Performance Analysis and Projections

Ronak Buch

20 April 2016

Ronak Buch rabuch2@illinois.edu
“We must not allow the clock and the calendar to blind us to the fact that each moment of life is a miracle and mystery.”

H.G. Wells
Each moment of life may be a mystery, but each moment of our programs shouldn’t be.
Measuring Performance

In the serial world:

- `clock_gettime()`, `gettimeofday()`
- `gprof`
- `valgrind`
Measuring Performance

In the serial world:

- `clock_gettime()`, `gettimeofday()`
- `gprof`
- `valgrind`

Parallel

These techniques don’t really work for distributed parallel programs.
Problems in Parallel Analysis

- Different processors may do radically different work
- Performance problems may be on the network
- Load may not be balanced between processors
Parallel Analysis Tools

In general, tools must be used to do parallel performance analysis:

- mpiP
- Vampir
- HPCToolkit
- Projections

These tools provide details on communication, scaling, mapping, load imbalance, etc.
Projections

• Projections is a performance analysis tool for Charm++
• Provides tools for analyzing most of the discussed issues in parallel performance
• Runtime traces application executions, creates logs for local analysis
Projections Tools
Projections Tools
Projections Tools
Profile of Usage for Processors 0-3
(Time 214.0 ~ 301.43 ms)

IDLE
Usage: 31.924%
PE: 2
Projections Tools

Histogram

[Graph showing a histogram with bin intervals and frequency counts across different intervals.]
Recent Advancements in Projections

Recently, we have added some advanced analysis tools to Projections:

- Cache latency measurement
- Communication thread tracing
Cache Latency Measurement

Using sampling techniques, we have developed a method to trace cache accesses and attribute them to specific lines.

- Intel PEBS - Precise Event Based Sampling
- Provides instruction pointer with sample
- Provides latency of access, not mere hit/miss count
Cache Latency Measurement

Collected data allows us to analyze:

- Spatiotemporal memory access pattern and latency
- Cache miss rate over time
- Cache latency per source line
Cache Performance Tools

[Graph showing a scatter plot with axes labeled as 'Time domain' and 'Distance of memory access from start of allocation'. The graph is divided into two regions: 'Tree Node Region' and 'Particle region'.]
Cache Performance Tools

Average Miss Rate Over Time

Miss Rate

Time (103.652ms resolution)
Cache Performance Tools

Performance Analysis and Projections

Ronak Buch  rabuch2@illinois.edu
Communication Thread Tracing

When Charm++ is used in SMP mode, every process has a communication thread. When built with `--enable-tracing-commthread`, the runtime will specifically trace this thread.

Using these logs, we can analyze network performance in detail.
Communication Thread Tracing

Excess Network Latency Over Time

Message Latency

Time (1.442ms resolution)

Ronak Buch   rabuch2@illinois.edu  Performance Analysis and Projections
Communication Thread Tracing

Network Messages with Highest Excess Latencies

Excess Latency Rank vs Message Latency
Communication Thread Tracing

![Network Latencies Per PE Graph]

- PE 6
- PE 7

Series G

Ronak Buch  rabuch2@illinois.edu  Performance Analysis and Projections
Communication Thread Tracing

Future work:

• Identify communication thread oversubscription
• Estimate runtime given ideal network
• Use topology and routing information to identify network hotspots
Conclusion

- Performance analysis tools are critical for optimizing HPC applications
- Detailed metrics (performance counters, network delay, etc) can provide insight
- Make performance problems as obvious as possible
- Make it possible for users to write ad hoc analysis tools
Thanks