Bringing GENI and OpenFlow to the Classroom
A Networking Curriculum for Secondary Education

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Goals and Motivation

The initial motivation of "bringing GENI to the classroom" was to abstract the broad goals of the GENI project in order to present it to a younger audience. While developing such a plan, a networking curriculum needed to be developed to uniquely integrate basic core networking concepts with ways in which current networking problems are being solved using new technologies such as GENI and OpenFlow. Additionally, high school students are unlikely familiar with computer networking other than its implementation in the Internet in day-to-day life.

As of the present, we have identified the core networking concepts needed and have created a framework for a lab-based curriculum around those concepts, working with Clemson's IT team (CCIT) in the process. A future goal will be to successfully implement the network curriculum.
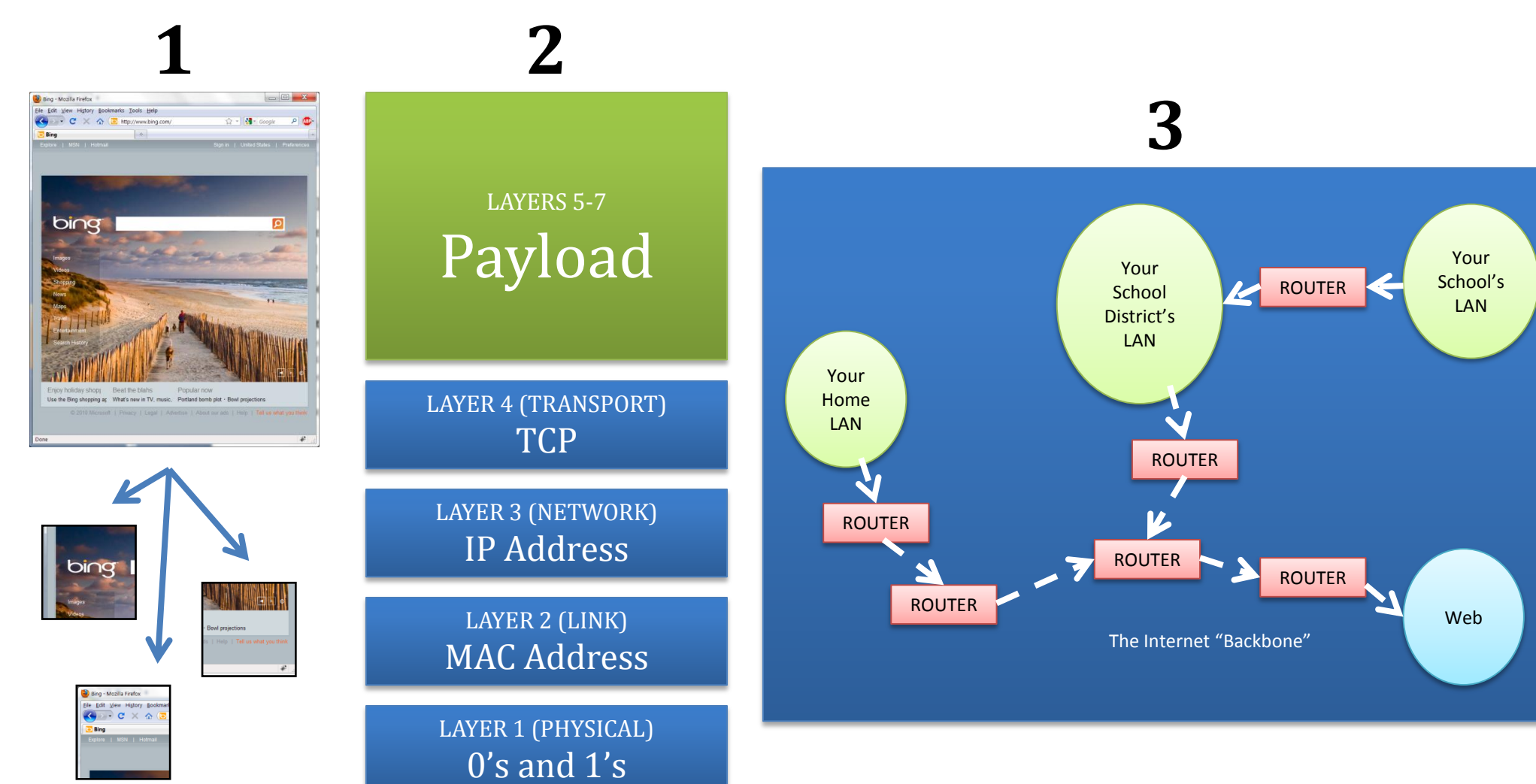
Sample Teaching Models

Figure 1: A figurative model of how one website request can be divided into individual packets.

Figure 2: A basic OSI model of the Internet Protocol Suite.

Figure 3: A model of local versus wide area networks with the concept of inter-domain routing shown.

IT Integration

At Clemson, there are strong connections between IT, faculty, and students in collaborating on research projects. One such activity in the future is allowing students to intern with CCIT to gain an understanding of working with networks in the real world. In turn, CCIT can harness the power of the university's talent in its entirety. Collaboration between faculty research and CCIT promotes new technologies that can be implemented campus-wide.
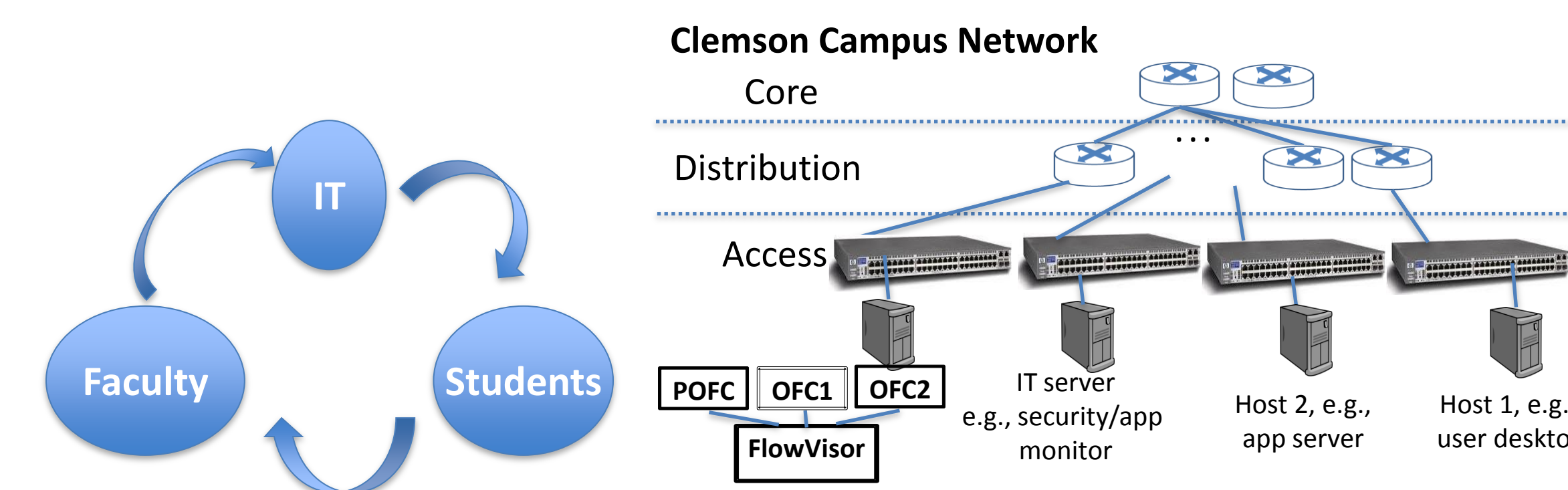
Sample Laboratory Experiment 1
Using `traceroute`

Goals: Establish an understanding of the `traceroute` utility, look at a host's geographic information to visually see its route, view how a packet flows across a network

Lab summary: Students are introduced to the concept of sending requests through the program by analyzing examples of actual requests. Later, students determine physical locations of IP addresses and do a visual traceroute to various hosts.

GENI/OpenFlow connection: Students are shown that the route of Internet traffic is often random and scattered even when two hosts are physically near each other. Each switch or router implements their own proprietary algorithm to determine the "best" way to send traffic. OpenFlow attempts to offer more control in being able to assign flows from a server. The concepts of a distributed and decentralized Internet are explored in the lab, and OpenFlow still allows for the distributed model in addition to offering centralized control of flows.

Sample Laboratory Experiment 2
Using Wireshark

Goals: Review the concept of packets and their various types by protocols, capture live network traffic on a network interface, analyze traffic on a rudimentary level

Lab summary: Students capture network data from either their computer's Wi-Fi or Ethernet interface. Then, they view the various types of network commands broadcast even when the computer is thought to be "idle". The capturing device records students as they go to websites, and the HTTP packets are later filtered to show the reconstruction of the data from its packet format.

GENI/OpenFlow connection: With a traditional switch, a computer with Wireshark or similar software would have to be directly connected to it, resulting in a cumbersome way to analyze traffic. Students are shown that with OpenFlow, an easy solution to the problem would be that commands are sent from the controller to have the switch return a copy of all traffic to be analyzed on a remote computer.

Sample Laboratory Experiment 3
IP Addressing

Goals: Identify how computers talk to each other at the network level, explain the format of IPv4 and the concept of addressing using CIDR notation, explain the IPv6 transition and its addressing

Lab summary: Students are taught the format of IPv4 addresses and how most can be used to globally route traffic. CIDR notation is introduced in order to easily show how blocks of IP space are assigned to certain networks of varying size. Finally, students see the consequences of the recent IPv4 /8 exhaustion.

GENI/OpenFlow connection: While some GENI projects may implement IPv4 or IPv6, it is important to show to students that the flexibility of the GENI framework does not limit the potential of using certain layers, in this case the network layer.