# OpenFlow Activities in Würzburg

Michael Jarschel, Dominik Klein
University of Würzburg, Institute of Computer Science, Würzburg, Germany.
Email: {michael.jarschel,dominik.klein}@informatik.uni-wuerzburg.de

***Abstract*—The OpenFlow concept of flow-based forwarding and separation of the control plane from the data plane provides a new flexibility in network innovation. While initially used solely in the research domain, OpenFlow is now finding its way into commercial applications. However, this creates new challenges, as questions of OpenFlow scalability and performance have not yet been answered. On the other hand the OpenFlow technology also opens up new possibilities for research in testbeds such as G-Lab and network management in general. Especially in the field of energy-efficient data centers OpenFlow is one of the most promising network technologies available. In Würzburg we try to overcome those challenges by applying methods from queueing theory and performance analysis to OpenFlow. Furthermore, we have introduced OpenFlow into the German research platform G-Lab and are also investigating possible energy-savings in data centers through the use of OpenFlow. This extended abstract briefly describes our work in these fields.**

***Index Terms*—OpenFlow, switch, performance evaluation, proxy management, energy efficiency**

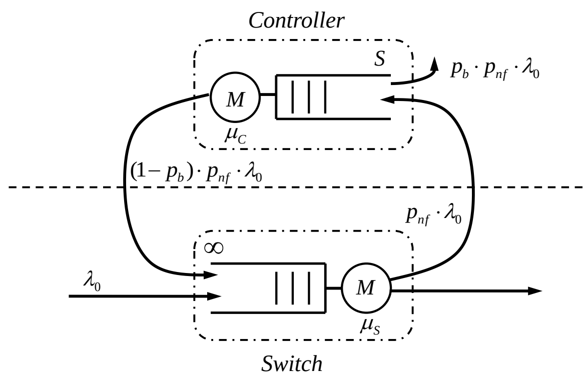


Fig. 1. A simple model of an OpenFlow switch.

## I. Introduction

At present, there is a research group at the University of Würzburg, which persues activities with a focus on network virtualization and cloud computing. Within this group, we investigate OpenFlow as a technology enabler. Current information on ongoing research, projects and activities is available at the chair's OpenFlow website [1]. The remainder of this abstract is organized as follows. Section II gives a brief summary of our activities in OpenFlow performance analysis. In Section III we describe a software project for creating arbitrary topologies through the use of OpenFlow supported proxy management. The integration of OpenFlow into the German network research platform G-Lab is described in Section IV. The last Section introduces our efforts with regard to energy efficient datacenters.

## II. Modeling of OpenFlow

Understanding the performance and limitations of the basic OpenFlow concept is a prerequisite for using it for experiments with new protocols and mechanisms. Therefore, we aim to provide a performance model of an OpenFlow system. The model is based on results from queueing theory and is verified by simulations and measurement experiments with a real OpenFlow switch and controller, cf. Figure 1. We intend to gradually refine the model and adapt it to the needs of the community. The advantage of an analytical model is the fact that it can quickly provide indicators for performance and scalability for an OpenFlow switch-controller system before detailed data is available. While simulation can provide detailed insight into a certain configuration, the analytical model greatly simplifies a conceptual deployment decision. Our results will be published at ITC 2011 in San Francisco [2].

## III. IPOM: Interactive Proxy Management

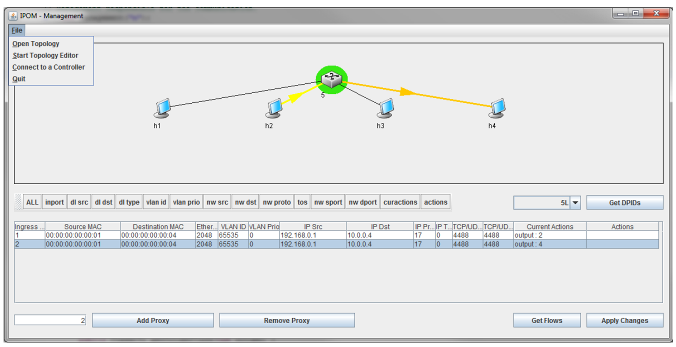


Fig. 2. IPOM GUI with a graphical representation of the network.

The Interactive PrOxy Management (IPOM) tool enables us to define and emulate networks of arbitrary complexity on top of existing experimental facilities by means of OpenFlow and network emulating proxy nodes. The IPOM tool is split into two parts, the topology editor for creating a network topology and the topology management tool for controlling the flows in the network. Before running experiments in a testbed environment, the physical network topology can be mapped using the IPOM topology editor. The IPOM management tool

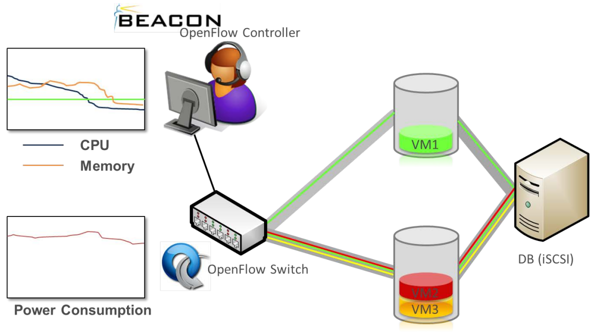


Fig. 3. Visualization of ECDC Testbed.

provides the possibility to dynamically add and remove proxies. Additionally, arbitrary OpenFlow actions can be installed for any flow. Figure 2 shows the graphical user interface of IPOM. The software has been demonstrated at NGI 2011 in Kaiserslautern [3].

## IV. OpenFlow in G-Lab

OpenFlow is quickly becoming the most dynamic topic in networking today. Therefore, it fits very well into G-Lab [4] and its mission to create and test ideas for the networks of the future. OpenFlow extends the G-Lab experimental facility by the ability for Software Defined Networking (SDN) and network virtualization. This allows the OpenFlow-enabled site in Würzburg to "break the star" using the G-Lab provisioning tool ToMaTo [5]. This provides researchers with dynamically created topologies utilizing all available server resources accelerating the creation and deployment of network experiments.

## V. ECDC: Energy Efficient Data Center

Another application area for OpenFlow is its usage in data centers. The ability of monitoring and managing of flows provides several possibilities within data centers. In Würzburg, we are especially interested in evaluating the trade-off between energy-efficiency and Quality of Experience (QoE) within data centers. To evaluate this trade-off, we implemented the below described approach in our testbed, cf. Figure 3, and are currently working on the validation and improvement of the approach via simulation.

We use the Beacon OpenFlow controller to monitor the load of the servers and the data center network as well as the power consumption of the different components. Based on these information, the management entity behind the OpenFlow controller decides whether a migration of virtual machines are useful to shutdown different servers and thus, save energy. The second option is to start new servers to balance the load and to decrease the service time. The monitoring of the loads as well as the flow redirection is handled using OpenFlow.

## References

[1] Chair of Communication Networks, "OpenFlow Research Activities," http://www3.informatik.uni-wuerzburg.de/research/ngn/openflow.shtml, 2011.

[2] M. Jarschel, S. Oechsner, D. Schlosser, R. Pries, S. Goll, and P. Tran-Gia, "Modeling and Performance Evaluation of an OpenFlow Architecture," in *23rd International Teletraffic Congress (ITC 2011)*, San Francisco, CA, USA, Sep. 2011.

[3] M. Jarschel, D. Schlosser, M. Duelli, and R. Pries, "IPOM: Interactive Proxy Management Tool for Future Communication Networks Using OpenFlow," Kaiserslautern, Germany, Jun. 2011.

[4] Federal Ministry of Education and Research, "German lab (g-lab)," http://www.german-lab.de, 2011.

[5] D. Schwerdel, "ToMaTo - Next Generation Testbed Software," ICSY Department of Computer Science, University of Kaiserslautern, Kaiserslautern, Germany, Tech. Rep. ICSY-2010-3, 2010.