USC University of Southern California

USC Viterbi School of Engineering

Ming Hsieh Department of Electrical Engineering

Complex Event Processing for Intelligent Energy Management in Microgrids

http://smartgrid.usc.edu/

Zach Gima, Qunzhi Zhou, Yogesh Simmhan and Viktor Prasanna

Introduction

Campus Microgrids

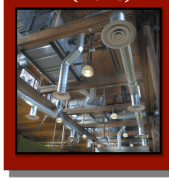
Evolution

- Evolving infrastructure
- Changing consumer profiles and preferences

Diversity

- Large Volume and fine-grained data
- Varied information sources
- Multi-disciplinary participants

Heating, Ventilation, and Air Conditioning (HVAC)

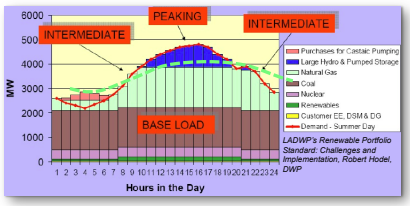


Smart Meters

Fan Coil Unit (FCU)

Target Application

Demand Response Optimization (DR)



Traditional DR

- Schedule based
- Incentive based

Dynamic DR (D²R)

- Adaptable
- Opportunistic curtailment
- Low latency

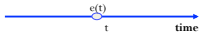
Energy Management Challenges

- Extensible application modeling
- Heterogeneous information correlation
- Real-time data processing
- Diverse and evolving client

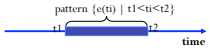
Solution Approach

Technology – Complex Event Processing (CEP)

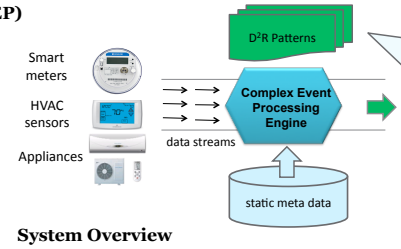
- Primitive event – information at a point of time, e.g., meter and sensor readings, class schedules



- Complex event – patterns of primitive events in a time window, e.g., sequence of meter readings



- Complex event pattern detection



D²R Semantic Complex Events (Event Patterns)

Pattern 1: The 5-minutes average consumption of **MHP** exceeds its pre-peak demand 27KW.

Pattern 2: A **Meeting Room**'s temperature is above 73 degree when it is not occupied.

Pattern 3: More than 6 **Fan Coils** in **MHP** operate at the same time.

Pattern 4: **EE Department**'s power consumption exceeds its pre-peak demand 600KW.

System Overview

- *Complex event processing engine* – correlate both static and dynamic information
- *Static meta data* – domain knowledge such as sensor locations, room types and so on
- *Data streams* – real-time data from meters, HVAC units and appliances on campus
- *D²R Patterns* – CEP queries categorized as monitoring, prediction, and curtailment patterns

Past & Present Experiments

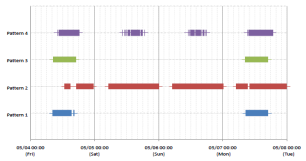
Past

- Model meaningful dynamic DR situations using complex event queries
- Validate real-time DR pattern detections

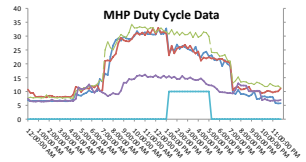
Present

- Classroom Scheduling vs. Building Energy Load
- Load Curtailment Potential for Buildings with many Air Handling Units (AHU)

Pattern Detection Results

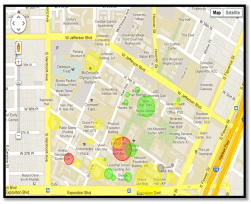


Previous Curtailment Data



Discussion & Future Work

- CEP can account for inconsistencies in some of our prediction models
- We will be exploring different CEP taxonomies to assist in dynamic DR optimization in microgrids.
- Coupled with DR, CEP could allow for Automated Demand Response, lessening the responsibility of system operators
- We plan to look into using CEP to send real time notifications to energy managers as well as use the smartgrid.usc.edu portal to display complex events in real-time



USC Smart Grid Portal Energy Heatmap

Acknowledgement

This work is supported by the Energy Informatics Center at the University of Southern California, Facility Management Services (FMS), Los Angeles, and its funding agencies, the US Department of Energy (DOE) and Los Angeles Department of Water and Power (LADWP). Special thanks to Carol Fern and Roddy Lee from FMS, Nicole Sintov and Mike Orosz from the ISI, and students in the Smart Grid group at USC.

Ming Hsieh Institute

Ming Hsieh Department of Electrical Engineering