

Developing a Software Defined Networking (SDN) Curriculum for Undergraduate Computer Engineering Students

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Outline

- What is SDN?
- How is SDN approached now?
- Computer Engineering Technology at Citytech
- Creating a SDN Curriculum for Undergraduate Computer Engineering Students

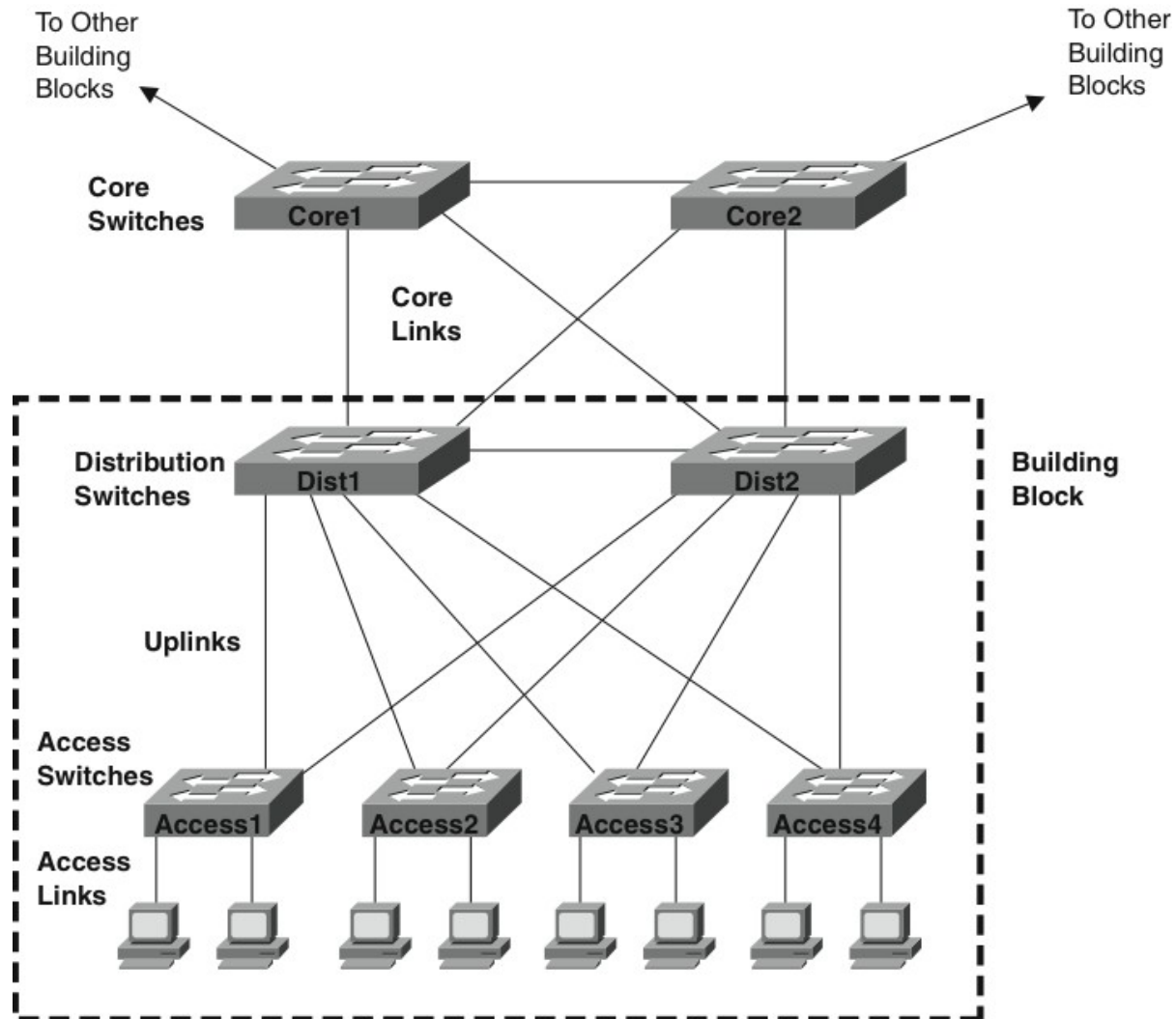


Figure 7-12 Campus LAN with Design Terminology Listed

How to train a network administrator

```
172.20.6.104 - PuTTY
Router>enable
Enable privilege granted.
Router#config t
Enter configuration commands, one per line. End with Ctrl/Z.
Router(config)#show vlan
VLAN          Name              Status          Ports
-----
1      Default VLAN     ena             INT1-INT14 EXT1
10     VLAN 10          ena             INT1 INT2
4095   Mgmt VLAN       ena             INT1-INT14 MGT1
Router(config)#
```

- Statically provisioned
- Box level scale
- PhD in vendor hardware
- Under utilized



SDN: Centralized Management & Control



- Ethernet topologies were built distributed

Scalable but hard to monitor



- Openflow topologies (today) are centralized

Control-data separation forces this model

Strengths of one approach are weaknesses of the other
Centralized is better suited to modern cloud applications

Approaches to Networking Education

Traditional Approach

- Train IT staff & network admins on use of conventional switches (CCNA)
- Install cloud middleware (OpenStack)
- Approximately translate user requirements into static, single tenant network configurations

SDN Approach

- Understand network programming interface; write or download network provisioning apps
- Design, program, & configure SDN controllers, switches (physical & virtual), and virtualization overlays
- Contribute to open source efforts (Project Open Daylight)
- Innovate – new ways to create workload aware, dynamic, multi-tenant enterprise networks with end to end QoS

Computer Engineering Technology at Citytech



Fact Sheet

Enrollment 16,208 students, 65% full time, 35% part time

By School 43.8% School of Technology & Design

Background 38.1% born outside of US
61% report language other than English spoken at home
33% list their parents as college grads

Finances 61% report household income less than \$30,000
80% incoming freshmen receive need-based aid
19% work more than 20 hours per week

- The total enrollment of the Computer Engineering Department is around 1000 students, around 250 of them in the BS program after completing the AAS degree
- Our students go into their senior year knowing how to design in HDL, with some background in C++, Python, Java & other languages
- Their background with fiber optic labs & data communications prepares them to take the CCNA exam
- They are ready to learn how to design & administer SDN OpenFlow switches



Computer Engineering Technology Programs

- Electromechanical Engineering Technology/AAS
 - Required courses in major that relate to SDN include Digital Control, Electromechanical Systems, Data Communications
- Computer Engineering Technology/BTech
 - Require an AAS in either EMT, EET/TCET or MECH
 - Additional classes in topics in computer control systems and Microcomputer Interfacing
 - Technical Electives to create specialties in various tracks, such a robotics or networking
 - Accredited by ABET



Associates Degree Networking Classes

- Logic and Problem Solving-Includes intro to Python
- Digital Electronics-how to design in HDL
- Data Communications - prepares them to take the CCENT exam
- Intro C++ Programming Language



Networking related upper division electives

- Electro-Optical Technology and Applications-themed this year- Fiber Optics
- Microcomputer Interfacing-Networking Examples
- Applied Digital Technology- themed this year- Cloud Computing
- Special Project-Technology (Capstone Project)

Creating a SDN Curriculum for Undergraduate Computer Engineering Students

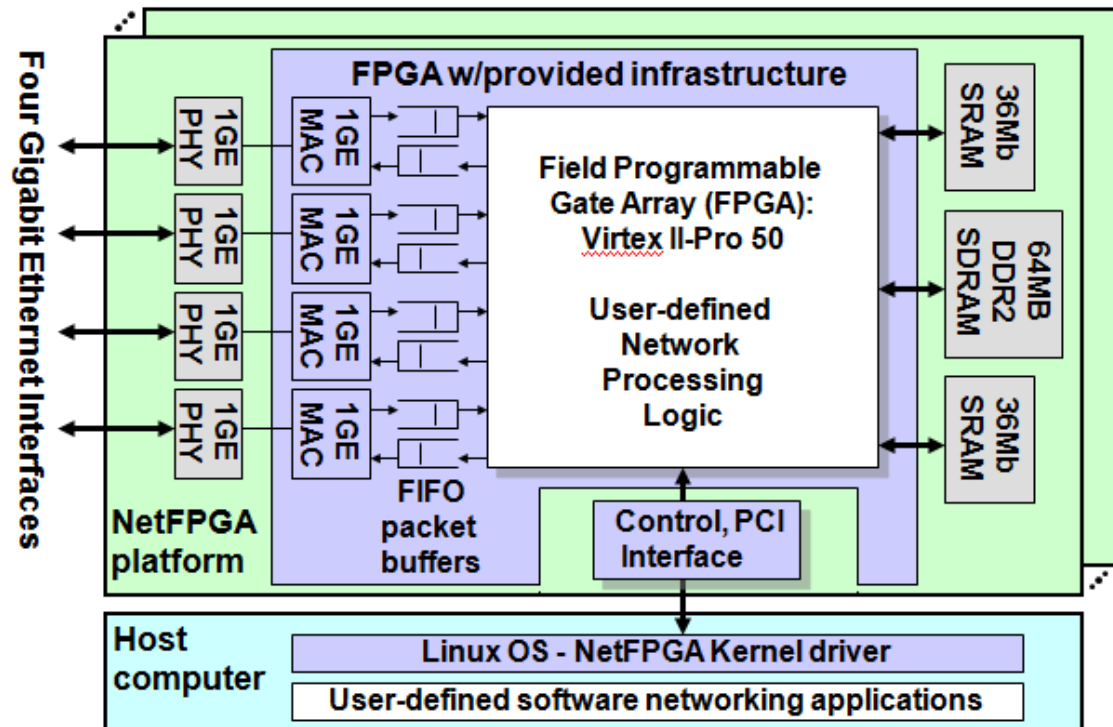
SDN goals

Our plan is to add a class on Software Defined Networking using NetFPGA

- Understanding how to configure and manage SDN networks
- Understanding how to design SDN routers
- Understanding how to program FPGAs to become other OpenFlow devices, such as firewalls
- Connect to the Cloud Computing Center at Marist

What is NetFPGA?

- Originally designed as a tool for education, the 1G platform consisted of a PCI board with a Xilinx Virtex-II pro FPGA and 4 x 1GigE interfaces feeding into it, along with a downloadable code repository containing an IP library and a few example designs.
- A board with 10GigE is also available
- It costs about \$1000 per 1GigE unit and \$3000 per 10GigE unit
- Sample software code for Ethernet and OpenFlow Switches is Available.



NetFPGA

- A line-rate, flexible, and open platform for research and classroom experimentation.
- More than 2,000 NetFPGA systems have been deployed at over 150 institutions in over 40 countries
- Sample projects available at http://netfpga.org/project_table.html



NetFPGA 1G (4x1G)



NetFPGA 10G (4x10G)

Summary & Next Steps

- Education plans will leverage NetFPGA for classwork that helps students understand Ethernet Switch Technology & OpenFlow
 - Program some FPGA examples related to low latency environments, such as stock market transactions
 - Program a sample Firewall for an OpenFlow System
- Research agenda in collaboration with the New York State Center for Cloud Computing & Analytics
 - CUNY labs have WAN equipment compatible with Marist College SDN lab (Adva Optical Networking WDM platform)
 - Connect to Marist using Internet 2(NYSERNET)
- SDN can be incorporated very naturally into our Computer Engineering Curriculum
- NetFPGA building on strengths in HDL design and networking

Websites of Interest

- <http://netfpga.org/videos.html>
- http://netfpga.org/project_table.html
- <http://groups.geni.net/geni/wiki/GeniNewcomers>

Any Questions?