Smart Spaces

Chapter 4:

The Smart-M3 Platform

Outline

§ 1. Architectural Overview

§ 2. Notion of Application (multi-agent)

§ 3. Interfaces
(agents <-> smart space)

Research scope

- SOFIA project
  Smart Objects For Intelligent Applications
- DIEM project
  Devices and Interoperability Ecosystem
- EIT ICT Labs
  one of Knowledge and Innovation Communities (KICs) selected by the European Institute of Innovation & Technology to accelerate innovation in Europe
- FRUCT
  Open Innovations Framework Program

http://sourceforge.net/projects/smart-m3/
BSD open source license

§1. Architectural Overview

Smart applications needs
a smart space infrastructure

Challenges from practice

- Digital convergence and interoperability
  - Many ways for communication with the external world
  - Domain specific interoperability standards, e.g., UPnP (in home entertainment)
  - Limited of use cases
  - Lengthy and uncertain standardization process
- Ubiquitous computing – devices everywhere
  - Ideally, interoperability with whatever devices that are in the locality at any given time

Key principles

- *Giant global graph* of semantic web vs. *dynamic and local* semantic web
- Interoperability via information sharing
  - Sharing local semantic information
    e.g., about the immediate environment of a device
  - Accessing locally relevant parts of the giant global graph
  - Cross-domain interoperability due to ontology compositions
  - Standardizing an ontology allows an indefinite set of use cases to be implemented

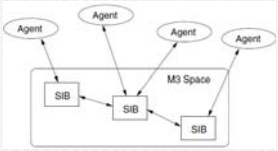
Release: two parts

Smart-M3 code at
http://sourceforge.net/projects/smart-m3/

1. Infrastructure (SIB side, shared knowledge)
   Deployed implementation of smart spaces for applications
2. SDK (KP side, interfaces to shared knowledge)
   Development tools for various platforms and network access protocols

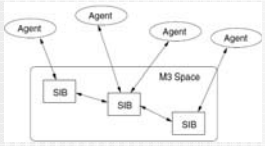
Basic Terms

- **SIB**: semantic information broker
- **KP** (M3 agent): knowledge processor
- **SSAP** (Smart Space Access Protocol)
- **M3 Space** is a named search extend of information



SIB network

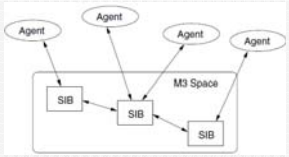
- Information stored in one or more SIBs
- Each SIB maintains a RDF store
- The global SIB network satisfies the distributed deductive closure
  - Any KP sees the same knowledge regardless the SIB it connects to



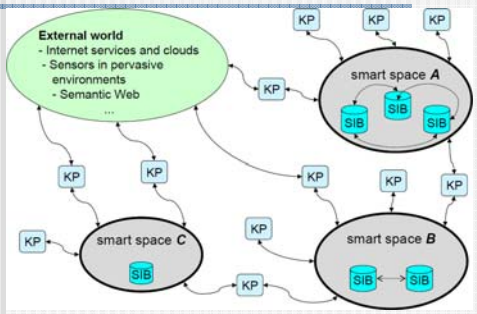
Global RDF graph of shared knowledge

Global RDF graph

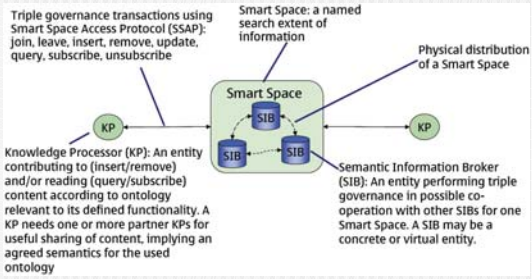
- Many subgraphs
- Many ontologies
- The use of any ontology is not maintained
- Information consistency is not guaranteed



Global view on Smart-M3 spaces

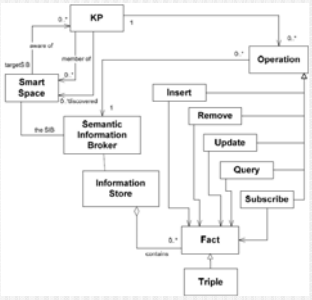


Smart-M3 Infrastructure 1



Smart-M3 Infrastructure 2

- M3 space (smart space)
- SIB
- M3 agent (KP, node)
- M3 store (knowledge store, RDF triples)
- SSAP operation



Smart-M3 Infrastructure 3

1. M: Multi-domain
2. M: Multi-device
3. M: Multi-vendor

- Many kinds of devices can interact with each other
  - mobile phone, television set, laptop, ...
- Device may be composed of parts that are considered as individual partners for interaction with another device
  - PC keyboard for typing input to a mobile phone
- Free in choosing the manufacturer
  - Nokia, Samsung, ...

Smart Space Access Protocol (SSAP): 1

- **Join**: Join a KP to a named space
- **Leave**: Leave a named space.
  After leaving, no more operations may be performed until a join operation
- **Insert**: Atomically insert a graph in the space
- **Remove**: Atomically remove a graph from the space
- **Update**: Atomically update a graph in the SIB.
  Update is a combination of remove followed by insert, executed atomically
  - A graph to remove
  - A graph to insert

Smart Space Access Protocol (SSAP): 2

- **Query**: Query for information in the space using any supported query language
- **Subscribe**: Set up a persistent query in the space; a change to the query results is reported to the subscriber
- **Unsubscribe**: Cancel an existing subscription

Guarantees

- Operations are done in the same order as they were performed by the KP
- For a received operation, the SIB will process no operation received later before processing the earlier operations

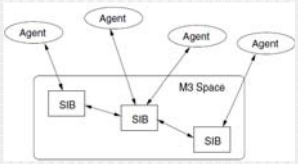
Smart Space Access Protocol (SSAP): 3

Not implemented yet

- SPARQL
- Logic rules over RDF triple store
  - deriving new knowledge (views, concepts) from the RDF graph, like in Prolog
  - resource allocation and access
  - Synchronization and conflict resolution
- Access control mechanism based on the information content
  - Knowledge privacy
  - Tagging information with ownership and access rights
  - KP provides credentials when joining a particular named M3 space
- Test-and-set type of primitives for basic synchronization
- SIB network and a protocol of distributed deductive closure

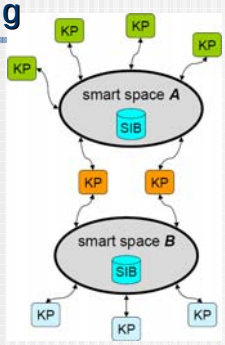
§2. Notion of Application

- Traditional application:
  - monolithic
  - single screen
  - strong coupling
- M3 application:
  - Scenario to meet user's goal
  - Scenario emerges from observable actions



Ad-hoc KP assembly with loose coupling

- Actions are from participating KPs
- Observations are from
  1. the M3 space
  2. the use of services



Transient Scenarios

- The scenario is changing as
  - KPs join and leave the M3 space
  - Services become available or unavailable
- The loose coupling between the KPs
  - KPs communicate by modifying and querying the M3 space content
  - KPs may also communicate with each other by other available means (non-Smart-M3)

KP ontology

- Each KP understands its own, non-exclusive set of information
  - RDF graph
  - KP ontology allows analyzing this graph
- Overlapping is essential for interoperability
  - KPs can see each others actions

KP mash up

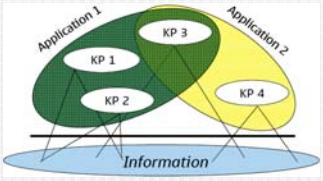
- KPs (e.g., sensors) are information providers
- KPs (e.g., clients) are information consumers
  - read the information
- KPs (e.g., reasoners) process further the information internally
  - publish the result (new knowledge)

Open problems:

- KPs compete for the same resources
  - synchronization
- KPs use different ontologies
  - compositions
  - overlaying

Combining Smart Apps

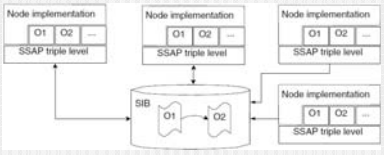
- Overlapping spaces due to overlapping ontologies
- KP intermediary
- Example
  - Smart conference
  - +
  - Smart blogging



§3. Interfaces

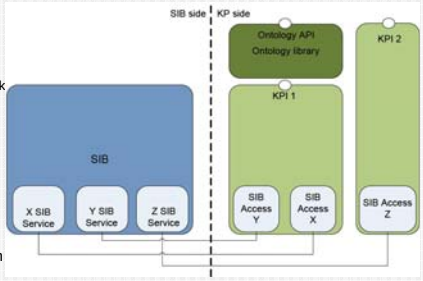
KP <-> SIB communication: KP Interface or **KPI**

1. KP can operate on the RDF triple level
   - Direct access with SSAP
   - Low-level programming
2. KP can understand the ontology behind the triples
   - RDF graph
   - Larger conceptual entities
   - Interpreting the information according to predefined ontologies



Logical architecture

- SIB: many communication mechanisms
  - TCP
  - NoTA: Network on Terminal Architecture
  - Bluetooth
- KP: selects appropriate mechanisms
- Ontology library: ontology concepts used in code



KP Development Tools

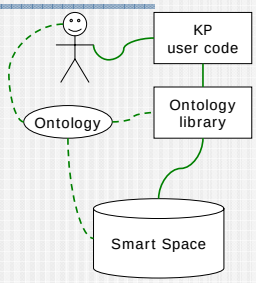
1. Low-level programming tools
   - Based on triples
   - Basic manipulations
   - RDF triple exchange
   - Mediator library for SSAP operations
2. High-level programming tools
   - Based on ontology entities
   - Advanced manipulations
   - Ontology library

KP Interface (KPI)

Library	Description
Low-level KP programming: RDF triples	
Whiteboard, Whiteboard-Qt + QML	Language: C/Glib, C/Dbus, C++/Qt. Network: TCP/IP, NoTA. BSD license. A part of the Smart-M3 distribution, http://sourceforge.net/projects/smart-m3/
KPI_Low	Language: ANSI C. Network: TCP/IP, NoTA. GPLv2. Primarily oriented to low-performance devices. VTT-Oulu Technical Research Centre (Finland), http://sourceforge.net/projects/kpilow/
Smart-M3 Java KPI library	Language: Java. Network: TCP/IP. University of Bologna (Italy) and VTT-Oulu Technical Research Centre (Finland), http://sourceforge.net/projects/smartm3-javakpi/
M3-Python KPI (m3_kp)	Language: Python. Network: TCP/IP. BSD license. A part of the Smart-M3 distribution, http://sourceforge.net/projects/smart-m3/
C# KPI library	Language: C#. Network: TCP/IP. University of Bologna (Italy).
High-level KP programming: OWL ontology	
Smart-M3 ontology to C-API generator	Language: Glib/C, Dbus/C. Network: TCP/IP, NoTA. BSD license. A part of the Smart-M3 distribution, http://sourceforge.net/projects/smart-m3/
Smart-M3 ontology to Python generator	Language: Python. Network: TCP/IP, NoTA. BSD license. A part of the Smart-M3 distribution, http://sourceforge.net/projects/smart-m3/
SmartSlog	Language: ANSI C, C#. Network: TCP/IP, NoTA. GPLv2. Petrozavodsk State University (Russia), http://sourceforge.net/projects/smartslog/

Ontology Library

- Simplifying KP code using high-level OWL terms
- Generator transforms OWL to ontology library
- KP code calls ontology library
- **SmartSlog**



Smart-M3 Value Offering

- USERS: Freedom of choice
  I want to select my device freely from any vendor knowing that it works with all devices I already have.
  – M3 = multi vendor
- DEVICE MANUFACTURERS: Seamless operation with all devices
  I want to create innovative products that consumers want to buy because they work seamlessly with other devices wherever he/she goes.
  – M3 = multi device
- SERVICES COMPANIES: Gaining competitive edge
  My company develops novel services using mash-up approach and we want seamless data portability to effortlessly create winning solutions for cross domain user experience.
  – M3 = multi domain
- APPLICATION DEVELOPERS: Focus on consumer 'wow'
  As an application developer I want to focus on creating consumer 'wow' instead of porting my code to all different platforms. I also want develop cross-domain mash-up services as easy as internet services are created today!
  – M3 = multi domain

Literature

- J.Honkola, H.Laine, R.Brown, I.Oliver. Cross-Domain Interoperability: A Case Study (ruSmart 2009)
- J.Honkola, H.Laine, R.Brown, O.Tyrkko. Smart-M3 Information Sharing Platform (ISCC 2010)
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- D.Korzun, A.Lomov, P.Vanag, S.Balandin, J.Honkola. Generating Modest High-Level Ontology Libraries for Smart-M3 (UBICOMM 2010). Extended version in International Journal On Advances in Intelligent Systems (vol.4, nr3&4, 2011)