Tofino Pods for Teaching and Research

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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

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

- Hosts 1-n store virtual machines (VMs) for virtual labs
- Management server runs vCenter, NETLAB+
- Partnership with NDG (NETLAB+)\(^1\) and VMware\(^2\) (ESXi, vCenter)

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2. VMware. [https://www.vmware.com](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 P4\textsubscript{16}
- 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

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)