

수치지도 2.0을 이용한 객체기반 데이터 모델 설계

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A Design of Feature-based Data Model Using Digital Map 2.0

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요 약

공간데이터에 대한 수요가 날로 늘어남에 따라 다양한 공간 객체들을 효과적으로 저장하고 관리할 수 있는 데이터 모델에 대한 수요도 늘어나게 되었다. 지금까지 수많은 공간데이터 모델에 대한 다양한 데이터 모델들이 제안되었으나 이런 데이터 모델들은 단지 특정된 기능을 위해 구축되었거나 혹은 구축은 용이하지만 효과적인 관리가 어렵고 활용성이 떨어지는 문제점들을 가지고 있다. 특히 국내에서 많이 사용되고 있는 수치지도 포맷은 도엽기반으로 되어 있어 구축은 용이하나 데이터 활용이 어렵고 대부분의 시스템들에서 사용될 수 없다. 따라서 본 연구에서는 도엽기반의 수치지도2.0에 기반한 객체기반의 연속 데이터 모델을 구축함으로써 모델 구축도 용이할 뿐만 아니라 관리하기 편리하고 많은 응용분야에 쉽게 활용할 수 있는 데이터 모델을 제안한다. 제안된 데이터 모델은 도엽단위가 아닌 객체단위로 데이터를 저장하고 처리하기 때문에 갱신비용이 낮고 신속한 갱신이 가능하다. 또한 지형지물들 사이의 연관관계에 의하여 자동 검수를 진행할 수 있기 때문에 갱신 데이터의 정확성을 보장할 수 있다. 본 논문에서 제안된 데이터 모델의 적용성에 대한 검증을 통하여 기존 데이터 모델들로 표현하기 어려운 객체기반 관리시스템의 특성들에 대하여 제안된 모델이 효율적으로 적용가능 하다는 것을 논리적으로 검증하였다.

▶ Keyword : GIS, 수치지도 2.0, 객체기반 데이터 모델, 수시갱신

Abstract

In With increase of a demand on the spatial data, the need of spatial data model which can

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effectively store and manage spatial objects becomes more important in many GIS applications. There are many researches on the spatial data model. Several data models were proposed for some special functions, however, there are still many problems in the management and applications. Digital Map is one of spatial data model which is being used in Korea. The existing Digital Map is based on the Tiles. This approach needs more cost in its construction and management. Therefore, in this paper, we propose a feature-based seamless data model with Digital map 2.0 which is based on Tiles. This model can be easily constructed and managed in the large databases so that it is able to apply to any systems. The proposed model uses the relationships between features to correct updated data and the Unique Feature Identifier(UFID) also makes system to search and manage the feature data more easily and efficiently.

▶ Keyword : GIS, Digital Map 2.0, Data Model, Feature-Based

I. INTRODUCTION

Recently, spatial data is widely used in many fields such as ITS, navigation systems, Global Positioning System(GPS)s, mobile applications and so on. With increase of a demand on the spatial data, the request for high quality spatial data is increased. A number of countries have their own spatial data models which are suitable to their geographic characteristic. The shapefile and GML are the most widely used spatial data model [13]. These models are based on file system. It leads to a difficulty in inserting, modifying and deleting a specific spatial object.

In Korea, the most popular data model is Digital Map 2.0 [10]. The Digital Map 2.0 model is an extended version of Digital Map 1.0. These models are constructed by tiles. The model consists of two main files. One represents the shape of these spatial objects and the other one represents common attributes of the spatial objects. The file-based spatial data management system needs high cost and long time for updating process, because the file should be newly constructed when a specific spatial feature is updated. This system cannot satisfy the requirement of users who want to obtain a up-to-data and reliable spatial data. Therefore,

feature-based spatial data management system needs for real time update. Feature-based system manage spatial data with each feature object, it is easy to search and update the specific feature object in real time. However, current spatial data models does not support feature-based systems.

In this paper, we propose a feature-based Seamless Digital Map data model which uses Digital Map 2.0 to support feature-based spatial data management systems. This model is based on database system.

In the section 2, some spatial data models would be introduced. Then we will describe about design of Data Model and model analysis in section 3 and 4. Finally complete paper with conclusion.

II. RELATED WORK

The spatial data model is a model that represent the spatial locations, shapes and the relationships of spatial objects in real world. Therefore, the spatial data model has more complex relationships between spatial features. In this section, we review existing spatial data models.

1. Spatial data model in foreign countries

In foreign, the spatial data models are divided into standard spatial data model and business

spatial data model. ISO/TC211 spatial schema and XML-based spatial data model such as GML and CityGML are commonly used standard spatial data models. Shape File is a widely used business spatial data model [13].

ISO/TC211 is an international standard organization which standards various fields of digital geographic information. In ISO/TC211, there are many standards about spatial data. Table 1 shows some ISO 19100 series standards about spatial data model.

CityGML is an XML-based spatial data model for the storage, management and transmission of Three-dimensional city model. This model is defined as OGC standard and registered in ISO 19136. Because CityGML uses XML grammar, it is based on file system [3][12].

Table 1 Standards of ISO 19100 Series

Standards for Data model	
ISO 19103	Conceptual schema language
ISO 19107	Spatial schema
ISO 19108	Temporal schema
ISO 19109	Rules for application schema
ISO 19110	Methodology for feature cataloguing
ISO 19111	Spatial referencing by coordinates
ISO 19112	Spatial referencing by geographic identifiers
ISO 19123	Schema for coverage geometry and function

One of the business spatial model is Shape File. This model is the most widely used spatial data model which is open structure [2]. Shape File model also is based on file system. The model includes three types of files shp, dbf and shx. Shp file represents shape information of each geographic

feature objects and dbf file shows common attributes for feature objects. Shx file is an index file which is used to connect shp file and dbf file. This file structure is very similar to Digital Map 2.0 in Korea.

2. Spatial data model in Korea

In Korea, the Digital Map 2.0 is the most popular spatial data model which is an extension of Digital Map 1.0 [7]. This model consists of ngi file and nda file which represent shape information and common attributes like Shape File. Because Digital Map 2.0 source is inner format in NGII and not opened, Digital Map 2.0 model is used in a few GIS systems that hold the core technique about Digital Map 2.0. Other GIS systems usually use Shape File whose data structure employs Digital Map 2.0 data structure. However, Digital Map 2.0 is used in many fields of GIS for example construction of 3D spatial data model [11].

Digital Map 2.0 uses tile-based management. The spatial data of Korea is too large to manage efficiently. The boundary of entire Korea is divided into several small tiles to avoid difficulty in large data. Each city or specify area is covered by some tiles. When there are some needs for spatial data of some city, it only use a few tiles that are covers the area.

Recently, to solve the problems of tile-based GIS systems, feature-based spatial data management system have been studied. Some spatial data models also have been proposed for feature-based spatial data management system [1].

One of the most popular research is Unique Feature Identifier(UFID) [1][4][5]. UFID is a code which can only identify each geographic feature object in spatial data model. For each system or data model, they have their own UFID coding system to manage their spatial data. Therefore, UFID has a strong dependency with each system or data model [7][8][9]. UFID has been researched in many R&D enterprises. However UFID provide

system to manager spatial data by features, the file-based data model makes it can not effect in feature based management.

An other one is National Geographic Framework Database. National Geographic Framework Database is a database model that defines basic feature types which are commonly used in most GIS systems. However it is a well designed data model that contains basic features in Korea, it can not represent various geographics in Korea. This model

also is too complex to apply in GIS systems. The almost data in National Geographic Framework Database data is made from Digital Map 2.0 data. They apply transformation system to transform data into National Geographic Framework Database model. It lead to National Geographic Framework Database model is difficult to construct and management so that is not popular in GIS. Figure 1 shows data model for traffic group in National Geographic Framework Database.

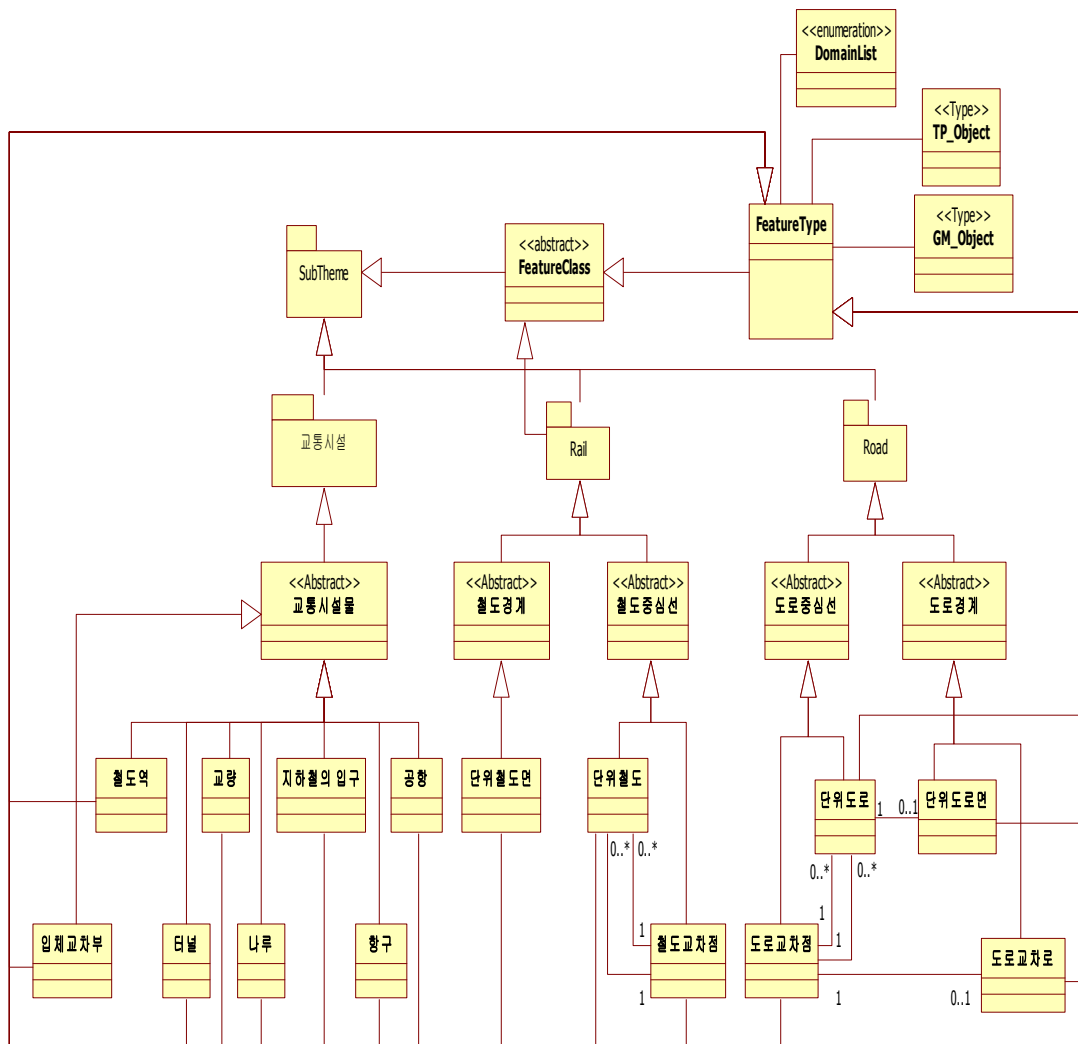


Fig. 1. Data Model for Traffic Group in National Geographic Framework Database

The features in this model are very different to Digital Map 2.0. For example, Crossroad feature

has different definitions in two data models. In National Geographic Framework Database, Crossroad feature is defined as the end nodes of the road segments which connect two road segments. In Digital Map 2.0, the Crossroad is the intersection of RoadChain objects. Therefore, the Crossroad have to be connected to more than three RoadChain objects in Digital Map 2.0. The road also has different representations. In National Geographic Framework Database, each Road object is represented by several line segments. It makes one Road feature is represented by several Road objects. In Digital Map 2.0, each Road feature is represented by one RoadChain features which are typed line string.

III. DATA MODEL DESIGN

The spatial data model proposed in this paper is based classification and data structure of Digital Map 2.0. Figure 2 shows the design process of our data model. Design process consists of three parts - conceptual design, logical design and physical design. In this paper we describe only conceptual design which is the most important part in whole design process and skip logical design and physical design.

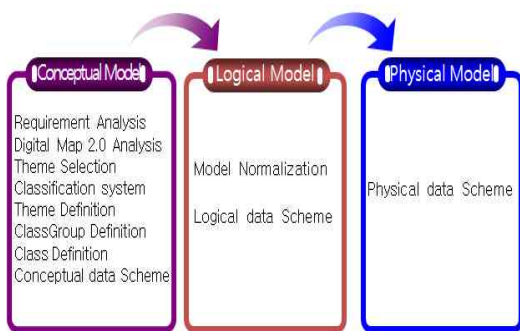


Fig. 2. Design Process for Feature-based Digital Map Data Model

1. Design for Conceptual Model

In conceptual design, we analyzed Digital Map

2.0 and decided the scope of feature and defined Theme, ClassGroup and Class. And then we designed the conceptual model and schema.

In this model, we applied data structure and classification of Digital Map 2.0. According to classification of Digital Map 2.0, in our model, all of spatial features are divided into artificial geographic feature and natural geographic feature. Artificial Geographic Feature Theme consists of traffic, building, establishment, boundary and label ClassGroups and National Geographic Feature Theme consists of vegetation, hydrography and terrain ClassGroup. Each ClassGroup also consists of several feature Classes. The classification of Digital Map 2.0 is shown in Figure 3. This classification makes our model easy to construct and manage spatial features effectively.

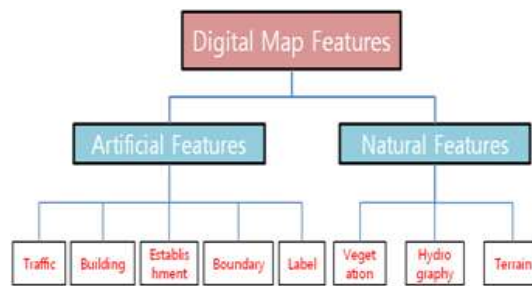


Fig. 3. Classification of Digital Map 2.0

To define features is an important part in conceptual design of our Feature-based seamless data model. Our model employs the data structure of Digital Map 2.0. In Digital Map 2.0, it defines 130 geographic features and the most basic geographic features which can represent all spatial features in the Korea are 104. In our model, we removed some features which is not too small to display on the map. These features are grouped in 8 ClassGroups which have similar functions.

There are 18 features in traffic ClassGroup. The features included in traffic ClassGroup have various relationships and a lot of errors during updating process. RoadChain feature and

RailroadChain feature are the main features in traffic ClassGroup. They have many relationships with other features to perform various functions. Especially, positional relation is used to improve the accuracy of updated data. Figure 4 shows the

overall conceptual data model for traffic ClassGroup.

2. Define for Relation between Geographic Features

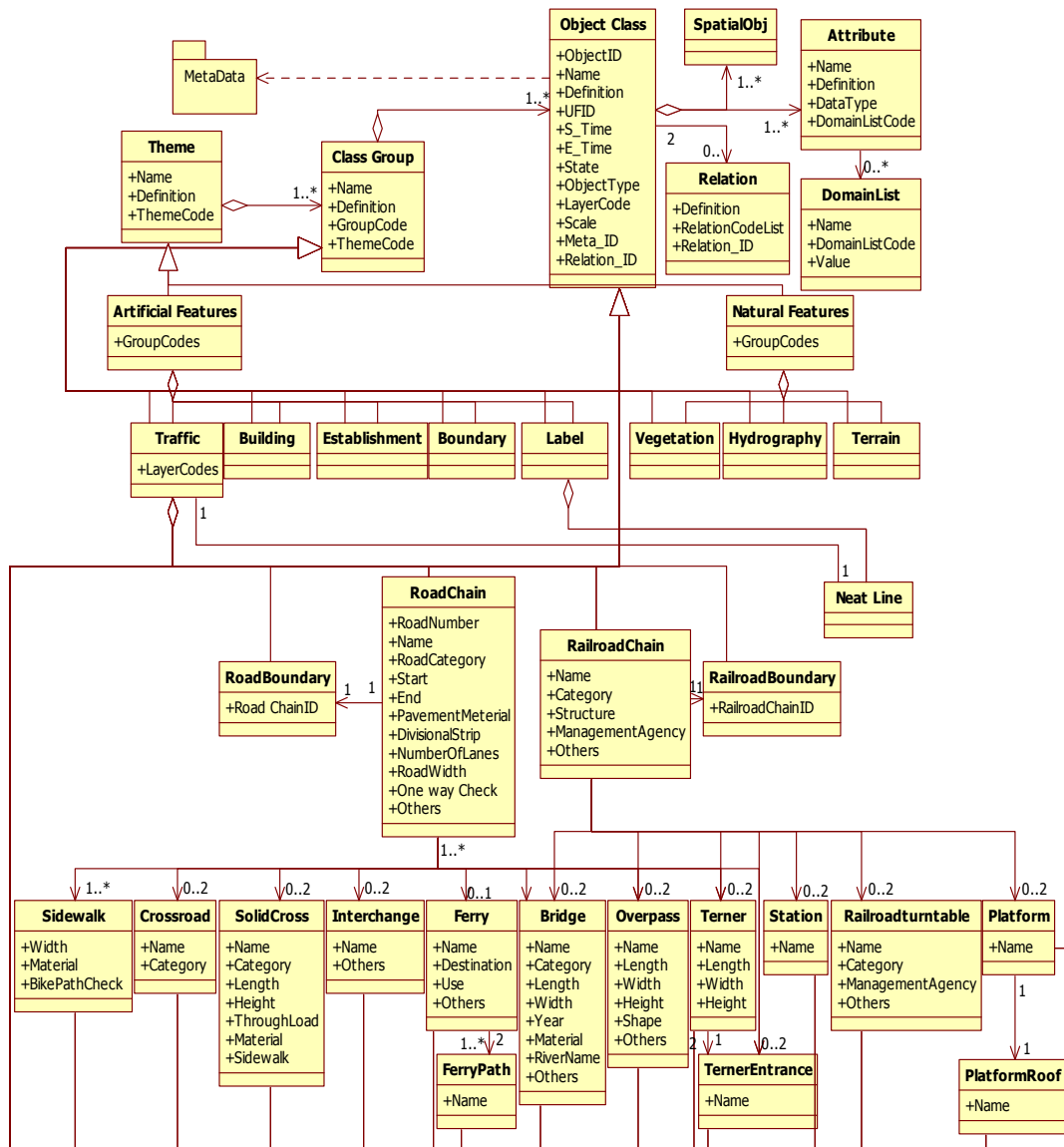


Fig. 4. Overall Conceptual Data Model for Traffic ClassGroup

Updating task is a process that old object is destroyed and new object is created. There are

many integrity errors in updating process. For example, when a new bridge object is inserted, this object should be on RoadChain object or RailroadChain object. For solving this problem, we construct various types of relationships. There are four types of relationships in the proposed model. Inheritance

Some features inherit all characteristics from other feature. For example, RoadBoundary represents the boundary of RoadChain feature. Therefore, the RoadBoundary feature has all attributes of RoadChain feature. RoadBoundary also has boundary information of RoadChain feature. To avoid duplicate data and integrity error, all the attribute values of RoadBoundary feature refer to attributes of RoadChain feature. These relationship also can be used to check the updating errors. When a new RoadBoundary object is inserted, there have to be a RoadChain object which is represented by inserted RoadBoundary object. If a RoadChain object is modified or deleted the related RoadBoundary object also have to be modified or deleted simultaneously. Relationship between RoadBoundary and RoadChain is shown in Figure 5.

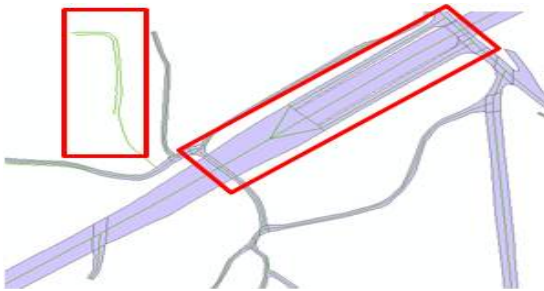


Fig. 5. Relationship between Road Boundary and RoadChain

Connection

This is the main type of relation in the proposed model. It shows many relations between each pair of features. For example, the Bridge and RoadChain has a positional relationship because

each Bridge object has to connect two RoadChain objects. If the Bridge object is not connected to any RoadChain object, the updated object might be an error data. Figure 6 shows an error insertion of Bridge object which is not connected to any RoadChain object.

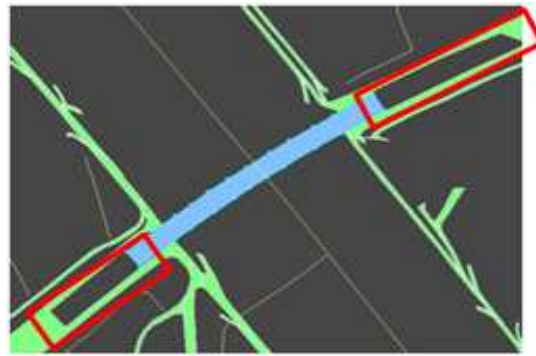


Fig. 6. An error insertion of Bridge object

Confluence

There are some errors in updating process. We suppose that there are three RoadChain objects that are crossed by a Crossroad object. When a RoadChain object connected to two of other RoadChain objects is deleted, there are only two RoadChain objects connected to the Crossroad object. Because a Crossroad object has to connected to more than three RoadChain objects, in this case, the Crossroad object should be deleted simultaneously.

IV. MODEL ANALYSIS

To analyze the applicability of proposed spatial data model in real environment, we choose some important functional elements to get logical tests.

1. Seamless expression for a feature

The feature-based seamless Digital Map 2.0 model proposed in this paper uses UFID to identify each logical features. Every geographic feature in

real world has their unique code. We use this code to search each logical feature from database. Suppose there is a building named "43 Dong, Chungbuk National University" and it's UFID code is "B00145624 320416". This code was assigned when the "43 Dong, Chungbuk National University" object is inserted. If a user wants to search this building from database, we can use following query shown in Figure 7.

```
Select *
From Building
Where UFID = 'B001456243320416'
```

Fig. 7. Query example for searching seamless object using UFID

After executing query, the system returns the following result shown in Figure 8. There are two feature objects in the result. Because the building object is cut into two different tiles which are "36706039" and "36706040", the building object is divided into two physical features and stored in database. However, we assign a same UFID code to physical features to show it is one logical feature object.

FID	Shape	ID	명칭	구분	종류	현도	주거	층수	UFID
11289	Polygon 2M	15172	주거	이동식	주거	사립중앙대학교	주거	13	B001456243320416
11289	Polygon 2M	39552	주거	이동식	주거	사립중앙대학교	주거	13	B001456243320416

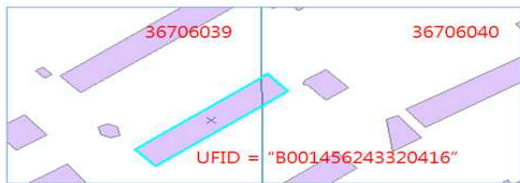


Fig. 8. Result for searching seamless object using UFID

2. Error checking in real time update

Checking errors from updated data is an

important but a very difficult task in real time update process. For most spatial management systems which use current data model, all the error checking tasks are performed manually. Proposed model supports system can check some logical error automatically. To test the process of error checking, we consider an updating case.

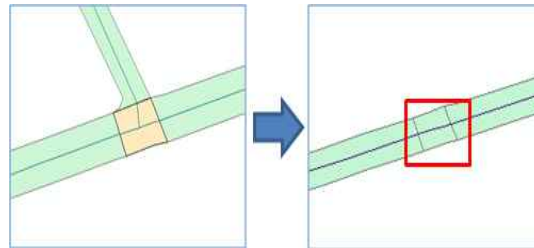


Fig. 9. Deletion of Crossroad by automatical error checking.

Suppose there is a Crossroad object which is connected to three RoadChain objects whose serial numbers are 1, 2 and 3. A RoadChain object which number is 3 is deleted by deletion operation. The system would delete RoadChain object from database and then count the number of RoadChain objects connected to Crossroad object from relation of the data model. There are only two RoadChain objects connected to Crossroad object. Since one Crossroad object have to be connected to more than three RoadChain objects, the system would automatically delete the Crossroad object from database simultaneity shown in Figure 9.

3. Compare with current data models

We compared proposed model with other main spatial data models such as Shap File, GML and Digital Map 2.0. The comparison of characteristics of each spatial data model is shown in Table 2. All data models use tile-based management system except the National Geographic Framework Database and proposed model. The file-based models can not support real time update since all the file should be constructed again when a feature object is updated. Proposed data model is designed

for feature-based management. To manage each feature directly, we use a relational database model. Therefore, proposed model can support any

real time update by accessing each feature objects directly.

Table 2. Comparison of characteristics for each spatial data model

data model		Shape File	Digital Map 2.0	National Geographic Framework Database	Proposed Model
functions					
Tile-based Management		○	○	X	○
Feature-based Management		X	X	Difficult to manage	○
Periodic Update		○	○	Difficult to manage	○
Real Time Update		X	X	Difficult to manage	○
Checking Update Error		X	X	basic operations (int ersection, overlap, etc.)	checking update error according to relationships in data model
Geometric elements	0D	○	○	○	○
	1D	○	○	○	○
	2D	○	○	○	○
	3D	X	X	X	X
File system		SHP file	NGI file	DBMS	DBMS

Because the National Geographic Framework Database is based on DBMS, it also can access each object directly. However, the definition of the feature is not based on logical spatial features, it is difficult to support feature-based management system. An other one problem in National Geographic Framework Database is that the construction is based on Digital Map 2.0 data. It lead update process more difficult.

V. CONCLUSION

Recently, with increase of a demand on the spatial data, user hopes more accurate and active spatial data. Therefore, the tile-based Digital Map management system can not satisfy user's requirement. Feature-based management system can store and manage each specific features easily. However, current spatial data model is not suitable to feature-based management systems.

To solve this problem, we propose a

feature-based seamless data model using Digital Map 2.0. Because the proposed model used Digital Map 2.0 structure which is the mainly used model in Korea, this model can apply to any current management system easily and the data is easy to get from other systems. In this paper, we analyzed the applicability of the proposed data model and compared with other models. The proposed model can be applied to various spatial data management systems to show it's ability.

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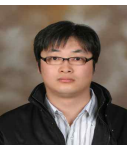
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