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Frederic Vroman², Nguyen Nguyen¹

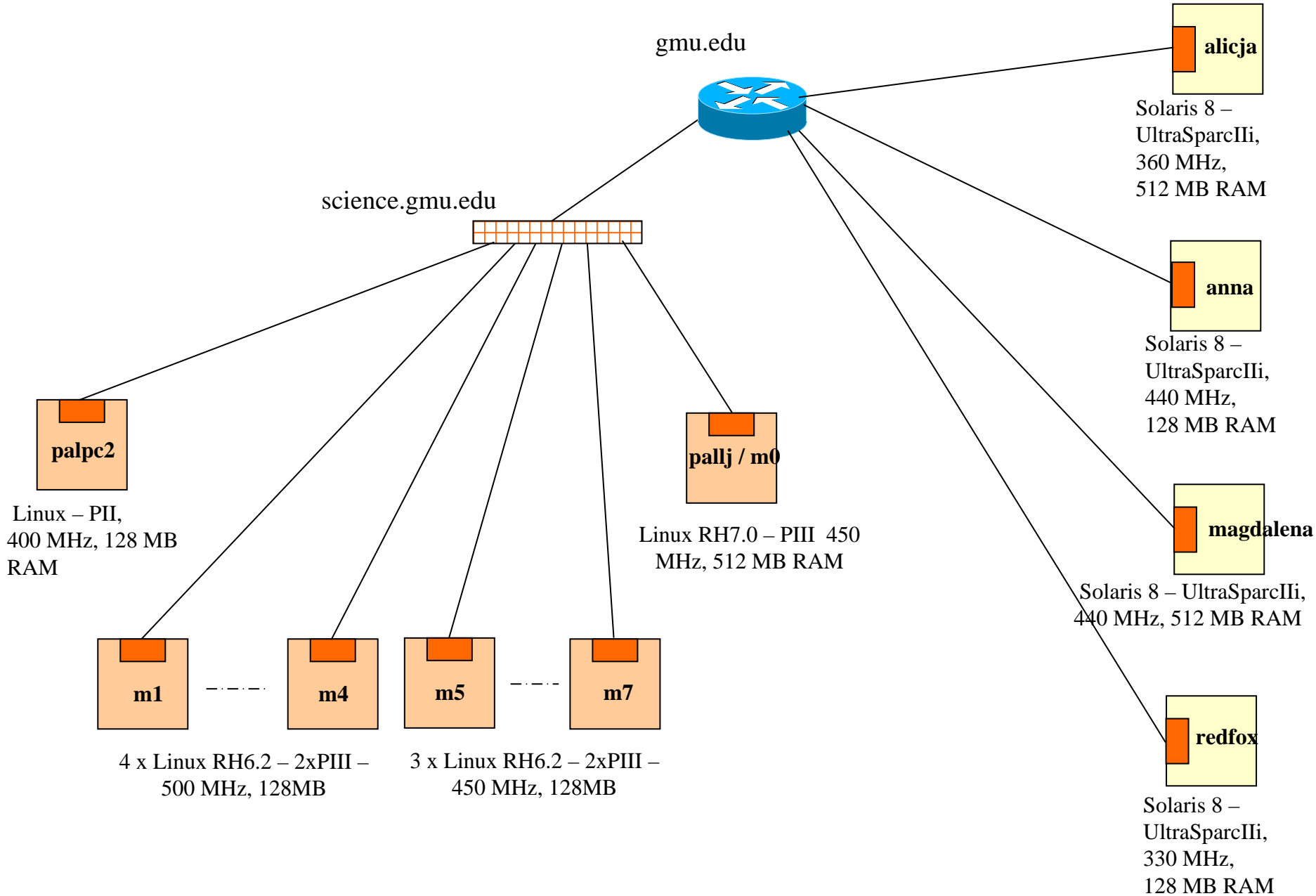
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Performance Evaluation of Selected Job Management Systems

Our Testbed

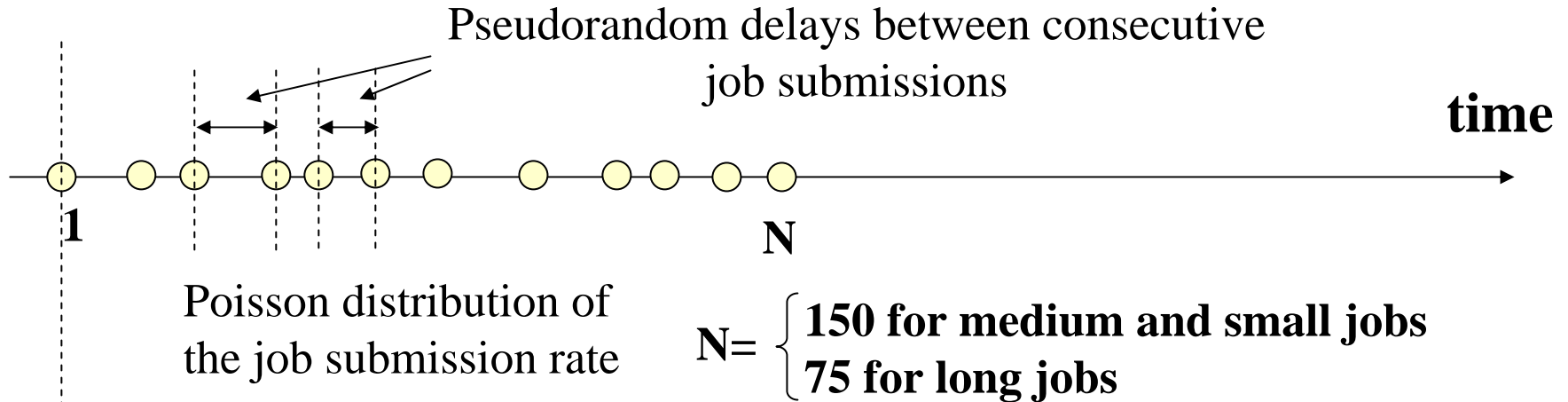


Classes of benchmarks

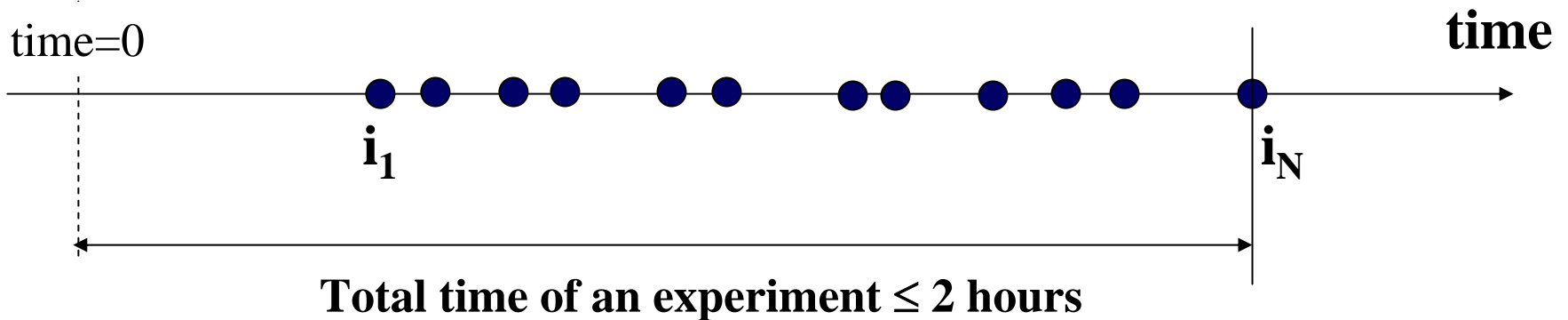
- NSA HPC Benchmarks
- NAS Parallel Benchmarks
- UPC Benchmarks
- Cryptographic Benchmarks

Typical experiment

Job submissions



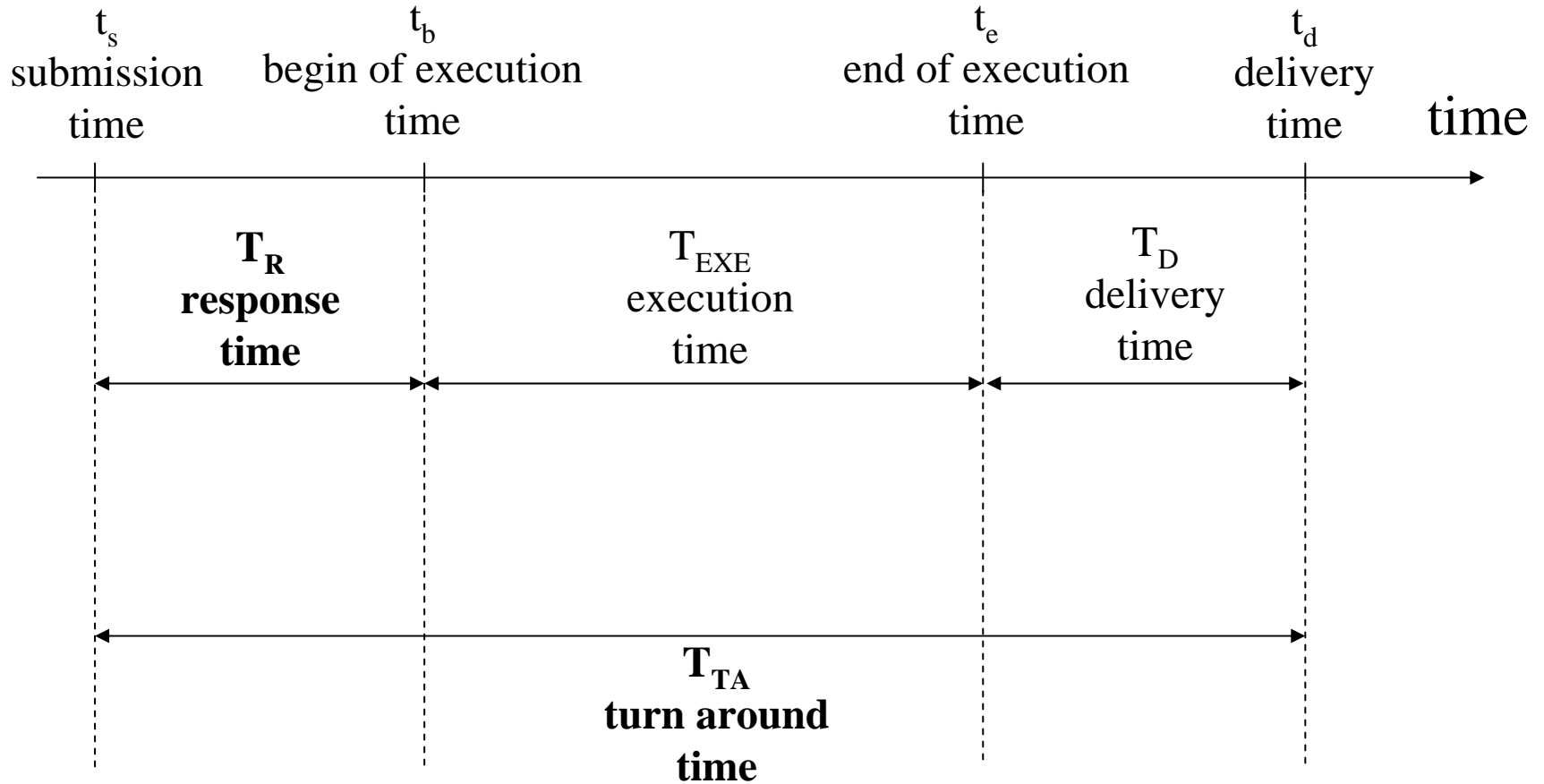
Jobs finishing execution



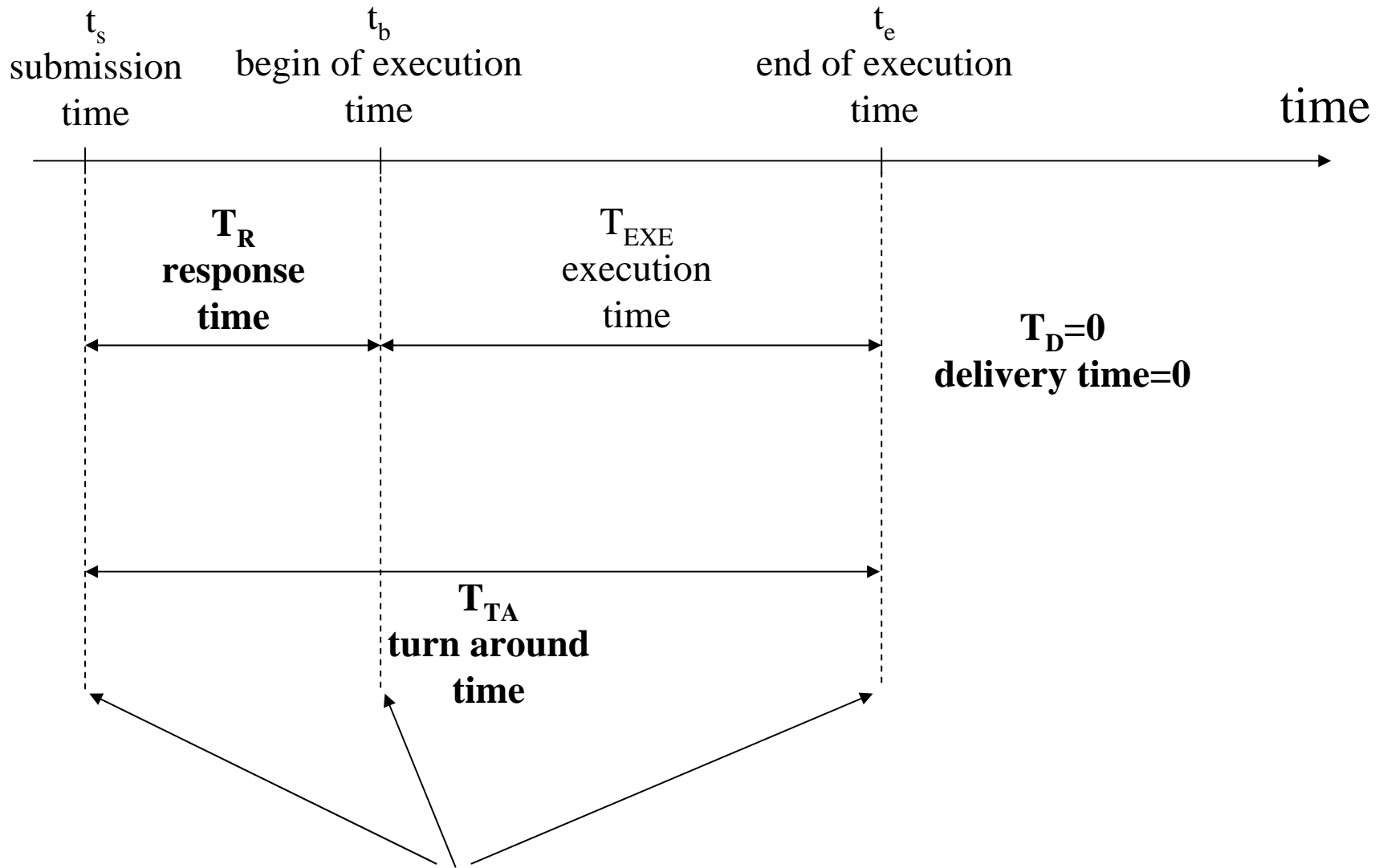
List of experiments

Experiment Number	Benchmark Set	Average CPU time / Job	Average Time Intervals Between Job Submissions	Total Number of Jobs	Special Assumptions
1	Medium job list	7 min 22 s	30 s, 15 s, 5 s	150	one job / CPU
2	Medium job list	7 min 22 s	15 s	150	two jobs / CPU
3	Long job list	16 min 51 s	2 min, 30 s	75	one job / CPU
4	Short job list	22 s	15 s, 10 s, 5 s 2s, 1s	150	one job / CPU
5	I/O job list	1 min 36 s	15 s	150	one job / CPU

Definition of timing parameters

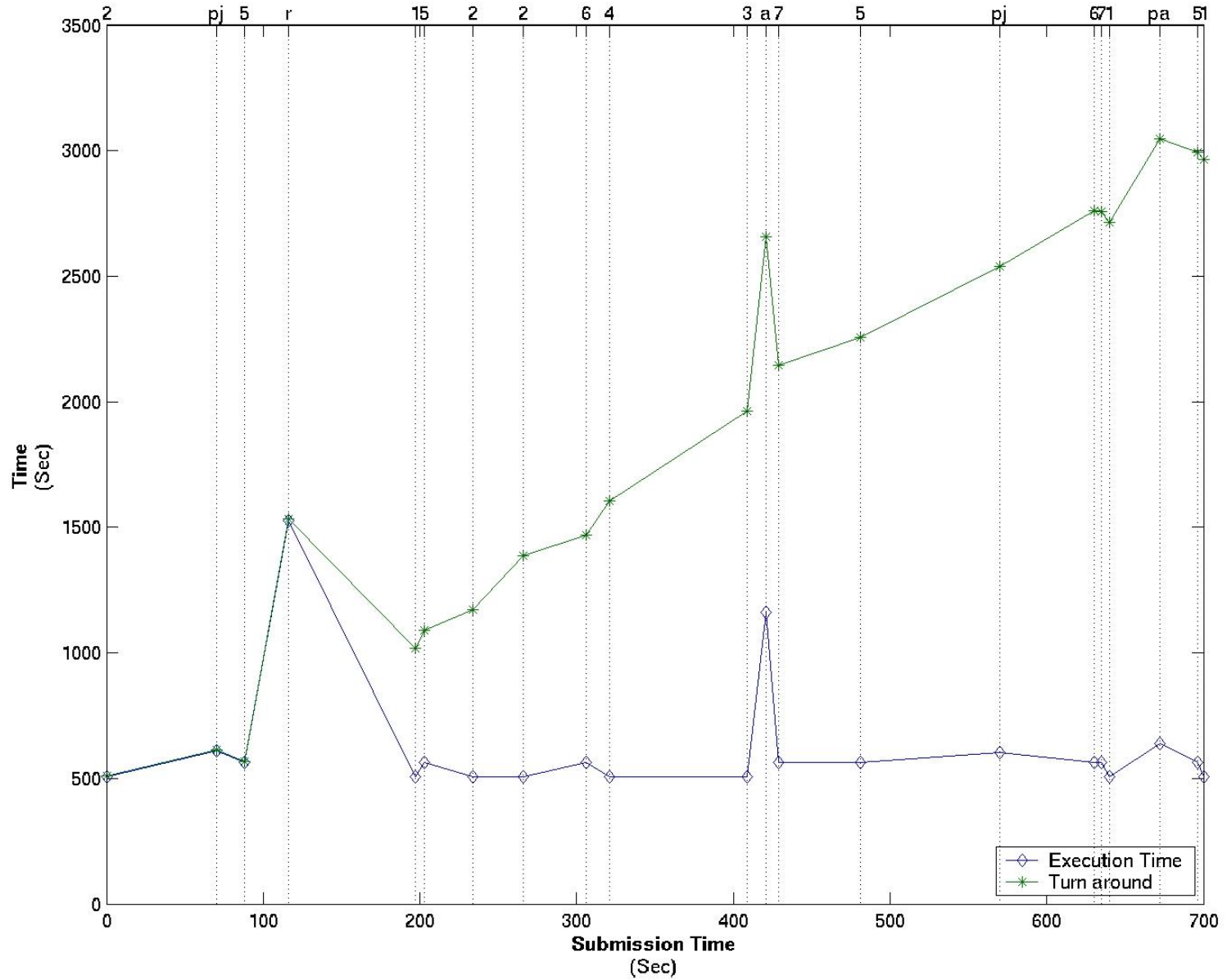


Typical scenario



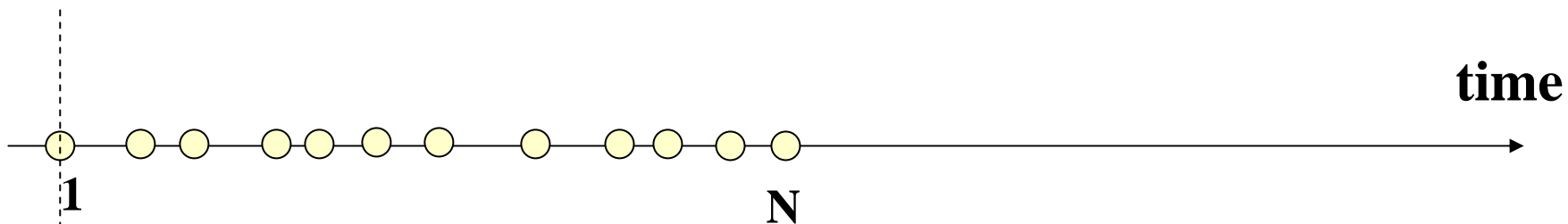
determined using the `gettimeofday()` function

Turnaround and execution time
Experiment: Isf MEDIUM delay5 mxj1 iter1 **Jobname:** crypto.mars.M.sh

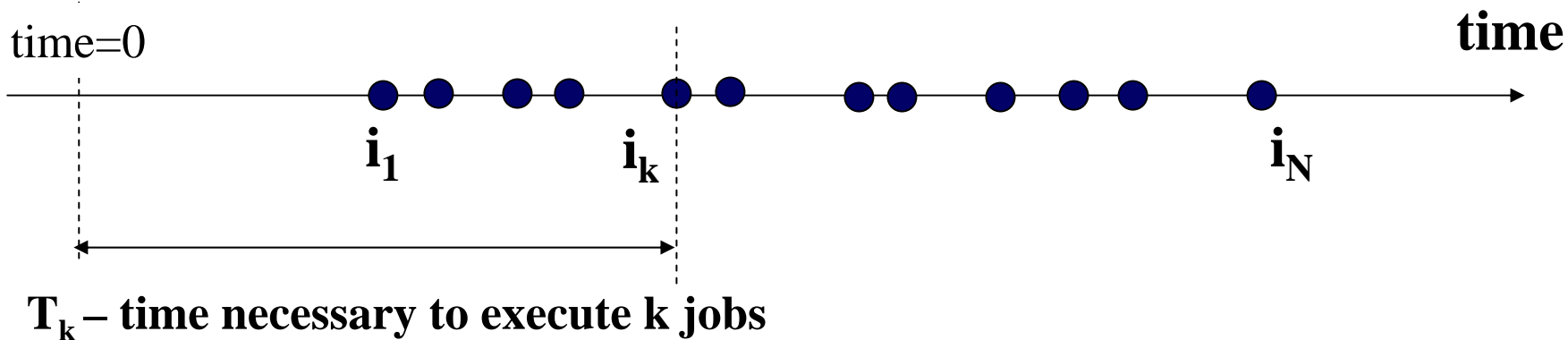


Throughput

Job submissions



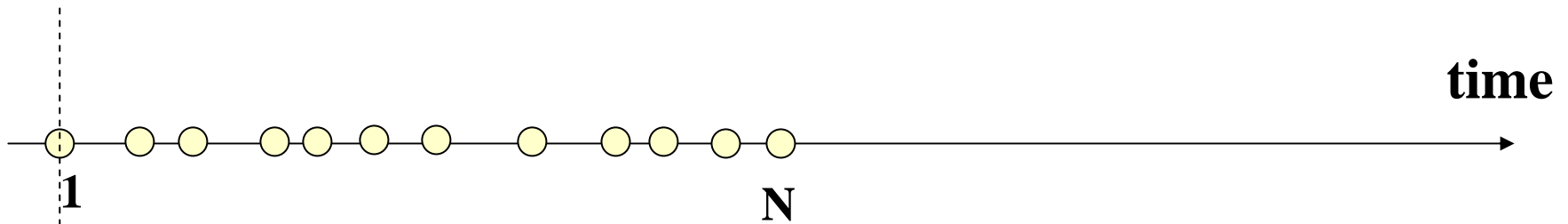
Jobs finishing execution



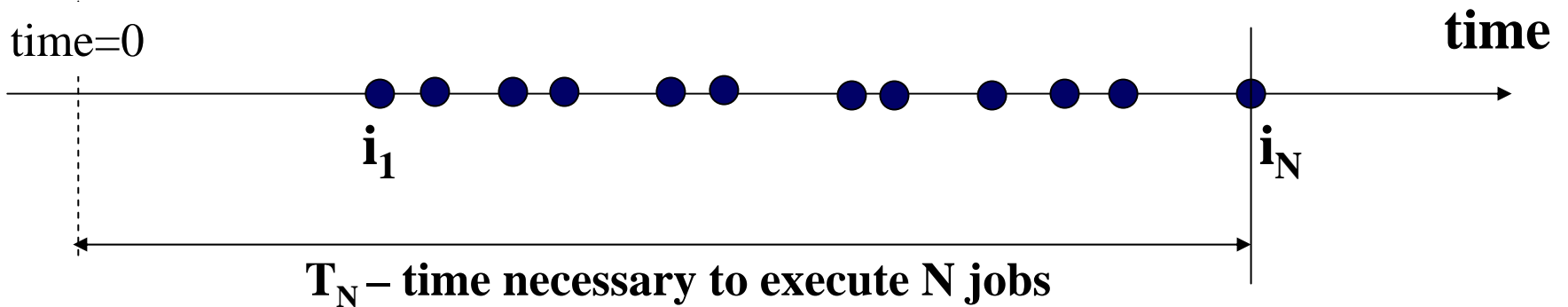
$$\text{Throughput (k)} = \frac{k}{T_k}$$

Total Throughput

Job submissions

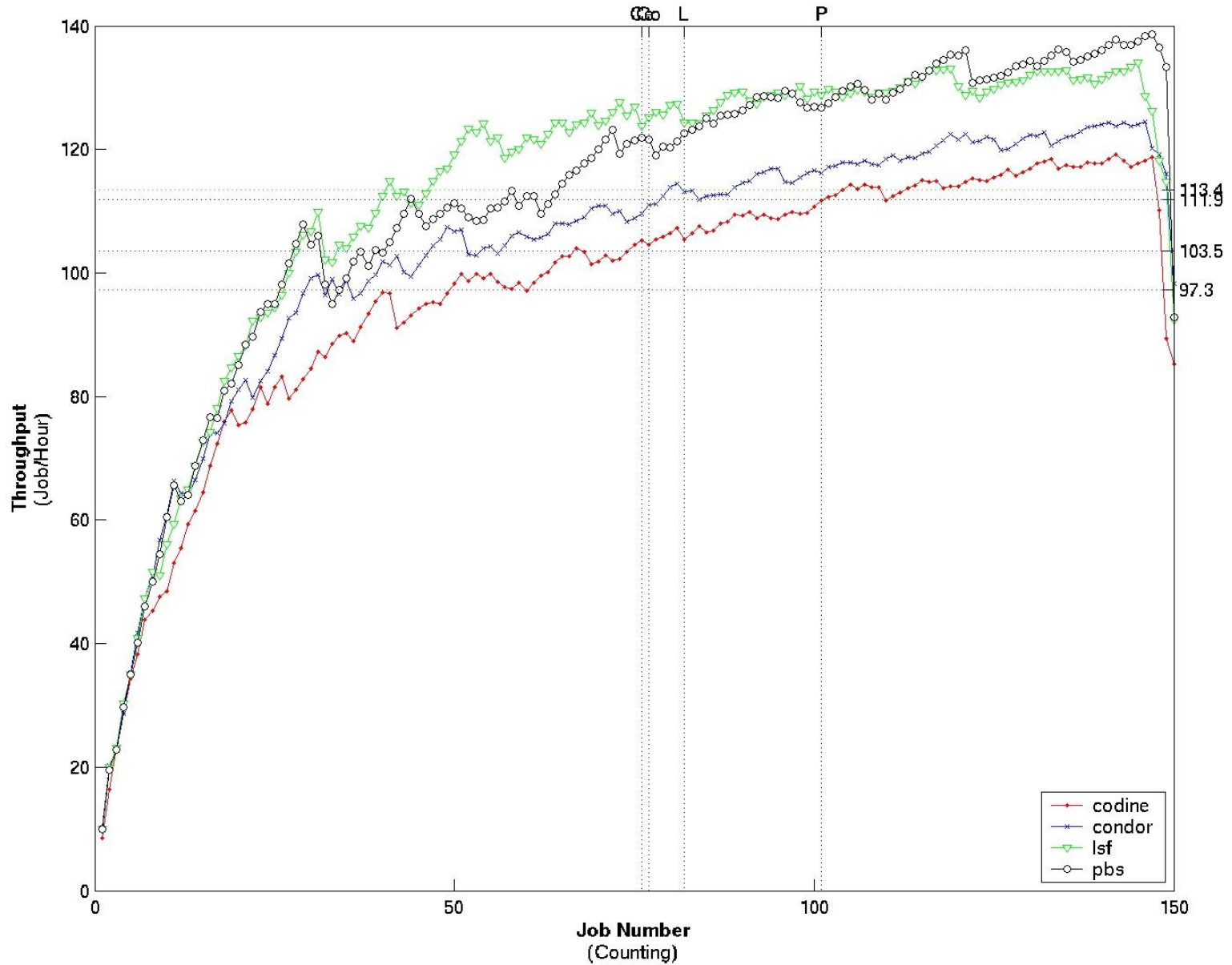


Jobs finishing execution

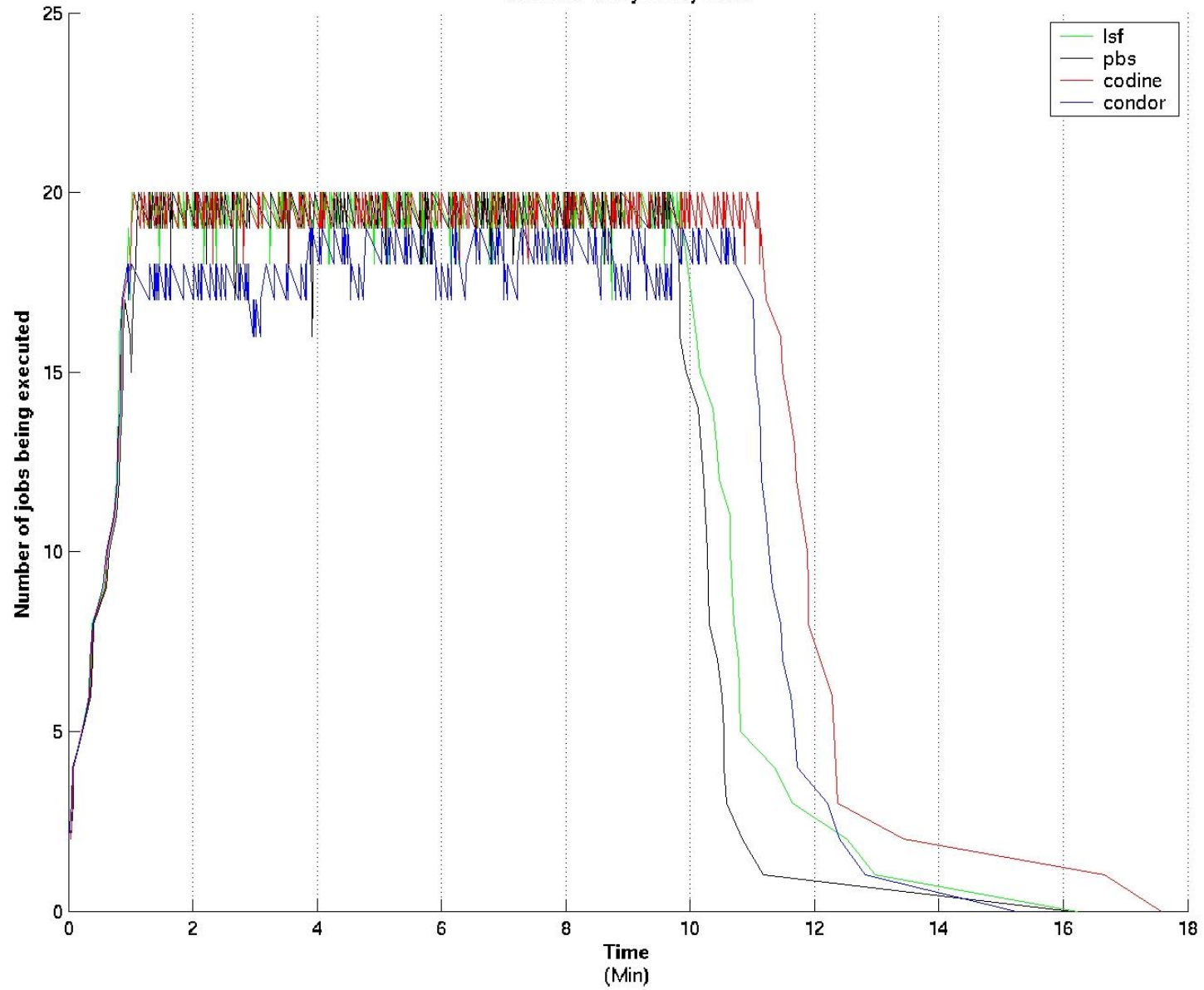


$$\text{Total Throughput} = \frac{N}{T_N}$$

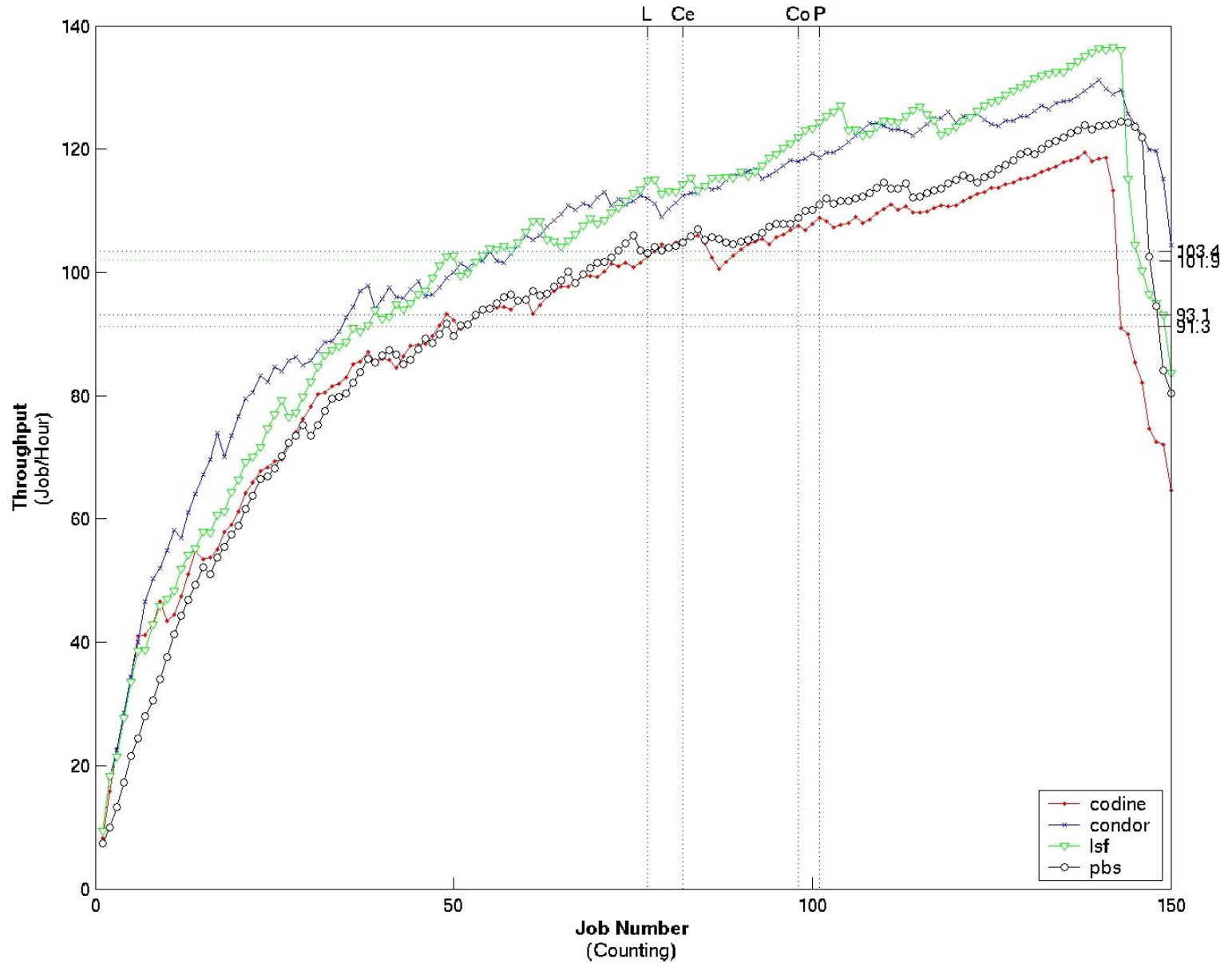
Throughput as a function of the number of jobs taken into account
MEDIUM delay15 mxj1 iter1



Number of job being executed in the system as a function of time
MEDIUM delay15 mxj1 iter1

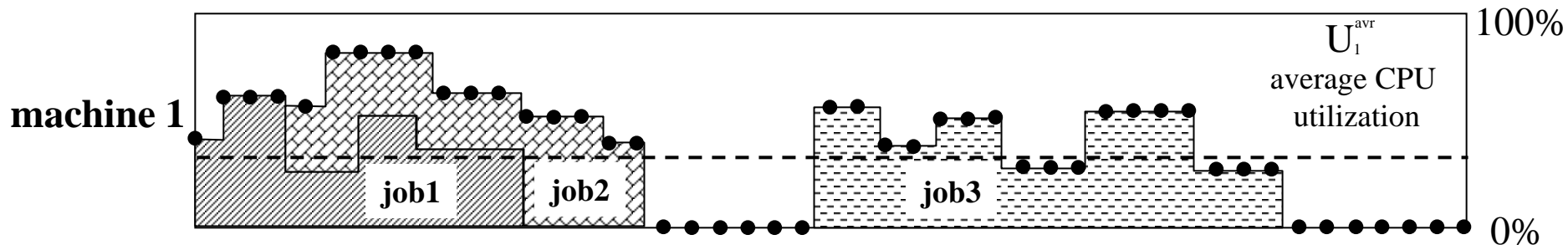


Throughput as a function of the number of jobs taken into account
MEDIUM delay15 mxj2 iter1

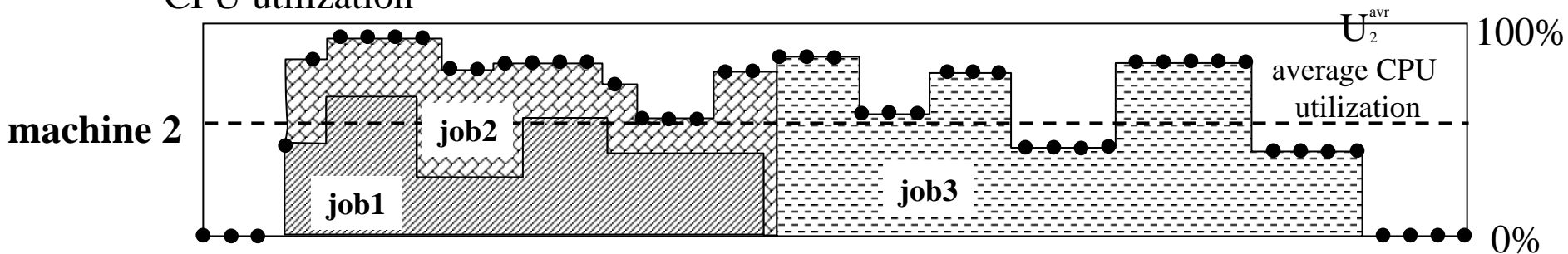


Utilization

CPU utilization



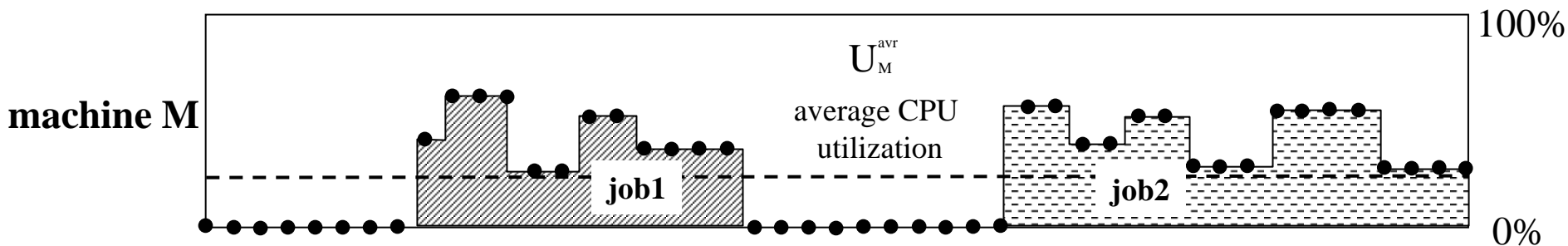
CPU utilization



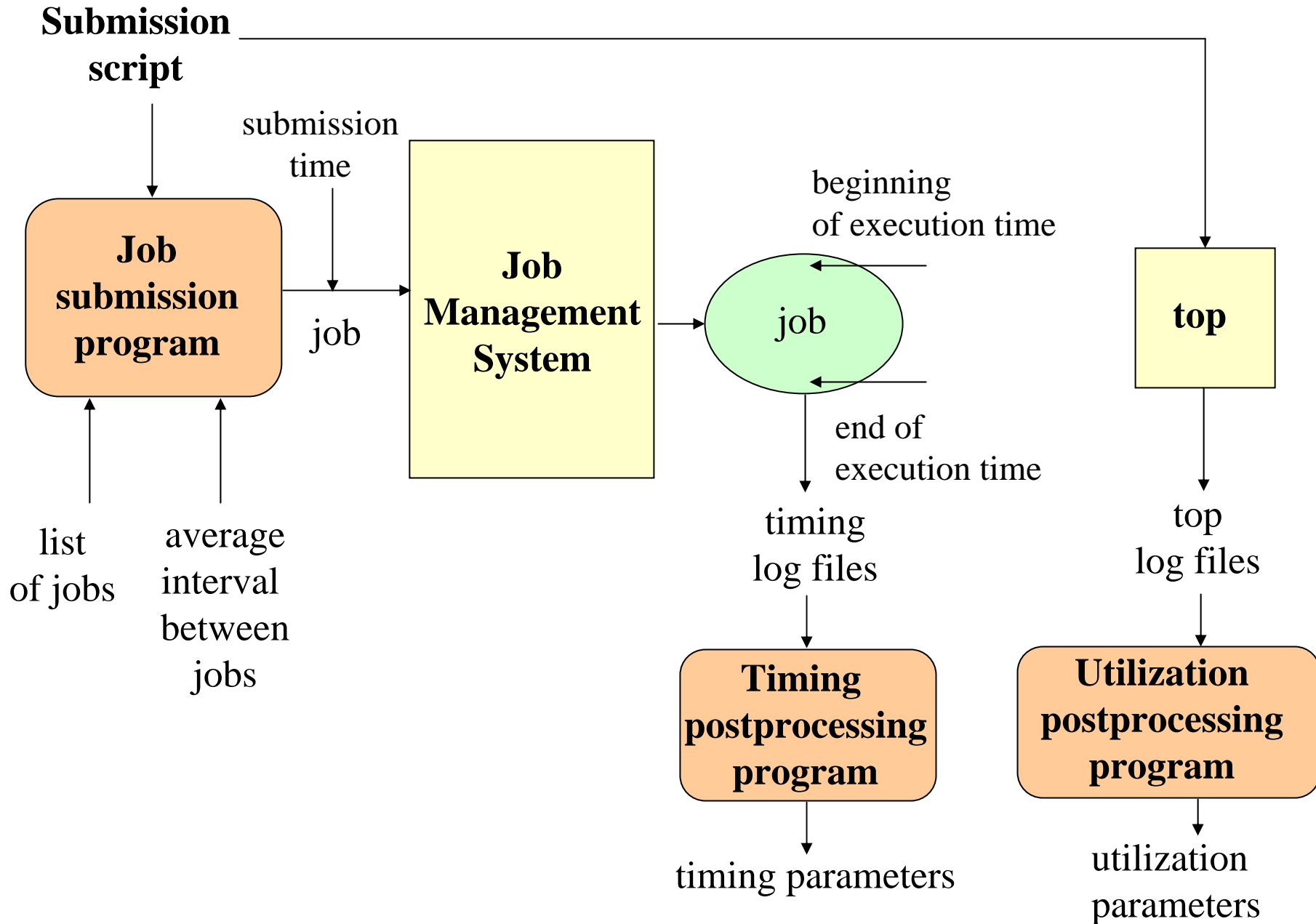
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$$\text{Overall utilization} = U = \frac{1}{M} \sum_{j=1}^M U_j^{avr}$$

CPU utilization

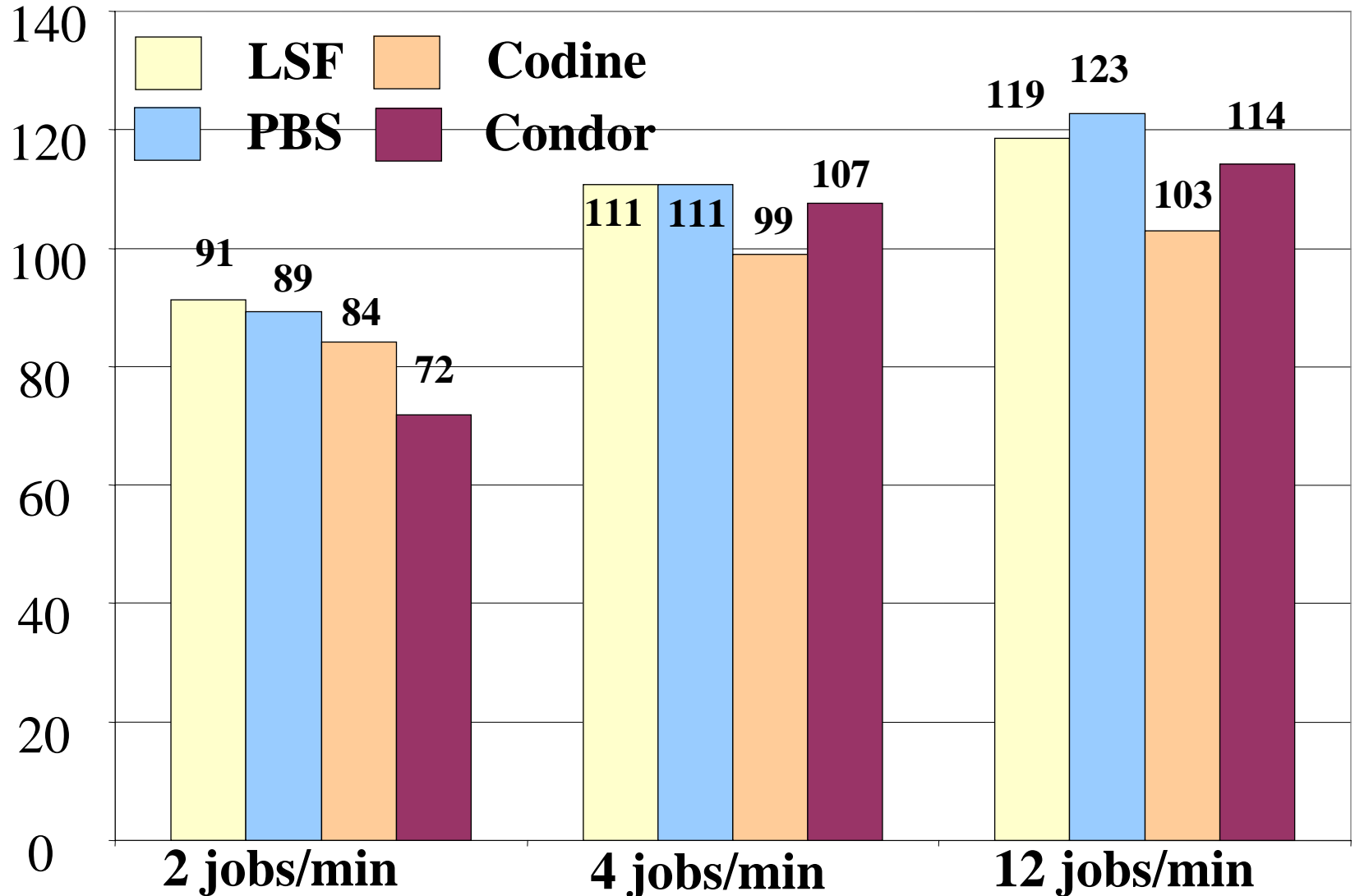


Software used to collect performance measures



Medium jobs – Average Throughput

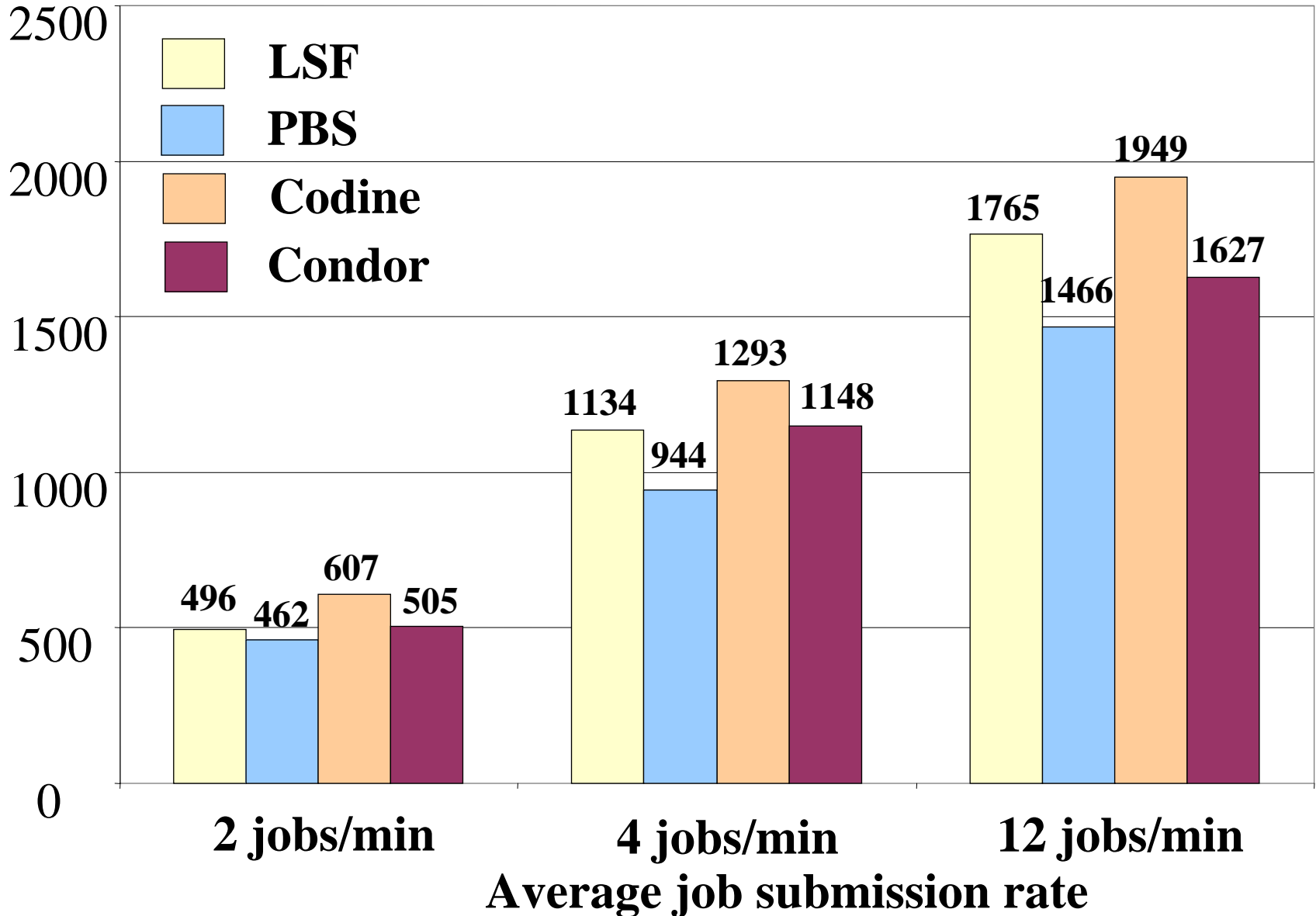
Throughput [jobs/hour]



Average job submission rate

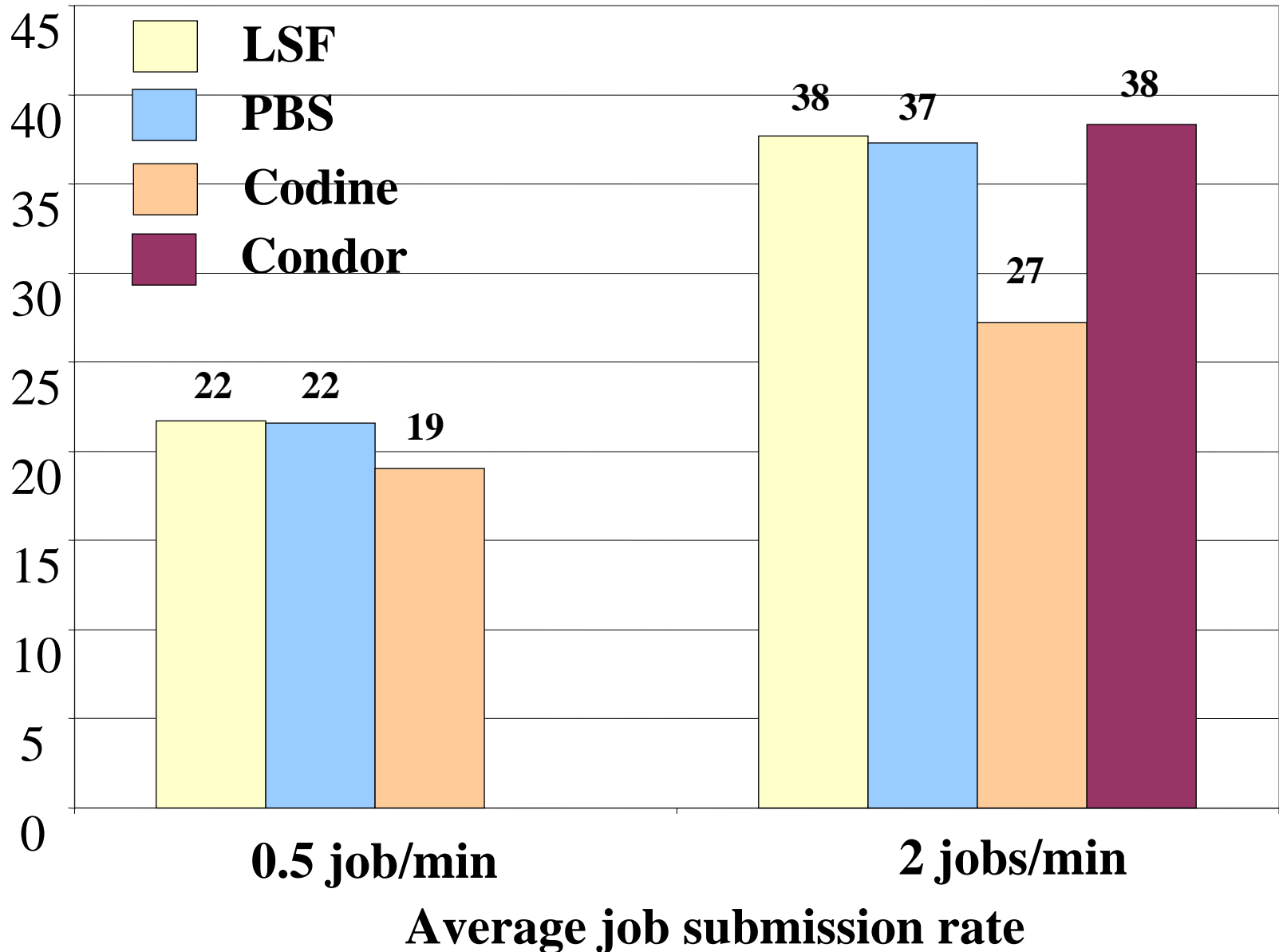
Medium jobs – Turn-around Time

Turn-around Time [s]



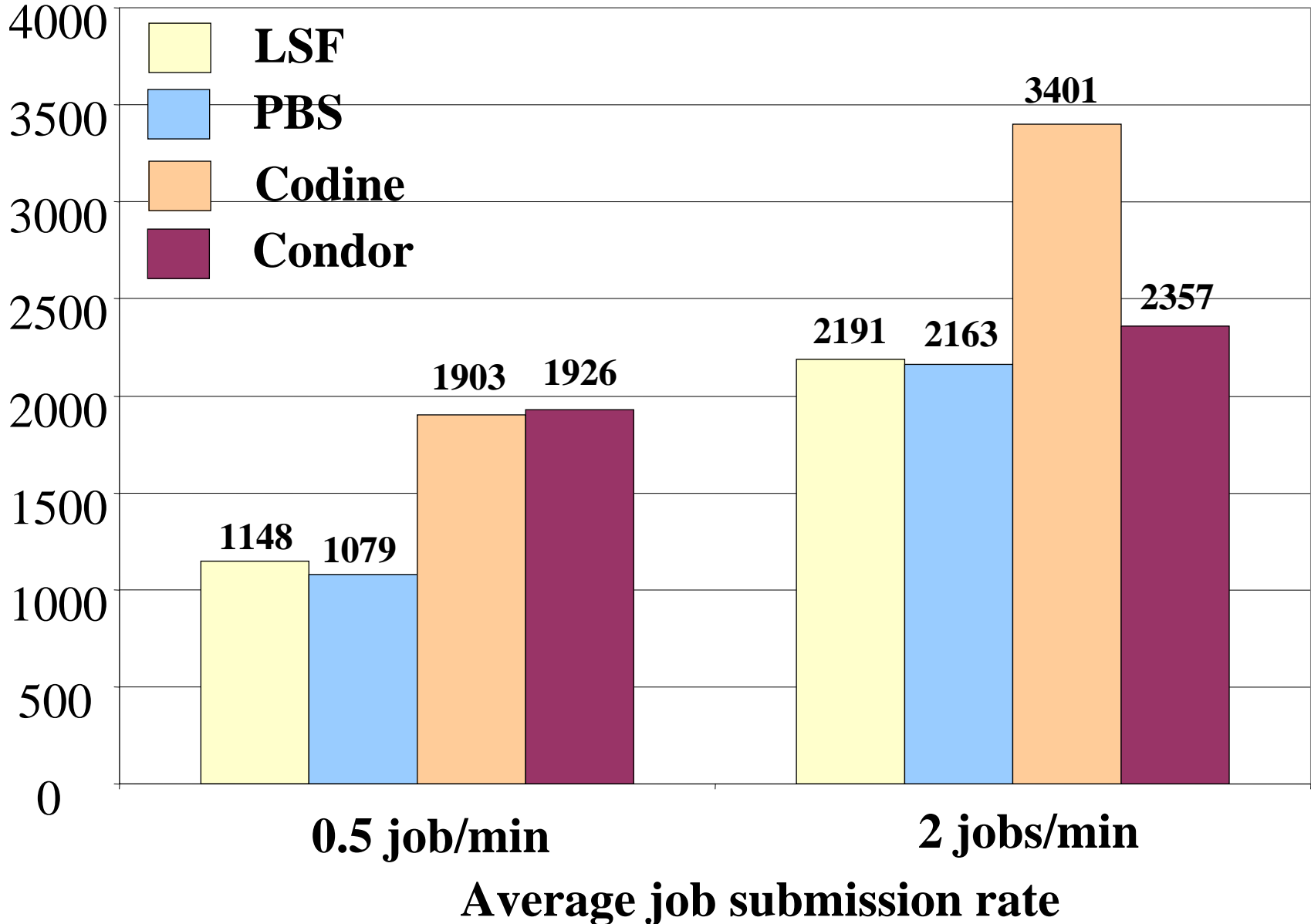
Long jobs – Average Throughput

Throughput [jobs/hour]



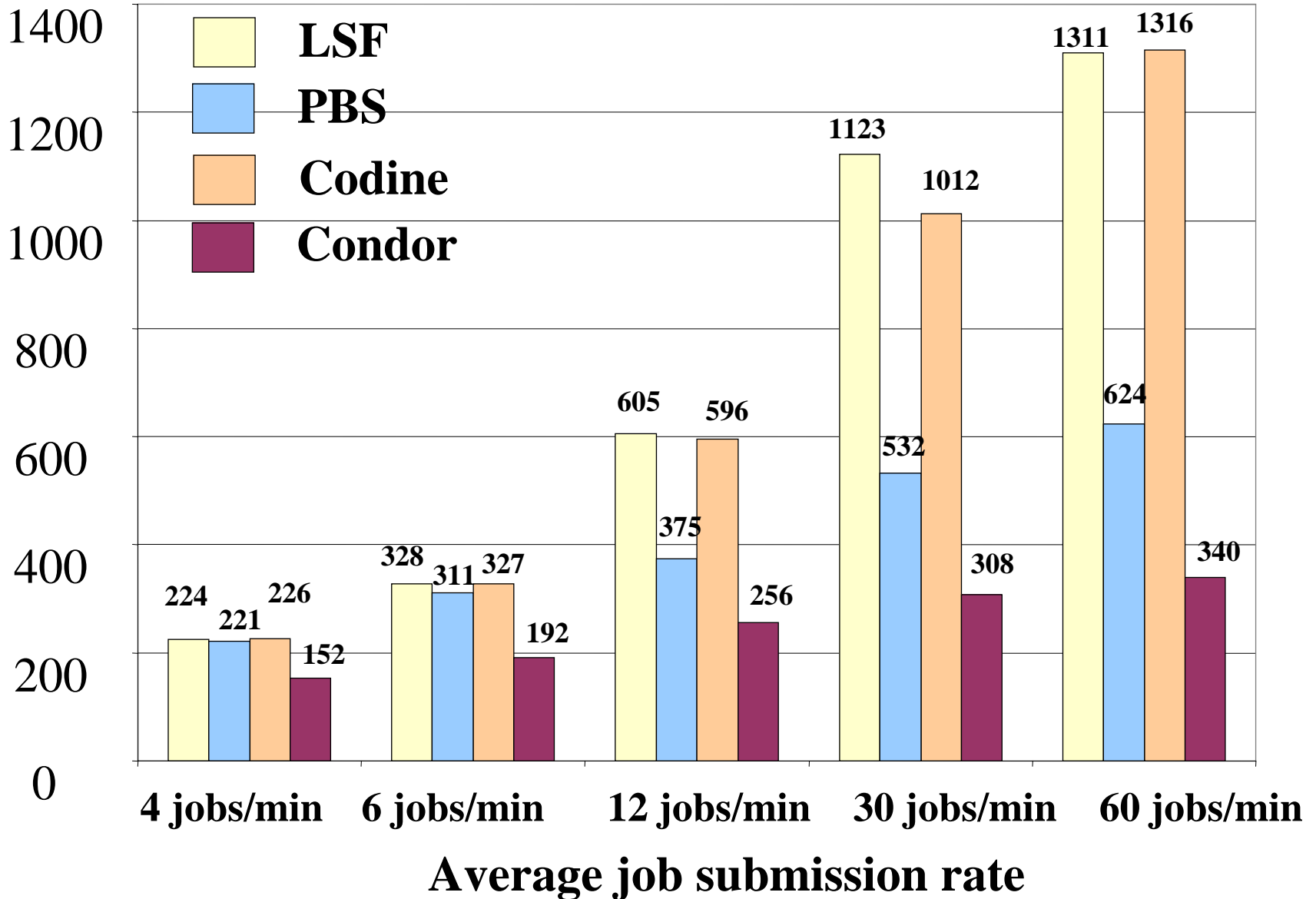
Long jobs – Turn-around Time

Turn-around Time [s]



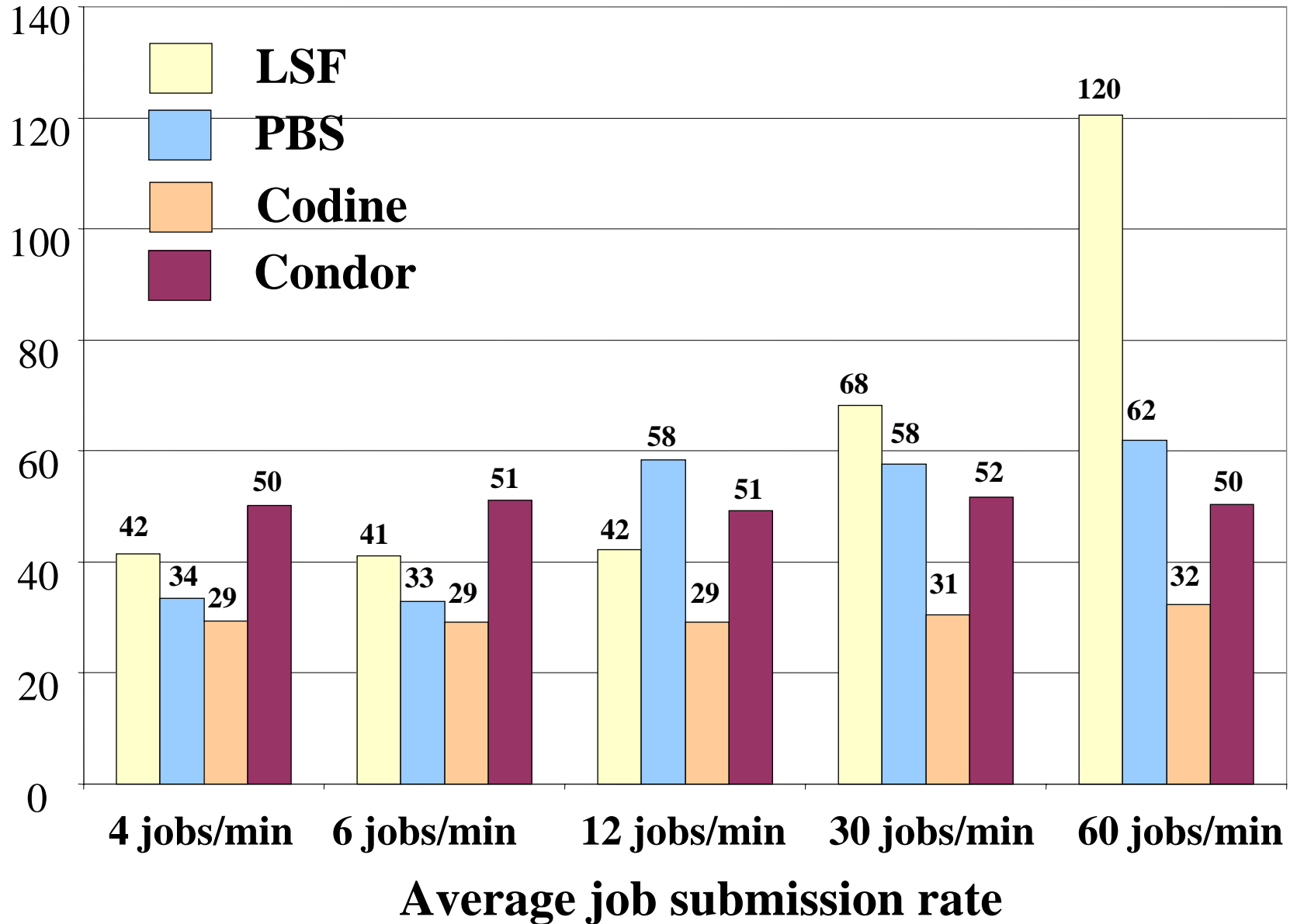
Short jobs – Average Throughput

Throughput [jobs/hour]



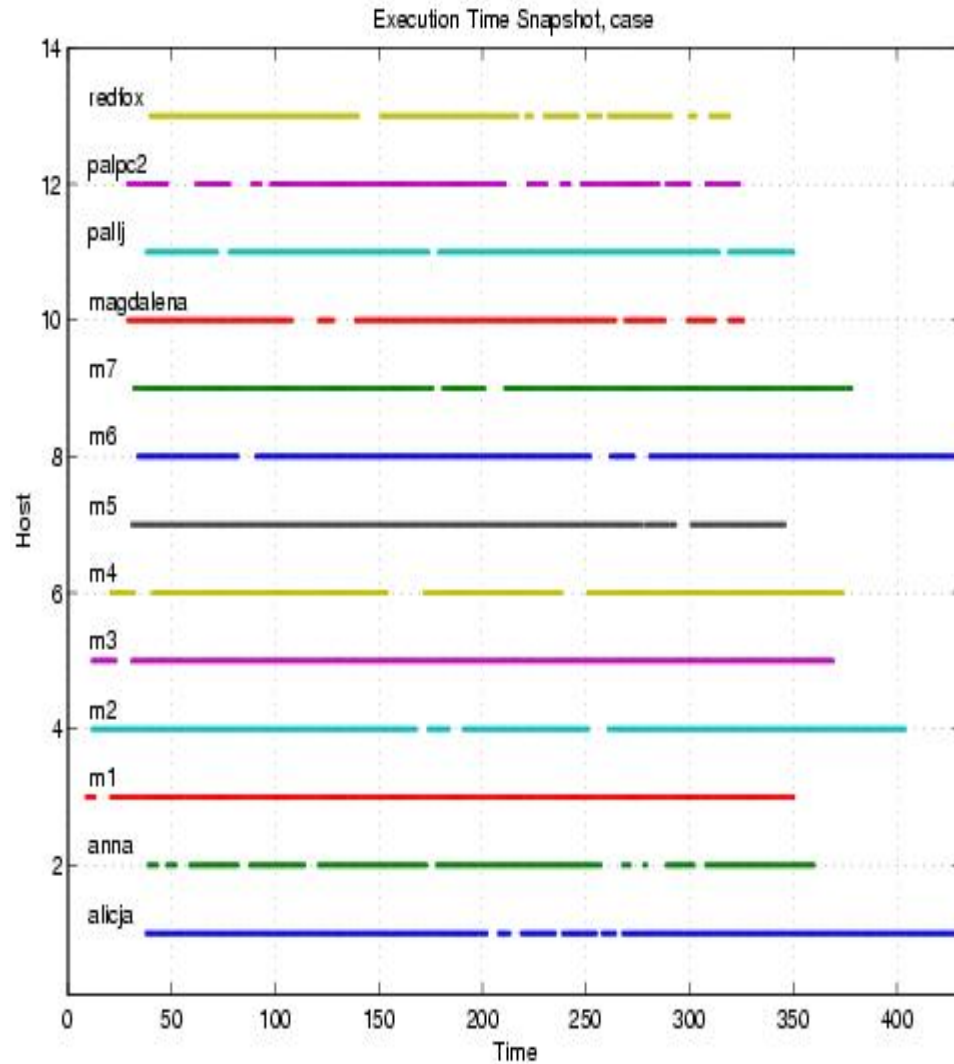
Short jobs – Turn-around Time

Turn-around Time [s]



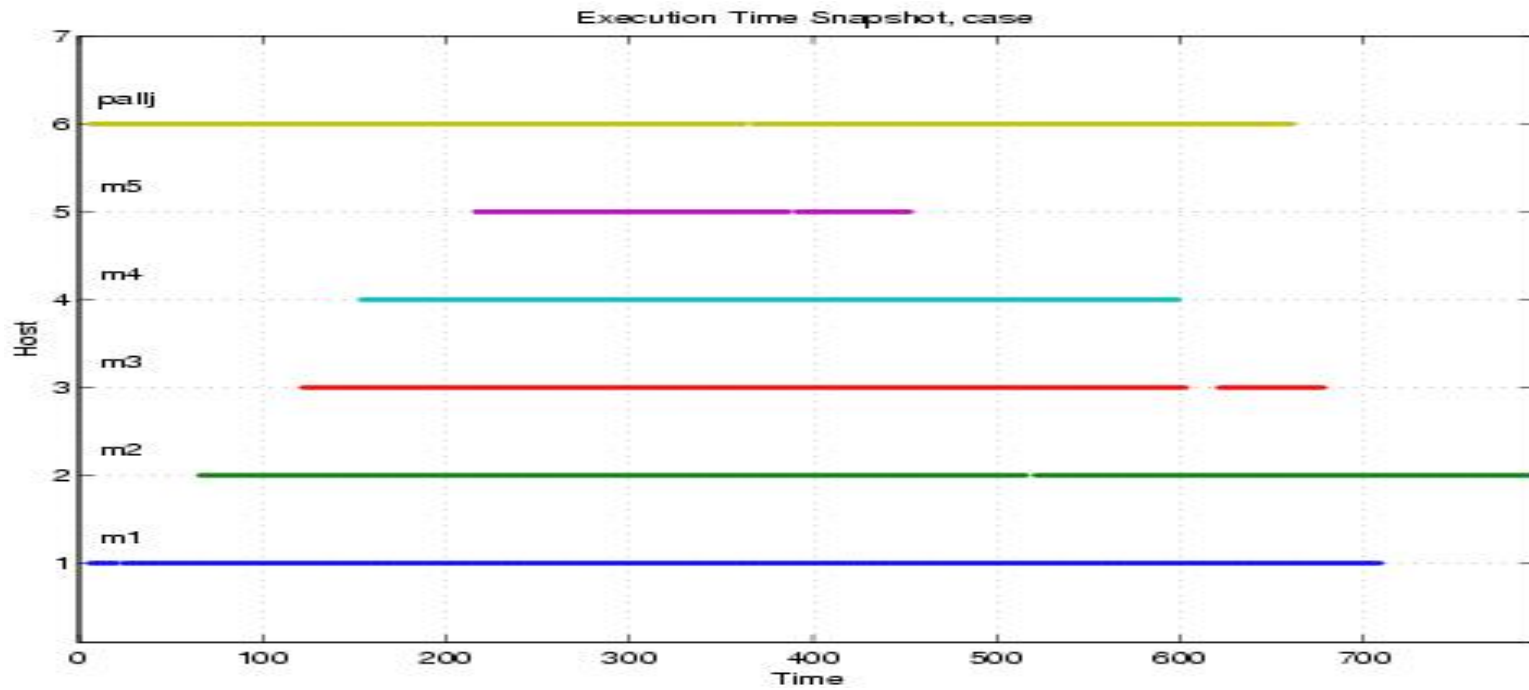
LSF

Small jobs, 60 jobs/min



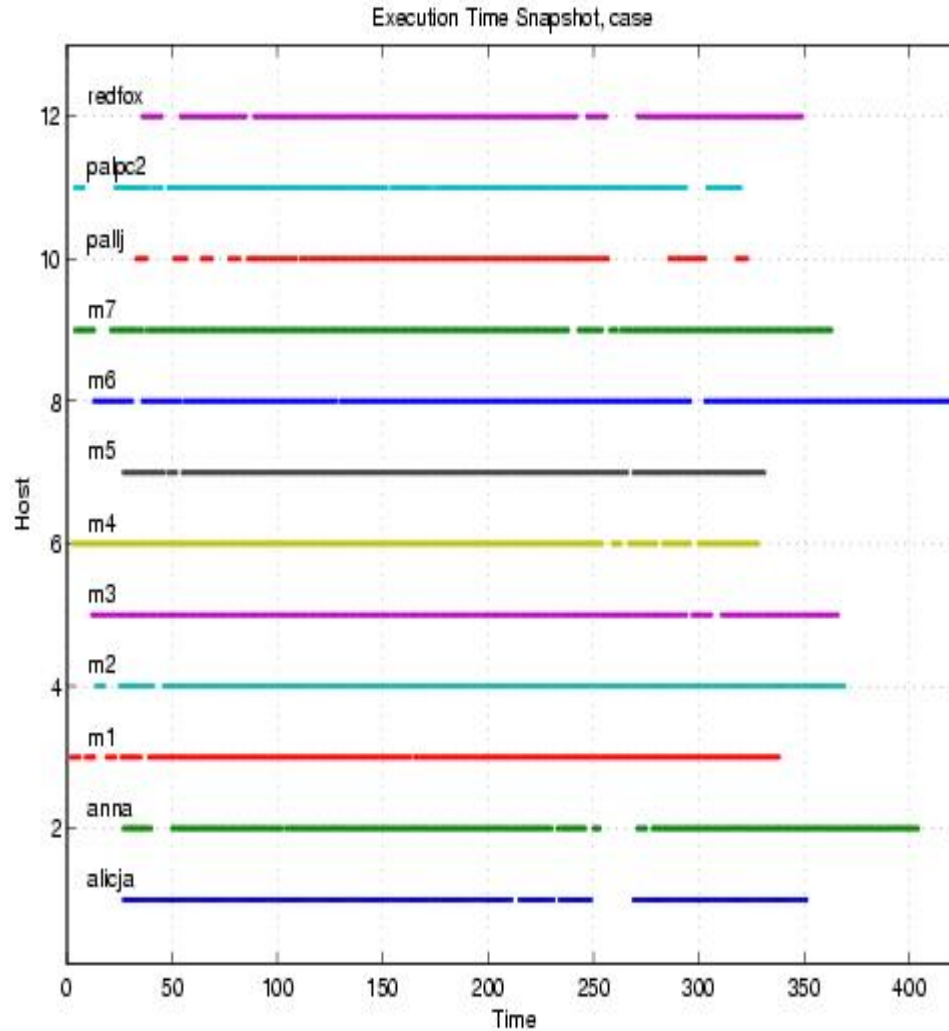
PBS

Small jobs, 60 jobs/min



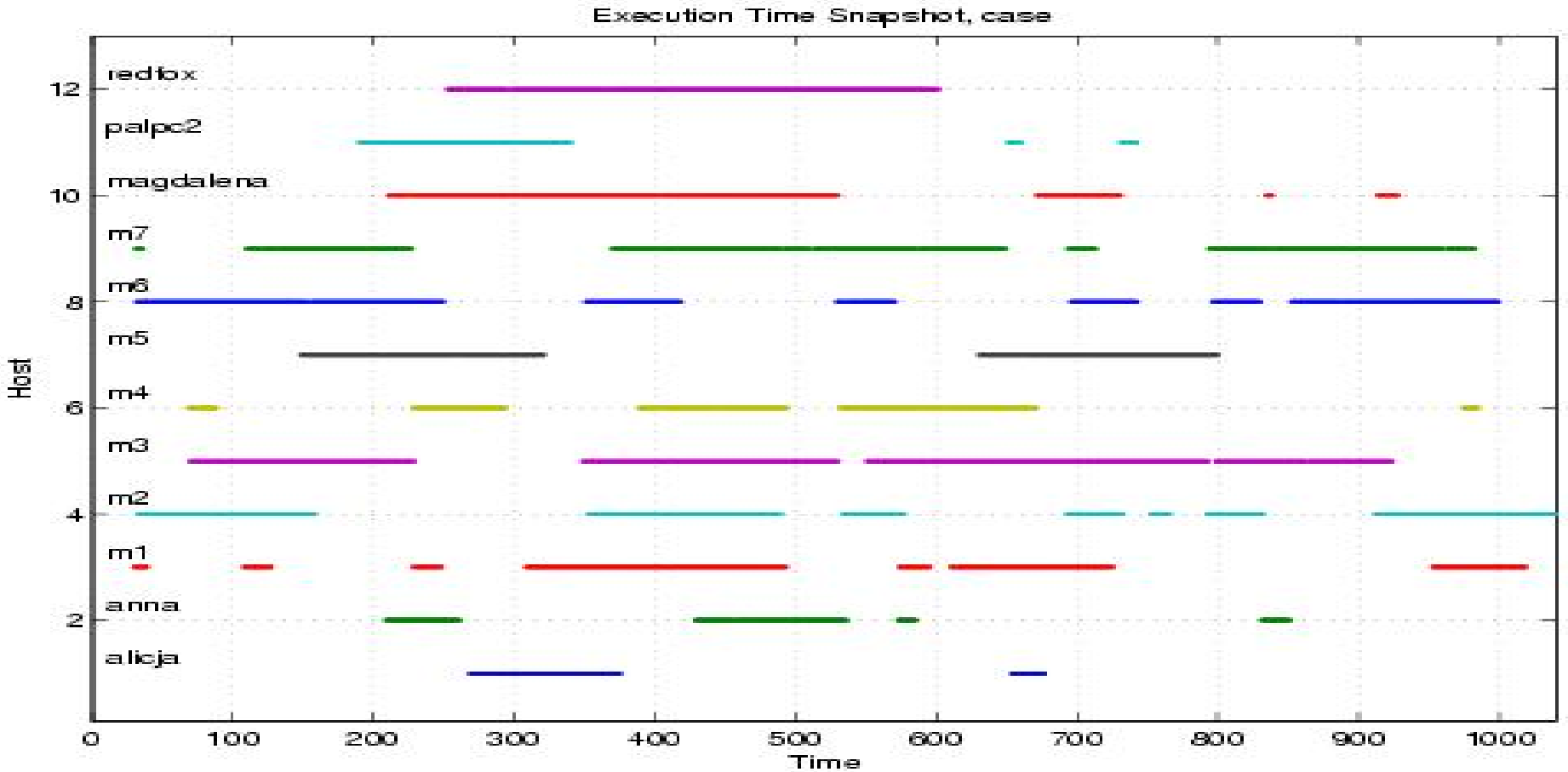
Codine

Small jobs, 60 jobs/min



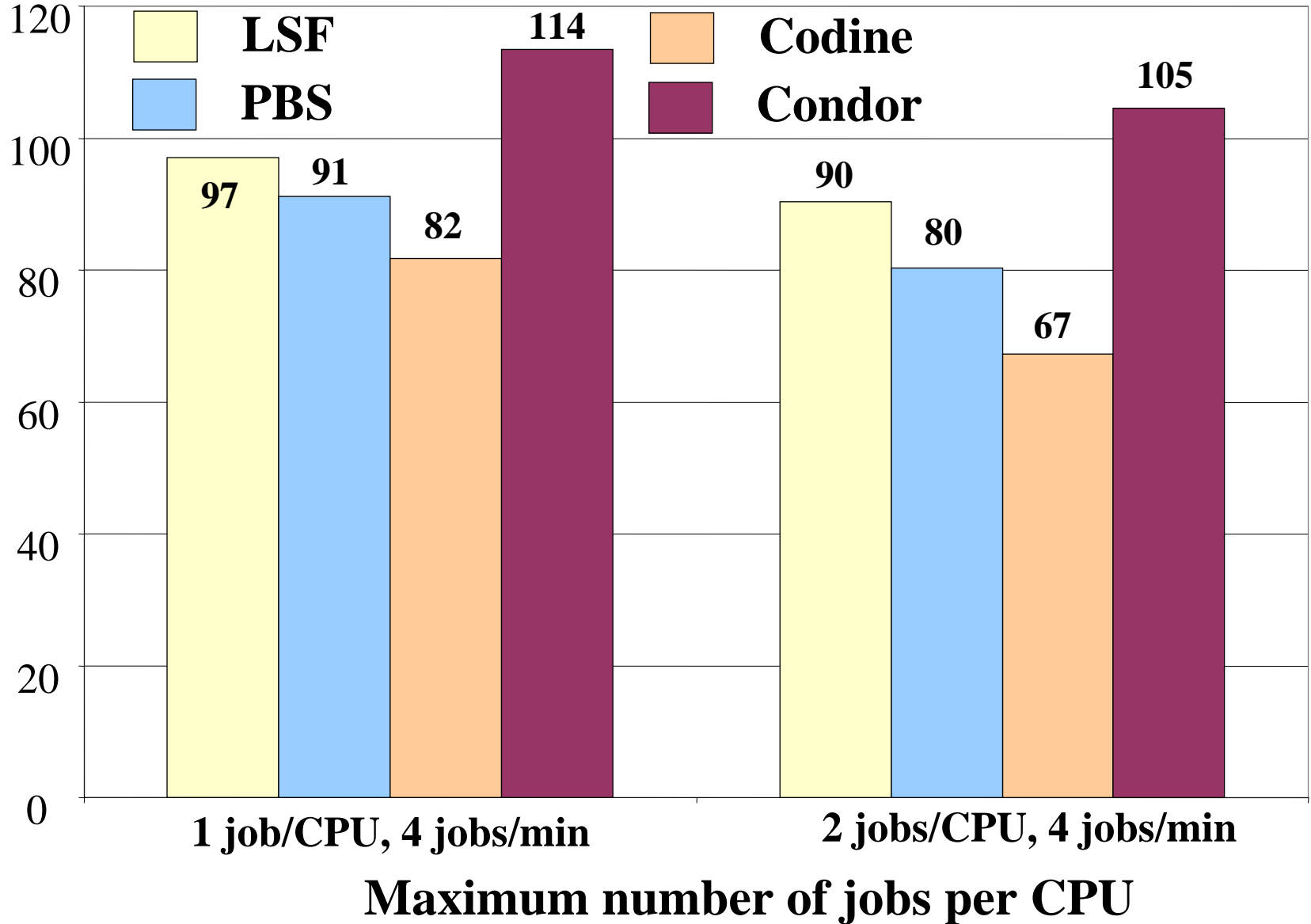
Condor

Small jobs, 60 jobs/min



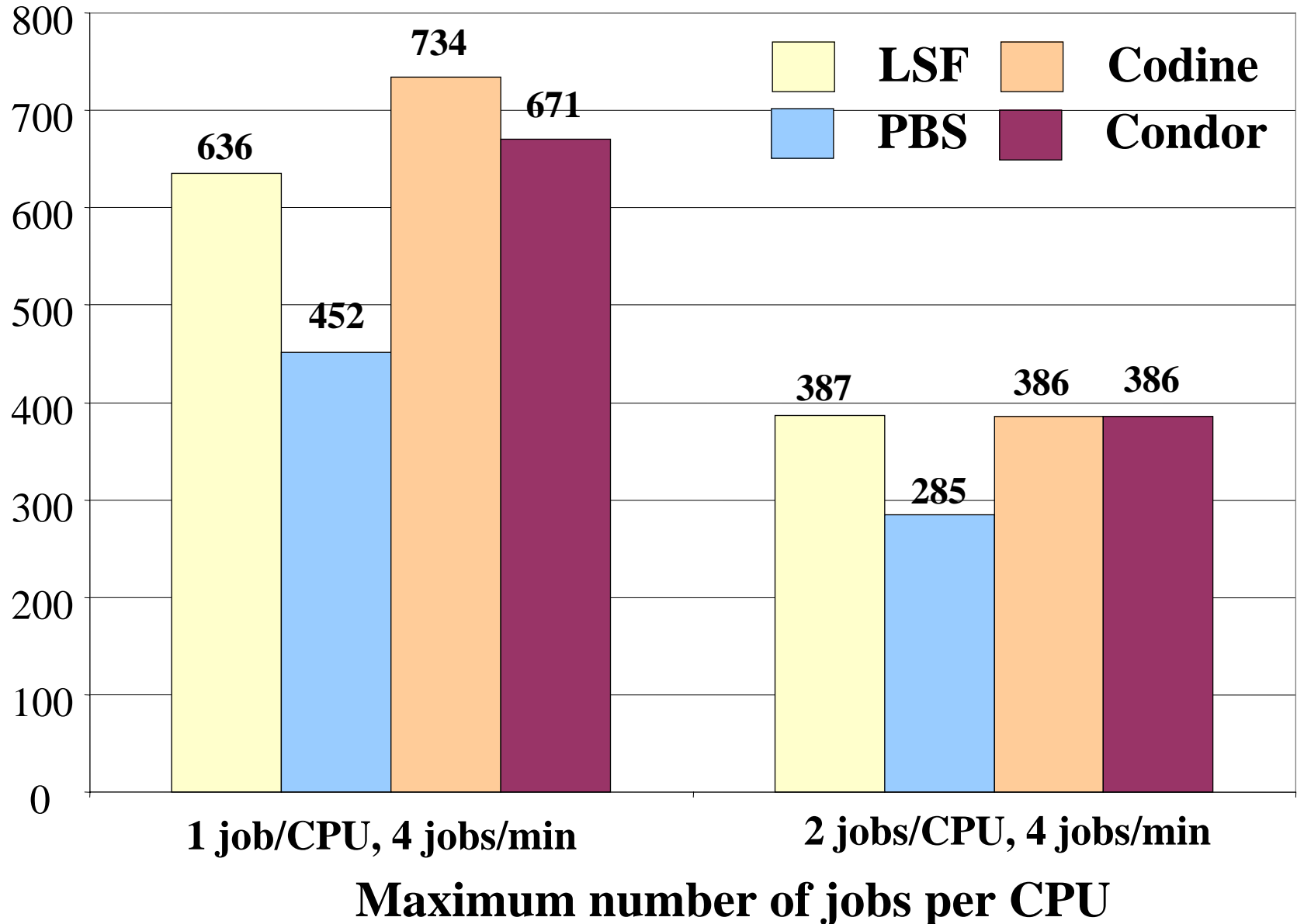
Medium jobs – Total Throughput

Throughput [jobs/hour]



Medium jobs – Response Time

Response Time [s]



Throughput - Summary

Submission rate

Size of jobs	Low	Medium	High
Large	B: LSF , PBS W: Codine (-14%)	B: Condor, LSF , PBS W: Codine (-29%)	
Medium	B: LSF , PBS W: Condor (-21%)	B: LSF , PBS W: Codine (-11%)	B: PBS, LSF W: Codine (-17%)
Small	B: LSF , Codine W: Condor (-57%)	B: LSF , Codine W: Condor (-69%)	B: LSF , Codine W: Condor (-71%)

B: BEST

W: WORST

Turn-around Time - Summary

Submission rate

Size of jobs	Low	Medium	High
Large	B: PBS, LSF W: Condor, Codine (+78%)	B: PBS, LSF W: Codine (+57%)	
Medium	B: PBS W: Codine (+31%)	B: PBS W: Codine (+37%)	B: PBS W: Codine (+33%)
Small	B: Codine W: Condor (+72%)	B: Codine W: PBS (+119%)	B: Codine W: LSF (+275%)

B: BEST

W: WORST

Summary

The best performance in the experimental study

In terms of the throughput

- **LSF** the best for all kind of jobs and submission rates

In terms of the turn-around time

- **PBS** the best for large and medium jobs
- **Codine** the best for small jobs

The worst performance in the experimental study

In terms of the throughput

- **Codine** the worst for medium and large jobs
- **Condor** the worst for small jobs

In terms of the turn-around time

- **Codine** the worst for medium and large jobs
- **LSF** the worst for small jobs and high submission rates