UNM SCHOOL of ENGINEERING
Department of Computer Science

Scalable Systems Lab

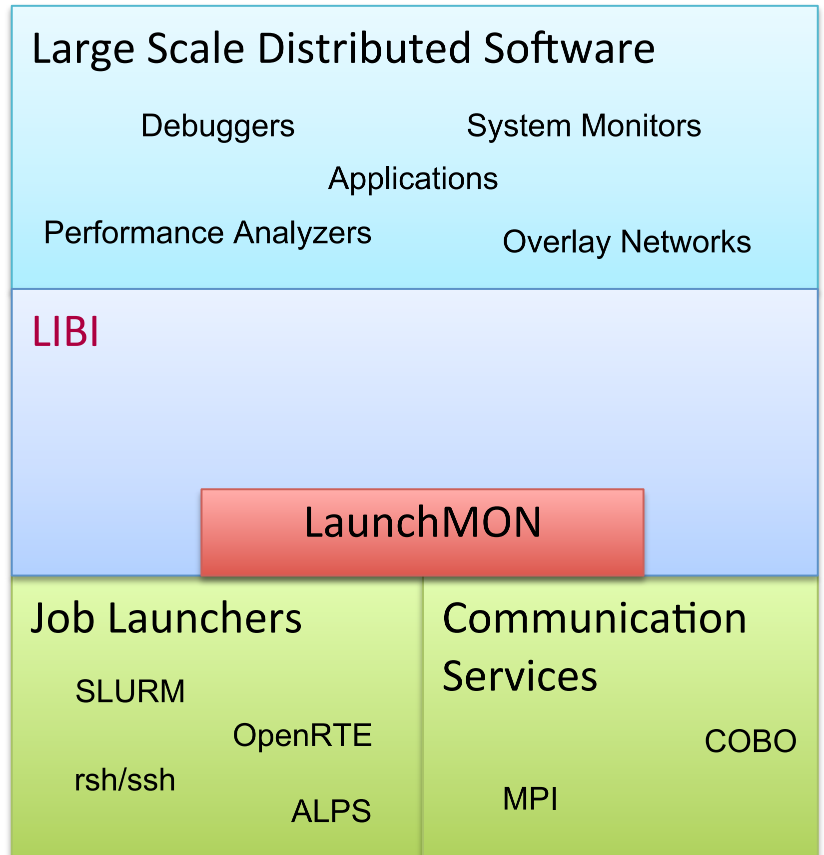
A (Brief) LIBI Update and Other MRNet-related Stuff

Joshua Goehner, Taylor Groves and Dorian Arnold
UNM

Dong Ahn and Greg Lee
LLNL

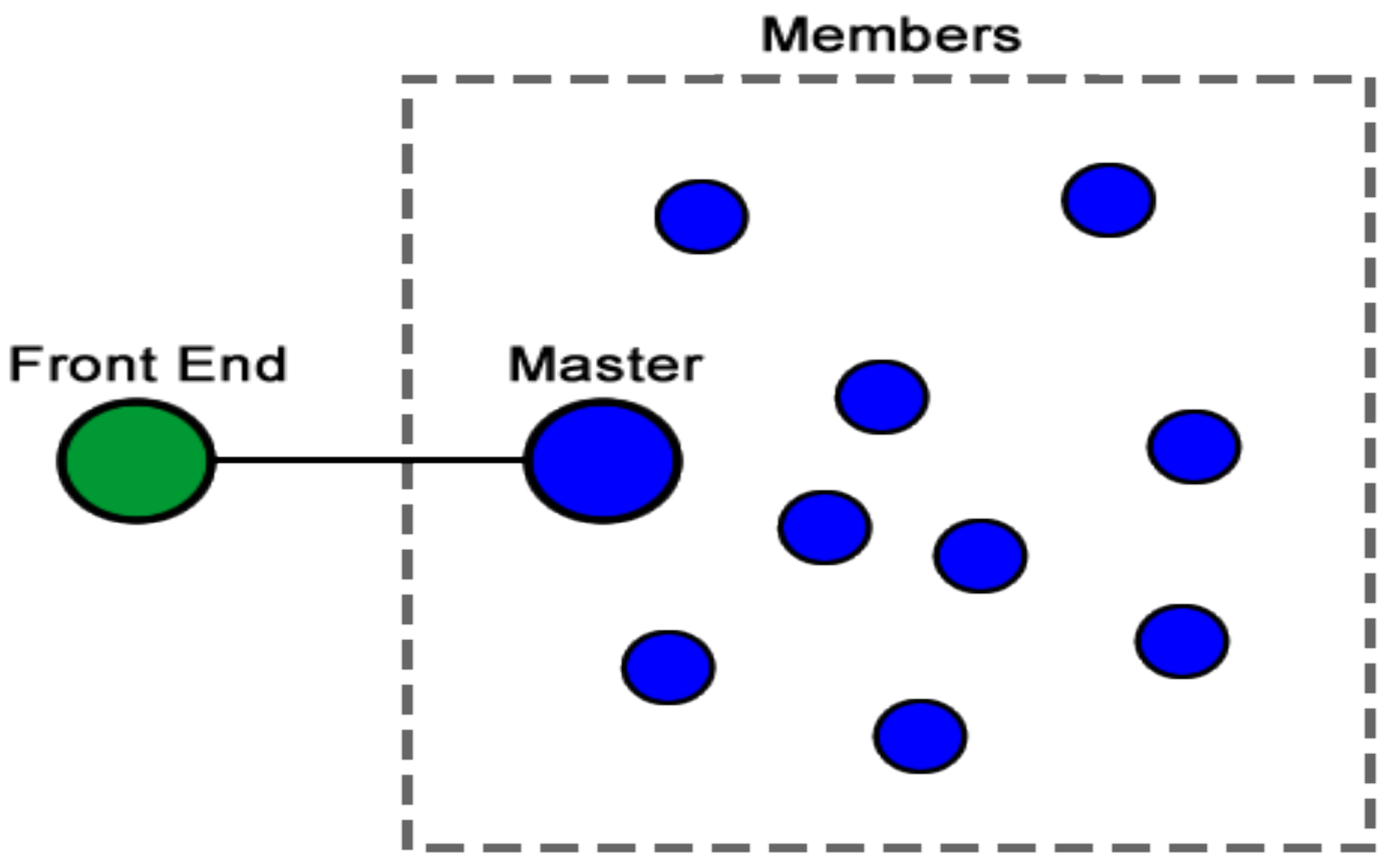
LIBI Approach

- LIBI: Lightweight infrastructure-bootstrapping infrastructure
  - Generic service for scalable distributed software infrastructure bootstrapping
    - Process launch
    - Scalable, low-level collectives



Scalable Systems Lab

LIBI Architecture



LIBI Abstractions

- *host-distribution*: where to create processes
  - <hostname, num-processes>
- *process distribution*: how/where to create processes
  - <session-id, executable, arguments, host-distribution, environment>

LIBI API

`launch(process-distribution-array)`

- instantiate processes according to input distributions

`[send|recv]UsrData(session-id, msg)`

- communicate between front-end and session master

`broadcast(), scatter(), gather(), barrier()`

- communicate amongst session members

Example LIBI Front-end

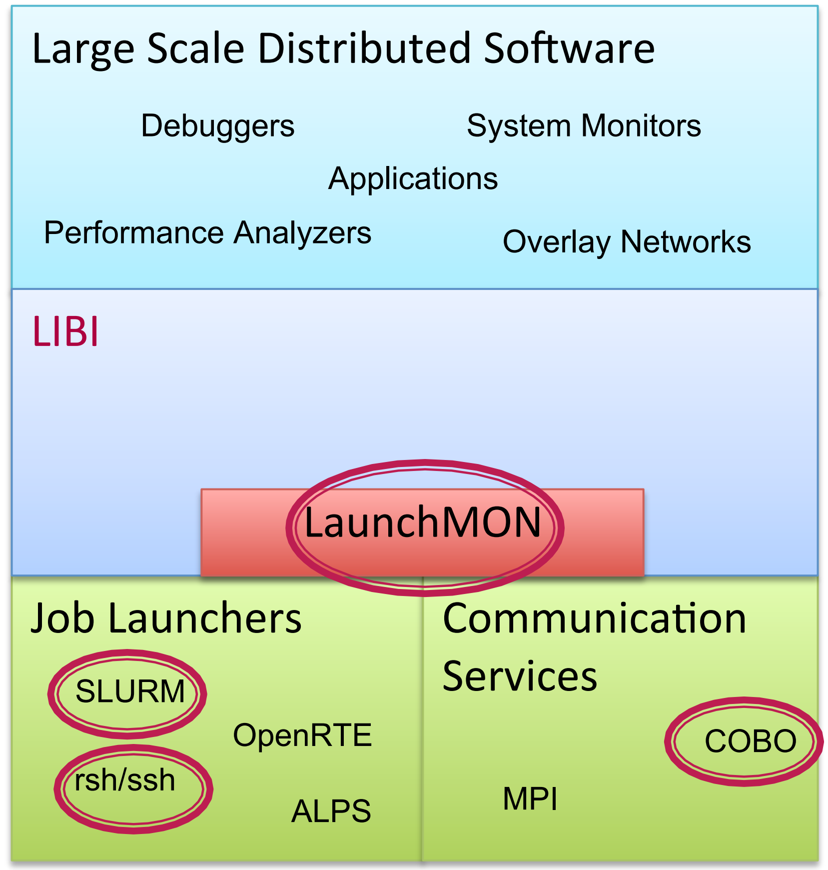
```
front-end( ){
  LIBI_fe_init();
  LIBI_fe_createSession(sess);

  proc_dist_req_t pd;
  pd.sessionHandle = sess;
  pd.proc_path = get_ExePath();
  pd.proc_argv = get_ProgArgs();
  pd.hd = get_HostDistribution();

  LIBI_fe_launch(pd);

  //test broadcast and barrier
  LIBI_fe_sendUsrData(sess1, msg, len );
  LIBI_fe_recvUsrData(sess1, msg, len);

  //test scatter and gather
  LIBI_fe_sendUsrData(sess1, msg, len );
  LIBI_fe_recvUsrData(sess1, msg, len);
}
```

Example LIBI-launched Application

```
session_member() {
  LIBI_init();

  //test broadcast and barrier
  LIBI_recvUsrData(msg, msg_length);
  LIBI_broadcast(msg, msg_length);
  LIBI_barrier();
  LIBI_sendUsrData(msg, msg_length)

  //test scatter and gather
  LIBI_recvUsrData(msg, msg_length);
  LIBI_scatter(msg, sizeof(rcvmsg), rcvmsg);
  LIBI_gather(sndmsg, sizeof(sndmsg), msg);
  LIBI_sendUsrData(msg, msg_length);

  LIBI_finalize();
}
```

LIBI Implementation Status

- LaunchMON-based runtime
  - SLURM or rsh launching
  - COBO PMGR service
- Rsh-based default
  - Pluggable launch topologies
  - Devised a provably optimal algorithm!



Optimal Launching Topology

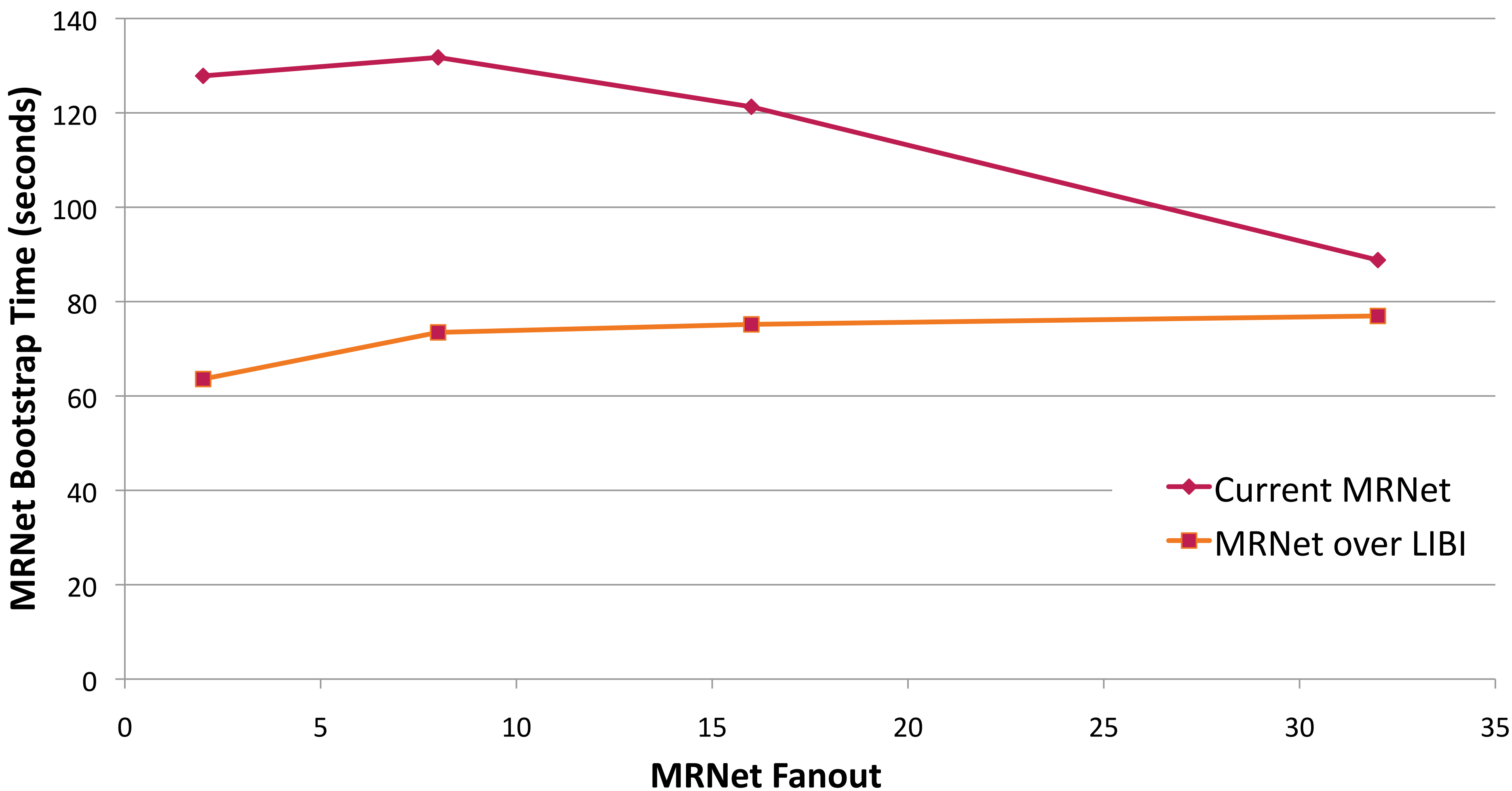
- Assumptions
  - Homogenous computing environment
    - All nodes have the same computational power
    - Constant wait time between each local launch command
    - Constant remote launch time
      - physical network topology?
      - file system (and other resource) contention?

- Algorithm Overview
  - Pick first node as root
  - For every subsequent node, place at minimal launch point

MRNet/LIBI Integration

- MRNet uses LIBI to launch all MRNet processes
  - Parse topology file and setup/call `LIBI_launch()`
- Session front-end gathers/scatters startup information
  - Parent listening socket (IP/port)

LIBI v.s. MRNet default



LIBI Updates

- Back-porting MRNet Integration
  - As fastpath to MRNet on BG/Q
  - Original integration had some regression
    - Replaced “XT” and “rsh” network modes with “libi” network
    - No XT support
    - No lightweight back-end support
  - Reintegrate as additional instead of replacement mode
    - until full support for XT and other features via libi mode

LIBI Things to Talk About at CSCaDS

- Can LIBI help with OSS startup issues?
- What's path forward for LIBI-based LaunchMON refactoring?
- (How) should LIBI interface w/ CDTI?
- Should LIBI be a CBTF component?

Other MRNet-related Happenings

- Desire an autonomous MRNet
  - Auto (re-)configuration for failure **and performance**
  - Need to understand how topology impacts performance
    - Performance models and validations
  - Online monitoring of relevant, dynamic parameters
  - Efficient heuristics for determining better configurations
  - Cost-benefit analyses to decide whether to change or not

Performance Model Assumptions

- Focus on reduction operations
- Single FE, IN or BE per physical node
- Filter latency is independent of in-degree
- Assume steady state workload
- Focus on both streaming and one-shot operations
  - Maximize throughput (for streaming operations)
  - Minimize latency (for one-shot interactive operations)

LogP-inspired Model Parameters

- Latency: l
- Gap: g (packet size/bandwidth)
- Fan-out: f
- Message processing overhead: o(f)
- Filter latency: c

- Build a per-node model:
  - Recursion for depth

Single Wave Model

$$T_i = l + g + o(f) + c + \max(T_c)$$

- Ti is the time to process the wave up to node i
- Tc is the time to process the wave for a node c, where c is a child of i.

Streaming Model

$$T_i = l + g + \max(c_i + o_i(x))$$

- Pipelining effectively removes recursion from single wave model

Parameter Value Generation

- Ping tests for platform dependent parameters
- Flat Topologies
  - To observe per-child costs
- Chain Topologies
  - To observe per-level costs
- Filer duration set to 0

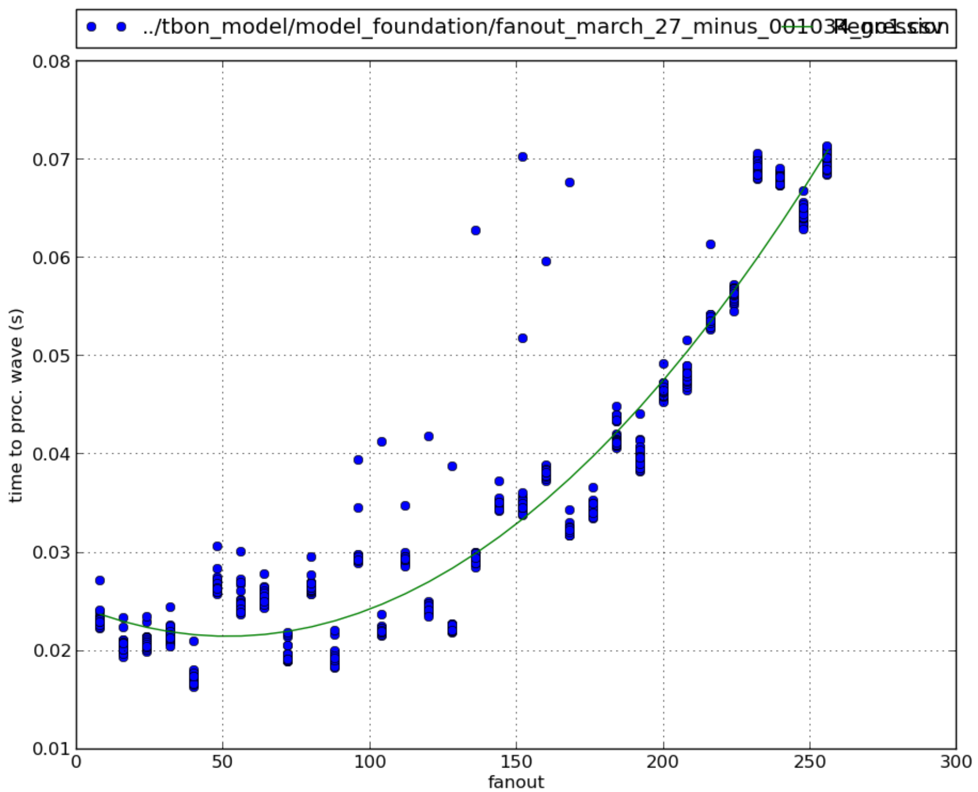
Flat Topology (Fan-out) Tests

- Initial Measurement Observations:
  - quadratic (not linear) performance with fan-out

- Find the coefficients that correspond to o(f): the message processing overhead as a function of fanout

- As fan-out increases, cost increases can be attributed to an overhead based on the breadth of the topology
  - assuming children are synchronized

Fan-out Tests



Chain Topology Tests

- As depth increases with other parameters accounted for, cost increases can be properly attributed to an overhead based on the height of the topology
  - assuming latency and bandwidth are constant at each level

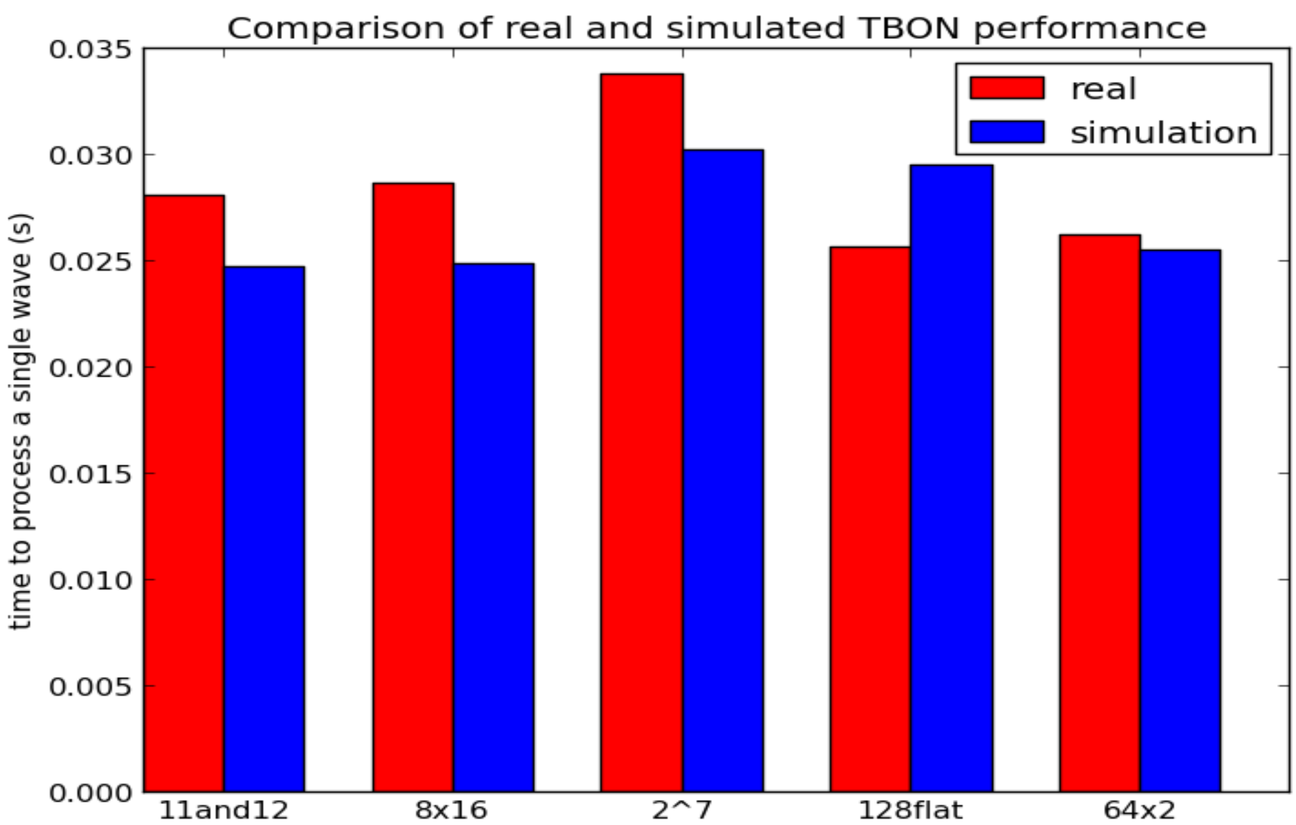
Combining the results

- Combined flat and chain topology
  - Allows us to fill in message processing overhead coefficients
- Generated values for all the parameters
- Test these values with our model on some more complex topologies

Initial Results

- Generated several topologies with 128 BEs
  - Varying the internal structure
- OMNet++ simulation
  - Each simulated overlay node operates according to model
- MRNetBench
  - Allows full control over all parameters that influence performance

Initial Results



Future Directions

- Larger scales
- Real tool/application (STAT)
- After model is validated, move on to next phases of autonomous operation

Autonomy Things to Talk about at CScADS

- Components of your computational model not captured or captured inaccurately?
- Overall relevance to your tool/analysis framework?
- Martin, why aren't we working together on this? ☺