CS 490.31: Software Defined Networks

3rd Lecture
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Virtualization and SDN Applications

Virtualization

- Sharing physical hardware or software resources by multiple users and/or use cases
- Examples
  - Operating system shares physical hardware resources
  - Virtual machine shares a physical machine with diverse and multiple operating systems
  - Multiplexing shares a physical channel with multiple communication flows

Network Virtualization

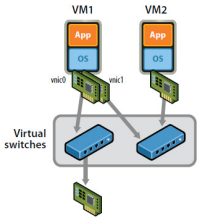
- Share physical network resources to form multiple diverse virtual networks
- Examples
  - Overlay and p2p networks
  - Virtual Private Networks (VPN)
    - Provide remote access to company's network
    - Group remote computers in the same Virtual Local Area Network (VLAN).
- Benefits:
  - Increases utilization of resources
  - Simplifies resource management

Network Virtualization

- Two categories :
  - External network virtualization (most of this talk)
    - Combining many networks, or parts of networks, into a virtual unit.
  - Internal network virtualization
    - Providing network-like functionality to the software containers on a single system.

Internal Network Virtualization

- Properties of virtual switch
  - A virtual switch works much like a physical Ethernet switch.
  - It detects which VMs are logically connected to each of its virtual ports and uses that information to forward traffic to the correct virtual machines.



Key properties of virtual network

- Partitioning: each resource can be used concurrently by multiple VN instances
- Isolation: the clear isolation of any VN from all others
- Abstraction: in which a given virtual resource need not directly correspond to its component resources
- Aggregation: aggregate multiple instances to obtain increased capabilities

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What are virtual networks used for?

- Same purposes as non-virtualized networks without interfering the operation of other virtual networks while sharing the key components among virtual networks
  - Coexistence of multiple VNs
    - Different VNs may use different network technologies without interference
    - Increase utilization
  - Can support seamless migration/update of VNs
  - Can provide normalized set of interfaces and make it easier to provision VNs

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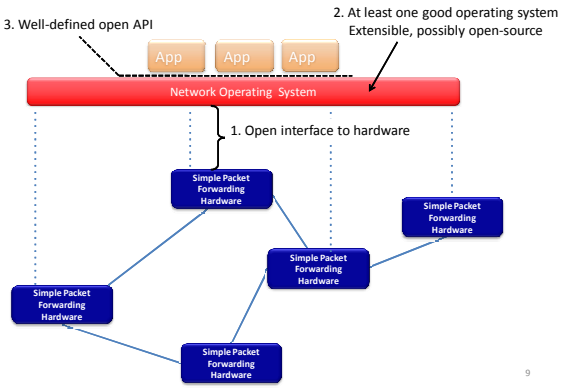
The "Software-defined Network"



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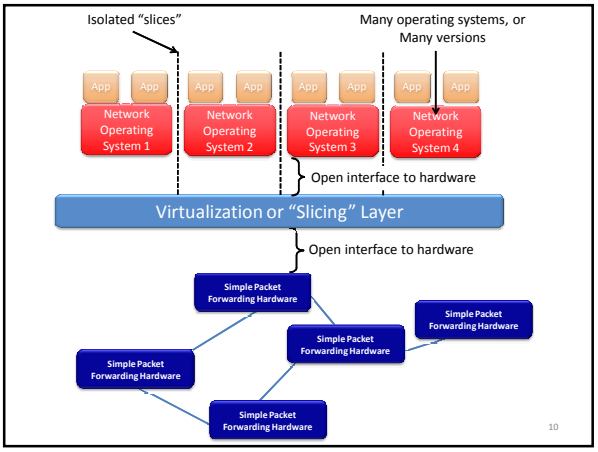

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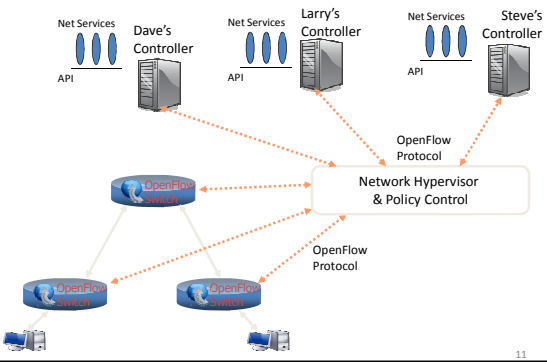
Virtualized OpenFlow Substrate



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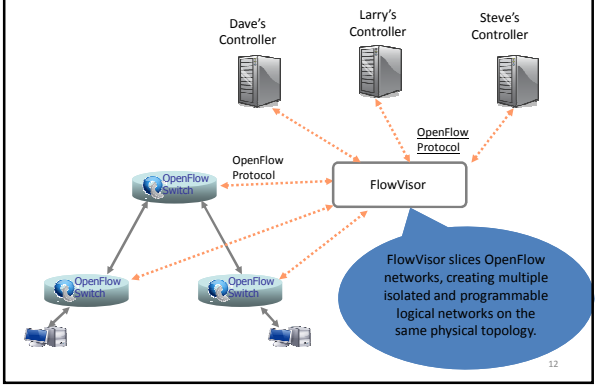
FlowVisor Creates Virtual Networks



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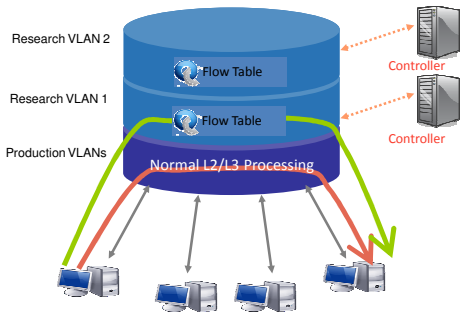
Slicing Policies

- The policy specifies resource limits for each slice:
  - Link bandwidth
  - Maximum number of forwarding rules
  - Topology
  - Fraction of switch/router CPU
  - *FlowSpace: which packets does the slice control?*

Switch Based Virtualization



Use Case: VLAN Based Partitioning

- Basic Idea: Partition Flows based on Ports and VLAN Tags
  - Traffic entering system (e.g. from end hosts) is tagged
  - VLAN tags consistent throughout substrate

	Switch Port	MAC src	MAC dst	Eth type	VLAN ID	IP Src	IP Dst	IP Prot	TCP sport	TCP dport
Dave	*	*	*	*	1,2,3	*	*	*	*	*
Larry	*	*	*	*	4,5,6	*	*	*	*	*
Steve	*	*	*	*	7,8,9	*	*	*	*	*

Use Case: New CDN - Turbo Coral ++

- Basic Idea: Build a CDN where you control the entire network
  - All traffic to or from Coral IP space controlled by Experimenter
  - All other traffic controlled by default routing
  - Topology is the entire network
  - End hosts are automatically added (no opt-in)

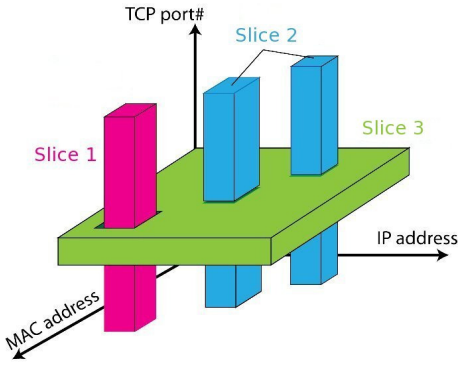
	Switch Port	MAC src	MAC dst	Eth type	VLAN ID	IP Src	IP Dst	IP Prot	TCP sport	TCP dport
Turbo Coral	*	*	*	*	*	84.65.*	*	*	*	*
	*	*	*	*	*	*	84.65.*	*	*	*
Default	*	*	*	*	*	*	*	*	*	*

Use Case: Your Internet Protocol

- A new layer 3 protocol
- Replaces IP
- Defined by a new Ether Type

	Switch Port	MAC src	MAC dst	Eth type	VLAN ID	IP Src	IP Dst	IP Prot	TCP sport	TCP dport
Your IP	*	*	*	YourIP	*	*	*	*	*	*
Rest	*	*	*	!YourIP	*	*	*	*	*	*

FlowSpace: Maps Packets to Slices



Applications of SDN

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Dynamic Flow Aggregation on an OpenFlow Network

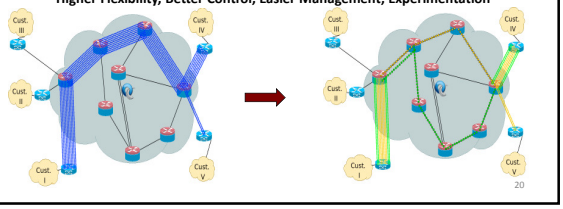
Scope

- Different Networks want different flow granularity (ISP, Backbone,…)
- Switch resources are limited (flow entries, memory)
- Network management is hard
- Current Solutions : MPLS, IP aggregation

How OpenFlow Helps?

- Dynamically define flow granularity by wildcarding arbitrary header fields
- Granularity is on the switch flow entries, no packet rewrite or encapsulation
- Create meaningful bundles and manage them using your own software (reroute, monitor)

Higher Flexibility, Better Control, Easier Management, Experimentation



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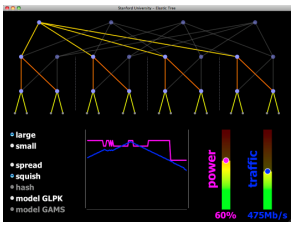
ElasticTree:

Reducing Energy in Data Center Networks

- Shuts off links and switches to reduce data center power
- Choice of optimizers to balance power, fault tolerance, and BW
- OpenFlow provides network routes and port statistics



- The demo:
- Hardware-based 16-node Fat Tree
- Your choice of traffic pattern, bandwidth, optimization strategy
- Graph shows live power and latency variation

demo credits: Brandon Heller, Srini Seetharaman, Yiannis Yiakoumis, David Underhill

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[Hands-on Tutorial]

http://www.openflow.org/wk/index.php/OpenFlow_Tutorial

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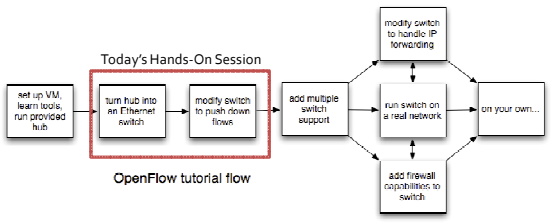
TutorialFlow



Part 5 of OpenFlow Tutorial:
http://www.openflow.org/wk/index.php/OpenFlow_Tutorial

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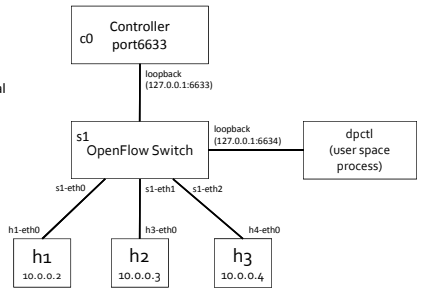
Tutorial Setup

OpenFlow Tutorial
3hosts-1switch
topology



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This talk wouldn't be possible without:

- Past slides from:
  - Brandon Heller
  - Nick McKeown
  - Rob Sherwood
  - Nick McKeown
  - Rob Sherwood
  - Guru Parulkar
  - Srini Seetharaman
  - Yiannis Yiakoumis
  - Guido Appenzeller
  - Masa Kobayashi
  - Scott Shenker
  - Sangjin Jeong
  - others