Context, Context-awareness and Context-aware Web Services

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Overview

- Context
- Context awareness
- Context awareness systems
- Close versus open systems
- Web services
- Context-aware Web services
- Discussion
Context

- http://www.m-w.com
  “the interrelated conditions in which something exists or occurs”

- http://dictionary.cambridge.org
  “the situation within which something exists or happens, and that can help explain it”

- [Dey, 2001] defines:
  “Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves.”

In computer science and engineering: we use information to describe a situation or interrelated conditions
What is Context Awareness?

- WikiMedia
  “refers to the idea that computers can both sense, and react based on their environment”

- Mobile distributed computing:
  “One challenge of mobile distributed computing is to exploit the changing environment with a new class of applications that are aware of the context in which they are run. Such context-aware software adapts according to the location of use, the collection of nearby people, hosts, and accessible devices, as well as to changes to such things over time.” [Schilit et al., 1994]

- [Dey, 2001]
  “A system is context-aware if it uses context to provide relevant information and/or services to the user, where relevancy depends on the user’s task.”
What is Context Awareness? (cont.)

Environment

sensing \rightarrow Context information \rightarrow reaction

User A1

Software Service

Environment
Context information

- Context information
  - Reflects “current situation”, characterizes “changing environments”
  - Context information is temporal, but there is no clear definition about how long does it last

- Types of context/context information
  - Social context, business context, operational context, etc.
  - Information associated with where, when, what, who and how that characterizes changes in the environment where context is examined.
Examples of context information

WORKPAD Scenario
(IEEE Internet Computing 1/2008)

Possible “interrelated conditions” in disaster scenarios (Truong et al., 2009)
Not perfect but a “situation” can be interpreted from the information.

Context information is dependent on individual systems, as a type of information might be considered as context information in one system but not in another one.

→ Domain-specific knowledge in the interpretation of „situations“
Examples of context information (cont.)

In inContext, http://www.in-context.eu
Context awareness techniques

- Two main actions derived from definition
  - Context sensing: How to sense/monitor/capture information characterizing a context
  - Context adaptation: How to adapt according to a context
- But we do need also (just some examples)
  - Context representation: How to represent a context? → models and languages
  - Context storage: Temporary storage → representation, management, query, etc
  - Context coupling: Linking different types of context → storage, dissemination
  - Context reasoning: extracting high-level information
- And the interfaces between supporting context components and applications/systems
Context awareness - close versus open environments

- **Close environments:**
  - Single organization
    - Less concerns in security and privacy, data exchange model
  - Tightly coupled components
    - Less concerns on data representation
    - More controlled quality

- **Open environments**
  - Multiple organizations
  - Loosely coupled applications
  - Multiple middleware
Context-aware systems – examples in close environments

- Java context awareness framework [Bardram, 2005]
  - P2P, distributed but based on JavaRMI, object-oriented context modeling, and specific context APIs
Web services and the Internet of Services

- Web services
  - A particular set of technologies to implement SOC/SOA
  - Facilitate integration and interoperability of services provided by different providers

- Web services technologies
  - WSDL/WADL, XML, SOAP/REST
  - Services, service consumers, supporting service components (registry, management, monitoring, etc.)

- Examples
  - StrikeIron Web services, Amazon Web services

- Web services in our view:
  - Abstract *software, devices/things, and human activities → the Internet of Services*
Web services interaction

Mobile Web Service Consumer

(a)

Mobile/Web Service Consumer

(b)

Mobile Ad-hoc Network

Mobile Application Gateway/Web Service Proxy

Mobile Service (Web Service)

Mobile Service (Web Service)

Intermediate Network

Web Service Registry

Mobile Service (Web Service)

Web Service Registry

Direct invocation

Direct/indirect invocation
Context-aware Web services

- Web services environments
  - Open, multiple-organization,
  - Loosely coupled

- Context-aware Web services
  - A particular type of context-aware systems
  - We consider a context-aware service as a smart Web service defined by Manes: "a web service that can understand situational context and can share that context with other services" (Manes, 2001).

- We consider context information as *any additional information* that can be used to improve the behavior of a service in a situation.
Examples of possible context-aware Web services
Context-aware Web services: basic components
ESCAPE Framework Overview

- SOAP-based communication
- Mobile adhoc network

REST-based communication

XML-based context information
- Context information is application-specific
- The middleware accepts any XML-based context information
The inContext Environment

Providing different types of end user applications for different platforms and devices

Providing context information, metrics and patterns, perform service selection and adaptation

Providing basic operations normally required in collaborations
# Overview of context-aware Web services

<table>
<thead>
<tr>
<th>System</th>
<th>Application domain</th>
<th>System type</th>
<th>Multi-organization support</th>
<th>Mobility support</th>
<th>Level of Web service implementation</th>
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## Types of Context Information

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<thead>
<tr>
<th>System</th>
<th>Calendar</th>
<th>Location</th>
<th>Activity/Task</th>
<th>Presence</th>
<th>Individual Profile Preference</th>
<th>Team</th>
<th>Service/Application</th>
<th>Machine/Device</th>
<th>Network</th>
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# Overview of context representation techniques

<table>
<thead>
<tr>
<th>System</th>
<th>Modeling</th>
<th>Implementation</th>
<th>Modeling context with service</th>
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Examples of context information representation

- Context associated with team collaboration is much more complex than HCI or location-based services
  - Human, services, teams, activities, and interaction between human and services
- Existing context models are not enough
  - Reuse existing concepts and develop new ones
- inContext relies on RDF+OWL
Examples of context information representation (cont.)

- Annotating Web services description [Mrissa et al., 2007]

![Diagram: Partial representation of the extended WSDL metamodel.]

```xml
<?xml version="1.0" encoding="UTF-8"?>
<wsdl:definitions .../>
  <wsdl:message name="CarRentalTicket">
    <wsdl:part name="inputPrice" type="xsd:double"
      ctxt:context="dom1:Price ctxt1:France ctxt1:VATIncluded ctxt1:ScaleFactorOne"/>
  </wsdl:message>
</wsdl:definitions>
```

Listing 1. Car rental annotation snippet.

# Context Sensor Techniques

<table>
<thead>
<tr>
<th>System</th>
<th>Mode</th>
<th>Sensing techniques</th>
<th>Sensor interface</th>
<th>Data retrieval and publishing</th>
<th>Quality of context support</th>
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| Anyserver| +       |                   | +                | +                             | +                          |
| CA-SOA | +        | +                  | +                | +                             | +                          |
| ESCAPE | +        | +                  | +                | +                             | +                          |
| inContext | +      |                   | +                | +                             | +                          |
| SiWS | +        |                   | +                | +                             | o                          |
## Context Storage Techniques

<table>
<thead>
<tr>
<th>System</th>
<th>Storage model</th>
<th>Storage database</th>
<th>Access interface</th>
<th>Request specification</th>
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</table>
# Context Distribution Techniques

<table>
<thead>
<tr>
<th>System</th>
<th>Overlay network distribution</th>
<th>Direct transport distribution</th>
<th>Access mechanism</th>
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</thead>
<tbody>
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<td>Akogrimo</td>
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- **Strongly dependent on the environment requirements**
Examples of Context Distribution Techniques

- Inside SOAP messages [Keidl and Kemper, 2004]

# Context Reasoning Techniques

<table>
<thead>
<tr>
<th>System</th>
<th>Reasoning capability support</th>
<th>Semantic-based reasoning</th>
<th>Specific reasoning</th>
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</thead>
<tbody>
<tr>
<td></td>
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<td>SPARQL</td>
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- **Reasoning techniques are strongly dependent on**
  - Context information representation
  - Context storage
Example: search for relevant context information

- Context information and GIS: *Team A wants to reach to a place „P“*. *Let’s check unusable roads leading to „P“*

  for $infrastructure in
collection('/db/contextinformation')//includeInfrastructure
where $infrastructure/category="ROAD" and
$infrastructure/condition="UNUSABLE"
return $infrastructure

- Context information and adaptive processes: *Let’s send one worker to place „P“ to take a photo*

  for $worker in collection('db/contextinformation')//SupportWorker
where $worker//hasCamera and $worker/belongsTo//description="Team 1"
and $worker//Activity/status="LOW"
return $worker
Examples of Context Reasoning – inContext case

- Context information can be inferred based on rules
  - Provide insightful information about context associated with people, teams, services and activities
  - Based on SPARQL++

- Example: using reasoning techniques to find all civil engineers available at a particular site.

```sparql
PREFIX team:<http://www.in-context.eu/team.owl#>
SELECT ?engineer
WHERE{
  ?engineer :hasProfile ?profile.
  ?profile :hasSkill ?skill.
  ?engineer :locatedAt :"Genoa sea port"
}
FILTER regex(?sname,"civil engineer","i")
```
## Security and Privacy Techniques

<table>
<thead>
<tr>
<th>System</th>
<th>Security</th>
<th>Privacy specification</th>
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<tbody>
<tr>
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- Very important in large-scale, multiple-organizational, and social-aware systems
# Context Adaptation Techniques

<table>
<thead>
<tr>
<th>System</th>
<th>Adaptation purpose</th>
<th>Adaptation specification</th>
<th>Adaptation layer</th>
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**Discussion**

- **Sharing context vocabularies:**
  - There are domain independent and domain-specific context information concepts.
  - Diverse concepts: individual profile, device, machine, network, activity, and service
  - Various ontologies (SIOC, FOAF, etc.)

- How to share and integrate common context concepts for context-aware Web services still requires a major research efforts
  - Think if different context-aware Web services use different types of concepts
Discussion (cont.)

- Context reasoning and quality of context are not well developed
  - Mostly centralized reasoning based on low-level facilities
  - High-level reasoning (by doing reasoning atop linked context + domain-specific knowledge) would be very useful
  - Quality of context (QoC)/data quality/data problems are very open issues.
- Course projects on context reasoning and QoC in the Internet of services would be interesting
The use of ontology for modeling context information increases, yet engineering challenges remain

- Ontologies are widely used
- Engineering problems
  - Context update, security, and access
  - Web services atop mobile devices

Course projects on data management issues for ontology-based context would be interesting
Distributed context management techniques need to be developed

- Dedicated centralized context repositories do not work well in the Internet of services
  - Security, privacy, and scalability issues
- A fully distributed P2P-based context management and sharing system would be beneficial.

Course projects on protocols for context coupling would be interesting

- More discussion will be on the Context Coupling lecture.
Discussion (cont.)

- **Security and privacy issues have not been well addressed**
  - Security is just applied for centralized context storages
  - Need security for distributed context dissemination
  - Privacy is an open issue
- More discussion will be on „Data governance“ topic
- A course project focused on privacy would be interesting
Discussion (cont.)

- **Modeling service description with context information is not enough**
  - Enriching service description at the design time is not enough
    - Multiple types of runtime context information cannot be obtained
    - But it could be good for specifying ontologies about context information
  - MDE (model-driven engineering) does not address the connection to other supporting context components

- We will discuss more on „Software Engineering Methodology“ lecture
Thanks for your attention!

For further information, pls. check the course link: https://www.infosys.tuwien.ac.at/teaching/courses/caws/