DEVELOPMENT OF A KNOWLEDGE BASED SYSTEM LINKED TO A MATERIALS DATABASE

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ABSTRACT

The distributed materials database system named 'Data-Free-Way' has been developed by four organizations (the National Institute for Materials Science, the Japan Atomic Energy Research Institute, the Japan Nuclear Cycle Development Institute, and the Japan Science and Technology Corporation) under a cooperative agreement in order to share new and accumulated information for use in the development of advanced nuclear materials and for use in the design of structural components, etc. In order to make the system more valuable, the development of a knowledge based system, in which knowledge extracted from the material database is expressed, is planned for more effective utilization of Data-Free-Way. XML (eXtensible Markup Language) has been adopted as the method of describing the retrieved results and their meanings. A knowledge note described with XML is stored as a knowledge item in the knowledge base. Since this knowledge note is described with XML, the user can easily convert the displayed tables and graphs into a data format that the user usually uses. This paper will describe the current status of Data-Free-Way, the method of describing knowledge extracted from the materials database with XML and the distributed materials knowledge based system.

Keywords: Knowledge based system, Materials database, Data-Free-Way, XML, Knowledge notes

1 INTRODUCTION

The distributed material database system named "Data-Free-Way", which can be accessed from the Internet, has been developed with the collaboration of four organizations: the National Institute for Materials Science (NIMS), the Japan Atomic Energy Research Institute (JAERI), the Japan Nuclear Cycle Development Institute (JNC), and the Japan Science and Technology Corporation (JST). The results retrieved using the system are displayed as tables and graphs, and the users assign meaning to the retrieved results themselves. Such a function is sufficient for the expert. However, if the meaning of the retrieved results and the analyzed results are stored as knowledge, the system becomes much more useful to many more users. Therefore, in order to make the system more valuable, the development of a knowledge based system, in which knowledge extracted from the material database is expressed, is planned for more effective utilization of Data-Free-Way.

This paper will describe the current status of Data-Free-Way, the method of describing knowledge extracted from the materials database with eXtensible Markup Language (XML) and the distributed materials knowledge based system.

2 PRESENT STATUS OF DATA-FREE-WAY

2.1 Outline of system

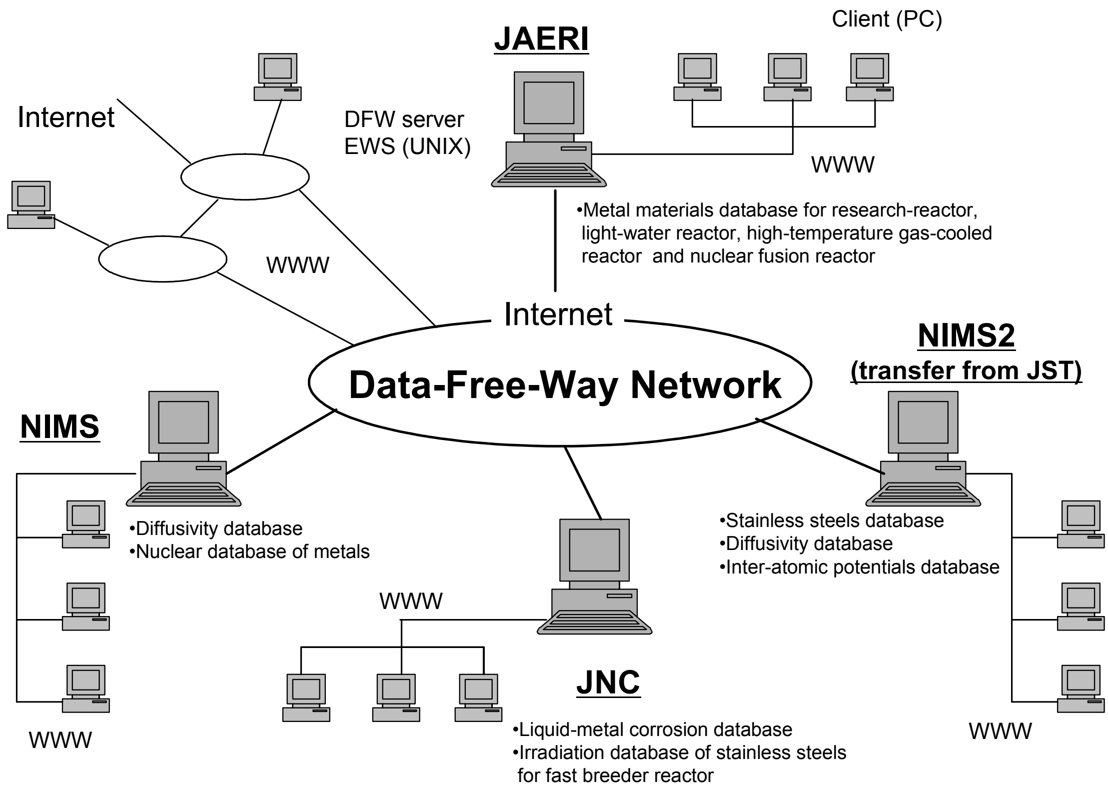

Figure 1. Outline of Data-Free-Way system

Nuclear materials are often used under extreme conditions such as neutron irradiation, high temperatures, corrosion and so on. Very little of material's behavior under service conditions in the nuclear field can be understood without practical examination. An easily accessed materials information system with a huge materials database using effective computers is, therefore, necessary for the design of nuclear materials and the analysis or simulation of the phenomena that occur in nuclear plant materials under the service conditions, especially relevant neutron irradiation phenomena.

Hence, as shown in Figure 1, the distributed database for advanced nuclear materials named "Data-Free-Way" was constructed with the collaboration of NIMS (http://dfw.nims.go.jp/), JAERI (http://jmpdpcda.tokai.jaeri.go.jp/), JNC (http:// dfw.jnc.go.jp/) and NIMS2 (http://dfw.nims.go.jp/jst) (Tsuji, Yokoyama, Fujita, Kano, Tachi, Shimura, Nakajima & Iwata, 1998; Tsuji, Yokoyama, Fujita, Kano, Tachi, Shimura, Nakajima & Iwata, 1999a; Tsuji, Yokoyama, Fujita, Kurihara, Kano, Tachi, Shimura, Nakajima & Iwata, 1999b; Fujita, Kinugawa, Tsuji, Kaji, Tachi, Shimura, Nakajima & Iwata, 2000) in order to share both new and accumulated information for use in the development of advanced nuclear materials and for use in the design of structural components, etc. over the Internet.

Referring to more than ten materials databases which have already been developed in Japan and in other countries (Doyama, Suzuki, Kihara & Yamamoto, 1991; Doyama, Kihara, Tanaka & Yamamoto, 1993; Glazman & Rumble, 1989; Barry & Reynard, 1992; Nishijima & Iwata, 1997), the data structure for advanced nuclear materials in the Data-Free-Way was originally a three-level hierarchy. The primary level contained six categories such as data source, material, specimen, test method & data reduction, test conditions and test results. Twenty-five tables made up the secondary level. More than 420 data items were prepared for the final level.

A world wide web (WWW) home page and a WWW server were prepared. The data input-output system has the following additional functions included to reinforce integration between the database and the internet, for example the retrieval-layout function for graphical data; a simple graph preparation function; a

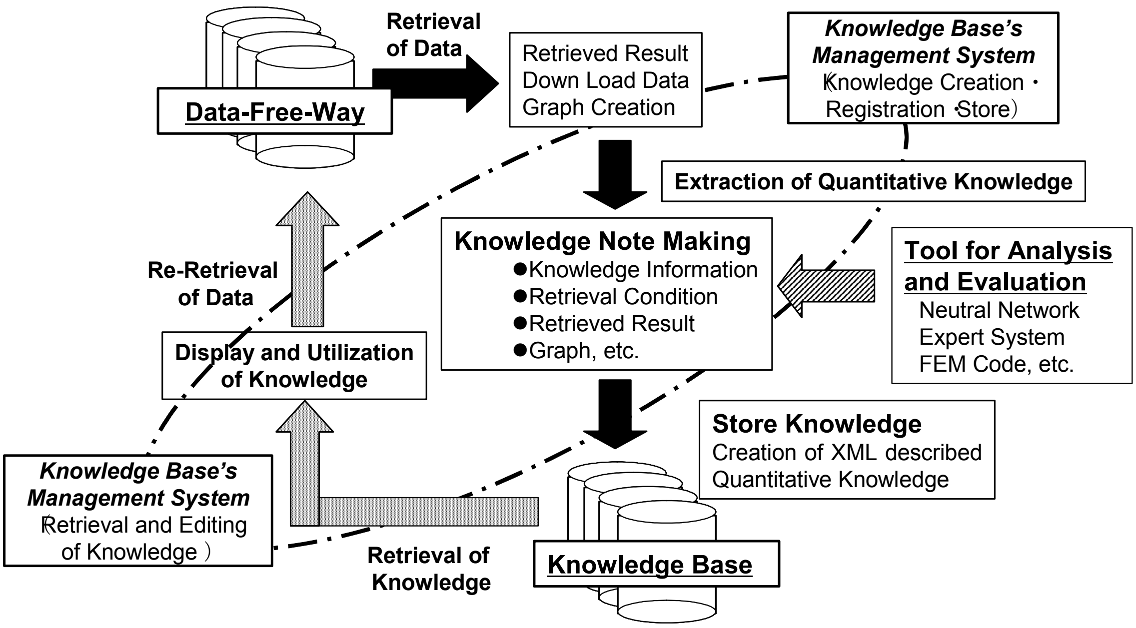

Figure 2. Concept behind the Data-Free-Way system, the knowledge creation function and the knowledge base

function integrating numerical data and graphical data; the preparation function of a standard retrieval screen; a function that saves & reproduces retrieval conditions, etc. The on-line manual, dictionary on data items and unit conversion function have also been incorporated into the users' support system.

2.2 Stored data

NIMS prepared mechanical properties data for stainless steels and super alloys. JAERI prepared a database of mechanical properties data for nuclear materials for research reactors, light water reactors, high temperature gas-cooled reactors and fusion reactors. JNC built a liquid metal corrosion database for fast breeder reactors and a mechanical properties database of irradiated stainless steels. JST built a database of publicly available data on irradiated stainless steels. Currently, data on more than 35000 specimens from various kinds of materials are stored in a common database.

3 A DESCRIPTION OF KNOWLEDGE OBTAINED FROM THE MATERIALS DATABASE

3.1 Conceptual design of the knowledge base

The existing materials databases were built according to an original concept and an original technique, which was not premised on sharing. It is difficult for users to use the databases cooperatively on their analysis systems. Even if the types of the materials are different, the materials database has many common data items. Other researchers have investigated using the XML description method on materials property data from other materials databases with different data structures (Yoshizu, Ijima, Halada, Shuto, Tsuchiya & Oyatsu, 1999; Shuto, Tsuchiya, Oyatsu, Yoshizu, Ijima & Halada, 1999; Shuto, Oyatsu, Halada & Yoshizu, 2002; Yoshizu, Yamazaki, Halada & Yoshizu, 2004). In this platform's system, the materials data is structured using XML-Document Type Definition (DTD) and the data itself is described using XML. The XML-DTD is analyzed by the Java program, and the search engine adapts to changes in the data's structure. MatML (MatML, n.d.), which determines the general framework for constructing of all material databases based on XML, is also considered a standard DTD for materials data. An important feature of the

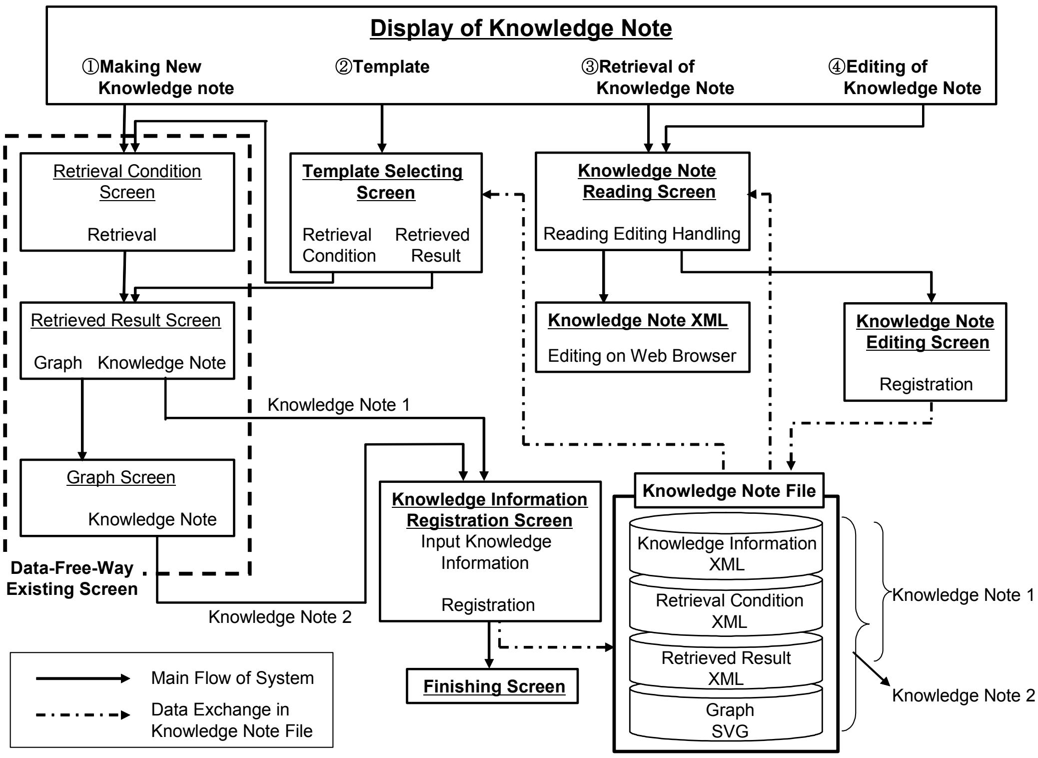

Figure 3. Flowchart of knowledge base system

MatML development effort was the inclusion of a broad range of input from the materials community. These individuals and groups represented private industry, government laboratories, universities, standards organizations, and professional societies, and their efforts were coordinated by the National Institute of Standards and Technology (NIST). An Internet based platform dedicated to composites design and thermophysical properties evaluation, which features a high-speed and light-weight calculation engine, with the capability to store and present large amount of materials information using XML, has also been developed (Xu, Kinugawa & Yagi, 2003; Xu, Tanaka, Goto & Yagi, 2004). As mentioned above, these studies are aimed at integrating several material databases using XML, but our system is aimed at describing the knowledge from the retrieved results, the data retrieval process using XML and sharing the knowledge among many users.

A standard retrieval screen was built for the users' convenience in Data-Free-Way. If typical retrieved results are available on the standard retrieval screen, users do not need to retrieve the query from scratch using the same conditions in order to retrieve this information from the database. Moreover, if the meaning of the retrieved results and the analyzed results are stored as knowledge, the system becomes more useful to many more users. Therefore, the purpose of this study is to describe the knowledge from the retrieved results, the XML data retrieval process and share the knowledge among many users.

Figure 2 shows the retrieval concept of Data- Free-Way, the knowledge note making function, and the knowledge base. Specialists from any organization can retrieve data, make graphs and evaluate the data using the distributed materials database (Data-Free-Way). Then if they discover new information, they can make knowledge notes with this new information, etc. Not only knowledge, but retrieval procedures for specialists are also recorded in a knowledge note. The knowledge notes are stored at each site and users can retrieve and read them through the knowledge base's management system. In this system, a knowledge note described with XML is stored as a knowledge item in the knowledge base. Therefore laymen can retrieve information without trial and error in the same way as specialists by using the retrieved procedures.

The flowchart of the knowledge base system is shown in Figure 3. In the introductory Display of Knowledge Note window, users can select four functions: (1) the Knowledge Note Creation function, (2) the Template function, (3) the Retrieval of Knowledge Note function and (4) the Editing of Knowledge Note function as shown at the top of Figure 3. In the case of making a new knowledge note, users determine the retrieval conditions and display the retrieved results by using Data-Free-Way's standard retrieval screen. In the retrieved results screen or graph screen, users can create a knowledge note. In the knowledge information registration screen, users can input the title of the knowledge, name of the register, the retrieval contents, the knowledge extracted from the retrieved results and references. By pushing the registration button in the knowledge information registration screen, the knowledge information, retrieval condition and retrieved results are stored in XML format and the graph is stored in SVG (Scalable Vector Graphics) format. By using the template, users can reload the retrieval condition and the retrieved results stored as the knowledge note file in the template selecting screen. The user can then carry out a new retrieval based on this knowledge note or initiate a new data retrieval action. When retrieving a knowledge note, the required knowledge note can be displayed in the Web browser by selecting the knowledge note reading screen. When editing a knowledge note, users can modify and re-register the knowledge information in the knowledge note editing screen after selecting the relevant knowledge note in the knowledge note reading screen.

As mentioned above, this knowledge based system is a useful system for solving materials phenomena, prospecting materials and developing new materials because the knowledge base system is linked to a materials database (Data-Free-Way).

3.2 An XML description of retrieved results

XML has been adopted as the description method for the retrieved results and their meanings. XML is a language, or a document form, which both people and computers can understand.

If the accumulation of knowledge notes described with XML increases, the following can be expected. In general, text information including figures, tables, and images enables sharing by current network technology. This becomes the same thing as sharing information by distributing text information in printed matter. However, when knowledge about what the information means is shared with the computer and network, people judge the information overall and can understand its meaning. The form of document that both computers and people can understand is XML. When a document described with XML is installed on

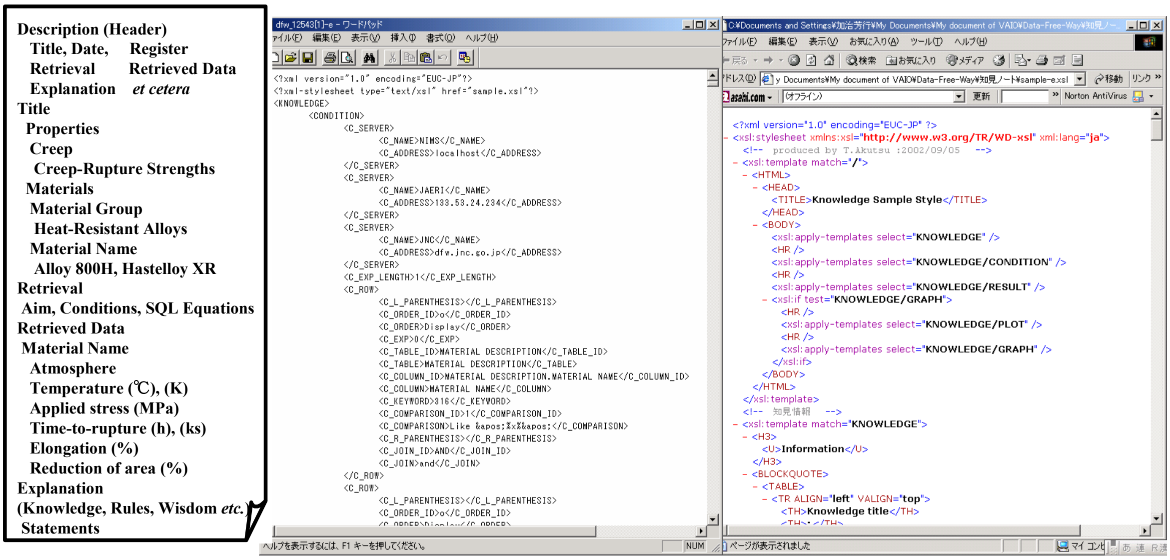

Figure 4. Description format of a knowledge note using XML and XSL

the Internet, a world wide available database is created.

3.3 Knowledge notes

Knowledge notes can be made at each stage of data retrieval; when the retrieved results are displayed or when graphs are created. At each stage a set of retrieval conditions can be reproduced from the knowledge note. Storing knowledge obtained as retrieved results, the items shown in the left side of Figure 4 are described with XML. In this XML file, the name of a data item is written as a tag, for example, <C_KEYWORD>. The value of the item lies between the start and end tags, for example, <C_KEYWORD> 316 </C_KEYWORD>, which means the retrieval keyword is “316”. Knowledge notes can also be displayed using XSL (eXtensible Style Language) as shown on the right hand side of Figure 4. It is possible to display data on a material’s characteristics by creating XSL styles for each characteristic.

Since this knowledge note is described with XML, the user can easily convert the display format of the tables and the graphs into a data format that the user usually uses, because XML files can be easily processed by computer, or as it is also a human-readable text file, it can also be edited with any text editor. Moreover, additional information about retrieved numerical values, such as units can be easily conveyed.

If such knowledge notes are created by many experts or materials researchers and accumulated, an effective knowledge base system can be constructed. As this knowledge based system is described with XML, the system can be shared world wide.

4 AN EXAMPLE OF A KNOWLEDGE NOTE

Figure 5 shows an example of a knowledge note which can be

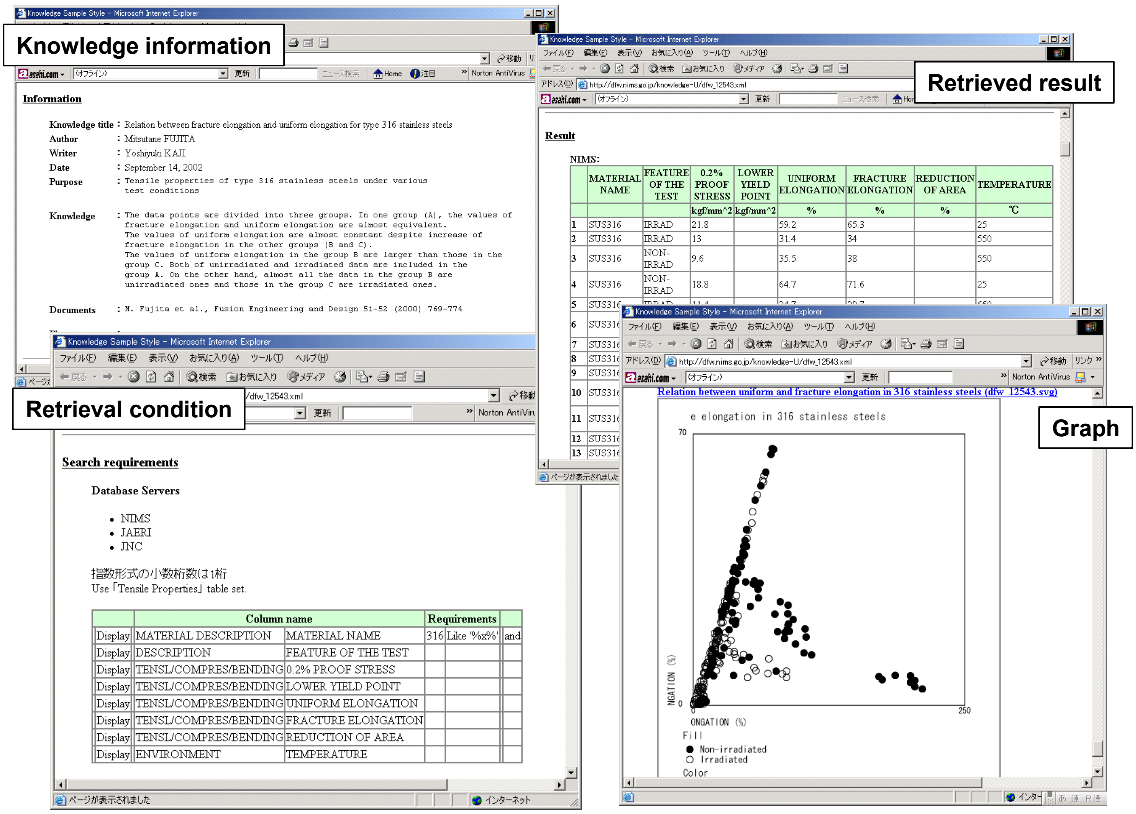

Figure 5. Example of a knowledge note

produced at each stage of the data retrieval process, for example, when the retrieved results are displayed, or when graphs are created. A knowledge note consists of a table and graph of the retrieved results, and a description of the following items: the title, the register, the date of registration, the retrieval contents, the knowledge document, and reference to where the knowledge is described in the literature.

In this example, the retrieved results and their meaning in relation to the tensile properties of unirradiated and irradiated stainless steels are described. The user can retrieve data items which are not described in the knowledge note from the facts database.

By describing knowledge obtained from the facts database using XML, the system possesses not only the advantage of being able to display the retrieved results as tables or graphs but also display knowledge.

5 SUMMARY

A distributed materials database system named "Data-Free-Way" that can be accessed via the Internet has been developed with the collaboration of four organizations: NIMS, JAERI, JNC, and JST. In order to make the system more valuable, the development of a knowledge based system, in which knowledge extracted from the material database is expressed, is planned for a more effective utilization of Data-Free-Way.

As a first step in the knowledge base's development program, knowledge notes have been created using XML from typical results retrieved through the standard retrieval screen and from the meaning of the retrieved results.

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