Devices And Interoperability Ecosystem – DIEM

Intelligent systems in homes and buildings: Smart-M3 information sharing solution

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Contents

• Future home and building
• Interoperability of devices and systems
• Objectives of DIEM programme
  – Vision
  – Objectives
• Information interoperability solution: Smart-M3
  – Principles
  – Layers
  – Architecture
• Research examples
  – Dynamically created smart spaces
  – Smart space based distributed embedded systems
  – Smart spaces with RFID extensions
• Summary
Future homes and buildings...

... are places that will implement peoples requirements for ubiquitous services and ambient assisted living

... have automated routines and operations
  – heating, cooling, lightning, locking, etc.
  – maintenance

... optimise costs and resource usage of living
  – energy, water, waste, etc.

... create safety and security
  – automatic monitoring, authorisation, etc.

... understand the contexts and situations and react to them
  – ambient intelligence – automatic context awareness
  – supports your living (elderly people, children)
  – optimises to conditions for the purposes of users

... are integrated, active objects in smart grids and in sustainable environment
Current solutions

• Complete solutions
  – Dedicated networks
  – (W)LAN based systems
• Home server based systems
  – ThereGate, DomoticServer, etc...
  – Purpose to link different home automation devices
  – Provide APIs for application programming
• Wireless sensor network based systems
  – Zigbee, Bluetooth, etc. radio systems extend towards service sharing
• Entertainment interoperability solutions
  – DLNA and UPnP type of service and content sharing solutions
• Internet of Things (IoT)
  – connecting everything to Internet, Device Profiles for Web Services
  – Middleware solutions for embedded systems allowing interoperability of services

• The problems: cost, business dependencies, standardisation rigidness, lack of cross-domain support, infrastructure requirements, etc.
Wouldn’t it be great ...

• To have capabilities in your device that allows rapid extension of your offerings, e.g. easy to manage user interaction or addition of functionality

• To have a capability that simplifies interaction with the rest of world by having one simple solution for multiple purposes, multiple use cases, and multiple domains

• To increase the market potential of your devices by allowing your device to be part of larger systems while keeping your independence (without massive of technology integration and legal negotiations)
Smart-M3: Unique opportunity

- Novel concept that simplify co-operation of companies
- Adaptable to various business domains and use cases

- Creates **cross-domain interoperability**
- Simple solution to design and implement

- In-depth understanding of core components exist
- Strong experience in development projects in background
- Large consortium behind the idea

- Tested prototypes, illustrative demonstrations, proven competencies
Devices and Interoperability Ecosystem vision

Open embedded data in various devices to applications to create local services in millions of places.

“heterogeneous legacy”

“very different device life cycles”

“1000 devices/person in 2015”
Objectives

• Opening embedded information of physical world to new applications
  – Information from embedded systems, smart objects, sensor networks, RFID tags, etc.

• Enabling interoperability of many devices from different vendors and different domains
  – Cross-domain and cross-industry interoperability
  – Using the legacy technologies at service and physical levels

• Supporting open innovation
  – Open source solutions for information sharing
  – Support for ontology driven mash-up application development
  – Smart environment interaction and interface techniques

• New smart environment ecosystems
  – Where objects from all possible sources can contribute to services simplifying our lives
Principles of Smart-M3

• **Voluntary sharing of information** by objects in physical space
  – Publish-subscribe/query architecture
  – It is up to information owner only to decide what and how information is published
  – Respects the integrity and independence of devices

• **Interoperability agreements on information level**
  – Common ontology model and data presentation format are the main requirements
  – On top of existing service and device level solutions

• **Agnostic** to use cases and **simple** to use
  – Means and techniques are use case independent
  – Support for enforcement to device and smart object manufacturers
Open sharing of information and services

Video surveillance systems

Fire place

Oven, fridge, etc.

Mobile terminal
  - Calendar
  - Activity monitors
  - Context awareness service

Home control system

Locking system

Heating system

Energy price monitoring

Whether forecast

Humidity sensor

Outside temperature

SIB

Electrical appliances

Doors

Windows
Smart-M3 interoperability layers

Smart Spaces based on Smart-M3

Smart World

Service Domain

Device Network
Smart-M3 functional architecture

Knowledge processor

Local information storage with RDF-store and information governance functionality

Device with embedded system

Semantic information broker service

Knowledge processor

Access protocol (SSAP), with basic operations, e.g. join, leave, insert, remove, subscribe. Etc.

Knowledge processor

Application logic and interface supporting the use of common use case ontology and access to information broker

Common ontology models for use cases as information interoperability enabler

A great idea involving two programmable devices that need to share information!

Create a common ontology model for your use case (or preferably take an existing one)

Generate a convenience library for your target environment that hides the ontologies and data formats

Write M3 KPs using generated libraries

Use M3 for sharing the information and create “The Bling!”

1) Smart-M3 Ontology compiler, published in Open Source
Demonstrations

1. Smart environment applications using commercial off-the-shelf components and open source code (OpenM3)
   - To promote the use in open source community
   - To demonstrate the simplicity of idea and low capacity device implementations

2. Dynamically created smart space with smart space application running in different platforms
   - Multi-vendor interoperability
   - Multi-platform interoperability
   - Ontology driven applications
   - Mobile smart environment

3. Demonstration of basic concept in control system (Greenhouse)
   - Information broker
   - Sensors, embedded control systems, mobile device as user interface
   - Ontology based interoperability

4. Extending to operations into RFID and Internet data bases
   - Local RFID space
   - Linking smart spaces to Internet services
Mobile contact info sharing in dynamically created local place

1. N900 starts JoikuSpot WLAN AP

2. N900 creates a SIB service that joins the zeroconf multicast group

3. Other devices discover the WLAN AP and join the AP

4. Users launch their business card applications that join the zeroconf multicast group and the SIB

5. Applications publish and subscribe information (name and phone number) in SIB
Ontology in RDF graph format

http://smart-m3#Meeting

http://smart-m3#Participant

http://smart-m3#hasName

http://smart-m3#hasPhoneNumber

http://smart-m3#hasParticipant
Smart-M3 based control system: Greenhouse (1)
Example scenario in Smart-M3 Greenhouse (3)
Item-level object identification with Smart-M3

- Possible applications:
  - Changing the status of the actuator e.g. air conditioner, lock
  - Reading sensor measurement
  - Receiving information about tagged object
  - Bringing new information to smart environment

- Smart-M3 provides methods for
  - information exchange between devices,
  - method to identify objects uniquely (locally defined Tag cloud)
  - methods to link Tags to any other service
Presenting tag information in Smart-M3

- Common ontology model is needed
- ID is stored in ontology

Example case:
- Knowledge processor (KP) makes query:
  - "E100123", "hasStatus", ANY
- Semantic Information Broker (SIB) responses:
  - "E100123", "hasStatus", "ON"
  - "E100123", "hasStatus", "ON"
  - "Greenhouse"
  - "Temperature"
  - "PUMP"
  - "E100123"
  - "E500623"
  - "E200456"
  - "E611223"
  - "25C"
Extending greenhouse with uCode tags and TRON based Ubiquitous Communicator

- RFID tags with unique IDs have been inserted to plants and locations

- Ubiquitous Communicator reads RFID tags → plant detection

- Autocontrol KP knows inserted plants -> proper care for different kind of plants from Database KP
Embedded Smart-M3 approach

- Solutions for implementing smart spaces in embedded system domain
  - **Scalable SIB solution** for lower capacity embedded systems
  - **Optional modified SSAP** for embedded domain
  - KP interface for embedded domain: **ANSI C KPI_low**
  - **Portable and scalable NoTA stack** for embedded devices

- Savings in energy consumption
- Smaller memory footprint
- Runs in lower capacity devices
- Fewer bits needed for communication
- Possible to keep the “ownership” of information in the embedded device

- Possible to modify with dedicated security, privacy, etc. features

KPI_low = ANSI C knowledge processor interface
eKP = embedded knowledge processor
Solutions being developed for extending Smart-M3 into Smart Environments

- **Smart-M3 application development tools** (smart modeller)

- **Authentication** (restricting the usage, access control, using various service level solutions for privacy and security)

- **Run-time security** features (adaptation to the new threats by changing the system configuration - encryption)

- **Distributed context awareness** (creating intelligence from simple objects and their information)

- **Run-time monitoring** (understanding what is happening in smart environment)

- Examples of **solutions for extending** of smart environment applications with new capabilities, functionalities, and information
Smart-M3 is ready for real use

- Core components are available for commercial use
  - C version of SIB (open source)
  - Reference design of KPs (open source)
  - Example systems/reference implementations
  - Ontology generator tool (open source)
  - Embedded (downscaled) versions of SIB and KPs at VTT

- Implementable directly on top of TCP/IP/ZeroConf or NoTA (also available as open source and embedded versions), portable to other SOA solutions
- Smart-M3 application lab is being set-up both in Tampere and Helsinki (EIT ICTLabs)

- **Smart-M3 is ready for** reasonable scale or restricted smart space **applications for homes and buildings**
Summary

• Interoperability is the missing element from intelligent homes and buildings
  – Integrated solutions are too expensive and too rigid for users
  – Flexibility is needed because diversity will never diminish
  – Interoperability requires business dependencies

• Smart-M3 is unique opportunity to
  – try something new and innovative with minimal risks
  – take large background in use and to be leader
  – exploit public support and use research organisations for what they are meant for

• Smart-M3 is mature – the timing is right – the bits and pieces exist
VTT creates business from technology