Dynamic Workload Management for Very Large Data Warehouses

Juggling Feathers and Bowling Balls

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Outline

- Problem statement
- Proposed solution
- Evaluation
  - Approach and settings for experiments
  - Impact of problem queries on a workload
  - Impact of execution control
- Conclusion and ongoing work

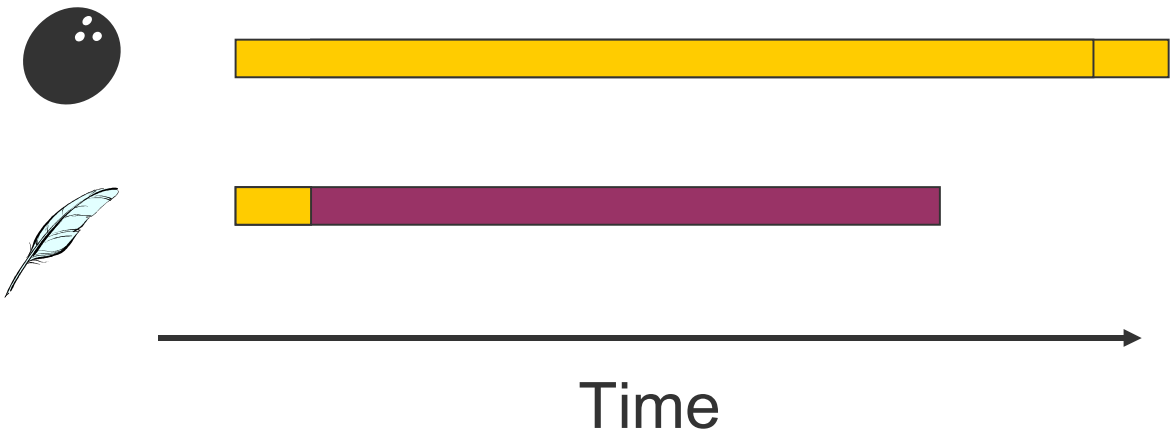
Background

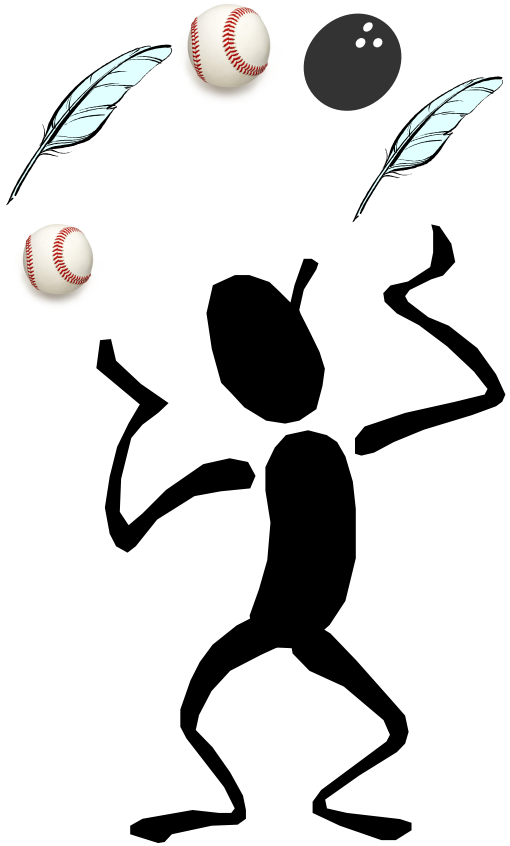
- HP has been building NeoView, a highly-parallel database engine for business intelligence
- Challenges for DBAs
  - How long should they wait to kill an unexpectedly long-running query?
  - When should they admit a newly arriving query if the currently executing batch of queries is in danger of missing its deadline?
  - What if the newly arrived query was submitted by the CEO?

➔ Automate workload management

Why BI Workloads Differ from OLTP Workloads

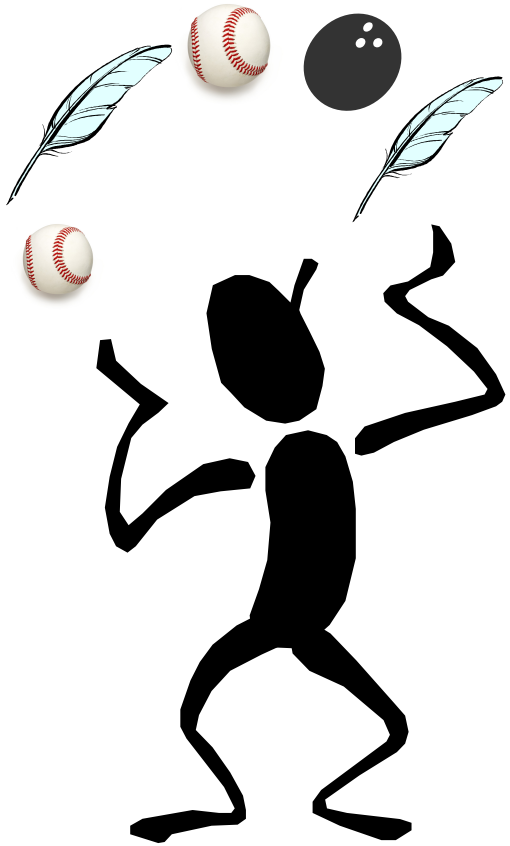
- Complexity
- Resource demands
- Different types of queries
- Unpredictability





Why BI Workloads Differ from OLTP Workloads

- Complexity
- Resource demands
- Different types of queries
- Unpredictability
- Problem queries
- Objectives



Vision: Automate Workload Management

Our approach

- Optimize execution of workload subject to service level objectives
- Explicitly consider “problem” queries as an inherent part of the workload
- Propose an architecture that allows us to …
  - … model problem queries with different characteristics
  - … implement and test workload management actions for dealing with problem queries based on their observed behavior

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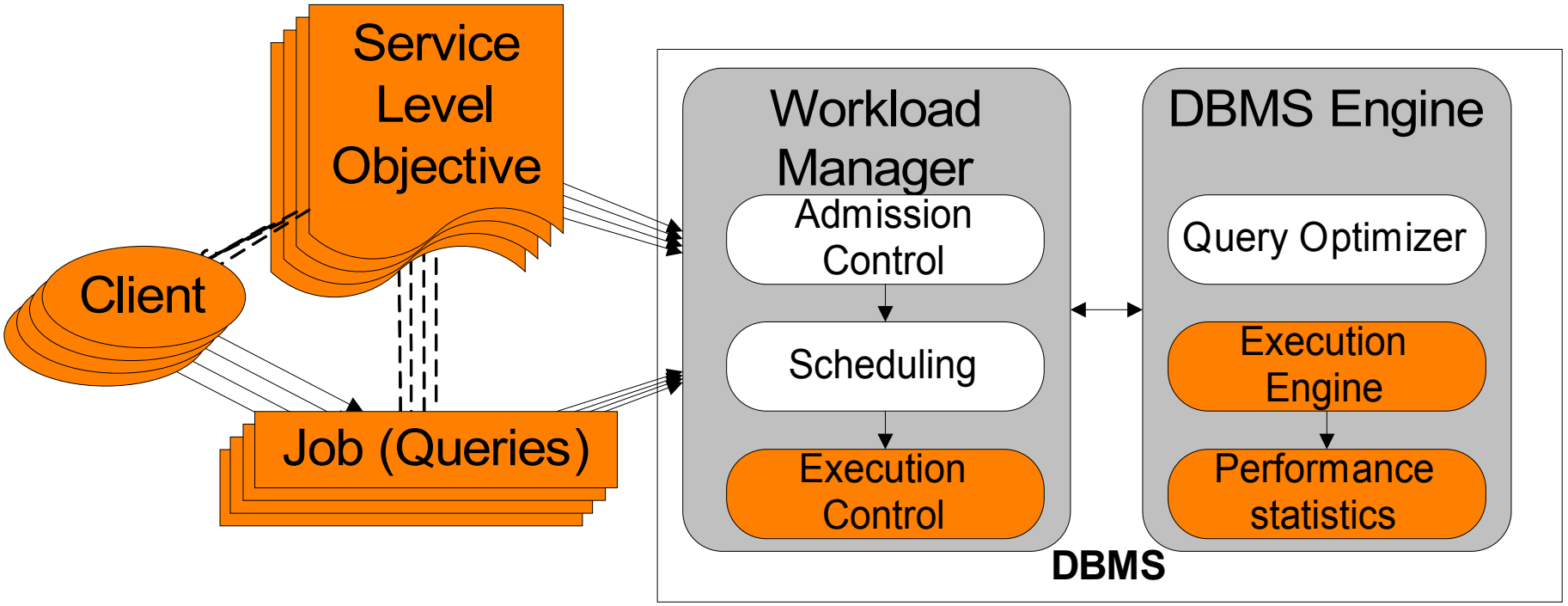
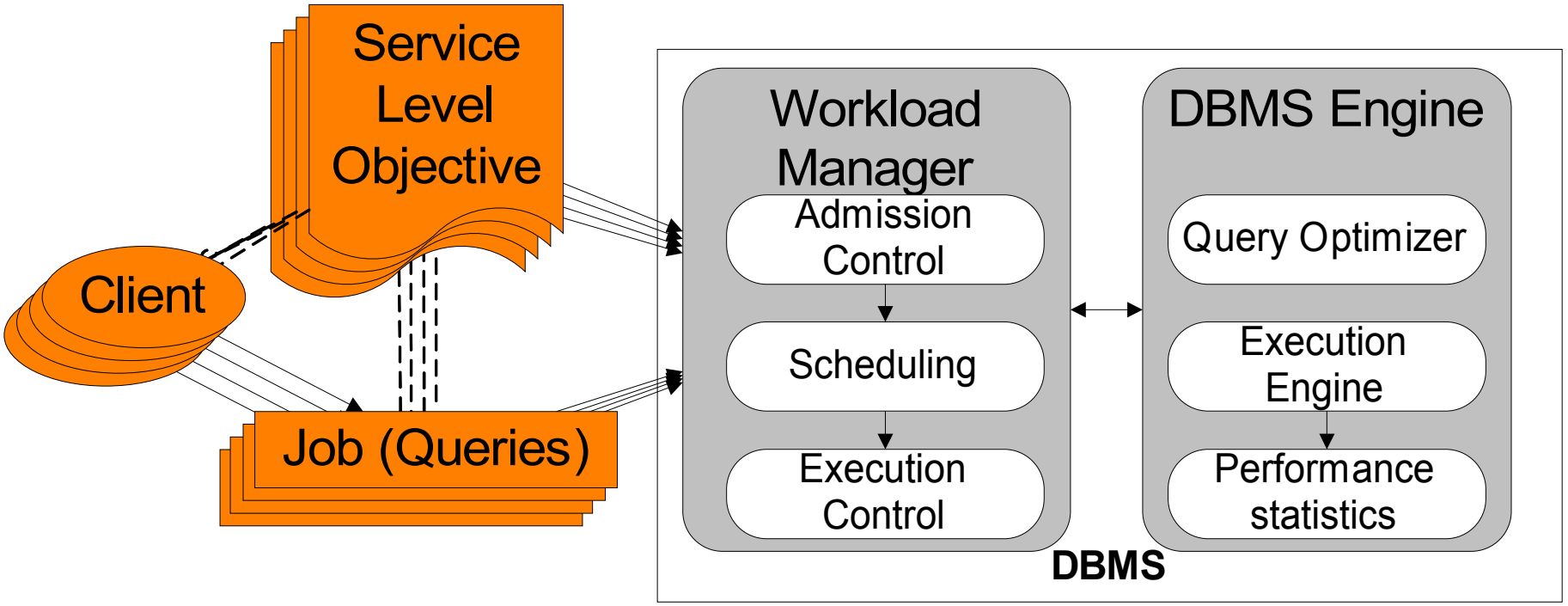
Workload Management Architecture



Service Level Objectives and Jobs



Service Level Objectives (SLOs)

- Job-facing SLOs (e.g., penalty functions used to optimize the scheduling of queries)

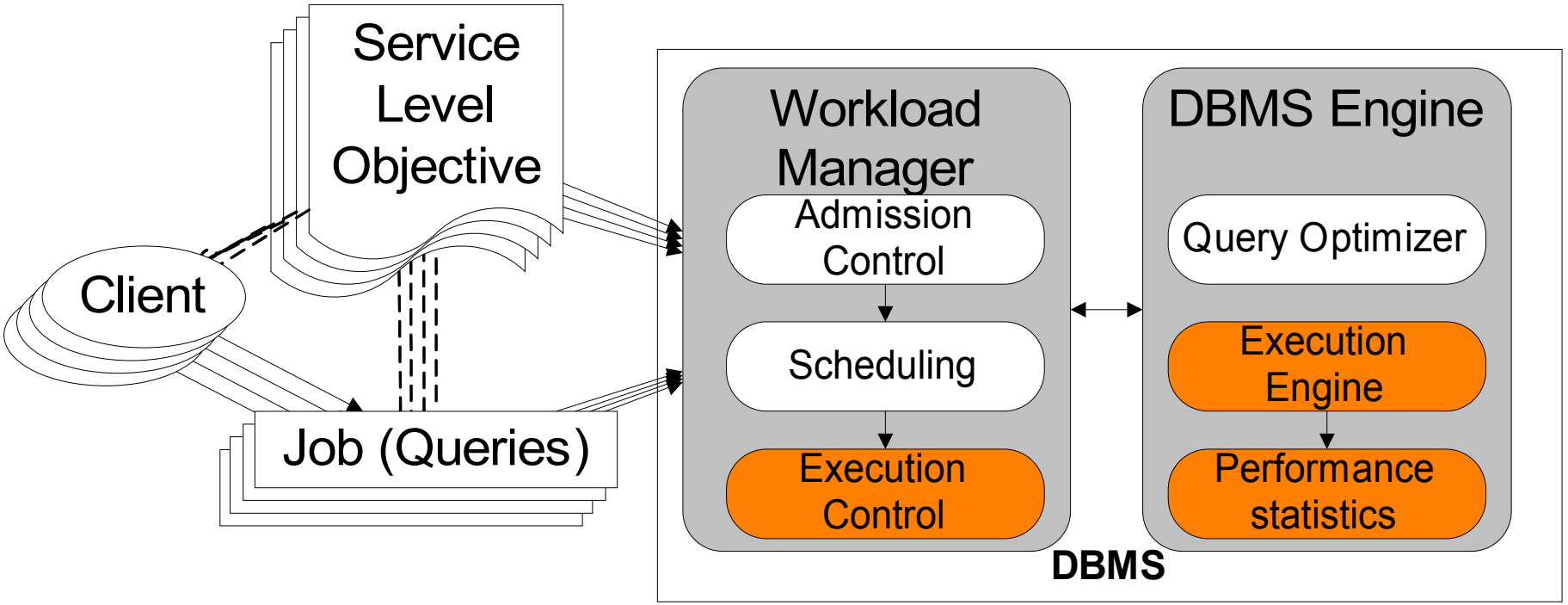
- Customer-facing SLOs
  - Minimize response time (derived from “challenges”)
  - Deadline-driven
  - Concrete quantities of computing time

Job Types

- Batch (e.g., reports)
  - Usually repetitive
  - All queries arrive at the database system at once
  - Queries may/may not have precedence constraints
  - SLO is deadline driven

- Interactive (e.g., business analysis)
  - All queries arrive at the database sequentially
  - Arrival time of the first query is not known in advance
  - SLO (“ASAP”)
    - Submitted by a special request for business reasons

Execution Engine



Workload Manger

- Admission Control
- Scheduling
- **Execution Control**
  - Set of actions that apply when certain conditions hold
  - Example:

```
IF relDBTime IS high AND progress IS low
 THEN cancel IS applicable
```

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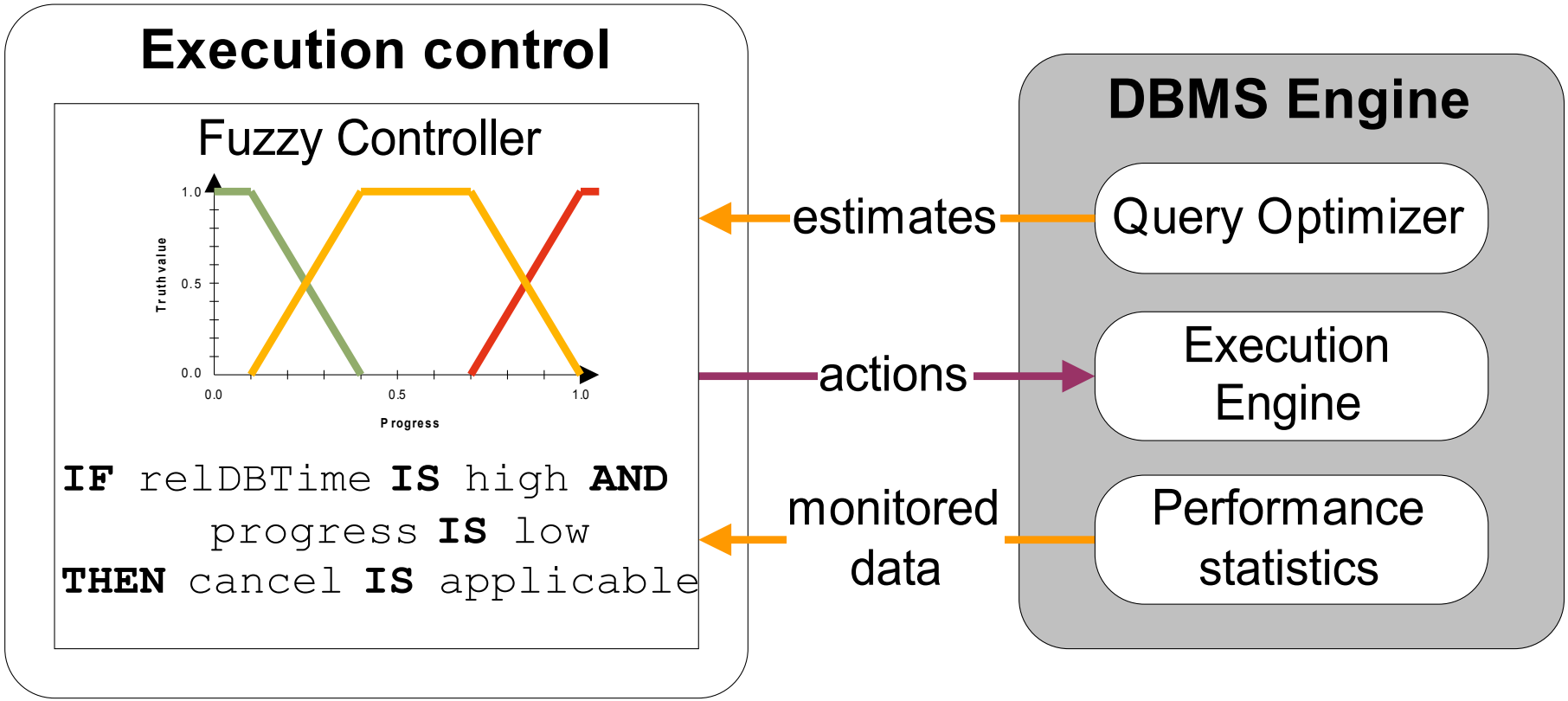
Monitored Metrics

- Relative database time (derived from elapsed time of queries and processing time estimates)
- Query progress (derived from progress indicator)
- Number of cancellations
- Resource contention
- Priority

Monitored Metrics



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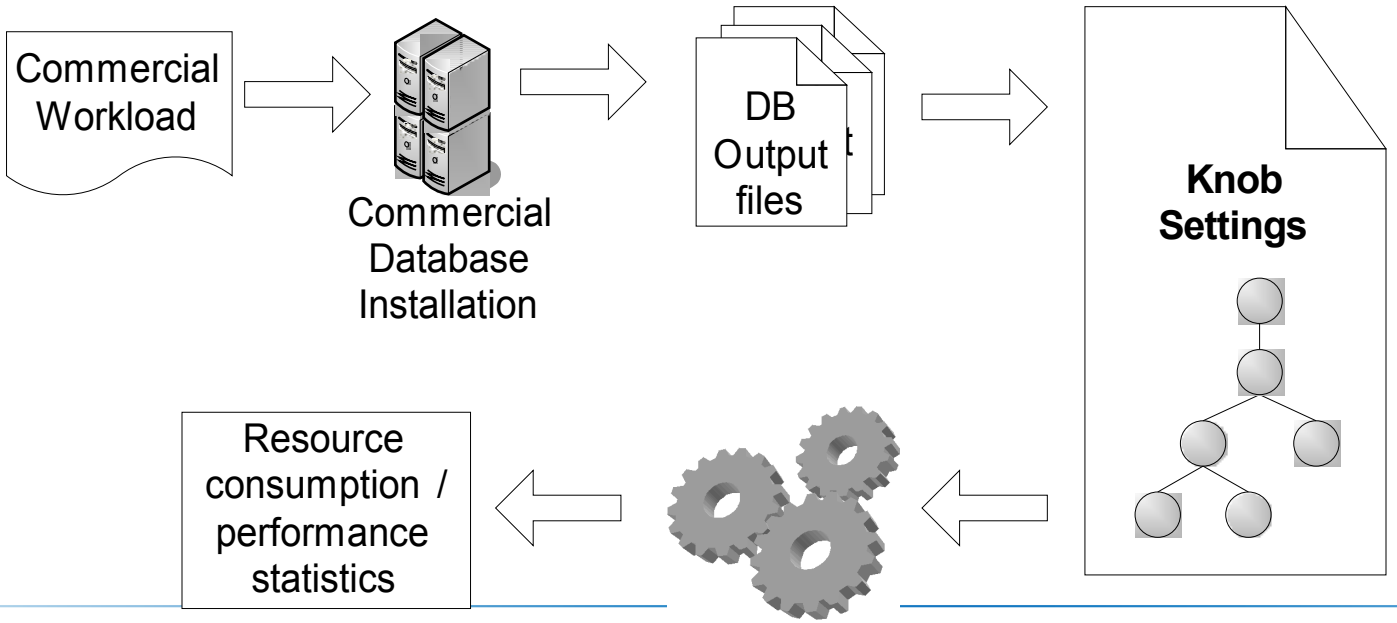
Implementation

- Use simulated execution engine instead of real database system installation
  - Inject problem queries
  - Real workloads can take days to process



- Number of queries in a job
- Number of jobs in a workload
- Number of problem queries
- …

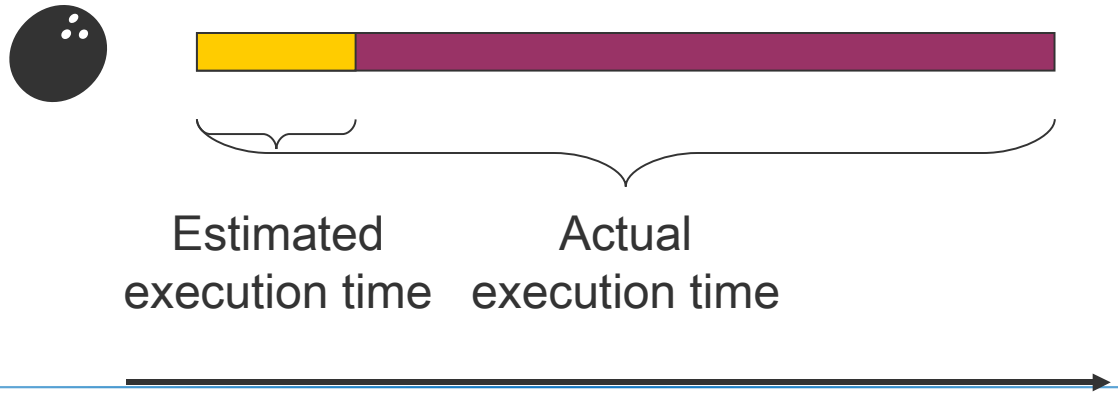
Settings for Experiments

- Interactive job
  - ~ 1100 feathers
  - Queries arrive sequentially
    - Inter-arrival time 0
    - Does not span entire workload interval
- Batch job
  - ~ 1700 feathers, baseballs, and bowling balls
  - Average execution time of batch queries ~1000 times higher than execution time of interactive queries

derived from commercial workload runs

Settings for Experiments

- Normal workload
  - Interactive and batch job executed in parallel
  - No problem queries
- Problem workload
  - Interactive and batch job executed in parallel
  - **Problem queries** injected into batch workload (75 queries with different “stretch factors”)

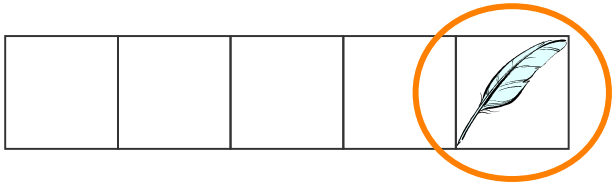


Settings for Experiments

- Normal workload
  - Interactive and batch job executed in parallel
  - No problem queries
- Problem workload
  - Interactive and batch job executed in parallel
  - **Problem queries** injected into batch workload (75 queries with different “stretch factors”)
  - Problem queries have a probability for showing the problem behavior after restarting them
- Admit interactive queries first

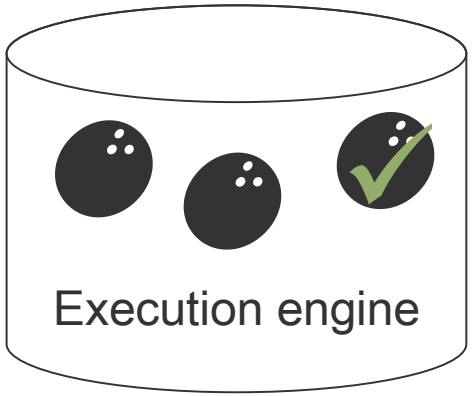
Admission Control: Admit Interactive First

Queue for interactive queries



Admit query

Queue for batch queries



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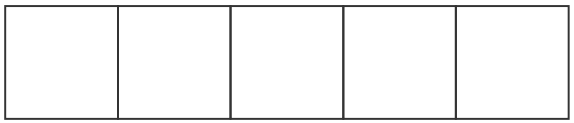

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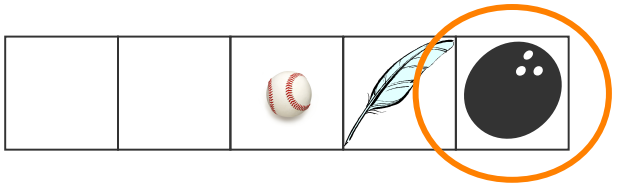

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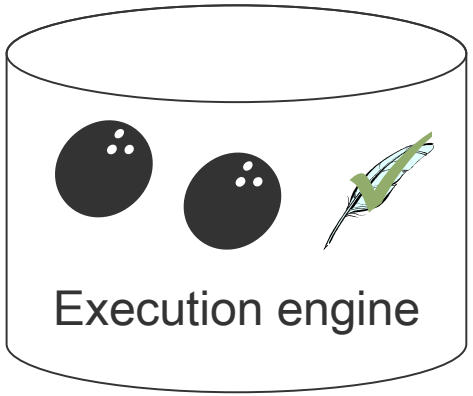

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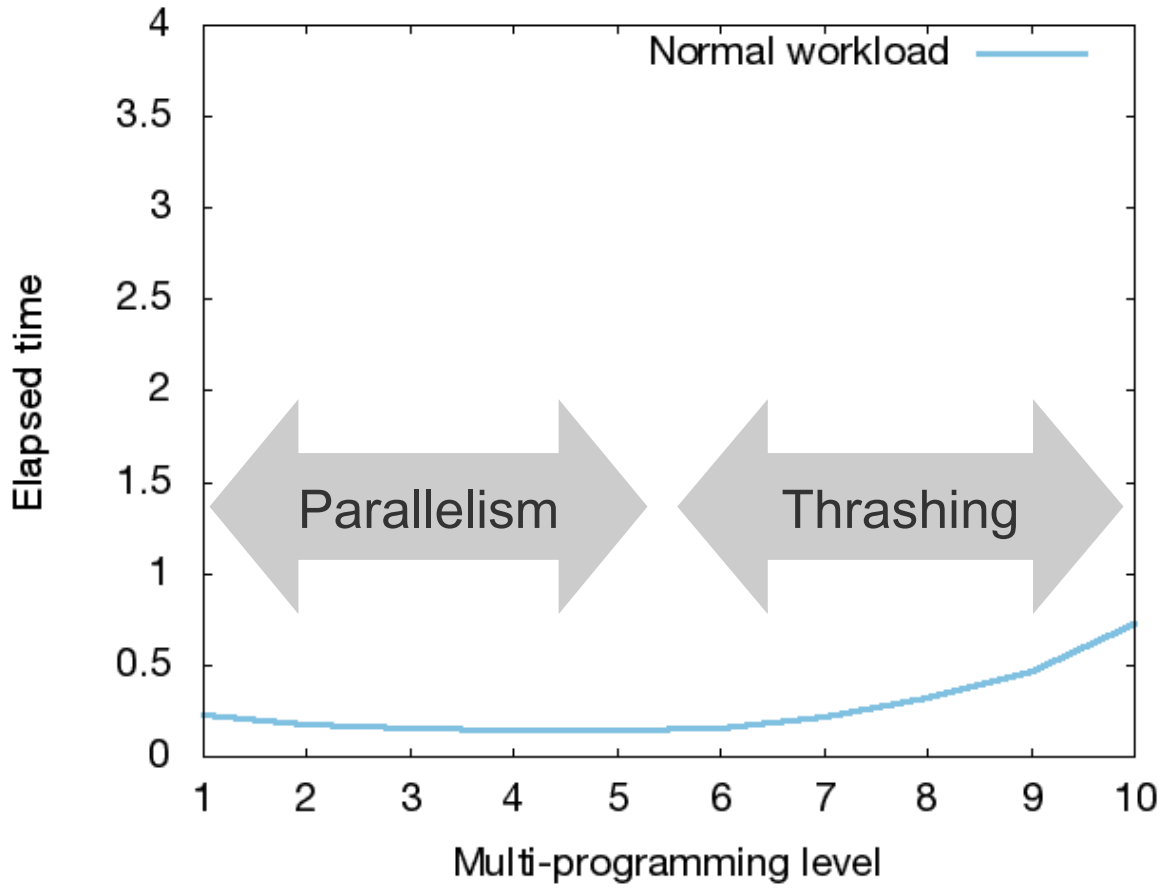
Impact of Problem Queries on Batch Job



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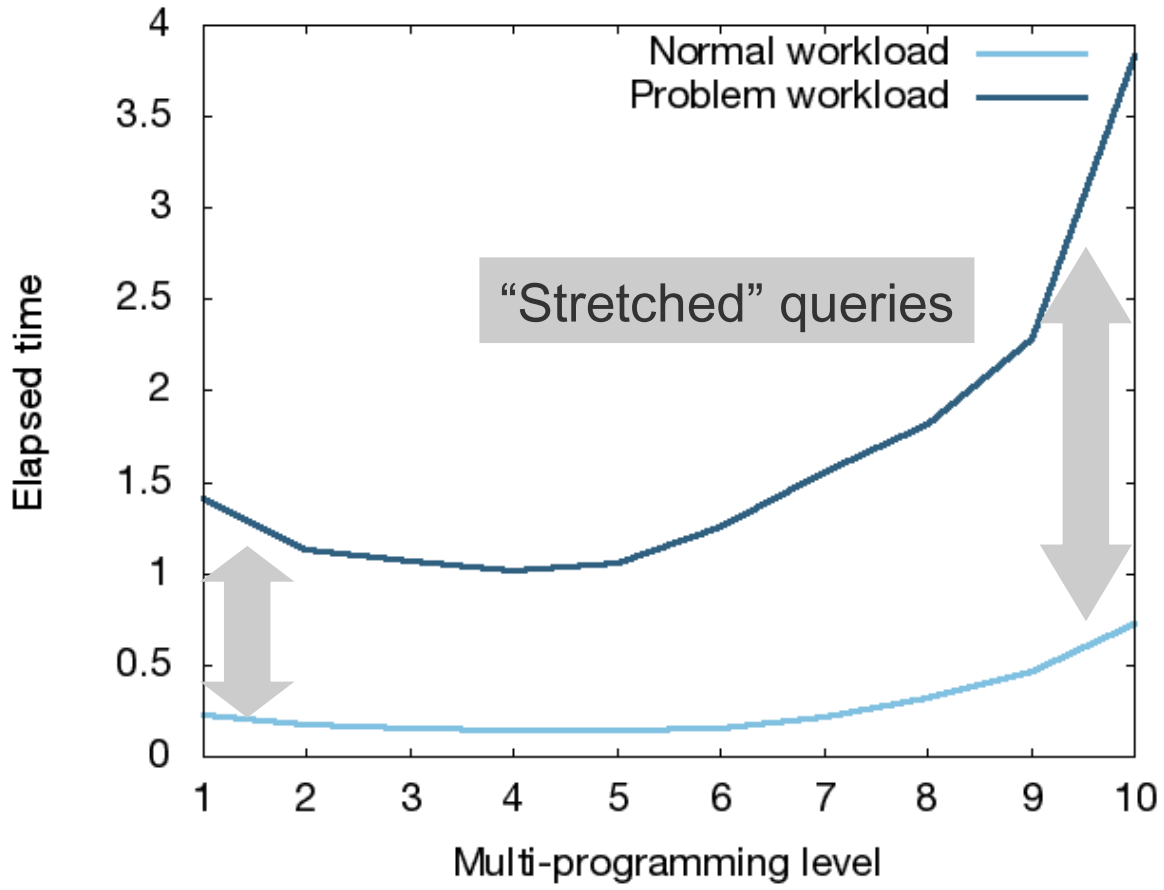
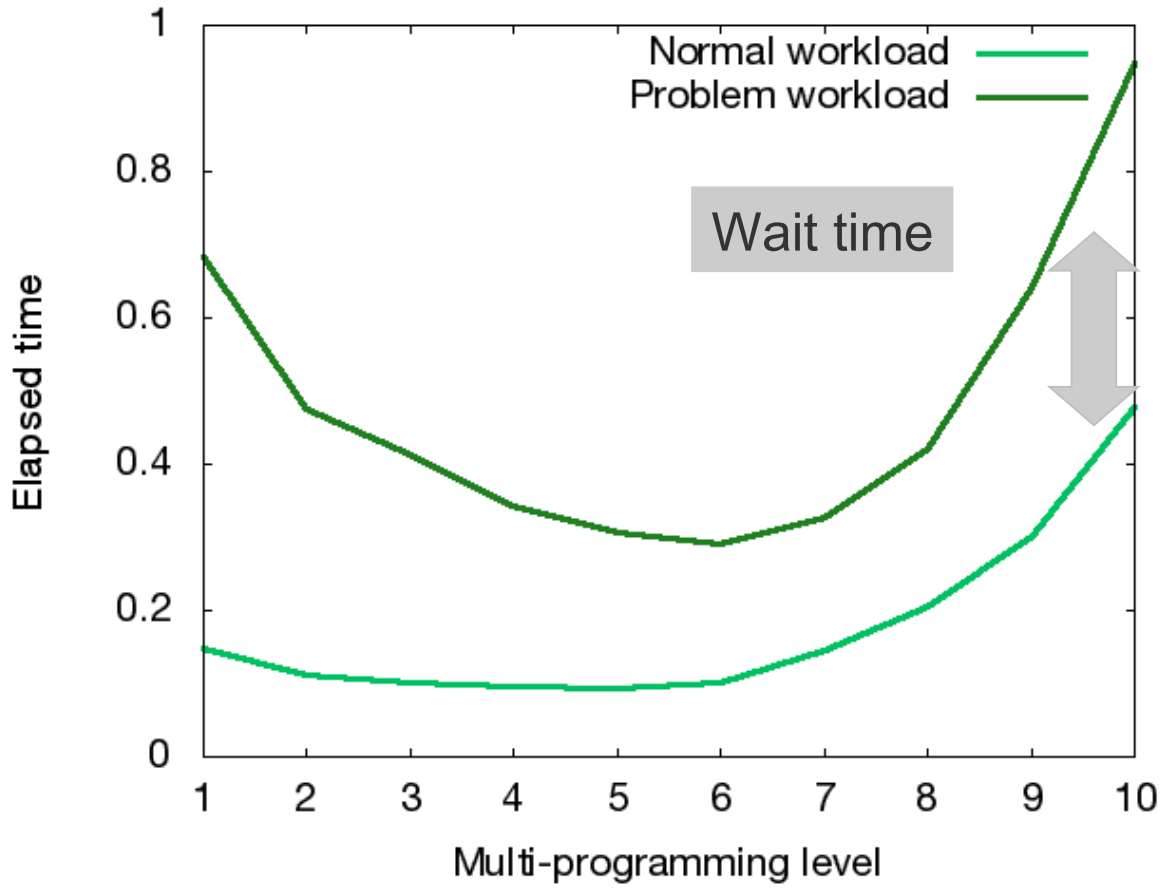


Impact of Problem Queries on Interactive Job



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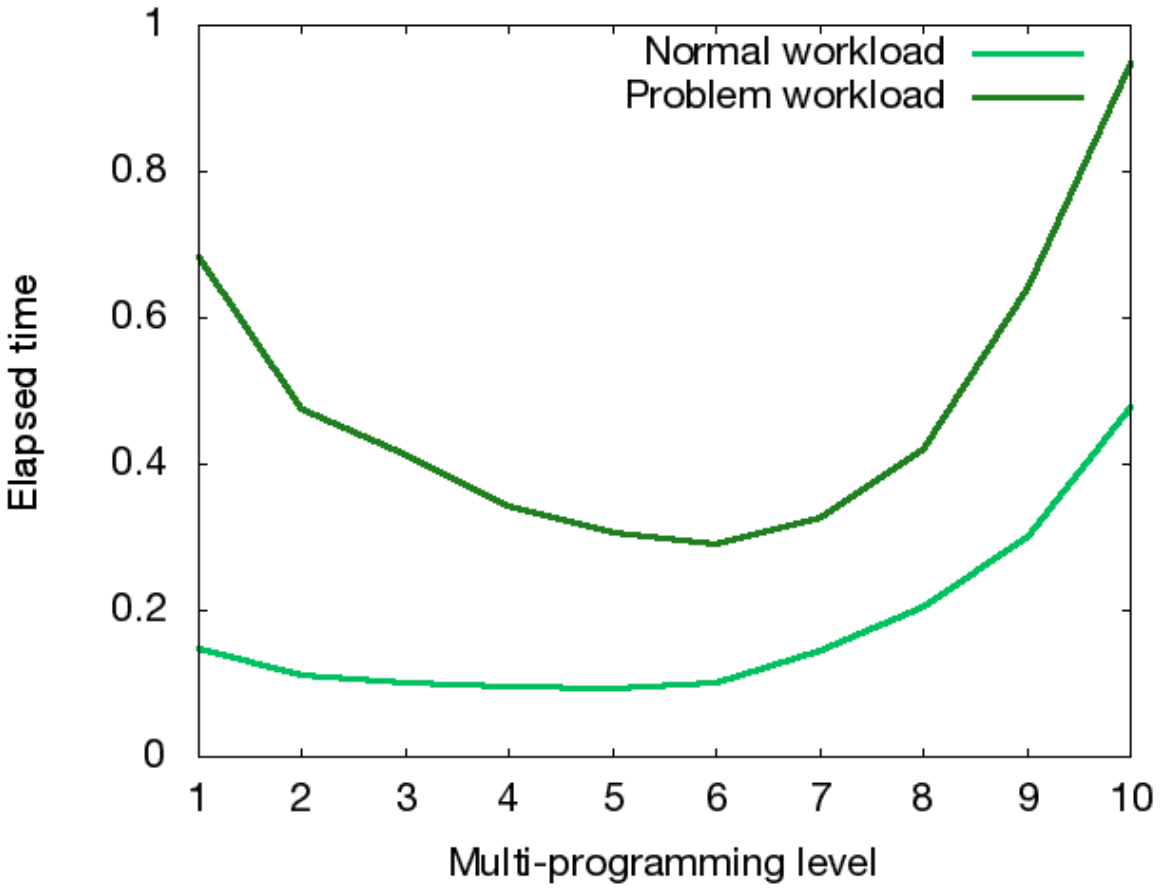

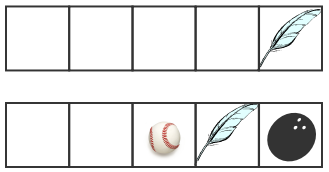

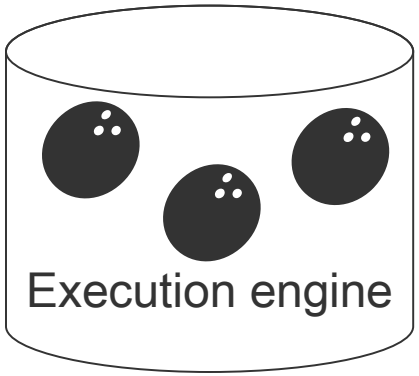

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Workload Management Policies

- Fix the MPL at 5
- Varying aggressiveness
  - If query exceeds estimated database time, take action

```
relative database time=
  actual database time/estimated database time
```

  - If query is almost finished, do not execute action
- Queries identified as problems are killed and immediately resubmitted (“cancel”)
- Canceled queries get two more chances to run to completion
- If queries do not complete, they are killed (“aborted”)

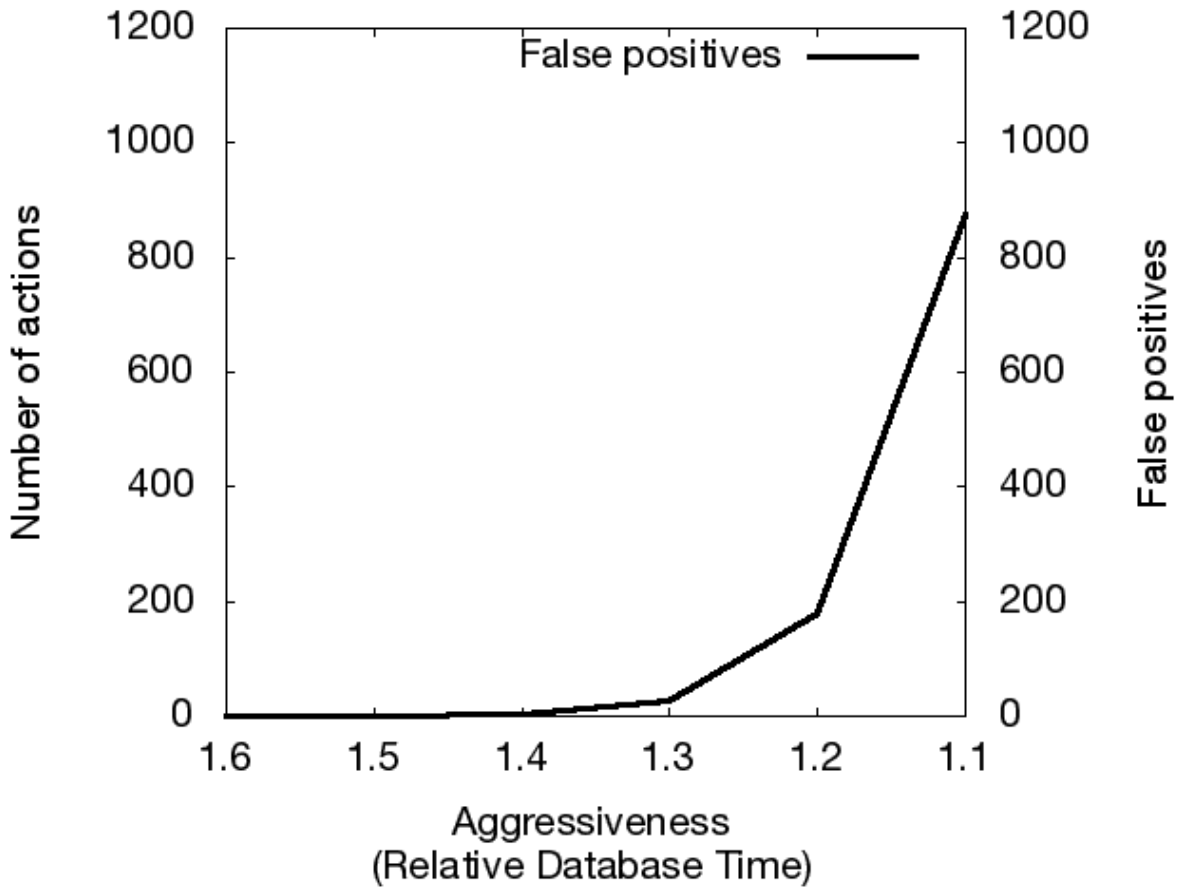
Impact of Workload Management Actions

- Batch job: Reduce elapsed time by 81% (problem queries)
- Interactive job: Reduce wait time by 67% (wait time)

- But…

False Positives Lead to Unnecessary Actions

Relative Database Time



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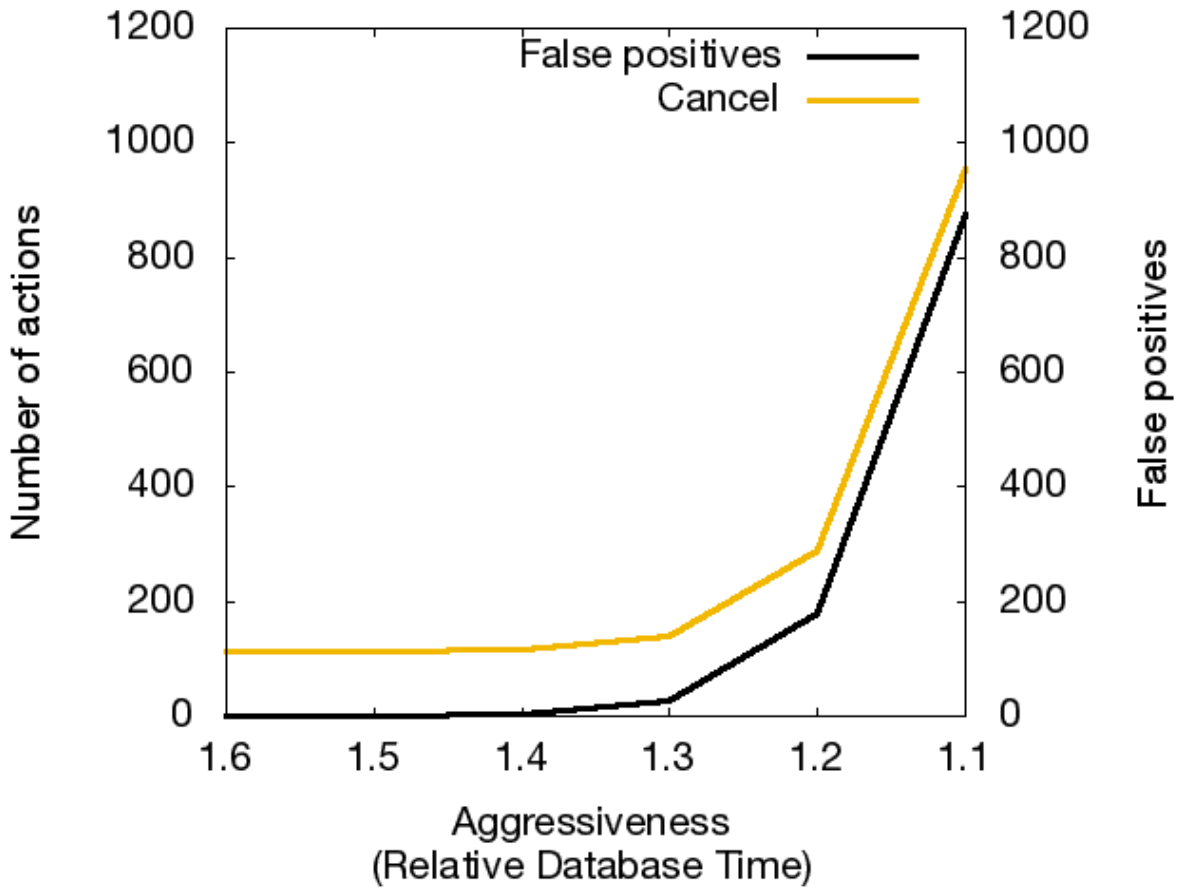

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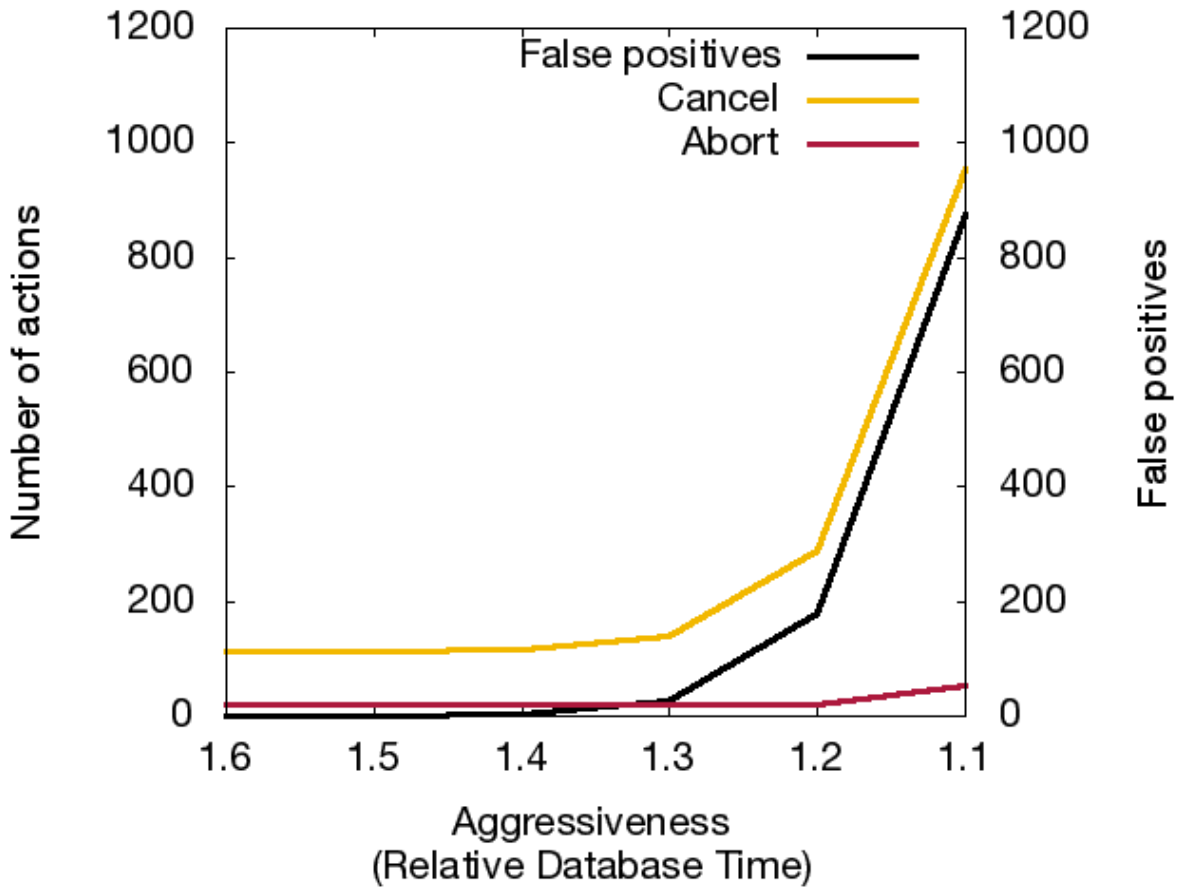
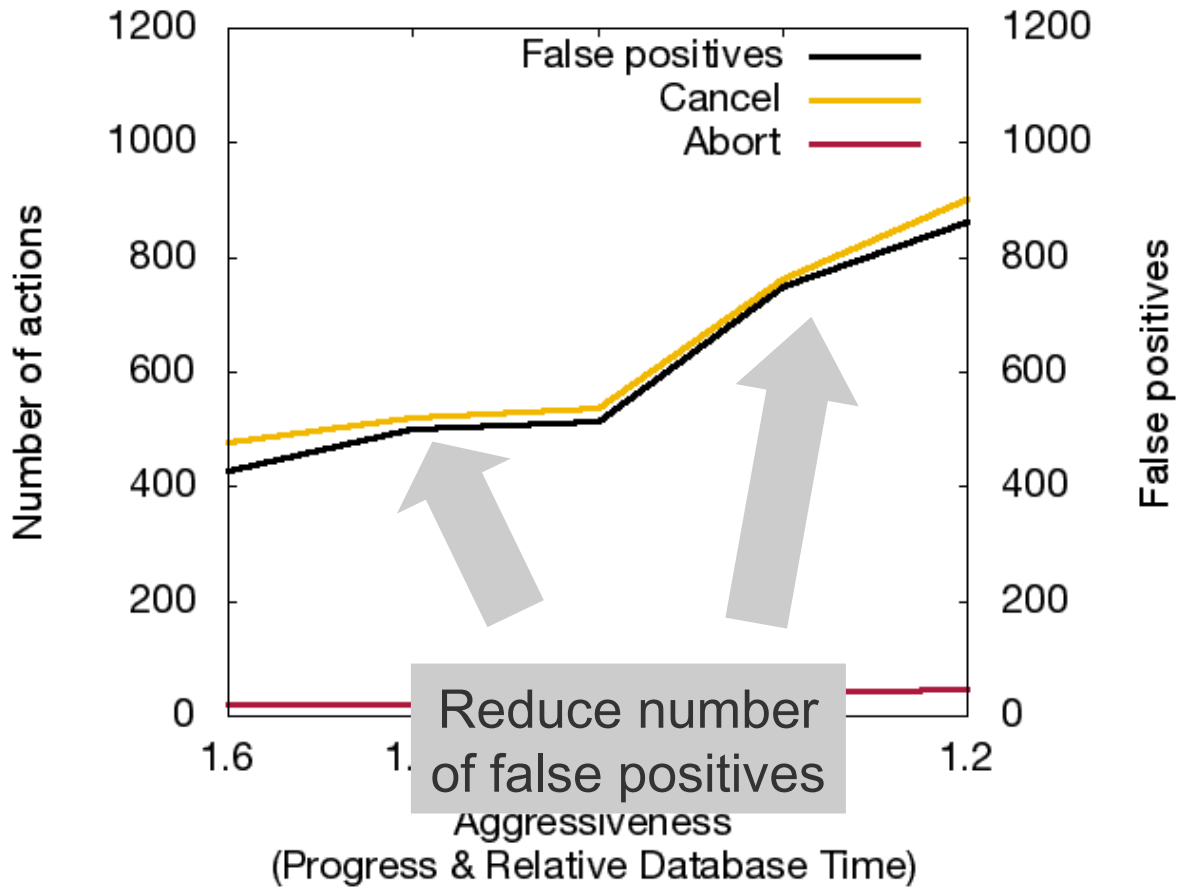
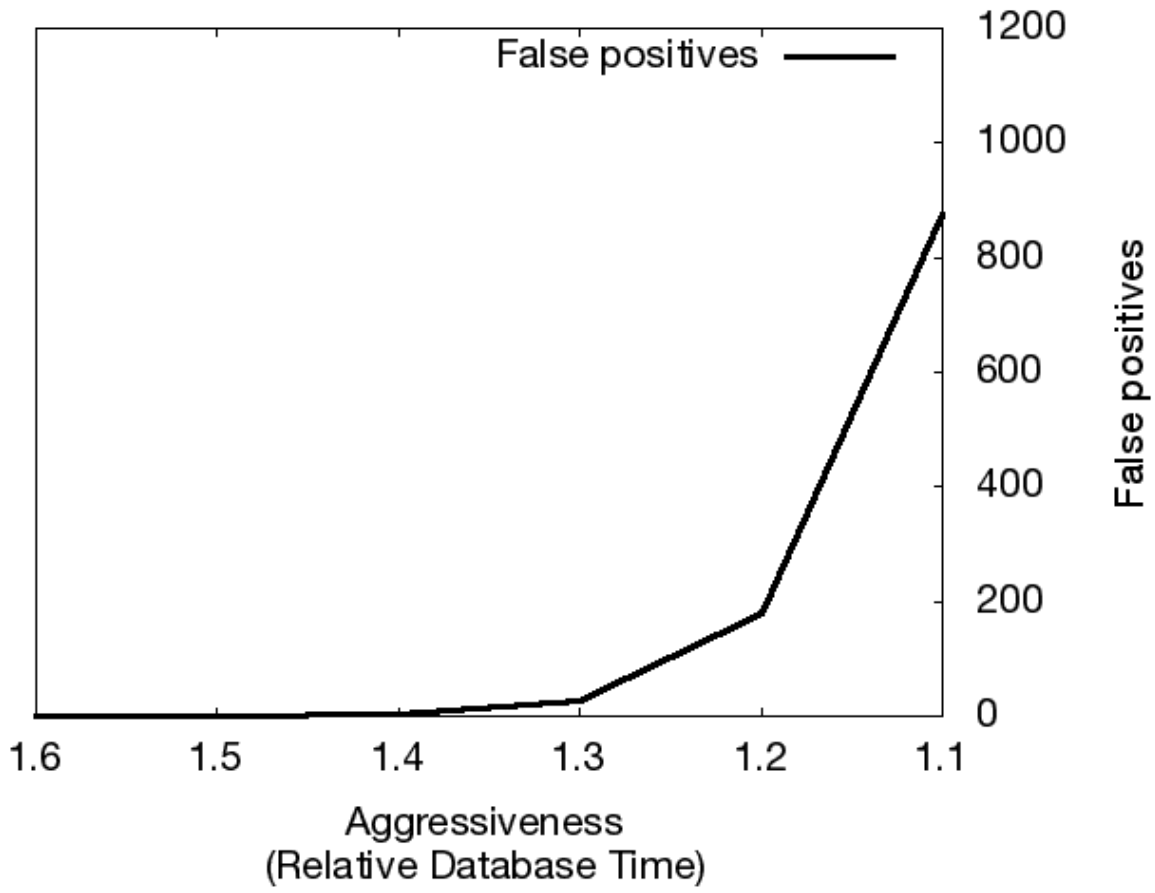


Number of False Positives and Actions Executed

Progress



Elapsed Time for Batch and Interactive Jobs



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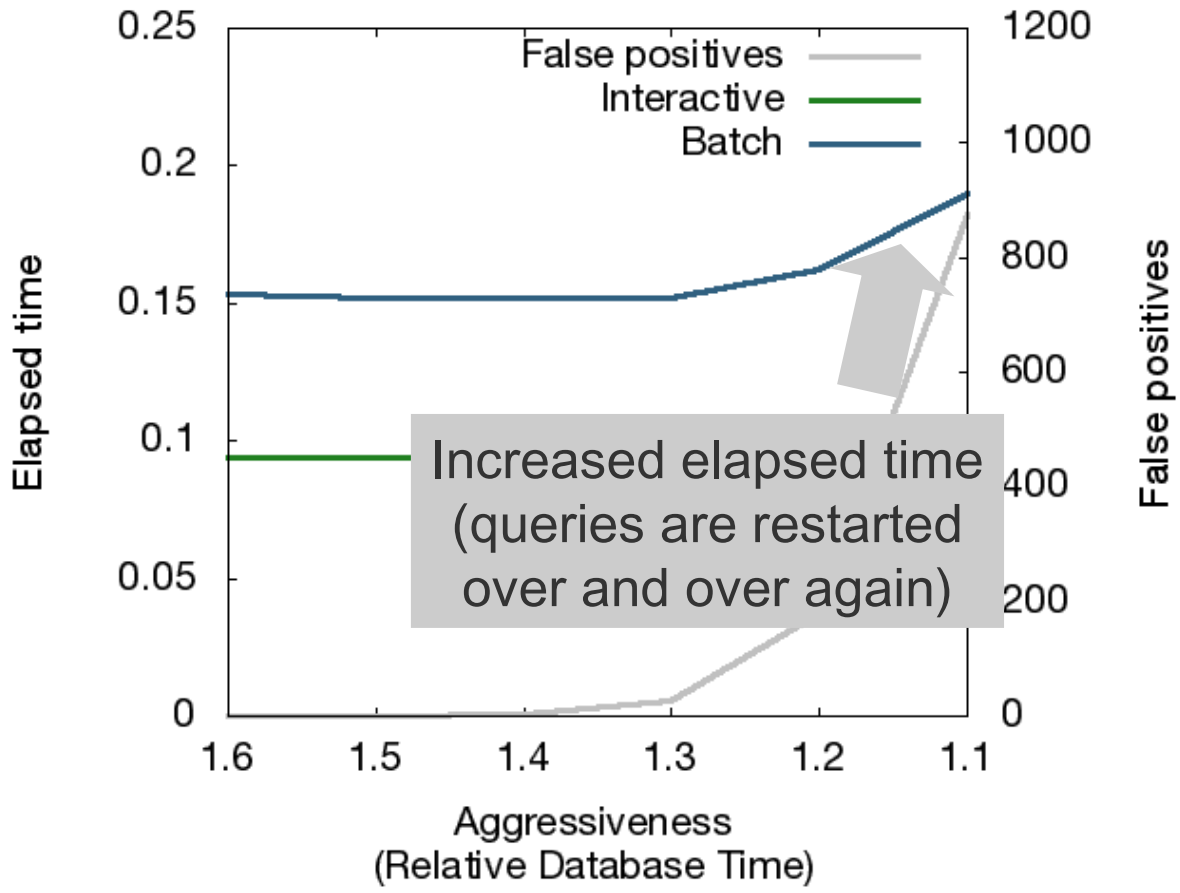

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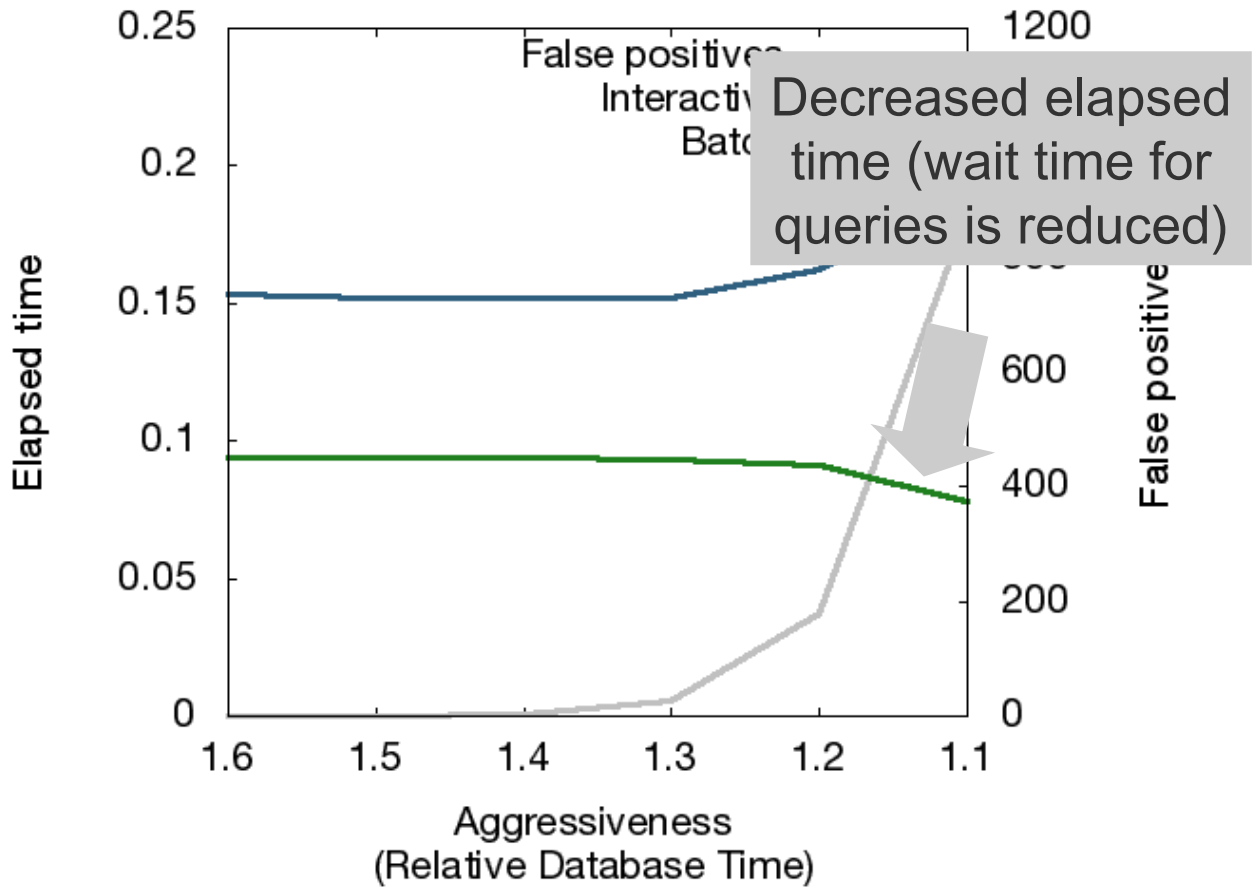

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Conclusion

- We implemented a workload management test bed
- Our experiments show that …
  - … even few problem queries have a significant impact on the execution of a mixed workload
  - … the number of false positives leads to an increase in execution time
- Lessons we learned
  - Applying actions too aggressively leads to unnecessary actions
  - Use controller and adjust parameters to right level of aggression

Ongoing Work

- Evaluate impact of admission control and scheduling of BI workloads
- Model query execution on a more detailed level
- Model additional problem types
- Evaluate new workload management techniques

Any Questions?