Software Defined Networking

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In this course, you will learn about software defined networking and how it is changing the way communications networks are managed, maintained, and secured.

Module: Network Virtualization

- Lessons
  - What is network virtualization and how is it implemented?
  - Examples of network virtualization and applications.
  - Virtual networking in Mininet
  - Virtualizing control: FlowVisor
  - Use case: Multi-tenant data centers (Nicira NVP)

This Lesson: Multi-Tenant Datacenters

- What is a multi-tenant datacenter?
  - Components: Network, compute, storage
- Virtualizing the network (case study: NVP)
- Challenges: Forwarding speed and scaling
- The role of SDN in network virtualization

Koponen, Teemu, et al. "Network Virtualization in Multi-tenant Datacenters." *NSDI*. April 2014.

Multi-Tenant Datacenter

- Single physical datacenter shared by many "tenant" users
  - Customers (Amazon, Rackspace)
  - Applications/services (Mail, Search, …)
  - Developers
- Challenges
  - Workloads require **different topologies, services**
  - Address space **overlaps with physical network**

Multi-Tenant Datacenter Architecture

- Each host in the datacenter has multiple VMs
  - Each host has a hypervisor with an internal switch
  - Switch forwards to local VM or another hypervisor

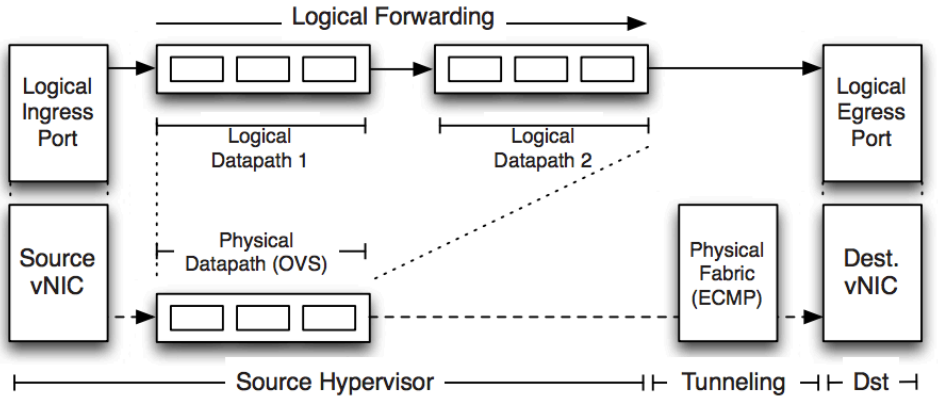
- **Need:** **Network hypervisor** to build right network abstractions for tenants

Network Hypervisor Abstractions

- **Control abstraction:** Tenants define a set of logical network data-plane elements that they can control.

- **Packet abstraction:** Packets sent by endpoints should see the same service as in a “native” network.

Implementing the Abstractions

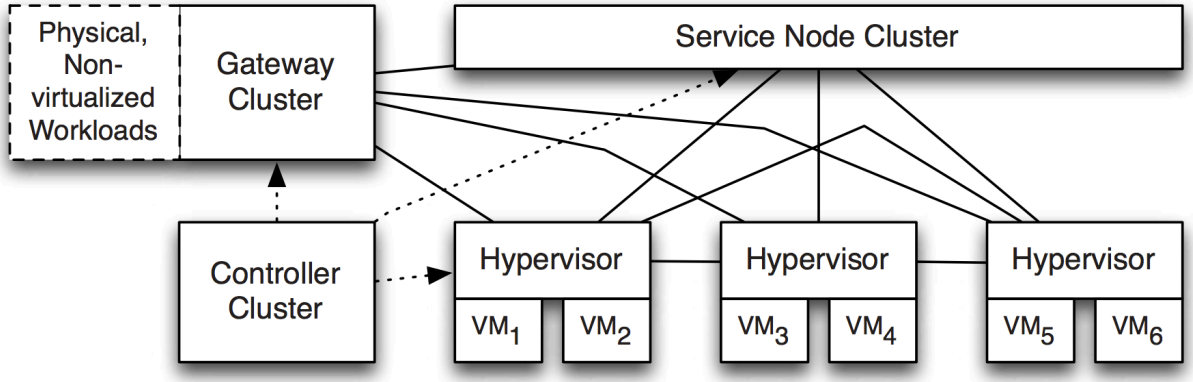


- Network hypervisor sets up tunnels between host hypervisors
  - Multicast implemented as an overlay service
- Physical network simply sees IP packets
- Centralized SDN controller configures the hosts' virtual switches
- Logical datapath implemented entirely on the sending host

Implementing the Logical Datapath

- Tunnel endpoints are virtual switches running on host hypervisors
  - Implemented with Open vSwitch
- Controller cluster can
  - Modify flow table entries
  - Set up tunnels

Controller Structure



- Hypervisors and physical gateways provide the controller with location and topology information
- Service providers configure the controller
- Forwarding state pushed to OVS via OpenFlow

Challenges

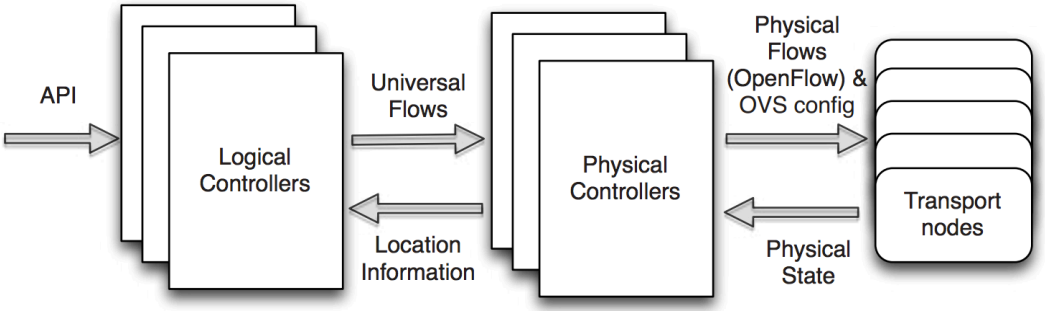
- **Datapath design:** Making software switching at end hosts fast

- **Scaling the computation:** computing the logical datapaths and tunnels

Making the Datapath Fast

- Exact-match flows in kernel
  - User-space program matches on full flow table, installs exact match in the kernel
  - Future packets for the same flow are matched in-kernel
- Hardware offloading of encapsulated packets requires some additional tricks.

Scaling Controller Computation



- Two-layer distributed controller
  - **Logical controllers:** Compute flows and tunnels for logical datapaths (and universal flows)
  - **Physical controllers:** Communicate with hypervisors, gateways, and service nodes
- Logical controller avoids dealing with the full mesh of tunnels.

Takeaways: The Role of SDN

- Network virtualization != SDN
  - Predates SDN
  - Doesn't require SDN
- Easier to virtualize an SDN switch
  - Run separate controller per virtual network
  - Partition the space of all flows
  - Use open interface to the hardware
- Network virtualization can also use software switches

Conclusion

- The rise of virtualization and multi-tenant datacenters has created a need for network virtualization
- SDN plays some role in configuring logical data paths and tunnels
- Interestingly, in the case of NVP, it all happens at the host!