

CONSTRUCTION AND IMPLEMENTATION OF CONTROL AND DAQ SYSTEM OF MICRO CRYSTALLOGRAPHY (MX) BEAMLINE VIA SERVER VIRTUALIZATION

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Abstract

The project aimed to implement a beamline control and data collection system through a server virtualization system, and was applied to the 5C beamline of the 3rd generation beamline of Pohang Accelerator Laboratory (PAL). The 5C beamline is currently under construction for the FBDD beamline with the goal of building a fully automated beamline. Therefore, the project was started to operate stably and efficiently various systems to be applied to the beamline.

The control system was implemented using EPICS software tools and MxDC/MxLive software for data acquisition and storage. The control and data collection system of this beamline is integrated using XCP-ng [1] (XenServer Based), and it is in operation. With the integrated server virtualization system, network organization / simplification and data send/receive between systems are more stabilized. The overall size of the system has been significantly reduced, making maintenance easier.

INTRODUCTION

The Beamline is operated by various single systems connected in various ways. The complexity of a system is the number of components, the various relationships between them, and the change in components and relationships. The opposite of complexity is simplicity. If a simple system consists of the components and relationships that are necessary for its purpose, a complex system is highly diverse, interdependent, and uncertain, making it difficult to predict any situation, process, or outcome. As a result, complexity often leads to unintended consequences or difficulties in resolving the situation.

As the system of the Beamline becomes more complicated, the inefficiency of the work due to the trouble of maintenance and management due to the failure or the transition to the new environment, and the cost burden for the maintenance of the system are generated. Server virtualization considered that it is appropriate to apply the virtualization system to the beamline in that it can reduce the management burden and increase the stability.

Virtual is described in a dictionary meaning as 'a false phenomenon that appears to be subjectively real but does not exist objectively'. Virtualization seems to exist from the user's point of view, but it can be interpreted as a phenomenon that exists from the point of view of the system as if it is running inside the system. As we will see, virtualization of a system, which will be explained in the future, refers to a way to make another system run inside the system. Commonly known virtualization methods include Virtual-

Box or VMware. Inadequate Hosted virtualization is another way of operating a guest OS on a machine with host OS, such as MS Windows and Linux, so the guest OS is affected by the performance of the host OS, resulting in significant performance degradation. In order to compensate for such performance degradation, the beamline integrated system was implemented and implemented through hypervisor virtualization (Para virtualization), a kind of server virtualization.

BACKGROUND

Computing speed and performance/environment are steadily improving, and the amount of resources and technologies available to one server equipment is rapidly expanding and evolving. This means that a system that used to operate in multiple computing environments can be supported by one server device for availability and scalability. However, even if the amount and technology of resources provided by one server equipment is expanded and developed, it is useless unless it is effectively utilized.

Server virtualization is a solution that is evaluated to be able to run various servers in one physical system to support the amount of resource and data operation of each server most effectively. Most existing beamline control and data acquisition systems are built using a variety of PC, workstation and server equipment. This means that it is difficult to manage because it is composed of complicated communication networks and different systems, and it is not easy to reconstruct the system due to equipment failure, install / upgrade the operating system, and trouble. To compensate for these shortcomings, the advantages of server virtualization have been applied to beamlines to operate systems operating in different environments.

OBJECTIVES

Server virtualization integrates several operating systems for fully automated beamline implementation into a single server machine. By systematically separating internal (private of virtualization system) or external (publicization of virtualization system) network, data send/receive is operated smoothly and stably. In order to ensure the stability of communication between virtual machines and virtual machines, an internal network is constructed and operated. Build a virtual machine that acts as a gateway, and let other virtual machines communicate internally and externally. External to internal connections are made through the virtual machine for the gateway. Build a single virtual machine operating environment, and system cloning ensures that other virtual machines maintain the same oper-

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ating environment as closely as possible to ensure compatibility with each other. The image of the virtual machine is backed up, and if a problem is occurs, the problem is solved by restoring the backed up image.

METHODS

Server virtualization enables the expansion (10 minutes) of operation and backup/restore (10-15 minutes) of various virtual servers on one physical server for quick response to failures and rebuilds, and different systems exist on one physical server. The difficulty of simplifying and managing the communication network between systems is minimized. Through these advantages, we tried to implement server virtualization(XCP-ng) as a way to build a stable beamline integrated system and applied it to PAL-5C MX Beamline.

The server virtualization system was built on a Dell PowerEdge R740XD device. The server was selected by referring to the Hardware Compatibility List (HCL) [2]. Hardware outside the HCL may or may not work, depending on how well the drivers are supported by the Linux kernel included in XCP-ng. The server device resources are shown in the Table 1.

Table 1: System Specifications

CPU	Intel® Xeon® CPU @ 2.10GHz x2
RAM	128 GB (32 GB x4)
HDD	8 TB (Configure Raid 5)
OS	XCP-ng 7.6.0
NET	BCM5720 Gigabit (Embedded) x4 Intel I350 Gigabit x4
USB	Intel X520 10G 2P x1 FT2232C Dual USB UART / FIFO

Beamline is consist of into control (EPICS [3, 4]), data acquisition (MxDC/MxLive from CLS), and data processing (DPS) systems, and there are nine virtual machine in total. Since the control system uses various communication interfaces (Ethernet, USB, etc.), the virtualization system enables the PCI / USB passthrough [5, 6, 7] function. Using this technology, a PCI card or USB device attached to a host (physical server) is directly connected to a virtual machine to interface with the device.

The Data Acquisition System has a virtual machine for controlling the Automounter [8, 9] / Goniometer / Detector. For data acquisition, the software for Mx Beamline (MxDC/MxLive [10, 11]) developed by Canada Light Source was reconfigured for the PAL-5C MX Beamline system. The data acquisition software uses MxDC [12] for acquisition functions and MxLive [13], where acquired data and analysis reports are managed / verified via a web server. Both software are run using Docker [14]. Because MxDC and MxLive have different operating environments, they are operating separately by creating an environment suitable for different virtual servers. The operating system and resources of the virtual machine are shown in Table 2,

and the construction on the current beamline is completed. As shown in Fig. 1, multiple systems were consolidated into virtual machines within a single server.

Table 2: Virtual Machine Specifications

	CPU s	RAM	HDD	OS
Gateway	2	2G	8G	Cen6
EPICS	4	4G	20G	Cen6
EPICS (Detector)	4	4G	20G	Cen6
EPICS (Robot)	4	8G	30G	Cen7
MxDC	4	32G	70G	Cen7
MxLive	2	4G	40G	Cen7
DCM (PZT)	4	4G	30G	Win7
HC1c	4	16G	100G	Win7
MD2s	4	16G	100G	Win7

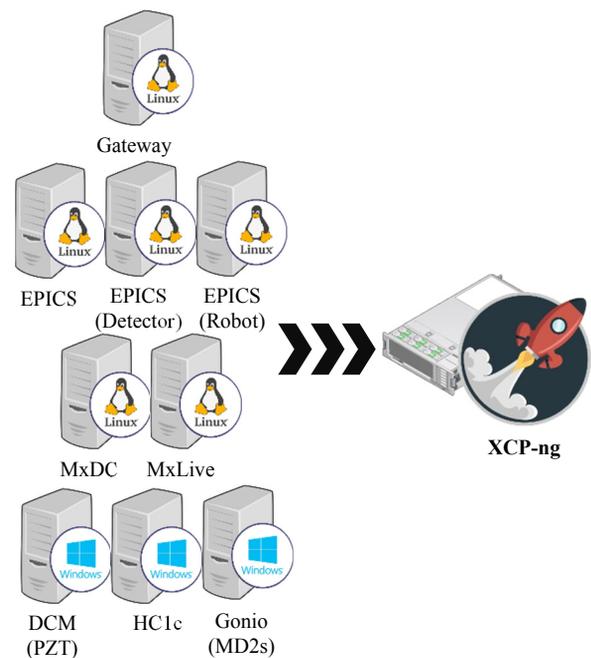


Figure 1: System integration.

The internal network of the virtual machine (external network, EPICS, LDAP, storage, detector communication, etc.) is systematically classified as shown in Table 3. By configuring the network suitable for each role, there is no interference between networks to ensure smooth data transmission and reception and stable network communication. The network consisted of a total of 10 networks, with server units installed with 1 Gbps and 10 Gbps PCI cards. There are nine physical ports and one private network. The physical port is connected to each device with a communication cable, using Moxa to control the device, control the Automounter device, control the Detector and Goniometer devices, send and receive streaming data from the camera, and send and receive data with the storage. One private network is an internal network that is not related to the actual network interface. You can only connect between specified virtual machines without connecting to an external server. However, I built a virtual machine that acts as a

gateway, and this virtual machine created both public and private network devices to communicate with the outside world through a private network. Virtual machines that need to communicate with the external network are configured to communicate with the outside when a private network device is created.

Table 3: Internal Network Specifications

	Gateway server	EPICS (PTL)	EPICS (Detector)	EPICS (Robot)	MxDC	MxLive	DCM (PZT)	HC1c	Goniometer (MD2s)
Private	■	■	■	■	■	■	■	■	■
EPICS		■	■	■	■		■	■	■
Machine		■		■				■	■
LDAP					■	■			
Data						■			
DCU			■		■				
PMAC					■				■
OVA					■		■	■	
AxisPZT					■				■

RESULTS

Backup, Recovery and Copy

Virtual machines in the virtualization system are managed through XenCenter. XenCenter is a kind of management console that connects to host server from outside by interworking with Xenserver of host role and provides window-based user interface. Backup, restore and cloning can be done through XenCenter, and the execution time depends on the performance of the server equipment and the virtual disk capacity of the virtual machine. When you back up, recover, and clone a 20GB virtual machine, it takes about 5 to 10 minutes.

PCI/USB Passthrough Technology

PCI/USB passthrough is a feature that allows virtual machines to directly connect PCI and USB devices. We have tested PCI passthrough using the NVIDIA Quadro P5000 model and plan to use this technology to apply the screen output of the virtual machine (data acquisition system) to the beamline system so that it can be output to a regular monitor. It has also been confirmed that 10Gbps or 100Gbps PCI network cards can be applied to virtual machines. With this technology, it is not difficult to drive most beamline controls.

Application of Server Virtualization Technology

The previous beamline consisted of several servers and industrial PCs (6 + 9 with DCU modules) as shown in Fig. 2. Each server, industrial PC (including VLANs), and PC

for device control consist of multiple cables. In addition, a dedicated interface cable was connected to the individual PC to communicate with the device. This made it difficult to identify and verify management, failures, and errors. In addition, different systems operate in environments with different operating systems, causing compatibility problems between systems. To overcome these problems, we applied server virtualization to the beamline, and as shown in Fig. 3, we consolidated our distributed systems into one server device, greatly improving maintenance and system reliability.



Figure 2: Beamline system (before).

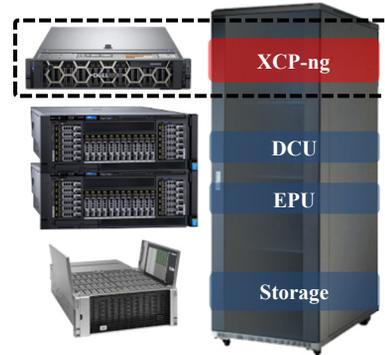


Figure 3: Beamline system (after).

Virtual machines built on the beamline were created and configured using XenCenter, and full maintenance was made possible in one place, as shown in Fig. 4. Console tabs provide easy access to virtual machines. If necessary, you can efficiently allocate, adjust, or manage the resources of your virtual machines.

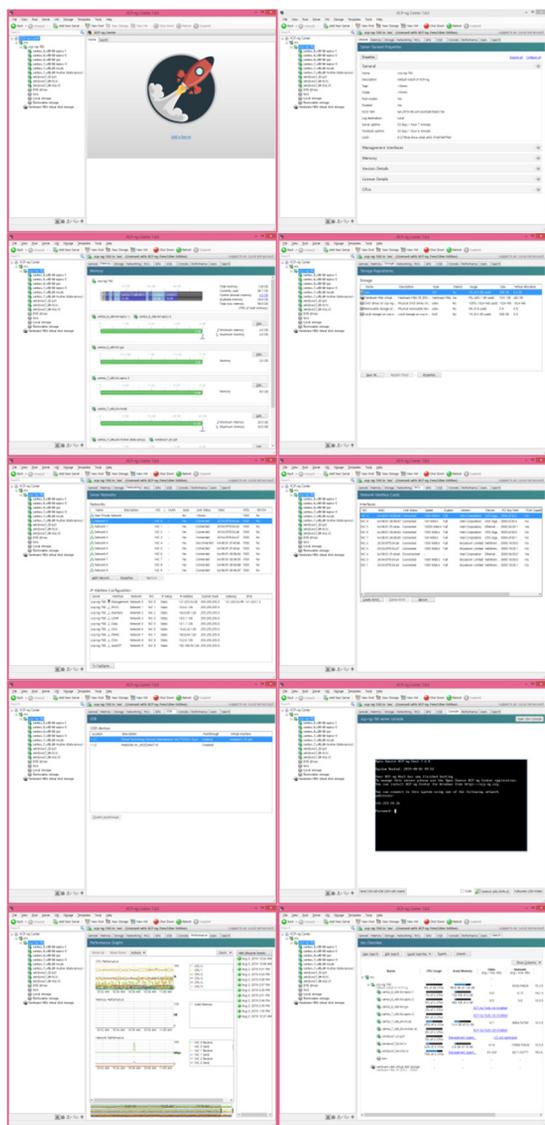


Figure 4: Use of XenCenter.

PAL-5C MX Beamline is building a fully automated beamline for the FBDD beamline from 2019 to 2020. From the sample preparation process, I will continue to build the system so that measurements, data storage and result analysis can be operated reliably and efficiently.

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