

# H1DCM - A NETWORK BASED DETECTOR CONTROL AND MONITORING SYSTEM FOR THE H1 EXPERIMENT

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## Abstract

From Oct. 2000 until July 2001 the H1 experiment at the e-p collider HERA has been considerably upgraded for higher luminosity running. The required modifications for the H1 detector control system have been the object of the H1 detector control and monitoring project. A variety of subsystems, some from the early 1990s as well as new subsystems with modern design and technology are to be controlled and monitored by a common detector control system. In order to reduce the manpower demand for operation and the burden on the on-site detector experts a common control system is proposed that is based on a commercial supervisory control and data acquisition system. In addition to the typical functionality of a modern control system, the choice for the product is driven by requiring a distributed network based system, support of Linux and WindowsNT, an object oriented modeling of the devices and the possibility of H1 specific implementations via an application programming interface. The control system for a CAEN based high voltage supplies, for the superconducting H1 magnet and for the H1 luminosity system successfully started operation in July 2001. Gradually further subsystems will be included. The aim is to enable a single person to supervise and control the experiment and its data taking and to allow remote access for experts. The basic design of the control system is presented and the experience during implementation and commissioning is discussed.

## 1 INTRODUCTION

After 8 years of operation the e-p collider HERA at DESY was upgraded for higher luminosity running in a shutdown starting at October 2000. At the same time the H1 experiment [1] was considerably upgraded and modified as well. The upgrade was successfully completed and the machine started up in July 2001, aiming for first collisions by November 2001 and regular luminosity operation from January 2002 onwards. During the upgrade several new subsystems have been implemented into H1 and some older systems have been modified.

To study the required modifications for the control system of the H1 experiment, the H1 detector control and monitoring project (H1DCM) was initiated [2]. Several approaches for a common control system were studied including the option of writing a complete control system from scratch in Java or C++. This finally resulted in the proposal to build the

common control system on the basis of a commercial supervisory control and data acquisition (SCADA) system. This was mainly due to the fact that limited personnel would not allow the project team to finish a Java based control system with all necessary ingredients in time for the new data taking period. The choice of the SCADA system used for H1DCM was driven by requiring a distributed network based system, support of Linux and WindowsNT, object oriented modeling of the devices, and an open architecture allowing H1 specific implementations via an Application Programming Interface (API).

An extensive study done at CERN for the Joint Controls Project [3] initiated for the LHC was used as a basis for the decision and PVSS-II [4] from the company ETM in Austria was chosen.

## 2 REQUIREMENTS

It is vital that a new control and monitoring system should reduce the diversity compared to the old control system. Modern controls should allow automatic action and recovery. Remote monitoring and remote expert intervention will improve the efficiency of the data-taking by faster or preventive action when necessary. Limited resources require the minimization of cost and manpower involved both for operation as well as during the development of the new control system. This results in a list of requirements for the new control system of H1.

- Most front-end electronics and hardware of older subsystems had to be kept in place and reused because it would have been too expensive to replace.
- Out-of-date parts of the control system, like old Apple Macintosh with NuBus, have to be replaced by some more modern systems to assure that the control system will survive at least the next 5 years without major change.
- The implementation of the new controls for older systems should be possible with the old controls in place to make the transition as smooth as possible.
- The design of the control system should allow the reuse of existing software that would otherwise require major efforts to rewrite. Therefore the control system should make use of the API to interface older subsystem controls easily via a well defined interface.

- The common control system should enable the running of the experiment under normal circumstances by one person, should perform standard actions automatically and inform experts and shift persons in case of unusual conditions.
- The system should allow experts to configure the controls for the subsystems easily and expert knowledge should be easy to implement into automatic actions.
- The amount of programming effort during the development of the control system should be kept small by the use of the functionality offered by the commercial SCADA system.

### 3 DESIGN

The design of the H1DCM system is based on the SCADA system PVSS-II. An overview of the PVSS-II structure is shown in figure 1. It is build as a set of separate processes or tasks, called managers, which communicate via TCP/IP connections. The communication is event driven to reduce network traffic. Around a central event manager which serves as a message dispatcher, several dedicated managers are grouped with specific functionalities, like database, device drivers, control script managers, APIs and graphical user interfaces (see ref.[4] for more details).

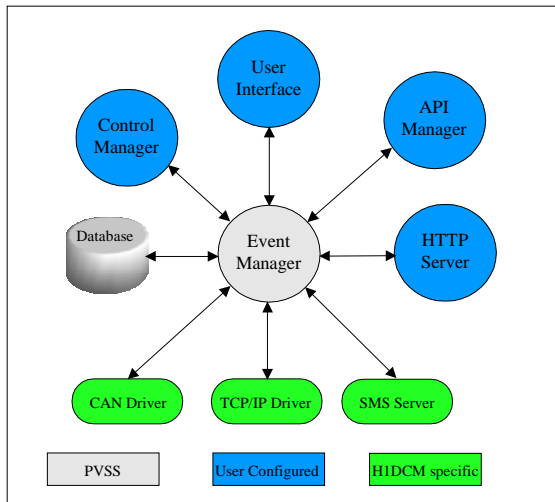


Figure 1: The basic structure of PVSS-II

Within PVSS-II complex devices can be modeled by so-called data point types (DPT) and data points (DP). A DPT defines the structure of a device type, and a data point is an instance of a specific physical device of this type.

By using references to another DPT inside a DPT definition it is possible to build complex devices out of basic types.

The graphical user interface in PVSS-II is built out of panels and the usual items needed for user interaction, like buttons, menus, text fields, tables, graphs. Scripts for complex actions may be attached to panels and the elements

inside a panel. The usage of references is also possible for panels, e.g. it is possible to define small reference panels and to build a larger complex panel out of these. This feature enables an effective reuse of code and panels and allows the definition of a common look and feel that can later be easily changed or adapted by changing the basic reference panels.

In addition, PVSS-II comes with the usual functionality of a SCADA system. Furthermore, it allows connection to a remote database, has a built-in HTTP server, automatic backup and can be operated in a redundant configuration.

The H1DCM design makes use of these features to reduce the effort for coding and development wherever possible. It takes advantage of the network based architecture of PVSS-II, which allows all components to run on different machines. This is especially used to distribute the shift and expert user interfaces as well as some drivers and the HTTP server among various PCs. In case of failure of a PC the overall system will stay intact and only a specific part has to be restarted or started on a different PC.

On top of the PVSS-II functionality the H1DCM system implemented a special fieldbus driver for CAN bus modules used for the H1 Solenoid control and a HV client/server which is based on the TCP/IP driver from the PVSS-API package. Extensive use of the control script manager is made to automatically act upon incoming data and to send control messages to the HV server. Two independent HV client/server models have been implemented.

**The C based server** One HV server is implemented in C and is running on a VME based CPU with either Solaris, LynxOS or Linux. It uses the feature of PVSS to call c-functions inside a control script. The HV client is a PVSS control script and a set of c-functions which use c sockets to communicate with the remote server. The server accepts a set of commands which result in simple write or read actions to the CAEN HV supply via the CAEN VMEinterface A200 [5]. The client is actively requesting the server to read data for monitoring or sends commands to set values or states.

**The Java based server** A second server was written in Java and is running on a VME based CPU with Linux. It communicates directly with the TCP/IP driver from the API package of PVSS. The incoming messages are ASCII formatted strings with a predefined syntax which are interpreted by the control scripts running in the control manager of PVSS. The server uses a configuration file to load the initial values for the HV system after restart and is monitoring the CAEN system continuously. It reports the monitored values and states to the clients and acts on commands received from the clients.

In both cases control scripts are used to process the incoming messages further. Depending on the contents these scripts will automatically set alarms or send messages to other processes or to experts.

The graphical interface is modeled with the PVSS user interface manager. The system allows the display of trends

of selected values, like currents or voltages and to send commands to the HV servers for operation, like HV-OFF, HV-ON, by pushing the appropriate buttons.

An automatic control of the HV systems by the H1DCM system is not yet fully implemented. In the automatic mode the system will collect the necessary information from the HERA collider, the experiment components and the DAQ system and will then act on the HV systems. The shift will only be notified in case of unusual conditions or in case an action has to be confirmed or an alarm has to be acknowledged. An automatic sending of SMS messages to experts in case of alarms is implemented.

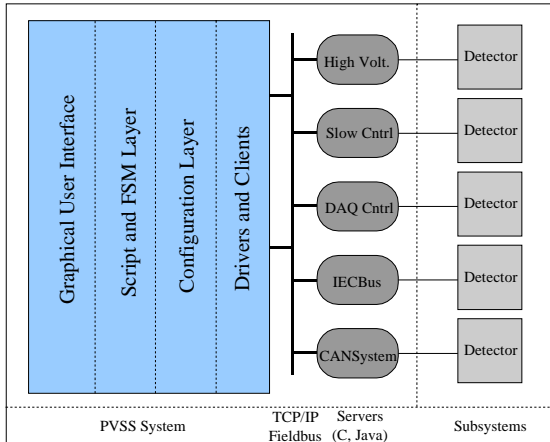


Figure 2: The basic structure of the H1 detector control and monitoring system

Figure 2 shows the overall structure of the H1DCM system. On the right the different subsystems are schematically shown. The connections between the subsystem front-end electronics, which stay untouched for the old systems, and the servers are mainly dedicated point-to-point connections. The servers are mainly located in VME crates. A VME based CPU (currently VMIVME7750 running Linux) is put into the server crate and the server process is implemented. The servers communicate via TCP/IP with the central control system which in turn is divided into 4 logical layers :

- The client layer which communicates with the server and transforms the messages into PVSS internal data formats,
- the configuration layer which enables the detector experts to configure the control system parameters according to the needs of the subsystem,
- the scripts and finite state machine layer which will perform the automatic actions during normal running according to the configuration parameters set by the experts, the external conditions and the requests received from the shift person
- and, finally, the shift control panel, which will enable one person to control and monitor the H1 experiment.

To reduce the effort during development and maintenance the tasks were grouped and responsibilities were combined where possible.

The subsystem experts remain responsible for the detector frontend and hardware.

The server experts, who might be subsystem experts as well, provide the server software.

A few PVSS client experts are responsible for the PVSS client implementation and the definition of the protocol in close cooperation with the server experts and the subdetector experts.

A PVSS script expert is in charge of properly designed and configured scripts and, if needed, of a finite state machine to operate the experiment under normal condition automatically.

One shift panel expert is responsible for the graphical user interface which is provided for the person on shift.

## 4 CONCLUSION

The control and monitoring of the H1 solenoid was successfully started at the end of the shutdown in July 2001. The operation of the HV systems started in the following cosmic test run with the modified forward tracking chambers and the newly installed central inner proportional chamber. The operation was successful from the start and suggestions for improvements which were raised by the detector experts could be implemented quickly. Additional HV systems were included in the control during the cosmic run which in total lasted 5 days. Including the various systems into the common control proved to be as easy as it was anticipated with the new system and, finally, all tracking chambers that were possible to be operated at that time were monitored and controlled with H1DCM.

The extensive use of reference panels and device types allowed the modification of the functionality in a consistent and efficient way even for a complex running system and kept the effort for maintaining the system low.

Both operating the H1 solenoid as well as the HV systems of the different tracking chambers in H1 proved that the H1DCM system will be capable of taking over the slow control tasks in H1 for the coming data taking period.

## 5 REFERENCES

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- [2] <http://www-h1.desy.de/h1det/h1dcm>.
- [3] <http://itcowww.cern.ch/jcop>.
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- [5] <http://www.caen.it>.