mSpace Mobile: A Mobile Application for the Semantic Web

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Abstract. mSpace Mobile is an application that provides access to location-based information while on the move. Especially applicable to those unfamiliar with their surroundings, the application provides information about topics of chosen interest, based upon the location, as determined by an optional GPS receiver. Described below are both the context+zoom user interface and the abstracted, layered, system architecture that allows for such access to information stored the Semantic Web.

1 Introduction

mSpace Mobile is a Semantic Web application that lets people explore the world around them by leveraging contexts that are meaningful to them in time, space and subject. Someone in an unfamiliar city, say London, for example, may find their physical location to be the main context around which they wish all other queries to circulate – queries like "where is a cinema near by showing the films I said I'd like to see; and where are sushi restaurants nearby that, so I can have dinner before the movie? In the meantime, what historical sites are around me right here, and are any near good coffee, or where my trusted source said I could get a good local beer?" Currently, such queries would have to be managed one at a time with a search engine; another application would need to be available to copy and paste times, places and locations. Multiple maps would need to be available to support compound queries like "show me restaurants and cinemas."

The mSpace Mobile application (Fig. 1) combines an innovative interface and architecture to support ready exploration of rich information spaces. Rather than forcing iterative, discrete keyword queries, it maintains the context of associated information while supporting the rapid exploration of a wide variety of semantically associated sources. It utilises the mSpace Software Framework [1], which supports the coordination and representation of distributed semantically associated resources. Further, the application supports the lightweight publication of new information: comments, annotations and recommendations can be semantically published on any element discovered through the interface; as well as reused by any other Semantic

Web applications and services. In these respects mSpace Mobile's use of Semantic Web technologies provides an effective information exploration experience while also contributing to the growth of knowledge stores for the Semantic Web.

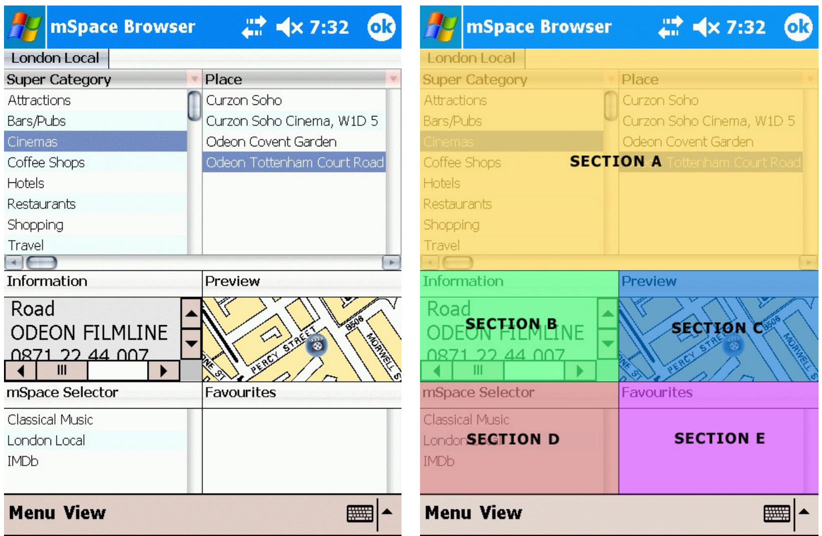


Fig. 1. There are five features within the user interface: A – the columnar mSpace browser; B – the information box; C – a preview cup map; D – an mSpace selector and E – a favourites list.

In the sections below, we describe the application in terms of its functionality, user interface and supporting architecture. Related work is discussed throughout the paper.

2 mSpace Application

The mSpace Mobile application features three core components: (1) a custom small-screen specific interface (Fig. 1) to support the mSpace interaction model [2] for contextual exploration of large information spaces, (2) the mSpace framework to support coordination of distributed semantic web resources and (3) location awareness. This combination means that physical location, a critical variable in mobile activities, can be used as an additional context to support exploration of associated information resources. While the approach is generic, we describe the features in terms of a specific embodiment: the mSpace Mobile London demonstrator.

The mSpace approach looks at an information space as a domain with dimensions. In the case of the mSpace Mobile application demonstrator, London is the domain, and some of the main dimensions are Cinemas, Restaurants, Public Transportation, Places of Interest and History. We use the location of the mobile device to act as a primary context and a map as a core reference point for associating information from dimensions.

There have been a variety of travel-oriented, location aware mobile applications, including the City Wide project from Equator [3] and CRUMPET [4] to name two. Information for these applications (and most other applications in the tourist/travel space) is stored and controlled by one source, one service. It is important to note that mSpace Mobile, in contrast, is an effort to work at "web scale" - to associate resources distributed across the Web. There are numerous Web sources of data used within the mSpace Mobile application such as the Open Guide to London[1] - which publishes semantic information through RDF for all of its London related information.

Another distinction between mSpace Mobile and the tourist/traveller applications is that while location acts as the default context for presenting information, location is not the only context. For instance, a person can move easily from the context of Albert Hall as a location and related information about what is playing there to a new context focusing on the composer, where the emphasis becomes to explore the composer's music, or the music of the composer's contemporaries, to samples of the music, to another new context like the history of the period in which the pieces were composed. In other words, mSpace mobile is designed to support the context and focus of interest for the person using the application.

Below we describe both the mSpace Mobile interaction and architecture that supports these context-based transitions through information.

2.1 User Interface

The mSpace Mobile interface is designed to let users of small screen devices run complex queries through direct manipulation – no typing required. To this end, the application utilises the primary features of the mSpace interaction model. The 5 key features of the mSpace interaction model are:

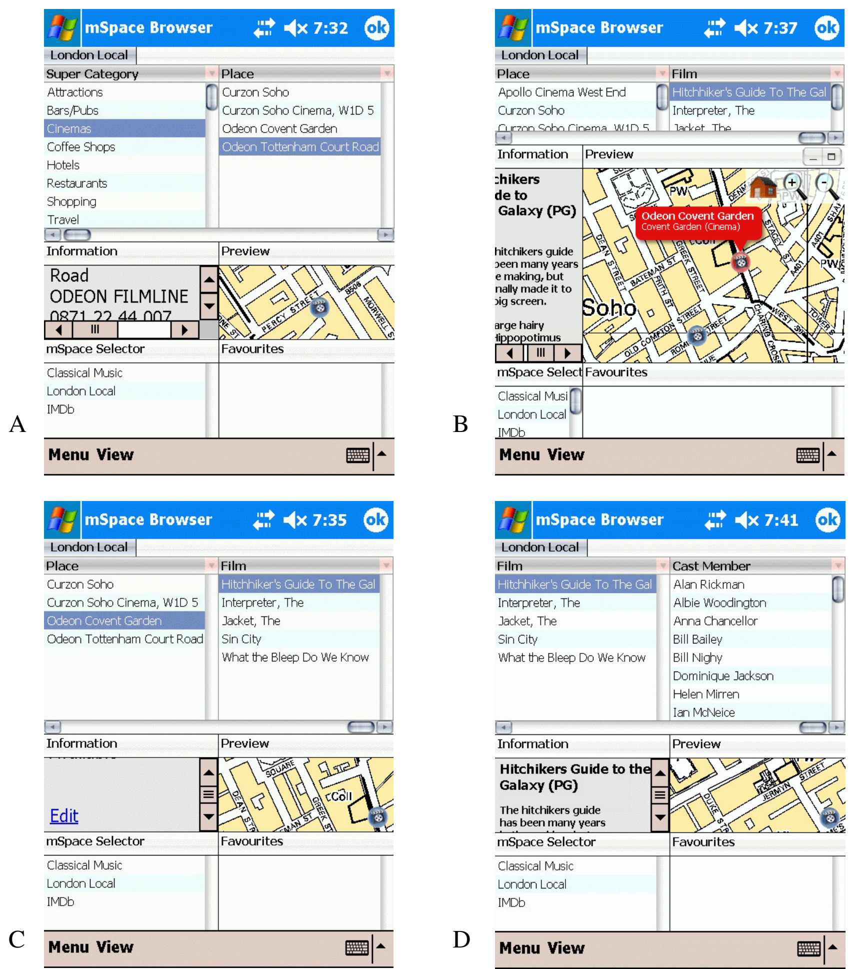
- A spatial browser, maintaining persistent display of domain dimensions, for browsing information within a domain
- User-determined organization of dimensions presented: they can be added, removed and swapped.
- Information area, providing contextual information about selected items in the column browser
- Preview cues [5], which provide typical examples of information within a domain
- Triage area, allowing the user to save items from the domain that are of particular interest for further exploration in the future.

The mSpace approach does not primarily attempt to display web pages. Rather, the spatial browser (Fig. 1 A) acts as a kind of *facetted browser* [6-8] which foregrounds presentation of the metadata about entities, rather than the entities themselves, first.

[1] http://london.openguides.org – The Open Guide to London

Each of these columns represents dimensions from the current domain, as mentioned above. This part of the UI is larger than the others because of the constant focus and interaction with the columns.

The rationale for this approach has been discussed elsewhere [9, 10] but suffice it to say that the multicolumn approach supports two critical attributes: persistent context of information surrounding current selection; persistent view of path through the information. In other words, a rich context is maintained. A person is able to rely more on recognising what is currently available in the interface than having to recall what was previously selected – using a web browser to follow numerous links from a Google search to a cinema website, its films and then to film reviews, means losing the context of your original Google search. Returning to Google's search results, users then have to recall cinemas that were showing the film they wanted to see. Recognition, we know, reduces cognitive load on task performance over recollection.



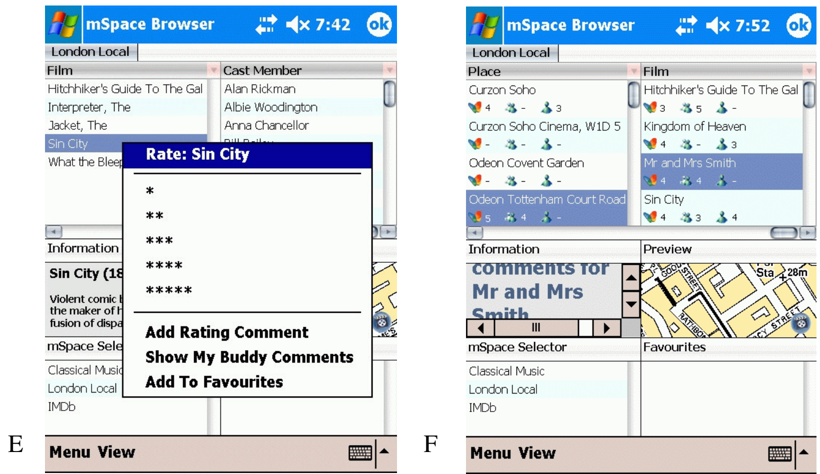


Fig. 2. Six screens from a developing scenario – browsing for cinemas and films. A – The user views a list of cinemas and their location is shown on the map. B – This map can be expanded. C – The user then sees a list of films on at the cinema. D – These actors in these films can be explored through an associative link to an alternative domain. E – Any entity, including the film Sin City, can be rated through the simple UI. F – These and the ratings of others can be explored in an alternative mode.

Using mSpace Mobile to explore the cinema scenario (Fig. 2), the multicolumn browser allows the user filter through the local location information to find instances of both Japanese restaurants and cinemas showing a particular film (Fig. 2 A); these appear on the map (Fig. 2 B). Alternatively the user could move the movie column to before the cinema and start with the film they wish to see; the cinemas showing this film would be listed and shown on the map. With Japanese restaurants also showing on the same map, it would be clear to see an appropriate solution for the problem described in the introduction.

As selections are made in each column, contextual information is displayed in the Information box (Fig. 1 B, seen throughout Fig. 2); when a particular film has been selected - listing related actors (Fig. 2 D) - the cinema's website may be shown here. Figure 1 E shows the Favourites list, used for persistent storage and triage of important items; possible cinemas and Japanese restaurants can be dragged here for later attention, so that the user can quickly view their locations on the map.

2.3 The mSpace Fisheye Interface: Focus+Context Techniques

Our challenge in wanting to maintain the cognitive values afforded by a spatial layout is how to create this kind of view in a small screen. The result is a combination of Focus+Context techniques to support user-determined focus while maintaining persistent context. There have been many examples of Focus+Context techniques being applied to classical user interface tasks [11, 12], however there has been less research into the use of these techniques in the mobile application field, with one notable exception, DateLens [13] - an application that has taken the fisheye lens Focus+Context technique and used it to improve contextual awareness of surrounding calendar events. Developed for small screens, it enables animated compression and expansion of areas within the calendar. The mSpace Mobile application, in a similar way to DateLens, uses a three level zoom fisheye lens technique to provide a contextual overview of each section of the UI, and the ability to focus in on each section individually (Fig. 3). This interaction can be viewed in the brief mSpace Mobile video[2].

A B C

Fig. 3. The 'mSpace: Where Am I?' zooming interface: A – basic starting layout. B – The zooming panels can be individually expanded. C – A zooming panel in full-screen mode. The user determines degree of context visible, but context is persistently recoverable.

2.4 Map as Additional Coordinating Context

In the Where Am I application, mSpace Mobile uses the map as a supplemental view of the context of currently selected information (Fig. 1 C). It is a location-oriented display summary of current selections in the interface in the same way that the information box is a textual display/summary of the current selections. This is the location-aware implementation of Preview Cues; the location can be set manually or through GPS. Different cinemas would show within the multicolumn browser as constrained by the current bounds of the map; as the map has expanded in Figure 2 B, it includes the extra option of 'Apollo Cinema West End' over Figure 2 A.

[2] http://mspace.fm/mobile/mov/mspace-mobile-montage.mov

2.5 Local Ratings/Extended Trust

mSpace Mobile supports a variety of lightweight preview, annotation and recommendation mechanisms to support decision making while exploring information. For the cinema-going user, the information pane provides descriptions of the different cinemas; including textual descriptions, images and/or multimedia (Fig.1 B). Whereas the information box is populated on the click/selection of the cinema, a preview cue is triggered by brushing the cursor over a preview cue icon by the cinema. Preview cues [14] specifically associate multimedia samples of an area of a dimension for inspection. For instance, if viewing movie genres, preview cues of Film Noir would make one or more trailers of film noir films available for rapid inspection. These previews help a person determine whether or not this kind of film is of interest for further exploration.

As an additional context for decision-making support, mSpace Mobile also supports comments and recommendations. A lightweight publishing method lets users add ratings or comments to any item – such as cinema, film or actor - in just a few clicks; Figure 2 E illustrates the ability to rate a film. These annotations are stored semantically and become available instantly to all other users who are browsing the knowledge base. mSpace Mobile takes a dual view to recommendations: it enables anonymous ratings by anyone using the knowledge bases to be viewed; it also supports user 'buddy' lists, containing people that they trust, or have similar tastes. Along with the ratings and comments of the community, the view of the user's 'buddies' can be shown simultaneously; Figure 2 F shows community, buddy and user ratings given for a set of cinemas and films.

2.6 Exploring Multiple Domains

The user interface, along with the back end architecture described in Section 3, facilitates the exploration of multiple domains of information and the relationships between them. These connections facilitate movement from one domain of interest (like London places, including cinemas) to another, (like movies). The mSpace selector component of the application (Fig. 1 D) is used to provide a list of alternative domains of information that are relevant to the current domain and the current selection within that domain. By selecting columns from a related domain, a user could then browse the actors from a particular film using the IMDB knowledge base (Fig. 2 D); the user is still connected to the original context of London.

While the connection between a selected film and the IMDB mSpace is apparent, the semantic relationships in the data can be used to introduce the user to more subtle links. If the user was again browsing films at a local cinema within the London services domain, or within the IMDB domain and they came across the Film 'Wimbledon', the semantic relationship would expose the link between this film and the sport tennis, more specifically the Wimbledon grand slam tournament. If there was an available information repository dealing with tennis related subjects then the user would be able to see this within the mSpace selector. If Wimbledon itself was currently in progress, that information would also be found in a local events area.

3 System Architecture

Above we discussed the need to function at web-scale, where the user can seamlessly flow between domains. To make these associative leaps, we need to be able to draw across multiple sources. The architecture described below is designed to query multiple triplestores, as well as support incorporation of resources, which may not yet be referenced in triplestores. Specifically, we allow the user to select their source of information through the system interface.

3.1 The Architecture Layers

The proposed system abstracts the internal concepts of query generation and triplestore querying in order to distribute the system, taking load away from low-power mobile devices. This allows multiple heterogeneous and distributed external data sources to be browsed from one mSpace Mobile device, under one view. Specifically, we have developed a three-layer architecture: The mSpace Mobile application (MA) queries the mSpace Query Service (MQ), which is connected to RDF triplestore knowledge interfaces (MK).

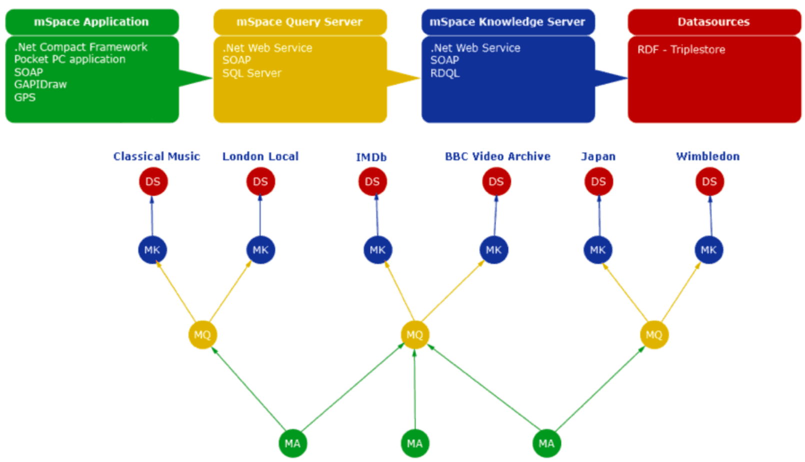


Fig. 4. mSpace Architecture of MA, MQ, MK layers

The MK makes it possible and tractable to use a WWW approach to data provision: to have multiple providers that remain controlled separately. The approach also supports other Web features like author-linking of resources, ease of creation of new data, simple distribution and user chosen data sources. The MK approach provides a generic interface to knowledge with a protocol that maps onto any triplestore implementation.

In order to allow client software to be written for multiple platforms, and to facilitate the use of the mSpace querying architecture, the concept of the client is described in the architecture as a generic mSpace Application (MA). These are separated from querying operations, which are translated to an mSpace Query Service (MQ). In order to: facilitate maximal compatibility among possible (Semantic) Web applications; enable applications to interact with this service easily, and to keeps the complexity of the protocol low, two specific access methods**,** Simple Object Access Protocol (SOAP) and HTTP, are used for the communication between the MA and the MQ. Hypertext Transfer Protocol (HTTP) is the core protocol for the Web and Web communication. SOAP is the open communication protocol for Web Services. Using SOAP/HTTP allows all servers to be accessible on the Web as Web Services for maximum compatibility and interoperability.

The MA communicates initially with the MQ, which acts as a broker (or, effectively, a distributed link-base), with knowledge of domains and of relevant mSpace Knowledge Services (MKs). The MA concept is designed such that the application can take any form that can implement the communication protocol. In this structure, the MKs communicate with the MA *after* consultation with an MQ. An MK is the equivalent of the triplestore in the current mSpace implementation, and in the case of initial implementations, the MK communicates via HTTP-RDQL with a 3store triplestore. The immediate purpose of the MK, once discovered by the MQ as an appropriate repository, is therefore to construct an RDQL query using constraining triples that are specified by the MA.

The equivalent of this to the WWW is that for a current affairs service, you might go to BBC News, who have aggregated content from their own reporters, as well as their own choice of articles from Associated Press, Reuters and more. The choice to select a particular news site such as BBC News is that of the person. Similarly, if one wanted to get information about a place to eat, they may visit a general-purpose local information supplier (such as Thomson Local) or a domain-specific restaurant guide. The same applies for the MQ model; the choice of MQ determines the content. This is equivalent to the ability to choose what links you have on your WWW site, making the information relevant, as well as preventing an information overload scenario. The key to this is that the client queries the MQ and as such, the client is only aware of the links provided by the MQ.

4 Future Work

4.1 Data Sources

We have used a variety of sources for the mSpace London demonstrator. One premium source is the Open Guide to London [15], which is creating localized information on London; for future development, the Open Guide network extends to other cities and countries. The information produced on a page can be freely updated by anyone, so that as people experience London, they can share their views publicly.

This information is stored semantically through RDF and has been used by the mSpace project as an example knowledge base; this is an example of an existing knowledge base that we expect to become increasingly common as the widespread adoption of the Semantic Web develops. Other sources we have used have been converted from available XML, or screen-scraped, into RDF.

For the Semantic Web to have widespread adoption with Web users, it must be easy to create and publish Semantic Web resources. Projects such as Piggy Bank, a FireFox[3] extension, [16] are working on this part of the equation by distributing a complex screen scraping module and converting it to RDF. As websites are browsed, pages can be 'captured' by request of the user and held semantically. This information, initially stored locally, can be viewed using a faceted browser taken from the sister project Haystack [17]. However, the information can be published onto servers, using the Piggy Bank server side companion, Semantic Bank[4], which allows the material to be accessed by the wider community. We are working on an addition to Semantic Bank so that it can also broadcast its resources as an MK. Indeed a mission critical part of the architecture in general is to make it easy for any triplestore to be automatically detectable as an MK.

4.2 Trust

One of our primary considerations for the project is the inclusion of concepts such as trust. Trust is a concept that is concerned with both the credibility and the reliability of information. Reliability could be provided by corporate status: information provided by the government or through sources such as the BBC might be considered both reliable and credible. Estimating reliability may be affected both an estimation of expertise, or even by humour and temperament. Here, mSpace is concerned assisting this calculation of trust as users browse seamlessly between knowledge sources and when reading recommendations from friends.

To address this problem, mSpace is planning a collaborative study with Jennifer Golbeck at the Mind Lab, University of Maryland to expand on her work in FilmTrust[5]. In FilmTrust, the project is concerned with the end user's confidence in film recommendations, based upon semantic Friend of a Friend (FOAF) networks [18]. In collaboration we expect to draw upon the principles for anything that users experience through mSpace and mSpace Mobile applications.

4.3 Real Mobility

The mobile application needs to communicate with servers in order to be updated; a network connection needs to be available in order to do this. With the introduction of GPRS and 3G capabilities, this - even multimedia transfer - is becoming increasingly feasible while on the move. Further, a number of projects are looking towards open-wireless networks and so it is our belief that this will be even less of a

[3] http://www.firefox.com – FireFox.com
[4] http://simile.mit.edu/semantic-bank/ - Semantic Bank
[5] http://trust.mindswap.org/FilmTrust/ - FilmTrust

problem in the near future [19]. Therefore, we are concerned mainly with the distribution of workload across the architecture. As mentioned above, our architecture already allows for the complex query processing to be distributed away from the mobile device, giving the workload to powerful MQ servers. However, we must still transfer media, such as maps, preview cues and information-box content to the user. Preliminary versions of the software include minor caches, yet there is still limited power on handheld devices. In future versions we wish to streamline our transfer protocols by exploring bandwidth-determined transfer of resources, as well as utilizing periods of low transfer in high-bandwidth areas.

5 Conclusions

In this paper we have presented the mSpace Mobile application for easy exploration of compound queries via small screen devices; end user interactions have been illustrated through a developing scenario. In this application, we have extended the existing mSpace Software Framework to include the obviously relevant additional context of physical location/location-awareness. Persistent context of the information explored is provided to encourage the seamless exploration of associated domains, while supporting publication of annotations on that material in Semantic Web form. mSpace Mobile is able to present these associations because it uses Semantic Web protocols which foreground relationships within information spaces.

This application demonstrates three main contributions to the Semantic Web. First, a framework has been developed to provide effective access to the Semantic Web for many applications and users, including those on the move. Second, a novel user interface has been developed in order to allow persistent context and exploration of information on a small screen. Finally, mSpace Mobile supports the lightweight publication of new information, contributing to the growth of reusable knowledge stores on the Semantic Web.

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