Inter-domain Routing

Outline

Border Gateway Protocol
Internet Structure

Original idea

- Backbone service provider
  - "Consumer" ISP
    - Small corporation
  - Large corporation
  - "Consumer" ISP
    - Small corporation
    - "Consumer" ISP
      - Small corporation
      - "Consumer" ISP
        - Small corporation
Internet Structure

Today
Route Propagation in the Internet

• Autonomous System (AS)
  – corresponds to an administrative domain
  – examples: University, company, backbone network
  – assign each AS a 16-bit number

• Two-level route propagation hierarchy
  – interior gateway protocol (each AS selects its own)
  – exterior gateway protocol (Internet-wide standard)

• Routes information is propagated at various levels
  – hosts know local router
  – local routers know site routers
  – site routers know core router
  – core routers know everything
Popular Interior Gateway Protocols

• **RIP: Route Information Protocol**
  – distributed with BSD Unix
  – distance-vector algorithm
  – based on hop-count (infinity set to 16)

• **OSPF: Open Shortest Path First**
  – recent Internet standard
  – uses link-state algorithm
  – supports load balancing
  – supports authentication
BGP-4: Border Gateway Protocol

• BGP-1 developed in 1989 to address problems with EGP.
• Assumes Internet is an arbitrarily interconnected set of ASs
• AS traffic types
  – Local
    • starts or ends within an AS
  – Transit
    • passes through an AS
• AS Types
  – stub AS: has a single connection to one other AS
    • carries local traffic only
  – multihomed AS: has connections to more than one AS
    • refuses to carry transit traffic
  – transit AS: has connections to more than one AS
    • carries both transit and local traffic
BGP-4 contd.

- Each AS has:
  - one or more border routers
    - Handles inter-AS traffic
  - At least one BGP *speaker* for an AS that participates in routing
  - BGP speaker establishes BGP sessions with peers and advertises:
    - local network names
    - other reachable networks (transit AS only)
    - gives *path* information
    - withdrawn routes

- BGP goal: find loop free paths between ASs
  - Optimality is secondary goal
  - It’s neither a distance-vector nor a link-state protocol

- Hard problem
  - Internet’s size (~12K active ASs) means large tables in BGP routers
  - Autonomous domains mean different path metrics
  - Need for flexibility
BGP Example

• Speaker for AS2 advertises reachability to P and Q
  – network 128.96, 192.4.153, 192.4.32, and 192.4.3, can be reached directly from AS2

• Speaker for backbone advertises
  – networks 128.96, 192.4.153, 192.4.32, and 192.4.3 can be reached along the path (AS1, AS2).

• Speaker can cancel previously advertised paths
Some BGP details

• Path vectors are most important innovation in BGP
  – Enables loop prevention in complex topologies
  – If AS sees itself in the path, it will not use that path

• Routes can be aggregated
  – Based on CIDR (classless) addressing

• Routes can be filtered

• Runs over TCP

• ASes can apply a variety of policies
BGP in practice

• 10-20 “backbone” ASs which are fairly richly connected to each other
  – Peers

• Other “lower tier” ASs hang off the backbone networks -> Customers
  – Some of them may also connect with each other at peering points \(\rightarrow\) Peers

• Corporations connect as Customers to lower tier ASs or to backbone ASs depending on their need/willingness to pay
Policy with BGP

• BGP provides capability for enforcing various policies

• Policies are not part of BGP: they are provided to BGP as configuration information

• **Enforces** policies by
  – *Choosing appropriate paths* from multiple alternatives
  – *Controlling advertisement* to other AS’s
Which route should Frank pick to 13.13.0.0/16?
Policy I: Prefer Customer routing

Set appropriate “local pref” to reflect preferences: Higher Local preference values are preferred.

Route learned from customer preferred over route learned from peer, preferred over route learned from provider.
Policy II: Import Routes

- **provider route**
- **peer route**
- **customer route**
- **ISP route**
Policy II: Export Routes

- **provider route**
- **peer route**
- **customer route**
- **ISP route**

Filters:
- Block

Diagram:
- Arrows indicating directions from/to provider, peer, customer, and ISP routes.
- Smiley faces, hearts, and other symbols indicating connectivity and interaction.