Information Strategy Planning for Digital Infrastructure Building with Geo-based Nonrenewable Resources Information in Korea: Conceptual Modeling Units

Kwang-Hoon Chi *, Young-Kwang Yeon *, No-Wook Park *, Kiwon Lee**

* National Geoscience Information Center,
Korea Institute of Geoscience and Mineral Resources,
30 Kajung-dong, Yusung-ku, Daejeon 305-350, Korea
E-mail : {khchi,ykyeon,nwpark}@kigam.re.kr

** Department of Information Systems, Information Engineering Division,
Hansung University, 389 Samsun-dong 2-ga, Sungbuk-gu, Seoul 136-792, Korea
E-mail : kilee@hansung.ac.kr

Abstract: From this year, KIGAM, one of Korean government-supported research institutes, has started new national program for digital geologic/natural resources infrastructure building. The goal of this program is to prepare digitally oriented infrastructure for practical digital database building, management, and public services of numerous types of paper maps related to geo-scientific resources or geologic thematic map sets: hydro-geologic map, applied geologic map, geo-chemical map, airborne radiometric/magnetic map, coal geologic map and off-shelf bathymetry map and so forth. As for digital infrastructure, several research issues in this topic are composed of: ISP (Information Strategy Planning), geo-framework modeling of each map set, pilot database building, cyber geo-mineral directory service system, and web based geologic information retrieval system upgrade which services Korean digital geologic maps scaled 1:50K. In this study, UML (Unified Modeling Language)-based data modeling of geo-data sets by and in KIGAM, among them, is mainly discussed, and its results are also presented in the viewpoint of digital geo-modeling ISP. It is expected this model is further progressed with the purpose of being a guidance or framework modeling for geologic thematic mapping and practical database building, as well as other types of national thematic map database building.

1. Introduction

In Korea, national project for nation-wide digital geologic mapping has been carried out for three years since 1999. As results of that national program, geologic maps by scale of 1:50,000, in the *de-facto* GIS data structure, such as ESRI shapefile and DXF format, in consideration to efficient geo-data model, were obtained. Followed by this product, an internet-based geo-information system for managing and editing these large volumes of digital data sets was also developed.

The objectives of this program can be categorized into 'National Geologic Digital Mapping', being comparative to USGS digital geologic mapping. While, new national program of 'Korean Digital Geologic Infrastructure Building' has been launched since this year. Some core parts within this new program are regarded as descendant of previous geologic digital mapping program.

Comprehensively, this program is composed of several core parts: (1) long-term or short-term ISP (Information Strategy Planning), (2) overall architecture design, (3) geologic database attribute in digital geologic map for public information and specific uses of actual geological studies, (4) producing and providing geo-multimedia contents for educational purposes, (5) geologic data acquisition system by field geologists at test-bed sites, (6) web-based geologic guidance system with some on-line tutorial functionalities for understanding domestic geologic issues, and (7) web-based geology/natural nonrenewable resources information service system, and so forth. Meanwhile, database building and/or digital data producing strategy for geo-based data and primary attribute information, has been studied and implemented at some counties, since mid 1990s when GIS-based geological applications using digital geologic map were addressed (Lamb et al., 1996; Laxton and Beckon, 1996; Allen, 1997; Bain and Giles, 1997; Sollar and Berg, 1997; Johnson et al., 1999; Mawer, 1999; Jackson and Kristine, 2002).

In this study, some intermediate results on ISP for 'Korean Digital Geologic Infrastructure Building' and framework model are presented and discussed.

2. Digital geologic mapping program: 1:50K Digital Geologic Map

Digital geologic map has been generated and released as the *de facto* forms in GIS data by KIGAM(1999).

This digital geologic data is composed of 11 layers such as base layer, boundary layer, and so on. Data users are divided into two types: viewer and application users. For viewer, web-based geologic information guide system is currently available at host site: URL http:/dzmap.kigam.re.kr. While, application user means geologists/geophysicists capable of utilizing digital geologic data sets for their works or researches. Actual examples of digital geologic map scaled 1:50000 were represented at Fig 1. This example data for application users is different types of same map, according to attributes such as stratigraphic class, geochronological classes, and lithological classes.

As reference, this digital geologic data in GIS data format has been started to release at the nominal cost in various media from the mid this year from KIGAM.

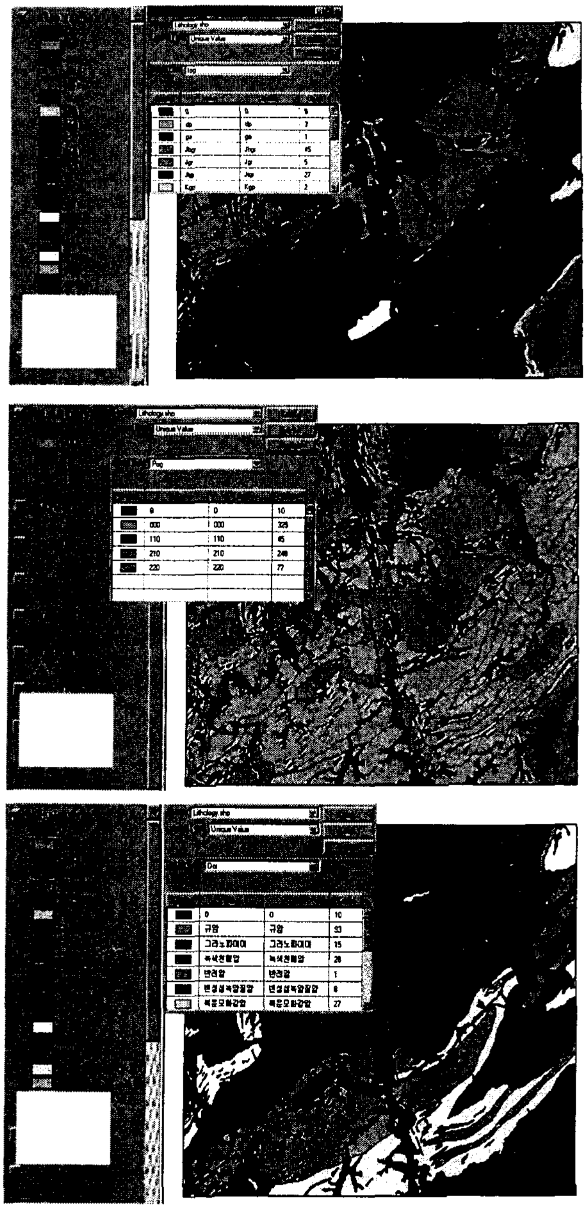

Fig. 1 Digital geologic map of 1:50K. (A) Lithological class, (B) Geochronological class, and (C) Stratigraphic class.

3. Digital geologic infrastructure building database building program: Overview

Followed by Digital geologic mapping program, this new program is briefly composed of these several parts:

(1) long-term or short-term ISP (Information Strategic Planning) for web-based geo-information systems, (2) architecture design for hosting web server and database server, (3) geologic database attribute building in digital geologic map for public information and specific uses of actual geological studies, (4) producing and providing geo-multimedia contents for educational purposes and operating cyber geologic museum, (5) geologic data acquisition by field geologists at test areas, (6) web-based geo-science tutoring system with some on-line tutorial functionalities for understanding domestic geologic issues, and (7) web-based geology/natural resources information service system (Chi et al. 2002).

Generally, ISP (Information Strategy Planning) is the first step for large-scaled database building and its information system. As a matter of fact, generation of digital geologic map is not a final goal of geologic information system emphasized on geo-infrastructure aspect, though this is very crucial primary data.

There are lots of data sets in digitally mappable geo-infrastructure toward the country-wide information

However, in most cases, those geo-based map data is from different sources which mean different investigator, mapping style, scale, or organization.

4. ISP for Geo-infrastructure database building and information system

Contents within ISP for this national program are as follows: (1) Defining Objectives and Vision, (2) Architecture as 'Big Picture' and designing main sub systems, e.g. geo-metadata management, digital geologic map storage/management, editing/manipulation of geo-based map sets, and so on (3) Analysis of International and/or Domestic conditions and trend surrounded this program, (4) Analysis of CSF (Critical Success Factor), (5) Framework modeling related to Geologic/Natural Resources Mappable data sets and concerned information, and (6) Planning for System development and Geo-based Database building in Long-term(Duration: ~ 5 years) and short-term (< 1 or 2 years)

Table 1 is summary of geo-based several data sets in consideration to digital geologic infrastructure, and most data sets, as paper map, have been managed in KIGAM, which data acquisition and compilation, besides cartographic publication, have been carried out by geoscience experts in charge of research section with KIGAM.

Table 1. Target geo-science data sets, as 'would-be' components in geologic infrastructure

Types of Geo-data	Contents or Map set	Map Scale
Geo-chemistry Map Data	Cu, Pb, Zn, Cd, Mo, W, Ag, As, Co, Ni, Bi, U, Sb, et al.	1:50K
Applied Geologic Map	Soil class, Soil and Land resources, Drainage density et al.	1:25K
Airborne Geophysical /Radiometric Map	Total Gamma ray, K, U, Th, U/Th, Total magnetic intensity, Residual magnetic intensity	1:50K
Hydro-geologic map	Hydrology map	1:25K
Marine Geologic Map of Continental Shelf	Bathymetric, Sediment mean grain size distribution, Surface Sediment distribution, Residual Magnetic Anomaly map, Free-air Gravity Anomaly Map, Seismic profile, Isopach map	
Coal field map	Surface geologic map, Underground Geologic Map	1:25K

5. Framework Data Modeling for Geo-infrastructure

Among ISP contents,. framework modeling is to model core elements among various types of geo-based data sets, in the conceptual level and logical level. In this case, geo-based data sets contain 'ready-made' digital geologic map and other data sets mentioned above. Currently, many types of geo-science data sets are under digitally recording, in Korea; therefore, framework modeling is one of important tasks for consistency and integrity between relevant data sets.

For example, in case of geo-chemistry map data, complied and processed from field measurements, and exploration geological map sets, some cartographic elements is commonly used, and then it is also necessary to frame-model digital processing or database building concerned storage and retrieval of these kinds of data.

Actually, framework model plays a role as guideline for common-components among multiple data, but data modeling for each data set may be also performed. In this program, both aspects are considered and researched: framework modeling followed by basic data modeling for digital cartographic processing of tens of geo-sciences data sets. While, this modeling is performing by using UML (Unified Modeling Language), supported by OMG (Object Management Group). The reasons of UML adoption in this program are as follows: Consideration of Inter-operability towards Open GIS by OGC (Open GIS Consortium, Inc) (Buehler and McKee, 1998), and Taking advantage standard symbolic notations among many kinds of data and 4+1 view of UML (OMG, 1997; ETRI, 1999). Therefore, this framework modeling is being carried out in OOAD (Object-oriented Analysis and Design), such as second approach in Figure 2.

Moreover, Fig. 2 represents relationship between ISP and data modeling, and further application development.

First, UML package diagrams mean modeling target, composed of geoscientific thematic map sets such as Table 1.

Figs 2 and 3 show actual UML class diagrams for geo-chemical data set and hydrogeologic map set within KIGAM. However, this version is currently not fixed ones, because needs modification in UML notations and iterations when physical modeling. Nevertheless, this kind of approach is first stage of whole geo-infrastructure process and provides a kind of modeling guide, as well as digital model of individual geo-thematic map sets, represented in Table 1. While, it is note that this draft model could not be regarded as full data model for database building, as but geo-framework model.

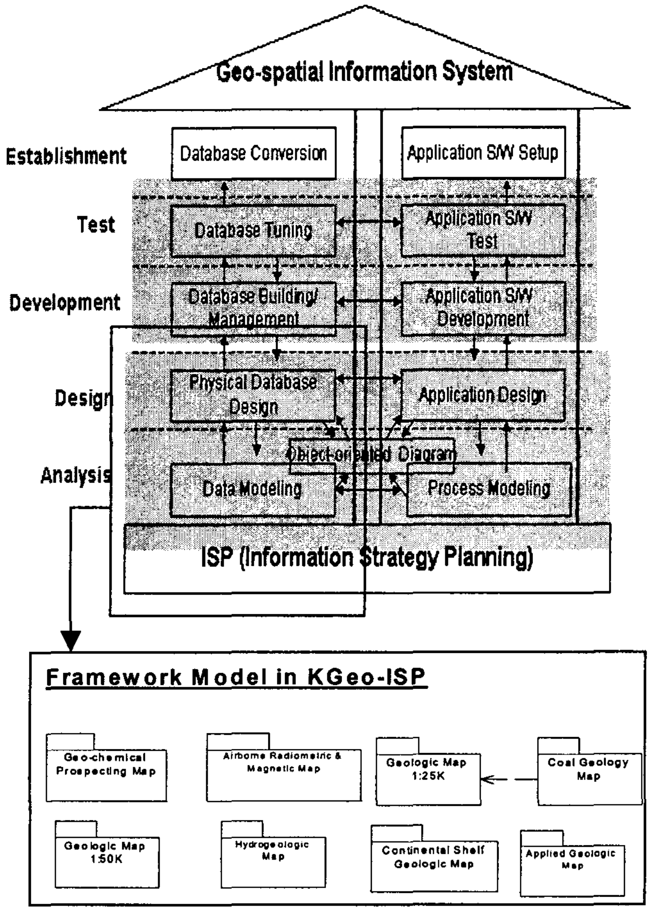

Fig. 2 ISP, Framework data modeling, and UML package diagrams.

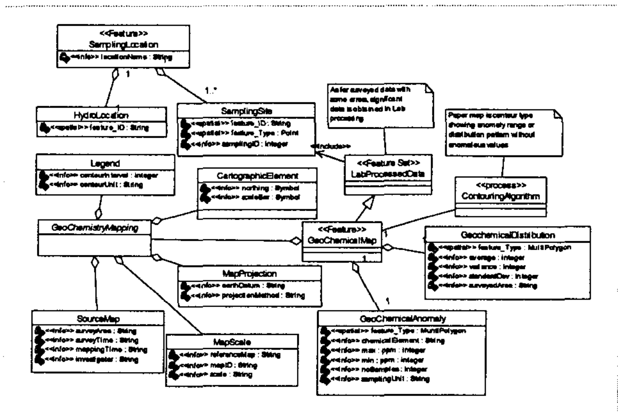

Fig. 3 ISP, Framework data modeling, and UML package diagrams.

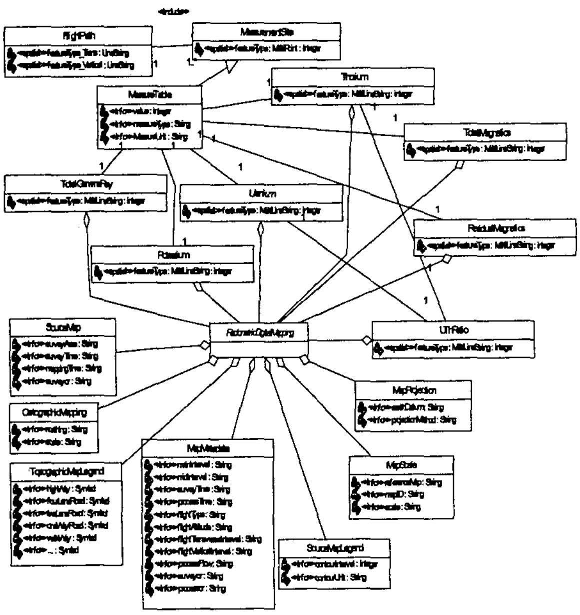

Fig. 4 ISP, Framework data modeling, and UML package diagrams.

6. Issues for Digital Geo-infrastructure

In this year, several points on progressing of this national program are to need considering: policy and technical aspects in ISP

As for policy aspects, the following issues are discussed. First, it is data ownership or copyright after users' re-creation using KIGAM digital data. Due to dual digital products of this program of public use and practical use, if one purchases digital data sets at nominal fee, it is possible to re-produce as other profitable thematic geo-data sets. Secondly, it is noted thay NGI(National Geographic Institutes)'s approval on by-product of 1:50K digital topographic map. Normally, geologic map also contains several layers, and it can be utilized as map of 1:50K. Thirdly, it is that data updating period or method. Unlike paper map, digital map data is subject to update or modify on request. Furthermore, most digital data sets can be used to other base digital data, so that inconsistent problems between multiple data sets at the same extents sometimes happens. Lastly, for geologists as application user, it is noted that it is needed GIS skill training program to handle GIS-typed digital data. As mentioned before, most digital data for practical user is GIS-typed data, and GIS tools are needed to data users. However, all geologists are not GIS users.

As for technical aspects in ISP, the following issues are also considered. First, there is database server managing: central host or guided node. Currently, digital geologic map is manipulated by file-based system, and digital data can be delivered as GIS-format files. However, many kinds of data to be digitally processed in geo-infrastructure in this program is built in database server. Therefore, technical strategy for database managing and maintaining is necessary. Database information can be used to further spatial query request. Second, it is noted that semantic and symbolic consistency on edge matching. Direct conversion of paper map to digital data is generally tile-based system. In this case, on edge between adjacent map sets, inconsistent problems happen. Because geo-science data is based on field measurements, detailed investigation and field survey are need, beyond this national program. Third, there are accuracy problem or quality control on spatial features and attribute. For practical user, integrity of spatial features and database attribute is need, for further their research. However, this problem happens sometimes data acquisition process in field rather than analog-to-digital process or framework data modeling. Therefore, metadata is included in this data searching system. Finally, national standards for digital data exchange, contents, symbol and are needed.

In GIS, there are several types of standards: Data classification standard, data content standard, data symbolic standard, transfer standard, usability or interoperability standard. Standards of Geo-science data should be covered all these aspects, not one or two standards. Therefore, this program is long-term program, supported by government.

These are pending issues for digital geological infrastructure building in short/intermediate/long-term.

7. Concluding Remark

During this year, the two core units of ISP and framework modeling are mainly studied; according to these results, actual database building is performed. While, this program is extended to national geo-data standardization, at the second stage.

At the current stage in this program of Korean Digital Geologic Infrastructure Building, ISP is somewhat progressing task, whereas drafting of framework data model is performed. This task is closely related to national/organizational standardization, including symbol, classification, data model. After ISP, each mappable geo-based data is digitally processed, and generated digital data with database building in Korea.

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