

Mission Critical Operation Archiving System Using A Database For Synchrotron Radiation Beam Lines At The Photon Factory

Noriichi KANAYA, Seiji ASAOKA and Hideki MAEZAWA

Photon Factory
High Energy Accelerator Research Organization (KEK)
1-1, Oho, Tsukuba, 305,
Japan

Abstract

The mission critical operation archiving system has been designed and built using the Oracle database for the twenty-two synchrotron radiation beam lines at the 2.5 GeV positron storage ring at the Photon Factory, where X-ray/VUV synchrotron radiation experiments are simultaneously carried out. When any one of beam lines is malfunctioning, neither injecting the 2.5 GeV beam into the storage ring nor operation of the ring is allowed due to the radiation safety reason. The system is designed for critical operation of the synchrotron radiation beam lines to provide a quick recovery from a failure, allowing a long term operation. The system has real-time capability to automatically store the database with all possible operational events of all vacuum valves/shutters and safety 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 allows to reproduce the physical behaviors that have occurred in the beam lines. The total number of items to be inspected by the system is over 40 million in order to obtain a correlation between the faulty component and other physical components that suggests the cause of the failure. With the aid of the system, the operator at the control room can easily determine the faulty component, and recover the accelerator component.

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 is a diagnostic system for such complex accelerator components that provides important trace-back information regarding the physical behavior of its components. The diagnostic system allows 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.

In order to provide operational data of the accelerator and the beam lines, the archiving system employing a database management system has been designed and implemented, particularly for synchrotron radiation beam lines.

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.

2. SYSTEM DESCRIPTION

Figure 1 shows a block diagram of the archiving System. The database management system employed is Oracle 7. Operational information regarding the beam lines is automatically stored to the Database [1].

These beam lines are automatically controlled by a distributed control system which comprises twenty two microcomputers and a VAXstation 4000/90, running under VAX/VMS through an optical-fiber network with a star configuration.

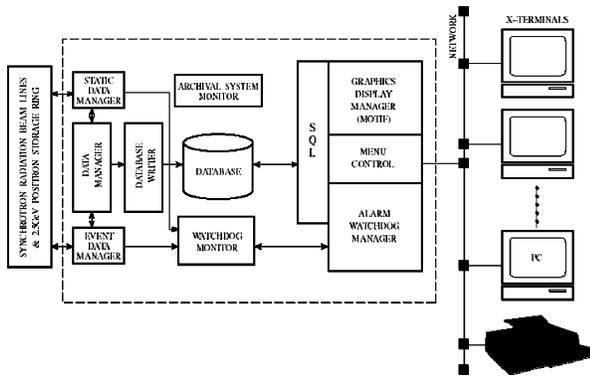


Fig.1 Block diagram of the archiving system for high energy accelerator components.

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 and READY/NotREADY signals generated by vacuum valves, shutters, driving signals for controlling the vacuum valves, and status signals of safety interlock signals. There are approximately 2000 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 at 9AM 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.

The retrieval viewer is a Motif-based 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. The retrieval viewer has a 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 archiving system, showing the retrieval result of a weekly operation to interpret 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.

3. CONCLUSION

The mission critical archiving system using the 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 archiving system provides valuable information regarding a faulty component and related physical components that would suggest the cause of a failure. By using the archiving 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. The system will be ported to a UNIX platform.

4. ACKNOWLEDGEMENT

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

5. REFERENCES

- [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. 1 Fig.2 Retrieval result generated by the archiving system to inspect whether two accelerator components are functioning properly.

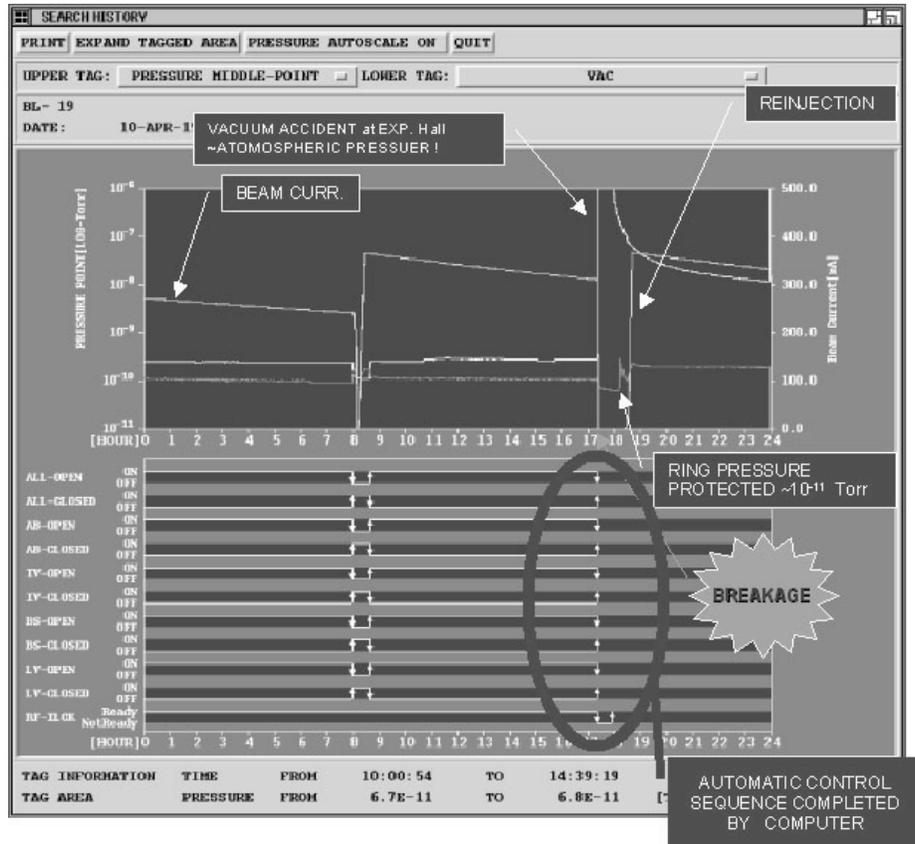


Fig.2 Retrieval result generated by the archiving system to inspect whether two accelerator components are functioning properly.