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Distributed Mobile GIServices :

Necessity of future GIS Community

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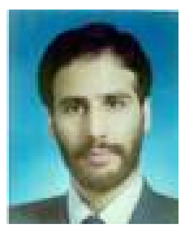

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Abstract
Several GIS functions are compatible with business models. This vision leads in a new pattern in GIS community. The new area is known as GIServices. With this pattern each person could use the ability of GIS functions without buying a GIS hardware and software and without any knowledge about GIS. GIServices could increase the number of GIS users.
In order to design a complete and correct GIServices, distributed systems is proposed. Distributed systems can improve the scalability and performance of GIServices.
Also with attention to expanding of mobile terminals, customizing such services for using in mobile terminals is described. And the ability of mobility in producing new distributed applications is described. In this paper the architecture of proposed system from this point of view is stated. Some applications in this new area is then presented.

1. Introduction

What are the main reasons of using GIS? What people can use the GIS? Current GISs are designed to serve big organizations and these organizations are most of the users of these systems. But with changing the patterns and viewpoints, GISs can serve a lot of people with different knowledge about geospatial analysis. This pattern is done with this viewpoint that, GIS vendors present services to the users instead of selling a complete software system, that these services accomplish the general tasks of a GIS with respect to customers request [Gunther et al 1998].

The goal of this paper is examining the architecture and designation of these services for presenting to the ordinary users of GIS in order to users can do their daily activities with these services without any requirements to a complete GIS. So the architecture of the proposed system that demonstrate the situation of services and computation is examined. Distributed Software systems is regarded as a basis for implementing these services. Another important viewpoint that is examined in this research is the mobility of the users. That is, our users are mobile in addition to be ordinary. So these users have mobile terminals for using these services.

2. Geospatial Information Services

Several GIS functions are compatible with business models that are different from the current models. Now, the users of GIS, are big organizations. These organizations have to buy software and hardware for their own activities. They must pay to GIS vendors for purchasing and maintaining such expensive system. A substituting model for current model is a service-oriented approach [Gunther et al 1998]. In this pattern, GIS vendors instead of selling a complete systems, presenting services that accomplish general GIS tasks with respect to customers request. In order to reach this goal, there is a need to change our viewpoint from GISystems to GIServices.

GIServices allow the users to access, collect, sale and renting spatial information and data and spatial analysis in a network environment (especially Internet and mobile communication systems). Generally, there are three reasons for developing GIServices [Tao 2001]:

1. Technological point of view
   With the advent of network technology, designing the software systems is changed from desktop-centric to network-centric systems. These revolution is effected the designing of

GIS software. This pattern leads to increase the number of GIS users and generally software systems.

2. Software Engineering point of view
   Most of GIS users only use a small fraction of the functionality offered by GISs. However users must to pay a full licensing fees for a complete system. Albrecht (1996) introduced about 150 independent analysis in GIS. He have explained that GIS users only use from 20 of them in average and other analysis occasionally use by the users, even some of the users don't know about the existence of some operations [Albrecht 1996]. Of course this matter is true for many software. It has been estimated by Microsoft that 90% of Excel's users worldwide only use from 10% of it's functionalities. The point that distinguished a GIS software from other software like Excel is high price of it that leads to escape many GIS users to use it's useful operations. Another point that is very common is that, in many cases a software isn't work well in many operations and the organization must buy another complete software for doing that analysis. This leads to another problems. With the advent of software components and using them in GIServices, a system can be decomposed to some interoperable functions. So, with this pattern many of potential GIS users can be a permanent GIS user only by paying a small fraction of GIS cost [Peng and Tsou 2003].
3. Users point of view
   Users can find and use their components or operations. These operations are simply accessible from network(Internet). Now a user with respect to favorite service or activity can choose his/her favorite analysis from a desired vendor and simply do his/her activity.

Generally, GIServices involve two kind of services: Spatial data services and geoprocessing services.Spatial data Services present the ability of sharing spatial data between different users. Geoprocessing services present the access and process of spatial data to the users [Yuan 2001].

3. Distributed Systems

In the past decades, with fast progress in information technology (especially with introducing Internet/Intranet) and distributed object technology, developing GIS software have been changed a lot. Perhaps the most important thing is changing software patterns from desktop-centric to network-centric that leads to presenting spatial data and geoprocessing tools to the users in a network environment. The evolution of GIS software with attention of this pattern is the following [Peng and Tsou 2003]:

Centralized/Traditional GIS, Client/Server GIS, Distributed GIS

In order to implementing a GIServices, network-centric software systems must be used. Consequently, client/server or distributed architecture must be used for implementing these systems. Client/Server systems have a lot of problems, so distributed systems is examined in this paper [Yuan 2001].

3.2. Distributed GIS

In the past decades, there were fast progress in two fields. First, the computers have been very powerful and cheap. Second is communication field that is effectively and cheaply feasible the communication between computers and processors at different locations.

These progresses lead to invention of distributed computing systems concept [Pressman 2000]. Such a system involve some computers that connect by the network and each of them process separate functions. The reasons that lead to using these systems are [Amirian 2006]:

- **Performance** : the performance of different distributed systems can increase only with adding some new computers to these systems. This option is very simpler and cheaper than updating the processor of a mainframe computer.
- **Scalability :** with dividing the load of computing and processing across some computers, these computers need management and synchronization and in some cases synchronous processes. A useful management of some computers is load balancing. For example, nowadays many of famous websites are placing in some servers and so they can answer to very large number of users simultaneously with high performance.
- **Resource Sharing :** a distributed system allow it's users to access a great volume of data that are in computers of the system. These data instead of repeat in all computers can distribute in these computers.
- **Fault Tolerance :** a distributed system can design in a such way that continue to it's work if there is a fault in software or hardware.

In a simple word, a distributed application is stated as an application that some parts running program is done remotely by different components that are running in more than one computer in the network. Logical components of a distributed applications are clients and servers [Amirian 2006].

In a distributed application the necessary processes and computing for accessing the database or accomplish processes aren't done by clients. Accessing to the database and accomplishing the processes are done by a set of software components that are running in computers except the client computers. So, Unlike the traditional client/server application, in a distributed application, most parts of the running program is assigned to server's computers. This approach leads to increase the answering time to users' requests, but instead the number of simulation users of distributed application is really greater than other application developing models. In fact, the most important reason for using distributed application have to be high performance with great number of simultaneous users.

3.1. Features of distributed systems in GIS

Special features of distributiveness in GIS are [Peng and Tsou 2003]:

1- GISs have distributed nature from the spatial data point of view. Different organizations provide spatial information and data with different methods and standards and maintain them at their own database.

2- Fast increasing amount of digital data leads to saving and processing of these data in ordinary computers couldn’t be possible. So, necessity of a powerful computing structure in many applications is felt.
3- The existence of different software from different vendors is in such way that each of these software have special capabilities. With the use of distributed systems and GIServices, vendors can concentrate on producing special components instead of an integrated system.

Distributed systems have other features that we explain some of them here.
1- These systems are made from distributed components. So that each component have their own functions. For example, “Buffer” and “Point-in-Polygon” are two kinds of components.
2- These components are distributed, that is, they can be in different computers but interact directly with each other.
3- These components are mobile, so they can load in other computers when is necessary.
4- These components are open and interoperable..
5- These components are searchable. So a catalogue service is needed to search the availability and functions of all components.
6- Data are distributed in these systems
7- Data are interchangeable

3.2. Designing a dynamic architecture for distributed GIServices

In the following figure, a simplified dynamic architecture for implementing distributed GIServices is illustrated in figure (1) using unified modeling language (UML) [Peng and Tsou 2003].
Based on the UML notation, figure (1) identifies four major classes in the distributed GIServices architecture : [Users], [User Scenario], [GIServices Architecture] and [GIServices].
The distributed GIServices model present a flexibility in construction of thick or thin client [Tao 2001].

3.3.1. Thick Client Architecture : In this model, the client side is the original source for computing, but geoprocessing analysis come from other places at the network. The client side in this model supports a workstation for local processing of data. This architecture specially is used when data are in the client computer.

3.3.2. Thin Client Architecture : In this model, the client side provide a user interface only that allow to the users to send request for a service. Most of computing in this model are done with services in another location of the network. This architecture is useful for applications that the workstation is mobile and communication methods are more wireless or need quite lower bandwidth.

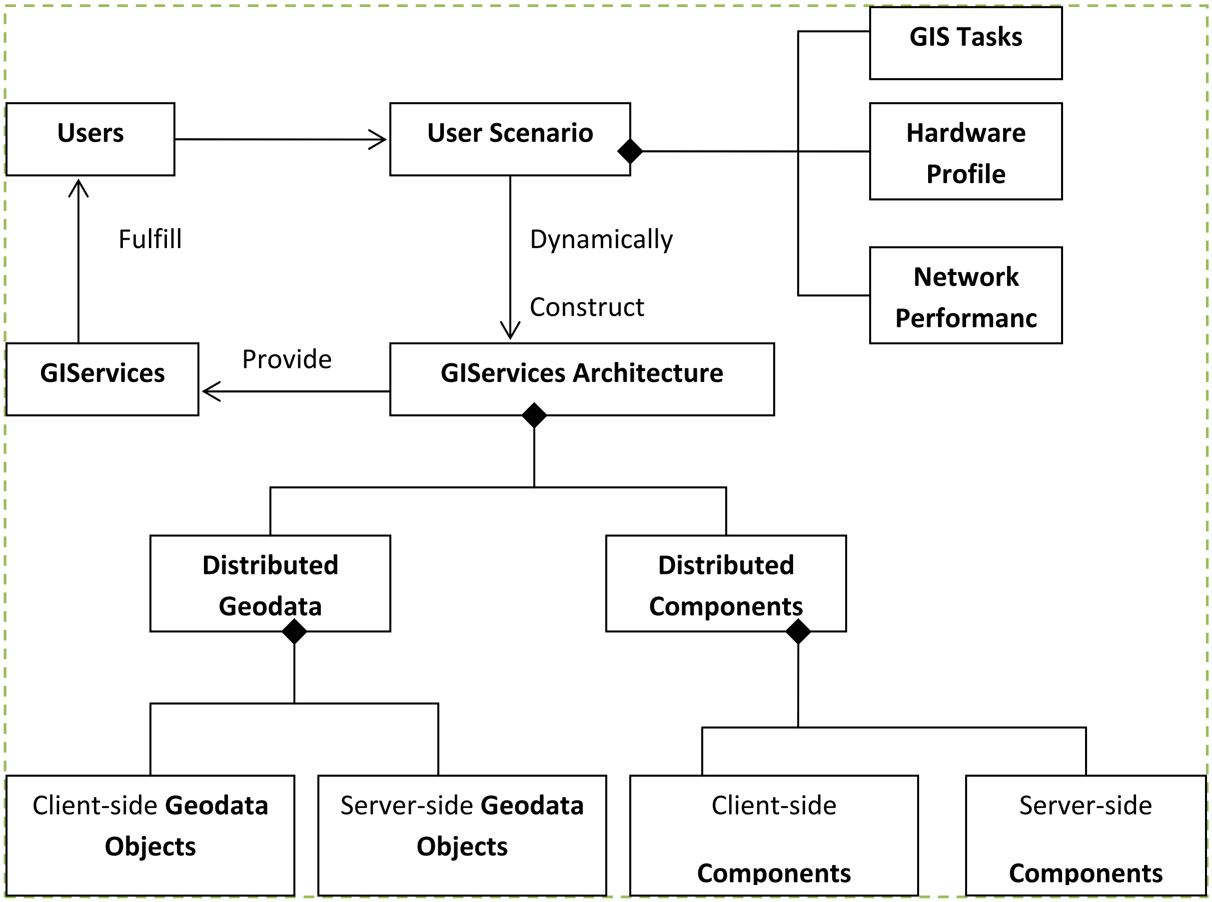

Figure 1 – A dynamic architecture for distributed GIServices

4. Distributed Mobile GIServices

The computing science is grown from mainframe computers that serve a lot of users' request in an inaccessible rooms to nowadays network-based environment that many computers can serve a person anywhere and anytime. So that, the tendency had been to ubiquitous or mobile computing [Hunter 2000]. Generally, mobile computing have special features that are very different from desktop systems. In order to implement a mobile system attending to these features is very important. These features are [Peng and Tsou 2003] :

1- Different forms of mobile terminals with different kind of processors
2- Different size of screens and different data entry methods
3- Resource constraints : Hard disk, RAM, Battery life
4- Different connecting methods to networks and continuous disconnection of network
5- Different platforms of mobile operating systems (Palm, Windows CE, Symbian)
6- Mobility

Mobility is the most important feature of mobile systems. The reason from this is that all of the other features are resulting from technological problems, but the mobility explain the nature and applications of mobile systems. Shortcomings of mobile systems will be better with technological progress of mobile terminals whereas the mobility feature can extend many applications to current systems.

Since many of data that a mobile agent deal with them are depend on mobile's location and the environment of it, so new fields are to come into in mobile community science that are known as Mobile GIS or Ubiquitous GIS.

4.2. Mobile GIS

Mobile GIS is a kind of GIS that it's matter is non-geographical features in the geographical environments. If add mobility to this definition, we can be reached to a more precise perception. One of the main differences between mobile GIS and traditional GIS and even with temporal GIS is that, it's matter is a mobile agent. In the other words, in mobile GIS, not only data but the agent, hardware and software can be mobile too [Malek et al 2005].

Generally, software design's patterns that use client/server model are the best kind of designation for mobile systems. Since requiring the GIServices in mobile systems is very necessary like static systems and in order to guarantee high performance and extension, distributed patterns is proposed for designing a mobile GIS [Alivand 2007].

Another issue that leads to propose distributed systems in mobile environment is the feature of mobility. A mobile agent has only some limited information about it's environment. So in order to solve a spatial problem, it hasn't many data and information for solving that problem. Consequently, it needs to provide it's information's requirements from some servers. In this pattern, mobile clients send their environment data to the server; then server do the analysis on those data and send back the results to that mobile clients. So it's clear that the best designing pattern for a mobile GIService is distributed architecture.

Goodchild et al (1997) explained four criterion that can be used in mobile systems, that emphasis the necessity of using distributed systems in mobile environment:

1- The system should be distributed, that is, data and processes must be at different locations.

2- The system should be disaggregated, that is, instead of a centralized system that is used a lot today, the system is replaced by 'plug and play' components. These components can be provided by different vendors with the base of interoperability standards.

3- The system should be decoupled, that is, the system should be able to access a number of components that may be required to complete a specific task, which may be distributed over many networks.

4- The system should be interoperable, which means the system is based on open standards.

4.3. Applications of Distributed Mobile GIServices

We can a lot of scenarios for implementing mobile GIServices, that two following scenarios have more applicable rather than others [Tao 2001].
In the first scenarios, the user have spatial data in their computer locally and needs one or some analysis for instantaneous processing of them. This scenario is very common in mobile systems. Fieldworkers are very communicate with this scenario. In this scenario a fieldworker that have a mobile GIS. Collect the data at the field. Then he/she needs some functions to process them and use the results at the field. For example needs to 3D analysis for calculating slope of the field and visualizing the 3D model.

In the second scenario, the user hasn't spatial data and geoprocessing tools in his/her computer, so in order to accomplish the spatial activities, the processes should be accomplish at the server side and then the results send to the user. A tourist is a good example of this scenario. When a tourist enter to a new region, spatial data and geoprocessing tools can help him/her for doing his/her daily activities [Alivand 2007].
For example a routing activity, that is very common activity for tourists, needs spatial data and the shortest path analysis.

The difference that this scenario have in static and mobile environments is related to constraints and problems in all mobile systems.

Since the network that mobile systems use is wireless network and the rate of data transferring in these networks is very lower than wired networks, and with attention to continuing disconnection of network in wireless networks (that is very common), so, interchanging spatial data that have high volume is very hard or impossible. Interchanging spatial data between mobile client and servers should be prevented as much as possible.

Also, with attention to low processing power of mobile terminals, if users need complicated analysis that requires powerful processors, it's better that the processes accomplish at server side. So, in the first scenario that data are in mobile clients, it's better to use the thick client model and at the second scenario use the thin client model [Alivand 2007].

Figure 2 illustrate an architecture for these scenarios [Hunter 2000]. In this architecture the services that mobile clients use are located in Internet and mobile clients can use these services with connecting to the internet.

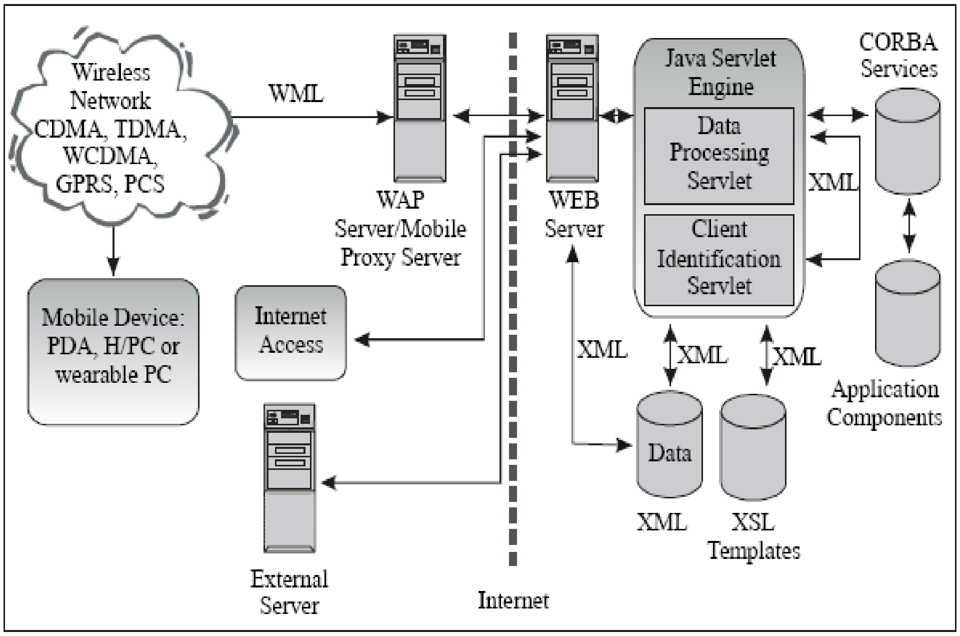

Figure 2- Distributed Mobile Computing Architecture

4.3. Connecting Mobile Clients to the Internet

One of the major networks structure that use in distributed systems is internet. So for implementing a distributed mobile GIServices, mobile clients need to have the ability of connecting to the internet via wireless network. In the previous sections, features of mobile systems is expressed. Two of them create a lot of problems for connecting mobile clients to the internet. Those are low bandwidth of wireless networks and small size of mobile terminals.

Most of current wireless networks can only transfer data with rate of 9.6-14.4 kbps. The screen size of mobile clients usually can visual only some lines of text. PDAs have larger screens but they also have lower screens compared to screens of desktop computers. Also a lot of mobile phones and PDAs haven't any keyboard for entry the data. So, locating web contents that has high quality graphics and animation isn't possible in these mobile terminals. So, it's necessary to rethink about designing wireless web for presenting to mobile GIS.

For customizing web for mobile phones, some open standards and special systems have been developed. Some of them are [Peng and Tsou 2003] :
C-HTML, XHTML, Web Clipping, HDML, WML, MEXE, WAP

4.3.1. Wireless Markup Language (WML)

WML is a special subset or schema of XML based on HDML. WML offers more flexibility than HTML to fit the specific needs of mobile devices. WML requires very little bandwidth resources compared to HTML. WML also requires less processing strength to render n microbrowser. Less processor power means longer lasting batteries at mobile devices.

4.3.2. Wireless Application Protocol (WAP)

WAP was designed to server internet contents and internet services to wireless clients with WAP-enabled mobile devices such as mobile phones. WAP is an open system. It is a complete new stack of protocols designed to overcome some of the wireless network's specific problems such as low bandwidth and high latency.

5. Conclusion and recommendations

The concept of GIServices change the way that users use a GIS and alter the pattern that vendors sell a GIS. Also change the methods that GIS providers use for using this information in GISs. A geoprocessing model should be developed in a such way that the system be open and interoperable. Also should be design appropriate standards for searching analysis (like metadata for searching data) in the Internet.

Using Task-Oriented methods for designing services in the internet is proposed in order to ordinary users can use them comfortably that in the future works we examine the designing such software with the basis of this pattern.

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