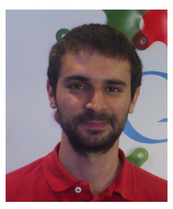
Energy Proportionality and Workload Consolidation for Latency-critical Applications

George Prekas [1], Mia Primorac [1], Adam Belay[2], Christos Kozyrakis [2], Edouard Bugnion [1]

1 ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE





2 Stanford University

Current Approaches for Low Latency

- **Dedicated servers in polling mode**
  - Low utilization due to diurnal patterns
  - High energy drain at low load

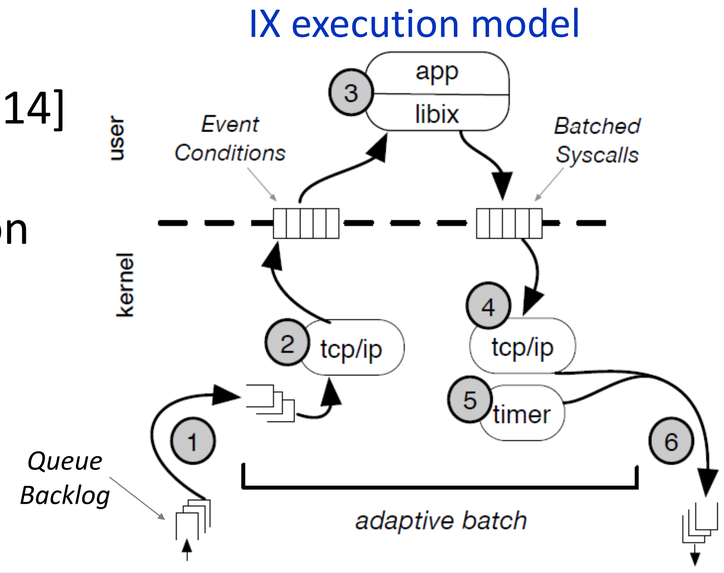
Motivation

- **Increase resource efficiency in data centers:**
  1) Reduce CPU power consumption under low/medium loads
     → energy proportionality of latency-critical app
  2) Minimize number of servers
     → workload consolidation of background job and latency-critical app
- **Maintain microsecond-scale tail latency**

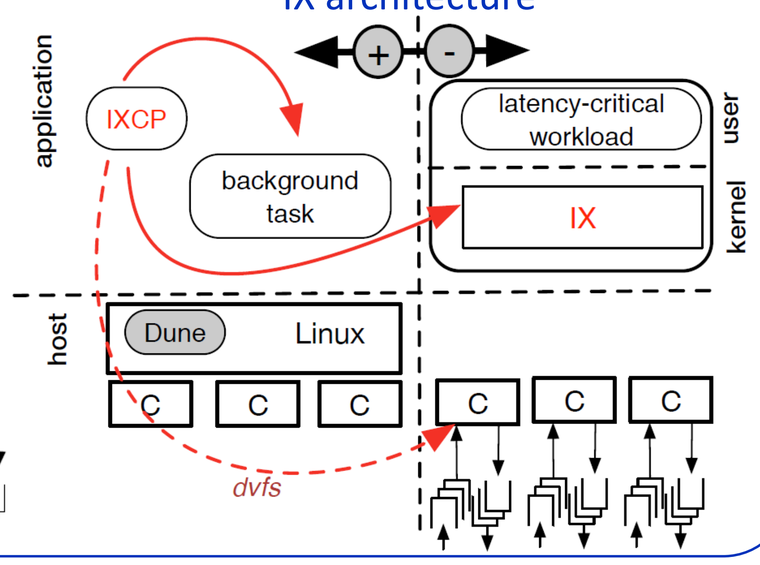
IX Design

- Dataplane OS for event-driven apps [OSDI '14]
  - Protection through virtualization (Dune): app, dataplane and control plane isolation
  - Efficient execution model
- **NEW**: control plane (IXCP) **dynamically allocates resources**
  - Add/remove cores/HT
  - Ajust DVFS

IX execution model

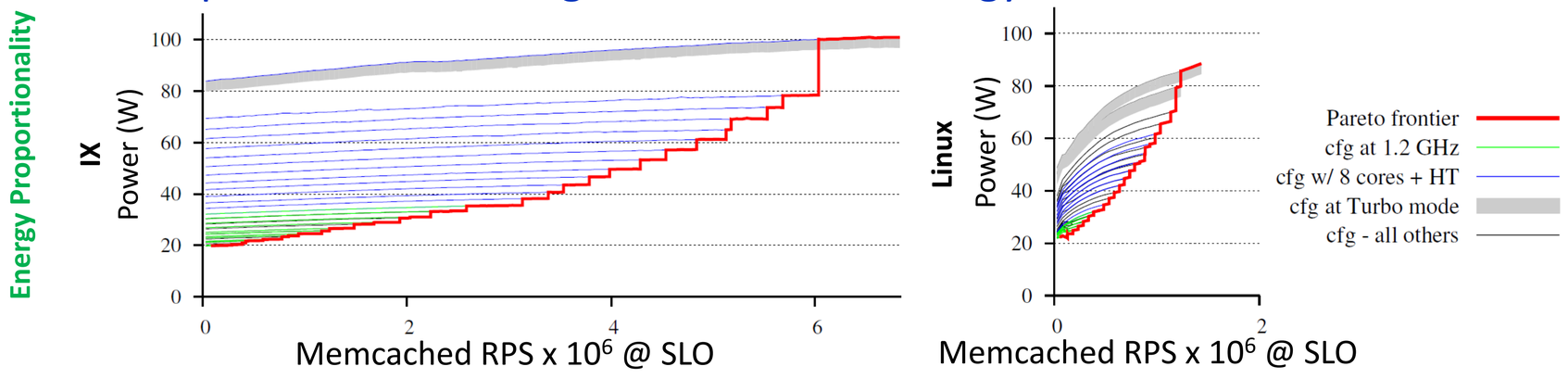


IX architecture



Pareto-Optimal Static Configurations Methodology

- **Two dynamic control policies** and **Pareto baseline** derived from the exhaustive analysis of 224 static configurations (configuring 16 HTs and 13+1 DVFS levels)

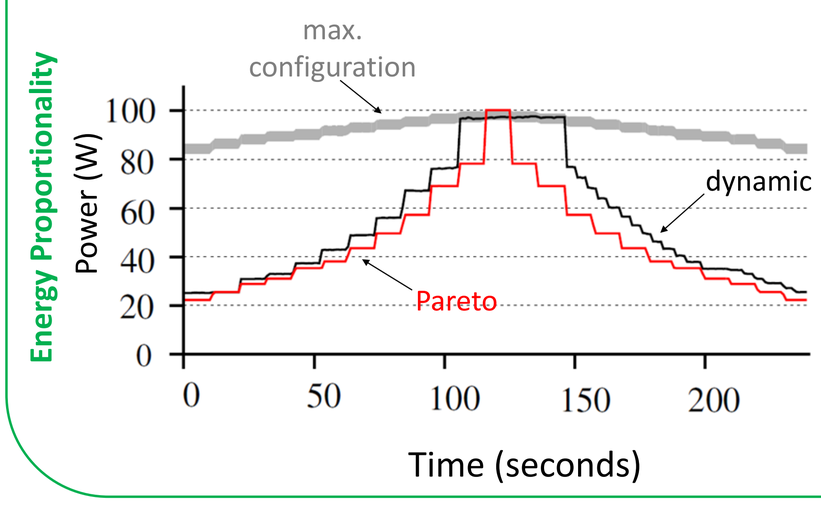


Mechanisms for Dynamic Configuration Management in IX dataplane OS

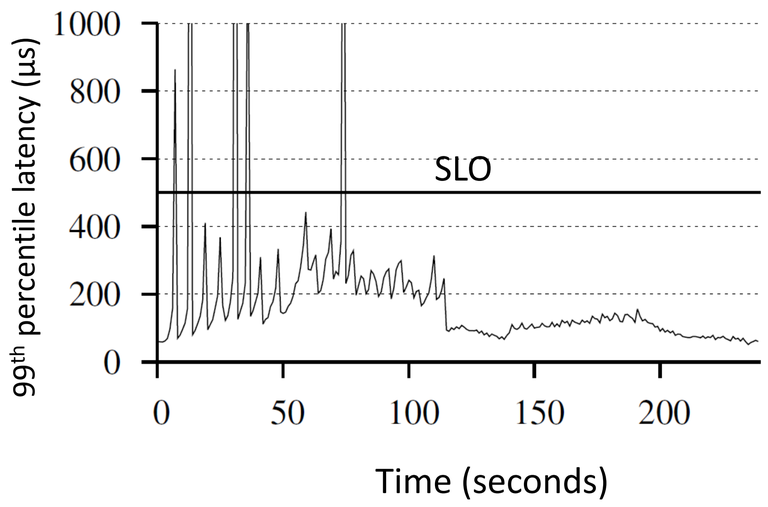
- **Detection of load changes**
  - Queue backlog
  - Detection in sub-second timescales
- **Adjusting current configuration**
  - Atomic RSS flow group migration w/o losing or reordering packets
    → Completes in less than 2 ms 95% of the time
  - DVFS (Dynamic Voltage and Frequency Scaling) via Linux host

IX Dynamic Resource Control Evaluation on Memcached

- Evaluation of IX control loop under multiple load patterns for memcached key-value store
- (1) Energy proportionality and (2) workload consolidation experiments



- **Memcached energy proportionality policy:**
  1. Add core by core
  2. Enable HTs on all cores
  3. Gradually increase the clock rate



1) **Saving 44%-54%** of CPU energy (**85%-93%** of Pareto bound)
2) **Running** bg app **at 32%-46%** of peak (**82%-92%** of Pareto bound)

- Adequate SLO compliance