Spatiotemporal Carbon-Aware Scheduling in the Clouds: Limits and Benefits

Thanathorn Sukprasert, Abel Souza, Noman Bashir, David Irwin, Prashant Shenoy
University of Massachusetts Amherst

Motivation

Objective

- Computing workloads are *flexible*
- Utilized flexibility to reduce carbon footprint
- Quantify carbon savings from workload shifting

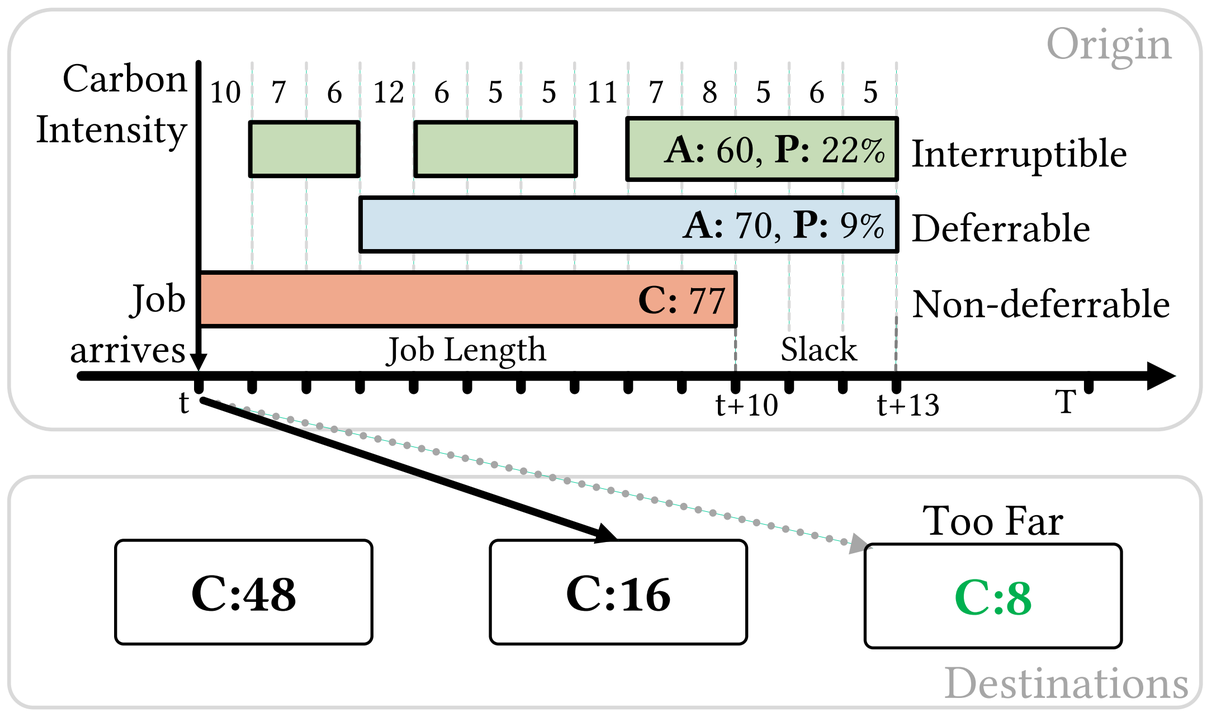
Methodology

- Collect the data from 123 regions worldwide
- Explore a variety of workload characteristics

Findings

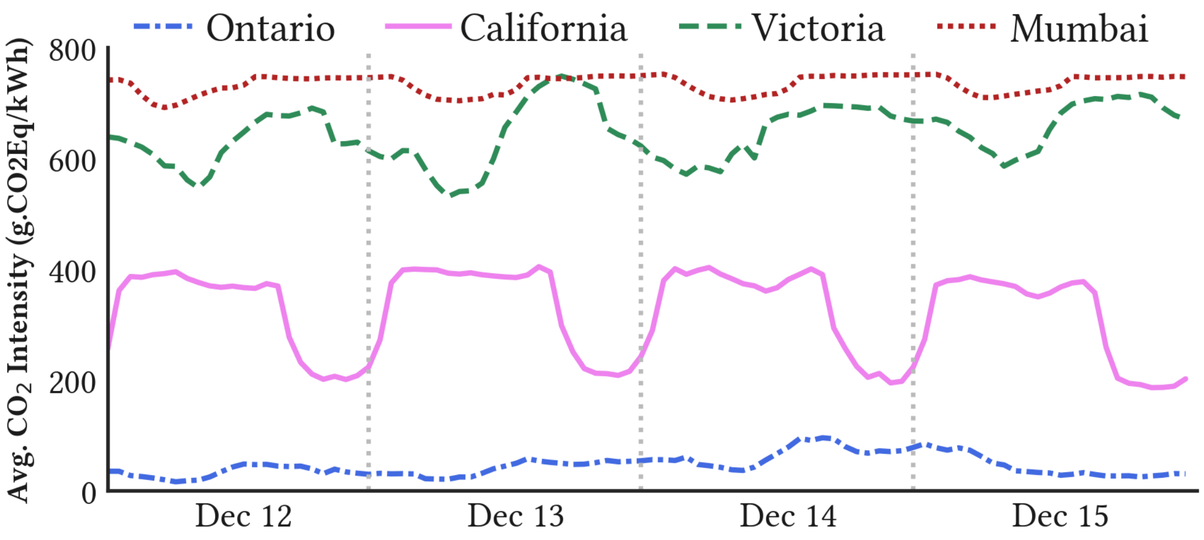
- Savings from workload shifting is often modest
- Complex, sophisticated policies are not needed

Spatiotemporal Workload Shifting



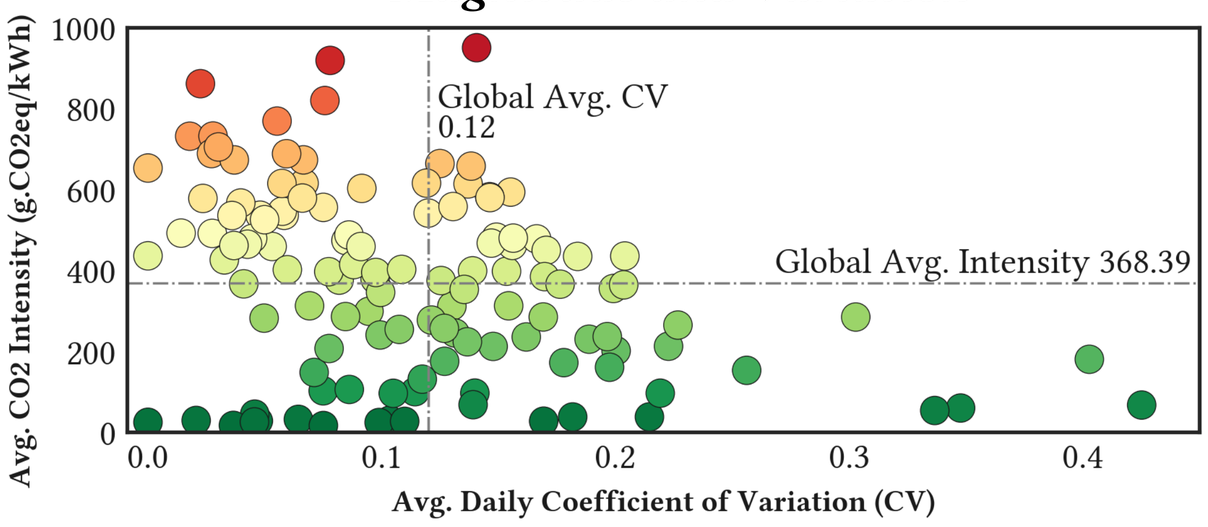
Global Carbon Analysis

Carbon Intensity Pattern



- CO_2 intensity or energy supplied by the electric grid can vary by 6-43x temporally and spatially

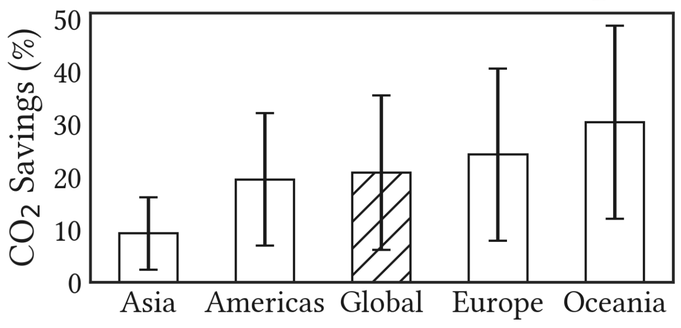
Magnitude and Variation



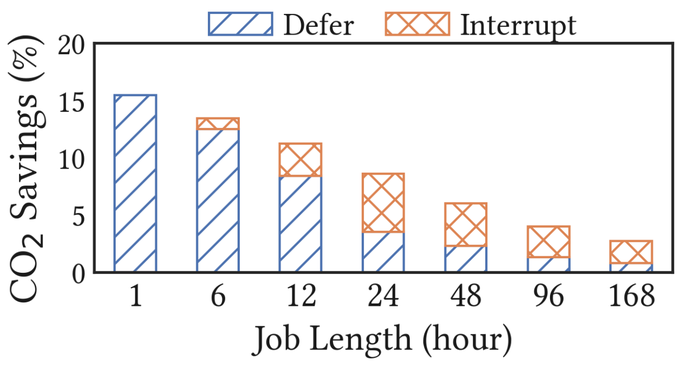
- 54% below-average CO_2 intensity, 57% below-average CV
- On a global scale – ***medium mean, low variance***
- Large window for spatial, limited benefits for temporal

Spatiotemporal Analysis

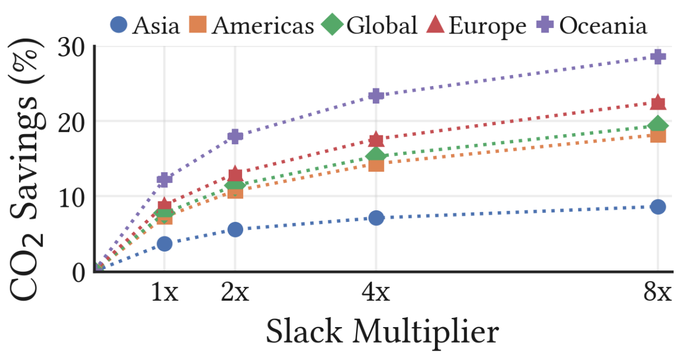
Temporal



Global temporal savings: **20%**

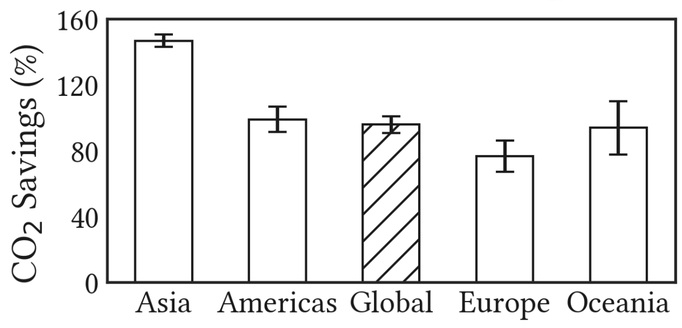


Savings:
Deferability: up to 15%
Interruptibility: up to 5%

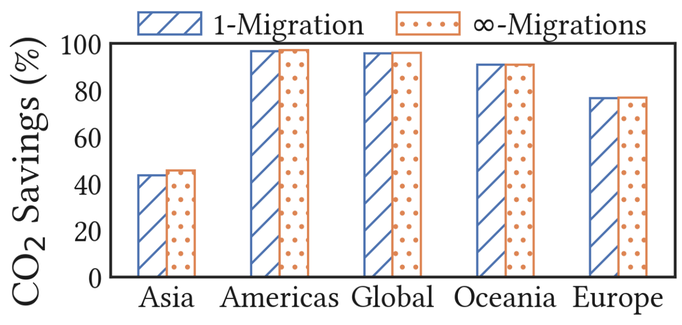


Savings from Deferrable and Interruptible jobs: 7-20%

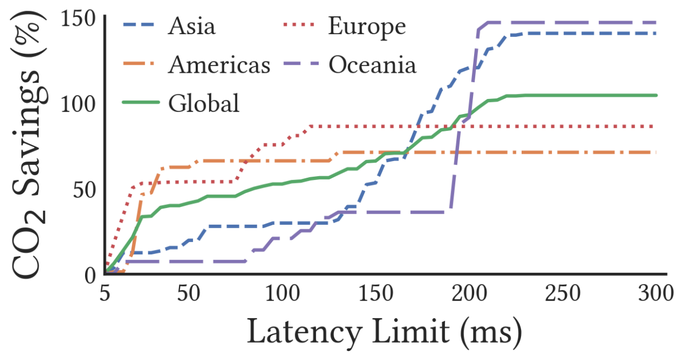
Spatial



95% carbon reduction by migrating to the greenest region



Majority of the savings comes from a very simple technique



Significant savings (~60%) for modest increase in latency

Temporal Takeaways

- There is a lack of variability in CO_2 intensity in most of the regions globally
- Even with high performance and temporal flexibility, the benefits are limited for temporal shifting

Spatial Takeaways

- Migrating once to the greenest region yields vast majority of the savings
- Sophisticated migration approaches are not necessary
- Constraints and overheads will further reduce savings

University of Massachusetts Amherst BE REVOLUTIONARY™

The 14th ACM International Conference on Future Energy Systems
e-Energy'23
Orlando, FL, United States

LASS
laboratory for advanced system software