Launch of Internet of Things - Egypt Forum
&
First SECC Hackathon on Semantic Technology
ITIDA, Smart Village
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The Role of Semantic Data Distribution in
Open Cyber-Physical Systems and IoT

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Overview

- Technologies for the *smart city*:
  - Internet of Things (*IoT*)
  - Open Cyber-Physical Systems (*Open CPS*)
- Data distribution based on semantic event processing in *IoT* and *Open CPS*
- An **M3** based semantic event processing engine
Urbanization and the «smart city» concept

Population in urban areas is growing fast:

2008: 50% --> 2050: 70% (UN)

Urbanization is a reaction to the slow economy and it requires services

There is a big gap between service demand and offer

- «smart city» is term used by governments as a reference to the technological solutions to bridge this gap
  - smart city technologies enable the co-operation between heterogeneous and remote devices interacting with the environment
  - co-operation requires information level interoperability
  - semantic technologies enable information level interoperability
Connectivity and interoperability domains in the city of the future

• Mobility: V2G for eMobility services, V2V, R2V for traffic management and car as a sensor (25% connected cars in 2023 - McKinsey&C, Cisco,...)

• Buildings: automation, management, security, metering, assisted living, home entertainment

• Energy: smart grid, virtual energy market, multi-modal energy systems (power, gas, heat), decarbonization of traffic sector

• Healthcare: remote clinical monitoring
## Key technologies for the smart city

<table>
<thead>
<tr>
<th>Technology</th>
<th>Market Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smart Grid</td>
<td>Emerging</td>
</tr>
<tr>
<td>Smart Spaces</td>
<td>Early</td>
</tr>
<tr>
<td>IoT</td>
<td>Fragmented</td>
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<tr>
<td>Sensors</td>
<td>Fragmented</td>
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<tr>
<td>Cyber-Physical Systems</td>
<td>Research</td>
</tr>
</tbody>
</table>

*Source: Prof. Sumi Helal, Bologna, Feb. 18 2014*
Smart Grid Communication Domains

Source:
Smart Space Application Domains
(early market)

Domains at different granularity levels:

- City
- Confined Spaces
  - Private Houses
  - Public Buildings
  - Specialized Sites
    - Hospitals
    - Museums
    - ...
- Personal Spaces
  - Vehicles
  - ...

... and cross domain...
Smart Spaces, M3 and semantic data distribution

• Smart Space (SS): a named and shared information search domain

• semantic SS: a SS based on RDF graph data model, with an ontology to represent knowledge

• M3: an architecture for semantic smart spaces with fine grain event detection and notification capability
Home based smart space for telemedicine or remote assistance

Purpose:
Supporting continuous patients monitoring and care

Source: CHIRON P3 Review Meeting - Brussels June 4, 2013
Home based smart space for telemedicine or remote assistance

Source: CHIRON P3 Review Meeting - Brussels June 4, 2013
The Class Tree of the CHIRON Ontology
Semantic Information Broker (SIB): entity for storing, sharing, and governing information

Knowledge Processors (KP): entities providing and/or consuming SIB content

Knowledge is expressed in terms of entities related to other entities or to specified property values
Turning the M3 Semantic Information Broker into a Semantic Data Distribution System

Interaction primitives:
- Update, Subscribe

Language: SPARQL 1.1
Protocol: WIP
Concept data-path of the Pipelined Superscalar Semantic Event Processing Engine (F. Morandi - UniBo)

Update / Subscribe Requests queue  
Updated Triples queues  
Notification queue

from semantic clients

Scheduler

Subscribe Processor 1

Subscribe Processor 2

Subscribe Processor n-1

Subscribe Processor n

To semantic clients

RDF ENDPOINT
Benchmark and performance indicators

Defined a benchmark consisting of:

- 300 K triples
- > 25 properties
- > 20 classes
- > 1000 semantic rules
- 9500 physical entities each with 3 sensors and 1 actuator

Defined two performance indicators:

- RpS: rules processed per second
- P2S: update processing time/main store update time

Both PIs need to be associated to a benchmark and an update profile
Internet of things

• The IoT is an abstraction of the Physical world as it is expected to be perceived in the near future, where:
  
  ➢ people and devices mutually interact and also
  ➢ interact with natural and artificial physical entities
  ➢ that are monitored and/or controlled by other devices and
  ➢ are uniquely identified by an ID, and
  ➢ may be discovered through a set of relevant properties or a set of relations with other entities
IoT domain model

Andreas Nettsträter (ed.), “The IoT Architectural Reference Model (ARM) - D1.3”
Adding a semantic interoperability level to the IoT (Jussi Kiljander, VTT)

<table>
<thead>
<tr>
<th>IoT</th>
<th>I-IOT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical Entity</td>
<td>Physical Entity</td>
</tr>
<tr>
<td>Virtual Entity</td>
<td>Semantic Virtual Entity</td>
</tr>
<tr>
<td>User (ADA)</td>
<td>Agent</td>
</tr>
<tr>
<td>Device</td>
<td>Device</td>
</tr>
<tr>
<td>Resource</td>
<td>Agent</td>
</tr>
<tr>
<td>Service</td>
<td>SIB</td>
</tr>
</tbody>
</table>

Access through unique ID or properties enabled by the Resolution Infrastructure

From local SS to IoT using
Cyber-Physical Systems

• CPS are control systems possibly with man in the loop
• They integrate computation, networking, and physical processes [1]
• They consist of a set of interconnected and collaborating embedded systems some of which interact with the physical world
• They are intended to offer situation dependent services
• They are considered boosters of sustainable development and are target of large interest and investments worldwide

http://ptolemy.eecs.berkeley.edu/ptolemyII/
Cyber–Physical Systems – a Concept Map

http://CyberPhysicalSystems.org

S. Shyam Sunder
Philip Asare
David Broman
Edward A. Lee
Martin Torngren
IoT and cyber-physical systems

Emphasis is on connectivity and services

CPS and IoT are intended to offer physical world dependent co-operative services

Emphasis is on performance and control

For an introduction to CPSs: CPS foundations - Edward Lee
From CPS TO OPEN CPS: the EU vision in H2020

- Connectivity includes the Internet
- Requirements for Interoperability at information level come into play
- A multi-level hierarchical architecture is envisioned
- Semantic event processing might be deployed at any level of the hierarchy

Source:
CYBER-PHYSICAL SYSTEMS: UPLIFTING EUROPE’S INNOVATION CAPACITY
Brussels, Belgium on 29th – 30th October 2013

- Jesús Angel García Sánchez, INDRA
Cloud based Open CPS

Connecting the field at the Enterprise

Business Applications

Enterprise Interfaces

M2M Integration Platform

M2M Protocol

Remote Gateway

Field Interfaces

Semantic data distribution may be Introduced at this level

Integrate
Act
Store
Connect & Control

Collect
Process
Communicate

Source: EUROTECH

ITIDA - Smart Village - Abu Rawash - Al Jizah

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Conclusion

• IoT and Open CPS technologies will facilitate business and quality of life in the cities of the future

• IoT and Open CPS share the need for:
  – interoperability at information level
  – efficient event processing and data distribution

• Smart space research provides a semantic architectural component to meet these needs
Thank you!!

Questions?