University of Massachusetts Amherst

ECE697AA – Lecture 4

Network Layer: IP

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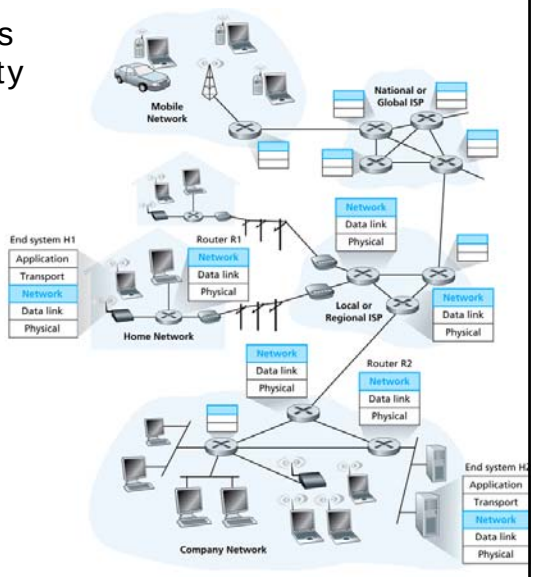
Today's lecture

- Network layer
  - Connectivity
  - Internet Protocol
  - Addressing and routing
- We ignore for now
  - Routing algorithms
  - Prefix lookup algorithms

Network layer

- Network layer provides end-to-end connectivity
  - Service to layer above
    - » Unreliable channel
  - Uses link layer
    - » Point-to-point links

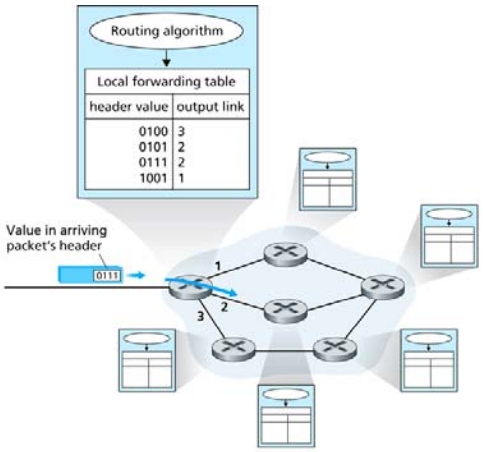


Connectivity

- How can we provide end-to-end connectivity if we can only send link by link?

Connectivity

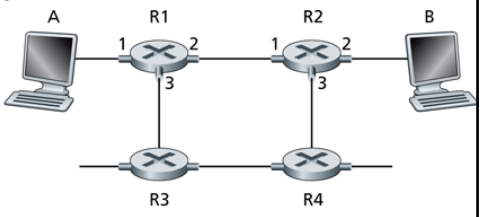
- Connectivity requires
  - Addressing
  - Routing and forwarding

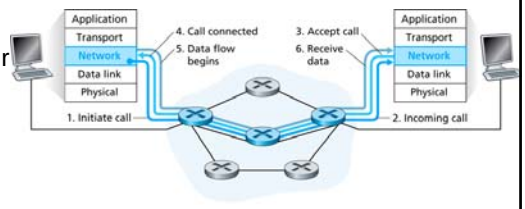


- Two different approaches for connectivity
  - Virtual circuit network
  - Datagram network

Virtual circuit networks

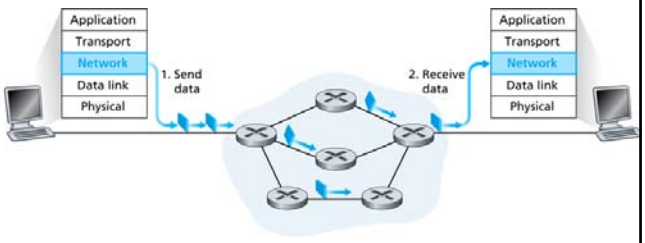
- End-to-end connectivity through virtual circuits (VC)
  - Connection has one VC number per path
  - VC number is changed on router
- Connection process
  - Connection setup
  - Data transfer
  - Connection teardown
- Router maintains state for every connection
- Possible services
  - In-order packet delivery
  - Guaranteed bandwidth
  - Guaranteed maximum jitter
- Example: ATM networks





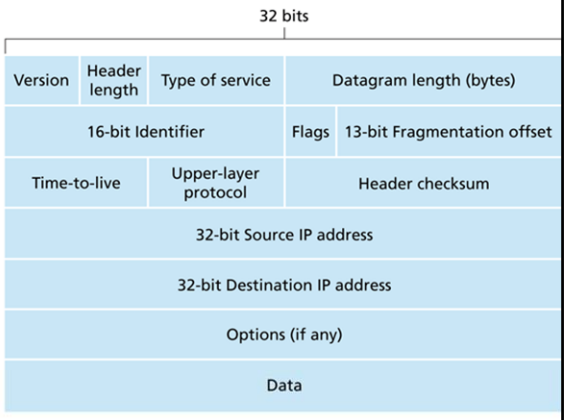
Datagram networks

- Packets are sent independently of each other
  - Each packet has full set of control information
- Every switch needs to be able to handle any packet
  - No need for per-connection state
- Service
  - Best-effort
  - Not in-order delivery
  - No guarantees on bandwidth, jitter



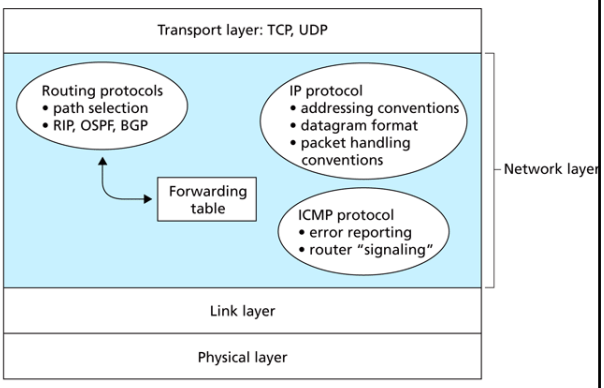
Internet Protocol

- The Internet's network layer: Internet Protocol (IP)
- IP packet format
  - 20 byte header + options + data
- IP header
  - Version
  - Source and destination addresses
  - Length
  - Upper layer protocol
  - Time-to-live (TTL)
  - Header checksum
  - Fields for "fragmentation"



Internet network layer

- There are multiple components to IP
  - Internet Protocol (IP)
    - » Data transfer
  - Internet Control Message Protocol (ICMP)
    - » Error handling
  - Routing protocols
    - » Determines forwarding

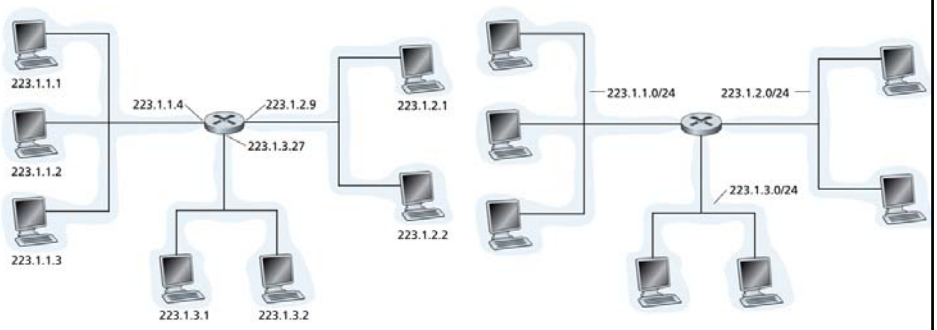


IP addressing

- A 32-bit globally unique identifier for an interface
  - Typically written in dotted-decimal notation: 192.168.0.1
- IP address assignment
  - In blocks of neighboring IP addresses: "subnets"
  - Notation: lowest address / prefix: 192.168.0.128/25
- Note: the classes are dead!
  - Long live Classless Interdomain Routing (CIDR)
- Allocation of addresses is crucial for routing
- Addresses assigned by Internet Assigned Numbers Authority (IANA)

IP address example

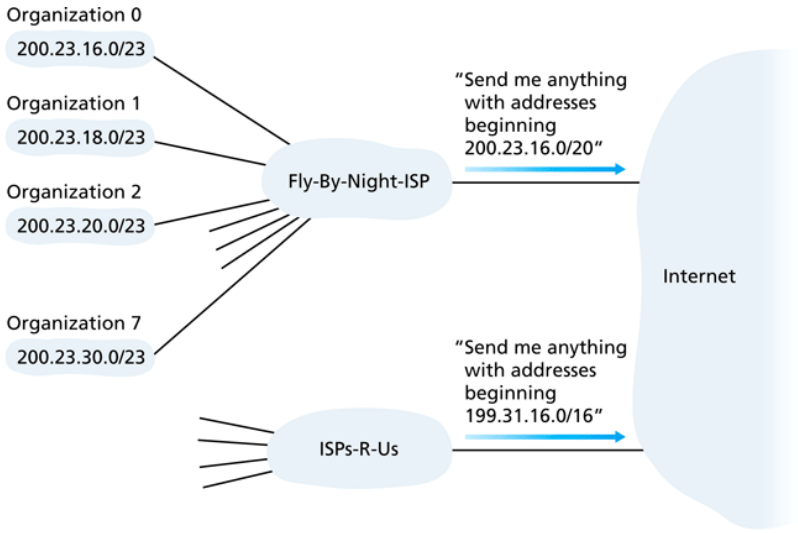
- Interface addresses and subnets



- Even point-to-point links require addresses for interfaces

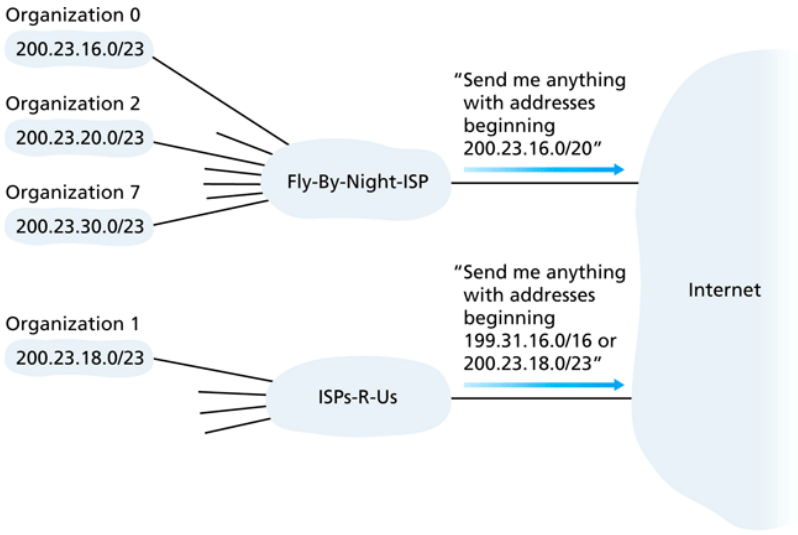
IP addresses and routing

- Address aggregation allows for simpler routing



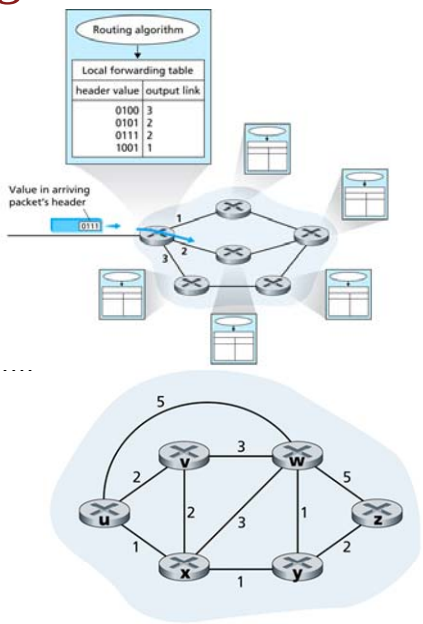
IP addresses and routing

- Most specific route (longest prefix) must be found



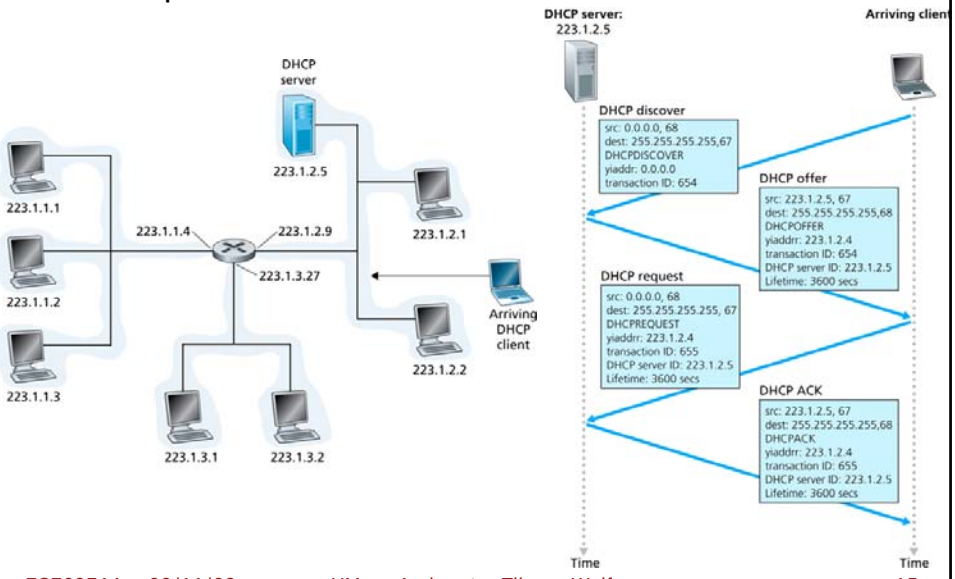
Routing algorithms

- Routing vs. forwarding
- Routing problem can be modeled as graph problem
  - Find the least cost path from u to z
- Approaches
  - Global routing algorithm
  - Decentralized routing algori……
- Routing details later in semester



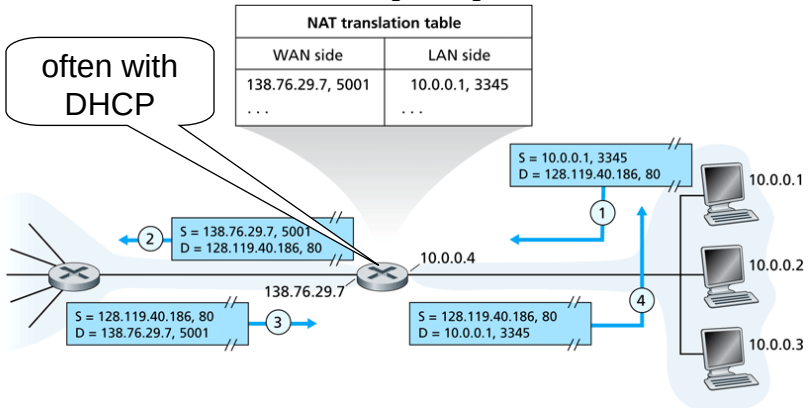
Dynamic Host Configuration Protocol

- DHCP provides IP addresses to hosts in LAN



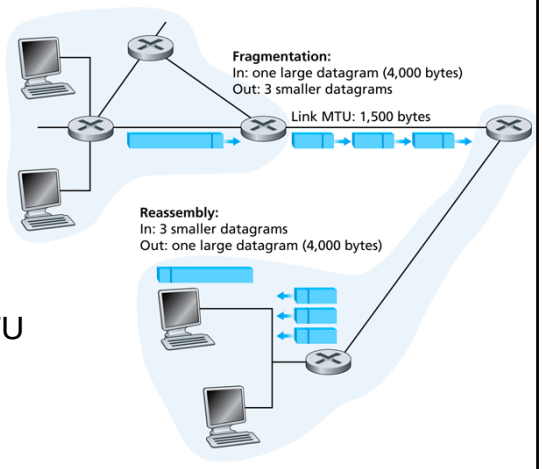
Network Address Translation (NAT)

- Limited number of IP addresses
  - Block of addresses reserved for “local” use
    - » 10.*.*.* and 192.168.*.*
- Network address translator
  - Connects local net through single outside IP address



IP fragmentation

- Data link layer determines Maximum Transfer Unit
  - E.g., 1500 bytes on Ethernet
- If packet encounters smaller MTU than size, then router fragments packet
- Reassembly on end-system
  - Not on router!
- Internet minimum MTU is 576 bytes

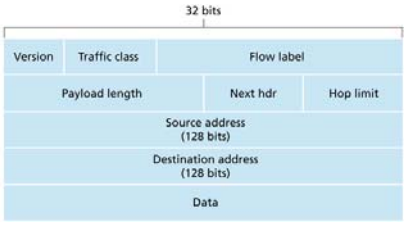


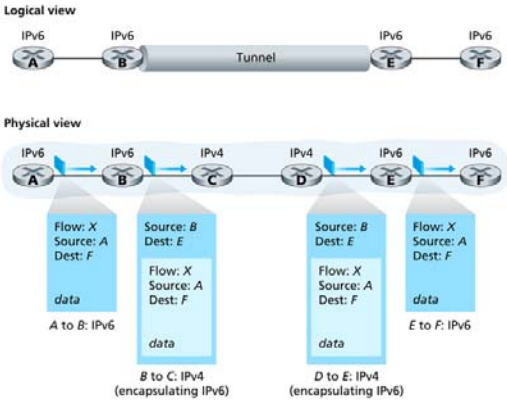
Internet Control Message Protocol

- ICMP provides control and error messages:
  - Echo request / reply
  - Destination unreachable (network, host, protocol, port)
  - Destination unknown (network, host)
  - Congestion control
  - Router advertisement
  - Router discovery
  - TTL expired
  - IP header bad
- Can be used (and abused) for many purposes
  - Intentional TTL expiration for route discovery

IP version 6

- IPv6 improvements
  - 128-bit addresses (unicast, multicast, anycast)
  - Streamlined header
  - Flow labeling and priority
  - No fragmentation
  - No header checksum
  - Option in next header
- Tunneled deployment
  - Or dual-stack





Homework

- Read
  - Kurose & Ross: Chapter 5
    - » Emphasis on 5.3 and 5.5
- SPARK
  - Assessment quiz