SMPI status

SUD, June 13, 2012

Motivations: why use simulation?

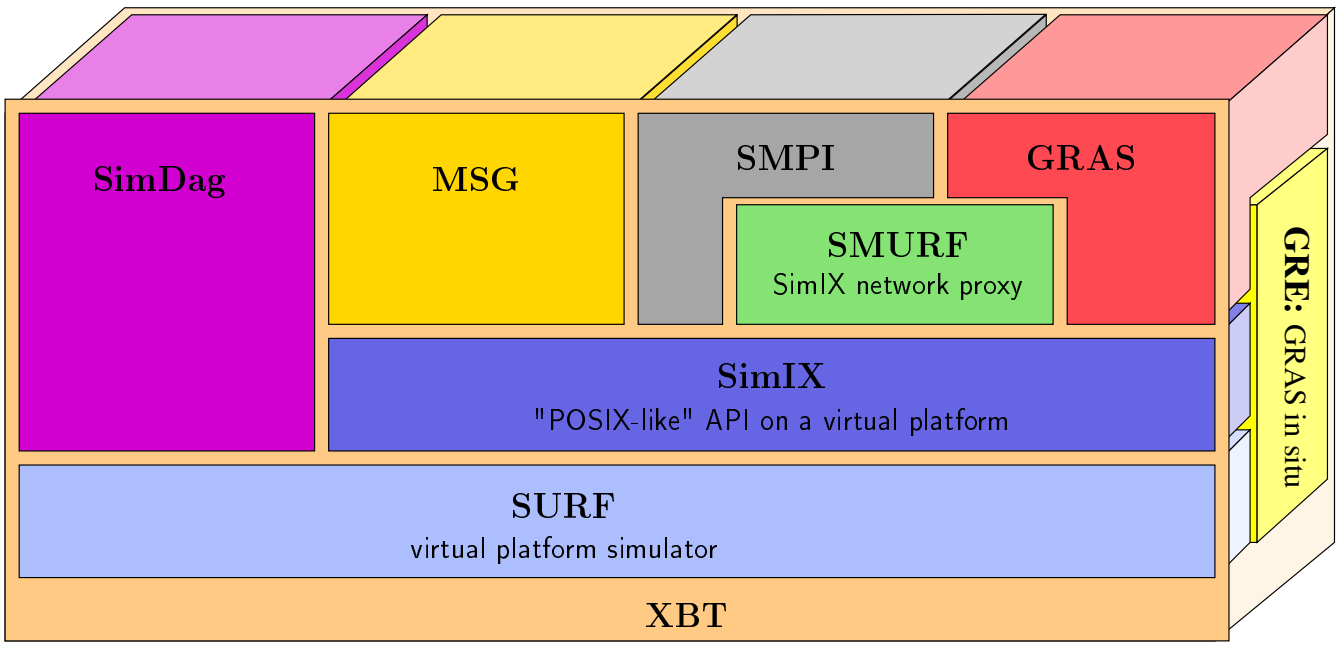
- Performance Prediction ("what-if?" scenarios)
  - Platform dimensioning
  - Tuning of application parameters
- Teaching (parallel programming, HPC)
  - No need for real hardware
  - Handy environment

Challenges

- Accuracy: How well does the simulation reflect reality?
- Scalability: Which problem size can we simulate? On which platforms?
- Speed: How fast is the simulation as compared to the real execution?
- Reproducibility: Are the simulation results stable and reusable?

SMPI overview

- Partial implementation of MPI on top of SimGrid



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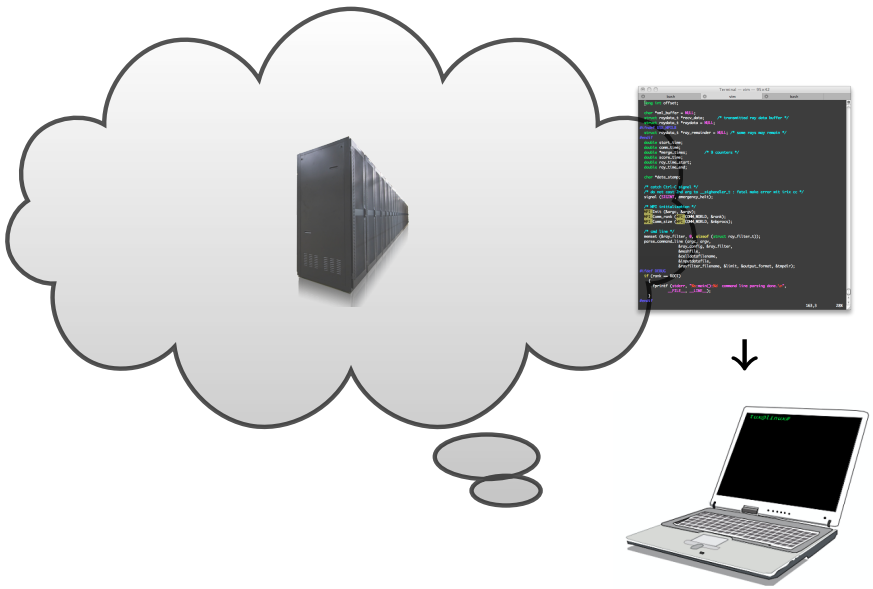

Howto

```
[laptop]% smpicc mympiprog.c -o mympiprog

[laptop]% smpirun -np 32 -hostfile machines.txt
-platform griffon_cluster.xml ./mympiprog
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Howto (with tracing)

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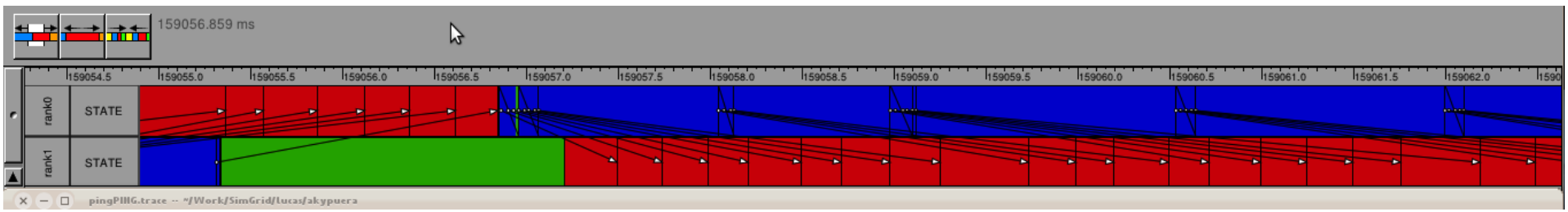

SMPI overview

- Computations: real execution on the host computer
  - CPU bursts are benched
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  - Network models are flow-based models (TCP)
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- Computations: real execution on the host computer
  - CPU bursts are benched
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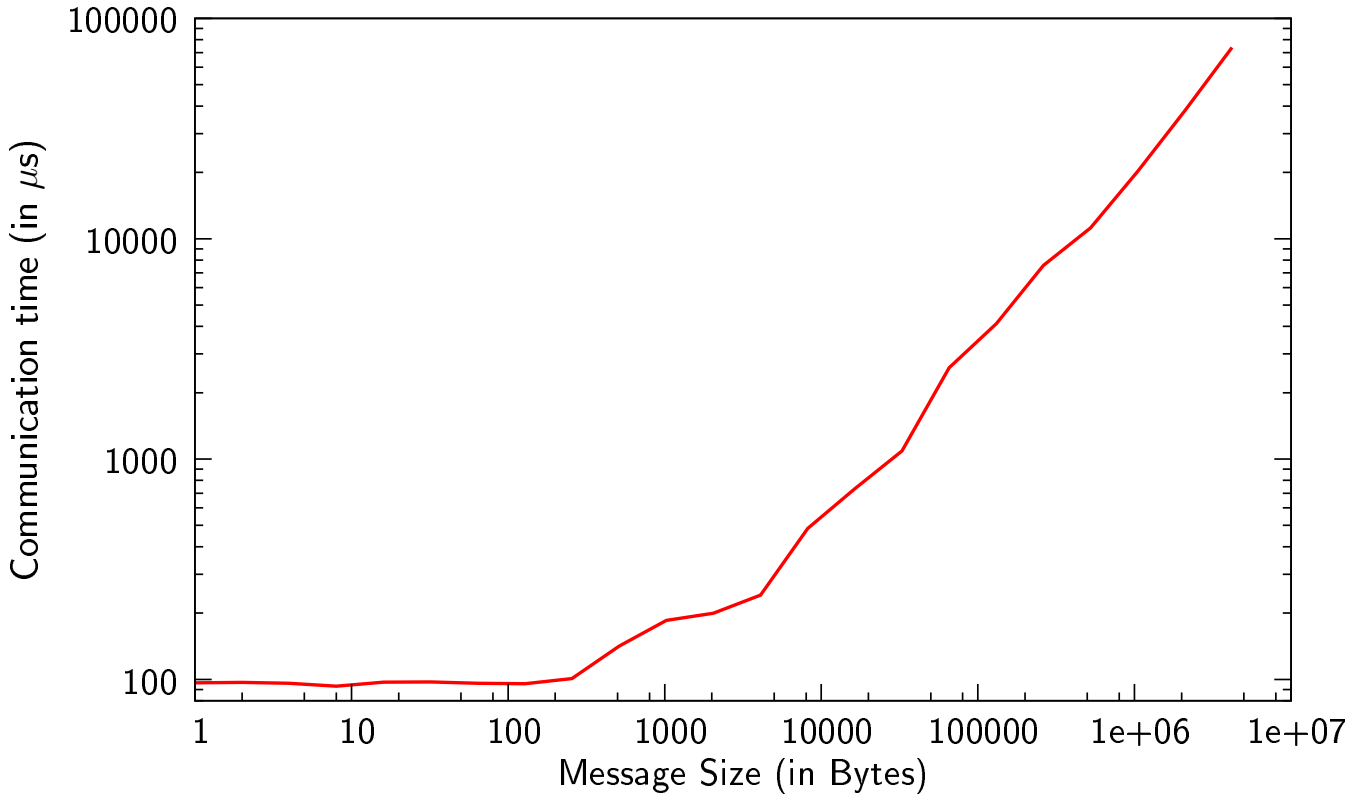
- Communications: simulated
  - Network models are flow-based models (TCP)
  - Validity of these models for MPI applications
- Folding of the parallel program processes onto a single node
  - Serialization of computations
  - Single address space
  - Requires to reduce
    - Memory footprint (scalability)
    - Simulation time (speed)

Existing Network Models in SimGrid

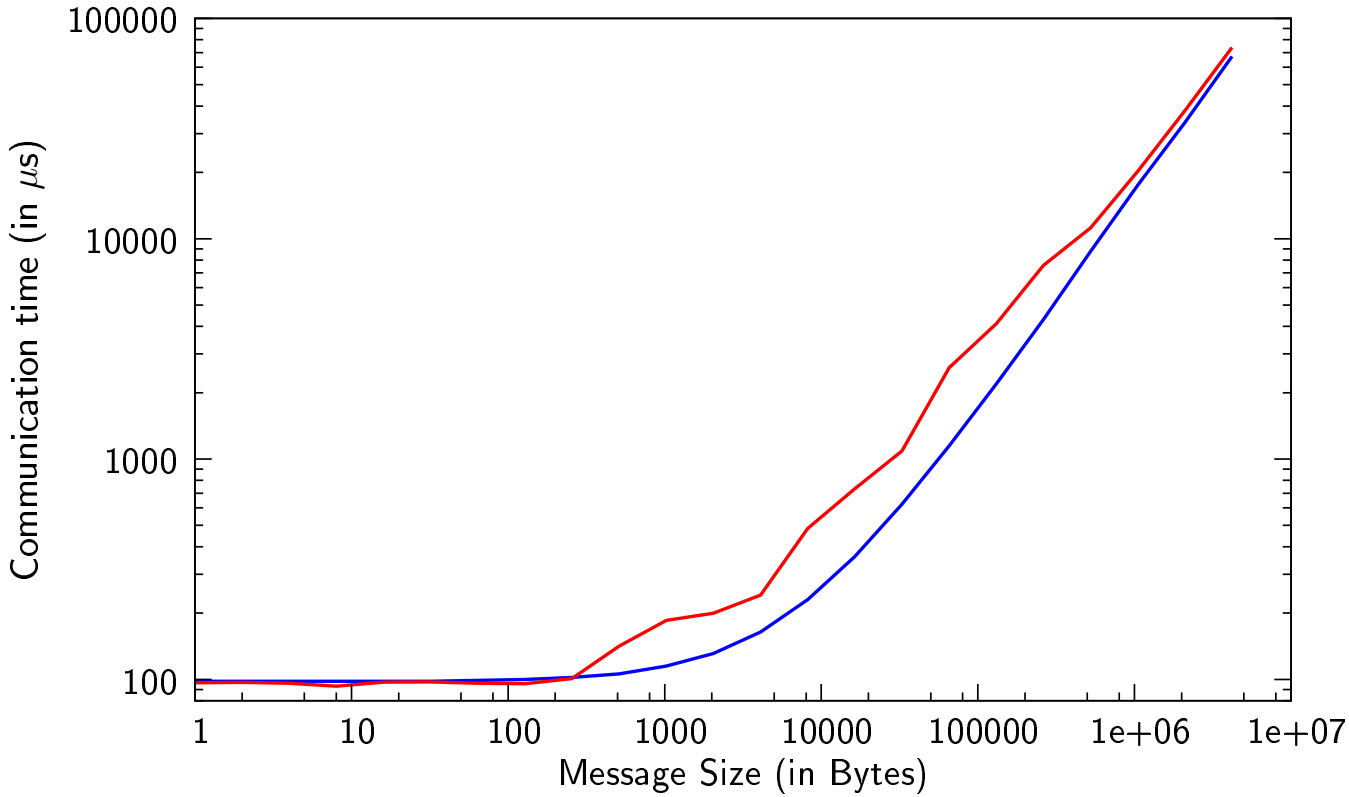
- Arbitrary topology, endpoints connected through multi-hop paths
- Network link caracteristics: latency (L) and bandwidth (B)
- Simulation using flows
  - Simulation is fast ($\neq$ packet-level simulation)
  - Contention evaluation is simple
- Simple Model: $T(S) = L + \frac{S}{B}$
  - Shown to be valid for $S \geq 10$ MB
- Improved model: $T(S) = \alpha \cdot L + \frac{S}{min\left(\beta \cdot B, \frac{\gamma}{2 \cdot L}\right)}$
  - α accounts for TCP slow-start
  - β accounts for the overhead induced by TCP/IP headers (*e.g* 92%)
  - γ enables the modeling of the TCP window induced behavior
  - Model valid for $S \geq 100$ KiB, does not address a lot of message sizes found in MPI applications
- Need for a new, accurate network model when $S < 100$ KiB

Point-to-point Communication



Experimental measurement using SKaMPI

Point-to-point Communication



Experimental measurement using SKaMPI
Default linear model, error: 32.1%
Ok with asymptotic message sizes,
but wrong for 1KiB-1MiB messages

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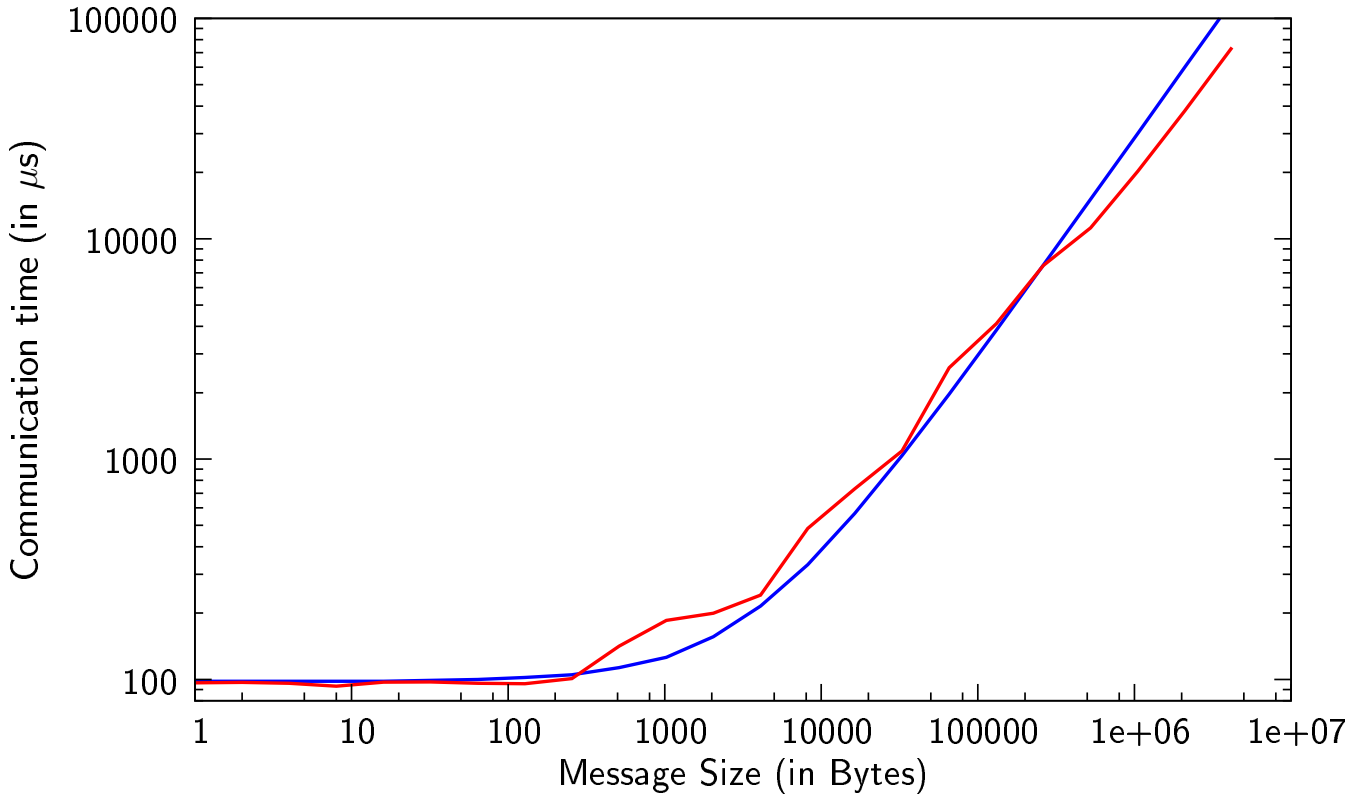


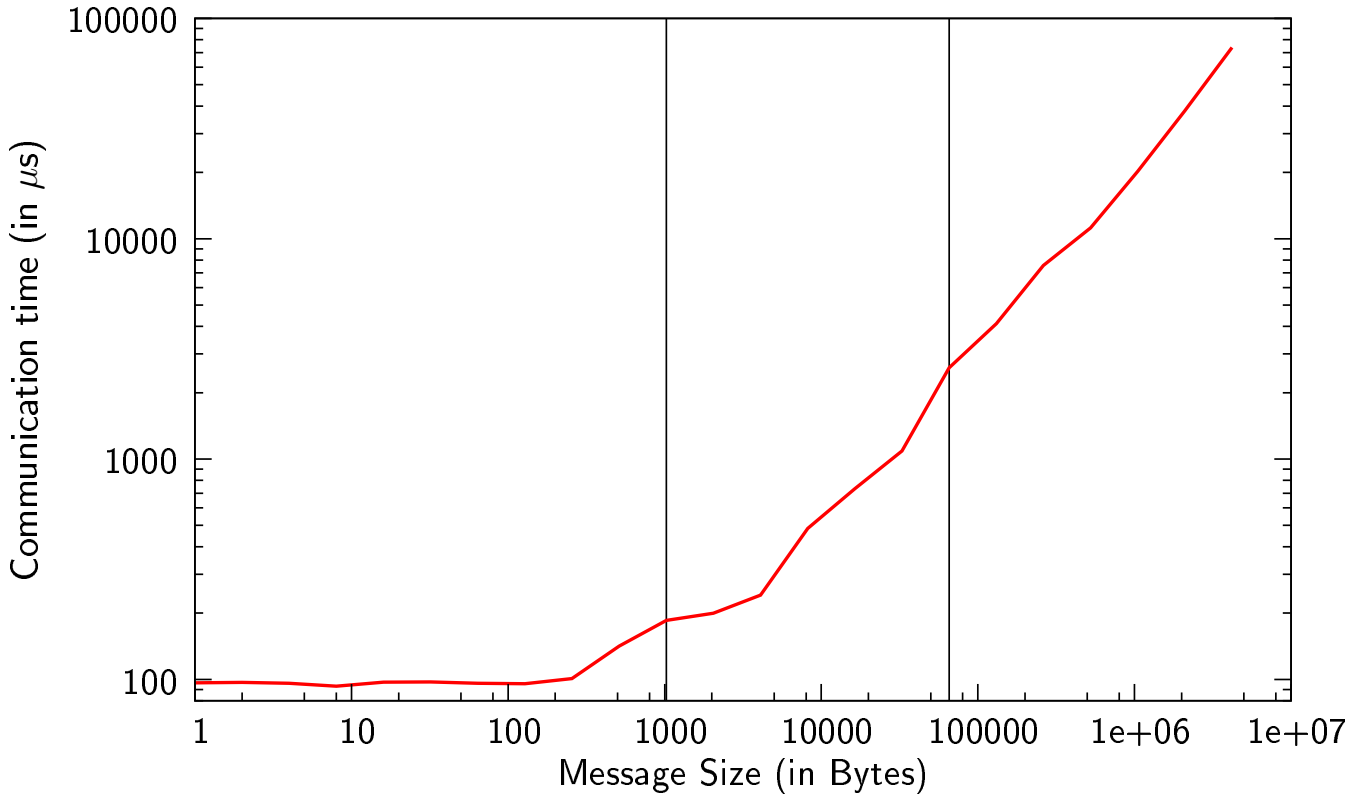
Experimental measurement using SKaMPI

Best-fitted linear model (α, β, γ), error: 18.5%

Better for a lot of sizes,

but cannot fit all real values

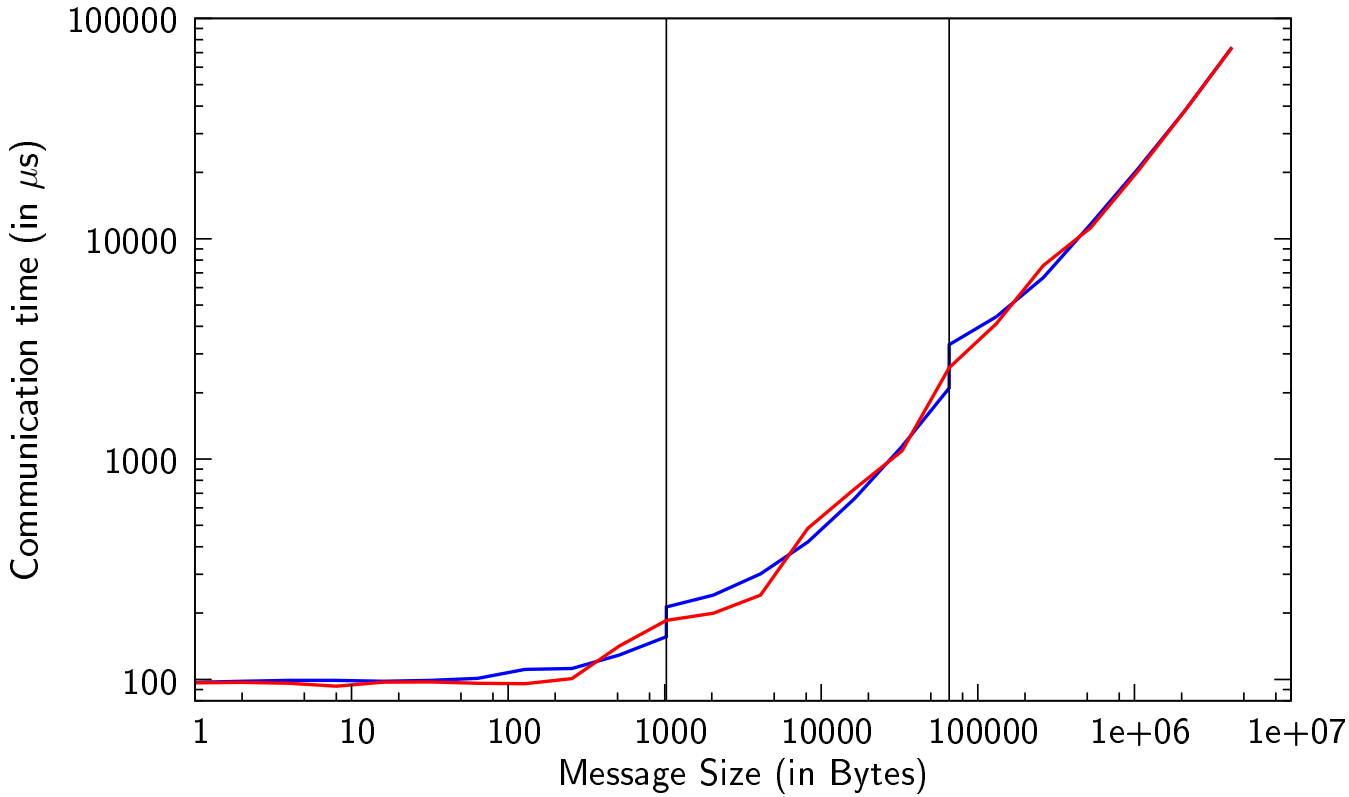
Point-to-point Communication



Experimental measurement using SKaMPI
Breakdown depending on message size

- packet size $<$ MTU,
- eager/rendezvous switch limit

Point-to-point Communication



Experimental measurement using SKaMPI

New piece-wise linear model, error: 8.63%

Correctly adjust linear segments

Calibration of the piece-wise linear model

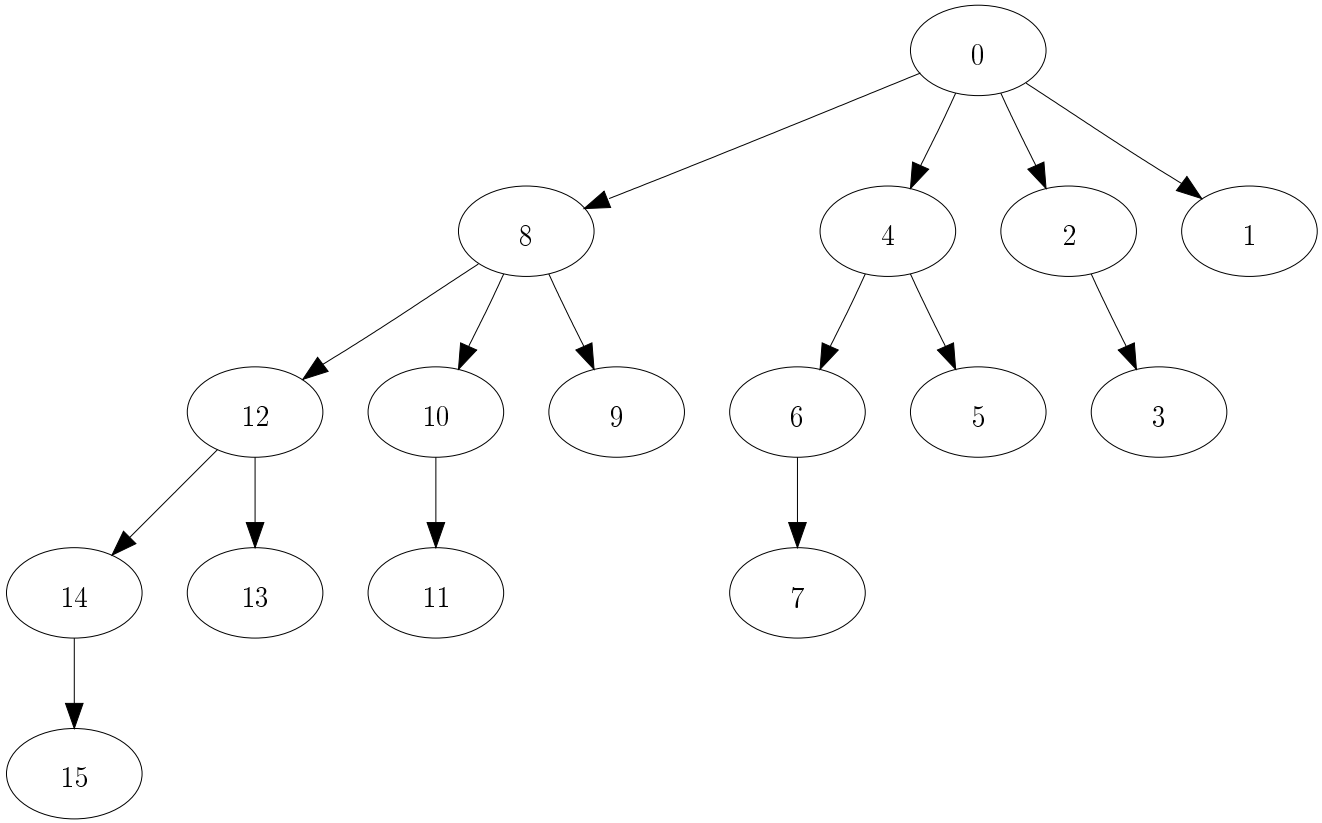
- Instantiate 9 parameters instead of 3
  - 2 segment frontiers
  - 2 factors α and β per segment
  - 1 global factor γ
- A calibration script comes with SMPI. Computes parameters given:
  - 1 SKaMPI-formatted datafile of a ping-pong performance measurement
  - The number of physical links crossed by packets in the ping-pong
  - L and B values for the links
  - segment bounds (computed by another script)

Collectives

Assess contention

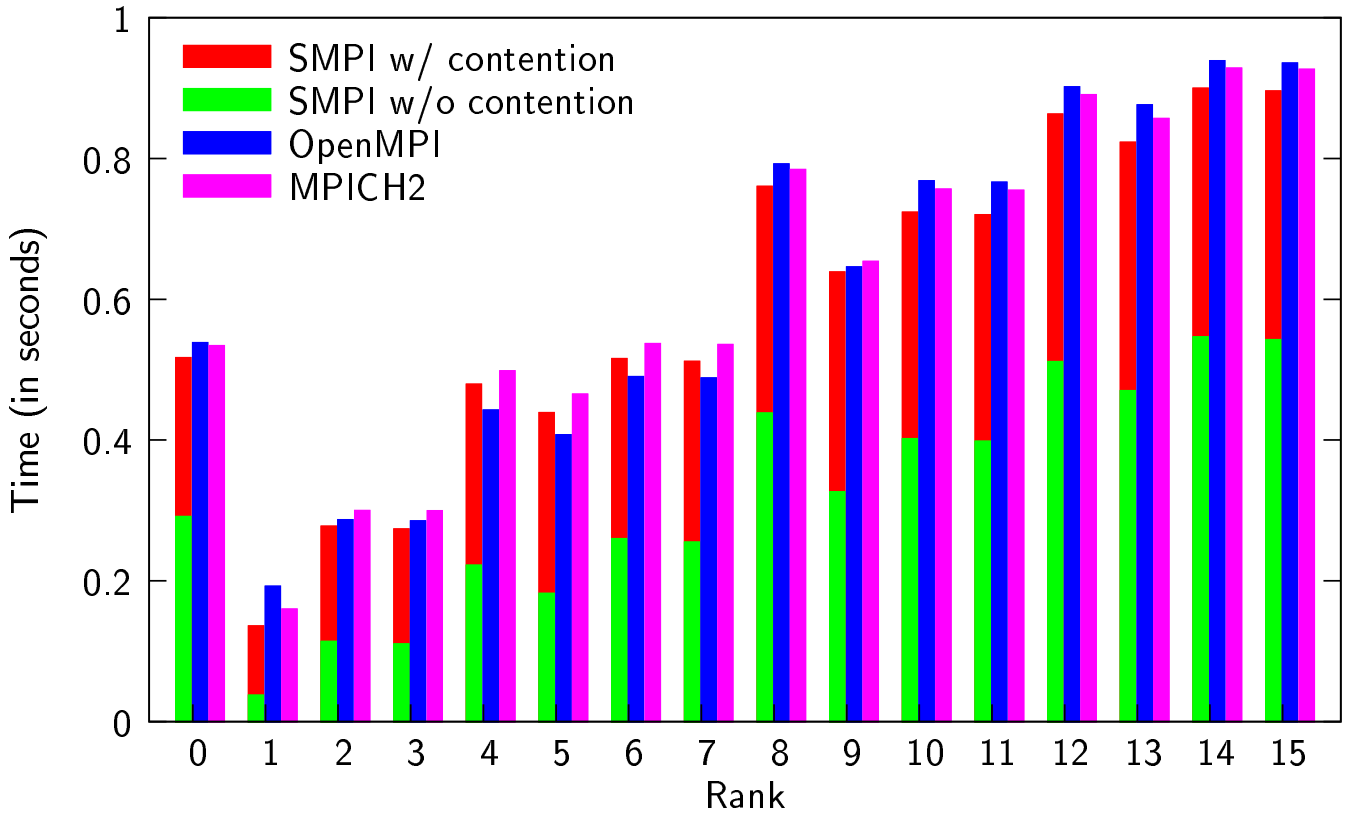
- Real world (OpenMPI, MPICH2)
  - Dynamic selection of tuned algorithms
  - Depends on the number of processes and message size
- Simulated world (SMPI)
  - Smaller variety of algorithms
- For a sake of comparison: use a manual implementation for real and in simulation

One-to-many: MPI_Scatter



- Algorithm: A binomial tree
- 64 MiB at the root, 4 MiB per process

Scatter: 16-processes test



- Comparison SMPI/MPICH2 $\Leftrightarrow$ OpenMPI/MPICH2: error 5.3%

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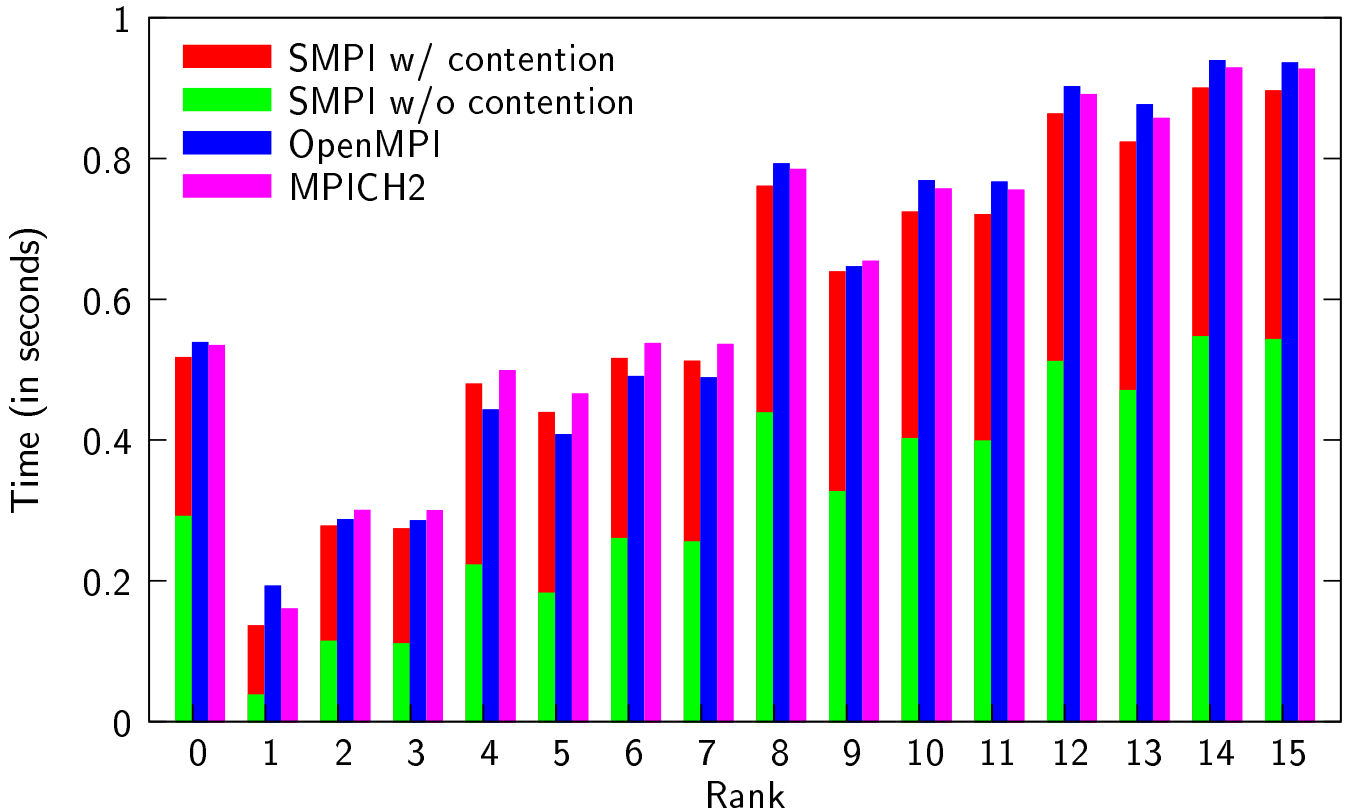

- Comparison SMPI/MPICH2 $\Leftrightarrow$ OpenMPI/MPICH2: error 5.3%
- Taking contention into account is important

Reducing the Memory Footprint

- Idea: Share arrays between processes
  - Pros: Allocate once, use plenty
  - Pros: Simulated times stay valid
  - Cons: Computed results become erroneous
- Implemented as (optional) macros

```
double* data = (double*)SMPI_SHARED_MALLOC(...);
...
SMPI_SHARED_FREE(data);
```

Reducing the Simulation Time

- Idea: Do not execute all the iterations
- Use sampling instead
  - LOCAL: each process executes a specified number of iterations
  - GLOBAL: a specified number of samples is produced by all processors
- Remaining iterations are replaced by average of measured values
- Implemented as (optional) macros

```
for(i = 0; i < n; i++) SMPI_SAMPLE_LOCAL( 0.75*n , 0.01 ){
    ...
}
...
for(j = 0; j < k; j++) SMPI_SAMPLE_GLOBAL(0.5*k,0.01) {
    ...
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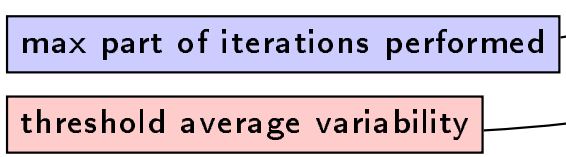

Requirements

- C or F77 fortran code (f2c is used)
- No global variable
  - f77: automatic privatization of common (smpif2c)
  - C: script `patch_source.sh` in `src/smpi`
    `int v;` becomes
    `SMPI_VARINIT_GLOBAL(int, v);` and then
    `SMPI_VARGET_GLOBAL(v);`
- TCP network only, IB (hopefully) in the short term.
  Therefore, we only consider one process per host mappings (no intra-host comms).
- Not all the MPI API is covered (about 70 primitives)

Future Work

- Mid term
  - Automate the privatization process that enables unmodified code to compile
  - Handle burst of point-to-point communications
  - Handle *receiver*-side gap for collectives.
  - Model other network interconnects: Myrinet, Infiniband
- Long term
  - I/O simulation
  - Automatic memory factoring and loop sampling
  - Simulation of a full implementation (OpenMPI or MPICH2)