OpenFlow/SDN Opportunities at Clemson

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Software defined networking (SDN) provides a novel paradigm to solve many existing challenges and enable many novel services on a university campus network. Overall, this enabling technology perfectly aligns with a university's mission to stimulate and support research, education (R&E), and success of the region and nation's development. Clemson University has deployed OpenFlow on its campus network and, through deep integration of IT, faculty, and students, has identified a number of imminent opportunities to leverage the technology for high priority academic (students and faculty R&E), administrative (IT), and regional development (education and business communities) needs.

Academic opportunities

Clemson has been engaged in the NSF GENI project since its early phases. Since the launch of Clemson's OpenFlow campus trial project in 2009, the number of faculty members and students engaged in projects related to GENI/OpenFlow has been steadily growing. Currently 10+ faculty members have an active or pending grant that requires OpenFlow in their research experiments. The projects span the areas of wired and wireless networking, network security, P2P computing, reconfigurable computing, cloud computing, automotive and transportation engineering, and smart energy grid. Staff from Clemson's IT organization, CCIT, actively partners with the faculty and students on GENI as well as other projects using the operational IT infrastructure as a test bed or living laboratory for testing and evaluating new tools and technologies.

In addition, the CIO office has actively facilitated the creation of cross-department faculty groups in different target areas to explore the use of cyber-infrastructure for research and education. To date, faculty groups have been created for the specific areas of health care, GIS, sustainable transportation, energy, bioscience, arts and humanities, parks and recreation and architecture. While the research focus varies widely across areas, they have shown a common need for flexible wired and wireless network connections for either their testbed experiments or remote collaboration. OpenFlow/SDN is instrumental in realizing more flexible topology, access control, network partitioning and provisioning; OpenFlow/SDN enables flexible insertion of network services that enhances end-to-end performance, security, and customized services; furthermore, OpenFlow/SDN shortens the time and improves accuracy of the delivery of such services through software that is extensible by faculty, students, IT staff, and vendors.

US Ignite: Clemson also participates in the White House and NSF joint initiative called US Ignite to develop gigabit applications for cities around the nation leveraging their city fiber networks. In particular, Clemson researchers are developing an advanced solution for enhancing transportation safety. OpenFlow/SDN helps manages the city fiber network to transport real time video and processed information that are transported among cameras on the street, high performance computing servers, and multiple audiences including city traffic authorities, pedestrians, and drivers.

IT opportunities

Clemson's IT organization administers the entire campus's wired and wireless network infrastructure. Its network also serves a large data center hosting critical applications for the university as well as external organizations including the State of South Carolina and partner educational institutions. In view of the high demand of availability, Clemson has provisioned redundancy in its network and data center infrastructure. Even so, there have been configuration related incidents that have brought down parts or the entire campus network when building complex network topologies. Restoring the network after such incidents often involves restoring configuration of a distributed infrastructure. With OpenFlow/SDN, troubleshooting and restoring networks will be much more efficient. And since many incidents involve improper configuration of the spanning tree protocol, a centralized control plane made possible by OpenFlow/SDN can prevent such instances from happening at the first place while allowing direct path configuration between related research and education systems in diverse locations.

Clemson has several science domains that either host or remotely render large data bases for research and since Clemson has a number of remote (some overseas) campuses, configuring the network connection for such large data exchanges across the local and remote firewall instances have been quite challenging and in many cases have created needless 'packet friction' between systems. Researchers also have had to set up specialized transport software (e.g., parallel TCP) to finesse these friction devices, a process that can be overwhelming without involved network configuration knowledge. With SDN/OpenFlow, such large data transfer services can potentially be achieved transparent to the researchers by configuring friction free paths.

Clemson adopts InCommon federated identity management system as well as a XACML based campus identity management system developed by Clemson's own IT staff. Increasing applications require customized network transport. SDN/OpenFlow can be integrated with the identity management systems to achieve these purposes. Another example is campus network monitoring; commercial data analysis network instruments are extremely costly and require significant manual configuration to channel traffic from parts of the network that are of interest to the few monitoring devices. With students, Clemson's IT staff has already implemented an OpenFlow-based data analysis network parallel to the campus backbone to flexibly select traffic of interest from anywhere in the network to anywhere the sniffer resides.

Regional development opportunities

Clemson University plays several unique roles and missions in the state of South Carolina. A number of these missions are closely relevant to the provision of flexible network connectivity.

SC Cloud: Since 2005, Clemson has been leading the development of research and education network across the state of South Carolina. In June 2011, Clemson has been recognized as a regional computational center in a NSF EPSCoR Research Infrastructure Improvement (RII) program. With this synergy, Clemson has established a partnership with 8 regional colleges and a selected set of high school and K-12 schools. Named SC-Cloud, the partnership's mission is for Clemson to help host these

campuses' applications at Clemson's data center over the high speed network. With OpenFlow/SDN, the hosting service can be provided fully transparent to the partner institutions, and the hosting service can seamlessly migrate among multiple data centers during system maintenance or disaster recovery.

CU-ICAR: Since 2005, Clemson has established the Clemson University International Center for Automotive Research (CU-ICAR). The center facilitates university-industry partnerships on automotive research and development endeavors. Currently, CU-ICAR with a number of industrial partners is building an advanced testbed for sustainable automotive technologies. The testbed expects to leverage OpenFlow/SDN for controlling its experimental network.

e-Health: Clemson University has been hosting the Medicaid processing center for the State of South Carolina for over 25 years. More recently, Clemson University becomes further engaged with the state's healthcare modernization efforts. Clemson closely collaborates with the SC Department of Health and Human Services, the SC Health Information Exchange, and the Health Sciences South Carolina to discover transformative solutions for public health. The endeavor spans potential efforts from health database access and management to telemedicine. With SDN/OpenFlow on Clemson's wide area network, such myriad of connections with diverse performance and security requirements can be flexibly and dynamically configured.

Internet2 Innovation Platform, Science DMZ, and condo-of-condos: Clemson is working with Internet2 to provide researchers with across the country 100 Gbps end-to-end connectivity. For such bandwidth to be accessible to researchers on campus, a frictionless Science DMZ is essential. OpenFlow/SDN can make the management of Science DMZ more easily and ubiquitously. Condo-of-condos is another initiative among a community of universities for shared use of high performance computing capacity as if the distributed computing servers are in the same vicinity. OpenFlow/SDN can help simply its implementation.

Summary Remarks

An OpenFlow/SDN strategy for Clemson is not an "if" but "how". Clemson has identified an initial set of stakeholders from within and beyond the university, and it has identified the initial actions that can be taken in each opportunity. This vision echoes the university's institutional goal of building a cyber-infrastructure that permeates all disciplines. The university Provost has recently announced an internal IT internship program for students and faculty to participate in such endeavors. Support from NSF will offer a much needed push of the larger ecosystem for the technology to gain sustainable momentum.