Impact of Objective Model on Search-based Parallel Computer Job Scheduling

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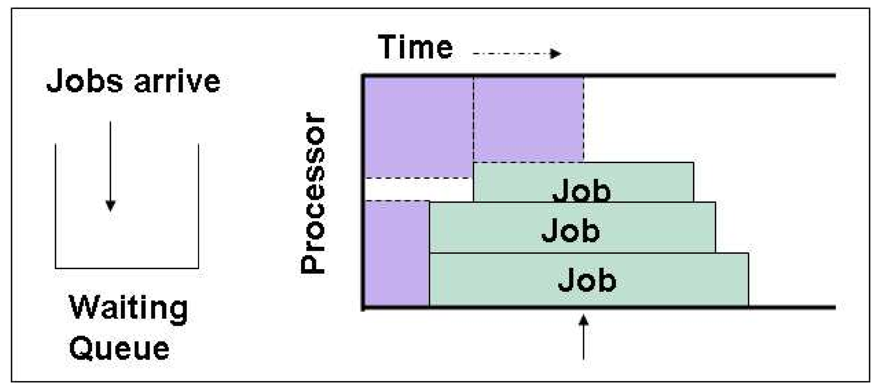
1. Parallel Job Scheduling



Properties of the scheduling system

- Similar to a rectangular Tetris without rotation
  - Pick any piece from the stack of pieces (jobs)
- Online scheduling
  - Don't know when the job will come
  - Don't know the job size
- Non-preemptive
  - Cannot undo any previous decision
- All jobs must be scheduled

2. Motivation

Performance goals

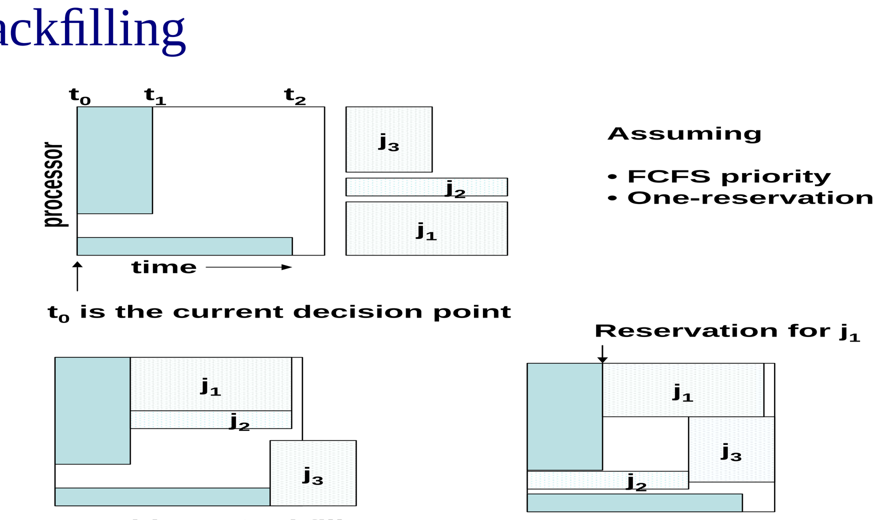
- Typically there are multiple goals, e.g.,
  - prevent 'starvation'
  - minimize average slowdown
  - maximize 'fairness'
- But they potentially conflict with each other

Challenges

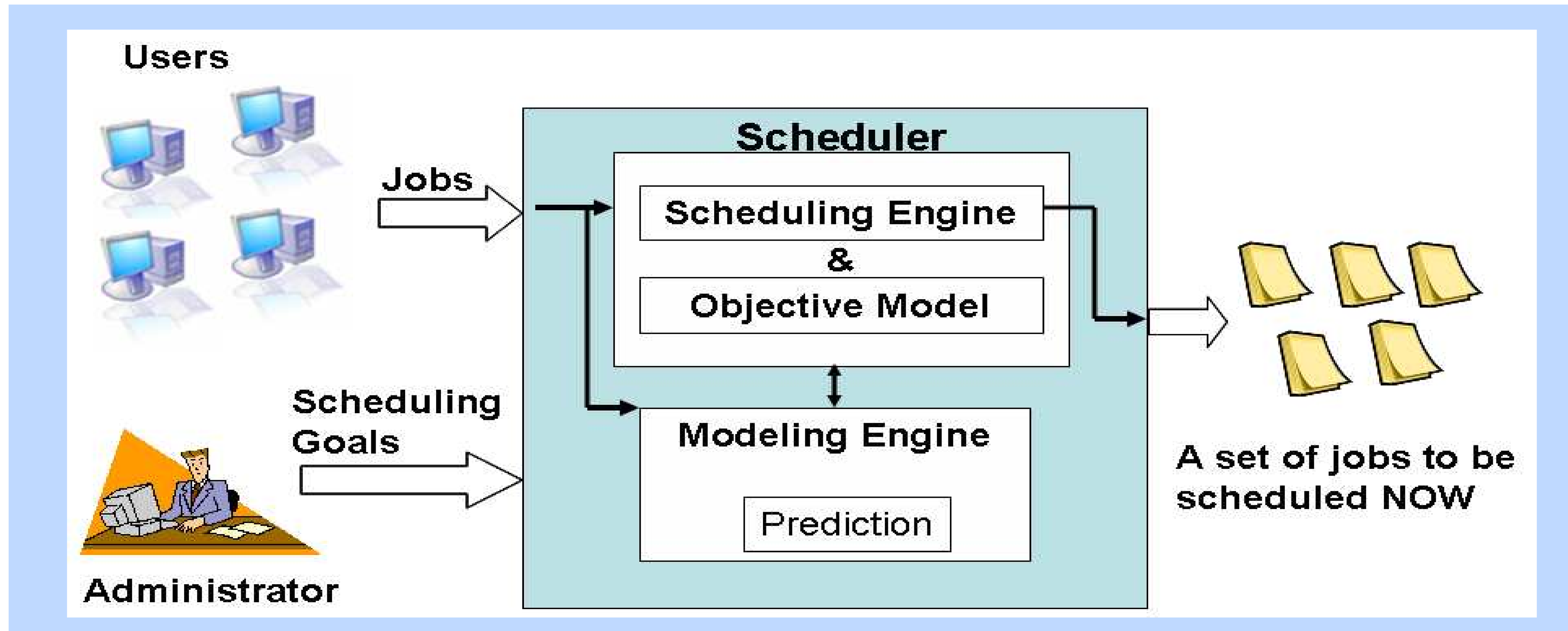
- How to optimize for multiple goals?
- How to define multiple goals in one objective?

3. Common approach

- Based on predefined priority function
  - Cannot specify objective
  - Need tune priority function in ad-hoc manner
  - Performance can be unexpected
- Backfilling



4. Our Approach: Search-based Parallel Computer Job Scheduling



Objective model (Sec. 6,7)

- allows administrator to declaratively specify high-level performance goals
- must be intuitive and flexible

Scheduling engine (Sec. 5)

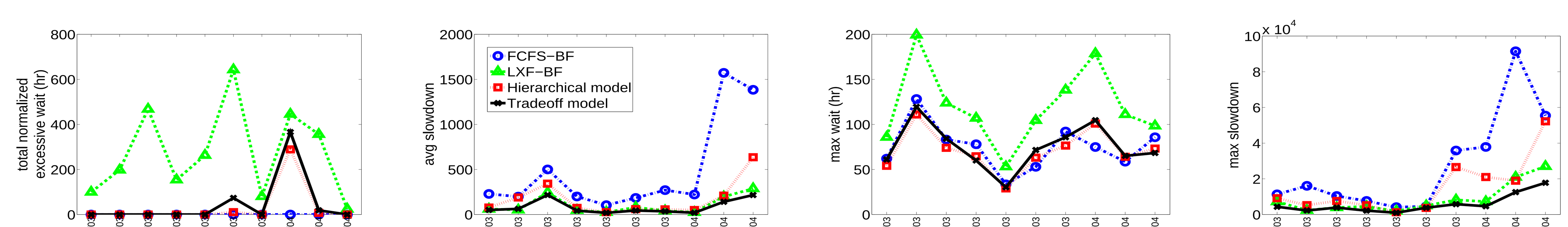
- employ combinatorial search to select jobs for execution

Modeling module (future work)

- collects workload and scheduler performance information
- wait-time, runtime, new arrivals prediction

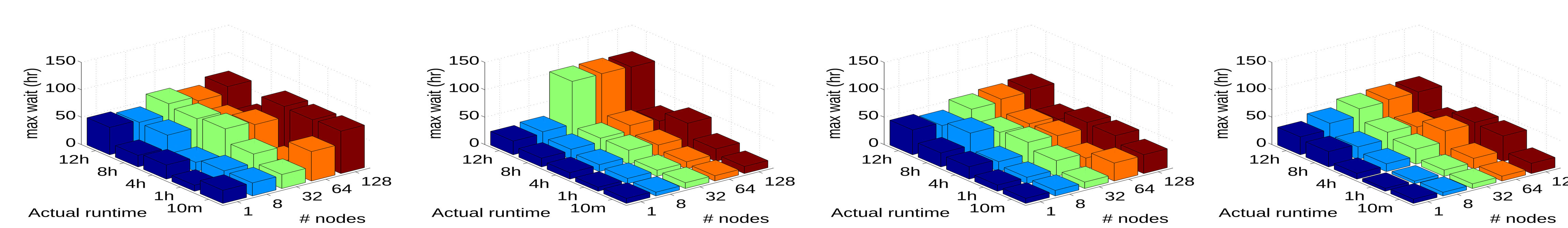
7. Impact of Objective Model Results

Hierarchical vs Tradeoff Model



(a) Total ExW (b) Avg. Slowdown (c) Max. Wait (d) Max. Slowdown

- LXF-backfill improves average slowdown but has worse maximum wait than that under FCFS-bf (Fig a,b)
- Search-based policies achieves best or close to the best for all measures except 1/04
- Hierarchical model has poor performance on slowdown measures (Fig. b,d) than that under Tradeoff model
  → Hierarchical improves high-level performance slightly at a huge expense on the low-level performance

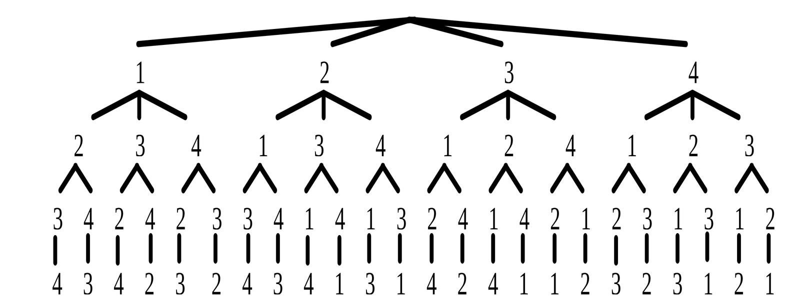


(e) FCFS-bf (f) LXF-bf (g) Hierarchical model (h) Tradeoff model

- FCFS-bf: poor performance for wide jobs (N>32), even if they are short
- LXF-bf: improve short-wide jobs ($T \leq$ 1h, N>32) but let long-large jobs (T>8h, N>8) suffer
- Hierarchical: improve short-wide jobs without sacrificing long-wide jobs as much as that under LXF-bf
- Tradeoff: improve short or small jobs further from that under Hierarchical

5. Search Algorithms

- Organize all possible ordering in to a tree



  - each path: an order of jobs for consideration
  - n waiting jobs have n! ordering
  - order of considering NOT the order the jobs can be started
- Search
  - Goal: find the path that optimize performance according to the objective
  - Problem: time consuming
    → find good solutions within time constraint
  - We found depth-bound discrepancy search (DDS) to perform well (see Cluster05)

6. Objective Model

Consider two goals commonly desired

1. prevent 'starvation'
   → let measure excessive wait (ExW)
2. minimize average slowdown ($\overline{X}$)

Intuitive models compared here

A) Hierarchical model, e.g.,
  * L1: minimize T_w: total ExW
    L2: minimize $\overline{X}$

B) Explicit tradeoff model, e.g.,
  1) $\triangle(T_w) > 0$ AND $\triangle(T_w) \geq \bigtriangledown(\overline{X})$, OR
  2) $\triangle(\overline{X}) > 0$ AND $\triangle(\overline{X}) \geq \bigtriangledown(T_w)$
     ($\triangle$: improvement; $\bigtriangledown$:degradation)

Ohter models studied, not shown.

8. Conclusion

- Search-based policies (using hierarchical or tradeoff objective model) simultaneously beat traditional backfill policies (FCFS-bf and LXF-bf) w.r.t. the objective studied
- Explicit tradeoff objective model shows potential to make a better tradeoff than hierarchical objective model

(Cluster05) S. Vasupongayya, S.-H. Chiang, and B. Massey, Search-based Job Scheduling for Parallel Computer Workloads, IEEE Cluster 2005, Boston, MA. Sep 2005.