Application of Wireless Communication and GIS in Agricultural Environment Monitoring

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Abstract: The SMS/GPRS technology and seamless integration of GIS technology were used to implement remote data real-time transmission and management analysis in agricultural environment monitoring. Through SMS/GPRS technology this system realized wireless real-time transmission of remote monitoring data. Based on the GIS visualization technology and spatial analysis the monitoring data were displayed visually as well as location of pollution area was realized. System mainly consists of three modules: monitor communication center, information center and GIS environment monitoring information management. The overall design system in fully reflects the GIS, wireless transmission, environment monitoring seamless integration of the three modules. Development language is Visual Studio2005 VC.NET comprehensive use of MFC and CRL and Oracle9i database is adapted to integratedly access attribute data and the of spatial data, using MapX component to implement map visualization display and spatial geographical analysis. The system is suitable for departments of agriculture to acquire and communicate the environmental monitoring data, to manage the GIS, and to analyze the decision. *Copyright © 2013 IFSA.*

Keywords: Agricultural environment monitoring, Wireless communications, Geographic information system, SMS/GPRS, Visualization technology.

1. Introduction

With development of society, the departments of agriculture need better methods to monitor the environment, mainly embodies in real-time dynamic monitoring data collection, dynamic tracking and management, dynamic analysis and visualization, and so on [1, 2]. In recent years, SMS, GPRS wireless communication technology has been applied to the environmental monitoring areas to solve the problem of remote data acquisition and transmission [3, 4]. In the environmental monitoring and management, GIS technology has been used to achieve environmental monitoring information visualization analysis and prediction.

The method based on GIS, SMS (Short Message Service), GPRS (General Packet Radio Service) was proposed to establish an environmental monitoring system. Through the wireless communication technology SMS and GPRS as well as the function of GIS spatial analysis, the monitoring data geographic visualization on the server was realized.

GIS technology and wireless communication technology was seamless integration in this system,

its key techniques are remote monitoring data of multithreading, multiple communications protocol real-time online transmission and space analysis and decision based pollution diffusion model.

2. System Theory

The terminal equipment of Environmental monitoring stations whether use which kinds of communication, must have function of pollution factor data collection and wireless data transmission launch [5, 6]. The data acquisition module and data transmission module were connected mainly through RS232, and wireless transmission was processed by short messages and GPRS.

2.1. SMS Principle

SMS message service based on GSM mobile network is a wireless application to send short message and it is an information process of storage and forward on the mobile network. The information send out from the sender is stored in the short message center (SMSC), and then is forwarded to the user terminals. The standard protocol is short message SMPP. Short message communication process as follows:

1) Terminal launch short messages (MO Process).

2) MO after GSM network to short SMSC information center.

3) Information received by short message center is transmitted to the corresponding gateway CMPP or other gateway.

4) CMPP through the Internet gateway transmits the original message launched by terminal server to SP operation.

5) SP operation server process data and the data processed back to gateway by the Internet (MT Process).

6) Gateway sends data to SMS again, and through the GSM to send message to user terminals.

The environmental monitoring system is on the SP operation server, and then, in this system data acquisition device has function of short message transceiver as well as environmental monitoring data collection.

2.2. GPRS Communication Principle

GPRS communication is based on data packet communications network which is through IP address. The mainframe computer in monitoring center is configured by fixed IP address, GPRS modules or devices are used to connect collect data and the mainframe computer [7, 8]. The communication process is like a computer in a network of computers via TCP/IP SOCK communication.

Data of pollution information automatic acquired by data acquisition module at environmental monitoring points are connected to GPRS transparent data terminals through RS232 interface and by GPRS transparent data terminal built-in embedded processors are processed and packaged late-development to GSM network protocol, and then, by GGSN (Gateway GPRS Support Node) wireless network to be transmitted and, eventually, reach the monitoring center IP address.

3. System Structure

As shown in Fig. 1, this environment monitoring system was divided into three parts:
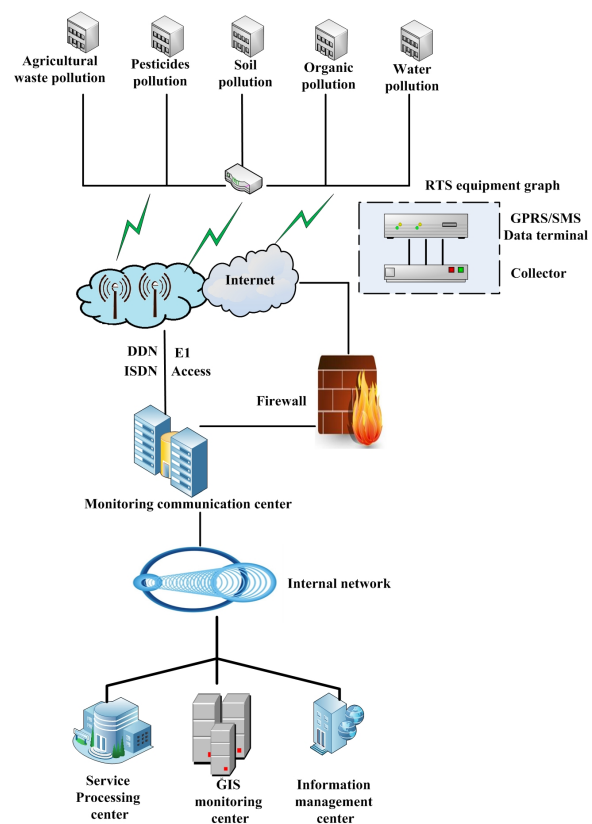

Fig. 1. System Structure.

1) RTUs (Remote Unit RTU) are distribution in different regions which have integrated data collectors and GPRS or SMS Terminal equipment. Data collectors can acquire various environmental parameters (agricultural waste pollution, pesticides pollution, soil pollution, organic pollution, water pollution) on the real time. GPRS or SMS equipment through RS232 interface sent data acquired by collectors to wireless public network based on GSM.

2) Data send by GPRS or SMS terminals are communicated to MSC (Mobile Switching Center by wireless network, again by GGSN or SGIP or CMPP or CNPP gateway, cabled to monitor communication

Center. Cable connections include straight line (DDN, E1) and ADSL and Internet connection. On the view of information security the Internet and ADSL are connected to the monitoring center through a firewall filtering.

3) Monitor communications center is mainly responsible for handling GPRS data packets and SMS packets, and for the database server data into operation, it also for radio communication SOCK to each subsystem.

4. System Requirements

System mainly consists of three modules: monitor communication center, information center and GIS environment monitoring information management.

4.1. Monitor Communication Center

Monitor communications center is mainly responsible for handling the terminals of the short message data or launched packets through GSM or GPRS wireless transmission to the corresponding mobile gateway, and then, gateway through DDN, E1, ISDN cable connection transmit the packet to monitor communication center.

The monitoring center receives packets for analytical processing (including protocol data and remote monitoring of environmental equipment acquisition system parameters). Monitor communications center adopts multithreaded programming technology, receiving and analytical data packets real-time information, and then write to the database server received information [9-11].

4.2. Information Management Center

Information management center function mainly includes:

1) Terminals information data entry, modification. Equipment information includes equipment models, SIM card short message center, special services based on SMS communication; Logon DSC Password; DTU Communication Port; Mobile Service Center (MSC) Service Code.

2) User management, including add, delete, modify user, different roles are divided according to the business logic levels, so different user permissions have different views and operation of the data.

3) Environmental protection agency information management.

4) Farmer information management mainly reflects the administrative area of peasant households, planting scale, equipment installation and main pollutants.

5) Management of pollutants, classification, name of pollutants, warning threshold level alarm and etc.

4.3. GIS Environment Monitoring Information Management

Based on GIS environment monitoring is the core of the system, it is built in commercial Oracle9i database through MapX component technology, using integrated secondary development. Through the GIS visualization technology system can visualize remote monitoring equipment transmission of data acquisition, when pollution index is overweight it show alarm information, and then highlight on the map. Besides system also combining GIS spatial analysis analyzes pollution area, provide the scientific method for the government's macro decision. Main features include:

1) Map storage.

Map using Oracle9i Object Relational Model to manage the geographic data storage, client use MapX5.0 data access requests, therefore system analysis and satisfy the mass of data management and multiple user data sharing and real-time concurrent processing.

2) Map operation and editing.

Map realize stepless zoom, roaming and reset operation, and through the eagle eye location.

3) Data query.

Click on the map layer of dot, line, face the elements can popup list, it based on the attribute information can also quickly locate geographic entities directly. The equipment picked by the mouse directly shows the key information such as SIM card, monitor alarm threshold, monitoring the variety of pollutants. System offers a variety of interactive selection method, rectangle, polygon area, circle choose etc.

4) Space analysis.

Space analysis is the key of environmental monitoring information management. Space analysis mainly is to select the suitable diffusion model, such as the dot, line, non-point source diffusion mode, and establish the pollution sources of regional influence.

5) Forecasting and analysis.

According to the historical environment monitoring data, using the regression analysis method, the exponential smoothing method and grey forecasting method, neural networks method can predict a regional environmental quality trend and combining GIS visualization technology in the map shows prediction results.

6) Statistics and output.

Statistics of the administrative division monitoring equipment, as well as daily, weekly, monthly, quarterly and annual statistical data, and the monitoring results in geographical map can be showed, and then generate the pie chart, histogram, etc.

5. Realization of Software System

The overall design system in fully reflects the GIS, wireless transmission, environment monitoring

seamless integration of the three modules. Development language is Visual Studio2005 VC.NET comprehensive use of MFC and CRL and Oracle9i database is adapted to integratedly access attribute data and the of spatial data, using MapX component to implement map visualization display and spatial geographical analysis.

5.1. Software Architecture

Key technologies of the system software are below two aspects:

1) Wireless data real-time transmission and communication center of packets of decoding.

2) The cooperation between modules.

As shown in Fig. 2, the software was divided into three layers, namely, the core layer, intermediate layer, and application layer. In order to ensure the whole system work together between each layer via TCP/IP protocol is used for packet distribution.
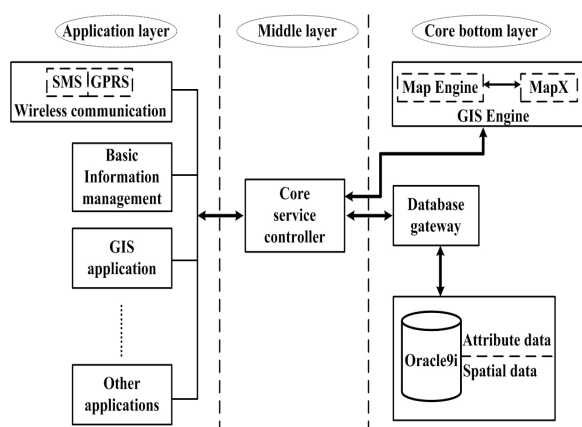

Fig. 2. Software Structure.

1) GIS engine based on MapX in the core layer is responsible for customer request response of map and space analysis. Because Oracle9i using object-oriented database containing a relational attribute database and spatial data, its access mechanism is more complex. Therefore, the system make encapsulation of database access, so database access are processed by database gateway, instead of directly on the database access, only database gateway to directly facing the underlying database.

2) The intermediate layer is the core services dispatch which is automatically packet distribution.

3) Application layer included wireless communication (SMS and GPRS), based information management, GIS application and other application module. Application layer is logic business, but not know Oracle9i space database and attribute database, simply manipulate technical details to the core of service dispatching tasks, sending requests or core services with GIS database request.

5.2. Realization of Communication Processing Software

Communication processing includes the TCP/IP communications of SMS, GPRS and software system structure. The message for system structure is simple, and can be directly through the Sock. Based on the wireless communication and using multithreading software realization is introduced, its core threads are as follows:

1) void Thread_Connect(LPVOID param);

According to the remote gateway IP and port, the TCP/IP protocol physical links.

2) void Thread_TCPSendAuth(LPVOID param);

After successful physical links, user name and password authentication binding, need MD5 encryption.

3) void Thread_SendAlive(LPVOID param);

To ensure the link links to send every time, when the link test kit to link failures, start (1) and (2), so as to realize the link links unattended.

4) void Thread_MsgNotify(LPVOID param);

Receiving the message thread which core are Deliver messages.

5.3. GIS Engine

In this system, the purpose of GIS integration is to let the real-time monitoring data visual expression on the map. Combining with the GIS spatial analysis function the influence sources of radiation radius can be analyzed. The key steps are as follows:

1) Map data loading

Data layer mainly includes monitoring equipment, villages, roads, river system, irrigation and drainage facilities and other features, through the EasyLoader tool in MapInfo upload the map data to Oracle9i database server, thus map of spatial data and attribute data are in integration storage.

2) Login Oracle9i spatial database server

In this system MapX due to the use of Oracle9i database, it is different from directly loading Tab document, needs to use CMapXLayerInfo class, such as:

a) Class instantiation

CMapXLayerInfo layerInfoObject;

layerInfoObject.

CreateDispatch(layerInfoObject. GetClsid());

b) Specifies data from a database

layerInfoObject.SetType(miLayerInfoTypeServer);

c) Call AddParameter database connection string, the method of database table Settings.

d) Add the MapX control to this layer and display

m_ctrlMapX.GetLayers().Add(layerInfoObject,1);

3) Space analysis

Spatial analysis mainly involves the following spatial operator in Oracle9i:

a) Space objects not judge:

SDO_FILTER

SDO_RELATE
b) Specified object search within a certain range:
SDO_WITHIN_DISTANCE
c) Buffer analysis: SDO_BUFFER
d) Adjacent retrieval: SDO_NN

6. Conclusions

SMS and GPRS wireless communication technology can solve the environmental monitoring equipment remote data transmission on real-time. Through the multi-thread programming method, automatic detection and communications link have been realized.

System based on object relational database Oracle9i has realized the GIS spatial data and attributes integration of storage. By GIS technology data collection has been visual displayed as well as the analysis of pollution diffusion and influence area have been completed.

The communication construction used TCP/IP protocol was used to construct system communication. Through the core of service dispatching module each module of the whole system was handled, so collaborative work has been realized.

Acknowledgements

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