The M3 Architecture for Smart Spaces
Overview of Semantic Information Broker Implementations

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Outline

1. Smart-M3 Overview
2. Smart-M3 SIBs
   - The Piglet-based SIB
   - RedSIB
   - The OSGi SIB
   - pySIB
   - CuteSIB
   - Suspended projects
3. Evaluation
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Smart-M3

Smart-M3 is an open source **interoperability platform** implementing the M3 paradigm (**multi-device, multi-vendor, multi-domain**).

Originally framed in:

- **ARTEMIS** JU European funded SOFIA (Smart Objects For Intelligent Applications) project;
- Finnish nationally funded **DIEM** (Device Interoperability Ecosystem) program.

Formerly developed by Nokia, it is now maintained by **FRUCT Association, SOFIA Community** and the **ARCES department** of the University of Bologna.
The M3 architecture relies on three main components:

- **SIB** (*Semantic Information Broker*)
- **KPs** (*Knowledge Processors*)
- **SSAP** (*Smart Space Access Protocol*)
The SIB is a SPARQL endpoint built on top of an RDF triple-store. This publish-subscribe broker allows to:

- update the knowledge base (using SPARQL, RDF/XML or a triple-pattern based formalism, i.e. RDF-M3)
- query the knowledge base (through SPARQL or RDF-M3)
- subscribe to user-defined subgraphs (through SPARQL or RDF-M3)
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The Piglet-based SIB

Where  Developed by Nokia Research Center

When  Project started in 2009

Why  To formalize the concept of space-based information sharing

What  It is the first official implementation of a Smart-M3 Semantic Information Broker
Piglet-based SIB Architecture
RedSIB

Where  Developed by the University of Bologna

When  Project started in 2012

Why  It is an evolution of the old Piglet-based SIB born to avoid some criticalities and improve performance

What  It provides:

- support for Virtuoso triple store and for volatile storage based on BDB
- prototype of access control mechanism
- optimized subscription engine
RedSIB Architecture
The OSGi SIB

**Where** Developed by the University of Bologna and Eurotech

**When** Project started in 2010

**Why** To provide a portable SIB for industrial domains

**What** A modular architecture based on OSGi bundles that:
- provides reliable query engine
- introduces the new Persistent Update (PU) primitive
- opened the way to the development of an Android SIB
The OSGi SIB Architecture
pySIB

Where  Developed by the University of Bologna

When  Project started in late 2015

Why  To provide a portable and lightweight SIB, with a modular and easy structure suitable for didactics

What  Lightweight Python implementation supporting an experimental JSON-encoded SSAP
pySIB Architecture
**Where**  Developed by the Petrozavodsk State University (PetrSU)

**When**  Project started in 2015

**Why**  To provide a renewed C implementation of the SIB

**What**  A fork of RedSIB that:
- is based on QT framework
- replaces the D-BUS
- has a modular structure
- is portable and extensible
CuteSIB Architecture
RIBS

**Where**  Developed at the VTT Technical Research Center of Finland

**When**  During the SOFIA project (2008-2012)

**Why**  To provide a secure architecture oriented at low-resources devices

**What**  RIBS was a SIB addressing two of the main problems of IoT: providing security and supporting low-resources nodes. Due to a not open source license it failed to build a community of users and developers, so the project was suspended.
The ADK SIB

**Where**  Developed by Indra & Tecnalia

**When**  During the SOFIA Project (2008-2012)

**Why**  It was designed to have a powerful suite for ontology based code generation and model based application development

**What**  ADK was developed using the OSGi framework and provided a SIB integrated in the Eclipse Development Environment.
Evaluation

The following performance tests have been performed on the available SIBs:
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  - i.e. the time needed to retrieve data from a SIB
Evaluation

The following performance tests have been performed on the available SIBs:

- The update mechanism
  - i.e. the time needed to put data into the SIB
- The query mechanism
  - i.e. the time needed to retrieve data from a SIB
- The subscription mechanism
  - i.e. the time needed to receive a notification
Evaluation of the Update mechanism

Time to insert n triples

- OSGi SIB
- RedSIB
- pySIB
- cuteSIB

Number of triples (n)

Time (ms)
Evaluation of the Query engine (with RDF-M3)
Evaluation of the Query engine (with SPARQL)

![Graph showing time to retrieve n triples for different SIBs]
Evaluation of the Subscription engine
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### Summarizing...

<table>
<thead>
<tr>
<th>SIB</th>
<th>Developer</th>
<th>Language</th>
<th>Active</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADK SIB</td>
<td>PetrSU</td>
<td>Java</td>
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</tr>
<tr>
<td>CuteSIB</td>
<td>ARCES</td>
<td>C</td>
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<tr>
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<td>NOKIA</td>
<td>Java</td>
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<td>pySIB</td>
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<tr>
<td>RIBS</td>
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</tbody>
</table>
Conclusion

Smart-M3 provides a promising technology for smart spaces. We reviewed the Smart-M3 platform by focusing on the main SIB implementations.

The evaluation of the currently available SIBs highlights good performance of CuteSIB and pySIB. On the other hand a weak point is represented by the SPARQL engine that looks less reliable than the one provided by the OSGi SIB.