Enabling buildings and smart grid resilience with aggregated demand response: a data-driven approach

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Panel 3: Data Driven Use Cases to Enable Resiliency I
Enabling buildings and smart grid resilience with aggregated demand response

Share value

Reduce costs +
Ensure added value

How?

Energy transactions
Transactive energy

Service provision

Business Models
Contracts
Demand response
Tariffs

Energy market simulation
Enabling buildings and smart grid resilience with aggregated demand response

Wide spreading of Demand Response

- Business models
- Fair remuneration
- Strategic resource aggregation

DG – Distributed Generation
RTP – Real Time Pricing
IDR – Incentive based Demand Response

Suppliers
DG
IDR
RTP

Types of DG
DG tariffs
Max DG

Types of Consumer
IDR costs
Max IDR

Elasticity
Max Reduction
Max Price Increase

Maximum of each Resource
Maximum Cost of each type of resource

Optimal Scheduling for Resources

DG
IDR
RTP

α DG
α IDR
α RTP

Total DG
Total IDR
Total RTP

Desired number of Groups
Variables to consider in aggregation

Aggregation of DG, IDR and RTP into separate groups/ clustering of resources

Evaluation of the obtained results for scheduling and aggregation

Tariffs Definition
Enabling buildings and smart grid resilience with aggregated demand response
MARTINE: Real-time multi-agent based platform

Java Agent Development Framework (JADE)

- OPAL-RT
- Simulated Facilities
- Resource (Building: N, Lab)
- Resource (Building: F)
- Resource (Building: N, Left)
- Prices / Markets
- Management Applications
- Contracts

Agent/Player
JADE
Web Service
Gateway
Energy Analyzer
OPAL-RT
MARTINE: Real-time multi-agent based platform
MARTINE: Real-time multi-agent based platform

100% effectiveness – choice rate

Context 1
smaller number of occurrences

Context 4
larger number of occurrences

The chosen strategies are different in distinct contexts

Results comparison

100% effectiveness

0% effectiveness

- With 100% preference for effectiveness all strategies are executed at their full potential
- With 0% preference for effectiveness only the faster strategies are executed
MARTINE: Real-time multi-agent based platform

Ontologies

Context awareness

Real-time simulation

Data Management

Historical data

Real-time data

Real-time Simulation & Control

Validation & Control

Physical Resources

Direct Control

Multi-Agent Framework

Computational Intelligence

Algorithms & Decision Making

Players

Demand Response

Optimisation

Contracts

Context

Decision Support

Business Models

MATLAB

SRAM

Security Service

Registration Service

Transaction Service

ESICG

Energy Systems Innovation Center

NSF Workshop

Horizon 2020

H2020
MARTINE: Real-time multi-agent based platform
MARTINE: Real-time multi-agent based platform
Living demo building: Real-Time Monitoring

Controller Board of SCADA
(3 Distributed PLCs, and 1 Main PLC)
Living demo building: Real-Time Monitoring

- Temperature Outside
- Light Outside

- Sensors
  - CO2
  - VOC
  - Temperature
  - Humidity
  - Light
  - Presence

- 4 Energy meters
- 19 DALI controllable lighting spots
Living demo building - intelligent energy management system
Living demo building - intelligent energy management system

- An aggregator has contracts with consumers and producers
- ISEP has a contract with that aggregator
- Intelligent energy management is demonstrated in GECAD building

Tiago Soares, Marco Silva, Tiago Sousa, Hugo Morais, Zita Vale
Energy and Reserve under Distributed Energy Resources Management—Day-Ahead, Hour-Ahead and Real-Time
Energies, vol. 10, no. 11, Nov. 2017

Ricardo Faia, Tiago Pinto, Omid Abrishambaf, Filipe Fernandes, Zita Vale, Juan Manuel Corchado
Case Based Reasoning with Expert System and Swarm Intelligence to determine Energy Reduction in Buildings Energy Management
Living demo building - intelligent energy management system

Real-Time Monitoring Loads

Load 4: residential consumer

Load 1: GECAD office building

Load 6: GECAD smart home lab
Living demo building - intelligent energy management system

LIS – Lighting Intelligent System

Inputs
- Total consumption
- PV generation
- Number of offices
- Number of lights
- Consumption of each light
- Max consumption of each light
- Max reduction of each light
- Required Reduction
- Max reduction
- Priority of each light
- Context awareness

Optimization

Algorithm for Managing Lighting Consumption
- Real-time operation
- Individual lighting points preferences
- Higher priorities first
- Meet a target consumption reduction
- Runs in Raspberry

Results

Lights Scheduling

Building lighting intelligent system
Living demo building: intelligent notifications and alerts

Real-time GECAD’s Building N monitoring and alerts

Uses GECAD forecasting and profiling algorithms (data-driven intelligence)

The real-time monitoring of GECAD’s building

<table>
<thead>
<tr>
<th>Zone</th>
<th>Power Consumption (W)</th>
<th>Light Intensity (%)</th>
<th>Humidity (%)</th>
<th>CO2 (ppm)</th>
<th>VOC (%)</th>
<th>Temperature (°C)</th>
<th>PV Production (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>HVAC: 500.00, Light: 380.00, Socket: 948.00, Total: 1828.00</td>
<td>N102 [Zone 1]: 96.00, N105 [Zone 2]: 100.00, N107 [Zone 3]: 0.00</td>
<td>N102 [Zone 1]: 40.97, N104 [Zone 2]: 52.93, N105 [Zone 2]: 48.97, N107 [Zone 3]: 50.10</td>
<td>N102 [Zone 1]: 898.00, N104 [Zone 2]: 1025.83, N105 [Zone 2]: 818.33</td>
<td>N102 [Zone 1]: 4.75, N104 [Zone 2]: 13.13, N105 [Zone 2]: 6.40</td>
<td>N102 [Zone 1]: 22.88, N104 [Zone 2]: 20.20, N105 [Zone 2]: 20.79, N107 [Zone 3]: 18.62, Outside: 11.98</td>
<td>N102 [Zone 1]: 754.17</td>
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<tr>
<td>2</td>
<td>HVAC: 1503.33, Light: 220.00, Socket: 935.00, Total: 2558.33</td>
<td></td>
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</tr>
<tr>
<td>3</td>
<td>HVAC: 0.00, Light: 0.00, Socket: 311.67, Total: 311.67</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>HVAC: 324.00, Light: 126.10, Socket: 0.00, Total: 450.10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Door Status:
- N102 [Zone 1]: Open
- N103 [Zone 1]: Open
- N104 [Zone 2]: Closed
- N105 [Zone 2]: Closed
- N106 [Zone 2]: Open
- N107 [Zone 2]: Closed
- N108 [Zone 3]: Closed
- N109 [Zone 3]: Open
Living demo building: intelligent notifications and alerts

Data
- historic + real-time

Knowledge

Expertise

BRICKS
Building Reasoning for Intelligent Control
Knowledge-based System

- Semantics enriches information
- The system is abstracted from a semantic model & SWRL rules
  - The model/rules may change without the need of reprogramming the system
  - Not depending on the used devices nor communication protocols
  - Considers an abstract context-based rules matching profiles model
- Outputs Notifications & Actions

Cognitive intelligence
Knowledge-Based system
Semantics/Ontologies
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Thank you

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