Web Hydrographic Service Based on Electronic Navigational Chart (ENC)

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Abstract: This paper developed a web service system providing hydrographic information encoded by GML rules. In order to achieve the goal, every data included in an ENC, which is following the rules of the S-57 and S-52 from the IHO, is transformed into a data structure form of OLE/COM from the OGC. In the system, hydrographic information can be provided through a data provider, and then it can be encoded into GML format for web services. This paper also implemented a web client that requests hydrographic information to the server and renders result data which is a GML format following the rules of S-57.

Keywords: Hydrographic Information, Electronic Navigational Chart (ENC), Geography Markup Language (GML), Web Feature Service (WFS).

1. Introduction

Geography Markup Language (GML) recently becomes a new modeling language for geographic information, which is an XML encoding for the transport and storage of geographic information, including both geometry and properties of geographic features [1]. As one of service platforms, the Open Geospatial Consortium (OGC) proposes a *Web Feature Service (WFS)* providing geographic features with 5 operations [2]. The WFS delivers GML representations of simple geospatial features in response to queries from HTTP clients. Clients can access geographic feature data through the WFS by submitting a request.

The upcoming trends such as web services have made GIS technologies spread geographic features widely and supported various kinds of services. With regarding to expanded web GIS, this paper touches a service technology for hydrographic information. An S-57 is a theoretical model for representing hydrographic information from International Hydrographic Organization (IHO) and an Electronic Navigational Chart (ENC) is a kind of product using the S-57. This paper develops a web service system providing hydrographic information encoded by GML rules. In this system, hydrographic information is acquired through a data provider, and then encoded into GML format for web services.

The rest of this paper is organized as follows. Section 2 and Section 3 review technological backgrounds for hydrographic services, electronic chart, and associated international standards respectively. The concept, developing architecture, and an example application of the proposed web hydrographic system are shown in Section 4. This paper is concluded with Section 5.

2. Electronic Chart

The electronic chart is a relatively new technology that provides significant benefits in terms of navigation safety and improved operational efficiency. More than simply a computer display, it is a real-time navigation system that integrates a variety of information that is displayed and interpreted by the Mariner. It is an automated decision aid capable of continuously determining a vessel's position in relation to land, charted objects, aids-to-navigation, and unseen hazards. The electronic chart represents an entirely new approach to maritime navigation.

1) Electronic Chart Data

Vector Electronic Charts, called *Electronic Navigational Charts*, are vector charts that also conform to IHO specifications, as contained in Publication S-57. They are compiled from a database of individual items/objects of digitized chart data which can be displayed as a seamless chart. When used in an electronic navigation system, the data can then be reassembled to display either the entire chart image or a user-selected combination of data. ENCs are intelligent in that systems using them can be programmed to give warning of impending danger in relation to the vessel's position and movement.

Raster Navigational Charts (RNCs) are raster charts that conform to IHO specifications and are produced by digitally scanning a paper chart image. The image may be either the finished chart itself or the stable color bases used in the multi-color printing process. The resulting digital file may then be displayed in an electronic navigation system where the vessel position, generally derived from electronic position fixing systems, can be show. Since the displayed data are merely a digital photocopy of the original paper chart, the image has no intelligence and other than visually, cannot be interrogated. The Special Publication S-61 Raster Navigational Chart Product Specification from International Hydrographic Organization (IHO) provides guidelines for the production of raster data. IMO resolution MSC.86 (70) permits system equipment to operate in a Raster Chart Display System (RCDS) mode in the absence of ENCs. The RCDS mode of operation is described in the Interna-

tional Maritime Organization (IMO) Performance Standard for ECDIS.

2) Electronic Chart System

There are two basic types of electronic chart system. Those that comply with the IMO requirements for SOLAS class vessels, known as the Electronic Chart Display and Information System (ECDIS), and all other types of electronic charts, regarded generically as, Electronic Chart Systems (ECS).

The ECDIS is the internationally adopted system for presentation of electronic chart data on a computer screen, and intended to replace paper charts as the legal base for safe navigation. An ECDIS is a computer-assisted navigation system which, when complying with all of the following specifications, can be accepted as the up-to-date chart required by V/20 of the 1974 SOLAS Convention.

For an ECDIS to meet a minimum level of reliability and functionality, the IMO has developed a performance standard for ECDIS. This standard specifies how an ECDIS must work in order that it serves as an adequate replacement for the paper nautical chart. The IMO Performance Standards permit National Maritime Safety Administrations to consider ECDIS as the functional equivalent to charts required by Regulation V, Chapter 20 of the 1974 SOLAS Convention. IMO has specifically requested that member governments encourage their National Hydrographic Offices produce ENCs and provide the associated updating service as soon as possible, and ensure that manufacturers conform to the performance standards when designing and producing ECDIS.

An ECDIS satisfying all the abovementioned requirements is not only an adequate replacement for the paper navigational chart but also a system containing all information important for navigation that can be called up at any time and without delay. Today, this information is still scattered about in various publications, and manual search procedures are laborious and time consuming. ECDIS also offers the possibility of automatic anti-grounding alarm, which is not possible with any other navigation aid.

A further advantage of ECDIS compared to all other navigation aids is the individual adaptation of the chart picture to the particular requirements. This is possible because the chart picture is produced only during operation. It is possible to produce the relevant shallow water contour for a supertanker with a draught of 25 m or for a ferry with a draught of only 3 m. The presentation library controls this via adjustment of the safety depth/safety contour.

The International Electrotechnical Commission (IEC) has identified and described the necessary of performance tests and checks for an IMO-compliant ECDIS. IEC Publication 61174 is the basis for type-approval specifications related to operational methods of testing and required test results for an IMO-compliant ECDIS [5].

The ECS is the charting software system for presentation of electronic chart data on a computer screen, which intended to improve the safety of navigation and help mariner in his day-to-day work. There are no strict standard for ECS in contrary to ECDIS.

3. IHO Standards

Several international authorities are involved in the standardization of ECDIS.

The IHO has the responsibility for standardizing the digital chart objects for ECDIS. The IHO has drawn up a data model, an object catalogue and an ENC product specification (PS) as standard for ECDIS data and published these in its Special Publication No. 57 (S57) [3]. The object catalogue is what the Chart 1 (INT 1) was for the paper navigational chart: a list of all permitted hydrographic object classes. In fact, Chart 1 is reflected almost entirely in the object catalogue. The S57 publication contains also the format description of the exchange format (also called S57) for digital navigational chart data. In addition, the S57 data should be encapsulated according to the ISO 8211 standard [8]. This guarantees that data from the various national HOs are compatible with one another and can be read by each ECDIS. Finally, it should be pointed out that the S57 data does not contain any information concerning the symbolization, the presentation of the chart on the screen.

As the second IHO standard important to ECDIS, the presentation library (PRESLIB) published in the Special Publication No. 52 (S52) describes how the colorful picture is created on the screen [4]. Presentation of the chart is generated on-the-fly in ECDIS upon reading of the chart data, the appropriate symbolization for each object being sought from the presentation library according to its characteristics. Hence the ECDIS supplier must install the presentation library in his unit with the definitions of the symbolization instructions and the colors to be used in an absolute manner irrespective of the color monitor. This, and color calibration instructions and techniques that the supplier of an ECDIS has to carry out, guarantees that the ECDIS charts look exactly the same on any unit from any manufacturer. Chart data comes without geographic projection, only with coordinates. ECDIS must then provide also geographic projection for a cartographic presentation. For shipping, it means usually the Mercator or sometimes gnomonic projection.

The above describes the standardization of the data side of ECDIS, or, to be precise, of the hydrographic data. There are indeed other chart objects that certainly must be specified in order to make ECDIS an adequate navigational tool. A wide range of 'objects' are entered into the chart by the captain and the navigators before and during the voyage of the ship. These include leg lines and waypoints, notes, observations, fixed positions and commands. To ensure that this is also possible with the electronic medium of ECDIS, the IMO has developed an ECDIS performance standard. This determines how an ECDIS has to work so that it can serve as an

adequate replacement for the paper navigational chart in accordance with the International Convention for the Safety of Life at Sea, 1974 (SOLAS 74) [9]. IMO has produced a catalogue of user-defined objects which has been published under the title 'Mariner's Navigational Objects' (NavObj) as an appendix to S52. The supplier of an ECDIS has to ensure that these objects can be generated, edited and deleted as required.

Another specification should be observed even if it does not come from an international standards organization but from the classification society Det Norske Veritas (DNV) [10], the Norwegian counterpart of Germanischer Lloyd (GL) as it is important for ECDIS functionality. This is the specification for one-man watch operation at night (Watch-1 specification), which lays down the minimum requirements for bridge equipment and navigation facilities (ECDIS is, first of all, a navigation facility) under these conditions. This watch modus is becoming increasingly significant in view of the need to promote the cost efficiency on modern oceangoing vessels.

4. System Development

1) Open GIS Standard

An open GIS interface provides an integration of spatial data and operations together, thus generalizes geographical software system. It supports interoperability of GIS systems with open spatial data and geographical operations on information infrastructure.

A *Data Provider* is a set of fundamental components in order for spatial information to be shared in different applications including simple collection, analysis, and visual display [6]. This gives an extensible benefit that a huge number of spatial data developed by vendors can be accessed without transformation of each specific data format into a single standard. Therefore, a commercial operator only develops and opens a set of interfaces in order to provide services to consumers without exposure their raw data.

As one of core technologies to implement open GIS interfaces, *OLE DB* provides a set of OLE interfaces with which a consumer can be provided a common method to access various data sources. Those interfaces make data be shared by implementing DBMS systems corresponding to data sources, which is suitable for the paradigm of an access to GIS database such as coordinates, topologies, and graphical features.

With regard to the interoperability between data providers, there is no rule how they should precisely cooperate with others. When a data provider does not support a specific service, a client system should handle the occasion. Followings list the minimum requirements that a data server should support for services.

- A minimum set of interfaces specified in OLE DB standard
- A registration of 'OGISDataProvider' component
- Exposure of geometry values in forms of 'Well Known Binary' (WKB)
- Naming rule of 'OGIS_GEOMETRY' for those data that support rowset schema or IColumnsRowset.

Table 1. Software Category and Geographical Applications.

Category	Applications
Data Provider	Commercial vendors of GIS software systems provide OLE source code exposing associated feature data as well as spatial data.
Service Provider	Geographic services such as spatial query processor, geocoding services, and network analysis might be provided by software vendors and normal users.
Consumer	ADO interfaces plan simple programming models to access data using OLE DB.

2) ENC Data Provider

In this paper, we design a data provider component where electronic navigational charts data on S57 can be accessed through OLE DB interfaces following the OGC specifications. Fig. 1 shows an overall architecture of our design.

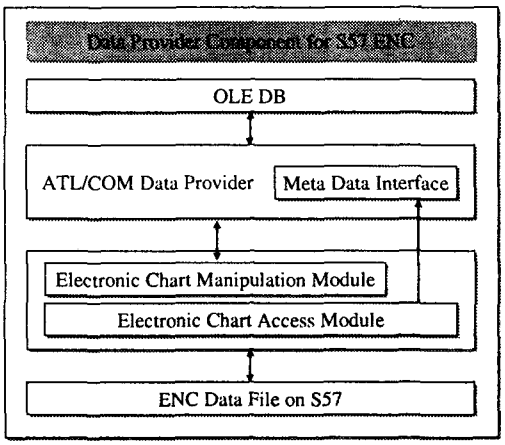

Fig. 1. Architecture of ENC Data Provider.

The ENC Data File on S57 data has been encoded with ISO/IEC 8211 Encapsulation Standard based on IHO S-57 ENC Product Specification, and can be bought from national hydrographic headquarters or international service centers. In Korea, national oceanographic research institute has provided data of all Korean coastlines since 2000.

The Electronic Charts Access Module loads and decodes electronic chart data, decomposes into logical

structure of S57, then access at the unit of objects. It generally acquires meta data or catalog files, then processes electronic chart files.

The Electronic Charts Manipulation Module decomposes S57 objects into record unit, and processes feature units of spatial information and referencing objects.

The Meta Data Interface assigns feature information of electronic navigational meta chart into the Geometry meta data in OGC specification and meta data in OLE DB.

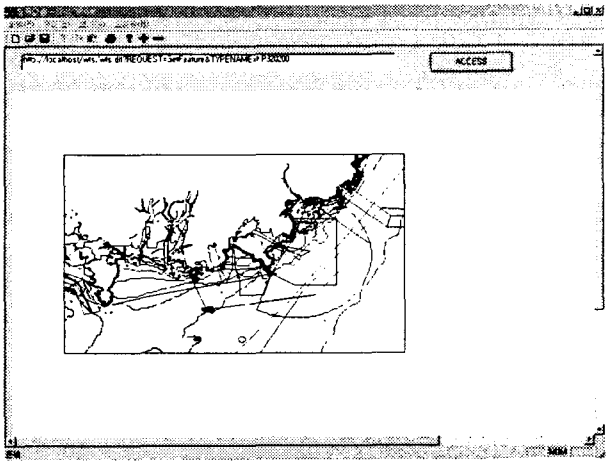

Fig. 2. A Simple GML-Encoded ENC Display.

The ATL/COM Data Provider Component implements ATL/COM OLE DB interfaces with electronic charts manipulation module and meta data interfaces.

The ActiveX GML Component displays ENC data encoded by GML specification on a user screen. A simple ENC display is shown in Fig. 2.

5. Conclusions

This paper developed a web service system, advanced WFS, providing hydrographic information encoded by GML rules. In order to achieve the goal, every data included in an ENC which is following the rules of the S-57 and S-52 from the IHO is transformed into a data structure form of OLE/COM from the OGC. In the system, hydrographic information can be provided through a data provider, and then it can be encoded into GML format for web services. This paper also implemented a web client that requests hydrographic information to the server and renders result data which is a GML format following the rules of S-57. Future researches include a development of graphical applications and analysis of hydrographic data in depth.

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