Automatic System Tuning for Distributed Stream Processing
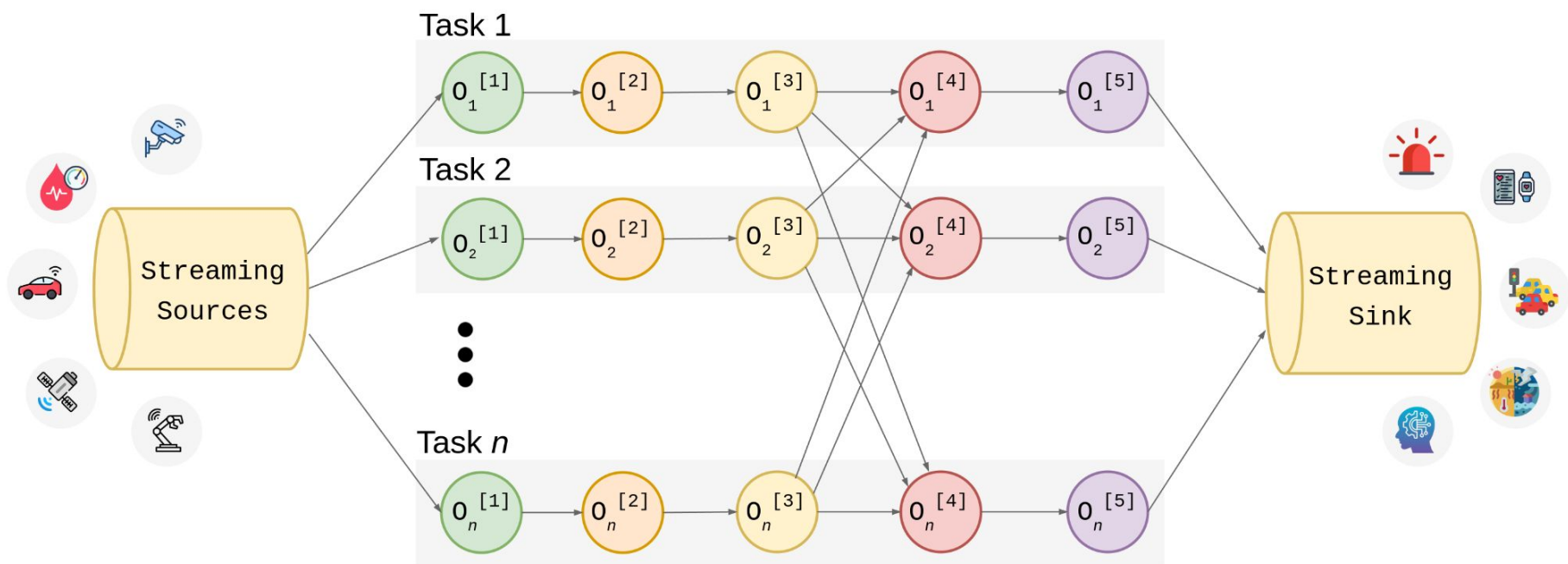
Morgan Geldenhuys, Dominik Scheinert, Odej Kao, Lauritz Thamsen*

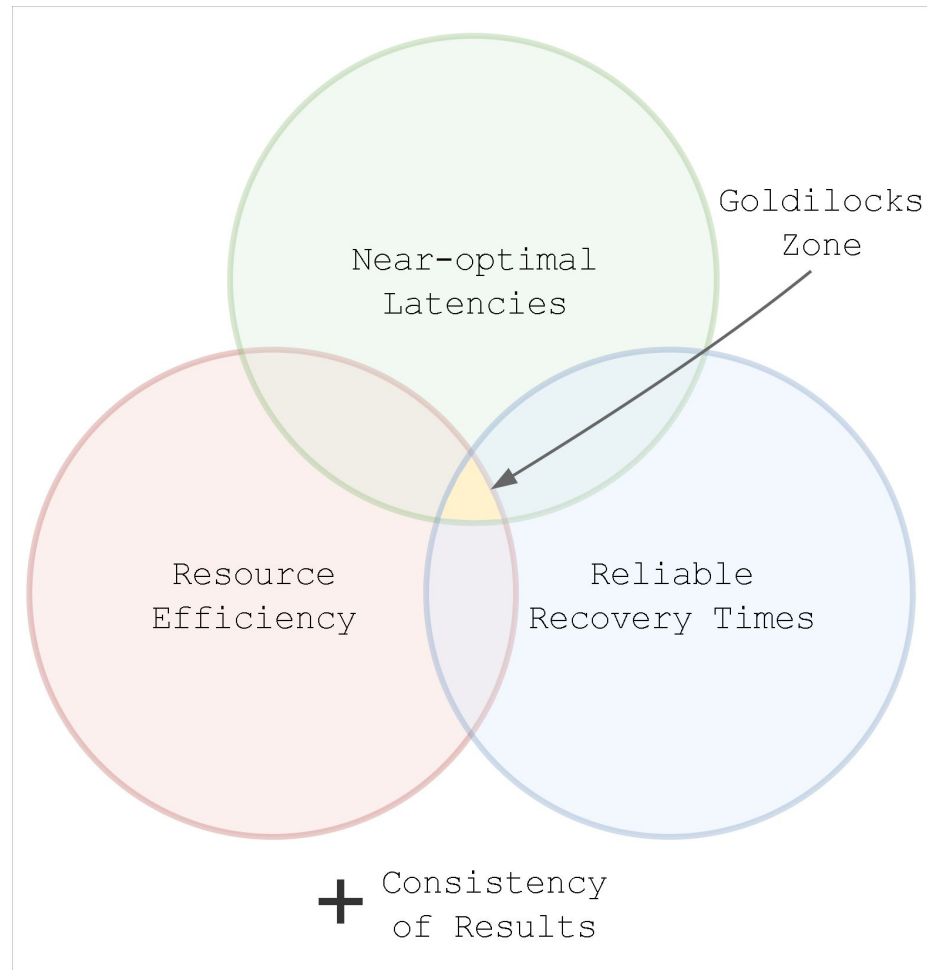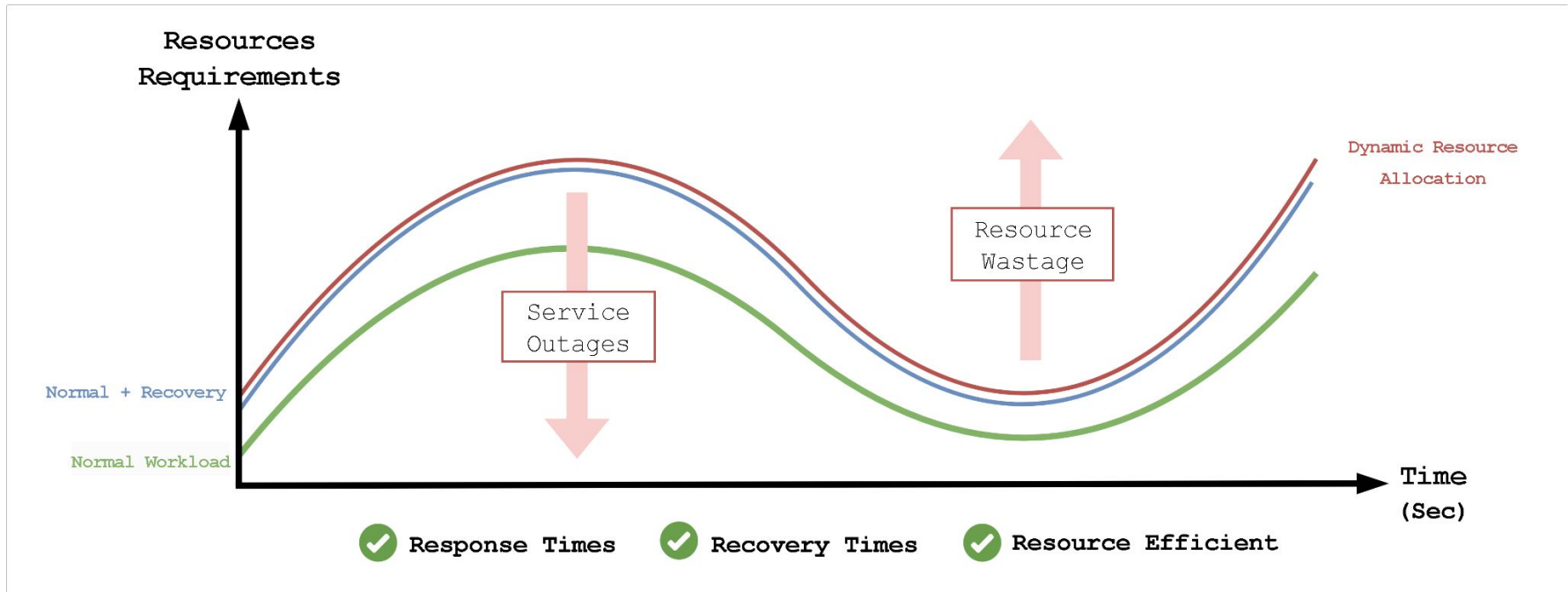Technische Universität Berlin, University of Glasgow*

2 May 2024

Background:
Distributed Stream Processing
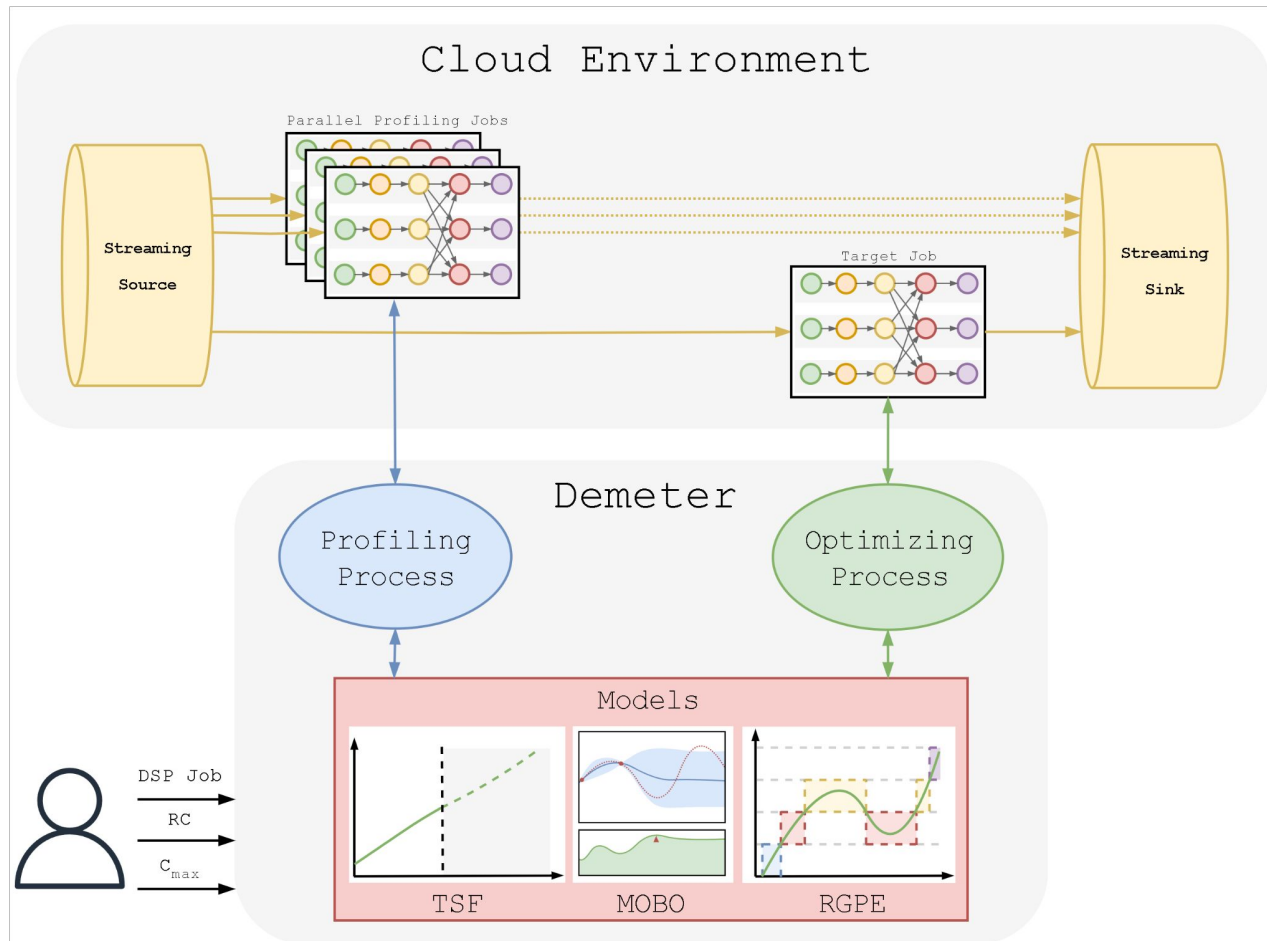
Problem:
DSP Operational Requirements
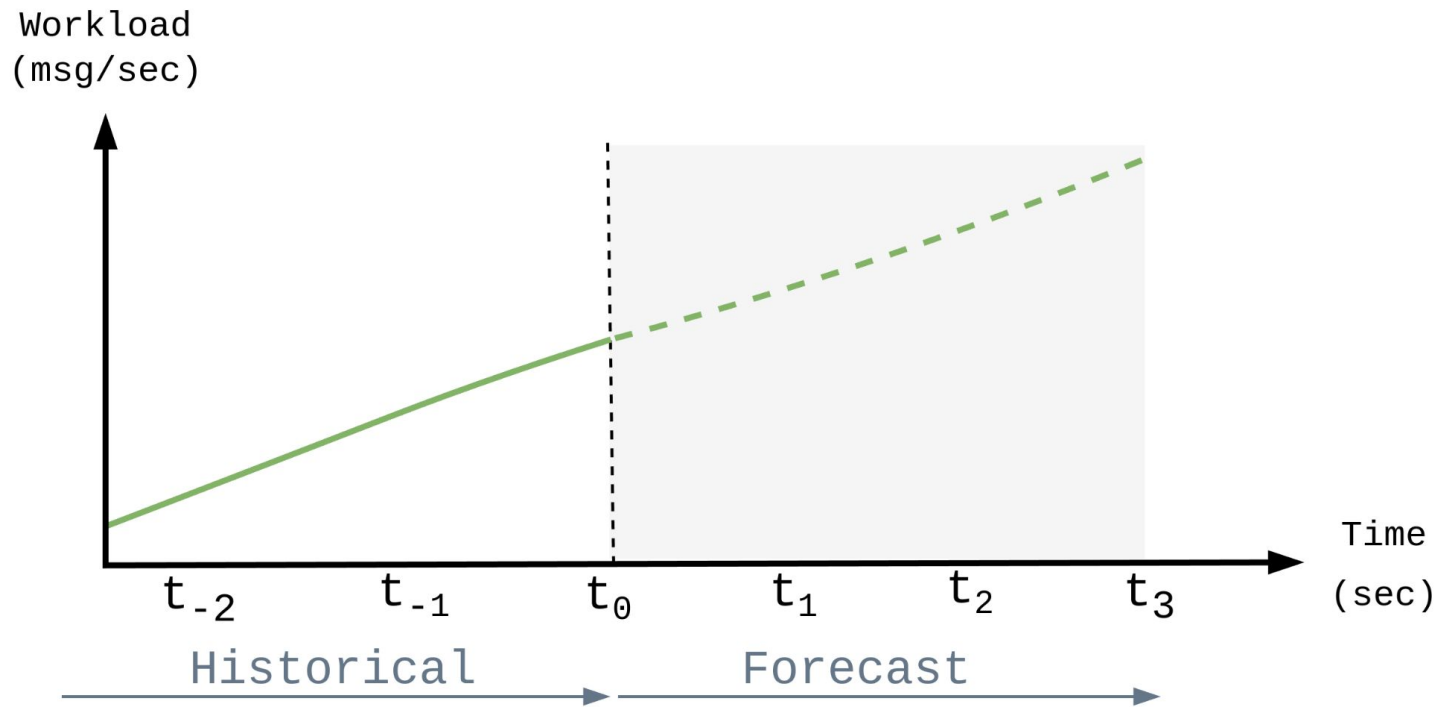
Solution:
Runtime Configuration Optimization

Dynamically match the resource requirements to the changing workload rate through runtime configuration optimization
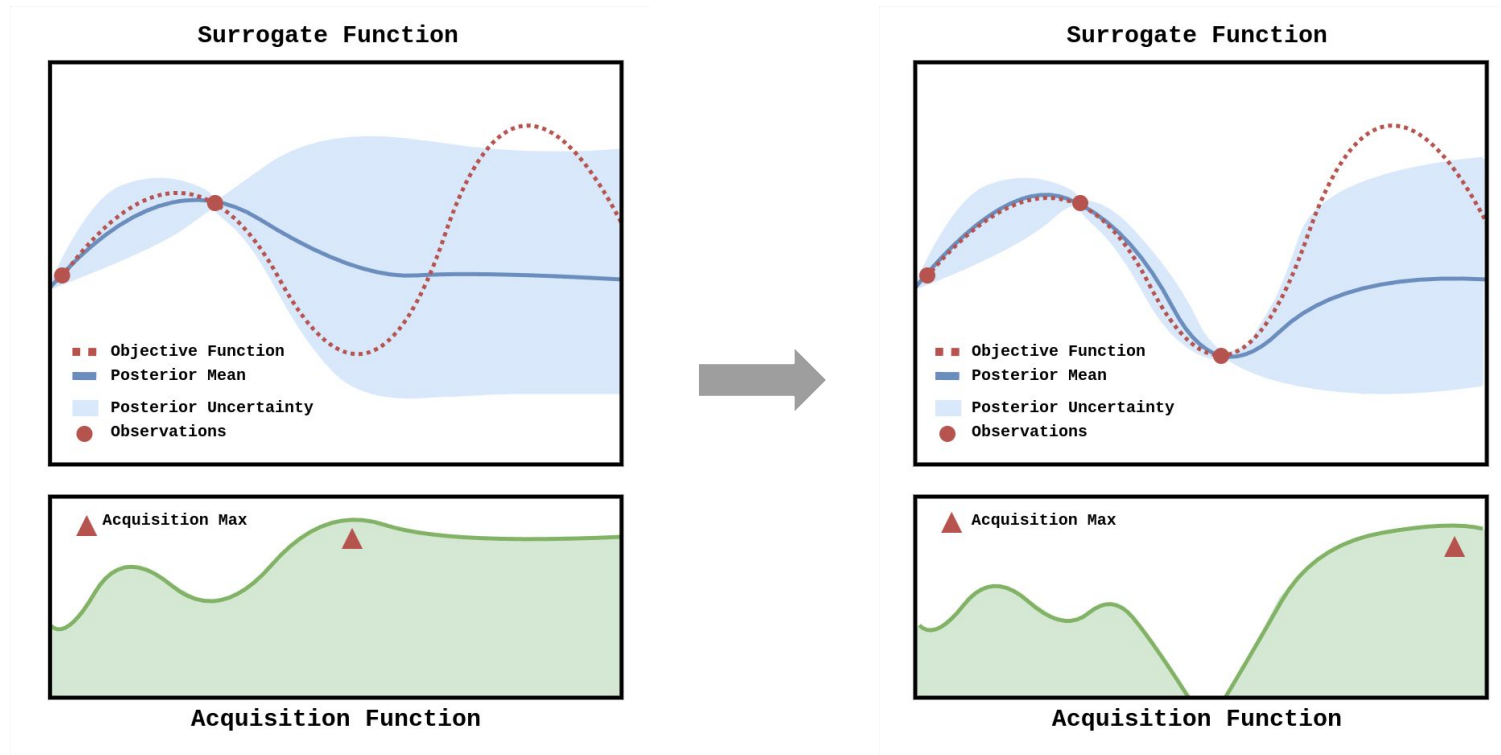
Approach:
Demeter High-Level Overview

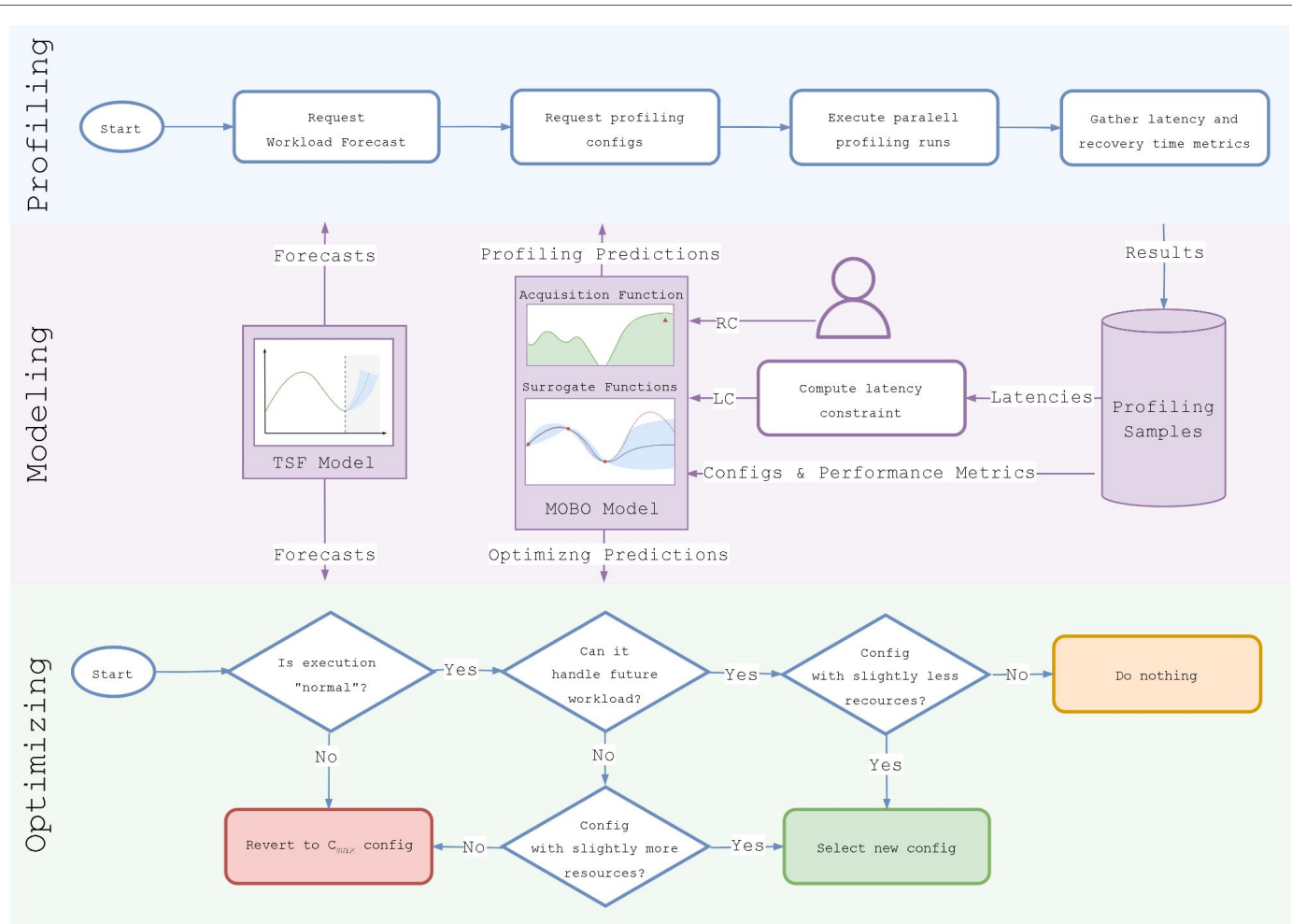# Approach:
Modeling Techniques

Multi-Step Ahead Time Series Forecasting (TSF)

Approach:
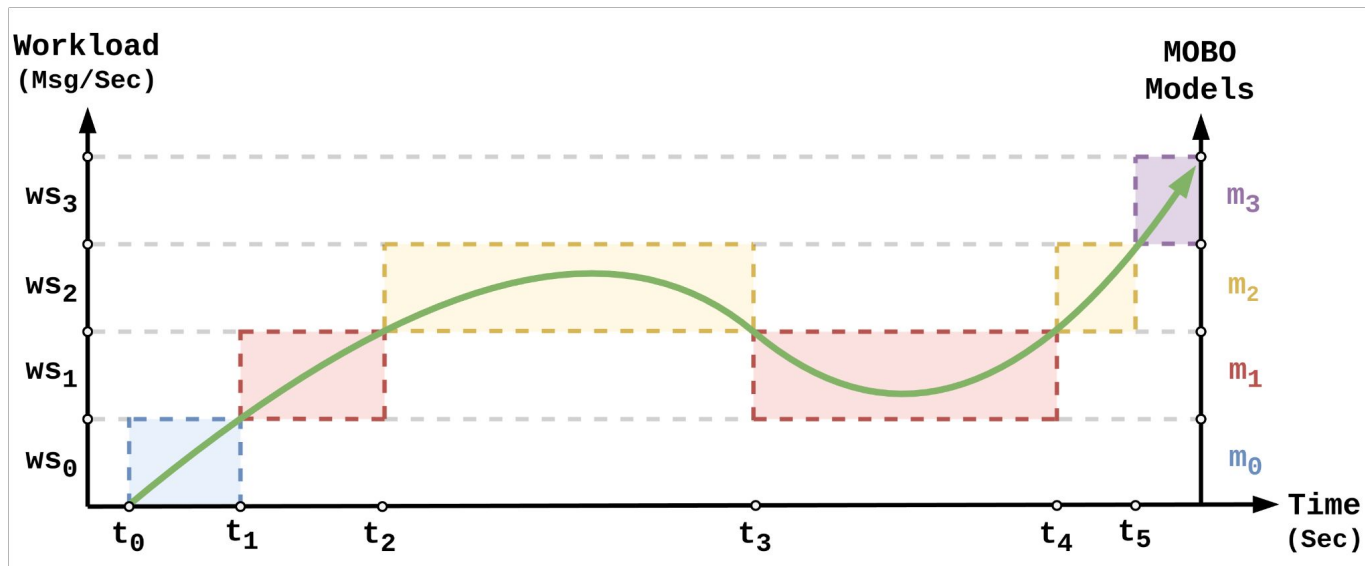## Bayesian Optimization

Multi-Objective Bayesian Optimization (MOBO)

Approach:
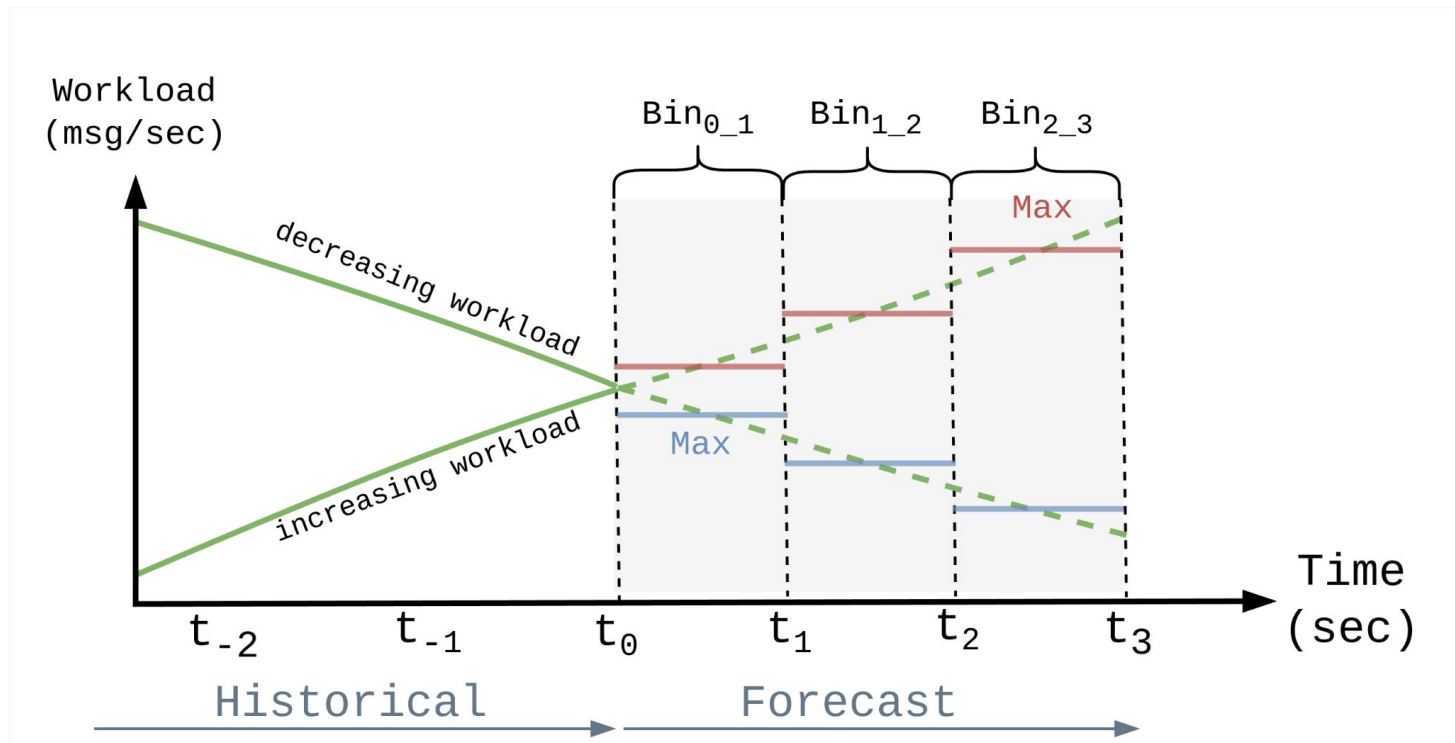## Profiling & Optimizing Processes
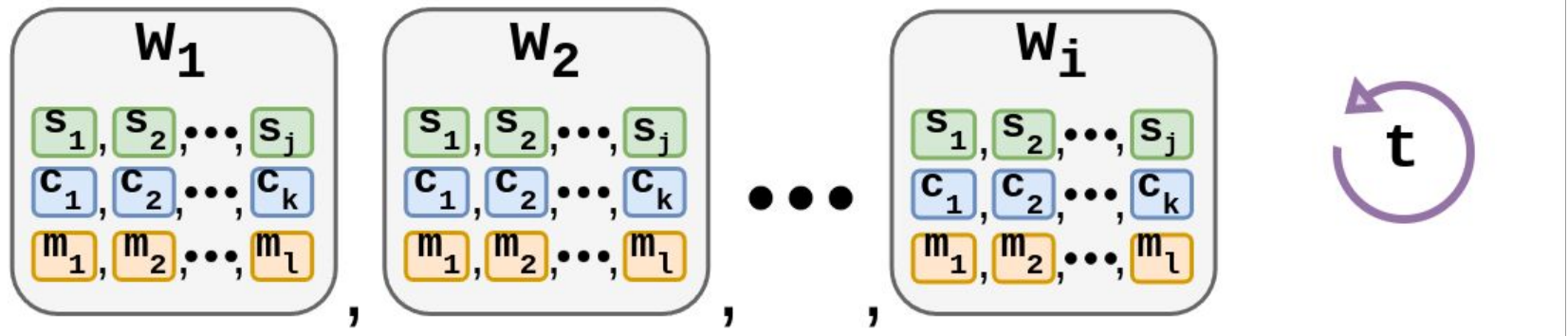
Approach:
Modeling Dynamic Workloads

Rank-Weighted Gaussian Process Ensembles (RGPE)

Approach:
Proactive Workload Predictions

Approach:
Configuration Parameters
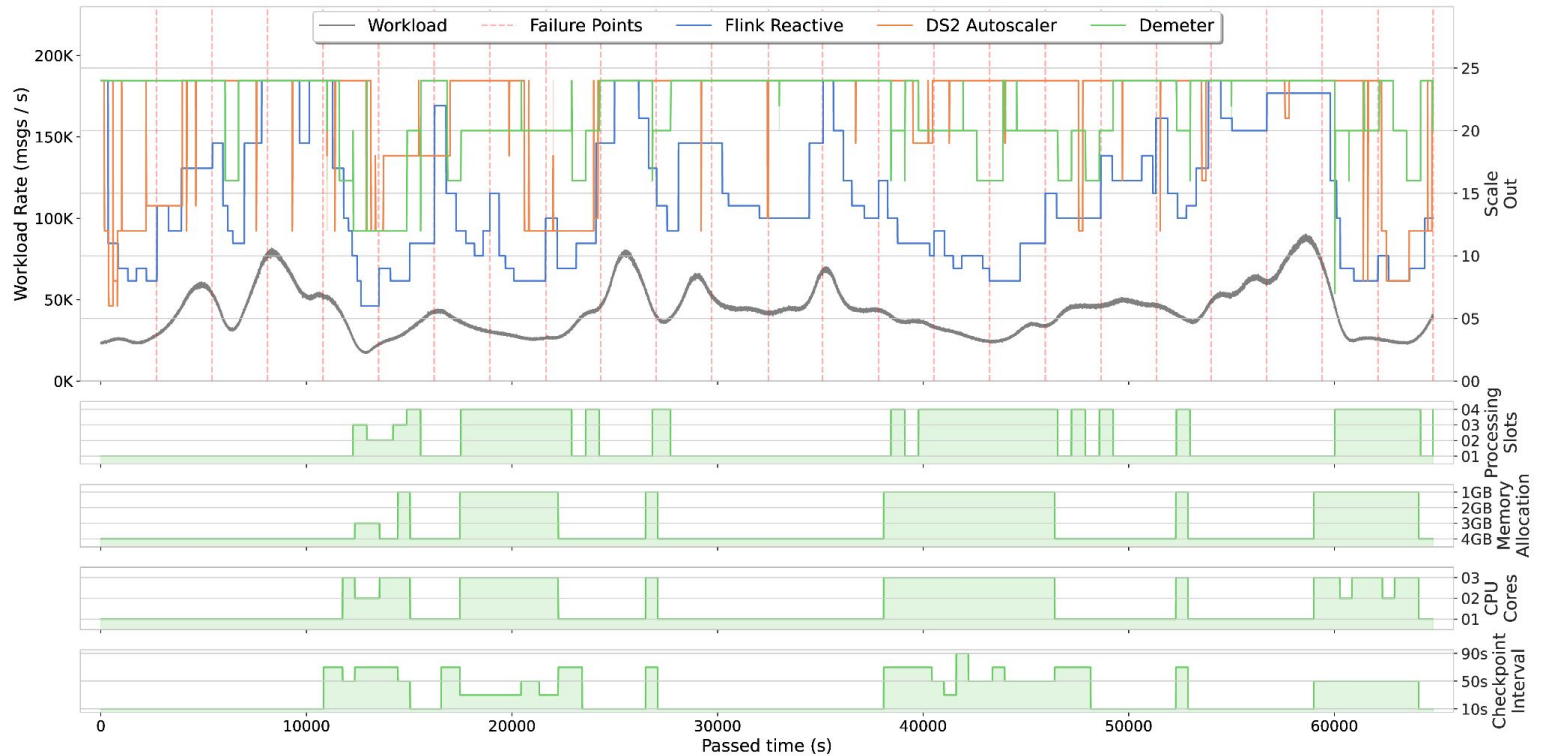
Evaluation:
Experimental Setup

- Experiments (Kubernetes + Apache Flink):
  - Yahoo Streaming Benchmark (click-stream analytics; 25K - 100K)
  - Top Speed Windowing (traffic monitoring; 35K - 125K)

- Baselines & Configuration Space:

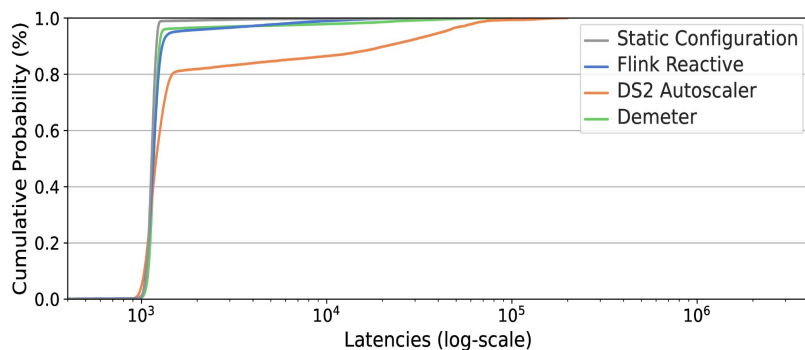| Method	Workers	Task Slots	CPU Cores	Memory (mb)	Checkpoint Interval (s)
Static (C_{max})	24	1	1	4096	10
Reactive	**1 - 24**	1	1	4096	10
DS2	**1 - 24**	1	1	4096	10
Demeter	**1 - 24**	**1 - 4**	**1 - 3**	**1024 - 4096**	**10 - 90**

- 18h experiment length; 23 failures; 180s recovery time constraint

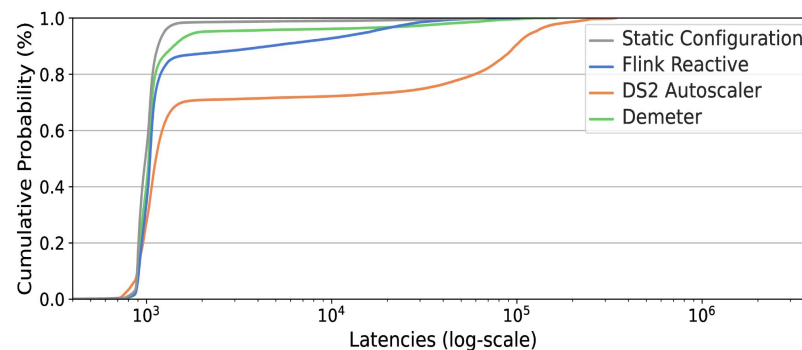# Evaluation:
Workload, Failures, & Configuration Parameters

YSB Experiment

Evaluation:
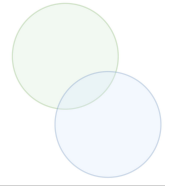## End-to-end Latencies Comparison

YSB Experiment

TSW Experiment

- 1st: Static with near-optimal L_{avg} ≈ 1000ms
- 2nd: Demeter at 95% of near-optimal
- 3rd: Reactive at 94% of near-optimal
- 4th: DS2 at 82% of near-optimal

- 1st: Static with near-optimal L_{avg} ≈ 1000ms
- 2nd: Demeter at 95% of near-optimal
- 3rd: Reactive at 85% of near-optimal
- 4th: DS2 at 70% of near-optimal

Evaluation:
Recovery Time Comparison

YSB Experiment

Recovery time averages: 1st Static 96s, 2nd Demeter 99s (0.03), 3rd Reactive 176s (0.83), 4th DS2 171s (0.78)

TSW Experiment

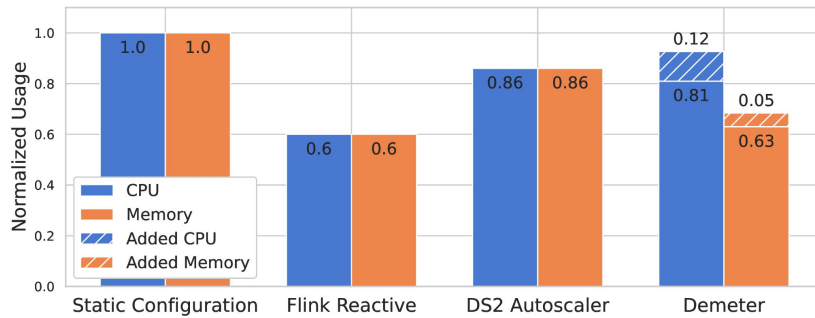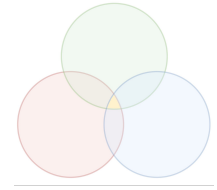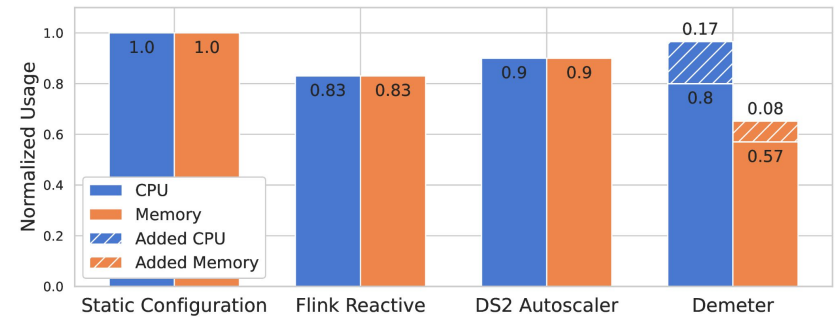Recovery time averages: 1st Static 107s, 2nd Demeter 113s (0.05), 3rd DS2 162s (0.52), 4th Reactive 174s (0.63)

■ Recovered within 180s　■ Recovered within 360s　■ Longer than 360s　□ No Result

Evaluation:
Resource Usage Comparison

YSB Experiment

TSW Experiment

Summary

- Demeter: Multi-configuration resource optimization for DSP jobs
  - Dynamic workloads
  - Exactly-once processing guarantees

- Experiments showed that Demeter is able to:
  - Deliver a stable near-optimal service
  - Recover reliably from failures
  - Improve resource utilization

- Future Work:
  - Improve the efficiency of the bayesian optimization component
  - Implement bayesian optimization component using GPU resources
  - Perform extended execution runs to observe efficiency over time

Thank you

Have a great conference!

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