

Tofino Pods for Teaching and Research

Jorge Crichigno, Elie Kfoury, Jose Gomez

University of South Carolina

<http://ce.sc.edu/cyberinfra>

jcrichigno@cec.sc.edu, ekfoury@email.sc.edu, gomezgaj@email.sc.edu

February 16th, 23rd, 2022

Online

Virtual Platform

- The Academic Cloud provides remote-access capability to laboratory equipment via the Internet
- It pools and shares resources (CPU, memory, storage, switch) needed to run virtual labs
- USC works closely with the Network Development Group (NDG)¹
- Libraries incorporate performance and realism along with NETLAB's features

1. Network Development Group (NDG). <https://netdevgroup.com>

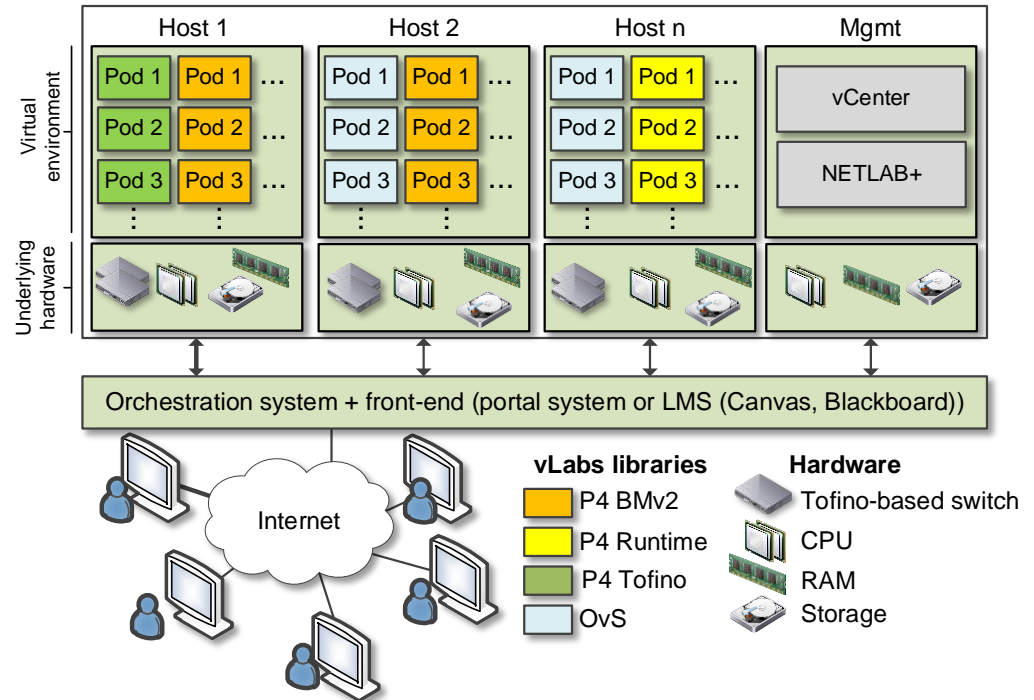
Virtual Platform

- Features

Feature	Description
Performance	High-performance (e.g., 40/100 Gbps)
Functional realism	Same functionality as IT hardware in a real deployment; execution of real code
Traffic realism	Devices within the virtual lab generate and receive real, interactive network traffic (including traffic to/from the Internet)
Presentation layer	Navigating through an experiment is easy for an inexperienced learner
Topology flexibility	Easy to create topologies for more complex experiments, including inter-connecting heterogeneous VMs
Physical devices	Physical hardware can be integrated into pods
Timesharing / calendar	Reservations are made through NETLAB calendar interface

Inside the Datacenter

- Hosts 1-n store virtual machines (VMs) for virtual labs
- Management server runs vCenter, NETLAB+
- Partnership with NDG (NETLAB+)¹ and VMware² (ESXi, vCenter)



1. Network Development Group (NDG). <https://netdevgroup.com>
2. VMware. <https://www.vmware.com>

Virtual Platform

- The environment is fully integrated (topology, lab experiments, etc.)
- Tofino switches come “empty”
- Considerable effort is required to
 - Acquire, Install, and learn the operating system (e.g., Open Network Linux)
 - Acquire, install, and learn Capilano compiler / Software Development Environment
 - Deploy and test fibers
 - Configure topologies
 - Agreement with Intel
- Tofino pods help USC to onboard new students and researchers
 - They can immediately focus on learning how to program the switch
 - Share environment

Tofino Programmable ASIC

- Tofino uses the Tofino Native Architecture (TNA)
- P4 programs are written in P4₁₆
- The switch model is Wedge 100BF-32X from Edgecore
- This switch has 32 x 100G QSFP28 switch ports

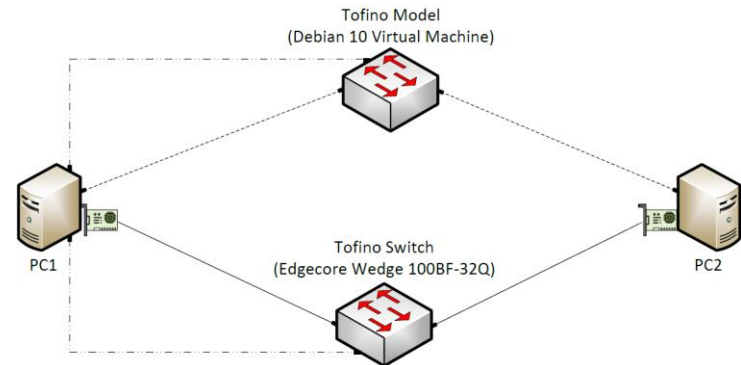
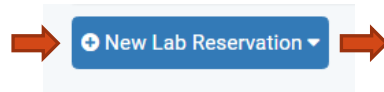
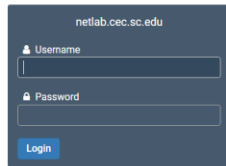


Tofino Model

- Tofino Model is a software switch used for testing and troubleshooting P4 programs
- The same code that runs on a Tofino model can be ported to a physical switch
- The model allows tracking the lifecycle of a packet traversing the pipeline
- The model has the same purpose as the BMv2 switch

Development Environment


- The user reserves a pod through the web calendar interface
- The pod consists of a physical switch, Tofino Model, and two virtual machines




----- Virtual Ethernet Link
(up to 10Gbps)

— 100GbE Multi-Mode
Fiber (QSFP28)

- - - - - Out-of-Band Link

 Dual-port 100GbE NVIDIA
Mellanox ConnectX® 5

 Lubuntu 20.04 Virtual Machine
(8 vCPUs, 16 GB Memory)

Cyberinfrastructure
Lab @ UofSC

¹www.netdevgroup.com

Introduction to P4 on Tofino

Lab experiments

- Lab 1: Introduction to P4 and BMv2
- Lab 2: P4 Program Building Blocks
- Lab 3: Parser Implementation
- Lab 4: Introduction to Match-action Tables (Part 1)
- Lab 5: Introduction to Match-action Tables (Part 2)
- Lab 6: Populating and Managing Match-action Tables
- Lab 7: Checksum Recalculation and Packet Deparsing

Exercises

- Exercise 1: Compiling and Testing a P4 Program
- Exercise 2: Parsing UDP and RTP
- Exercise 3: Building a Simplified NAT
- Exercise 4: Configuring Tables at Runtime
- Exercise 5: Building a Packet Reflector

Demo

Demo

- Tofino Model and ASIC running on NetLab
- Programmer can select the target (Tofino model for debugging; physical switch for performance)

The screenshot displays the NETLAB+ web interface. The browser address bar shows the URL <https://netlab2.cec.sc.edu/lab.cgi>. The page header includes the University of South Carolina logo and navigation links for Home, Reservation, and a user profile for jgomez. The main content area shows a lab session titled "Lab1: Introduction to P4 and Tofino" with a "Time Remaining" of 1 hour and 23 minutes. Below the navigation tabs, a network topology diagram is shown. The diagram features three main components: PC1, PC2, and a central switch. PC1 is connected to the switch via interface ens224 (port 1) and ens256np0 (port 1). PC2 is connected via interface ens192 (port 2) and ens224np0 (port 2). The switch is labeled "Tofino Switch" with IP 192.168.0.0/24. Above the switch is a "Tofino Model" component with IP 10.0.0.0/24, connected to the switch via Veth 0 (port 1) and Veth 2 (port 2).