DIAGNOSTIC SYSTEM USING JAVA APPLET AND DATABASE FOR HIGH ENERGY ACCELERATORS

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Abstract

The Diagnostic system has been designed and implemented using Java applet for high energy accelerators. The system was implemented on PC computers running under WindowsNT4.0, and SUN workstations under Solaris operating system. The system allows to diagnose the accelerator using Java Applet. The system provides functionality of accessing the database in which operational and control data of the accelerator are automatically stored. The operator can, if a failure occurs in the accelerator, diagnose the accelerator in the vicinity of the faulty accelerator component, resulting in greatly reducing shutdown time caused by the malfunctioned accelerator component. The design and implementation of the system is described.

1 INTRODUCTION

High energy accelerators comprise a large number of accelerator components and sensors to be controlled, including digital I/Os and analogue I/Os. The components involve a number of actuators, vacuum valves, cooling-water flow sensors, vacuum sensors, pneumatic-pressure sensors, atmosphere sensors, radiation-safety interlocks, vacuum-pressure gauges and valve-driving units.

There are twenty-two synchrotron radiation beam lines at the 2.5-GeV positron storage ring, Photon Factory at the High Energy Accelerator Research Organization. These beam lines feed synchrotron radiation to the experimental hall where experiments, such as surface physics, x-ray lithography, microscopy and crystal structure analysis, are simultaneously carried out. These beam lines are simultaneously in operation, providing intense synchrotron radiation beams. The pressures in the storage ring and the beam lines are maintained at an ultra-high vacuum (UHV) of less than 10^{-10} Torr to achieve a long beam lifetime, typically more than sixty hours.

A diagnostic system for such complex accelerator components is a key to R&D for the accelerator, providing important trace-back information regarding the physical behavior of its components.

In addition, from the view point of accelerator operations, the diagnostic system must allow the operators to easily diagnose the cause of a failure by retrieving operational information to reproduce the physical behavior that has occurred in the accelerator.

The System has a real-time capability to automatically store the database with all possible operational events of all vacuum valves/shutters and interlock signals, and all static operational data, including the pressures of the beam lines and the storage ring, and related operational data which represent the physical behaviors of the beam lines.

By retrieving any combination of operational data, the system must allow to reproduce the physical behaviors that have occurred in the accelerator.

2 SYSTEM DESCRIPTION

Figure 1 shows the block diagram of the diagnostic system. The diagnostic System has a database management system Oracle 8. Operational information regarding the beam lines is automatically stored to the Database [2]. The system comprises an applet on World-Wide-Web (WWW) browser and a proxy server on a SUN/UNIX workstation.

There are two categories of operational data available from the accelerator components: asynchronous event data and static data. The event data is obtained from pick-ups as digital ON/OFF signals generated by vacuum valves, shutters, driving signals for controlling the vacuum valves, and status signals of safety interlock signals.

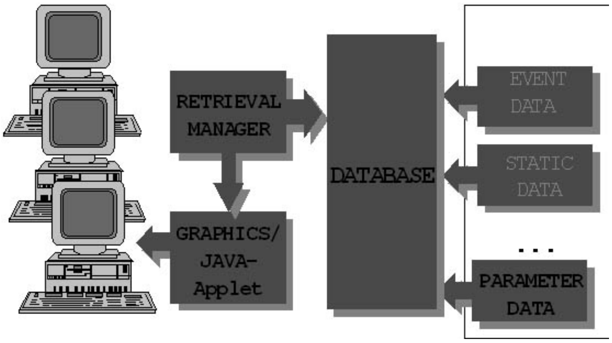

Fig1 Configuration of the Diagnostic System using DB

There are approximately 5000 pick-ups in total. Event data is obtained at any instance of time when a component changes its status.

The maximum rate of event signals reaches ~300 events/sec, which occurs just before and after the routine procedures for beam injection. The event signals are archived at an accuracy of 20 ms. This also happens when one of the interlocks is triggered in the case that an unexpected failure occurs .

The second category includes static data: static data comprises analogue values that are periodically measured at a specified interval of three seconds. The static data involves a beam current and pressure signals of the storage ring, measured at an interval of three seconds. The total amount data to be stored into the database reaches approximately 40 million items, consuming approximately 2 GB of disk space per year.

The configuration of an accelerator always tends to be modified in accordance with the physics experiments. This leads a new problem: how can we add a new category of a device/ component without adding a row to a table in the database, and keeping compatibility for future modifications of the accelerator. If you add a new row into a table, you must reorganize the data table, and great care must be taken to make it compatible with the existing archived data.

All event data are mapped to a tree data structure with a maxim of seven branch levels, which correspond to the category of devices and components (for examples, a valve category and radiation interlock category). The lowest branch level has leaves, i.e., the status of the component associated with a timestamp. Each level of the tree is mapped to a row of a table in the database, having a unique index, which allows efficient retrieval. This means that the table is normalized to have seven rows plus one row for a timestamp. Adding a new tree (or branch) to the existing tree is done by inserting a new column into the table without the need of reconfiguring the table at all. This does not violate the configuration of the table, indices, and the primary key.

In addition, If there is a failure in the accelerator, it is useful to be able to locate a faulty component in the field, i.e., at the vicinity of the accelerator. Particularly, there are a number of users for a synchrotron radiation facility who use an intense photon beam for their experiment at the same time. Shutting down the accelerator caused by a malfunctioned device should be avoided as much as possible, even for a half day.

Applet can provide functionality of retrieval viewer that provides a full set of menus to allow an operator to choose any combinations of operational data of the components to be retrieved.

In addition to Java's capability, due to its tight network-security mechanism than CGI, the Java Applet was chosen as the implementation language for the system. Needless to say, the system can be utilized on any WWW browser on a PC or a workstation that support Java Applet. Due to the security restrictions of the WWW browser, the Applet is not allowed to make a direct link to the control system, except for the host http server is always listening to a TCP/IP port, and (i.e., the UNIX workstation) from which the Applet is loaded. Thus the server works as a proxy server. The accepts a request from a WWW browser.

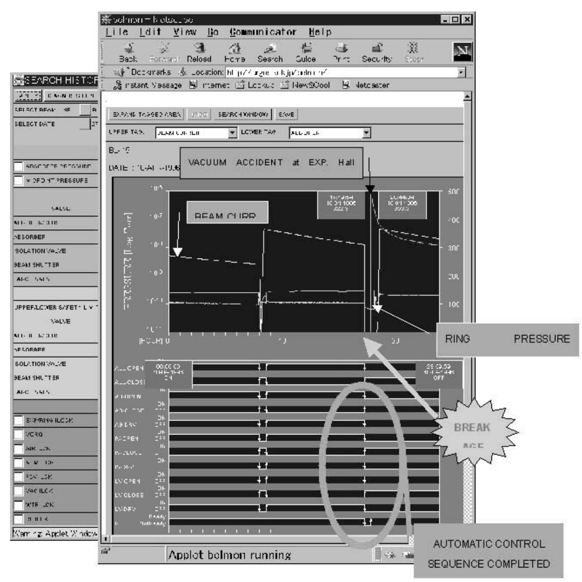

Fig.2 Retrieval result generated by the diagnostic system to inspect whether two accelerator components are functioning properly.

When invoked, the WWW browser on the PC loads the Java class library of the system from the http server on the UNIX workstation through the network. After invoked, the system establishes a connection with the proxy server on the UNIX workstation across the network. As shown in Fig.2, the operator can specify operation information of the accelerator components to be concerned. The system composes a request message associated with the operator's choice.

The packet includes a list of components and time information to be concerned. Then, the system sends the request message to the proxy server on the UNIX workstation using a socket communication, and wait for a reply from the proxy server. Upon receiving the request, the proxy server relays it to the server, inquiring status information on the accelerator components. After authenticating the contents of the request, the server fetches operational information and control data from the control systems, for example, the control system for the synchrotron radiation beam lines [1]. The server replies to the proxy server by transmitting the operation information to the proxy server. The system can display the operational and control information on the WWW browser at the console screen. For security reason, the proxy server accepts a request from PCs and workstations that have been registered to access.

The retrieval is done by an SQL query manger that communicates with the Oracle Database using stored-procedures through an SQL-Net driver

Figure 2 shows an example of how a water-cooled photon mask and an UHV valve are inspected using the diagnostic system, showing the retrieval result of a weekly operation when an unexpected pressure rise in the storage ring. The upper window indicates traces of the beam current and UHV pressures in the 2.5 GeV storage ring and beam line. The lower window is correlated to the upper window area, showing trace-back information of the photon-mask's status and the vacuum valve, including the status of Open/Close signals and the driver's signal. Any region on the screen can be panned by dragging the four boxes on the both corners to scrutinize details concerning how these are functioning properly, or to locate a malfunction part.

When there is a failure of an accelerator component during an accelerator operation, the operators can inspect the faulty component of the accelerator and the cause of the failure using the diagnostic system in order to recover the accelerator. It then fetches operational information and control data from a remote host computer. Finally, it displays the operational and control information on the WWW browser as the console screen.

3 CONCLUSION

The diagnostic system using Java Applet and a database for high energy accelerators has been discussed. The system has been shown reliable in operation. The system allows diagnosing the cause of a failure that has occurred in the numerous accelerator components. The diagnostic system provides valuable information regarding a faulty component and related physical components that would suggest the cause of a failure. By using the diagnostic system, the operator at the control room can easily locate any faulty component, and recover the accelerator component quickly. This system can be extended for various kinds of accelerator components.

4 ACKNOWLEDGEMENT

The authors wish to express their gratitude to the staff of the Photon Factory Light Source Division for operating the beam liens and the storage ring.

5 REFERENCE

[1] N.Kanaya, S.Asaoka and H.Maezawa, "Operational Logging System Using the Database for the Synchrotron Radiation Beam Lines at the Photon Factory," Proc. of Particle Accelerator Conference 1997, Vancouver, Canada, Mar.