경영정보학연구
제8권 제2호
1998년 9월

# Design of Environmental Information Systems Architecture Based on the Internet****

## : The Building of a Database for Environmental Factors and GIS

Suh, Eui-Ho*, Lee, Dae-Ho**, Yu, Sung-Ho***

# 인터넷 환경에 기반한 환경정보시스템 아키텍처 설계

## : 환경요인을 Database 구축과 이를 이용한 GIS 구축

서의호, 이대호, 유성호

As the management and preservation of the environment become an important social issue, information required to support environmental task is required. So, there is an increasing demand for environmental information and appropriate systems to manage it. The vast volume of environmental data is distributed in different knowledge domains and systems. Environmental data objects have the complex structure containing environmental quality data and attribute data. Environmental information systems must be able to address these properties. This research has aimed at constructing well-defined schema design of environmental data, and making system architecture that environmental data kept by authorities should be made available to the public user.

There are 3 major components in environmental information systems architecture : User interface, Catalog libraries, Communication Provider. Web browsers provide consistent and intuitive user interfaces on Internet. The communication provider is a collection of diverse CGI functions. The main roles of the CGIs are to build interfaces between the Web, databases. Catalog libraries is libraries of various matadata including administration matadata. Administration matadata support the environmental administration and the managerial aspects of environmental data rather than explain a database itself or its properties.

---

* Associate Professor at Pohang University of Science and Technology

** Graduate Student at Pohang University of Science and Technology

*** Graduate Student at Korea Advanced Institute of Science and Technology

**** Acknowledgement: The authors wish to acknowledge the financial support of the Korea Research Foundation made in the program year of 1997.

# I. Introduction

## 1.1 Motivation

The preservation and management of the environment has become an important public issue throughout the world. Governments are concerned about their environmental resources such as river, soil, seawater and so forth. In addition, they are establishing environmental policies to control their consumption and to manage overall environment-related tasks. Companies must report on the environmental impact of their products and activities [O. Gunter and A. Voisard, 1997]. Citizens begin to recognize their rights to access the environmental information available [James Frew and Jeff Dozier, 1997].

Environmental planning and management require a broad range of data such as the natural, social and cultural environment [Yukio OHNISHI, Yukio KADA, 1992]. Therefore, environmental information systems have a wide range of data types such as textual and graphic documents, digital maps, real-time acquired observations, legacy databases of tabular historical records, scientific algorithms and multimedia components including audio and video [Kenn Gardels, 1997]. They also consist of a wide range of technology on data collection, data processing, data analysis and data presentation. The more important the use of environmental information systems that deal with a vast volume of environmental data becomes, the broader the application area of environmental information systems becomes.

From this point of view, the goals of environmental information systems are as diverse as their individual applications [Kenn Gardels, 1997]. This is one of the main reasons that make the overall development procedure difficult [David J. Abel et al., 1997; Gilles Clement et al., 1997; Ralf Kramer et al., 1997; Anthony Tomasic and Eric Simon, 1997]. So, we can conclude that environmental information systems must have the capability to deal with these diverse and heterogeneous characteristics of environmental information and related technology.

## 1.2. The Roles of Environmental Information Systems

Environmental information systems perform the systematic and integrated management of a variety of data for recognizing the current status of the environment correctly, identifying environmental problems, forecasting the future status of the environment, establishing environmental policies, monitoring environmental pollution, etc [Eun-Mi Kim, 1993]. The important roles of environmental information systems are as follows.

- Supporting and managing a vast amount of environmental data
- Establishing various environmental policies
- Satisfying citizens' right to access environmental information available and to be provided with them
- Analyzing and interpreting data for the coordination of interests between local communities.
- Encouraging the voluntary participation

of administrative offices and their citizens for maintaining the clean environment

The main focuses of this research will be on the first 3 roles. These roles enable environmental information systems to be used in the following tasks [Dept of Environment, 1996].

- Evaluation of environmental influences
- Environmental information systems consultation
- Evaluation of results of environmental policies
- Tasks of public relations
- The applications of legal regulations
- A census and a survey about various topics

## 1.3 Objectives

All issues discussed above emphasize that there is an increasing need to carry out research for efficient and effective environmental information systems and to develop technology that can be applied to them. Environmental data have huge, distributed and heterogeneous datasets and applications. In other words, there is an increasing demand for computerized systems to manipulate environmental data and to exchange information and also to combine information across the different system environment. However, because an environmental information system is a relatively recent scientific discipline, there is little consensus on how to make system planning and which components must be involved.

This research aims at suggesting a well-defined methodology for developing an efficient and effective environmental information system. To do this, a research is carried out to perform following 3 activities.

**Three Objectives :**

- Investigate the characteristics of environmental data: To develop an information system, the characteristics of data processed by the system must be derived in advance. This activity enables a system developer to determine overall properties and functionality of the entire system.
- Define the components of environmental information systems and design the schema: At this stage, the detailed functionality of the systems can be defined to determine the configuration of environmental information systems. At first, considering the application domain of the system and characteristics of data derives system requirements. And then, the components that can satisfy system requirements are defined. They make up the entire system. Lastly, the structure of each component is determined: What technology can be employed at each component, How they can be applied to each domain-specific system. The main focus of this step will be on the structure of the metadata describing environmental information in detail.
- Suggest the architecture of environmental information systems based on the Web environment: At this stage, the relationships between system components defined above are presented. Based on the Internet environment, each component will be connected by mechanisms for the interoperability of environmental infor-

mation systems. Interoperability among distributed heterogeneous datasets and applications is a hot issue in the field of information system engineering. It must be provided in environmental information systems or geographical information systems architectures [David J. Abel et al, 1997; Grilles Clement et al, 1996; Steve Vinoski, 1997].

In short, this research proposes the architecture for environmental information systems that can address the characteristics of environmental information and applications as well as connect the well-defined system components logically and physically.

# Ⅱ. Research on Environmental Information

## 2.1 Past Research

Environmental information systems as a focus area of research are quite young. Much of the research literature has focused on application-level, technical approach to system architecture. While the implementation of computer systems on environmental data has been studied, there are few studies on effective design of representing environmental data.

Nowadays, several researchers and practitioners describe the design and implementation of environment information systems that address the problems that are caused by the characteristics of environmental data. Ralf Kramer et al. [1997], David J. Abel et al. [1997], and Oliver Gunter [1997] presented the environmental information systems architecture for the open computing environment. But there is little explanation for the effective representation of real world. It is important for environmental information systems to reflect the real world effectively and efficiently. So, this research has aimed at constructing well-defined schema design of environmental data, and making system architecture that environmental data kept by authorities should be made available to the public user.

## 2.2 The Characteristics of Environmental Data

Many researchers summarized the characteristics of environmental data by its volume, diversity, structure and data processing method. The detail characteristics will be explained. Effective environmental information systems must be designed and implemented to satisfy these properties and to solve problems that come from a viewpoint of data management.

### 1) The vast volume of data

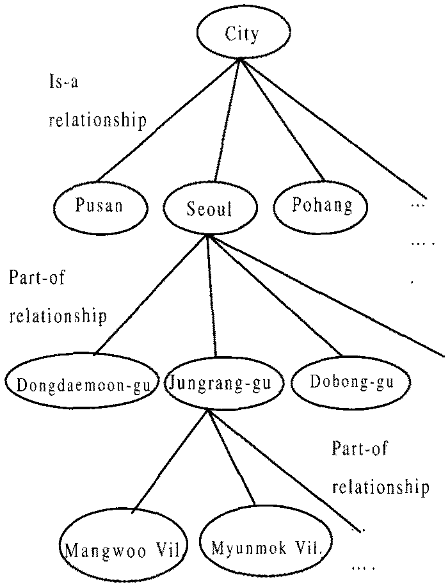
The volume of data to be processed by the system is unusually large. The Ministry of environment in Republic of Korea, for example, collects data monthly from about 2000 environment monitoring stations throughout the country. Moreover, the number of data items collected in monitoring stations is up to 2700 [Dept of Environment, 1996]. For the reason that environmental data have various types including integer, float, string and graphic, the total amount of data is in the several thousands megabyte range. The data sent from a satellite shows another example. In the case of meteorological observations, the amount of imagery records is in the terabyte range.

The total volume of environmental data varies with its scope and resolution, for environmental data is spatial information to express geographical and topological features [Stan Aronoff, 1989]. For example, when the precision of data is improved by replacing integer data with float data, the total volume of data increases several times. Also, the lower the scale of map data is, the larger the total amount of data on the same region is. In spite of its high cost, it happens frequently to collect environmental data with various scales and resolution.

### 2) The complex structure of environmental data objects

Environmental data consist of subobjects and contain the relationships between these subobjects. Environmental information has not only simple location data but also attribute data and topological data. These various data can be connected like a web. In addition, several objects can form one composite object by grouping them logically or spatially. These relationships can be divided into two types : 'Is-a relationship' and 'Part-of relationship'. <Figure 1> shows them. 'Seoul' is a city - 'Seoul' is an instance of 'City' - and 'Jungrang-gu' which consists of several villages is a part of 'Seoul'.

This structure means that the change of one object effects or invokes the changes of other objects. For example, when Youngil County is incorporated into Pohang City, regions in Youngil County discard attributes of Youngil County and inherit attributes of Pohang City. In this way, the clear and




<Figure 1> 2 types of relationship

accurate relationships among objects must be defined for the effective use of environmental data. Due to this property of environmental data, it takes a great effect on the efficiency of systems to determine how a database must be structured. The data model to represent complicated environmental data will be discussed in section 3. The structure of environmental data must be able to help a user understand the contents of data and reduce the data storage and access time.

### 3) Heterogeneity of data

Environmental data is collected, processed and stored on a variety of systems in diverse institutions or agencies. Hence, the environmental information management has inevitably a distributed environment. Data storages are so widely scattered geographically that related systems or applications are extraordinarily distributed. This trend would be accelerated [National Research Council, 1995]. Because all environmental systems or applications do not have the exactly same hardware or software platforms, information required to perform environmental works is found in different knowledge domains and data formats [David J. Abel et al., 1997; Grilles Clement et al., 1997; K. Greve and H. McGilton, 1994; Ralf Kramer et al., 1997].

A distributed system environment implies that the data management and applications are extremely heterogeneous. For example, the Ministry of Environment in Korea has large computer networks made up of mainframes, workstations and PC systems running various operating systems such as UNIX, MS Windows, IBM OS/2, etc. Moreover, they may be connected in diverse networks by various network protocols.

Vinoski [1997] identified several factors for computing systems being heterogeneous.

- Cost : Vendors and customers want the 'best systems' at the 'lowest cost'. Many customers tend to buy the systems that best satisfy their requirements at the most reasonable prices, regardless of brand name loyalty.
- Legacy systems : Replacing legacy systems with a new one is often too expensive. If the replacing cost is too high or legacy systems must be operated continuously, they might be improved or updated instead of being replaced.
- Engineering tradeoff : In most cases, there are several acceptable solutions to an engineering problem. As a result, different people across a discipline may select a different solution to the same or similar problems.

### 4) Spatio-temporal data

As explained in section 2.1.2), environmental data is a group of objects containing locations, attributes and topology. In general, they may change over time because they are usually collected or updated periodically. A location is the basis of other data. A location data expresses the geographical position - latitude, longitude and administrative address - where data is collected. Also, it can be a site where data is processed or stored. Many attribute data are attached to location data. They may be data collected at that place or a general description of that place. These data items constitute one object. For example, Youngil, one of monitoring stations where the water quality data of Hyuongsan River is collected, consists of its location, details about that region and measured water quality data such as temperature, pH, DO, etc.

The fact that environmental data is spatial implies that a data object must be able to be referenced by other objects spatially or logically [Henry F. Korth and Abraham Silberschatz, 1991]. For example, contents of an object, 'Youngil', are important not only as itself but also as a member of its high level object, 'Pohang' or a neighborhood of other objects. To gather overall information of 'Pohang', there may be a need for data of its subobjects. When environmental influences of 'Youngil' are evaluated, there must be information on neighborhoods such as 'Wolsong' or 'Saengji'. That is to say, the environmental status of 'Youngil' may be influenced by that of 'Wolsong'. The example of this spatial query will be explained in section 3. To do this, this research will define the clear relationships between environmental information and their metadata, which will be defined, by designing their data structures.

### 2.2 Geographic Information Systems for Environmental Data

Essential components of any environmental information system are geographical data and geomatic technology. Geographic information system is a branch of computer mapping systems dealing with data on something, which take a position in geographical space. Computer mapping systems create, represent, process and store geometrical objects and non-geometrical objects in appropriate data formats [Eun-Mi Kim, 1993]. Detailed explanation of GIS functions is omitted because they are out of research scope. Geographic information systems were initiated to use data on the management of administrative regions with the development of computer systems.

Nowadays, great interest is given to these systems because they can help establish policies to solve many social and environmental problems: a gap of the industrialization and urbanization among regions, an explosive increase of population, the traffic congestion, environmental pollution and utilization of land [Kyewha, Kang, 1990].

Geographic information systems are concerned with geographical data referenced by spatial or geographical coordinates and non-geographical data associated with geographical data. Any data having a property of spatial distribution is a geographical data [Digital Geographic Information Systems Working Group, 1995]. To be a complete geographical data, attribute data must be defined along with spatial data. Spatial data is about locations of various geographical features and relative spatial relationships between objects. Spatial information are marked by points, links and polygons on a map [F. G. Fegeas et al., 1992]. Attribute data is about properties of objects specified by spatial data.

In our research, for example, when a geographical object marked by a point on a map is a water quality monitoring station, a pair of longitude and latitude coordinates is transformed into spatial data. Attribute data contains a name of the monitoring station, a purpose of that land and various values measured to evaluate the water quality such as BOD, DO, etc.

## Ⅲ. Schema Design

In this section, we will define our research domain and suggest the schema to meet the characteristics of environmental data above mentioned.

### 3.1 Data Collection

Tomasic and Simon mentioned problems of collecting environmental data [Anthony Tomasic and Eric Simon, 1997]:

- Lack of data: Data do not exist or are often insufficient

- Hard to access: Data is private, expensive or complex.
- Hard to use: Accessed data are non-compatible or inconsistent.
- Domain specific data: Data is referenced by domain specific criteria.

To overcome above problems and meet system requirements, it is necessary to carry out researches on the network environments and database disciplines.

The target data of environmental information systems are all data related to the environment. These data can be classified into the following 4 categories according to their contents and purposes. This research concerns mainly with first 2 data, i.e., environmental quality data and regional data.

- Data on the environmental quality of regions
- Data on the properties of local communities
- Data on citizens' interests in the environment
- Results of literature review

To prevent environmental pollution and maintain the clean environment over a long time, it is essential understanding the current status of utilization of environmental resources such as the soil, the water, the air, etc. Environmental quality data of regions are about these resources. They can be classified into 3 groups: data on occurrence of environmental pollution, data on monitoring the status of the environment and data on environmental effects. <Table 1> shows detailed data items of environmental monitoring.

## 3.2 Research domain

To explain the results of this research with plentiful examples, the domain of environmental information systems must be specified.

<Table 1> Environmental monitoring

| Targets | Data items |
|---|---|
| The origin of pollution | • Distribution of sources of pollution<br>• Discharge types of pollutants<br>• Volume of pollutants discharged<br>• Application of regulations |
| Environmental quality | • The status of environmental pollution<br>• The spatial distribution of pollutants<br>• The movement of pollutants over a times<br>• The satisfaction of environmental standards |
| Effects | • Effects on human beings<br>• Effects on animals and plants<br>• Relationship between other pollutants or environmental factors |

The target system of this research, named PEIS (POSMIS Environmental Information Systems, constructed by using Oracle & UniSQL DB), concerns about the air quality data, the water quality data and data of monitoring networks which consist of many monitoring stations where various data is collected. To the art of simplicity, monitoring networks are restricted to Seoul and Pohang. i.e. the air quality data is collected in the monitoring network of Seoul and the water quality data is collected in the monitoring network of Pohang. This specific domain can be generalized because other monitoring networks have similar structures.

The air qu ality data consists of the measured concentrations of Sulfur dioxide (SO2), Total suspended particulates(TPS), Carbon monoxide(CO), Nitrogen dioxide(NO2) and

Oxidant(O3). The water quality data consists of the observations of Temperature, pH, Dissolved oxygen(DO), Biochemical oxygen demand(BOD), Chemical oxygen demand(COD), Suspension substance(SS), Colitis germs(E_COLI) and specified hazardous materials such as Cd, CN, Pb, Hg, As, etc.

Data on monitoring networks contains the detailed description of monitoring stations. Each monitoring station can have a location, an administrative office, and the usage of that land and so forth. These attribute data will be treated as metadata enabling the above quality data to be referenced. Metadata is one of most important components of environmental information systems [David J. Abel et al., 1997; Kenn Gardels, 1997; Ralf Kramer et al., 1997; Anthony Tomasic and Eric Simon, 1997]. There must be mechanisms for connecting various quality data required to answer environmental questions and monitoring networks data treated as metadata to support them.

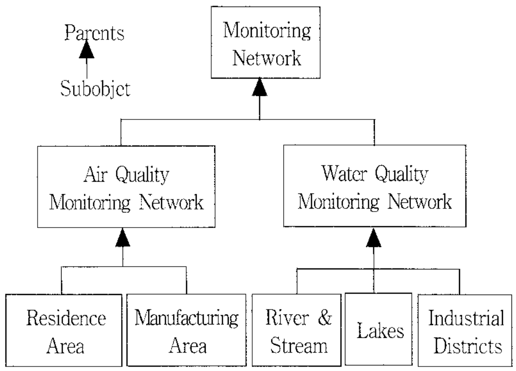
This research will suggest the data structure to determine the schema of each data for a database and to define the relationships between the above two kinds of data. In addition, there may be imagery data on a region and the contextual data on the environmental legislation or regulations.

## 3.3 Data Structure

### 1) Data model

There are 2 kinds of data models that are most preferred when constructing a database : relational data model and object-oriented data model [Stan Aronoff, 1989; R. Williamston and J. Strucky, 1991]. A data model takes a great effect on the efficiency and the capability of systems. Therefore, it is very important to determine which data model is appropriate. Selected data model must be able to address the properties of environmental data and to solve problems arising from them.

As explained in section 2, environmental data consist of spatial data and non-spatial data. Both 2 types of data explain one environmental fact, i.e. one data object. One object may consist of several subobjects and contain the relationships between them. This hierarchical structure of objects is the most conspicuous feature of environmental data. The hierarchy of objects is shown in <Figure 2>. Rectangles and arrows represent objects and 'part-of' relationships respectively.




<Figure 2> The hierarchical structure

The above example is a part of PEIS schema. 'Monitoring Network' consists of 2 subobjects : 'Air Quality Monitoring Network' and 'Water Quality Monitoring Network'. Each subobject also contains subobjects as shown in <Figure 2>. Subobjects can inherit attributes of their parents. For example, 'Residence Area' has not only its own attributes but also attributes of 'Air Quality Monitoring Network'.

When considering the properties and structure of environmental data explained in section 2.1.2), an object-oriented data model can be thought of a reasonable approach to environmental information systems. The object-oriented data model has the following advantages over the relational data model in expressing the hierarchical structure [O. Gunter and A. Voisard, 1997; N. Yasuaki and A. Shigeru, 1993].

- Easy to represent the hierarchical structure : The object-oriented data model represents the hierarchy very well because it is able to implement the linkage between objects easily
- Easy to understand: People tend to regard a variety of things having common properties as one object. Thus, objects in the object-oriented data model coincide with users' concepts about the real world
- Flexible and extensible: The relationships between objects can be easily changed and extended by altering linkages or creating a new object. Updating, inserting or deleting data of objects is also easy because the object-oriented data model has various methods about database transactions and each object exchanges messages about them with others

### 2) Administration Metadata

To obtain environmental data required to answer environmental questions, a user must know *where* and *how* to find it [Ralf Kramer et al., 1997]. In addition, obtained data must be validated whether they are suitable for a particular problem or not. To do this, there is a need for additional data that are describing data, i.e. Metadata. Metadata used in many database areas have similar goals: the efficient data access, the correct data interpretation and the effective data integration [O. Gunter and A. Voisard, 1997]. This research defines Administration Metadata to satisfy 3 fundamental requirements:

- Its operations must be based on WWW communication because the architecture of this research is based on the Internet.
- Metadata itself should be able to express environmental facts: Detailed description of environmental data may be also another environmental data.
- Its data model must be compatible with that of environmental data: In this research, metadata and data are incorporated into the same data model.

The main concerns of environmental information systems are related with data on all kinds of environmental resources: the air, the water, the soil, etc. These values in data sources are arranged by the site where they were collected or stored in the system of each sampling site. Hence, it can be said that data on the monitoring network play a role of metadata for environmental quality data. Because monitoring network data are a description of regions where environmental quality data are collected, its usage focuses on supporting environmental administration rather than explaining a database itself or its properties. So, it is named as administration metadata.

Now, let us examine the relationship between administration metadata and environmental data with examples of PEIS. PEIS has a data model for various kinds of water quality measurements in Pohang. For example, this is simple predicate in PEIS:

Item(Year, Month, Mean, Min, Max,
    Monitoring_station)
BOD(1997, 1, 3.0, 2.3, 3.1, Youngil)

This predicate explains one environmental fact, BOD values measured on 1997. 1 at Youngil. It has following structure. All variables in this structure were defined in advance. There may be another predicate and its structure.

Youngil(Pohang, 2, Hyungsan, Kyungbuk,
    residence, Taegu)
Monitoring_station(Monitoring_network,
Class, River, Address, land_type, Admin_ office)

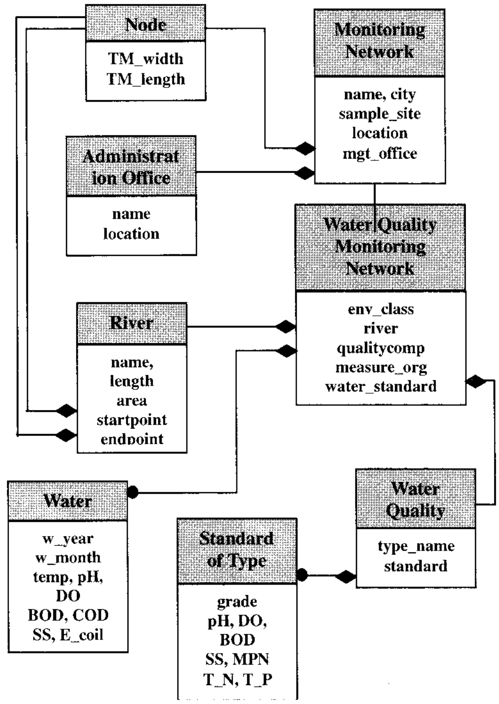
This explains another environmental fact that Youngil in residence area of Kyungbuk is a member of Pohang monitoring network and managed by Taegu Environment Administration Office. Therefore, this second data is administration metadata of the first one.

River(year, month, Water_type, Rainfall, In_flow, Missed_flow, Life_water, Factory_water)

The data of variables in River are used in the management of a river.

The relationship between administration metadata and environmental data can be defined in this way. The variables of an object, environmental data, can be connected with its administration metadata by having other class as data type. The part of schema in PEIS is shown in <Figure 3>. In the case of PEIS, all data is organized around the Monitoring Network. Therefore, they are referenced by data in Monitoring Network. <Figure 4> is the overall schema of PEIS.

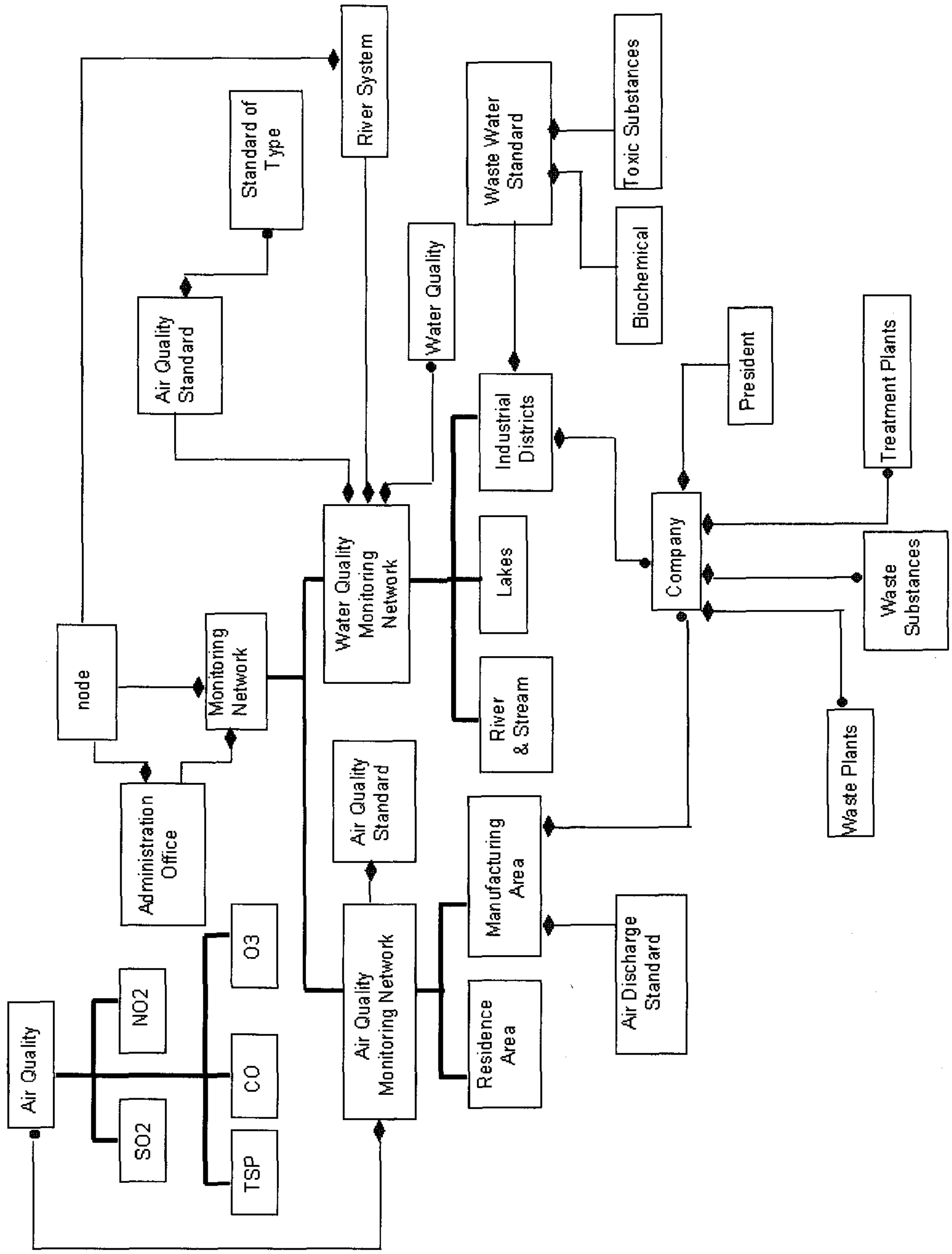
### 3.3 Data access and retrieval with Geographic properties




<Figure 3> OMT notation of Schema about water quality

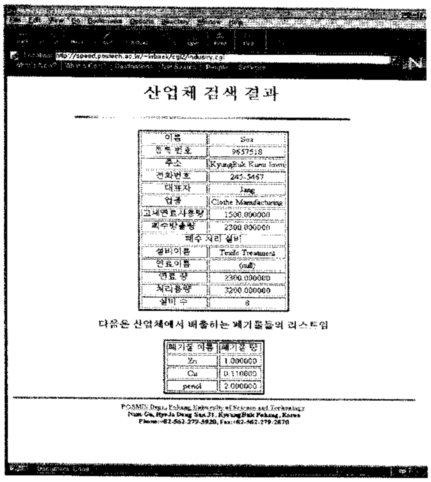
Various commands or points on a map, imagery data, are translated into structured query languages automatically and various CGIs execute them. <Figure 5> is a result of querying another administration metadata on a company in the industrial complex of Pohang. Like this examples, a user can perform various database queries for environmental data and administration metadata.

Coordinates of the pointed feature on imagery data are transformed into standardized coordinates, TM coordinates, through the coordinates translation mechanism. Also, user can insert or retrieve another data spatially via this TM coordinates. Administration metadata of a region having TM coordinates

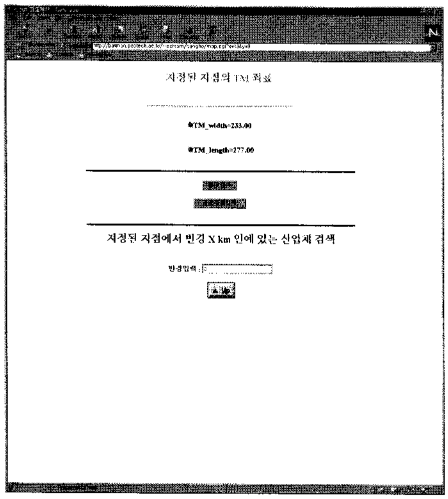



<Figure 4> Overall schema

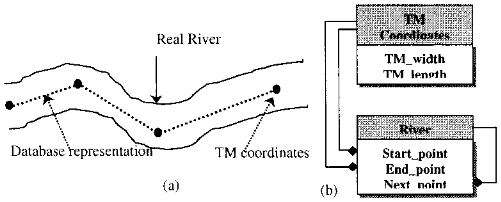
in <Figure 6> can be retrieved. It is the result of the query to find out companies influenced by the pointed feature in the downstream. Coordinates of that region are compared them of 'River' which are represented as collection of links like dashed lines of <Figure 7> is its database schema. And then, companies in the downstream are found by calculating the distance between each company and a river.




<Figure 5> The result of querying of another administration metadata



<Figure 6> Result of the query on a map

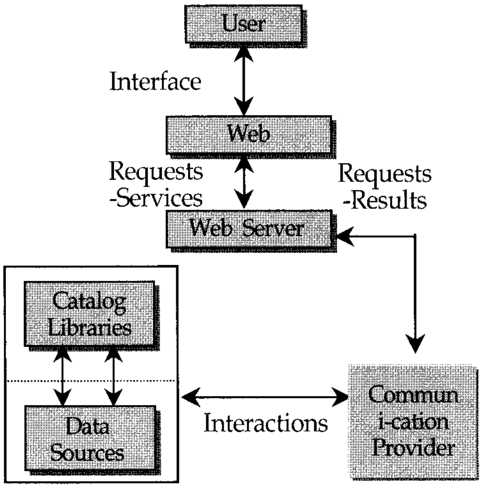



<Figure 7> Representation of 'River'

# Ⅳ. System Architecture

## 4.1 The Architecture of Environmental Information Systems

<Figure 8> is the overall system architecture that all system components are incorporated into. Details will be explained in the next section.



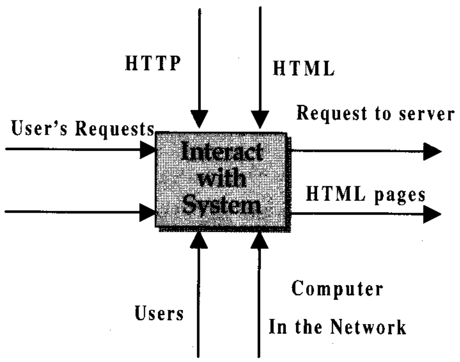

<Figure 8> The overall system architecture

## 4.2 System Components

In this section, each component of environmental information systems in <Figure 9> is defined and its functionality is modeled by using IDEF 0, *Integration DEFinition* 0. The functions of each component must be able to satisfy system requirements described in section 3. The prototype of this research, PEIS, would be one kind of data sources that contain catalog libraries and user interface.

### 1) Web browsers

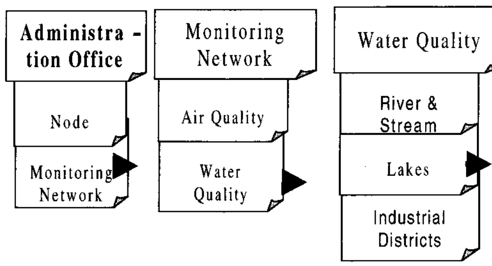
The Web browsers are the user interface of the system. The interaction between a user and a system take place on the user interface. The user can enter keywords, commands or queries into systems to search for environmental data or launch diverse applications through the user interface.




<Figure 9> Functional Model of the User interface

### 2) Catalog libraries

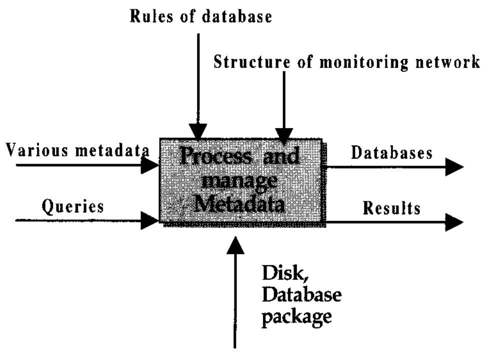
In general, metadata contains various indices for searching, data dictionaries and descriptions of the database itself such as vendors, data formats, etc. This research leaves details about them on further studies. Catalog libraries is libraries of various metadata including administration metadata defined by this research. Catalog libraries also provides users with easy access of environmental information. Minder Chen proposed IOIS (Integrated Organization and Information System) model for the efficient access of information [Minder Chen, 1995]. IOIS model consists of various meta-mata-model, meta-model. Users can access the information by menu-driven user interface [Minder Chen, 1995]. The relationship between menus is derived from the DB schema.



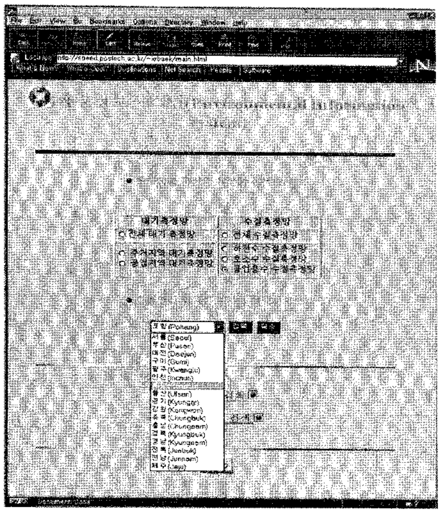

<Figure 10> Menu-driven User interface

Menu-driven user interface enables users to access target information easily and users can come by needed information in spite of not knowing the location of information. This research made catalog libraries on the basis of meta-model which is one of the IOIS model

The main functions of this component are directory services for the monitoring network. <Figure 11> is a functional model of Catalog libraries. <Figure 12> is an example of the directory service of PEIS.




<Figure 11> Functional model of Catalog libraries



<Figure 12> Directory service of PEIS

### 3) Communication provider

The communication provider is the collection of diverse CGI functions. As explained in section 3, the CGI is a part of the user interface. The main roles of the CGIs are the connection among the Web, databases. The CGI makes it possible to process dynamic users' requests by embedding the HTML in other programming languages such as C. The diverse CGIs are programmed according to various purposes. Moreover, the problem of complex database interactions across the network can be solved by other techniques such as Java, JavaScript, etc. They build the various interfaces according to their own functions.

## V. Conclusion

As the concern about the preservation and management of the environment has increased drastically, much research are being carried out to develop the methodologies and technologies that can handle the environmental threats. As a result, there is an increasing demand for environmental information and appropriate systems, *Environmental Information Systems,* to manage it.

This research is carried out to design the architecture of the effective and efficient environmental information systems based on Internet. To do this, the characteristics of environmental information are investigated and each component of environmental information systems is defined to satisfy systems requirements. Lastly, this research suggests an architecture for environmental information systems based on the Web environment.

From the data management of view, the scope and diversity of environmental· information systems have something to do with the characteristics of environmental data. The volume of data is very large. Data and applications are extremely distributed and heterogeneous. Data objects containing environmental data and non-environmental data have very complex structures. Main focus of this research is on the model of data structure.

The architecture of environmental information systems proposed by this research has 3 major components: User Interface, Catalog Libraries. They operate and interact with others on the Internet. Information systems based on the Internet are easy to implement and to use. They enable a user to save his or her time and cost. Because Internet is an open system based on standards, it enables the communication among diverse platforms.

The Web browsers are user interfaces of the systems. Web browsers provide consistent and intuitive methods for communication between users and systems on the Internet. Catalog libraries are libraries of various metadata including administration metadata defined by this research. Administration metadata focuses on supporting the environmental administration and the managerial aspects of environmental data rather than explaining a database itself or its properties. The communication provider is a collection of diverse CGI functions. The main roles of the CGIs are the connection between the Web, databases. They build the various interfaces according to their own functions.

In conclusion, this research proposes the standard schema of environmental information systems to represent environmental data efficiently and effectively. In PEIS, everyone can get the environmental information via WWW - the environmental regulation, water quality data, air quality data, the quality data which have violated the regulation and etc. And consequently, this will lead to the effort to observe and to improve environment.

# 〈REFERENCES〉


[1] Anthony Tomasic and Eric Simon, "Improving Access to Environmental Data using Context Information," *SIGMOD Record*, Vol. 26, No. 1, 1997.

[2] Council of the European Communities, *Council Directive of 7 June 1990 on the freedom of access to information on the environment*, 1990.

[3] Daniel J. Berlin, *CGI Programming Unleashed*, pp. 1-45, SAMS NET, 1997.

[4] David J. Abel et al., "Integrating Modeling Systems for Environmental Management Information Systems," *SIGMOD Record*, Vol. 26, No. 1, 1997.

[5] Dept of Environment, *The Annual Report on Environment Data*, Dept of Environment, 1996.

[6] Digital Geographic Information Systems Working Group, *Digital Geographic Information Exchange Standards*, http://132.156.33.161/engineer/DIGEST_1.2a, 1995.

[7] Eun-Mi Kim, *A Study on the EIS using GID*, Younsei Univ., 1993.

[8] F. G. Fegeas et al., "An Overview of FIPS 173, the Spatial Data Transfer Standard," *Cartography and Geographic Information Systems*, Vol. 19, No. 5, 1992.

[9] Gilles Clement et al., "OGDI : Toward Interoperability among Geospatial Databases," *SIGMOD Record*, Vol. 26, No. 3, 1997.

[10] Henry F. Korth and Abraham Silberschatz, *Database Systems Concepts*, McGraw Hill, 1991.

[11] J. Dangermond and C. Freedom, *The Conceptual System Design Process in Practice : The San Diego Regional Urban Information System Experience, Annual conference of the urban and regional information systems association*, 1986.

[12] James Frew and Jeff Dozier, "Data Management for Earth System Sciences," *SIGMOD Record*, Vol. 26, No. 1, 1997.

[13] K. Greve and H. McGilton, Metainformation in Umweltinformation Systems, *Information for Umweltschutz 8th symposium*, Hamburg, 1994.

[14] K.J. Dueker, Multipurpose Cadastre : Terms and Definitions, *ASCM-ASPRS annual convention*, Baltimore, Maryland, 1989

[15] Kenn Gardels, "Open GIS and On-Line Environmental Libraries," *SIGMOD Record*, Vol. 26, No. 1, 1997.

[16] Kottman Clifford, Geographical Information Communities, an *Object-Oriented Approach using Open GIS*, http://ogis.org/members/project, 1996.

[17] Kyewha, Kang, *Research on GIS*, Dong-kuk Univ., 1990.

[18] Lam Simon., *Achieving Geospatial Data Interoperability Through Data Warehousing*, DREV Report, 1996.

[19] Mellanie Hills, *Intranet Business Strategies*, pp. 17-42, Wiley, 1997.

[20] Minder Chen, "A Model-Driven Approach to Accessing Managerial Information : The Development of a Repository-Based Executive Information Systems," *Journal of Management Information Systems*, Spring 1995, Vol. 11.

[21] N. Yasuaki and A. shigeru, Interactive Graphics and Spatial Data Management for GIS Using the Hierarchical Data Structure, *Proc. Of the Far East Workshop on GIS*, Singapore, 1993.

[22] National Research Council, *A Review of the U.S. Global Change Research Program and NASA's Mission to Planet Earth/ Earth Observing System*, National Academy Press, 1995.

[23] O. Gunter and A. Voisard, *Metadata in Geographic and Environmental Data Management*, pp. 11-20, McGraw Hill, 1997.

[24] Oliver Gunter, "Environmental Information Systems," *SIGMOD Record*, Vol. 26, No. 1, 1997.

[25] R. Williamston and J. Strucky, *An Object-Oriented Geographical Information System*, p98-124, Prentice Hall, 1991.

[26] Ralf Kramer et al., "WWW-UDK : A Web-based Environmental Meta-Information System," *SIGMOD Record*, Vol. 26, No. 1, 1997.

[27] Stan Aronoff, *Geographic Information Systems : A Management Perspective*, pp. 21-67, WDL Publication, 1989.

[28] Steve Guengerich and Douglas Graham, *Building the Corporate Intranet*, p21-47, Wiley, 1997.

[29] Steve Vinoski, "CORBA : Integrating Diverse Applications Within Distributed Heterogeneous Environments," *IEEE Communications Magazine*, Vol. 14, No. 2, 1997.

[30] Won Kim, *Engineering Databases*, Springer-Veralag Berlin Heidelberg, 1990.

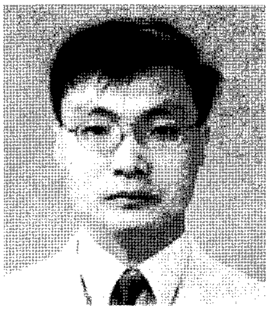
[31] Yukio OHNISHI, Yukiko KADA, *Computerized Information System Applied for Lake Biwa Water Environment Management*, Lake Biwa Research Institute, 1992.

◈ 이 논문은 1998년 5월 7일 접수하여 1차 수정을 거쳐 1998년 8월 10일 게재확정되었습니다.

# ◆ 저자소개 ◆

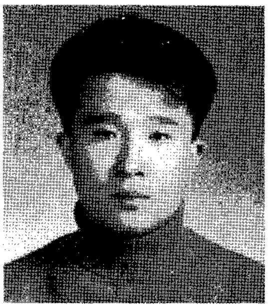
서 의 호 (Suh, Eui-Ho)

공동저자 서의호는 Stanford University(M.S., 1982), University of IIlinois (Ph.D, 1987)를 졸업하고 Oklahoma State University 조교수를 거처 1989년 이후 포항공대 산업공학과 교수로 재직 중이다. 현재 POSMIS Lab(정보전략경영연구실)을 운영하고 있으며 주요 관심 분야는 전략경영, 전략정보시스템(SIS), 경영혁신, 기술경영 등이다.



이 대 호 (Lee, Dae-Ho)

공동저자 이대호는 1997년에 포항공대 산업공학과를 졸업하고, 1997년부터 지금까지 포항공대 산업공학과에서 경영정보시스템(POSMIS Lab)을 전공하고 있다. 주요 관심 분야는 지식관리시스템(KMS), 전사적자원관리(ERP), 지리정보시스템(GIS) 등이다.



유 성 호 (Yu, Sung-Ho)

공동저자 유성호는 1996년에 포항공대 산업공학과를 졸업하고, 1998년 포항공대 산업공학과 경영정보시스템(POSMIS Lab)을 전공하고, 1998년 현재 한국과학기술원 경영공학(MOFIS Lab) 박사과정에 있다. 주요 관심 분야는 지식모델링, 지식관리시스템(KMS) 설계 등이다.