An Open Distributed Monitoring and Control System

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A distributed computer monitoring and control system constructed at the Fermilab's Development and Test Department is presented. The architecture of the system, the mechanism of distributed communication and synchronization, the real-time data base, the scan system, and the system graphical user interface are described.

Key words: Distributed systems; Monitoring and Control Systems

1 Introduction

The renewed Fermilab superconducting accelerator magnet R&D program as well as the process of phasing-out obsolete VAX-based systems created a need for a new monitoring and control system. Testing of superconducting accelerator magnets presents unique challenges for the data acquisition and control system design. A multitude of intrinsically different variables must be measured concurrently with varying accuracy, speed, and dynamic range. The system is required to have guaranteed real-time response for control, system protection, and capturing transient system states. At the same time the R&D environment calls for a system that is flexible, multi-purpose, easy to reconfigure or modify, extensible, and scalable. In response to these requirements an Open Distributed Monitoring and Control System (ODMCS) has been developed.

2 Architecture

The ODMCS is an open software platform for building multi-user distributed control and monitoring as well as test and measurement systems. The system is a configurable set of communicating distributed objects. The ODMCS is multiplatform: graphical user interfaces and data analysis parts run under Unix while data acquisition and direct control run on so-called *process control computers* under the VxWorks real-time operating system. Most of the system components are available on both platforms and there are plans to extend this functionality into the Windows-NT environment.

The core of the ODMCS-based system is composed of the following components:

- real-time data bases,
- various type scans,
- universal data display utilities,
- animated schematic displays,
- system control panels, and
- event and message based communication subsystem.

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The system is open and its functionality can be extended or modified at three different levels: a) module level, by selecting or implementing new modules that plug into an event-based software communication bus; b) program level, by writing new modules that use supplied APIs to access system resources; and c) configuration level, by updating the system configuration to modify data acquisition, hardware configuration, data processing, and control algorithms.

The ODMCS system is decentralized and, unlike in many other systems, no single computer assumes a supervisory role. As a result, the overall system is more fault tolerant.

3 Communication and Synchronization

The ODMCS offers transparent system-wide event-based communication and synchronization. Events are exchanged using a concept of a *software bus* where objects can communicate with each other without having direct knowledge of each other. In this scheme any active object (e.g., data acquisition scan) that wants to receive events registers its interest in specific types of events. Events are multicast to all interested parties in a local computer as well as in remote computers. Active system objects can be blocked on a selected set of events or can test for the presence of the "interesting" events. The mechanism of events is a primary way of synchronizing actions of all system active components, primarily all data acquisition scans and special measurement-type programs. The ODMCS also provides uniform message-oriented data access based on a client-server model of cooperative computing.

4 Real-Time Data Base

At the heart of the ODMCS is a fast memory resident *real-time database* (RTDB) located in each of the process control computers. The database provides transparent access to local and remote objects via names, indices, and object attributes. It contains a caching mechanism for remote objects and locking mechanism to control access to objects. Objects stored in the RTDB belong to various classes. The crucial class for operation of the system is the *process variable (PV)* class that represents objects containing either control parameters or values acquired from the process under control.

5 Graphical User Interfaces

The ODMCS system provides users with general purpose tools to select and display values and attributes of any set of process variables either graphically (trends) or numerically. The system also supports rapid development of animated process schematics for operators based on standardized access to process variables with absolutely no programming efforts. Viewing and analyzing historical trends is possible, too. An example of GUI is shown in Figure 1.

6 Scan System

Monitoring, control, and data saving features of the ODMCS are implemented through an elaborate scanning system offering coherent, device-independent I/O and powerful synchronization capabilities. The scan system links the real-time data base with the process under control by uniformly accessing devices and pseudo-devices and passing the data to and from the RTDB. Some of the scan system advanced features include both time-driven and event-driven data acquisition and control, PV-based or device-based scanning lists, data saving scans, and PID control scans. All scans and their attributes are user-configurable and can be monitored and manipulated in real-time. The data acquisition scans access both the VME and GPIB instrumentation buses. The system also transparently integrates PLC-

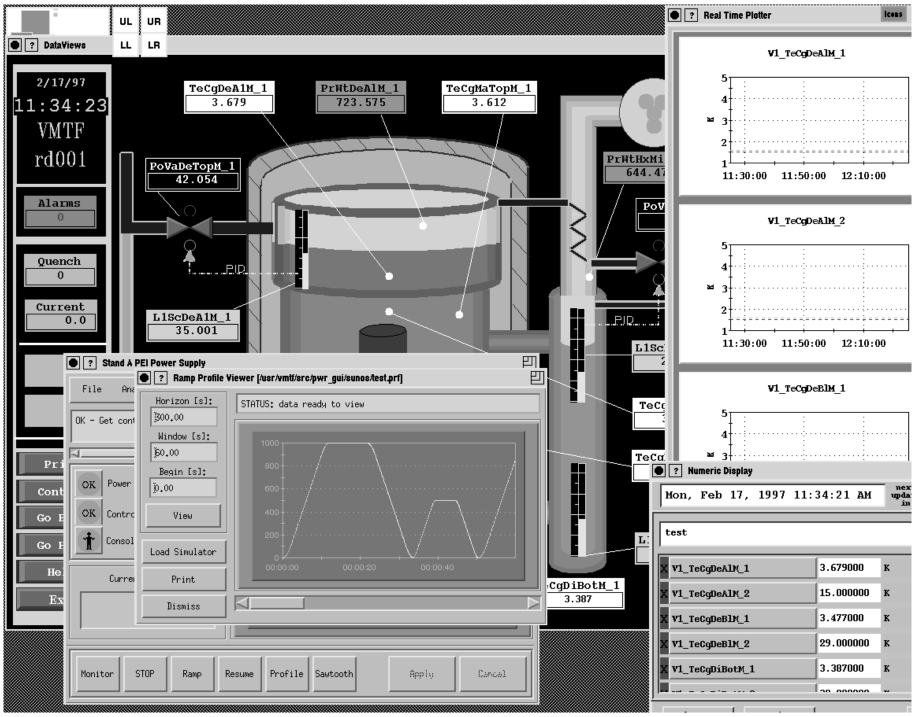

Fig. 1. Snapshot of ODMCS GUI.

based I/O systems.

7 Summary

The ODMCS system has been successfully applied to monitoring and control of the Horizontal and Vertical Magnet Test Facilities in the Fermilab Technical Division. The system is also expected to be used to control the Magnet Test Facility cryogenic plant.

Experience from running three systems constructed on the base of the ODMCS in a constantly changing R&D environment confirmed that although open distributed systems require more efforts to design and implement, the user benefits greatly from their flexibility and versatility during operation. Distribution and multi-user access allow for remote system diagnostics, operations, and maintenance, while openess of the system removes proprietary hardware limitations and allows creation of heterogeneous systems.