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Performance Analysis for VTS-Based Data Exchange Protocol in E-Navigation Environment

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Abstract

. IVEF is the protocol designed for the exchange of marine transportation information between the vessel traffic control systems and between the vessels. Standardization of the IVEF service is under way as a part of the next-generation marine navigation system called e-Navigation. This paper suggests an IVEF protocol based on the XmlPullParser, which supports faster processing speed and requires less memory than the existing SAX parser. It also suggests a server/client system which simulates the V-145 protocol in the wireless environment. Android-based smart phones were used to emulate the vessels, and Windows 7-based desktops were used to emulate the VTS (Vessel Traffic Service) service center.

***Keywords**: IVEF, VTS, Mobile Platform, Mobile Middleware, Performance Analysis*

1. Introduction

The VTS (Vessel Traffic Service) field – which is about maritime safety – has mostly relied on overseas technology, unlike the shipbuilding industry that has recently retained its leading position in the global market as a traditional industry. VTS technology in the maritime safety field consists of maritime IT technology and has desperately required grafting with up-to-date IT technology. In the maritime field, the concept of "e-Navigation" for the grafting of electronic information technology was introduced into Europe, and the popularity of this concept has steadily been rising internationally in the last two to three years. The e-Navigation promoted by IMO is about collecting/integrating/ expressing/analyzing marine data between ships and the land in harmony through an electronic method with the purpose of marine safety/security and marine environment protection through the improvement of maritime-related services.

E-Navigation, which was introduced in 2005 for safe vessel navigation, has prompted IALA (International Association of Lighthouse Authorities) to standardize e-Navigation through IT convergence. An objective of e-Navigation, which is being led by IMO (International Maritime Organization), is to support data exchange, convergence, and analysis between vessels and with the onshore control center, thereby maximizing safety and security on the sea and protecting maritime environment. The VTSC (Vessel Traffic Service Center) relies on navigation support equipment such as radar and ECIDS (Electronic Chart Display and Information System) and VHF audio communication to monitor any risk of collision, or gathers information on collision or stranding to ensure safe entry of vessels into coastal waters and prevent accidents. However, the time from identifying a risk situation to evasion flight takes a long time and the procedures are complicated, too. This is supported by the fact that 30% of maritime accidents are caused by collision, out of which over 90% is associated with human error. This raises the need to apply IT-driven next-generation maritime traffic control systems to both vessels and VTSC, and to develop a distinct technology that can replace the existing VTS.

This paper describes how the DOM-parser-based IVEF library is converted into the XmlPullParser-based library. The XmlPullParser library is an intermediate form between

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SAX and DOM. It has the advantages of SAX (requiring less memory) and DOM (an easy to design code). Therefore, the XmlPullParser-based V-145 protocol is expected to enhance speed and memory use when compared with the existing library. This paper summarizes the theory of SAX, DOM, and Pull parser, and describes how to implement the IVEF Pull Parser. This paper also compares the performance between the parsers when they are used in the V-145 protocol, and provides the login method using the MAC Address of the phones [7,8]. This paper suggests a library that supports different parsers depending on applications in order to make up for the defects of open source. Using this library, systems have been developed to simulate IEVF service on the wireless environment, and time and memory used for the V-145 protocol for each parser have been measured.

2. VTS and Data Exchange Format

In general, the elements composing VTS are as follows. VTS is the system in which the following are connected to one another: the VTS Center on land, the base station site where various sensors (sensing devices such as CCTV, Radar, DF, MET, *etc.*) and AIS are installed, the Control Center that actually operates VTS, which is a complicated system consisting of various types of telecommunications networks that connect ships, satellites, and sensing devices [3-5]. In the past, VTS had a narrow or classical meaning where the VTS' purposes were mainly to control the applicable area through monitoring and controlling vessel traffic in the radar signal control area. However, VTM that has been promoted by IALA recently has no limit to the control area and no limit to competent offices for the expansion of information sharing. In other words, not only have competent offices expanded to various sensors such as AIS, satellites, *etc.*, but the concept of information sharing also has expanded to the provision of aids-to-navigation and various other information. In the existing VTS, low-cost telecommunications system in the vest waters does not exist and remote telecommunication technology, except for satellites, is not available. Thus, the aids-to-navigation function in the ship's maritime situation is weak and seldom used. Aside from that, the risk management is done at the level that the alarms sounds for the anchored ships are generated on the basis of the degree of risk that is calculated based on the simple distances and speeds so that the risk management is seldom used in the service, which is a weak point [15-18].

Various algorithms that calculate the degree of ship collision risk and apply it to sailing have been studied continuously as technologies for safe ship controls. For example, a risk management method that calculates the degree of collision risk at the ship's location on the basis of the fuzzy theory is available, but the accuracy of the moving direction according to the ship's intention and the predicted location is most important [25]. However, in general, the existing sailing patterns or the preferred routes might be available to a ship-navigation officer, and these cannot be obtained through simple mining for the existing sailing data. It is because the situation on the sea is always dynamic and ever changing. Consequently, it is desirable to analyze the contexts of the situation-specific preferred routes, establish the profile data of the detailed historic tracks, and predict the degree of collision risk by combining this data with that on the situation in the sea.

The control system requires an efficient system structure, because it should be able to recognize the current situation on the sea by analyzing the data about numerous contexts and to transfer the applicable situation to the controller rapidly and intuitively. Aside from that, as the control system also requires the situation analysis function to predict dangerous situations through the analysis of the situation on the sea, the visualized screen for intuitive recognition, and the function to create and transfer data for processing the collision-avoiding event. In this thesis, the author proposes a Mobile VTS Middleware Service System that will satisfy these requirements.

The IVEF service is the framework for exchanging information for vessel traffic, and is being developed by the e-Navigation Working Group of IALA. The IALA committee recommends V-145 as the communication protocol between the VTS systems, and provides the downloading service of the V145-protocol-related SDK and document on the OpenIVEF site. The IVEF service works as the server/client model in exchanging traffic conditions between the VTS systems. Messages are roughly divided into the control information messages and the real-time information messages. Control information messages are subdivided into the user authentication messages, shutdown messages, service requests to servers, response messages, and the messages providing the server status. Real-time information message consists of the current location of a vessel, the expected route, the place anchored, and other physical information on the vessel.

2. Security Requirements of Vessel Traffic Service

Table 1 indicates security requirements for each service type. All IVEF data is provided without filtering in VTSC-VTSC data exchange to support accurate vessel control. This is the highest level of security requirement, which should be fully satisfied. VTSC-shipping company information exchange is vulnerable to security threats since its service is provided via an external network, unlike VTSC-VTSC information exchange service, which is provided in a closed network. As such, its level of security should be as high as that of VTSC-VTSC information exchange service. Physical security, which is only applied to VTSC- VTSC, is not necessary. Availability is emphasized in VTSC-user mobile device information exchange since its objective is to confirm maritime traffic situation. Hence, IVEF data reception is important even if it composes reliability of IVEF data for emergency situations and vessel confidentiality.

Table 1. Security Requirements of Vessel Traffic Service

Security requirements	VTSC -VTSC	VTSC – shipping company	VTSC - user mobile device
Access control	O	O	O
User certification by service type	O	O	O
Confidentiality	O	△	△
Message integrity	O	O	O
IVEF data reliability for emergency situations	O	O	X
Physical security	O	X	X

O: Yes, X: No, △: Partially yes

3. Mobile Inter-VTS Data Exchange Format Middleware Platform

A VTS server/client emulation system was implemented to exchange data using the IVEF protocol between VTS servers and the vessels. The client system was implemented with smart phones running on Android Jellybean (4.1.2), and the VTS server was implemented with a desk top running on Windows 7 and Intel Core-i5 [20,21,22,23]. The systems communicated with each other over the wireless Internet network. In order for scalability and maintainability of the protocol, IVEF SDK was adapted to this system. The code was modified so that DOM parser and XmlPullParser, as well as SAX parser, can be selected [5,7].

3.1. Service Client Program

In the client program, 9 major message protocols were implemented pursuant to the IALA recommendation V-145. The interface for the messages was implemented using Android ListView. If a specific item of ListView is selected, a request for the message is sent to the server. The request is in the standard XML format in accordance with the recommendation of V-145. The server analyzes the requested message and sends the response message. The received message is displayed, as shown in the right hand side of Figure 1, ① as major information acquired through parsing of XML, ② as the XML message received from the server, and ③ as the secured data.

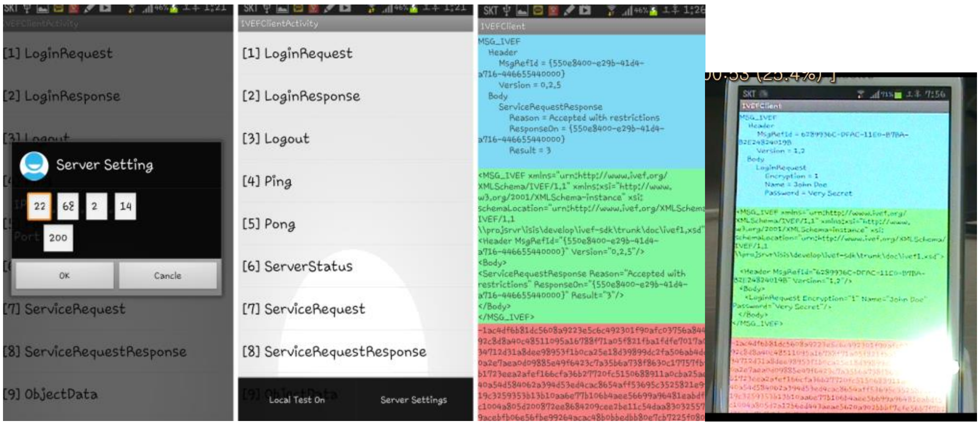

Figure 1. Mobile VTS (IVEF) Service's Client Screen

3.2. Server Service Program

The major functions of the server program are to receive the V-145 recommended message requested by the client through a specific port, analyze the requested message, and provide the appropriate navigation information. The BIS service was implemented according to the recommendation V-145. The server then creates a thread for each access of a client and handles the request for messages of the client [12-14,19].

Figure 2. Mobile VTS (IVEF) Service's Server Screen

4. Implementation of Parser Platform

In the org.xmlpull.v1.XmlPullParser package, Android provides the API of XMLPULL v1. next() and nextToken() are used to search the parent nodes and the child nodes, and getEventType() is used to check the status of the current node. XmlPullParser is an intermediate form between DOM parser and SAX parser. SAX parser uses less memory than DOM parser. Since all the events are processed at the library, users cannot control individual nodes. XmlPullParser, however, provides the developer with the control of callback. Therefore, it doesn't have to handle any unnecessary event code, whiling maintaining the advantage of SAX parser (low memory consumption).

4.1 Performance Time on Android (ms)

The tests on the Android phone showed that the Pull parser has better performance in general. It was unusual that, unlike the tests on PC, the DOM parser showed better performance than the SAX parser. It is because functions are invoked frequently in the SAX parser, and the function call processing is delayed on the Android platform [8-10].

Table 1. Performance Time on Android Phone for Each Parser

Object Data	OpenIVEF (SAX)	Jeju-IVEF_Parser (DOM)	Jeju-IVEF_PullParser (Pull)
200	1,337	994	851
400	2,538	1,836	1,512
600	3,799	2,750	2,284
800	5,569	3,655	2,956
1000	6,620	4,595	3,769

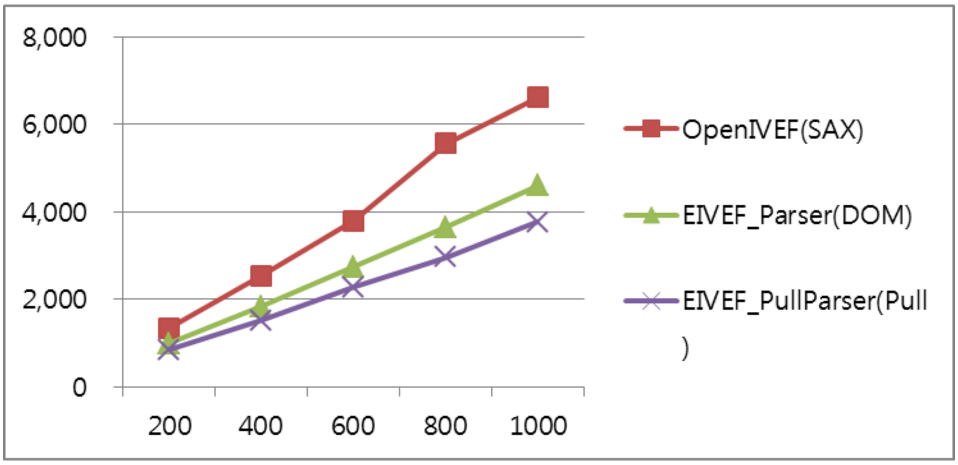

Figure 3. Performance Time on Android Phone for Each Parser

V-145 message protocol was performed in XMLPullParser about 70% faster than in the SAX-based open source, and about 20% than in the DOM parser. It was unusual in that it was slower in the SAX parser than in the DOM parser, which is because it took time to process frequent function calls to process SAX parser due to the characteristics of the Android system. Also, it is because all the node events are handled for SAX, and no more events are handled for XmlPullParser once the required data are extracted [28-30].

5. Conclusions

According to the recent worldwide trend, the VTS and the maritime computing environment have been rapidly changing to adopt the e-navigation-based intelligent broad control service architecture through active fusion with rapidly-developing IT technology. This paper describes the wireless IVEF protocol system using XmlPullParser, which is the intermediate form between the DOM parser and the SAX parser. The performance of handling V-145 protocol message was analyzed with the developed system. The experiment showed that XmlPullParser processes messages faster and requires less memory space than the DOM parser or the SAX parser. Since the V-145 protocol messages generate a large number of small messages, selecting the parser is needed depending on whether the protocol is received by vessels or the VTS control center. In the test, all the nodes and attributes of the V-145 messages were measured. In future studies, it should be required to measure the performance for random access of a specific message to a specific node.

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