# Server-Side Data Selection Framework for GeoMobility Service Environment

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**Abstract**: The most significant feature of Location-based GIS is its service content may vary dependent on the situation, demand, and location of individual users, such that users may always get updated information as long as they can access to the internet. Though the bandwidth has been tremendously improved in the past few years, how to intelligently determine the appropriate service content remains to be a major challenge to most service providers. The service must have a better understanding about users' current situation and environment factors, so as to analyze possible data request from users and automatically adjust service content. Based on the location-aware concept, we proposed a server-side data selection framework capable of dynamically selecting and organizing corresponding data that meets users' demands based on their locations, request, and even personal information. The introduction of data selection knowledge allows on-the-fly data combination to generate service contents that does not exist beforehand. Furthermore, data mining technology can be applied to the users's profile to derive useful information for specifying more customized constraints to business database (e.g., interested goods on sale), such that the provided service content can be more precise and accurate.

Keywords: GeoMobility Service, data selection, Location-aware.

## 1. Introduction

With the increasing popularity of mobile computing and communications, the demand for Location-based Services (LBS) and adaptive applications has been continuously growing over the past few years. LBS may provide users important information in unfamiliar environments or emergency situations [4]. These needs imply that the services should be easily available when the spontaneous need for them arises. The services should be easy to find, easy to take into use and use thereafter. Location-based applications store knowledge about the physical location of real world objects like mobile persons and devices, and can adapt their functional behavior and their appearance towards the users. The most significant feature of Location-based GIS is its services may vary dependent on situation, demand, and location of individual users, such that users may always get updated information as long as they can access to the internet. Though the bandwidth has been tremendously improved, how to intelligently determine appropriate service contents remains to be a major challenge to service providers. Challenges may include tasks like (1) constraints of hardware/software and rather limited bandwidth of transition, (2) ready-made maps do not possess the flexibility to change its content according to users requirements and position changes [8] and (3) current systems usually lack the ability of Location-Aware Service (LAS). How to have a better understanding about users' current situation and environment factors, so as to analyze possible data request from users and correspondingly adjust service content would be the major topic of this paper.

Based on the location-aware concept, we develop a server-side data selection framework capable of dynamically selecting and organizing corresponding data that meets users' demands with respective to their locations and situations. The architecture design of this LAS Service is based on the open platform of OGC OpenLS (Open Location Services). Extensible Markup Language (XML) is the core technology used for data transition and request/response between systems, the schema of XML request/response in OpenLS is called XML for Location Services (XLS). The introduction of data selection knowledge allows on-the-fly data combination to generate service contents that does not exist beforehand. With given spatial and thematic constraints, the system framework retrieves the corresponding data layers from data archives and sends the results back to users with only the information needed. The design of the service framework will also include a customers' database, a business database, and metadata of related maps data or services. Furthermore, data mining technology can be applied to the customer's profile to derive useful information for specifying customized constraints to business database (e.g., interested goods on sale), such that the provided service content can be more precise and accurate.

In the following, section 2 provides an overview of Mobile GIS, GeoMobility, and service environment, followed by the discussion about the architecture of our proposed system in section 3. Section 4 introduces data selection behaviors, data selection rules and software components of data selection framework. Experiments and analysis is discussed in section 5. Finally, section 6 concludes our major findings in this paper.

## 2. Mobile GIS and GeoMobility Service Environment

Mobile GISs are systems that allow users to receive geographic information by mobile devices in a wireless environment. With continuously updated location of users, Mobile GIS is capable of adjusting service content dependent on users' locations and requests. Typical data request scenarios of LBS service relate to information about location and navigation, such as "Where am I?" and "How can I get there?" queries. Maps, driving directions, directory and yellow page listings, and business descriptions in a given geographical radius can all contribute to answer such queries. Some researches use the concept of "context-aware" in the architecture of Location-based services[2][6]. "Context" is any information that can be used to characterize the situation of an entity. An entity can be a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves [3]. Kassinen argued that an efficient way of improving the usability of mobile services and applications is to adapt the contents and presentation of the service to each individual user by his/her current context of use [7]. Under such circumstances, the amount of user interaction can be minimized and users can quickly access to the information or service they needs. To compare with the concept of location-based services, a location-aware service has two more additional characteristics: (1) Services can be provided to the users automatically. (2) System can adapt services to each individual user by his/her current context of use.

The Open GIS Consortium (OGC) has issued a public call for comment on the proposed OpenGIS Location Services (OpenLS) Implementation Specification. This specification defines open standard for Location-based services, such as message encoding, services, GeoMobility Server functionality…etc. The primary objective of OpenLS is to define the Core Services and Abstract Data Types (ADT) that comprise the GeoMobility Server, an open location services platform. XML for Location Services (XLS) is defined as the method for encoding request/response messages and associated Abstract Data Types for the GeoMobility Server. Two OpenGIS Implementation Specifications and six Interoperability Program Reports have been released with OpenLS. The specifications are titled:

1. OpenGIS Location Services (OpenLS): Core Services [Parts 1-5]
2. OpenGIS Location Services (OpenLS): Navigation Service [Part 6]

## 3. Service Architecture

To reduce the number of interactions between clients and servers in wireless environment, the data selection framework must be able to select and organize corresponding data that meets users' demands based on their demands and locations as accurate as possible. Fig. 1 shows a functional overview of the system architecture. Whenever a user submits a request to the server with the client device, or the client automatically transmits user's location to the server within a specified time interval, the client software transforms the request parameters and location information into a XML-format file called XML Request. The XML Requests from users are sent to the ASP Processor of the server. The ASP processor has the ability of parsing XML file and forming XML file, its job is to transform XML Request into parameters for the data selection framework, and build XML Response when the query is completed. The data selection framework analyzes parameters, determines the spatial and thematic constraint rules used, and on-the-fly generates a system-dependent query based on the rules. The query for GIS system is designed as an XML file, which includes all necessary parameters for GIS system. The GIS system then selects and combines the qualifying spatial data and other information according the query. After all the process is completed, the result will be transmitted to the ASP processor to become an XML Response. The client receives the XML Response from the server, parses the data inside and display the information about the request. The data and service is presented as JPEG files or HTML pages such that it can be opened with regular mobile GIS devices.

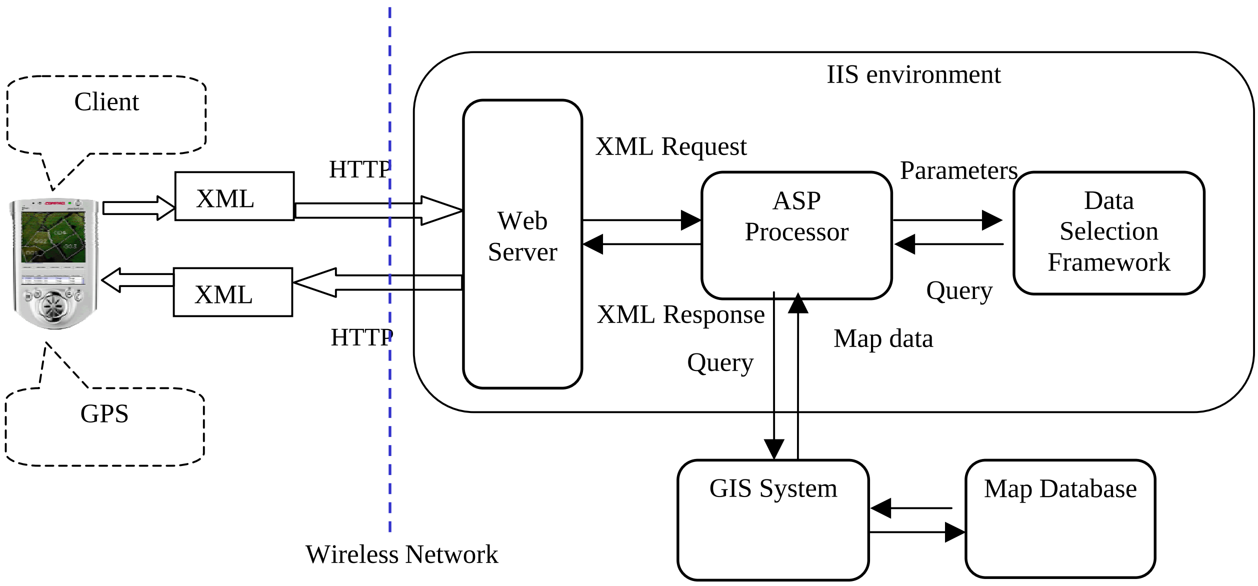



**Fig. 1 System architecture of GeoMobility Service Environment.**

## 4. Data Selection Framework

The data selection behaviors of map data discussed in this paper lies on the concept of a pre-defined layer structure of geographic data. The data in the map database is divided into different layers by selected themes. Every layer in the map database has its own theme and pre-designed attributes. For every individual query from user, the data selection framework needs to select the most necessary and appropriate data according the query analysis result.

### 4.1 Data Selection Behaviors and Data Selection Rules

The data selection behaviors consist of three steps: (1) Layer Selection: determine the map layers associated with the query. (2) Attribute Constraints: select spatial objects in map layers with attribute constraints. (3) Spatial Constraints: select spatial objects in map layers with spatial constraints.

(1) Layer Selection

The goal of the dynamic layer selection is to dynamically determine appropriate map layers based on the users' requirement. Every individual query may need one or more map layers to fulfill its content request. How to select appropriate map layers thus becomes the most important task. Layer selection is the base of server-side data selection framework, but in the end, layer is either selected or not selected. How to determine the necessary layers will be discussed in more detail in 4.2. Fig. 2 shows the concept of layer selection.

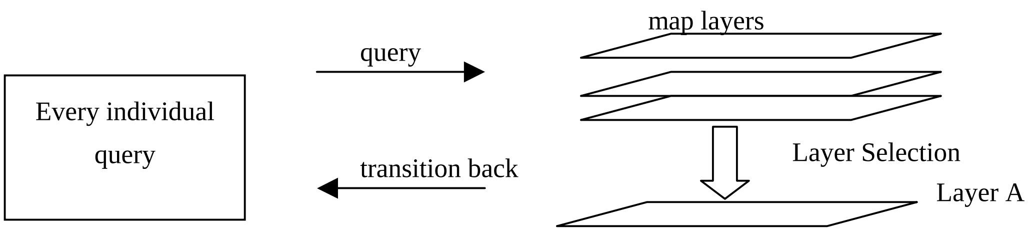



**Fig. 2 The concept of layer selection**

(2) Attribute Constraints

A map layer may include a number of objects, but only some of them qualifying certain attribute conditions are needed by users. A typical scenario will be like "Find the hotels that still have vacancy and the price is less than 3000." In the example of Fig. 3, three spatial objects exist in Layer A with a list of attributes like ID, attribute1 and attribute2. The data selection framework generates a SQL command with syntax 「select A.object from A where attriute1>500」. After this command is executed, only the object whose attribute1 value is more than 500 will be selected. Business data can also be associated with spatial objects with specific IDs, therefore all information which meets user's demands can be selected and combined by attribute constraints, and sent to users.

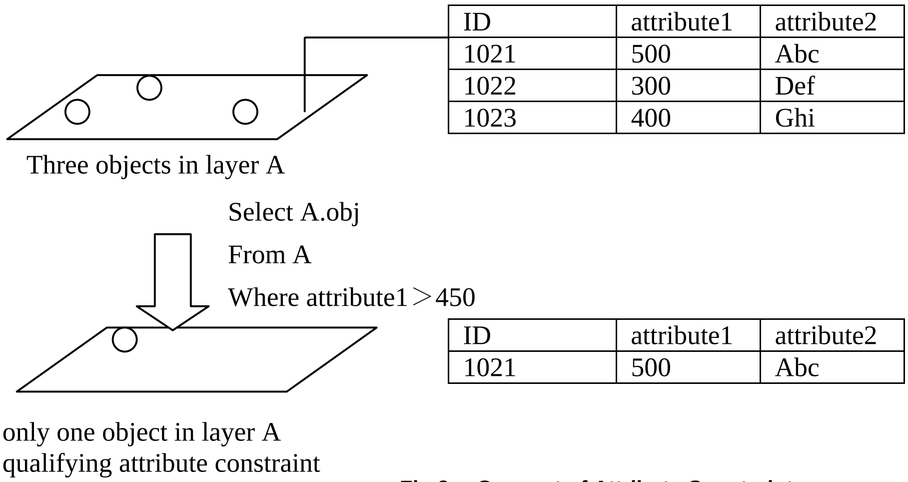



**Fig 3. Concept of Attribute Constraints**

(3) Spatial Constraints

The spatial constraints use the spatial relationship among spatial objects as constraints to select data, e.g. distance, direction, and topological relationships. With the spatial operators of current GIS software, the data selection framework can easily apply appropriate spatial constrains to filter objects fulfilling certain spatial conditions. In the example of Fig.4., five spatial objects exist in Layer A and uses are looking for objects within a specific distance of users' current location, a buffer operation is executed to filter qualifying objects. In this case, only two objects qualify the given spatial constraints.

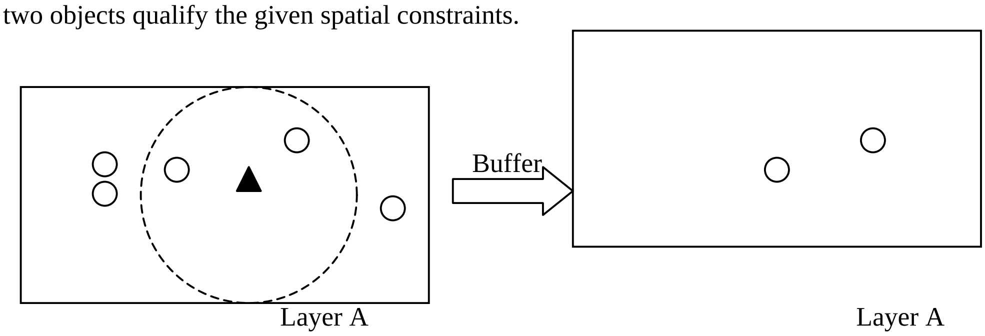



**Fig. 4 Concept of Spatial Constraints – example of Buffer operation**

Based on the three types of constraints and their possible corresponding relationships to the users' request, there are eight possible scenarios of data selection rules during the query execution (Table 1):

**Table1 . General data selection rules.**

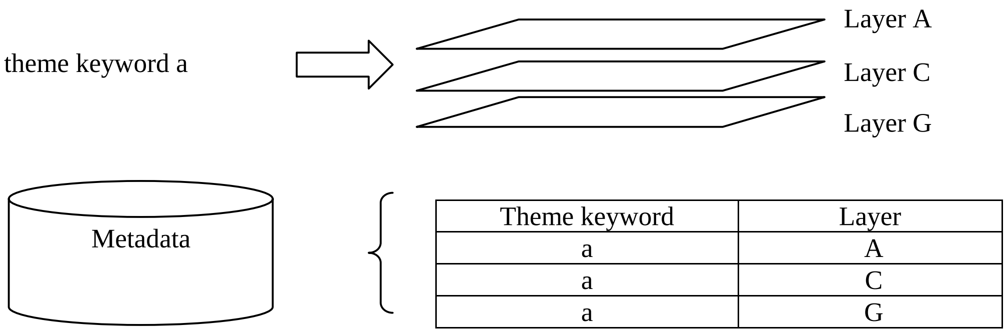
| | General data selection rules | description |
|---|---|---|
| 1. | Single layer. | The theme keyword associates only one layer, no other constraints. |
| 2. | Single layer with attribute constraints. | The theme keyword associates only one layer, the layer has attribute constraints. |
| 3. | Single layer with spatial constraints. | The theme keyword associates only one layer, the layer has spatial constraints. |
| 4. | Single layer with attribute and spatial constraints. | The theme keyword associates only one layer, the layer has attribute and spatial constraints. |

| | | |
|---|---|---|
| 5. | Multiple layers. | The theme keyword associates with two or more layers, no other constraints. |
| 6 | Multiple layers with attribute constraints. | The theme keyword associates with two or more layers, the layers have the same attribute constraints. |
| 7 | Multiple layers with spatial constraints. | The theme keyword associates with two or more layers, the layers have the same spatial constraints. |
| 8 | Multiple layers with attribute and spatial constraints. | The theme keyword associates with two or more layers, the layers have the same attribute and spatial constraints. |

In a standard layer-based framework, the general data selection rules are applied to filter objects qualifying given layer, spatial and attribute constraints. Furthermore, the selection rules can also be applied to constraints on business database and customer database (see 4.2 for information about these two database).

### 4.2 Data Selection Framework

No matter how detailed we design the layer-based structure, there is no way for the pre-defined layer structure to satisfy any request with an individual map layer. For a single layer request, the match of query keyword and the theme keyword of the corresponding map layer is enough to solve the problem. The challenge, however, lies on how to select multiple map layers, with correct semantics, that fulfill the request. Other than every individual map layer is described with a "theme keyword", a special "metadata" mechanism is introduced to link multiple map layers sharing common and special semantics. This metadata mechanism does not store any physical data and virtually transform the given constraint to the request of associated map layers. In Fig 5, three map layers, Layer A, Layer C, and Layer G, are stored in map databases. Though each map layer has its own semantics, they may share some property or can be abstracted to a higher level of map layer, such that these layers can also be described with a single theme keyword "a". Therefore, if the information users request matches theme keyword "a", all of the three layers are selected and sent back to users.




| Theme keyword | Layer |
|---|---|
| a | A |
| a | C |
| a | G |

**Fig 5. relationship between thematic keyword and layer**

Server-side data selection framework has four core components:

(1) Data Selection Agent：It plays the major role of the data selection framework, performs operations like receiving the parameters from the ASP Processor, determining the appropriate data selection rules, and output the query command to GIS system.
(2) Metadata：Collection of information about the map database and layers.
(3) Business Database：Database that contains business data from a variety of providers
(4) Customer Database：The customer database consists of four major parts
    - person profile
    - log database, system will log every user's individual queries.
    - location history
    - constraint parameters, the data selection framework uses Association Rule Mining [1] and FP-tree algorithm [5] to analyze recorded logs in log database and generate customized constraint parameters for clients.

The data selection agent serves as the core of the framework. It analyzes every individual query and interacts with metadata, business database and customer database. After the ASP Processor receives parameters from XML Request, the data selection agent will interact with other three components and select the corresponding data selection rule. Then it will form a XML query and send it to the ASP Processor. ASP Processor will then transit the query to GIS system or Business Database to get the map and information that meet user's need. The components of data selection framework show in Fig 6：

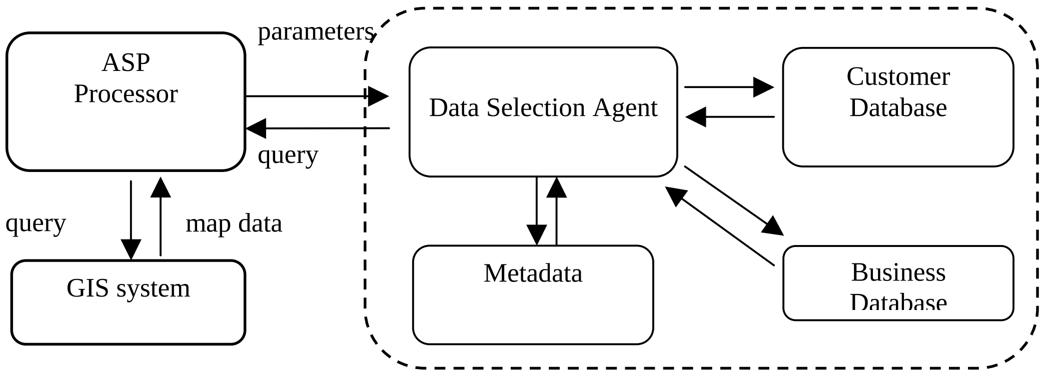



**Fig 6. Components of Data Selection Framework**

## 5. Experiments and Analysis

A system prototype is created to test the proposed data selection framework. The mobile device of this test system is PDA, and the wireless environment is a network with IEEE 802.11b protocol portable. GPS was chosen as the position determination technology. A pre-defined map database, a simulated business database of shopping, and a customer database are also created. In the example described below, a user walk in the street and receive a location-aware message from the server. This is done by data selection framework. After analyzing the metadata, business database and customer database, the data selection agent match the categories of goods in user's interested list, and find out interested goods on sale. Only the information meets the discount and user's interest will be transmited to users (Fig. 7). After clicking the "show map" button, the client software display the location of stores with goods on sale. Fig. 8 illustrates the map of all data in the database (left) and the queried result (right). This scenario presents the "automatic service" character of Location-aware service. Based on the information in user profile, the data selection framework queries the business database and finds out the user's interested goods.

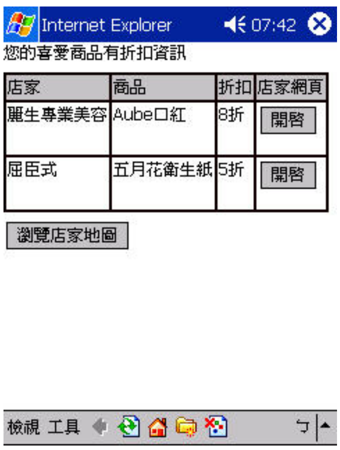



**Fig. 7 Information automatically transfor to specific user**

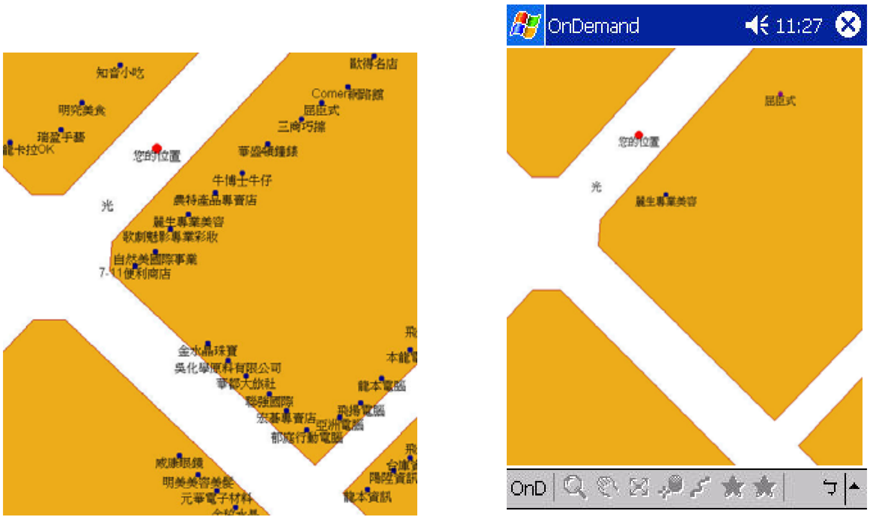


**Fig. 8 Contrast of full data (left) and query result (right).**

In the next example, a user is looking for the location of lavatorys. All map layers (and their associated features) that may have lavatorys are recorded and for each individual map layer, a corresponding relationship to “lavatory” theme keyword is created in the metadata mechanism, as showed in table 2. When the user submits this query to find the location of lavatory, the data selection framework can quickly find the correct map layers based on the query of the metadata mechanism. Fig. 10 shows the difference between all map layers (left) and layers related to the theme keyword “lavatory” (right). With design of the theme keyword, our system can dynamically create a map whose contents may come from a number of map layers, even if they are independent and separated in the map layer architecture..

**Table 2 theme keyword “lavatory” and its corresponding map layers.**

| Metadata | |
|---|---|
| theme keyword | layer |
| Lavatory | Hotel/Restaurant |
| Lavatory | Public lavatory |
| Lavatory | McDonalds |
| Lavatory | Gas station |
| Lavatory | Fire station |
| Lavatory | Department store |
| Lavatory | KFC |
| Lavatory | Park |

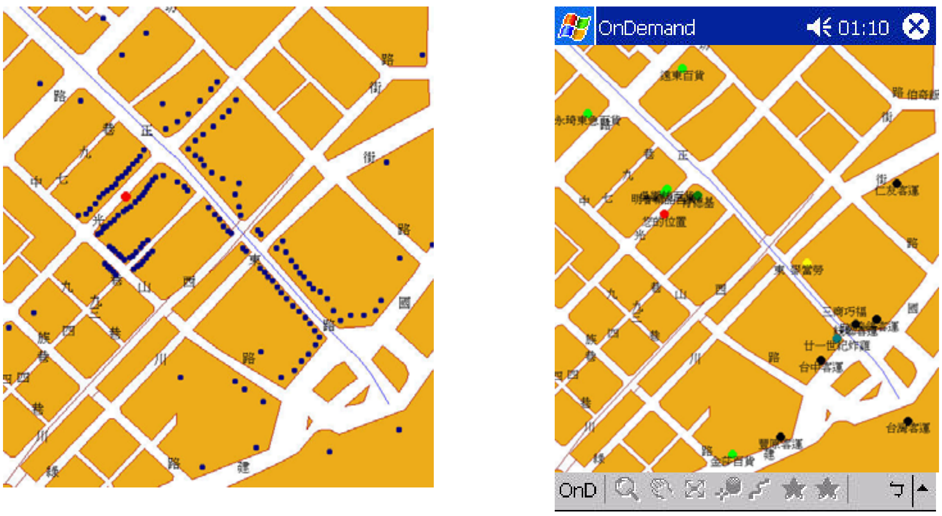


**Fig. 10 Illustrations of all map layers (left) and layers corresponding to theme keyword “lavatory” (right)**

## 6. Conclusions

We proposed a server-side data selection framework capable of dynamically selecting and organizing service contents based on their demands and locations in this paper. This service framework can reduce the interaction between users and servers in a low-bandwidth wireless environment.

1. Compared to other Mobile GIS systems, the proposed system framework introduces the concept of location-aware services, and can expand data selection rules to business database and customer database dependent on different domain needs.
2. This paper discusses the general data selection behaviors, and classifies them into eight scenarios of data selection rules. The experiments show that data selection framework can dynamically filter data, and the client interface is easier to use. Users no longer need to interact with service many times in wireless environment and the useful information can sends to users automatically.
3. Data mining technology can be further applied to the customer's profile to derive useful information for generating effective constraints implicitly stored in business database, e.g., interested goods on sale.
4. XML for Location Services (XLS) is chosen for message encoding. The open interface increases the interoperability between client and server. Further work is still needed to combine GeoMobility Server and business database, and to design distributed GeoMobility Servers environment with data selection framework.

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