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.

This Module: SDN In the Wild

- Three Lessons
  - **Data Centers**
  - Wide-Area Backbone Networks
    - SDX: A Software-Defined Internet Exchange
    - B4: Google's Wide-Area Backbone Network
  - Home Networks
- Programming Assignment
- Quiz

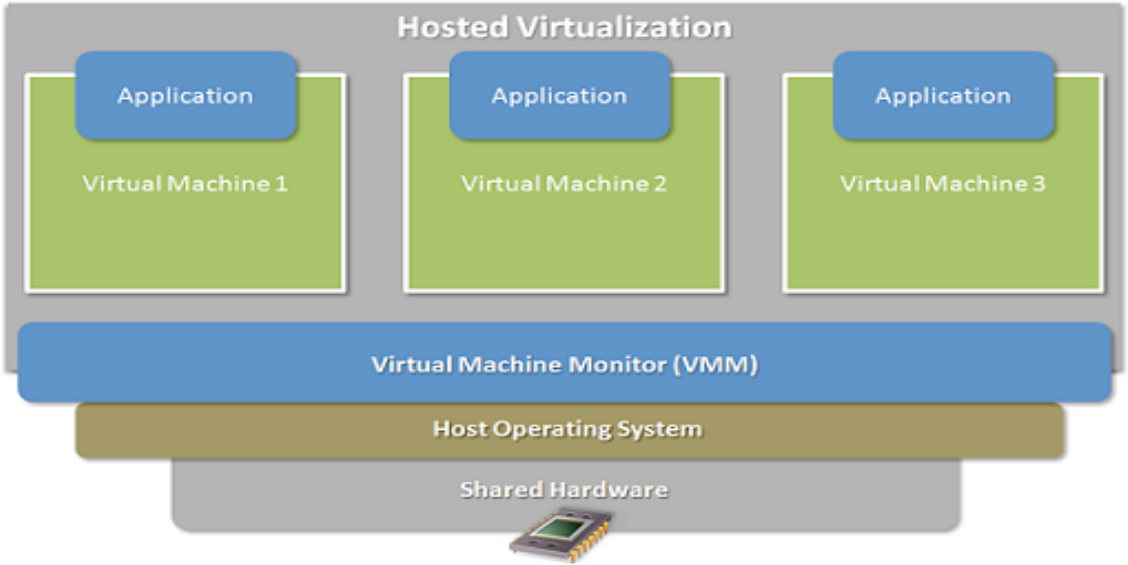
Cloud Computing

- Elastic resources
  - Pay-per-use
  - Infrastructure on demand
- Multi-tenancy
  - Multiple independent users
  - Amortize the cost of the (shared) infrastructure

Cloud Service Models

- Software as a Service
  - Provider licenses applications to users as a service
  - Avoid costs of installation, maintenance, patches, …
- Platform as a Service
  - Provider offers software platform for building applications
  - Avoid worrying about scalability of platform
- Infrastructure as a Service
  - Provider offers raw computing, storage, and network
  - Avoid buying servers and estimating resource needs

Enabling Technology: Virtualization

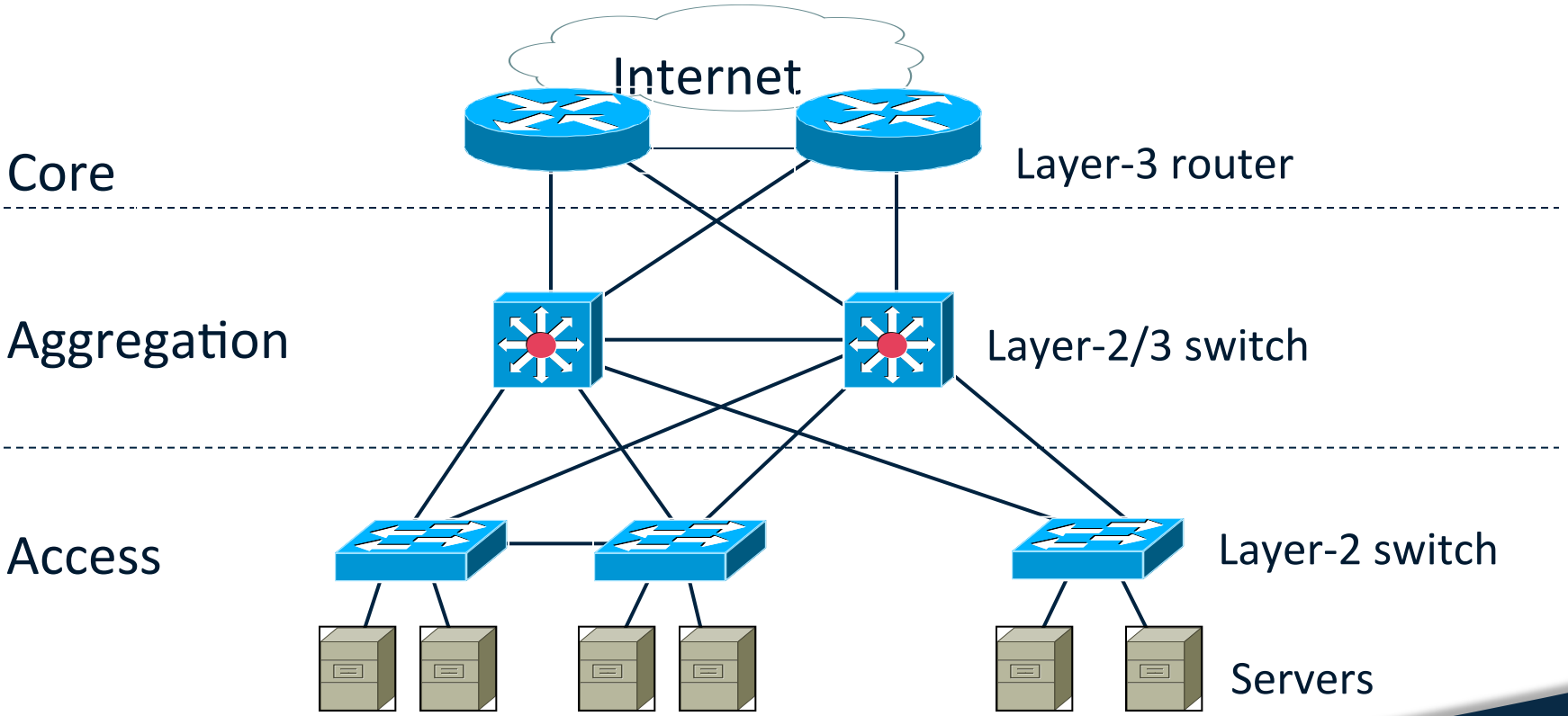


- Multiple virtual machines on one physical machine
- Applications run unmodified as on real machine
- VM can migrate from one computer to another

Design Requirements for Data Centers

- Easy migration of virtual machines
- Minimal switch configuration
- Efficient communication along forwarding paths
- No forwarding loops
- Fast, effective failure detection

Common Data Center Topology

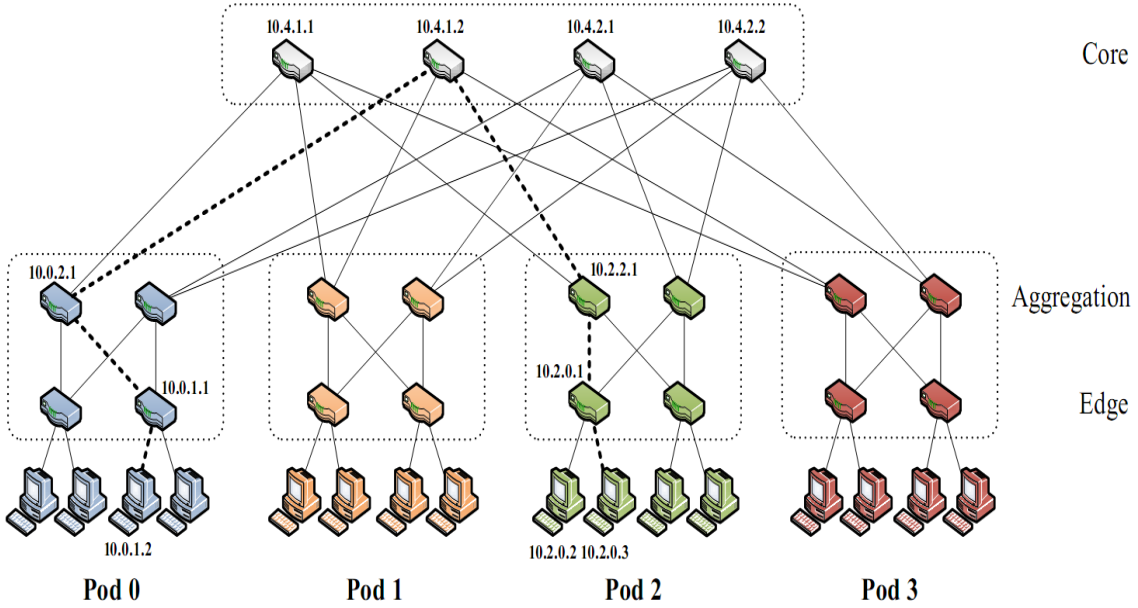


Problems with Common Topologies

- Single point of failure
- Over subscription of links higher up in the topology
- Tradeoff between cost and provisioning

Fat-Tree (Clos) Topology

- Multi-rooted tree topology
- Capacity increases towards the root(s) of the tree
- Inherent fault tolerance



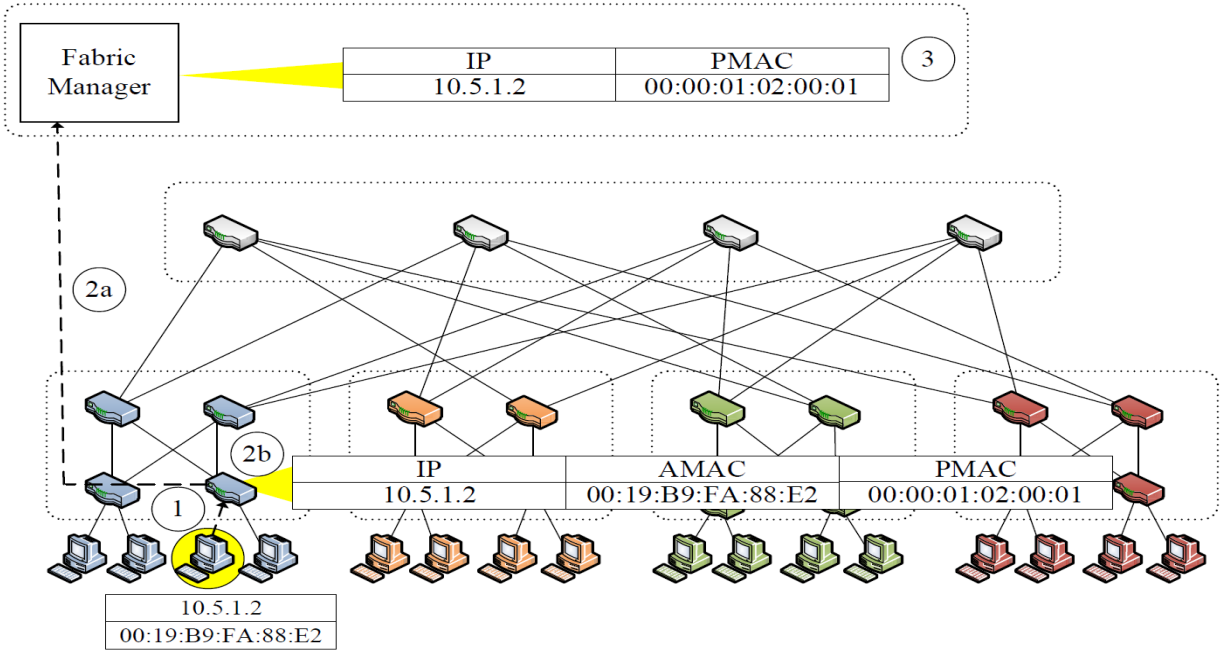
Charles E. Leiserson Fat-trees: universal networks for hardware-efficient supercomputing, IEEE Transactions on Computers, Vol. 34 , no. 10, Oct. 1985, pp. 892-901.

Satisfying the Design Requirements

- Need for a large, layer two topology
  - Plug-and-play, minimal configuration
- Many scaling problems to solve
  - State required for layer-2 forwarding
  - Avoiding flooding (e.g., ARP requests)
  - Fast updates to addressing upon VM migration

PortLand: SDN for Data Center Networks

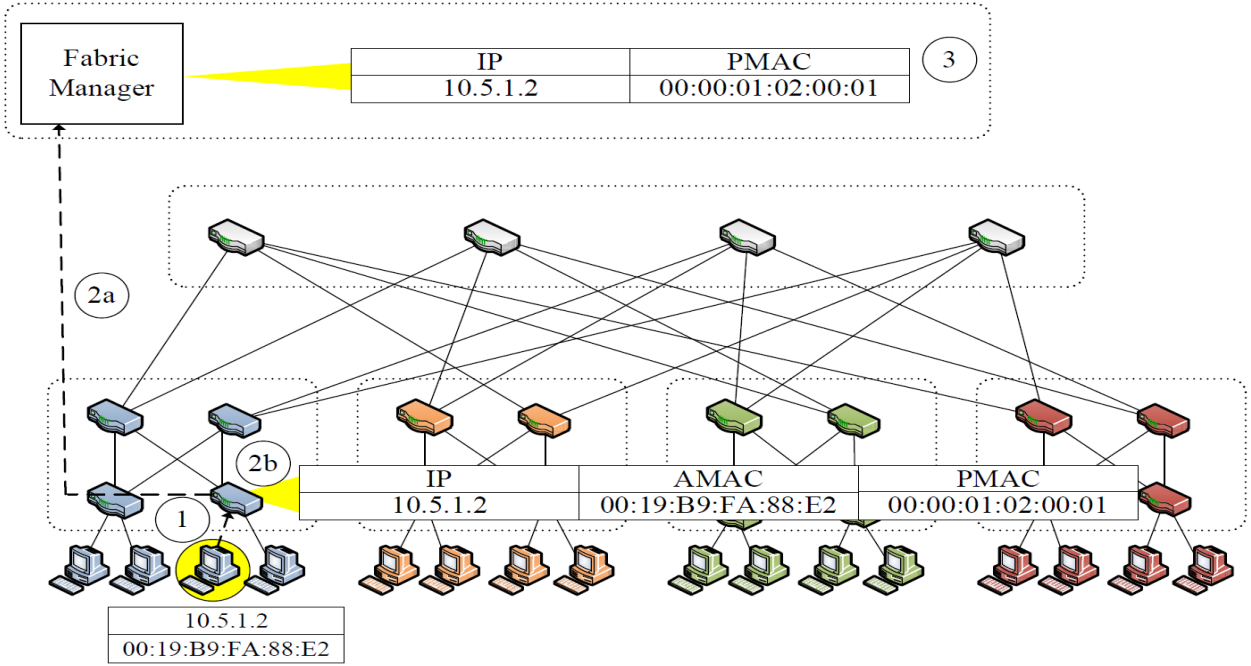
- Logically centralized **fabric manager**
- Positional **pseudo MAC addresses**
  - Address resolution: Proxy ARP
  - Forwarding based on pseudo MAC
  - Efficient forwarding



Niranjan Mysore, Radhika, et al. "PortLand: a scalable fault-tolerant layer 2 data center network fabric." ACM SIGCOMM Computer Communication Review. Vol. 39. No. 4. ACM, 2009.

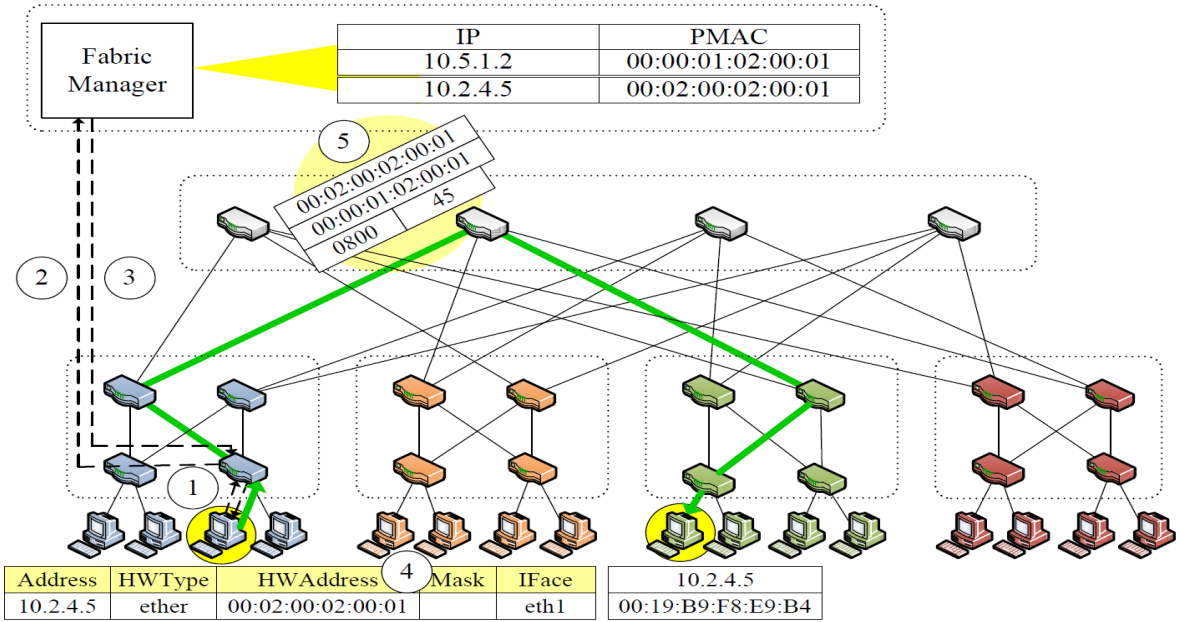
Fabric Manager: MAC Learning

1. New source MAC
2. Frame vectored to fabric manager.
3. FM constructs mapping to PMAC.



Fabric Manager: Proxy ARP

1. Edge switch intercepts ARP query.
2. Forwards to FM.
3. Return PMAC to edge switch.
4. Edge switch creates ARP reply.
5. Host sends to PMAC.



Summary

- Data center networks have unique requirements for scaling and flexibility
  - Tens of thousands of hosts
  - Need for minimal configuration and state
  - Ability to quickly migrate virtual machines
- PortLand Fabric Manager: An early SDN controller for data centers
  - PMACs, Proxy ARP