# Adaptive Sharable Personalised Spatial-Aware Map Services for Mobile Users

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**Abstract.** Geospatial-aware services which combine maps with location determination are now mainstream tools to enable various assets to be located and tracked with respect to destinations and routes. Current mainstream geospatial services for mobile users tend to lack support for many aspects of personalisation, to enable users to set preferences to select content, and to mark up a map in situ, e.g., to remember short-cuts, good parking spaces, etc. These services also lack provision to enable such tagged personal spaces to be extended to operate within shared social spaces. An interactive map service that adapts to personal preferences and that supports persistent and sharable mark-up entered in situ, have been developed and tested in a demonstrator.

## 1 PERSONALISED MAP SERVICES

Spatial-Aware Map Services (SAMS) are now mainstream applications used to locate and track mobile users and business assets. Pervasive, portable, networked, devices enable nomadic users to seamlessly access spatial information services, anytime, anywhere. Typical components of SAMS are wireless networked access mobile devices, interlinked to local or a remote Geograhic Information System (GIS) and interlinked to a location determination system such as a satellite based Global Positioning System (GPS). Many commercial SAMS applications such as SatNav systems for vehicle navigation tend to offer generic maps, that are location-aware, e.g., they are centered around the current location, but these tend not to be user, (personalised and application) aware.

A user-aware application is aware of two main aspects of the user, the type of user or application task and the preferences of the user or constraints of the application. Non application-aware SAMS must either provide lowest-common denominator content or must combine content for a variety of services, These approaches either crowd too much information, much of which is unneeded and is a particular problem for low-resource devices, or omits useful content because it adopts a lowest denominator approach. In contrast application-aware SAMS adapt content to the application and to the user task, e.g., content about footbridges for crossing over main roads can be included for pedestrians whereas it can be excluded for motorists. GISs that structure spatial content into layers of spatial objects enable GIS applications to query and select spatial objects and then to build customised spatial views that relate to particular applications and user tasks.

Different users for the same type of application or user task may use different preferences. 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 any translations of names relative to the visitors' home language in order to make content more understandable to users. Other preferences may relate to selecting higher quality, highly recommended services from the set of all possible services.

Users often wish to create and store spatial annotations, e.g., good or bad routes to a particular destination and good or bad parking areas which they directly experience, in the field, in order to reuse these spatial experiences, when they revisit an area and to share these with others.

The objectives of this research are to develop and demonstrate a system to adapt spatial content for mobile users to the user task and to users' preferences and to allow users to create their own markup for content in the physical environment and to share these.

## 2 RELATED WORK

Personalised spatial aware services for mobile users have been investigated by several researchers. The main motivation is that personalisation can act as an additional filter to the location to retrieve information. The GUIDE project (Cheverst et al., 2000) supports direct input of user preferences. In the CRUMPET project, personal profiles are specified by combining a mix of persona models with direct and indirect input by the user such as observations of where and what users choose visit (Poslad et al., 2001). AmbieSense project situates each user task within a use-case using case-based reasoning and location-awareness in order to make user recommendations (Göker and Myrhaug, 2002). RECO (Pignotti et al, 2004) is similar to AmbieSense but instead of using case-based reasoning, situates each user task within a sequence, by learning a user's preferences over time, in order to make user recommendations. However, none of these projects also enables mobile users to also personalise information through creating and sharing their spatial markup information to enhance the personalisation model – this is the main aim of this research paper.

## 3 PERSONALISED SAMS APPLICATION

The architecture of the personalised application uses an extension of the CRUMPET system called USHER (Titkov et al., 2006) based upon a three tier client server architecture, which consists of the client access device, client proxy/mediator and provider services. The implementation of the map server is based upon a spatial extension of MySQL[1] to store and retrieve spatial data. The client calls the Geotools[2] 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. The map demonstrator uses GIS content based on the Queen Mary, University of London Mile End campus and surrounding areas. These spatial services are

### 3.1 Personalised and Adaptive Spatial Map Service

The SAMS system of USHER used in this demonstrator requires user input to construct the user profile. Different user profiles can be initialised with different pre-defined stereotypes at the beginning of the interaction. These can then be adapted to the individuals. In the user profile, preferences can be set for: the travel mode, e.g., pedestrian or driving; the types of sights of interest to the user, e.g., the *New Global pub*, the display preferences, e.g. using different colours for different GIS objects and different symbols for different types of user mark-up information, etc.

The demonstrator in Figure 1 shows a mobile user using the pedestrian mode map which has been personalised with their profile. When the pedestrian travel and various sights is set in the user's preference, the map filters and displays the information in the locality, accordingly. Figure 2 displays the map results when the vehicle travel prefence has been set. It displays the route between two places, e.g., from *EE* to *W J Meade*, in the map for user B. In the driving mode, the map focusses on the road information, and objects that are found along the road.

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[1] MySQL Spatial Extension: http://dev.mysql.com/doc/refman/5.0/en/spatial-extensions.html
[2] Geotools The open source Java GIS toolkit: http://geotools.codehaus.org

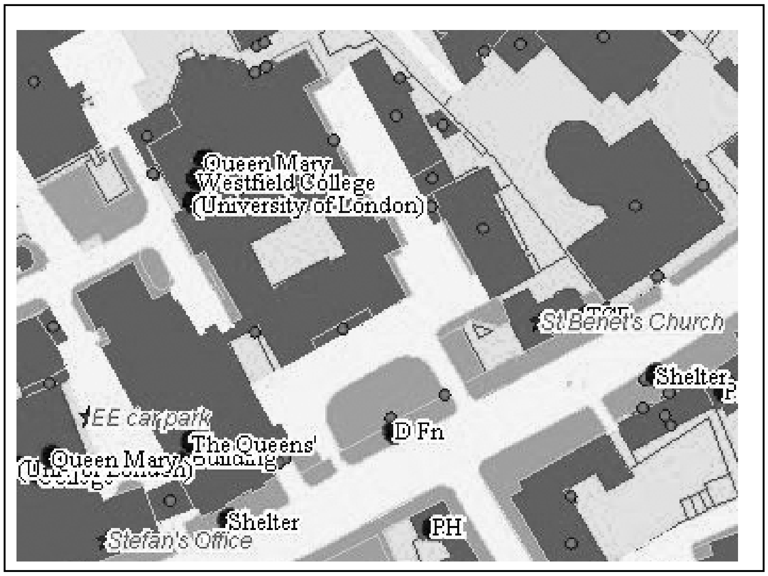


Figure 1: Mobile User A‘s pedestrian mode map

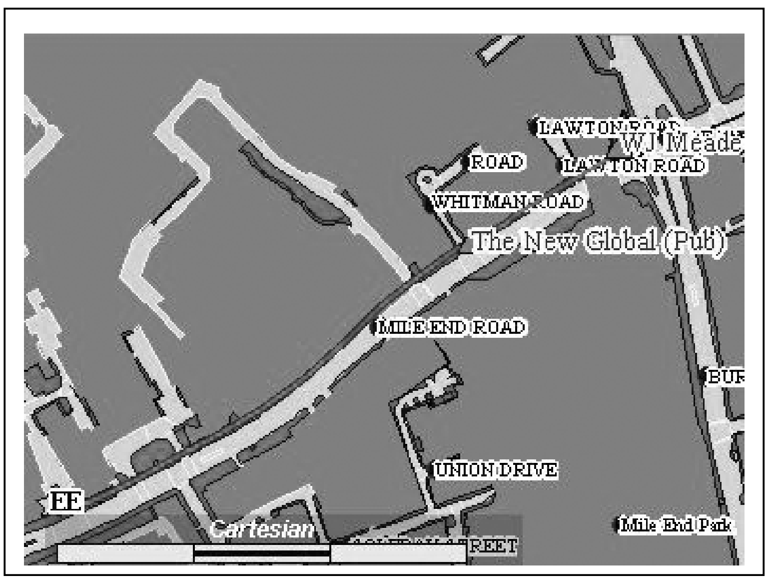


Figure 2: Mobile User B‘s driver mode map

## 3.2 Location-Aware Map Adaptation

On higher resource access devices with volatile network connections some inital 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. Whereas when using a lower resource access device and thin-client server system, with a more stable, higher bandwidth, connection, a Web browser client can pull (map) data on demand (Poslad and Charlton, 2008). A variant to handle on demand map access over slower links is oriented to mobile users who will normally be interested in a a specific area of the map, just accessing the map part that has changed and is of user interest.

Figure 3 shows map adaptation for moving users. 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.

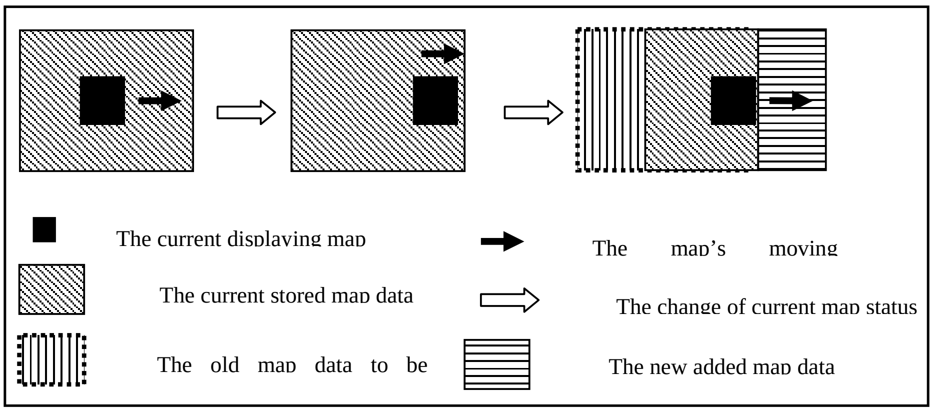


Figure 3: Dynamic map data extracting for moving users

### 3.3 Mobile User Map Markup and Management

Examples of some mark-up information are shown in the two users' maps, (Figure 1 and Figure 2). Individual users can use different symbols and colors to customise their own maps to make them more understandable to the individual user, e.g. mobile user B uses different shapes to represent different types of information on the map in Figure 1. Moreover, shared information can be accessed on the map by others, e.g. User A can access the reference points *EE car park* and *St Benet's Church* which are created and shared by another user for the map in Figure 2.

The structure of the mark-up information is given in Figure 4. It contains the information's coordinates in the spatial map, the name, a privacy field and the content. 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.

| Field | Type | Null | Key | Default | Extra |
|---|---|---|---|---|---|
| gid | int(8) | | PRI | | auto_increment |
| uid | int(8) | | MUL | 0 | |
| published | int(1) | | | 0 | |
| the_geom | point | YES | | | |
| pname | varchar(50) | YES | | | |
| pdesc | varchar(250) | YES | | | |

Figure 4: User-created map mark-up data structure.

Data storage design needs to consider how new markup data can be self-managed. Filters are used to select how to exchange new markup information according to the privacy field. A time of life field can be set (not shown), for use so that filters can also delete out of date information and retained highlighted data designated for permanent storage. Users can also issue queries to search the mark-up information based upon category.

Interaction protocols are specified to support uploading of newly created user markup to a remote data server and to allow multiple users to subscribe to selected markup updates.

## 4 CONCLUSION

Existing spatial aware map services can adapt spatial content for mobile users to the user task, to users' preferences and to access device characteristics. An extension to this existing personalisation model has been proposed to allow users to create their own personalised markup for content in the physical environment and to share these.

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