Barcelona Supercomputing Center
Centro Nacional de Supercomputación

EXCELENCIA
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Evaluating SLURM Simulator with Real-Machine SLURM and Vice Versa

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PMBS18

Outline

- Introduction and motivation
- BSC SLURM Simulator structure
- Contributions in BSC SLURM Simulator
- Evaluation of the simulator
- Evaluation of real SLURM: use cases
- Conclusions & future work

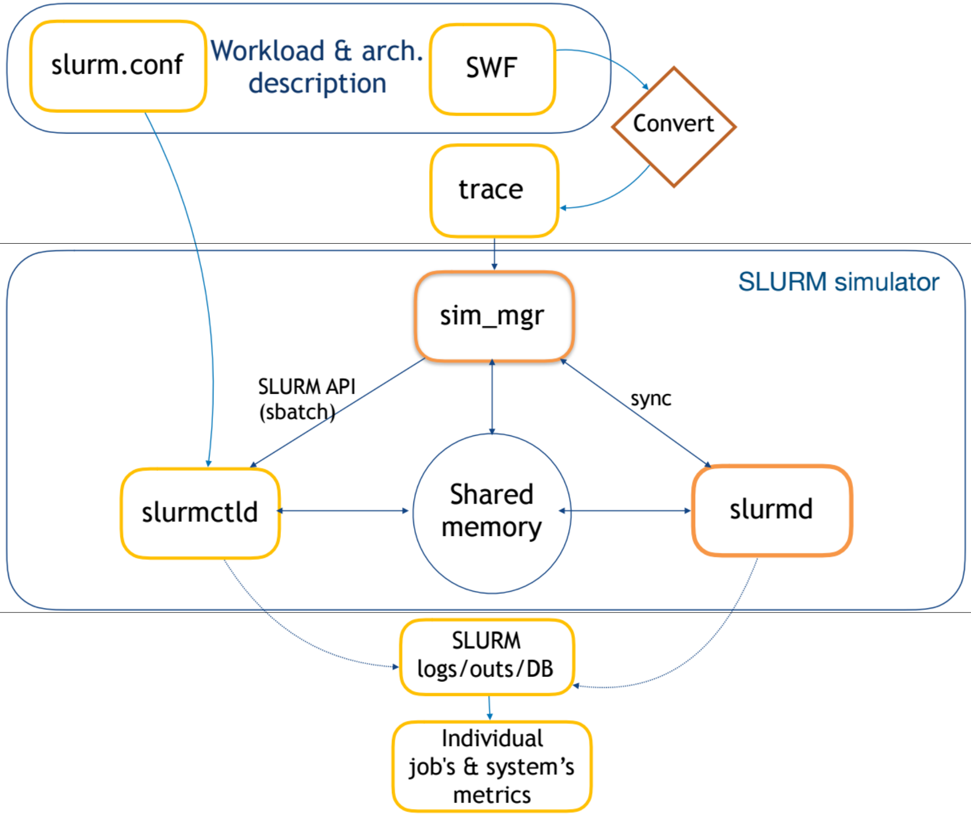
Introduction and motivation

- Why slurm simulator and not a generic simulator?
  - It keeps code structure, features, parameters of SLURM
  - It allows reusing code developed for SLURM, i.e. plugins
- Used in research:
  - Evaluate new scheduling policies
  - Evaluate new systems not yet in production
- Used in production systems:
  - Improve cluster performance

A bit of history

- BSC SLURM Simulator was born in 2011:
    - *Slurm Simulator*, Alejandro Lucero, BSC (SLUG’11)
        - Based on SLURM v2.2.6
- Latest version:
    - *ScSF: A Scheduling Simulation Framework*, Gonzalo P. Rodrigo at al. (JSSP’17) → **our starting point!**
        - Based on SLURM v14.03
        - Faster
        - Partially addressed problems affecting the simulator accuracy

SLURM Simulator structure



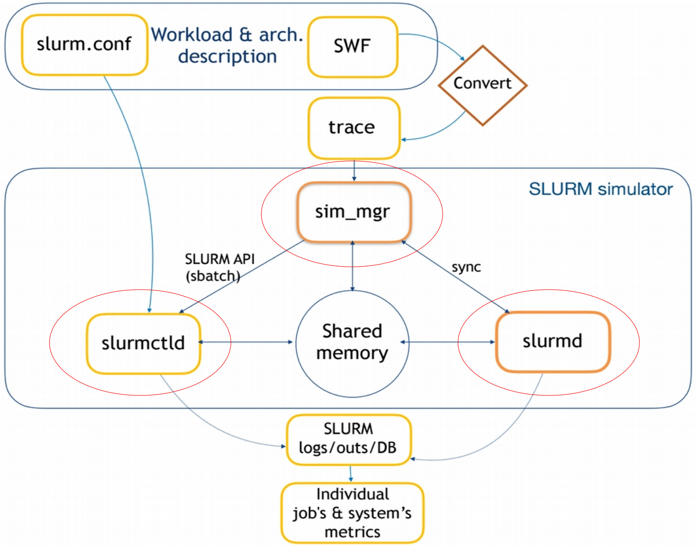
Input preparation

Simulation

Output analysis

SLURM Simulator

- A new component, *sim_mgr*, manages:
  - Simulation start/end
  - Simulation time – simulating one second per iteration
  - job submissions
- *slurmd* was modified to fake job execution
  - Multiple nodes are represented by the same *slurmd*
  - batch jobs are simulated (no steps, no tasks created)
- *slurmctld* synchronizes with a new RPC: MESSAGE_SIM_HELPER_CYCLE
  - Allows to process all the messages and operations happening in a specific second



Contributions in the SLURM Simulator

We encountered different bugs, producing delays and deadlocks:

- Wrong synchronization between simulator components
  - Caused by sleeps, concurrent operations on shared variables, semaphores
  - Solved by implementing a two semaphores synchronization
- Delays in RPC exchange and jobs duration
  - Caused by uncontrolled epilog messages
  - Solved by managing the number of running epilogs
- Delays in scheduler calls
  - Caused by oversimplification of scheduler calls and time dependent events: periodic call of scheduler and background operations
  - Solved by removing sleeps and implementing periodic calls into SIM_HELPER window

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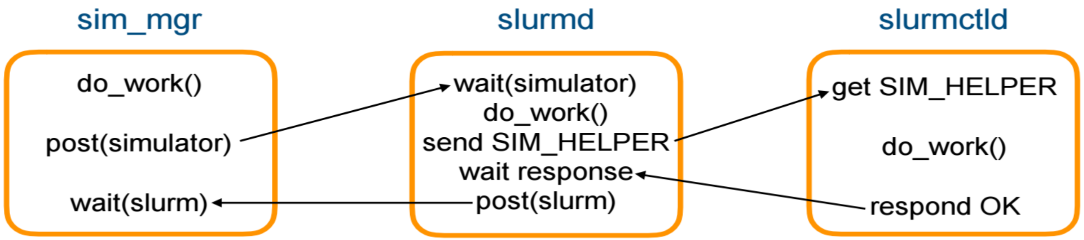

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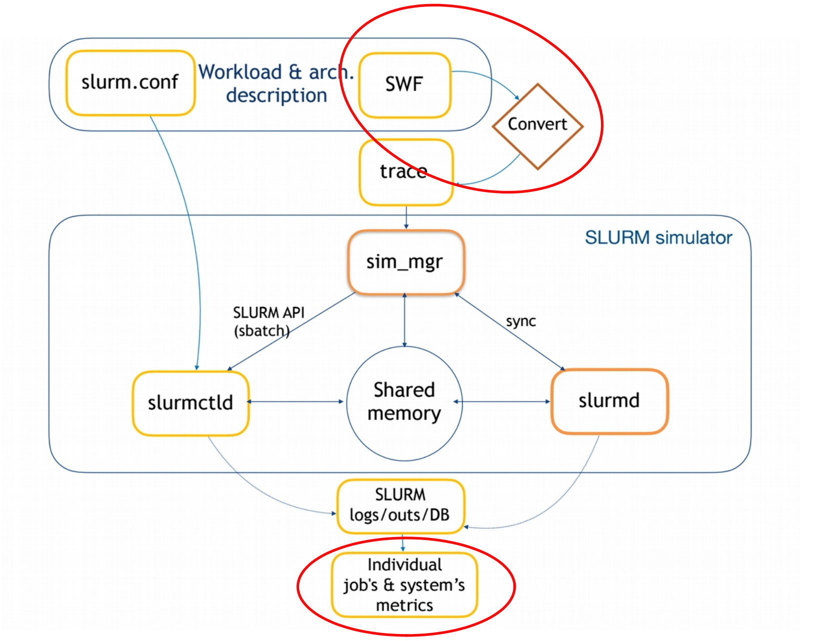
Other improvements

- Ported to version 17
- Implemented reading from SWF
- Implemented multiple simulation in the same machine (no VM are necessary)
- Scripts for lunching simulations, collecting results, output extraction, analysis and graphs generation
  - Demo at BSC booth on: Tuesday 13, at 3pm



Evaluation

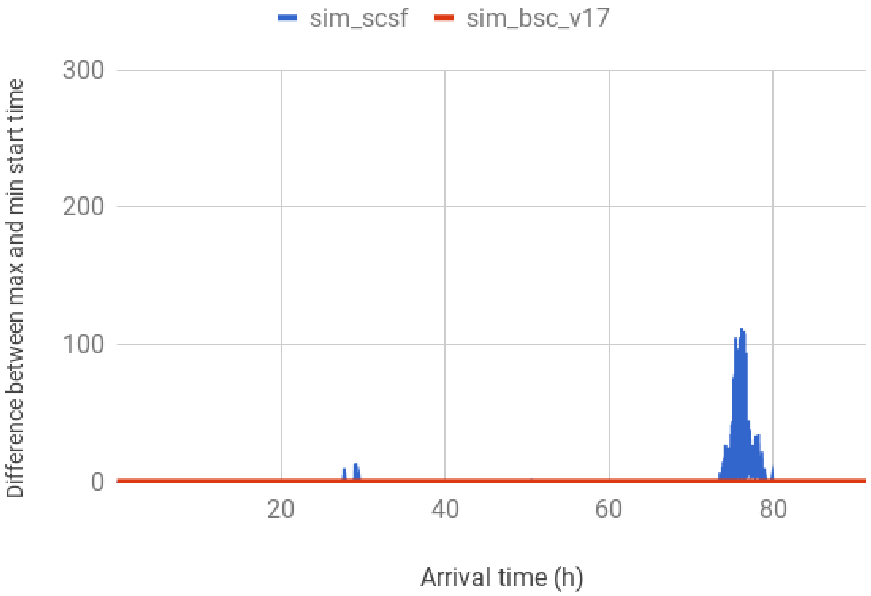
- **Consistency** evaluation: we compare multiple runs of the same simulation, and we try to understand causes of variation between runs
- **Accuracy** evaluation: we run the same workload in real SLURM and in the simulator
- **Performance** evaluation: we run big workloads in terms of system size and number of jobs and we evaluate Simulator speedup

- We compared *ScSF* Simulator with BSC version

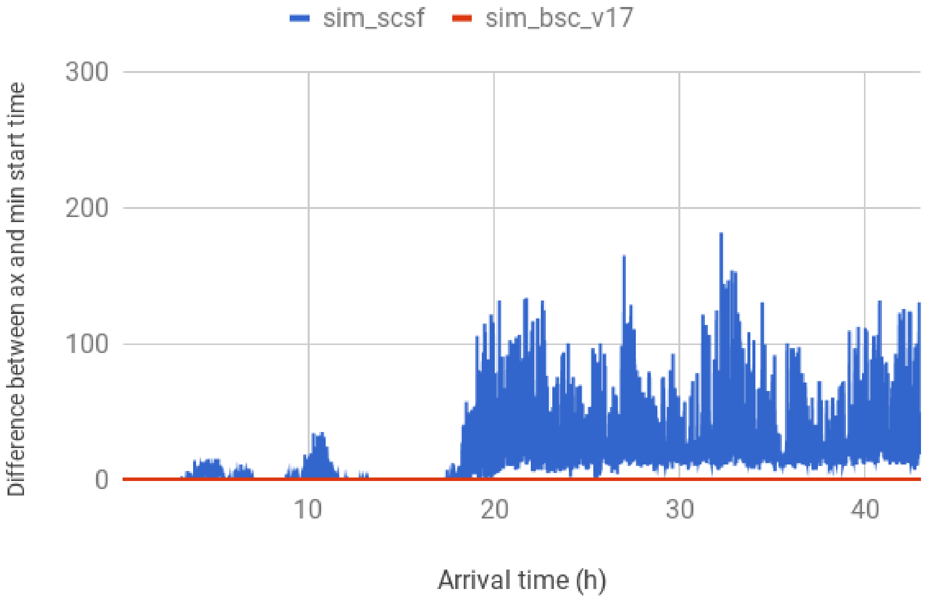
Evaluation: Consistency

- **Consistency** evaluation: 4 logs generated with Cirne model, 5000 jobs, 3456 nodes:
  - ANL, CTC, KTH, SDSC arrival patterns
  - About 5 days of simulated time
- In sim_scsf variance depends on the system load

KTH



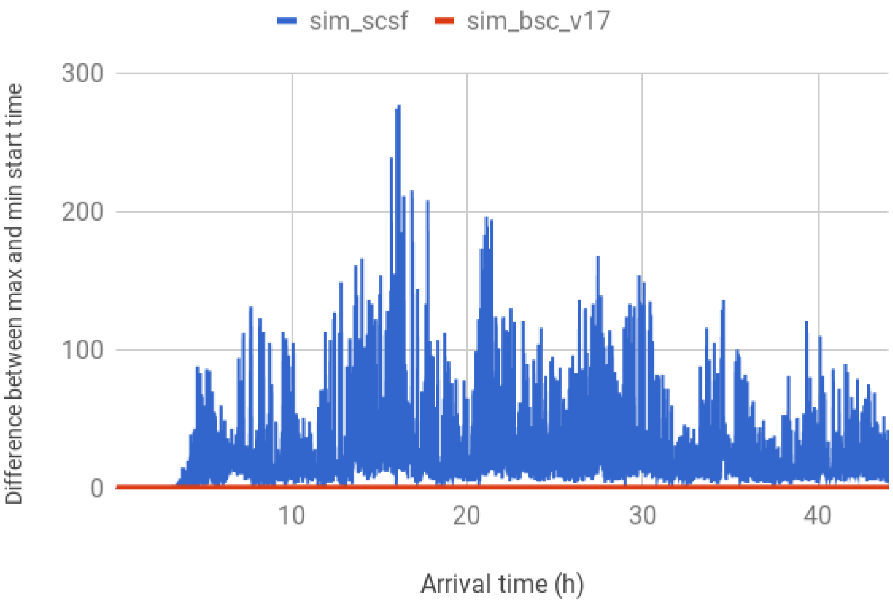
SDSC



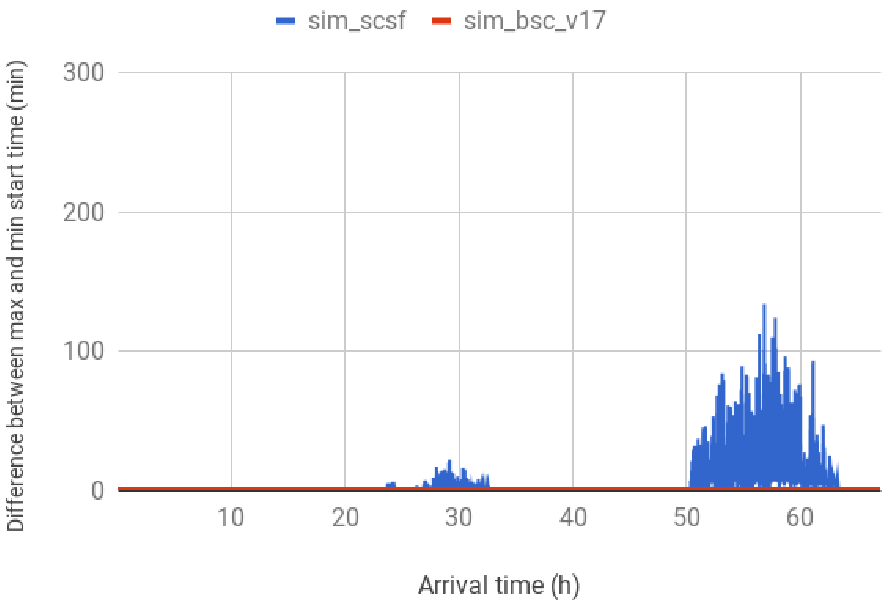
Evaluation: Consistency

- **Consistency** evaluation: 4 logs generated with Cirne model, 5000 jobs, 3456 nodes:
  - ANL, CTC, KTH, SDSC arrival patterns
  - About 5 days of simulated time
- BSC Simulator is deterministic, variance was caused by errors!

ANL

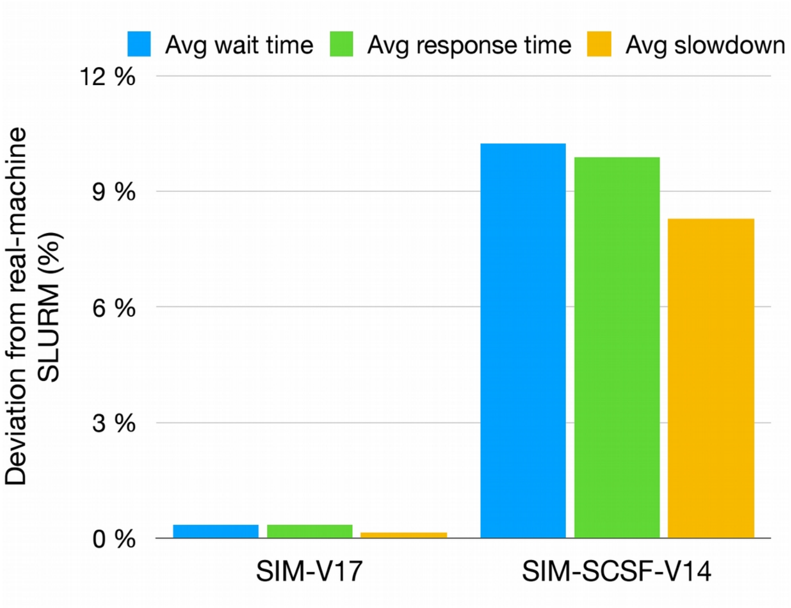


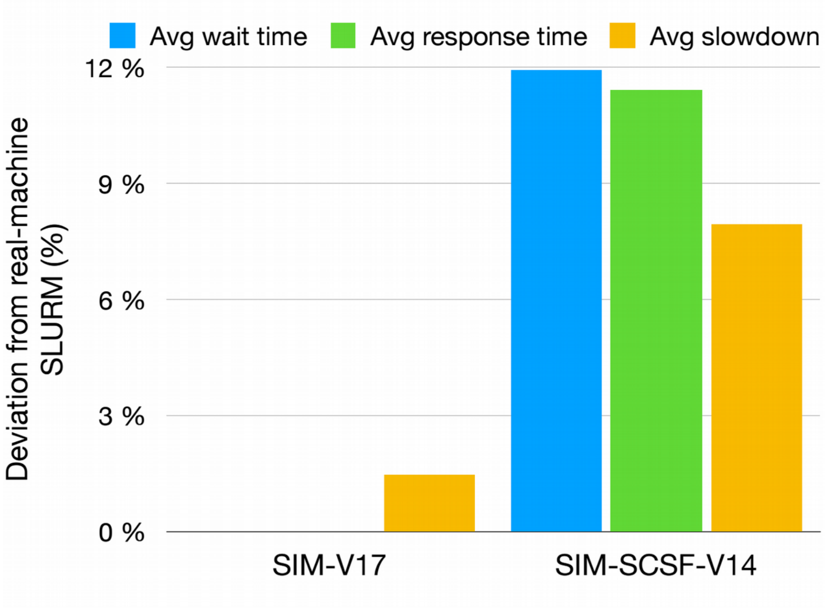
CTC



Evaluation: Accuracy

- **Accuracy** evaluation: 4 logs generated with Cirne model and converted to real jobs submissions
  - Comparing SLURM simulator and real SLURM in Marenostrum 4
  - 10 nodes, 200 jobs, about 2 hours makespan





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Evaluation: Accuracy

- **Accuracy** evaluation: 4 logs generated with Cirne model and converted to real jobs submissions
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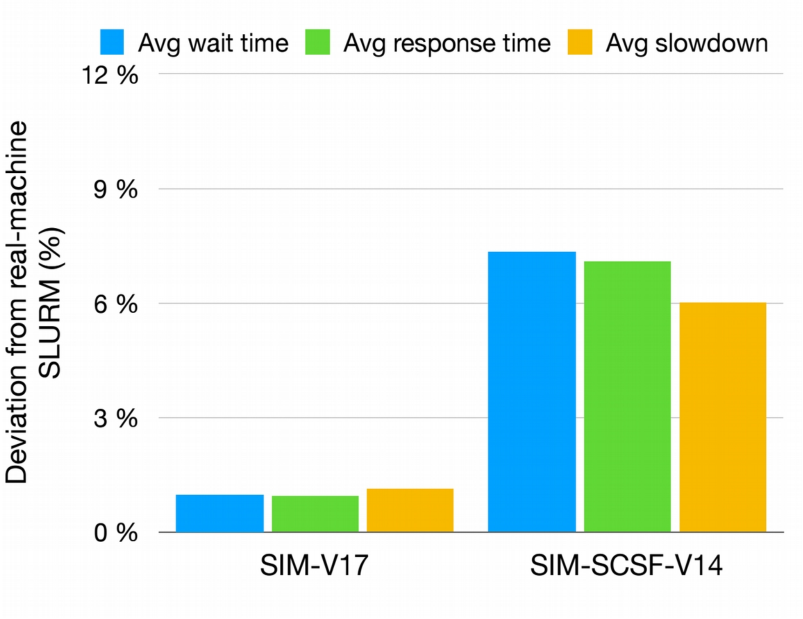
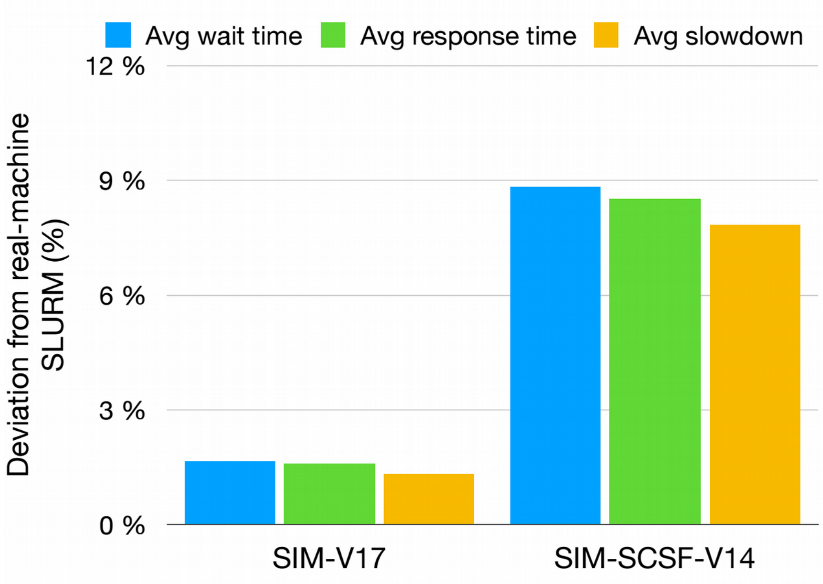
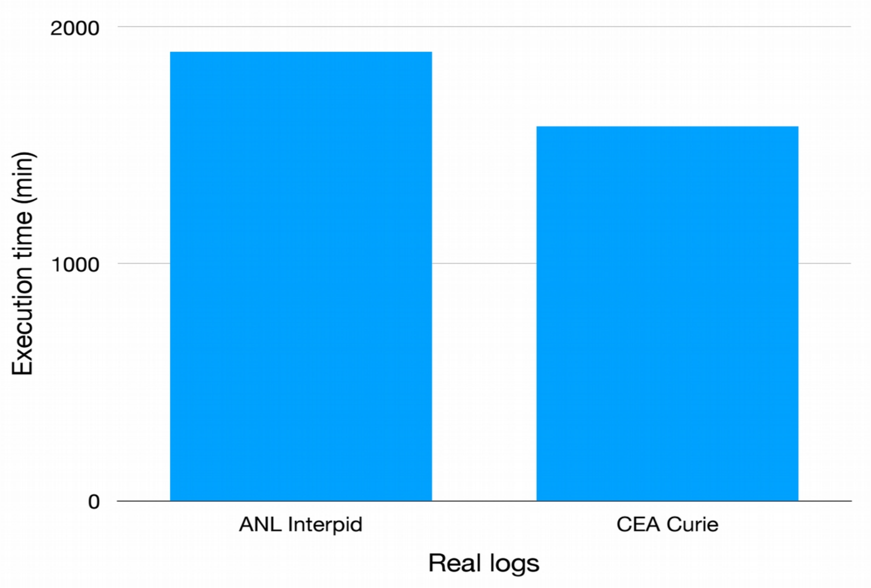
  - 10 nodes, 200 jobs, about 2 hours makespan
- Real SLURM is not deterministic!

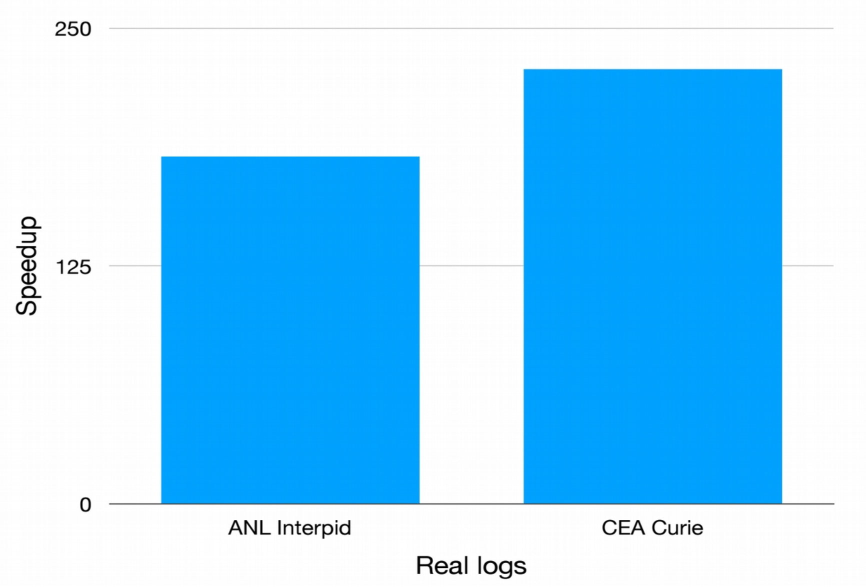




Evaluation: Performance

- **Performance** evaluation:
  - ANL Intrepid complete log: 68936 jobs, 40960 nodes, Jan 2009 to Sept 2009, 9months
  - CEA Curie complete log: 198509 jobs, 5040 nodes, Feb 2012 to Oct 2012, 9 months
- Up to 240x speedup



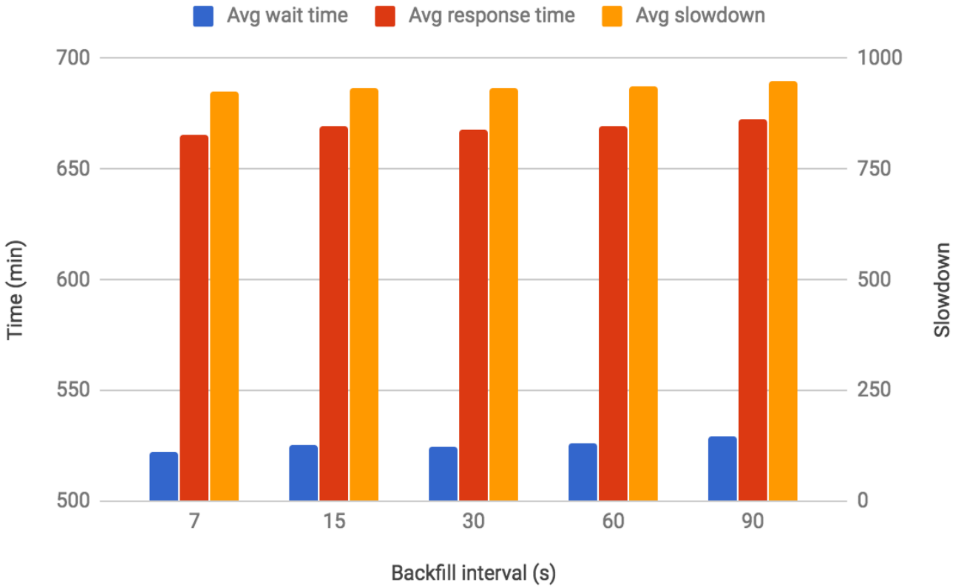


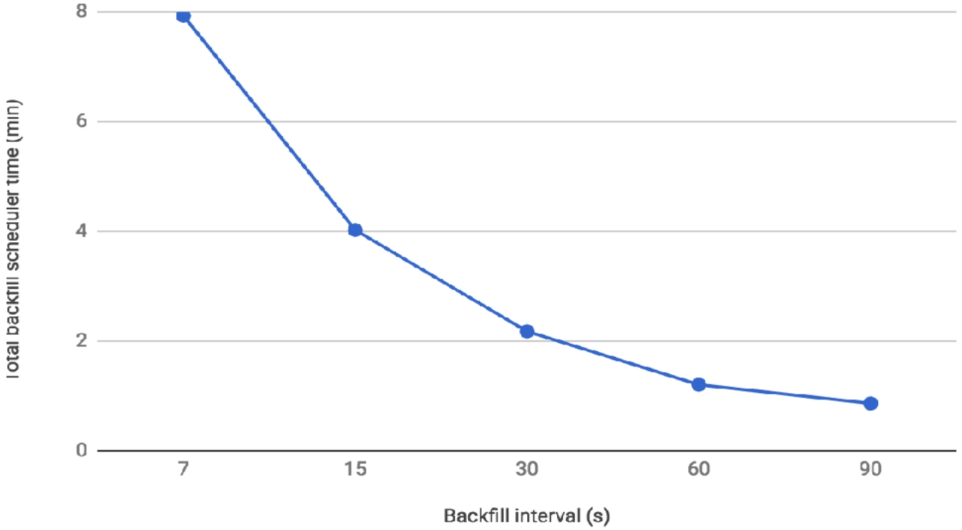
Use cases

- **Use cases** evaluation: evaluate a system by using SLURM Simulator
  - Running Cirne with ANL arrival pattern, 5000 jobs, 3456 nodes

1) Analyze backfill interval
2) Analyze number of tested jobs by the scheduler
3) Analyze scaled up/down system performance

Use case 1: backfill interval





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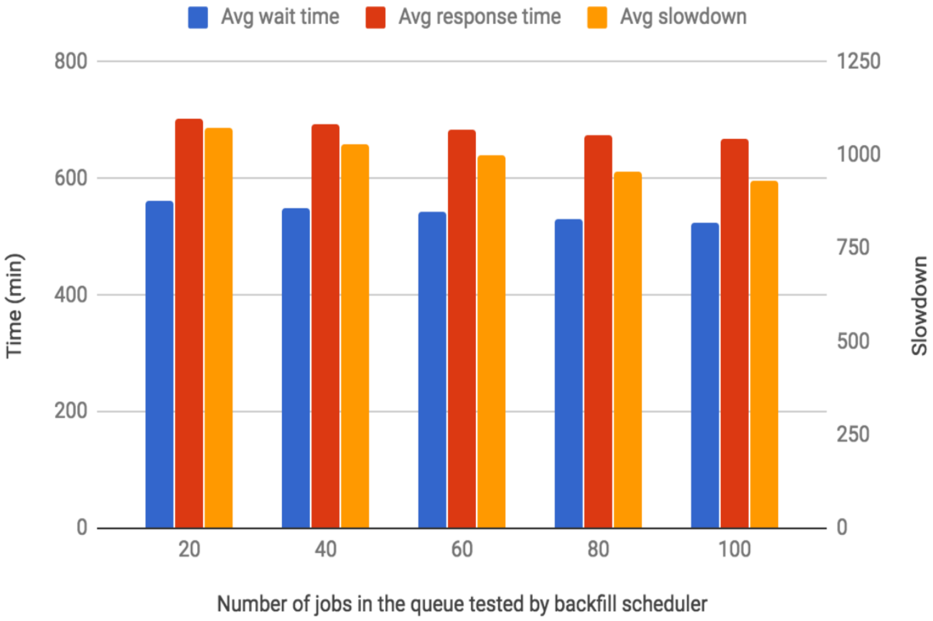
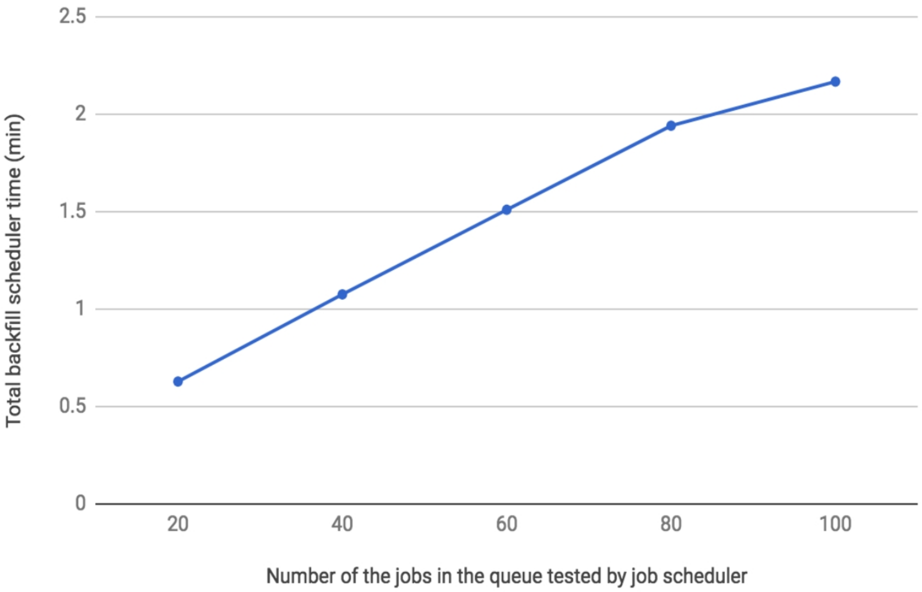
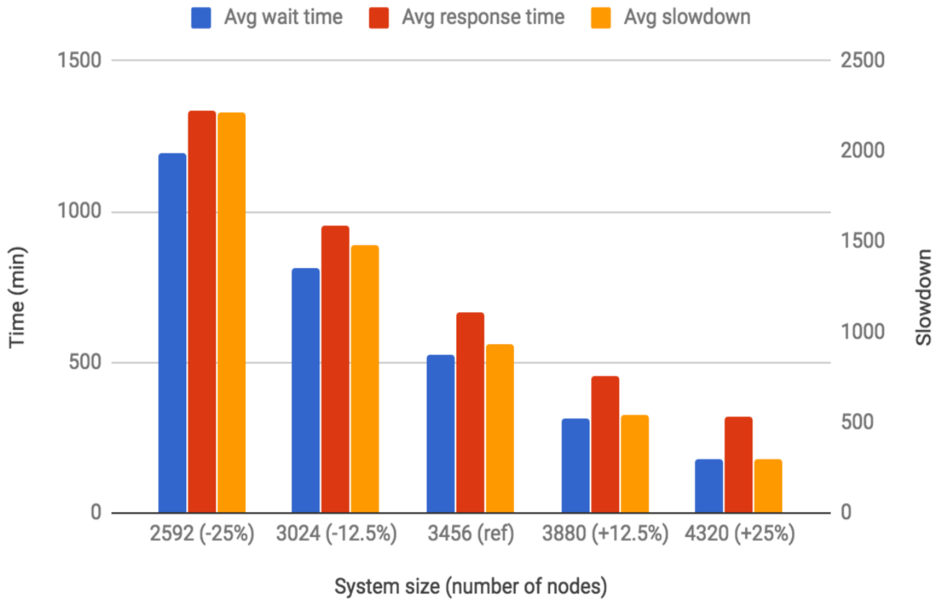
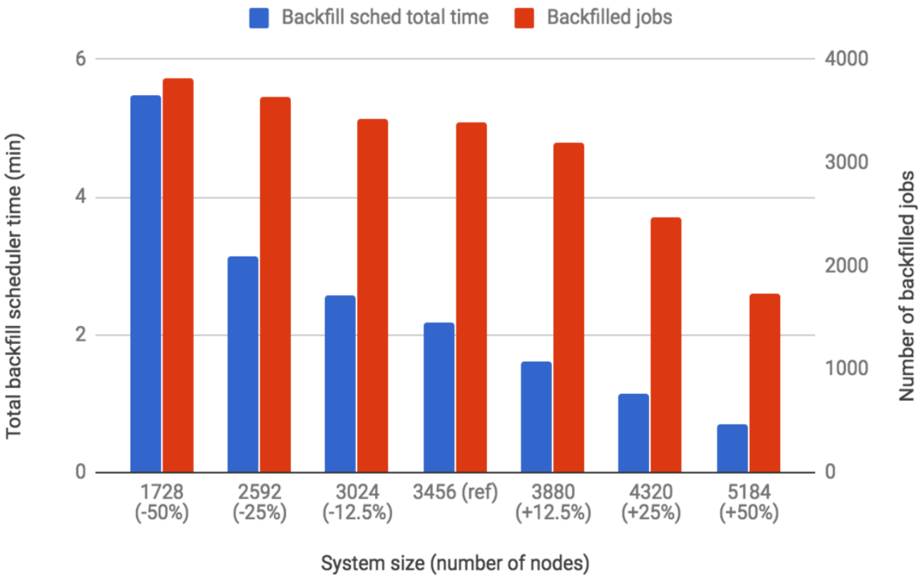
Use case 2: number of tested jobs





Use case 3: system size





Conclusion and future work

- SLURM Simulator is a powerful tool for research and system administration
- We did the first ever accuracy evaluation with a real scheduler implementation
- SLURM Simulator is used in European Projects (DEEP-EST)
- We published BSC Simulator's code at:
  - https://github.com/BSC-RM/slurm_simulator
  - https://github.com/BSC-RM/slurm_simulator_tools
- Future work
  - Evaluate the accuracy comparing bigger runs
  - Event driven simulator, not updating time second by second
  - Model execution time based on hardware
  - Implement support for heterogeneous jobs

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Thank you

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