Enabling IoT Platform Interoperability Using a Systematic Development Approach by Example

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Motivation

- IoT solutions are often vertical silos
- Communication across platforms is desired
- Exchanging data is important
  - Each platform uses its own data model
  - Semantic operability needs to be addressed
- The development of an interoperable IoT system is not easy
- Applying a systematic development process
  - Interoperability is considered in the analysis phase as a requirement
- symbIoTe provides an interoperability framework
Overview of symbIoTe Functionality

Interworking Interface

IoT Platform A

Interworking Interface

IoT Platform B

symbIoTe User

Search for resources

Registry

Search

Interworking Interface

IoT Platform A

Access Resources

Access Resources

symbIoTe Core

Register

- Platform
- Resources
- Information model
- Semantic Mapping

(1) Register

(2) Search for resources

(3) Access Resources

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Cooperation & Management (C&M, Prof. Abeck)
Institute of Telematics, KIT Department of Informatics
Use Case Example – Navigation Service

Show Location

Room 01

Room 07

Backend

DB

Platform Campus A (@KIT)

Beacons

Current location

Area

Portal
Use Case Example with symbIoTe

Platform Campus A (@KIT)

- App of Campus A
  - symbIoTe Core
    - Search
    - Registry
  - symbIoTe Adapter
    - Interworking Interface
    - Resource Access Proxy
    - Information Model
    - Semantic Mapping

- Backend

Platform Campus B (@IOSB)

- App of Campus B
  - symbIoTe Core
    - Search
    - Registry
  - symbIoTe Adapter
    - Interworking Interface
    - Resource Access Proxy
    - Information Model

Additional dataflow after integrating symbIoTe
Implementation provided by symbIoTe framework
Analysis Phase: Feature Description

- Behavior-driven development is used for analyzing the requirements
  - Specifying the requirements as features
  - Interoperability aspects

1. Feature: Show my location on Campus B
2. As a member of Campus A
3. I want to use my well-known application
4. In order to determine my current location on Campus B

5. Scenario: Show my location on Campus B
6. Given I am at Campus B
7. And a **beacon** from Campus B inside a **building** is available
8. When I open the "Current Location" page
9. Then my current **location** on Campus B should be displayed
Design Phase:
Information Model of Campus A

- Derived from the analysis phase using domain-driven design

- Hallway
- Sanitary Facility
- Student Union
- Office
- Library
- Seminar Room
- Lecture Hall
- Wall plugs
- Ethernet
- Air Conditioning
- Seating Cap
- ATM
- Beamer
- Computer
- Helpdesk
- Beacon
- Door
- Elevator
- Stairs

Diagram:
- Building
  - Name: String
  - Floors
    - Floor
      - Name: String
      - Location
        - Location: Double
        - Portal Gates
          - Portal
            - Description: String
            - Passing Priority: Integer
          - Location
            - Vertices
              - Area
                - Name: String
                - Description: String
                - Room Number: String
            - Areas
              - Gate
                - Name: String
                - Description: String
                - Smart Campus Link: URL
            - Gates
              - Feature
                - Name: String
                - Description: String
                - Room Number: String
                - Smart Campus Link: URL

- Point Of Interest
  - Name: String
  - Description: String
  - Location
    - Location: Double
    - Portal Gates
      - Portal
        - Description: String
        - Passing Priority: Integer
Information Model of Campus B

- **Feature**
  - DockingStation
  - Projector
  - Whiteboard
  - AirConditioning

- **Thing**
  - name: String
  - description: String

- **BleBeacon**
  - beaconId: String
  - major: Integer
  - minor: Integer

- **Workspace**

- **Room**
  - capacity: Integer
  - roomNo: String

- **MoveableThing**

- **BeaconDetection**
  - datetime: DateTime

- **CateringRequest**

- **Reservation**
  - start: DateTime
  - end: DateTime

- **User**
  - createdBy
  - detectedBy

- **<<enumeration>>**
  - DockingStation
  - Projector
  - Whiteboard
  - AirConditioning

- **MoveableThings**
  - DockingStation
  - Projector
  - Whiteboard
  - AirConditioning

- **Room**
  - capacity: Integer
  - roomNo: String

- **BeaconDetection**
  - datetime: DateTime

- **User**
  - createdBy
  - detectedBy
Implementation Phase: Differences and Integration of the Models

- Area and room are different concepts and must be mapped
- Differences in naming and attributes

Campus A

<table>
<thead>
<tr>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name: String</td>
</tr>
<tr>
<td>Description: String</td>
</tr>
<tr>
<td>RoomNumber: String</td>
</tr>
<tr>
<td>SmartCampusLink: URL</td>
</tr>
</tbody>
</table>

Campus B

<table>
<thead>
<tr>
<th>Room</th>
</tr>
</thead>
<tbody>
<tr>
<td>capacity: Integer</td>
</tr>
<tr>
<td>roomNo: String</td>
</tr>
</tbody>
</table>

Example of semantic mapping

1. BASE <http://iosb.fraunhofer.de/ilt/ontologies/educampus#>
2. PREFIX kit: <http://cm.kit.edu/SmartCampus/DomainModel#>
3. PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
4. RULE
5. CONDITION
6. CLASS :Room
7. :name TYPE xsd:string
8. AND :description TYPE xsd:string
9. AND :roomNo TYPE xsd:string
10. AND :capacity TYPE xsd:integer
11. PRODUCTION
12. CLASS kit:Area
13. kit:Name VALUE REFERENCE :name
14. AND kit:Description VALUE REFERENCE :description
15. AND kit:RoomNumber VALUE REFERENCE :roomNo
Conclusions

- Enabling interoperability using the framework symbIoTe
- A formal information model is required
  - Registering at symbIoTe Core
  - Creating this model is not easy for IoT platform providers
- The systematic development approach leads to the information model
  - Assists developers in this process
Thank you for your attention!

Questions?