DEVELEPMENT OF A SPATIAL DATA PROCESSING INTERFACE FOR LOCATION BASED GIS SERVICES

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ABSTRACT:

For location based GIS(Geographic Information Systems) services, to provide spatial data and spatial data processing functions to various users including personal users and other ASPs(Application Service Providers), a standard interface is necessitated. As location based GIS services can be provided through a layered architecture, separate interfaces are needed for each layer. The focus of this paper is to define a common interface for the layer that lay on the bottom of the layered architecture and provides spatial data and spatial data processing functions for upper layer's use. The spatial data and spatial data processing function accesses supported by this interface are specifically designed for location based GIS services in the wireless internet environment. And also, for the sake of interoperability, the interface definitions of this paper are based on XML(eXtensible Markup Language) schema and compatible with corresponding OGC(OpenGIS Consortium) standard interfaces.

1. INTRODUCTION

Recently, the rapid development of wireless telecommunication and location determination technology provides an opportunity for various location based GIS(Geographic Information System) services to be developed and serviced over the wireless internet. Location based GIS services are the kind of services that provide personal users or other ASPs(Application Service Providers) with various GIS information based on the past, current and future locations of moving objects.

As for other newly appeared applications, to continuously enlarge the market and to promote the technology development of location based GIS services, standard interfaces are needed to be developed. And also, because location based GIS services are generally organized in a layered architecture, so that separate interface definitions are needed for each layer.

A lot of efforts are made by international standard groups and organizations to develop standard interfaces for location based services including location based GIS services. OGC(OpenGIS Consortium) has published an Implementation specification called "OpenGIS Location Services(OpenLS): Core Services," to define interfaces for the basic services of location based services identified by OGC in it's OpenLS platform definitions.

Spatial data and spatial data processing functions are the common base for all location based services especially for location based GIS services. It forms a layer in the layered architecture of location based GIS service and can be called as GIS data service. The core services defined in OpenLS platform all need to access spatial data and spatial data processing functions i.e. GIS data services to complete there functions.

But currently existing standard interfaces for GIS data service are mainly designed for the wired internet environment. So, there is a need to refine the interface definitions of GIS data services to take into account the special characteristics of location based GIS services in the wireless internet environment.

Our focus in this paper is no other than to define a common interface for GIS data service to satisfying the specific needs of location based GIS services in the wireless internet environment. For the sake of interoperability, all of our interface definitions are based on XML(eXtensible Markup Language) schema and are compatible with corresponding OGC standard interface definitions.

To define the service request/response messages of GIS data service, we need to be able to encode spatial data and operators needed for spatial data processing function access. So, our common interface definitions of this paper can be divided into 3 parts, they are data encoding, operator encoding and request/response message.

The three parts of the interface definitions of this paper are compatible with OGC GML(Geographic Markup Language) 3.0.0, OGC Filter Encoding 1.0.0 and OGC WFS(Web Feature Service) 1.0.0 separately. At the same time, new features of location based GIS services in the wireless internet are reflected into our interface definitions.

The rest of this paper is organized as follows. In the next section, we introduce a layered architecture for location based GIS service and plot out the scope of our interface definitions. And then, we elaborate on the data encoding, operator encoding and request/response message definitions of our common interface development. Finally, we conclude this paper in the last section.

2. INTERFACE DEFINITION SCOPE

2.1 Layered Architecture

Location based GIS services generally can be organized into a layered architecture. Figure 1 shows a three layered architecture that divides location based GIS service into GIS data service, location based core service and location based GIS application service.

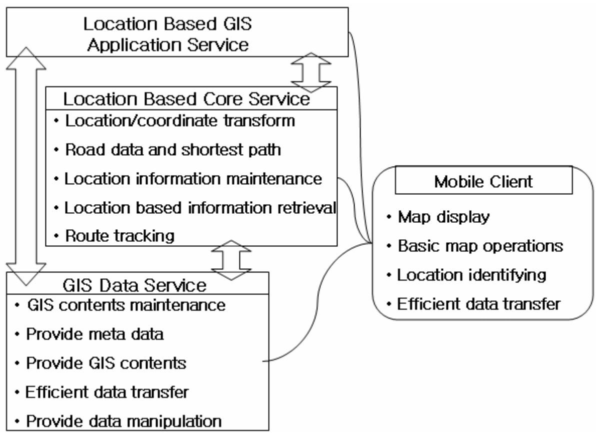

Figure 1. Layered architecture

Location based GIS application services provide the wireless internet users with various GIS related application services based on the past, current and future locations of moving objects. In order to do this, it is needed that location based GIS application services have a method to access various spatial data and location based service supporting functions.

Location based service supporting functions are provided by location based core service in the layered architecture. OGC's OpenLS platform defines the basic services that can be classified as location based core services, including directory service, route service, presentation service, geo-coding service, reverse geo-coding service etc.

Spatial data and spatial data processing functions i.e. GIS contents are provided by GIS data service. Spatial data and spatial data processing functions are the common base for all location based services especially for location based GIS services. The core services defined in OpenLS platform all need to access spatial data and spatial data processing functions to complete there functions.

2.2 Interface Definition Scope

Recent efforts for the standard interface definitions of location based services are mainly concentrated on location based core service. OGC has published an Implementation specification called "OpenGIS Location Services(OpenLS): Core Services," to define interfaces for location based core services. Korea LBS industry consultation is now working on its own standard interface definitions for location based service core services.

But currently existing standard interfaces for GIS data service are mainly designed for the wired internet environment. So, there is a need to refine the interface definitions for GIS data service to take into account the special characteristics of location based GIS services in the wireless internet environment. Figure 2 shows the scope of our interface definitions of this paper.

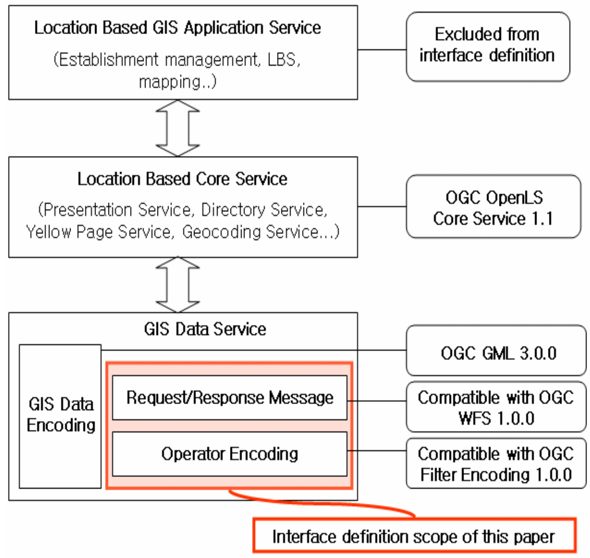

Figure 2. Interface definition scope

As shown in Figure 2, the interface definition scope of our paper is to define a common interface for GIS data service. To define the service request/response message of GIS data service, we need to be able to encode spatial data and operators that support spatial data and spatial data processing function accesses of GIS data service.

Therefore, the interface definitions of this paper can be divided into data encoding, operator encoding and request/response message 3 parts. Data encoding contain definitions for spatial reference system, geometric objects and spatial objects with spatial and non-spatial attributes.

GML is a standard for spatial data encoding. It can be predicated that in the near future, GML will be widely used in various application service domains to encode spatial data. OGC's OpenLS core services use GML 3.0.0 to encode spatial data. In this paper, we also use the element definitions of GML 3.0.0 with no changes to encode spatial data.

Operator encoding is used in the request/response messages of GIS data service to indicate data range or spatial data processing functions client wants to access. It defines a constraint expression framework and series of spatial/non-spatial operators that can be applied to spatial objects. These operators are chosen and designed to have the characteristics that are appropriate to the location based services in the wireless internet environment.

The request/response message definitions define the format of request and response message of GIS data service. According to the spatial data formats serviced by GIS data service, it can be a map service or a feature service. Map service provides spatial data in styled image data formats while feature service provides spatial data encoded in GML.

OGC's specification for OpenLS cores services includes interface definitions for a basic service called presentation service. Similar to map service, presentation service provides imaged view of spatial data to location based services. Hence, in this paper, we ignore map service and defines request/response message format only for feature service.

3. INTERFACE DEFINITIONS

3.1 Operator Encoding

Our definitions for operator encoding are compatible with OGC Filter Encoding 1.0.0. Meanwhile, new operators and changes to existing operators are added in order to reflect the specific characteristics of location based GIS services in the wireless internet.

The element definitions of OGC Filter Encoding 1.0.0 can be divided in to expression, operator and filter 3 parts. Figure 3 shows the relationships of the element definitions of Filter Encoding 1.0.0.

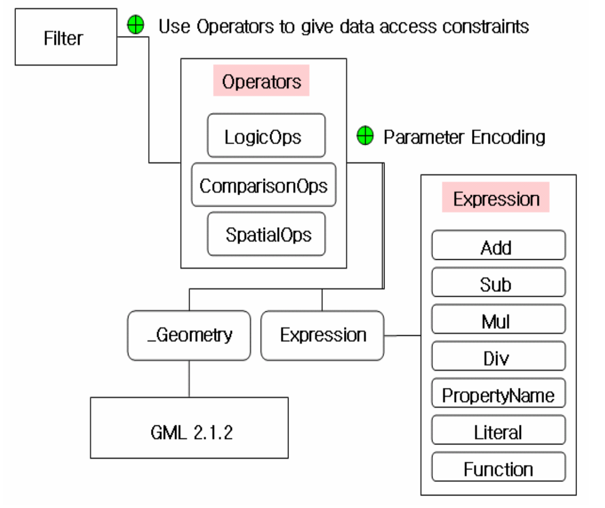

Figure 3. Relationships of operator encoding elements

As shown in Figure 3, expression is a substitution group header defined to represent elements needed to compose mathematic expressions. It is used by operator elements to represent the parameters of operator. Spatial objects can also be a parameter of an operator, to encode this, _Geometry is used. _Geometry is a substitution group header defined in GML 2.1.2 to represent all spatial objects.

Operators are used by filter to set a constraint condition to indicate data range. Operators defined in Filter Encoding 1.0.0 all return Boolean value and can be classified into logical operator, comparison operator and spatial operator 3 groups. For each of these groups, a substitution group header is defined, namely logicOps, comparisonOps and spatialOps. Figure 4 shows the operators included in each of these groups.

As mentioned above, our definitions for operator encoding are compatible with OGC Filter Encoding 1.0.0. This means that if a XML instance document is valid with OGC Filter Encoding 1.0.0, then it is also valid for the operator encoding definitions of this paper.

OGC Filter Encoding 1.0.0 only defines operators with Boolean result. It can only be used in the request/response messages of OGC web feature service or web map service to indicate data range by setting a constraint condition. However, GIS data service not only provides spatial data but also provide spatial data processing functions.

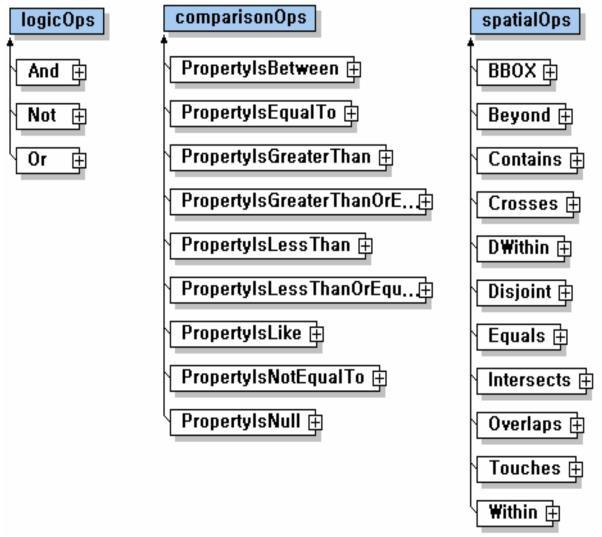

Figure 4. Operators defined in each of the groups

To enable spatial data processing function access, operators with various result types are needed to be defined in the interface definitions for GIS data service. And also, the relative orientation information of spatial objects will be continuously needed in location based GIS Services. So, for GIS data service to provide this kind of information efficiently, corresponding operators are necessitated.

To reflect these considerations, the operator encoding definitions of this paper contain some newly defined operators. They are all spatial operators. Based on the result type, these new operators can be divided into 3 groups, namely spatial operators with Boolean result, spatial operators with scalar result and spatial operators with spatial object result. The operators in each of these groups can be seen in Figure 5.

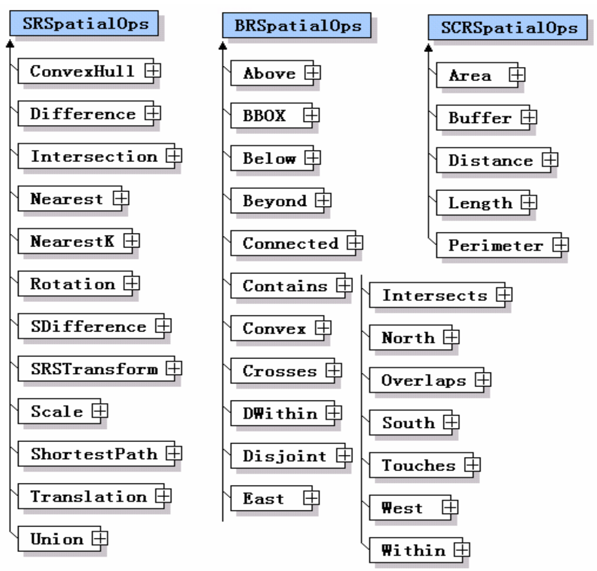

Figure 5. New operators

As shown in Figure 5, for each group of these newly defined operators, a substitution group header is defined to represent it. Combined with the operators already defined in Filter Encoding 1.0.0, the operator definitions in operator encoding can be divided into 6 groups. This is shown in Table 1.

Substitution Group Header	Operator Type	Result Type	Change
ArithmeticOps	Arithmetic	Scalar	Def, Group
LogicOps	Logic	Boolean	Def, Group
CompareOps	Compare	Boolean	Def, Group
BRspatialOps	Spatial	Boolean	Add, Group
SCRspatialOps	Spatial	Scalar	New
SRspatialOps	Spatial	Spatial	New

Table 1. Groups of operators

In the Change column of Table 1, Def means the definitions for the operators of that operator group has been changed. Group means the substitution group header defined for that operator group has been changed. Add means new operators have been added to an already existed group and New means a totally new group of operators are defined.

As In Table 1, ArithmeticOps represents arithmetic operator group that contains Add, Sub, Mul and Div operators. These operators are defined in Filter Encoding 1.0.0 and are simply used to construct mathematic expressions. In operator encoding, definitions for these operators have been changed to reflect newly added operators and to make these operators more useful in the construction of complicated data proceeding function access.

Similar changes have been made to logic operator group and comparison operator group. As mentioned above, spatial operators defined in operator encoding can be divided into 3 parts. Substitution group header spatialOps defined in OGC Filter Encoding 1.0.0 are changed to BRspatialOps that represents only spatial operators with Boolean result. The newly defined operators for relative orientation information, such as North, South, Above etc. are included in this group.

Figure 6 shows the relationships of these 6 operator groups with other definition elements of operator encoding.

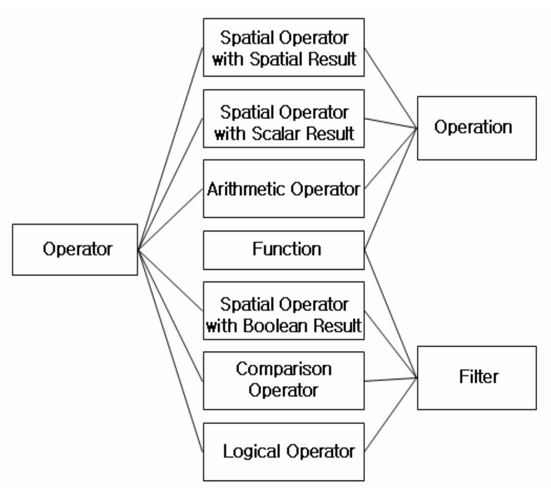

Figure 6. Relationships of operator encoding elements

As shown in Figure 6, all these 6 groups of operators can be represented by substitution group header Operator. Among these 6 operator groups, groups with Boolean result are used by Filter element and groups with scalar or spatial object results are used by Operation element.

As defined in OGC Filter Encoding 1.0.0, Filter element is used by request/response message of GIS data service to indicate data range. All the spatial data that satisfying the constraint conditions encoded in a Filter will be considered inside the data range indicated by that Filter. Operation element is newly defined to use Operator and Function to describe spatial data processing function access in the request/response messages of GIS data service.

Function element is defined to represents special functions provided by GIS data service. Similar to the usage of operators, functions with scalar or spatial object result are used by Operation and functions with Boolean result are used by Filter. All operators in operator encoding are defined so that if data type is appropriate, it can have Function or other operator elements as parameter. Through this structure, very complicated spatial data processing function access can be described.

3.2 Request/Response Message

The interface definitions for request/response message are compatible with OGC WFS 1.0.0. Meanwhile, changes are made to reflect new characteristics of location based GIS services in the wireless internet environment.

OGC WFS provides spatial data based on feature data model. Feature data model is a simple but efficient data model that has been widely used in various GIS application area. GML is a feature model based XML encoding method for spatial data. OGC WFS 1.0.0 use GML 2.1.2 to encode spatial data and use Filter Encoding 1.0.0 to indicate data range.

The interface definitions of OGC WFS 1.0.0 can be divided into capability encoding, basic interface, transaction interface 3 parts. Capability encoding defines interface elements used to encode information about the spatial data and spatial data processing functions that are currently available from specific WFS.

Basic interface defines the request/response message format for simple data access, while transaction interface defines request/response message format for expansion functions, such as create, modify and delete spatial data maintained by WFS. Figure 7 shows the message exchanges of basic and transaction interface.

As shown in Figure 7, basic interface defines request message GetCapability, DescribeFeatureType and GetFeature. Clients of WFS send GetCapability request message to WFS server, WFS server return WFS_Capability response message to describe spatial data and spatial data processing functions currently available from this WFS server.

For DescribeFeatureType request message, WFS server returns the XML schema for the feature types indicated in the request message. For GetFeature request message, WFS server returns FeatureCollection response message that contains requested feature object data. For the format of FeatureCollection, WFS 1.0.0 use element definitions of GML 2.1.2.

Request message GetFeatureWithLock and LockFeature are defined in transaction interface to support locked access to feature objects. The corresponding response message for these two request message is WFS_LockFeatureResponse. Transaction is the request message for create, modify and delete operations. The corresponding response message is WFS_TransactionResponse.

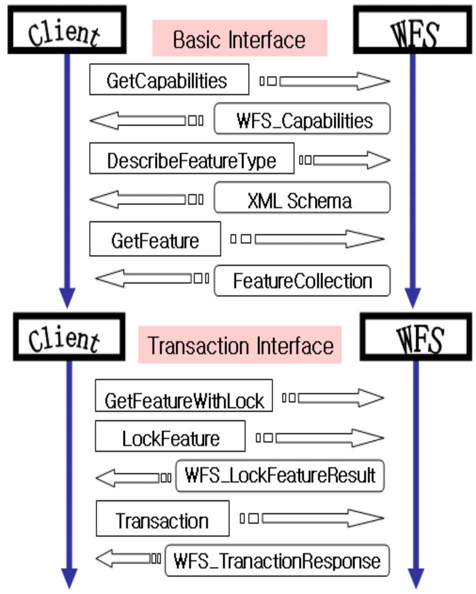

Figure 7. WFS request/response message exchange

As mentioned above, in this paper, the definitions for request/response message encoding are compatible with OGC WFS 1.0.0. This means that if a XML instance document is valid for OGC WFS 1.0.0, then it is also valid for the request/response message definitions of this paper.

Because location based GIS services are mainly serviced in the wireless internet environment, how efficiently to reduce delay time and network bandwidth consuming are very important. In order to do this, compressed data transfer is usually necessitated.

For roaming clients of location based GIS services, the current location of it may have been changed when requested location related information arrive. In this case, the arrived information may not useful anymore. Because the current location of a roaming client keeps changing, location uncertainty is needed to be reflected in the interface definition.

And also, clients may continuously request spatial data related to their changing current location, so the spatial data requested in the previous and current location may have a common part if these two locations are close enough. In this case, spatial data related to some area may be transferred repeatedly. Therefore, a method is needed to response to request message only the spatial data that is actually necessitated.

In this paper, these considerations have been reflected into the interface definitions for request/response messages. We add interface elements to enable client and server to negotiate about compression method for compressed data transfer, and to provide interface support for transfer to client only necessitate data. To support access not only to spatial data, but also to spatial data processing functions, request and response message for spatial data processing function access are newly defined.

Table 2 shows the main request/response messages defined in this paper.

Request/Response Message	Change
GetFeatureCapabilities	Partly changed
WFS_Capabilities	Partly changed
DescribeFeatureType	Partly changed
ExecuteOperation	New
GetFeature	Partly changed
GetSSFeature	New
FeatureCollection	Unchanged
FSReturn	New
GetFeatureWithLock	Unchanged
LockFeature	Unchanged
Transaction	Unchanged
WFS_LockFeatureResponse	Unchanged
WFS_TransactionResponse	Unchanged

Table 2. Request /response message for GIS data service

As shown in Table 2, we add ExecutionOperation request message and its corresponding response message FSReturn to support spatial data proceeding function access. Request message GetSSFeature is newly added to support an interface to access only actually necessitated data. Request messages GetCapabilities, GetFeatureType, GetFeature and response message WFS_Capabilities are partly changed to reflect the compression an uncertainty factors.

4. CONCLUTION

The focus of this paper is to define a common interface that is well suited to the wireless internet environment for GIS data service. GIS data service provides spatial data and spatial data processing function accesses and form a common base for all location based services especially for location based GIS services.

The common interface definitions of this paper can be divided into data encoding, operator encoding and request/response message 3 parts. All of our interface definitions are based on XML schema and are compatible with corresponding OGC standard interface definitions. In this paper, GML 3.0.0 is used with no changes for spatial data encoding.

Our definitions for Operator Encoding are compatible with OGC Filter Encoding 1.0.0. This means that if a XML instance document is valid with OGC Filter Encoding 1.0.0, then it is also valid for the operator encoding definitions of this paper.

OGC Filter Encoding 1.0.0 only defines operators with Boolean result. GIS data service not only provides spatial data but also provide spatial data processing functions. To enable spatial data processing function access, operators with various result types are newly defined and changes are made to enable more complicated spatial data processing function access.

The interface definitions for request/response message are compatible with OGC WFS 1.0.0. This means that if a XML instance document is valid with OGC WFS 1.0.0, then it is also valid for the request/response message definitions of this paper.

In order to reduce delay time and bandwidth consuming, compressed data transfer is usually necessitated. And also, because the current location of roaming clients keeps changing, location uncertainty is needed to be reflected in the interface definition. The spatial data requested in the previous and current location may have a common part if these two locations are close enough. Therefore, a method is needed to response to the client request only the spatial data that is actually necessitated.

In this paper, these considerations have been reflected into the interface definitions for request/response messages. We add interface elements to enable client and server to negotiate about compression method for compressed data transfer, and to provide interface support for transfer to client only necessitate data. To support access not only to spatial data, but also to spatial data processing functions, request/response message format for spatial data processing function access is newly defined.

The interfaces defined in this paper can be selectively supported by specific GIS data service. Client use GetCapabilities request message to gain the information about the spatial data and spatial data processing functions that are currently available from specific GIS data service. The definitions for WFS_Capabilities response message have been modified to reflect the changes made in the interface definitions of this paper from OGC Filter Encoding 1.0.0 and WFS 1.0.0.

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