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RESEARCH ARTICLE

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Application of PDA forest fire monitoring based on web service technology

Abstract The difficulty in information communication and sharing are major problems for forest fire monitoring and early warning in China. As authors, we applied web service technology to a personal digital assistant (PDA) forest fire monitoring system and propose the framework of a monitoring system based on service-oriented architecture (SOA). At the same time, we describe the composition and function of web services from a server side and a client side. The method for developing a web service invocation engine on the PDA is introduced in detail. Finally, an example of a fire danger rating and fire weather services system are established, based on the Beijing Forest Fire Control System. The results show that the PDA forest fire monitoring system based on web services can effectively take advantage of the existing fire protection decision information services, realize real-time information interaction and sharing, and improve the level of forest fire monitoring.

Keywords forest fire monitoring, personal digital assistant, web service

1 Introduction

The main purpose of forest fire monitoring is to discover forest fires on time, so they can be extinguished from the start. The improvement of the monitoring level contributes to discovering fires on time, early organization of fire fighting, and reducing fire losses. In recent years, tools such as GPS, interphones, digital maps, and DV cameras have been applied to forest fire monitoring in China (Fang et al., 2003; Guo et al., 2003; Bian, 2005). However, forest rangers use these tools independently, which results in the lack of a comprehensive forest fire information service. In order to establish an integrated wildfire monitoring system that can combine various forest fire services that could satisfy the criteria of ease of use, portability, mobility, integration, and instant information interaction, we applied web service technology in the personal digital assistant (PDA) forest fire monitoring system in order to resolve these problems.

A PDA is a kind of embedded electronic mobile equipment that can integrate aids such as GPS and digital cameras and can satisfy the need for map displays, data collection, communication, and positioning in the field (Tsou, 2004; Hunger et al., 2004; Appleton, 2005). Web service is a kind of realization method of service-oriented architecture (SOA) and can be accessed by open and standard agreement (Tian et al., 2004; W3C, 2007). Several web service applications can be integrated to work out a complicated work flow or business. Applying web service techniques can resolve the orchestration and interaction of different information services in forest fire monitoring. A PDA combined with these web service techniques can expand the application field of web services. It enables forest rangers, who are in the field, to obtain the necessary services in time and to expedite communication with the fire prevention command center.

A PDA integrated with web services has already been used in a number of aspects of forest fire management. Abroad, it has been applied in fields such as forest fire prediction, determination of forest fire positioning, image data collection, and fire brigade tracking (Myung, 2005; ESA, 2006). In China, it has been applied in other fields, such as in electronic commerce (Xu and Xie, 2004), but there are no reports that it has been put into use in forest fire monitoring in China. We apply web service technology to a PDA forest fire monitoring system and propose an application framework of this monitoring system, based on web services. Simultaneously, we describe how this web service was designed and realized from the point of view of a server and a PDA client. In the end, we present an example of how the fire danger rating and fire weather forecast services have been established, based on the

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Beijing forest fire prevention and suppression management system.

2 Structure and information flow of forest fire monitoring system

Forest fire monitoring is an interactive, comprehensive monitoring system. A forest fire command center needs to synthesize all kinds of data that arrives from weather stations, earth satellite stations, and forestry departments. After being analyzed and handled, this data forms the latest forest fire prediction information and can be provided to any customer who wants to know about it. Based on this information, forest rangers who work in the field can take correct actions. For example, when they receive information on hot spots, they need to go to the right place to check whether a forest fire has taken place. If a fire did take place, they need to send information about the position of the fire and field conditions to the fire prevention command center. The center will quickly position the fire spot, report the fire to the fire brigade, and publish fire conditions to the public. Here, the technique of web services can give powerful support. A PDA can be used to transport and synthesize web services for a forest fire, and a mobilized, convenient, and integrated forest fire monitoring system frame, in real time, can be constructed (Fig. 1).

As can be seen from Fig. 1, after consultations with the departments concerned, the command center of forest fire prevention can obtain the various data necessary. These data will be processed and analyzed comprehensively in the center, and they then become forest fire prediction information, such as fire weather forecasts, fire insurance ratings, positions of hot spots, and fire insurance early warnings. Finally, the information will be transformed into various distribution diagrams and reports, where all of this information will be deployed in the form of web services on the servers of the fire command center. Forest rangers need only to open the PDA and choose what they want to know, and all the work can be immediately accomplished in the background. The PDA will automatically generate a client web services agency, calling for services from the fire command center, after succeeding in obtaining the fire information of these services and completing the data transmission through a wireless network. The PDA will collect and integrate this information, then provide it to the forest rangers. When forest rangers find that a forest fire has started, the PDA can automatically collect GPS data and forest data and transmit this information to the services of the fire command center through this wireless network. Based on this information, the command center can make decisions on a scientific basis. The fire command center can also directly order a PDA customer to take some appropriate measures. In this way, bilateral communication is implemented between the fire command center and fire fighters.

The key to realize the structure of the system is to develop and design the web server of the fire command center and the PDA web client side. The design largely involves the layout and interface of each web service and the realization of a translation and communication module on a PDA.

3 Design of web service server and PDA client

Figure 2 shows the framework in which web services are invoked on the PDA in a forest fire monitoring system. From this figure, we can see that the design is essentially divided into two parts: one part is the design of the server, which mainly suggests how to establish and publish each web service in the fire command center; the other is the design of the PDA client side, mainly including the development of the simple object access protocol (SOAP) communication module, a translation module, and a user interface design.

3.1 Design of a web server

For the server of the fire command center, the main task is to synthesize various web services and publish all of them, receiving HTTP POST that comes from the PDA client, and to deliver requests to certain servers of the web service, returning the SOAP answer to the PDA client after the web service server has supplied the answer.

The server application layer is a series of services, mainly consisting of forest fire weather forecasts, a forest fire insurance rating, positions of hot spots, daily

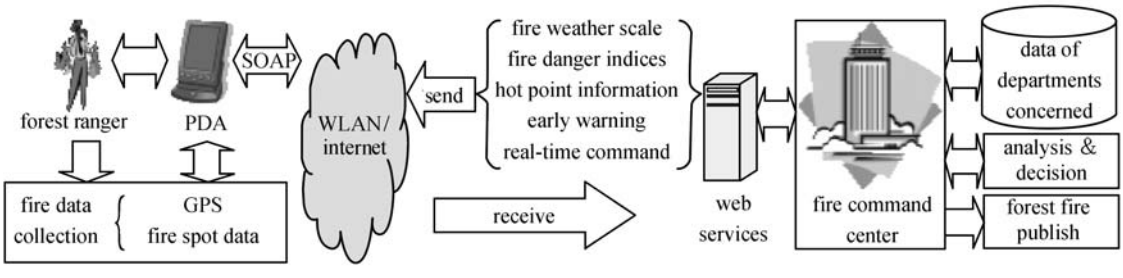

Fig. 1 Structure and information flow of forest fire monitoring system based on a PDA and web services

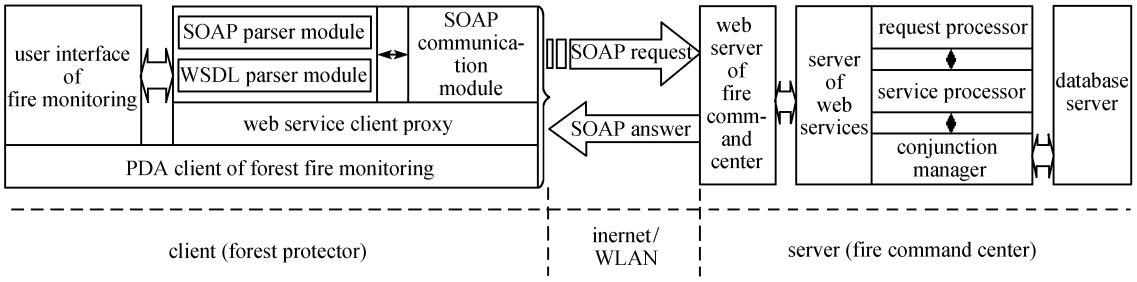

Fig. 2 Framework of invoking web service on a PDA in forest fire monitoring

maintenance, and fire news reports. These services come from two sources: the first one consists of web services that have already been built in many departments and can be published after service composition; the other consists of services that have not, as yet, been built up and need to be developed.

The application layer of new developing web services is made up of a request processor, a service processor, and a conjunction manager. At first, the request processor analyzes the SOAP requester and calls for the corresponding service processor, which then becomes responsible for requesting the question of a customer and sending the answer back to the request processor. In the end, the request processor organizes the corresponding SOAP information and sends it to the web server to answer the client. In this process, the conjunction manager is responsible for searching the background database server, sending the related data that the request processor needs, and updating the background database according to the direction of the request processor.

Web services are generally realized as one group, where some member functions are designed as the interface of the group, which is exposed to the requester of the web service in order to provide services. The server can provide two type of services, web map service (WMS) and Web Feature Service (WFS). The various services have different development modes, but all of them can be deployed with the web service, described and explained by web service definition language (WSDL), and called by a SOAP message.

3.2 Design of a PDA client

SOAP messages are always different with a certain web service. For example, what a WMS returns to the client are the images of a certain data format or some map elements, which customers have already indicated, but a WFS returns attribute-encoding data, described by the language of the geography markup (GML), which can easily be transformed into geographic data (Li et al., 2006). The SOAP message can be translated and replied to in the same way in which they are encoded by fixed format and regulation. For these different SOAP messages, the client only needs to handle things according to the SOAP messages that have been interpreted.

In the PDA client, the web service is invoked by way of setting up a web service agent class. An agent class of web service is mainly made up of a WSDL parser module, a SOAP parser module, and a SOAP communication module. The WSDL parser module is mainly used to analyze the WSDL provided by the server, including whatever services the server can provide as well as the addresses of web services. It can form different SOAP requests by composing a SOAP message frame and the message that came from user selection or available data. The SOAP parser module is mainly used to analyze SOAP messages, including the interpretation of an element requested from the SOAP message, or to analyze data types and values of an appointed element, which will be provided to the upper-level interface to display. The SOAP communication module is mainly responsible for the SOAP interaction between client and server, whose SOAP query information from the WSDL and SOAP parser modules will be embedded in the HTTP POST message and sent to the web server. At the same time, the module is responsible for receiving the SOAP reply from the server and delivering the SOAP reply to the SOAP parser modules for detailed analysis.

The presentation layer of the client directly communicates with users through each defined user interface. Users can select what interested web services they need and look into the results that the fire command center returns; at the same time, they can input forest fire data into the PDA and sends those messages back to the fire command center. The use of a web service proxy class can lead to tremendous flexibility for PDA clients to assemble and integrate web services according to their actual requirements. This characteristic contributes to designing a powerful PDA client interface that can include several web services.

4 Realization

For developing the server of the web service, we can cite many references on how to develop the mobility of clients.

The methods to develop PDA and (personal computer) PC clients are different. Developing tools for a PC client can directly call web services by a proxy class that is created by the development environment, while for the PDA client, which uses a Windows customer embedded (Windows CE) system as operating system (OS), the main development tool is the Embedded Visual C++ (EVC) without such support. This implies that a web service client proxy class needs to be developed by the developer himself.

PDA client software is mainly programmed with EVC, combined with a document object model (DOM). The creation of a web service client proxy class needs the support of WSDL and SOAP. We designed two classes to analyze WSDL and SOAP messages, called CvAnalysisWSDL and CvAnalysisSOAP. Simultaneously, we designed a class called CvSoapComunication, a response to the delivery and receipt of SOAP information between a PDA client and its web server. Table 1 describes the main variables and functions of these three key classes.

We can use CvAnalysisWSDL and CvAnalysisSOAP to interpret the final web service proxy classes, then combine these proxy classes and call web services by way of using the CvSoapComunication class. When designing a user interface, one can make it so that the interface can integrate several results from the server. An application layer completes the operation by invoking several proxy classes of web services.

5 Application

At present, we are developing a Beijing forest fire management information system. Some web services, such as forest fire weather grades, forest fire danger ratings, woodland fire danger ratings, and hot spot information predictions, based on the ArcGIS Server, have already been providing services. A translation module and SOAP communication module of PDA clients have also already been constructed, and some fundamental web services and their integration can be accessed from a PDA. At the same time, we have succeeded in using a PDA to receive GPS data and sending it to the server using SOAP messages.

Here, we apply the methods introduced in sections 2 and 3 to call two web services on a PDA. One is the Beijing forest fire danger rating service, which is a WMS service, and the other is the Beijing forest fire weather forecast service, a text message service. We interpret SOAP messages and pass the results to the related display module. In the meantime, the interface calls the forest fire danger rating service and the weather forecast service. It shows the integration of different services.

6 Conclusions and outlook

It is a great progress to use PDA equipment and the technique of web services in forest fire monitoring. The application of a multi-function PDA solves the problem of equipment integration in forest fire monitoring. If its use is based on this web service technique, the problem of integration of different services in the forest fire monitoring platform can be solved. Invocation and integration of these forest fire monitoring web services on a PDA enable forest fire monitoring systems to obtain the capability of calling several remote services. It will help us to build a mobile, real-time, integrated, and scientific forest fire monitoring system.

At present, there are still some shortcomings in using a PDA to call web services. The main problems are the lack of a complete wireless network and data transmission delays. At the same time, the security problems of SOAP communication remain suspended, but with the development of a wireless network, these web service techniques become mature, the SOAP protocol will improve, and all

Table 1 Main variables and functions of key classes

class name	main variables and function	description
CvAnalysisWSDL	m_pWSDLDOM	DOM object of WSDL
	LoadWSDLDocument()	load WSDL file
	GetWebServiceURL()	get URL of web service
	EnumerateServices()	enumerate all operations of web service
	CreateSoapFrame()	construct a dummy body of SOAP
	SearchFactorDiscription()	search the description of a factor
CvAnalysisSOAP	m_pSOAPDOM	DOM object of SOAP
	LoadSOAPDocument()	load SOAP message
	WithdrawFactor()	get factor information from SOAP message
	CombineSOAPInformation()	compose SOAP query with certain factors
	AlaysisFactorFromSOAP()	get factor value from SOAP message
CvSoapComunication	m_pXMLHTTP	object for SOAP query and reply
	SOAPComunication()	sending or receiving SOAP message

problems will eventually be solved. It cannot be denied that the application technique of PDA forest fire monitoring based on web services will play an important part in designing and developing a forest fire monitoring system. It is also expected that this system will be extensively applied in forest fire management, where it can look forward to a finely honed development.

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