Performance Evaluation of Packet Forwarding Mechanism in Virtual Networks

Ulisses da Rocha Figueiredo, Antonio Gonzalez Pastana Lobato, Otto Carlos M. B. Duarte
Universidade Federal do Rio de Janeiro - GTA/COPPE - Rio de Janeiro, Brazil

***Abstract*—The network virtualization technique is essential to create environments for experimentation of Future Internet proposals. The pluralist architecture for the Future Internet relies on virtualization, in which several different networks run on the same physical substrate. In this paper we analyze network virtualization architectures based on personal computers, focusing on performance evaluation of the switching mechanisms on OpenFlow and Xen platforms, in comparison with the hybrid virtualization technique XenFlow.**

I. Introduction

Virtualization is the technique used to provide a pluralist environment in virtual networks for future network experimentation. In virtualization, the function executed by a network element is decoupled from it's hardware, therefore multiple isolated virtual networks can run over the same physical substrate.

In this paper the following forwarding mechanisms were evaluated: Xen's router and bridge mode; NetFPGA and Open vSwitch running OpenFlow; and GTA's hybrid virtualization technique XenFlow [1]. It was measured both the packet forwarding rate and the jitter of these mechanisms.

The FITS (Future Internet Testbed with Security) [2] platform was used to create the virtualizated environment. FITS allows the creation of multiple virtual networks in parallel, based on virtualization tools Xen and OpenFlow. The testing environment is geographically distributed, with the collaboration of Brazilian and European institutions.

II. Network Virtualization through Xen

Xen [3] is a personal computer virtualization tool. Xen's is based on a layer right above the hardware, called hypervisor. It's architecture consists of a privileged domain (dom0) which has access to the I/O mechanisms and the unprivileged domains (domU) that have to communicate with the dom0 in order to perform I/O operations.

Xen Bridge: The communication between the dom0 and the domU machines is established through a bridge and the packets that arrives to the physical machine are forwarded in the layer 2 from the dom0 to the virtual machines.

Xen Router: In the Router mode, the dom0 acts as a router, verifying the packet's IP destination and sending them to the corresponding virtual machine.

III. OpenFlow's flow switching

OpenFlow [4] is based in the Software Defined Network plane separation paradigm. The data plane, responsible for simple packet switching, and the control plane, in charge of the network's intelligence, by defining the packet next hop, are now separated.

OpenFlow is a open protocol and can be implemented in different network elements. With Open vSwitch, it's possible to create a software switch, changing a virtual machine behavior, so it can act as a switch. Furthermore, OpenFlow can be used in a NetFPGA, which is a programmable network device, allowing line-rate packet processing, a capability generally unafforded by software.

IV. XenFlow hybrid system

XenFlow is a hybrid virtualization technique based on the Xen and OpenFlow platforms. In XenFlow's architecture the data plane is placed in the dom0, in order to achieve high forwarding rate, and the control plane is placed in Xen's virtual machines.

XenFlow's main idea is to place copies of the virtual machines' data plane in the dom0, that way the all data plane of a physical machine is paced in it's dom0. Therefore, it allows a better forwarding rate.

V. Results and Conclusion

The results showed the higher performance of the mechanisms that uses OpenFlow's plane separation approach. NetFPGA's hardware achieved the best forwarding rate, however, the other OpenFlow based mechanisms, including XenFlow, also showed a competitive performance. Due to Xen's network virtualization complexity, both bridge and router modes obtained a worse performance.

Therefore, the XenFlow hybrid mechanism was able to combine both Xen's flexibility and OpenFlow's performance. Since it achieves a high performance in packet forwarding and doesn't need a specific hardware, XenFlow is a viable option for packet forwarding in virtual networks.

Acknowledgments

This work was supported by FINEP, FUNTTEL, CNPq, CAPES, and FAPERJ.

References

[1] D. M. F. Mattos and O. C. M. B. Duarte, "QFlow: Um sistema com garantia de isolamento e oferta de qualidade de serviço para redes virtualizadas," in *SBRC'2012*, Apr. 2012.

[2] P. H. V. Guimaraes, L. H. G. Ferraz, J. V. Torres, I. D. Alvarenga, C. S. Rodrigues, and O. C. M. Duarte, "Experimenting content-centric networks in the future internet testbed environment," in *Workshop on Cloud Convergence, ICC*, 2013.

[3] 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 *ACM SIGOPS Operating Systems Review*, vol. 37, no. 5. ACM, 2003, pp. 164–177.

[4] N. McKeown, T. Anderson, H. Balakrishnan, G. Parulkar, L. Peterson, J. Rexford, S. Shenker, and J. Turner, "OpenFlow: in campus networksenabling innovation in campus networks," *ACM SIGCOMM Computer Communication Review*, 2008.