Business from technology

Resolution Infrastructure for M3 based Systems

M3 Semantic Interoperability Workshop

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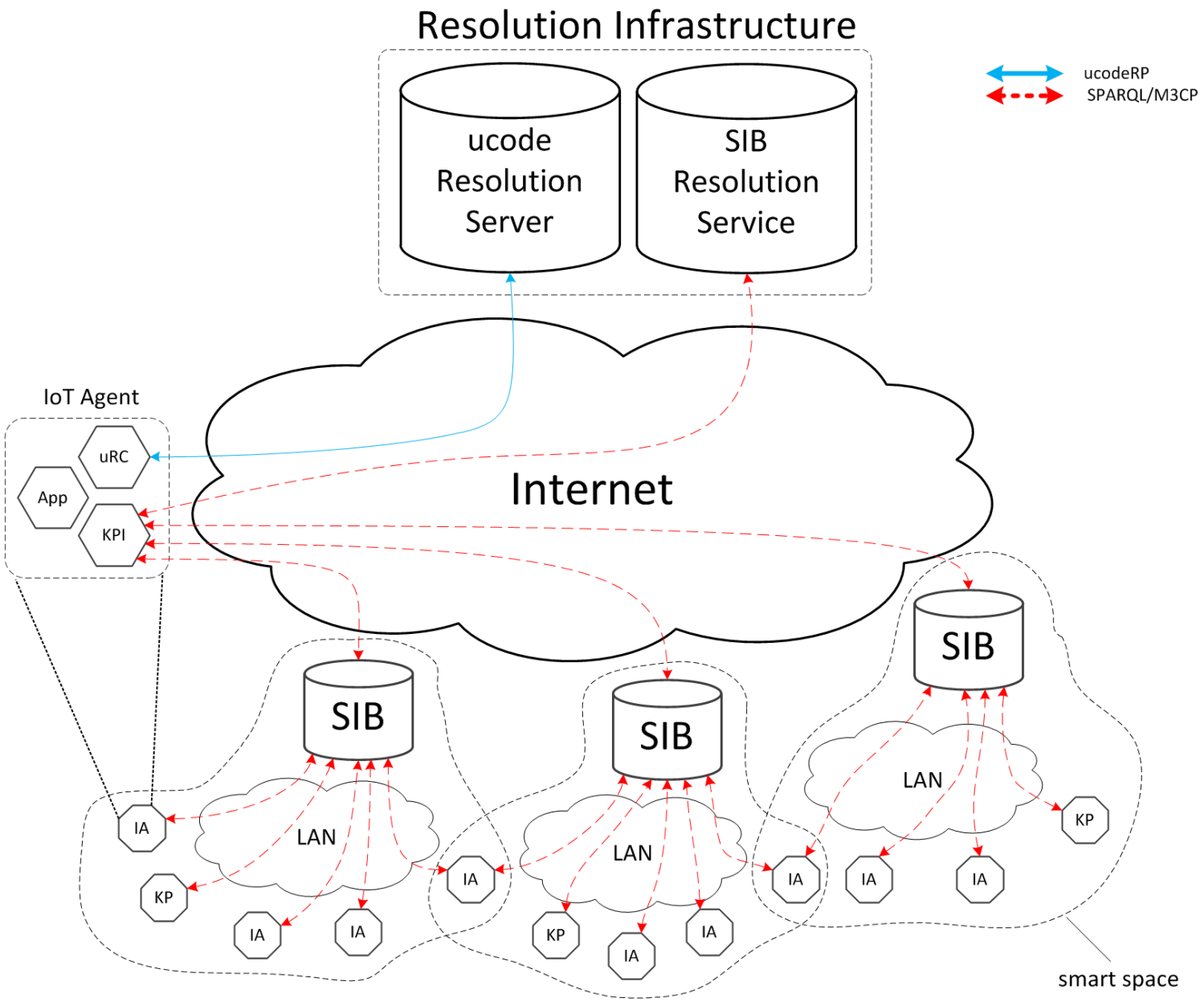
Introduction

- Internet of Things (IoT) can be seen as a global scale extension of ubiquitous and pervasive computing paradigms.
- When the idea of M3 based semantic interoperability is extended from local pervasive computing environments to the IoT there is a need for:
  1) Global identification methods for the physical objects
  2) Resolution infrastructure that provides methods to resolve the address of a SIB containing information about the physical objects of interest
- To this end, we combine M3 with uID Architecture and propose:
  - an identification scheme based on *ucodes*
  - a novel resolution infrastructure consisting of ucode Resolution Server and SIB Resolution Service

Ubiquitous Identification Architecture

- The uID architecture (from uID Center, Japan) is a ubiquitous computing solution that provides methods to uniquely identify and locate information about physical world objects.

- Central concepts in uID architecture are:
  - ***ucode:*** The *ucode* is 128 bit code without a meaning that can be stored into any kind of tag medium (*e.g.* RFID, BLE, NFC, QR code).
  - ***ucode Information Server:*** The *ucode Information Server* is a database that contains information about an object identified with a *ucode*.
  - ***ucode Resolution Server:*** The role of the *ucode Resolution Server* is to both manage *ucodes* and resolve *ucodes* to corresponding *Information Server* addresses. In practise this functionality is achieved with three operations: *issue*, *change entry*, and *resolve*.


Resolution Infrastructure
ucode Resolution Server
SIB Resolution Service
ucodeRP
SPARQL/M3CP
IoT Agent
uRC
App
KPI
Internet
SIB
SIB
SIB
LAN
LAN
LAN
IA
KP
smart space

VE Identification

- The *ucode* is used as unique identifier for both the physical object and its virtual counterpart.
- *The ucode* based URN is used instead of HTTP URI recommended for Linked Data mainly for three reasons:
  1) M3 does not use HTTP protocol and implying that the resource is available via HTTP is a bad practice.
  2) The HTTP URI points always to a specific network location. This causes problems in typical IoT applications where data can be distributed into multiple heterogeneous information systems.
  3) The *ucode* has a fixed length and it is thus more predictable in term of memory and also faster to process.

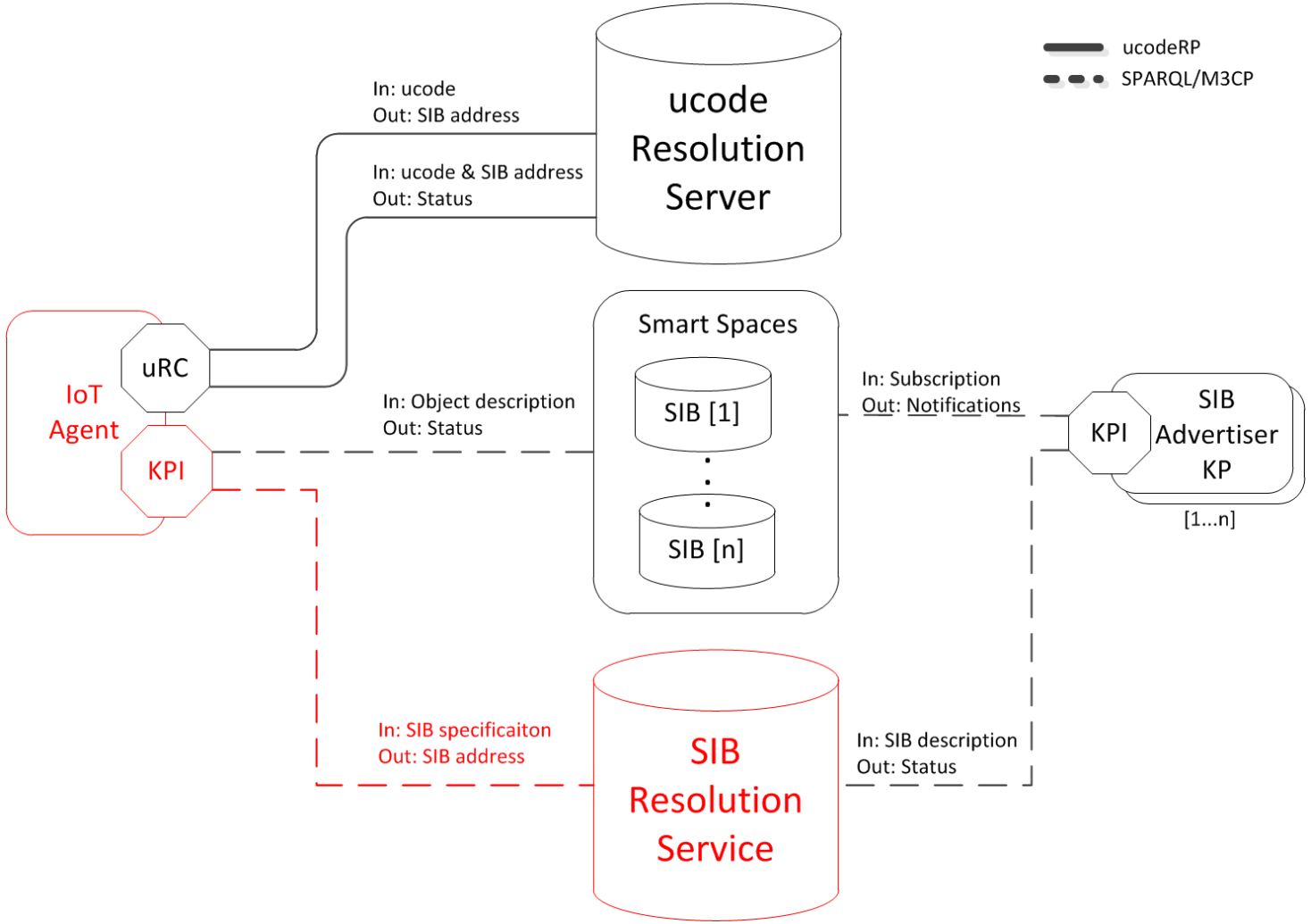
SIB Resolution

- Resolution Infrastructure is responsible for SIB resolution in the Internet of Things.

- Two type of resolution operations are provided:
  - **Lookup:** SIB address containing information about the physical object is resolved based on the object ID (i.e. *ucode)*.
  - **Discovery:** SIB address is resolved based on SIB specification expressed as a SPARQL query.

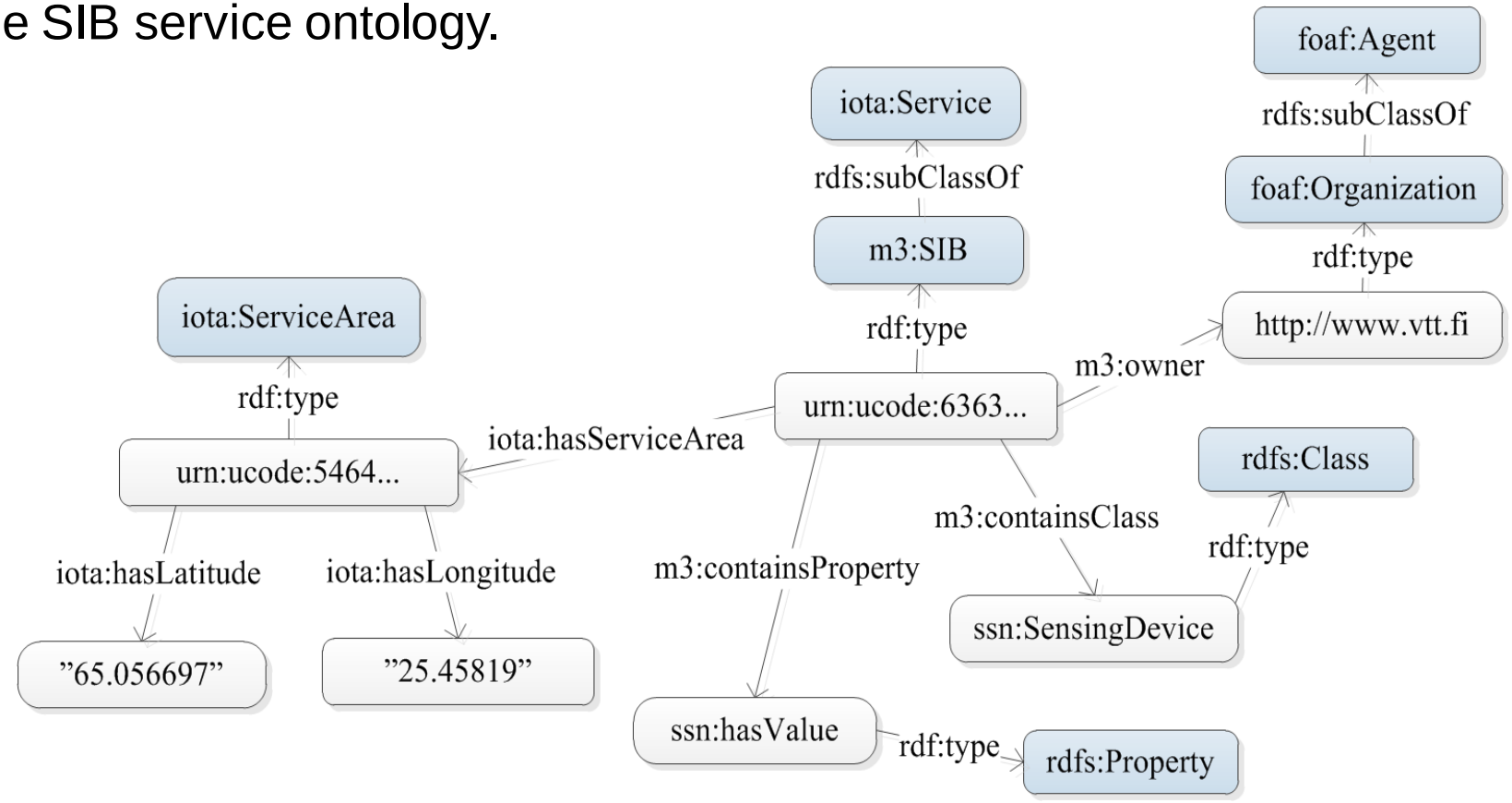
- The Resolution Infrastructure consist of two components:
  - *ucode* Resolution Server
  - SIB Resolution Service

SIB discovery

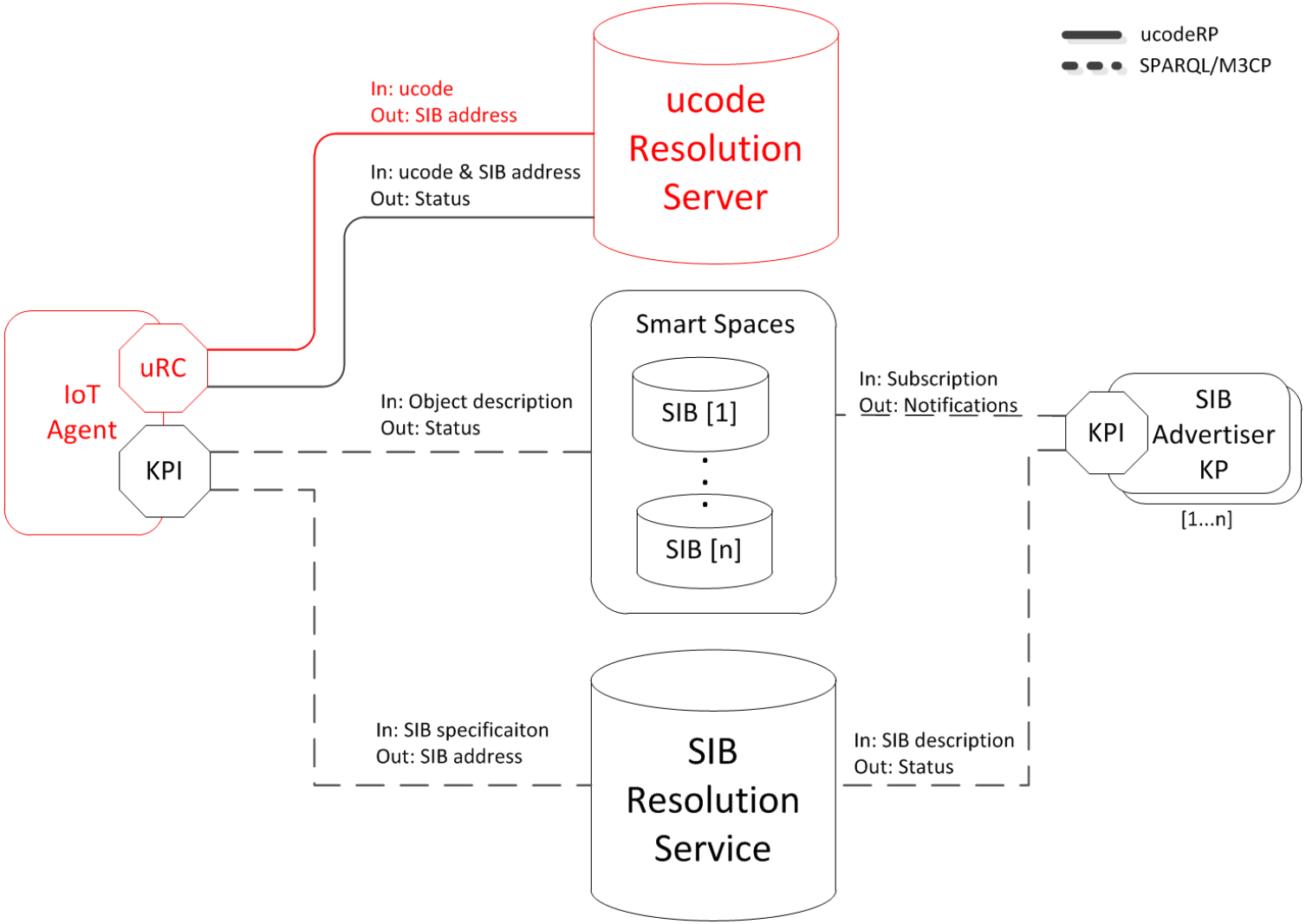


Ontology for SIB Service descriptions

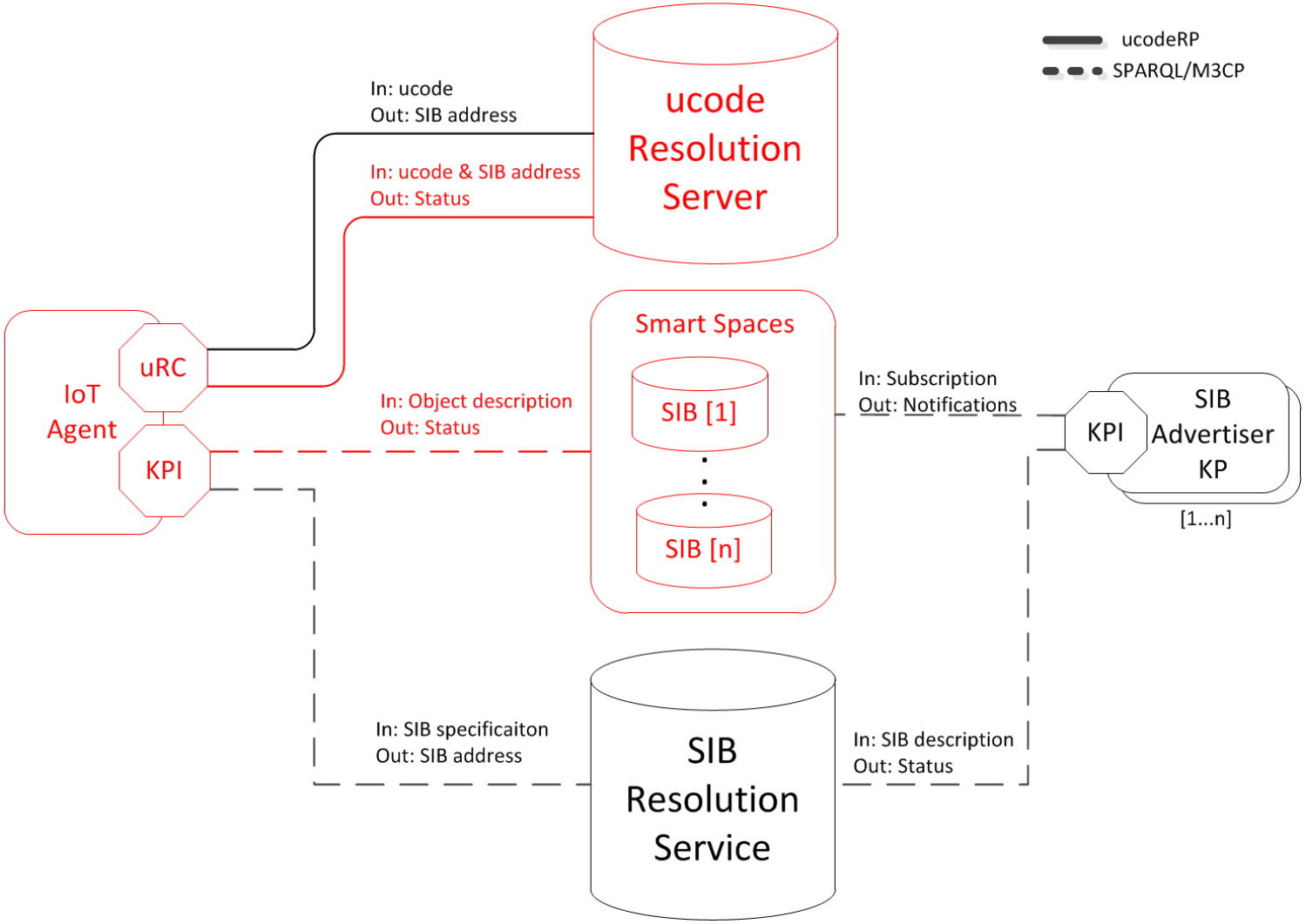
- The vocabulary for SIB service specifications and descriptions is presented in the SIB service ontology.



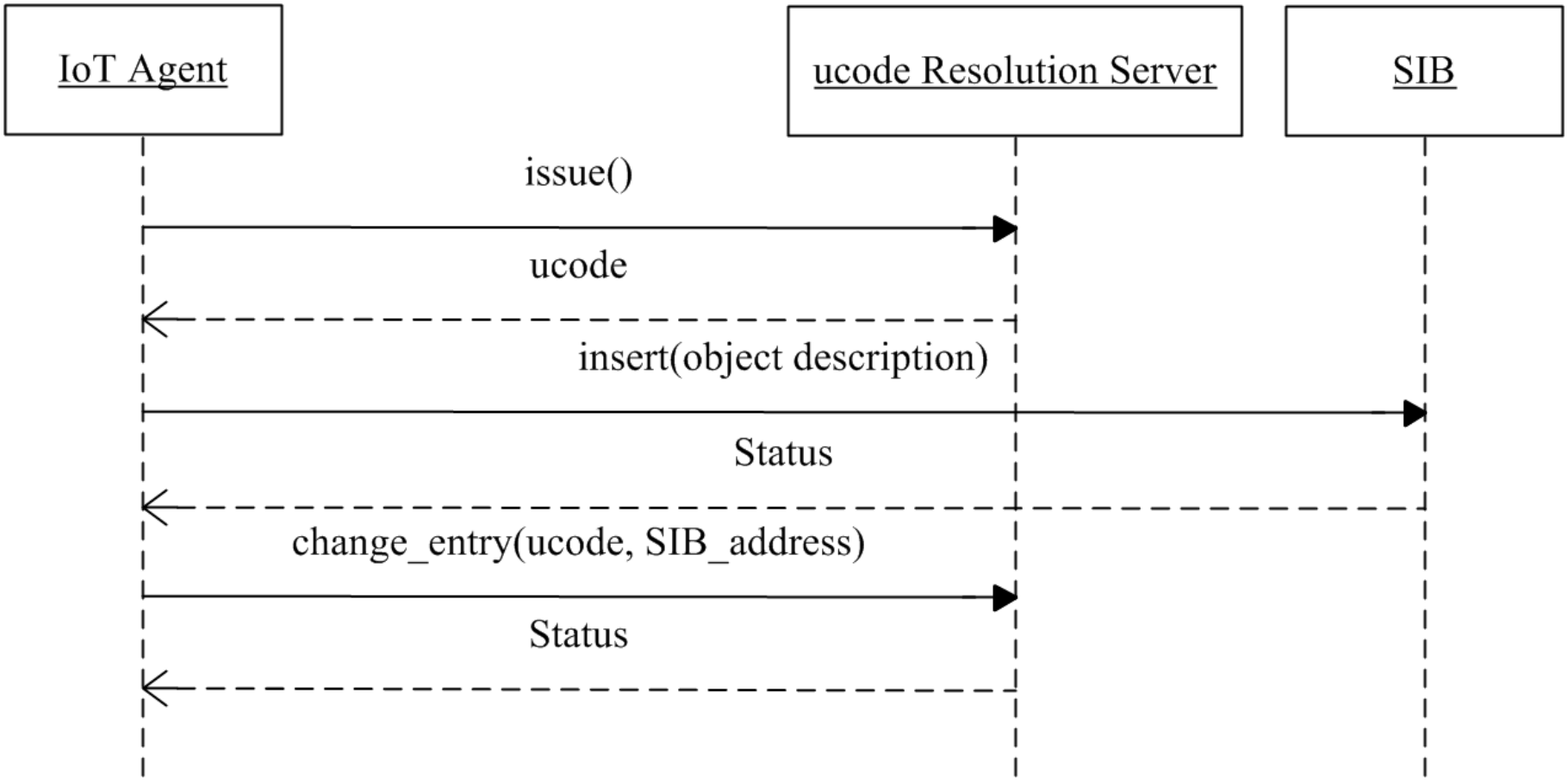
SIB Lookup


ucodeRP
SPARQL/M3CP
ucode Resolution Server
In: ucode
Out: SIB address
In: ucode & SIB address
Out: Status
IoT Agent
uRC
KPI
Smart Spaces
SIB [1]
SIB [n]
In: Object description
Out: Status
In: Subscription
Out: Notifications
KPI
SIB Advertiser KP
[1...n]
SIB Resolution Service
In: SIB specificaiton
Out: SIB address
In: SIB description
Out: Status

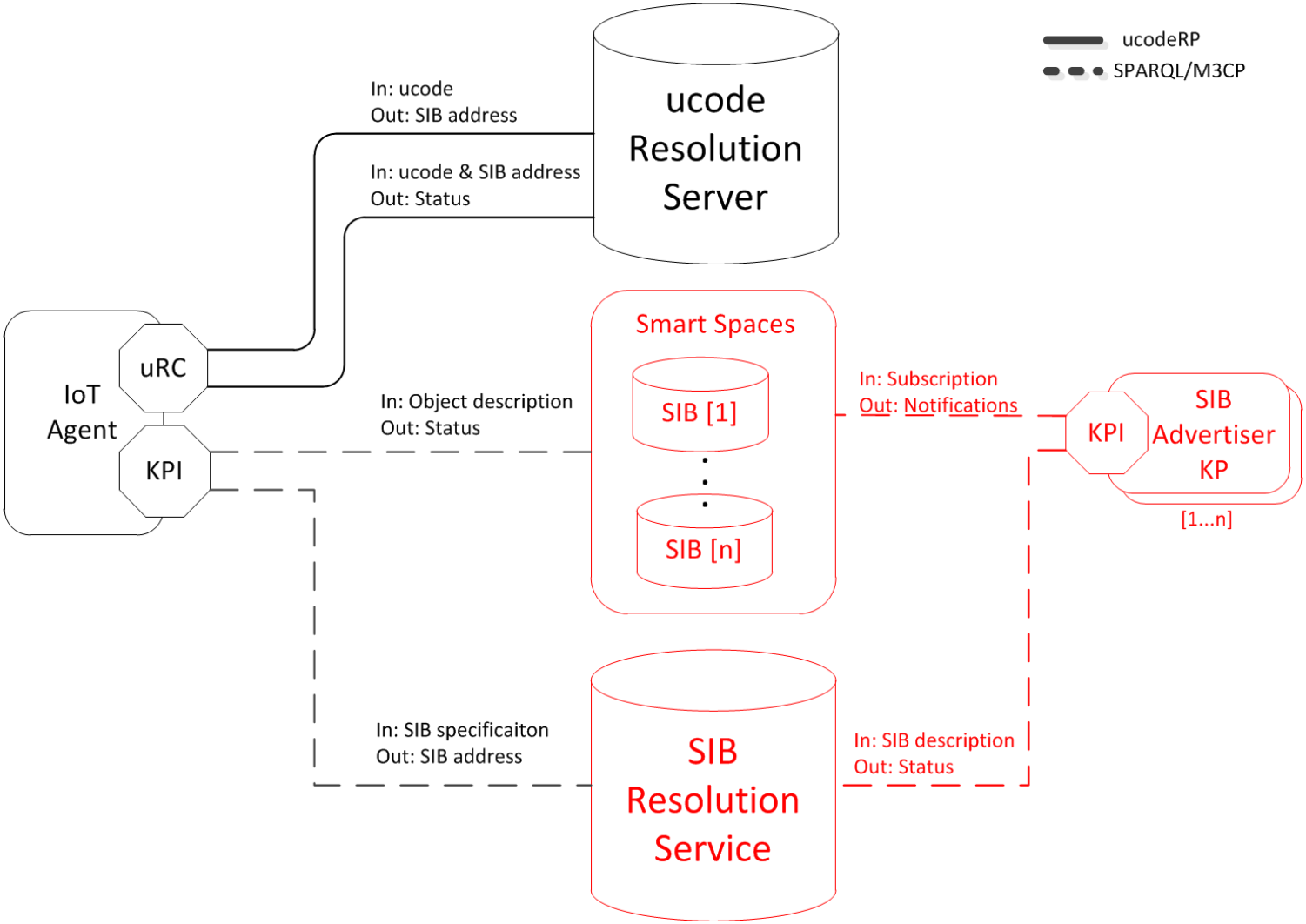
Creating and Publishing object descriptions



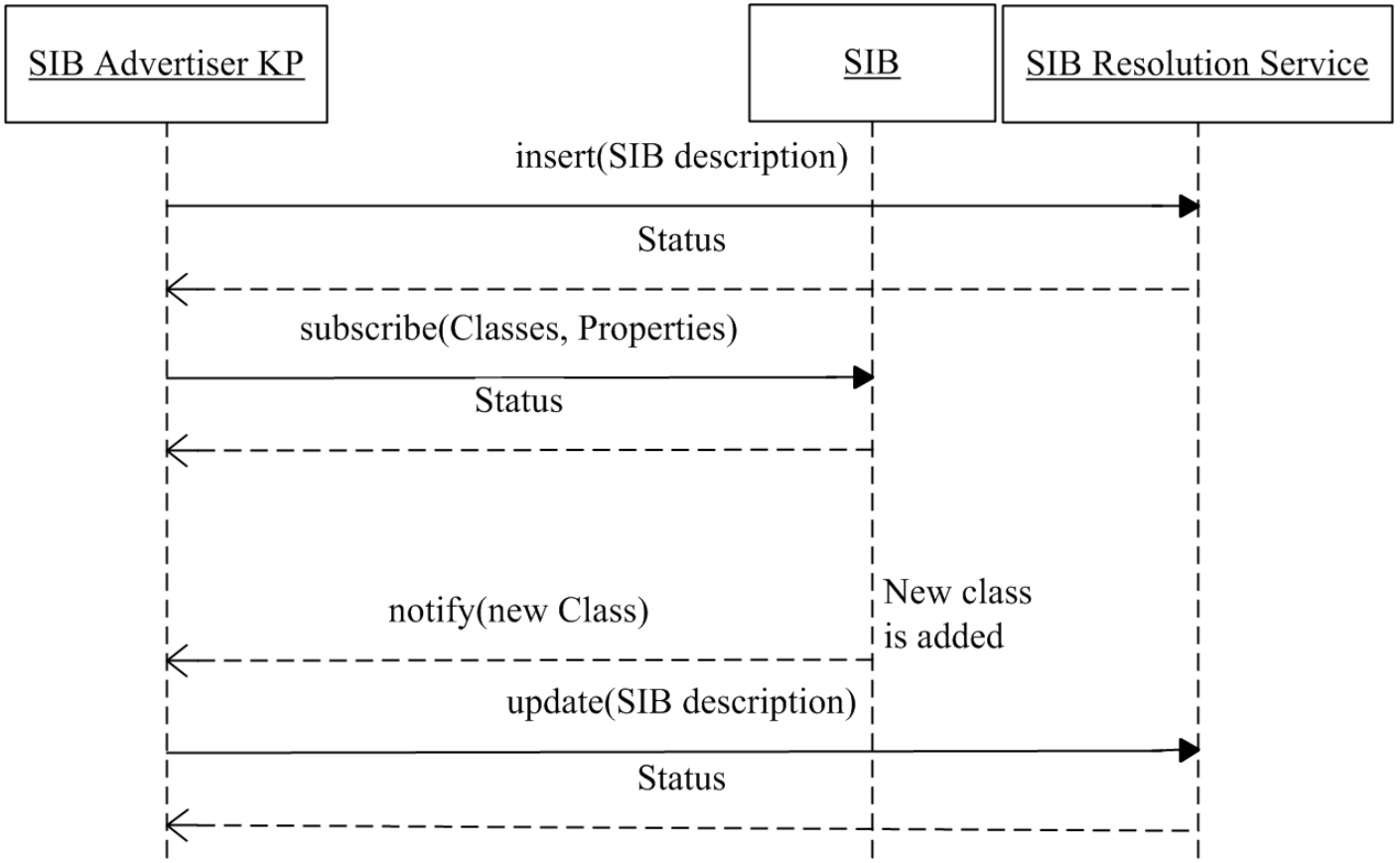
Creating and Publishing object descriptions



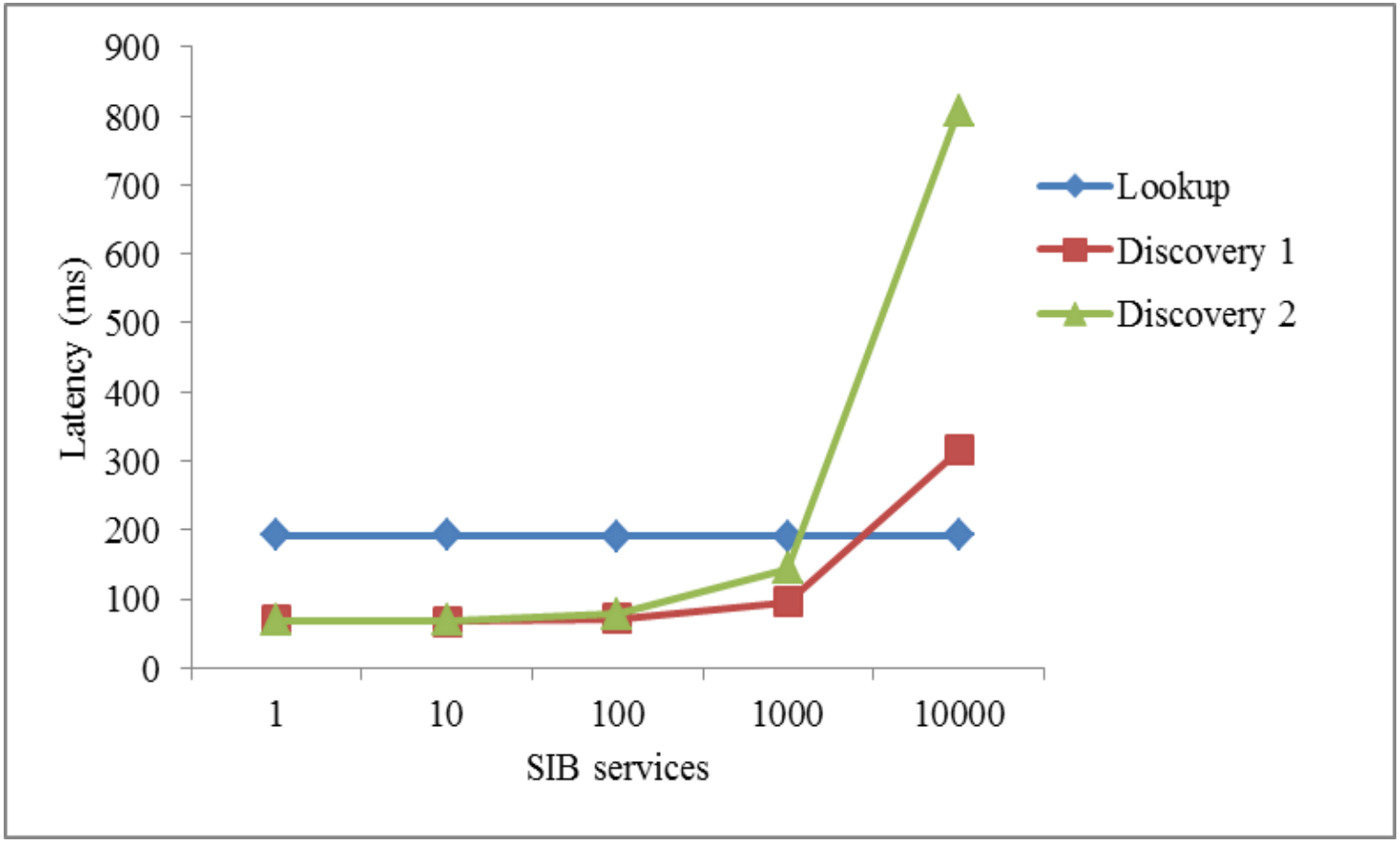
SIB service management



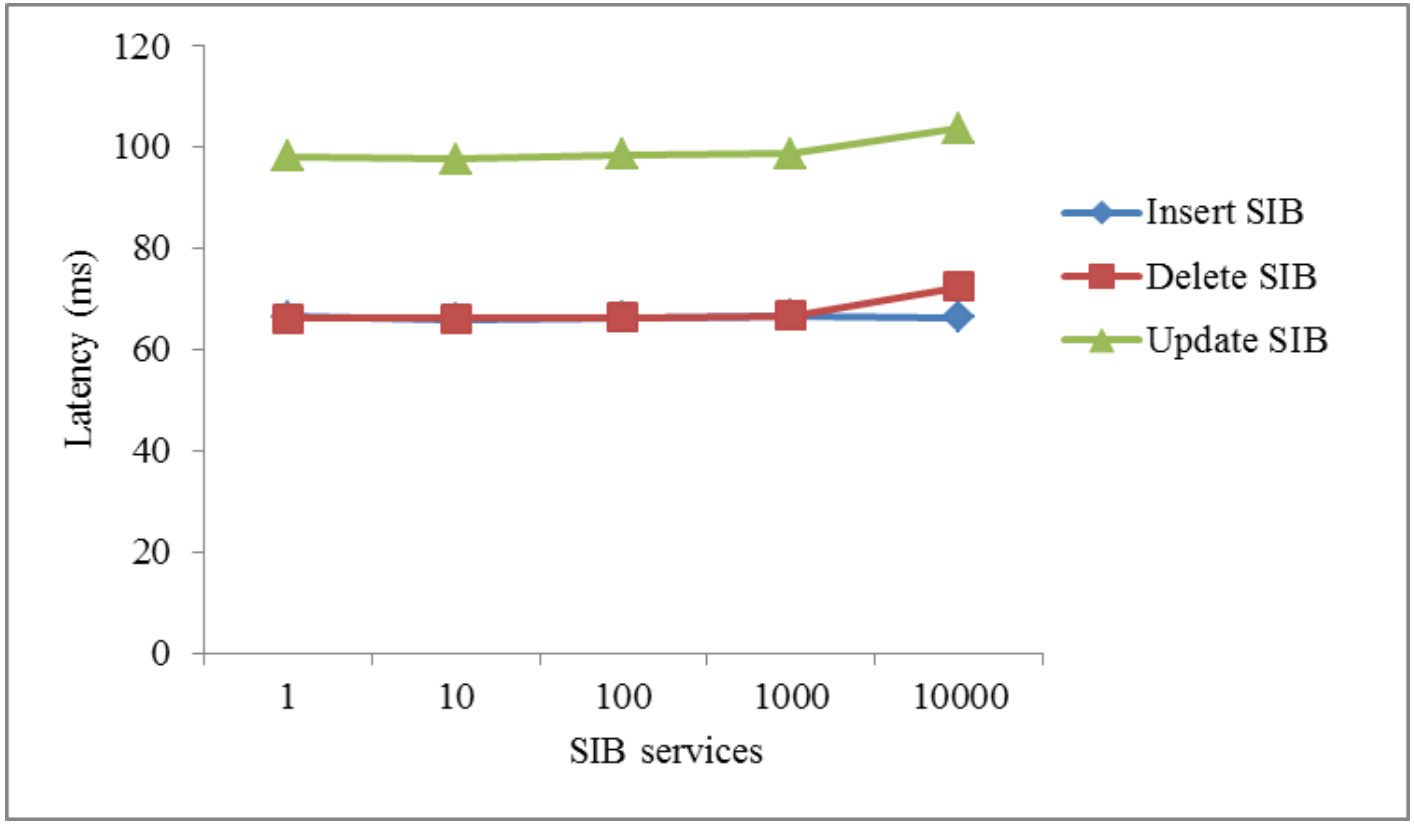
SIB service description management process



Evaluation: SIB resolution



Evaluation: SIB management



Evaluation: observations

- The discovery operation has significant increase in latency when the service count is increased from 1000 to 10000 services.
- Network latency constitutes majority of the latency for most operations:
  - In SIB *discovery* and management operations with 100 SIB services the network latency is around 95 %
  - In SIB *lookup* the network latency part is 78%
- If we ignore network latency the Resolution Infrastructure is able to process around 350 *discovery* and *management* operations per second (assuming maximum of 1000 SIB services).

Conclusions and Future Work

- The Resolution Infrastructure scales well up to 1000 SIB services and 100000 VEs (evenly distributed)
- Network latency is a big factor in the communication and could be optimized by utilizing more compact M3 communication protocols.
- In order to make the resolution infrastructure scalable for large scale IoT systems a distributed implementation of the *SIB Resolution Service* is needed in the future.

Thank You!