

Java Online Monitoring Framework ¹

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Abstract

An online monitoring framework has been written in the Java Language Environment to develop applications for monitoring special purpose detectors during commissioning of the PEP-II Interaction Region. PEP-II machine parameters and signals from several of the commissioning detectors are logged through VxWorks/EPICS and displayed by Java display applications. Remote clients are able to monitor the machine and detector performance using graphical displays and analysis histogram packages. In this paper, the design and implementation of the object-oriented Java framework is described. Illustrations of data acquisition, display and histogramming applications are also given.

I. INTRODUCTION

High-level graphical user interfaces (GUI's) are used extensively in operating and monitoring High Energy Physics accelerators and detectors. Their use allows operators and scientists to quickly interpret the state and performance of the machine or experiment. Integrated control system architectures require that these processes communicate effectively with several different concurrent processes which coordinate various activities, such as occurrence reporting, database transfers or other operations. Performance, modularity, portability and ease of use are important issues in designing effective tools; and, in commissioning applications, seamless integration of a collection of distributed systems is critical.

Figure 1 illustrates a typical arrangement of monitor screens, each with a number of display windows, receiving data from different sources. In this case, the sources are fully compatible Internet servers. To minimize network traffic, a framework allows for the coordination of the different displays within each application. After being instantiated by the package manager, which determines their appearance, the window processes pass their monitor data requests to a broker that retrieves the data from the appropriate servers.

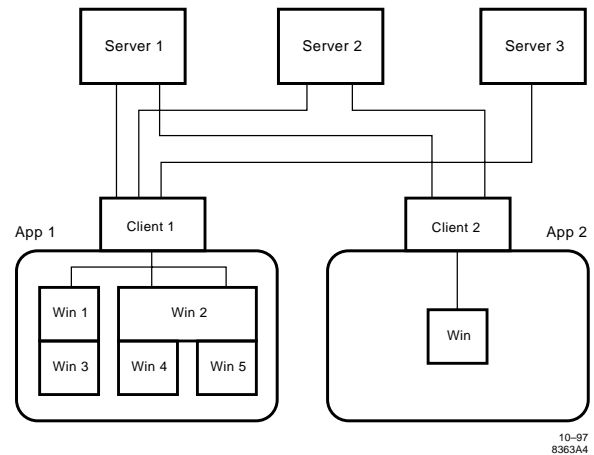


Fig. 1 Illustration of several servers providing monitor data to different client applications, each with a number of display windows. A framework coordinates the actions of the processes within each application.

A. Commissioning Monitor Applications

During the commissioning of the PEP-II High Energy Ring (HER) in Fall 1997 and of the BaBar Interaction Region (IR) in 1998, a number of PEP-II parameters are being monitored as the machine is brought into operation, while an extensive suite of particle detectors are being employed to measure beam backgrounds. A good understanding and reduction of the backgrounds and the attendant radiation exposure will be achieved through validation of detailed Monte Carlo simulations and through dedicated machine experiments. For example, backgrounds due to synchrotron radiation and beam losses in the IR straight section are being measured using an array of PIN Diode detectors. Several other devices, in many cases with their own independent data acquisition systems, are now in place or will be installed to measure different aspects of these backgrounds. In addition, environmental quantities will be measured within a central detector monitoring system. Several monitor display screens have been provided to allow the experimenters to correlate background measurements with machine conditions, to develop and integrate beam loss monitors, and to calibrate and protect the instruments themselves.

Monitor applications implementing the Online Monitoring

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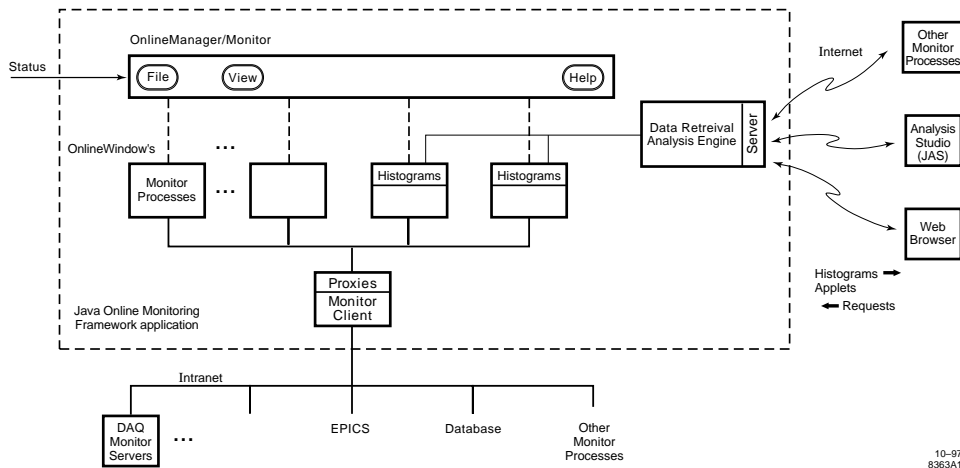


Fig. 2 Conceptual diagram of a complete Java Online Monitoring application, whose components are shown within the dashed box.

framework described here have been written to integrate the monitoring tasks and to provide common graphical representations. The Java language allows these applications to operate anywhere on the Internet, on almost any platform, with little programming overhead and no porting obstacles.

B. Java Language Environment

The Java Language Environment, developed by Sun Microsystems, offers several advantages in implemented such a disperse data acquisition system. It's object-oriented methodology allows the development of reusable components, graphical user interfaces are easy to implement and it's distributed techniques (such as Remote Method Invocation) provide an excellent software environment for building multitiered network applications.

The Java language itself has the look and feel of C/C++, and is fully object-oriented (see Ref. 1,2). As an interpreted language it allows for quick turn around during program development and for complete platform independence. Graphical components, separate threads of execution, and easy-to-use, highly sophisticated interfaces to the network are all built into the language, allowing the straight-forward implementation of broadly-distributed client/server applications and informative graphical user interfaces.

Portable Java display applications, called Applets, can be executed on any Java-enabled browser. The Java Virtual Machine (JVM) embedded in the browsers allows the Applets to operate on any platform. Similar JVM's have been provided by Sun, Microsoft or machine vendors to interpret compiled Java classes, which are machine-independent. Just-In-Time compilers, available for most platforms to provide machine level code, allow Java to reach computing speeds of established languages such as Fortran, C and C++.

II. ONLINE MONITORING FRAMEWORK

The Java Online Monitoring Framework has been written to satisfy some of the real-time requirements for machine

commissioning and to provide for remote monitoring. This modular framework allows personalized applications to be assembled with different collections of standard displays. Within the framework one class is used to coordinate the data requests for the different displays and to retrieve the data from several different servers as illustrated in Fig. 2. The framework schedules updates, imposing any control system status requirements, and monitors and reports errors in satisfying system requirements. Multiple servers can be created within a monitor application to provide extended remote monitoring.

A. Conceptual Design

A modular framework for multithreaded real-time processes has been chosen; an architectural diagram is shown in Fig. 2. A typical Online Monitoring application consists of the following components. A monitor thread (OnlineMonitor) to interact with the local control system and to monitor the performance of update threads within each display processes. A client thread (MonitorClient) to gather requests for monitoring quantities and to retrieve them from the real-time system. And, several modules coordinated and displayed by the framework (OnlineManager) and its screen manager (ScreenManager). Each module (OnlineWindow) provides a separate interface and display to the user, but with a common (inherited) appearance and behaviour. As a separate subprocess, it updates displays and checks for errors at regular intervals. These windows include simple display or dialog windows, standard history plots, and histogram or histogram summary windows. A server process (MonitorServer) can be employed for remote monitoring over the Internet.

B. Java Implementation

The modelling, prototyping and implementation of the Online Monitoring framework is in progress. The following base classes, reference applications and utilities, described in this and the following sections, have been implemented.

The **OnlineManager** class provides the template for the top-level framework coordinators. Sub-classes for different detector subsystems or for various monitoring applications

are used to define the contents of each package; that is, the collection of monitor threads and display windows within an application. The standard constructor creates a screen manager, a monitor to sequence operations within the package, and the requested number of windows. The **ScreenManager** sets the location and size of selected windows from predetermined layouts, and in the future will allow resizing and saving of modified layouts using the Java Bean component technology.

The **OnlineMonitor** thread of standard Online Monitoring packages: recognizes the state of the local data acquisition system in controlling the operation of framework windows and threads, outputs any reportable occurrences to the local logging system, provides a common time stamp and maintains a continually responsive thread of execution.

Following specifications defined in an **AbstractWindow** interface, the **OnlineWindow** class defines standard monitoring display objects, their appearance and their action responses and update methods. The standard constructor creates a new window, incrementing the window count, displays the window and starts up the window's update thread. Normally each window thread updates its display every few seconds at reduced priority compared to the application's **OnlineMonitor** thread.

The data transport for the monitor is organized in two classes, a subscriber [**MonitorClient**] and a publisher [**MonitorServer**]. These classes take care of the communication and bookkeeping of data requests within the framework. A monitoring program then uses the **MonitorClient** class to subscribe to various remote channels, and to serve all **OnlineWindow**'s within the application. Online tasks can use the **MonitorServer** to publish current monitor readings or their accumulated history data. Data that can be published has to implement the **MonitorData** interface. This interface provides a **ToStream** function to serialize the data and add some bookkeeping information (time-stamp, sequence no,...).

The following classes inherit from **OnlineWindow**: The **OnlineFrame** class provides an interface for Applet's to operate within the framework, while maintaining the Applet's ability to be displayed within compatible browsers. Methods include: **display()** to get a screen location and display the frame, **getNumber()** to return the **OnlineWindow** number, as well as **thread init, start, stop** and **run** methods. **OnlineHistory** objects display online history plots. The **OnlineHistogram** class displays continuously updating histogram displays. Standard interfaces allow online monitoring classes to book and fill histograms which can be accessed and viewed remotely. **HistogramSummary** objects display a summary of the histograms being accumulated.

III. REFERENCE APPLICATIONS

We give two reference applications for the PEP-II subsystem: One is a pure visual monitoring package, **IRMonitor**, which displays several windows in providing different views of the data. It includes instantaneous readings, graphical charts, and history plots of different time-averaged quantities. The other is a histogramming package,

PEPHistogram, which accumulates histograms and serves them up to remote analysis clients, with an optional histogram summary display.

A. An IR Monitor Display Package

In the sense of modular Online Monitoring applications, packages are collections of existing **OnlineWindow**'s for individual subsystems (e.g. PEP-II, PIN Diode, Straw Chamber, etc.). An IR Monitor package might include windows displaying PEP-II quantities and different commissioning detector summary windows to allow the correlation of detector effects with machine operation. Other packages might include different PEP-II quantities, detector windows or might just present a different focus. Different packages might actually be different representations of the same software collection. For this example we chose a PEP-II summary display, an Applet client display and two history plot windows, two PIN Diode history plots and a Straw Chamber points and line event display.

The **IRMonitor** class inherits **OnlineManager** methods and creates an IR Monitor package with the following **OnlineWindow**'s. A **PEPWindow** object uses the Java AWT **TestArea** class to display instantaneous readings of PEP-II parameters. The **PEPFrame** class displays a **PEPApplet** which charts the readings of several PEP-II parameters in different colors that can be high-lighted by selecting the corresponding label. **PEPHistory** plots record the time-averages of PEP-II readings. Two **PINHistory** plots display raw temperature sensor or leakage current readings from the PIN Diode detectors, and a **SCWindow** object shows different views of the points and lines fitted to hits in the Straw Chamber. The PEP-II readings are obtained as **PEPData** objects from a Java RMI server, **PEPServer**. The PIN Diode data packets and Straw Chamber event types are provided by DAQ Monitor servers described below. In a running application, the **OnlineManager**, **OnlineMonitor**, **ScreenManager** and **OnlineHelp** can be accessed through a menu bar window.

B. A PEP-II Histogramming Package

This package accumulates histograms and serves them up to remote display and analysis clients. An online histogram summary showing the contents and under/overflows is provided for quick visual checks of the accumulation process. The **OnlineMonitor** thread is designed to allow the control of histogramming during machine fills.

The **PEPHistogram** class inherits **OnlineManager** methods and creates a PEP-II histogrammer process and a histogram summary window, with no other displays. The **PEPHistogrammer** books several histograms and fills them as updates become available. A **HistogramServer** is created to allow the histograms to be accessed remotely using the Java Analysis Studio described below. The **PEPHistSummary** inherits methods from **HistogramSummary** to display the booked histogram contents. Normally, once the histogram accumulation has been checked, the **PEPHistSummary** display can be dismissed at any time. Using the remote interface, Fig. 2, clients can fetch and display existing histograms, and

may request that new histograms be booked and filled as monitoring continues or that new histograms be made from recorded quantities.

IV. DAQ AND MONITORING SYSTEMS

Remote monitoring has been provided for some of the PEP-II commissioning devices. The data acquisition and monitoring systems for the PIN diode detectors and the straw tube chambers are described below.

A. PIN Diode Data Acquisition and Monitoring

A sophisticated data acquisition and monitoring system has been written in Java for the PIN Diode detectors, Ref. 3. The detectors and associated temperature sensors are read out by a VxWorks based system which sends out data on a TCP/IP socket, Fig. 3. The data acquisition system receives the packets, provides real-time **HistoryPlot** displays and writes the data to a local file on a Solaris UltraSparc station. The DAQ process includes servers which respond to remote run control commands and which transmit data packets to remote clients. Clients can be used remotely to check the DAQ status, to print ongoing message logs, to display real-time HistoryPlot's or to access processed data files.

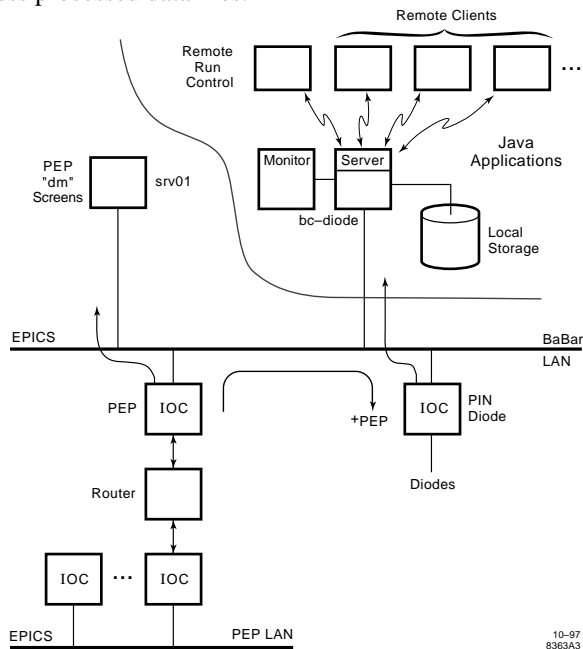


Fig. 3 PIN Diode Data Acquisition and Monitoring System

B. Straw Chamber Data Acquisition and Monitoring

The data acquisition for the Straw Chambers, written in C, reads hardware through a GPIB bus, fits for tracks and writes both the raw and reconstructed data to a local file on an AIX/3.2 RS6000 platform, Fig. 4. Besides the in-line monitoring, a forked subprocess pipes a sample of the data through a TCP/IP socket for remote monitoring. The **StrawChamber** DAQ Monitoring system, written entirely in Java, consists of a client monitor process which connects to the DAQ child process to receive the event sample and then creates servers to handle

individual requests from remote clients. Clients which request different types of StrawChamber data, over the network, have been written to provide various event displays. For each event, only the requested data packets are sent. The remote clients perform event handling and display on Sun, IBM, HP, Dec, Windows PC or Apple platforms.

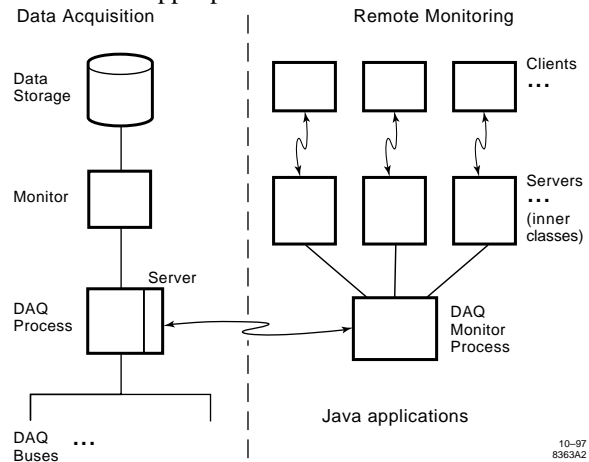


Fig. 4 Straw Chamber Data Acquisition and Monitoring System

V. JAVA UTILITIES

The following utilities have been developed as separate Java class libraries, called packages.

A. History Plots

The facility for making time history plots, Ref. 3, consists of classes to both maintain and graph a history record. In their constructor method, **HistoryRecord** objects are divided into time slices and attached to a particular graph. The size and title of **HistoryGraph** objects are set by their constructor, while appropriately named methods set the grid spacing and label the ordinate axis.

B. Histogram Facility

A hep/analysis package, Ref. 4, is used to partition, book and fill histograms. A named **HistogramServer** object is created to allow remote access to the histograms. Each histogram, booked by constructing a labeled **Histogram** object, is then filled with an appropriately named method.

C. Java Analysis Studio

The Java Analysis Studio is being developed, Ref. 4, to allow remote viewing of histograms and Applets. A JAS HistogramServer, such as the one included in the Java Online Monitoring Framework shown in Fig. 2, makes histograms available remotely during online monitoring or analysis processes. Histogram objects can then be accessed and displayed using the Java Analysis Studio which allows rebinning and fits to the histogrammed data. Requests for new histograms or for reanalysis of recorded data can be sent back from the analysis studio to the server which may employ an analysis engine to reanalyze data. Applets which present histograms or real-time data can be obtained from the remote

server and displayed.

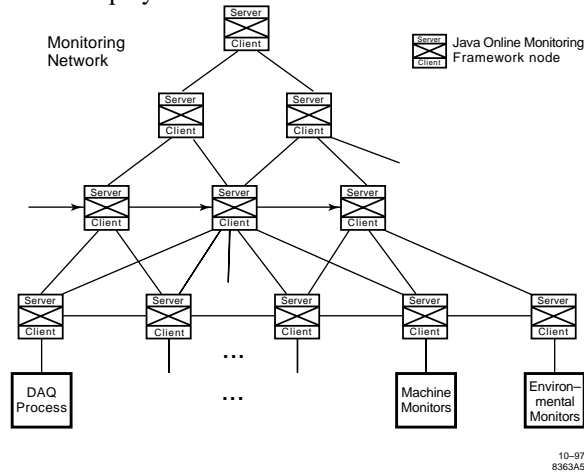


Fig. 5 Network configuration for a Java Online Monitoring application with a multitiered client/server architecture.

VI. FURTHER APPLICATIONS

Client/server applications, built within the framework described here, make efficient access to multiple sources of incoming data, and handle requests from any number of remote clients. At each node of a multitiered client/server architecture, such as shown in Fig. 5, these client/server applications may each have multiple data monitoring and display processes. At any level, the framework may impose common state conditions to insure a uniform monitoring environment. Such a design provides a scalable model for developing complete real-time monitoring or processing solutions.

VII. ACKNOWLEDGEMENTS

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