A Semantic Enhanced Adaptive Sharable Personalised Spatial Map for Mobile Users

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Outline

- Motivation
- Research Objectives
- Related Work
- Method
- Conclusion
Spatial-Aware Services (SAS)

- SAS adapt services to (1D, 2D or 3D) determined spatial contexts:
  - e.g., Map Services (SAMS): select map centered on current location, etc
  - e.g., Content mark up (photos) with positions
- Pervasive wireless networks combined with mobile devices enable nomadic users to seamlessly access spatial information services, anytime, anywhere.
  - e.g., call routing to mobile users etc.
- Many commercial mainstream, SAMS applications exist, e.g., SatNav systems for vehicle navigation tend to offer generic maps, that are spatial-aware, e.g., relate the current location to a route to the destination
- These SAS tend not to be user (personalised and task) aware & are not semantic, not interoperable with other services.
Motivation: context-aware content adaptation

- Semantic User-aware applications are aware of several aspects:
  - Types of user or application task
  - Social model: privacy vs. shared
  - User Preferences or constraints for the application (personalisation)

- Non user-aware SAMS must either
  - Provide lowest-common denominator (LCD) content
  - Select content, e.g., maybe revenue driven
  - Must combine & include content for a range or all services

- Limitations: these either crowd too much information, much of which is unneeded, a particular problem for low-resource devices, or omit useful content because they adopt a lowest denominator approach.

- User-aware SAMS adapt content to user tasks & user preferences, e.g., content about footbridges for crossing over main roads can be included for pedestrians whereas it can be excluded for motorists.
Motivation: personalised content adaptation

- Different users for the same type of application or user task may use different preferences for viewing content.
- Users may be interested in filtering content that is presented to them, e.g., users may be interested in specific types of building by architecture or by function.
- Users may also prefer to customise the presentation of content, e.g., to include both local names of services and translations of names relative to the visitors’ home language in order to make content more understandable.
- Other preferences may relate to selecting higher quality, highly recommended services from set of possible services.
Motivation: user driven spatial content mark up

- User driven rather than provider driven annotation
- Users often wish to create and store spatial annotations,
  - e.g., good or bad routes to a particular destination
  - e.g., good or bad parking areas, etc.
- To personalise & share live annotations in order to:
  - Create personalised spatial experiences
  - Reuse these spatial experiences, when they revisit an area
  - Share these with others.
Motivation: ICT awareness for mobile users

- Many Web Content services assume:
  - Always on, high enough bandwidth, Internet connections
  - Preset terminal profiles
- But in practice, access device characteristics, & local loop bandwidth, etc, varies
- Need to be able to adapt to ICT infrastructure (ICT awareness)
Objectives

- To dynamically adapt spatial views to users’ spatial tasks, & to users’ preferences
- To allow (mobile) users to create their own markup for content, in situ and to share this within social networks
- To dynamically adapt spatial views to mobile ICT device context
- To support semantic modeling of person context, spatial context, ICT context and interoperability
Survey: personalised location awareness

Web-based systems:
- OGC WPS (Web Processing Service) defines profiles for commonly used processes
- OpenStreetMap: static maps, can be localised not personalised
- Web 2.0: user-driven content shared via Web

Limitations of Web-based systems
- Little strategy for dealing with volatile service access, very common for mobile users
- Are aimed at provider service building blocks, not user task driven.
- Contexts and mark up often not personalised.
OpenStreetMap allows registered users to create user diaries with location information but in a rather simple form.

Freebase provides a strong semantic structure for registered users to create their own types of data that can be shared on the Freebase web. Does not support mobile users, sharing and overlaying the marked up data on a map.

GUIDE project supports non-semantic based on direct input of user preferences.

CRUMPET project: personal profiles derived from mix of persona models with direct and indirect input by users such as observations of where and what users choose to visit - models are not semantic.

No projects are semantic based that enables mobile users to personalise spatial aware information, create and share spatial markup tags, support mobile users.
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Method: Basic System Components

Typical components of SAMS for mobile users are:

- Wireless networked access mobile devices
- Interlinked to a location determination system such as a satellite GPS.
- Interlinked to local or a remote GIS that structures spatial content into layers of spatial objects, enable GIS applications to query and select spatial objects & to build customised spatial views that relate to particular applications and user tasks.
Method: SAMS Design

- SAS system here uses an extension of the CRUMPET system, called USHER (Ubiquitous System Here for Roamers) based upon a three tier client server architecture, which consists of client access devices, client proxy/mediators and generic and application specific spatial services.
- Client calls the Geotools open source map API that supports advanced interactive map services via a client proxy which masks some of the complexity of the map retrieval and adaptation from the client device.
- Map server is based upon a spatial extension of MySQL to store and retrieve spatial data.
- Framework design is based upon:
  - Semantic Web to support rich, personalised and sharable markup
  - Multi-Agent System that supports rich interaction patterns
Method: Spatial Tag Design

- Data structures for the mark-up information contain spatial coordinates, name, privacy field, time created, lifetime.
- Using the privacy field, users can choose to keep the markup private to themselves, to share with others in a designated group or even to mark it up as public so that everyone who subscribes to markup updates can see it.
- *Data storage* design needs to consider how new mark-up data can be automated and self-managed.
- *Filters* are used to select how to exchange new mark-up information according to the privacy field.
- A *lifetime* field can be set (not shown), for use so that filters can also delete out of date information and retain highlighted data designated for permanent storage.
- Users can issue queries to search the mark-up information based upon categories.
- Representations: XML->RDF->OWL
Method: Semantic based modelling for users and their point of interests

- To model users and their point of interests, a semantic ontology model has the advantage of building up a potentially detailed relation between components.

- These allow better management and more precise searching, e.g., user A can search where User B has been, within the constraints of the last seven days and within the vicinity of QMUL, providing user B gives permission.

- Core Ontology Concepts include UserGroup, PointType, MapMode, UserGroup, and User

- Searches on RDF instances use SPARQL.
Method: SAMS Ontology Class & Instance Relations
Method: The Ontology Model of the Point of Interests

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<thead>
<tr>
<th>Name</th>
<th>Cardinality</th>
<th>Type</th>
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<tr>
<td>hasContent</td>
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<tr>
<td>hasLocationX</td>
<td>single</td>
<td>Float</td>
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<tr>
<td>hasLocationY</td>
<td>single</td>
<td>Float</td>
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<tr>
<td>hasModifiedDate</td>
<td>single</td>
<td>Integer</td>
</tr>
<tr>
<td>hasName</td>
<td>required single</td>
<td>String</td>
</tr>
<tr>
<td>hasOwner</td>
<td>required single</td>
<td>Instance of User</td>
</tr>
<tr>
<td>hasType</td>
<td>required multiple</td>
<td>(1:5) Instance of PointType or UserGroup</td>
</tr>
<tr>
<td>isLocked</td>
<td>single</td>
<td>Boolean</td>
</tr>
</tbody>
</table>
Method: RDF Format of An Ontology

Instance of PointOfInterests

```xml
<rdf_:PointOfInterests
    rdf:about="&rdf_;smap2008_Instance_11"
    rdf_:hasContent="has nice meals and drinks"
    rdf_:hasCreatedDate="20080605"
    rdf_:hasLocationX="51.527615"
    rdf_:hasLocationY="-0.051452026"
    rdf_:hasModifiedDate="20080606"
    rdf_:hasName="Good pub"
    rdfs:label="smap2008_Instance_11">
    <rdf_:hasOwner
        rdf:resource="&rdf_;smap2008_Instance_16"/>
    <rdf_:hasType
        rdf:resource="&rdf_;smap2008_Instance_2"/>
</rdf_:PointOfInterests>
```
Method: Interaction Protocols

Multiple Interactions need to be supported

- Request-(Optional Ack)-reply: download content updates
- Notify-whenever condition is true: upload newly created user markup to a remote data server, this then triggers download to any subscribed clients
- Broker: combine multiple services into a single service which is simpler to interact with
- Etc.
Method: ICT Aware Spatial Aware Services

- On higher resource access devices with volatile network connections, some initial map data can be precached onto the access device using a fat client-server architecture but this requires the device to have more application pre-configuration before it can be used.

- On lower resource access devices, thin-client server systems, with a more stable, higher bandwidth, connection, a Web browser client can pull (map) data on demand.

- A variant to handle on demand map access over slower links is oriented to mobile users, normally be interested in a specific area of the map, & just accessing map parts that have changed & is of user interest.
Mobile Service Design: fat client architecture

This deployment architecture has a larger client-side footprint and is suitable for deploying in high end mobile devices and PCs.
Mobile service Design: thin client architecture

This deployment architecture has a very small client-side footprint and is suitable for deploying in low end mobile devices and suitably equipped mobile 'phones.
Initially, map data centered on the user’s current location and their surrounding areas, will be accessed and loaded to the mobile terminal based on the user’s location.

According to the user’s movement direction and distance, new map data will be added and part of the old map data will be deleted to economise local storage space and to keep the user’s current location at the center of the map.

SAMS for Mobile Users
Dynamic map data extracting for moving users
SAMS for Mobile Users

Dynamic map data extracting for moving users

- Current displaying map data
- Current loaded map data
- Old map data to be removed
- User moving direction
- Change of map status
- New Loaded map data
Semantic Based Personalised and Adaptive Spatial Services
Semantic Based Personalised and Adaptive Spatial Services: Pedestrian Mode
Semantic Based Personalised and Adaptive Spatial Services: Driver Mode Map
Conclusion

- Many Spatial aware map services can adapt spatial content to be location aware.

These also need to be:
- Semantic based modelling to support detailed relations between the components to allow better management and more precise searching
- ICT awareness to support mobile users
- User aware (spatial tasks and movements)
- Customisable by end users

Open research questions
- Will a single GIS framework combine support for all sub-types of location-awareness, user-awareness, ICT awareness?
References

  http://www.elec.qmul.ac.uk/people/stefan/ubicom
  - Chapter 1: Vision and Basics Concepts
  - Chapter 2: Applications and Requirements
  - Chapter 3: Smart Devices and Services
  - Chapter 4: Smart Mobile Devices, Device Networks and Smart Cards
  - Chapter 5: Human Computer Interaction
  - Chapter 6: Tagging, Sensing and Controlling
  - Chapter 7: Context-Awareness
  - Chapter 8: Intelligent Systems
  - Chapter 9: Intelligent Interaction
  - Chapter 10: Autonomous Systems and Artificial Life
  - Chapter 11: Ubiquitous Communication Networks
  - Chapter 12: Smart Device Management
  - Chapter 13: Challenges and Outlook