Maximizing Return On Investment for Sustainable Operations through Smart Workload Migration

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1. Problem Space

Challenge: Increased Carbon Emissions due to **exponential growth** of Computing.

Current Approach: Spatial and **Temporal** Workload Shifting.

Spatial Shifting ☑
Fossil-fuel-heavy regions
↓ Workload Migration
Greener areas

Temporal Shifting ☑
Pause when no strong latency requirements (e.g., batch jobs)
Resume when green energy available.

Problem: Existing approaches have **Performance, Resource and Cost** constraints.

Performance Constraints
Only **specific types** of jobs can be shifted in time.

Resource Constraints
- Resource Waste
- Energy Inefficiency

Idle!
Temporal Shifting

Cost Constraints
Small national companies need **additional budget** to rent remote resources in greener regions for spatial shifting.

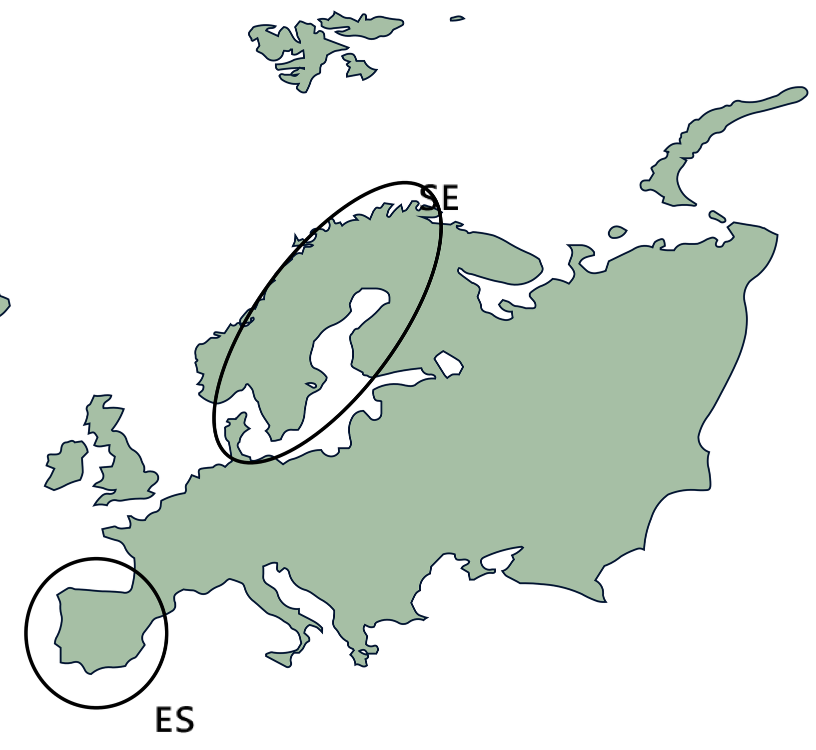
How can a **national** company operate with **reduced carbon** emissions, in return for **minimal cost** and uninterrupted **user** service and **satisfaction**?

1. Experimental Methodology

Usecase: Company with entire cloud-edge infrastructure deployed in Spain.

Location	Carbon Intesity
Spain ES	206 gCO2eq/kWh
Sweden SE	20 gCO2eq/kWh

↓ The lower the better



Goal: Quantify the additional **cost ($)** to rent resources in Sweden to reduce the **carbon footprint**.

2. Experimental details

Applications (using the Microservices benchmark **DeathStarBench**)

Social Network	Media streaming
Users send requests to compose posts.	Movie platform where users can log in and upload movie reviews.

Workload — 10 minutes
- 1,000 requests to each application
- Time steps follow a Poisson distribution, emulating multiple concurrent users

2. Experimental Results

Workload characterization is critical for expanding operations in greener regions by smart offloading of selected applications.

1. Performance Characterization.

Composing and uploading a movie review is **more computationally demanding** than creating a social media post.

Application	AVG Latency
Social Network	9.49 ms
Media Streaming	26.08 ms

2.89x

2. Carbon & Cost Characterization.

Running the applications in Sweden, is a 10 times more **sustainable** solution.

	App (Location)	Carbon (mgCO2eq)	Local ($/hr) *
ES	Social Network (Spain)	72.72	0.0912
S	Social Network (Sweden)	7.06	0.0864
ES	Media Streaming (Spain)	166.17	0.0456
S	Media Streaming (Sweden)	16.13	0.0432

Double the budget is needed for similar infrastructure in a different country because the application runs on both locations.

Insight: Hosting the media streaming in Sweden will lead to a **larger reduction** in the **absolute number** carbon emissions.

***Source: Amazon EC2 On-Demand Pricing**. Hourly rate in the eu-south-2 region (Spain), and eu-north-1 region (Sweden).

Different applications have a different impact in carbon reduction, based on how **computationally expensive** they are.

Takeaway: Become **greener** → Invest more **money**.

Choose wisely **which** application to offload to maximize return on investment!

We need an **application-specific solution** for the **carbon – cost trade-off,** for:

↓ Net Carbon Emissions

↓ Migration Overheads

3. Future Work

New systems solution that deploys online **selective workload migration**, and focuses on applications that **maximize carbon savings** while **minimizing cost**.

Carbon — 1. Minimizes emissions with spatial shifting.

Resource — 2. Minimizes idle resources by predicting future resource usage.

Cost — 3. Minimizes the overall cost of the infrastructure.

Performance — 4. Minimizes network and request execution latency, enforcing the SLAs.

Proposed Solution Parameters & Goals

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