MPLS, Data Centers and Retrospective

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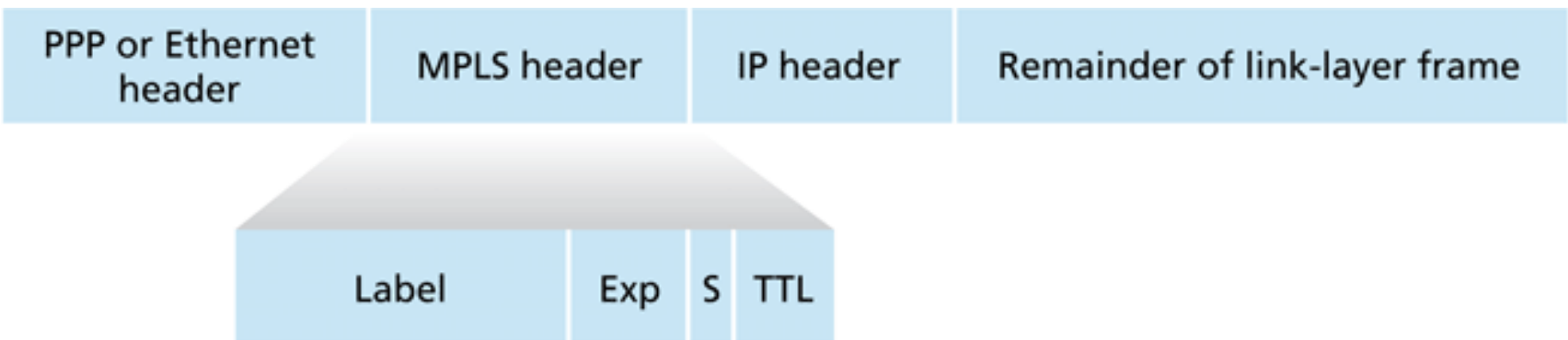
MPLS

MPLS: Multiprotocol Label Switching

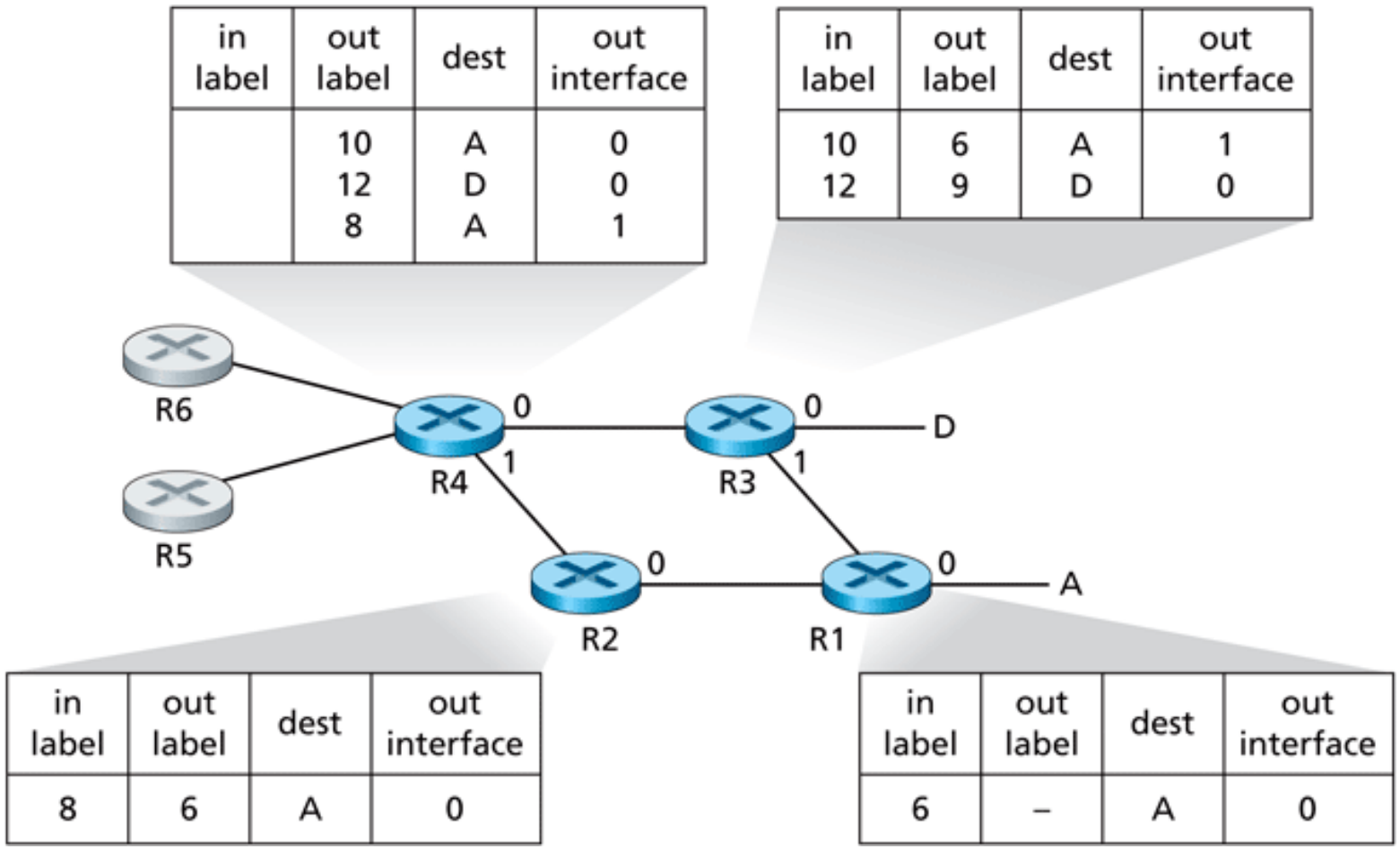
- initial goal: speed up IP forwarding by using a fixed-length label instead of the IP address
  - uses virtual circuits
  - acts as a virtual network/linkh
- current use: traffic engineering, VPNs
  - setup a network of label-switching routers
  - use a signaling protocol to setup paths among the routers
  - use paths to determine where to carry IP flows through the ISP's network

MPLS Header

- Label: label identifying the virtual circuit, swapped at each switch
- Exp: experimental
- S: stacked MPLS headers (hierarchy of circuit paths)
- TTL: time-to-live



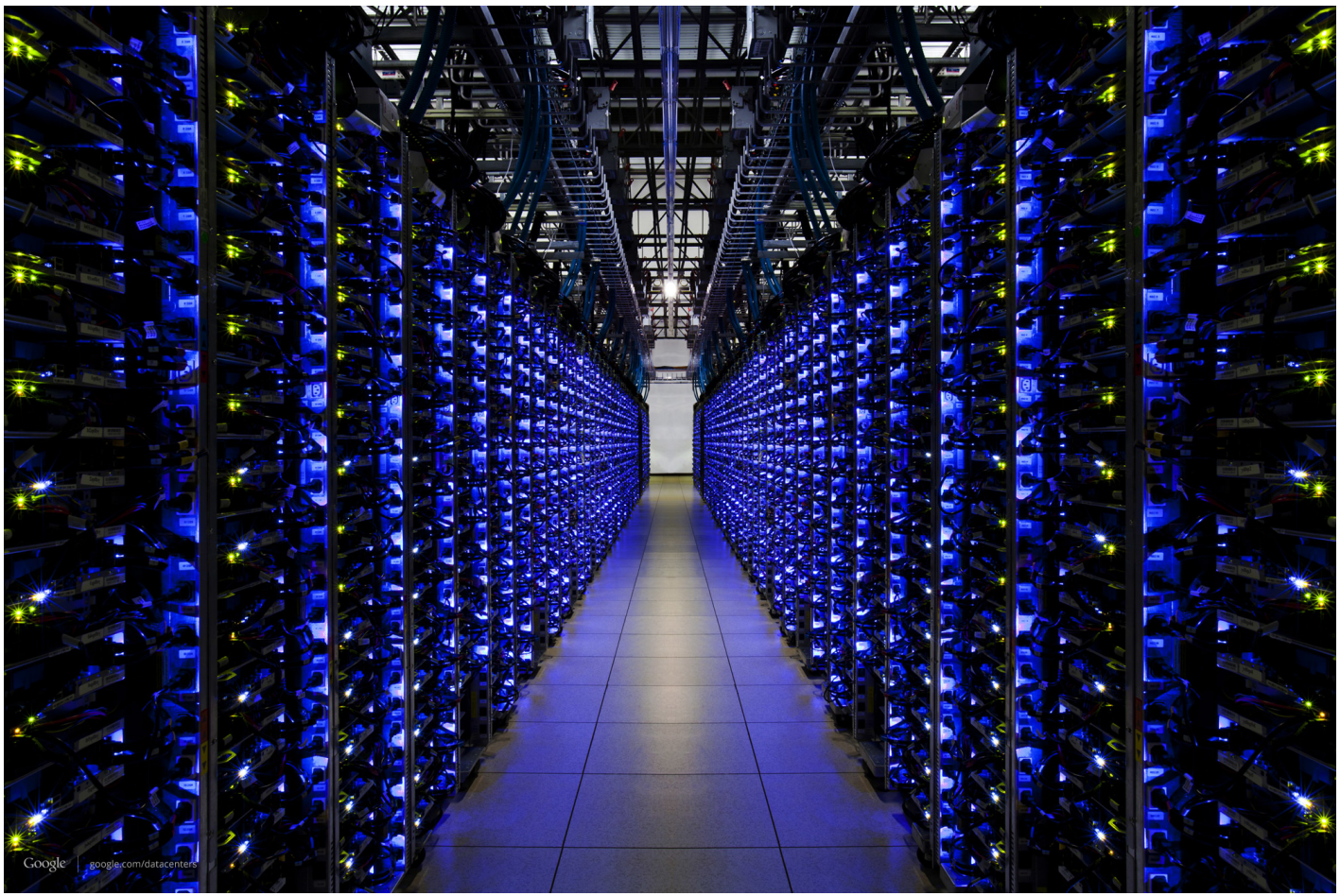
MPLS Forwarding Table



Data Center Networking

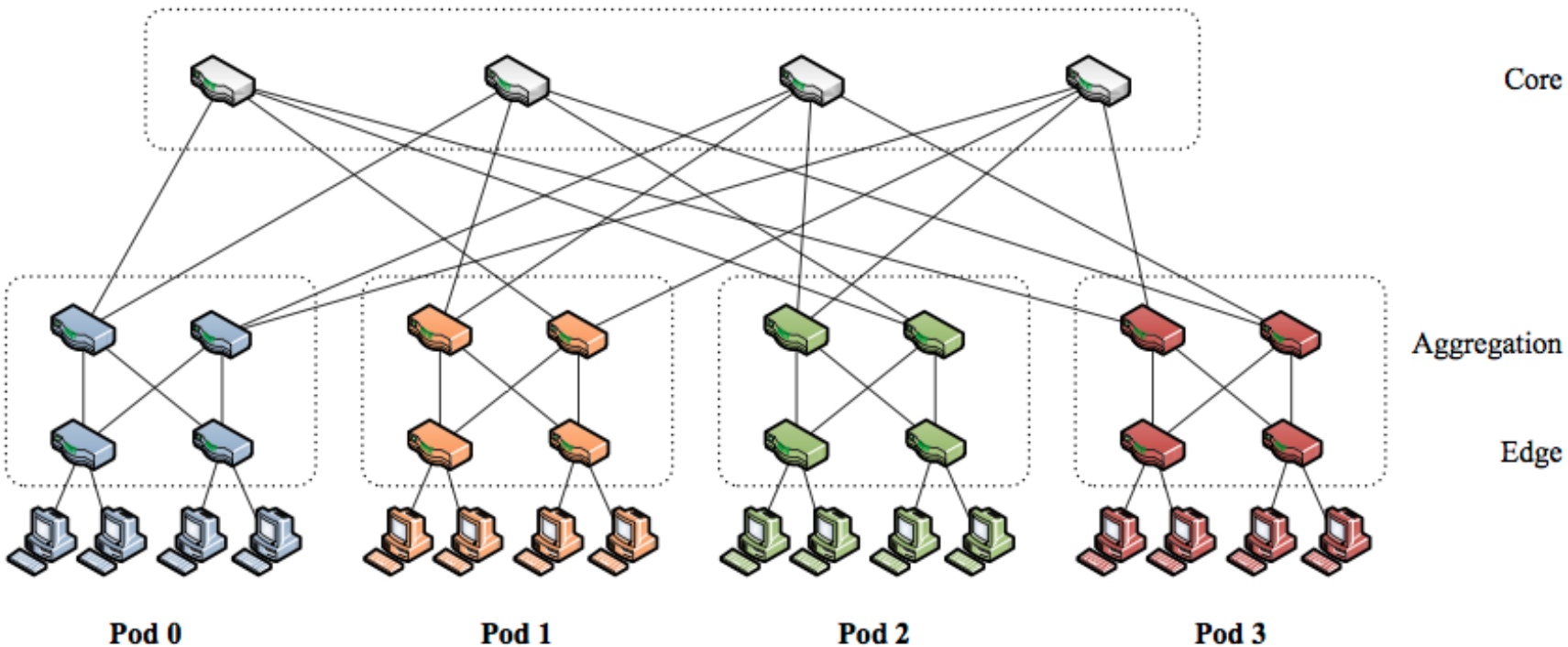
Data Center Networking

- large companies (Google, Facebook, Amazon, Microsoft)
- 10,000 to 100,000 machines, running cloud applications
- $1,000,000 to $10,000,000 per month in maintenance



Features

- *load balancing:* route requests to the hosts based on load
- *hierarchy:* tiers of switches, design to avoid bottlenecks between hosts in different racks
- *innovation:* shipping containers, routing algorithms, etc.



Retrospective

Internet Access: DHCP

1. laptop sends DHCP request in a UDP packet using IP broadcast address
2. IP packet sent in Ethernet broadcast frame
3. switch broadcasts on all ports
4. DHCP server responds with allocation message, sent to laptop's Ethernet address directly
5. switch has learned laptop's MAC address, so frame not flooded
6. laptop gets IP address for itself, IP address of default router, IP address of resolver

Internet Access: ARP

1. laptop wants to send DNS query for www.google.com to DNS resolver
2. laptop uses ARP to default router's MAC address using a broadcast ARP query
3. router responds with ARP reply directly to MAC address of laptop

Internet Access: DNS

1. laptop sends UDP DNS query to resolver
2. laptop routes this request to the router using its MAC address
3. router uses routing protocol to determine next router to send it to
4. ARP may be used again at each hop
5. eventually the request reaches the DNS resolver, which sends a response back to the laptop

Internet Access: TCP and HTTP

1. laptop sends a SYN segment to www.google.com
2. routers forward packets between laptop and Google using BGP and internal routing protocols
3. Google responds with a SYN-ACK segment, sent to laptop's IP address
4. laptop sends ACK and then follows this with an HTTP GET message inside a TCP segment
5. Google responds with an HTTP response message
6. laptop displays web page