IoT Interoperability at Bosch

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What Does Bosch Do?

Automotive Technology

Household products

Industrial Systems

Building Management

Software Solutions

Research and Technology Center
Bosch in IoT

- Not traditionally a software business
- In the IoT of the future, everyone will be a software company!

- Acquired Software Innovations, 2008
  - Business process management
  - Cloud-based IoT solutions

- Acquiring Prosyst (announced February 2015)
  - Provider of dynamic gateway solutions based on OSGi
  - Leader in OSGi technology and standards development

- Corporate Research in IoTS
  - Middleware
  - Assistance services
  - Security & Privacy
  - Partner with local universities
IoT Interoperability

Characteristics of IoT Applications

- Asynchronous communication
- Peer-to-peer communication
- Message- or event-based
- Must be resilient to loss of connectivity

- Current trend is towards cloud hosted web services, hub-and-spoke architectures, vertical integration
- In the future, IoT systems will:
  - Require sophisticated automation and assistance services
  - Exhibit systems-of-systems, decentralized architectures
  - Support for large range of platforms, data formats, protocols
  - Require interoperability between vendors
Bosch Approach

*Bosch is committed to an open platform approach for IoT, since we know that “nobody can do it alone”*

--Stefen Ferber, blog.bosch-si.com
Contributions to Open Source and Standards

Mortar.io
An Extensible Sensing and Control Platform for Building Energy Management

Semantic Sensor Network Ontology
Author
W3C Semantic Sensor Network Incubator Group

Vorto
„Real“ „Abstract“

OSGi Alliance
Great! We want to leverage open protocols and open source frameworks ... how do we choose??

A recent review of application level protocols found:
- ~30 communication protocols
- ~70 Java-based communication frameworks

Most of these protocols are based on some traditional concepts…
- Message oriented middleware
- Publish-subscribe
- Client-server

BUT, they are lighter weight in terms of communication overhead
SOME are looking towards a future of systems of systems
A Sample of Protocols and Frameworks

- **Service Orientation: CoAP (Constrained Application Protocol)**
  - RESTful protocol design, supports discovery (web linking)
  - Low header overhead and parsing complexity.

- **Message Broker: MQTT (Message Queue for Transport Telem.)**
  - Broker-based pub/sub system for constrained environments
  - OASIS Standard (MQTT v3.1) as of November 2014

  - OASIS Standard, supports arbitrary topologies
  - Aims to standardize (binary) wire format for all types of MoM
  - First cross-platform MoM specification
How Will the IoT Evolve?

If the Internet of Things is going to be successful it needs to be built on the principles that made the Internet successful – open standards and open source software.

--Ian Skerret, Eclipse IoT Working Group
Smart Campus at Bosch RTC Pittsburgh

The Smart Campus Opportunity

→ Harnessing the Power of Open Innovation in the IoTS
What is the **Smart Campus** concept?

→ **Smart Campus** is a vision for the future of smart commercial spaces
  - Current R+D efforts focus on **individual home / building automation**
  - **Medium-scale** (e.g. multi-building) spaces have **unique requirements**
  - Opportunity to create **connected campus environments** that enhance: *Productivity + Efficiency, Safety + Security, Social + Professional Interaction*

→ **Challenges / Problems to be Solved**
  - Identify **high-potential business** opportunities in medium-, large-scale IoTs
  - Address **technical requirements** unique to segment: scalability, security, integration
  - Deliver **high-quality User Experiences (UX)** for both Web and Mobile

→ **Approach**
  - Utilize CMU* campus as a “Living Lab” for **ideas, prototyping, validation**
  - Focus on **leveraging existing Bosch portfolio** to enter adjacent markets
  - Increase innovation **via direct engagement** of end users / domain experts

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*CMU: Carnegie Mellon University*
### Smart Campus at Bosch RTC Pittsburgh

**Our Testbed Partner:** Carnegie Mellon University

| CMU Statistics¹ |
|-----------------|-----------------|-----------------|
| Population      | 15,507          | Housing         | 4069 beds      |
| Area            | .6 km²          | Facilities (useable) | .6 km²        |
| Electricity     | 118K mWh        | Input Energy*    | 522,759 mmBTUs |
| Buildings       | 109             | Parking         | 3,309 units    |

¹Factbook 2014, CMU Institutional Research and Analysis
*Natural Gas, of which ~73% converted to steam
M2M* Interfaces: Focus on Energy, Environment

- **EnFuse Panel Meters**
  - Electricity usage
  - $11 \times 48 = 528$ feeds

- **AutoMatrix PUP Controller**
  - HVAC
  - $30 \times 6 \text{ (inter-building)} \times 24 = 4320$ feeds

- **Thermostat**
  - 802.15.4 Pneumatic thermostat with branch pressure monitoring
  - 70 feeds

- **Fan Control Units**
  - 802.15.4 units for heat exchangers in each room
  - Control and power metering
  - 170 feeds

- **Lutron Lighting Controller**
  - 277 VAC lighting control

- **FireFly Environmental**
  - Light, temp, humidity, sound, motion, vibration, pressure
  - 120 feeds

- **Chilled Water and Steam**
  - Temperature and flow-rate
  - $2 \times 2 = 4$ feeds

- **Localization**
  - ALPs + VLC Localization
  - Feed per person

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* M2M: Machine-to-Machine communication
Out of the Lab: Professional Install and Support

Smart Campus at Bosch RTC Pittsburgh

Panel Electrical Metering

Beaglebone Gateway

Fan Blower Control

Environmental Sensing

Wireless Thermostat

Lutron Lighting Control

Big Data Target: 270K source points, 40B records, 1.5TB data, ~500 writes/sec

Research and Technology Center
Sensor Andrew: Powerful End-User Features

Explicit Privacy Handling

This device is part of the Sensor Andrew research project. It periodically senses:
- Light, Motion, Temperature, Vibration, Barometric Pressure, Sound Level Intensity

Our Privacy Policy can be found here: http://sensor.andrew.cmu.edu/privacy

Mobile Application Framework

Electricity Usage

Temperature

Temp Warmer

Temp Good

Temp Colder

Lights On

Lights Off

Infrastructure-based Localization

Application Authoring Environment

\(^1\) MakerSwarm, Maya Design, www.makerswarm.com