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Design and Evaluation of an Autonomic Workflow Engine

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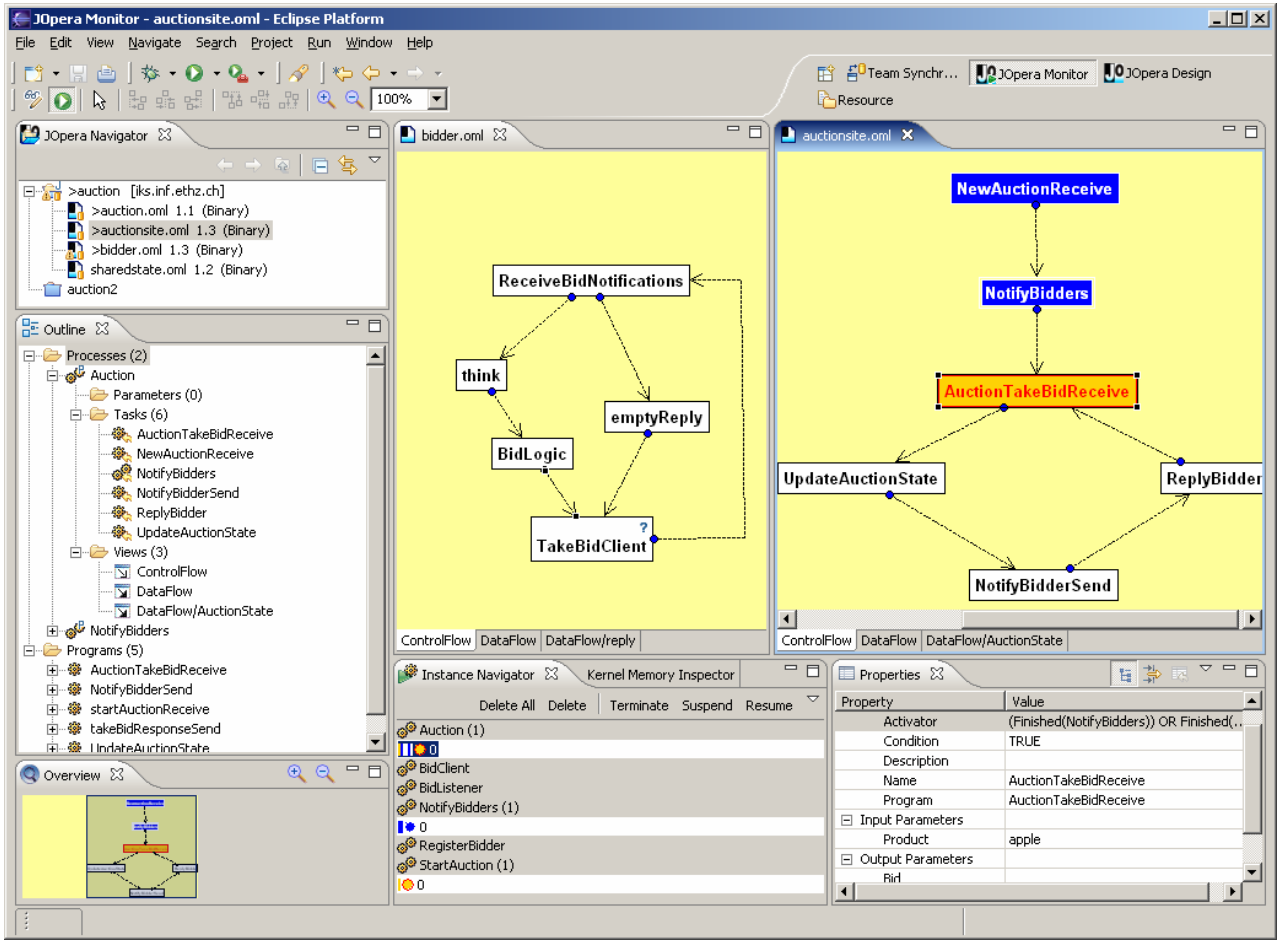
Motivation

- Workflow management systems are applied to domains having unpredictable workloads
  - Scientific Workflows running in a grid environment
- Replicating functionality of the engine to achieve scalability
- But how to configure a distributed engine?
- We applied autonomic principles to a distributed workflow engine to tackle these problems

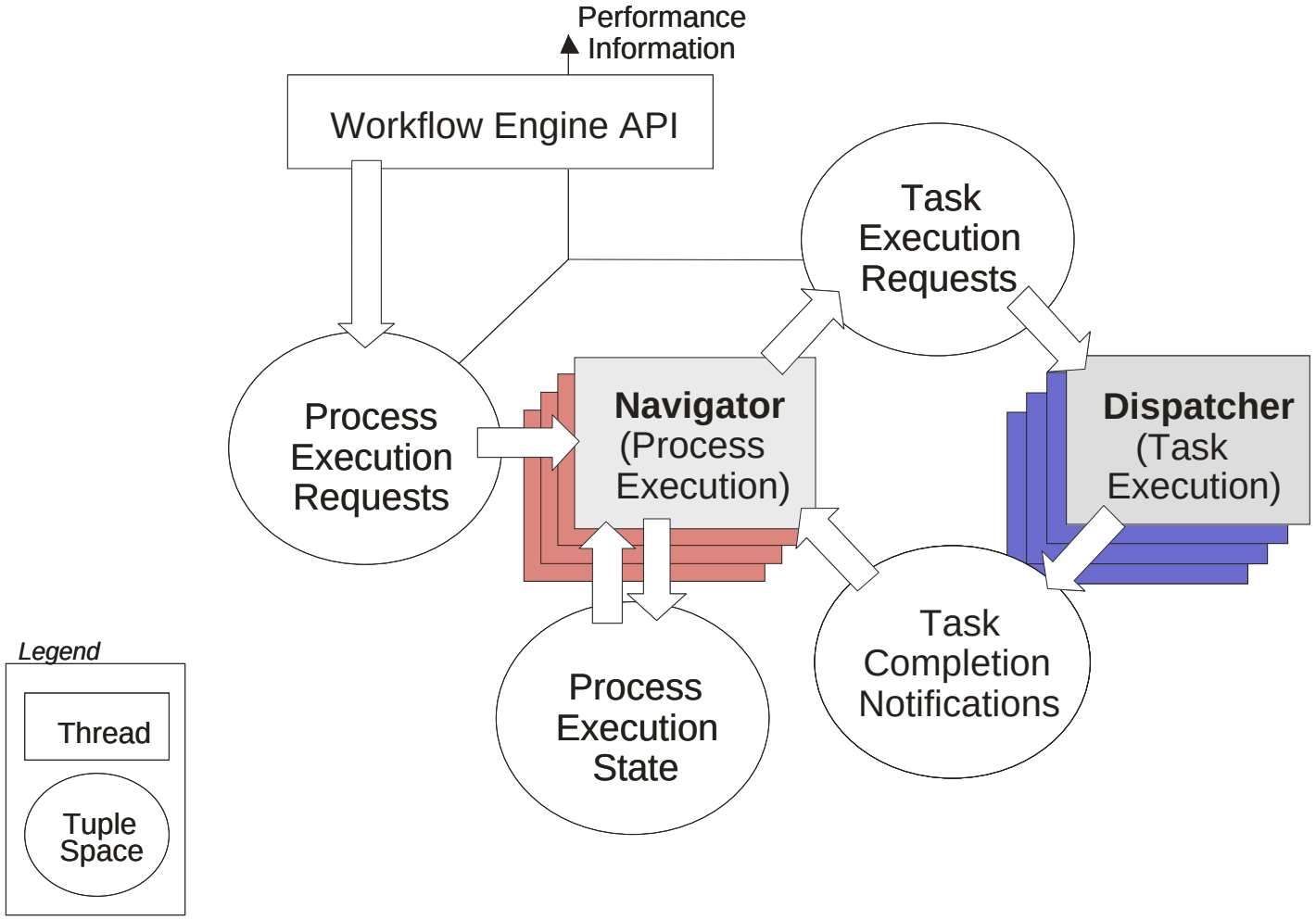
JOpera Workflow Execution Engine

- Engine that can be replicated across a cluster
- It is able to handle large number of concurrent workflow executions
- Exposes system information
- Provides means that allow reconfiguration at runtime

JOpera Workflow Model

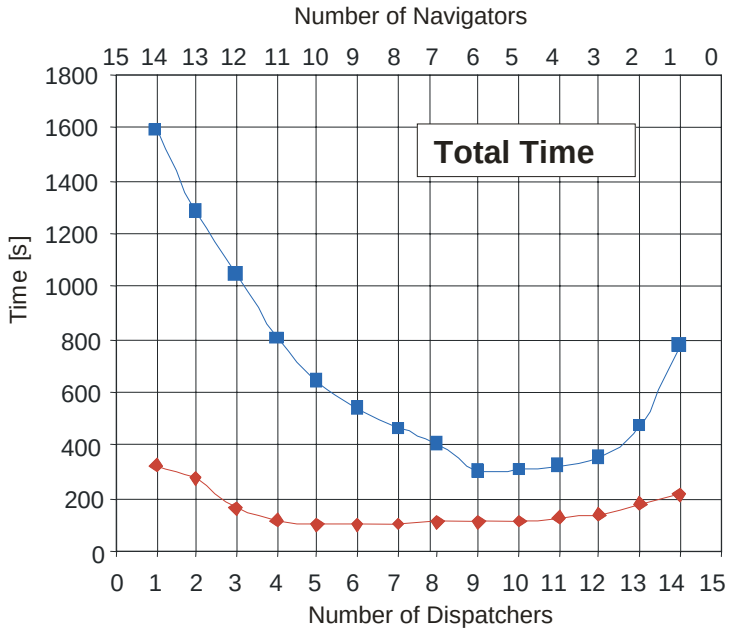


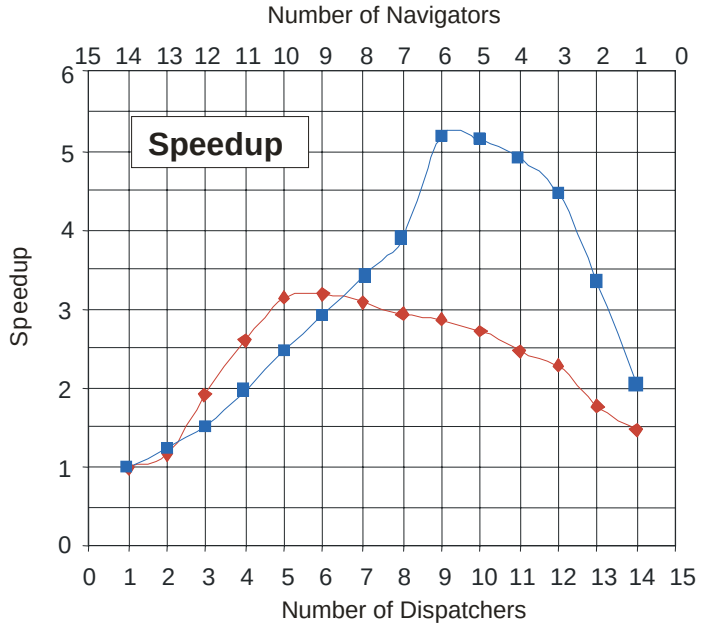
JOpera Execution Engine Architecture



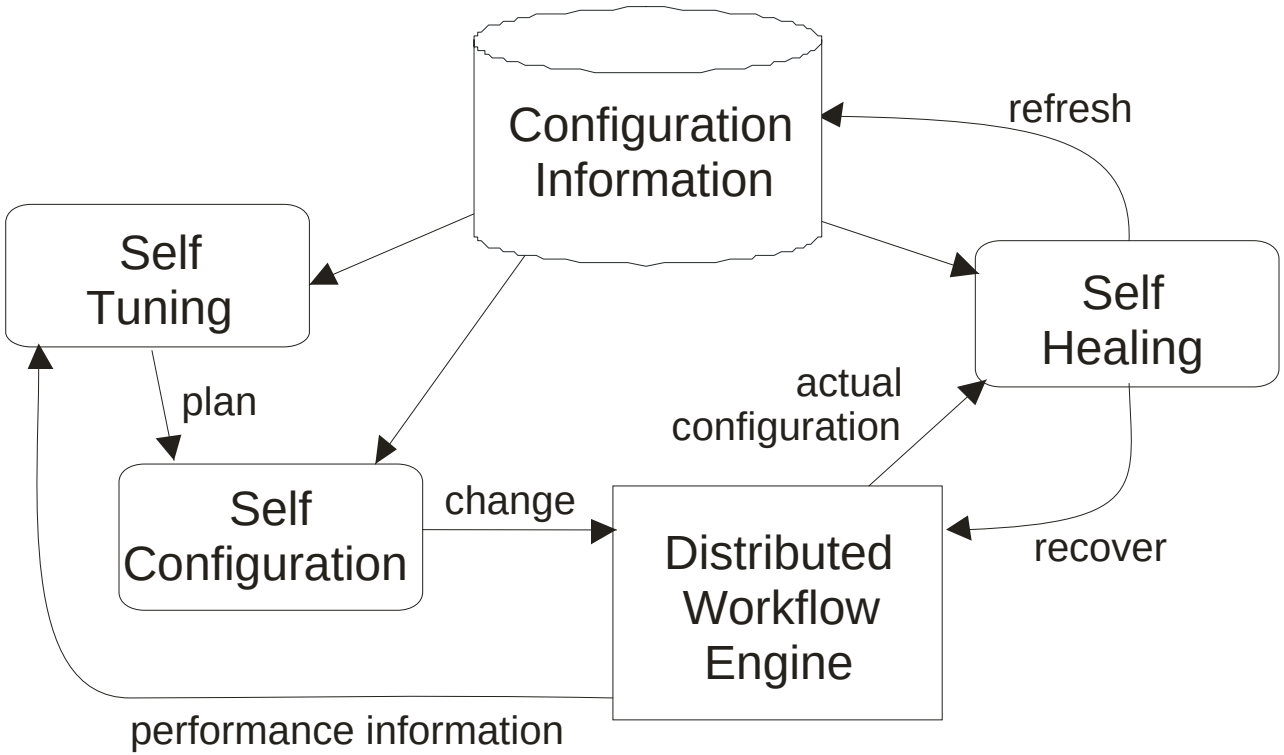
Static Configuration

- Two different workloads:
  - Workload 0: 1000 processes with 10 parallel tasks of 0 seconds
  - Workload 20: 1000 processes with 10 parallel tasks of 20 seconds





Autonomic Controller



Self-Tuning

- Information Strategy
  - What performance indicators should be monitored to determine a new configuration?
    - Growth of the task execution request space (waiting tasks space) size as well as the process execution request space (waiting processes space) size
    - Current configuration information
- Optimization Strategy
  - What is the best configuration to balance the number of dispatcher and navigator threads?
    - The configuration is adapted such that growth of either space is bounded

Self-Configuration Actions

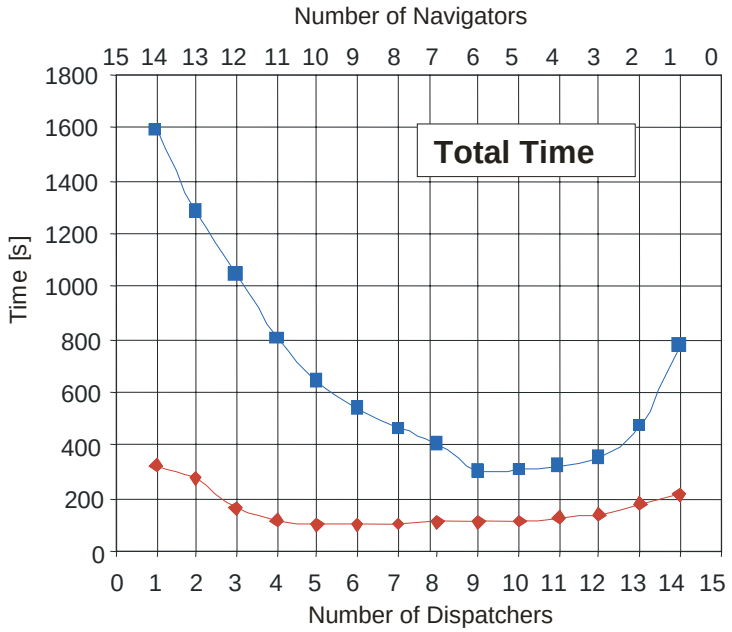
- Starting Threads
- Stopping Navigator Threads
- Stopping Dispatcher Threads
  - Involves stopping the execution of tasks
    - Kill method: stop all tasks immediately
    - Stop method: let all tasks finish but do not start new tasks
  - Stopping a dispatcher may thus introduce reconfiguration overhead
    - Random selection selects dispatcher threads arbitrarily
    - Smart selection selects dispatcher that introduces the least reconfiguration overhead

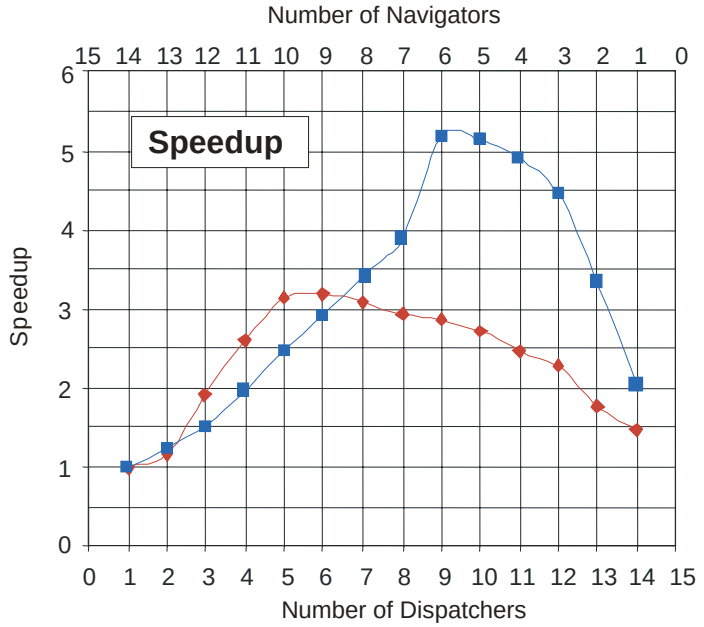
Self-Healing

- Failures are detected by comparing the current configuration of the execution engine with the configuration information
- Handling dispatcher thread failures
  - State of the execution of the process is queried to determine which tasks need to be re-executed
  - Requires tasks running on the failed dispatcher to be rescheduled
- Handling navigator thread failures
  - Execution state is still available in the global process execution state space

Evaluation

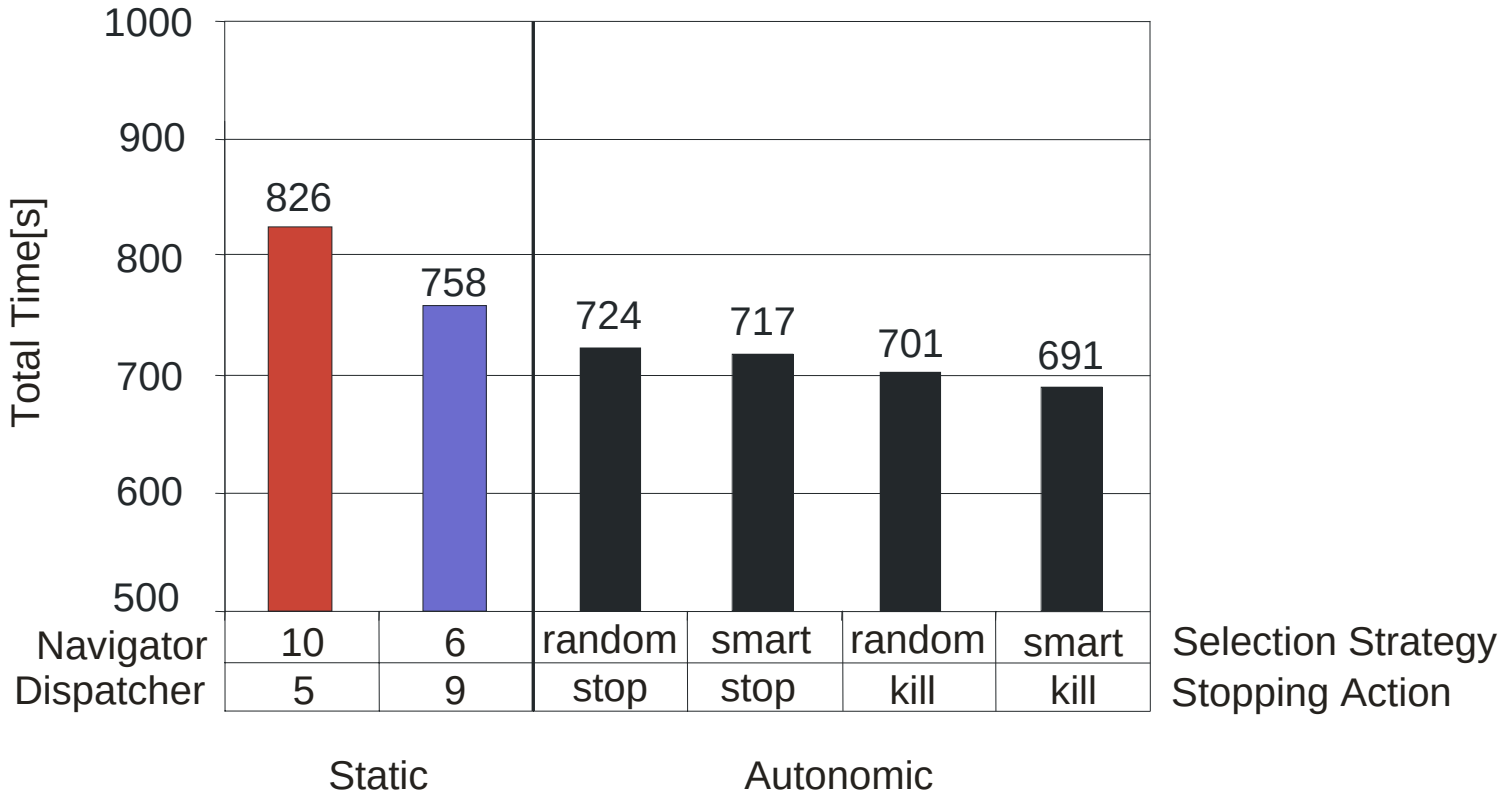
- Two different workloads:
  - Workload 0: 1000 processes with 10 parallel tasks of 0 seconds
  - Workload 20: 1000 processes with 10 parallel tasks of 20 seconds





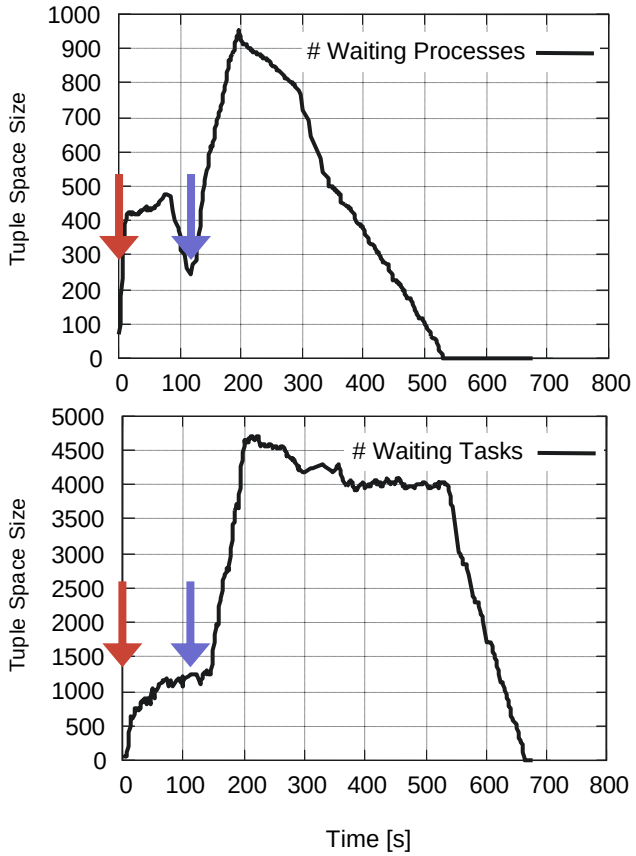
Evaluation: Comparison

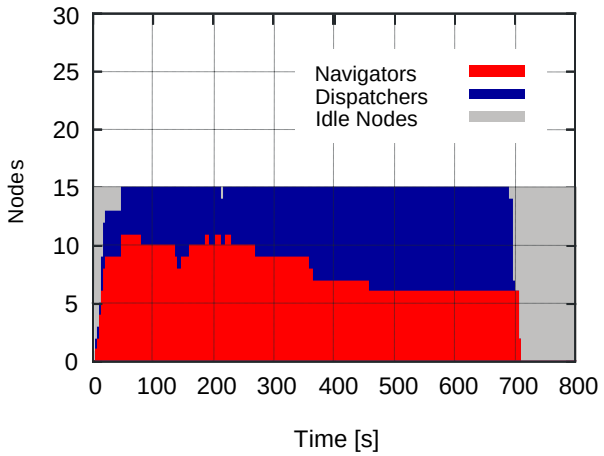
- Combined Workload: Workload 0, Workload 20



Evaluation: Trace

- Combined Workload: Workload 0, Workload 20





Conclusions

- Manual configuration of distributed workflow execution systems is difficult:
  - Workload characteristics are not known a priori
  - Misconfiguration leads to performance penalty
- We applied the autonomic computing paradigm on JOpera to add self-tuning, self-configuring and self-healing capabilities
- Our experiments indicate adaptation of the configuration of JOpera to a unforeseeable, changing workload

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available at http://www.jopera.org