Development of a GML 3.0 Encoding System Using Mapping Rules

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Abstract: Recently, because of the extensive use of geographic information in the various fields, the requirement for the easy circulation and utilization of the various geographic information among the individuals, organizations, societies and countries is raised. In order to support the interoperability of the heterogeneous geographic information in the various fields, OGC(Open GIS Consortium) proposed the GML(Geography Markup Language) specification that defines the XML encoding rule about the heterogeneous geographic information. In addition, ISO/TC 211 adopted the GML specification to make it as the international standard.
Therefore, in this paper, we first analyzed the GML 3.0 specification in detail that can support the interoperability of the heterogeneous geographic information. And then we suggested and applied the mapping rule that define the encoding method to improve the encoding process easily and efficiently. Finally, we designed and implemented the GML 3.0 encoding system using the mapping rule to encode the geographic information that was constructed in spatial databases into the GML 3.0 document. Especially, we used ZEUS as a spatial database system to test our encoding system in this paper.

Keywords: GML 3.0, Encoding, Interoperability, ZEUS, Application Schema, Data

1. INTRODUCTION

As the use of geographic information increases, the demand on distribution and application of various geographic information, which has been separately accumulated in diverse fields, has been increased[16,19] among individuals, organizations and even societies and countries.

Thus, in order to efficiently circulate and make use of various geographic information, a diversity of standard data formats are proposed and utilized. However, the standard data formats used are subject to be different according to the applied field and purpose. So, there is an issue arisen that the data format in one geographic environments should be converted into another standard data format in order to make use of it efficiently[17].

Hence, it comes to be necessary for users to have a way to efficiently interact with diverse geographic information regardless of its storage data format, management program, and storage location. Therefore, for the purpose of interactive and easy access to various geographic information spread in diverse fields, it is essential to have the geographic information encoding system to perform the data process that makes the geographic information in heterogeneous environments efficiently transformed to be usable in various fields[2,6-9].

The Open GIS Consortium (OGC) already addressed the specification of Geography Markup Language(GML) that involves in encoding different geographic information in XML[10] for the usage in a wide range fields in order to interact with geographic information in various fields in an easy way[9].

ISO/TC 211 is also planning to adopt GML for the international standard[2]. In accordance with that, numerous studies have been conducted on how to encode the existing geographic information in GML. However, they are mostly based upon the specification of GML 2.0, and the applied encoding process is too complicated. Consequently, there is a desperate need for a method to solve such problems.

This paper is designed to analyze GML 3.0, the representative method to provide the interactive operation of current geographic information, formulate the mapping rules to define the encoding method as a simple and efficient way of encoding geographic information and address its application methodology. In addition, this paper designs and implements the GML 3.0 encoding system, which utilizes the mapping rules to encode the geographic information, constructed in the spatial database as the GML 3.0 document.

The GML 3.0 encoding system in this paper is the system to encode the geographic information already established in ZEUS, the spatial database system, into GML 3.0 documents. The GML 3.0 encoding system defines the concrete mapping rules between ZEUS and the GML 3.0 documents, and analyzes the modùle that encodes the actual geographic information into GML 3.0 documents. Based upon that, the GML 3.0 application schema and GML 3.0 documents are generated.

This paper is composed as follows. Following the chapter 1 the introduction, the chapter 2 analyzes GML 3.0 and ZEUS, the spatial database system utilized in this paper. In the chapter 3, the mapping rules and their generation are addressed. The chapter 4 and 5 explain the design and implementation of the GML 3.0 encoding system at which the mapping rules are applied. Finally, the conclusion on the paper is made in the chapter 6.

2. RELATED STUDIES

In this chapter, the specification of OGC's GML 3.0 and ZEUS, the spatial database system, used in this paper is analyzed.

2.1 GML 3.0

GML is the encoded text in XML, the structured document, in order to model, store and transfer geographic information containing spatial feature's spatial/aspatial properties, and it was established as the international standard by OGC. The specification of GML includes the usage purpose and advantage of GML specification, definition of object model used in GML, method to encode in GML, basic schema provided in GML, guidelines to generate application schema on the basis of the basic schema, and the application schema and GML document examples.

Since OGC released GML 1.0 in 1999, it has released GML 2.0[6] based upon XML schema[11,12,13] in 2001, and GML 2.1.1[7] and GML 2.1.2[8] with a little bit of modification have been published in 2002. And until now, it has proposed up to GML 3.0[9].

GML 3.0 is using about twenty GML 3.0 schemas in order to support various standards of OGC and ISO/TC 211, and defines diverse objects that can be usable in a wide range of application fields(for example, LBS). Fig.1 shows the GML class structure provided in GML 3.0.

As you can see in Fig.1, GML 3.0 is able to represent numerous objects including feature, geometry, and topology. Such objects can be represented via various schemas provided in GML 3.0.

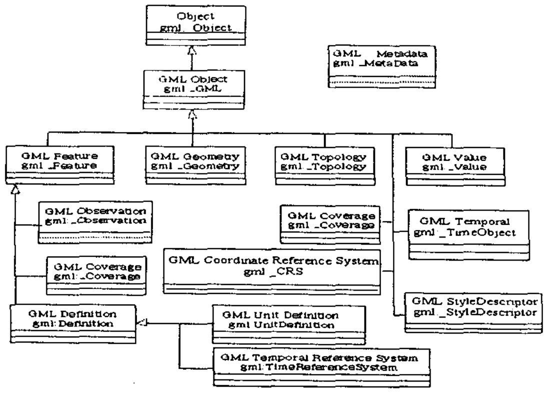


Fig. 1. GML Class Structure

2.2 ZEUS

ZEUS is a spatial database system that combines the object relational database system and spatial data process technology[18]. ZEUS provides the basic database types to support spatial data types such as Point, Simpleline, Polyline, Polygon, Rectangle, and Circle, and all spatial classes are resulted from the inheritance of special_object_class. This paper makes use of ZEUS that supports spatial data types as the basic data types of the database system, as the data source to generate the GML 3.0 document after retrieving geographic information.

3. MAPPING RULES

This chapter will discuss the mapping rules used in GML 3.0 encoding system and the usage of the mapping rules.

3.1 Mapping Rules

The mapping rules are defined information needed for encoding GML 3.0 document, which contain data source structure to be transformed, information about the structure of the transformed GML 3.0 document and so on. Such information is encoded in XML for storage.

The mapping rules are mainly describing how input data are transformed into output data. Input data refer to the database or file storing geographic information, and output data become the GML 3.0 application schema and GML 3.0 document, or vice versa. In other words, they describe how to encode from the geographic information storage system to GML 3.0 efficiently.

The mapping rules define the mapping process between the spatial database system and GML 3.0 document and they are encoded in XML aimed for the easy definition and usage. An encoding system generates the GML 3.0 application schema and GML 3.0 document, which can be instantly utilized or transferred to another system.

When it come to the mapping rules, only single rule is defined and used without the need to define two transformation rules to be used between the GML 3.0 application schema and GML 3.0 document. And it is analyzed in the application schema creation module for the use of creating GML 3.0 application schema, and it is analyzed in the encoding module for the use of creating the GML 3.0 document. But all information necessary for this process is stored in the mapping rules.

The mapping rules that this paper originally suggests were generated in the XML format for the easy analysis and usage. In addition, they usually contain information about mapping elements and data types used when they are encoded in GML 3.0 on the basis of ZEUS schema structure and system information needed for geographic information encoding process.

3.2 Usage of Mapping Rules

The mapping rules are utilized in figuring out the conversion method when encoding geographic information into GML 3.0, and they can be used to define and reuse existing encoding process. Fig.2 shows the document conversion process between ZEUS spatial databases and GML 3.0 with the use of mapping rules.

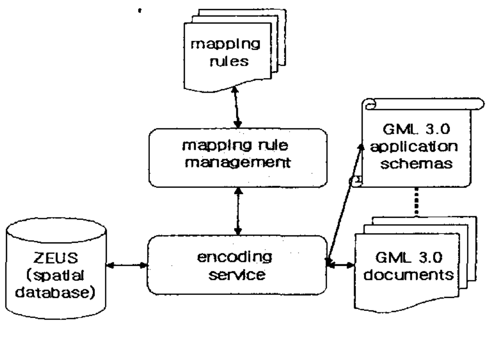


Fig. 2. Mapping Rule Usage

In order to generate the mapping rules, users can generate them from the existing encoding process they generated before, or they can be immediately generated from what they need or it is possible to automatically generate the mapping rules.

4. SYSTEM DESIGN

This chapter will discuss GML 3.0 encoding system configuration with the use of the mapping rules, and then review the system modules of the GML 3.0 encoding system.

4.1 System Configuration

Fig.3 shows the system configuration of the GML 3.0 encoding system using the mapping rules.

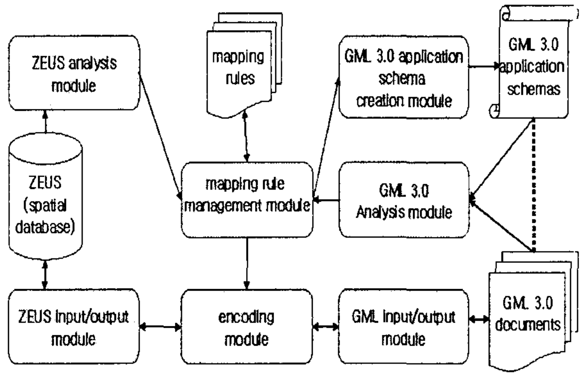


Fig.3. GML 3.0 Encoding System Configuration

As Fig.3 shows, the GML 3.0 encoding system is composed of a ZEUS analysis module to analyze ZEUS, a spatial database system designed for retrieving customized geographic information, a ZEUS input/output module to input and output ZEUS geographic information, a mapping rule management module to create and manage mapping information between ZEUS and GML 3.0, an encoding module to encode geographic information in GML 3.0 according to the mapping rules, a GML 3.0 application schema creation module to generate the application schema of the GML 3.0 document, a GML 3.0 analysis module to analyze the GML 3.0 application schema and documents, and finally a GML 3.0 input/output module to input and output data into the GML 3.0 document.

4.2 System Modules

The ZEUS analysis module is designed to use ZEUS API to provide information about geographic information structure stored in ZEUS. And it is featured to retrieve information of the ZEUS spatial classes and attributes.

The mapping rule management module is designed to show users ZEUS geographic information retrieved from the ZEUS analysis module by the use of the mapping rule management module. And it involves in creating and managing the mapping rules with information about ZEUS spatial classes and attributes necessary when encoding in the GML 3.0 application schema and document.

The GML 3.0 application schema creation module is designed to generate the GML 3.0 application schema referred from the GML 3.0 document. This module has a feature to transform from the spatial classes and attributes that user wants among ZEUS spatial classes to the GML 3.0 application schema in accordance with the mapping rules created in the mapping rule management module and the GML 3.0 application schema creation rules addressed in the GML 3.0 specification.

The GML 3.0 analysis module is devised to analyze the selected GML 3.0 application schema and GML 3.0 document. This module is featured to retrieve and transfer necessary information from the GML 3.0 application schema or document, to retrieve and transfer information about Feature and Feature Collection model, and to inspect whether it complies with GML 3.0 application schema referred from the GML 3.0 document.

The ZEUS input/output module is designed to input and output the values of ZEUS spatial classes and corresponding attributes in order to input and output ZEUS geographic information needed for the encoding module of the GML 3.0 encoding system in accordance with the mapping rules created in the mapping rule management module. This module has functions to create new classes in ZEUS, to input geographic information into ZEUS, and to output geographic information from ZEUS.

The encoding module is devised to output geographic information by the use of the ZEUS input/output module according to the mapping rules generated in the mapping rule management module and encode it, and then it delivers the result into the GML input/output module and vice versa. This module has the functions to analyze the mapping rules, to encode ZEUS spatial classes in GML objects, to transform GML objects to ZEUS spatial classes, to convert ZEUS spatial data types into GML geometry, and to convert GML geometry into ZEUS spatial data types.

The GML 3.0 input/output module is designed to input and output the appropriate elements of the GML 3.0 document in order to input and output geographic information of the GML 3.0 document necessary for the encoding module of the GML 3.0 encoding system according to the mapping rules generated in the mapping rule management module. This module is featured to create the GML document, to input new elements into the GML 3.0 document, and to output elements from the GML 3.0 document.

5. SYSTEM IMPLEMENTATION

This chapter is designed to review GML 3.0 encoding scenario and explain the process of each module of the GML 3.0 encoding system in detail.

5.1 GML 3.0 Encoding Scenario

Firstly, in order to retrieve geographic information, the spatial classes of ZEUS, spatial database system, should be figured out through the ZEUS schema analysis process. If any necessary mapping rule is found, it is utilized after being edited, and if there is no mapping rule found, a new mapping rule is generated.

And then, the GML application schema is generated to be used in the GML document. According to the mapping rules and user's input, spatial/aspatial data of ZEUS spatial class are retrieved and encoded in GML 3.0 through the ZEUS input/output module, and then input through the GML input/output module. At this time, in the process of retrieving spatial data, information about Spatial Reference System(SRS) to which retrieved data belong is entered into. The GML document generated in this way can be utilized for diverse fields.

When storing and updating the GML 3.0 document into ZEUS, the mapping rules related to the appropriate GML 3.0 document are edited for the use or new mapping rules are generated. According to that, data are output from the GML document and entered into as ZEUS spatial class data through the GML input/output module in the encoding module.

5.2 ZEUS Schema Analysis

In the GML 3.0 encoding system, in order to encode geographic information in GML 3.0, it is mostly necessary to find out the data source containing spatial classes that user prefers among ZEUS data sources. Fig.4 shows the ZEUS schema dialogue designed to show and select information about ZEUS data sources.

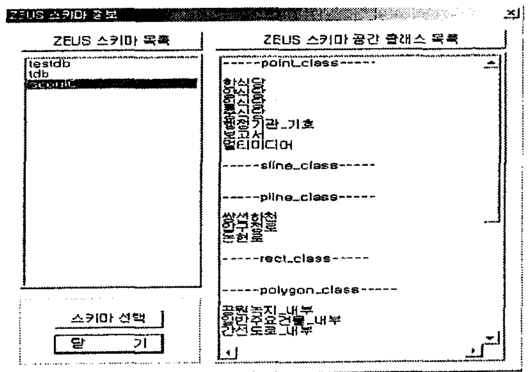


Fig. 4. ZEUS Schema Dialogue

5.3 Mapping Rule Generation

In this section, how the mapping rules that are featured in Chapter 3 are generated is discussed, and Fig.5 shows the GML encoding dialogue that generates the mapping rules. If you look at the classes shown in Fig.5, each of classes contains property information of ZEUS spatial classes and mapped GML object structures that are encoded and saved in XML. In the mapping rules, such object structures are stored.

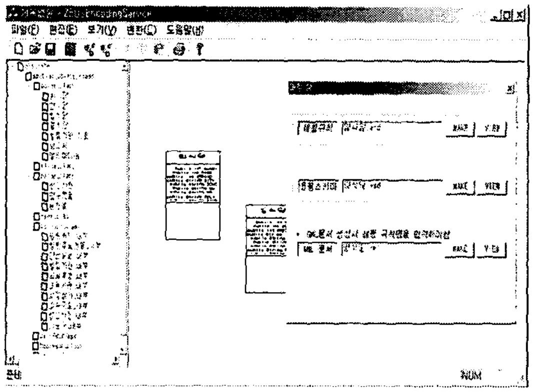
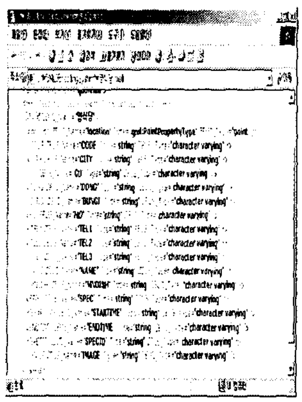


Fig. 5. GML Encoding Dialogue

Fig.6 shows the generated mapping rules represented via IE 6.0. Other than that, the mapping rules contain necessary meta information such as the name of ZEUS data source, generation date and so on.



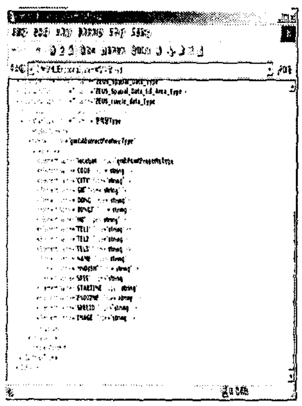


Fig. 6. Mapping RulesFig. 7. Application Schema

In the GML encoding dialogue shown in Fig.5, the GML 3.0 application schema can be generated and Fig.7 shows the GML 3.0 application schema represented via IE 6.0. The generated mapping rules can generate the GML 3.0 application schema referred from the GML 3.0 document through the GML 3.0 application schema creation module.

5.4 GML 3.0 Document Generation

The GML 3.0 document is generated in the encoding module, which analyzes the mapping rules generated, and the GML 3.0 analysis module analyzes information necessary for the GML 3.0 document. Based on these, the GML 3.0 document is produced by the use of the ZEUS input/output module and GML 3.0 input/output module.

To generate the GML 3.0 document, enter the name of the GML 3.0 document in the GML encoding dialogue shown in Fig.5, followed by clicking the button "MAKE". As viewing the generated GML 3.0 document, the button "VIEW" opens the document in a notepad. At this time, the mapping rules file name or GML 3.0 application schema file name must be entered. Fig.8 shows the outlook of the GML 3.0 document in IE6.0.

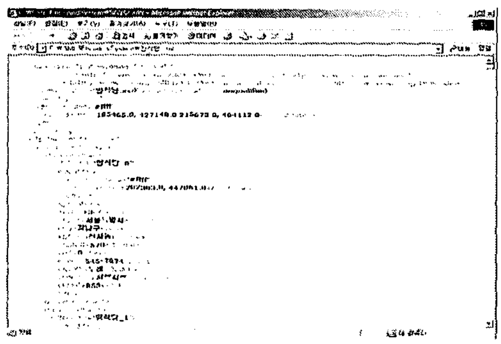


Fig. 8. GML 3.0 Document

6. CONCLUSION

From this point of time when the necessity of interactive use and application of the geographic information in various fields, many domestic and foreign researches on XML encoding of the existing heterogeneous geographic information have its common in numerous fields.

In this paper, the mapping rules defining the encoding technique is proposed as an alternative to improve the encoding of the existing geographic information, and to more conveniently and efficiently encode it into GML. In addition, the GML 3.0 encoding system applied with the mapping rules is designed and implemented based on this to encode the geographic information stored in the spatial database in the GML 3.0 document.

The users using the GML 3.0 encoding system can more easily and conveniently encode ZEUS geographic information in GML 3.0 or vice versa. This encoding technology brings a basis where it can be expanded to a variety of OGC-based services, namely WMS or WFS, which utilizes GML.

In future, it is necessary to fulfill a basic study for implementing a system that various GML documents can be automatically converted without user input by expanding the GML 3.0 encoding system, which applies the mapping rules developed in this paper.

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