IoT-based Smart Parking System for Sporting Event Management

S. Kubler*, J. Robert*, A. Hefnawy#, C. Cherifi#, A. Bouras#, K. Främling+

* University of Luxembourg, Interdisciplinary Centre for Security, Reliability & Trust
# Qatar University, DCSE, College of Engineering
+ Aalto University, Computer Science

sylvain.kubler@uni.lu
http://sylvainkubler.fr
SUMMARY

• IoT (Internet of Things) — The road ahead

• EU’s Vision & Ambition

• O-MI & O-DF Messaging Standards used as foundation of the (bIoTope) IoT ecosystem

• IoT-based Smart Parking Scenario

• Conclusion
IoT— The road ahead

Global Revenue Forecast

Revenues by sector (EU Baseline scenario)

Architectural issues & Structural considerations still need to be addressed for businesses to benefit!

Source: Definition of a R&I strategy leveraging The combination of IoT & Cloud for DG CONNECT
The Internet of Things

IoT— The road ahead

Smart Planet
- Environmental sensors
- Pollution, leak detection
- Weather monitoring

Smart Cities
- Traffic management
- Security
- Lighting control
- Water management
- Smart bins

Smart Buildings
- Smart homes
- Lighting & A/C control
- Presence sensor
- Smart security
- Utility metering

Smart Transport
- Electric mobility
- Smart logistics
- Infrastructure
- High-speed trains
- Commuter apps

Smart Industry
- Optimized production
- Lighting, security
- Actuators
- Robotics

Smart Energy
- Smart grid
- Fault detection/monitoring
- Voltage/power sensors
- Consumption meters
- Virtual power plant

Smart Health
- Bio sensors
- Remote diagnostics
- Health monitoring

Smart Living
- Leisure and entertainment
- J.I.T. information
- Anytime connection

Source: Definition of a R&I strategy leveraging The combination of IoT & Cloud for DG CONNECT
IoT— The road ahead

Legend

Today’s IoT: Data collected into vertical silos (pushed to vertical servers)
Ideal IoT: Communication allowed between vertically-oriented closed systems
SUMMARY

• IoT (Internet of Things) — The road ahead

• EU’s Vision & Ambition

• O-MI & O-DF Messaging Standards used as foundation of the (bIoTope) IoT ecosystem

• IoT-based Smart Parking Scenario

• Conclusion
EU’s Vision & Ambition

FP7 programmes (IERC, FI-PPP, …)

Industry
Mobility
Environment
Farming
Wearable
Cities
Living
EU’s Vision & Ambition

http://www.aioti.eu

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Integration of devices</th>
<th>Creation of platforms</th>
<th>Interoperable APIs</th>
<th>Autonomous reasoning</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGILE – Adoptive gateways for diverse multiple environments</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>BIG IoT – Bridging the Interoperability Gap of the Internet of Things</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>bIoTope – Building an IoT oPen innovation ecosystem for connected smart objects</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>INTER-IoT – Interoperability of heterogeneous IoT platforms</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>symbIoTe – Symbiosis of smart objects across IoT environments</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>TagItSmart – Smart Tags driven service platform for enabling ecosystems of connected objects</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>VICINITY – Open virtual neighbourhood network to connect intelligent buildings &amp; smart objects</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
Project Coordinator

Aalto University (Finland)

Prof. Kary FRAMLING
School of Science and Technology
☎ +358 505 980 451
✉ kary.framling@aalto.fi

Project Consortium

EPFL: École Polytechnique Fédérative de Lausanne (Switzerland)

Uni.lu: University of Luxembourg (Luxembourg)

Fraunhofer IAIS: Fraunhofer Institute for Intelligent Analysis and Information Systems (Germany)

BIBA: Bremer Institut für Produktion und Logistik GmbH (Germany)

CSIRO: Commonwealth Scientific & Industrial Research Organisation (Australia)

BMW: Bayerische Motoren Werke Aktiengesellschaft (Germany)

The Open Group (United Kingdom)

eccenca GmbH (Germany)

OpenDataSoft (France)

Cityzen Data (France)

Holonix (Italy)

ittrust consulting (Luxembourg)

Enervent Oy (Finland)

ControlThings (Finland)

IS-Practice (Belgium)

Forum Virium Helsinki (Finland)

Grand Lyon La Métropole (France)

IRISnet (Belgium)

CIRB: Centre Informatique pour la Région Bruxelloise (Belgium)

Brussels Mobility (Belgium)

This project has received funding from the European Union’s H2020 Programme for research, technological development and demonstration under grant agreement n° 688203.

Visit & Join us

• www.bIoTope-project.eu

• Twitter: @bIoTope_project

Building an IoT Open Innovation Ecosystem for Connected Smart Objects

Scope & Objectives

The Internet of Things (IoT) brings opportunities to create new services and products, reducing costs for societies, and changing how services are sold and consumed. A critical obstacle to further IoT innovation is the “vertical silos” that shape today’s IoT landscape. These silos impede the creation of cross-industry, cross-platform and cross-organisational services due to their lack of interoperability and openness.

bIoTope lays the foundation for creating open innovation ecosystems by providing a platform that enables companies to easily create new IoT systems and to rapidly harness available information using advanced Systems-of-Systems (SoS) capabilities for Connected Smart Objects – with minimal investment.
IoT— The road ahead

Source: AIOTI
SUMMARY

• IoT (Internet of Things) — The road ahead

• EU’s Vision & Ambition

• O-MI & O-DF Messaging Standards used as foundation of the (bIoTope) IoT ecosystem

• IoT-based Smart Parking Scenario

• Conclusion
O-MI & O-DF Messaging Standards
A High-level Introduction of the standard specifications

Four common **IoT communication models**:
- Device-to-Device (D2D)
- Device-to-Gateway (D2G)
- Device-to-Cloud (D2C)
- Backend Data Sharing Model (S2S + Analytics)
O-MI & O-DF Messaging Standards
A High-level Introduction of the standard specifications
“bloTope is about platform federation for cross-domain innovation” (API economy)
Find the best charging point for your EV if battery low (depending on the city, your agenda, weather forecast...)

BMW developer (customer services)

Enable APIs ‘uniformization’

- Need for “cognitive” systems (**Context-Aware computing**)
- Need for **Ad-hoc Security** mechanisms
- Need for a **Service Market Place** to foster co-creation
- Need for **Standardised (Semantic) Vocabularies**
- Need for discovering and accessing available services (across IoT platforms) in a **standardised & uniformed manner**

Find the best charging point for your EV if battery low (depending on the city, your agenda, weather forecast...)

BMW developer (customer services)

Enable APIs ‘uniformization’

- Need for “cognitive” systems (**Context-Aware computing**)
- Need for **Ad-hoc Security** mechanisms
- Need for a **Service Market Place** to foster co-creation
- Need for **Standardised (Semantic) Vocabularies**
- Need for discovering and accessing available services (across IoT platforms) in a **standardised & uniformed manner**
Use Case Providers

Aalto Smart Campus: https://otaniemi3d.cs.hut.fi/omi/node/html/webclient/index.html
Colleague Smart House: http://jeremyshouse.jeremy-robert.fr

Standardised Service Description & Messaging Interfaces (O-MI/O-DF)

José de Luna

JCDecaux API
Other...
Other...
BMW API
Hue API
Netatmo API
Standardised Service Description & Messaging Interfaces (O-MI/O-DF)

JCDecaux API  Other...  Other...  BMW API  Hue API  Netatmo API

O-MI node URL

Security-as-a-Service

Policies

O-MI/O-DF Ref. Implem.

0  1  2
Standardised Service Description & Messaging Interfaces (O-MI/O-DF)

Discovery-as-a-Service
Billing-as-a-Service

Service Catalog

Security-as-a-Service

Policies

http://85.171.192.185

http://biotope.sntiotlab.lu:8080/Objects/BrusselsBikesParkingSpot/328

O-MI/O-DF Ref. Implem.

O-MI node URL

JCDecaux API

Other...

Other...

BMW API

Hue API

Netatmo API

JCDecaux API

Other...

Other...

BMW API

Hue API

Netatmo API
Standardised Service Description & Messaging Interfaces (O-MI/O-DF)

IoT ecosystem end-users
(cities, citizens, SMEs, etc.)

Peer-to-Peer IoT data exchange (depending on access rights)

Demo Part 1

https://www.youtube.com/watch?v=gYdFOVXd25o

http://85.171.192.185

http://biotope.sntiotlab.lu:8080/Objects/BrusselsBikesParkingSpot/328

O-MI/O-DF Ref. Implem.
Citizen

Bike Alert Service

Enable Service: On

Your home address:

Distance max when bad weather (in meter): 0
Distance max when good weather (in meter): 0

Departure Time:
08:00

List of parking spot:

First Device Alerting:
Your Mobile Vibrator will be used to alert you

Second Device Alerting to show the bike unavailability rate
Hue Light

Write Request (control command)

Subscription (interval-based)

O-MI Node Brussels
O-MI Node Weather-data
O-MI Node Smart bulb

O-MI/O-DF standards + Standardised vocabularies (schema.org, SSN...)

JCDecaux API
Netatmo API
Hue API
SUMMARY

• IoT (Internet of Things) — The road ahead

• EU’s Vision & Ambition

• O-MI & O-DF Messaging Standards used as foundation of the (bIoTope) IoT ecosystem

• IoT-based Smart Parking Scenario

• Conclusion
IoT-based Smart Parking
FIFA World Cup 2022 (Qatar)

Area A
Area B
Area C
Area D

Transportation data
Industry data
Healthcare data
Sports data

Cognitive City Services

Node O-MI node 1
Node O-MI node 2
Node O-MI node 3
Node O-MI node 4

App for real-time guidance

Cognitive Stadium Services

Buy Apps
O-MI Subscriptions

Stad. KPIs

Sports data

Transportation data
Industry data
Healthcare data

Stad. KPIs

Cognitive City Services

Node O-MI node 3

O-MI node 4

Node O-MI node 2

Node O-MI node 1

© bIoTope Consortium
SUMMARY

• IoT (Internet of Things) — The road ahead

• EU’s Vision & Ambition

• O-MI & O-DF Messaging Standards used as foundation of the (bloTope) IoT ecosystem

• bloTope City Pilots

• Conclusion
bIoTope City Pilots

Open Calls — May 2017
750k€ in total (50-150K€ per open call)

http://www.biotope-project.eu
Thing/Service Description (O-MI/O-DF)

Domain Independent Semantic Models (e.g., schema.org, SSN…)

Domain Dependent Semantic Models (e.g., DATEX, eCl@ss, Mobivoc, Smart City…)

IoT Visual Programming Tools

- Node-RED
- Query Language (e.g., SPARQL…)

Discovery-as-a-Service

- Billing-as-a-Service
- Smart City

Security-as-a-Service

IoT ecosystem end-users (cities, citizens, SMEs, etc.)

Peer-to-Peer IoT data exchange (depending on access rights)

http://85.171.192.185

Policies

O-MI node URL
IoT-based Smart Parking System for Sporting Event Management

S. Kubler*, J. Robert*, A. Hefnawy#, C. Cherifi#, A. Bouras#, K. Främling+

* University of Luxembourg, Interdisciplinary Centre for Security, Reliability & Trust
# Qatar University, DCSE, College of Engineering
+ Aalto University, Computer Science

sylvain.kubler@uni.lu
http://sylvainkubler.fr
Development stages:

1. Search for data sources
2. Pay for accessing them (if needed)
3. Token generation
4. Re-Use Token in your IDE

bIoTope Service Marketplace

O-MI/O-DF standards + Standardised vocabularies (schema.org, SSN...)

Jéremy

JCDecaux API

Netatmo API

Hue API
Development stages:

1. Search for data sources
2. Pay for accessing them (if needed)
3. Token generation
4. Re-Use Token in your IDE

Jérémy

Cart

<table>
<thead>
<tr>
<th>Data Source</th>
<th>Validity Period (in week)</th>
<th>Amount</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="http://biotope.sntiotelab.lu:8080/Objects/BrusselsBikesParkingSpot/59/AvailableBikes">http://biotope.sntiotelab.lu:8080/Objects/BrusselsBikesParkingSpot/59/AvailableBikes</a></td>
<td>-</td>
<td>1</td>
<td>10 B</td>
</tr>
<tr>
<td><a href="http://85.171.192.185:8080/Objects/LyonBikesParkingSpot/9010/BikeStands">http://85.171.192.185:8080/Objects/LyonBikesParkingSpot/9010/BikeStands</a></td>
<td>-</td>
<td>2</td>
<td>10 B</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Total:</td>
</tr>
</tbody>
</table>

Buy Data

Show Cart
Development stages:

1. Search for data sources
2. Pay for accessing them (if needed)
3. Token generation
4. Re-Use Token in your IDE

Welcome to IoTBNB
Publish, discover or bill amazing data over the world.

Billing-as-a-Service

© J. Robert - University of Luxembourg, SnT. All rights reserved.
Development stages:

1. Search for data sources
2. Pay for accessing them (if needed)
3. Token generation
4. Re-Use Token in your IDE

- Search for data sources
- Pay for accessing them (if needed)
- Token generation
- Re-Use Token in your IDE

Tell Brussels’ O-MI node that developer X is allowed to access data items he paid for

Tell Weather-station’s O-MI node that developer X is allowed to access data items he paid for

P2P data exchange between O-MI nodes

Welcome to IoTBNB
Publish, discover or bill amazing data over the world.

Your Token:

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brussels Parking spot-related live data</td>
<td>Token for access to Brussels Parking spot-related live data</td>
</tr>
<tr>
<td>Weather station-related live data</td>
<td>Token for access to Weather station-related live data</td>
</tr>
</tbody>
</table>

© bIoTope Consortium
Development stages:

1. Search for data sources
2. Pay for accessing them (if needed)
3. Token generation
4. Re-Use Token in your IDE

My favorite IDE

Node-RED

bloTope Service Marketplace

Welcome to IoTbB
Pub/Ins, discover or sell amazing data over the world.

O-MI/O-DF standards + Standardised vocabularies (schema.org, SSN...)

- JCDecaux API
- Netatmo API
- Hue API
- O-MI Node Brussels
- O-MI Node Weather-data
- O-MI Node Smart bulb

Jérémy
Development stages:

1. Search for data sources
2. Pay for accessing them (if needed)
3. Token generation
4. Re-Use Token in your IDE

My favorite IDE

Node-RED

Jérémy
Demo Part 1

IoT Visual Programming Tools

Check the following Video clip (Demo):
https://www.youtube.com/watch?v=OueY3o-Rf_4

Standardised Service Description & Messaging Interfaces (O-MI/O-DF)

Internal Agent
- Java
  https://github.com/AaltoAsia/O-MI
- Scala
External Agents
- Node-Red
- Shell-script
- ...
Objective 5:
Towards more cognitive IoT applications
Investigate and develop more autonomous and
cognitive IoT systems
Investigate and develop more efficient P2P Identity &
security management in the IoT
Enable IoT developers to both publish and discover — in an efficient manner — relevant services for their
own business (domain-dependent and -independent vocabularies for enhanced service description
subscription…) to enable P2P data exchange between smart systems

Enable APIs ‘uniformization’

- Need for “cognitive” systems (Context-Aware computing)
- Need for Ad-hoc Security mechanisms
- Need for a Service Market Place to foster co-creation
- Need for Standardised (Semantic) Vocabularies
- Need for discovering and accessing available services (across IoT platforms) in a standardised & uniformed manner

Objective 2:
Enhanced service description:
Extend O-DF standard with domain-dependent and -independent vocabularies for enhanced service
description

Objective 3:
IoT Service Marketplace
Enable IoT developers to both publish and discover — in an efficient manner — relevant services for their
own business

Objective 4:
Enhanced security mechanisms
Investigate and develop more efficient P2P Identity & security management in the IoT

Objective 5:
Towards more cognitive IoT applications
Investigate and develop more autonomous and cognitive IoT systems
Need for “cognitive” systems (Context-Aware computing)