Toward a Sustainable Future: Theory, Models, and Data

Omid Ardakanian

Software Defined Buildings Group
UC Berkeley
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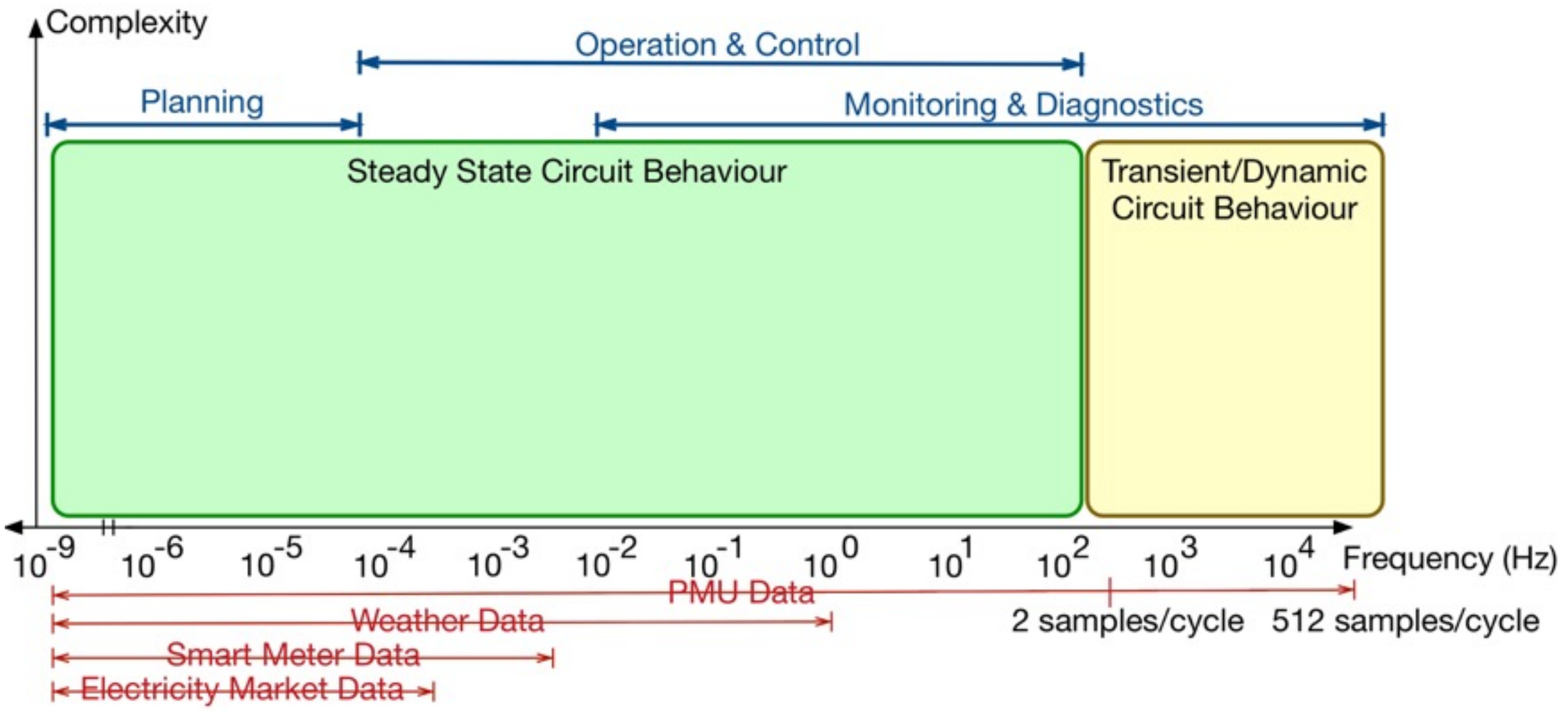
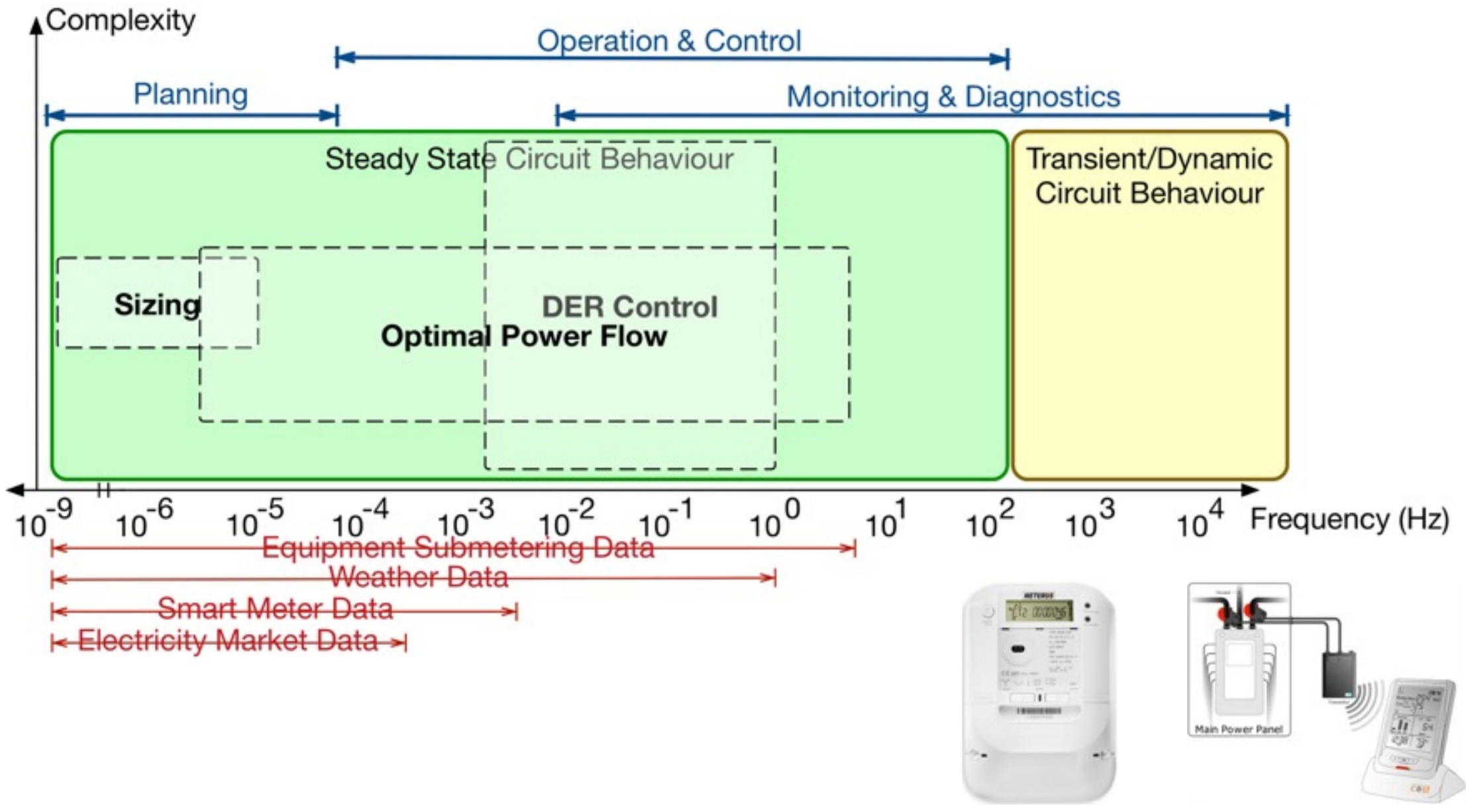
Planning and Operation of Power Systems

Data Sources and Application Domains



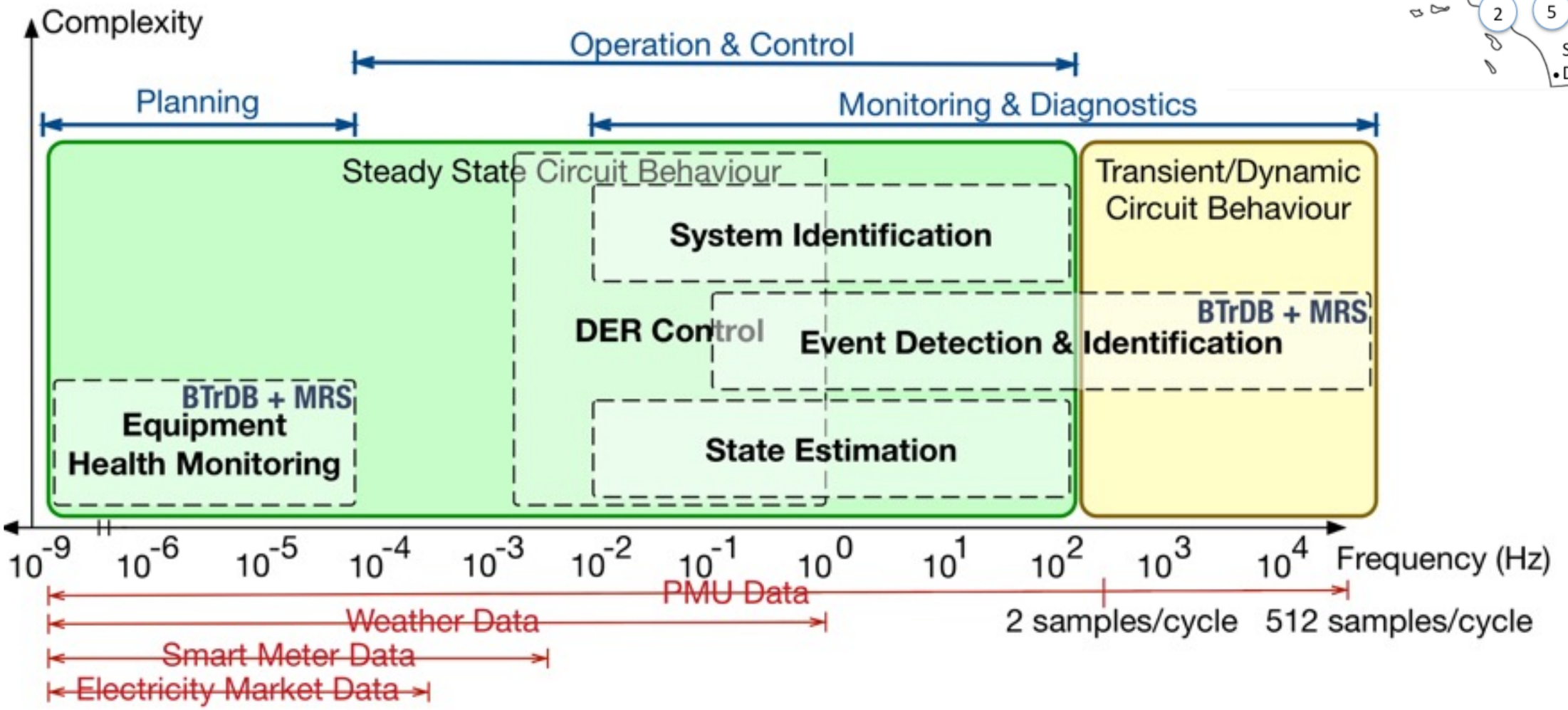
Prior Work


Complexity
Operation & Control
Planning
Monitoring & Diagnostics
Steady State Circuit Behaviour
Transient/Dynamic Circuit Behaviour
Sizing
DER Control
Optimal Power Flow
10^{-9} 10^{-6} 10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1} 10^{0} 10^{1} 10^{2} 10^{3} 10^{4}
Frequency (Hz)
Equipment Submetering Data
Weather Data
Smart Meter Data
Electricity Market Data
Main Power Panel

Control of Distributed Energy Resources

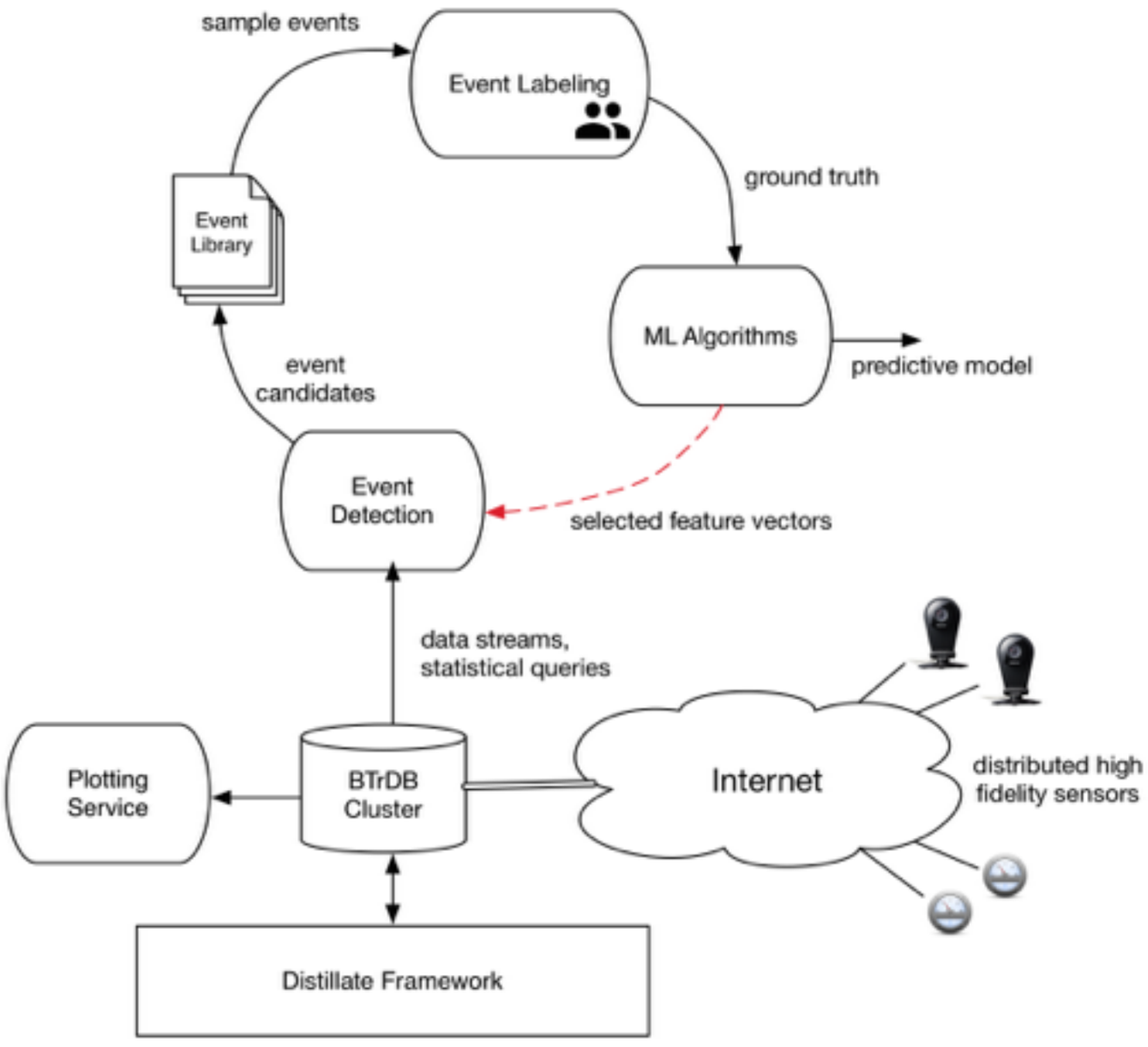
Balancing demand and supply to the extent that is possible at the distribution level by controlling new technologies

Our Recent Work



BTrDB and Multi-Resolution Search

- “Predictive Distribution Component Health Monitoring with Distribution Phasor Measurement Units”
    - joint work with Sascha von Meier, Emma Stewart, Ciaran Roberts, Anna Lio, Kyle Brady
- “Event Detection and Classification Techniques: A Data Driven Approach”
    - joint work with Daniel Arnold and Ciaran Roberts



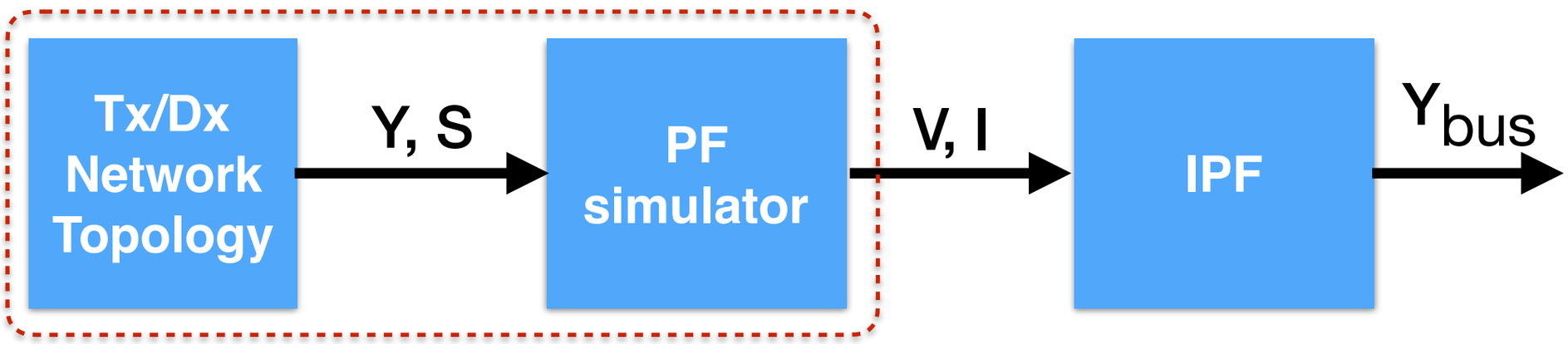
Inverse Power Flow Problem

- Identification of the bus admittance matrix and the network topology from voltage and current phasor measurements of a **subset** of buses

$$I_{bus} = Y_{bus} V_{bus}$$

- Online detection and identification of events using the inferred bus admittance matrix

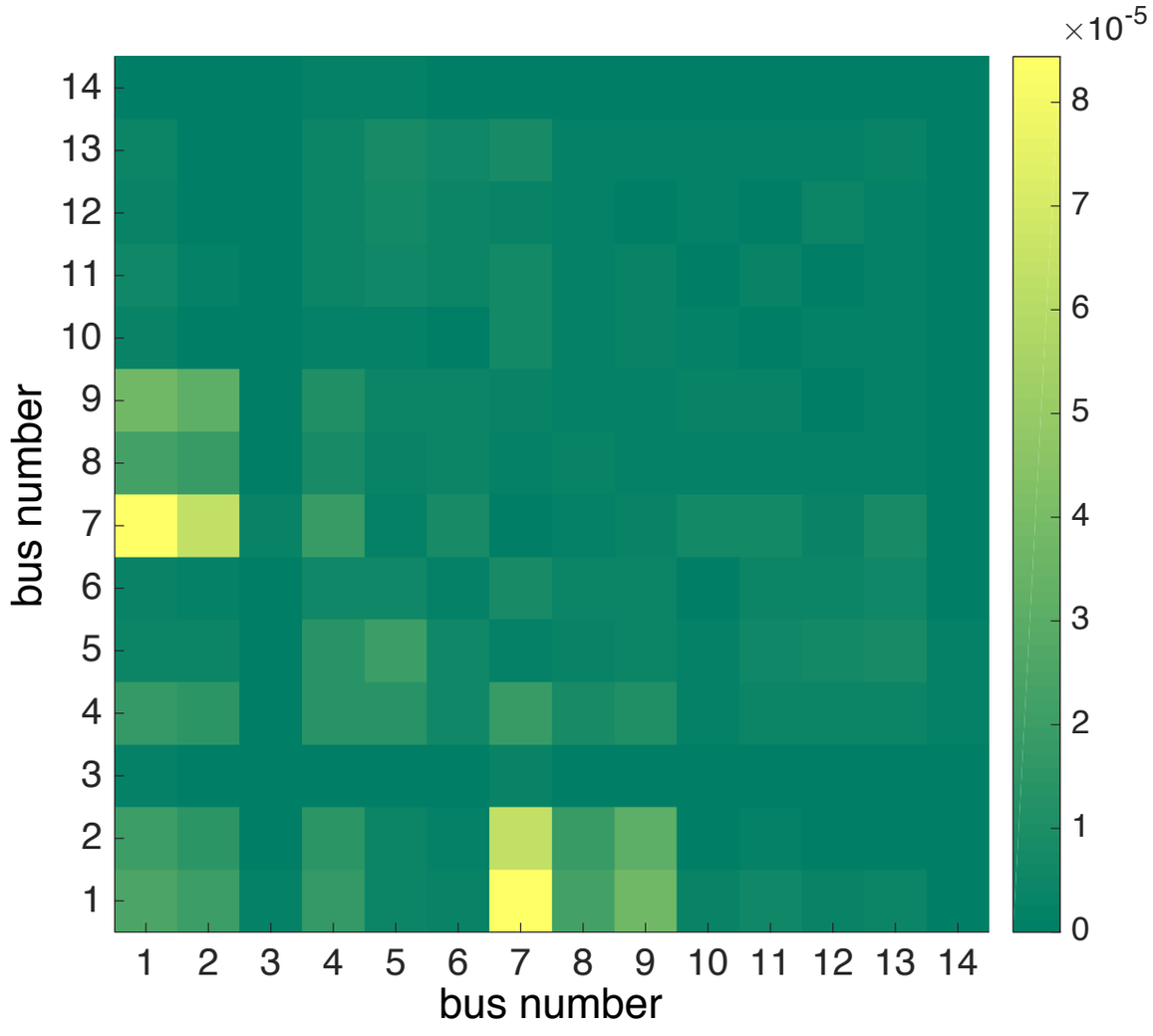
- Extend the results to three-phase distribution systems
  - Low rank structure of PMU data
  - Measurement noise



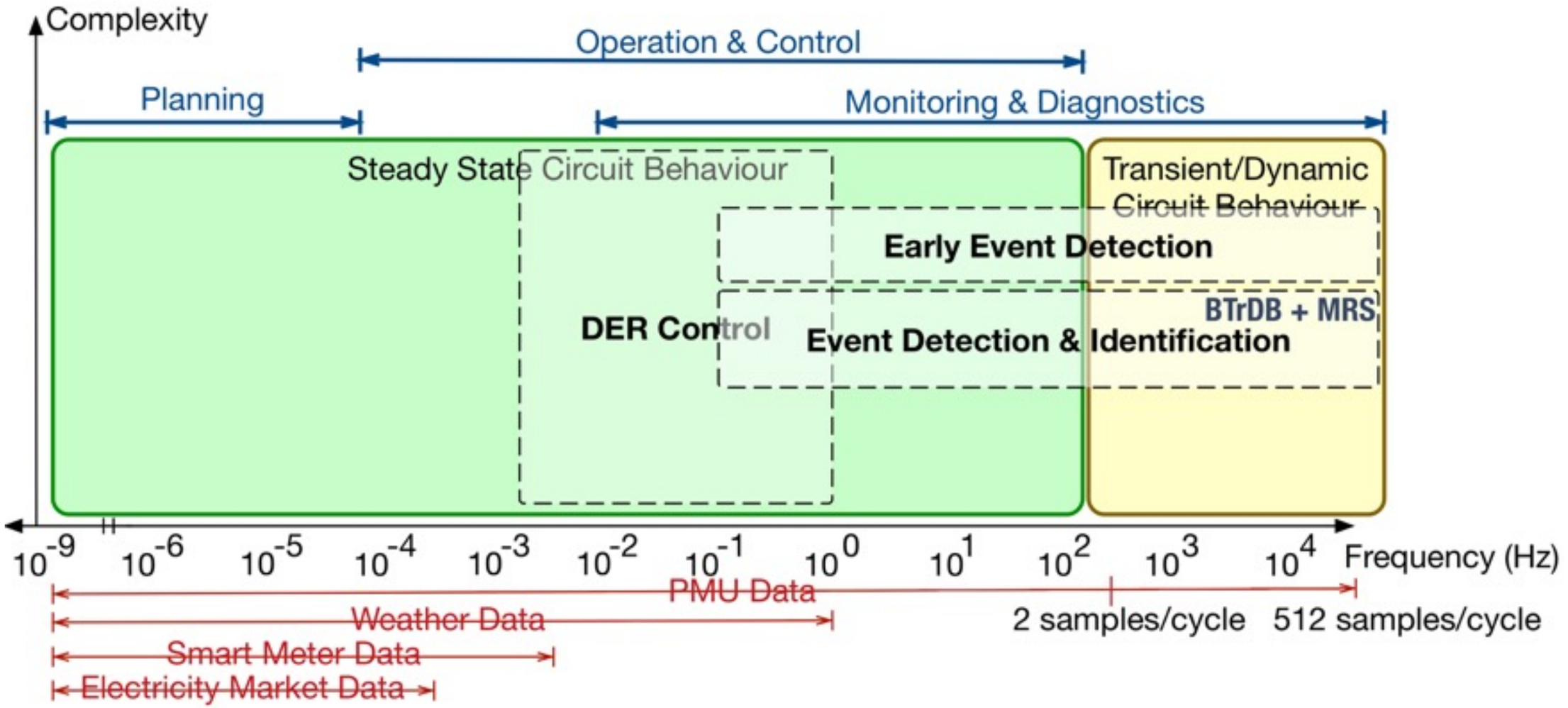
Convex Optimization and its Applications

- "On the inverse power flow problem"
    - joint work with Ye Yuan, Steven Low, and Claire Tomlin

- "Event Detection and Identification in Distribution Grids with Phasor Measurements"
    - joint work with Ye Yuan, Roel Dobbe, Sascha von Meier, Steven Low, and Claire Tomlin

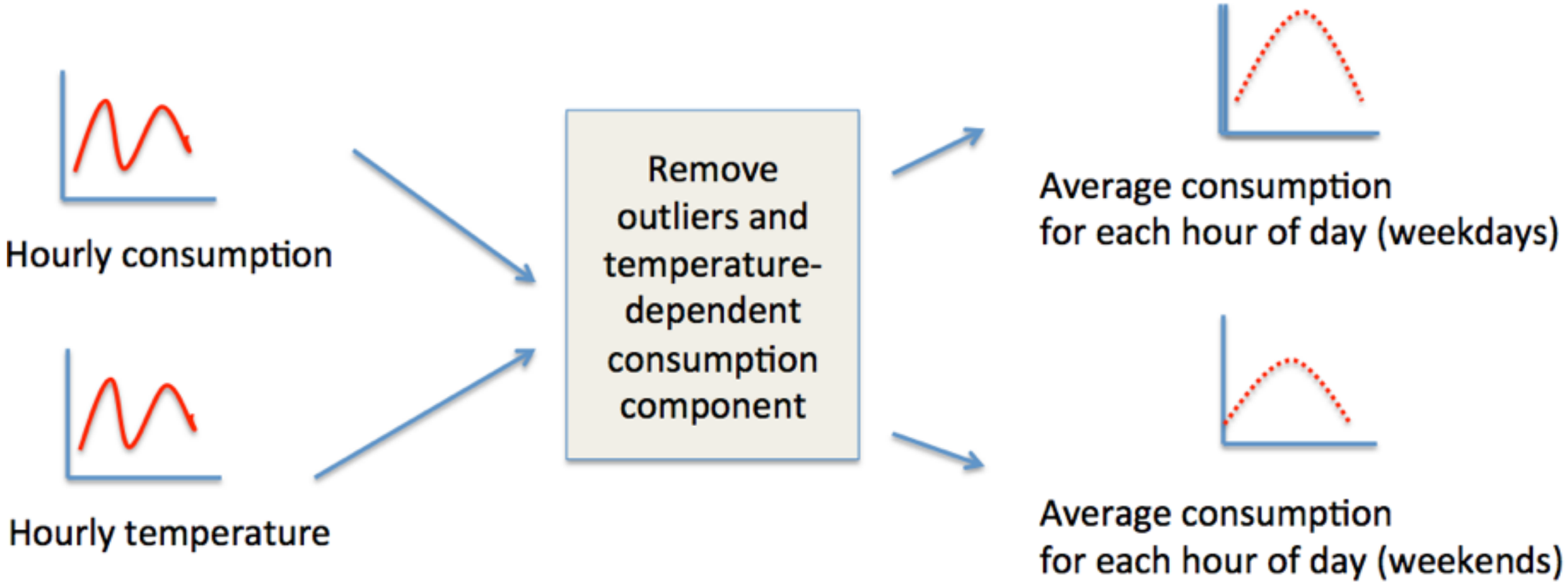


Directions for Future Work



Reducing Energy Consumption of Residential and Commercial Buildings

Our Prior Work



PARX model

$$Y_t = \sum_{i=1}^{p} \phi_{i_s} Y_{t-i} + \psi_{1_s} XT1_t + \psi_{2_s} XT2_t + \psi_{3_s} XT3_t + \psi_{4_s} XO1_t + \psi_{5_s} XO2_t + C_s + \epsilon_t, \qquad \text{for } t \in s$$

$$Y_t^* = Y_t - \psi_{1_s} XT1_t - \psi_{2_s} XT2_t - \psi_{3_s} XT3_t - \psi_{4_s} XO1_t - \psi_{5_s} XO2_t \qquad \text{for } t \in s$$

Establishing Occupancy-Related Energy Savings in Commercial Buildings

- Why do you need to reheat supply air?
  - AHU supplies air at 62F to account for hottest rooms and losses
  - This is too cold for occupants in many zones

- So we are first over-cooling and then reheating the air
  - Leads to avoidable energy loss

Basic Idea

- If an occupant injects enough heat into a room so that the HVAC system responds, then we can detect it

- There is always one sensor (occupancy indicative sensor) which picks up this response

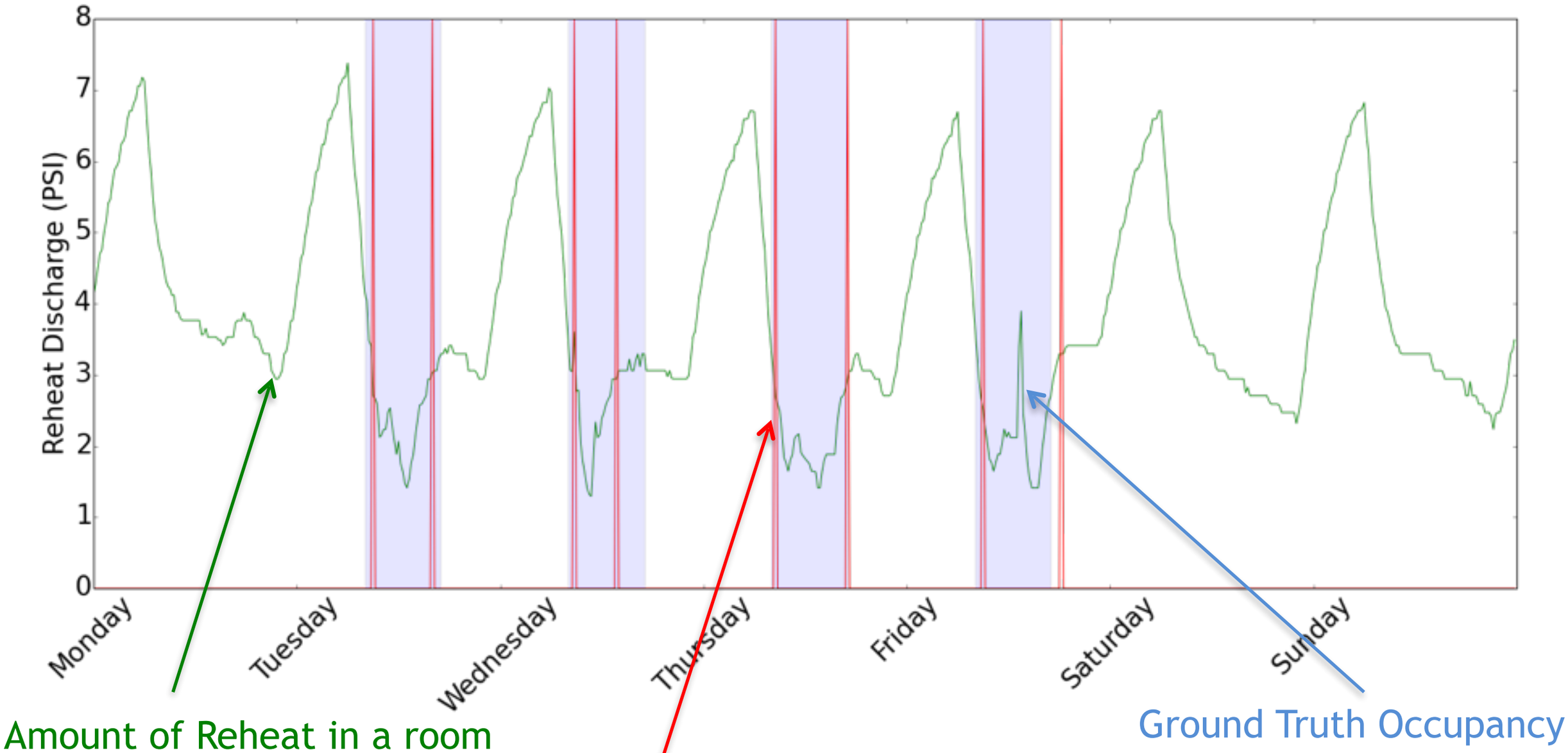
- We want to systematically determine those edges
  - Canny detector

- If we have enough weeks worth of data and pick up enough of the edges, we can get a good estimate of occupancy.

How do we save energy?

- We determine schedules for each room using unobtrusive techniques
- Ensure that a VAV does not reheat supply air outside those schedules
  - Saving the nefarious “reheat” energy.

Zone Occupancy and the VAV Response

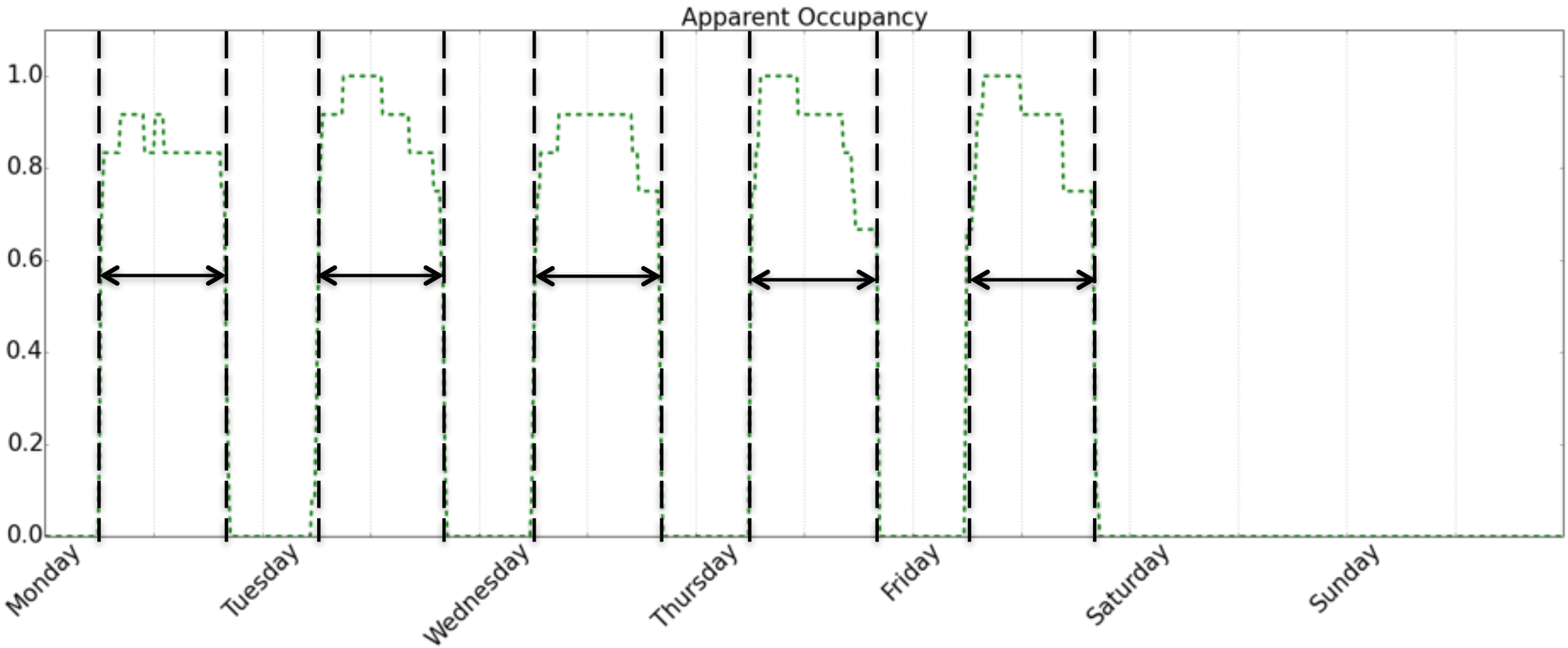


Amount of Reheat in a room

When our technique thinks there is occupancy

Ground Truth Occupancy

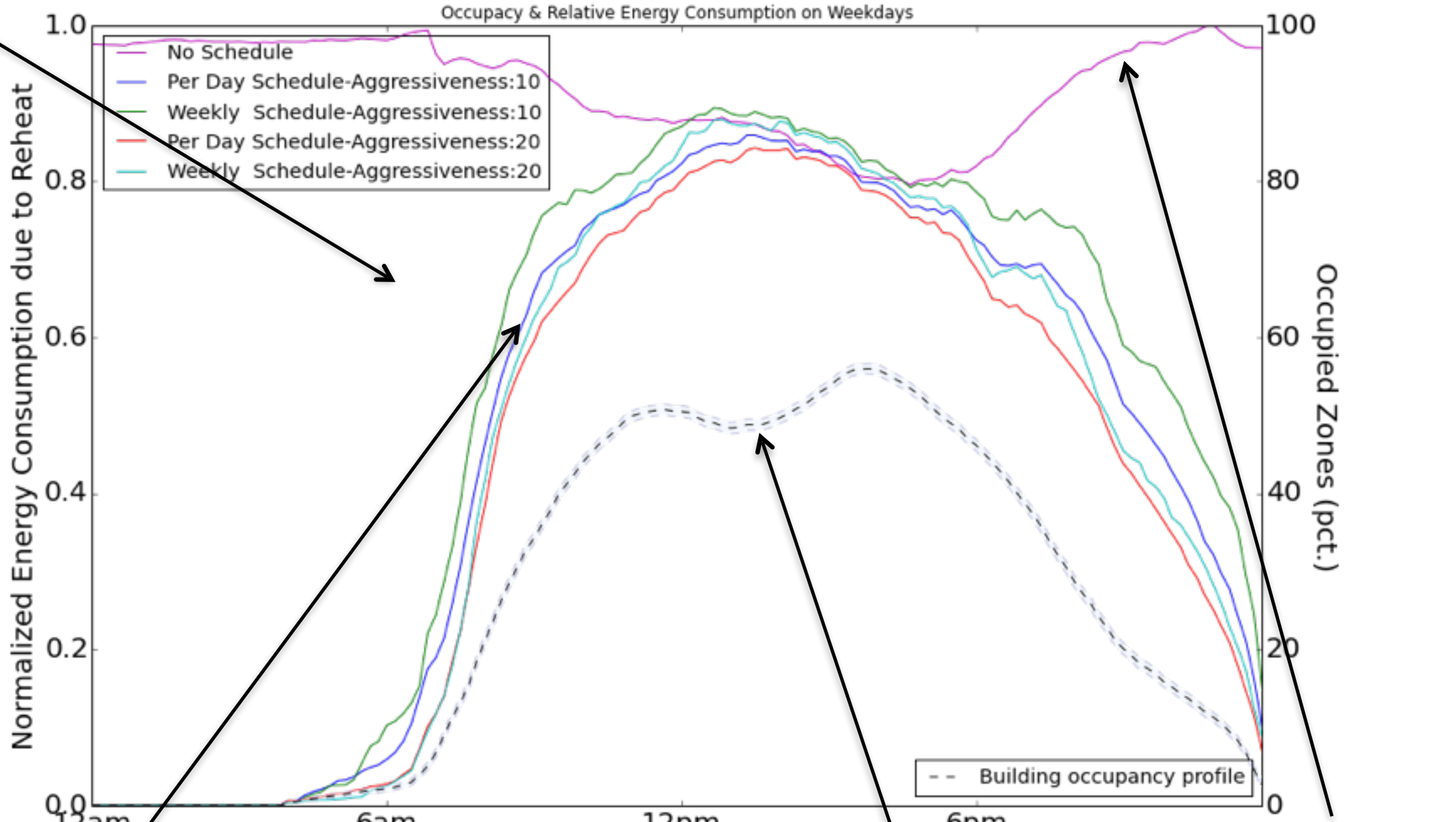
Determining Schedules



Schedules can be more aggressive …
Tradeoff: Less time the HVAC system is operating, hence more energy savings
However, there are times when an occupant comes in and finds his room unconditioned

How are we actually saving reheat energy?

Possible reheat energy savings



reheat profiles under our smarter schedules

Inferred occupancy

Current reheat schedule

Our Recent Work

- BuildSys paper, joint work with Arka Bhattacharya and David Culler
- KETI motes are brought up in SDH
  - PIR, CO2, Light, …
- Occupancy inference using sensor fusion
  - very high accuracy reported in the literature
- Plan to compare the so obtained occupancy profiles with those inferred from the VAV response

over the past year…

- At Berkeley, I had the opportunity to work with real data
- Co-authored 2 journal papers, 2 conference papers, and a brief
- Collaborated with 14 researchers on various projects
- Currently working on two new projects