PRESENT STATUS OF VEPP-5 INJECTION COMPLEX CONTROL SYSTEM

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Abstract

VEPP-5 injection complex is being put into operation as beam source of VEPP-2000 and VEPP-4 colliders at the end of 2016. Its control system is being upgraded in order to reliably work with beam users and increase its manageability computer infrastructure was reconsidered to provide high availability and flexibility through virtualization of control servers. The paper presents architecture and implementation of complex computer infrastructure. A control software set based on CXv4, EPICS and VCAS frameworks under operating system Linux deals with a set of CAN, CAMAC and Ethernet specialized hardware. The software and hardware architecture and implementation is described.

INTRODUCTION

VEPP-5 injection complex [1] (IC) is linear accelerator based e+/e- beam source with a damping ring and transfer lines. IC is now being put into operation to provide beams for VEPP-2000 and VEPP-4 colliders. This requires continuous functioning of control system infrastructure and development of software for joint operation with colliders.

In order to ensure reliability of control system infrastructure and hence on the whole injection complex it is proposed to deploy separated network infrastructure and high availability cluster of control servers based on modern virtualization techniques.

Software structure principles for joint operation with beam users was proposed earlier [2] and then corrected according to development and operation experience.

CONTROL SYSTEM INFRASTRUCTURE INITIAL STATE

There is the following set of control system hardware at the beginning of work:

- 126 CAN DAC/ADC and other devices developed in BINP [4, 5, 6] connected via CANGW [3] embedded computers or dedicated desktop PC,
- 17 CAMAC crates with specialized electronic modules and fast ADCs, 1 cPCI crate with ADC200me [7]
- 8 Ethernet photo-cameras
- 15 Ethernet BPM processors [8]
- 5 RS-485 controllers connected via Moxa UC-7112-lx plus embedded computer
- 2 former control room workstations working as control system servers, 3 main control room workstations and 6 old PCs as control system terminals

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All the Ethernet controllers are connected to dedicated controllers network, which is also connected to control system servers. PCs are connected to BINP network, which is currently used for communication between IC and colliders control systems. Hardware related issues are the following: lack of CANGW performance for some tasks, no reliability assurance for mission-critical devices and network connections (control servers, vacuum control, communications with beam users), complexity of infrastructure service and deployment of new devices. Historically injection complex computers were bare metal with Linux OS installed, and there were no network infrastructure services. Therefore, additional difficulty was to work around maintenance or failure of institution network infrastructure services.

INFRASTRUCTURE UPGRADE

The project

In order to solve the described above problems control system infrastructure upgrade was proposed with following outline:

- Replace network switches with managed ones and build VLANs for BINP network, controllers, computers and IPMI.
- Add direct optical links from IC network to beam users networks for operation data exchange.
- Deploy infrastructure servers for internal networks: 2 servers as hosts for general services, network boot servers and remote storage for operating systems, 2 Firewall servers.
- Create high-availability cluster of 4 control servers based on virtualization platform. 2 CAN servers (with 5 PCI/PCIe slots for CAN adapters) connected to the same CAN lines for reliability assurance, 2 Main control system servers directly connected to high volume shared storage for operation history data or other big data volume applications.
- Replace CAMAC-based stepper motor controllers with CAN ones. This is required due to incompatibility of old CAMAC controllers with managed switches.
- Replace old PC terminals with thin clients in order to reduce maintenance requirements.

The resulting sketch of control system infrastructure is shown on Fig. 1.

The implementation

In order to reduce the range of equipment we decided to use close Supermicro platforms for servers and control room workstations. Since some of servers have 10G

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ISBN 978-3-95450-181-6

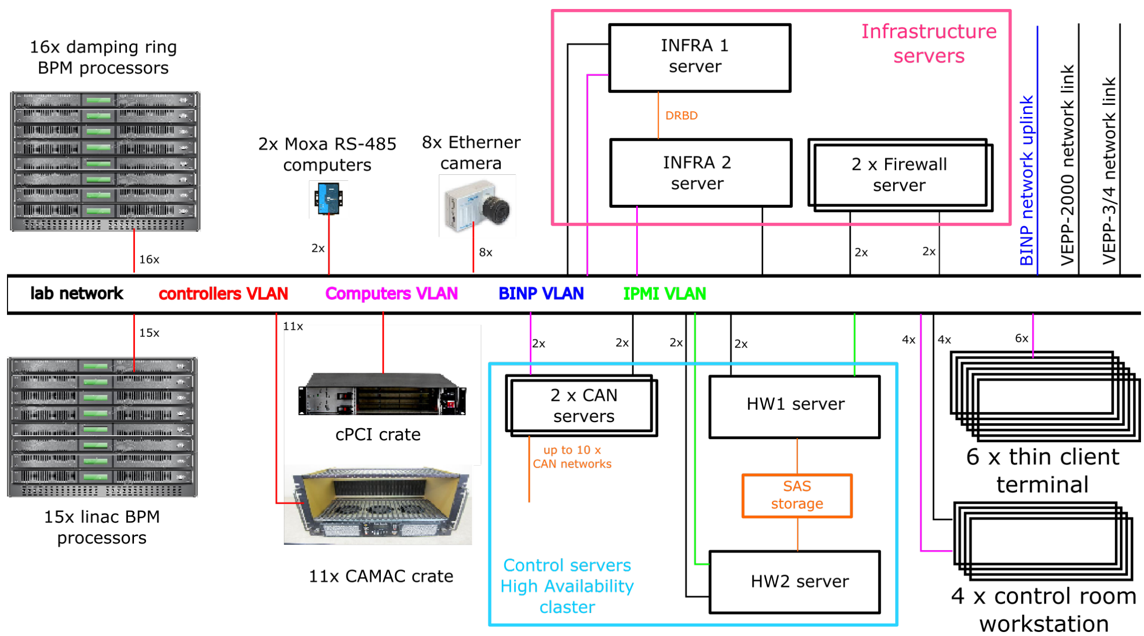

Figure 1: Injection complex control infrastructure layout.

network interfaces, 3 HPE-1950-24 are selected to build the network base, HPE-1920 series is used as peripheral switches. Raspberry Pi 2 is successfully tested for remote terminal role. Proxmox VE is selected as virtualization platform due to authors experience and easy enough management. KVM virtual machines are used now due to available live migration and authors experience while Linux Containers have better performance in some cases [10]. Virtual machines are deploying on per service group basis. There are 7 virtual machines now. Described infrastructure is under construction and only partially in operation.

CONTROL SYSTEM SOFTWARE

Injection complex software is currently based on three control system frameworks:

- CXv4 [11] serves most of complex equipment and transfers messages between applications.
- EPICS [12] serves some of complex equipment.
- VCAS [13] works with beam transfer lines hardware.

Injection complex software was earlier a set of CX and EPICS servers, drivers and basic GUI applications separately for each framework. In order to start regular operation a set of common instruments is required. Since all the mentioned above frameworks can run client software under Qt main loop common tools currently based on Qt framework.

CXv4 client libraries Python bindings were implemented in Cython in a high-level object-oriented way. Resulting Python module can run native CX main loop or use Qt 4/5 one (from PyQt). EPICS Python bindings working with PyQt4 were developed in Diamond Light Source [9]. Both these bindings are used to implement common CXv4 and EPICS control system applications.

CXv4 was selected for interprocess communications since it is easier to deploy than other used frameworks and we do not want to increase the range of used protocols.

The following control system tools were implemented:

- Configuration database and Django based management tools for simplification of software configuration.
- Machine mode service as joint tool to saving/restoring complex state to database.
- GUI tool for injection complex mode control.
- Machine loop service automating injection/extraction and based on synchronization hardware functions and machine mode service.

These instruments allowed us to start semi-automatic operation with colliders: automatic beam storage-transfer loop and manual particle type or beam consumer switching. This operation way is acceptable for initial injection complex and beam transfer lines tuning and collecting data for future automatic work. In order to implement fully automatic work it is required to create machine scheduler service, which will accept beam user requests and command by other services according to the most effective schedule. The resulting injection complex software structure is shown on Fig. 2.

There are two database tasks now: structured configuration information storage for different software and machine mode storage. First PyCDB [14, 15] was considered as a tool for configuration information management. Since PyCDB is not supported centralized configuration tools for high-level software were implemented with Django framework and Postgresql databases. Hardware and its servers and hardware control applications are now configured separatly in decentralized way.

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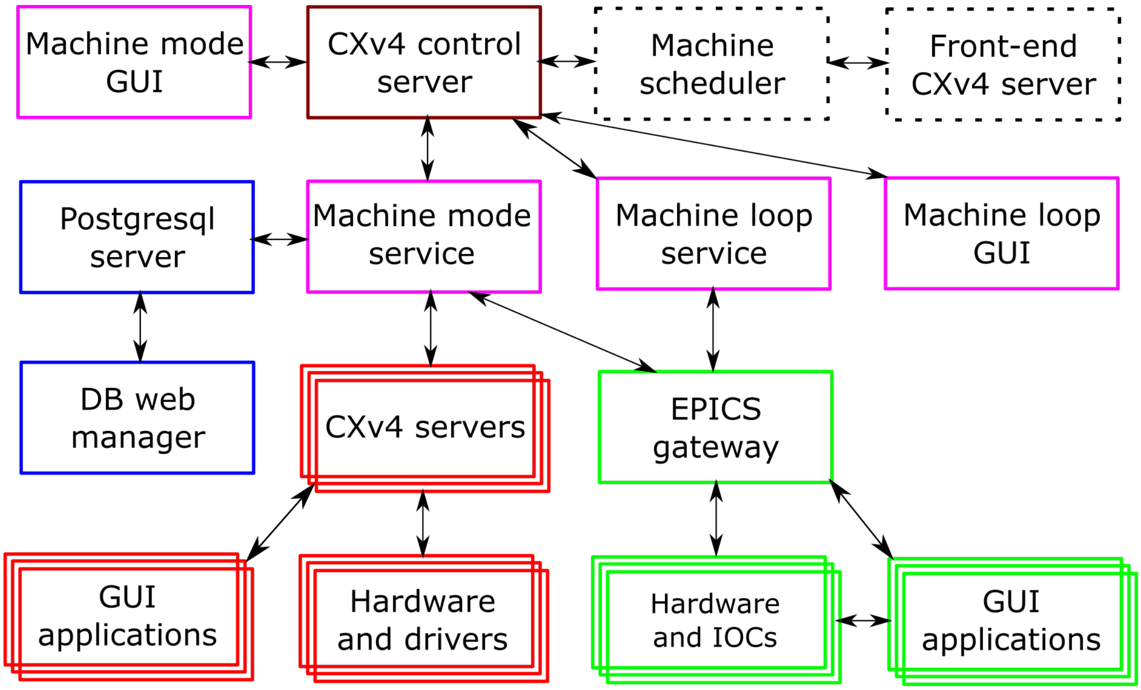

Figure 2: Injection complex software structure layout

CONCLUSION

Proposed and implemented control infrastructure and software is sutable for semiautomatic operation of VEPP-5 injection complex and data accumulation for further automatic techniques development.

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