Paper ID： 106

ECE2024

Online Low-Carbon Workload, Energy, and Temperature Management of Distributed Data Centers

Rui Xie[1], Yue Chen[1]*, and Xi Weng[2]
[1]The Chinese University of Hong Kong
[2]Peking University

Introduction

Background

- Distributed data centers could be coordinated to reduce cost and emissions
- Operation faces strong **uncertainties**

Method: Lyapunov optimization

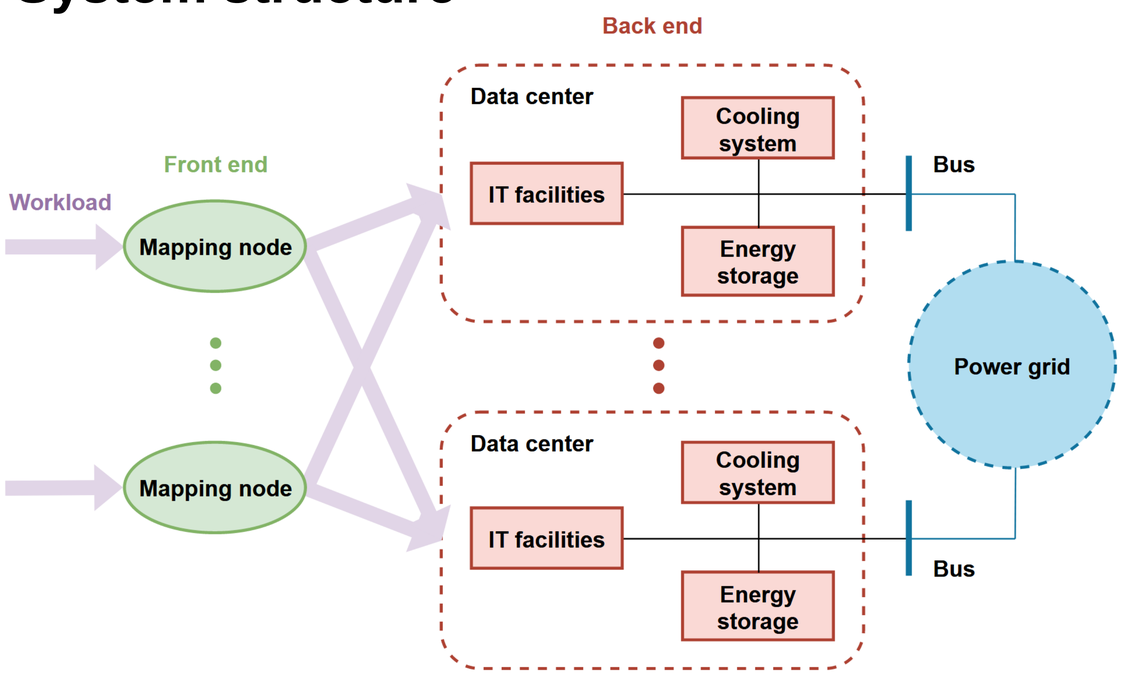
- Prediction-free
- Can estimate the optimality gap
- Relies on careful theoretical deduction to consider operational constraints

Our contributions

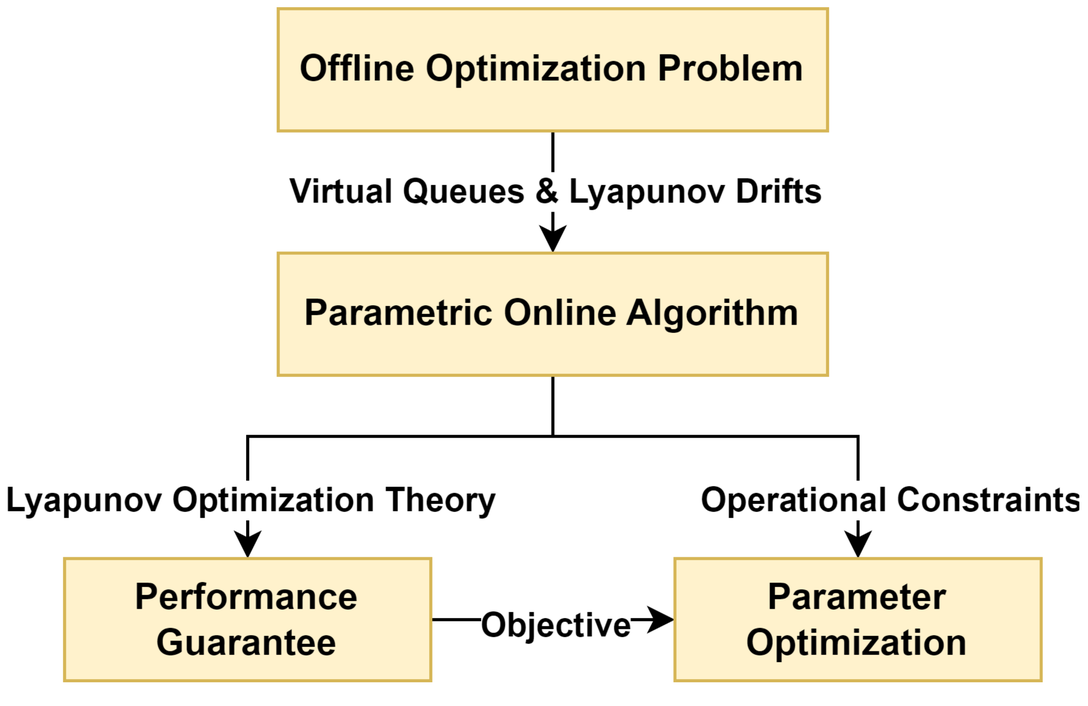
- Considers **emission** and **temperature** management
- Develops a **linear program**-based method to decide the parameters of operation strategy to **avoid** substantial theoretical analysis

Method

System structure

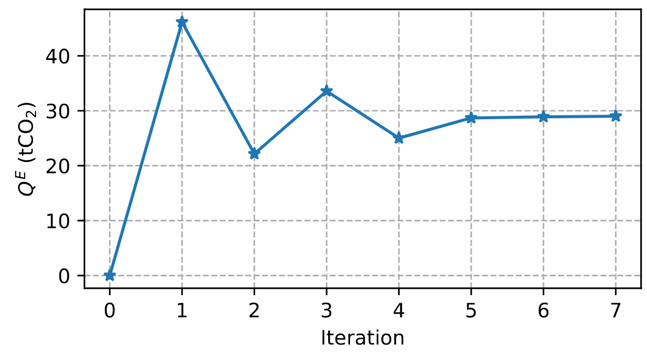


Framework of the proposed method

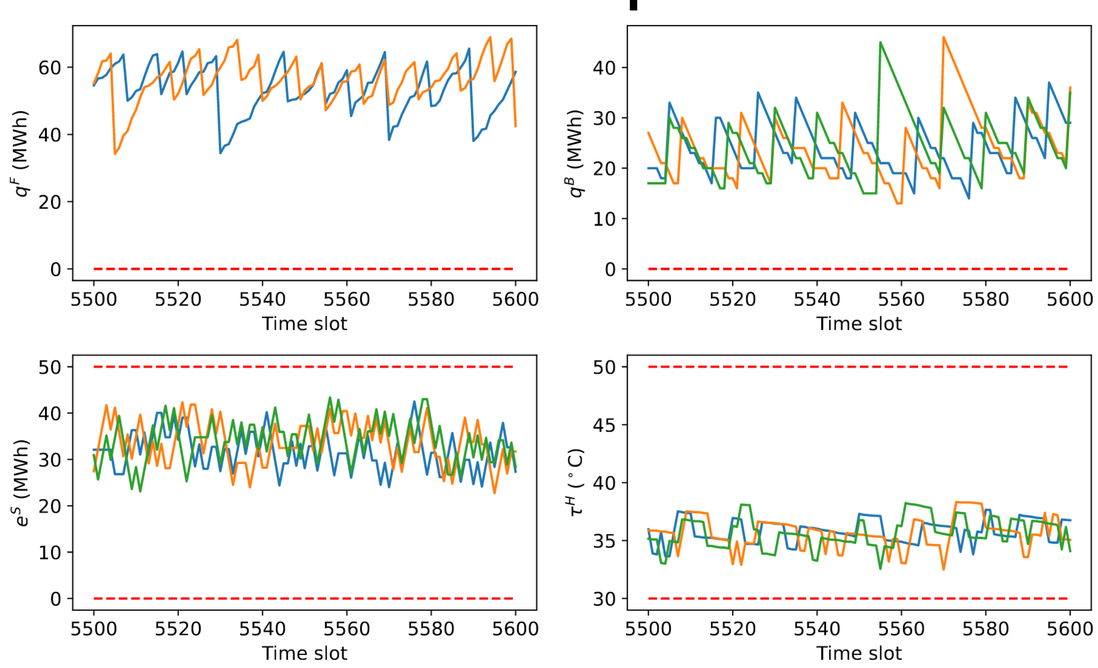


Case Study

Iteration process



Bounds and simulated queues



Method comparison

- C1 (offline & low-carbon): Impractical
- C2 (greedy & low-carbon): High cost
- C3 (offline): Impractical & high emission
- C4 (greedy): High cost & emission
- C5 (no emission bound): High emission

Method	Cost rate ($/h)	Emission rate (tCO$_2$/h)
Proposed	335.3	1.160
C1	251.2	1.200
C2	1378	1.200
C3	231.7	2.784
C4	457.2	2.384
C5	251.6	2.803

Conclusion

A novel online low-carbon management method for distributed data centers:

- Minimizes the total operation cost
- Jointly considers workload, energy, and temperature **operational constraints**
- Deals with the **uncertainties** of workload demands, ambient temperature, electricity prices, and carbon intensities
- **Prediction-free** thanks to the Lyapunov optimization technique
- Effective in **low-carbon** operation