A novel middleware for smart grid data exchange towards the energy efficiency in buildings

Authors: Susana Martín, José L. Hernández, César Valmaseda

Presenter: José L. Hernández

Fundación CARTIF, Valladolid, Spain
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Gaps in existing energy systems

- Underperformance use of energy systems
  - Micro-grid
- Simple ICT energy management systems
  - Operational costs
  - Energy consumption
- Lack of common vocabulary
  - Context awareness
- Integration of heterogeneous data sources
  - Internet of Things in building
BaaS project: Overview

- Building as a Service
- Project number: 288409
- Call: FP7-ICT-2011-7
- Topic: ICT 2011.6.2 ICT systems for energy efficiency
- Partners

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<tr>
<th>No.</th>
<th>Participant organisation name</th>
<th>Short name</th>
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BaaS project: Overview

The BaaS system aims to optimize energy performance in the application domain of “non-residential buildings, in operational stage, when three main tasks have to be continuously performed:

- collect information and assess the buildings current state;
- predict the effect that various decisions will have to Key Performance Indicators (KPIs);
- optimize performance.

A generic ICT-enabled system will be developed to provide integrated assess, predict, optimize (APO) services that guarantee harmonious and parsimonious use of resources:

- A data management component
- A service middleware platform
- Energy models
- APO (assessment, prediction and optimization) services

End-user acceptance analysing the replication potential and a sensibility study
BaaS project: Overview

1. Components development
   - EN5232 functionalities
   - Middleware
   - Data layer

2. Verification
   - Test-bed 1: TUC Building

3. Integration
   - EN5232 Analytics
   - Middleware
   - Data layer
   - ZUB building
   - CARTIF building
   - Demo site 1 and 2: Office Buildings
   - Demo-site 3: School

4. Validation
   - M&V Procedure IPMVP

Alignment of the BaaS solution with the application domain

End-user acceptance
BaaS platform overview

Application Layer
- TBM - Technical Building Management
- BAC - Building Automation Control

Communication Layer (Middleware)

Middleware

Local - Building
- Building information
- Local data bases
- BMS Control and Monitoring
- External ICT Systems (weather station)
- External Web Services (weather forecast)

Extended BIM

Modeling and Simulation Capabilities

BIM Server

Data Warehouse
BaaS platform overview

Application Layer
- TBM - Technical Building Management
- BAC - Building Automation Control
- ..... 
- ..... 

Communication Layer (Middleware)

End-users

Local - Building

Building information
Local data bases
BMS Control and Monitoring
External ICT Systems (weather station)
External Web Services (weather forecast)

Unique Vocabulary

Modeling and Simulation Capabilities

Data Model

Extended BIM

BIM Server
Data Warehouse
Middleware system

Application Layer
- Models
  * Building Thermal Model
- Modules
  * Building Automation and Control
  * Technical Building Management
- Services Kernel
  * Signal Handler
  * Event Handler
  * Simulation Mgr
  * Module Registry
  * Time Control
  * Config Mgr
  * Service Handler
  * Permissions

Communication Logic Layer
- Domain Controllers (DC)

Core Communication Sub-layer
- Data Acquisition and Control Manager (DACM)
  Logic and Communication services

Data Access Object Sub-layer
- DC Data Access Objects
- DACM Data Access Objects

Data Layer
- Plant (Building)
  * BMS / BACN
  * ICT: weather
  * ICT: access control
- BIM Server
  * BIM 1.2 RC4
  * IFC4
  * xBIM - eXtended BIM
- DWH
  * Data warehouse
  * IFC based
- External Services
  * weather forecast
  * ...

Tools
- Simulation
- External
- Optimization
- Resources

GUI
- Visualisation
### Middleware system

- Communication protocols and translation

<table>
<thead>
<tr>
<th>Element</th>
<th>Protocols</th>
<th>Data Model</th>
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<td>BMS</td>
<td>SOAP, BACnet/IP, OPC</td>
<td>Particular BMS representation to IFC4</td>
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<tr>
<td>DWH</td>
<td>Oracle JDBC drivers and Hibernate</td>
<td>IFC4 compliant</td>
</tr>
<tr>
<td>BIM</td>
<td>JSON</td>
<td>IFC4 compliant</td>
</tr>
<tr>
<td>ICT Services</td>
<td>FTP, Web Services</td>
<td>XML and text files to IFC4</td>
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<tr>
<td>External Services</td>
<td>Web Services and HTTP</td>
<td>XML to IFC4</td>
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<tr>
<td>External Tools</td>
<td>Java APIs</td>
<td>XML and text files to IFC4</td>
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<td>APO Services</td>
<td>OSGi events</td>
<td>IFC4 compliant</td>
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Middleware system

- IFC4-based data model

The whole Building Information into the BIM Server.
Middleware system

- IFC4-based data model: Example I-5 – BMS-MW

Physical connections

Logical Connection

Geometrical placement into the building
Middleware system: Components

- BMS Connector
- Generation systems
  - Micro-grid
- Distribution system
- Comfort sensors
- ID Mapper
  - Mapping tables
  - From building context to IFC4

- General Integrator
  - Merge the IoT in the building context to the common vocabulary in a single signal
Middleware system: Deployment

- Distributed DCs
  - Scalability
- RESTful based
  - Application layer
  - DC-DACM
- Event mechanism

- VPN communication channels
- Authentication mechanism
Middleware system: Deployment
Conclusions

- Interoperability among energy management systems
- Integration of heterogeneous data sources
- “Internet of Things” in the building context
  - “Smart grid”/”Micro-grid”
- Homogenization of data frames
  - Common vocabulary – IFC4-based
- Building as a Service
Future work

- Performance analysis
- Extensibility of functionality
- Scalability and replicability in other buildings
- Analysis of energy savings
Thank you for your attention

Any question is welcome!

José L. Hernández
joshier@cartif.es / baas_tech@cartif.es
+34 983548911