CSE/EE 461 – Lecture 21
Interdomain Routing Policy
Internet Addresses

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Reading: Peterson 4.3.1-4.3.3

Announcements

A note on Fishnet 3 & 4

- Fishnet assignments – tension between interoperability and design freedom
- IETF standards based on “rough consensus and running code”
- Now that you have the running code, what should the standard be?

Last time...

- “Routing is cool, but only on a scale that can be managed. Break huge Internet up using hierarchy, so we have many manageable parts.”
- Autonomous Systems and the structure of the Internet
- Interdomain vs Intradomain routing
- BGP & path vector routing
Questions from last time…

- Extra credit for snazzy Fishnet 3?
- What is a peering point?
- What’s this about the Westin building?

This time…

- Interdomain routing policy
- BGP over TCP
- Internet Addressing
  - Address classes
  - Subnets
  - Next time: supernets and resolution

Border Gateway Protocol (BGP-4)

- Inter-domain routing protocol used in the Internet today

- Features:
  - Path vector routing
  - Application of policy
  - Operates over reliable transport (TCP)
  - Uses route aggregation (CIDR)

Policies

- Choice of routes depends on

- Local policy dictates
  - Which routes we
  - Which routes we
Transit Relationships

- Provider → Customer: “You can reach the rest of the Internet through me.”
- Customer → Provider: “Here are paths to all of my IP address blocks.”
- Provider → everyone else: “Here are paths to reach my customers’ IP address blocks.”

Multi-Homing

- Connect to multiple providers for reliability
  - For each IP address block, choose best path announced by any provider
    - Easy to control outgoing traffic, e.g., for load balancing
  - Advertise our address blocks to both providers
    - Less control over what paths other parties will use to reach us

Peer Relationships

- Peers exchange traffic for mutual benefit
- Peers A and B announce paths to their customers’ IP address blocks to each other

With whom should I peer?

- Backbone ISPs have no transit provider
  - Must peer to provide global reachability
- Economics
  - How much traffic is there between us?
  - Would we both save money on transit by peering?
  - Do we already have a peering point in common?
- Politics
  - Do we have an existing business relationship?
  - Do I trust you to be competent and responsive?
Impact of Policies – Example

• Early Exit / Hot Potato
  – If it’s not for me, get rid of it as soon as possible!
• Best local policies don’t always lead to best global routes
• Side-effect: route asymmetry

Aside: BGP over TCP

• Intradomain routing protocols operate directly over IP
• BGP uses TCP
  – TCP handles retransmission and reacts to congestion
  – Allows for incremental updates
• Issue: Data vs. Control plane
  – Shouldn’t routing messages be higher priority than data?

Routing Scalability

• What problems would we face if we used link state routing across the entire Internet today?
  – Huge routing tables
  – Huge link state databases
  – Lots of routing traffic
  – Dijkstra’s algorithm is \( O(n^2) \)
  – Routers fail all the time – constantly recomputing

IP Addresses

• Globally unique
  – (except private address blocks)
• Assigned
  – Statically by administrator
  – Dynamically by DHCP server
• Hierarchical; reflect location in topology
  – Unlike “flat” Ethernet or Fishnet addresses
**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!

**IPv4 Address Formats**

- 32 bits written as dotted quad (e.g. 128.208.3.56)

<table>
<thead>
<tr>
<th>Class</th>
<th>0</th>
<th>14</th>
<th>21</th>
<th>24</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Network</td>
<td>Host</td>
<td>Network</td>
<td>Host</td>
</tr>
<tr>
<td>B</td>
<td>0</td>
<td>14</td>
<td>21</td>
<td>16</td>
</tr>
<tr>
<td>C</td>
<td>11</td>
<td>21</td>
<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>

**Network Example**

- Network number: 128.96.0.0

**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.
Subnets – More Hierarchy

- Split up one network number into multiple physical networks
- Internal structure isn’t propagated
- Helps allocation efficiency

<table>
<thead>
<tr>
<th>Network number</th>
<th>Host number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class B address</td>
<td>Subnet mask (255.255.255.240)</td>
</tr>
<tr>
<td>11111111111111111111111111110000</td>
<td></td>
</tr>
</tbody>
</table>

Subnet Example

- Subnet mask: 255.255.255.128
- Subnet number: 128.96.34.0
- Subnet number: 128.96.34.128
- Subnet mask: 255.255.255.0
- Subnet number: 128.96.33.0

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

Key Concepts

- Policy dominates interdomain routing
  - Depends on economics and relationships
- Hierarchical address allocation helps routing scale
  - Addresses are constrained by topology
  - Compute routes for whole networks, not single hosts
  - Hide internal structure within a network via subnets
- Next time: supernets (CIDR), address resolution (ARP), naming…