Middleware and Virtualization Management

Resource Co-Allocation for Large-Scale Distributed Environments

Claris Castillo (IBM T.J. Watson Research Center)
George Rouskas (North Carolina State University)
Khaled Harfoush (North Carolina State University)

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Motivation (1)

- **Co-allocation of resources: allocation of multiple resources within the same time window**
- **Emergence of new paradigms**
  - On Demand computing (Amazon EC2, SalesForce, IBMCloud)
- **Requirements**
  - QoS/SLA support
  - Efficiency
  - Scalability
- **Emergence of new applications that capitalized on the availability of distributed computing to perform tasks with spatial and temporal dependencies (MapReduce/financial apps.)**

Motivation (2)

- **Applications**
  - Virtual Computing Lab (VCL)
  - MapReduce framework (Hadoop)
  - Grid lambda scheduling
  - Workflow scheduling

Background

- **Naïve Approach: A co-allocation request can be treated as a group of sequential scheduling requests**
  - Inappropriate for time sensitive applications
- **Batch scheduling**
  - Resource driven: optimizing for system performance
    - Limited support for QoS by means of backfilling and priorities
  - Job driven: optimizing for application performance
- **Advance reservations**
  - QoS provisioning
  - Workflow support
  - Multiple drawbacks

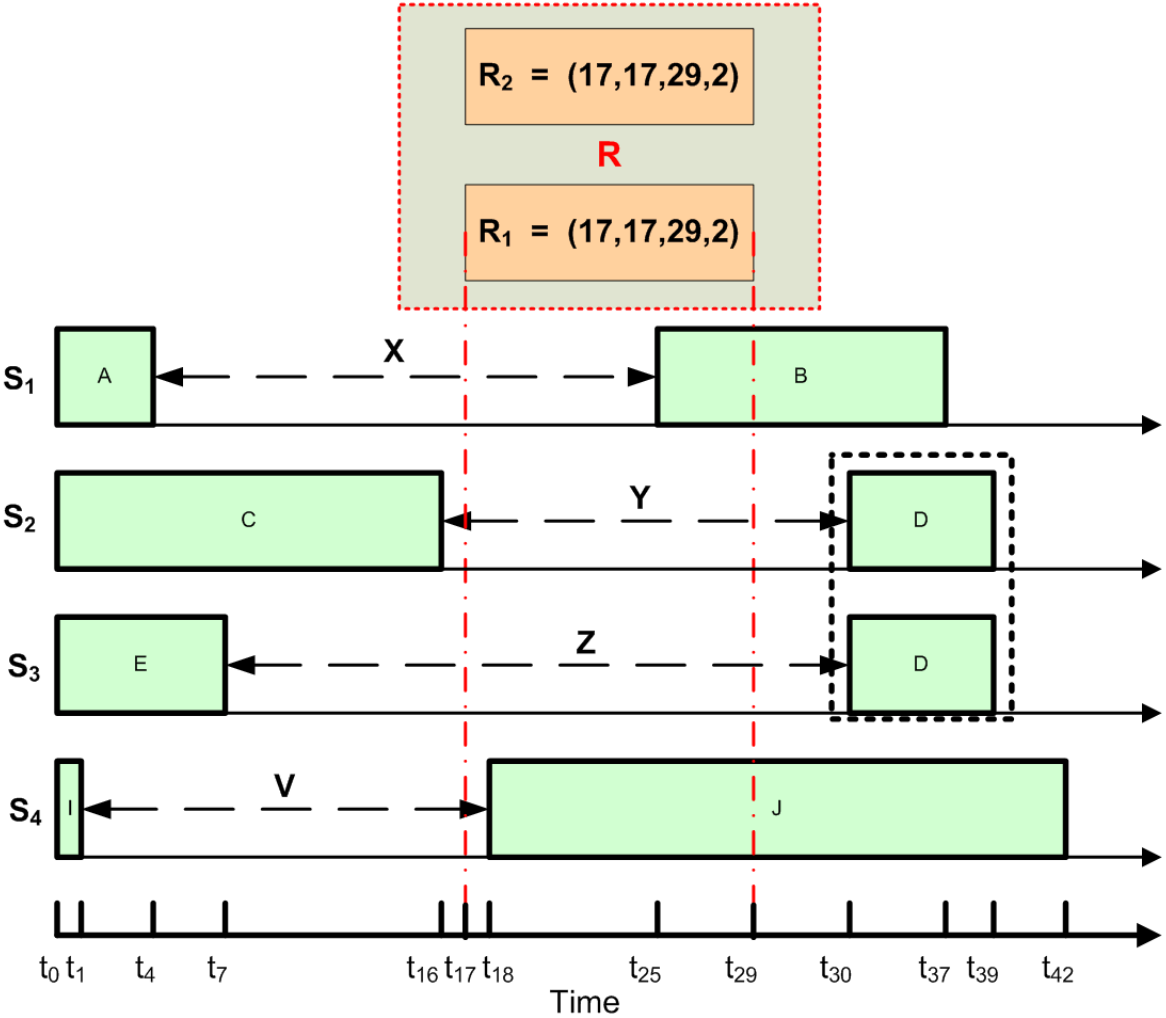
Goals

- **Providing users with time guarantees by scheduling jobs as they arrive** *without promoting resource fragmentation*
- **Allowing better scheduling decisions by keeping look ahead until the horizon of the schedule in a way that is** *efficient*

Contributions

- **A co-allocation scheduling algorithm**
  - Effective in co-allocating resources and provides support for *advance reservations* and *range search*
- **Range search**
  - Ability of the system to find a set of resources available within a given time window
  - Enable selection and scheduling algorithms that are application specific
- **Efficient data structure to organize resource availability**
  - Leading to the design of an algorithm that allows a single search operation to identify all required resources *efficiently*

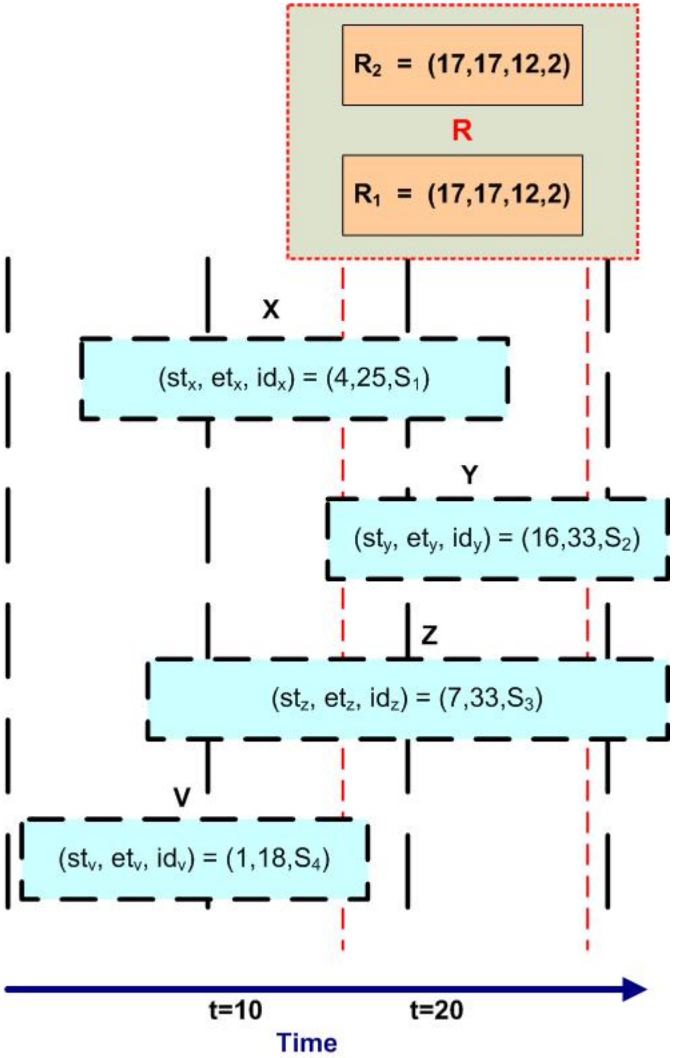
Problem Description



System Model

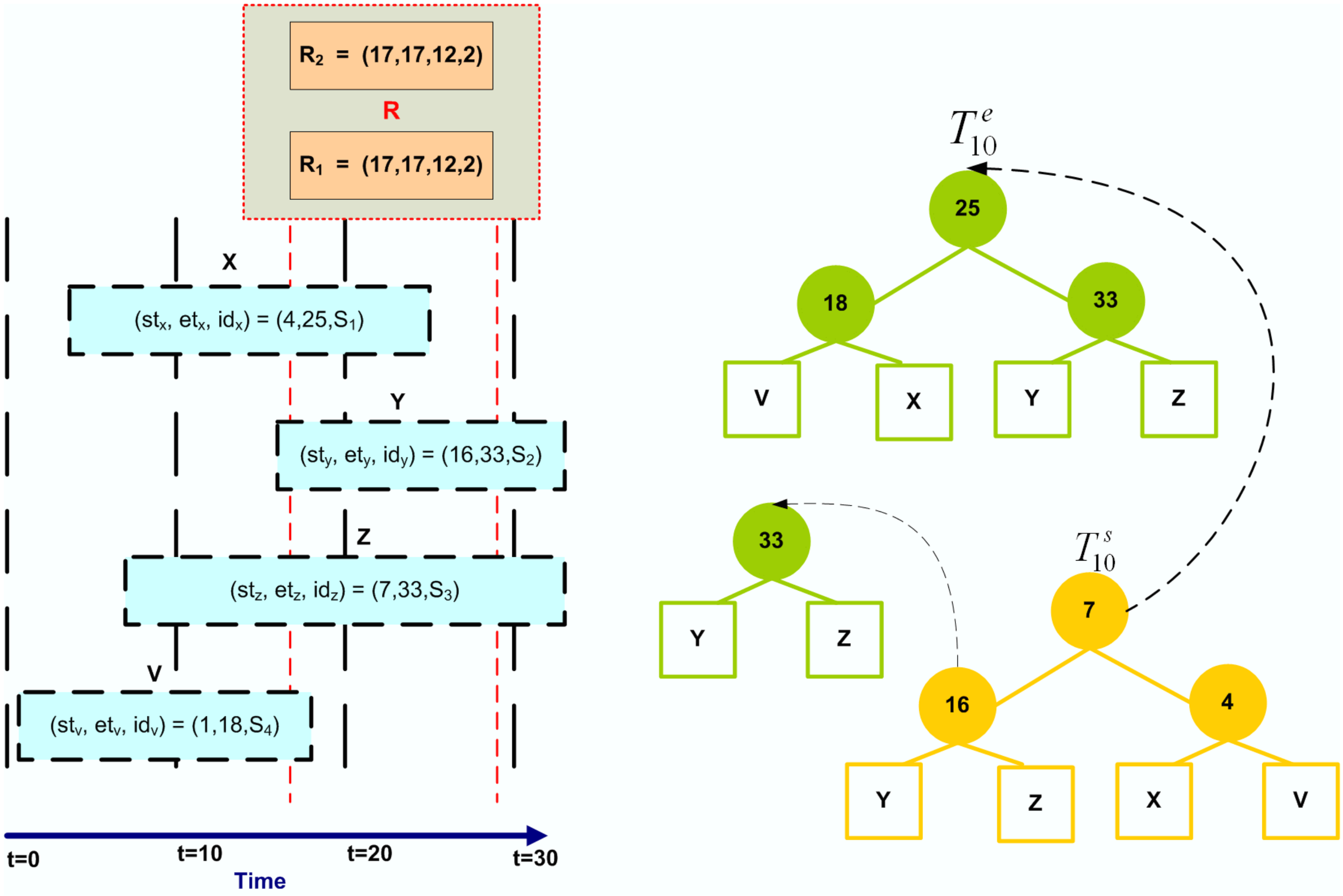
- **We consider the following settings:**
  - Scheduler ***S***
  - ***N*** servers
  - Reservation request ***r*** requires service
  - Request (q_r, s_r, l_r, n_r)
    - q_r request time
    - s_r earliest time the reservation is needed
    - l_r temporal size of the request (duration)
    - n_r spatial size of the request (no. or servers)
  - Idle period (st_i, et_i, id_i)
    - st_i starting time
    - et_i ending time
    - id_i server offering the idle period

Data Structure and Algorithm



- **Time space is partitioned into time slots of equal length**
- **Idle periods are stored in each time slot they span over**
- **Algorithms searches only into the time slot containing s_r**
- **Upon failure to schedule: $s_r = s_r + \Delta_t$**
- **Honor atomicity of the request by means of temporal counters**
- **Number of idle periods per time slot can be bounded to N if time slot size is set to the minimum temporal size**

Data Structure



Two feasibility criterion: **$\underline{st_i < st_x}$** and **$\underline{et_i > et_x}$**

Performance Evaluation

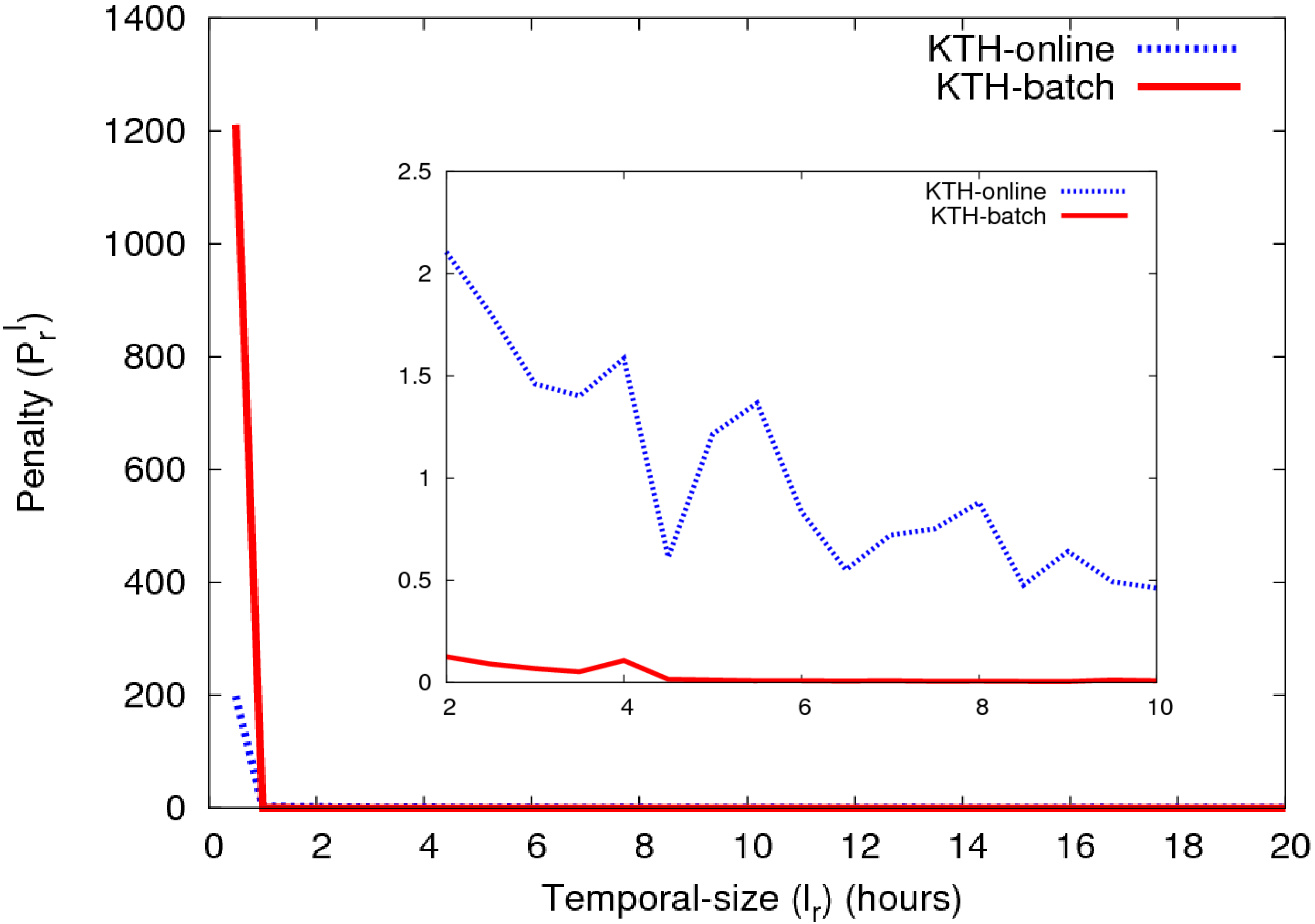
- **Real workloads drive simulations [ParArch]**

Workload	No. of processors	No. of jobs	Avge. length (hrs)	Avge. spatial size
CTC	512	39,734	5.82	9.48
KTH	128	28,481	2.46	7.67
HPC2N	240	202,825	4.72	6.56

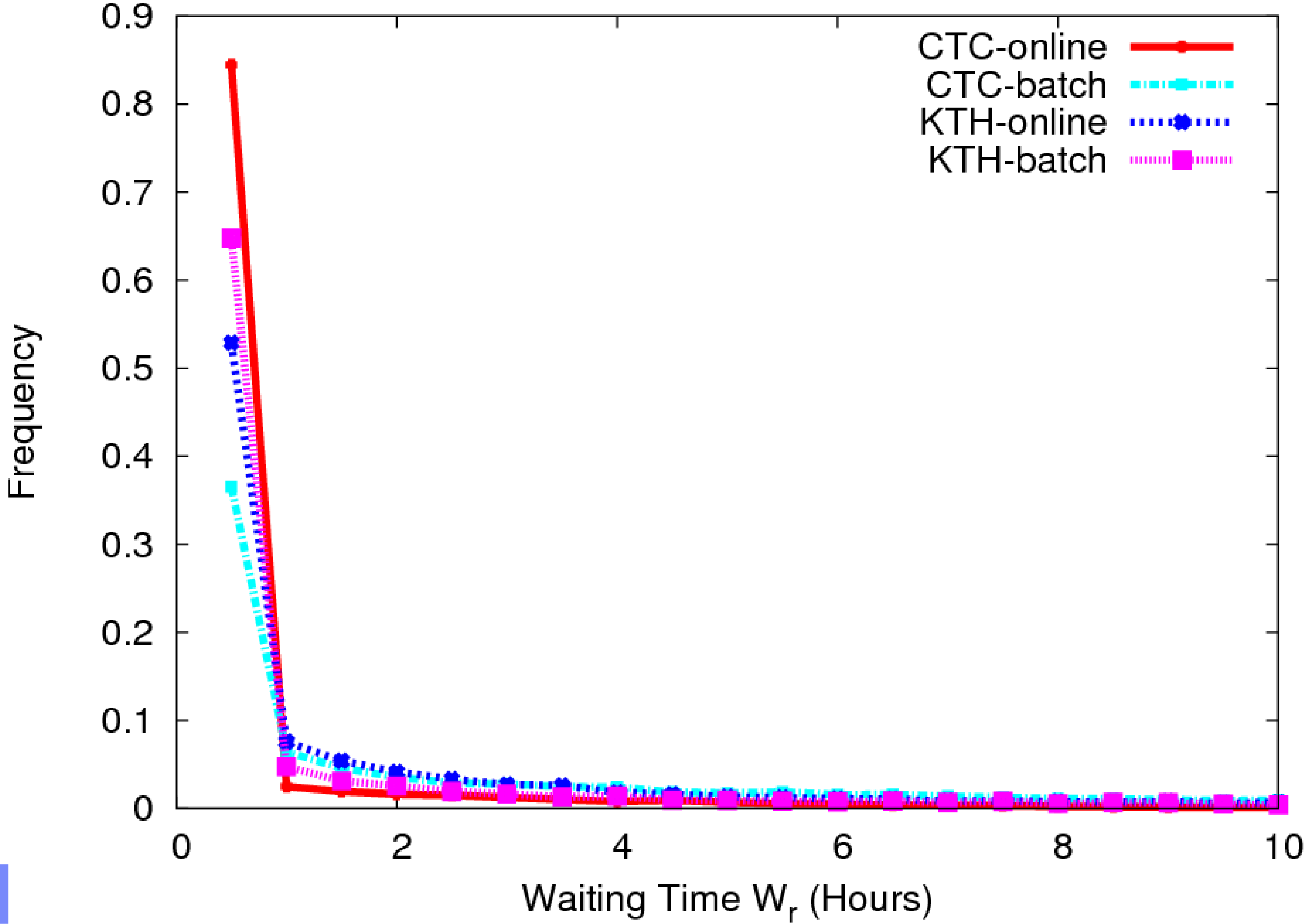
- Two experiments
  - Comparison to batch scheduling
  - Impact on performance of advance advance-reservations

[ParArch] Parallel Worklaod Archive at www.cs.huji,ac.il/labs/parallel/workload/ .

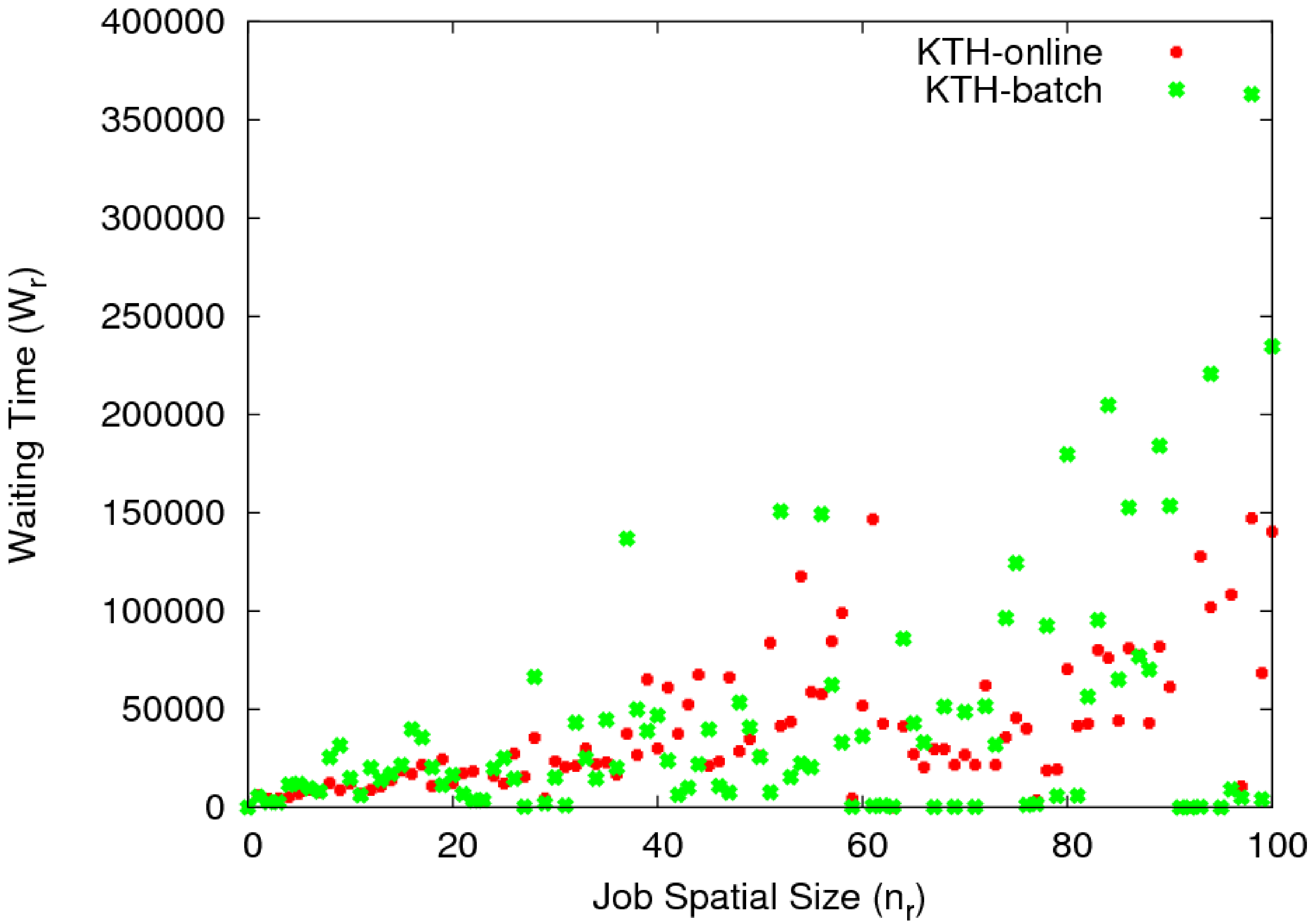
Temporal-size Penalty



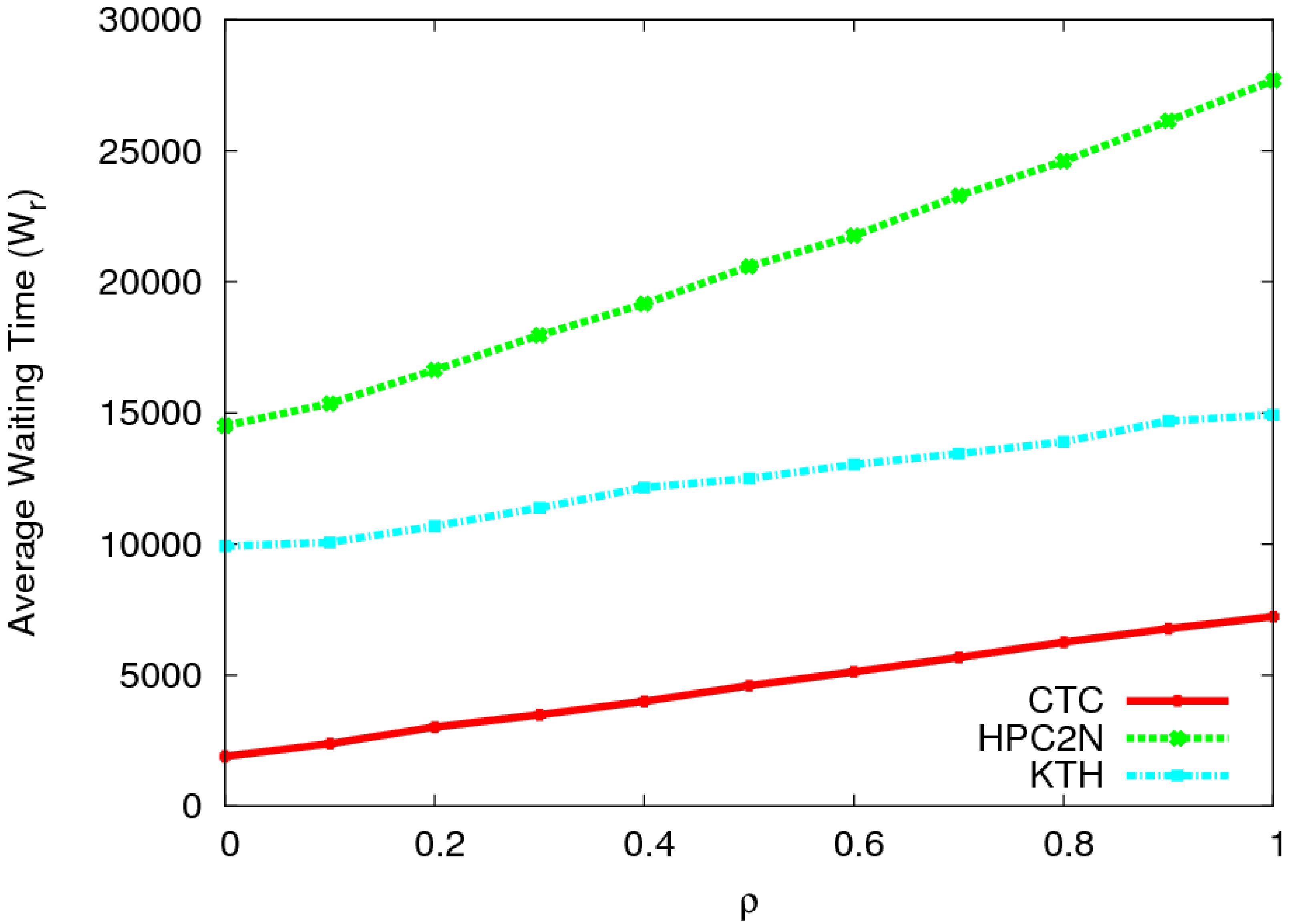
Waiting Time Distribution



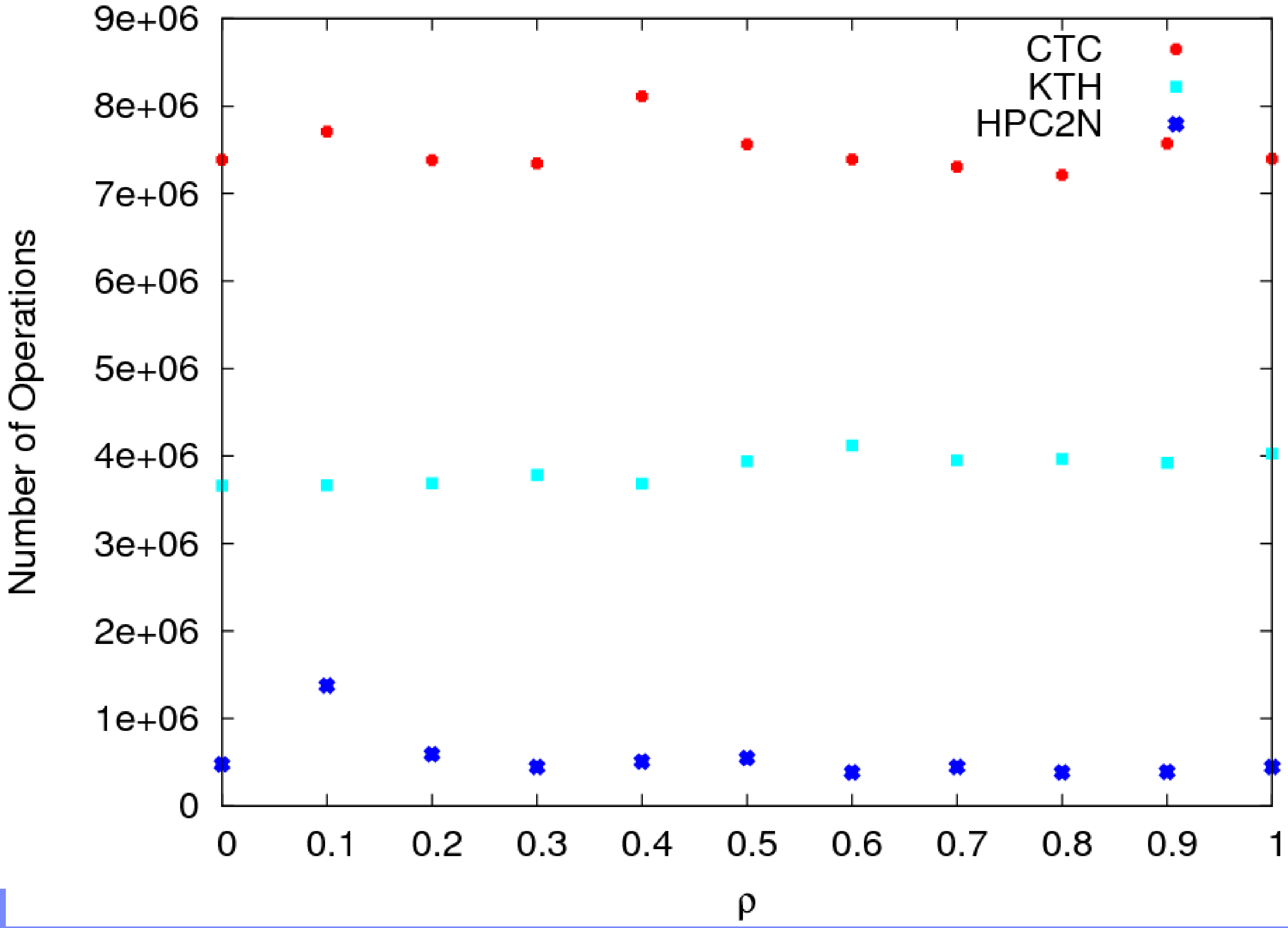
Waiting time distribution as a function of spatial size



Avg Waiting Time vs. fraction of advance reservations (ρ)



Number of operations vs. fraction of advance reservations (ρ)



Number of retrials vs. spatial size

Workload/n	(0:50]	(50:100]	(100:150]	(150:200]	(350:400]
CTC (No. of retrials)	2.96	5.34	7.22	13.25	127.44
KTH (No. of retrials)	10.27	60	120	--	--

- Larger spatial size distribution results in larger number of attempts.
- Temporal size distribution of KTH shows large proportion of small jobs.

Discussion of Results

- **Our algorithm can efficiently co-allocate resources while supporting advance reservations**
- **Online advance reservations mechanisms might offer a better solution to the problem of co-allocating resources as compared to conventional batch scheduling**
- **Our work can be easily extended to support deadlines**

Future Work

- **Implement the co-allocation algorithm proposed in the context of**
  - Hadoop
  - End-to-end path problem in Grid lambda scheduling
- **Impact of workload characteristics on system/user performance**
- **Uncertainty of completion times**

Thank you!

I can be reached by email at:

claris@us.ibm.com