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BATCH JOB SCHEDULING USING ENHANCED WALLTIME PREDICTION

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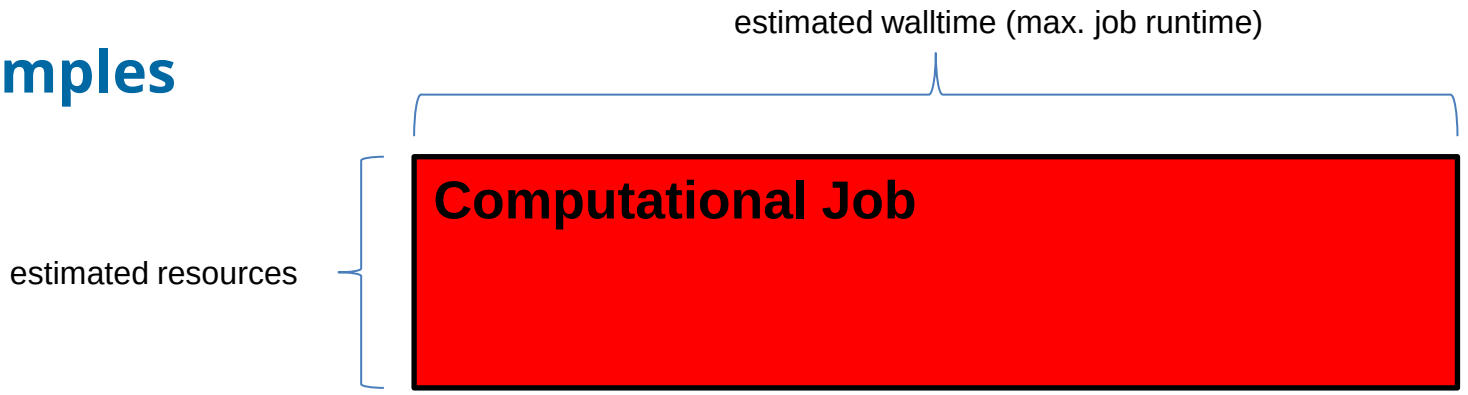
Motivation

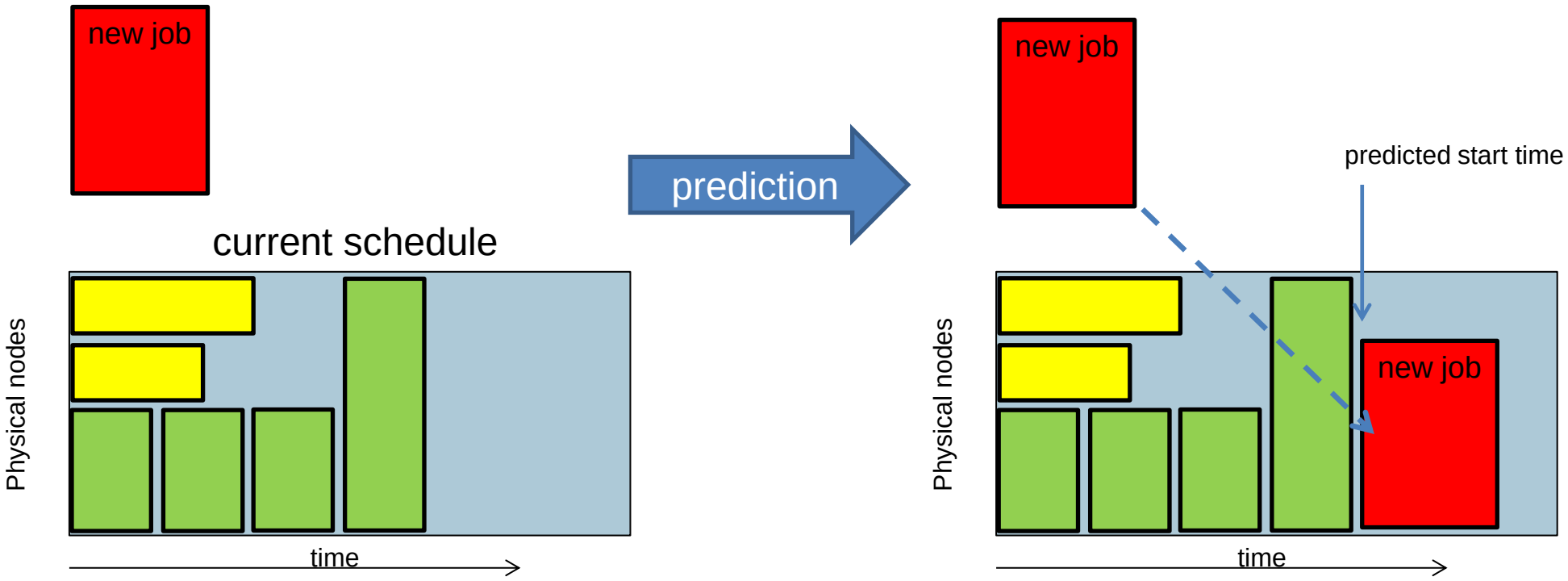
- **Batch job schedulers rely on user-provided walltime estimates**
  - When selecting proper queue (short/normal/long)
  - When performing predictions (when and where will a job start)
  - When staging data in advance of a computation
  - When optimizing the performance / utilization of the system (backfilling)

- **Few examples**

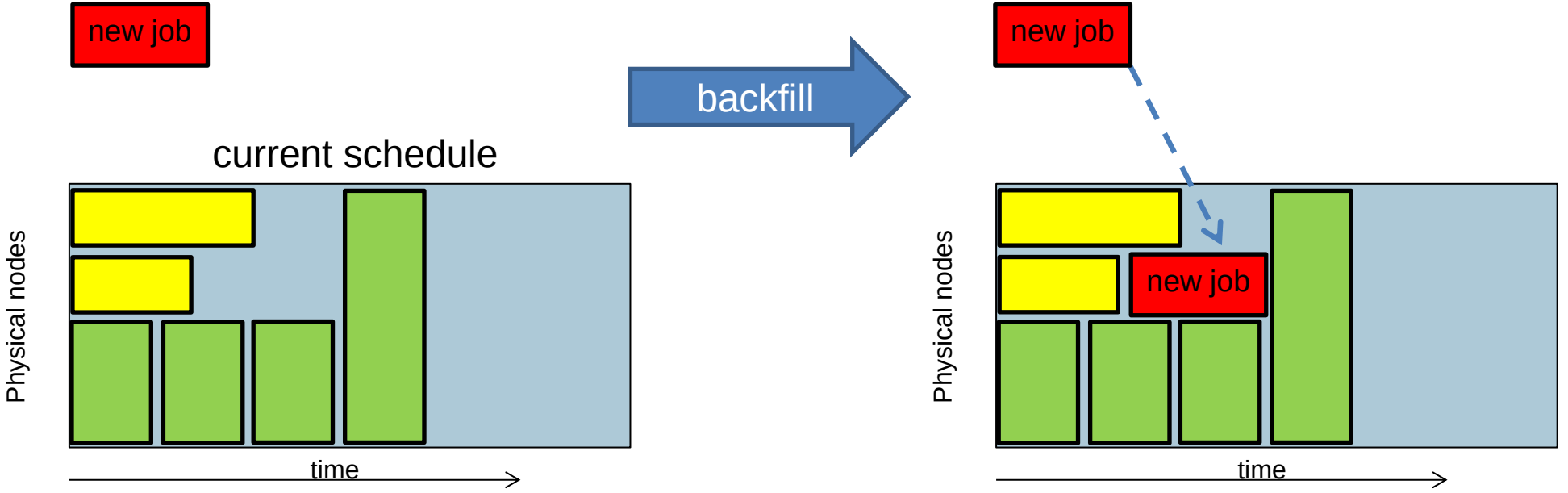


Predictions

When will a new job start?

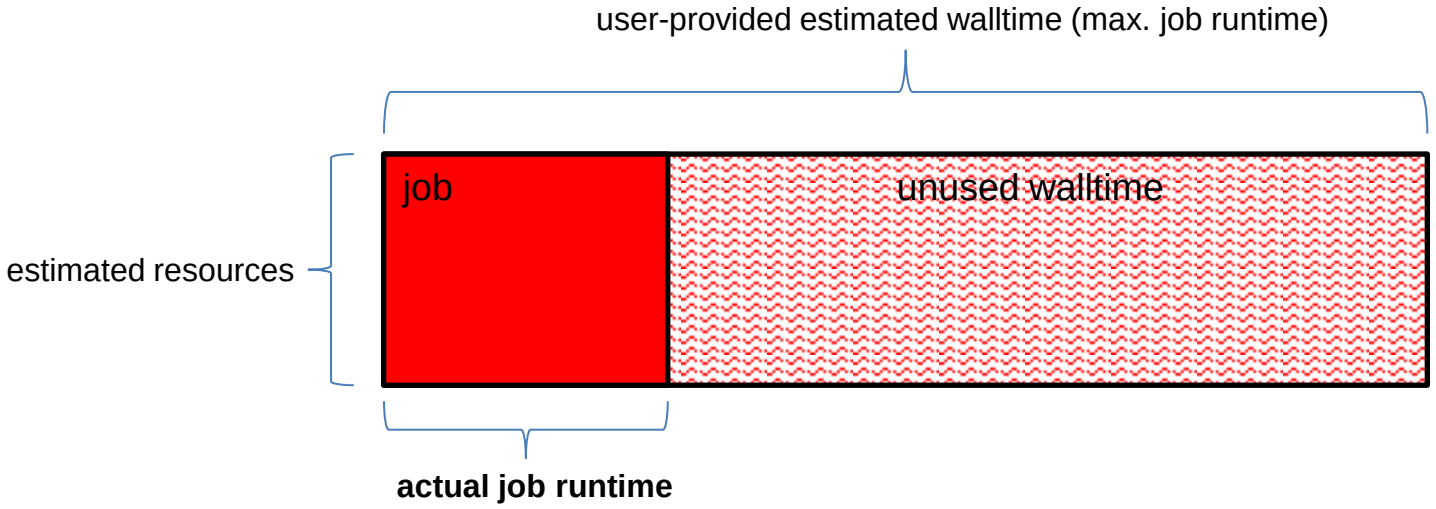


Backfill new job to increase utilization



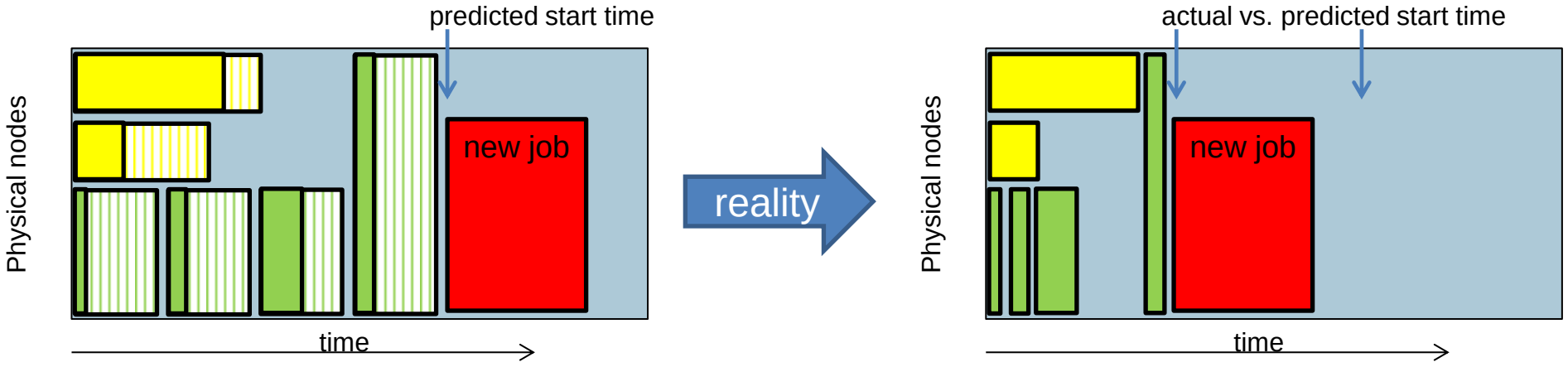
Inaccurate Estimates

- **Users are bad and/or lazy when delivering estimates**
  - Estimates are typically very over-estimated and coarse grained
  - To prevent jobs from being killed due to exceeding their walltime
  - Fast vs. slow machines (worst case scenario: slow machine => larger runtime)



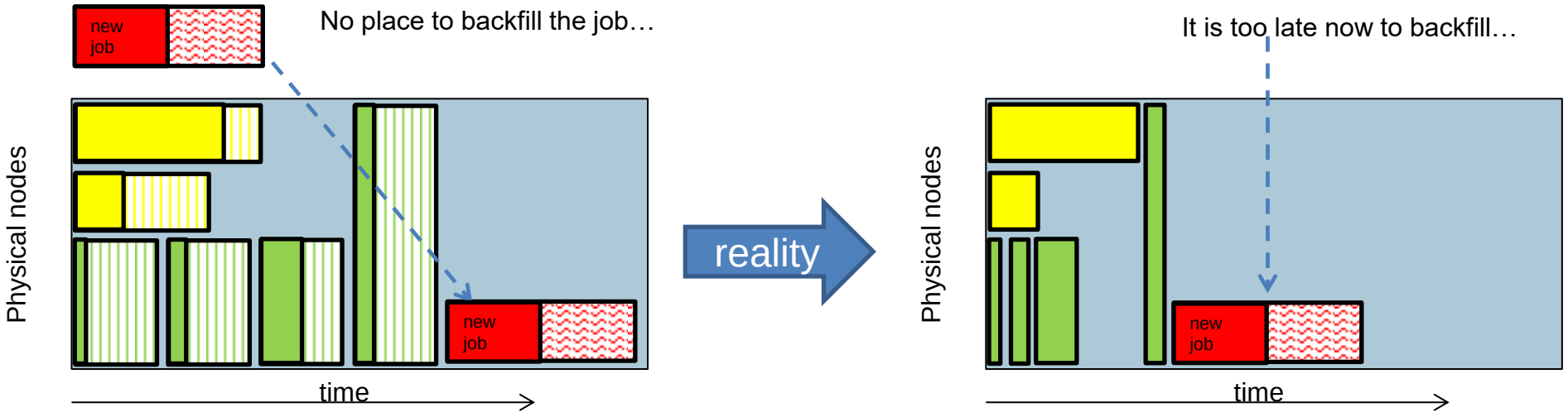
Suboptimal Scheduling

- Schedule is “shorter” than expected
- Inaccuracies then impact predictions



Suboptimal Scheduling

- Inaccuracies hamper scheduling (utilization & other metrics)



Suboptimal Scheduling

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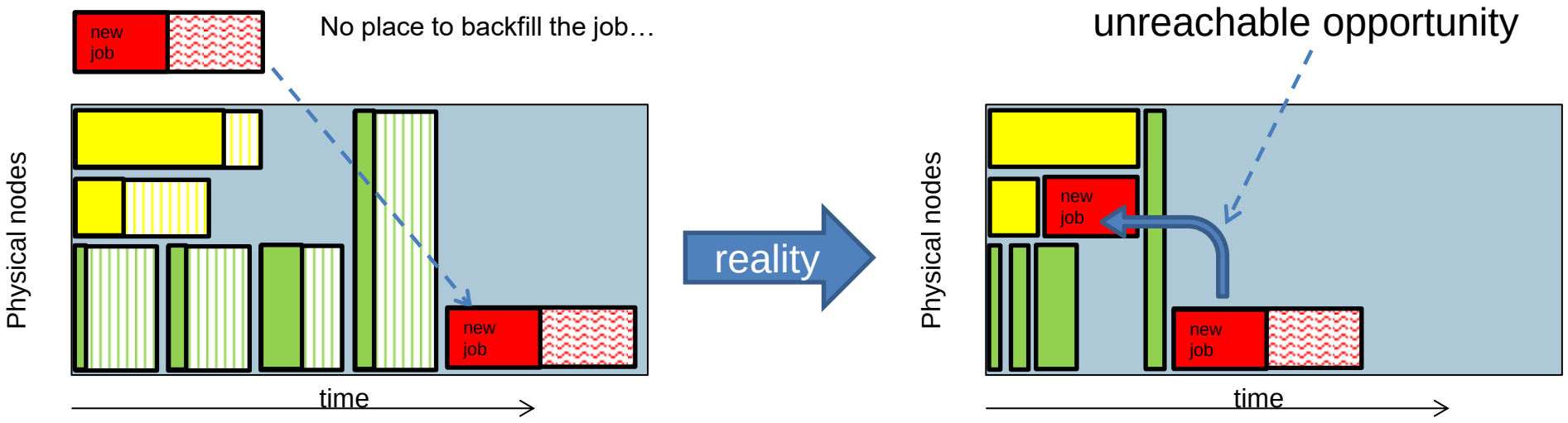

Walltime Prediction

- **Walltime predictions has been largely studied in the past**
- **Various techniques and approaches**
  - How to motivate users
  - How to predict job runtime automatically
- **„Soft walltime“**
  - New feature in PBS Professional since 2017
  - Actual implementation allowing for the use of such refined estimates
  - Original estimate is still used for job killing (but not the soft walltime)
  - A predictor must be implemented on your own
- **Soft walltime cannot be specified by user**
  - To prevent users from cheating

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SIMULATIONS AND RESULTS

Considered Problems

- **How good is simple predictor vs. user estimates?**
  - Predictor uses historic runtimes of few past jobs to generate new estimate (soft walltime)
- **What is its impact on performance?**
- **Metrics**
  - Predictor's accuracy – distribution of absolute errors (error = estimate – runtime)
  - Number of backfilled jobs
  - Avg. wait time
- **Simulator and historic workloads used for the analysis**

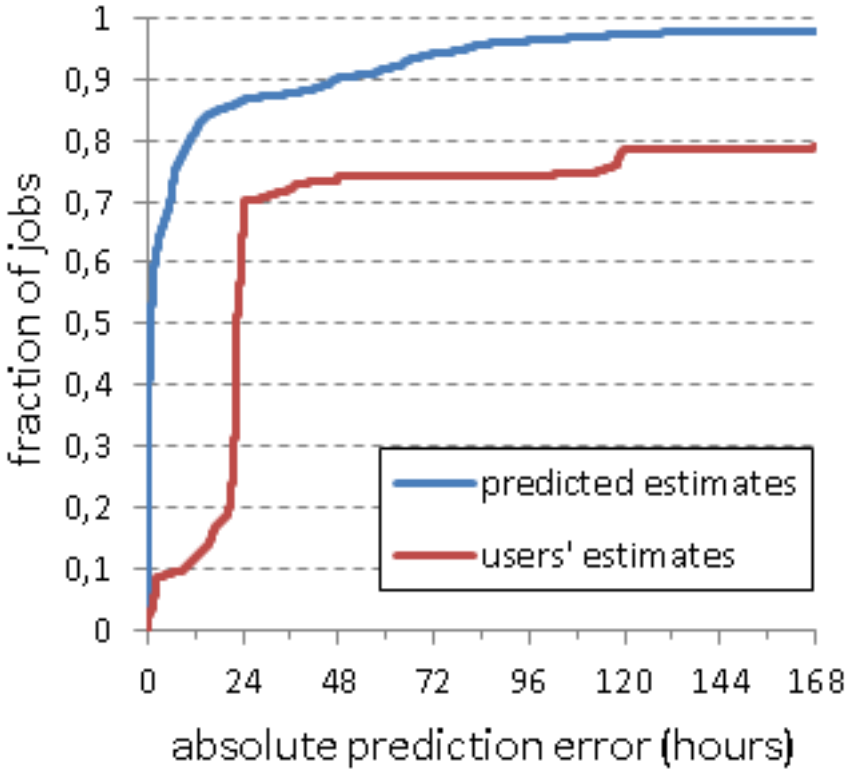
Predictor accuracy

- **Does the predictor beat user-provided estimates?**

YES! ☺

Predictor accuracy

- **Simple predictor**
  - Using historic runtimes of few past jobs to generate new estimate (soft walltime)
- **CDF of absolute errors**
  - For all jobs



Predictor accuracy

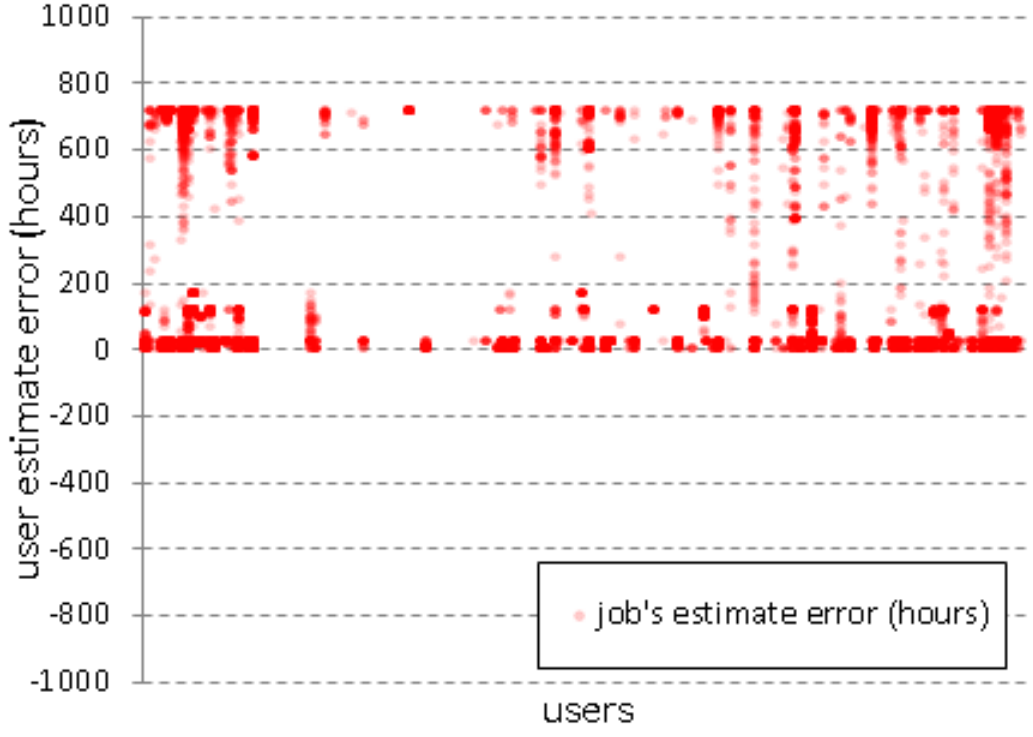
- Does the same predictor work for all users?

Almost... 😐

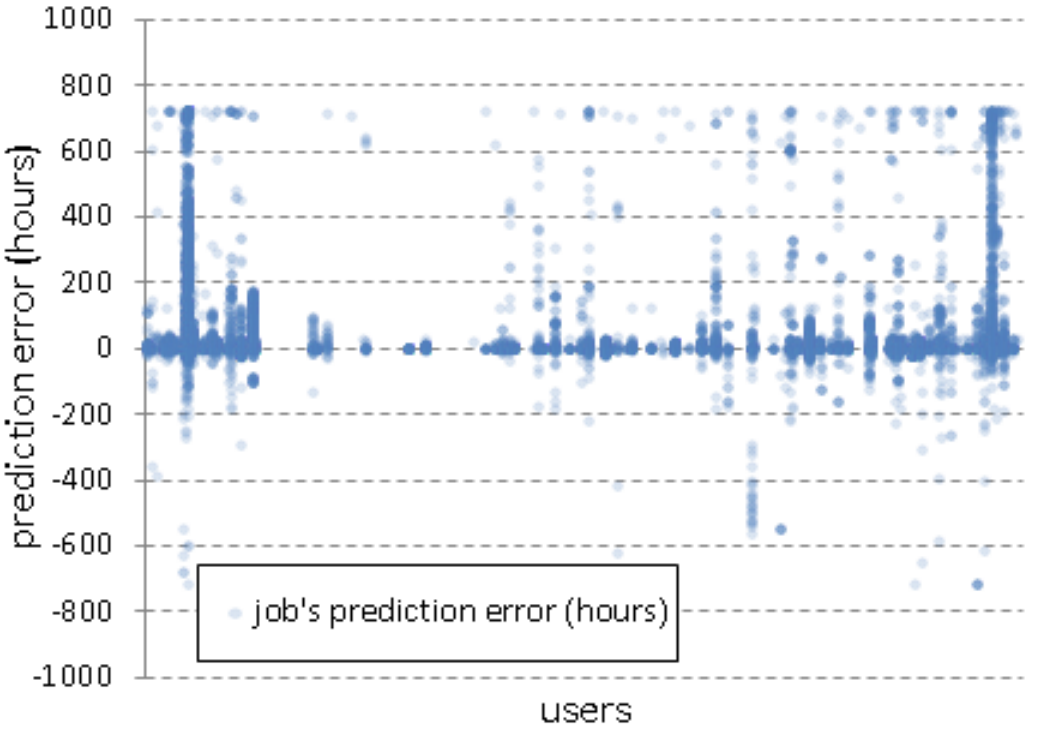
Predictor accuracy

- "Per user" view of job's estimate error

Original estimates



Predictor



Backfilled Jobs

- Does the predictor increase backfilling opportunities?

YES! ☺

Backfilled Jobs

- **Number of backfilled jobs**
  - Indicates the ability of the scheduler to “fill gaps” with small-enough jobs
  - In order to increase utilization
- **Original estimates: 7.8% of jobs is backfilled**
- **Predicted estimates: 15.3% of jobs is backfilled**
  - Higher variability of estimates increases the chance to “fill gaps”

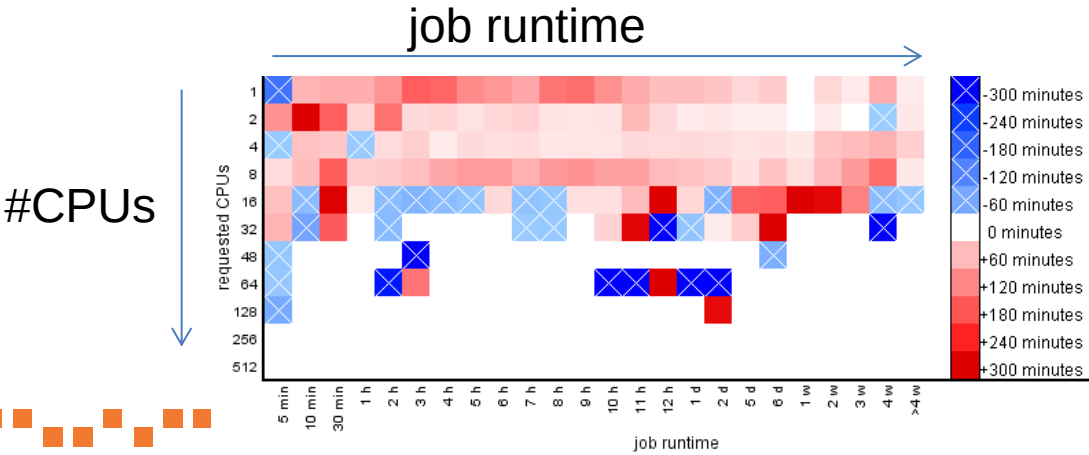
Wait Time

- Does more accurate estimates guarantee lower avg. wait time?

NO! ☹

Average Wait Time Difference

- **Comparison of job wait times using “heatmaps”**
- **Compare the impact of user- and predictor-based walltimes**
  - Jobs divided into “buckets” wrt. #of CPUs and job duration
  - A “bucket” then shows improvement/deterioration of avg. wait time when then predictor is used instead of the original user-provided estimate
  - “**blue color**” => **worse avg. wait time wrt. user estimate**
  - “**red dot**” => **better avg. wait time wrt. user estimate**



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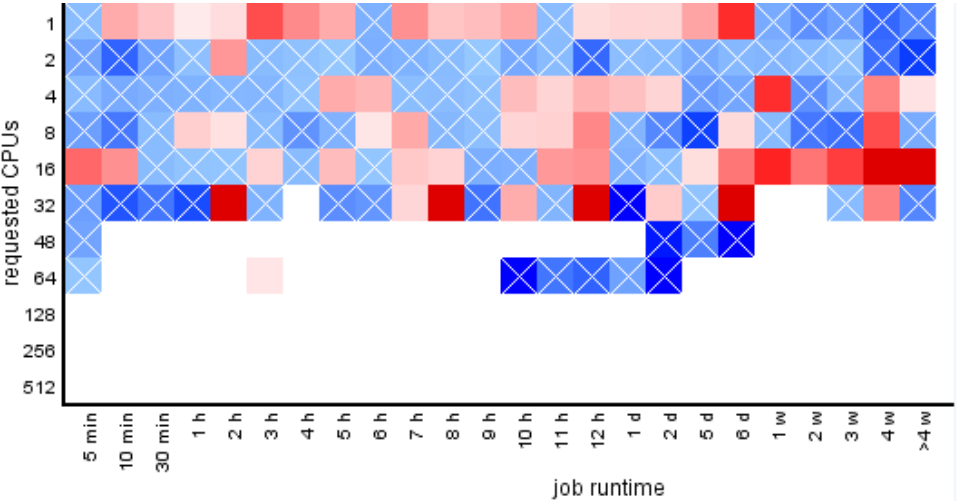
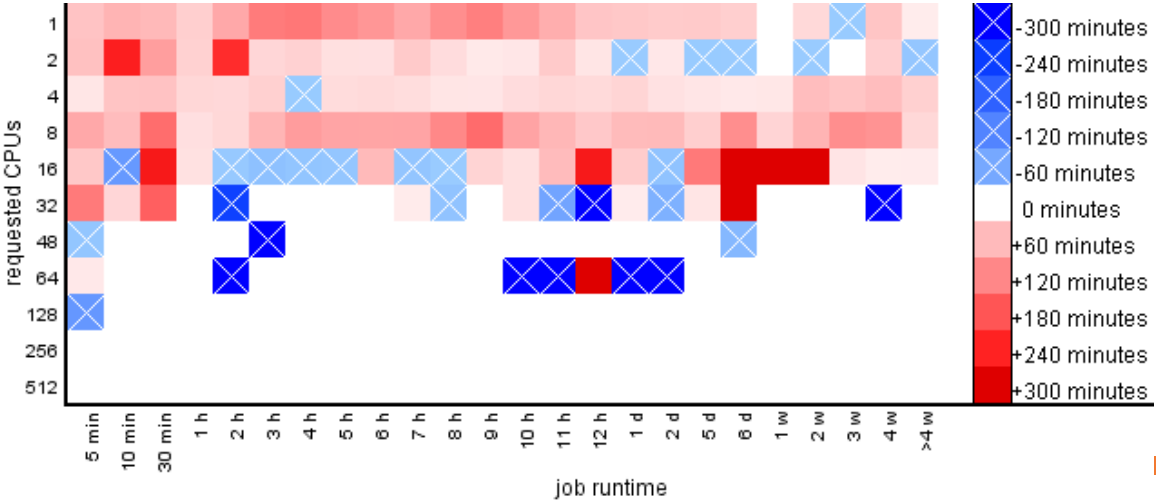
Average Wait Time Difference

- **Better precision does not imply better wait time**
- **Other factors (beside estimates' precision) play important role**
  - Job ordering as a result of "different" job duration (depending on prediction)
  - Differences in scheduling algorithms
  - No simple correlation between estimates' accuracy and the performance

CONSERVATIVE backfilling



EASY backfilling



Results Overview

- **Predictions represent an interesting optimization option**
  - Better job start time and node predictions
  - Can be used to reflect different computing capabilities of the underlying HW
    - E.g., assign smaller soft walltime if a job is scheduled on a faster and/or more I/O capable machine
- **User-transparent (does not require user cooperation)**
  - Also minimizes the possibility of users cheating the scheduler
- **Our goal is to deploy walltime predictors in our systems**
  - MetaCentrum & SCC (predictions, advanced data-staging)
  - Further analyze our workloads and various predictors' suitability

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THANK YOU!

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