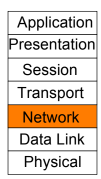
## CSE/EE 461 – Lecture 12

## IP Addressing

## This Lecture

- Focus
  - How do we make routing scale?
- IP Addressing
  - Hierarchy (prefixes, class A, B, C, subnets)
  - Also allocation (DHCP, ARP)






## Scalability Concerns

- Routing burden grows with size of an internetwork
  - Size of routing tables
  - Volume of routing messages
  - Amount of routing computation
- To scale to the size of the Internet, apply:
  - Hierarchical addressing
  - Use of structural hierarchy
  - Route aggregation

## IP Addresses

- Reflect location in topology; used for scalable routing
  - Unlike "flat" Ethernet addresses
- Interfaces on same network share prefix
  - Prefix administratively assigned (IANA or ISP)
  - Addresses globally unique
- Routing only advertises entire networks by prefix
  - Local delivery in a single "network" doesn't involve router
  - (will make "network" precise later on)



## Getting an IP address

- Old fashioned way: sysadmin configured each machine
- Dynamic Host Configuration Protocol (DHCP)
  - One DHCP server with the bootstrap info
    - Host address, gateway address, subnet mask, …
    - Find it using broadcast
  - Addresses may be leased; renew periodically
- "Stateless" Autoconfiguration (in IPv6)
  - Get rid of server – reuse Ethernet addresses for lower portion of address (uniqueness) and learn higher portion from routers

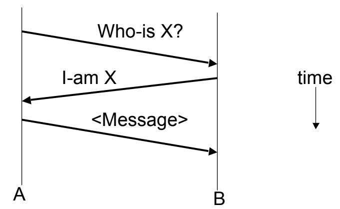


## Address Resolution Protocol (ARP)

- On a single link, need Ethernet addresses to send a frame … source is a given, but what about destination?
  - Requires mapping from IP to MAC addresses
- ARP is a dynamic approach to learn mapping
  - Node A sends broadcast query for IP address X
  - Node B with IP address X replies with its MAC address M
  - A caches (X, M); old information is timed out (~15 mins)
  - Also: B caches A's MAC and IP addresses, other nodes refresh

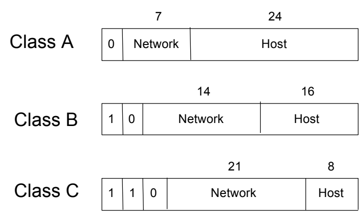
## ARP Example

- To send first message use ARP to learn MAC address
- For later messages (common case) don't need to ARP






## IPv4 Address Formats



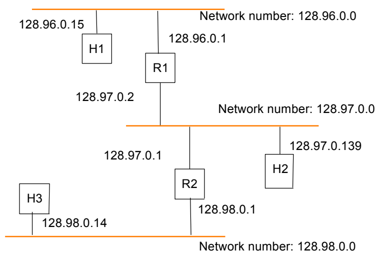

- 32 bits written in "dotted quad" notation, e.g., 18.31.0.135



## IPv6 Address Format


- 128 bits written in 16 bit hexadecimal chunks
- Still hierarchical, just more levels

## Network Example





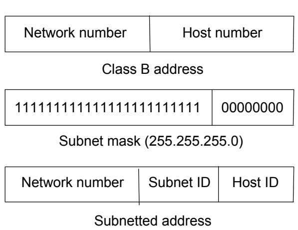

## Updated Forwarding Routine

- Used to be “look up destination address for next hop”
- Now addresses have network and host portions:
  - If host: if destination network is the same as the host network, then deliver locally (without router). Otherwise send to the router
  - If router: look up destination network in routing table to find next hop and send to next router. If destination network is directly attached then deliver locally.
- (Note that it will get a little more complicated later)

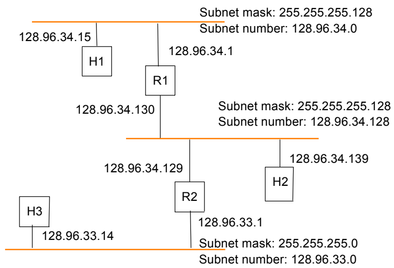


## Subnetting – More Hierarchy

- Split up one network number into multiple physical networks
- Helps allocation efficiency -- can hand out subnets
- Rest of internet does not see subnet structure
  - subnet is purely internal to network
  - aggregates routing info



## Subnet Example






## Updated Forwarding Routine

- Used to know network from address (class A, B, C)
- Now need to "search" routing table for right subnet
  - If host: easy, just substitute "subnet" for "network"
  - If router: search routing table for the subnet that the destination belongs to, and use that to forward as before
- (Note that it will get a little more complicated later :)

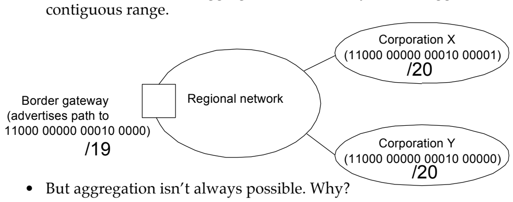


## CIDR (Supernetting)

- CIDR = Classless Inter-Domain Routing
- Generalize class A, B, C into prefixes of arbitrary length; now must carry prefix length with address
- Aggregate adjacent advertised network routes
  - e.g., ISP has class C addresses 192.4.16 through 192.4.31
  - Really like one larger 20 bit address class …
  - Advertise as such (network number, prefix length)
  - Reduces size of routing tables
- But IP forwarding is more involved
  - Based on Longest Matching Prefix operation

## CIDR Example

- X and Y routes can be aggregated because they form a bigger contiguous range.




- But aggregation isn't always possible. Why?
  - can only aggregate power of 2



## IP Forwarding Revisited

- Routing table now contains routes to "prefixes"
  - IP address and length indicating what bits are fixed
- Now need to "search" routing table for longest matching prefix, only at routers
  - Search routing table for the prefix that the destination belongs to, and use that to forward as before
  - There can be multiple matches; take the longest prefix
- This is the IP forwarding routine used at routers.



## Key Concepts

- Hierarchical address allocation helps routing scale
  - Addresses are constrained by topology
  - Only need to advertise and compute routes for networks
  - Hide internal structure within a domain via subnets
  - Keep host simple and let routers worry about routing
- ARP learns the mapping from IP to MAC address