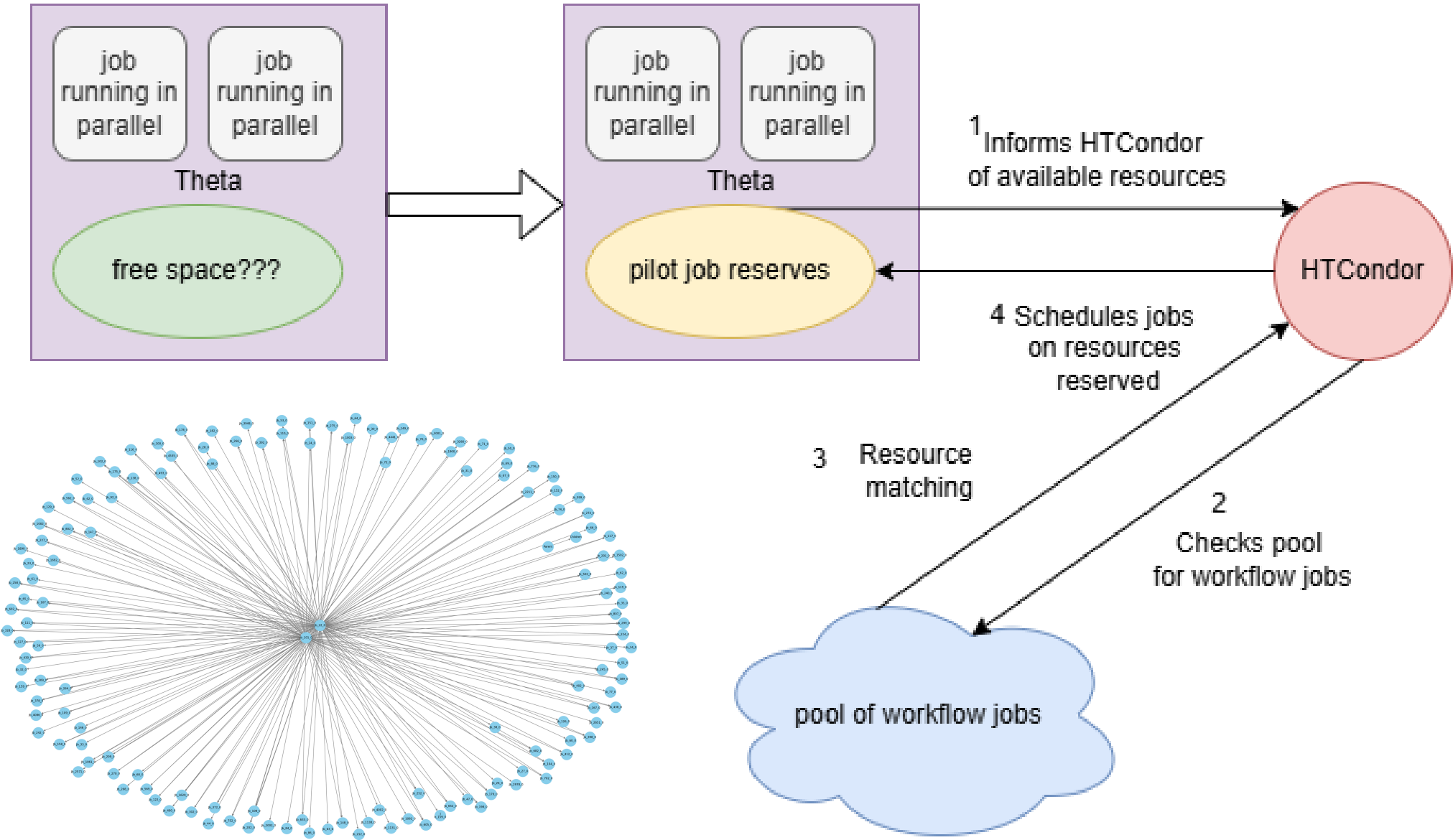


On-Demand Pilot Job Scheduling for Adaptive Execution of HEP Workflows on HPC Systems

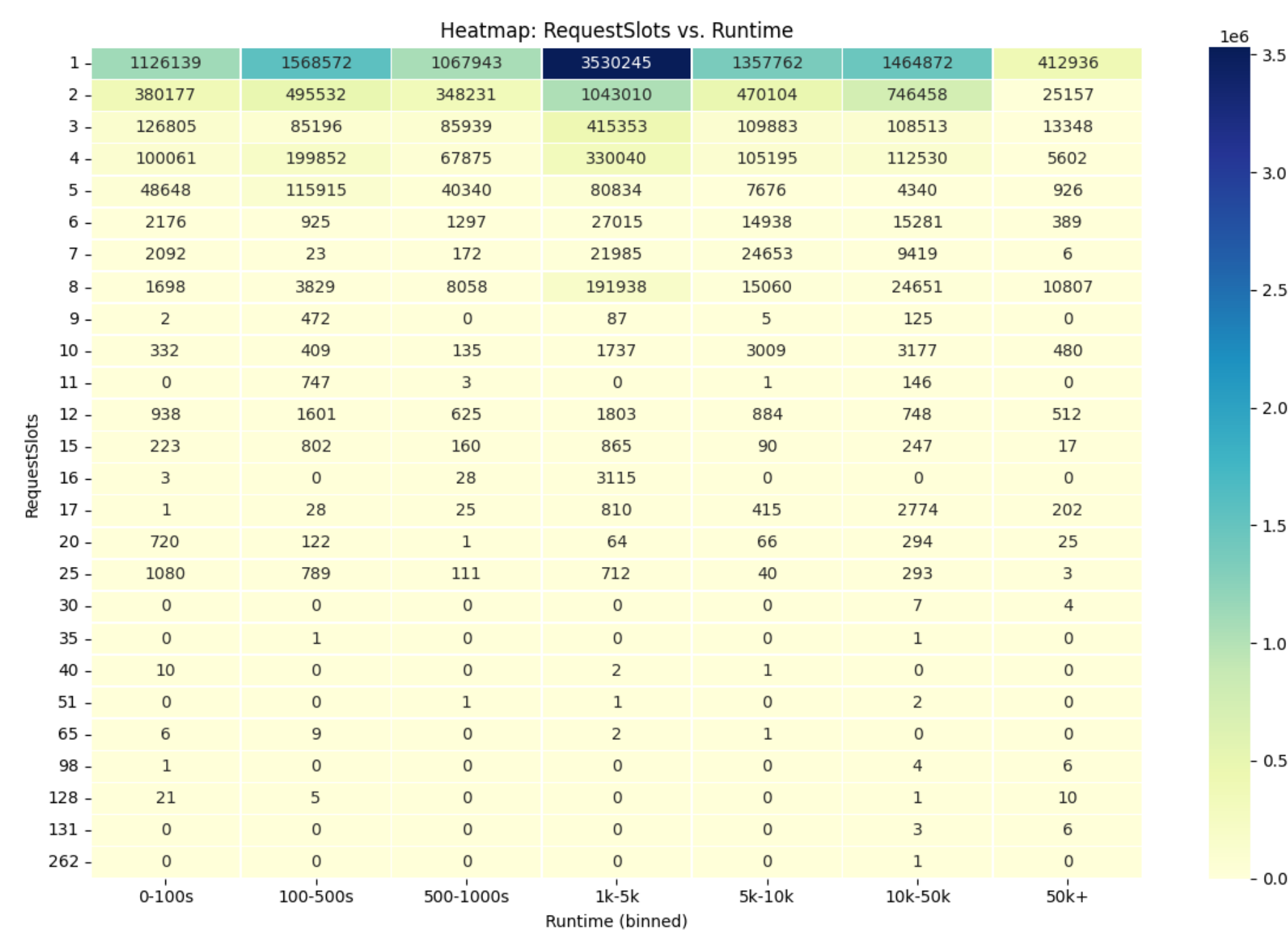
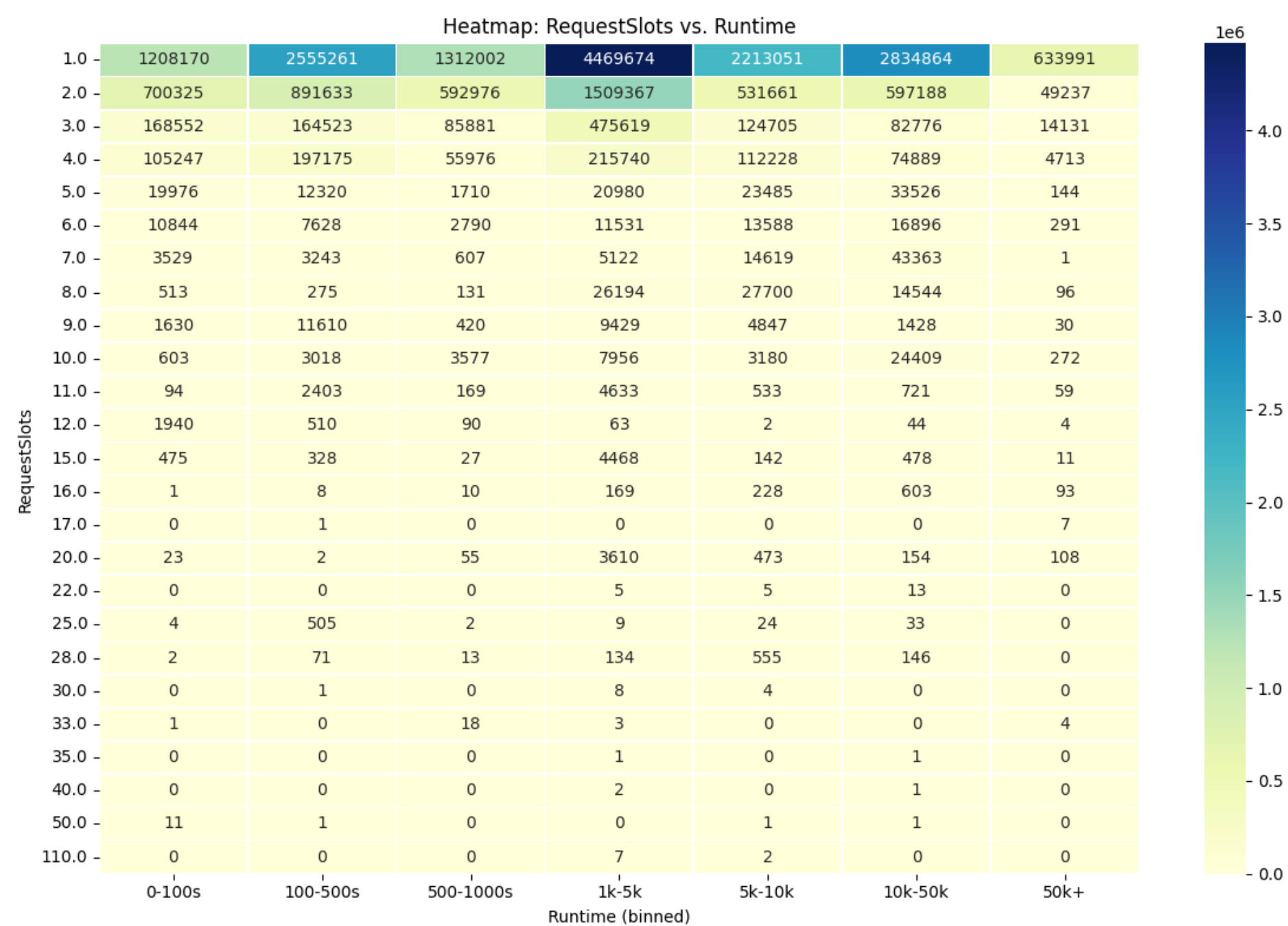
Shambhawi Sharma, Xin Wang, Zhiling Lan, Michael E. Papka

Background and Motivation

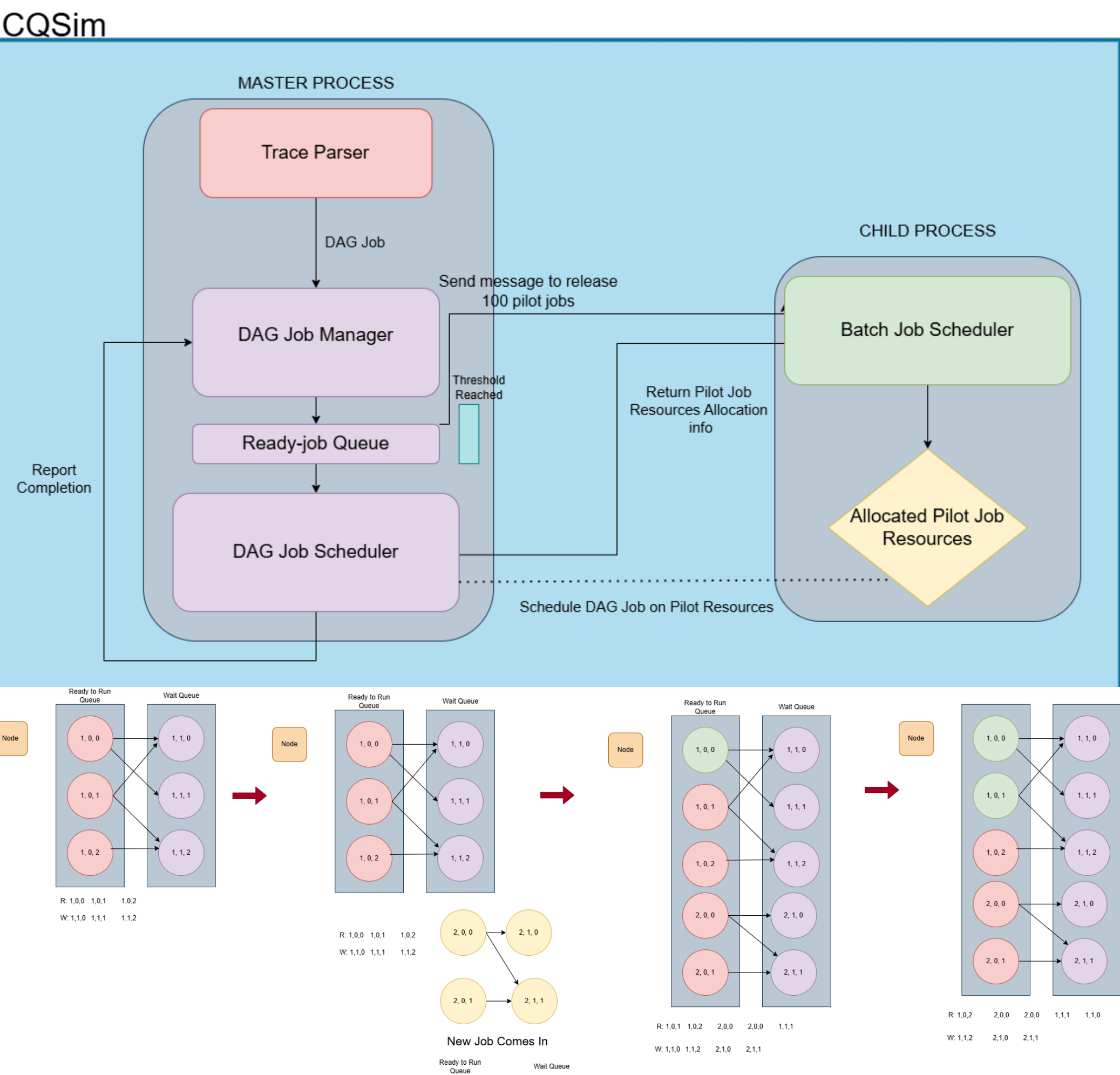
HEP workflows often consist of complex DAGs with streaming job arrivals that challenge traditional static scheduling approaches. We introduce a dynamic pilot job scheduling model that allocates HPC resources on demand when queued DAG jobs reach a configurable threshold. The simulation framework models interactions between the trace parser, DAG manager, pilot job manager, and HPC resources. The system improves scheduling responsiveness and resource utilization by reserving nodes as needed and scheduling jobs in batches based on DAG dependencies.



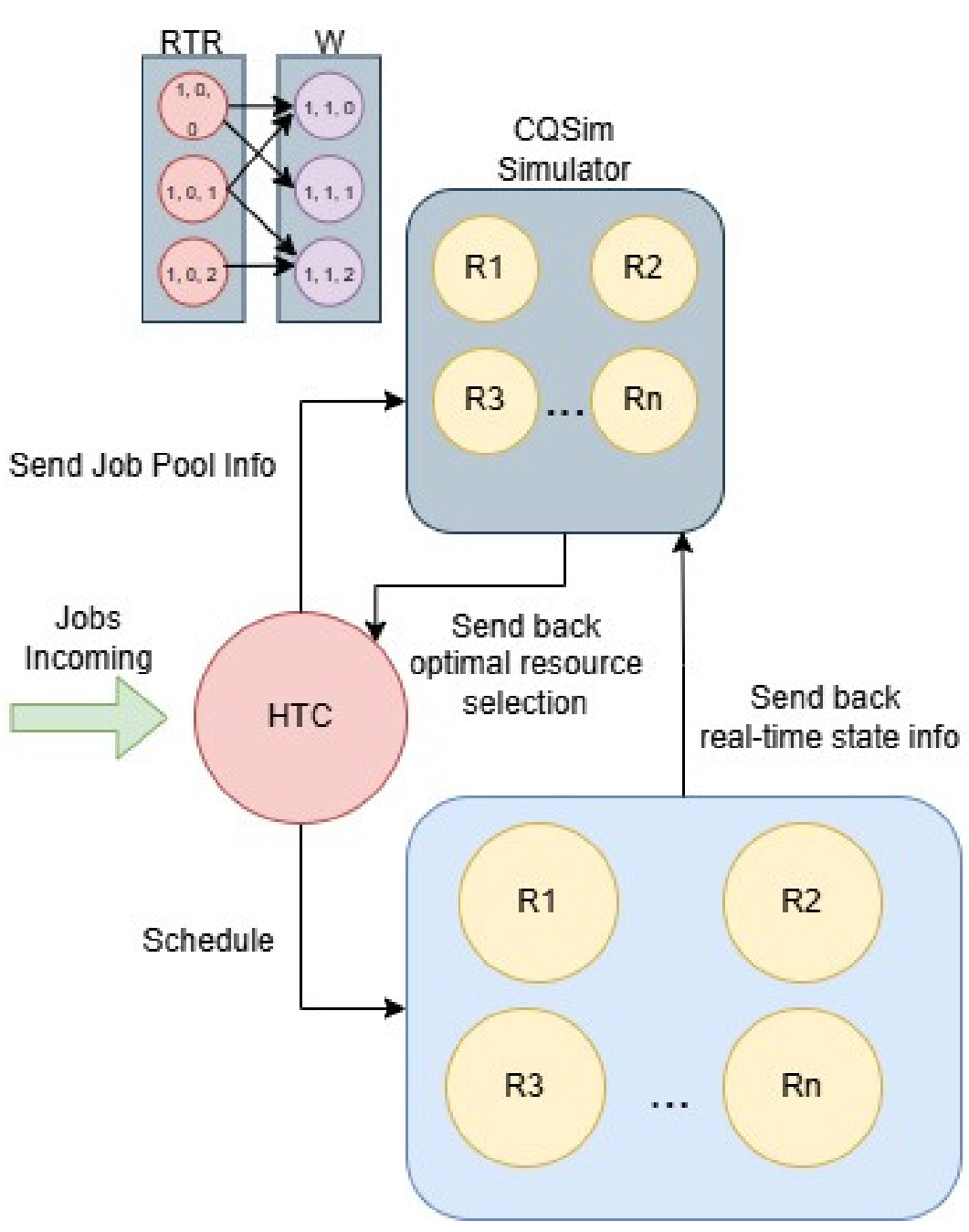
BatchSystem FNAL Log Analysis



Design



- Jobs parsed into DAG (tuple format: <task_id>, <level>, job_id)
- Two queues: Parent jobs → Ready-To-Run Q, Child jobs → Wait Q
- Schedule RTR jobs via pilot jobs when threshold reached
- If > 2× threshold → send multiple pilot batches
- On job completion, unlock dependent child jobs, Wait → RTR



- Multi-resource scheduling for HEP Workflow Jobs
- Resource matching to schedule RTRQ
- Simulate job dependency and running on each resource
- Calculate most optimal decision and send back decision to HTC
- Receive resource state information after each scheduling cycle

- Assumes static threshold values, work needed for dynamic or learning-based thresholds
- No failure modeling yet, resilience and retry mechanisms are out of scope for the initial design
- Simulates job scheduling behavior, performance metrics are indicative, not empirical
- Octopus: Use GNN and DRL for scheduling decisions
- GRAPHENE: Prioritize troublesome tasks in an offline phase, enforce the order online.
- Pegasus: Task clustering for efficient workflow mapping.
- DAGMap: Prioritization, grouping, heuristic scheduling for grid
- LAPS: Round-robin strategy for scalable online DAG scheduling, SJF to greedily schedule DAG jobs