A Short Note in Support of OpenFlow/SDN on University Campuses

Lead Author: Johan van Reijendam, Stanford University
Contributors:
Dan Schmiedt, Clemson University

Guru Parulkar, Stanford University Russ Clark, Georgia Tech
Matt Davy, Indiana University Chris Tengi, Princeton University
Ivan Seskar, Rutgers University Patrick Christian, University of Wisconsin
Ian Cote, University of Washington Jim Bottum, Clemson University
Jim Pepin, Clemson University

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1 Executive Summary

Software Defined Networking (SDN), in particular OpenFlow, is emerging as one of the most promising and disruptive networking technologies in recent years. SDN decouples the network data and control planes through a well-defined interface and enables innovation, making it possible to create new networking capabilities and address a number of persistent problems. Many universities and research laboratories around the world have been experimenting with SDN to demonstrate its potential. Internet2 has announced plans to build a nation-wide SDN backbone network for universities. The industry is also embracing SDN; over 40 companies have joined the Open Networking Foundation (ONF) to standardize and promote SDN, and 15 vendors demonstrated OpenFlow/SDN offerings at this year's Interop Show in Las Vegas

Universities operate some of the most complex and demanding network infrastructures, and face challenges as the try to keep up with rapid advances in computing, communication technologies, and applications. SDN can help universities directly in their mission to promote research, education, and engagement. For example, OpenFlow/SDN allows researchers to create their own customized virtual networks without interfering with each other. It also means that network engineers can manage mobile payment systems more easily and efficiently, can create more scalable private clouds, and no longer need to depend on the L2 spanning-tree protocol. Similarly a researcher can experiment on their customized virtual network within and across campuses, at scale, and without interfering with the production network.

As SDN gains momentum, universities have the opportunity to upgrade their network infrastructure by deploying SDN on their campuses. NSF and the US IGNITE initiative seem willing to help fund this upgrade if universities put forward a strong case.

2 University Networking Challenges

University campus networks typically serve 20,000 to 60,000 or more users. Users include students, researchers, administrators, physicians, patients, and others. This user community has diverse requirements. Researchers strongly favor open and unconstrained networks, both on and off campus, so that they can collaborate unhindered by network obstacles. On the other hand, administrators want networks to be secure and reliable to ensure confidentiality of data.

A considerable part of the university user community also wants access to bleeding-edge technologies including end-devices, networks, and services. Universities are expected to have leading-edge infrastructures in support of research and education.

As computing, storage, and networking have become mission-critical, and with user requirements growing fast, universities find themselves in a quandary. Having to deploy increasingly sophisticated and expensive commercial solutions, universities have become too dependent on commercial vendors. Their capex and opex of the networking infrastructure have been growing too fast, putting excessive pressure on CIO resources.

Increasing dependence on proprietary and closed vendor solutions also means universities have lost their ability to customize the networking infrastructure and to innovate. Universities are confined to solving their problems by using mechanisms that are provided by commercial vendors. The use of VLANs is one such mechanism. VLANs are extensively used to segregate networks but introduce added complexity into the network. VLAN numbering schemes often clash. The use of VLANs results in the loss of bandwidth capacity due to the loop-prevention mechanism. Redundant link fail-over can take up to 50 seconds.

Universities are also forced to deploy security appliances such as firewall, IDS, and access-control devices to help provide basic network security. These are generally expensive solutions. Moreover, they hinder scientists wanting to create customized high-bandwidth applications and connections to other institutions. This is a big problem for campus network operators and for key stakeholders.

The net result is that universities are spending too much on their networking infrastructure and have lost the ability to invent and create when it comes to networking and computing infrastructure.

3 Promise of SDN

Key aspects of SDN include: the separation of data and control planes; a uniform vendor-agnostic interface between control and data planes called OpenFlow; a logically centralized control plane; and slicing and virtualization of the underlying network. The logically centralized control plane is realized using a network OS that constructs and presents a logical map of the entire network to services or control applications implemented on top of it.

In a software defined network, a researcher or network administrator can introduce a new capability by writing a simple software program that manipulates the logical map of a slice of the network. The rest is taken care of by the network OS.

SDN promises more control of the network by infrastructure owners. It also promises to enable network innovation that will create new networking capabilities and address a number of persistent problems. A significant number of universities and research laboratories around the world have been deploying and experimenting with SDN on their campuses to explore and demonstrate its potential. Internet2 has announced plans to build a nation-wide SDN backbone network for universities. SDN is being embraced by the industry as is demonstrated by the more than 40 companies that have joined the Open Networking Foundation (ONF) to standardize and promote SDN. ONF member companies include some of the largest network operators as well as networking equipment vendors.

SDN provides a central vantage point for network operations and engineering staff, through the Network Operating System. This simplifies network operation and management, and can significantly increase operational efficiency. The Network Operating System also provides a well-defined API to add new network management and control capabilities, either by local network operation staff or by third-party vendors. Some of the issues with VLAN mentioned above can be easily addressed by SDN-based solutions, increasing the capacity of the network. Network operators will be able to reduce the number of devices in the backbone as more of their functionality is taken over by the network itself, simplifying the infrastructure and making considerable cost savings possible.

The Network Operating System API also makes it possible for researchers to experiment with their research ideas on a slice of a production network without interfering with the production traffic. A SDN approach will allow the control and management of certain segments to be delegated to researchers and allow university science communities to create their own customized, application-specific, high-bandwidth network flows/slices. They will be able to do so within or across campuses, and without interfering with

the production network, offering researchers a much larger infrastructure to experiment on than has been available until now. A more flexible, interoperable, and scalable access-control infrastructure can be built which will be more responsive and resilient. Access control and security are taken care of in the control plane when the flows/slices are created, so that performance-limited firewall and IDS systems no longer need to be traversed.

4 University Opportunity with SDN

A number of universities have now demonstrated the potential of SDN. In addition, the industry is embracing SDN and starting to offer products such as OpenFlow-enabled switches, network OS, and control and management applications. Thus, a broader group of universities has an opportunity to aggressively deploy SDN solutions to upgrade their networking infrastructure. This will

- allow network operation and engineering staff to increase their operational efficiency and bring capex and opex under control,
- enable innovation to create new capabilities and address a number of persistent problems, and
- enable university science communities to do interesting research within and across campuses without being limited by networks.

Universities will once again have the ability to lead and to invent the future in networking. NSF and the US IGNITE initiative are keen to support universities in this mission. This opportunity is ours to lose.