A Comparative Study of Open Source Softwares for Virtualization with Streaming Server Applications

Sritrusta Sukaridhoto†*, Nobuo Funabiki†, Toru Nakanishi†, and Dadet Pramadihanto*

†Department of Communication Network Engineering, Okayama University

3-1-1 Tsushimanaka, Okayama 700-8530, Japan

Email: dhoto@sec.cne.okayama-u.ac.jp, {funabiki,nakanisi}@cne.okayama-u.ac.jp

*Electronics Engineering Polytechnic Institute of Surabaya

Jl Raya ITS, Surabaya 60111, Indonesia

Email: dadet@eepis-its.edu

Abstract—**Currently, several streaming servers are available to provide a variety of multimedia applications such as VoD (Video-on-Demand), IP-phone, and IP-TV. As a result, the provision of multiple streaming servers on a single machine using the virtualization technology has become important in order to save the operational/management costs while enhancing the performance and the reliability of the system. In this paper, we show the performance evaluation of two representative open source softwares for the virtualization technology, *Xen* and *OpenVZ*, in various configurations of applications on three open source streaming servers, *Red5*, *Darwin*, and *VLC*. Our experimental results indicate that OpenVZ provides the better performance for streaming applications with Darwin and VLC whereas Red5 can run only on Xen.**

I. INTRODUCTION

Recently, the access of multimedia contents through the Internet has increased rapidly due to the popularization of broadband networks and inexpensive high-performance computers. The growth of Web services offered by multimedia applications such as music videos, animated movies, Internet-protocol television (IP-TV), and IP-phone has actually contributed the improvement of the Internet transmission speed. Under these circumstances, the number of streaming server machines has also increased to afford them. For example, the *E-Studio system* that has been developed at our institute, uses 10 dedicated streaming servers. Multiple servers and their applications require high labor costs for the machine maintenance, software upgrades, and operations. Thus, there have been significant interests in reducing the number of server machines that are necessary to run these applications.

The consolidation of multiple servers into a fewer server machines has become a common practice in enterprise data centers to cut costs and increase returns from IT investments, although the server consolidation may suffer from a great potential of increasing the resource utilization and the complexity in managing the consolidated servers. This fact has given rise of re-surging interests in the virtualization technology. Nowadays, there exist two main types in virtualization technologies, the *hypervisor-based virtualization* technology and the *operating system (OS) level virtualization* technology. The most popular open source softwares based on the OS-level virtualization technology are *Xen* and *OpenVZ* [1]–[3].

They allow a single server machine to be partitioned into multiple isolated virtual containers to run different applications with their platforms at the same time. This feature achieves the easier centralized server administration and the higher operational efficiency. Then, the selection among these popular open source softwares has become the important problem to achieve the higher performance for multimedia applications.

In this paper, we present the experimental results to answer the above-mentioned problem. In our experiments, we compare the application-level performance such as the throughput and the response time when we run three open source softwares for multimedia applications, *Red5*, *Darwin Streaming Server*, and *VLC*, on a virtualization software. Actually, we prepare three scenarios for the platform, namely on the Linux native system, on Xen, and on OpenVZ for comparisons. Our results show that OpenVZ achieves the higher performance for Darwin and VLC, whereas Red5 can run on Xen only.

Within our surveys, several papers have reported performance evaluations for Xen and OpenVZ. In [4], the performance of Xen was reported using the benchmarks of *SPEC CPU2000*, *OSDB*, *dbench*, and *SPECWeb*. Their results have been reproduced by a separate group in [5]. In [6], the performance of Xen and OpenVZ was compared using *top* for Linux, *Xentop* for Xen, and the output from */proc/vz/vestat* for OpenVZ. In [7], Menon et. al. evaluated the networking performance of the Xen environment, and found various overheads in the network stack. In [8], Espen at Oslo University studied the management of high availability services using virtualization.

The remainder of the paper is organized as follows. Sections II and III introduce open source softwares for streaming server applications and virtualization technology, respectively. Section IV introduces the tools used in our testbed. Section V discusses our experiments and their results. The conclusion with future works is given in Section VI.

II. OPEN SOURCE SOFTWARES FOR VIRTUALIZATION

A. Xen

Xen [9] is a para-virtualization technology that allows multiple guest operating systems (OSs) to run in virtual containers called *domains* in a single machine. As shown in Fig. 1, the Xen hypervisor provides a thin software virtualization layer
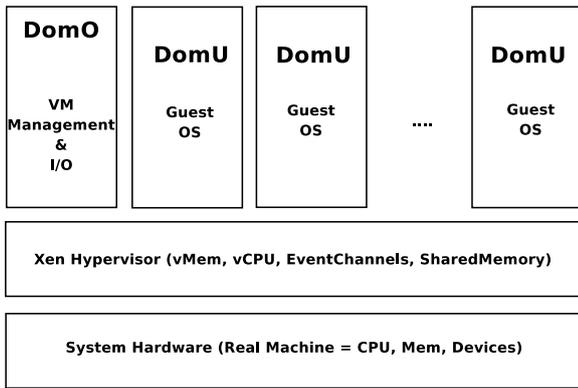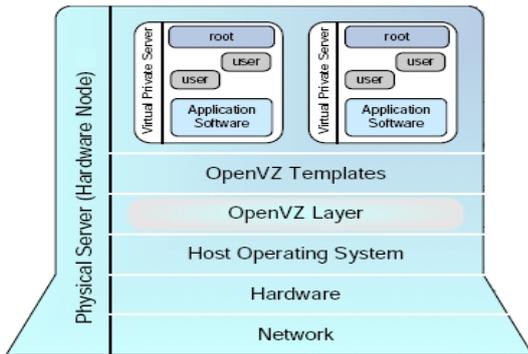
Fig. 1.   Xen architecture.

Fig. 2.   OpenVZ architecture.

between the *guest OS* and the underlying hardware. Each guest OS is actually a modified version of Linux called *Xen-Linux*, because the hardware presented by the hypervisor is not identical to the raw hardware. The hypervisor contains the CPU scheduler that implements various scheduling policies such as the proportional fair-share, along with other modules such as the memory management unit. In our experiments, we use the *Xen 3.0.3 stable branch* with the *Debian GNU/Linux* distribution.

B. OpenVZ System

OpenVZ [10] is a Linux-based OS-level server virtualization technology that allows the creation of secure and isolated virtual environments (VEs) on a single machine for the server consolidation. As shown in Fig. 2, each VE behaves exactly like a stand-alone server. Any VE can be rebooted independently, and can be set up by a different distribution with the separate root directory. One main distinction between OpenVZ and Xen is that the former one uses a single kernel shared by all the VEs whereas the latter one does not. Therefore, OpenVZ cannot provide the same fault isolation level as in Xen. In our experiments, we use both the uni-processor and multi-processor versions of *OpenVZ stable 2.6 kernel*.

III. OPEN SOURCE SOFTWARES FOR STREAMING SERVERS

A. Red5 Streaming Server

Red5 [11] is an open source software for the server application to deliver *Flash* files. Red5 is coded in Java, and includes the steaming video for the VoD and the audio/video webcam streaming. Red5 also supports the real-time multi-player gaming, the multi-user video chat, the live streaming, and the client stream recording. Red5 is essentially a clone of *Adobes Flash Media Server* that enables the user to stream live audio and video contents to/from Flash clients, to record media, to generate shared objects, and to perform RPC messaging. A Red5 streaming server supports the file formats of mp3, FLV, and RTMP. In our experiments, we use *Red5 v0.8.0 release candidate 1*.

B. Darwin Streaming Server

Darwin Streaming Server [12] is an open source software version of *Apple QuickTime Streaming Server* technology. Darwin allows the user to send the streaming media to clients across the Internet using the industry standard RTP and RSTP protocols. Darwin provides the high-level customizability, and can run on a variety of platforms. Darwin is built on a core server that provides the skip protection and the instant-On, and supports the latest digital media standards such as MPEG-4 and 3GPP. In our experiments, we use *Darwin Streaming Server 5.5.5 for Linux*.

C. VLC

VLC is one product from the *VideoLAN* project [13]. This project has developed various free/open source softwares for multimedia players and servers to stream multimedia files and real-time inputs from a camera, a TV tuner, and a data base. VLC supports a variety of audio and video formats including MPEG-1, MPEG-2, MPEG-4, DivX, mp3, and others, in addition to DVDs, VCDs, and several streaming protocol. VLC can be used as a server to stream multimedia data in unicast or multicast communications using IP-v4 or IP-v6 protocols through the network with the high bandwidth available. In our experiments, we use *VLC 0.9.6* for Linux.

IV. PERFORMANCE MEASUREMENT TOOLS

A. Siege

Siege [14] is a software to give stress tests to streaming servers. Siege is actually the http regression testing and the benchmarking utility. It allows Web-system developers to measure the performance of their systems under stress, so as to see how they can stand up loads from the Internet. The user of Siege can give loads to the Web server with a configurable number of concurrent simulated users. These simulated users are placed on the Web server "under siege." The duration of the siege is measured by transactions, where the number of transactions is given by the multiplication of the number of simulated users and the number of access times by each user. Thus, for example, if 20 concurrent users are accessing 50 times, 1000 transactions are generated. In our experiments, we use this tool to give stress test to the streaming server.

B. UnixBench

UnixBench [15] is a general-purpose benchmarking suite that has been designed to provide the basic performance evaluation for a Unix-like system. It has originated from Monash University, and then, has been taken up and expanded by the Byte magazine. UnixBench can run multiple test programs in order to evaluate various aspects of the system performance. In our experiments, we apply this tool to each virtualization container.

C. Built-in Tools

To measure the CPU utilization accurately, we prepared scripts of using existing tools to collect data. For the base system, the output from the *top -b* command is collected, and then it is analyzed. Similarly, *xentop -b* is used for the Xen system, which provides the information on the CPU utilization of individual domains. For the OpenVZ system, there is no tool to directly measure the CPU utilization by a particular container. Instead, the information provided from */proc/vz/vestat* can measure the amount of the CPU time spent by a particular VE.

V. EXPERIMENTS

A. Testbed

This section discusses our experiments for the performance comparison between Xen and OpenVZ in multimedia streaming applications. For reference, we use the plain *Linux 2.6* kernel that comes from the *Debian GNU/Linux 4.0* standard distribution as the native system. Standard packages available from the Debian repository are used to set up various applications. In our experiments, we build several multimedia applications such as video conferencing, IP-TV, and Internet gaming, based on core streaming servers of Red5, Darwin, and VLC.

Figure 3 shows the network topology in our testbed. We use *Core 2 Duo Intel Processor 2.66GHz* with 4GB RAM and 250GB SATA Drive for server machines. We generate three virtual containers for Xen and OpenVZ, respectively. The first container is allocated with the Red5 streaming server, the second one is with the Darwin, and the third one is with the VLC. A Gigabit switch is used for connections between the virtualization server and clients.

The experiments using this testbed consist of three parts:

1) First, we run the Xen container with access to each streaming server from clients. Then, we apply the loop of Siege benchmark to the streaming server, where we analyze the result from the Siege stress benchmark. After obtaining the result for Xen, we repeat the same procedure for OpenVZ. Finally, we compare the results between both virtualizations.

2) Instead of Siege, we use UnixBench, and repeat the same procedure as in 1).

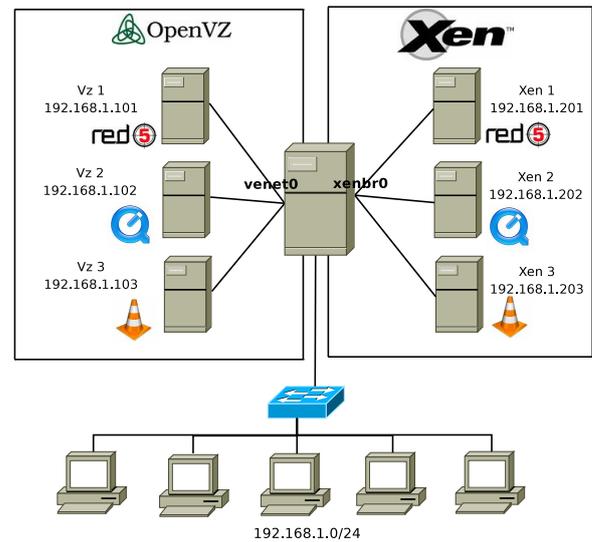3) Without using the measurement tool, we run streaming applications from concurrent clients, and analyze
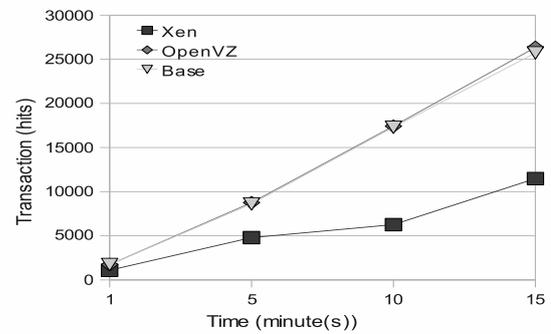

Fig. 3.   Testbed topology.

Fig. 4.   Siege Benchmark - Number of Transactions

the CPU utilization for the Xen system using *xentop-b* scripts. For the OpenVZ system, we use the *grep* command to obtain the result from */proc/vz/vestats*.

B. Results

1) Siege Benchmark: Siege benchmark gives several performance indices such as the number of transactions, the amount of data transmission, the response time, the transmission rate, and the throughput. After the testing for 15 minutes, we can obtain enough data to compare the performance between the base Linux system, the Xen system, and the OpenVZ system. Siege benchmark results indicate that the OpenVZ system has the better performance than the Xen system, and provides the nearly equal performance with the base system. On the other hand, the Xen system shows the only half performance of the base system.

Figures 4 and 5 show changes of the number of transactions and the amount of data transmissions when the streaming time is increased from one to 15 minutes, respectively. The performance of the Xen system is worse than the OpenVZ system and the base system. Figure 6 shows the change of the
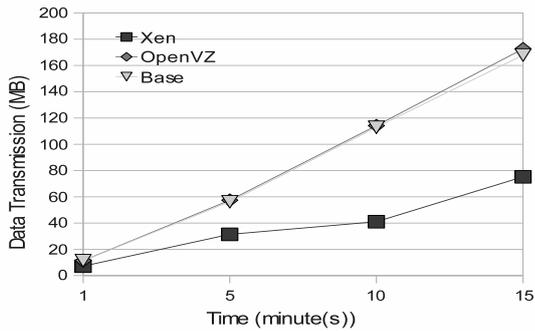
579

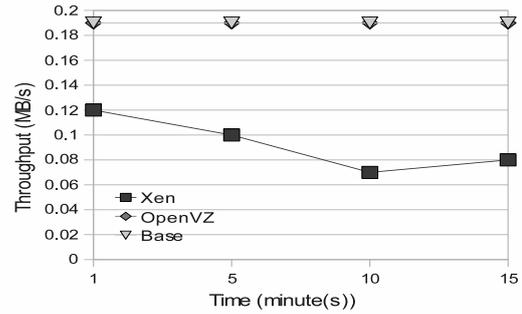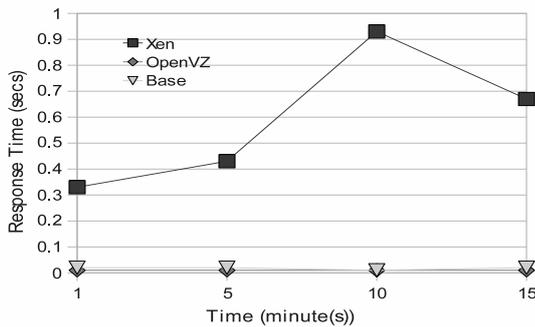Fig. 5.   Siege Benchmark - Data Transmission Amount

Fig. 6.   Siege Benchmark - Response Time

Fig. 7.   Siege Benchmark - Transmission Rate

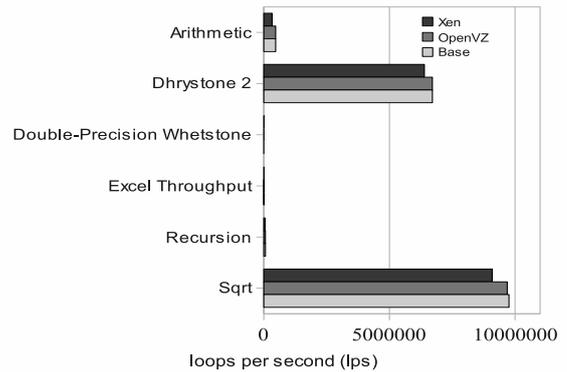Fig. 8.   Siege Benchmark - Throughput

Fig. 9.   UnixBench - CPU Benchmark

response time, where the Xen system spent much longer time than the others. Figure 7 shows the change of the transmission rate, where the OpenVZ system and the base system can handle 29 transactions per second, while the Xen system can handle only 18 transactions per second at maximum. Figure 8 shows the change of the throughput, where the OpenVZ system and the base system showed 0.19 MB/s while the Xen system showed only 0.12 MB/s.

2) UnixBench: UnixBench performs three tests, namely the CPU benchmark, the inter-process communication (IPC)

benchmark, and the file system benchmark. The CPU benchmark is the testing tool to measure the capability of CPU with the number of loop executions per second. It is actually measured by running sample programs using arithmetic and recursions. The IPC benchmark is the testing tool to measure the capability of inter-process communications between processes in a Linux system. The file system benchmark is the testing tool to measure the hard disk performance using *read*, *write*, and *copy* processes with the transmission data size per second.

Figure 9 shows the result of the CPU benchmark tests. The result indicates that both Xen and OpenVZ can offer the nearly full CPU performance without large degrading.

Figure 10 shows the result of the IPC benchmark tests, where the IPC performance for OpenVZ is significantly higher than that for Xen. Figure 11 shows the result of the file system benchmark tests, where the performance for Xen is much worse than that for OpenVZ in any case. The reason of these results comes from the fact that OpenVZ can directly communicate with the host kernel, whereas for Xen, any process in the guest OS first communicates with the guest kernel and then communicates with the host kernel via the virtualized Xen architecture.

3) Built-in Tools: Figure 12 shows the change of the overhead of the CPU utilization for each combination of a virtualization software and a streaming server when the
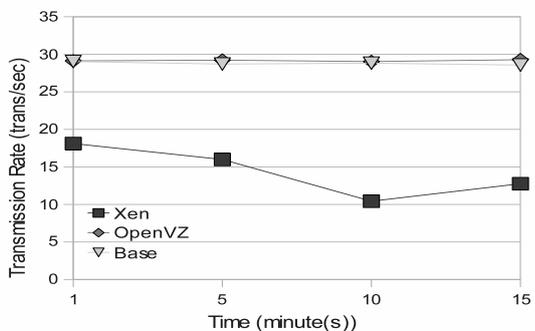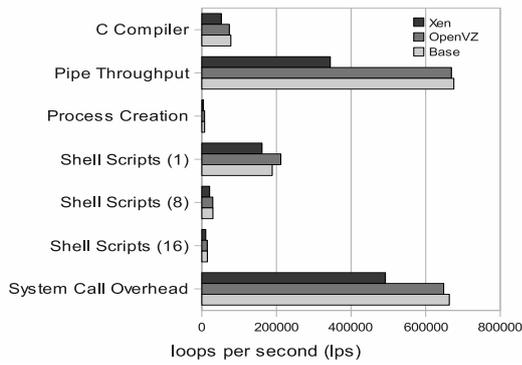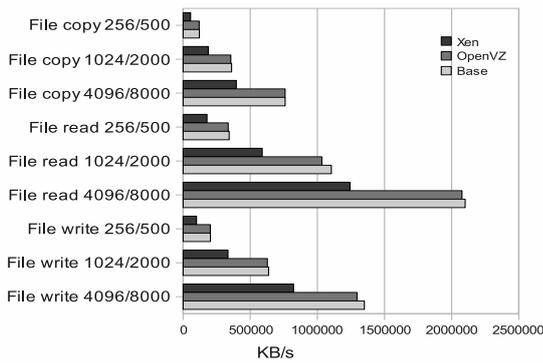
Fig. 10.   UnixBench - IPC Benchmark

Fig. 11.   Unixbench - File System Benchmark

number of clients is increased from one to five. The result shows that the combination of Xen and Red5 is the highest among them. Here, we note that we could not run Red5 on OpenVZ, although we have tried to increase the *privvmprivilage* parameter for Java, and to install the Java application in the base system using the *vzsplit* tool. Thus, we found that this OpenVZ system cannot run with Java in Red5. On the other hand, Java in Red5 can run in the Xen system without any problem.
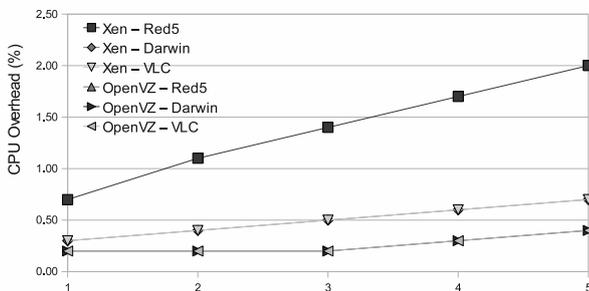
VI. CONCLUSION

In this paper, we have evaluated the performance of *Xen* and *OpenVZ* as representative open source softwares for the virtualization technology with three streaming servers *Red5*, *Darwin*, and *VLC*. Our experimental results have showed that OpenVZ provides the better performance for streaming applications with Darwin and VLC whereas Red5 can run only on Xen. Our future studies include performance evaluations of Internet servers such as Radius, DHCP, and LDAP, and other applications on the virtualization technology.

REFERENCES

[1] DjRob, "What virtualization software are you using?" 2007. [Online]. Available: http://ubuntuforums.org/showthread.php?t=589563.
[2] itsec, "Do you use virtualization?" 2007. [Online]. Available: http://www.debian-administration.org/polls/105.
[3] LaptopFreak, "What virtualization software do you like?" 2008. [Online]. Available: http://www.webhostingtalk.com/showthread.php?p=5432334.
[4] P. Barham, B. Dragonvic, K. Fraser, S. Hand, T.Harris, A. Ho, R. Neugebauer, I. Pratt, and A. Warfield, "Xen and the art of virtualization," in *19th ACM Symposium on Operating Systems Principles (SOSP)*, Oct 2003, pp. 164–177.
[5] B. Clark, T. Deshane, E. Dow, S. Evanchik, M. Finlayson, J. Herne, and J. Matthews, "Xen and the art of repeated research," in *USENIX Annual Technical Conference FREENIX Track*, 2004, pp. 135–144.
[6] P. Padala, X. Zhu, Z. Wang, S. Singhal, and K. G. Shin, "Performance evaluation of virtualization technologies for server consolidation," *HP Techinal Report HPL-2007-59R1*, 2008.
[7] A. Menon, J. Santos, Y. Turner, G. J. Janakiraman, and W. Zwaenepoel, "Diagnosing performance overheads in the Xen virtual machine environment," in *Proceedings of the First ACM/USENIX International Conference on Virtual Execution Environment(VEE)*, June 2005, pp. 13–23.
[8] E. Braastad, "Management of high availability services using virtualization," Master's thesis, Oslo University College, May 2006.
[9] "XenSource." [Online]. Available: http://www.xensource.com/.
[10] "OpenVZ." [Online]. Available: http://en.wikipedia.org/wiki/OpenVZ.
[11] "Red5 : Open source flash server open source flash." [Online]. Available: http://osflash.org/red5.
[12] "Darwin streaming server." [Online]. Available: http://dss.macosforge.org/.
[13] "Vlc media player." [Online]. Available: http://www.videolan.org/vlc/.
[14] "Beware of the dog — joedog / siege." [Online]. Available: http://www.joedog.org/JoeDog/Siege.
[15] "A fundamental high-level linux benchmark suite, UnixBench integrates CPU and file I/O tests, as well as system behaviour under various user loads." [Online]. Available: http://www.tux.org/pub/tux/benchmarks/System/unixbench/.

Fig. 12.   Overhead of CPU utilization for streaming server on virtualization