Scalable Tool Infrastructure for the Cray XT Using Tree-Based Overlay Networks

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Motivation

• Leadership class resources like Jaguar Cray XT at Oak Ridge National Laboratory (ORNL) are scarce, allocation is valuable

• Systems growing larger and more complex (e.g., heterogeneity, deep memory hierarchies)

• Tools are critical for making good use of such systems
  – Debuggers
  – Performance, especially on-line automated tools
  – System administration

• Tools must scale at least as well as \{application, system\} under study
Barriers to Tool Scalability

• Managing performance data volume (collection and processing)

• Communicating efficiently between distributed tool components

• Making scalable presentations of performance analysis results
Traditional Parallel Tool Organization

- Direct communication between tool FE and tool BEs
- FE is a communication, computation bottleneck
Tree-Based Overlay Networks

Tool Front End

Multicast/Reduction Network

Tool Daemons
- d₀
- d₁
- d₂
- d₃
- ...

App Processes
- a₀
- a₁
- a₂
- a₃
- ...

Internal Process
Filter
MRNet

• Implementation of Tree-Based Overlay Network concept

• Supports scalable multicast and data reduction operations
  – Data transferred over streams
  – Filters associated with streams manipulate data passing across network

• Integrated in Paradyn automated performance tool (University of Wisconsin-Madison)

• Used by Stack Trace Analysis Tool (STAT)

• Used as runtime for programming model for data intensive applications
Porting MRNet to Cray XT

• Catamount
  – No server side TCP/IP sockets
  – No information about tool support library
  – Too many barriers

• Compute Node Linux/Cray Linux Environment
  – More straightforward port from Linux cluster implementation
  – Differences mainly during process network instantiation
    • Process creation
    • Process connection
  – Users requested support for new “flattened tree” process placement
MRNet/XT Process Placement: Traditional

- Gray boxes indicate node boundaries
- FE on service node
- BEs co-located with app processes
- IN processes on “additional” nodes to avoid perturbing application
MRNet/XT Process Placement: Flattened

- MRNet/XT internal, back-end processes co-located with application processes
- Uses no additional nodes beyond those used by the application
Traditional MRNet Instantiation

• FE on login node
Traditional MRNet Instantiation

- FE on login node
- FE creates Level 1 processes with ssh
- Level 1 processes connect back to their parent
- Parent delivers topology to Level 1 processes
Traditional MRNet Instantiation

- Level 1 processes create Level 2 processes with ssh
- Each Level 2 process connects back to its parent on Level 1
- Level 1 parent delivers topology to children on Level 2
• Level 2 processes create BE processes with ssh (or connect to BE processes created with parallel job launcher)

• BE processes connect back to Level 2 parent
MRNet/XT Instantiation (flattened)

- FE launches app with aprun
MRNet/XT Instantiation (flattened)

- FE launches first MRNet process on each node in single operation
MRNet/XT Instantiation (flattened)

- FE connects to Level 1 children
- FE delivers topology to Level 1 processes
MRNet/XT Instantiation (flattened)

- Level 1 processes create co-located Level 2 processes
- Level 1 processes connect to Level 2 processes
- Level processes deliver topology to Level 2 processes
MRNet/XT Instantiation (flattened)

• Level 2 processes create any co-located BE processes
• Level 2 processes connect to Level 3 processes
• Level 2 processes deliver topology to Level 3 processes
MRNet/XT Instantiation (flattened)

- Level 3 processes become tool BE processes
- BE processes attach to application processes
Example MRNet/XT tool: mpiP

- Lightweight profiling library for MPI programs
- Collects statistics about each MPI call site, e.g.:
  - Maximum message size
  - Average operation latency
- Collects data with instrumented functions at PMPI interface
- Now collects point-to-point communication topology
- Aggregates statistics and communication topology when generating reports

Communication topology matrix visualization
AMG2000 from ASC Sequoia Benchmark Suite
256 processes on a Cray XT4 at ORNL
MRNet/XT mpiP

• Traditional mpiP uses MPI point-to-point operations to aggregate data

• Investigating benefit of MRNet/XT for mpiP aggregation
  – MRNet filters implement mpiP aggregation
  – Inductively, tool front-end receives aggregated MPI statistics for whole program
  – Concatenation for more efficient messaging of data that cannot be aggregated (e.g., communication topology)

• Generalizes to xP: statistical profiling of programs at any API, e.g. netCDF or POSIX I/O
Summary

- Tree-based overlay networks, and MRNet in particular, are effective scalable tool infrastructure
- We have ported MRNet to the Cray XT
- We added support for “flattened tree” MRNet topologies
- We are integrating MRNet/XT into scalable tools for Cray XT such as mpiP and variants

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- For more information:
  - rothpc@ornl.gov
  - http://ft.ornl.gov
  - http://www.paradyn.org/mrnet (general MRNet information)

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