Simulation of CSE Lab Cluster

CS633 2018-19-II Course Project

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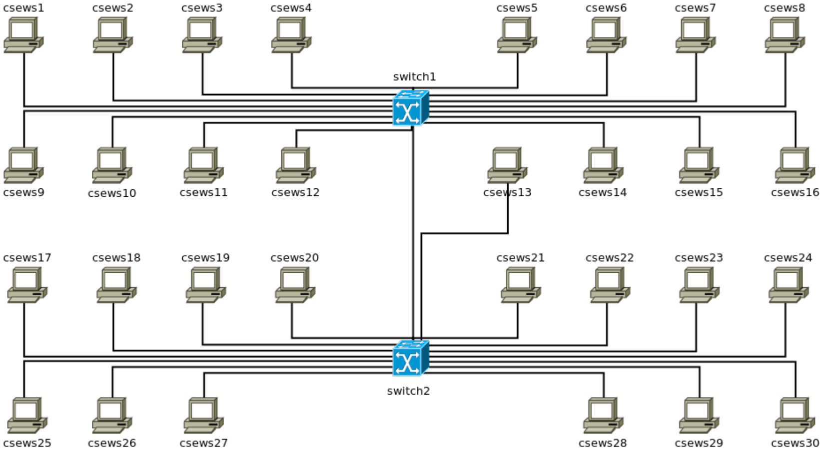
- Would enable simulating under different hostfiles and use it to decide upon which one to use

CSE Lab Cluster Topology



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

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Related Research Papers

- MPI-NeTSim: A network simulation module for MPI [PWTR09]
- Simulation of MPI Applications with Time-independent Traces [CDMS15]
- Single Node On-Line Simulation of MPI Applications with SMPI [CSG+11]
- Toward Better Simulation of MPI Applications on Ethernet/TCP Networks [BDG+14]
- Simulating MPI applications: the SMPI approach [DLM+17]

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Initial Approach (without referring to related work)

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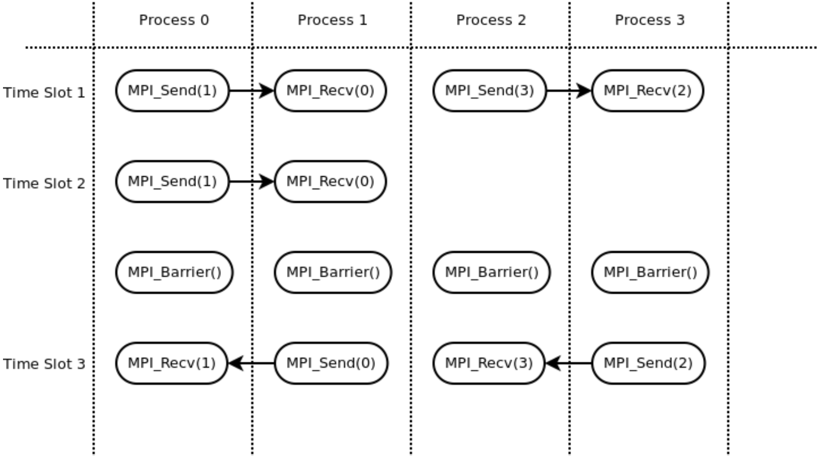
- Report the expected time taken for communications and congestion points/links, if any.

Sample Time Slotting



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- Also computation time would come out to be different for different ranked processes based on scheduling / other loads on the CPU / etc even if they were running the same set of instructions.

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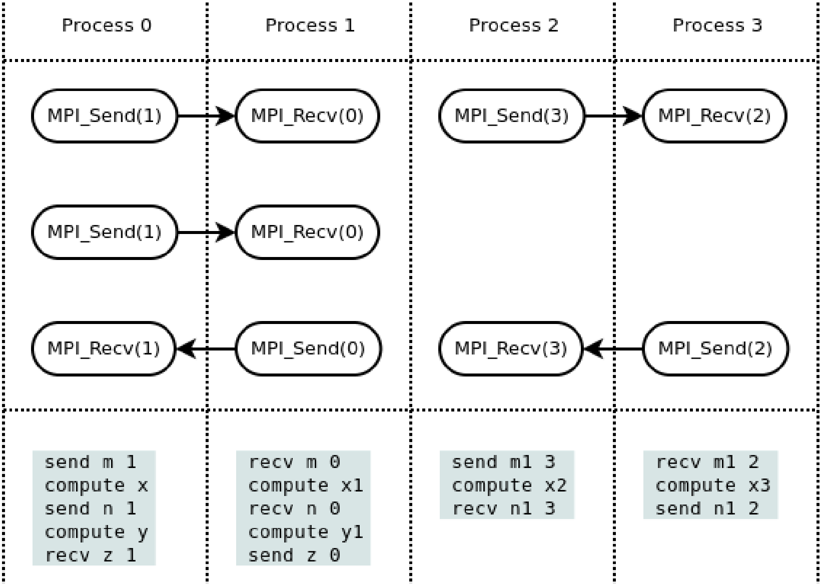
Sample Trace



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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 is the computation.

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- 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.
- The computation time during MPI calls is ignored by our simulation but its ok because its expected for it be negligible compared to the communication time over the network.

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- This should give us the expected time for each event and also allow us to identify limiting link contentions.
- **NOTE:** The ns3 framework needs a little more exploration to finalize this part.

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MPI Calls

The final simulator should be able to simulate/handle the following synchronous MPI calls with accurate algorithms as used in default `MPICH v3.2.1`:

- `MPI_Send`
- `MPI_Recv`
- `MPI_Broadcast`
- `MPI_Reduce`
- `MPI_Scatter`
- `MPI_Allreduce`
- `MPI_Alltoall`
- `MPI_Gather`
- `MPI_Allgather`
- `MPI_Barrier`

Simulation Semantics

This is how the final **Sim**ulated **MPI** should be invoked:

```
$ simpicc $FLAGS -o prog.x prog.c
$ simpirun -f hostfile -np 32 prog.x
```

`hostfile` should contain only hosts on the cse lab cluster with hostnames as `csews1`, etc.

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MPI Calls

The final simulator may be able to simulate/handle the following MPI calls:

- Async variants and associated calls like `MPI_Wait`
- Vector variants (like `MPI_Allgatherv`)

Simulation Semantics

This is how the final **Sim**ulated **MPI** may be invoked (I'm not sure if this is possible):

```
$ export LD_PRELOAD=/path/to/simpilib/
$ simpirun -f hostfile -np 32 prog.x
```

This would allow us to simulate precompiled binaries without modifying the makefile or recompiling.

Misc Targets

- Optimized tracefile size by using better binary formats like protobuf for trace storage.

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- Proper `autotools` based installation setup for `simpi`.

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Future Possibilities

Apart from the maybes described earlier, there are quite a few improvements which could be made:

- Distributed trace collection: The trace collection itself could be run parallelly on multiple machines for faster trace collection and simulation.
- Including / Predicting cpu cycles for the communication algorithm itself.
- Packet level simulation which is harder to get right.

Trace Generation

- The current implementation of libsimpi can be used to generate traces for `MPI_Send` and `MPI_Recv`.

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- Extending to others should not be difficult.
- Next target is to obtain computation count/cycles.

Sample MPI_Send PMPI callback

```
int MPI_Send(const void *buffer, int count,
             MPI_Datatype datatype, int dest,
             int tag, MPI_Comm comm) {
  int size;
  int result = PMPI_Send(buffer, count,
                   datatype, dest, tag, comm);
  PMPI_Type_size(datatype, &size);
  fprintf(stderr, "[%d] send %d to %d\n",
    rank, count * size, dest);
  return result;
}
```

Sample Trace

```
$ mpicc -g -O3 -profile=simpi asgn1-1.o -o asgn1-1.x  # li
$ mpirun -np 16 ./asgn1-1.x 1 > /dev/null  # discard stdout
[0] send 1024 to 1
[1] recv 1024 from 0
[2] send 1024 to 3
[3] recv 1024 from 2
[4] send 1024 to 5
[5] recv 1024 from 4
[6] send 1024 to 7
[7] recv 1024 from 6
[8] send 1024 to 9
[9] recv 1024 from 8
[10] send 1024 to 11
[11] recv 1024 from 10
[12] send 1024 to 13
[14] send 1024 to 15
[13] recv 1024 from 12
```

Thank You!

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

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