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:
  - \textit{ucode}: The \textit{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).
  - \textit{ucode Information Server}: The \textit{ucode Information Server} is a database that contains information about an object identified with a \textit{ucode}.
  - \textit{ucode Resolution Server}: The role of the \textit{ucode Resolution Server} is to both manage \textit{ucodes} and resolve \textit{ucodes} to corresponding Information Server addresses. In practise this functionality is achieved with three operations: \textit{issue}, \textit{change entry}, and \textit{resolve}. 
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. \textit{ucode}).
  - **Discovery:** SIB address is resolved based on SIB specification expressed as a SPARQL query.

- The Resolution Infrastructure consist of two components:
  - \textit{ucode} Resolution Server
  - SIB Resolution Service
Ontology for SIB Service descriptions

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

IoT Agent

issue()

rcode Resolution Server

insert(object description)

Status

change_entry(rcode, SIB_address)

Status

SIB
SIB service description management process

SIB Advertiser KP

insert(SIB description)

Status

subscribe(Classes, Properties)

Status

notify(new Class)

New class is added

update(SIB description)

Status

SIB

SIB Resolution Service
Evaluation: SIB resolution

![Graph showing SIB resolution with lines for Lookup, Discovery 1, and Discovery 2.]
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!