MONITORING AND CONTROL SYSTEM OF BM@N EXPERIMENTAL EQUIPMENT AND PROSPECTS FOR MPD

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MAIN TASKS

• Monitoring of the diverse experimental hardware
  (High Voltage, Low Voltage, Gas systems, Temperature, Humidity, Pressure sensors, etc.)

• Alarm system

• Archiving data from devices

• Centralized control of the equipment
MAIN GOALS OF THE SYSTEM DEVELOPMENT

- Reliability – monitoring of hardware and software operation;
- Storage of Slow Control data in unified format;
- Common Slow Control configuration database for all subdetectors (HV, thresholds etc.);
- Easy incorporation of existing subsystems and new hardware;
- Modern and easily customizable user interface;
- Scalability;
- [Centralized as much as possible and reasonable] control of diverse hardware;
- Access control.
• Long historical background of Slow Control hardware and software in subdetectors groups;
• Weak “connections” between subdetector groups concerning SC equipment/software;
• Extremely heterogeneous set of equipment to be monitored/controlled;
• Slow Control typically being developed later than major parts of all subdetectors -> requires easy scalability.

FFD - Fast Forward Detector
TOF - Time of Flight system
TPC - Time Projection Chamber
Ecal - Electromagnetic CALorimeter
CPC tracker - Cathode Pad Chamber
ZDC - Zero degree Calorimeter tracker
TANGO VS EPICS VS COMMERCIAL SCADA

Criteria:
• entry level complexity;
• existence of wide active collaboration;
• open source / price;
• support price;
• …

Tango:
• Already used LHEP accelerator complex;
• Open source;
• Competitive support price;
• JINR is a member of Tango Controls community.

All mentioned SCADA systems are mature and can fulfil requirements of large physical experiment.

The most important point - team of people who can implement the system.
TANGO-BASED SCS SCHEME

Client layer – PCs (Linux, Windows)

Service layer - VMs (Linux)

Central Services:
- Tango DB
- Configuration DB
- Archiving
- ……

Front-end layer

Ethernet – serial bus convertors(RS485, RS232 …)
• Service layer tasks uses existing MPD computing farm.
• Virtualization is done using PROXMOX Virtual Environment.
• All centralized services are running on dedicated VM’s

Front-end layer includes a wide variety of devices which are uses different buses and protocols, such as Ethernet, RS-485, RS232 etc. etc.
BM@N ↔ MPD
BM@N STATUS MONITORING SYSTEM

- Client - Server Model
- Event Based
- Online Monitoring
- Alarms
- Customizable
- Scalable

Client Applications

Status Server (VM)

Status and Values Data

Software Device Servers (VM & PCs)

Status Data Archiving

Values Archiving

Historical Database MySQL (VM)

Hardware Devices

• Client Applications
• Event Based
• Online Monitoring
• Alarms
• Customizable
• Scalable

Client - Server Model
Event Based
Online Monitoring
Alarms
Customizable
Scalable

Client Applications

Status Server (VM)

Status and Values Data

Software Device Servers (VM & PCs)

Status Data Archiving

Values Archiving

Historical Database MySQL (VM)

Hardware Devices
BM@N STATUS MONITORING SYSTEM

The Device Server and GUI application were developed to monitor the statuses of experiment subsystems. Event-based system subscribes to “State” and “Status” attributes and sort information according to the device type and detector. Client is based on Python3 + PyQt4.

Data acquisition is ready (not started)
BM@N STATUS MONITORING SYSTEM

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Data acquisition is running
The Hall sensor's values are read via ADC ICP DAS PET-7017-10.

- Modbus TCP
- 16 bit

EXAMPLE OF ARCHIVED DATA

SP-41 magnetic field archived data in 55th Nuclotron run
MAGNETIC FIELD ARCHIVED DATA VS LOGBOOK

Data from devices is used in offline analysis.

This plot shows the delta between saved measurements and LogBook values, entered manually during the shift.

Difference between LogBook values and archived values
A number of applications was developed for data access and visualization:
Tango Graph, Tango DB Extractor, Tango Web View

Intent to monitor, not to control or modify.

Our task is to create and provide tools for SC data presentation for BM@N and MPD experiments.
Powerful solution was created with python3 and pyqt for monitoring SC data.

**FEATURES**

- Flexible and highly configurable
  - Load pre-history from DB
  - Work with multiple plots in one window
  - Annotations for data values
  - Attributes alias and quality parameters support
  - Event-driven
  - Asynchronous access

**DRAWBACKS**

- Desktop application
- Requires special .cfg file
- Designed for live monitoring
- Requires direct DB connection
Client solution for extracting archived data is developed in Python. It allows users to access the MySQL database and download required data.

**FEATURES**
- Provides user-friendly interface
- Extracts data in both JSON and CSV format

**DRAWBACKS**
- Desktop application
- No visual preview for data
- Requires direct DB connection
TANGO WEB VIEW

It is possible to combine the features and get rid of drawbacks. This is contribution to modern approach of displaying data using web browser.

TANGO WEB VIEW is an application for displaying, monitoring and extracting values, that allows secure access to the database.

ADVANTAGES

- Direct DB connection is not required;
- No installation or any additional files required on client side, works in browser;
- Easier configuration process.
DEVICE CONFIGURATION SYSTEM (under development)

- Centralized Configuration Storage and Loading
- One Click Device Configuration
- Online Device Configuration Tracking
- Multiple Device Configuration Support

**Configuration Client**

**Config Server (VM)**

**Configuration Database (VM)**

**Device Servers (VM & PCs)**

Hardware Devices

- New Configuration
- Existing Configurations
- Configuration Name
- Configuration status
- Config Data & Status
TOF detector uses Wiener MPOD crates for HV and LV systems. The crates communicate via SNMP protocol.
TOF400 GAS SYSTEM

- Monitoring and control of gas system based on MKS Instruments PAC-100 modules;
- Scales with RS-232 interface to control the weight of gas bottle;
- Oxygen and humidity sensors made by GE Measurement to control the quality of gas mixture.
TOF400 GAS SYSTEM

TOF400 Gas System flows, gas bottle weight, water and oxygen level in gas mixture
GUI application that allows to monitor FEE parameters and temperature and set DAC values. Uses Socket protocol.
TOF700, Ecal and ZDC detectors are using HVSys modules for HV systems, which are made by small company in JINR. These devices has its own software, written on TCL, and communicates via Socket protocol with only one active connection.

TCP-server was implemented to the existing software in order to acquire data from the equipment. It sends data on request in JSON format.
Application for HP Aruba switches control. Uses SNMP protocol.

- Multidevice support;
- Power consumption and status for every connected device;
- Allows to switch on/off network and/or power for every port.
Monitoring and control for Wiener and ELMA VME crates

- Multidevice support;
- Displays state and status for every crate;
- On/off/reset buttons for crates.
The application that allows to monitor status of the UPSes in BMN racks.

The Device Server communicates via SNMP protocol. Multidevice support.

Displays:
- Input/Output voltage;
- Load;
- Battery status.

<table>
<thead>
<tr>
<th>UPS Status</th>
<th>Input Voltage</th>
<th>Output Voltage</th>
<th>Battery Life</th>
<th>Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>201 V</td>
<td>220 V</td>
<td>8.95 min</td>
<td>3 W</td>
</tr>
<tr>
<td>R6</td>
<td>219 V</td>
<td>230 V</td>
<td>9.73 min</td>
<td>0 W</td>
</tr>
<tr>
<td>R2</td>
<td>206 V</td>
<td>230 V</td>
<td>155.37 min</td>
<td>0 W</td>
</tr>
<tr>
<td>R8</td>
<td>222 V</td>
<td>220 V</td>
<td>52.56 min</td>
<td>0 W</td>
</tr>
<tr>
<td>R3</td>
<td>222 V</td>
<td>230 V</td>
<td>48.67 min</td>
<td>0 W</td>
</tr>
<tr>
<td>A1</td>
<td>227 V</td>
<td>230 V</td>
<td>15.05 min</td>
<td>1897 W</td>
</tr>
</tbody>
</table>

...
TEMPERATURE, HUMIDITY, ATMOSPHERIC PRESSURE MONITORING

The module PIR-230-E contains a temperature and humidity sensor for measuring indoor temperature and humidity.

Temperature, humidity and atmospheric pressure plots
12 hours, TOF detectors assembling area

Honeywell Heavy Duty Pressure Transducer
15 psi range, 0.25% accuracy
MPD TOF assembling and testing stand requires clean room. We use Dylos DC1100 Pro Air Quality Monitor to control number of dust particles.
MPD TOF TEST STAND
DEVELOPMENT OF MPD ECAL TEST STAND
CONCLUSION

- Created base structure of Slow Control for MPD including databases, archiving system, alarms system, etc.
- Developed software specific for MPD experiment (status monitoring system, applications for data access and visualization, device configuration system);
- Developed software for various hardware used in MPD subdetectors Slow Control;
- Essential part of MPD Slow Control system was tested during several BM@N runs at Nuclotron.
THANK YOU FOR YOUR ATTENTION