SCOJO – Share-Based Job Coscheduling with Integrated Dynamic Resource Directory in Support of Grid Scheduling

Angela C. Sodan and Xuemin Huang
University of Windsor, Canada

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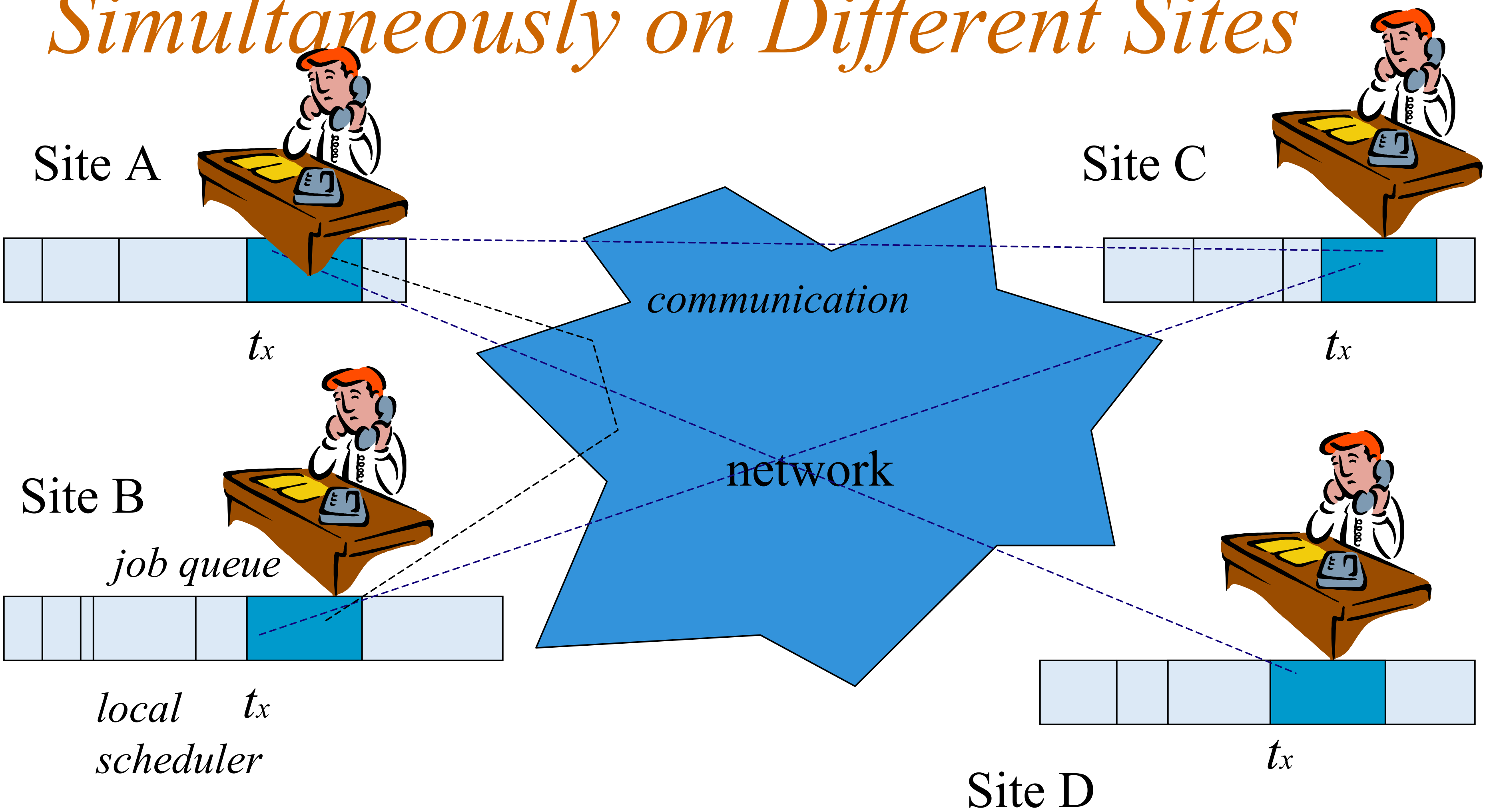
Outline

- Introduction
  - Scheduling on the Grid
  - Local Support for Grid Scheduling
- SCOJO Scheduler
  - Reservation and QoS Scheduling
  - Dynamic Resource Directories
  - Experimental Results
- Summary and Future Work

Computational Grids – Our Goal

- Make resources from different sites jointly available and run application across multiple sites
- Requires middleware like Globus for bridging heterogeneous software and hardware, providing security, and QoS
- Needs to prepare local scheduling

Problem: Scheduling Jobs Simultaneously on Different Sites

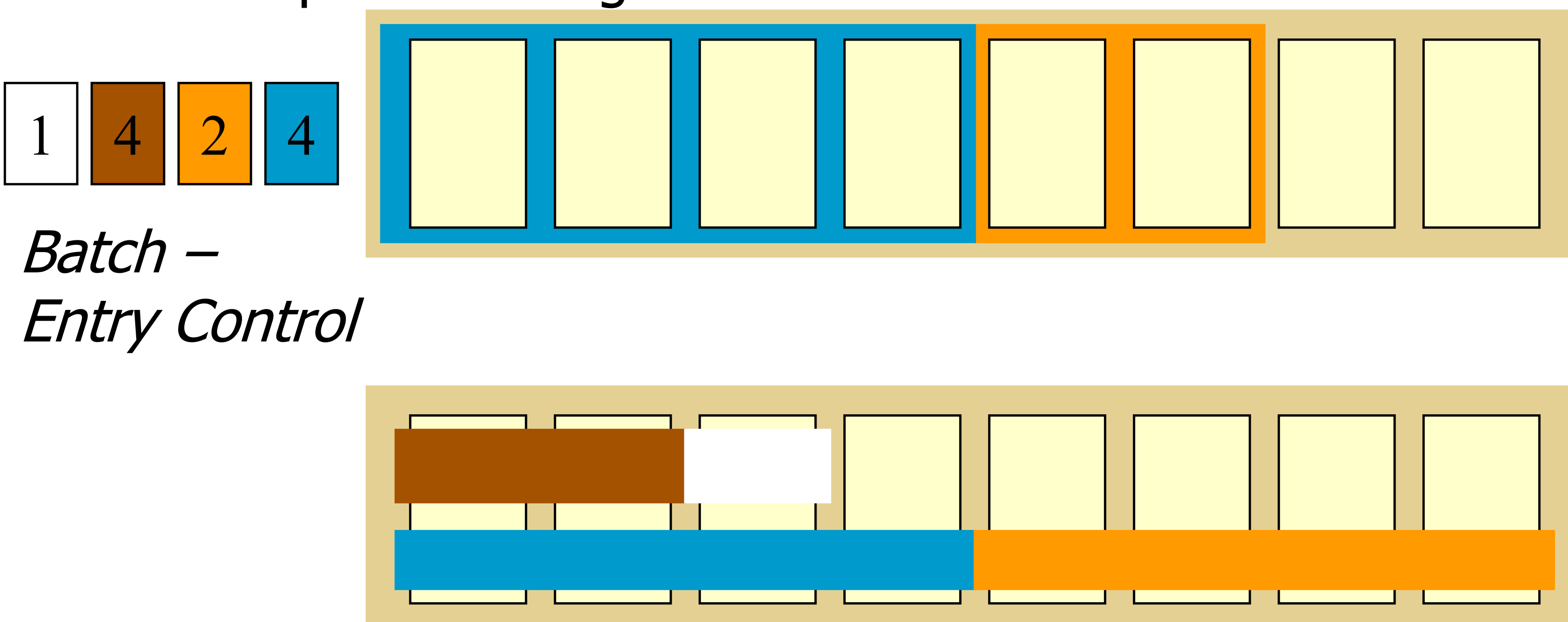


Possible Approaches to Local Scheduling

- Immediate scheduling for flexible time-shared execution
  - On most shared-memory machines (e.g. IRIX switched back to it as default in 6.5)
  - In NOWs
- Batch scheduling with job queues
  - In most clusters
  - In most cases exclusive resource assignment (space sharing), possibly gang

Job Scheduling

Space Sharing

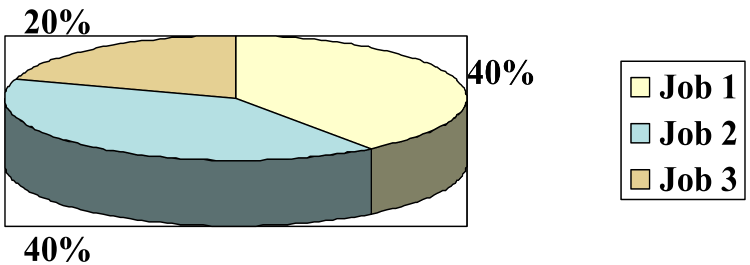


Time Sharing

Loosely-Coordinated Coscheduling

- Motivation:
  - Close to standard time sharing
    → Permits latency hiding (communication, I/O)
    → Better exploitation of hyperthreading
    → Better resource utilization
  - Multiple time-shared applications mean multiple virtual machines and thus scheduling options (esp. important if no preemption / adaptation)
    → Better response times

SCOJO: QoS Loosely Coordinated Coscheduling



- Exploits loose coscheduling
- Adds again entry control (which, how many)
- Permits start-time and share reservations for simultaneous grid applications
- Guarantees certain time shares

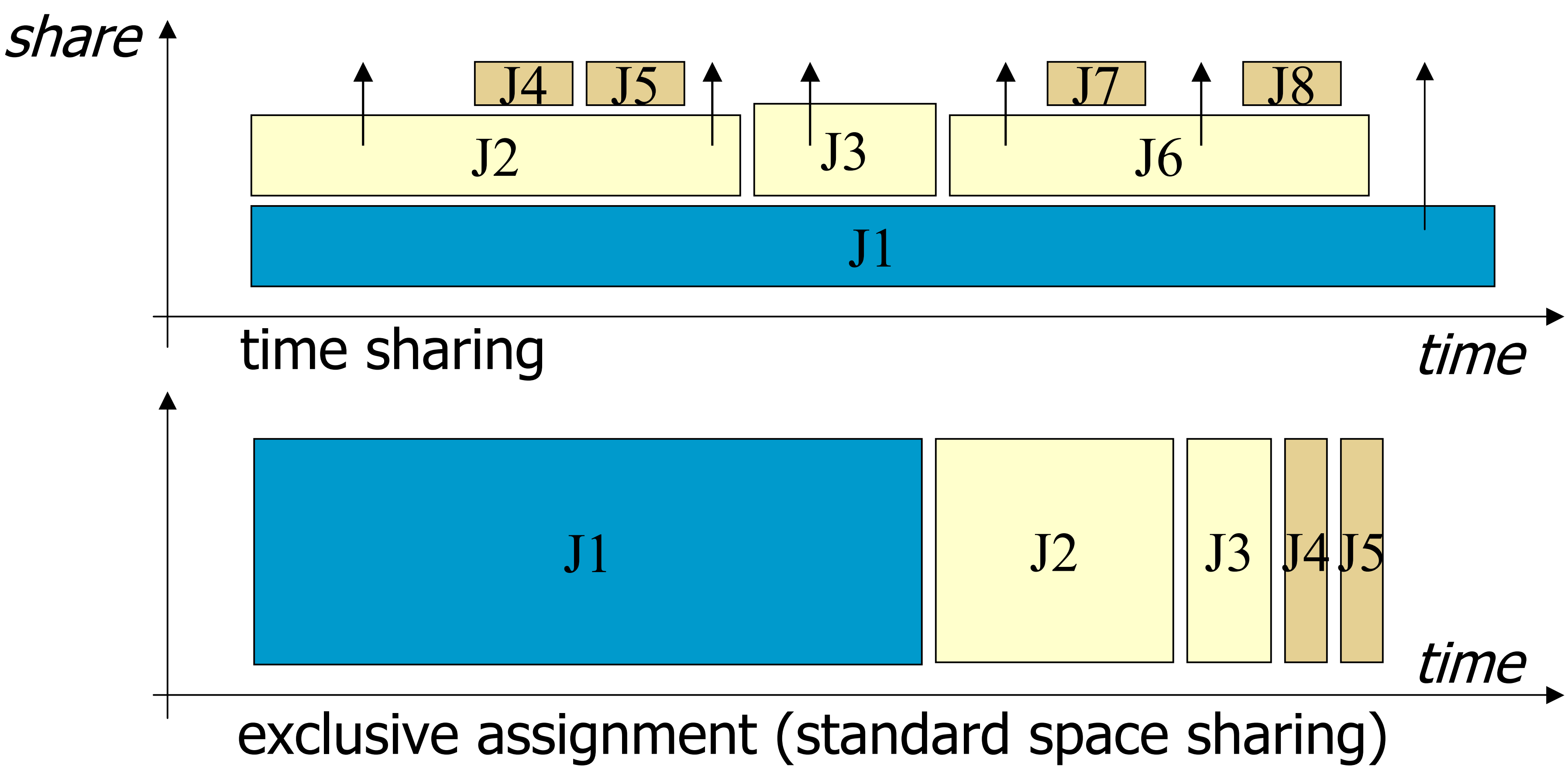
Taking a Closer Look at Co-Scheduling

- Requires loose coordination and limited use of polling → change in MPI implementation and OS support
- Speedup: I/O and long communication latencies can be hidden
- Slowdown: medium-range communication - slowdown increasing with multiprogramming level

Some Special Features in SCOJO

- Exploits application characteristics
- Guarantee effective shares
- Can easily exploit all free shares
- Can deal with wrong estimates
- Uses backfilling and priorities (aging)
- Envisions (distributed) protocol to find all possible matching slots at different places (master per application)

Co-Scheduling with Guaranteed Shares and Full Utilization



Our Findings

- Slowdowns differ – patterns, granularity and combination matter

	Grid-300	Grid-1200	Grid-2400	Central	Random
Grid-300	1.2	1.4 / 1.1	2.2 / 0.9	0.9 / 1.6	1 / 1.3
Grid-1200		1.2	1.4 / 0.8	1.1 / 1.7	1 / 1.4
Grid-2400			1.1	1 / 3.1	1.5 / 2.3
Central				1.3	1.3 / 0.9
Random					2

Effective Shares

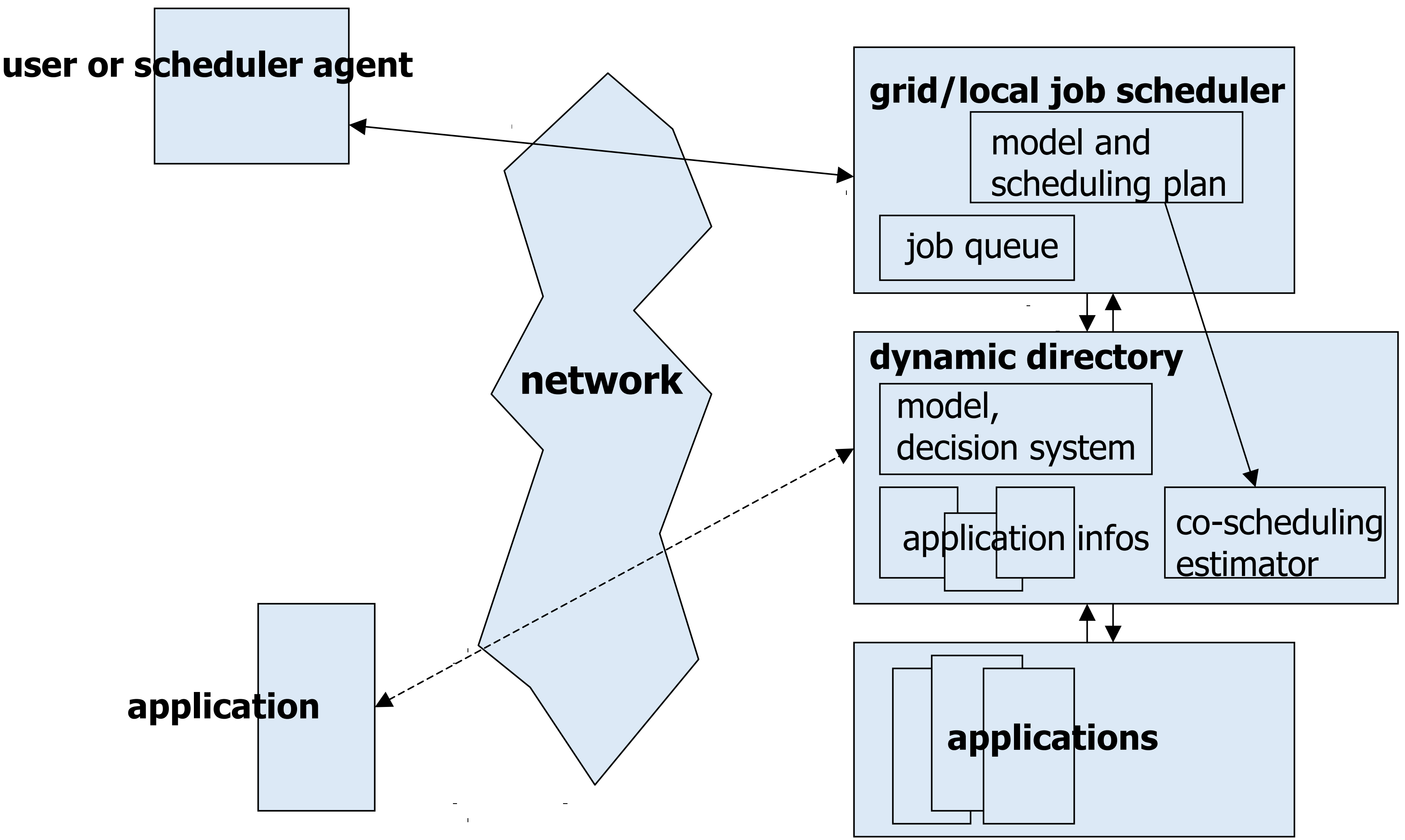
- Use application characteristics to determine slowdown/speedup factor
- Determine coschedule yes/no
- Calculate *effective shares* to provide stability and keep (remote) guarantees
- If slowdown, increase actual share

  e.g. if requested and guaranteed share is 30% and slowdown 1.2, then actual share of 30%*1.2 = 36% would be reserved

SCOJO – Our Approach for Share-Based Scheduling (cont.)

- Additional measures/benefits:
  - Reserve only up to R_{max} share and priorities
    →Enable short jobs to get through quickly (if long one running), better response times
    →Give the possibility to schedule other work if start-time reservation for remote job
    →Use for overrun, can do without preemption
  - Free shares easy to use (fragmentation only if cross-site extra shares not usable)

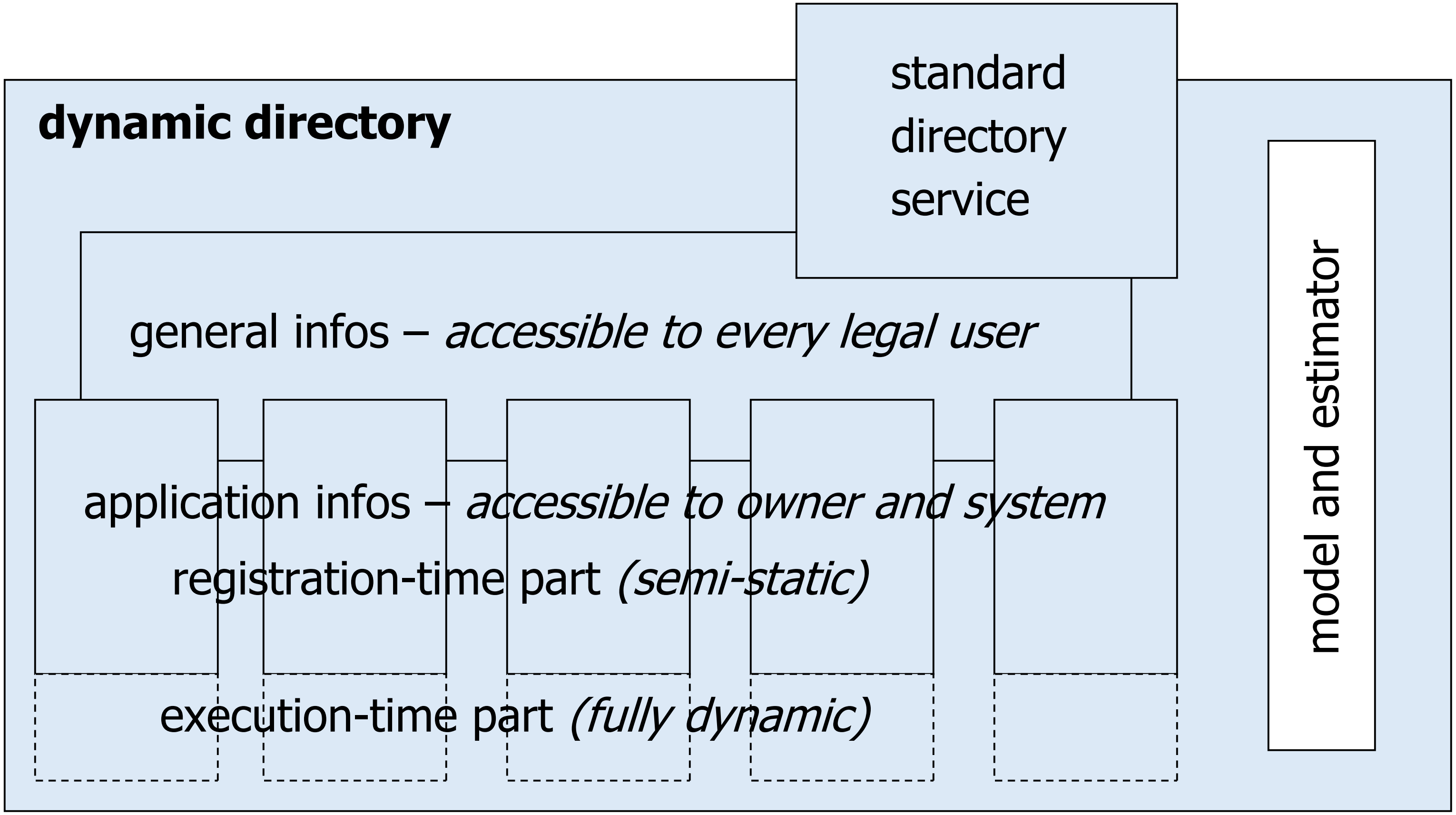
SCOJO – The Overall System



The Dynamic Directory

- Stores application characteristics
  - Runtime, granularities, patterns, owner etc.
- Problem:
  - Exposes details of site and applications
- Solution:
  - Multiple views / access on data with different access permissions / keys
  - Private data of application not exposed to other applications

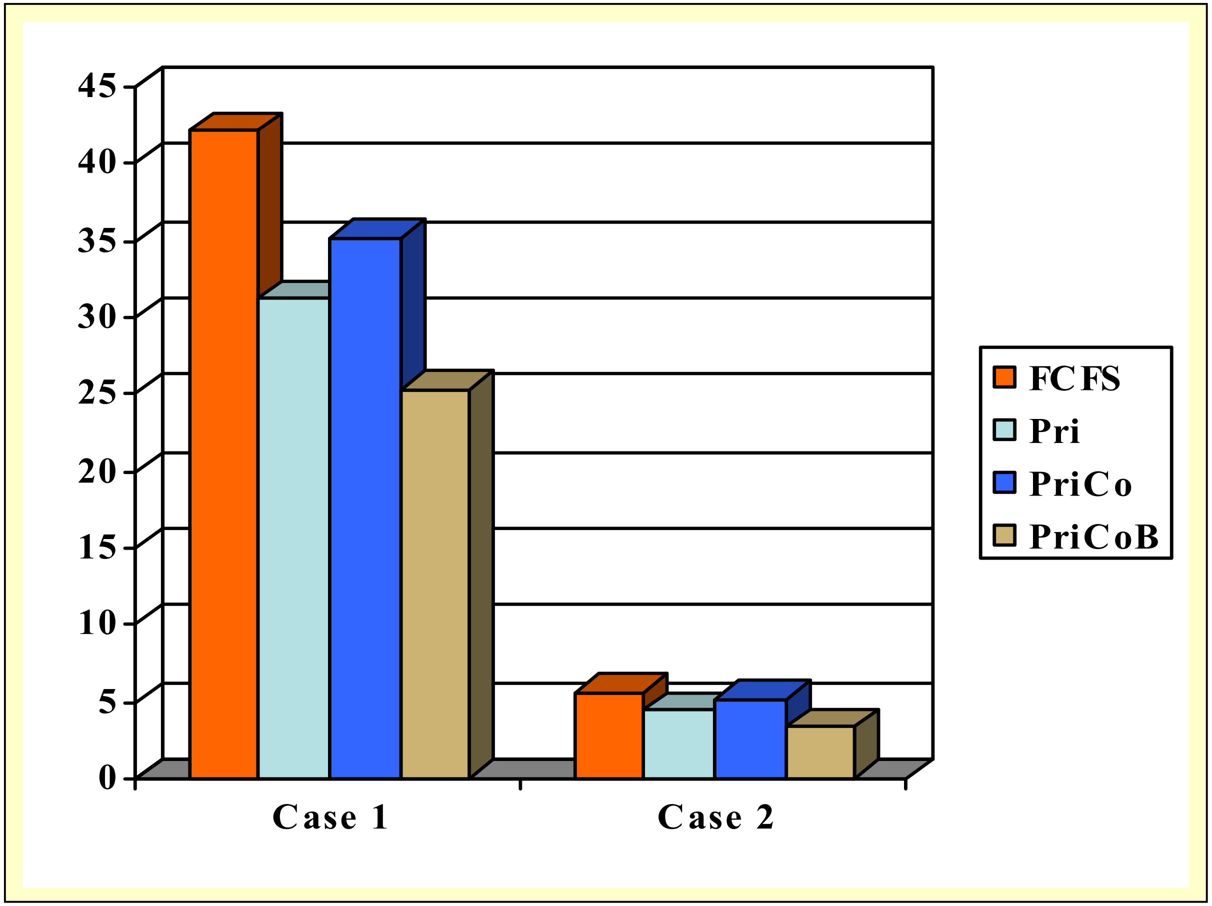
The Dynamic Directory



Experimental Results

- Enabling cross-site scheduling with start-time and share reservation, overrun
  - →Demonstrate feasibility
- Response-time improvement
  - →Quantification
- Used simulations and test runs on SMP server (Sun Enterprise 6500 / Solaris 8, SUN MPI)

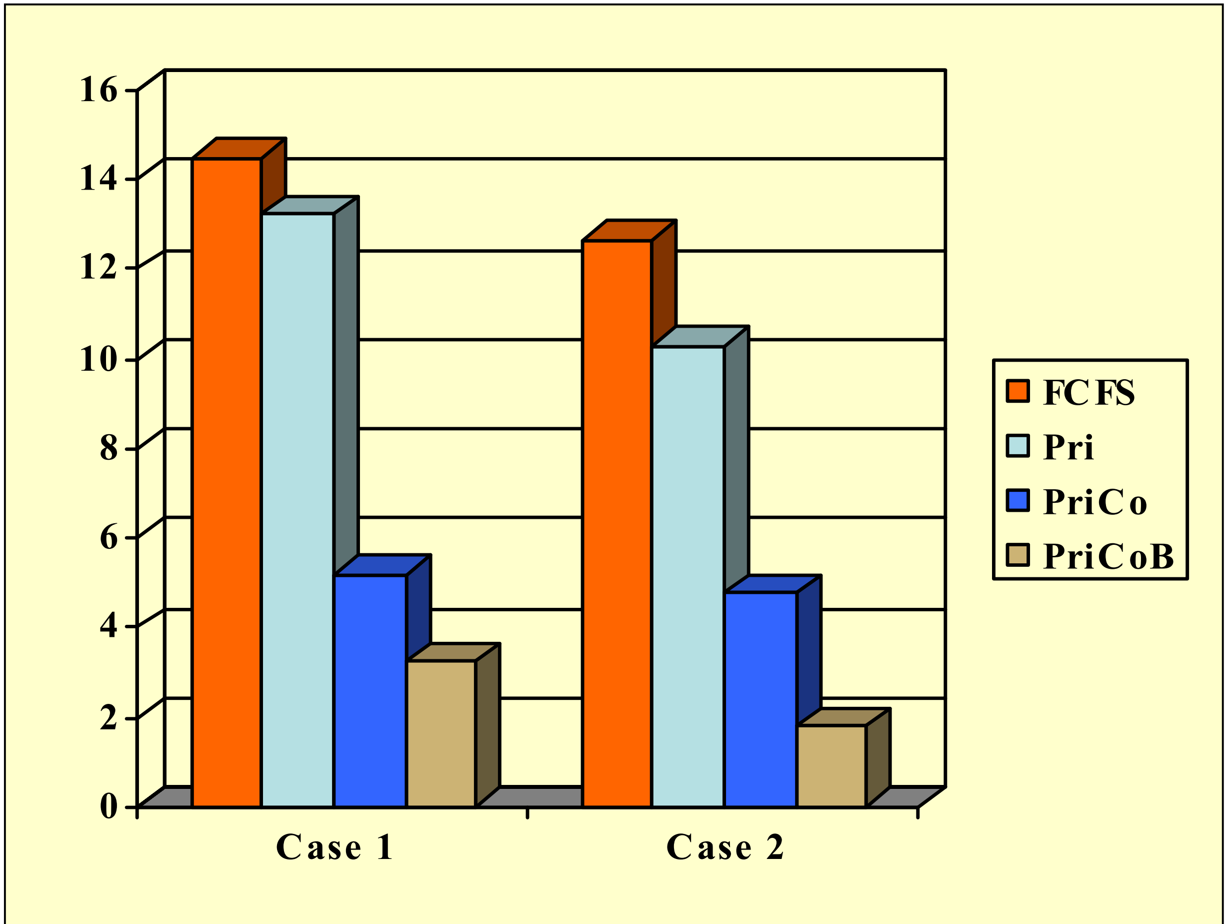
SCOJO – Results of Simulation Study



avg. response time,
Mlevel = 2,
equal shares,
real program runs
(test overrun)

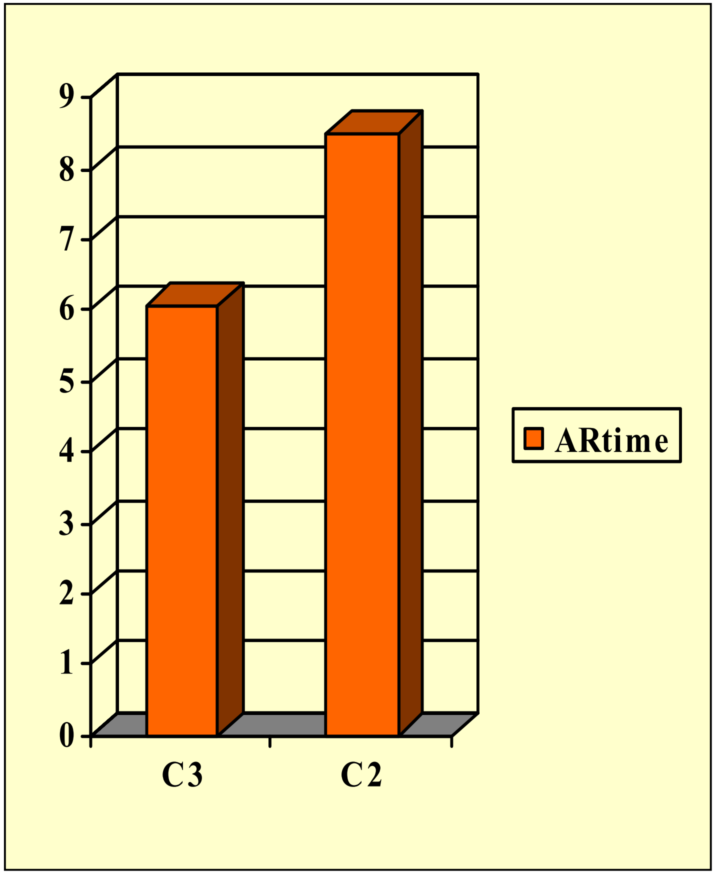
2 workloads:
Case 1:
similar to NASA Ames,
iPSC/860
Case 2:
similar to NCSA,
Origin 2000

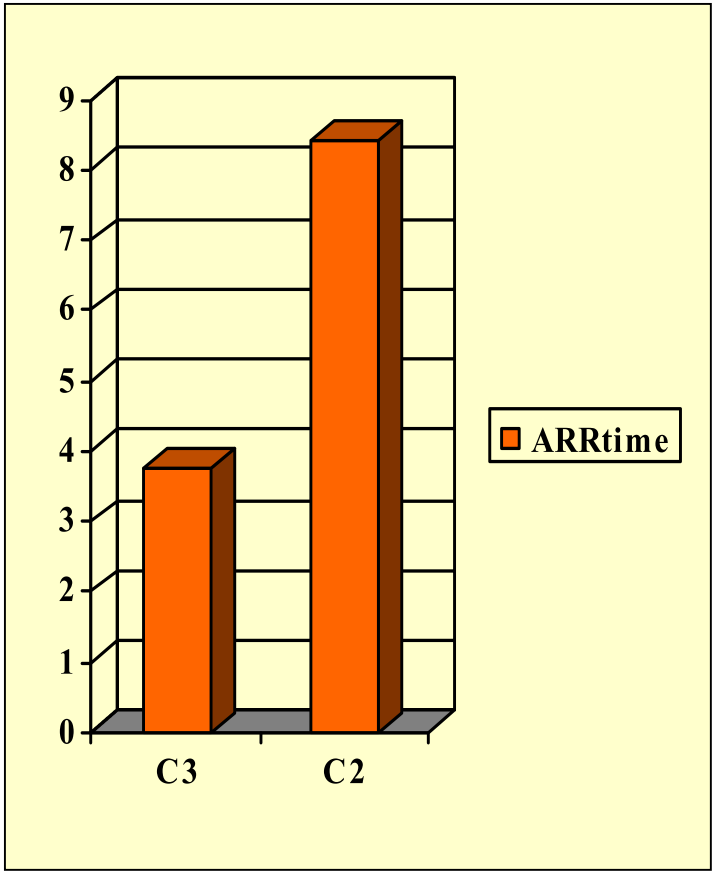
SCOJO – Results of Simulation Study



average relative response time, same setting

SCOJO – Results of Simulation Study





average and average relative response time, flexible shares, slowdown 1.2,
C2: Mlevel = 2
C3: Mlevel = 3

Summary

- SCOJO
  - QoS share reservation in batch/time-scheduling (with backfilling and priorities)
  - Dynamic directory with application infos
- Benefits
  - Stable/QoS scheduling
  - More flexible scheduling across sites
  - Better response times
  - Better resource utilization

Future Work

- Integration into existing job schedulers
- Combination with space sharing, adaptation
- Test I/O- and memory-bound applications
- True local share allocation
- Integration into grid software like Globus
- Dynamic Directory: Globus OGSA which permits stateful dynamic services, database
- Improvements of co-scheduling, model