Tools for Enabling Automatic Validation of Large-scale Parallel Application Simulations

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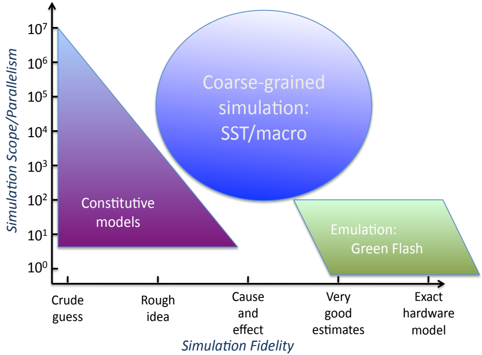
Hardware/Software Co-design

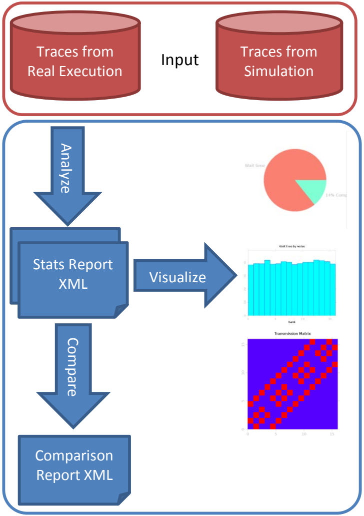


- Exascale co-design
- Simulation is key

Hardware Model Validation

- Hardware model is a set of simulation input parameters, e.g., network topology, network bandwidth/latency, node frequency, etc.
- The goal of of simulation validation is to establish the accuracy by quantizing the error between the simulated execution and the execution on the physical machine
- The error of the simulation can be used to guide future tuning process

Validation Work Flow



- Gather execution traces
- Distill statistical data
- Compute errors through comparison

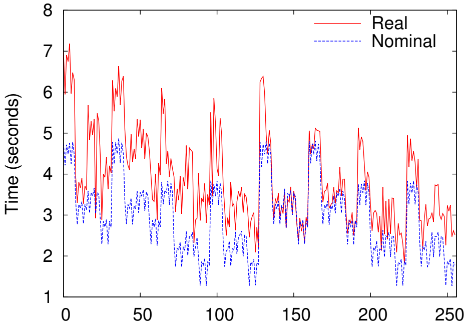
Existing Metrics

- Coarse-grained metrics, such as total execution time, lacks fidelity to identify fine-grained execution differences
    - Insensitivity to some parameters
    - Some parameters have adversarial effects
- Detailed traces are not ready for quantitative comparison
    - TAU, Scalasca, Vampir, IPM, mpiP, etc.

Proposed Metrics

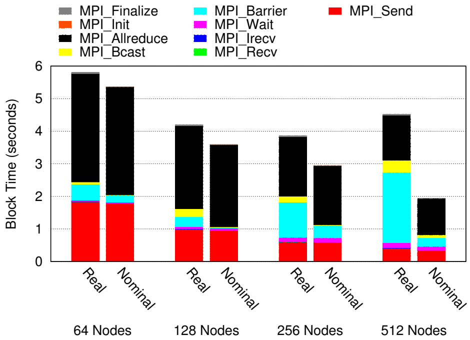
- Benefits
  - Fine-grained metrics improves validation fidelity
  - Matrix format facilitates quantitative comparison
- Experiment Environment
  - *Hopper* at SNL (a Cray XE6 cluster)
  - Gemini interconnect with two communication paths: fast memory access (FMA) and block transfer engine (BTE)
  - miniMD and coMD as benchmark

By-node



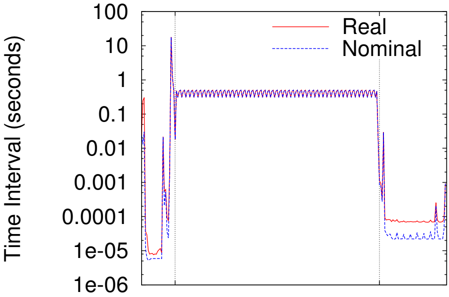
- Break down by rank
- $2 \times N$ matrix

MPI Histogram



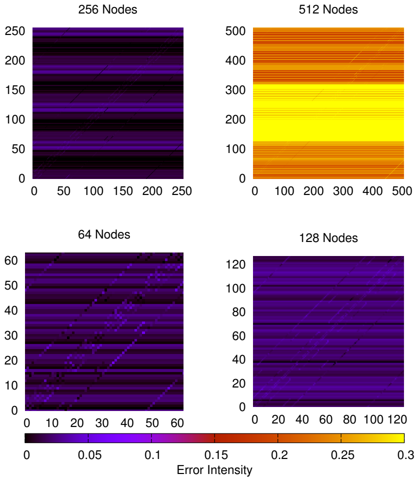
- Break down by MPI functions
- $F \times N$ matrix

Collective Synchronization



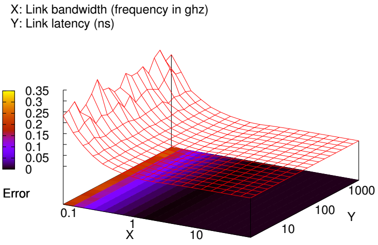
- Collective functions as synchronization barriers
- Break down by collective phases
- $S \times N$ matrix

Node-to-node Communication

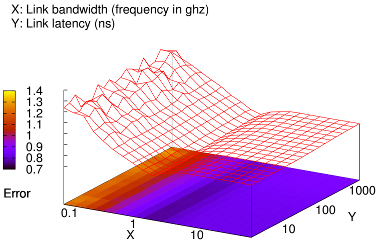


- Pair-wise timing
- $N \times N$ matrix

Link Bandwidth and Latency



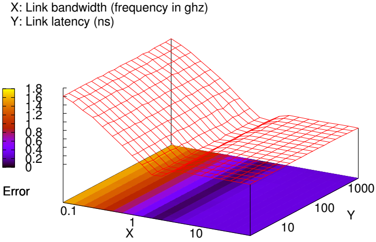
(a) Total execution time



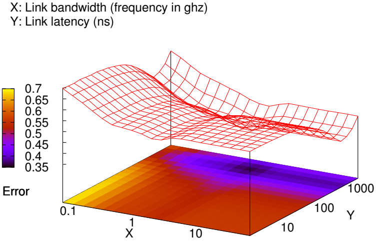
(b) MPI histogram

The error measured by MPI histogram converges at 2.4Ghz, which is the nominal value

Link Bandwidth and Latency



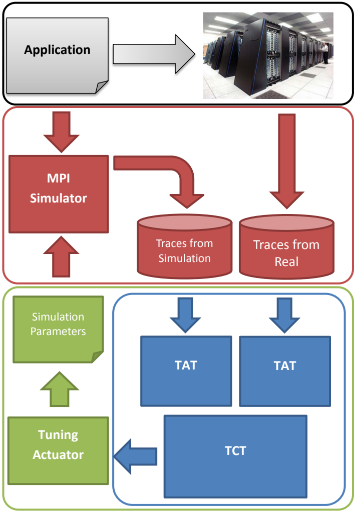
(c) Node-to-node timing



(d) Collective Synchronization

The error measured by node-to-node timing and collective synchronization converges at 2.4Ghz.

Auto-tuning Work Flow



- Search the parameter space for the optimal values