OpenStack hypervisor, container and Baremetal servers performance comparison

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Abstract: Recently, IaaS services provide not only virtual machines on hypervisors but also Baremetal servers or container based virtual servers. In this paper, we measure performances and start up time of Baremetal server, container servers, virtual machines on OpenStack with virtual server number changing and evaluate quantitative performances.

Keywords: performance, cloud computing, IaaS, Baremetal, container, hypervisor, OpenStack

Classification: Network

References

1 Introduction

Recently, cloud technology has been progressed and many providers have started cloud services. To build IaaS systems, many providers adopt open source software such as OpenStack \cite{ref1} and CloudStack. NTT group also has started IaaS services based on OpenStack since 2013.

Currently, many cloud services provide virtual servers to users using virtual machines deployed on hypervisors such as Xen or KVM. However, hypervisors have a demerit of much virtualization overhead. Therefore, some providers have started to provide non-virtualized Baremetal servers (hereafter, Baremetal) or container based virtual servers which overheads are small (hereafter, Container).
It is generally said that Baremetals and Containers show better performances than virtual machines on hypervisors. However, there are few works to compare performances and start up time of those three in same conditions and appropriate usage discussions based on quantitative data are not enough. For example, [2] compared performances of Baremetal, Docker and KVM but there is no data of start up time. The work of [3] includes Baremetal, Docker and KVM results of boot up time, reboot time and other performance data other than Unixbench data. However, it did not compare 3 types with virtual server number changing.

Therefore, this paper measures performances and start-up time of Baremetal using Ironic, Containers by Docker and virtual machines on KVM with virtual server number changing on OpenStack and shows quantitative data. The previous work of [2] and [3] do not have enough data with virtual server number changing.

2 Outline of Baremetal, Container and Hypervisor

In this section, we compare Baremetal, Container and Hypervisor qualitatively.

Baremetal is a non-virtualized physical server and same as an existing dedicated hosting server. IBM SoftLayer provides Baremetal cloud services adding characteristics of prompt provisioning and pay-per-use billing to dedicated servers. In OpenStack, Ironic component provides baremetal provisioning. Because Baremetal is a dedicated server, flexibility and performance are high but provisioning and start-up time are long and it also cannot conduct live migrations.

Containers’ technology is OS virtualization. OpenVZ or FreeBSD jail were used for VPS (Virtual Private Server) for many years. Computer resources are isolated with each unit called container but OS kernel is shared among all containers. Docker which uses LXC (Linux Container) appeared in 2013 and attracted many users because of its usability. Containers do not have kernel flexibility but a container creation only needs a process invocation and it takes a short time for start up. Virtualization overhead is also small. OpenVZ can conduct live migrations but Docker or LXC cannot conduct live migrations now.

Hypervisors’ technology is hardware virtualization and virtual machines are behaved on emulated hardware, thus users can customize virtual machine OS flexibly. Major hypervisors are Xen, KVM and VMware ESX. Virtual machines have merits of flexible OS and live migrations but those have demerits of performances and start up time.

Next, we compare performance and start-up time quantitatively.

3 Performance measurement conditions

This paper measures performances and start up time of 3 types servers with same conditions. We use OpenStack version Juno as a cloud controller, a physical server provisioned by Ironic as Baremetal, Docker 1.4.1 as a container technology and KVM/QEMU 2.0.0 as a hypervisor. Ironic, Docker and KVM are de facto standard software in OpenStack community. Server instances are Ubuntu 14.04 Linux servers with Apache2 web servers from 10 GB image file and we request 3 types instances provisioning to a same physical server using OpenStack compute component Nova.
3.1 Performance measurement items
- Measured servers: Baremetal provisioned by Ironic, Containers based on Docker, Virtual machines on KVM
- Virtual server number: 1, 2, 3, 4
  Only 1 for Baremetal case, 1–4 containers for Docker case and 1–4 virtual machines for KVM case. When there are plural virtual servers, all physical resources are equally separated to these plural servers.
- Performance measurement
  UnixBench [4] is conducted to acquire UnixBench performance indexes. Note that UnixBench is a major system performance benchmark.
- Start up time measurement
  A time from Nova server instance creation API call to each Linux and Apache2 server start up is measured. For Baremetal case, we measure not only total time but also each processing time of start up and we also measure the 1st time boot and the 2nd time boot.

3.2 Performance measurement environment
For a performance measurement environment, we prepared 1 physical server on which 3 types servers were provisioned and 1 physical server which had OpenStack components (Nova, Ironic, PXE server for Ironic PXE boot and so on). These servers were connected with Gigabit Ethernet and Layer 2 switch. Fig. 1 shows each server specification.

4 Performances of Baremetal, Docker and KVM
4.1 UnixBench performance
Fig. 2 shows a performance comparison of 3 types servers. Vertical axis shows UnixBench performance index value and horizon axis shows each server with virtual server number changing.

Based on Fig. 2 results, it is clear that Docker containers performance degradation is about 75% performance compared to Baremetal performance. And it is also said that Docker performance is degraded when we change virtual server number but it is not inverse proportion. Almost all performances of Docker are
better than KVM but file copy performances are worse than KVM, therefore the total index value is not much higher than KVM. Meanwhile, virtual machines on KVM performance degradation is more larger and only 60% performance compared to Baremetal performance and KVM performance degradation tendency with virtual server number change is as same as Docker.

4.2 Start up time

Fig. 3(a) shows start up time of 3 type servers. When virtual servers are plural, average start up time is showed. Fig. 3(b) shows each processing time of Baremetal start up for the 1st time boot and the 2nd time boot. From Fig. 3(a), Baremetal start up takes much long time than KVM and Docker. This is because Baremetal start up needs image writing for PXE boot for the 1st time boot and it takes long time. For the 2nd time boot, it does not need image writing and total start up time is about only 200 sec (see, Fig. 3(b)).

Comparing Docker and KVM, Docker containers start up are shorter than KVM virtual machines and are less than 15 sec. This is because a virtual machine start up needs OS boot but a container creation only needs a process invocation. Precisely, Docker instance creation only takes several hundred msec but OpenStack processing such as API check, port creation and IP address setting take about 5 sec.
4.3 Discussion
Here, we discuss appropriate usages of IaaS servers based on quantitative data. Because Baremetal shows better performances than other 2 types servers, it is suitable to use large scale DB processing or real time processing which have performance problems when we use virtual machines. Containers lack flexibility of kernel but performance degradation is small and start up time is short. Thus, it is suitable for auto scaling for existing servers or shared usages of basic services such as Web or mail. Hypervisors are suitable to use for areas which need system flexibility such as business applications on specific OS.

5 Conclusion
This paper measured performances and start up time of 3 types IaaS servers; Baremetal, Docker and KVM with virtual server number changing and showed quantitative data. We also studied application areas of each type based on the results. In the future, we plan to enhance IaaS services line up for appropriate use of 3 types servers.