Simulation of CSE Lab Cluster

CS633 2018-19-II Course Project

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Table of Contents

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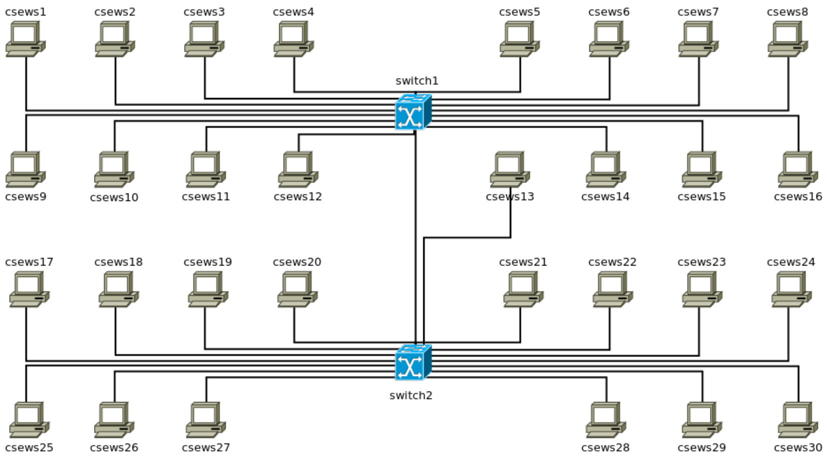
- Hostfiles used for MPI programs usually don't take topology or placement into account
- We want to simulate the running of an MPI program on this cluster and predict time taken for communications
- Would enable simulating under different hostfiles and use it to decide upon which one to use

CSE Lab Cluster Topology



- `csews13` is on different switch from remaining `csews1-16`

Table of Contents

Related Research Papers

- MPI-NeTSim: A network simulation module for MPI [1]
- Simulation of MPI Applications with Time-independent Traces [2]
- Single Node On-Line Simulation of MPI Applications with SMPI [3]
- Toward Better Simulation of MPI Applications on Ethernet/TCP Networks [4]
- Simulating MPI applications: the SMPI approach [5]

Possible Approaches

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- Online (in-situ): Perform simulation while executing the program itself, usually by hooking into the network layer and redirecting network requests to a simulator.
- Hybrid: A combination of the above to have prior knowledge of the types of network communications supposed to happen and simulate better accordingly.

Salient points of previous papers

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- [5] and [3] use a complete reimplementation of the MPI specification on the **SimGrid** simulation kernek with a hybrid approach. Hence its not possible to switch out one MPI implementation for another.
- Even [2] uses the above smpi implementation even though it is an offline approach

Table of Contents

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- Report the expected time taken.

Obtaining Event Traces

- We use the `PMPI_` interface exposed by nearly all MPI implementations inorder to override calls to `MPI_` functions with custom code. This allows us to trace calls to those functions.

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- At the end of an invocation of an MPI call, we note down the value of the performance counter. At the start of the next MPI call, the difference between the counter value are the computation instructions.

Obtaining Event Traces - Challenges / Drawbacks

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- In order to collect the traces on a single machine, the machine should have enough memory for all the processes.
- The trace size grows pretty large for non-trivial applications.
- The tracing machine should have the same processor architecture as the CSE lab cluster. Since our tracer would run on one of the lab machines, it is not an issue.

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- This should give us the expected time for each event.

Table of Contents

MPI Calls

The simulator simulates/handles the following synchronous MPI calls with algorithms as used in default `MPICH v3.2.1`:

- `MPI_Send`
- `MPI_Recv`
- `MPI_Scatter`
- `MPI_Gather`
- `MPI_Broadcast` (only the algorithm for short messages for now)

Simulation Semantics (tracing)

This is how the **Sim**ulated **MPI** tracer is used:

```
$ export LD_PRELOAD=libpapi.so:libsimpi.so
$ mpirun -np 32 prog.x
$ cat *.log
```

This gives us a trace/log of all MPI function calls we are interested in.

Simulation Semantics (simulation)

This is how the simulator is invoked:

```
$ ./run-simulator.sh 64 hostfile path/to/log
```

This gives us a value for the expected simulation time.

Table of Contents

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- Each MPI process opens up a log file during `MPI_Init` and closes it during `MPI_Finalize`.

Simulator

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Simulator

- Consists of 3 major components: the parser, topology generator and the main `MPINode` `ns3::Application`.
- The parser parses the given log files to generate event log for every process
- The topology generator sets up the entire network as per the CSE lab cluster.
- `MPINode` is an `ns3::Application` supposed to behave like our MPI process. An `ns3::Application` can be installed on any node on the network. We install 1 MPI application corresponding to each MPI process. So there are PPN number of applications running on a node.

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- Event stream consists of only the following types of events: `Compute`, `Recv` & `Send`.
- Any other kind of event like `MPI_Scatter` is converted into a mixture of the above events as per the communications taking place according to the algorithms.

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- Events are processed sequentially as soon as the previous one finishes. Once there are no more events left, the application is stopped. Once all applications stop we can claim that the simulation has ended.
- For compute events, an artificial delay is introduced.
- For send and receive, normal socket operations are used.

Table of Contents

Demo

Table of Contents

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- Comparison with other `MPI` simulation frameworks developed as part of other works.
- Distributed trace collection: The trace collection itself could be run parallelly on multiple machines for faster trace collection and simulation.

Thank You!

"So long and thanks for all the fish." – Douglas Adams

Table of Contents

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