



# Data Center Networks

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## COS 461: Computer Networks

<http://www.cs.princeton.edu/courses/archive/spr15/cos461/>

*Acknowledgments: Lecture slides are from Computer networks course thought by Jennifer Rexford at Princeton University. When slides are obtained from other sources, a reference will be noted on the bottom of that slide and full reference details on the last slide.*

# Outline

- **Why are data centers important?**
  - Cloud computing
- **How are data centers structured**
  - Hierarchy of VMs, servers, racks, pods, etc.
- **How is traffic routed between VMs?**
  - Traditional designs and newer flat architectures

# Cloud Computing

# Cloud Computing

- **Elastic resources**
  - Expand and contract resources
  - Pay-per-use
  - Infrastructure on demand
- **Multi-tenancy**
  - Multiple independent users
  - Security and resource isolation
  - Amortize the cost of the (shared) infrastructure
- **Flexible service management**



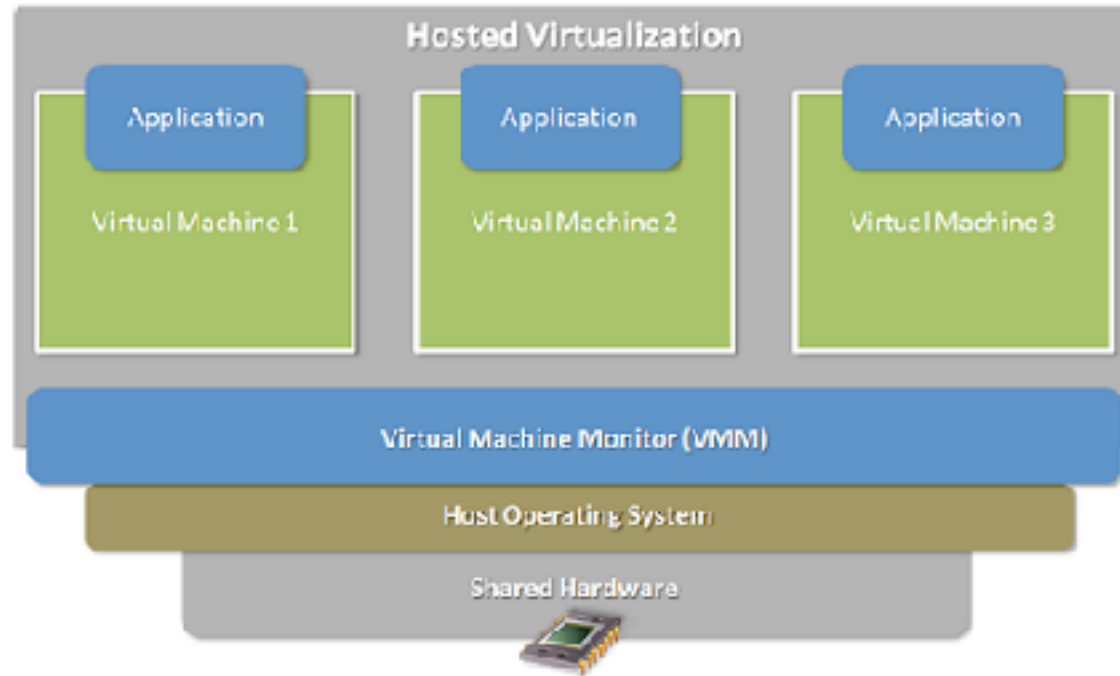
# Cloud Service Models

- **Software as a Service**
  - Provider licenses applications to users as a service
  - E.g., customer relationship management, e-mail, ..
  - Avoid costs of installation, maintenance, patches, ...
- **Platform as a Service**
  - Provider offers platform for building applications
  - E.g., Google's App-Engine
  - Avoid worrying about scalability of platform

# Cloud Service Models

- **Infrastructure as a Service**
  - Provider offers raw compute, storage, and network
  - E.g., Amazon's Elastic Computing Cloud (EC2)
  - Avoid buying servers and estimating resource needs

# Enabling Technology: Virtualization



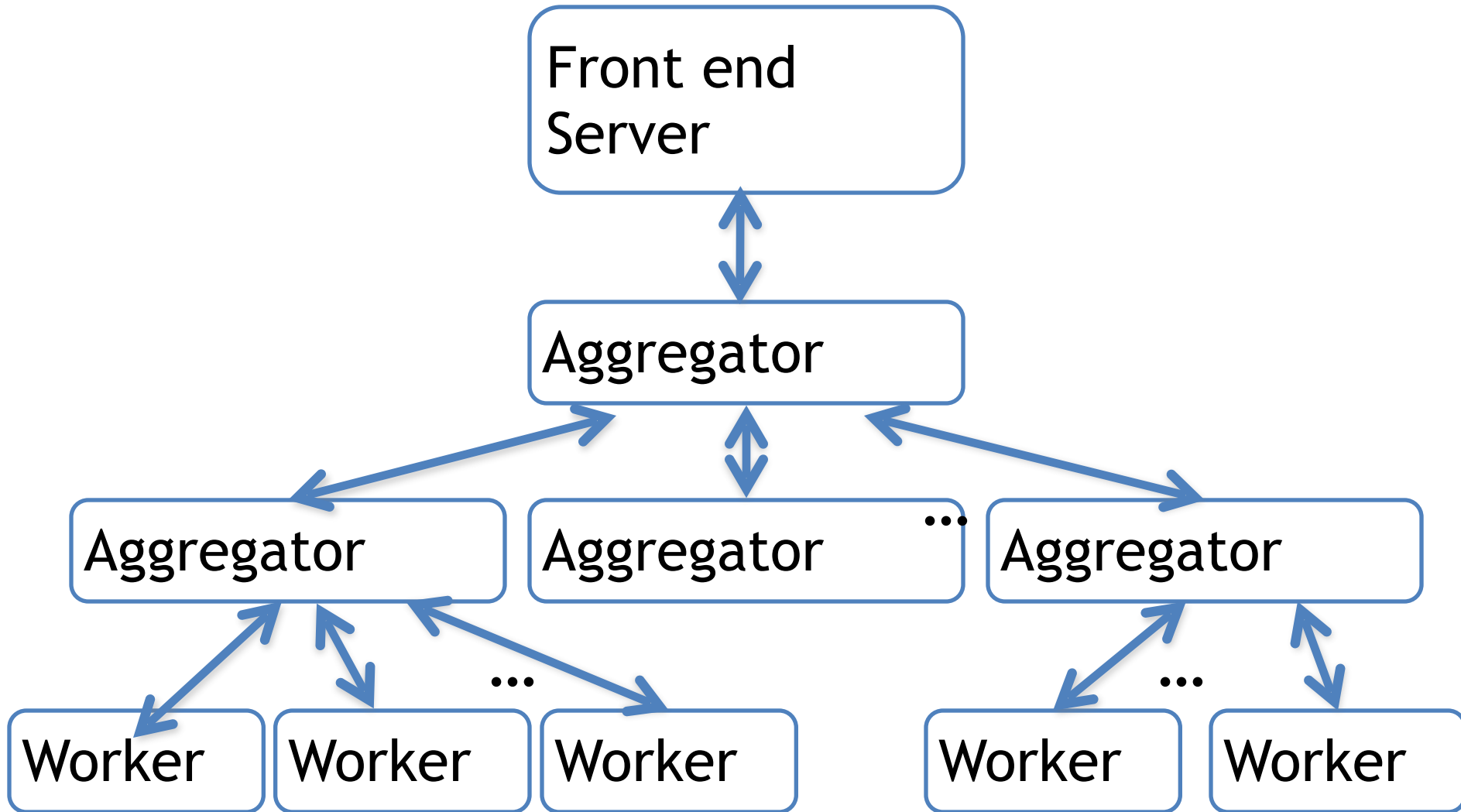
- Multiple virtual machines on one physical machine
- Applications run unmodified as on real machine
- VM can migrate from one computer to another

# Multi-Tier Applications

- **Applications consist of tasks**
  - Many separate components
  - Running on different machines
- **Commodity computers**
  - Many general-purpose computers
  - Not one big mainframe
  - Easier scaling

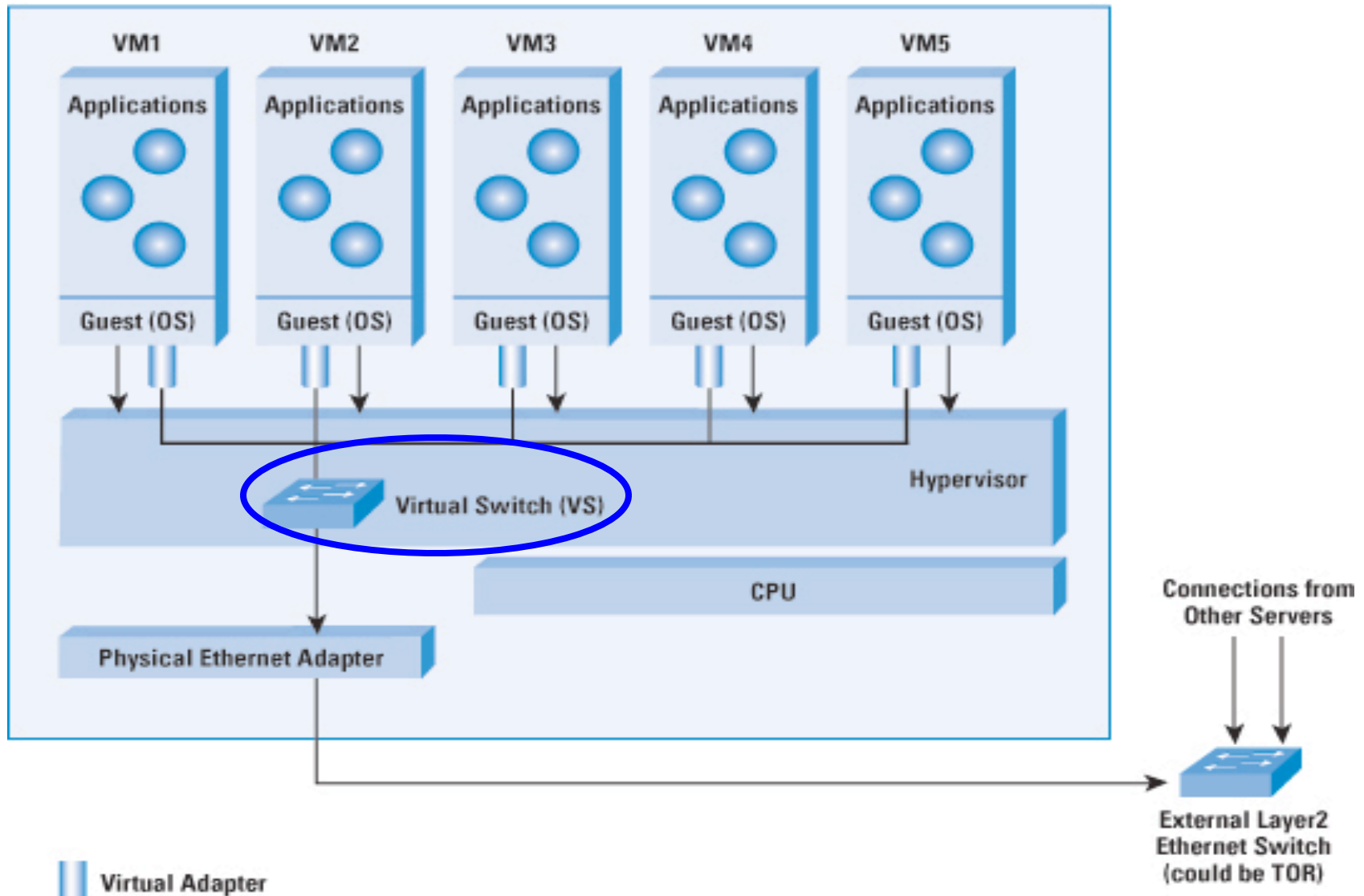


# Multi-Tier Applications



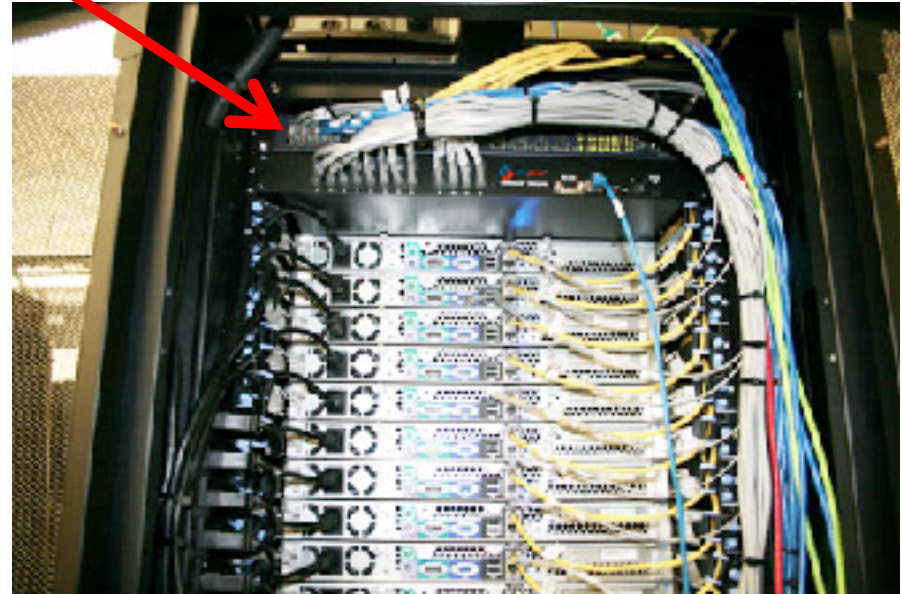
# Data Center Network

# Virtual Switch in Server

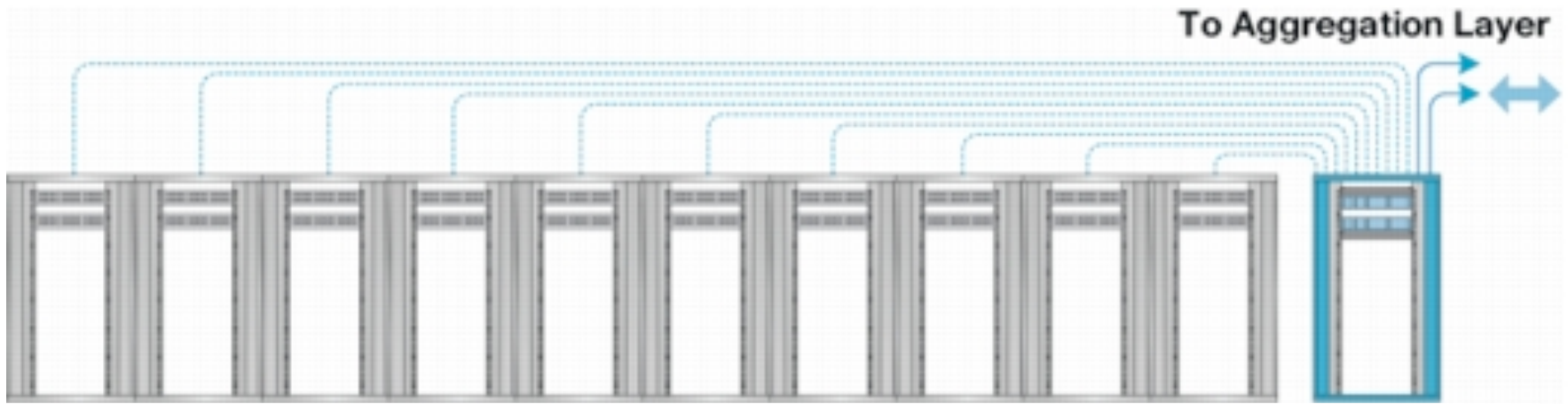


# Top-of-Rack Architecture

- **Rack of servers**
  - Commodity servers
  - And top-of-rack switch
- **Modular design**
  - Preconfigured racks
  - Power, network, and storage cabling



# Aggregate to the Next Level



# Modularity, Modularity, Modularity

- Containers

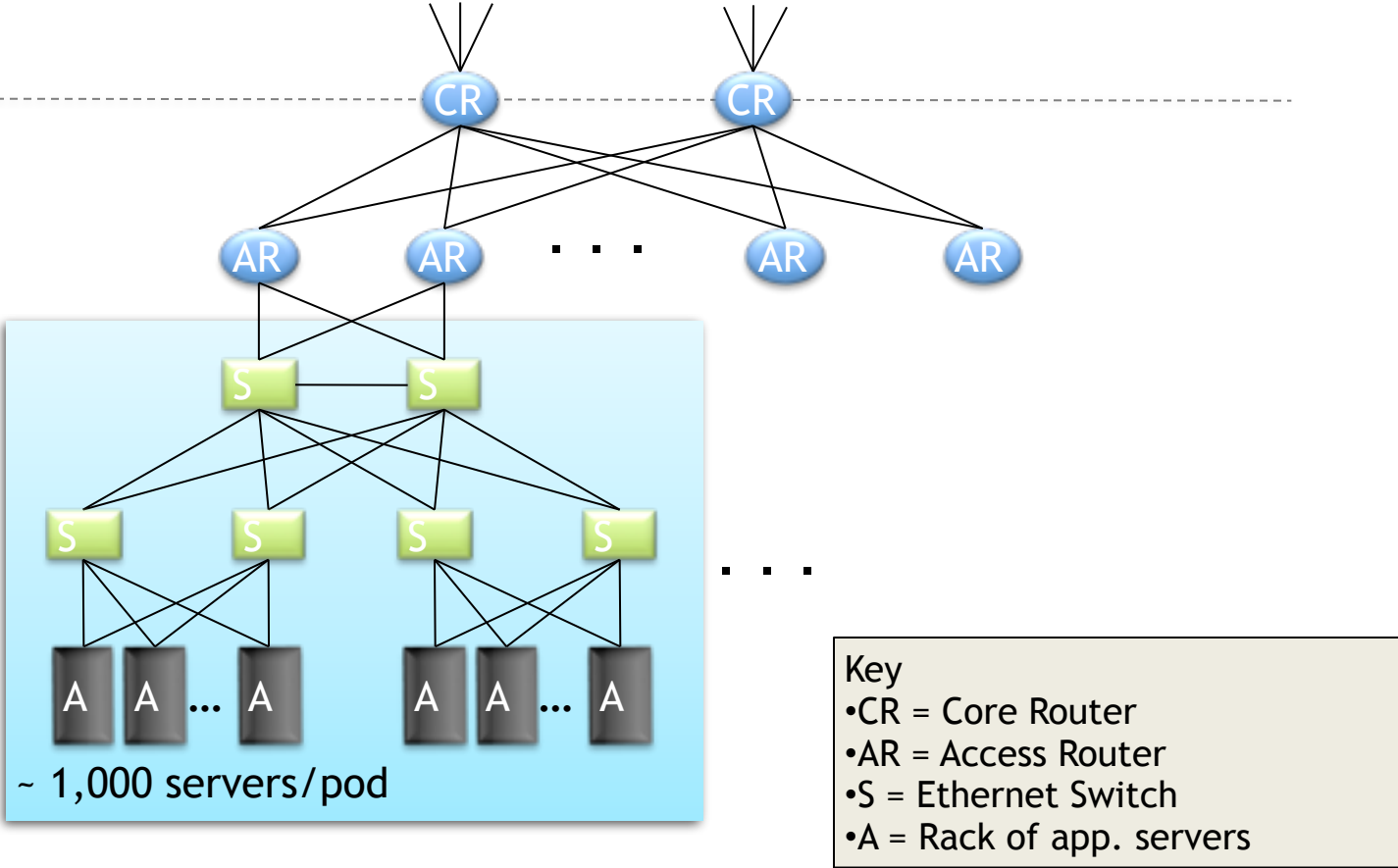


- Many containers

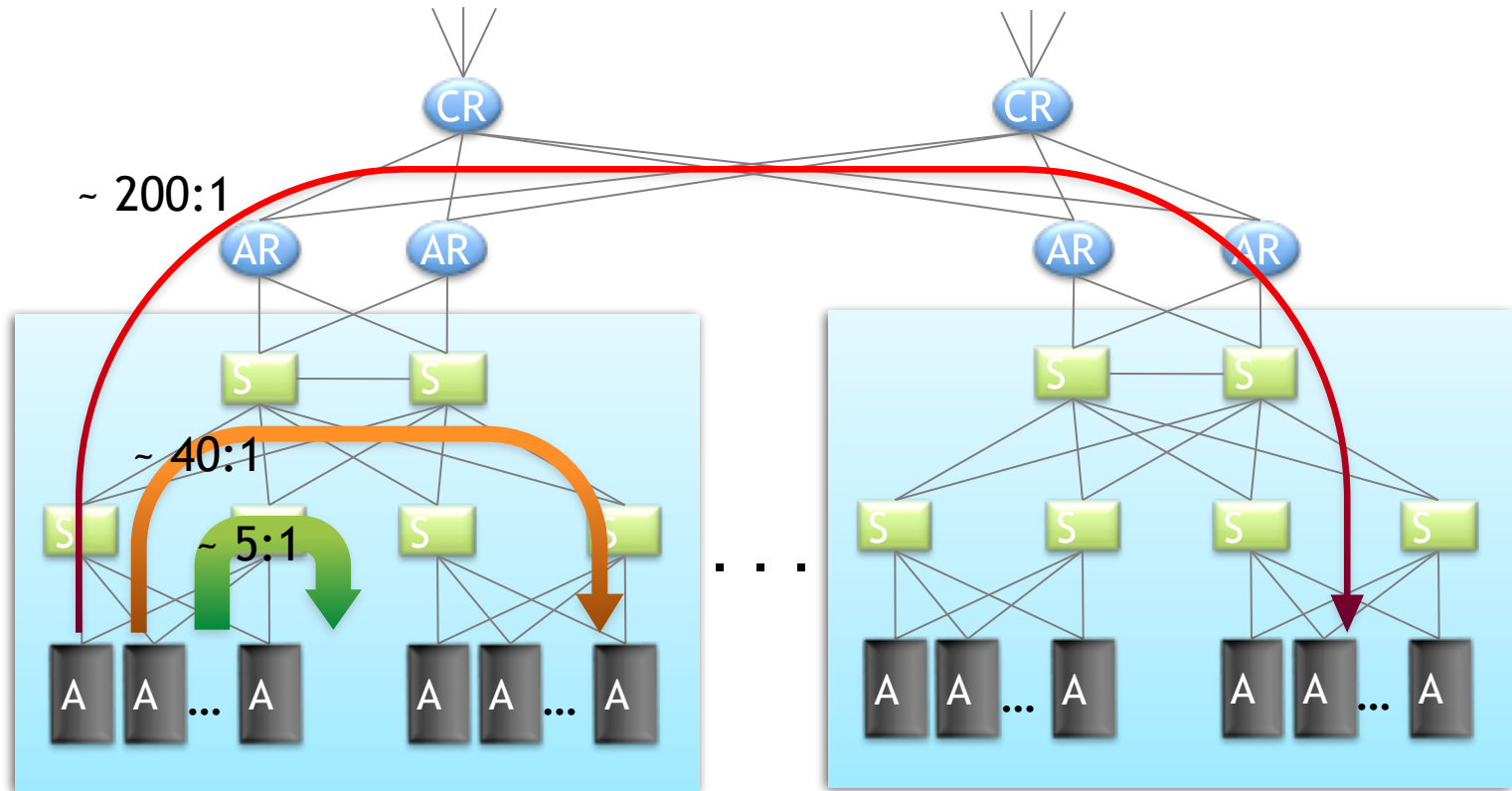


# Data Center Network Topology

Internet

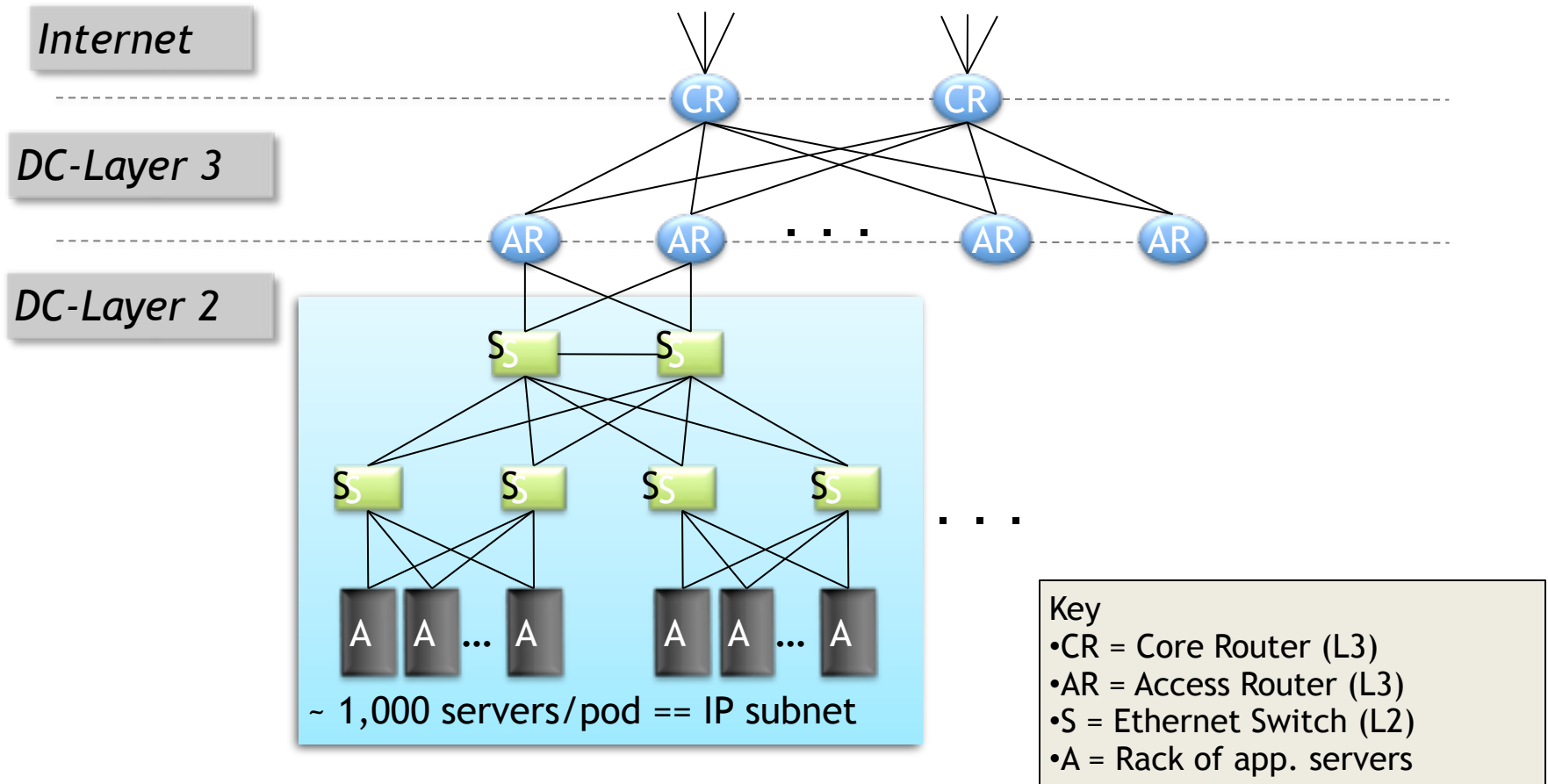


# Capacity Mismatch





# Traditional Data-Center Routing



# Reminder: Layer 2 vs. Layer 3

- **Ethernet switching (layer 2)**
  - Cheaper switch equipment
  - Fixed addresses and auto-configuration
  - Seamless mobility, migration, and failover
- **IP routing (layer 3)**
  - Scalability through hierarchical addressing
  - Efficiency through shortest-path routing
  - Multipath routing through equal-cost multipath
- **So, like in enterprises...**
  - Connect layer-2 islands by IP routers

# Newer “Flat” Routing Architectures

- **Virtual switch abstraction**
  - All VMs for the same tenant
  - ... connected by a single switch
- **Advantages**
  - Assign any address to any VM
  - Place any VM anyway
  - Freely move VMs across locations
- **Challenges**
  - Scalability