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Research on Voyage Navigation S/W Development Architecture Using Open Source Base GIS Modules

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Abstract

Recently, as the number of voyage accident is increasing, massive damage of human life and property is following depends on scale of accident. ECDIS is navigation equipment essential for safe sailing and clean marine environment. However, ECDIS S/W is relatively expensive, and ocean-related international organizations such as IMO and IHO are designing the programs mainly for medium and large ships. OPEN CPN, SeaClear are existing as product based on Open Source Project, however they are lack of functions to use in actual voyage. ECDIS development by making combination with modules based on open source could be an alternative to follow the standards and develop efficiently

KeyWord : Open Source; Marine GIS; eNavigation;ECDIS; ENC

1. Introduction

Recently, as the number of voyage accident is increasing, massive damage of human life and property is following depends on scale of accident. Early, IALA suggest to install ECDIS (Eletronic Chart Display Information System) for safe voyage, and appoint time of installation of ECDIS depends on scale of ship. An **Electronic Chart Display & Information System** (ECDIS) is a computer-based navigation information system that complies with International Maritime Organization (IMO) regulations and can be used as an alternative to paper nautical charts. IMO refers to similar systems not meeting the regulations as Electronic Chart Systems (ECS)[1].

ECDIS is a system which shows geographical features of sea space information for voyage, weather on screen. ECDIS is basically loaded ENC format electronic navigation chart, and has a function of interlocking information from all sorts of sensor and telecommunications equipment to electronic navigation chart.

Nowadays, ECDIS is mainly developed by companies of voyage telecommunication equipment such as PRUNO.JRC, TRANSAS, and most of them are for common use. Although OPEN CPN, SeaClear are existing as product based on OPENSOURCE, however they are lack of functions to use in actual voyage. Also, existing voyage S/W based on open source doesn't guarantee interlock with various voyage communication equipment, which is used in field, such as AIS, GPS, RADAR ,ECHO Sounder. Also, they must follow standards of voyage communication equipment such as IEC 6174 and should be installed necessary function in S/W for this to use open source base voyage S/W. Because of these reasons, there are difficulties on developing ECDIS in one unit of open source project.

Therefore, ECDIS S/W, based on open source, needs combination with open source project, not a unit of project based on open source. ECDIS development by making combination with modules based on open source could be an alternative to follow the standards and develop efficiently. This research will suggest the way to develop

ECDIS through introduction of Open Source and S/W structure to achieve the goal

2. Discussion

1) Analysis of ECDIS standards and ECDIS-related open source modules

There are basic S/W and H/W standards required for building ECDIS (Electronic Chart Display Information System). Only when these standards are applied and tested, the system is usable for actual voyages. One of the major characteristics of ECDIS standards is that they are modularized into the functional units of ECDIS.

The most representative ECDIS standard is IEC 61174, The performance requirements for ECDIS are defined by IMO and the consequent test standards have been developed by the International Electrotechnical Commission (IEC) in International Standard IEC 61174.[2]

individual functions of ECDIS are tested and verified through the IEC 61174 standard. Figure 1 defines ECDIS-related standards and roles played in the functional parts of ECDIS.

ECDIS S/W and H/W and related modules can be mounted on a ship as radio communication and navigation equipment only when they are designed and developed to satisfy such modularized standards and finally to meet the IEC61174 standard. Because ECIDS functions accommodate various IT technologies including GIS and network, ECDIS producers have so far developed their products using components of ECDIS functions, and such components have been called ECDIS kernels. Some of them were commercialized and provided to ECDIS developers (SEVENCS, CMAP, etc.), and sometimes ECDIS producers developed and used their own ECDIS kernels. The basic functions of ECDIS kernels are defined as follows.

ECDIS Standard	Role	Current Version
IEC 61174	Operational and performance requirements, methods of testing and required test results	edition 3.0
ISO/IEC 61162	Maritime navigation and radiocommunication equipment and systems – Digital interfaces –	ISO/IEC 61162-1,2,3
S-57	IHO Transfer Standard for Digital Hydrographic Data,	IHO S-57 Edition 3.0
S-52	Specifications for Chart Content and Display Aspects of ECDIS	IHO S-52 Edition 4.0
S-63	standard for International Hydrographic Organization (IHO) standard for encrypting, securing and compressing electronic navigational chart (ENC) data.	IHO S-63 Edition 1.1
S-58	Recommended ENC Validation Checks	IHO S-58 Edition 5.0
S-66	Facts about Electronic Charts and Carriage Requirements	IHO S-63 Edition 1.1

Table 1. ECDIS-related standards and definitions

Electronic chart database visualization and management - Sea chart security processing and update - Sea chart visualization (apply the S-52 visualization standard) - Sea chart object information service - Sea chart screen manipulation (zoom in/out, change)	Navigation planning and waterway surveillance - Navigation plan plotting - Navigation plan information management and validity check - Navigation monitoring and information service
Interoperation with navigation equipment - Interoperation with radio communication and navigation equipment such as AIS, DGPS, and Echo Sounder through communication - Radar image presentation and interoperation - Interoperation on the electronic chart screen	Navigation recording and other functions - Navigation record storage and display - Seafaring victim information management - Other information services including weather information and interoperation

Figure 1. Classification of ECDIS kernel functions

Figure 1 classified and restructured the functions defined in IEC 61174. If a system is equipped with all of these functions, it is regarded to have all of the basic functions required of ECDIS, and if the functions meet the ECDIS system test standards of IEC 61174, the system is usable in actual voyages.

In order to satisfy these conditions, most of ECDIS producers or engineers develop ECDIS using ECDIS kernel module components compatible with the IEC 61174 standard. As mentioned above, however, most of ECDIS kernels are commercial products to be purchased. In addition, because they support only limited development platforms and languages, they impose restrictions on the composition of manpower and the setting of development environment. Table 2 below shows the results of surveying the development environment of commercial ECDIS kernels.

ECDIS kernel	Development platform	Operating environment
SEVEN CS	QT, MS(C++,C#).opengl	Standalone
Geomaris	Microsoft .net, direct X	Standalone
CMap	Microsoft .net, direct X	Standalone
Cher Soft	Microsoft.net	Standalone

Table2. The development environment of major commercial kernels

The development environments and platforms listed above have the problem that they are far different from the latest IT development environments such as Cloud and smartphone. In order to solve this problem, it is desirable

to adopt development using open sources, but it is difficult for open sources related to ECDIS and marine GIS to reflect recent IT trends while providing the IEC 61174 functions. Moreover, there are representative open sources related to marine systems such as OPEN CPN[4] and SeaClear[5], but commercial products have the problem mentioned above and they support only part of the functions. In addition, they have been found to be poor in supporting the standards.

Table 3. The support of open sources to navigation-related S/W ECDIS standards

Open source	Running environment	S-57	S-63	S-52	ISO/IEC61162	IEC61174
OPENCPN	Standalone	Support	Not support	Support	Partially support	Partially applied
SeaClear	Standalone	Support	Not support	Support	Partially support	Partially applied
OpenSeaMap	Web	Not support	Not support	Not support	Not support	Not support

Because, like ECDIS kernels of commercial environment, current projects based on navigation-related open sources use running environment far different from the latest IT operating environment, it is difficult to develop ECIDS using current open source projects.

2) Development of ECDIS S/W using open source S/W and data standards

Open source-based projects related to marine navigation are poor in supporting ECDIS standards, and in interoperability with radio communication and navigation equipment. Because there is not an established community of developers, it is not easy to patch up and upgrade.

Furthermore, time and human resources need to be considered in implementing a large number and variety of ECDIS functions within a single project. In order to develop ECDIS as an open source, therefore, the development architecture should be in the form of mesh-up integrating multiple open source projects, and the structure of database used in ECDIS must guarantee interchangeability to overcome problems raised by differences among development languages and development platforms.

Service data used most often in ECDIS are largely electronic charts, navigation records, and sensor data generated from radio communication and navigation equipment. For electronic charts, the database embedded in ECDIS is used instead of the S-57-based original copies of sea charts for reduced system load and high performance.

The embedded database, which is called System ENC, has a structure unique to each ECDIS system. Because of the uniqueness of the structure, most of ECDIS systems cannot interchange and share data with one another.

In order to solve this problem, OGC and general-purpose data standards may substitute for the use of database embedded in ECDIS. The application of data standards makes it possible to integrate many open source projects.

OGC(R) standards are technical documents that detail interfaces or encodings. Software developers use these

documents to build open interfaces and encodings into their products and services.[6]

Existing data	Alternative open data structure	Related open source projects
System ENC	-GML, -GEOJSON - ST_GEOMETRY - XML	- GeoAPI - GeoServer - DotSpatial - MapServer - FDO
Navigation records	GML XML GEOJSON	- GeoAPI - Map Window - FDO
Sensor information (AIS, GPS, etc)	Sensor ML	- Apache - GeoAPI

Table 4. Application of open data structure to ECDIS data

By applying standards such as OGC and W3C as data structure used in ECDIS, we can diversify ECDIS development platforms, and this enables interoperation with various data including weather information. Moreover, SLD, one of the map style methods of Geoserver, an open source Java server, is utilized in order to observe S-52 electronic chart standards, which is most essential in geographic information services of ECDIS. The CSP algorithm should be used to implement the S-52 standards. Constraint satisfaction problems (CSPs) are mathematical problems defined as a set of objects whose state must satisfy a number of constraints or limitations. CSPs represent the entities in a problem as a homogeneous collection of finite constraints over variables, which is solved by constraint satisfaction methods.[7] This is the core algorithm for presenting electronic charts in ECDIS using different object expression methods depending on the condition of data. The method of utilizing SLD of Geoserver defines the display method according to the data value of the corresponding object, so it is possible to observe standards in development without directly implementing the CSP algorithm.

Besides, communication among H/W units, one of major functions of ECDIS, becomes possible through the application of open sources.

Communication in ECDIS usually adopts RS-232 and RS-422, but with the advance of communication technologies, Internet-based communication is being studied for ships. At present, terminal communication is being used in various open source S/W programs including IFTOOLS(), and it is also used often in actual development.

3. Conclusion

ECDIS is navigation equipment essential for safe sailing and clean marine environment. However, ECDIS S/W is relatively expensive, and ocean-related international organizations such as IMO and IHO are designing the programs mainly for medium and large ships. Because ECDIS S/W is essential navigation equipment for preventing marine accidents, it should also be available to economically stricken ship owners or small vessels.

Therefore, the development of ECDIS based on open sources or free ware is demanded socially. There are a number of applicable open source S/W programs, but they do not contain all the functions required for sailing. The range of ECDIS functions is too broad to be covered by a single open source project. Accordingly, we need to develop necessary functions through integrating open source projects and utilizing standardized data structures.

This study opened the possibility for developing efficiently the extensive functions of ECDIS S/W by suggesting a development method utilizing open source S/W and OGC standards. Based on this method, future research will develop and test ECDIS compatible with the IEC61174 standard.

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