OpenFlow/SDN Opportunities At Stanford

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1 Summary

The ability of *OpenFlow/SDN* to solve a number of shortcomings that currently exist in Stanford's campus network makes it a promising new technology. The fact that sophisticated applications can be developed on top of an *OpenFlow* network is especially promising, and Stanford wants to make this a reality in order to enable students and researchers. A standardized control API will not only create a larger selection of equipment to choose from, but will also simplify management of a large infrastructure such as that of Stanford. The network would become more flexible, would be able to respond faster, and would allow the deployment of new services and features with less effort and cost. Stanford has recognized the importance of *OpenFlow* and has already recognized a number of opportunities where *OpenFlow* could make a difference.

2 Opportunities

2.1 Network Administration

2.1.1 Guest Access

A comprehensive guest access system is necessary in order to accommodate current and future visitors to the Stanford campus. Where the current implementation is generally one of security through obscurity, and access is controlled through a single bottleneck, it is not a scalable one. More flexibility is needed and interoperability must be improved to make certain that future needs can be met. One of the advantages of *OpenFlow* is that it moves access control and policy enforcement to the edge of the network, making access control more responsive and resilient while also adding flexibility and function.

2.1.2 General Campus Wireless

Stanford has approximately 4000 lightweight Access Points (APs) distributed across campus which provide wireless network access to its community. These APs are managed by a small number of controllers through which all wireless traffic needs to be routed. In addition, the way in which current wireless clients associate to an AP does not provide the best mobility for these clients. Through *OpenFlow* it is possible to develop a seamless hand-off between APs as well as eliminate the need to backhaul wireless traffic. Both would improve the wireless experience for Stanford users and visitors.

2.1.3 Data Center

In the data center, VLANs are extensively used across a large number of switches providing the fabric that interconnects servers, storage, and more. Systems often need to be moved between network segments which requires configuration changes to multiple switch devices. The need for VLANs and much of this configuration work can be eliminated if *OpenFlow* is implemented on top of the switching fabric. It makes "Any Network Anywhere" possible which would give the data-center network much-needed flexibility and

increased control. VLANs would no longer be necessary. With the removal of Spanning-Tree Protocol (STP), the capacity and available bandwidth of the data center network could be doubled.

2.1.4 Campus Backbone Network

A big impact can be made by using *OpenFlow* on the Stanford backbone network. The backbone requires a considerable infrastructure, with multiple devices performing functions such as load-balancing, firewall services, and more. This infrastructure has a large impact in the IT Networking budget. The potential to collapse many of these devices into a smaller number and to centralize the policies which would otherwise have to be configured on the individual systems, is significant. It would allow more direct connections between end-points, and improve the performance and bandwidth capacity of the network. The cost saving, in equipment and staff needed to manage such a network, can be significant.

2.1.5 Delegated Management

The flexibility and centralized control that *OpenFlow* brings, makes delegating control of certain segments to researchers or other network administrators trivial. They can then make the necessary changes to their own resources without the need to consult with IT network administrators or impacting the rest of the network.

2.2 Residences

There is an opportunity to improve and innovate in the way wired and wireless network services are provided to the faculty residences and student dorms on the Stanford campus. Visitor access is currently not available largely due to authentication and accountability limitations. By introducing *OpenFlow* many of these limitations can be resolved. This would make it possible for faculty and students to directly access restricted resources on campus, while still providing a segregated and secure environment for visitors. The advantages of *OpenFlow* however are not limited to just general network access but can be extended to include cable, IPTV, and other services.

2.3 Science Communities

Science communities on campus increasingly need faster communication, preferably with a minimum of interference caused by intermediate devices. Scheduling or implementing such connectivity is generally time consuming and often costly due to the nature of the current infrastructure.

2.3.1 Connecting To Other Research Communities

A proper *OpenFlow* infrastructure would allow researchers to connect directly to resources needed for their work whether they are on the Stanford campus or not. It will make it possible for them to directly connect with their counterparts and to facilitate their work by removing communication roadblocks.

2.4 Network Researchers

It has been difficult for network researchers to perform experiments or do research on large-scale networks without being confronted by the high cost of building such an infrastructure. Production networks cannot be used because any interruptions would impact other users on campus. The ability of *OpenFlow* to slice the resources of a production network based on IP subnet, port, or other qualifiers can change this. A slice on the Stanford production network could provide this large-scale infrastructure researchers are looking for, without the large investment that would have to be made otherwise.

2.5 Shared infrastructure

The flexibility that can be introduced into the network by *OpenFlow* for departments can also be applied in the reverse direction. Departments that have an *OpenFlow* infrastructure could delegate a slice to the central IT organization so that it could provide new services to that department without the cost of new equipment. This creates a shared infrastructure where resources on equipment owned and operated by each can be shared. So long as it understands the *OpenFlow* protocol, the choice of equipment would not matter.

3 Conclusion

Many opportunities for *OpenFlow* exist on the Stanford campus, and we believe that the number of opportunities will grow significantly. Deploying an *OpenFlow* infrastructure will require the replacement of a large part of the equipment. The coming year's budget has already been committed for other projects which makes a significant deployment in the near future uncertain. Project priorities determine when such an infrastructure could be implemented. NSF funding could make a big difference in that it would provide financing outside of budget limitations. It would lend legitimacy to such a project which would otherwise depend on leftover budget to progress. Funding separate from the Stanford budget would enable a successful deployment.