Designing of Multi-tier GIS Architecture with Sematics Filter

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Abstract: Geographic Information System(GIS) has become an essential tool for making efficient interaction with both natural and artificial envirionment. Currentry, it is being used on an inteligent tool in many device like the personal digital assistant(PDA) and the cellular phone and so on. However, these devices show very low performance comparing to a personal computer(PC). These devices(PDA, celluar phone) posses a less powered device profile. The less powerful hardware make these devices in capable to handle GIS based large spacial data. In this paper, we propose a new concept of multi-tier GIS oriented architecture to improve the data transfer performance providing only the necessary information required by the user using semantic filter.

1. Introduction

Currentry, the way of data access and dissemination has been changed by the Internet. the Web-Based GIS handling spatial data and geographic information on the Internet has been rapidly evolving with the change of the Internet and web technologies[1][2][3][4]. Recently, the server-side Web-Based GIS and the client-side Web-Based GIS are two major kinds of Web-Based GIS[1]. Further, GIS is being used for mobile devices like PDA and celluar phone. The server-side Web-Based GIS is used in PDA and celluar phone. Generally, the spatial data being used for GIS is large. When a mobile device request some spatial data to GIS software, most GIS software response which is relatively small spatial for processing. This method has several drawbacks.

1. As client user increase. the performance of a system fall rapidly.
2. It is difficult to provide a high interactive geographic information such as space analysis information.
3. Preparation of the spatial data for each device which has the possibility to access the GIS software.
4. It can't provide user's favorite data.

The problem 1,2 are fundamental problems of server-side Web-Based GIS. Therefore, it is requires to propose the client-side Web-Based GIS. However, due to the large size of data transmission, enormous diversity in the transmission speed of the network and the computer, the Web-Based GIS has the main drawback of the low late of data transmission. Usually this problem has not been considered in traditional desktop GIS. To solve these problems, it is required to divide the server-side process into the client-side process. Generally, the low performance of Web-Based GIS can be solved in two ways: 1) increasing the speed of the network and 2) developing more efficeient program. To solve these problems our approach includes the followings: 1) Defining the smallest transfer unit called "feature" which present the information of the point in the real world. 2) Designing 4 parts of layers: the presentation, function, filtering and data layer, are suitable for the distributed network envirionment. 3) Developing a traffic reduction technique among layers with semantics filter.

The problem 3 is obviously impossible because too many devices access to the GIS software. The problem 4 exists because it can't personalize the spatial data. The problem 3,4 are how to provide the spatial data. To solve these problems, we propose the Semantics Filter using fuzzy reasoning. So, it would be possible to provide the user by his/her favorite spatial data.

2. Spatial data

Most GIS software treat the spatial data of layer unit. This layer has several categories such as buildings, roads, rivers and so on. On the other hand, object-oriented GIS doesn't handle a spatial data in layer unit. It can handle a building, a road and a river as one object. Using the object expression data, we can handle the spatial data in detail. Figure 1 shows the image of layer, and object expression. To improve data transfer perfomance, we use spatial data of an object.

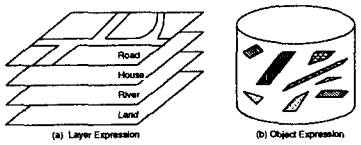

Figure 1. Layer Expression and Object Expression

The format used for spatial data is G-XML[6] Its specification was created by G-XML Project[6]. The G-XML is the data format based on XML. Until now, a spatial data format depends on vendors. If we don't have a vendor's GIS software, we can't use these spatial data. In other words, these situations hindered spreading out of GIS. G-XML has opened specification and

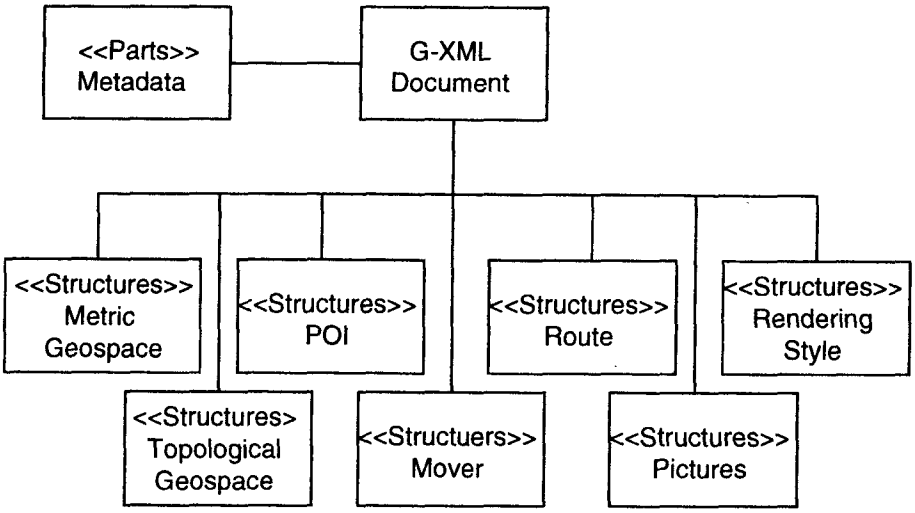

Figure 2. G-XML Object model

everyone can use this format. It is easy to use this data format because it is based on XML. In the near future, G-XML will be unified with GML which is provided by OpenGIS Consortium[7]. Figure 2 shows the G-XML object model. There are more detail G-XML information found in reference[6].

3. Design of Semantics Filter

Generally, a map helps person to understand information easily, it consists of three major kinds of the topics:

1. Purpose of this map.
   (route map, location map)
2. User's geographical knowledge.
   (How much does user know around this map?)
3. Priority of a spatial data.
   (Which building becomes a mark?)

The purpose of this map is fixed by contents of GIS service. Other cases, since many patterns are assumed, formulization is difficult. Therefore, in this research, we design the "Semantics Filter". Figure 3 shows the features of this filter. "Semantics Filter" dynamically determines the transferable spatial data which is favorite data in each user. "Semantics Filter" is based on fuzzy reasoning. Using user's information, it reasons out the geographical knowledge and the priority of each spatial objects. A user's information are age, sex, residence and so on.

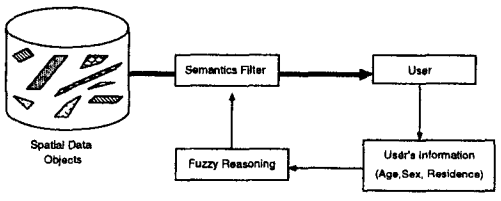

Figure 3. Feature of Sematics Filter

We proposed the basic idea of the semantics filter[5]. Figure 4 shows the Sematics filtering flow.

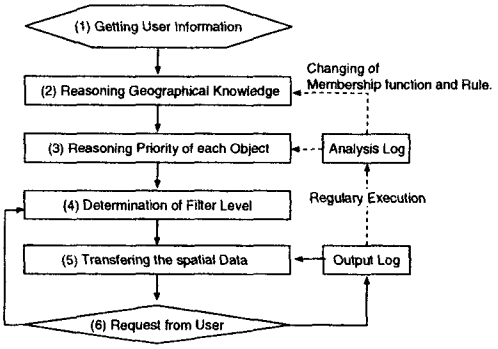

Figure 4. Filtering Flow

Step1: Getting user's information
A user's infomation(age, sex, residence) is inputted.

Step2: Reasoning of geographical knowledge
A user's geographical knowledge is calculated by fuzzy resoning. This depends on the distance of the residence region and the destination region.

Step3: Resoning of the priority of each objects
The priority of each spatial objects is determinated by user's geographical knowledge.

Step4: Determination of filter level
The filter level is determined by a network speed and the device used.

Step5: Transfering the spatial data
Transfering user's favorite spatial data.

Step6: Request from User
If user doesn't like this data, can changes the filter level.

Step7: Output Log
The user's operation is recorded in logs.

Step8: Analysis Log
Membership function and rule are changed by analyzing

logs and reasoning geographic knowledge.

4. Architecture of multi-tier GIS with Semantics Filter

We have integrated some parts of the Object-Oriented GIS[10]. The architecture of multi-tier GIS with Semantics Filter is shown in Figure 5

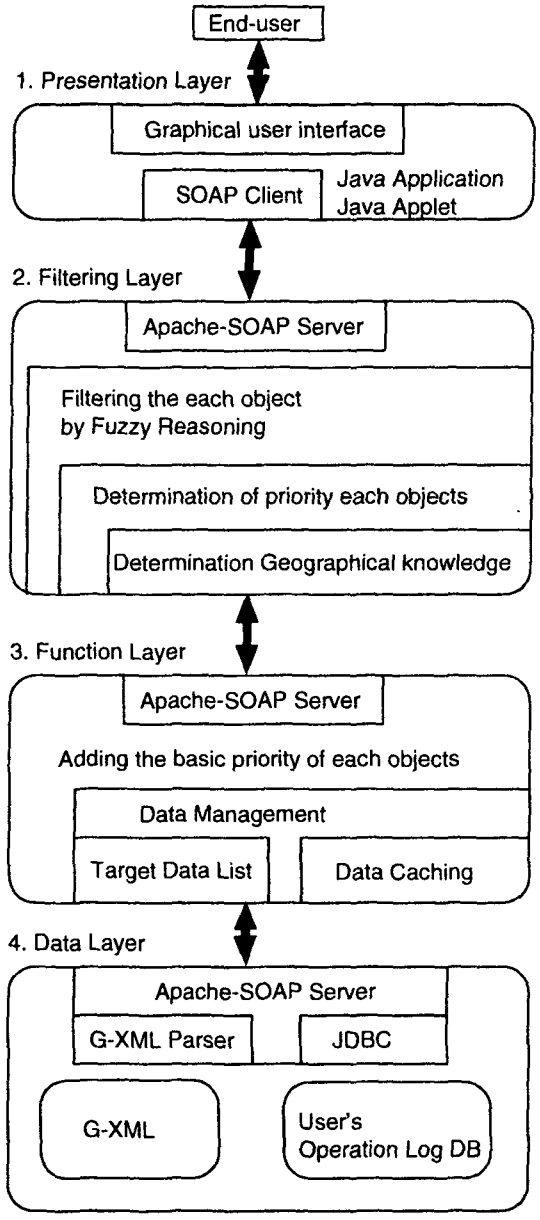

Figure 5. Architecture of multi-tier GIS with Semantics Filter

This system has a four layers, presentation layer, filtering layer, function layer and data layer. Each layer interface can be obtained by the technology of Apache Simple Object Access Protocol(Apache-SOAP[8]). In Apache-SOAP, a network transparent object is easily defined by adding a few steps into the original object definition. We explain the each layers in brief. Note that end-user client has only presentation layer. Other layers are in the server-side.

4.1 Presentation Layer

The main role of presentation layer is drawing the spatial data which have been sent from filtering layer. When a end-user log in this system, the end-user's basic information is sent to filtering layer. On the other hand, the end-user's operation of the filtering level is sent to user's Operation Log DB on Data Layer.

4.2 Filtering Layer

At first this layer, determine the geographical knowledge with fuzzy reasoning based on the end-user's information. The second step, reconstruct each object's priorities is based on end-users geographical knowledge. The third, it determines a end-users filter level based on geographical knowledge, network speed and device used. In the fourth step, it creates the data which is the most suitable for end-user. Finally, created new data is sent to the presentation layer.

4.3 Function Layer

When this layer receives a messeage from filtering layer, checking a data which is requested from filtering layer. If the Data Caching doesn't have the data, it gets the data from data layer. So, it add the basic priority to each object and transmitting it to the filtering layer. If the Data Caching has the data, immediately transmitting it to the filtering layer. We add the priority to eache objects on the DOM-tree structure since G-XML specification has no decision on priority. Then, it is possible to exchange the G-XML data without destroying the G-XML specification because of the G-XML data file is unchanged.

4.4 Data Layer

This layer is very simple. It has two roles. The first, it receives the request from function layer, it find out the data which is specified by location. If it contains the data, these send the persed data to function layer. But if it doesn't have these, it send the null data to function layer. The second, it receives the request from presentaion layer. This request has a end-user's operation, then it inserts the this request to the User's Operation log DB.

5. Evaluation

We evaluate the decresing of spatial data. We compared the transferrable data quantity with the different filter level. Figure 6 shows the data in 0.0 filter level. In other words, it was row spatial data. On the other hand, Figure 7 shows the spatial data in 0.6 filter level. These experimentations carried out without the consideration of network speed and a client performance. How to determine the priority of each objects is divided into

two ways. To determine the priority of road objects, we calculated the length of a road. So, we found out the longest road and we normalized the other roads by it. In the same way, to determine the priority of building objects, we calculated the area of a building. We found out the building of maximum area and we normalized the other buildings by it. We think that the most longest road is important in the roads and the most largest building is the most important in the buildings.

The process is very simple, as well as the caluculating costs decrease low. It decrease the number of objects dramatically when Figure 7 is compared with Figure 6. Figure 6 has 1758 objects. On the other hand, Figure 7 has only 158 objects.

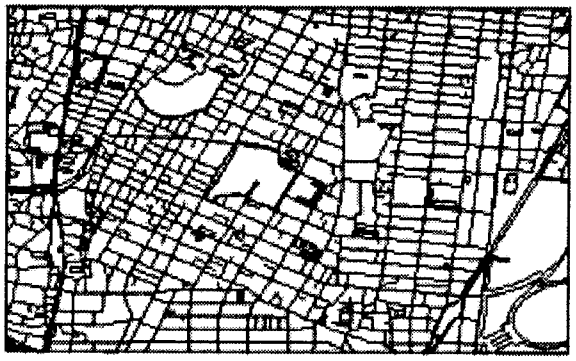

Figure 6. Filter level 0.0

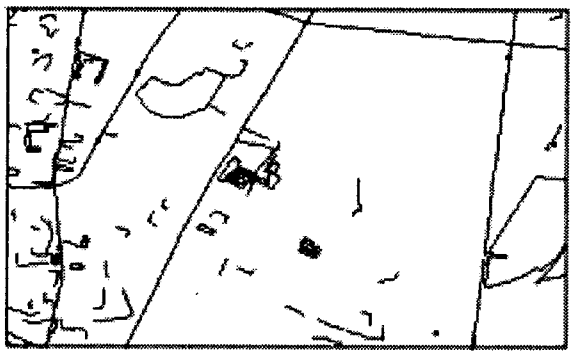

Figure 7. Filter level 0.6

Figure 8 shows the graph of the changing in the number of objets by the filter level.

6. CONCLUSION

We implemented the mult-tier GIS software and evaluated it. The evaluation shows that number of objects dereased by a end-user. Then, the semantics filter is useful for the decreasing objects.

On the other hand, we have to prove that these decreasing data is realy a end-user's favorite data. Figure 7 shows the data which aren't important. For example, the road cut off halfway. It is necessary to solve this problem by joing the relation of roads.

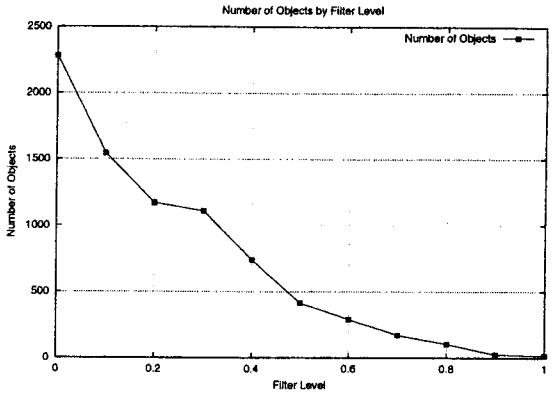

Figure 8. Number of Objects

Moreover, this paper isn't stated about the perfomance of this system. We have to research it on the some devices like PDA and cellular phone.

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