Simulating Large-Scale Systems with MVAPICH2 and SST

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Presentation at MUG '21

Kaushik Kandadi Suresh, Tu Tran

Network Based Computing Laboratory (NBCL)

Dept. of Computer Science and Engineering , The Ohio State University

kandadisuresh.1@osu.edu

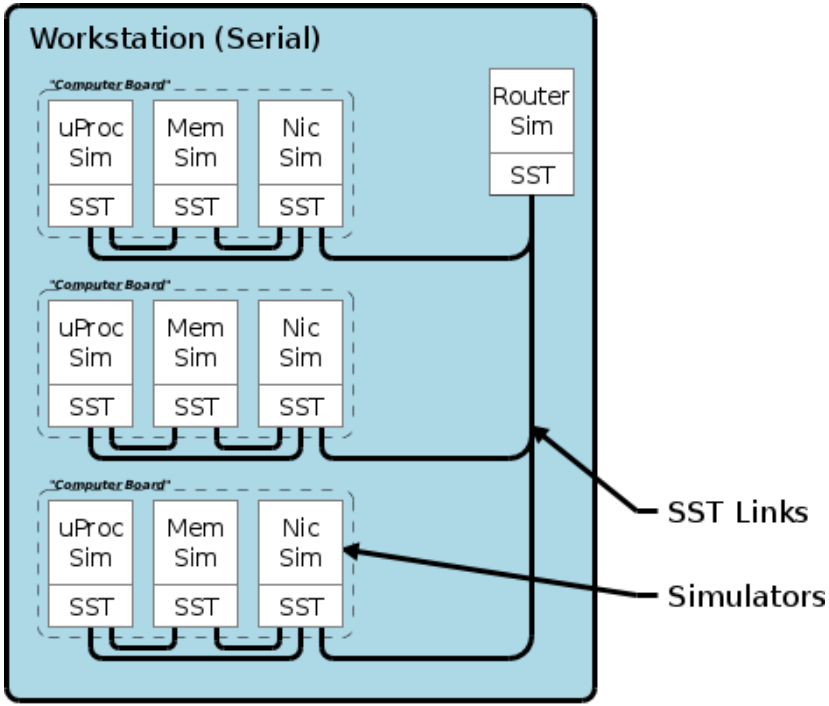
Outline

- Introduction
- Example
- Architecture
- SST Macro
- MVAPICH2 + SST Macro Integration
- SST+MVAPICH2 : Performance prediction of collective algorithms
- SST+MVAPICH2 : Performance of MPI_Alltoall on different topologies

Introduction

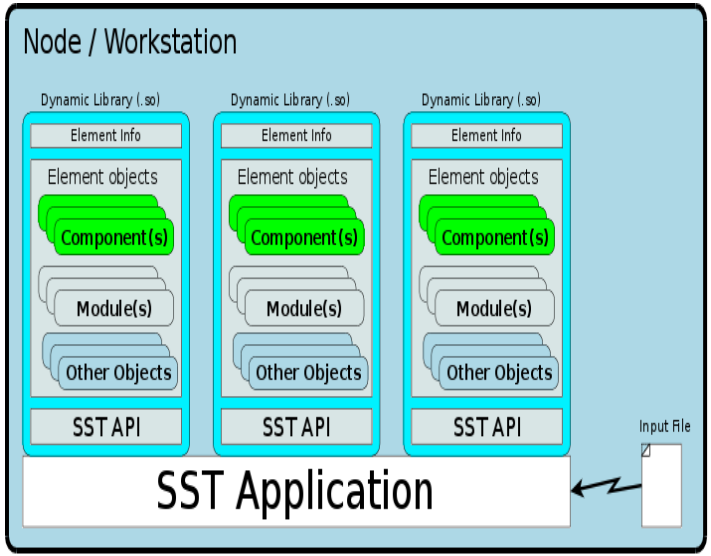
- The Structural Simulation Toolkit (SST) is an open-source software framework used for simulating large-scale High Performance Computing (HPC) systems
- The simulations can be run on one or many nodes.
- SST lets multiple disparate/discrete simulators to share data with each other in order to perform very large scale simulations.

SST-Example



- Simulation of 3 “computer boards”
- Each “computer board” simulations are comprised of 3 different simulators sharing data using SST
- There will be 10 separate concurrent simulations running on this single workstation all sharing data using SST

SST- Architecture



- SST is a standalone application
- When run, it loads set of Dynamic Libraries (called Element Libraries) using a config file
- These Element Libraries contain several internal objects (Components, Modules, etc) that represent the simulators and support objects to perform a simulation.
- The Element Libraries are developed in C++ using SST API

SST-Macroscale Element Library

- The macroscale element library provides functionality for simulating extreme-scale applications

```
1  int size = atoi(argv[1]);
2  if (rank == 0){
3   int partner = 1;
4    MPI_Send(buffer, size, MPI_INT, partner, tag, MPI_COMM_WORLD);
5  } else {
6    int partner = 0;
7    MPI_Recv(buffer, size, MPI_INT, partner, tag, MPI_COMM_WORLD, MPI_STATUS_IGNORE);
8  }
9  MPI_Barrier(MPI_COMM_WORLD);
10
11 if (rank == 0){
12   printf("Rank 0 finished at t=%8.4f ms\n", MPI_Wtime()*1e3);
13 }
```

```
node {
 app1 {
  name = send_recv
  launch_cmd = aprun -n 2
  argv = 20
 }
}
```

SST-Macro Working

- Discrete Event Simulation (DES)
  - Components and Events
  - Component send events to other components
  - Each Event has Arrival time
  - Components process events in time-order (stored in sorted queue of events)
  - Time advances as components pop and process events from the queue
- Components:
  - NIC, Router, Memory Models, Node
- SST macro has ‘Application’ which is just a stack and a heap without event queue
- SST macro intercepts MPI calls when compiled with sst++, which defines macro to replace the MPI calls

SST macro parameter file

- Network and Application launch configuration
- Network parameters
  - Switch
  - Topology
  - Communication model
  - NIC
- CPU
  - Processor
  - Memory

```
app1 {
 exe = ./run
 argv =
 launch_cmd = aprun -n 256 -N 1
 env {
   SLURM_NPROCS = 256
 }
}
```

```
topology {
  name = torus
  geometry = [32, 32, 32]
  redundant = [32,32,32]
}
```

```
memory {
 name = snappr
 channel_bandwidth = 7GB/s
 num_channels = 10
 latency = 10ns
}
proc {
 ncores = 56
 frequency = 2GHz
}
name = simple
}
```

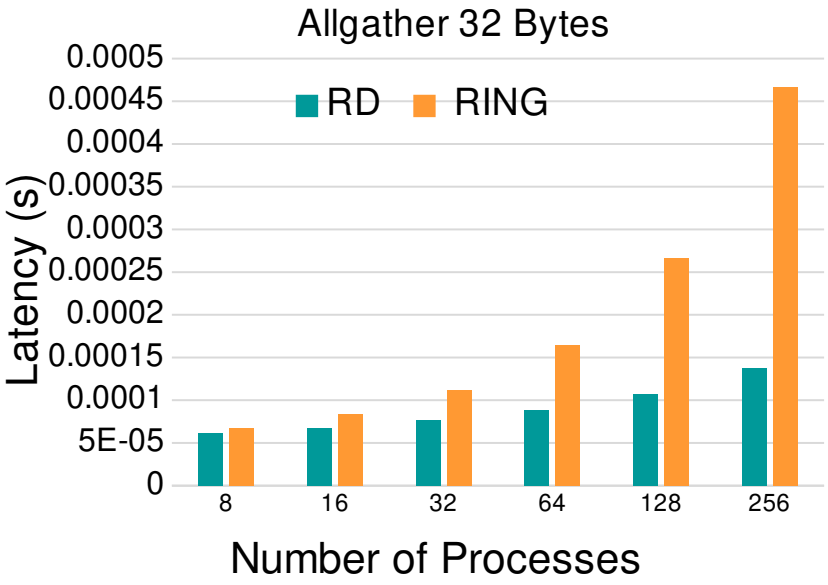
```
switch {
 name = snappr
 link {
  bandwidth = 10.0GB/s
  latency = 100ns
  credits = 8KB
  xmit_active {
   group = test
   type = accumulator
  }
```

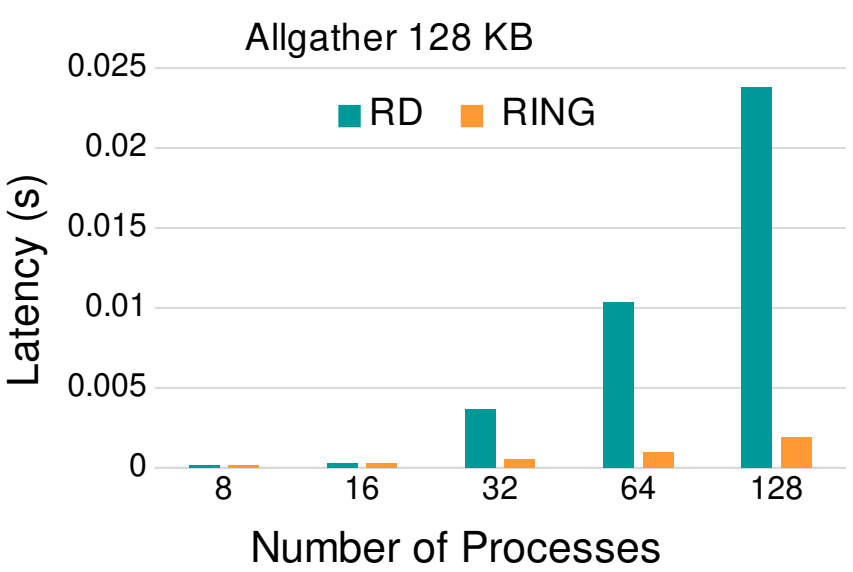
SST macro + MVAPICH2

- SST Transport:
  - Emulates transport library (eg: libfabric)
- Steps to run MPI Application with SST macro + MVAPICH2
  - Install Clang
  - Build SST macro using clang. This generates sstcc (a wrapper for compiling with sst)
  - Build SST transport using clang, SST macro
  - Build MVAPICH2 with sstcc and link it with SST-transport library [provides libfabric, pmi cache emulation]
  - Compile MPI program with mpicc generated in the previous step
  - Add run time params to config file : parameter.ini
  - Run as follows:
    - sstmac –f parameter.ini ./app.exe

Estimate relative performance of algorithms with SST

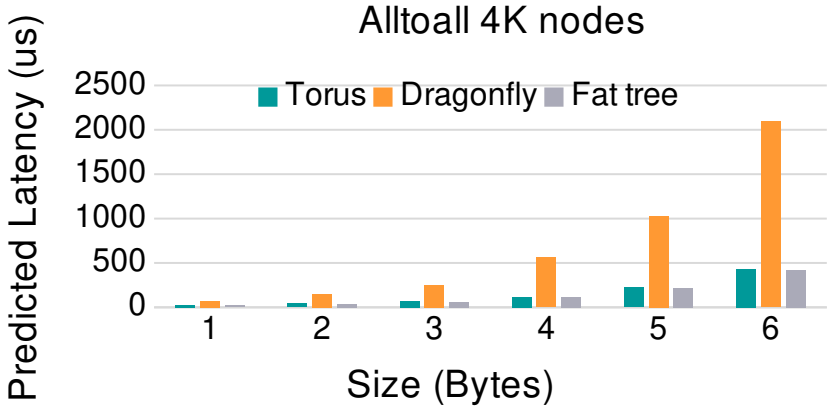
- Ring algorithm good for large messages
- Recursive doubling good for small messages
- Useful for estimating any new algorithm implemented in MVAPICH2





Understanding the impact of topology

- Large scale simulation of MPI_Alltoall using OMB
- Impact of topology on Alltoall algorithm implemented in MVAPICH2



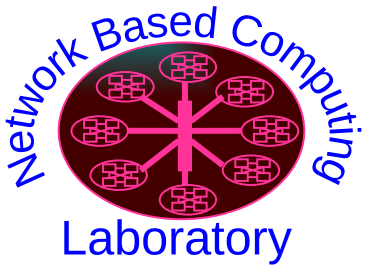

```
topology {
  name = torus
  geometry = [32, 32, 32]
  redundant = [32,32,32]
}
```

```
topology {
  name = fat_tree
  leaf_switches_per_subtree = 64
  agg_switches_per_subtree = 64
  concentration = 64
  up_ports_per_leaf_switch = 64
  down_ports_per_agg_switch = 64
  num_agg_subtrees = 2
  num_core_switches = 64
  up_ports_per_agg_switch = 64
  down_ports_per_core_switch = 128
}
```

```
topology {
  name = dragonfly
  geometry = [32,9]
  h = 16
  inter_group = circulant
  concentration = 16
}
```

Thank You!

Kandadisuresh.1@osu.edu



Network-Based Computing Laboratory
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MVAPICH
MPI, PGAS and Hybrid MPI+PGAS Library

The MVAPICH2 Project
http://mvapich.cse.ohio-state.edu/