Secure and Semantic Web of Automation

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Automation Systems Group

- Computer Engineering/Software Engineering
  - System analysis and design of networked embedded systems
- Deep integration
  - QoS in control networks
  - Security & safety
- Management level integration
  - Information modeling
  - Middleware & Web Services
- Applications
  - Advanced control strategies
  - Energy efficiency & performance optimization
  - Cyber-physical Production Systems (Industrie 4.0)
  - Smart Homes/Buildings → Smart Grids → Smart Cities
Building Automation

Building Management

Control Networks

Internet

HVAC

Lighting Shutters/Blinds

Security

Safety

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Smart Homes

Home Server (Set-top box) → Internet → Control and IT networks

Domotics
White Goods
Consumer Electronics
Tele-Care Monitoring

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SeWoA: Use Cases (Building Information Modeling)

- Optimize control strategies using knowledge about the building
  - Structure of the building (e.g., start/stop of HVAC)
  - Building layout (e.g., heat transfer between rooms)
  - Orientation of rooms (e.g., visual comfort)

Source: http://allinoneinsulation.com/insulation/the-all-in-one-system/
SeWoA: Use Cases (Resources)

- Facilities in the building
  - Abstract from underlying heterogeneous devices
  - Calculate current energy consumption and production
- Energy providers and tariffs
  - Satisfy high energy demand through green energy providers
  - Shift scheduled processes to times when cheap energy is available

SeWoA: Use Cases (Weather)

- Exploit favourable weather states
  - Optimize HVAC control (e.g., night purge, solar heat gain)
  - Optimally schedule shiftable loads w.r.t. available renewable energy (e.g., predicted PV output)

Call for Action!

Semantic Communication Stack for the IoT

- Open standard including the application layer service and annotated information models
- Based on existing interoperable Web and Internet technologies
- Reusing existing standards as much as possible
SeWoA: Protocol Stack and Ontology

- Semantic Interoperability Layer
- Automation Systems Ontology
- Domo ML
- Spitfire Ontology
- Sensor ML
- Combined and enhanced
- Model transformation

- Technology specific information models
  - oBIX information model
  - OPC UA information model

- Communication Interoperability Layer
  - oBIX, OPC UA protocol binding + RDF annotation
  - XML/EXI encoding
  - Coap
  - HTTP
  - UDP
  - TCP
  - IPv6

- Physical Compatibility Layer
  - 6LoWPAN
  - IEEE 802.15.4
  - IEEE 802.3 Ethernet
  - Other links

- Security
SeWoA: Architecture

- Facility Management
- SPARQL queries & updates
- SPARQL Endpoint
- Knowledge Base
- Apache Jena
- Semantic BMS Server
  - Apache Jena
  - CoAP/HTTP Client

- OPC UA building automation server
  - TU Vienna
- OPC UA metering server TU Vienna
- NETxAutomation BMS
- IoT
  - LoWPAN

- Lighting
- HVAC
- Metering

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Proof of Concept

- Existing oBIX and OPC UA integration servers shall be extended
- Automation Systems Group develops
  - Semantic, Knowledge Based BMS Server
  - IoTSyS prototype (multi-protocol gateway)
  - 6LoWPAN devices including oBIX interface
- NETxAutomation provides
  - NETx BMS Server
  - OPC server for KNX and other technologies
  - KNX ETS app for importing KNX ETS projects
SeWoA Gateway: NETx BMS Server

Semantic BMS Server

NETx BMS Server as SeWoA gateway

Interfaces to existing home and building automation systems
E.g. KNXnet/IP

oBIX → OPC UA

Other technologies...
SeWoA Use Cases (revisited)

- Are all switching and dimming actuators of a distinct floor in “off” state?
  - Actuator states: BAS communication objects
  - Physical location of the devices: BIM
  - SPARQL query:

```sparql
ASK
WHERE {
  ?lamp sewoa:hasState ?state.
  ?state sewoa:hasStateValue sewoa:OffStateValue.
  sewoa:4thFloor sewoa:contains ?room
}
```
SeWoA Use Cases (revisited)

- Which lamps in a building have exceeded a distinct operating time?
  - BMS Server module for monitoring operating hours
  - Definition of limits of operating hours using virtual datapoints
  - SPARQL query:

```sparql
SELECT ?lamp ?hours
WHERE {
    ?lamp sewoa:hasOperatingHours ?operatinghours.
    ?operatinghours time:hours ?hours
    FILTER(?hours > 700)
}
```
SeWoA Use Cases (revisited)

- Which unoccupied rooms at the southern or western front of the building have their shutters in “down” position?
  - Hotel room occupancy: interface to hotel management systems (e.g. Micros Fidelio)
  - Physical location of hotel rooms: BIM
  - State of shutters: BAS communication objects
SeWoA Use Cases (revisited)

- Which unoccupied rooms at the southern or western front of the building have their shutters in “down” position?
  - SPARQL query:
    ```sparql
    SELECT ?room ?shadevalue
    WHERE {
      ?room sewoa:hasSensor ?sensor.
      ...
      ?shade sewoa:hasState ?state.
      ?state rdf:type sewoa:ShadeState.
      ?state sewoa:hasStateValue ?shadevalue
      FILTER(?shadevalue < 10)}
    ```
Conclusion and Outlook

- Semantic Web
- Aggregating information from different application domains → Smart Control
- SeWoA
  - Suitable ontology
  - Querying interfaces
  - Semantic engineering
- Proof of concept
  - Knowledge Based BMS Server
  - IoTSyS
  - NETx BMS Server