

## Development of Nuclear Reaction Data Retrieval System on Meme Media

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A newly designed retrieval system of charged particle nuclear reaction data is developed on Meme media architecture. We designed the network-based (client-server) retrieval system. The server system is constructed on a UNIX workstation with a relational database, and the client system is constructed on Microsoft Windows PC using an IntelligentPad software package. The IntelligentPad is currently available as developing Meme media. We will develop the system to realize effective utilization of nuclear reaction data: I. “Re-production, Re-edit, Re-use”, II. “Circulation, Coordination and Evolution”, III. “Knowledge discovery”.

**KEYWORDS:** Nuclear reaction data, database retrieval system, NRDC, JCPRG, NRDF, EXFOR, IntelligentPad, SQL, Meme Media, sharing environment of nuclear data via network

### I. Introduction

Nuclear data compilation is one of the most important bases for the application of atomic nuclei to science and technology. There are various nuclear data compilations in the world<sup>(1)</sup>. As a consequence of continuous activities in such compilations, the utilization of nuclear data is expanding from nuclear engineering and nuclear physics to the other related fields. For every data compilation, the amount of data becomes larger year by year, and the contents of data will be more complex. Therefore, development of utility systems for compiled data is an important subject. In recent years, development of computer technologies, infrastructures and software architectures enables us to support and expand utilization of the nuclear data. Indeed, the real issue is how to organize the system which extends our research activities.

We show a new type of nuclear data retrieval system, in which NRDF (Nuclear Reaction Data File), a kind of charged particle nuclear data (CPND) compilation in Japan<sup>(2,3)</sup>, is applied as an example. To get benefits from recent computer and network technologies, we adopt the IntelligentPad architecture<sup>(4)</sup> as a framework of the present system. This software architecture has many useful features for handling multimedia, media-based system construction, and graphical user interface.

We call the present system CONTIP, which is an abbreviation of “Creative, Cooperative and Cultural Objects for Nuclear data and Tools on IntelligentPad”. A prototype of the system was built by one of the authors (M.C.) on a UNIX workstation

in 1995<sup>(5,6)</sup>. For the practical use, development of the system is now pursued<sup>(7,8)</sup>. The purposes of this paper are i) presentation of the feature of CONTIP, ii) discussion of the functions and the elements to be essentially possessed by CONTIP, from the viewpoint of effective utilization of nuclear data.

### II. NRDF – A Charged Particle Nuclear Reaction Data Compilation –

For the purpose of international exchange of experimental nuclear reaction data, EXFOR compilation is used as a de facto standard<sup>(9)</sup>. EXFOR was designed to accumulate mainly the neutron nuclear reaction data (NND). Therefore, the data description format of EXFOR was not necessarily suitable for CPND. For this historical background, The Japan Charged Particle Reaction data Group (JCPRG) designed NRDF, as a study of database, to accumulate scientific information of CPND from experiments of nuclear reactions. Using the own data description rule in NRDF, which is different from EXFOR, the contents are taken from published papers associated with nuclear experimental physics. The detail of the data structure of NRDF is shown in Ref. (2,3).

JCPRG has compiled CPND on NRDF (Nuclear Reaction Data File) for more than 20 years. NRDF consists of over 20,000 of data what are mainly produced in Japanese experimental facilities<sup>(2,3)</sup>. Due to the large variety of particles and physical quantities, CPND has a large number of reaction types in contrast to NND. Furthermore, measured reaction types are evolved with the development of the experimental techniques. In addition, motivation of experiment and considering aspects are changed along with the progress of research. Therefore, in order to utilize the data in the future, each data of NRDF is encoded maximum information of CPND from the published papers.

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Whereas JCPRG compiles CPND produced in Japanese experimental facilities, parts of NRDF data are transported as CPND in EXFOR<sup>(10)</sup>. Thus, JCPRG contributes as a member of nuclear reaction data centers (NRDC) coordinated by the IAEA NDS<sup>(11)</sup>.

### III. IntelligentPad - Meme media architecture -

The IntelligentPad architecture has been proposed and developed at Hokkaido University since 1987<sup>(4)</sup>. The development was started as making somewhat object-oriented system construction toolkit that is based on the graphical user interface (GUI). A pad in the IntelligentPad can be treated as an object of GUI, like a view of "real paper pad", and each pad has functions such as data control programs, input/output devices between other pads, and so on. On this environment, programming of tools can be carried out by intuitively pasting and peeling off operation with pads. In addition, through the research and the development of the IntelligentPad, fundamental prospect and directivity of this architecture are clarified: IntelligentPad is not only a specific software package, but also a fundamental environment architecture to support the effective utilization of computerized resources. It is called Meme media architecture<sup>(4)</sup>.

As shown in Ref. (4), Meme media is the environment that shares and re-uses the resources of all over the world connected to the Internet. In order to develop and enlighten this architecture, more than 60 Japanese and other foreign companies organize the IntelligentPad Consortium (IPC)<sup>(12)</sup>. Furthermore, in the future, the kernel system of the IntelligentPad will be distributed freely to all users. Recently, the IntelligentPad system is available as some commercial software packages on personal computers<sup>(13,14)</sup>.

### IV. CONTIP

#### 1. System Design

**Figure 1** shows a basic image of network communications of this system. Using a database management system (DBMS) based on SQL, we construct the NRDF data management server on a UNIX workstation. UniSQL<sup>(15)</sup> is adopted for the present system. Using a common gateway interface (CGI) on this server, the network communications between the NRDF server and clients are achieved.

We have constructed this CONTIP client on MS-Win-

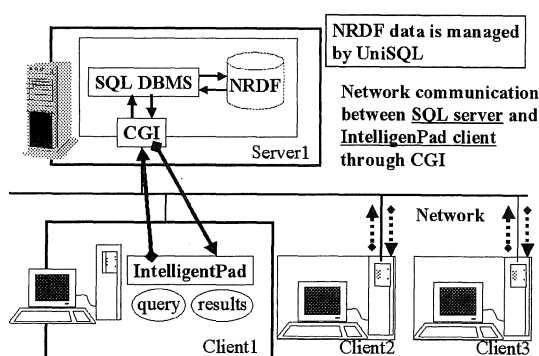


Fig. 1 Network-based system design.

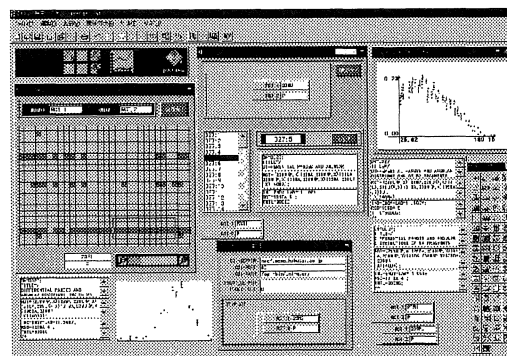


Fig. 2 Overview of the system

dows95, 98/NT-based IntelligentPad<sup>(13)</sup>. **Fig. 2** shows the overall appearance of CONTIP for the NRDF data retrieval system. On this system, each utility component is constructed as a composition of primitive pads. For example, database proxy pad is used for the connection to the database server. We construct "Data navigation pad" and "Data retrieval pad" composing the database proxy pad and other primitive pads. The functions of these composite pads are given in the following.

#### 2. A Reference Example and Functions of the Trial System

We show a reference example to discuss features of the present system. Suppose that user wants to retrieve the data of the  $^{238}\text{U}(p, X)$  reaction, the procedure is shown in the following steps (1), (2), and (3).

##### (1) Data Navigation

As a first step, we show the function of data navigation pads. Using this pad, existence of the  $^{238}\text{U}(p, X)$  is navigated. **Figure 3** shows each step of the search: i) Set the network address of SQL server. ii) Specify the two attributes of the NRDF database, in this case, target and projectile. iii) Execute the search with a click the "QUERY" button on the pad.

Thus, the result is displayed on a grid in the middle region of the pad. The status of the NRDF database is mapped in 2-dimensional  $x$ - $y$  plane, where  $x$ - and  $y$ - correspond to targets and projectiles, respectively. Dark colored points show the NRDF database has some reaction data for the target ( $x$ ), and projectile ( $y$ ). In this way, we find NRDF has some data about the  $^{238}\text{U}(p, X)$  reaction. Using click and drag operations, a

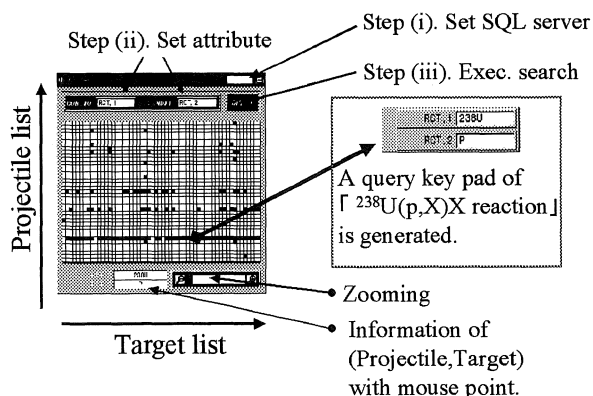


Fig. 3 Data navigation pad.

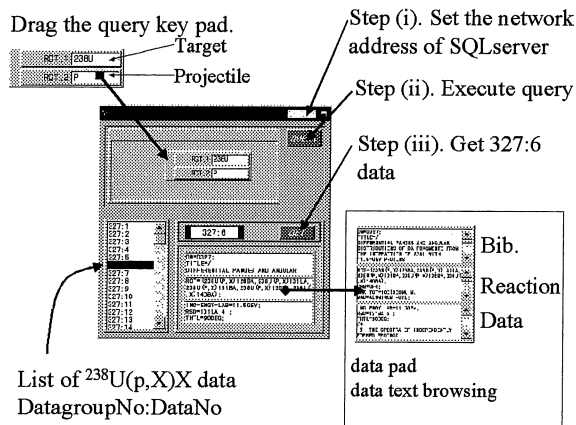


Fig. 4 Data retrieval pad.

query key pad, which is used for the query of this reaction data, is generated.

## (2) Data Retrieval

After the query key pad of the  $^{238}\text{U}(p,X)\text{X}$  reaction is obtained, user retrieves the data by using the data retrieval pad (See Fig. 4). The processes of the retrieval are as follows: i) Set the network address of database in the same way as the data navigation pad. ii) Drag the query key pad into the data retrieval pad, and execute the search using the "QUERY" button. The data set of the reaction is listed in the lower left part of the pad. iii) Select a dataset number from the list and get the data using "Get" button. The data pad, which specifies the retrieved data, is generated in the lower right part of the data retrieval pad. Consequently, we obtain a data pad for the  $^{238}\text{U}(p,X)\text{X}$  reaction. The data pad holds the description of data, and displays it using text-browsing pad. Repeating step iii), other data pads of this reaction are also retrieved.

## (3) Interactive Data Visualization and Comparison

Data pads are also used for visualization as shown in Fig. 5. Once you drag a data pad into a 2D data plot pad, you can see the graph representation of the data. Data comparison is also achieved by just a drag and drop operation of data plot pads into the graph base pad.

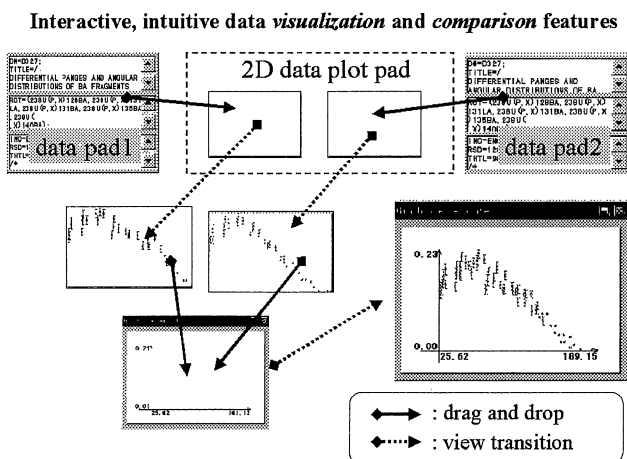


Fig. 5 Interactive data visualization and comparison.

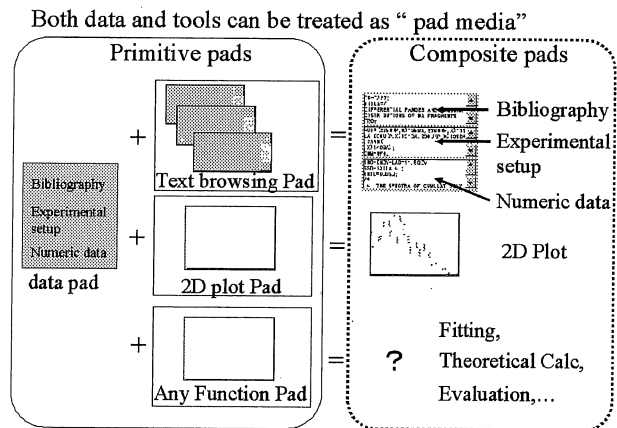


Fig. 6 Synthetic features of pads.

## 3. The Aim of Nuclear Database towards the Effective Use

As shown in the previous subsection, major features of this system are: i) 2-dimensional intuitive of data navigation, ii) interactive data visualization and comparison. Furthermore, we discuss the aim of the system towards support of the effective use of nuclear reaction data with computer facilities.

### (1) Re-production, Re-edit, and Re-use

Any tool can be decomposed into more primitive pads, thus you can re-use such primitive pads to re-construct another tool. Such a synthetic feature of the IntelligentPad would be achieved by many users' co-operative activities of "Re-produce, -edit, -use" of both nuclear data and useful tools (Fig. 6).

### (2) Circulation, Coordination, and Evolution

The IntelligentPad supports cooperative fundamentals through the networks. Once we construct a server to distribute and circulate not only data but also tools, it is already a basis of a circulation field of integrated intellectual resources for nuclear data. Fig. 7 shows a schematic figure for the circulation system of data and tools as pad media by PIAZZA<sup>(16)</sup>, which enables to circulate pads through the network. Using PIAZZA, many users can retrieve many tools and data as the pad media. Ultimately, even though any resources are scattered all over

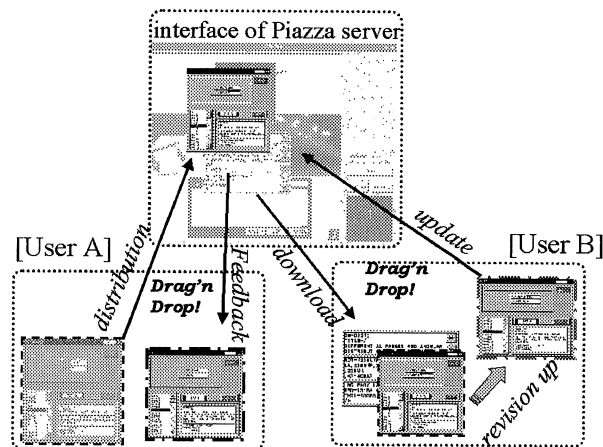


Fig. 7 PIAZZA: circulation and coordination are supported by using these architectures.

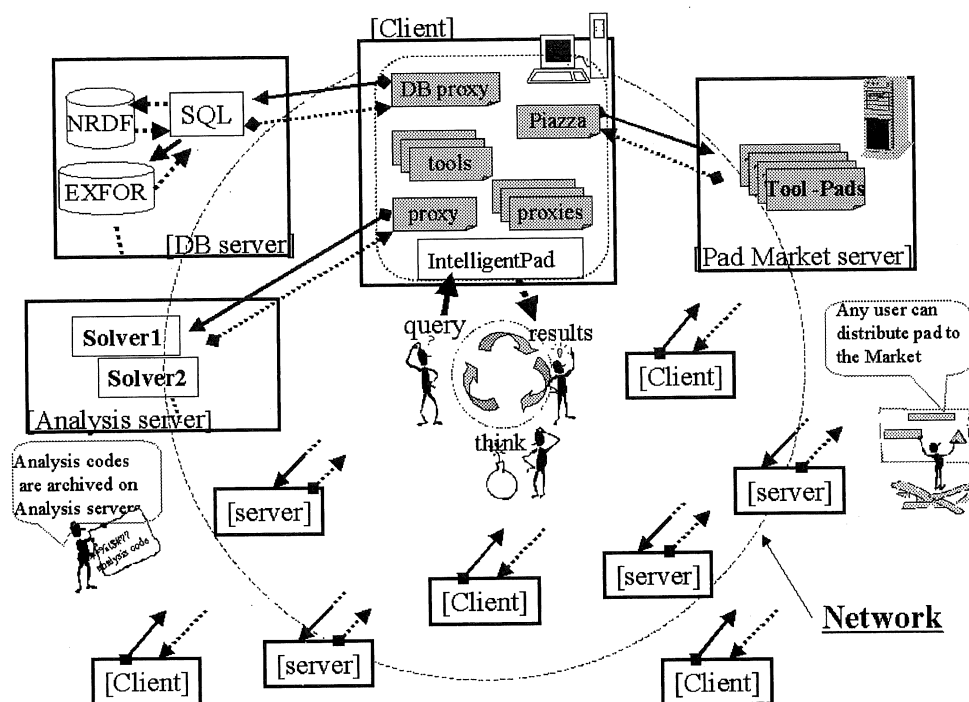


Fig. 8 An schematic image of the ideal system for nuclear data.

the world, user can use them as pad media on the IntelligentPad architecture (Fig. 8).

### (3) Knowledge Discovery

The amount of nuclear reaction data is increasing day by day. In addition, variety of the data will also be more complex. Hence, it will be more difficult to get essential information from huge databases. In the case of the data navigation pad, user doesn't have to know specific commands to retrieve the data, e.g., SQL statements. Therefore, development of utility pads realizes easier navigation to needed data, and would support a new discovery of knowledge concerned with nuclear data.

## V. Summary and Future Extension

Development of CONTIP is reported where NRDF is applied as an example. The current trial system has mainly two features: i) interactive data visualization and comparison, ii) 2D intuitive data navigation.

Recent computer properties allow us distributing nuclear data and tools to anyone on the network, e.g. WWW techniques, but it is still difficult to share and to circulate resources within all users of the system. We attempt to develop a system, which will be used by a huge number of users and which would be supported to share and evolve the knowledge of all users. The concept of Meme media seems to be one of the prospects for effective utilization of nuclear data.

As the future extensions, inclusion of EXFOR<sup>(9)</sup> to CONTIP leads to be more comprehensive retrieval system for the nuclear reaction data. We are planning to distribute the system to researchers and to bluish-up the trial system with feedback. Furthermore, through our development, we aim at giving the frame-

work of the ideal environment for nuclear data as discussed in Section IV-3.

### ACKNOWLEDGMENT

The authors wish to thank Professor Y. Tanaka for helpful discussions on integrating the nuclear data utility system into Meme media architecture.

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- (14) Apple Macintosh version : <http://www.hitachi-sk.co.jp/>.
- (15) UniSQL Web page : <http://unysql.www.nttdata.co.jp/>.
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