

Internet Technology

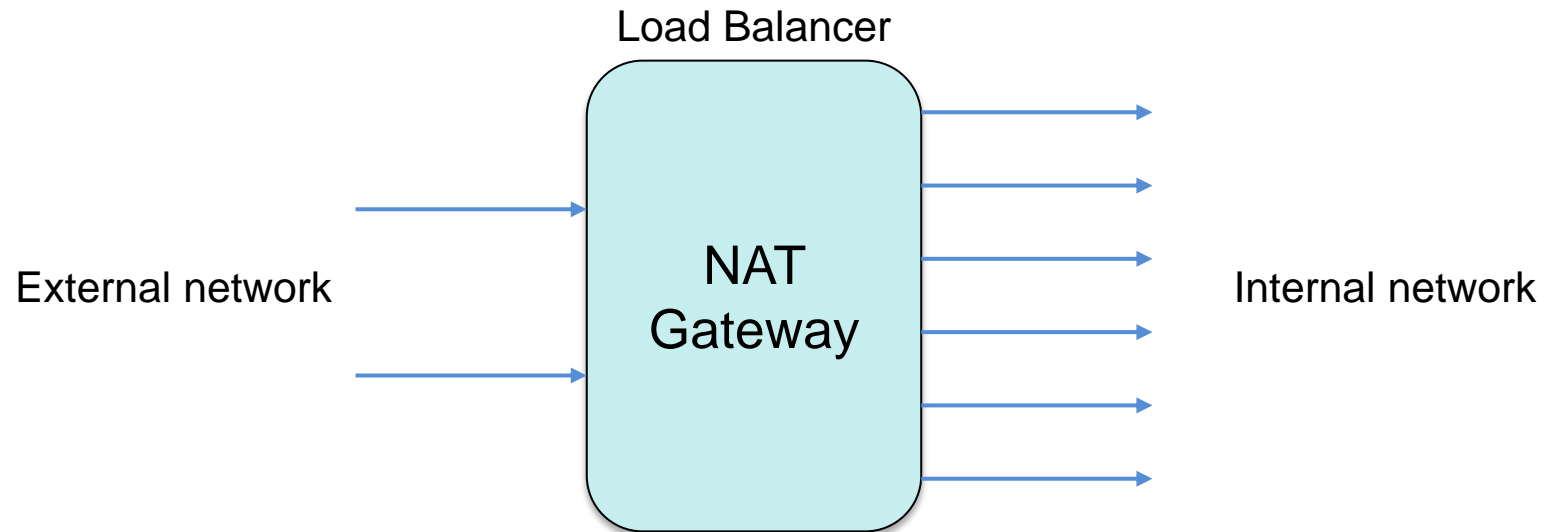
15. Things we didn't get to talk about

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Load Balancers



NAT: consistent mapping to internal address

Load balancer: map to one of several internal addresses

- May be grouped by original destination address and/or port
- Connection affinity, source affinity (easier to manage sessions & stateful behavior)
- Distribution: round robin, weighted round robin, fastest SYN-ACK
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Software Defined Networking

- Routers & switches are proprietary hardware
 - Evolve slowly (usually designed with custom ASICs)
 - Need to be configured individually – making changes in a large organization is a pain
- But the computers connected to the network
 - Can change spontaneously – thanks to VMs

It can take minutes (or seconds) to bring up or reconfigure a node ... but days to reconfigure a network!

Software Defined Networking (SDN)

- “Standard” software-based approach to managing network hardware
 - Decouples the network control & forwarding functions
 - OpenFlow™ - dominant SDN protocol, defined by the Open Networking Foundation (ONF)
- Features
 - **Directly programmable**: decoupled from forwarding engine
 - **Dynamic**: easy for administrators to make spontaneous changes
 - **Centrally-managed via SDN controllers**: global view of an organization’s network – which appears as a single switch
 - **Programmatic configuration**: open APIs

SDNs allow you to mix and match network vendors

Network Virtualization

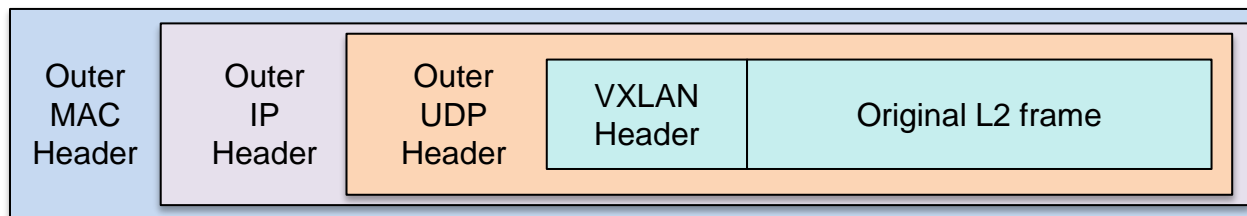
- Virtualization & Cloud computing
 - Let someone else manage resources for you
 - Access computing, storage, & networking resources without worrying about where they are or how they are implemented

Virtual machines → software defined data center

- Create logical networks that are decoupled from the underlying hardware
 - Software-based view of networking HW (switches, routers, firewalls, load balancers, VPNs)
 - Physical hardware is responsible for forwarding packets

Network Virtualization

- Virtual Machines (VMs) send standard layer 2 (ethernet) frames
- Hypervisor encapsulates the frame in a UDP datagram
 - VXLAN: Virtual Extensible LAN – Layer 2 over Layer 3 encapsulation

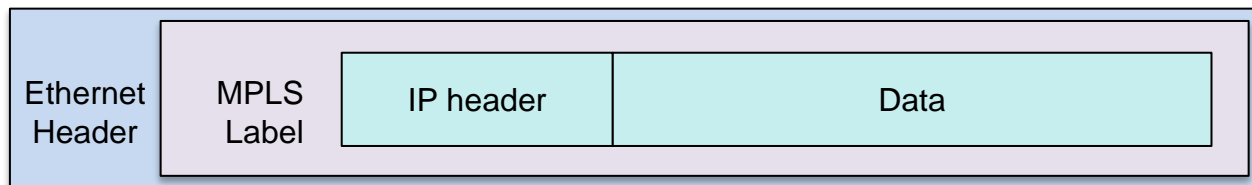


- Datagrams are forwarded to the destination
- Destination decapsulates headers & sends original frame to the VM
- Create overlay virtual network topologies on a common network
 - Central management (via APIs)
 - Virtual switches (vSwitch) or virtual routers at each device route traffic

See Open vSwitch

Multiprotocol Label Switching (MPLS)

- Use fixed-length packet **label** to decide where to forward a packet
 - Routers do not have to look at IP headers
 - Each destination is associated with a 20-bit label
- Routing:
 - First device looks up the final destination router & pre-determined path
 - Label is used to route the traffic via MPLS-aware routers
 - Final MPLS router removes the label



Multiprotocol Label Switching (MPLS)

- Original reason for MPLS
 - Improves performance: simple lookup, no IP header modification
 - No need to do longest prefix matching
 - But ASICs can handle tens of millions of IP lookups per second
 - Although they can be expensive
- Why is MPLS still used?
 - Protocol independent
 - No dependence on data link layer (2) or network layer (3)
 - Support routing of IP traffic as well as other data services
 - Supports traffic engineering
 - E.g., distribute traffic among several links – not just shortest path
 - Choose uncongested path with higher latency than a “better” congested path
 - Routing is transparent to the IP layer
 - Bandwidth reservation with RSVP-TE
 - Enables resilient networks (Fast Reroute)

MPLS is
layer 2.5!

Wide Area Ethernet (WAE)

- Virtual Private LAN Services (VPLS)
- Provide the simplicity of a “flat” Ethernet
- Makes multiple sites look like they are on one logical Ethernet
- Common deployments
 - Ethernet (in building) – MPLS (wide area) – Ethernet (in building)
 - Carrier-Ethernet Transport

Internet of Things

- In-home
 - Connectivity
 - Ad-hoc mesh networks (ZigBee): each node participates in routing – route discovery
 - Wi-Fi
 - Bluetooth
 - Lights, thermostats, switches, appliances
- Wide area
 - Cellular connectivity (usually)
 - Microcontrollers (usually)
 - Sensors
 - Internet access
 - Back-end acquisition & analytics
 - Loose connectivity
 - Domains: smart grid, smart cars, smart homes/cities, shipping containers

The end