

Location Aware Mobile Cooperation-Design and System

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Abstract

With the development of mobile technology, Internet and GIS, LBS plays an important role in various applications. In this paper, we present our work on this area. The LaMOC's system, a location based mobile spatial cooperative system with cooperative and spatial group decision supported characters, developed by ICA-ECNU is presented. LaMOC is a Location Based System, a Mobile Cooperative System and a Spatial Group Decision Support System. A map based co-browser is designed as user interface. The design of the LaMOC, its system architecture, user interface, and key issues are discussed here.

Keywords: *LBS, mobile Collaboration, map based browser, context awareness, Spatial Group Decision Support*

1. Introduction

Now it is a fast developing era. ICT evolves rapidly. Especially, fixed network based communication is more and more replaced by mobile communication. Geographic Information System (GIS) is now evolved to Web GIS. Mobile Internet attracts more users than traditional Internet. These techniques converge to a new area-Location Based Service (LBS), as shown in Figure 1. [1,2]

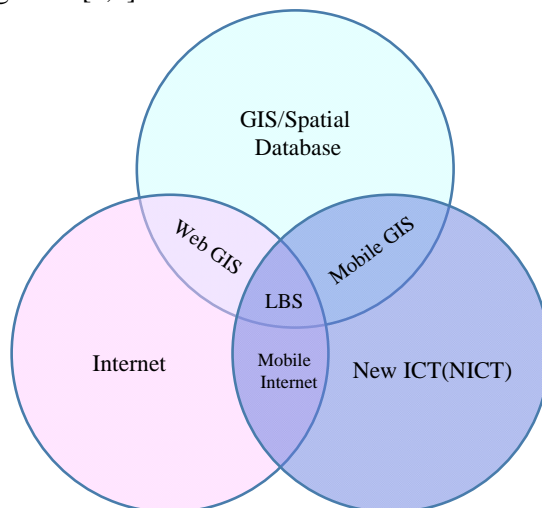


Figure 1. Location based service

¹ Location Aware Mobile Cooperative System-The work is supported by Shanghai Science & Technology Development Funds, with the Grant No. 075107006 and 09510703000.

While designing a wireless infrastructure which has to support LBS, there are some issues in mobile environment must be taken into account, such as:

1. The service has to provide various kinds of information, covering different geographic regions, and coming from different sources;
2. The service has to provide dynamic information;
3. Interoperability of different LBS components must be well managed;
4. Mobile terminals have limited memory, limited computational power, limited screen size and resolution;
5. The characters about mobile networks must be considered carefully also, such as having highly cost, limited bandwidth, high latency, low connection stability and low availability.

ExPo2010 will be held in Shanghai from 1. May 2010 to 31. Oct. 2010. Nearly 70 million (on an average, 400 thousands everyday) visitors will come to the Expo village which is in an about 5.28 km² area. They are often grouped, in family, pair, as well as in tourist group. It is a big challenge to efficiently guide such a huge number of visitors according to their actual locations, distribution, visit plans, as well as exhibition programs of ExPo2010. This is a sample scenario of LaMOC.

Besides inherent problems appearing respectively in Mobile Internet, Web GIS and Mobile GIS, as their harmonizing, LBS meets more challenges. A lot of problems should be solved, such as how to realize adaptive positioning, how to converge the actual position with GIS, how to atone for inherent shortcomings of mobile computing, how to use background systems to counteract the weaknesses of mobile terminals, etc. Furthermore, there is a demand about location based mobile cooperation. Mobile cooperation of a group results in some new problems, such as, collaborative model changes dynamically accompanied with changes of users' locations. Especially it is hard to estimate, determine and make decision, when users in moving. Related systems should have characters such as context aware and adaptive react to changes of context [3, 5].

Therefore, LaMOC is focused on: minimizing user's efforts to access information in moving, being aware of environmental conditions and users' activities, offering natural interaction techniques, visualizing relevant information in 2D/3D maps on small screen effectively, and mobile cooperation of group users. In short, main challenges met by us: mobile computing and context awareness, on demand mapping and visualizing geographic (in short, Geo) data on small screen, spatial decision support, mobile cooperation, etc.

The paper is organized as follows: Section 2 is about the scenario based design and development; Section 3 presents LaMOC system; some key issues solved in LaMOC are discussed in Section 4.

2. Design and Development of LaMOC

Various kinds of services should be provided by LaMOC. Each should be deeply analyzed. The key analysis and design technique in LaMOC is the scenario-based design and development approach, as shown in Figure 2.

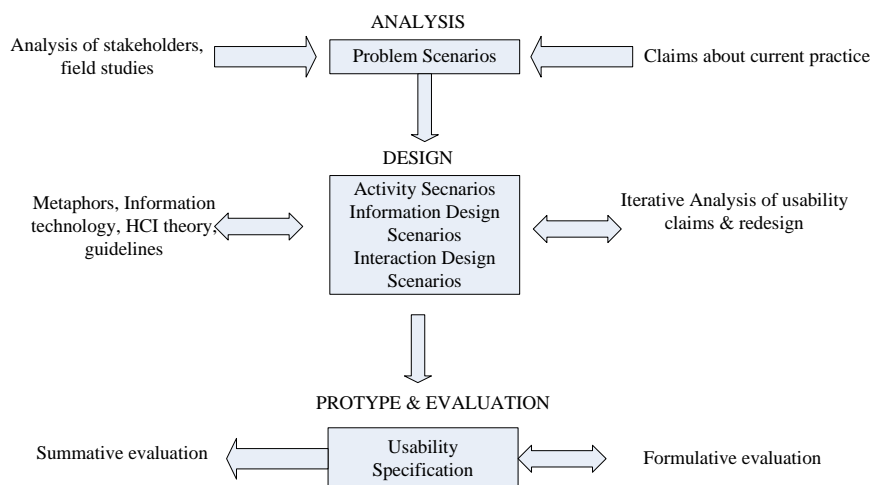


Figure 2. Scenario-based frameworks [4]

There are three phases as in Figure 2, i.e. ANALYSIS phase, DESIGN phase, and PROTOTYPE & EVALUATION phase respectively. The first phase (ANALYSIS phase) is scenario analysis. During the development, we consider five kinds of scenarios in LaMOC system

Scenario 1 User sessions begin and end, i.e. user Login/Logout. LaMOC users should log in before using the system, and log out when the end of the session. As soon as user logged in, a personalized map will be shown on his/her mobile device.

Scenario 2 Information Retrieval- LaMOC has facilities for Yellow Page retrieval; location based information retrieval (IR); Internet based information retrieval and intelligent (context aware) IR.

Location based IR service in LaMOC means that it can answer user's questions based his/her actual location, such as:

- Where am I now?*
- Who are near me now?*
- Is there any friend just near me?*

Another information service in the LaMOC system is the context aware IR. It means that responses from LaMOC are personalized, environment adaptive and user-oriented.

Scenario 3 Group application

Considering such a scenario: a group of users work together, but they distribute in different places, to achieve a common target, such as to muster at a determined time, to select an optimal mustering site, to select an optimal route to arrive there in time, etc. Or a group of people communicates on line to share information. Participants here are distributed and mobile, i.e. their locations change during a session.

Scenario 4 Map based browsing

A map based browser is the main user interface of LaMOC. It's a map based co-browser, i.e. users in same group share information with the browser. Each user navigates on a personalized map, where his/her location is centralized.

Users can click an icon on the map to dial (make a phone call), click an icon to SMS (send a short message), as well as click an icon to IM (Instant Message).

Scenario 5 Location based application

In this kind of scenarios, a user can query based on his/her location, such as to find a favorite restaurant near himself/herself just now, the nearest metro station, or the best route to arrive the target place.

And these services can be extended to a group, such as, to find a favorite restaurant for five distributed members of a group, or to find the nearest appropriate service zone on highway for three cars just on the way.

The second phase in Figure 2 is the DESIGN Phase. During this phase, problem scenarios are studied.

The main problem scenarios met by us are: On-demand mapping, Context awareness, Mobile collaboration and others.

About the On-demand mapping, we focus on dynamic location based mapping, narrow band map data transmission, smart small display screen display mechanism, etc. On-demand mapping enable users to define contents by themselves, as well as coverage, scale and visual appearance of the requested products. Approaches such as on-demand mapping, real-time and object-oriented generalization of the content of geo-databases may be used to address the challenge of better delivering the location-related information to mobile users.

About the Context awareness, we try to answer some questions, such as: how to capture position information of clients? How to get parameters of mobile devices automatically? How to get user profile as well as group profile? How to get behavior information of individual user and group? What is the meaning of the captured context?

About the Mobile collaboration, we consider challenges such as: the dynamic change of the group organization structure, communication model, as well as collaborative mechanism. And it should answer how to react to the change.

During the DESIGN Phase, Activity scenarios are analyzed are, such as: creating group, active group, running a session, etc.

Then, a prototype of LaMOC is developed, as follows.

3. The LaMOC System

3.1. The Architecture of LaMOC

LaMOC is a mobile computing system, actually a hybrid environment, as shown in Figure 3. Three layers appear in LaMOC: fixed hosts (FH), mobile support stations (MSS), and Mobile hosts (MH). Here, FH contains the computing devices, such as PC desktops, servers, etc. Databases are active on servers, to supply reliable data services. MH means laptops, smart phones, PDAs etc. Huge differences appear in such mobile hosts, either in computing power, or the duration of the battery. The layer connecting FH and MH is MSS. In LaMOC the IP channel based on GPRS/CDMA/WiFi or 3G is used. A web gateway works as a portal to link mobile systems and fixed systems.

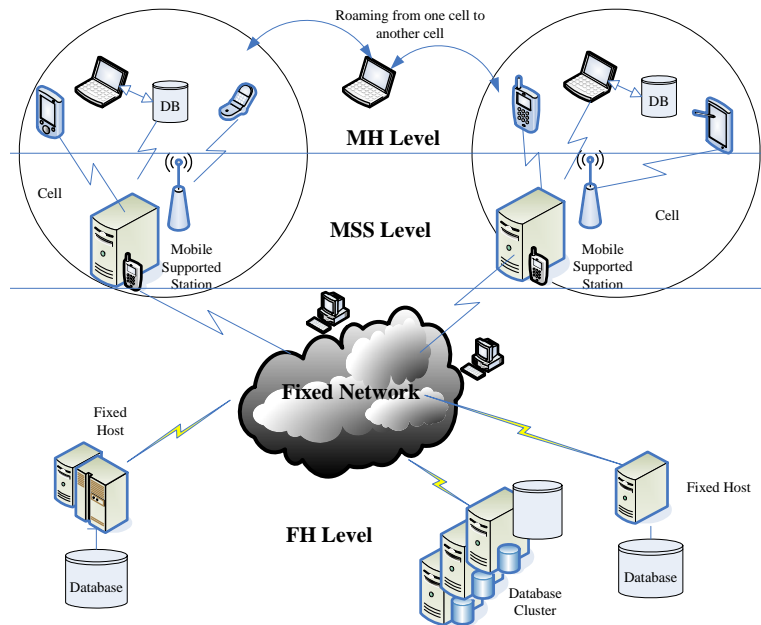


Figure 3. LaMOC mobile computing referential model

Even though it's layered, functionally LaMOC is a global system as shown in Figure 4.

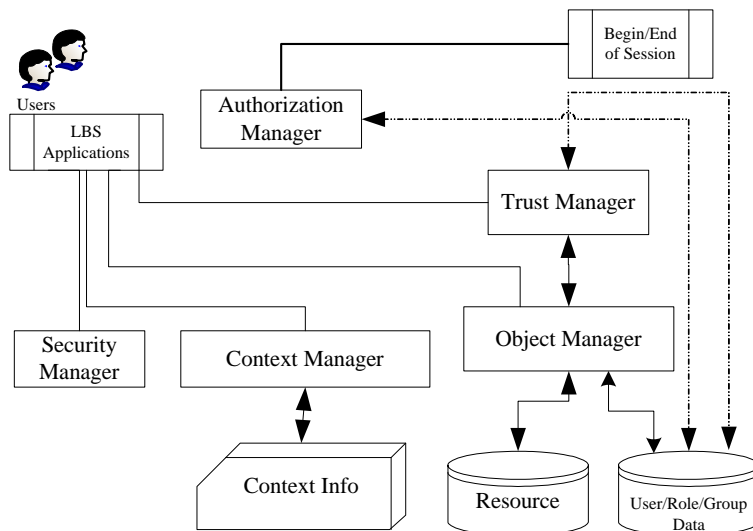


Figure 4. Software architecture of LaMOC

As shown in Figure 4, some main components of LaMOC are Object manager, Trust manager and Security manager. Here:

- Object manager, used to manage objects, such as Yellow Page Object, Geo Object, etc;

- Trust manager-Trust manager is in charge of ensuring LaMOC running in a trusted environment. It should care the trust in person-thing/object, trust in person-person, trust in person-group, trust in person-system, and trust in group-group.
- Security manager-The security manager is in charge of safety. The portal of LaMOC is the only one channel to connect mobile devices and the background server group behind the web portal. To access servers the Firewall/NAT is used as protective screen. For the application security some safety measures are necessary, such as anti-pretend, strict certificate authority, trusted client and server connection, etc.

3.2. Clients-User Interface and Software

Mobile devices in LaMOC are mainly smart phones. As a prototype, mobile devices in LaMOC are based on Microsoft Windows Mobile v6.0. GPS (Global Positioning System) is used for positioning. Because that GPS works not so good in-door, Pseudo-GPS is designed and developed in LaMOC project to support in-door positioning. A Pseudo-GPS station is actually a GPS signal sender located at ground, especially in buildings. In this way position info can be captured either out-door or in-door.

A location based personalized user interface is demanded. It's a map based browser.

Map Based Browser



Figure 5. Map based browser

Different from a text/picture based browser, such as Microsoft IE (Internet Explorer) or Google Chrome, a map based browser named as SiNan is designed as a main user interface of LaMOC. A map based browser is a spatial information based browser, which is user oriented and user favorite object oriented. It means, as soon as a user has registered (logged in), a user-centralized map will be presented at his/her terminal. The user preferred objects such as favorite restaurants near him/her or favorite stores near him/her, are illustrated as icons on the map. Actually, it's a map based co-browser. It has ability to co-navigate the map with other people at-a-distance. As soon as user A logs in LaMOC, a map based interface where his/her location shown in the center, will be presented. The other members in a same group will also be illustrated as icons in the

map exactly corresponding to their location. Accompanied with it, A's information with his/her location will be automatically illustrated in his/her partners' map browsers.

SiNan, the map based browser of LaMOC can be illustrated as in Figure 5.

LaMOC Client

As explained, clients in LaMOC are mainly smart phones. The software architecture in clients can be illustrated as in Figure 6.

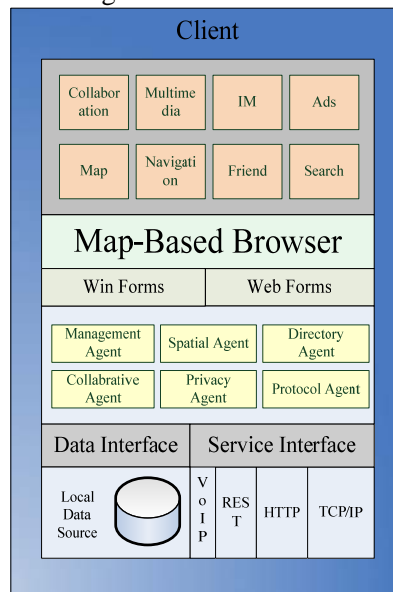


Figure 6. Client software architecture

As shown in Figure 6, a map based browser (SiNan) is a main component in clients. With the functions such as information search, retrieval, and navigation, similar to text based browsers, SiNan users can search information via Yellow Page service, or Internet, and query to databases. It has also the facility for user to browse the map finding interested objects, such as friends near himself/herself, favorite restaurant near himself/herself, etc. And user can based the map request LaMOC to find an optimal restaurant for eating with his/her friends just near himself/herself.

Because of the limitation of communication bandwidth, it's better to keep some data in clients. A small mobile database is used in clients to keep spatial data (e.g. the map just illustrated on the screen), temporary data as well as context data.

To sense context, software agents are designed and running in clients. Besides physic sensor (e.g. GPS sensor), soft agents, such as spatial agent, collaborative agent, and privacy agent, are designed here. They are in charge of capturing context info, adapting the change of environment, and making intelligent reactions. Two internal interfaces, i.e. data interface and service interface, are used to connect agents and local data source/communication services. Data interface is used for local database interaction. Service interface is the interface to TCP/IP communication, VoIP, as well as traditional mobile communication, such as phone call, SMS, etc.

3.3. Fixed Host Layer in LaMOC

The fixed host layer of LaMOC is composed of a server group and workstations.

Because of the inherent shortages of mobile devices, such as lower computing power, and limited battery capacity, narrow communication bandwidth, a background server system remedies congenital deficiency of mobile devices. That is, LaMOC computing is distributed in clients and servers, mainly in servers. It can be illustrated as in Figure 7.

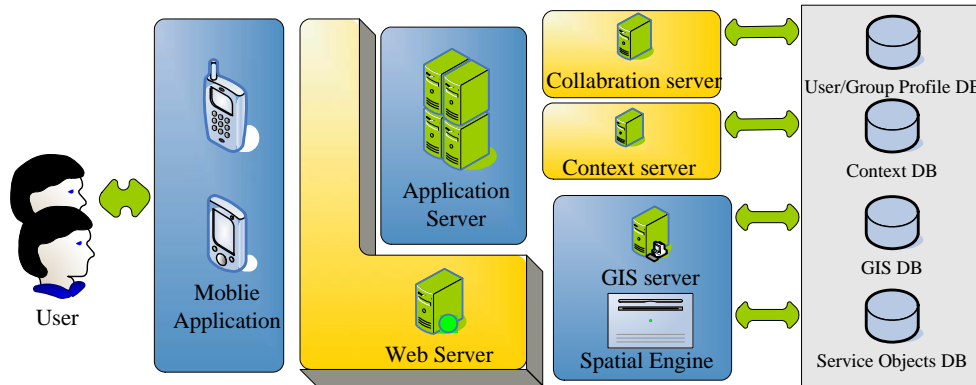


Figure 7. The back ground system of LaMOC

Some servers can be deployed remotely. LaMOC accesses them via Internet.

The FH Layer in LaMOC mainly is a group of servers, containing:

- Web Server- Web Server is used as a gateway to connect MH with FH;
- Application Server-The kernel of Application Server is the LaMOC Engine. The engine analyses and dispatches the user commands to produce a corresponding running plan.
- GeoData Server (i.e. GIS Server)- It manages spatial data, and carries out basic Geo computing.
- Database Server- It is in charge of fundamental data management, and managing yellow page data, user data, group data, and application data.
- Collaboration Server- It is used to coordinate participants of group and their activities.
- Context Server- The context server is used to store and manage context data, as well as process context data.

4. Some Key Issues

4.1. Context Awareness

The word “context” means here physical context and logical context. That is:

- Physical context-position, terminal/device context, etc.
- Logical context-user profile, usage preferring, user/group behaviors, etc.

LaMOC has (hard and soft) sensors to capture context. Hard sensors such as GPS receivers are used to capture location data. Soft sensors are actually soft agents that can capture logical context.

There are various smart phones in market. Especially, their display screen size differs from one another. The way to solve adaptive problem in LaMOC is by device sensing and device awareness. An on-demanded map can be adapted automatically to suit different display screens of various smart phones.

GPS is well used for positioning. But GPS has its inherent shortage. Mainly GPS signal is poor in some places, especially in tunnels, or buildings, where the signal is lost in the worse. In LaMOC project a pseudo GPS system is developed by SITP². A pseudo GPS station is actually a GPS signal sender, following the signal standard of GPS. It can be installed in buildings, tunnels, and so on. Thus, LaMOC sensor can capture position information covered nearly anywhere.

Logical context awareness in LaMOC means, automatically user/group profile capturing, user/group usage awareness, etc.

User and group profiles are defined and stored in the context database. They are static context of users and group. Besides, user/group usage as dynamic context is captured during the running of LaMOC. Soft sensors (agents) are used for usage awareness. The agents are engaged in:

- Collaborative awareness- e.g. where is my friends? Is there any of my friends near me?
- Group feature awareness – e.g. in the case of the system recommendation, decisions often depend on the group’s historical activities. Group’s historical activities are captured via group feature awareness. Such that, it can be answered: what are the common favorites of the group users?
- Partner behaviors awareness – e.g. which friends of mine is going to dinning? What is the planed program of my partner next hour? Can I meet him on next hour?

4.2. Mobile Cooperation

Mobile collaboration is an imported feature in our scenarios. Mobile users of same group cooperate with each other to achieve common target. For example, a co-visitor in Expo Village recommends a common interested exhibition pavilion to his/her partners of the same group. Or a group of distributed tourists try to find each other and determine a muster place. Some things concerned mainly by us are:

- Spatial Group Decision Support (SGDS).
- Social network and group application
- Co-browsing-user interface

In order to discuss the above techniques well, let’s consider some scenarios:

² The Shanghai Institute of Technical Physics of the Chinese Academy of Sciences, one partner of LaMOC project.

Scenario 1: A group of distributed users are on the way, someone occasionally supposes to take a group meeting as soon as possible. Other participants agree with him/her. Where is the suitable mustering place to the group?

Scenario 2: Five participants in a group are driving 5 cars on highway to a city at same time. One of them suggests to take a rest and to meet each other, and other four persons agree with his/her suggestion. Then, which service zone is optimal for the five cars?

These above scenarios involve Spatial Group Decision Support (SGDS). LaMOC is focused on supporting such applications. GIS Server and Collaboration Server are used to support SGDS. The GIS Server has the functionalities of spatial modeling and Geo computing. The commercial GIS products are lack of the functionality for wide domain spatial modeling and intelligent computing. Therefore, a self developed spatial data management system, LaMOC spatial engine as the kernel, with spatial modeling and intelligent computing toolkits are developed in LaMOC project. PostgreSQL³ is used as the base system for LaMOC. The spatial engine has the Geo computing capability, such as finding the optimal objects related to the user's location according to his/her favors, or finding an optimal route to the target place. LaMOC is focused on the group application. The spatial engine can find a favorite or an optimal restaurant for all members located in difference places of a group, to find an optimal route for each member to arrive the aim place or building, and so on.

LaMOC supports group decision, such as finding an optimal mustering place for a group of Expo visitors distributed in an area such as Expo village.

Because LaMOC works in a mobile environment, compared with traditional cooperative environment, user mobility is a big challenge.

For example, five members located in a restricted area (e.g. in the Expo2010 Village) take part in a collaborative activity. While they are in moving, ten minutes later one member will be out of the area, so he/she will leave the collaborative activity automatically. At same time, there are other two members belonged to the same group maybe enter the area, then these two persons will join the collaborative activity automatically. We design the Collaboration Server to support collaborative activities. Some algorithms and mechanisms have been worked out in the LaMOC system to handle these applications.

4.3. On-Demand Mapping

On-demand mapping is also a key issue in LaMOC. In a mobile environment, to dynamically obtain a real time map, how to face the limited mobile communication bandwidth and limited screen size of terminal is a big challenge to us. In LaMOC, spatial data in GIS server is well-form modeled and indexed. As soon as user logged in, a user centric map in a limited boundary will be determined in GIS Server. It composes of a base map and some object-oriented map layers. To suite the limited communication bandwidth the base map and some objects layers will be transferred to the clients. To satisfy such situation spatial data are modeled as objects and stored in the PostgreSQL based GIS database. As soon as getting the position data of the

³ <http://www.postgresql.org/>

registered user, the Geo Data server retrieval spatial data with the position data as parameter. The queried result (i.e. an individual map) will be transformed to a normal form, i.e. in SVG form.

It should be noted, the choice of spatial data exchange standards is important. Obviously XML is a well form for data exchange. Based on XML there are various choices, such as GML (Geography Markup Language)⁴ or SVG (Scalable Vector Graphics)⁵. SVG is used by us as the spatial data exchange form.

Accompanied with the map browsing, users will request more spatial data to LaMOC, such as to find the distribution of barbershops, or find the nearest McDonald®, as well as map zooming in/out or moving map in different directions. An increment spatial data on-demand transferring approach is used by LaMOC, that is, spatial data is transferred to clients incrementally according to the demand. Therefore it can suite the limited communication bandwidth. To incremental spatial data transferring, spatial data in clients is also well indexed. Find the required spatial data in GIS database is via the comparing of spatial data indexes in the client and server.

5. Conclusion

Actually, LaMOC is based a joint work developed by East China Normal University, Fudan University, SITP, and some other partners. Restricted by the length, some details, e.g. some algorithms proposed, have not been presented here. We will report our works in other papers.

A prototype of LaMOC is developed. Furthermore a middleware system based on the first version of LaMOC is in study and development, such that the experience from LaMOC can be extended to other applications.

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⁴ <http://www.opengeospatial.org/standards/gml>

⁵ <http://www.w3.org/Graphics/SVG/>

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