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# A WEB-based integrated data processing system for the TRIAM-1M

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**Abstract**

In TRIAM-1M, plasma discharge can be sustained for over five hours [H. Zushi, et al., Steady-state tokamak operation, ITB transition and sustainment and ECCD experiments in TRIAM-1M, Nucl. Fusion 45 (2005) S142–S156]. In order to avoid sitting in front of one console for the purpose of monitoring the plasma discharge, it is recommended that the experimental information be accessible from any location at any time. In addition, simple services to access experimental information are required in order to promote the participation of multiple researchers in the TRIAM-1M experiment. Thus, A WEB-based integrated data processing system that provides management for experiment planning, an experimental log, numerical data, and plasma supervision has been installed in the TRIAM-1M. These services are composed primarily of an Apache WEB server, a Tomcat JSP/Servlet container, and a MySQL relational database. This system is constructed using the object-oriented Java language, which is easy to maintain and develop because of the intrinsic characteristics of the Java language. When participating in experiments, researchers are required only to prepare a WEB browser on any platform and are no longer required to memorize complex operations because all services are provided with a uniform user interface through a WEB browser. Furthermore, with the integration of these services, the required information and numerical data can be provided promptly by tracing HTML links that are created dynamically by server applications.


*Keywords:* TRIAM-1M; Data processing; Apache WEB server; Java; Tomcat JSP/Servlet; MySQL

## 1. Introduction

The Torus of the Research Institute for Applied Mechanics (TRIAM-1M) is a high-field superconducting tokamak ($R = 0.84$ m, $a < 0.12$ m, Bt $< 8$ T) that can sustain a plasma for over five hours [1]. Although data processing systems, such as systems for data acquisition and plasma supervision, were already installed in the TRIAM-1M, the data processing system can be updated to a more sophisticated system according to recent progress in computer technology. The design concepts of a new data processing system are thus considered, and a new integrated data processing system is installed on the TRIAM-1M.

For large experimental devices such as the TRIAM-1M, since a number of researchers participate in experiments, the sharing of experimental information is important for the effective execution of experiments. The experimental information should also be distributed to researchers at other facilities located far from the experimental device and should be accessible via familiar software for the smooth participation of researchers who often have different platforms. Furthermore, the experimental information should be accessible from any location and at any time, so that researchers do not need to remain in front of a console. In the case of the TRIAM-1M, in which a plasma discharge can be sustained for over five hours, the burden of researchers can be large if they must remain in front of one console during the entire plasma discharge process.

In other devices, some functions of data processing systems have already been developed with WEB-based technologies [2,3]. However, in some cases, platform-dependent software or specialized techniques are adopted in these systems. With respect to the development of a data processing system, the usage of familiar technology is preferable, because this enables not only a particular person but many developers to be involved in the development. As a result, a data processing system will be stable. Furthermore, the usage of familiar technology allows the utilization of existing infrastructure. In future experiments, experimental information should be provided not only to per-

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sonal computers but also to various devices such as mobile phones and PDAs in order to allow the access from any location and at any time. If a familiar technology is adopted for a data processing system, existing infrastructure, such as the Internet and wireless communications, can be used effectively.

Based on the above-mentioned background, a WEB-based integrated data processing system developed with the Java language is considered as a new system for the TRIAM-1M. The development of a data processing system with WEB-based technologies offers the following advantages.

### *1.1. Simple information sharing and high information accessibility*

WEB technology is convenient for the sharing of information and has become indispensable. Required information can be found immediately by tracing HTML links.

### *1.2. Easy participation in experiments*

When participating in experiments, researchers are only required to prepare a WEB browser using their familiar platforms and are not required to set up their own computer to access a data processing system. Moreover, researchers are not required to memorize complex operations in order to access information because the WEB-based integrated data processing system provides a uniform user interface via a user-friendly WEB browser.

### *1.3. Familiar technology, high scalability and reliability*

WEB technology has become increasingly familiar, and WEB browsers can be used to browse various types of files, such as PDF files, picture files, and movie files. This means that a data processing system based on WEB technology can be easily extended to systems that can treat pictures and movies. In addition, the data processing system developed with the Java language can be expected to have the characteristics of the Java language derived from the object-oriented language such as high maintainability and reliability. Moreover, since the Java language is a platform-independent language, the most appropriate platform can be chosen for the data processing system according to progress in computer technology.

## 2. WEB-based integrated data processing system for the TRIAM-1M

Recently, the Java language [4] has been adopted for various applications in the form of executable files, java applets, and server applications because the Java language is an object-oriented language that has an enormous library that is convenient for developing applications from small standalone applications to large-scale systems. This library provides various functions, such as graphical user interface components, transaction of multimedia files, network protocols, and database access. An integrated data processing system for the TRIAM-1M is organized by WEB-based architectures based primarily on the Apache WEB Server [5] and the Tomcat JSP/Servlet container [6] to provide server applications. Server applications are described by the Java language, which provides scalability, maintainability, and reliability because of its characteristics as an object-oriented language. The adoption of a server application based on the Java language offers the advantages of being platform-free, having tolerance with respect to an increase in the number of clients, and having a quick response to clients compared to systems based on interpreter languages such as CGI or PHP that must analyze each statement in a program each time the program is executed.

An overview of the WEB-based integrated data processing system is shown in Fig. 1. The installed fundamental services are:

- A management service for experiment planning.
- A management service for an experimental log.
- A management service for numerical data.
- A management service for plasma supervision.

### *2.1. Management service for experiment planning*

The arrangements and sharing of experiment plans between researchers is important for the effective execution of experiments. However, this often becomes troublesome in time-limited experiments because there are too many researchers involved in the experiments to arrange and share experiment plans. On the TRIAM-1M, a service to administrate experiment plans on a server is installed. This enables all researchers to browse experiment plans using only a WEB browser. In addition authorized researches can edit experimental plans via the WEB. This service may contribute to the arrangement and sharing of experimental plans for more effective execution of experiments.

The document data of experiment plans are stored in the familiar form of an XML (extensible markup language) data file. The advantage of the XML format lies in its flexibility, whereby the data format can be defined freely and hierarchically. Thus, the document data is easily arranged systematically and can correspond to the sudden modification of specifications, such as the requirements of the addition or deletion of items. These XML files are treated using the document object model (DOM) parser of the Java language and are transferred to the WEB document dynamically by the Tomcat JSP/Servlet container. Researchers can browse and edit this XML file via a WEB browser without considering the structures of the XML data file.

### *2.2. Management service for an experimental log*

Detailed analysis of data during an experiment is difficult due to time limitations. Experimental logs that record various parameters of measurement devices and comments on each plasma discharge are important for conducting a detailed analysis after an experiment. With regard to the TRIAM-1M, these experimental logs were previously stored individually by the researchers who managed the measurement devices. As such, experimental logs tended to become scattered and lost,

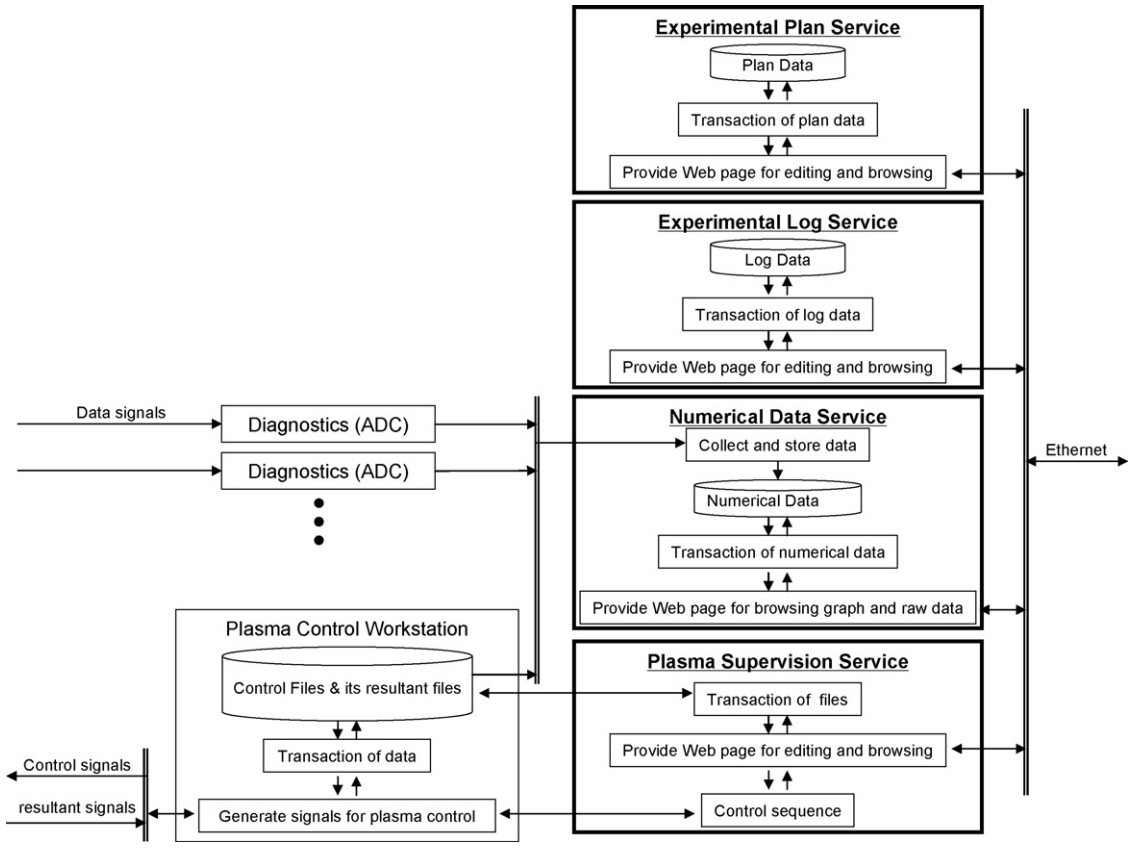


Fig. 1. Overview of the WEB-based integrated data processing system. All information can be accessed by researchers through a WEB browser. Each service is related to every other service by HTML links.

which caused trouble with regard to detailed post-experiment analysis.

To avoid such a situation, it is preferable that experimental logs are administrated intensively on a server. This can be realized with the installation of a service that enables researchers to browse and edit the experimental logs on a server using only a WEB browser. In the TRIAM-1M, this service is composed of an Apache WEB server, a Tomcat JSP/Servlet container, and a MySQL relational database [7]. The experimental logs may be edited simultaneously by a number of researchers and may have many opportunities to be retrieved for the record of past experimental logs. Hence, this service should have the functions of transaction processing and search capability. In addition, the utilization of a Relational DataBase Management System (RDBMS), such as MySQL, that has these functions inherently is required. MySQL is well known and is the most popular open-source database. Since the Java DataBase Connectivity (JDBC) which is the API that is required for connection to MySQL by Java language, is provided by the MySQL WEB site, the Java language is useful for the manipulation of MySQL, and the cooperation between MySQL and the Java language provides an efficient development environment in the sense that there is no need to use particular statements to access the RDBMS. Furthermore, this service has functions to record the time of plasma discharge automatically and to display the experimental log of the last shot number by default, in synchronization with other services. Thus, this service contributes to preventing the loss of experimental logs, preserving the record with certainty, and making it easy to refer to past experimental logs.

### 2.3. Management service for numerical data

Measurement data are normally stored in individual measurement instruments. In order to browse measurement data, researchers must access individual measurement instruments that have different user interfaces. This imposes a burden on researchers. Furthermore, data stored in individual measurement instruments tend to become lost. Therefore, measurement data must be stored systematically and in one location, and data browsing should be performed using a uniform user interface. In the TRIAM-1M, a service to provide measurement data to researchers in the form of graph charts or numerical text via a WEB browser is developed and installed. Fig. 2 shows a sample WEB page of this service. This service also monitors a workstation for plasma supervision and various measurement instruments and systematically gathers measurement data stored on various measurement instruments during plasma discharge or after plasma discharge in order to prevent measurement data from being lost. Depending on the plasma discharge duration, an average of approximately 60 Mbytes of measurement data is transferred to the server and stored for every shot.

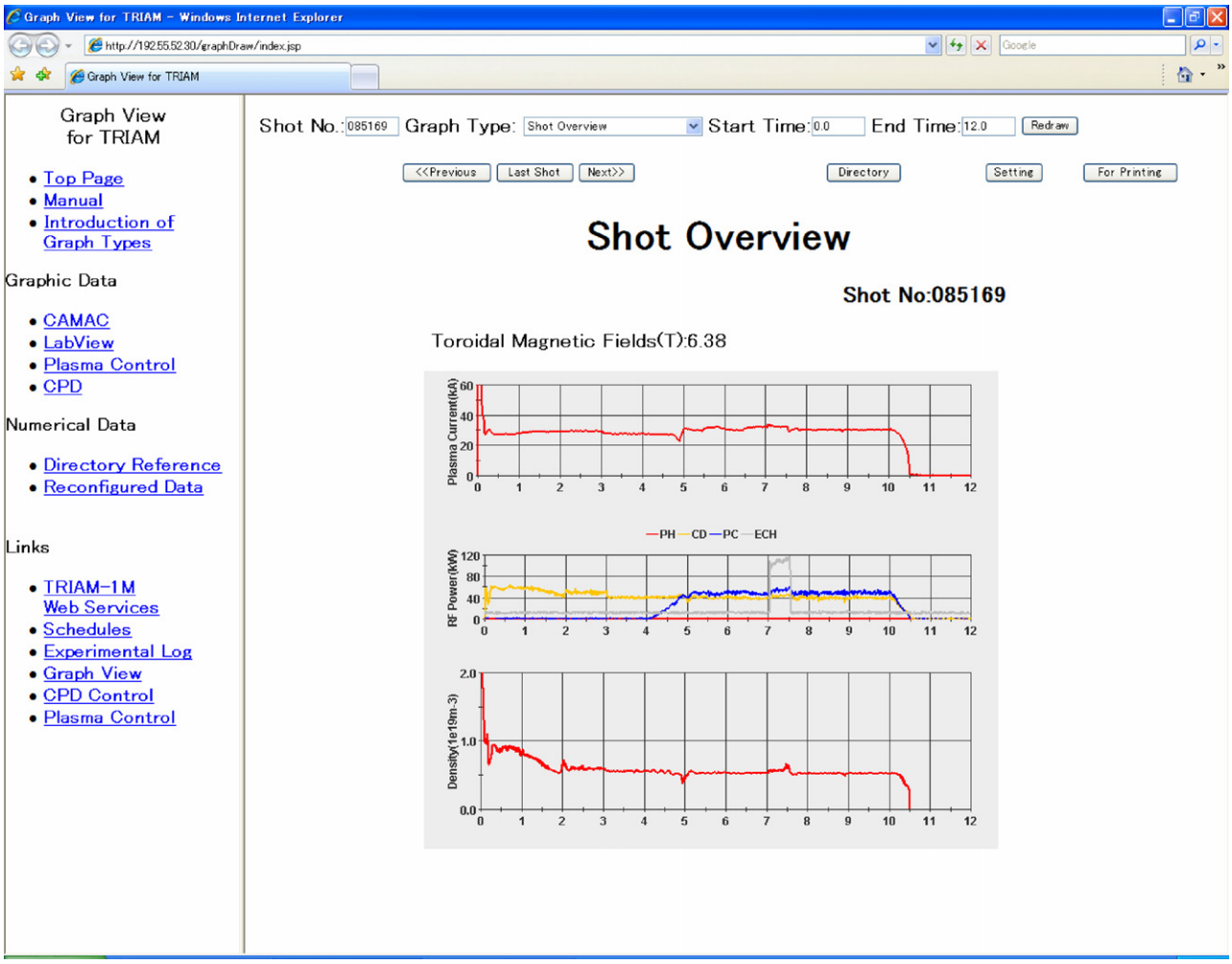


Fig. 2. Snapshot of a WEB page for a management service for numerical data. All researchers can browse the numerical data through a WEB browser.

This function is realized by an Apache WEB Server, a Tomcat JSP/Servlet container, and a Java Applet. The Tomcat JSP/Servlet container receives the requirements stated by the researchers and then calculates and prepares the required chart data or numerical text data. This data is then provided via the WEB. Although this service does not provide functions for analyzing measurement data on the WEB, each user can analyze the numerical data using preferred analysis tools because the numerical text data can be downloaded using a WEB browser. For the drawing of graph charts, the ready-made Java Applet is utilized. The Java Applet is software that is delivered in the form of Java byte code to a WEB browser and is run in a WEB browser. Since the numerical data and Java Applet are delivered to client PCs, and the graph charts are drawn on client PCs, modifications of graph charts such as the enlargement or plot styles can be realized without accessing the server. Thus, the utilization of Java Applet enables a server to reduce the computational loads.

### 2.4. Management service for plasma supervision

In order to allow researchers to concentrate on executing their experiments without the need to learn how to operate the plasma discharge system, a simple user interface is important. A graphical user interface (GUI) based on WEB browsing technology is provided in the plasma supervision system, which was previously operated via a character-based user interface. In the TRIAM-1M experiments, experimental parameters, which control the main plasma discharges but not the subsystems, were previously described as text files that were stored in the workstation for plasma supervision. These parameters, including plasma position, coil current, gas puff timing, gas puff volume, RF heating power, and RF heating timing, but not the vacuum, water cooling or liquid helium systems of the superconductor, were edited for every plasma discharge. With previous supervision system, these text files ware manually downloaded and uploaded by FTP protocol using common FTP client programs and were edited with normal text editors. This process imposed a burden on researchers and the entry of parameters was difficult because of the character-based user interface.

Therefore, a service to provide a graphical user interface (GUI) based on WEB browsing technology is developed. Fig. 3 shows a sample WEB page of this service. This service enables researchers to edit experimental parameters along with their plots via a WEB browser and to exchange experimental param-

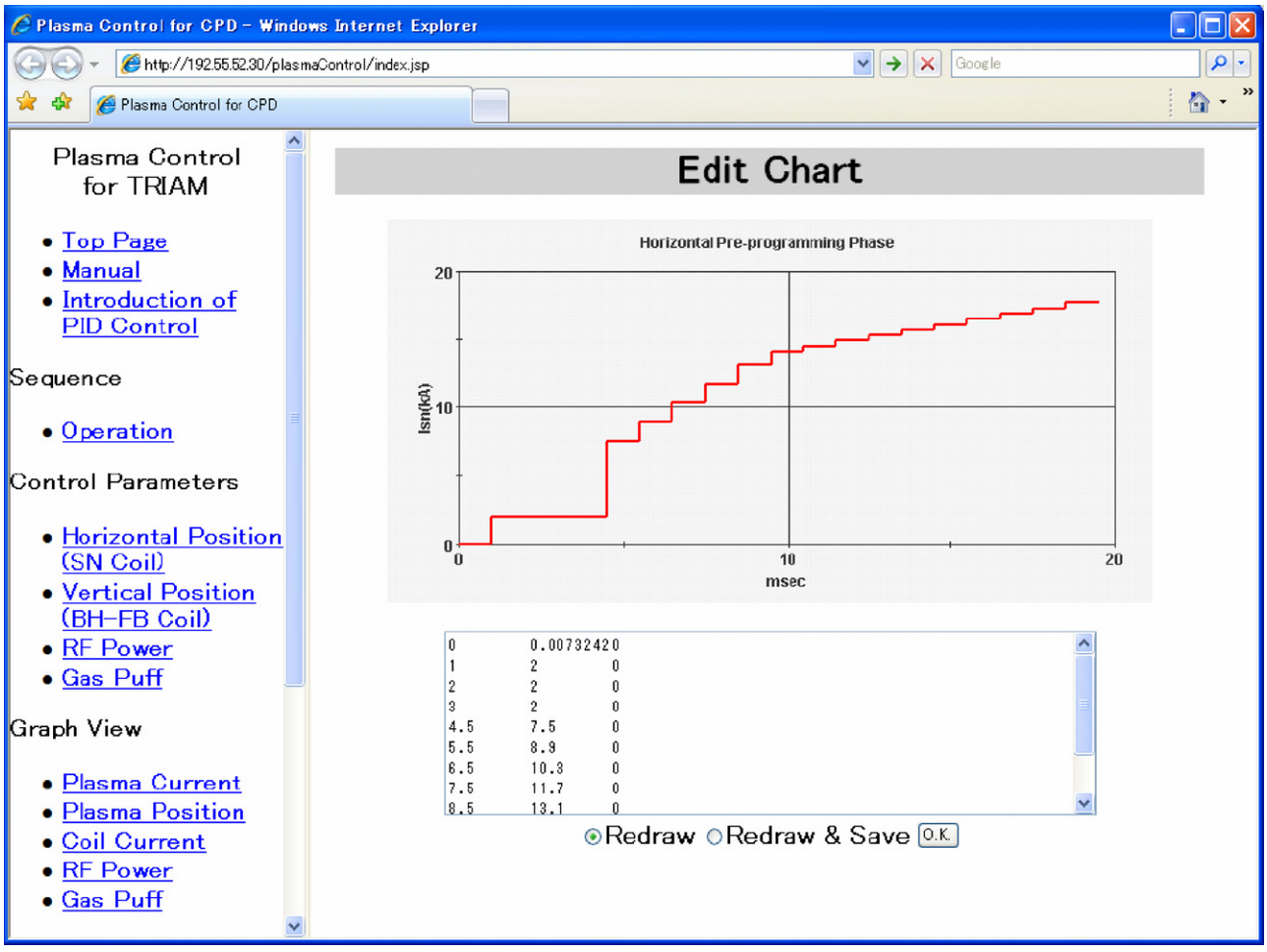


Fig. 3. Snapshot of a WEB page for a management service for plasma supervision. Researchers can supervise and control plasma through a simple user interface via a WEB browser.

eters with the workstation for plasma supervision in the FTP protocol. In addition, this service administrates the shot number and sequence status, such as the countdown time of plasma discharge, and distributes this information to researchers via a WEB browser. This service also enables researchers to activate or terminate the sequence of plasma discharge by WEB browser.

This is achieved by an Apache WEB Server, a Tomcat JSP/Servlet container, a Java Applet, and JavaScript. The Java Applet is used to draw the graph charts in the same way as the management service for numerical data. To communicate with the workstation for plasma supervision in the FTP protocol, an FTP client for this service is required and is coded by Java language. This coding is possible because the Java language has libraries that manage the network socket. In order to display the countdown time on the WEB browser, since accesses to a server to obtain the countdown time every second impose substantial loads on the server, the countdown is required to be executed on client PCs once the countdown time is obtained. JavaScript is a scripting language embedded in HTML pages and runs on the client PCs. Thus, in this service, JavaScript is used for the countdown and the display of the countdown time on the WEB browser to reduce the computational loads on the server.

### 2.5. *Integration of these services*

Currently, the proposed WEB-based integrated data processing system is composed primarily of two web servers. Management services for experiment planning and an experimental log are installed on the same Windows-based web server, and the other services are installed on another Linux-based web server. Since each service is composed of standard languages and techniques (Java, Apache WEB server, Tomcat JSP/Servlet, and MySQL relational database), this WEB-based integrated data processing system can be managed easily by system administrators. In addition, if one service imposes a burden on one WEB server, this service can be separated from the WEB server and installed on a new highly capable WEB server of any platform because of the utilization of platform-independent techniques.

At present, for security reasons, these services are available in a local area network (LAN) of the TRIAM-1M, and are related to each other by HTML links that are created dynamically by server applications, as shown in Fig. 1. This enables researchers to obtain the required experimental information promptly from any location and at any time over the LAN by tracing HTML links.

## 3. Summary

A WEB-based integrated data processing system that provides management services of experiment planning, an experimental log, numerical data, and plasma supervision, is constructed for the TRIAM-1M. Researchers can participate in experiments by simply preparing a WEB browser using a familiar platform, and the uniform user interface allows researchers to concentrate on carrying out experiments without considering system operations.

All of the services are related by HTML links, which are created by server applications. In addition, researchers can promptly obtain required information from any location at any time over the LAN of the TRIAM-1M by tracing HTML links. Therefore, this WEB-based integrated data processing system contributes to consensus building among researchers and promotes effective execution of experiments by allowing effective information sharing, including experiment planning, an experimental log, numerical data, and plasma supervision.

By making this WEB-based integrated data processing system available on the Internet, remote participation and remote operation of experiments is possible because systems based on WEB technology can easily utilize existing infrastructure, such as the Internet. However, in this case, the system must be equipped with a user authentication or resource authentication function in order to avoid conflicts among users. These are areas for future study.

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