Mediator based Approach for Smart Spaces Integration

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Triple governance transactions using Smart Space Access Protocol (SSAP): join, leave, insert, remove, update, query, subscribe, unsubscribe.

Smart Space: a named search extent of information.

Physical distribution of a Smart Space.

Knowledge Processor (KP): An entity contributing to (insert/remove) and/or reading (query/subscribe) content according to ontology relevant to its defined functionality. A KP needs one or more partner KPs for useful sharing of content, implying an agreed semantics for the used ontology.

Semantic Information Broker (SIB): An entity performing triple governance in possible cooperation with other SIBs for one Smart Space. A SIB may be a concrete or virtual entity.
Interoperability problem

- Problem of integration of independent applications processing multiple heterogeneous data sources.
- Integrated systems exist independently and know nothing of each other.

![Diagram showing two smart spaces connected through a mediator](image)
Application Integration Interface

Example of service interface:

```java
public String findInCache(String key);
```

Web Services

```xml
<wSDL:message name="findInCacheRequest">
  <wSDL:part name="key" type="soapenc:string"/>
</wSDL:message>

<wSDL:message name="findInCacheResponse">
  <wSDL:part name="result" type="soapenc:string"/>
</wSDL:message>
```

Space-based computing

```xml
(<request_ID>,
 'findInCacheRequest',<request_data_ID>);
(<request_data_ID>,'rdf::value',<key>);
(<request_data_ID>,'rfd::type','xsd:string');

(<request_ID>,
 'findInCacheResponse',<response_data_ID>);
(<response_data_ID>,'rdf::value',<result>);
(<response_data_ID>,'rfd::type','xsd:string');
```
1. **Smart space applications matching**: process of establishing logical correspondences between elements of the source and target ontologies of integrated applications. As a result of this process integration scenarios are formed.

2. **Run time instance mapping**: process of mapping the instances between several smart spaces.
Integration of Smart Conference System and SmartScribo System

### Smart Conference System Ontology

- **Time Slot**
  - is
  - length
- **User Profile**
  - is
  - interests
  - photo
  - email
  - phone
  - language
- **Presentation**
  - title
  - url
  - keywords

### SmartScribo Ontology

- **Account**
  - nickname
  - hpassword
- **Post**
  - title
  - text
  - tags
- **Comment**
  - title
  - text
  - tags

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Smart Space Applications matching

The expert must determine:

1. The events that initiate the process of integration;
   
   $\langle application\_ID\rangle,\langle notification\_name\rangle,\langle data\_id\rangle$;

2. Input data for integration;
   
   ```
   SELECT *
   WHERE {
      ?person foaf:name ?name .
   }
   ```

3. Mapping rules to transform entities of the source smart space to entities of target smart space.

   'title'(postId, titleValue) :-
   "Title"(presentationID, titleValue),
   generateUID(postId).
Run time instance mapping

\[ S_s \rightarrow \text{Instance mapping} \rightarrow S_t \]

- \( S_s \) is a source smart space;
- \( N \) is a data loading notification;
- \( Q \) is a set of graph queries to the source smart space;
- \( R \) is a set of mapping rules for the source and target smart spaces;
- \( S_t \) is a name of the target smart space.
Mapping rules types

**Ontology mapping**

- Semantic equivalence: \( O_1 = O_2 \).
- Semantic subsumption: \( O_1 \subseteq O_2 \).
- Semantic intersection: \( O_1 \cap O_2 \).
- Semantic incompatibility: \( O_1 \neq O_2 \).

**Run time instance mapping in Smart Space**

- Simply copying the attributes;
- UIDs (URIs) generation;
- Manipulations with
  - numbers;
  - strings;
  - date and time;
- Comparison with previously integrated entities;
Mediator Architecture

Mediator Architecture

- SIB 1
- ... SIB N
- non-Smart-M3 RDF store

subscriptions for notifications, graph queries, triples

queries.txt
notification model, graph queries

interaction module

Mapping module

mapping.txt
mapping rules

Synchronization module

Rule-based Inference Engine

Correspondence of the objects UIDs

Adapter

UIDs

triples

triples

rules, triples
Mediator Activity Diagram
Conclusion and Future work

Results

- the idea of mediator-based agent for the integration of Smart Conference System and SmartScribo System was successfully demonstrated at the 9th and 10th Conference FRUCT.
- specified input information that uniquely describes the scenario of integration smart space application.
- defined the general architecture of a mediator that can automatically integrate the smart space applications.

Plans

- to develop a software platform for automatic integration of several smart spaces using the integration scenarios defined by an expert.
- to develop a declarative domain-specific modeling language which best defines the smart space integration process.