Cloud Networking (VITMMA02)
Networks in the cloud

Markosz Maliosz PhD

Department of Telecommunications and Media Informatics
Faculty of Electrical Engineering and Informatics
Budapest University of Technology and Economics

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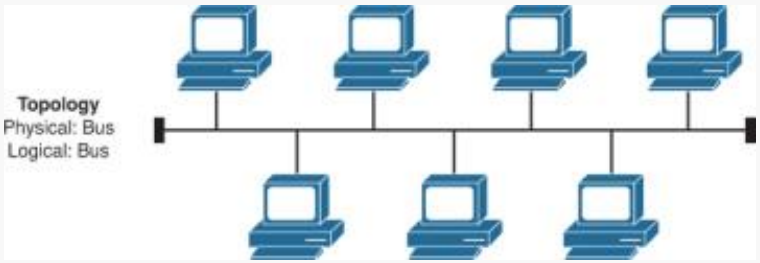
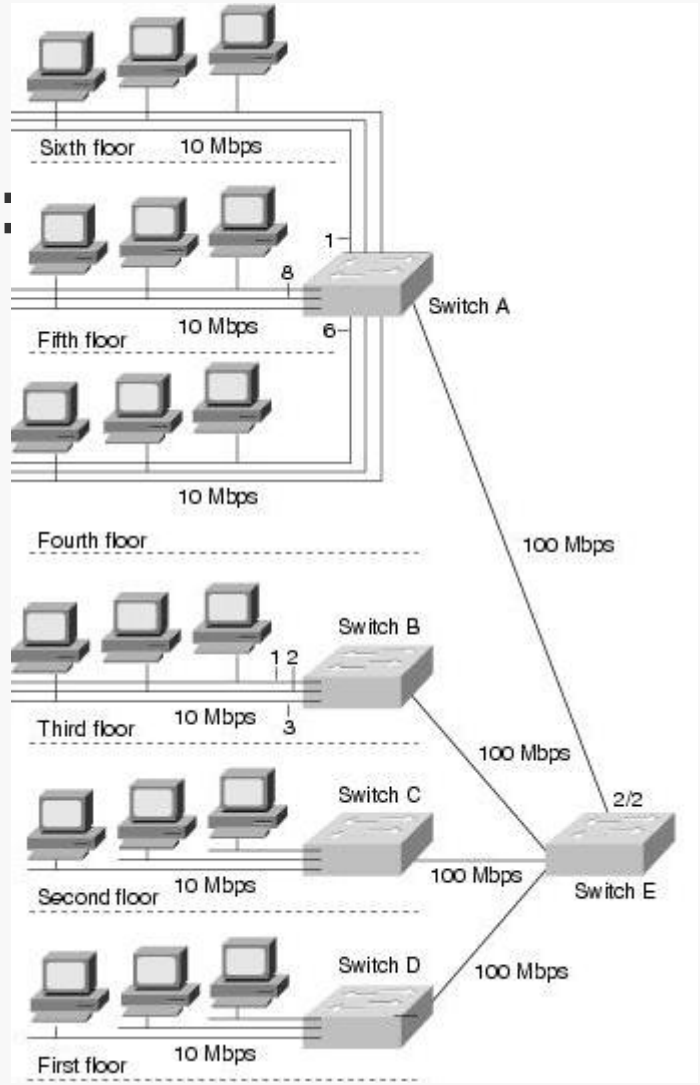
Ethernet

- Layer2 network
- Ethernet bridging or switching: bridged/switched Ethernet
  - emulating shared media

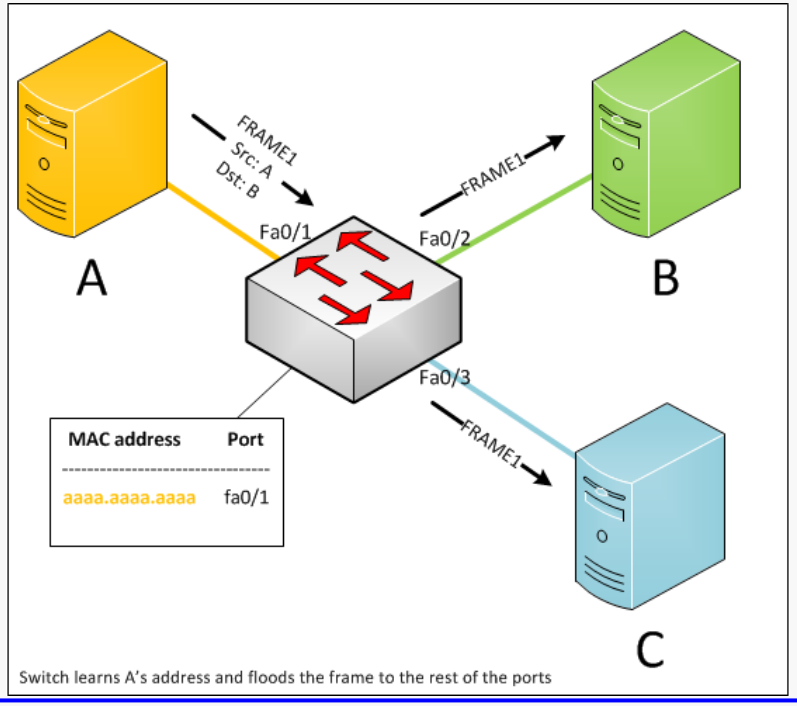


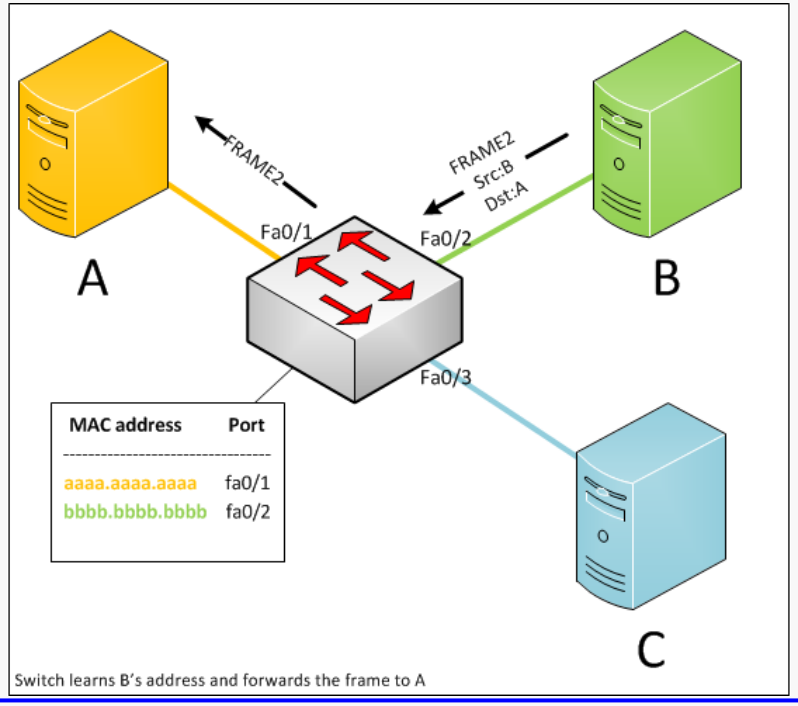


Backgrounder: http://www6.ietf.org/edu/documents/82-RoutingBridgingSwitching-Perlman.pdf pp.18-44

Ethernet

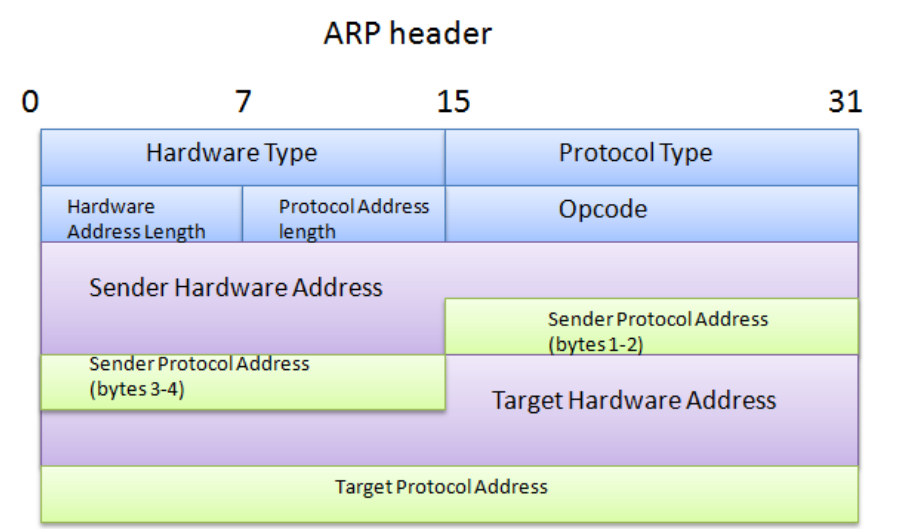
- Spanning Tree Protocol (STP)
- MAC address learning
- transparent bridging
- flooding: broadcast, unknown unicast and multicast packets
- possible errors: implementation error, misconfigration
- forwarding loop is causing 100% CPU load for the affected switches

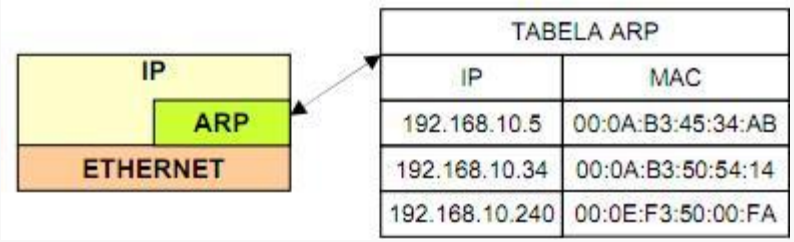


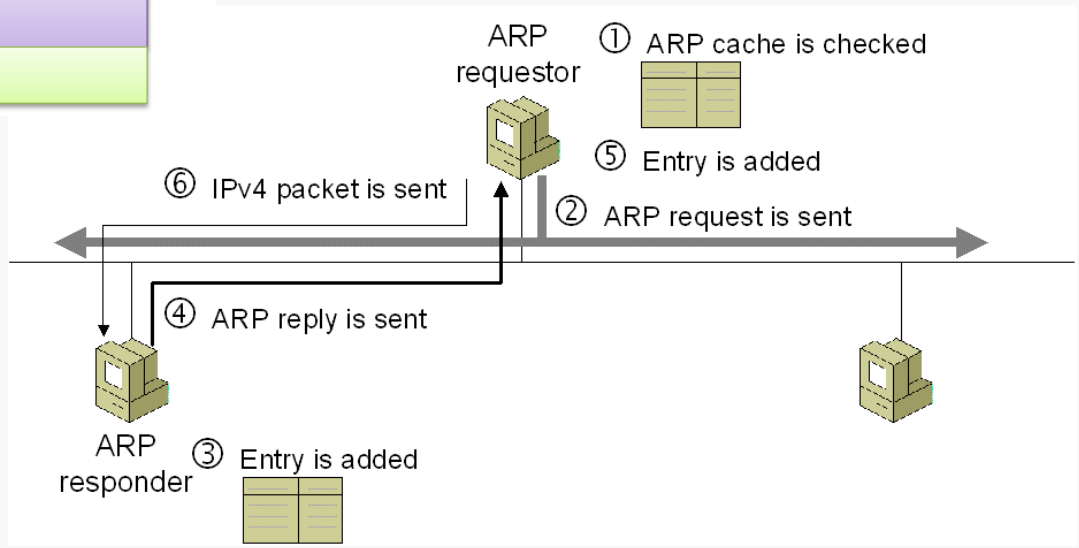


IP address and MAC address mapping

» Address Resolution Protocol (ARP)

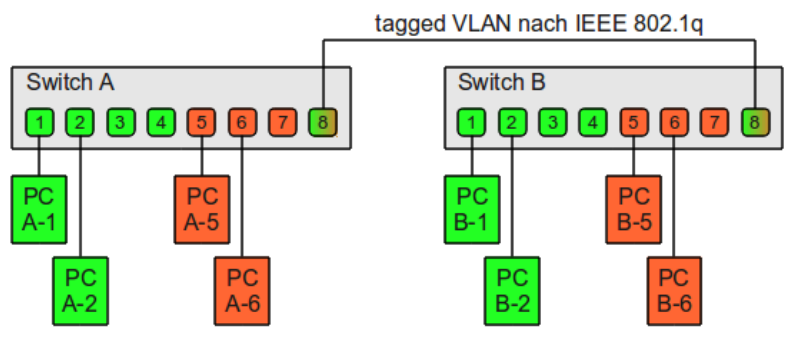


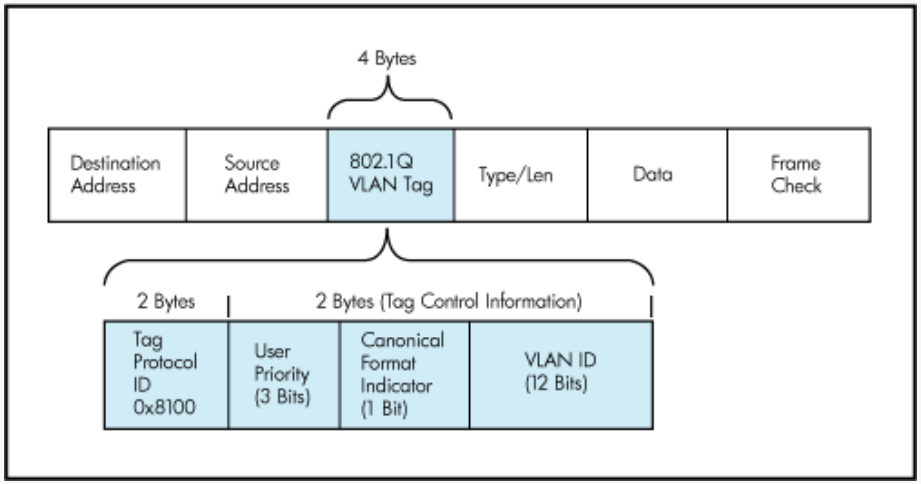




Isolation: Virtual LAN (VLAN)

- Isolated virtual network segments: VLANs (IEEE 802.1Q)
  - without Layer3
  - better scalability





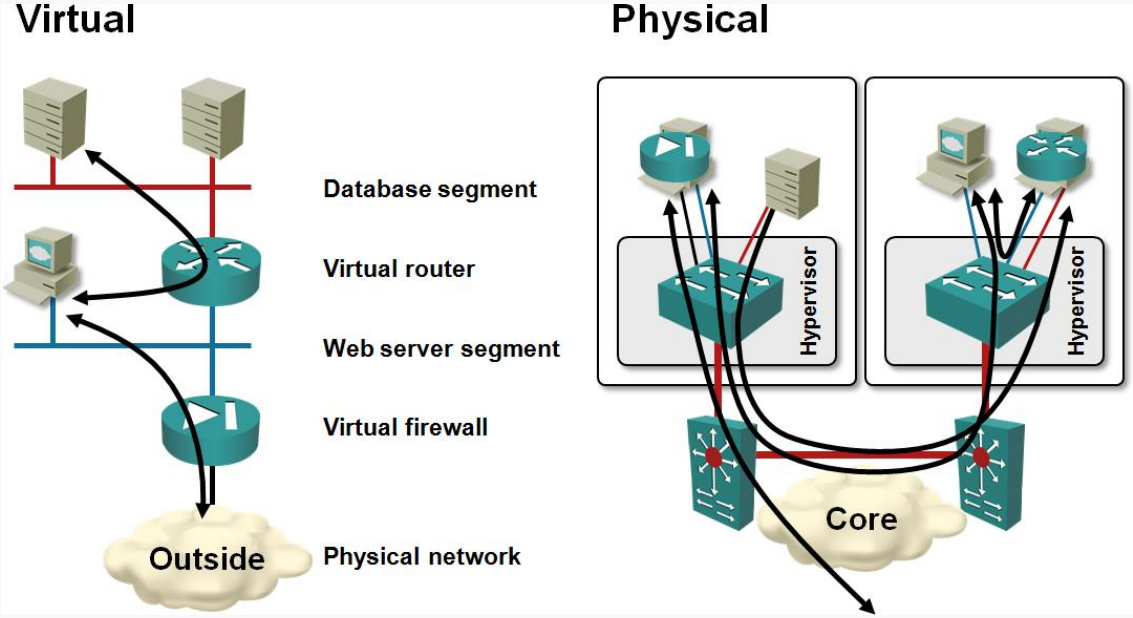
- Forwarding is based on VLAN ID and destination MAC
- Ethernet Network Interface Card (NIC)
  - MAC address filtering
    - for one or several unicast and multicast addresses, processes only frames destined here
  - Virtual Machines (VMs) on a physical machine (PM)
    - many VM (and corresponding MAC addresses) on the same PM
    - hypervisors usually set the physical NIC to „promiscuous mode" (accepting frames without filtering)
      - each frame is processed with the help of the CPU

Scalability of VLANs

- Maximum 4094 VLANs in an Ethernet network
  - 12 bits VID (0x000 and 0xFFF reserved)
- hypervisor physical NIC in promiscuous mode
  - flooded frames are processed by CPU
- Usual implementation
  - all VLANs available on all server NICs
    - hypervisor processes all flooded frames, even if there is no active VM in that VLAN on the host
  - it is like we had only one VLAN

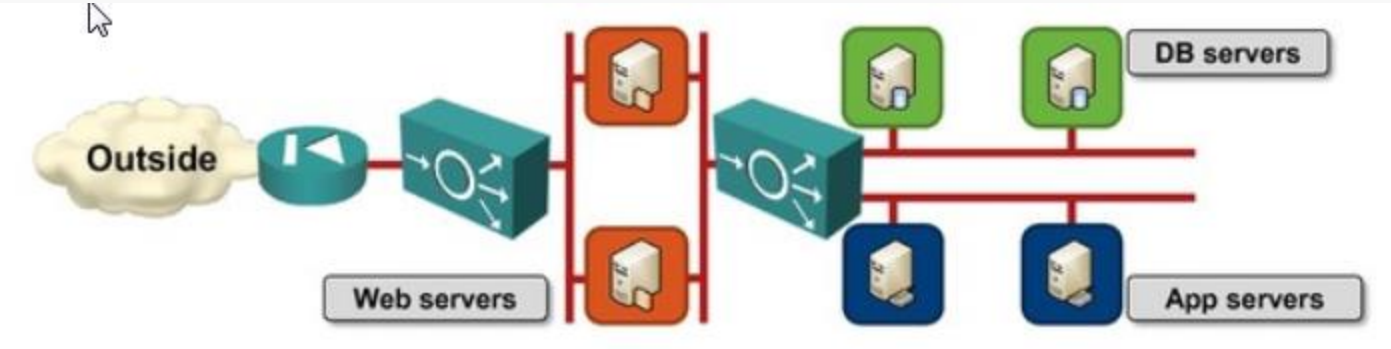
Virtual Network Architectures

- One physical network – many virtual networks
- Many customer in the data center
  - each customer has many VMs
  - must work like they are on a private network
  - adaptation to the changing needs
- Tunneling, encapsulation
  - one or more tag



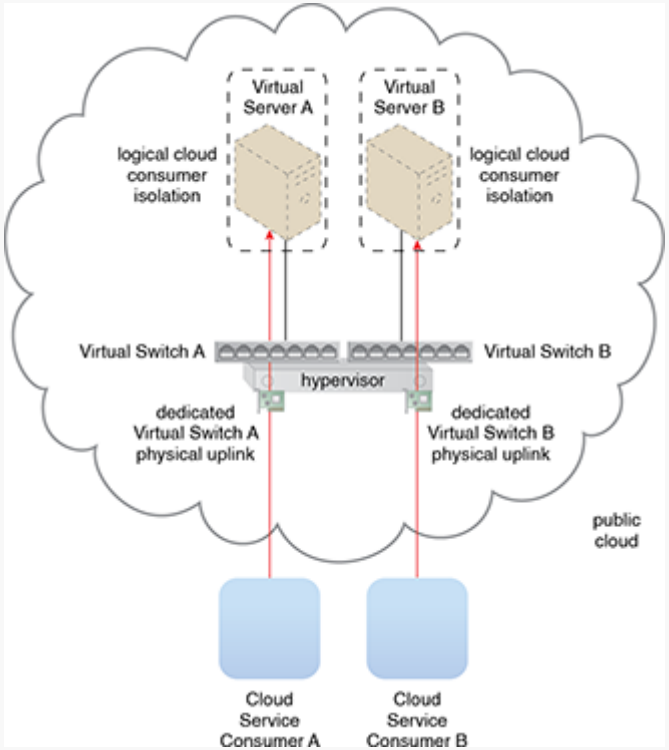
Web Application Architecture

- A complex application requires network functions too
  - L2/L3 packet forwarding in multiple subnets
  - firewall
  - load balancing
  - NAT
  - VPN access



Web Applications in the Cloud

- For multiple customer all applications must be separated from the others
- Keeping the existing network connections in operation
  - internal addressing
  - network services
  - security modell
  - virtual segments
  - QoS

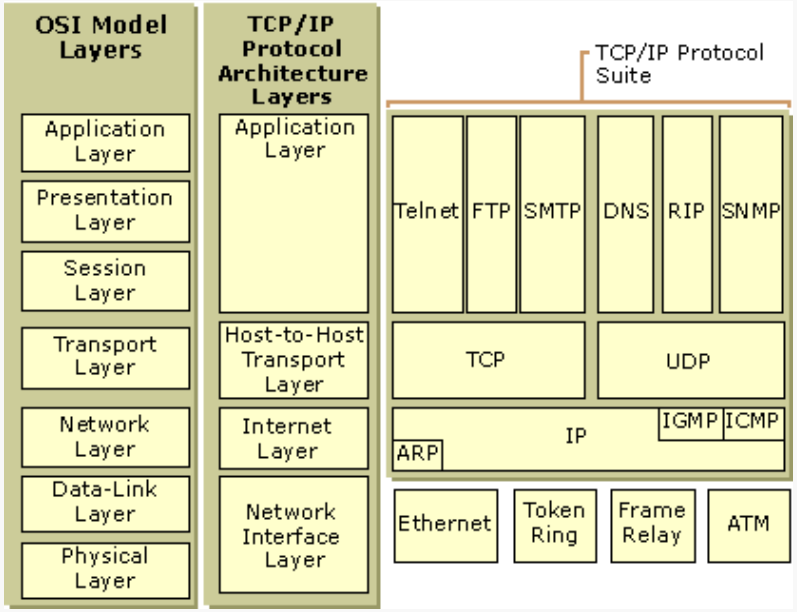


Virtual Network Architectures

- The important question: is it scalable?
- Goal: scalable infrastructure for several thousand virtual networks
- Scalability
  - keep the performance with the increasing workload by adjusting the processing capability
  - scaling up/down: vertical scaling
    - larger resource (faster or more CPU, larger or quicker memory and storage drive)
    - in the cloud the resources of the VM can be enlarged
  - scaling out/in: horizontal scaling
    - adding more server instances

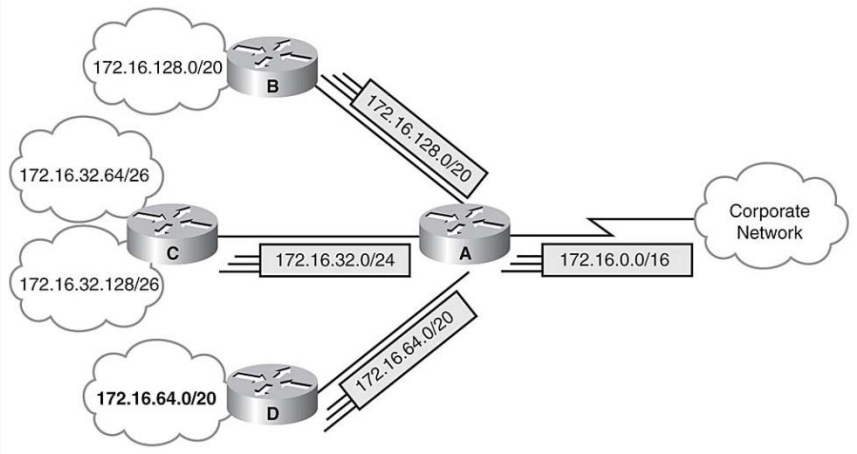
Networking inside the Cloud

- Internet
  - world-wide, huge number of endpoints, it works quite good ☺
- Data center
  - similar requirements
  - even VMs in the order of million (e.g. AWS)
  - exponential growth
  - often the network bandwidth is the bottleneck
  - Options
    - Layer2
      - switching
      - simpler, plug-and-play
      - VM migration keeps the IP address
      - scalability?
        - up to small and medium size
      - typical in enterprise data centers
    - Layer3 (Amazon, Facebook, etc.)
      - routing
      - scales well
      - for any network size
      - however not a "small Internet"



Networking in the Cloud

- Options
  - Layer2: Ethernet
    - MAC address is location independent
      - flat addressing
    - scalability limit: learning all the MAC addresses in the switches
  - Layer3
    - hierarchical address space
    - routing information is aggregated



Networking in the Cloud

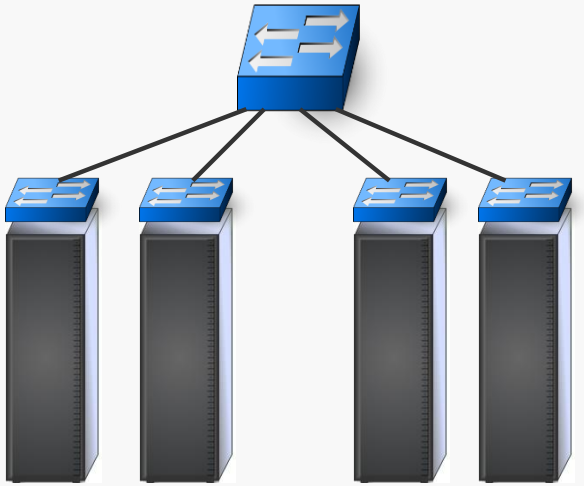
- Layer2: Ethernet
  - easy to configure and deploy: plug and play
  - approx. up to 1000 servers
  - communication within the local segment
    - traffic destined outside of the segment is sent to the default gateway
  - customer can manage the allocated IP address range
    - starting new VMs
    - change, reallocate IP addresses
  - Spanning Tree Protocol
    - no multipath

Networking in the Cloud

- Layer3
  - each network device is a router
    - protocol: Open Shortest Path First (OSPF) or Intermediate System to Intermediate System (IS-IS)
    - distributing topology information
  - one VM – one L2 "network"
    - no L2 broadcast, multicast is difficult
    - no VLAN
    - e.g. Windows servers use broadcast to discover each other
  - Equal Cost MultiPath (ECMP)
    - better network bandwidth utilization
  - shortest path
    - Dijkstra's algorithm
  - VM migration is more complex
    - IP address change

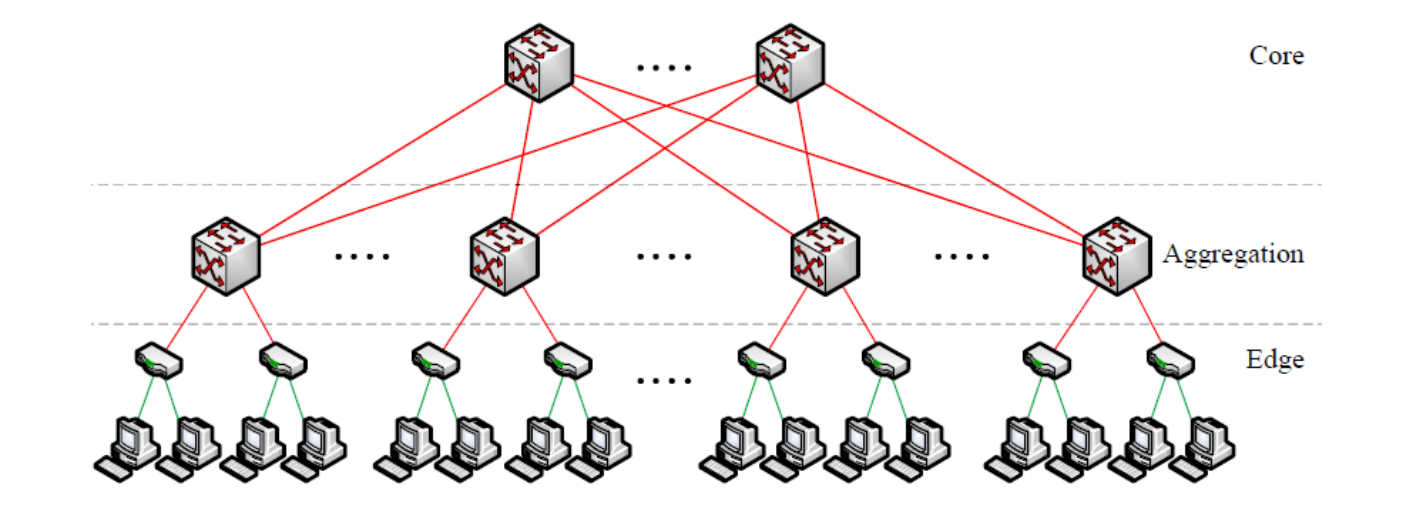
Network Topologies

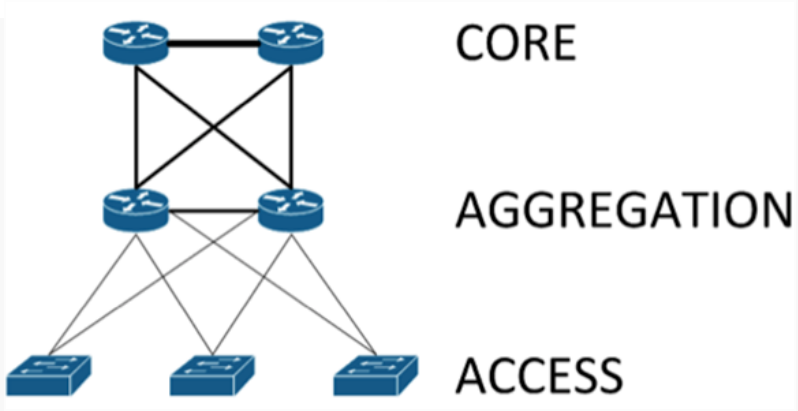
- 3 level hierarchy: ToR, aggregation, core switch
- flat(ter) topology, 2 levels: ToR and core switch
  - one central switch: expensive, port number is limited
    - e.g. the price of a 128 port GbE switch is approx. 100 times the price of a 48 port switch



Network Topologies

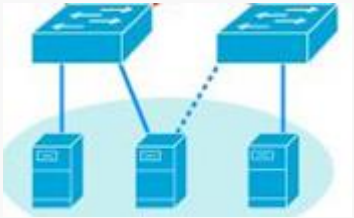
- Redundancy and/or load balancing
  - dual star

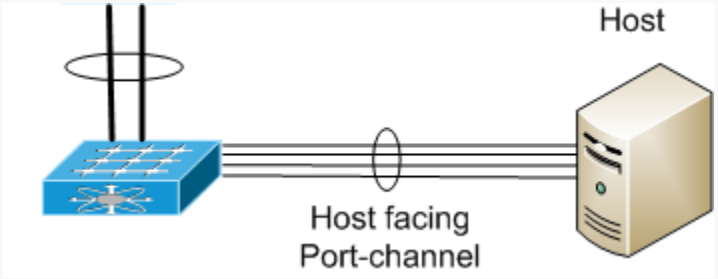




Server – ToR Switch

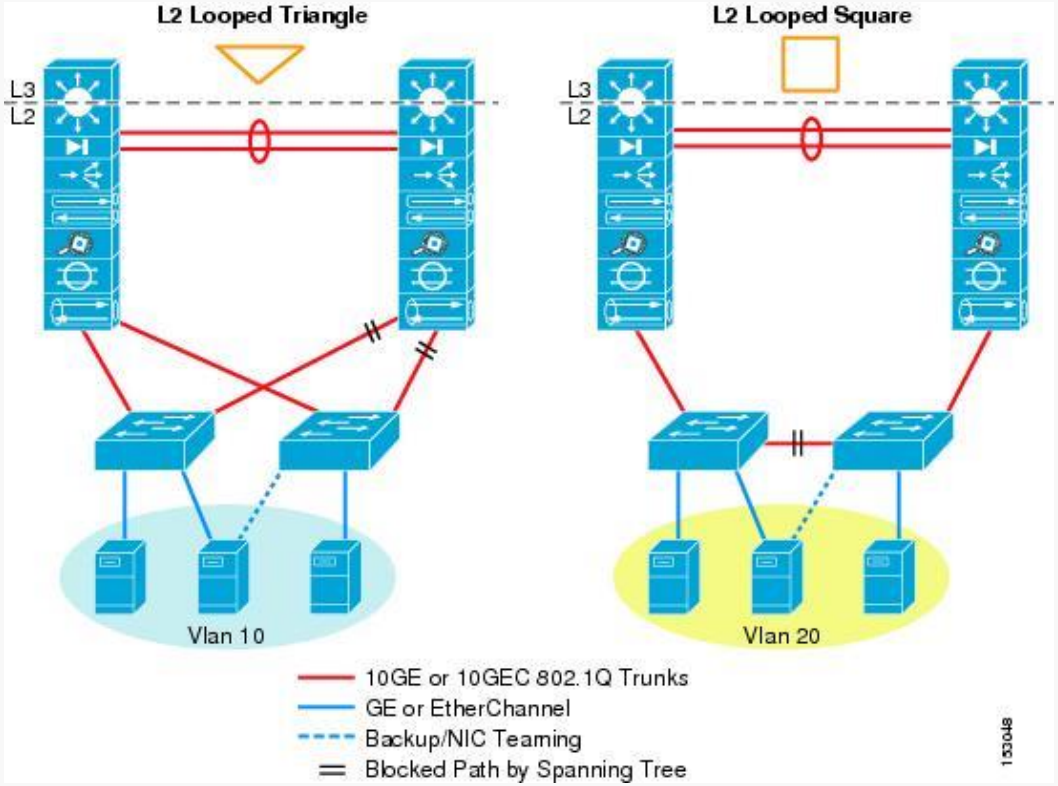
- Single homed
  - 1 server – 1 switch
  - resiliency can be provided by external mechanisms
  - Single Point of Failure
    - NIC, cable, switch port, switch
- Multi homed
  - 1 server – 2 switches
    - working/backup, primary/secondary
    - simultaneous operation
      - different MAC, IP addresses
- Port-channel
  - requires switch configuration
  - one logical connection, aggregation of more physical links
  - 1 server – 1 switch
  - 1 server – more switches
    - virtual port-channel
    - ending on different physical switches
    - shared or communicating control planes
    - switches are also connected
      - forming a ring if there are more than 2 switches





ToR – Core Switch

- Looped Topology
  - triangle
    - wide-spread solution
    - half of the connections are unused
    - more ports on the core switch
  - square
    - less redundant
    - less ports on the core switch



ToR – Core Switch

- Loop-Free Topology
  - STP not running
  - U
    - ToR switch operates in transit mode in case of failure
  - inverted U
    - less ToR switch port
    - not applicable for single homed servers
    - without network level redundancy