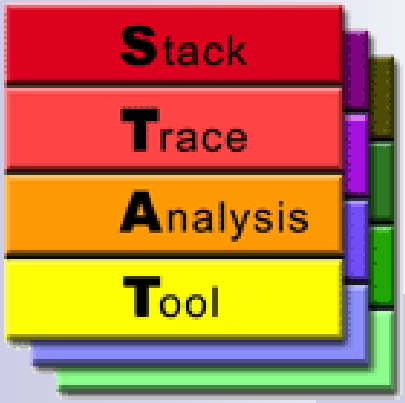

Scalable Emulation for Tool Performance Tuning

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Overview

- The Stack Trace Analysis Tool (STAT) is a scalable, lightweight debugging tool
- STAT is effective at debugging large scale applications
- Validating STAT's scalability is difficult

Large Scale Tool Validation is a Challenge

- Limited machine resources
  - Access to large scales
  - Machine time
  - Low priority for iterative tool development
- Goal: identify STAT scalability issues using minimal resources

Tool Scalability is Lagging Behind System Scaling

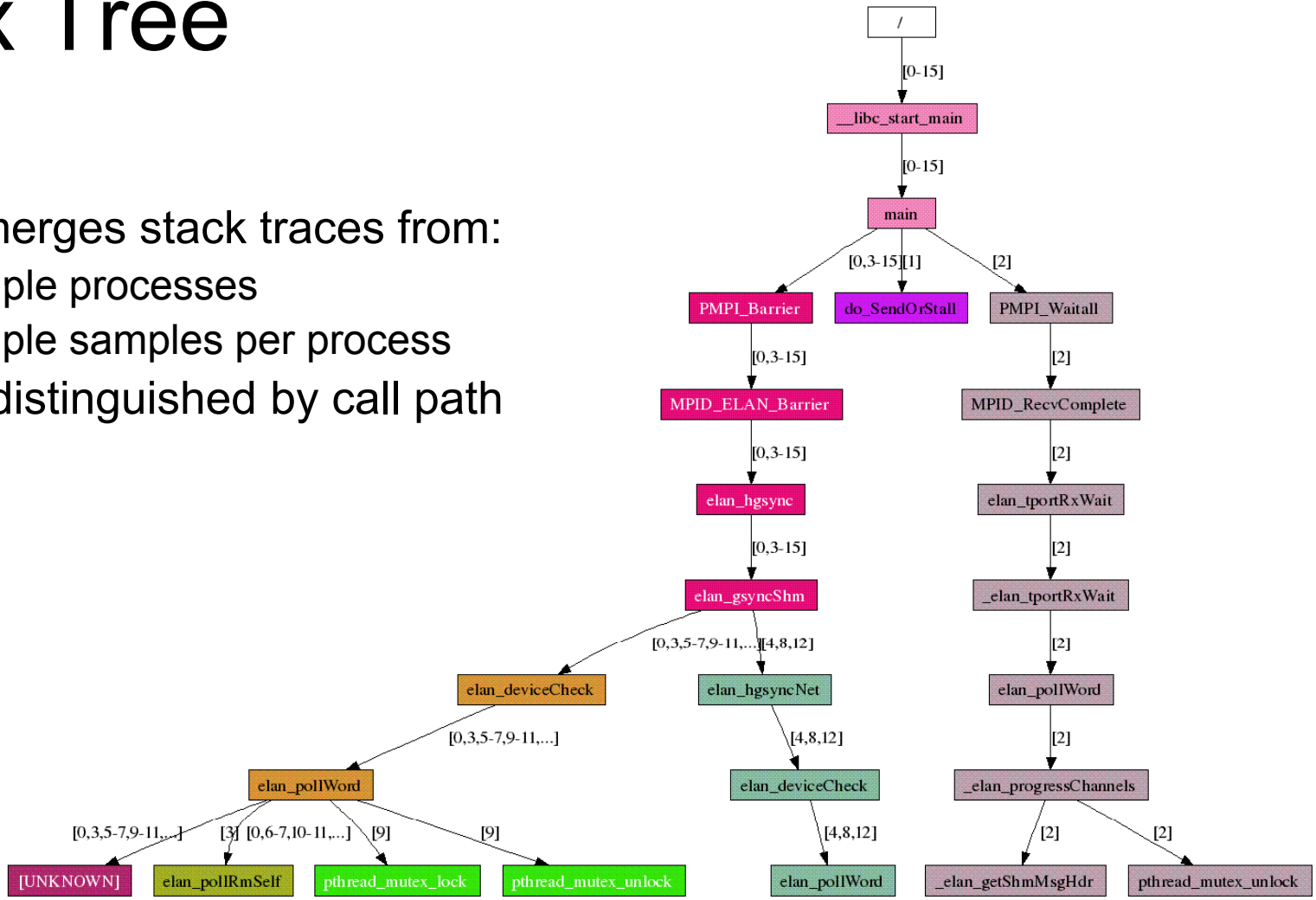
- System scales ever increasing
  - 131,072 processors for BlueGene/L at LLNL
  - O(1M) on the horizon
- Tool scalability is lagging
  - TotalView Debugger operations on BG/L at 4,096 tasks:
    - single step (~15-20 secs.)
    - breakpoint insertion (~30 secs.)
    - stack trace sampling (~120 secs)
  - 4,096 is only 3.125% of BG/L

Why are tools lagging?

- Large volumes of data
- Tool front-end bottleneck
- Vendor licensing costs and limitations
- Large scale resource limitations
- Solution: scalable, lightweight tools
  - Reduce exploration space to a small subset of tasks
  - Full-featured tool for in depth analysis

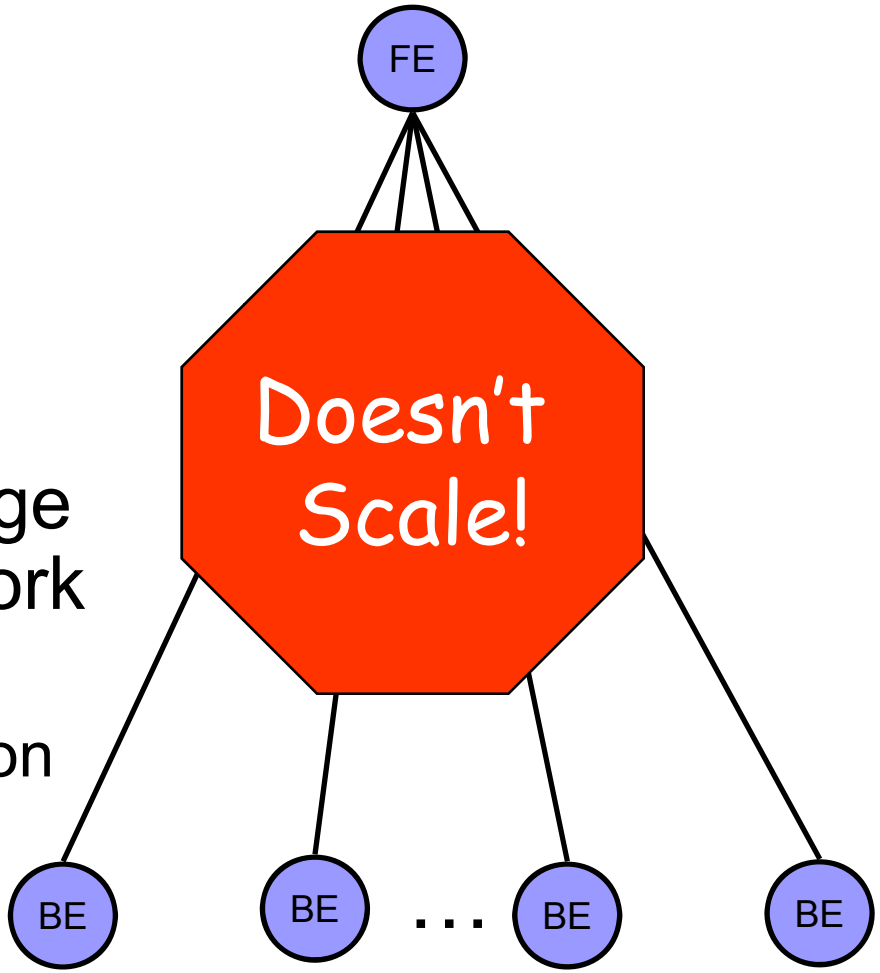
3D-Trace/Space/Time Call Graph Prefix Tree

- STAT merges stack traces from:
  - Multiple processes
  - Multiple samples per process
- Nodes distinguished by call path

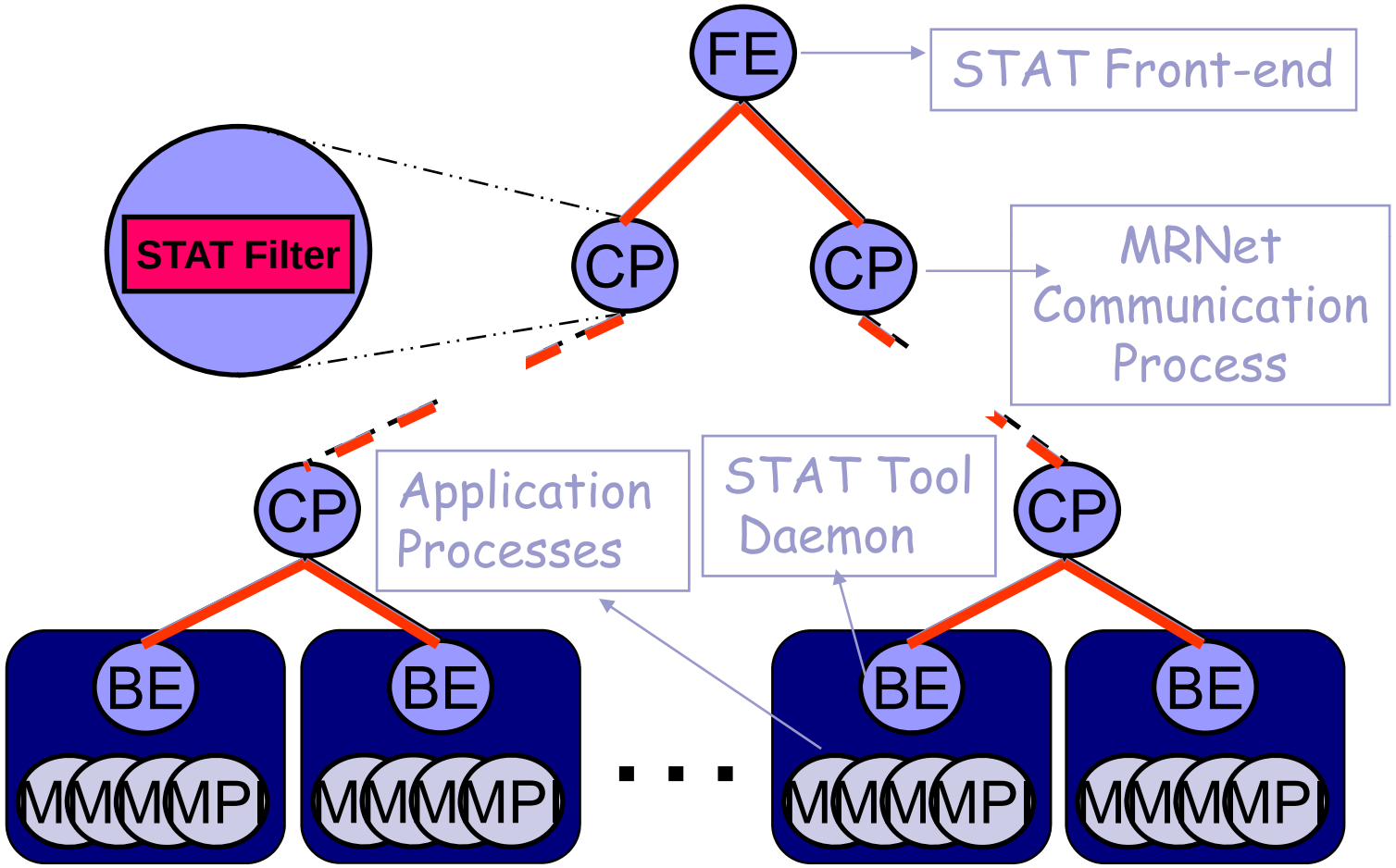


Implementing a Scalable Tool

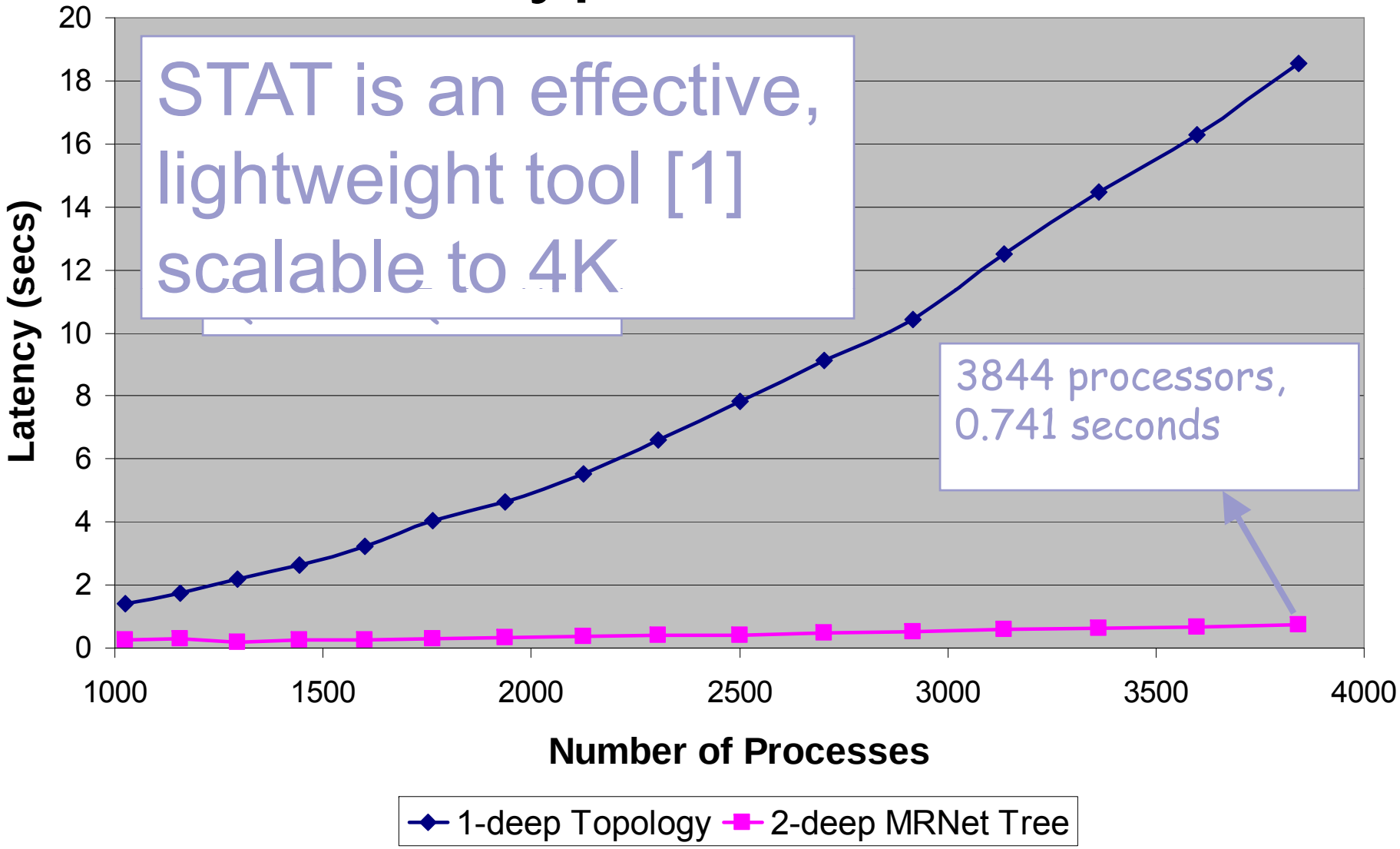
- Hierarchical Topologies
  - Application Control
  - Data collection
  - Data analysis
- A scalable solution: leverage Tree-Based Overlay Network (TBŌN) model
  - MRNet: A Multicast Reduction Network



STAT Architecture



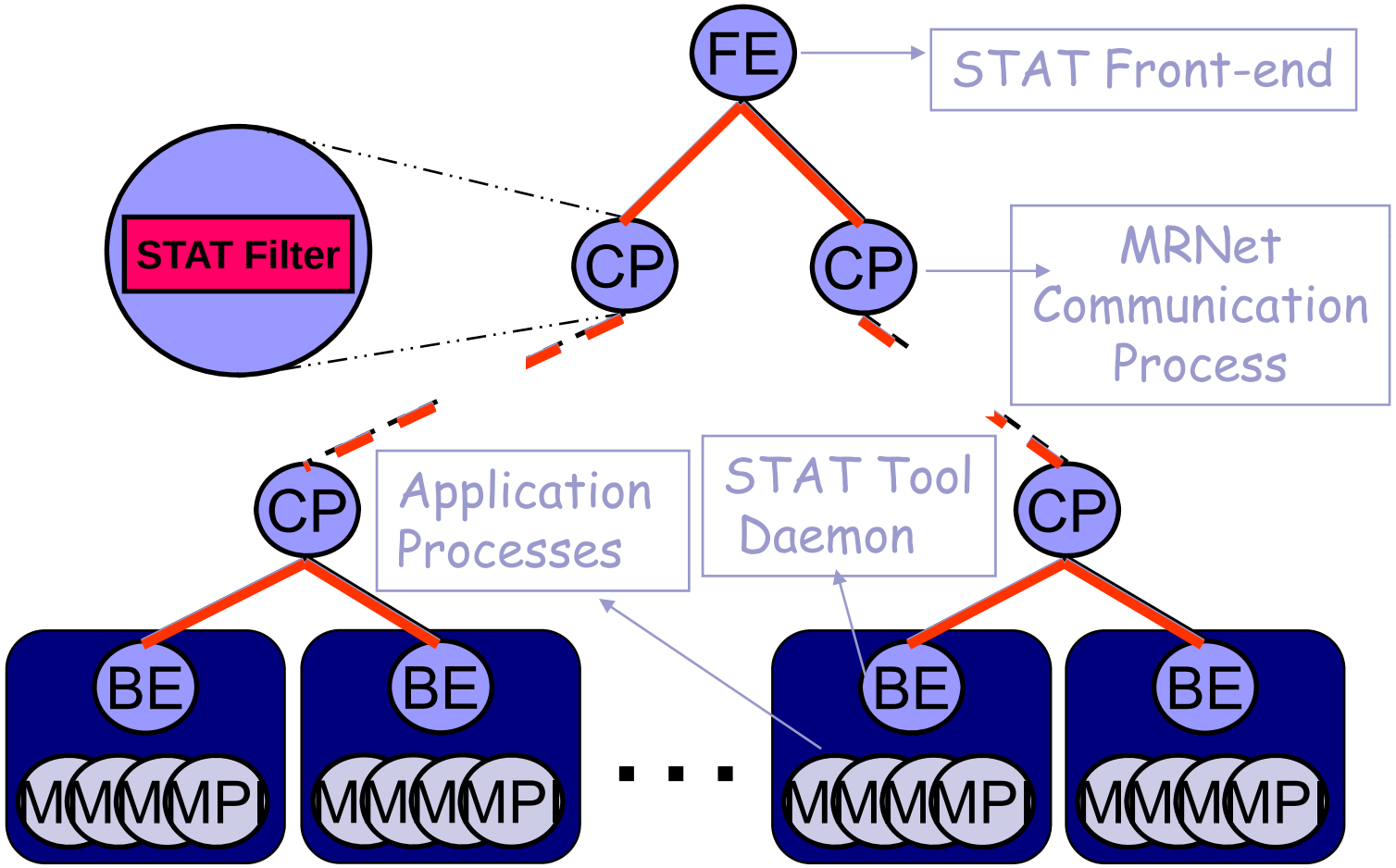
STAT Prototype Performance



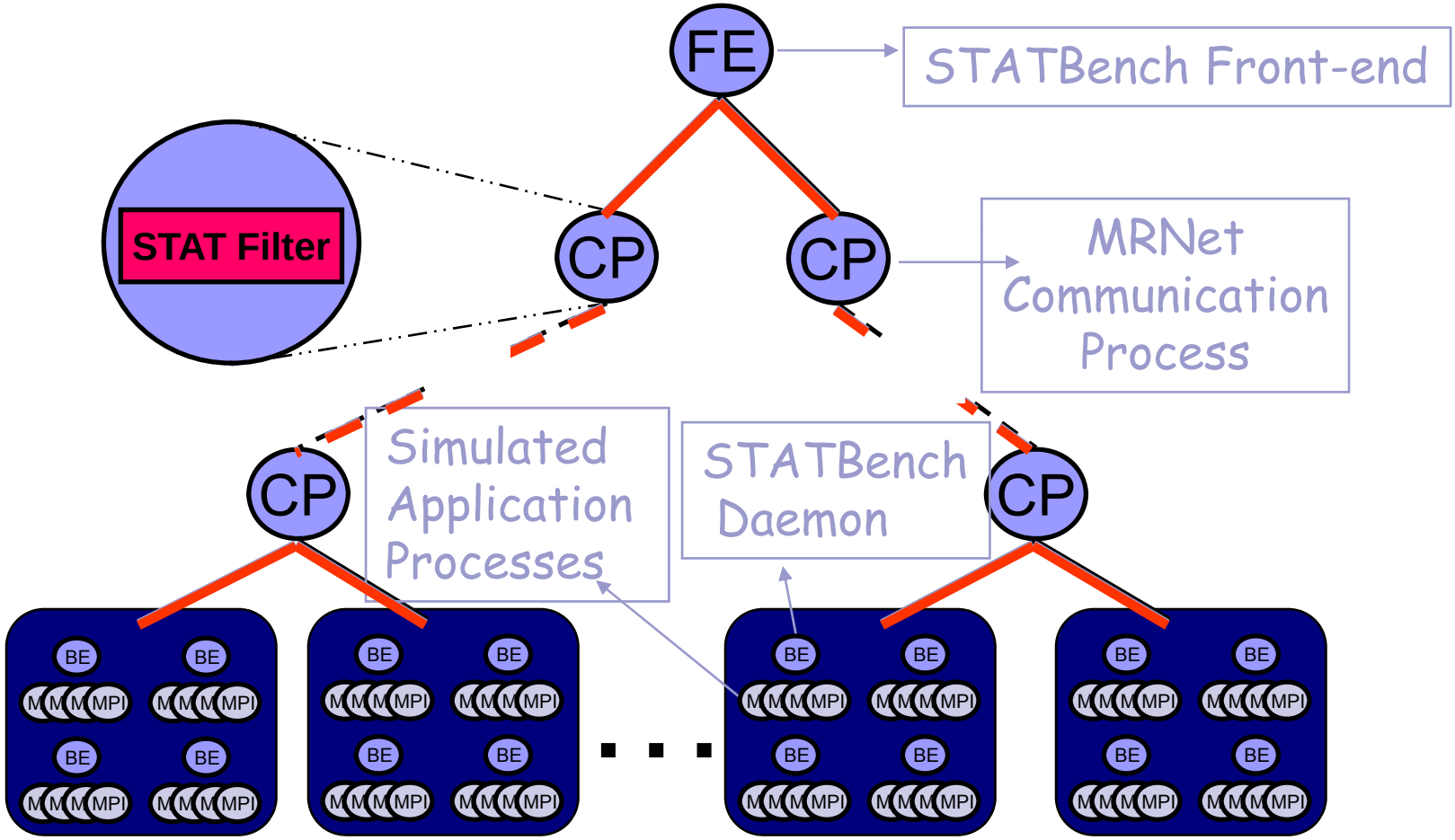
STATBench Emulates Large Scale STAT Runs

- Inherits code from our STAT Prototype
  - Communication via MRNet
  - Same merging/analysis routines
- 2 major differences
  - STATBench architecture
  - Stack trace generator

STAT Architecture



STATBench Architecture

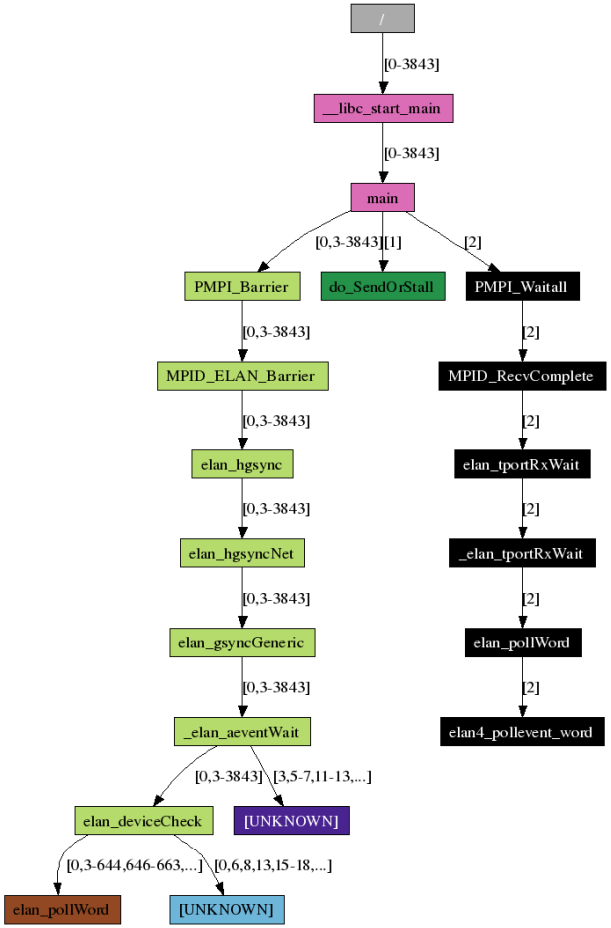


STATBench Stack Traces Model Application Behavior

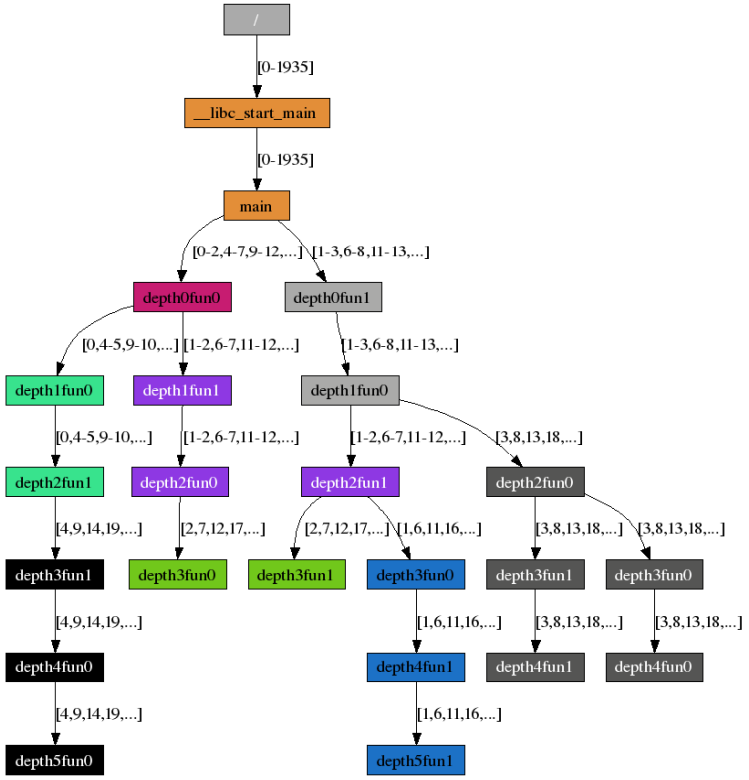
- Randomized call traces generated
- Controlled by several parameters:
  - Number of tasks per daemon
  - Number of traces per simulated task
  - Max call depth
  - Function branching factor
  - Number of equivalence classes

STATBench Validation

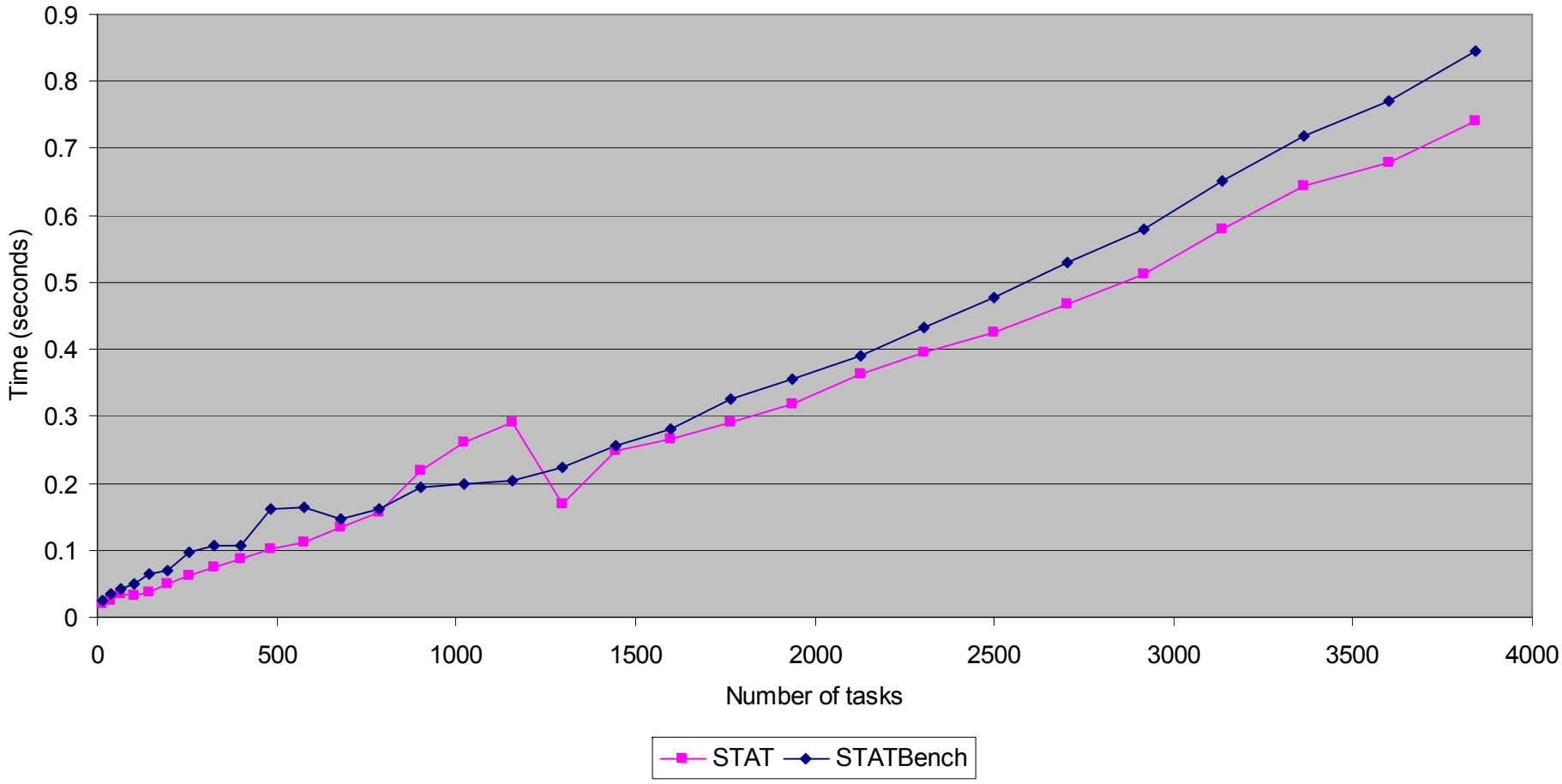
STAT on target application



STATBench approximation



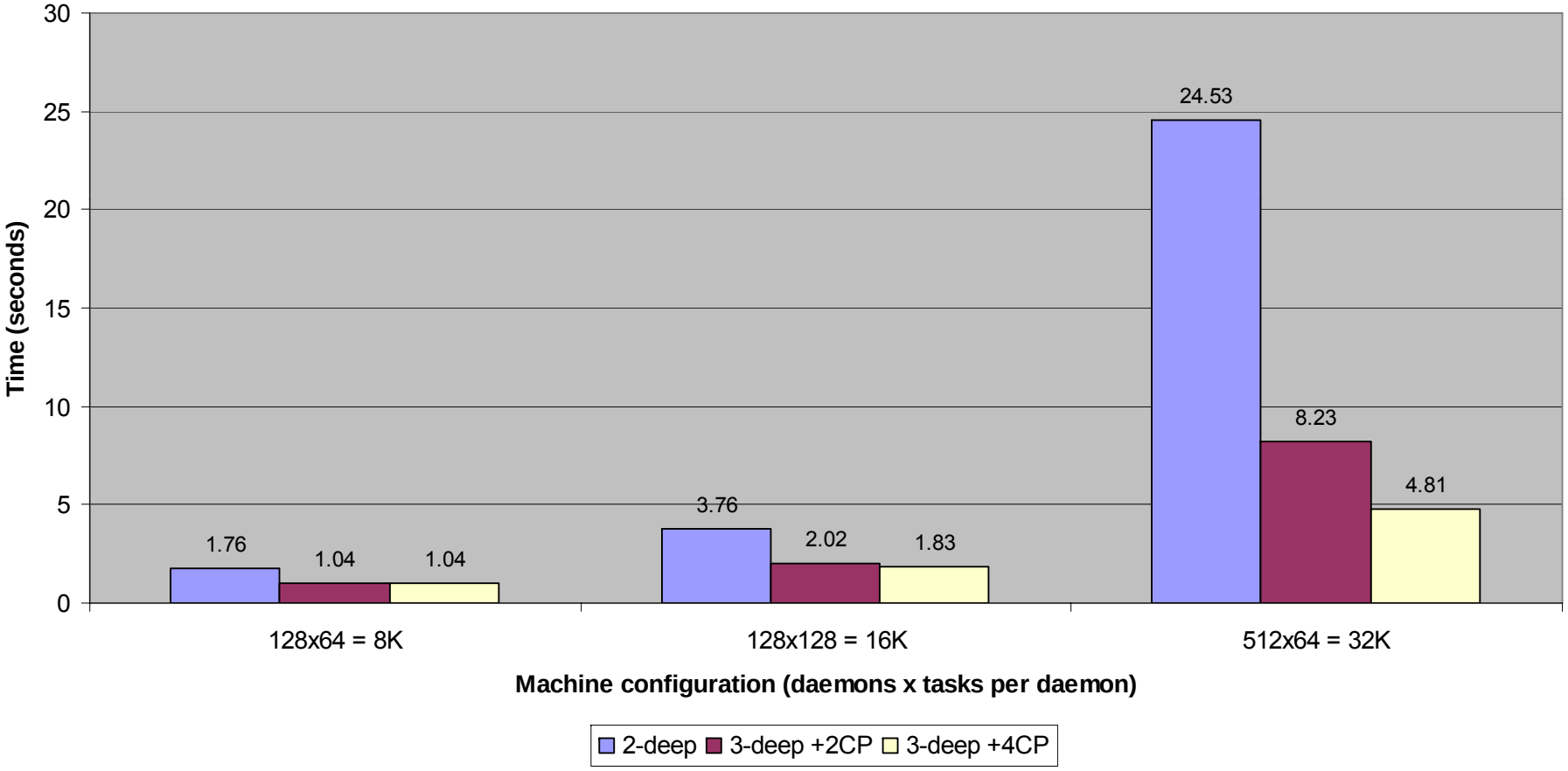
STATBench Performance Validation



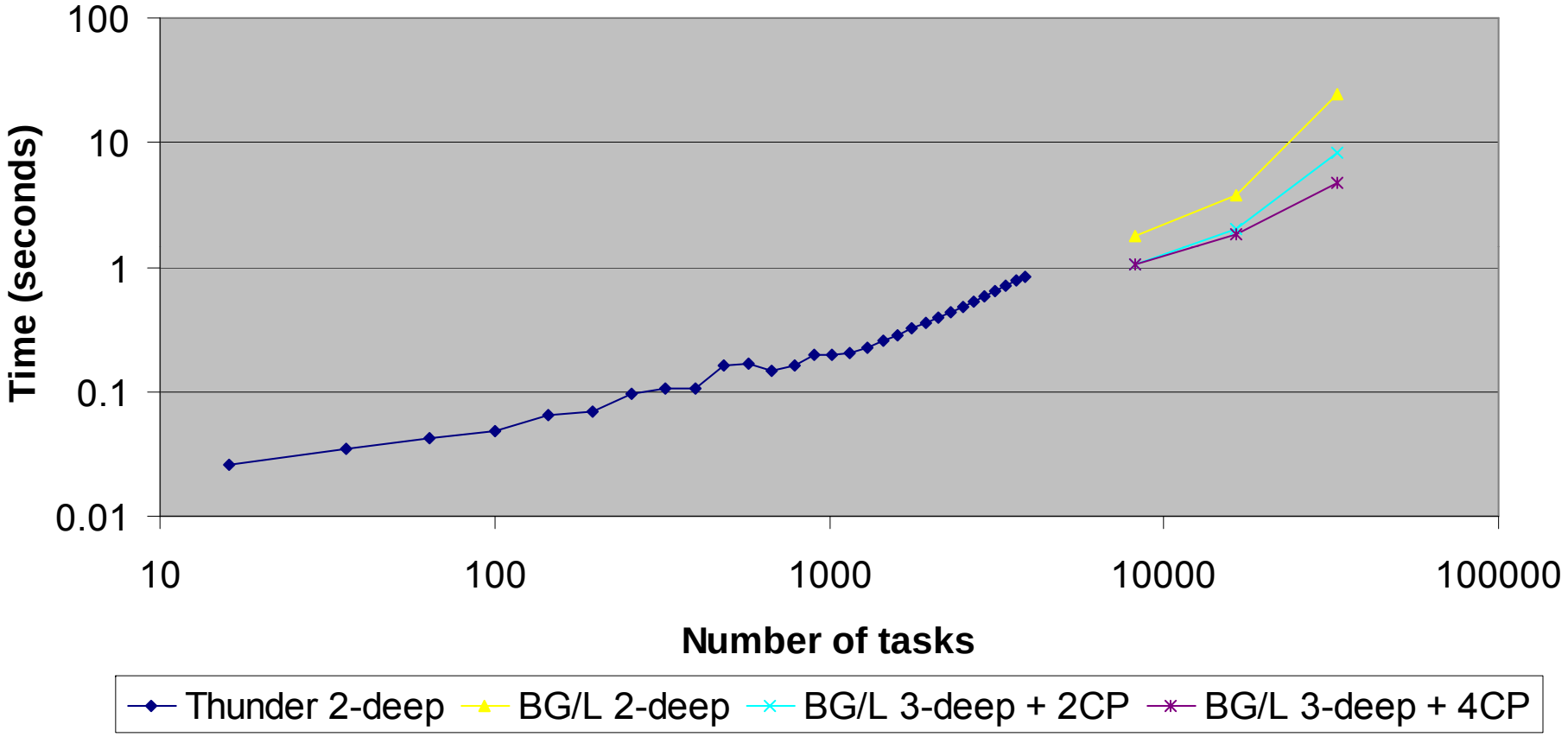
Emulating STAT on BG/L

BG/L Properties	STATBench Model
1024 I/O Nodes where tool daemons run	Ran on single rack, 1024 CN BG/L system
64 tasks per daemon in coprocessor mode	Simulate 64 tasks per STATBench daemon
128 tasks per daemon in virtual node mode	Simulate 128 tasks per STATBench daemon

STATBench BlueGene/L Scaling



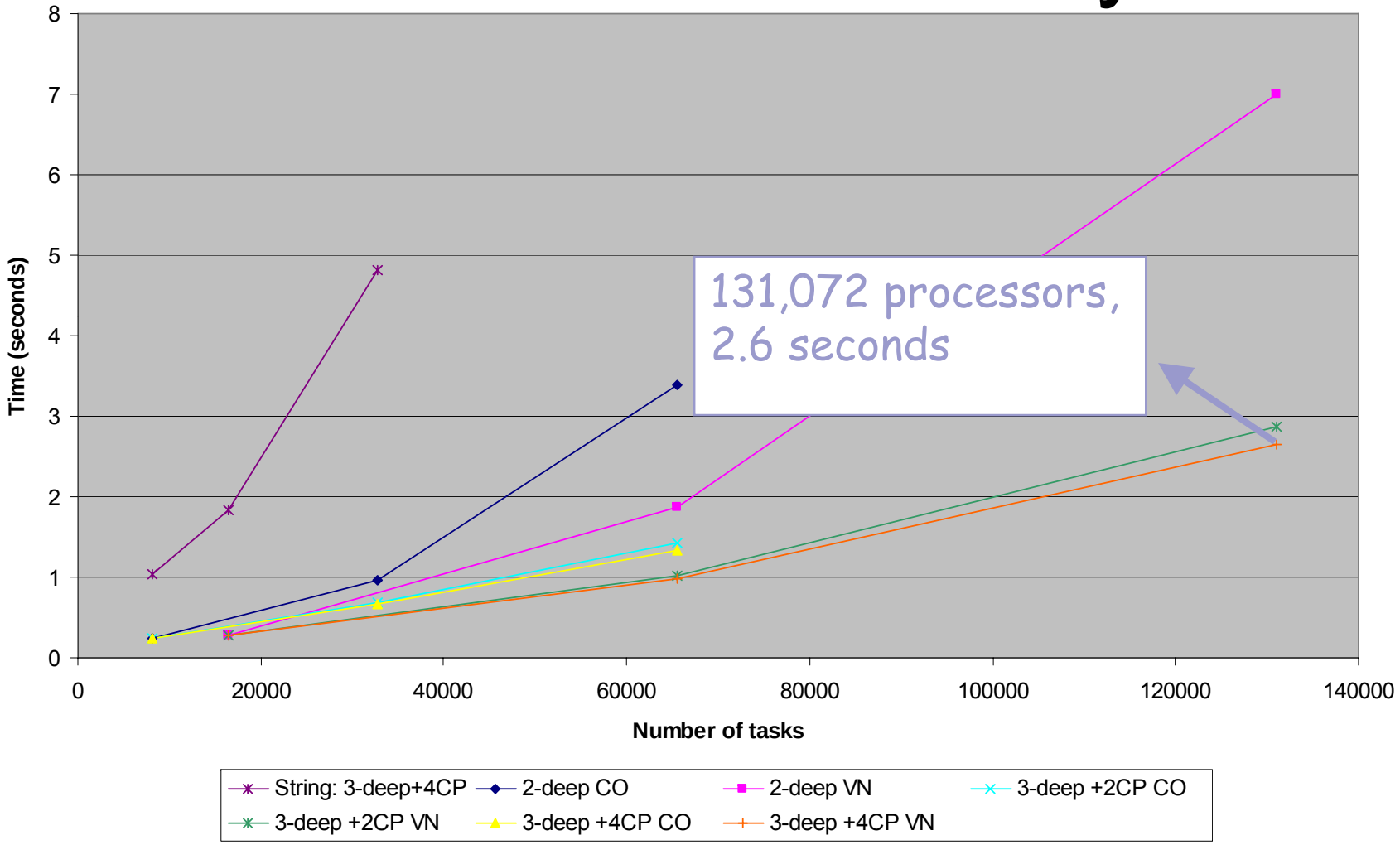
STATBench Performance Validation



STATBench Revealed a STAT Scalability Issue

- Edge labels represented by task lists
  - Original implementation as strings
  - [1,3,4,5,6,9,10,11,15] -> “[1,3-6,9-11,15]”
  - Up to 75KB at 32,768 tasks
- Re-implemented edge label as a bit vector
  - 1 bit per task
    - Set to 1 if the task is in the list
    - Set to 0 otherwise
  - Merging done with *bitwise or*

Full BlueGene/L Scalability



Conclusions

- STAT merges traces in an estimated 2.6 seconds running on full BG/L
- Emulation a powerful technique to test tool scalability
  - Run tool on all compute resources
  - Simulate application data
  - Decreased time and resource requirements to identify scaling issues

References

1. D. C. Arnold, D. H. Ahn, B. R. de Supinski, G. L. Lee, B. P. Miller, and M. Schulz, *Stack Trace Analysis for Large Scale Debugging*, 21st International Parallel and Distributed Processing Symposium 2007 **mar**, 2007
2. P. Roth, D. Arnold, and B. Miller, *MRNet: A Software-Based Multicast/Reduction Network for Scalable Tools*, Proceedings of the IEEE/ACM Supercomputing '03 **nov**,2003