DATA COMMUNICATOIN NETWORKING

Instructor: Ouldooz Baghban Karimi

Course Book: Computer Networking, A Top-Down Approach, Kurose, Ross

Slides:

- Course book Slides
- Slides from Princeton University COS461 Spring 2012 offering, Jennifer Rexford

Course Overview

- **Basics of Computer Networks**
  - Internet & Protocol Stack
  - Application Layer
  - Transport Layer
  - Network Layer
  - Data Link Layer

- **Advanced Topics**
  - Case Studies of Computer Networks
  - Internet Applications
  - Network Management
  - Network Security

Cloud Computing

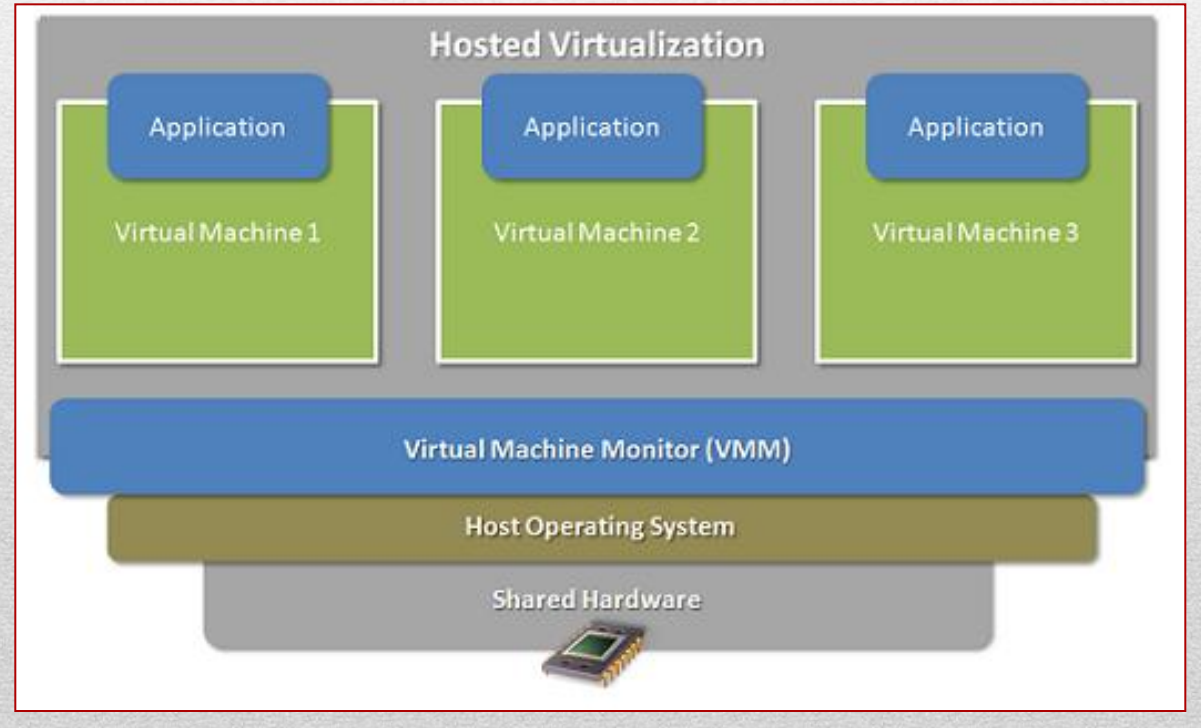
- **Elastic resources**
  - Expand and contract resources
  - Pay-per-use
  - Infrastructure on demand
- **Multi-tenancy**
  - Multiple independent users
  - Security and resource isolation
  - Amortize the cost of the (shared) infrastructure
- **Flexible service management**

Cloud Service Models

- **Software as a Service**
  - Provider licenses applications to users as a service
    - Customer relationship management
  - Customer avoids costs of installation, maintenance, patches
- **Platform as a Service**
  - Provider offers platform for building applications
    - Google App-Engine
  - Customer does not have to worry about scalability of platform
- **Infrastructure as a Service**
  - Provider offers raw computing, storage, and network
    - Amazon Elastic Computing Cloud (EC2)
  - Customers can avoid buying servers and estimating resource needs

Enabling Technology: Virtualization

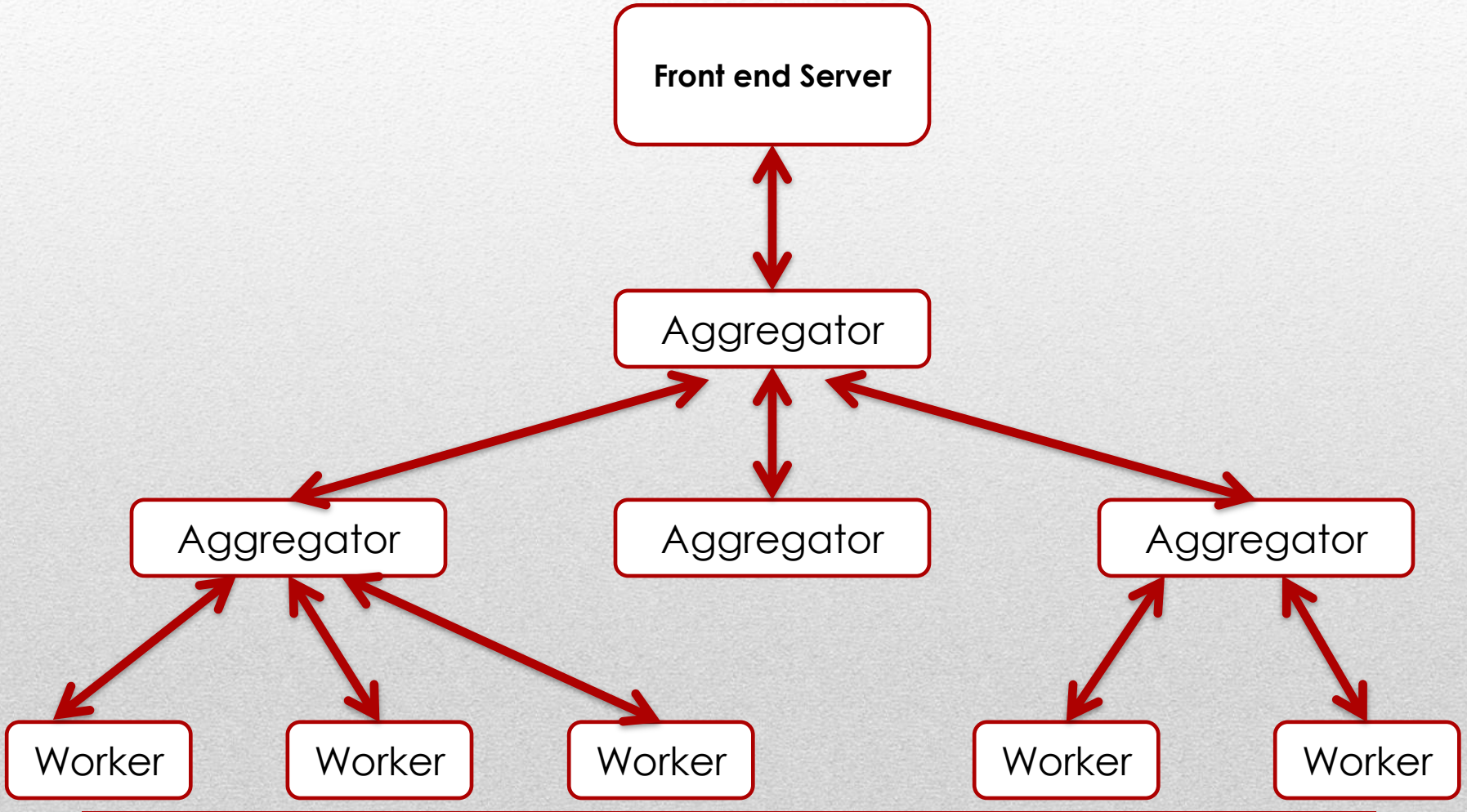
- Multiple virtual machines on one physical machine
- Applications run unmodified as on real machine
- VM can migrate from one computer to another



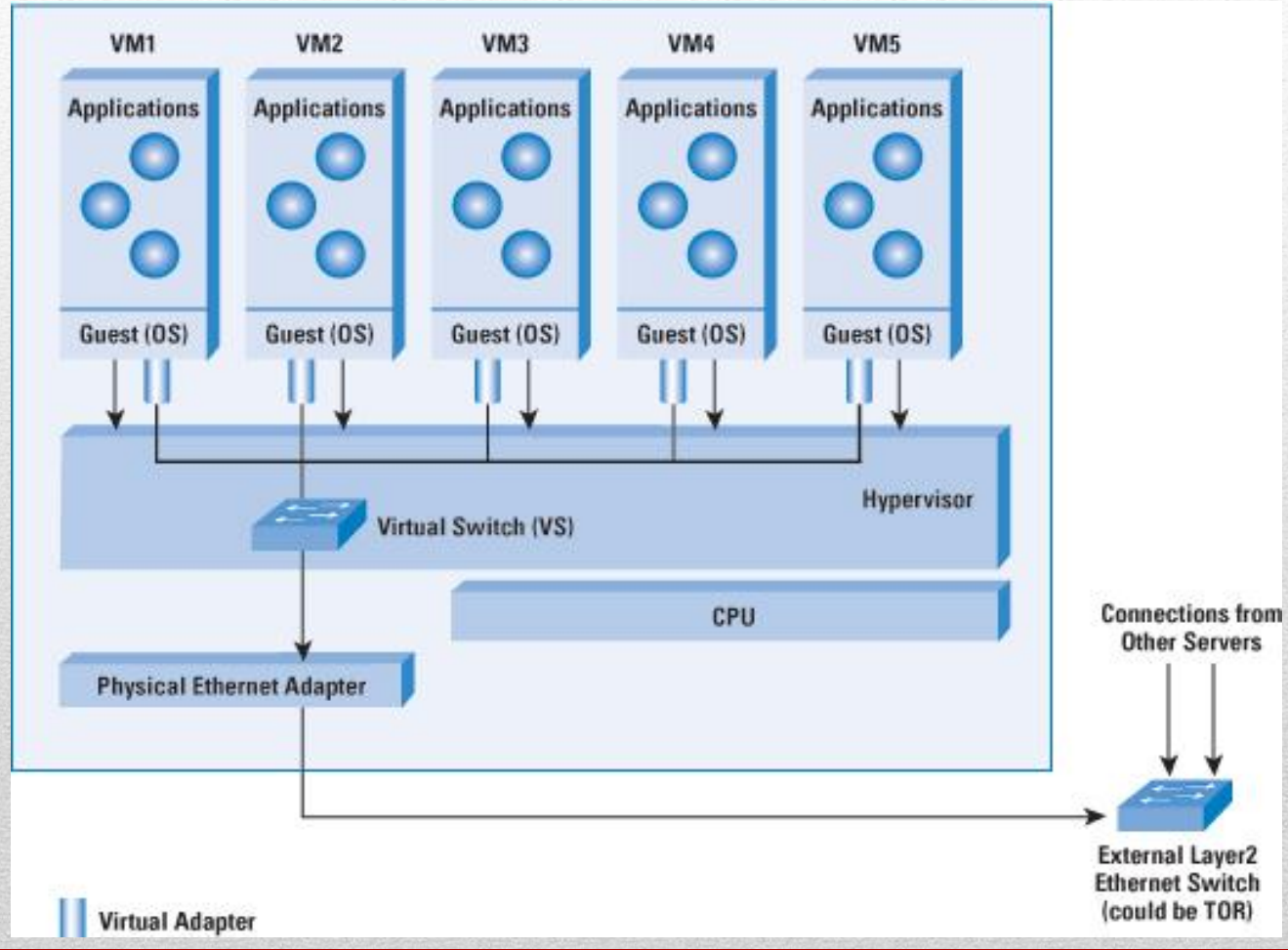
Multi-Tier Applications

- **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



Virtual Switch

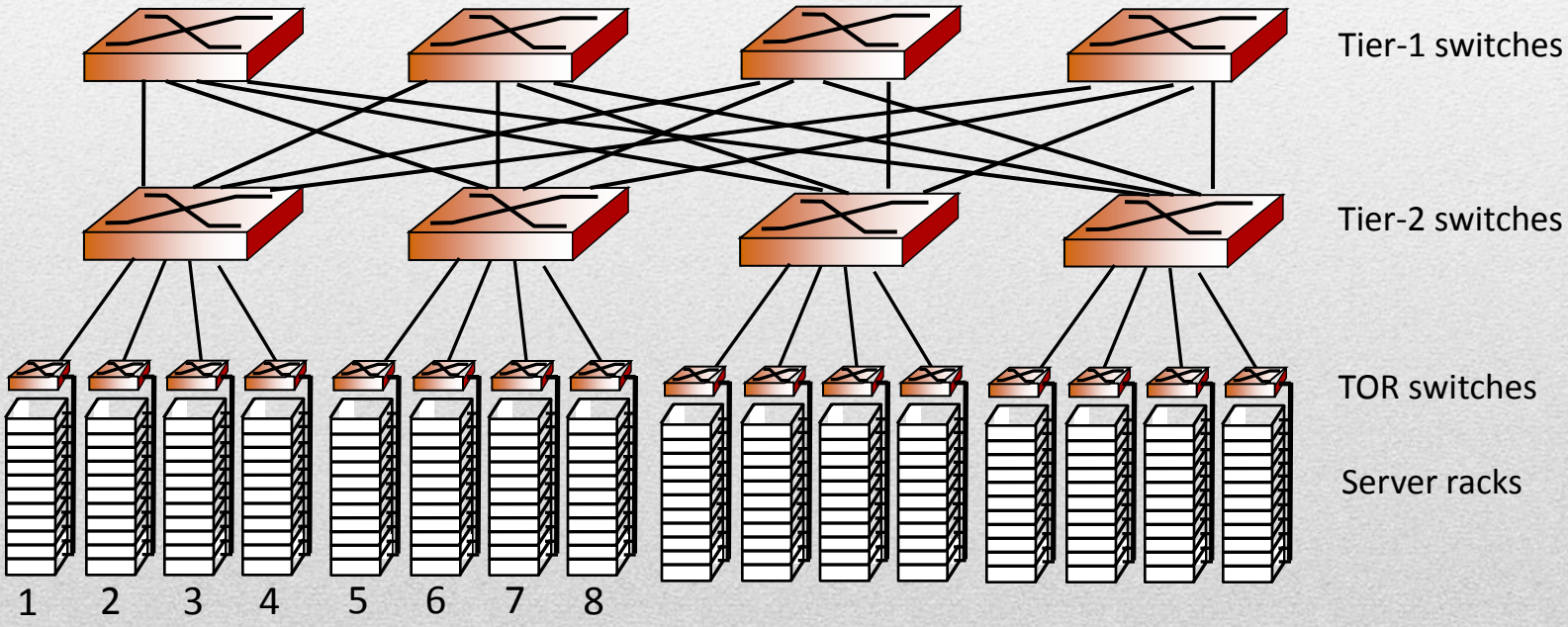


Data Center Networks

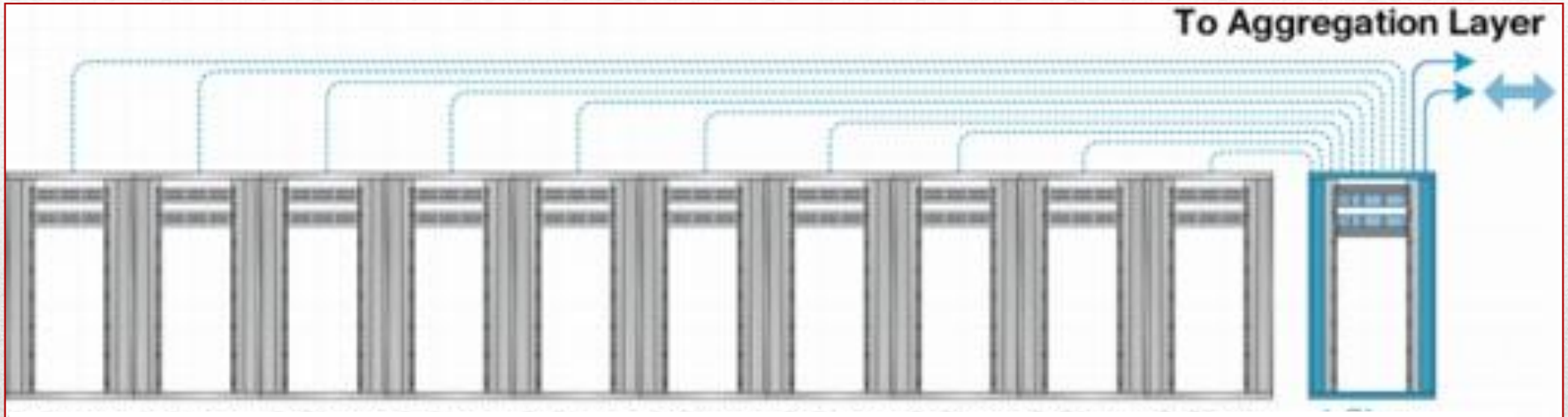
- Hundreds of thousands of hosts, often closely coupled, in close proximity
  - **E-business**
    - Amazon
  - **Content-servers**
    - YouTube
    - Akamai
    - Apple
    - Microsoft
  - **Search engines**
    - Data mining
      - Google

Inside a 40-ft Microsoft container Chicago data center

Data Center Networks



Data Center Networks



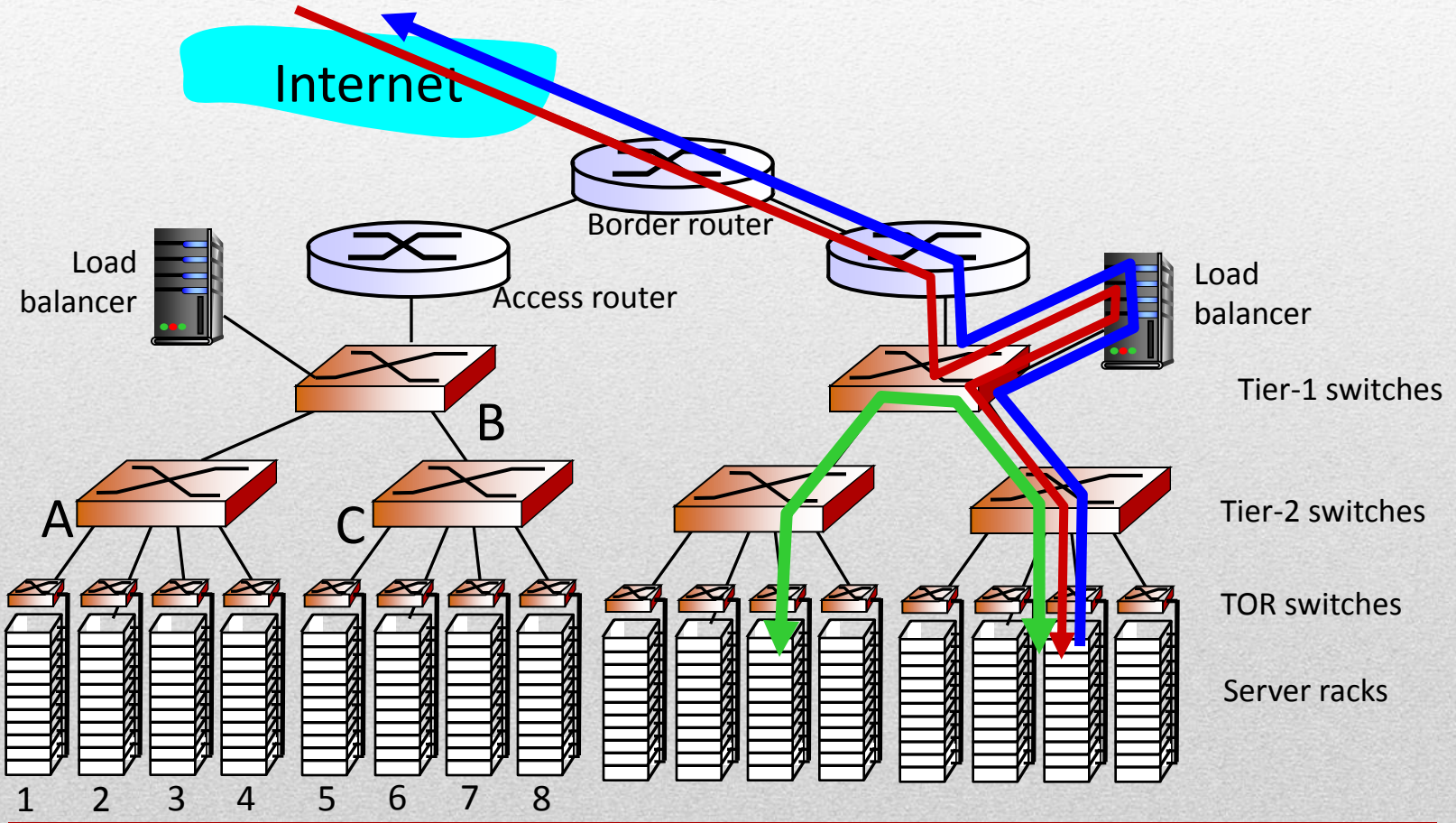
- Modularity
- Aggregation

Data Center Networks

Challenges

- Multiple applications
  - Each serving massive numbers of clients
- Managing/balancing load
  - Avoiding processing, networking, data bottlenecks
  - Google

Data Center Networks



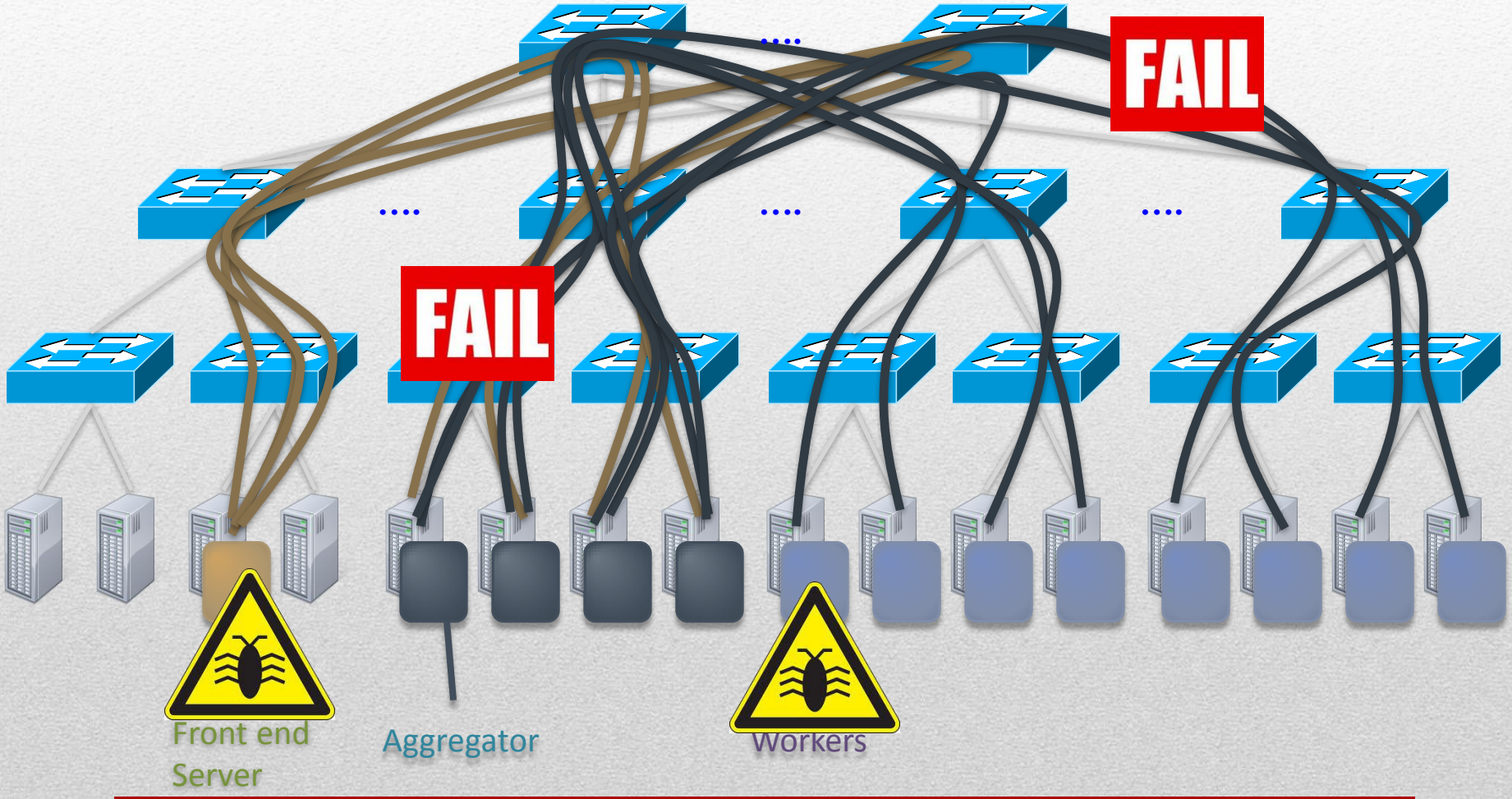
Data Center Networks

- **Load balancer**
  - Application-layer routing
  - Receives external client requests
  - Directs workload within data center
  - Returns results to external client
    - Hiding data center internals from client

Data Center Networks

- **Rich interconnection among switches & racks**
  - Increased throughput between racks
    - Multiple routing paths possible
  - Increased reliability via redundancy

Data Center Networks



Data Center Networks

- **Challenges of Diagnosis**
  - Multi-tier applications
    - Hundreds of application components
    - Tens of thousands of servers
  - Evolving applications
    - Add new features, fix bugs
    - Change components while app is still in operation
  - Human factors
    - Developers may not understand network well
    - Nagle's algorithm, delayed ACK, etc.