Performance Isolation of Network Virtualization for Cloud Computing

Sung-Won Ahn[1] and Chuck Yoo[1]
[1] Dept. of Computer Science and Engineering, Korea University,
Anam-dong, Seongbuk-gu Seoul 136-713, South Korea
[e-mail: swahn@os.korea.ac.kr]
[e-mail: chuckyoo@os.korea.ac.kr]
*Corresponding author: Chuck Yoo

Abstract

Network virtualization is a study that supports future internet environment and Cloud computing. The network virtualization can mitigate many hardware restrictions and provide variable network topologies to support variable services. One of typical study of network virtualization is software based router which has many advantages such as relatively low cost, high flexibility, better manageability. Software router and virtualization is the study to get closer Cloud computing. In many issues for Cloud computing, we especially focused on isolation of network and performance to make sure management of service quality and integrity. In this paper, we implement multiple virtualized networks to offer variable service on a physical network by using Xen based virtual software router. And we describe network isolation by using network ID to ensure integrity of service contents. Moreover, we implement and discuss performance isolation method with dynamic adaptation of bandwidth usage to ensure flexible quality of many services.

Keywords: Network virtualization, Performance isolation, Cloud computing, SR-IOV, Xen

1. Introduction

Virtualization is the way of reducing hardware restrictions. It provides varied adaptation of scalability. Recently, virtualization has been studied not only system virtualization but also network virtualization. Network virtualization is the base technology to support future internet environment and Cloud computing. Since network virtualization can provide variable network topologies to support variable service, it can ensure flexible and scalable network[1][2].

Network virtualization is a technique that provides separation of physical network resource to isolated logical network. It takes manage-ability advantage that accommodate existing network service and makes varied topologis.

Network virtualization can devided two parts as router virtualization and link virtualization. The router virtualization technique provides multiple independent logical router on a physical router platform by using system virtualization. And the link virtualization provide multiple virtual link on a phycial link or integrated virtual link on multiple phycial link.

To support virtualized network, it needs virtualized router. Recently proposed software routers that beyond existing limitations of hardware can support many service such as CCN[3] and CDN[4]. Software router has higher flexibility and manageability than hardware router. Moreover, software router relatively more cheaper. Therefore, software router can be

This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MEST) (No. 2010-0029180)

used to network virtualization because it can easily add or change the necessary functions.

Many existing studies of network virtualization is confined to large server and storage system[5]. And there is few cases of analysis for variety of network. It is same between physical link and logical link in the existing environment of network. Howerver, it is different in virtualized network environment. Varied topologies need isolation because there are various charasteristics of virtual network with various service. And it is need that adaptive bandwidth allocation scheme to ensure QoS(qulity of service) of varied contents.

In this paper, we suggest network isolation to ensure integrity of virtual network. And we also suggest performance isolation on virtualized network to ensure effective bandwidth resource management. We implement these technique on Xen[6] environment and use Intel 82599 10G ethernet card[7] which support SR-IOV[8] as a hardware platform.

2. Related Works

2.1 Xen virtualization

System virtualization is divided two part such as full-virtualization and para-virtualization. VM-ware[9] is an example of full-virtualization. It does not require modification of guest os and most work is operated as software. Howerver, fullization has low performance.

Para-virtualization complement disadvantages of full-virtualization. A typical example is Xen. Xen increase virtualization by modifing guest os code. It manage instruction by using hypercall that is similar to system call. Therefore, there is no additional conversion operations during guest os operation.

In this paper, we use Xen for virtualization environment. Xen can support more flexible and ensure performance.

2.1 Software router

A software router has been studied as a solution to save cost and apply varied platforms to alternate hardware router. It has many advantages such as flexibility, manageability, scalability. A software router architecture is configured by software routing application on operating system on hardware.

There are many studies in software router. For instance, the Click[10] ensures freely configurable routing scheme by making it possible to change module dynamically. And the Openflow[11] ensures managing dynamic routing flow table by separating data and routing control. Moreover, the XORP[12] can support varied routing protocol such as uni or multi-cast.

Howerver, still there remain age-old problem that low performance of software router. Therefore, there is performance increment study like PacketShader[13] that using GPU(Graphic Process Unit) which has hundreds multi- core on nowaday.

But, these software router does not ensure complete isolation of virtualized network in sared resource environment that coexist various protocols. As a consequence, the studies of isolation is necessary to support multiple isolated virtual network for future internet scheme. Also it is need for explode limitation of software router.

In this paper, we describe the importance of isolation and implementation of isolation. Additionally, we suggest our method that can ensure isolation of network and performance to manage various virtualized network stable.

2.3 SR-IOV(Single-Root I/O Virtualization)

The SR-IOV is a new I/O virtualization technique that using Intel-VT[9] in Intel. This method is a kind of HVM(Hardware-assisted Virtual Machine) to solve performance degradation. And Xen can support this mechanism.

The SR-IOV allows that a guest os can access physical NIC(Network Interface Card) directly. As a result, it increases performance of virtualized network I/O which infects to performance of network virtualization significantly.

Furthermore, it classify clearly role and definition of PF(Physical Function) and VF(Virtual Function). Accordingly, it is possible that each geust os can use isolated virtualized NIC without influence from other virtual network.

In this paper, we use SR-IOV mechanism to ensure isolation of network and performance for virtualized network.

3. Network Virtualization Architecture

Fig. 1 shows router virtualization architecture of our system. The virtualized network is constituted with this architecture that configured for network isolation and performance isolation.

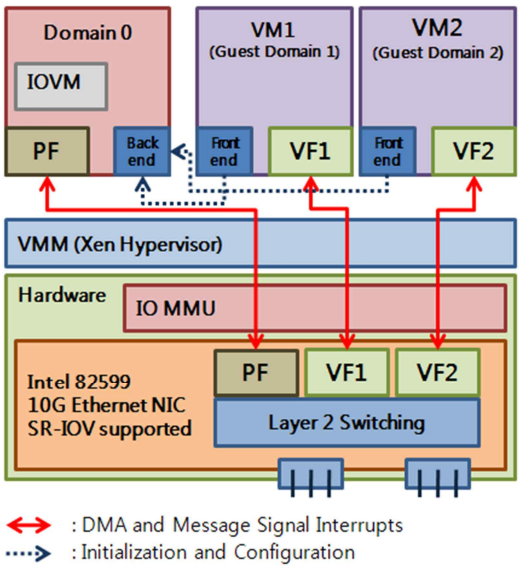

Fig. 1 System Architecture

As shown **Fig. 1**, the hardware platform is Intel 82599 10Gigabit ethernet network interface card and we use Xen as a hypervisor. There are several domains on Xen hypervisor. These domains are a Domain0(Dom0) and Guest Domains(VM1, VM2 – VM:Virtual Machine).

The NIC is seperated several virtual interface such as PF(Physical Function) and VF(Virtual Function) by SR-IOV supporting virtualization. The PF is assignment to Dom0 directly in PCIe(PCI Express) supported environment. Therefore, a PF has independent network interface with no influence from other domains. SR-IOV can make several VFs that has relatevely light PCIe function. VFs are assigned to each virtual machine, and provide isolated communication which controlled by VM.

PF and VF can work as a belonged NIC which controlled by each domain directly in each domain. Each VF set initial configuration through IOVM(SR-IOV Manager) of Dom0. Then VF use DMA(Direct Memory Access) for communication after initial configuration.

4. Isolation of Virtualized Network

Network Isolation means perfectly isolated network form which does not affect other networks. The configuration of network to support various protocols is as shown **Fig. 2** by using virtualization that is metioned above as **Fig. 1**.

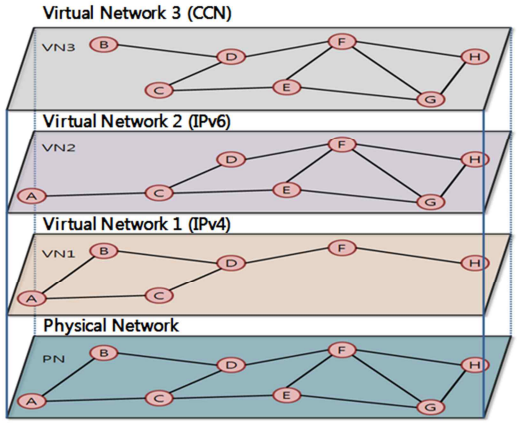

Fig. 2 Virtualized Network

As shown **Fig. 2**, virtual network 1,2,3 share one physical network. In other words, it is possible to configure virtual networks that support different protocols such as IPv4, IPv6 and CCN by network virtualization on a physical network. These protocols coexistence on single router or a relay node.

Howerver, even they use same physical hardware, they must operate independently. For instance, there do not inflow secure packet of virtual network 1 to other virtual network and also it is not allowed to inflow worm virus packet of virtual network 2 to other virtual network. In addition, each network should not be infect massive problem such as DDOS (Distributed Denial of Service) attack.

To make sure isolation of virtual network, we gave VLAN ID(Virtual Local Area Network Identification) to each packet of each virtual network. A VLAN ID is given according to service or protocol. Each virtual network has inherence VLAN ID and construct network with VLAN ID. Only the virtual networks which have same VLAN ID can communicate each other. Therefore, if the VLAN ID is different, then it cannot join to other virtual network infra.

Each virtualized router get several different VLAN ID depending on each service and protocol. And they belong to their virtual network. The virtualized router A in **Fig.2** has two different VLAN ID depending on two services. The router A provides both IPv6 and CCN. It belong to two different topologies at the same time. And it has two different routing table.

5. Evaluation of Performance Isolation

As we mentioned before, several virtualized networks coexist on a physical network. It means the offered maximum bandwidth of a virtual network is the maximum value of the physical network. Therefore, there need several different bandwidth to each virtual network within range of maximum bandwidth. This technique is performance isolation. The performance isolation is a management and a distribution of available network bandwidth.

In virtualized system architecture as shown **Fig. 1**, the offered bandwidth of each domain is determined by how often a damain occupies the NIC. In this paper, we implement performance isolation by controlling NIC occupancy rate of each domain. To possible this technique, we use BCN(Backward Congestion Notification)[8] which is supported in SR-IOV.

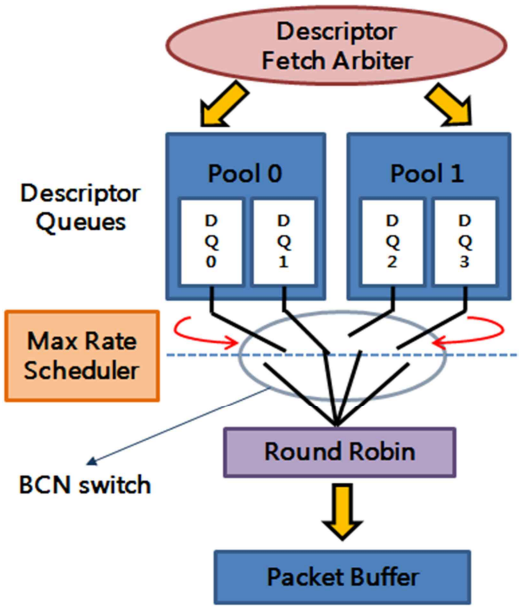

Fig. 3 Performance isolation Scheduling

Fig. 3 shows BCN rate scheduler to apply performance isolation. The descriptor fetch arbiter allocates a packet to send to assigned pool from ring-buffer of memory.

Pool0 and Pool1 in VFs which are existed on the NIC are assigned to each VM1 and VM2. There are BCN registers in Descriptor Queue(DQ) that is present inside of each Pool. The throughput and packet buffer share value is different by how set the value of the register allocation. Max rate scheduler allocates less bandwidth which is assigned to register. If bandwidth is increased over the assigned value, the BCN bridge should be disconnected.

The order of packet transmission is according to round robin method basically. A pool which satsfies register value get connection to DQ and occupies packet buffer and communication. It means the packet of virtual domain which occupies corresponding pool is transmited through NIC.

VM1 BCN Rate	VM2 BCN Rate	VM1 BW (Kbps)	VM2 BW (Kbps)	BW Sum (Kbps)
3000	7000	2986	6891	9877
4000	6000	3873	5987	9860
7000	7000	4825	4968	9793
8000	6000	6151	4009	10160
x	x	4876	4925	9801

Fig. 4 Result of performance isolation

Fig. 4 shows result of performance isolation among VMs in network isolation ensured environment. If BCN rate of VM1 and VM2 is set to 3:7, 4:6, it is as works as assigned value. If BCN rate is set both as same as 7000, then it works 5:5 rate in maximum bandwidth range. This is similar result when BCN rate does not set. If BCN rate is set to 8:6, it also works with proper bandwidth as close as assigned ratio.

As idenfied in Fig.4, performance isolation manage bandwidth which is allocated each domain in various virtual network coexistent environment. Moreover, it can ensure QoS and efficient resource management.

6. Conclusions

Network virtualization which is underlying for future internet mitigates hardware restriction. Moreover network virtualization provides

various topologies to offer varied services. The needs for virtual router in virtual network environment is coexistence of various virtual networks which provide different services on a physical network, and manage these virtual network efficiently. To possible this work, it needs isolation of network and control quality of service.

In this paper, we implement virtual network that can provide network isolation and control bandwidth allocation with SR-IOV on Intel 82599 10G NIC. Network isolation can ensure integrity of each virtual network with VLAN ID. Also, performance isolation can ensure balance of bandwidth allocation for better quality of service.

It can realize security, isolation, efficient resource management on virtual network. Moreover, it can also provide low cost, flexibility, managablity. We expect that this study can be a good test bed platform for many other future internet researches.

References

[1] Y.H. Kim, "Technical Trends of Network Virtualization in Future Internet", trend analysis of electronic communication, Vol25 (1). Feb 2010.

[2] N. Chowdhury, "A survey of network virtualization," Computer Networks, Jan. 2010.

[3] V. Jacobson, D. K. Smetters, J. D. Thornton, M. F. Plass, N. H. Briggs, and R. L. Braynard, "Networking named content," Proceedings of the 5th international conference on Emerging networking experiments and technologies (CoNEXT '09),2009, p. 1-12.

[4] A. Vakali and G. Pallis, "Content delivery networks: status and trends," Internet Computing, IEEE, vol. 7, no. 6, p. 68- 74, 2003.

[5] N. Egi, A. Greenhalgh, M. Handley, M. Hoerdt, F. Huici, and L. Mathy, "Towards high performance virtual routers on commodity hardware," Proceedings of the 2008 ACM CoNEXT Conference, 2008, p. 20.

[6] [P. Barham, B. Dragovic, K. Fraser, S. Hand, T. Harris, A. Ho, R. Neugebauer, I. Pratt, and A. Warfield, "Xen and the art of virtualization,"In Proceedings of the nineteenth ACM symposium on Operating systems principles(SOSP), 2003

[7] Y. Dong, et al. SR-IOV Networking in Xen: Architecture, Design and Implementation. 1st Workshop on I/O Virtualization, San Diego, CA, 2008.

[8] Intel Corporation, Intel® 82599 Gigabit Ethernet Controller Datasheet. http://www.intel. com

[9] VMware, http://www.vmware.com/

[10] E. Kohler, R. Morris, B. Chen, J. Jannotti, and M. F. Kaashoek, "The click modular router," ACM Transactions on Computer Systems (TOCS), vol. 18, no. 3, p. 263-297, Aug. 2000.

[11] N. McKeown et al., "OpenFlow: enabling innovation in campus networks," ACM SIGCOMM Computer Communication Review, vol. 38, no. 2, p. 69-74, Mar. 2008.

[12] M. Handley, O. Hodson, and E. Kohler, "XORP: an open platform for network research," ACM SIGCOMM Computer Communication Review, vol. 33, no. 1, p. 53-57, Jan. 2003.

[13] Sangjin Han, Keon Jang, KyoungSoo Park and Sue Moon, "PacketShader: a GPU-accelerated Software Router,"In proceedings of ACM SIGCOMM 2010, Delhi, India. September 2010.

[14] G. Neiger, A. Santoni, F. Leung, D. Rodgers, and R. Uhlig "Intel® Virtualization Technology: Hardware support for efficient processor virtualization," Intel® Virtualization Technology, Volume 10, Issue 03 Published August 10, 2006.