A Sensor Based Web GIS System for Urban Sewage Monitoring

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Abstract

Flooding in residential areas poses great challenges to sewer network operators. The damage caused by waste water from sewer networks can be enormous due to high quality additions and installations in basements and underground car parks. It is not economically justifiable to prevent flood during extreme precipitation by expanding sewer networks. Instead, it is necessary to analyze the potential dangers that arise due to flooding, assess the associated risk, and establish a risk management program. In order to describe the potential hazards, area-related geographic data can be used as it is normally collected and managed in geographic information systems (GIS). GIS is used extensively in various applications such as environmental monitoring, disaster management, land-use mapping, transportation mapping and analysis, urban development planning, and natural resource assessment, etc. and huge volumes of geospatial data have been produced and collected. In this paper I proposed a Web based technique with the use of GIS and sensor for monitoring urban sewage pipelines which may useful for govt. as well as local agencies to take immediate action on critical flooding situation.

1. Introduction

Geographic Information System (GIS) has long been essential tool for governments, environmental institutions, military and others who depend on geographic information. GIS combines layers of data about a location to create more accurate picture of that location. These data are obtained from different sources in different formats, datum and coordinate systems. The rapid and enormous development of the Internet technology today results in usage of the Internet as a tool for data access, data transmission and access to GIS analysis tools. [1,2] Access of geographic data and geo-processing applications become much easier with the development of internet technology.

The combination of GIS and Internet offers great possibilities, such as the interactive access of geospatial data, enhancement of the functions of geographic information, and the access to GIS analysis tools. As a result of advancements in both technologies, Web services used based on Service Oriented Architecture. Web services let applications share data and even use other application capabilities, without regarding what operating system or platform on which those applications runs.

2. Web based GIS

Web Based GIS provides key decision support capabilities for disaster and emergency management. It helps professionals in mapping, monitoring, modelling and maintenance of sewer related systems. In doing so, a considerable time and money is saved. It allows the collection and processing of massive amounts of information. Information can be distributed to the public easily.

It allows building positive relations between the authority and individual citizens, businesses, investors and tourists via sharing essential information in an intuitive and understandable way. [2] E-government promotes the deployment of new technology for the better operation of Local Authorities. Web based GIS helps to meet the requirements of e-Government via geographical data sharing within the organization and with the outside world.Today widely known online mapping applications such as Google Maps and Yahoo Maps provide GIS services to ordinary Internet users.

The Open Geospatial Consortium (OGC) has introduced standards for the GIS services by publishing specifications. [3] OGC defines GIS services which are used to build distributed systems using principles of Service Oriented Architectures. Web Service standards are a common implementation of SOA ideals. Internet GIS is a network-based geographic information services that utilize both wired and wireless Internet to access geographic information, spatial analytical tools, and GIS web services (Peng and Tsou, 2003).The contents of Internet GIS include not only displaying Internet maps or sharing on-line geospatial information,

but also providing advanced GIS analysis functions and new information services. [1,4] The future applications of Internet GIS will highlight the concept of service-oriented. It indicates that geographic information services are provided to help people accomplish their works and meet the needs of the public.

Wireless sensor networks have received a lot of attention. It is a system which forms a network by small sensor nodes with sensing devices, wireless communication capability and collects sensing data observed by these nodes. Wireless sensor networks aim to obtain the current information in the real world. Considering that sensor networks are used at places which are difficult to be observed by human such as underwater, forest and desert. Sensor networks should be designed so that they are easy to deploy with small installation cost. Generally, it takes a large cost to observe long rivers or sewages.

3. Architecture of the web GIS system

3.1 Service Oriented Architecture

For implementing Web GIS system Service Oriented Architecture proposed by OGC is important. There are lots of services available over the internet. It is not possible for individual standalone service to meet all service requirements of many users. The number of geospatial services increased rapidly. So an emerging need has also appeared for methodologies to locate desired services that provide access and data mining capabilities to geospatial data.

The Service Oriented Architecture tries to construct a distributed, dynamic and flexible service system over Internet that can meet information and service requirements of many different users. SOA is used for building software applications that use services available in a network such as the Web services. It is a principle concept for Web Service implementation. Web services are loosely coupled between software components so that they can be reused. As shown in figure 1, There are three components in service oriented architecture: Service Requester, Service Provider and Service Registry.

- **Service provider** publishes services to a registry and makes it available on the Internet for the requests of the consumers.
- **Service requester (client)** performs service discovery operations on the service registry in order to find the service and access it.
- **Service registry** helps service providers and service requesters to find each other by acting as a registry of the services. [5,6]

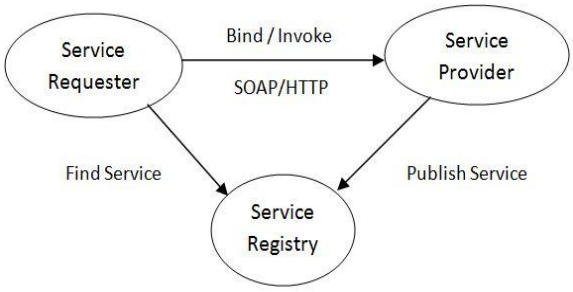

Figure 1-Basic components in SOA

The SOA approach to system development can produce systems that can be flexibly adapted to changing requirements and technologies, and offers easier maintainable and more consistent systems of data and functionality.

3.2 GIS Web Services

The OGC has developed the OpenGIS Web Services Architecture to improve the interoperability among geospatial system. [3,6] Following are the services based on OGC specification.

- **Web Features Service (WFS)**: It defines web interfaces for accessing feature-based geospatial data (vector data like administrative and political information, streets, cities, etc). WFS allows a client to retrieve and update geospatial data encoded in GML from multiple Web Feature Services. The specification defines interfaces for data access and manipulation operations on geographic features, using HTTP as the distributed computing platform from which, a Web service can combine, use and manage geospatial data and the feature information behind a map image from different sources.
- **Web Map Service (WMS)**: It produces maps of spatially referenced data dynamically from geographic information. This service defines a map as a digital image file suitable for display on a computer screen.
- **Web Coverage Service (WCS)**: It represents a web interface for supporting electronic retrieval of geospatial data as digital geospatial information (like remotely sensed imagery, ortho-photos, etc). A WCS provides access to detailed and rich sets of geospatial information that are useful for client-side rendering and input into scientific models and other clients.
- **Web Registry Service (WRS)**: It specifies web interfaces for finding data or services from registries.

GML is widely used as the universal encoding for georeferenced data. GML is an XML grammar written in XML Schema for the modeling, transport, and storage of geographic information. GML provides a variety of kinds of objects for describing geography including features, coordinate reference systems, geometry, topology, time, units of measure and generalized values.

4. Functional Architecture of the web GIS system for sewage monitoring with sensor

Following figure 2 shows the functional flow diagram of the sensor based system with the use of web services described above.

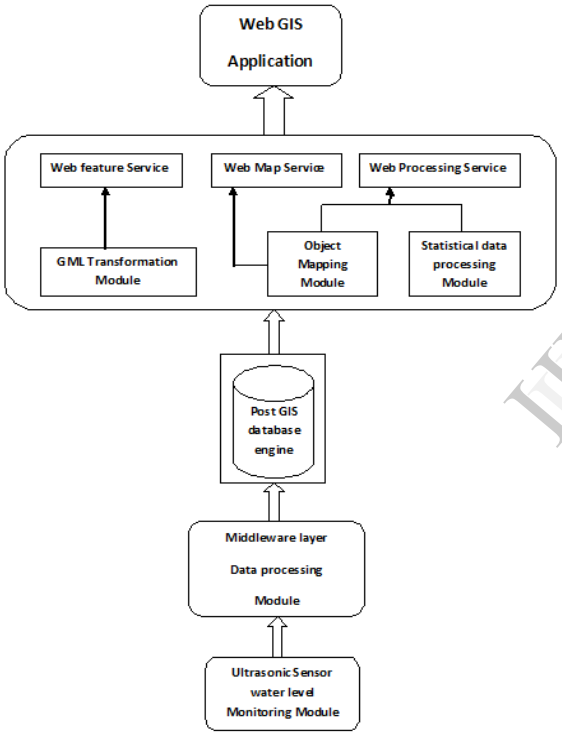

Figure 2-Functional diagram for proposed web GIS system using web services

The ultrasonic sensor level monitoring module measures water level in sewer and gives alert to middleware data processing module. The middleware module then process that data and manipulate to GIS compliant data and send to the data layer of the system where PostGIS database engine stores the data. These data could be available from databases or Web Services.

The service tier implements WMS, WFS, and WPS for data fetching. WMS provides standard interfaces to generate maps and charts for visualization of data. It utilizes the data mapping module to generate maps to show affected area after flooding. WFS use the GML transformation module to share spatial data through GML. It can be linked with the mapping values to create thematic Hazard maps. WPS is used to analyze spatio-temporal data. WPS uses the object mapping module and statistical procedures for processing data and generating graphs and charts. The input data of WPS could be obtained through Post GIS database engine.

The Web Application module is a client for the visualization of data and maps. It can show the sensor location, alarm signals, street maps-Road maps with different colours on the map.

4.1 Benefits of the system

This system can be very helpful to municipal government as well as sewage operators. Using sensor based Web GIS system gives alert message to the operator and operator can open the web GIS system from remote location. No need to personally go to monitor the sewage pipeline blockage. As shown in figure 3 System can show the location of the sensors on the map. It shows alarm at sensor location on critical flood situation. Also flooded area due to sewer flood can be shown.

Web GIS system provides maps with different aspects like road maps, pipeline maps with highlighted pipelines, the blockage location, affected area of the city due to blockage etc… If government wants to examine some particular location for accounting and auditing, it can be done directly from the map by extracting that much area from map.

Figure 3-Functionality of the web GIS system

5. Conclusion

Geographic information systems are an indispensable tool for analysis of the area-related potential hazards. GIS fundamentally involves the integration of data from different and diverse sources and in different formats. With the advancements in Geographic Information Systems and Internet technologies, it is becoming easier for anyone to access to geospatial data and geographic data analysis or visualization applications. The concept of Web services is based on service oriented architecture paradigm where a complete application can be constructed from various services which provide different functionalities.

In this paper I have proposed a system which is important for monitoring the sewage pipeline in urban area using sensor. The web services are used as essential component in this system by which GIS system will become intelligible. In this system, The Ultrasonic sensor is used which could be placed inside the sewage pipeline manhole which can measure the level, velocity and temperature of sewage material and send this data to the dedicated system. This data could be used for monitoring the sewage pipeline and we can also represent it on GIS so that operator can easily identify the location where the blockage will be created.

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