Conceptual Situation Spaces for Situation-driven Processes

- ESWC 2008, Tenerife, June 03, 2008 -

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Outline

- Situation-driven Processes for Semantic Web Services
- Conceptual Situation Spaces
- Prototype Application (Demo)
- Conclusions
Objectives that a client wants to achieve by using Web Services

Formally specified terminology of the information used by other WSMO components

Connectors between components with mediation facilities for handling heterogeneities

Semantic description of Web Services:
- **Capability** *(functional)*
- **Interfaces** *(usage)*
Semantic Web Services: Challenges

The real World

Symbolic Representation

Semantic Web Services

G  M  SWS

G  M  SWS

G  M  SWS
Semantic Web Services: Challenges

...with a variety of User Contexts...

Symbolic Representation

Semantic Web Services

G — M
SWS
SWS
SWS
SWS
SWS
SWS
SWS
Semantic Web Services: Challenges

...with distinct **Context Parameters**...

- Location $X_1$
- Device $X_2$
- Language $X_3$
- Platform $X_4$
- ...

Symbolic Representation

User context

Semantic Web Services

G → M → SWS

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G → M → SWS
Semantic Web Services: Challenges

...which evolve throughout the 
Course of a Process.

Symbolic Representation

- Location $X_1$
- Device $X_2$
- Language $X_3$
- Platform $X_4$
- ...

- Location $Y_1$
- Device $Y_2$
- Language $Y_3$
- Platform $Y_4$
- ...

User context

- Location $X_1$
- Device $X_2$
- Language $X_3$
- Platform $X_4$
- ...

- Location $Y_1$
- Device $Y_2$
- Language $Y_3$
- Platform $Y_4$
- ...

User context

- Location $X_1$
- Device $X_2$
- Language $X_3$
- Platform $X_4$
- ...

- Location $Y_1$
- Device $Y_2$
- Language $Y_3$
- Platform $Y_4$
- ...

User context

- Location $X_1$
- Device $X_2$
- Language $X_3$
- Platform $X_4$
- ...

- Location $Y_1$
- Device $Y_2$
- Language $Y_3$
- Platform $Y_4$
- ...

User context
Semantic Web Services: Challenges

The real World

Symbolic Representation

Semantic Web Services

User context

G → M → SWS

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G → M → SWS
Semantic Web Services: Challenges

**Issues:**
- WSMO lacks notion of context and process.

User context

Symbolic Representation

Semantic Web Services

G —— M

G —— M

G —— M

G —— M
Issues:
- WSMO lacks notion of context and process.
- Potentially infinite and highly heterogeneous real-world contexts…
- …which are costly to represent on a symbolic level.
Semantic Web Services: Challenges

Issues:
- WSMO lacks notion of **context** and **process**.
- Potentially **infinite** and highly **heterogeneous** real-world contexts...
- ...which are **costly to represent** on a symbolic level.
- **Matchmaking** between real-world contexts and finite set of symbolic representations?
Issues:

- **WSMO lacks notion of context and process.**
- Potentially infinite and highly heterogeneous real-world contexts...
- ...which are costly to represent on a symbolic level.
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Situation-driven Processes (SDP) for Semantic Web Services

Semantics Situation-driven Processes

S1

S2

G1

G2

BG1

BG2

BG3

S1.1

S1.2

M1

M2

M3

SWS1

SWS2

SWS3

SWS4

SWS5

SWS6

SWS7

SWS8

SWS9

affords

leads to

affords

leads to
Situation-driven Processes (SDP) for Semantic Web Services

SDP user perspective.

- (User) Situations (S) represent a state of context …
- … and afford certain user Goals (G).
Situation-driven Processes (SDP) for Semantic Web Services

SDP service provider perspective.

- Goals (G) supported by Brokered Goals (BG)...
- …which are achievable in terms of SWS goal invocations.
Situation-driven Processes (SDP) for Semantic Web Services

Semantic Situation-driven Processes

- **S1**: leads to **G1**
- **S1**: affords **G1**
- **S2**: leads to **G2**
- **S2**: affords **G2**

Semantic Web Services

- **BG1**: affords **S1.1**
- **BG1**: leads to **M1**
- **BG2**: affords **S1.2**
- **BG2**: leads to **M2**
- **BG3**: affords **S1.3**
- **BG3**: leads to **M3**

- **SWS1**
- **SWS2**
- **SWS3**
- **SWS4**
- **SWS5**
- **SWS6**
- **SWS7**
- **SWS8**
- **SWS9**
Situation-driven Processes (SDP): Ontology Overview

SDP formalised through (domain-independent) **SDP Ontology** …
(upper level concepts shown below)
Situation-driven Processes (SDP): Ontology Overview

...introducing **Situations** represented by **Situation Descriptions**...
(derived from DOLCE Descriptions & Situations)
Situation-driven Processes (SDP): Ontology Overview

…which represent the assumptions/effects of Goal Descriptions…
(Brokered Goals derived from WSMO)
... and serves as basis for **domain-specific derivations**.
(e.g. LPMO as SDPO specialisation for eLearning; used within EU STREP LUISA)
The real World

Symbolic Representation

SWS incorporated into SDP

Semantic Web Services

SWS

SWS

SWS

SWS

SWS

SWS

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SWS

SWS

SWS

SWS
Issues:

- WSMO lacks notion of context and process.
- Potentially infinite and highly heterogeneous real-world contexts…
- …which are costly to represent on a symbolic level.
- Matchmaking between real-world contexts and finite set of symbolic representations?
Need for rather fuzzy matchmaking between large variety of user contexts and finite symbolic representations.
Utilization of Conceptual Spaces (Gärdenfoers) to represent situations …
Utilization of **Conceptual Spaces** (Gärdenfoers) to represent situations … …in multi-dimensional vector spaces.
Enabling **calculation of distances** between actual context and symbolic representations…
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…to support **similarity-based matchmaking**.
Conceptual Situation Spaces: Formalisation
CSS C as specific derivation of a Conceptual Space (geometrical vector space)…
- **CSS C** defined by **quality dimensions** $c_n$:

  $$C^n = \{ (c_1, c_2, \ldots, c_n) | c_i \in C \}$$

- $C$ refined gradually ("subspaces") by refining its dimensions, for instance:

  $$c_j = D^n = \{ (d_1, d_2, \ldots, d_n) | d_k \in D \}$$
- Each **quality dimensions** $c_n$ measured on a specific **metric scale**. (ratio, interval, ordinal)

- Impact of dimension $c_n$ defined through **prominence value** $p_n$.

$$C^n = \{(p_1 c_1, p_2 c_2, \ldots, p_n c_n) | c_i \in C, p_i \in P\}$$
- **Situation(s) (parameters)** represented as CSS (or particular subspaces).

- **Situation (parameter) instances** represented as members (points) in a CSS.
Conceptual Situation Spaces: Formalisation

- **Members** (particular contexts) in CSS C defined by set of **valued dimension vectors**.
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- **Semantic similarity** between two members V and U in a multi-metric space C calculated by means of their **Euclidean distance**:

  \[
  |d(u, v)|^2 = \sum_{i=1}^{n} p_i (z(u_i) - z(v_i))^2 \quad \text{with} \quad z(u_i) = \frac{u_i - \underline{u}}{s_u}
  \]
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- **Prototypical members** (prototypical contexts) enable classification of arbitrary members.
Utilisation of WSMO, SDP and CSS representations in OCML.
(reasoning engine IRS-III)
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- **WSMO capabilities** defined through (SDP) situation (parameter) instances ...
Utilisation of WSMO, SDP and CSS representations in OCML.
(reasoning engine IRS-III)

- **WSMO capabilities** defined through (SDP) situation (parameter) instances …
- … which are refined as **prototypical members in CSS**.
- **Similarity-based SWS selection through distance calculation** (based on CSS).

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**Diagram:**

- CSSO
- SDPO
Reasoning on SDP/CSS: Approach based on IRS-III

Process Presentation Layer

Semantic Execution Layer

Data Layer

Conceptual Situation Spaces (CSSO)

Situation-driven Processes (SDPO)

Semantic Web Services (WSMO)

Web Service Layer

Web Service Repository

Web Service Repository

Web Service Repository

Data Repository

Data Repository

Data Repository

Situation parameters

Resources

Process Runtime Environment

Process Runtime Environment

Web Interface

Data

Data

Data
- **Web Interface** / process metadata standard-compliant **runtime environments**

- **User interfaces enable:**
  - **Raising context-awareness** through gradual refinement of situation, (automatic detection/user-driven definition of situation parameters)
  - Presentation of **process**… (generic or metadata standard-compliant XML representations)
  - …and **resources**.
1. Detection of most similar prototypical situation parameters.
   (based on distance-calculation within CSS(O))
Reasoning on SDP/CSS:
Approach based on IRS-III

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   (based on distance-calculation within CSS(O))

2. **Selection of Goals** which target (assume) closest prototypical situations.
   (based on SDPO)
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   (based on distance-calculation within CSS(O))

2. **Selection of Goals** which target (assume) **closest prototypical situations.**
   (based on SDPO)

3. **Composition of SDP** in terms of **Goals and Brokered (SWS) Goals.**
   (SDPO, WSMO)
Reasoning on SDP/CSS: Approach based on IRS-III

Brokered Goal achievements during process runtime:

- Orchestration and **invocation of distributed (S)WS**,
- Context-adaptive delivery of **data resources** out of distributed repositories.
Prototype application aimed at **context-adaptive composition of learning processes**
(and transformation into eLearning metadata standards, e.g. IMS LD, ADL SCORM)

Leading to **context-adaptive delivery of learning resources** at process runtime.

Used within EU STREP LUISA [http://www.luisa-project.eu].
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Utilises **SDP(O) and CSS(O) derivations** for eLearning.
(distance calculation / process composition through SWS)

**Considers context parameters** such as technical environment, user language, learning objective (defined in SDPO).

Some parameters exemplarily **refined through CSS subspaces (CSSO)**…
(e.g. location, aim, learning style; detailed description in the proceedings)
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Some parameters exemplarily **refined through CSS subspaces (CSSO)…** (e.g. location, aim, learning style; detailed description in the proceedings)

…enabling similarity-based **selection of SWS/SDP Goals** given a set of context parameters.
Prototype Application: Demo

- **Process Presentation Layer**
  - Process Runtime Environment
  - Process Runtime Environment
  - Web Interface

- **Semantic Execution Layer**
  - Situation parameters
  - Resources
  - Semantic Execution Environment (IRS-III)

- **Web Service Layer**
  - Web Service Repository
  - Web Service Repository
  - Web Service Repository

- **Data Layer**
  - Data Repository
  - Data Repository
  - Data Repository

Optional Application: *demo*

- Situation-driven Processes (SDPO)
- Semantic Web Services (WSMO)
Some issues (CSS):

- **Necessary description depth and granularity** of a CSS?
- => CS(S) might just shift symbol grounding issue. (i.e. dimensions lack grounding and are ambiguous)
- Similarity-calculation only between members in same CSS.
- Requires **measurable quality dimensions**.
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  (i.e. dimensions lack grounding and are ambiguous)
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- Requires **measurable quality dimensions.**

..., however:

- **CSS enable fuzzy, similarity-based SWS selection** for given (runtime) context.
- **SDP support incorporation of SWS Goals** into **context-adaptive processes.**
- Well-suited for environments which naturally provide set of context measurements.
  (e.g. sensor-driven ones)
- Validation through initial **proof-of-concept prototype.**
Future work (CSS):

- Application of CSS to further **context parameters / domain contexts**.
- Incorporation of CS(S) into **SWS mediation facilities**. (similarity-based mediation based on CS(S)/WSMO)
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- Application of CSS to further context parameters / domain contexts.
- Incorporation of CS(S) into SWS mediation facilities. (similarity-based mediation based on CS(S)/WSMO)

... and potentially plenty of other stuff:

- Improvement of process planning/composition approach.
- Performance tuning (SWS/WS invocations).
- Provision / reuse of semantic descriptions.
Thank You!

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