Towards a Value-Added Information Layer for SWIM:
The Semantic Container Approach

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BEST Project

• An exploratory research project (TRL 1)
• June 2016 – June 2018

• In BEST we apply semantic technologies for:
  • **Description** of the data you want/have
  • **Discovery** of the information you are seeking
  • **Filtering** information
  • **Combining** information
Semantic Container Approach
Towards a value-added Information Layer for SWIM

- Information services in SWIM receive ATM information as input
- Returning ATM information as output

- The semantic container approach considers *packages of ATM information*, which SWIM services store in a repository and retrieve as needed
  - For example, a SWIM service filters and prioritizes NOTAMs for individual flights.
  - From that SWIM service, a briefing application requests all NOTAMs relevant for flight EK 127 from Dubai to Vienna on 23/02/2017
  - The SWIM service returns a semantic container with exactly that information
  - The semantic container can then be redundantly allocated at multiple sites, e.g., inside the aircraft or on airport servers, for improved availability.
  - The SWIM service, knowing that many applications request NOTAMs relevant to the flight from Dubai to Vienna, may keep a semantic container with all NOTAMs relevant for the route from Dubai to Vienna in cache.
Semantic Containers in SWIM

Database

Knowledge base

Semantic Description

Semantic Description

Information Service Instance

Information

Technical Infrastructure (BP/YP)
Semantic Containers in SWIM

SWIM Enabled Application

Query

Result

SWIM

Database

Knowledge base

Semantic Container

Semantic Container

Information Service

Information

Technical Infrastructure (BP/YP)

Technical Infrastructure (BP/YP)

Technical Infrastructure (infrastructure)

Registry

IP-Based Network

+BEST
Semantic Container

- **Membership condition**
  - Description of the content
  - The semantic container comprises all data items that fulfil the membership condition
  - Serves to find containers that satisfy application’s information need

- **Administrative metadata**
  - Technical metadata (format, encoding, etc.)
  - Quality metadata (last update, last check, etc.)
  - Provenance metadata (What SWIM service produced the container?)

- **Contents**
  - The actual ATM information
  - A set of data items, where each data item fulfils the membership condition
  - Can be materialized or just a pointer

--- Membership Condition ---

- Data item type: METAR
- Location: Route MUC-FRA
- Time: 2017-02-23

--- Administrative Metadata ---

- Data format: XML
- Last change: 2017-02-23T11:00:00
Semantic Labels

class Facet

LogicalContainer

SemanticLabel

Facet

Ontology

SpatialFacet TemporalFacet SemanticFacet

SemanticLabelToFacet

definedBy

1..* 1

* 1

+facetValue

1..* 1

1

1

+membershipCondition

* 1

* 1

* 1

1

* 1

* 1

1
## Semantic Containers and Ontologies

### (a) Semantic containers

<table>
<thead>
<tr>
<th>METARs&lt;FixedWingAircraft&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>--- Membership Condition---</td>
</tr>
<tr>
<td>Data item type METAR</td>
</tr>
<tr>
<td>Aircraft: FixedWingAircraft</td>
</tr>
<tr>
<td>--- Administrative Metadata---</td>
</tr>
<tr>
<td>...</td>
</tr>
</tbody>
</table>

### (b) Concepts in Ontology

```
Aircraft
  FixedWingAircraft
  SeaPlane
  RotaryWingAircraft
  Helicopter
```

---

**METARs< RotaryWingAircraft>**

--- Membership Condition---
Data item type METAR
Aircraft: RotaryWingAircraft
--- Administrative Metadata---
...

---

**METARs< SeaPlane>**

--- Membership Condition---
Data item type METAR
Aircraft: SeaPlane
--- Administrative Metadata---
...
**Semantic Containers and Ontologies**

(a) Semantic containers

(b) Concepts in Ontology
Semantic Containers and Ontologies

--- Membership Condition ---
Data item type METAR
Aircraft: FixedWingAircraft
--- Administrative Metadata ---

METARs<FixedWingAircraft>

--- Membership Condition ---
Data item type METAR
Aircraft: RotaryWingAircraft
--- Administrative Metadata ---

METARs<RotaryWingAircraft>

--- Membership Condition ---
Data item type METAR
Aircraft: SeaPlane
--- Administrative Metadata ---

METARs<SeaPlane>

(a) Semantic containers

(b) Concepts in Ontology
Semantic Containers and Ontologies

(a) Semantic containers

METARs<FixedWingAircraft>
--- Membership Condition---
Data item type METAR
Aircraft: FixedWingAircraft
--- Administrative Metadata---
...

METARs<SeaPlane>
--- Membership Condition---
Data item type METAR
Aircraft: SeaPlane
--- Administrative Metadata---
...

METARs<RotaryWingAircraft>
--- Membership Condition---
Data item type METAR
Aircraft: RotaryWingAircraft
--- Administrative Metadata---
...

(b) Concepts in Ontology

Aircraft

FixedWingAircraft

SeaPlane

RotaryWingAircraft

Helicopter
Semantic Container Derivation Chains

**Combine**

- E1<f1>
- E1<f2>
- E1<f3>
- E1<f1 U f2 U f3>

**Compose**

- E1<f1>
- E2<f2>
- A1<f3>
- E1<f1 > U E2<f2 > U A1<f3 >

**Filter**

- E1<f1>
- filter <f2>
- E1<f2 >

**Derive**

- E1<f1>
- derive A1<f2>
- A1<f2 >

**Constraint:** f2 subsumed by f1
DNOTAM Route Semantic Container

Combine DNOTAMs for Specific Areas

DNOTAMs <Region 1>
Provider 1

DNOTAMs <Region 2>
Provider 2

DNOTAMs <Region 3>
Provider 3

...
DNOTAM Route Semantic Container

- DNOTAMs <Region 1>
  Provider 1

- DNOTAMs <Region 2>
  Provider 2

- DNOTAMs <Region 3>
  Provider 3

... 

Combine DNOTAMs for Specific Areas

- DNOTAMs <Area 1>
  - DNOTAMs <Region 1>

- DNOTAMs <Region 2>

- DNOTAMs <Region 3>

... 

ROUTEs relevant for <AEP - ADES, Date>

Filter DNOTAMs <AEP - ADES, date>

DNOTAMs <AEP - ADES, date>
DNOTAM Route Semantic Container

- DNOTAMs <Region 1> Provider 1
- DNOTAMs <Region 2> Provider 2
- DNOTAMs <Region 3> Provider 3

Combine DNOTAMs for Specific Areas

DNOTAMs <Area 1>
  - DNOTAMs <Region 1>
  - DNOTAMs <Region 2>
  - DNOTAMs <Region 3>
  - ...

ROUTEs relevant for <AEP - ADES, Date>

Filter DNOTAMs <AEP - ADES, date>

Rules relevant for a specific <Aircraft Type>

DNOTAM Route Container <Flight Number, date>
  - DNOTAMs <AEP - ADES, date>
  - DNOTAM PRIORITIES <Flight Number, date>

Enrich with: Prioritize DNOTAMs <Flight Number, date>

DNOTAMs <AEP - ADES, date>

Semantic Container Management Platform

Subsumption Hierarchy
- DataContainer1
  - DataContainer4
  - DataContainer3
- DataContainer2
  - DataContainer5
  - DataContainer3

DataContainer5

Descriptive Metadata
- Data Model: AIXM
- Data Type: NOTAM
- Aircraft: AircraftType717
- Temporal Filter: 
- Temporal Interval: Year2017
- Spatial Filter: 
- Spatial: FirAustria
- Spatial Temporal 4D: 
- Specific Interest: 

Administrative Metadata
- Data Format: XML
- Data Encoding: 
- Data Volume: 
- Data Location: 
- Data Service: 
- Last Check: 
- Last Change: 
- Updated Till: 
- Refresh Interval: 
- Refresh Until: 29.06.17
- Data Source: 

Actions:
- Delete this container
- Modify this container
- Refresh this container
Operational Context
Digital Briefing

Dispatcher/ARO

INTEGRATED BRIEFING PORTAL
Flight planning functionality
PIB functionality

Flight Trajectory Management System
Provide flight data trajectory/FPL
Get data AI/MET/Flow/etc.

Digital Briefing Application
Get flight data trajectory/FPL
Get data AI/MET/Flow/etc.

On-board briefing device

Pilot

SWIM DATA POOL

ATM Operator
SWIM Application using a Semantic Container
Benefits

Value-added Information
➢ Semantic, temporal and spatial facets
➢ Technical, quality and provenance metadata in combination with the derivation chains will lead to the following benefits:

Defined Quality of Information
➢ freshness
➢ provenance
➢ quality

High Availability of Information
➢ better reliability

Decreased Network Load
➢ performant SWIM
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