CONCEPTUAL DATA MODELING OF THE INTEGRATED DATABASE FOR THE RADIOACTIVE WASTE MANAGEMENT

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ABSTRACT

A study of a database system that can manage radioactive waste collectively on a network has been carried out. A conceptual data modeling that is based on the theory of information engineering (IE), which is the first step of the whole database development, has been studied to manage effectively information and data related to radioactive waste. In order to establish the scope of the database, user requirements and system configuration for radioactive waste management were analyzed. The major information extracted from user requirements are solid waste, liquid waste, gaseous waste, and waste related to spent fuel.
The radioactive waste management system is planning to share information with associated companies.

INTRODUCTION

A Waste Comprehensive Internet Database system (WACID) is being developed to support the routine reporting of status and trends in spent fuel and radioactive waste information based on quantitative data and to integrate information of nuclear agencies domestically via the internet. A Radioactive Waste Management Integration System (RAWMIS) is being constructed to manage the information of radioactive waste in the Korea Atomic Energy Research Institute (KAERI) and to support WACID. Conceptual data modeling has been carried out to maximize data sharing, minimize data redundancy, and to make a positive impact on the effectiveness based on the theory of information engineering. In order to analyze user requirements, we have reviewed many reports and materials and interviewed experts. The major information extracted from user requirements are solid waste, liquid waste, gaseous waste, and waste related to spent fuel. This paper explains mainly the solid and liquid radioactive waste aspects. The waste classification scheme used is based on both qualitative criteria (wastes are grouped according to their origin, activity content, radiotoxicity) and quantitative criteria (wastes are grouped according to the safety aspects of their management).
The software and hardware that is needed in the operation of the database system was reviewed. The Database Management System (DBMS) is divided into Relational DBMS, Object-Oriented DBMS, and Object-Relational DBMS. Relational DBMS that has an outstanding capability to manage structured large amounts data was selected. We are planning to operate both web systems in relation to reporting and a client/server system for the radioactive waste management information. A RAWMIS system will be a great contribution to the radioactive waste policy that is promoted by MOST (Ministry Of

Science Technology). We are going to expand other information that includes waste of the Korean Research Reactor 1&2 (KRR 1&2) and waste in relation to spent fuel.

USER REQUIREMENTS

Plenty of methods are discussed in the literature regarding requirement determination of users. Most of them are business oriented and related to the overall process in the organization starting from the mission and ending with the final outcome. The general method is based on 1) reviews of current reports, 2) conducting research that is already done, and 3) visiting similar system installations. Foundations of the individual method are interviews, observations, questionnaires, and prototype systems [1].

Radioactive waste arising from KAERI is very small in quantity, and has diverse characteristics. For this reason, it has been difficult to analyze the radioactivity of the solid radioactive waste and α, β nuclide included in liquid radioactive waste due to a lack of funds. To solve this dilemma, we must focus on the establishment of a database system that can classify systematically the radionuclide and activity concentration included in solid and liquid radioactive wastes. For instance, asphalt solidification needs to be included in a system that can assess all the nuclides collected during an operation.

The management process of radioactive waste in KAERI is shown in Figure 1.
According to the methods of user requirements, a diversity report in relation to radioactive waste was collected and reviewed, also interviews with expert groups such as radioactive waste managers, radiation safety managers, and radioactive waste supervisors were carried out. The following are the principle contents that were extracted from user requirements:

- Radioactive waste consists of small packages and is managed in containers
- Radioactive waste managed by a small package may contain various nuclide and contents
- A stored container has to be measured by repackage and relocation
- Changed container information should be able to track
- A record of the changed information should be kept as a history
- A container can be reused after removing its ID
- Radionuclide, contents, and radioactivity concentration in container must be measured
- The standardization for compatibility with WACID system will be observed

Characterization and classification of a radioactive waste

The waste classification scheme in KAERI is based on qualitative criteria (wastes are grouped according to their origin, activity content, radiotoxicity) and quantitative criteria (wastes are grouped according to the safety aspects of their management). The quantitative classification of waste according to Low and Intermediate Level Waste: Short-Lived (LILW-SL), Low and Intermediate Level Waste: Long-Lived (LILW-LL), High Level Waste (HLW), Spent Fuel(SF), and Decommissioning Waste(DW) class is based on "Classification of Radioactive Waste"[2].
According to its form and component of radioactive waste, solid waste has combustibility,

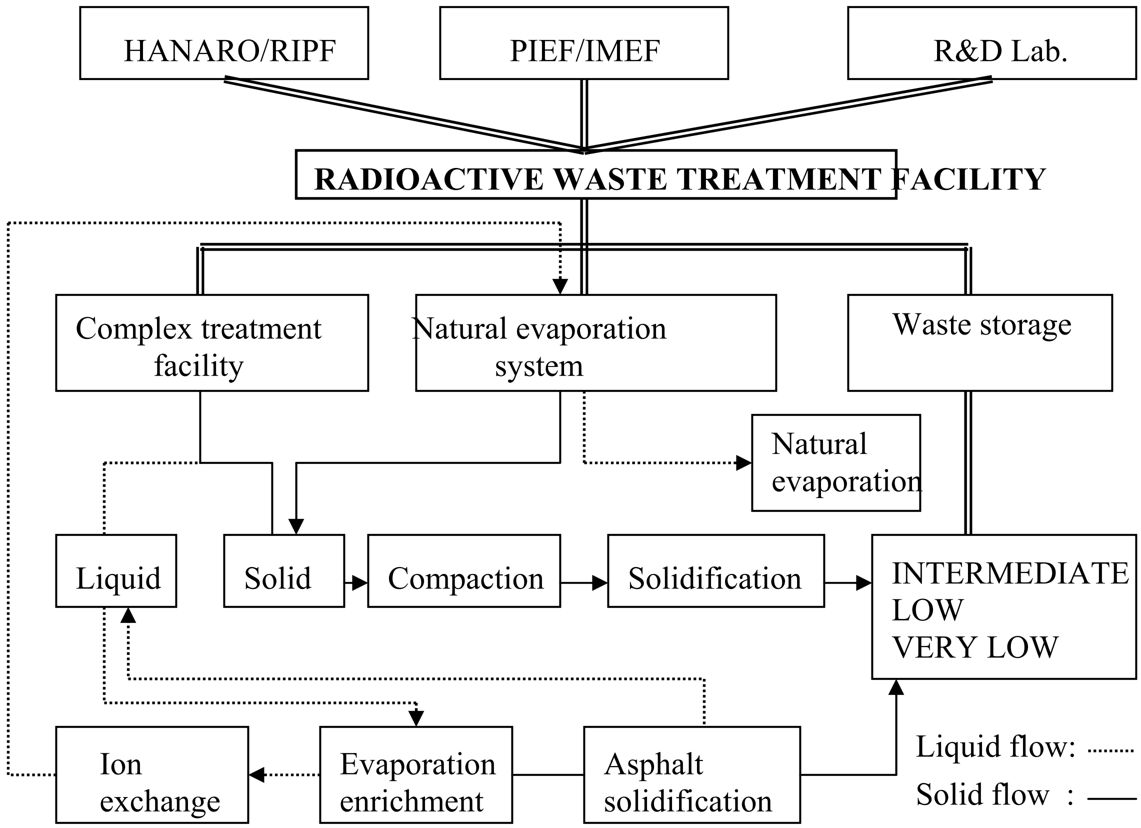

Figure 1: Management process of a radioactive waste in KAERI

incombustibility, compressibility, incompressibility, spent resin, spent filter, and spent source. Liquid waste is divided into an organic solution, inorganic solution, and corrosiveness. And also, a half-life of radionuclide is classified into short lived (less than 30yr) and long lived. The contents of the radioactive waste management rules that are applied in KAERI are described in Table 1.

Management of a liquid radioactive waste

Liquid radioactive waste is generated from High-flux Advanced Neutron Application Reactor (HANARO), Instrument Materials Experimental Facility (IMEF), Radionuclide Isotope Production Facility(RIPF), Post Irradiation Examination Facility (PIEF), and R&D laboratory at KAERI site. Liquid waste consists of low-and intermediate and very low level classifications. Very low level waste is processed at the natural evaporation facility. The disposal treatment of liquid waste is shown in Figure 2. The distribution of a major nuclide included in liquid waste is shown in Table 2.

Table 1. Radioactive waste classification scheme(in KAERI)

Level	Radioactivity Concentration of Liquid Waste A(kBq/cm^3)	Surface Dose rate of a Solid Waste D(mSv/h)			
VL	A < 1.85×10 □	—			
LL	1.85×10 □≤ A < 3.7	D < 2			
ML	3.7 ≤ A < 3.7×10²	2≤ D < 20			
HL	3.7×10²≤ A	20 ≤ D			
α	-	α-Activity(kBq/□)			
O	organic liquid waste	C	combustible solid waste	SR	spent resins
A	inorganic liquid waste			SF	spent filter
		IC		L	laundry waste
				SS	spent source
		NC	non-combustible solid waste		

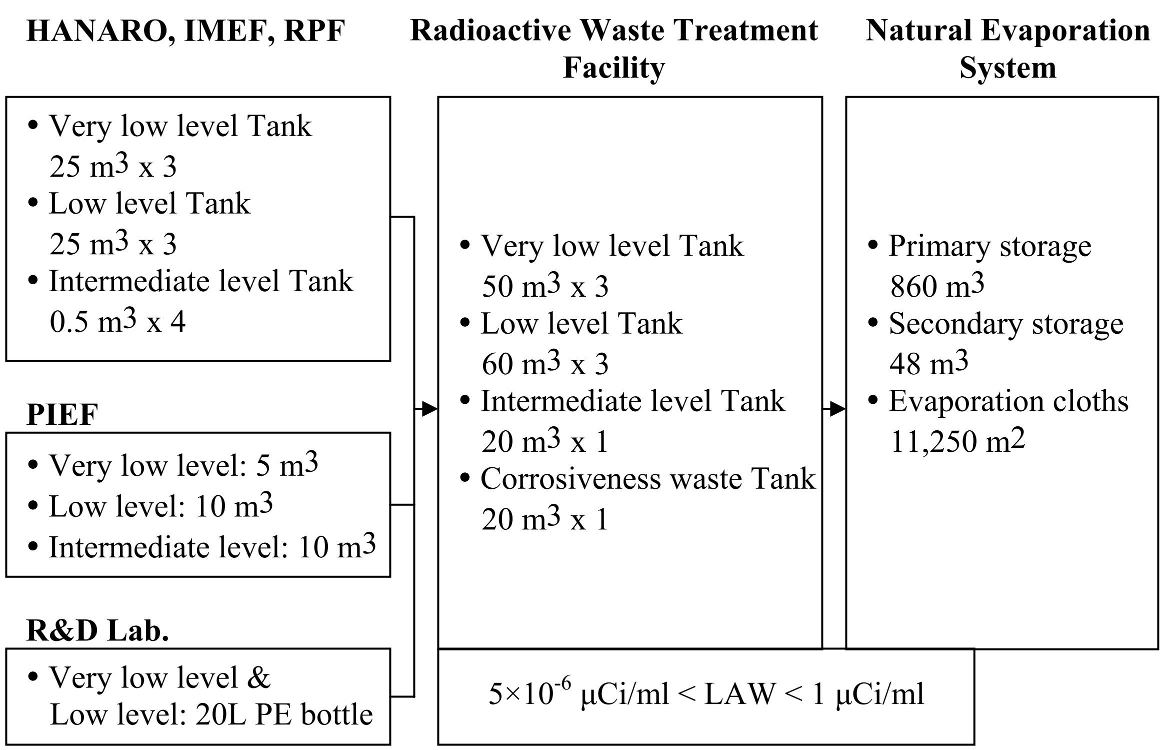

Figure 2: Disposal treatment of liquid radioactive waste

Table 2. Major nuclide code of liquid waste

Particle (Bq/cc)	**MPC of atmosphere**	**MPC of water**	**Inert gases**		**Iodine**
				Bq-Mev	
Be-7	Sr-90	Ba-135	Ar-41	1.2836	I-124
C-14	Nb-95	Ba-135m	Kr-85	0.0022	I-126
Na-24	Zr-95	Cs-137	Kr-85m	0.1577	I-130
K-40	Nb-97	Ba-139	Kr-87	0.7931	I-131
Cr-51	Zr-97	Ce-139	Kr-88	1.9546	I-132
Mn-54	Mo-99	Ba-140	Kr-89	-	I-133
Mn-56	Ru-103	Ce-141	Xe-127	0.2790	I-134
Co-57	Ru-106	Ce-143	Xe-131m	0.0201	I-135
Co-58	Cd-109	Ce-144	Xe-133	0.0453	
Fe-59	Ag-110m	Eu-152	Xe-133m	0.0415	
Co-60	Te-123m	Gd-153	Xe-135	0.2479	
Zn-65	Sb-124	Gd-159	Xe-135m	0.4307	
Ga-66	Sb-125	Hf-181	Xe-137	-	
Br-82	Cs-134	W-187	Xe-138	1.1258	
Br-83	Cs-134m	Au-198			
Sr-85		Hg-203			
Rb-88					
Y-88					
Sr-89					

Management of solid radioactive waste

Solid radioactive waste in KAERI is managed in drums at a temporary storage site located at radioactive waste treatment facility. In order to manage solid radioactive waste effectively, first of all, the drum information must be obtained.

Figure 3 shows the process for solid wastes that are loaded into drums and moved to the disposal repository. Drums loaded with solid radioactive waste have information such as serial number, types of contents, date of generated, dose rate, contamination level, nuclide, and radioactivity rate.
Table 3 describes types and shapes of solid radioactive waste that will be included in a database. In repackage and treatment information, it has a serial number, contents, and date produced and so on. Drum information of solid radioactive waste is shown in Table 4. Table 5 illustrates radioactive waste disposal repository information.

SYSTEM DESIGN

The development of the computer hardware is based the environment of central

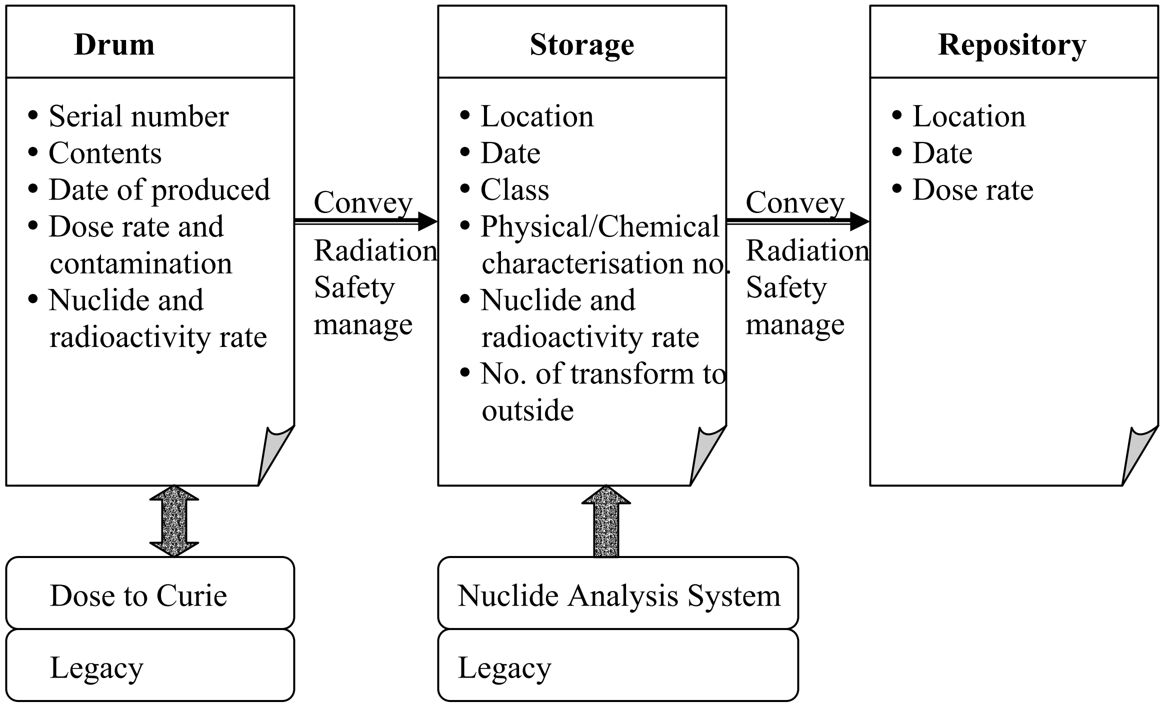

Figure 3: Major process of solid radioactive waste

computing at the mainframe to the distributed client/server system and in the present circu mstances is connected to the environment of the Web [3].

Table 3. Contents and dose rate and contamination of solid radioactive waste

Contents(Standard)					Dose rate and Contamination (Standard)			
General Trash		Shape			Date of measurement			
Vinyl Plastic Cotton Rubber Concrete Asbestos Plaster Timber Glass S. P	Wire	Aridity Compression Asphalt s Cement s	Non-iron	Iron	Dose rate: Bq/cm^2			
			Kilete	Non-kilet	Surface	High		
			Drum generation			Medium		
			Drum damage			Low		
					Measurement Device			
					Type	Name	No.	Duration

Table 4. Drum information of solid radioactive waste

Location of storage(standard)		**Class**		
Name	Location	Class A	LILW-SL	%
High level LI level Very low level RWTF	B-C-R-F	Class B	LILW-LL	%
		Class C		

Repackage and treatment	
Serial number	Dose rate/Contamination/Nuclide
Contents	Drum storage
Date of produced	

Table 5. Disposal repository information of solid radioactive waste

Location of disposal(standard)					
Name	Disposal Site Name		Disposal Container		Location of D.C
XXX 1 XXX 2	V1(C1) V2(C2) V3(C3) V4(C4) V5(C5) V6(C6) V7(C7) V8(C8)	200L drum High compression drum Cylindrical concrete 1 Cylindrical concrete 2 Cylindrical concrete 3 Cylindrical concrete 4 HIC Asphalt solidification drum	Name	S.N	X-Y-Z
			Container 200L 9 pack Repackage 9 pack Cylin. Con1(C1) Cylin. Con2(C2) Cylin. Con3(C3) Concrete 4 pack	xxxx xxxx xxxx xxxx xxxx xxxx xxxx xxxx	

V: Vault, C: Cave or Cavern

Dose Rate(standard)			**Filling materials(Standard)**
Date of measured		xx-xx-xx	Ventonite + grinding rock
Surface Dose rate	High	mSv/hr	Sand + Pebbles
	Medium	mSv/hr	Concrete grouting
	Low	mSv/hr	

Client/Server system

Client/server computing is the logical extension of modular programming. Modular programming has its fundamental assumption that the separation of a large piece of software into its constituent parts ("modules") creates the possibility for easier development and better maintainability. Client/server computing takes this a step further by recognizing that those modules need not all be executed within the same memory space. With this architecture, the calling module becomes the "client" (that which requests a service), and the called module becomes the "server" (that which provides the service). The logical extension of this is to have clients and servers running on the appropriate hardware and software platforms for their functions. The client is a process (program) that sends a message to a server process (program), requesting that the server perform a task (service). The client-based process is the front- end of the application that the user sees and interacts with. The client process contains solution-specific logic and provides the interface between the user and the rest of the application system. The client process also manages the local resources that the user interacts with, such as the monitor, keyboard, workstation CPU and peripherals. One of the key elements of a client workstation is the graphical user interface (GUI). A server process (program) fulfills the client request by performing the task requested. Server programs generally receive requests from client programs, execute database retrieval and updates and manage data integrity and dispatch responses to client requests.

Web (Intranet) system

A Web server is a program that, using the client/server model and the World Wide Web's Hypertext Transfer Protocol (HTTP), serves the files that form Web pages to Web users (whose computers contain HTTP clients that forward their requests). Every computer on the Internet that contains a Web site must have a Web server program. Two leading Web servers are Apache, the most widely installed Web server, and Microsoft's Internet Information Server (IIS). Web servers often come as part of a larger package of Internet- and intranet-related programs for serving e-mail, downloading requests for File Transfer Protocol (FTP) files, and building and publishing Web pages.

Relational DBMS

A Relational Database Management (RDBMS) is built on the three-schema structure, such as external, conceptual, and internal. The external schema defines how users access and view the output from the RDBMS, independent of how the data is physically stored or accessed. Such access and manipulation is performed by users who employ procedural languages, such as Structured Query Language (SQL). In some instances, a query language may be embedded in a procedural language to facilitate Online Transaction Processing (OLTP) and similar applications. The conceptual schema defines the relational database model. It consists of a set of normalized tables. The internal schema consists of the physical organization of the data (e.g., sequential, indexed sequential, and direct) in terms of physical data structures and access methods of the computer’s operating system. The internal schema is usually covered in computer hardware courses. The relational model is based on the set of theory of mathematics [4]. Tables define the structure. Tables are called relations in mathematical terms. Systems professionals often use terms “table” and “relations” interchangeably [5].

Object-Oriented DBMS

Object-Oriented Database Management (OODBMS) concepts have evolved in three different disciplines; firstly in programming languages, then in artificial intelligence, and then in databases. An object-oriented approach to programming is based on the concepts of encapsulation and extensibility. Object-oriented programming encapsulates in an object some data and, programs to operate on the data; the data is the state of the object, and the code is the behavior of the object. Extendibility refers to the ability to extend an existing system without introducing any changes to it. Extendibility is an especially powerful concept for building and evolving very large and complex software system. An object-oriented approach to programming offers extendibility in two ways: behavioral extension and inheritance [6].

Object-Relational DBMS

Central to object-oriented analysis and design is the idea that an object's interface (the means by which it is handled) should be separate from any details on its implementation (the data structures and logic within it). The role object-oriented analysis plays in developing ORDBMS databases is as a conceptual framework for working with the extensible type system. What distinguishes an object-relational DBMS from more conventional software frameworks-such as pure object-oriented DBMS, application-servers, or TP-monitor middleware-is that the embedded object classes are deployed within an abstracted or logical data model. Some important principles of the ORDBMS data model are those types which do not have to be used to define a table's structure or a column. The behaviour of this object can be used to implement complex query operations over otherwise conventional data. Also, most object-oriented methodologies acknowledge that sometimes what you want is not really an object, but simply a function or procedure [7]**.**

WACID SYSTEM

WACID is being developed to manage a function of safety management and statistical data and to make up for the weak points in the application of regulations about the overall radioactive waste process. The organizations that participated in WACID are Korea Hydro&Nuclear Company (KHNP), KAERI, Nuclear Environment Technology Institute (NETIC), and KEPCO Nuclear Fuel Company (KNFC). A configuration of WACID system is represented in Figure 4.

CONCLUSION

Conceptual data modeling of the whole radioactive waste management process for the establishment of a radioactive waste management database was carried out. The major information related to solid and liquid radioactive waste from the user requirements was extracted. The hardware system for the radioactive waste database, a client/server system that has outstanding security features was selected. The software elements that will be used is RDBMS, has wide use and an ability to manage huge amounts of data.

These results are used to create a basic data-user interface and prototype design. The RAWMIS will be a useful tool to analyze radioactive waste management and radiation safety management. Also, this system is developed to share information with associated companies. Moreover, it can be expected to support the technology of research and development.

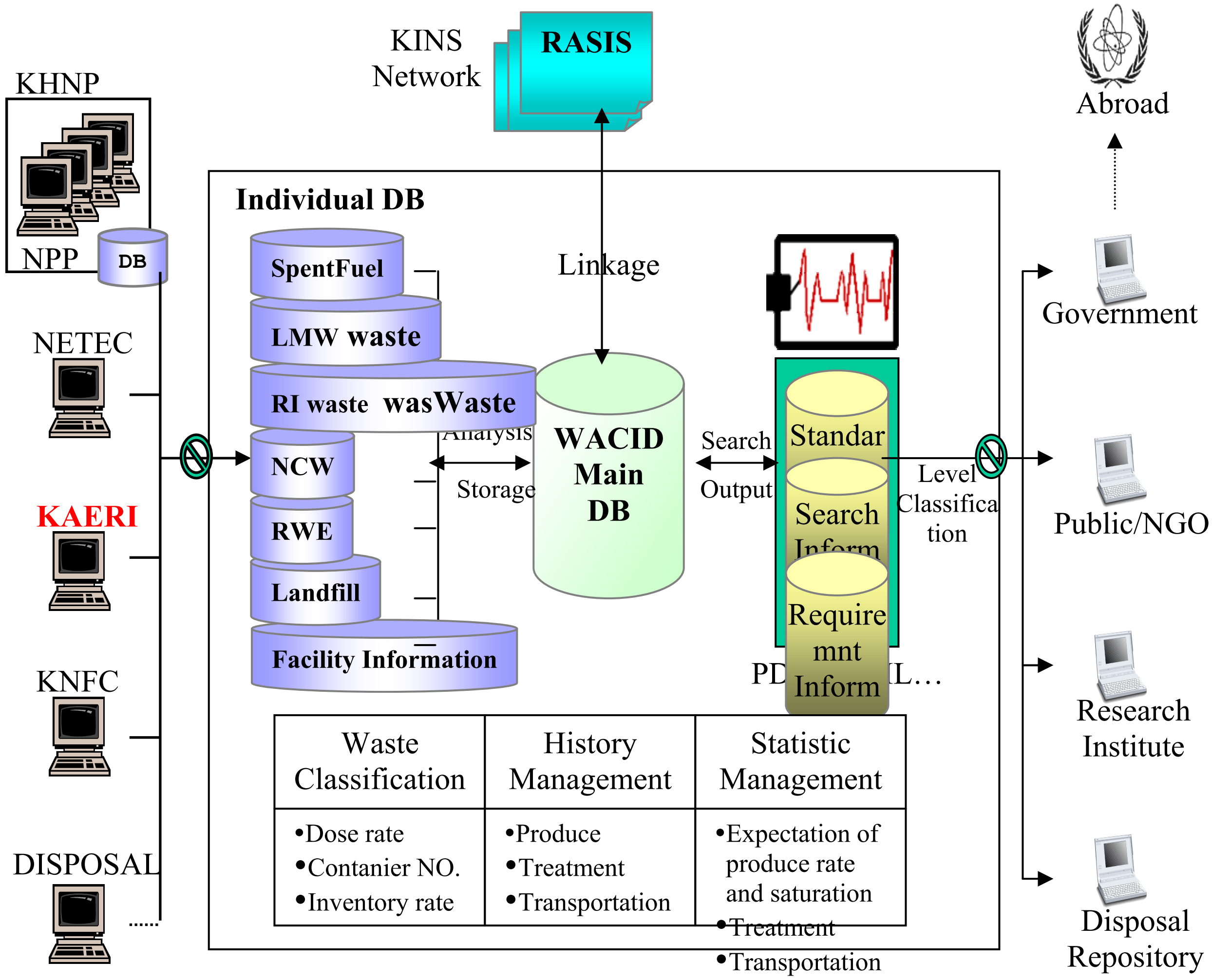

Figure 4: A configuration of WACID system

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