THE DESIGN OF U-GIS CONVERGENCE MIDDLEWARE

In-Sung Jang, Min-Soo Kim, Young-Jun Lee

Telematics Research Laboratory, Electronics and Telecommunications Research Institute
{e4dol2, minsoo, yjl} @etri.re.kr

ABSTRACT ... Traditionally, Geographical Information System can only process static spatial data, which include geometries and attributes. Recently, According to Special attention is paid to ubiquitous computing environment, we require a u-GIS convergence middleware to efficiently process ubiquitous data and improves the existing GIS engine in order to enable converged processing of spatial and sensor data. So, in this study, we propose a design of u-GIS Convergence Middleware, which are based on the integration between GIS and USN technologies

KEY WORDS: USN, GIS, Middleware

1. BACKGROUND

Information about dynamic spatial fields, such as temperature, windspeed, or the concentration of gas pollutant in the air, is important for many environmental applications. At the same time, the development of geosensor networks(wirelessly communicating, sensor-enabled, small computing devices distributed throughout a geographic environment) present new opportunities for monitoring dynamic spatial fields in much greater detail than ever before.[1]

Sensor networks are distributed ad-hoc wireless networks of sensor-enabled miniature computing platforms. A Geosensor network is defined as a sensor network that monitors phenomena in geographic space [2]. And GeoSensor is like WSN, RFID, Web Cam, Network Camera, CCTV, Smart Phone, PDA, and so on.

Substantial advances over the last few years have provided us with diverse and robust techniques to quickly and precisely capture large amounts of geospatial information. For example, using cameras, laser scanners and GPS sensors on-board static or mobile platforms allows us to collect geospatially rich information, such as the locations of moving objects, or detailed 3-D terrain models as they are captured by an unmanned aerial vehicle flying over an area of interest [3]

In this paper, we present a project that develops a u-GIS convergence engine to efficiently process ubiquitous data and improves the existing GIS engine in order to enable converged processing of spatial and sensor data. We are expecting many kinds of new u-GIS services will be available in near future, if the USN and GIS technology are cooperatively integrated.

In figure 1, it shows how we think about the convergence between USN and GIS. We call it u-GIS. Recently, such convergence of GIS and USN technology (in brief u-GIS technology) are emerging as a very interesting issue. Here, there is GIS infrastructure, and here there is USN infrastructure. 3-dimensional spatial data are transmitted from the GIS infrastructure, sensing data are transmitted from the USN infrastructure. The 3-dimensional spatial data is a kind of static data which is not changed when times go on. While the sensing data is a kind of dynamic or live data. Actually, the sensing data is continuously changed when times go on. So, the u-GIS technology should be able to control, manage, and analyze the two kinds of data, at the same time.

In other words, by integrating and converging the two kinds of data, we can develop new kind of u-GIS services that was impossible at former times.

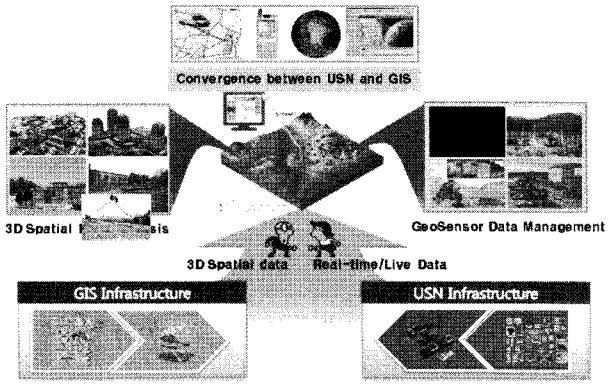

Figure 1. The Conception u-GIS middleware

2. RELATED WORK

2.1 NGIS Project

Since 1995, Korea has performed the government-led NGIS(National GIS) project for the purpose of utilizing the nationwide spatial information in various service fields such as traffic, environment and disaster management. That project is funded by the government, Ministry of Land, Transport, and Maritime Affair. [4]

While the first and second NGIS projects focused on the development of the GIS base technology which is related to the construction of the nationwide spatial information, the third project which has been performed since 2006 has focused on the development of the newly converged technology of GIS and USN for realizing the ubiquitous-based national land development. At that time, it built digital spatial data infrastructure from paper-based spatial data.

In the second step of NGIS from 2001 to 2005, it focused on building a spatial data clearing house. Using the spatial data clearing house, it intended to provide national spatial data infrastructure in public. And it developed various kinds of mobile GIS services and web-based GIS. At that time, many kinds of GIS-concerned service market started to be revitalized. Especially, navigation and web GIS services had a major growth.

The third step of NGIS started at 2006 is focusing on the convergence with USN.

Recently, as one of the ubiquitous-based national land development projects, the u-City construction project that can provide intelligent urban information services (u-City services) using the information super highway and the USN technology has been actively promoted. The u-City services that include various kinds of services such as urban facility management, urban administrative information management and disaster management services requires ubiquitous spatial data that are different from the existing spatial data. Such ubiquitous spatial data are forming multi-dimensional spatio-temporal data type or streaming data types that are continuously transmitted from GeoSensor network. Therefore, the ubiquitous spatial data are more complex than the existing spatial data. Currently, according to the rapid increase of the complexity and size of such ubiquitous spatial data, the requirement for the u-GIS convergence technology has been rapidly increased to achieve the following objectives.

- By securing basic technology of u-GIS core s/w technologies for efficient processing and analysis of GeoSensor data and spatio-temporal data, we can drive u-GIS concerned the international standards and technology development.
- By developing the standardized u-GIS convergence platform, then by applying it to various kinds of u-City services development, we can reduce the time and cost that may be consumed at the development of such kinds of services.
- By developing the advanced u-GIS engine that can integrate, converge and manage the spatio-temporal data and the GeoSensor data stream, we can extend our technologies abroad and increase technologies export.

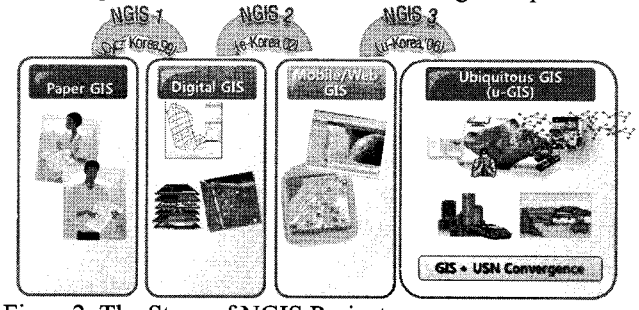

Figure2. The Steps of NGIS Project

2.2 USN Middleware

Figure 3 shows a architecture of USN middleware. This system is mainly composed of two parts: server part and In-network part. Server part is implemented at server computer, while in-network part is implemented at sensor nodes. The Server part is composed of USN abstraction, Data management, Context-aware, and Services component. A main role of USN abstraction component is to manage RFID reader, sensor node and USN gateway. Data management component, efficiently process real-time stream data and process complex user queries. Context-aware component processes business rules using the existing rule database. Services component provides various interfaces such as web service.

In-network part is composed of In-network data management and sensor node management component. Sensor node management component manages sensor nodes deployment and dynamic topology updates. In-network data management component executes in-network data processing.

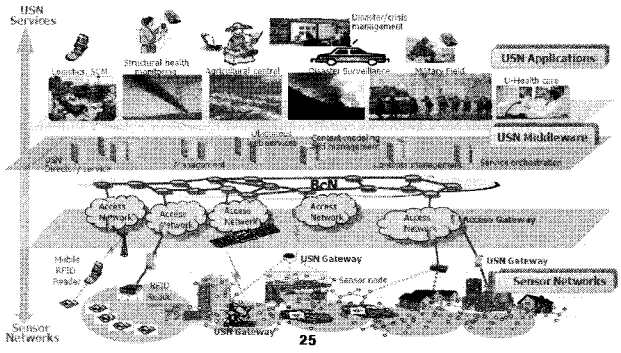

Figure 3. USN Middleware (Source: USN PLAN of MIC)[5]

2.3 The SensorWeb of OGC

The term "Sensor Web" is sometimes used to refer to sensors connected to the Internet or World Wide Web. Such terms are occasionally used in conjunction with projects of the Open Geospatial Consortium (OGC). In this case, the network architecture requires the Internet to link together the individual sensing elements. The OGC architecture is very different than that of a true Sensor Web system and requires schemes to bring together vastly different datasets, in the same way that TCP/IP is used to tie together vastly different pieces of hardware and computing platforms. Note also that a single Sensor Web may be an individual sensing element inputting into an OGC-type network[6].

The Sensor Web is a type of sensor network or geographic information system (GIS) that is especially well suited for environmental monitoring and control. The term describes a specific type of sensor network: an amorphous network of spatially distributed sensor platforms (pods) that wirelessly communicate with each other. This amorphous architecture is unique since it is both synchronous and router-free, making it distinct from the more typical TCP/IP-like network schemes. The architecture allows every pod to know what is going on with every other pod throughout the Sensor Web at each measurement cycle

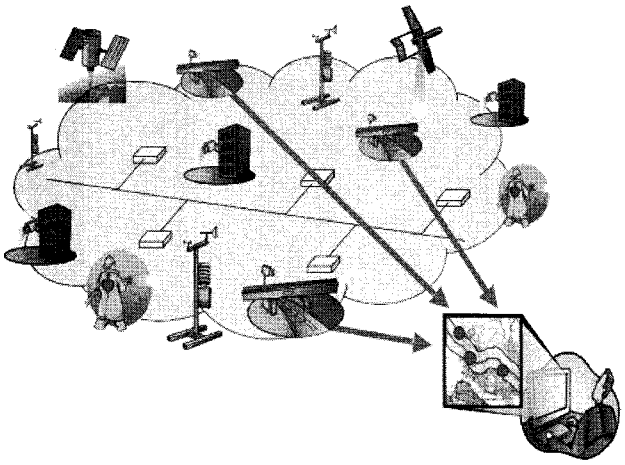

Figure 4. The SensorWeb of OGC (Source:OGC)[5]

2.4 The SensorMap of MS

In Figure 5, It is the SenseWeb that shows a convergence example of USN and GIS technology.
This is started by MS Networked Embedded Computing Research Group at 2006. First, they developed SenseWeb that allows developing sensing applications that use the shared sensing resources and our sensor querying and tasking mechanisms. Then, using the SenseWeb, they developed this SensorMap. The SensorMap is one application that mashes up sensor data from SenseWeb on a map interface, and provides interactive tools to selectively query sensors and visualize data.
In this figure, you can see that 3-dimensional background spatial data and contour map generated using GeoSensor data are integrated.

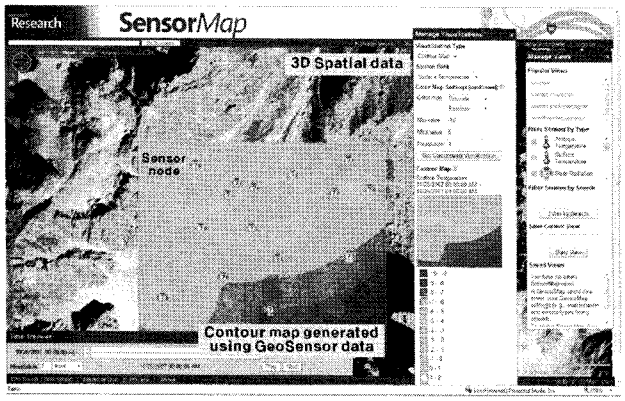

Figure 5. The SensorMap of Mircrosoft

The SenseWeb is a peer produced sensor network that consists of sensors deployed by contributors across the globe. It allows developing sensing applications that use the shared sensing resources and our sensor querying and tasking mechanisms. The SensorMap is one such application that mashes up sensor data from the SenseWeb on a map interface, and provides interactive tools to selectively query sensors and visualize data, along with authenticated access to manage sensors.

3. SYSTEM ARCHITECURE

3.1 Overall

This system is a technology that can efficiently manage real-time stream data which are collected from various kinds of Geosensor network.
Figure 6 shows what technologies are needed in the u-GIS middleware project. The research goal of the u-GIS middleware project is to develop technologies for integration and management of GSN data and spatial information at the same time, and technologies for convergence and analysis of GSN data and spatial information. Actually, such u-GIS middleware is located between GIS/GSN data infrastructure and u-GIS services. This u-GIS middleware should be able to connect various kinds of heterogeneous GSN and GIS DB, integrate and manage GIS and GSN data, analyze the converged GIS and GSN data, and provide standard interfaces to u-GIS services.
They are Spatial Data Management System, GeoSensor Data Stream Management System, and u-GIS Data Convergence and Analysis System. In the spatial data management system, we develop GIS-related technology that is disk and main memory based 3-dimensional DBMS technology. In the GeoSensor Data Stream Management system, we develop GeoSensor data manager and Geosensor query processor. In the u-GIS data convergence and analysis system, we will integated u-GIS query processor, u-GIS data mining engine, u-GIS event procesing engine.

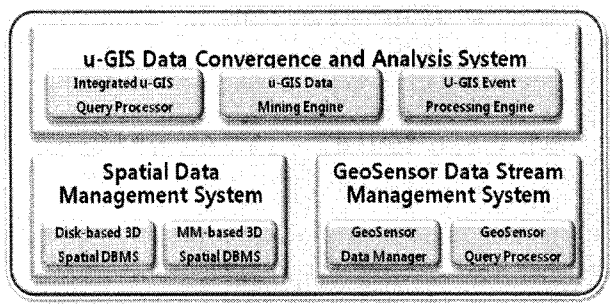

Figure 6. The u-GIS Middleware

Actually, we are preferentially developing the u-GIS query processor. So, in this paper, we concentrate on development of the u-GIS query processor

3.2 u-GIS Query Processor

Figure 7 shows you our system architecture of the u-GIS query processor. The u-GIS query processor is composed of four components. They are u-GIS data acquisition component, u-GIS data management component, u-GIS query processing component, and u-GIS service management component.

3.2.1 u-GIS Service Management Component (USMC): This is to expose web service/RMI/Socket interface for various kinds of application users including u-GIS Data Miner and u-GIS Event Processor

3.2.2 u-GIS Query Processing Component (UQPC) : It is processing of integrated query of GIS and USN / Supporting of various kinds of query types (Snapshot, Continuous and Spatial queries are possible)

3.2.3 u-GIS Data Management Component (UDMC): **It is a** main memory-based GeoSensor data and GIS data management using efficient indexing methods

3.2.4 u-GIS Data Acquisition Component (UDAC): Acquisition of GeoSensor and GIS data from the GeoSensor edge server and the GIS DB

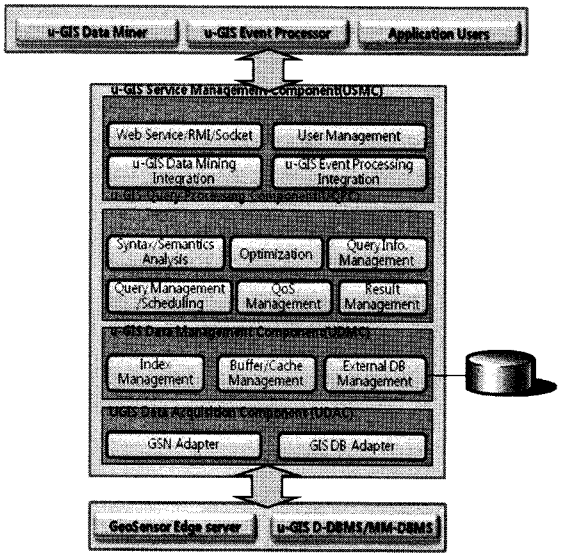

Figure 7. u-GIS Query Processor

In Figure 8, it shows screen shot of u-GIS Query Processor. The Query is containing spatial query type, moving query type and temporal query type for sensor and GIS.

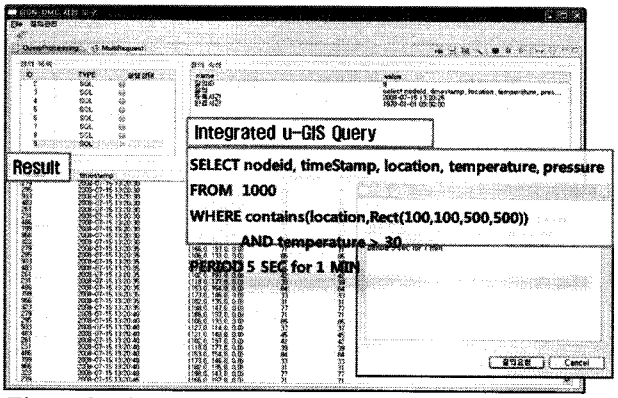

Figure 8. The screen shot of u-GIS Query Processor

3.3 u-GIS Data Miner

The u-GIS Data Minier has a role to Clustering, Classification, Association for integrated GeoSensor and GIS dataset. And It is to generate Thematic map using GeoSensor and GIS dataset. It is to visualize results of mining or analysis.

3.4 u-GIS Event Processor

The u-GIS Eveent Processor has a role to GeoContext data and semantic model, Authoring tool for the GeoContext and Integration with BRE(Business Rule Engine)

4. CONCOLUSION

Recently, USN and GIS technology are integrated and converged. And according to the convergence between USN and GIS technology, we expect new u-GIS service markets will be created and revitalized in near future. As one of the ubiquitous-based national land development projects, the u-City construction project that can provide intelligent urban information services (u-City services) using the information super highway and the USN technology has been actively promoted. The u-City services that include various kinds of services such as urban facility management, urban administrative information management and disaster management services requires ubiquitous spatial data that are different from the existing spatial data. Such ubiquitous spatial data are forming multi-dimensional spatio-temporal data type or streaming data types that are continuously transmitted from GeoSensor network. Therefore, the ubiquitous spatial data are more complex than the existing spatial data. For this, we subject u-GIS middleware in this paper.

Acknowledgements

This research was supported by a grant(07KLSGC05) from Cutting-edge Urban Development - Korean Land Spatialization Research Project funded by Ministry of Land, Transport and Maritime Affairs of Korean government.

Reference

[1] M.Duckham, S. Nittel, M.Worboys, "Monitoring Dynamic Spatial Fields Using Responsive Geosensor Networks"

[2] S. Nittel, A. Stefanidis, I. Cruz, M. Egenhofer, D.Goldin, A. Howard, A. Labrinidis, S. Madden, A. Voisard, and M. Worboys."Report from the first workshop on geo sensor networks". ACM SIGMOD Record, 33(1), 2004.

[3] The Emergence of GeoSensor Networks (Feb, 2006) Directions Magazine :

[4] MLTM, http:// www.mltm.go.kr/

[5] MIC," The strategy for USN" , 2005

[6] OGC, http://www.opengeospatial.org/.