# VIRTUALIZATION OF OPERATOR CONSOLES ON BEAMLINE CONTROL SYSTEM

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*Abstract*

We consolidated more than 50 operator consoles of SPring-8 beamlines into four server computers by using virtualization technology. Virtualization technology has been a hot topic in server computing in recent years. We evaluated and studied several virtualization products for several years. To test feasibility of virtualization technology, we installed Xen into the control systems of a few beamlines two years ago. We presented the results of our experiment of introducing virtualization technology at the previous ICALEPCS conference. In the past six months, we installed Xen into the rest of the beamlines. We were able to reduce the number of computer hardware systems and maintenance costs while ensuring the capability of the control system. In this paper, we describe an example of introducing virtualization technology into operator consoles.

## INTRODUCTION

In SPring-8, about 50 beamlines are in operation. Each beamline has at least a front-end VMEbus system and a workstation (BL-WS) as an operator console. The BL-WS is set on each beamline, which are located around a storage ring with a 1.5 km circumference. The BL-WS have independent network configurations and run different control applications in each operating environment [1]. The maintenance of distributed computers is difficult. In the case of a computer failure, the downtime of the control system on a beamline might be about 1 hour. The frequency of problems increases proportionally to the number of computers, although the reliability of recent computers is high. A marked increase in the number of computers has pushed up the total cost including the management cost in recent years. Server virtualization is a good solution to these problems [2].

Virtualization technology has attracted considerable for simplifying the management of computers. The proliferation of computers leads to an increase in the number of maintenance tasks. Virtualization technology is able to run many virtual machines (VMs) on a server computer and can consolidate many existing computers into fewer servers. By server virtualization, we can reduce the number of computers and maintenance costs.

Each VM has an independent computer resource and can run an individual operating system instance with satisfactory computing performance. In this paper, we describe the result of operator console consolidation by using virtualization technology.

## INSTALLATION AND CONFIGURATION

As a result of extensive test on performance and maintainability, we adopted a Xen virtualization product for the operator console of the beamline control system. From a previous performance measurement, when all the VMs were operating with full speed, about six VMs used up the CPU power of a dual-core Xeon 3.0 GHz processor of the NetBurst core. Because the utilization rate of a real

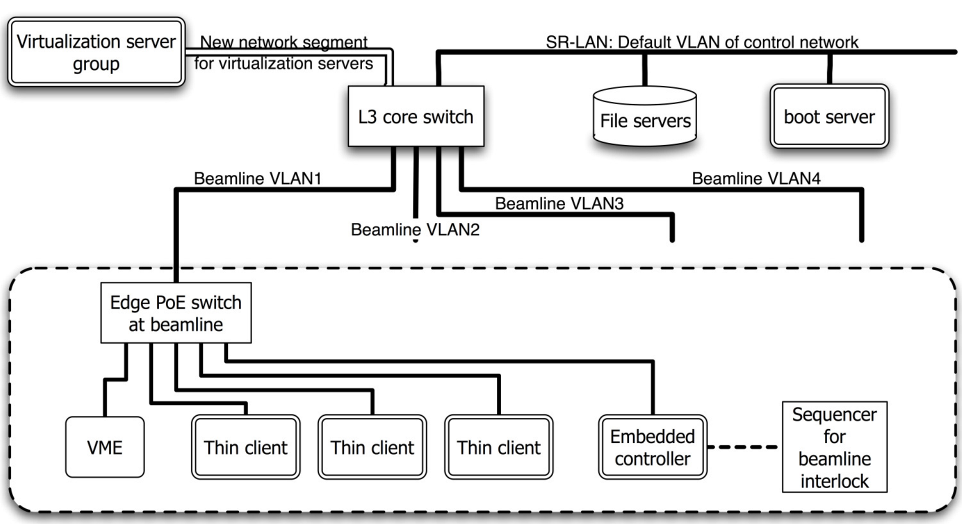


Figure 1 Schematic view of network system for virtualization environment. Components denoted by a double line were newly installed.

operator console is about 20% at maximum, we operated more than 20 VMs safely in one host computer without severe performance deterioration.

This summer, we completed the replacement of all Hewlett-Packard workstations with Xen VMs. For the high availability (HA) of the operator console, a redundant configuration was built by using the live migration function of Xen. To achieve an appropriate setting for HA, we changed the logical network topology [3] and tuned the location of the root file system of VMs. The details of the installed virtualization environment are discussed as follows.

### *Design outline*

Figure 1 shows an overview of the network topology specified for the redundant virtualization environment. The beamline control network was separated into four network segments by using a VLAN. Because of the redundancy scheme of the virtualization technology, virtualized server computers must be set on the same network segment. Therefore, we added a new network segment and installed all virtualized server computers into the virtualization environment. Primary and secondary file servers and a boot server, which boots up thin clients as mentioned below, were set on the default VLAN of the control network. Each beamline has a VME, thin clients as an operator console and an embedded computer as a front-end system for the data acquisition of a beamline interlock system.

For the root file systems of VMs, a dedicated redundant storage system was developed with the consideration of performance and stability. The root file systems were shared by using a network block device (NBD). NBD is better than NFS in performance. Figure 2 shows performance measurement data for NFS and NBD. A marked difference in writing speed was observed. Moreover, the level of performance deterioration was

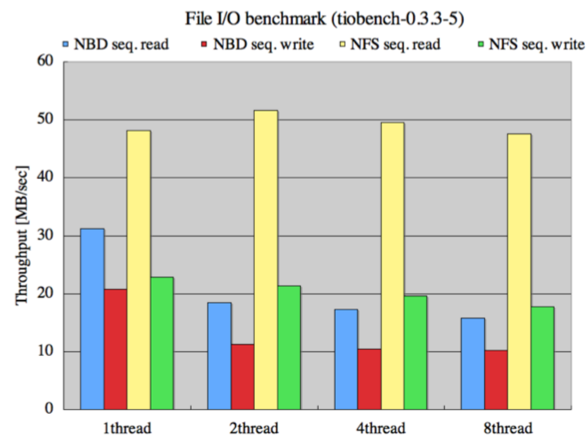


Figure 2 Result of file I/O benchmark program comparison between NFS and NBD. NBD keeps high throughput during multiple access.

observed to be low during multiple client access. To increase an availability of the root file systems, we prepared two network storage systems, which are duplicated by a software mirror. If there is a problem in the storage systems, VMs can operate continuously. It is possible to continue operation during hardware maintenance even if a computer requires rebooting when the live migration function is used. Figure 3 shows the redundant root file system layout using an NBD.

### *Hardware and software of virtualization servers*

We adopted an HP c-class blade system for the virtualization host servers. As CPU modules, five BL465c units with two dual-core AMD Opteron processors were installed. Since it is important to install sufficient memory, we installed 8 GB memory units into each module. The maximum number of VMs operating on one CPU module is 16. Because of the large impact of CPU module

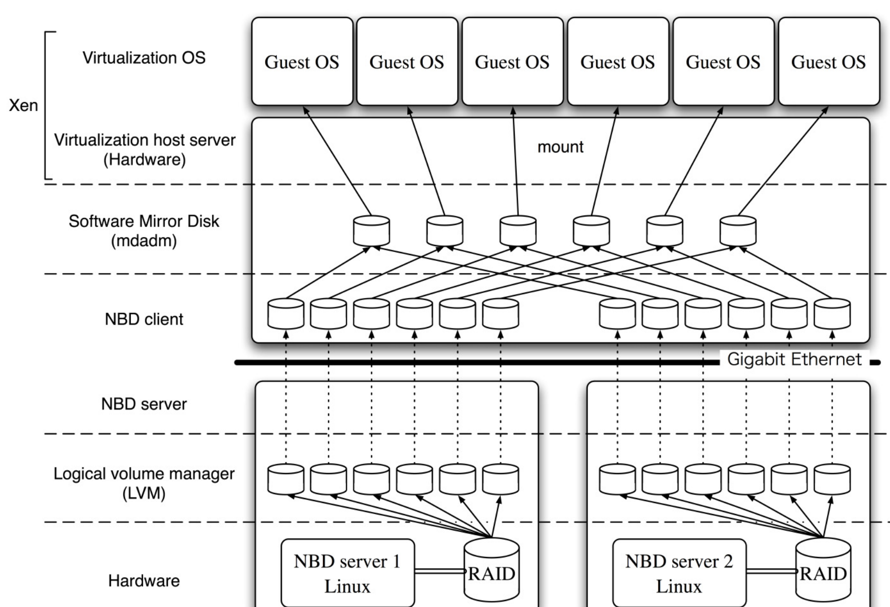


Figure 3: Layout of the Root file system with high availability and high performance.

breakdown, one of these VMs was assigned to be in a hot standby mode. The root file systems of VMs were set in a RAID module, SB40c, on the blade system. The RAID module has six 2.5 inch SAS disks and was configured as RAID level 6.

Xen 3.03 was adopted as the virtualization environment from the result of a previous study. In terms of performance, Xen is superior to VMware. Ubuntu Linux was adopted because of its stability, easy management, ease of VM installation and low installation cost. The base kernel version is 2.6.19. Since their introduction, VMs are operating stably.

### *New operator consoles and front-end systems for sequencer control*

Hewlett-Packard workstations were transferred to the virtualization environment. Two operator consoles were introduced into the beamline control system instead of these workstations. One is the SunRay client, which has comparable graphical performance characteristics to the workstations. The other is the VNC client, which has a network boot function. Because the latter can be used to see a user's operation screen remotely, the capability of troubleshooting of the control system has improved. These clients only display the user interfaces of application software running on VMs.

The workstations were front-end systems for a sequencer control of the beamline interlock system. As an alternative front-end system, an embedded Linux computer with a "Power of Ethernet" (PoE) [4] capability was introduced.

## BENEFITS

The benefits of introducing the above-mentioned virtualization environment are as follows. First, the number of computers was reduced from fifty to four. The management and hardware costs were cut markedly. We reduced the total cost to about 1/10 of the previous cost. In addition, the number of underlying failure points, such as power supply units and hard disks, was reduced, and the stability of the control system was markedly increased. We achieved a higher data protection level by integrating the storage system. The virtualization environment reduced the time necessary for setting up a new operator console; we simply duplicate the image file of a root file system. In addition, when failure occurs, we can obtain sufficient information to solve it from the Internet. There are more documents for open source Linux than for proprietary UNIX.

It is noteworthy that the control response speed of the virtualization environment using the beamline control system is superior to that of previous workstations. Table 1 shows comparative data for the response speeds of old and new systems measured in a user's experimental environment at BL41XU. Another comparative data is shown in table 2. These are measuring data of network communication delay during a motor control of the diffraction grating at BL27SU. The virtualization environment shortens the average communication delay of about 64%.

Table 1 Comparison of response speeds between old and new control systems. Values show the total measuring time of the oscillation camera in protein structural analysis.

| | Total measuring time |
|---|---|
| HP workstation | 619 s |
| Virtualization environment | 581 s |

Table 2 Comparison of communication overheads between old and new control systems. Values show the interval time of a one step moving of motor unit.

| | Communication overhead |
|---|---|
| HP workstation | |
| Condition 1 | 3.98 s |
| Condition 2 | 4.00 s |
| Virtualization environment | |
| Condition 1 | 2.73 s |
| Condition 2 | 2.36 s |

## CONCLUSION

We integrated about 50 operator consoles into four server computers by applying server virtualization technology and constructed an efficient control environment. The total cost of the beamline control system was markedly reduced by improving the control performance and management. Additionally, the stable operation of the control system was achieved.

## ACKNOWLEDGEMENTS

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## REFERENCES

[1] R. Tanaka et al., "Control system of the SPring-8 storage ring", Proceedings of ICALEPCS 1995, Chicago, USA (1995)
[2] T. Ohata and M. Ishii, "A study of introduction of the virtualization technology into operator consoles", Proceedings of ICALEPCS 2005, Geneva, Switzerland, TH1.3-80 (2005)
[3] T. Fukui et al., "Toward a reliable gigabit network – An upgrade of the SPring-8 network", Proceedings of ICALEPCS 2001, San Jose, USA (2001)
[4] IEEE Std 802.3af-2003