CSE/EE 461 – Lecture 22
Internet Addresses

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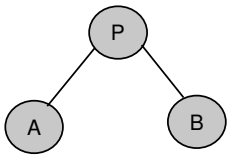
Reading: Peterson 4.3.1, 4.3.2; 4.1.5

Last time…

- BGP policies
  - "Business relationships and money are very important for determining relationships between networks."
- "Routing scalability requires an IP address hierarchy."
  - IP address reflects where you are in the network

Questions from last time…

- How can you avoid paying a transit provider?



This time…

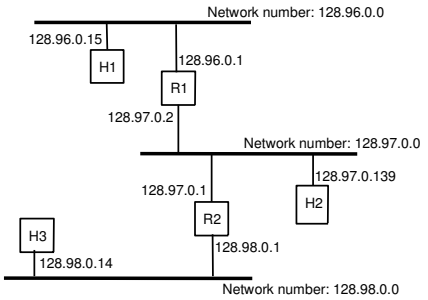
- IP addresses
  - Subnets
  - Supernets (CIDR)
  - Address resolution (ARP)
- Pre-final-review exercise

IP Addresses and Routing Scalability

- Interfaces on same network share a prefix
  - Prefixes are administratively assigned
- Routing advertises entire networks by prefix, not individual addresses
  - Local delivery in a single network doesn't involve router
  - Hierarchy helps routing scale!

L22.5

Network Example



L22.6

IP Forwarding Routine

- If host:
  - If destination network is the same as the host network, then deliver locally (without router).
  - Otherwise send to the router.
- If router:
  - If destination network is directly attached then deliver locally.
  - Otherwise, look up destination network in routing table to find next hop router.

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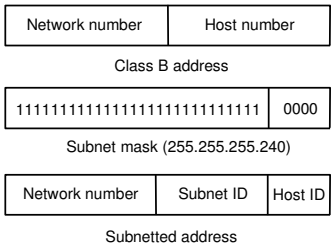
Subnets – More Hierarchy

- Idea: Share one network number among many networks
- Split up one network number into multiple physical networks
- Internal structure isn't propagated
- Helps allocation efficiency



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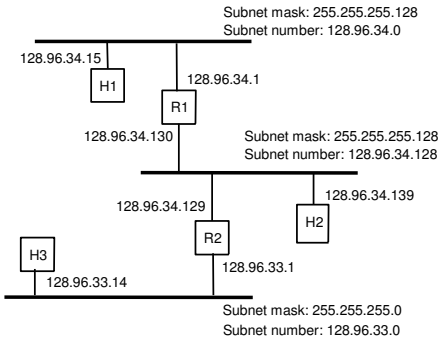
Subnet Example



Forwarding Routine with Subnets

- Used to be able to tell network number 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 number and mask that match the destination, and use that to look up the next hop

Problem

- What if our network is too big for a class C network number (255 nodes), but much too small for a class B (64K nodes)?
  - Many organizations fall into this category
  - Class B network numbers are a scarce resource

CIDR (Supernetting)

- CIDR =
- Idea: Combine several network numbers into one network
- Generalize class A, B, C into prefixes of arbitrary length
- Now must carry prefix length with network number

Route Aggregation

- 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:
  - Reduces size of routing tables
- But IP forwarding is more involved
  - Might be multiple nested prefixes!
  - Lookup based on Longest Matching Prefix operation

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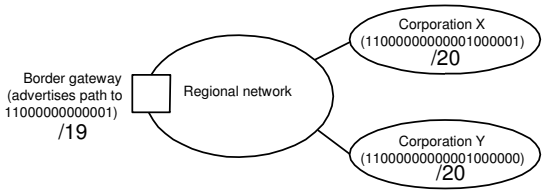
CIDR Example

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



- But aggregation isn't always possible. Why?

L22.14

IP Forwarding Revisited

- Routing table now contains routes to "prefixes"
  - Network number and length of prefix
- Now need to "search" routing table for longest matching prefix
  - Search routing table for the prefix that the destination belongs to, and use that to forward as before
  - If multiple matches, take the longest prefix
- This is the IP forwarding routine used at routers.

L22.15

Address Resolution

- We want to send an IP packet to a host/router on the same network. How?
  - Have the IP address
  - Need to find out MAC address

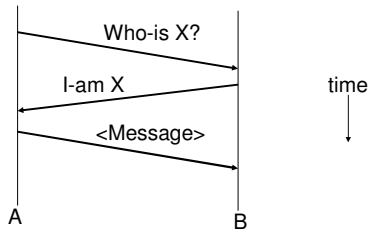
L22.16

Address Resolution Protocol (ARP)

- ARP lets us learn mappings on demand!
  - 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)
  - Also: B caches A's MAC and IP addresses
  - Anyone else who has A or B in their cache refreshes it
  - Old information is timed out

ARP Example

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



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)
  - Reuse Ethernet addresses for unique portion of address
  - Learn higher portion from routers

IPv6 Address Format

001	RegistryID	ProviderID	SubscriberID	SubnetID	InterfaceID

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

Aside: Multi-homing and IP addresses

- A student asked: Do hosts in a multi-homed ISP have more than one IP address?

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Key Concepts

- Hierarchical address allocation helps routing scale
  - Hide internal structure within a domain via subnets
  - CIDR provides route aggregation
  - Keep hosts simple and let routers worry about routing
- ARP learns the mapping from IP to MAC address
- Next time (finally!): Naming and the DNS

L22.22