Semantic agents for location-aware service provisioning in mobile networks

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Agenda

- Research motivation
- Semantic Web Vision
  - Semantic Web architecture
  - Web ontology languages
  - Semantic Web services
- Semantic agents
  - Semantic matchmaking
  - Approach for service provisioning in mobile networks
- Location-aware content delivery system
  - Requirements and usage scenarios
  - Architecture
  - Prototype implementation
- Conclusion
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As the functionality of mobile devices grows, configuring and maintaining mobile applications becomes a complex and time-consuming task.
- E.g. enabling WAP, GPRS, MMS and data connectivity requires configuration of multiple settings.

Over-The-Air (OTA) provisioning:
- Remote management of device settings and applications.
- Operators can easily introduce new services and manage provisioned services.
Research motivation (2)

♦ **Problem:**
  - users need to manually search for services on Web
  - searching for Web services by *keywords* is not always successful
  - existing Web services model
    - *not able* to dynamically discover the most appropriate service that meets user’s requirements

♦ **Semantic Web concept**
  - dynamic, heterogeneous, shared knowledge sources providing machine-understandable content (in a similar way as in WWW)
  - Web of interactive, automated and intelligent services that communicate via Internet
Research motivation (3)

- Intelligent software agents
  - able to dynamically discover, invoke, compose, and monitor Semantic Web services

- Idea: *semantic service matchmaking*
  - synergy of both *intelligent-agent* and *Semantic Web technologies*
  - meets the needs of users *and* service providers in the electronic market
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Semantic Web Vision

♦ Most of today’s content is human-understandable
♦ The *meaning* of data
  ■ has to be added to content and its formatting information
♦ *Metadata*
  ■ refers to data about data → the term *semantic*
♦ Tim Berners-Lee - the initiator of Semantic Web
  ■ Semantic Web will gradually evolve from the existing Web
  ■ adding the meaning of information - important role!
♦ The aim of Semantic Web:
  ■ to represent Web content in a machine-processable form
  ■ use intelligent techniques to take advantage of these representations
Semantic Web Vision - contd.

- Knowledge management
  - **Metadata**
    - identify and extract information from Web sources
  - **Ontology**
    - *an explicit and formal specification of conceptualization*
    - easily processed by computer and queried by user
    - new knowledge can be derived using inference rules
  - **Logic**
    - formal languages → expressing knowledge
    - well-understood formal semantics → describing meaning of sentences
    - automated reasoners → deduce conclusions

- Complex Semantic Web
  - many small ontologies point to each other, developed by web users
Semantic Web architecture

- Self-desc. doc.
- Data
- RDF + rdfschema
- XML + NS + xsmlschema
- Unicode
- URI
- Ontology vocabulary
- Logic
- Proof
- Trust
- Digital Signature

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Web Ontology Languages

- **RDF (Resource Description Framework)**
  - framework for describing and exchanging metadata on Web

- **RDF Schema (RDFS)**
  - specifies how to use RDF to describe RDF vocabularies
  - provides modelling primitives for expressing information on the Web

- **OWL**
  - introduced due to the limited expressivity of RDF and RDFS
  - DAML+OIL
    - created by a joint initiative of research groups from US and Europe
    - a starting point for W3C in defining OWL
    - richer expressivness <-> efficient reasoning ???
    - three sublanguages: OWL Lite, OWL DL and OWL Full
Semantic Web Services

♦ Intelligent, interactive, and automated services that interoperate through the Internet
  ■ perform tasks, provide information, transact business
  ■ important - conducting business faster and more efficiently!

♦ Existing Web services
  ■ discovered and invoked by human users
  ■ rapid growth of information and services on the Web
  ■ problem: finding the service that matches user’s requirements

♦ OWL-S
  ■ OWL-based Service ontology
  ■ provides a core set of markup languages constructs for:
    ● modelling Web services to be machine-interpretable
    ● describing properties and capabilities of Web services
Semantic Web Services - OWL-S service ontology

- Resource
- Service Profile
- Service Model
- Service Grounding

How to access it?
Communication protocol
Port number
Marshalling/Serialization

How it works?
Process flow
Composition hierarchy
Process definition

What it does?
Inputs, Outputs
Preconditions, Effects

Service

How does it work?
How to access it?

Service provides
Service supports
Service presents

Semantic Web Services - OWL-S service ontology
Semantic Web Services - OWL-S Service Model

♦ Three types of processes:
  ■ atomic
  ■ simple
  ■ composite

♦ Control constructs:
  ■ Sequence
  ■ Split
  ■ Split+Join
  ■ Choice
  ■ Any Order
  ■ If-Then-Else
  ■ Iterate
  ■ Repeat-While
  ■ Repeat-Until
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Semantic agents

♦ Agents
  - pieces of software that work autonomously and proactively
  - perform tasks on behalf of a user or other agent

♦ FIPA
  - an international non profit association of companies and organizations for producing standard specifications for agent technology

♦ Intelligent agents
  - incorporate some reasoning or planning

♦ Semantic agents
  - intelligent agents that run on the Web, performing complex tasks on behalf of their users
  - Semantic Web services will be discovered, invoked, composed and monitored automatically by semantic agents
Semantic matchmaking

- **Terminology:**
  - *service requester*  
  - *service provider*  
  - *requested service*  
  - *advertised service*

- Semantically comparing advertised service(s) with the requested service
  - used to find a service that best meets user requirements
  - requires both services to be described in OWL-S
  - based on service process model
  - produces a matching degree (ranking result)
Semantic matchmaking - semantic agent components

OWL-S Matchmaker
  Matchmaking Algorithms

OWL Inference Engine
  OWLJessKB
  Rule-based Engine
    Jess rules encoding semantics
    OWL
    RDF
    XSD

Service query
  OWL-S
  Buyers

Service advertisement
  OWL-S
  Brokers
  Sellers
Semantic agents - Demo (1)

Service request

Select inputs:
- bookmarked landmark
- location on map
- landmark name input
- content topic

Select outputs:
- output landmark name
- geographical map
- current location
- location-aware content

Select target location:
- manually
- automatically

Second screen

Hello! ServiceOfferAgent alan@161.53.19.119:1099/JADE is ready.

Agent alan: sent CFP!
Agent alisa: proposed
Location-aware content delivery
Agent alan: Accepting proposal from responder
alisa@161.53.19.119:1099/JADE
Agent alan: received inform from alisa
Agent alan: service path= http://localhost/ota/midpclientproject.jad

Service requestor agent

Service offerer agent

CFP
- propose/refuse/not-understood
- accept proposal/reject proposal
- inform/failure

install service

semantic matchmaking
Semantic agents - Demo (2)
Demo - OWL-S advertisement of location-aware service
## Demo - Inputs and outputs for service advertisement

<table>
<thead>
<tr>
<th>Atomic Process</th>
<th>Inputs</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retrieve geographical map</td>
<td></td>
<td>geographical map</td>
</tr>
<tr>
<td>Select bookmarked landmark</td>
<td>bookmarked landmark</td>
<td>landmark name</td>
</tr>
<tr>
<td>Mark landmark on map</td>
<td>location on map</td>
<td>landmark name</td>
</tr>
<tr>
<td>Input landmark name</td>
<td>landmark name</td>
<td></td>
</tr>
<tr>
<td>Use detection of current location</td>
<td></td>
<td>current location</td>
</tr>
<tr>
<td>Determine content type</td>
<td>content type</td>
<td></td>
</tr>
<tr>
<td>Subscribe to content</td>
<td></td>
<td>location-aware content</td>
</tr>
</tbody>
</table>
Demo - Agent interaction using FIPA Contract Net

Service requestor agent

Service offerer agent

CFP

propose/refuse/not-understood

accept proposal/reject proposal

inform/failure

install service

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Location-aware content delivery system

- Mobile location-based information service
- Delivers personalized content to mobile users
  - depending on user’s current location, terminal, and preferences
Two users are simulated in Zagreb city area

Set of landmarks:
- Home$_i$
- Work$_i$
- Shopping$_i$
- Recreation$_i$

Subscription types:
- non location-based
- landmark-based
- current location-based
System architecture and deployment

Positioning system
- WLAN access point
- Bluetooth access point
- GPS
- RAN

Location-aware content delivery service
- Status server
- Location server
- Map server
- User profile management
- Content provider
- RMI

User profile management
- Profile repository
- Location repository

City map provider
- Apache Web server
- Joram messaging system

Content provider
- Tomcat servlet container
  - User profile management
  - Location-aware content delivery service
- MySQL server
  - Profile repository
  - Location repository

Service provider
- Mobile network operator
  - Mobile Positioning System
  - Multimedia Message Service Center
- Short Message Service Center

User equipment
- J2ME/MIDP Client application
- Mail server pop.tel.fer.hr

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Prototype implementation

- User profile management

Profile registration

- administrator’s role
- access to the service using a web browser
Client application

- Authentication (by both subscriber and publisher)
Client application

- Menu options

Menu screen
Choose action from Menu!

Menu
1 Define landmark
2 Create content
3 View visited landmarks
4 Subscribe to content
5 Modify contacts & priorities
6 Modify user availability

Timeline

subscriber

publisher

subscriber
Client application - publisher

- Create content action

New content screen
- Select topic:
  - News
  - TV Guide
  - Traffic
- Location-based content
  - Yes
  - No
- Expires: Fri, 08 Apr 11:48:30 A

Add text
Today's news: Traffic jam at the road to Split!

Add image
- motorway.png
- commuters.png
- croydon.png

Preview screen
- Topic: News
- Text: Today's news: Traffic jam at the road to Split!

Image
- Expires: Fri, 08 Apr 11:48:30 A

Menu
- OK
- View image

Back
Client application - subscriber

- Define landmark action

Define Landmark screen

<table>
<thead>
<tr>
<th>Time: Thu Apr 07 13:46:49 CEST 2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longitude: 15 41 18E</td>
</tr>
<tr>
<td>Latitude: 45 40 43N</td>
</tr>
</tbody>
</table>

Landmarks

- Home
- Work
- Shopping
- Recreation

Define Landmark screen

<table>
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Notification Screen

- Landmark= Home
  - Longitude= 15 41 18E
  - Latitude= 45 40 43N

already declared!
Client application - subscriber

- Subscribe to content action
Client application - subscriber

- Modify contacts & priorities action

existing contacts

<table>
<thead>
<tr>
<th>Contacts:</th>
<th>SMS</th>
<th>MMS</th>
<th>e-mail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Priorities:</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

preferred contacts

Select contact:

- MMS
- e-mail
- SMS

Select priority:

- 1
- 2
- 3

Menu

1 Modify
2 Back
Client application - subscriber

- Content delivery

[Images of MMS Player and Location aware content mail delivery: News - Message (Plain Text)]
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Conclusion

♦ an approach for service provisioning in mobile networks using semantic agents is proposed

♦ location-aware content delivery system is presented
  - provisioning of client part - using semantic agents
  - provisioning of server part - using multi-agent system for remote software maintenance and execution
    - http://agents.tel.fer.hr

♦ Future work
  - use camera API for taking photos
  - improve user interface
  - utilize additional positioning technologies
  - scalability
  - add time component to the context
References


Thank You!
Any Questions?

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