” posted receive list from “remote” posted receive list

Software Optimization Impact



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Infinipath

- HyperTransport connected custom IB NIC
- Extreme message rates
- All work done on the host processor
- Primary issue: big, fat, optimized processor
  – Processor has aggressive benchmark optimizations (caches, prefetching)
  – Such resources should be polluted by application (means benchmark behavior is poorly matched to application behavior)

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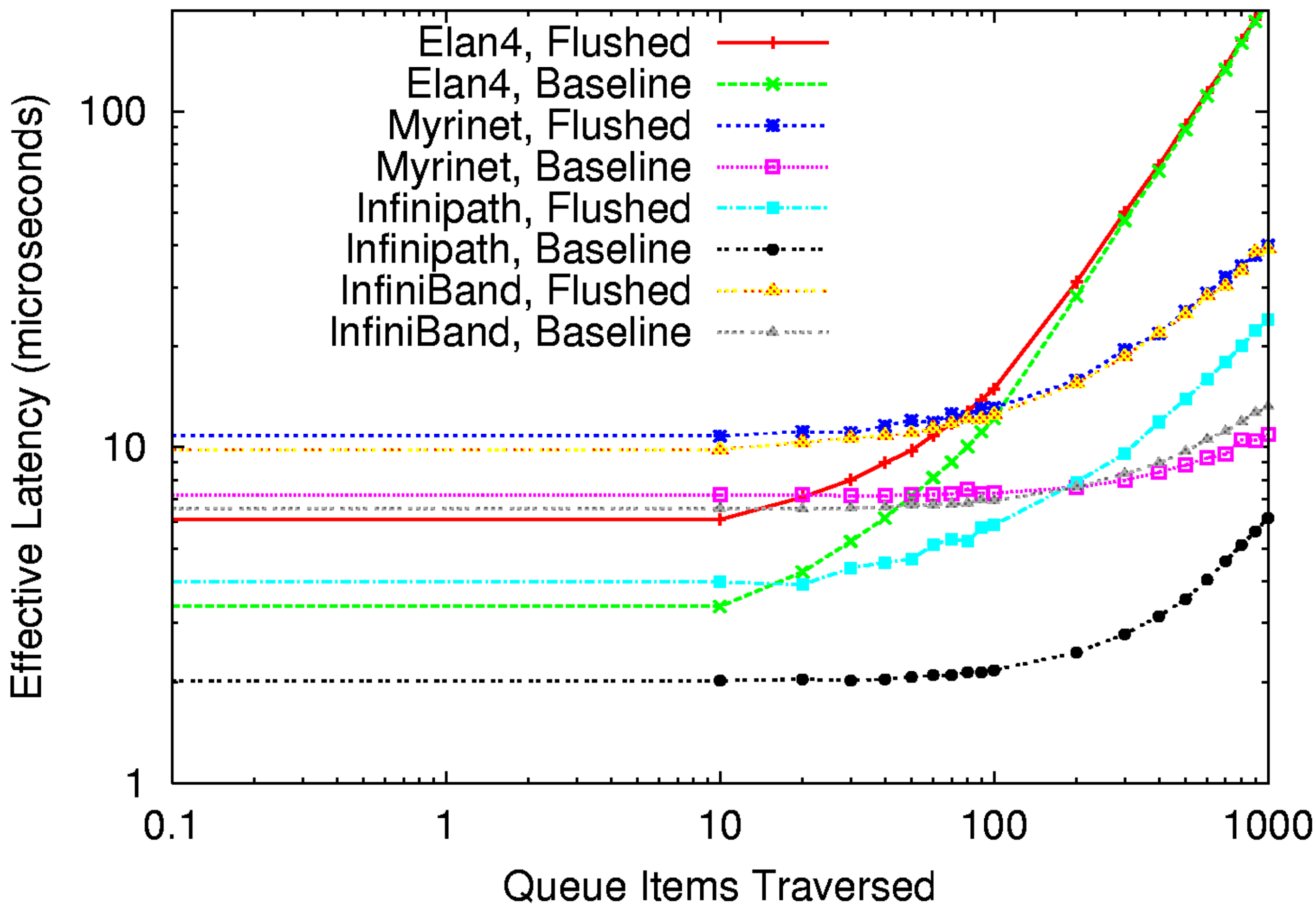
Flushing Cache – Latency



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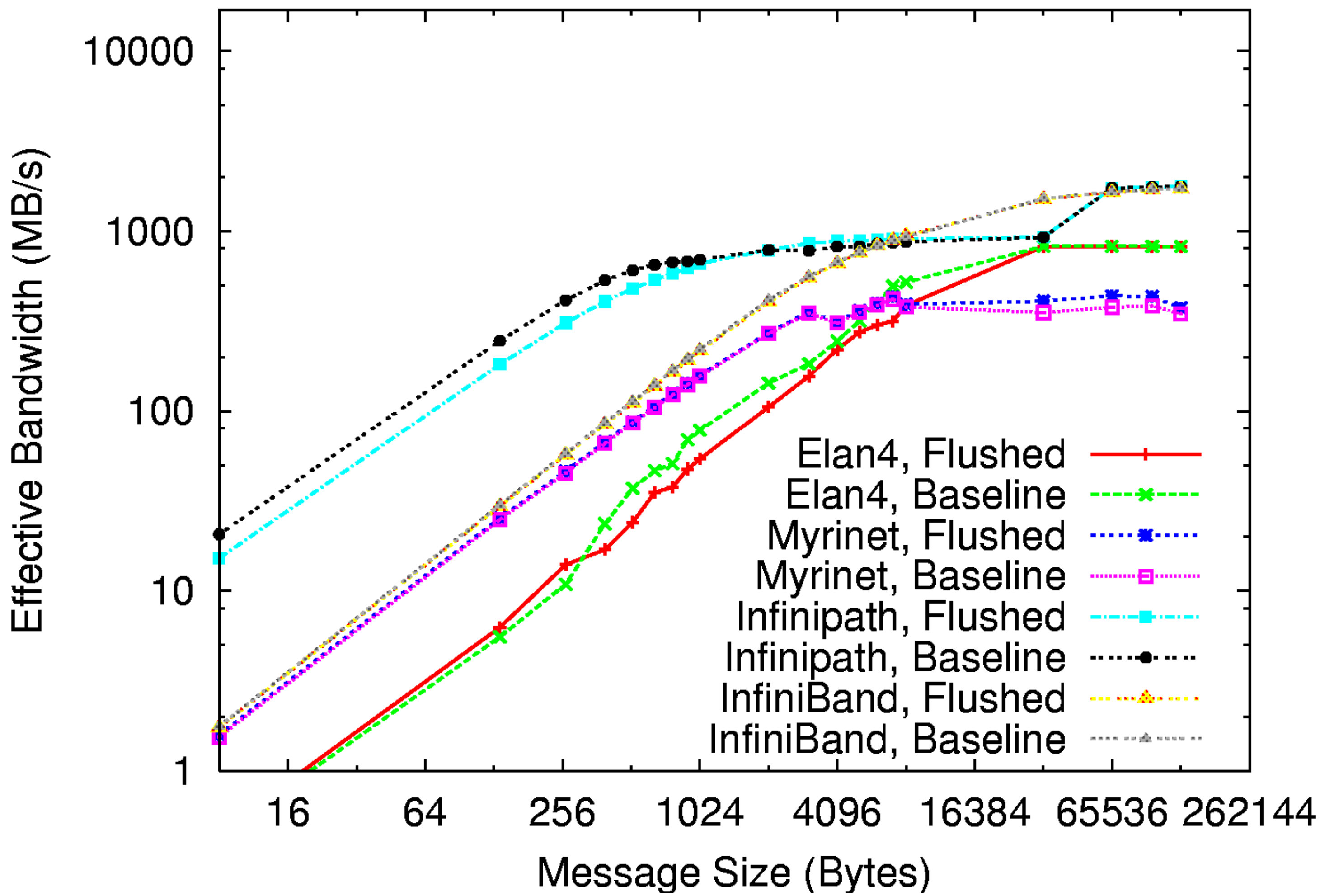
Flushing Cache – Message Rate



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Flushing the Cache Not Enough

- **Modern latency tolerance techniques go beyond caching**
  - Techniques now include aggressive prefetching
  - Prefetching should make very little difference in MPI processing
- **Unfortunately, good software optimizations interact with prefetching to yield a large benefit**
  - MPI data structures are allocated from a slab cache
  - Most benchmarks cause these to be allocated and then freed sequentially
  - Result: a linked list that is stride-1 in memory

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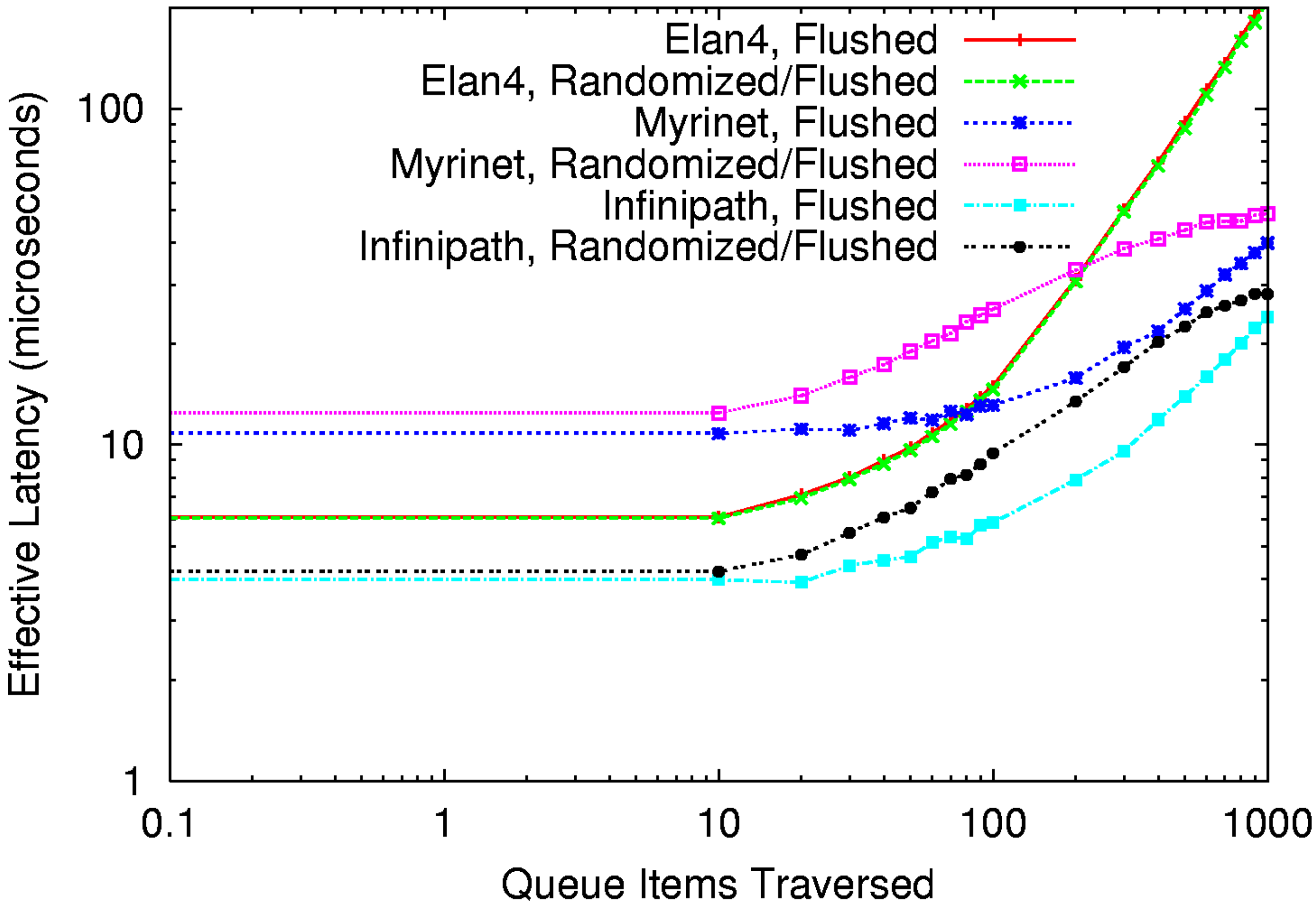
Randomizing Slab Cache



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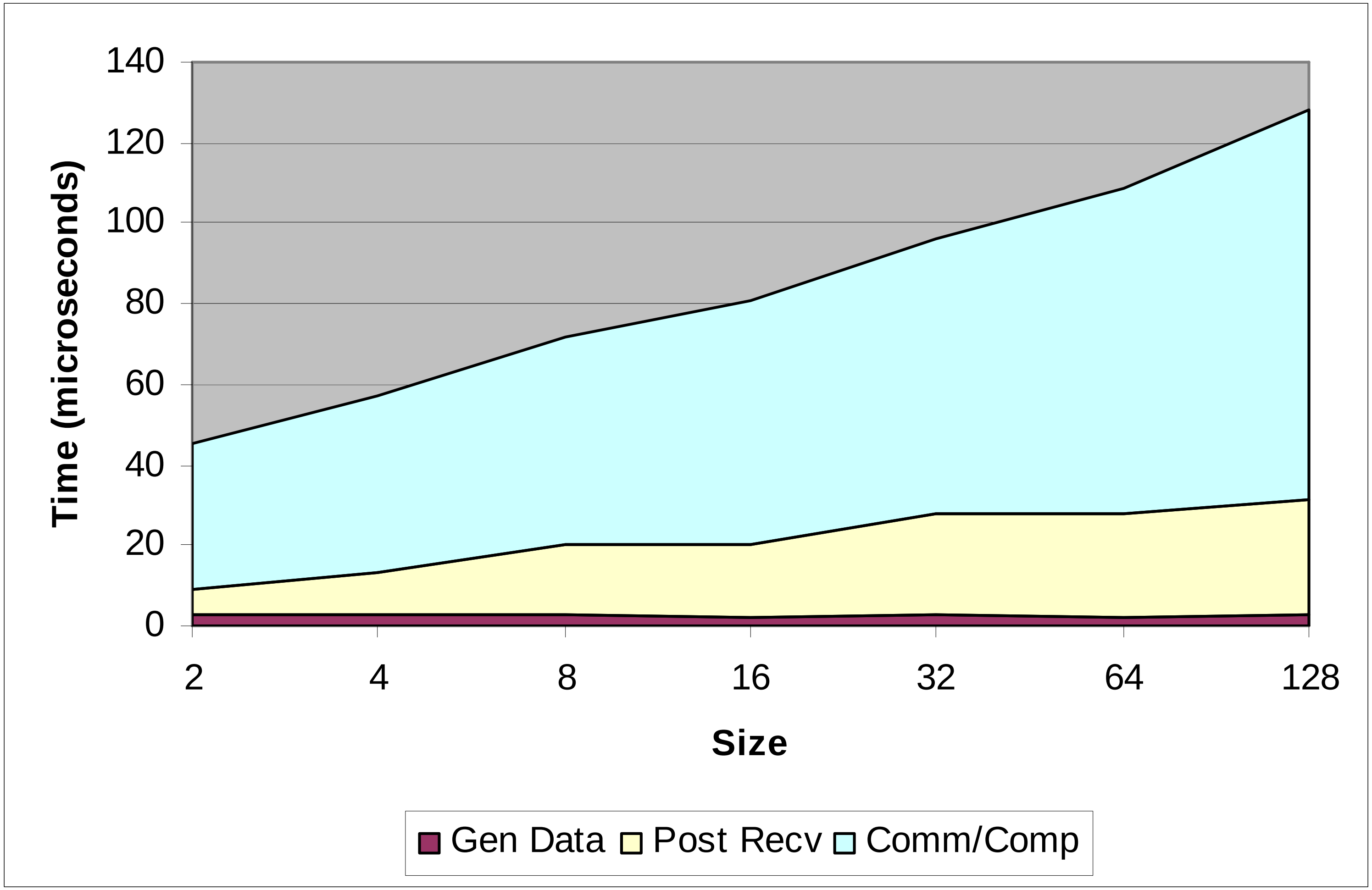
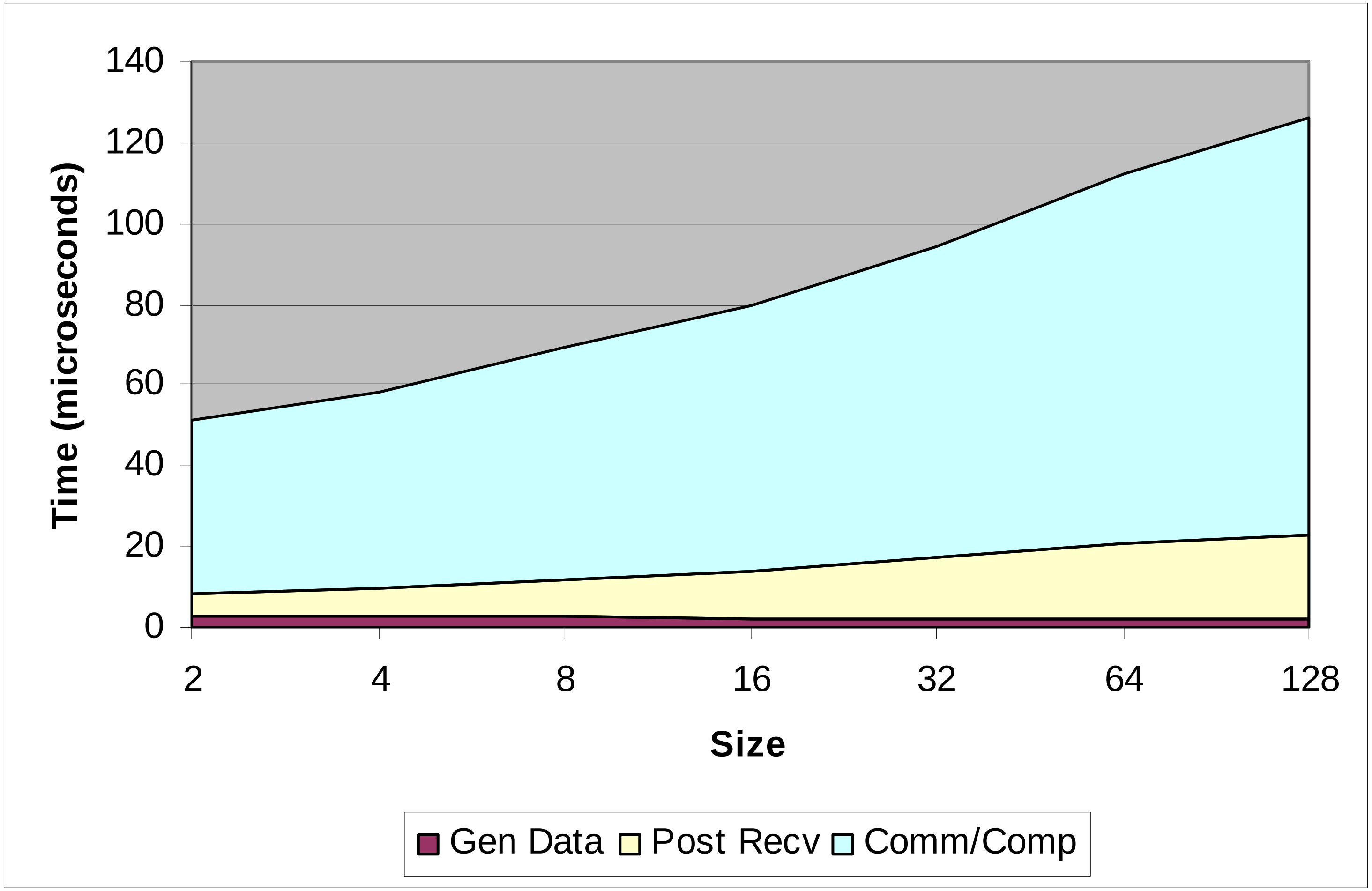
A Case Study: HPCC RandomAccess

- HPCC RandomAccess benchmark was limited by message rate
  - Implemented a new version that uses “hypercube” style algorithm
  - Optimized using aggressive overlap and leveraging independent progress
- Expected bottlenecks
  - Memory bandwidth (many random accesses)
  - Network latency (messages of 8KB)
  - Network bandwidth (comm. time = latency + size/bw)
- Additional bottleneck: time to post a receive ?!?
  - Never appears in “microbenchmarks” as critical factor

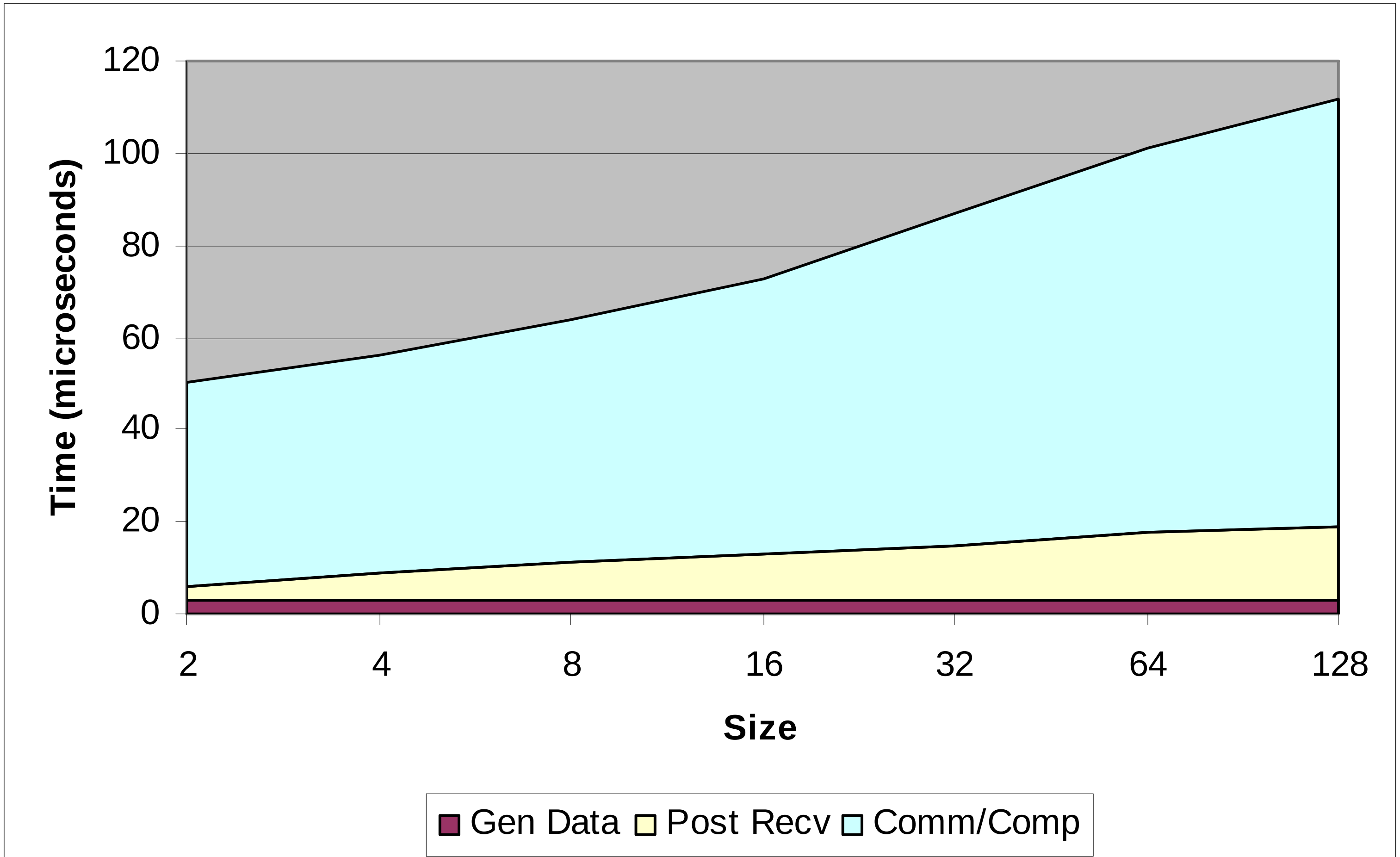
Posting Receives takes HOW LONG?



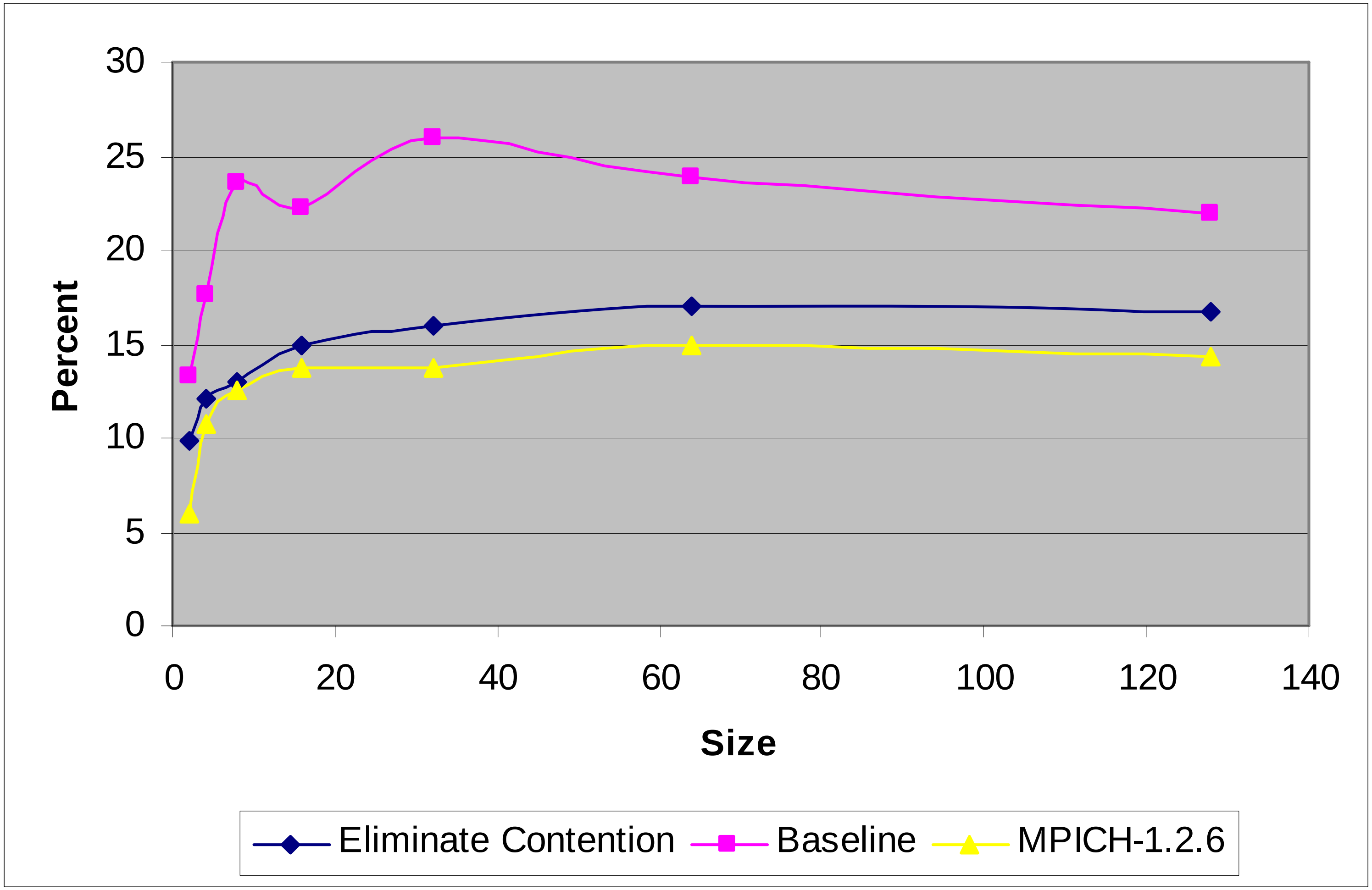
You must have done SOMETHING wrong… (Eliminate Contention)



Try MPICH-1.2.6



Comparison of Impacts



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Conclusions

- Benchmarks are hard to do “right”
  – Good software optimizations have too much impact on the typical benchmark case
  – Software optimizations can interact with hardware optimizations to have unrealistically positive impact in the benchmark case
- Typical benchmarks make it impossible to predict performance
  – The goal of a good benchmark should be enabling performance prediction
  – Real application impacts make things like posting a receive take much longer than the benchmark case

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