COMP476
Networked Computer Systems

Internet Routing

Goals of Routing

- Minimize delay
- Minimize hop count
- Maximize throughput
- Balance load
- Minimize jitter
- Respond quickly to change
- Minimize administrative cost
- Conform to political policies

Internet Routing

- Internet routing is based on the NetID.
- Once a packet is delivered to the proper subnet, the Internet routing protocols are no longer needed.

Static and Dynamic Routing

- Most hosts on the Internet use static routing. Frequently there is only one way out of your local network.
- Routers use dynamic routing that can recover from errors and change based on system load.

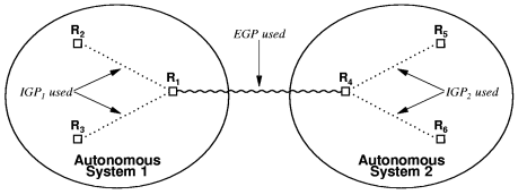
Internet Routing Protocols

- Internet routing is a two layer hierarchical system.
- Interior Gateway Protocols (IGP) route within an Autonomous System (AS).
- Exterior Gateway Protocols (EGP) route between Autonomous Systems.

A&T Autonomous System

- The NCAT domain represents an AS.
- There are many subnets within the ncat.edu domain connected by routers.
- Routing at A&T between subnets uses an Interior Gateway Protocol
- The OSPF routing system is the currently used Interior Gateway Protocol.

IGP and EGP example



Routing Information Protocol (RIP)

- An older Interior Gateway Protocol
- Provides routing within an AS.
- Uses hop count as routing metric
- Uses UDP for routing communications

Open Shortest Path First Protocol

- OSPF is a newer Interior Gateway Protocol.
- Provides routing within an AS.
- Uses Authenticated Message Exchange
- May balance load over multiple lines
- Uses the link state routing algorithm
- Supports a hierarchy within the AS

Count to Infinity Problem

A — B — C — D

A	0	-
B	1	B
C	2	B
D	3	B

A	1	A
B	0	-
C	1	C
D	2	C

A	2	B
B	1	B
C	0	-
D	1	D

A	3	C
B	2	C
C	1	C
D	0	-

Count to Infinity Problem

A — X — B — C — D

A	0	-
B	-	-
C	-	-
D	-	-

A	1	A
B	0	-
C	1	C
D	2	C

A	2	B
B	1	B
C	0	-
D	1	D

A	3	C
B	2	C
C	1	C
D	0	-

Network between A and B breaks

Count to Infinity Problem

A — X — B — C — D

A	0	-
B	-	-
C	-	-
D	-	-

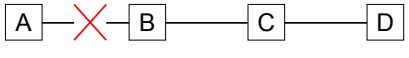
A	3	C
B	0	-
C	1	C
D	2	C

A	2	B
B	1	B
C	0	-
D	1	D

A	3	C
B	2	C
C	1	C
D	0	-

After 1st Exchange of Routing Table data

Count to Infinity Problem



A	0	-
B	-	-
C	-	-
D	-	-

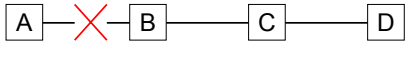
A	3	C
B	0	-
C	1	C
D	2	C

A	4	B
B	1	B
C	0	-
D	1	D

A	3	C
B	2	C
C	1	C
D	0	-

After 2nd Exchange of Routing Table data

Count to Infinity Problem



A	0	-
B	-	-
C	-	-
D	-	-

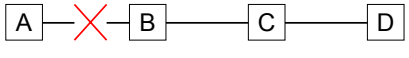
A	5	C
B	0	-
C	1	C
D	2	C

A	4	B
B	1	B
C	0	-
D	1	D

A	5	C
B	2	C
C	1	C
D	0	-

After 3rd Exchange of Routing Table data

Count to Infinity Problem



A	0	-
B	-	-
C	-	-
D	-	-

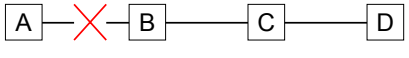
A	5	C
B	0	-
C	1	C
D	2	C

A	6	B
B	1	B
C	0	-
D	1	D

A	5	C
B	2	C
C	1	C
D	0	-

After 4th Exchange of Routing Table data

Count to Infinity Problem



A	0	-
B	-	-
C	-	-
D	-	-

A	7	C
B	0	-
C	1	C
D	2	C

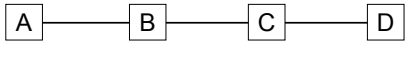
A	6	B
B	1	B
C	0	-
D	1	D

A	7	C
B	2	C
C	1	C
D	0	-

After 5th Exchange of Routing Table data

Responsiveness

- Algorithms that exchange destination times may suffer from the count to infinity problem.
- Problems are slow to propagate.
- Good news travels fast.



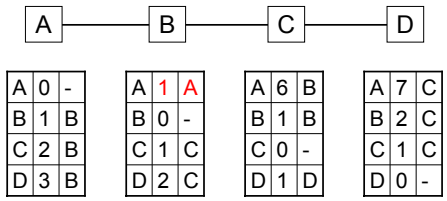
A	0	-
B	1	B
C	2	B
D	3	B

A	7	C
B	0	-
C	1	C
D	2	C

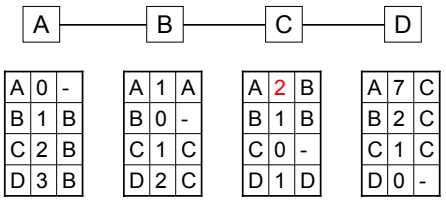
A	6	B
B	1	B
C	0	-
D	1	D

A	7	C
B	2	C
C	1	C
D	0	-

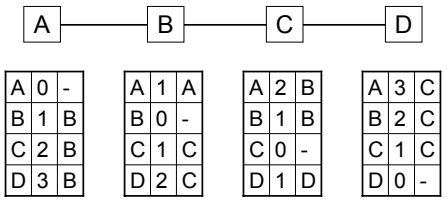
Network Restored



After 1st Exchange of Routing Table data



After 2nd Exchange of Routing Table data



After 3rd Exchange of Routing Table data

Border Gateway Protocol

- A popular Exterior Gateway Protocol
- Routes among Autonomous Systems.
- AS can be either **transit** systems (providing transmission of packets through the system) or **stub** systems that only route packets for that AS.
- Uses TCP for inter-AS communications.

Border Gateway Protocol

- Exchanges paths of autonomous systems.
- Each router scores the paths
  - Paths using this router are discarded
  - Paths violating rules are discarded
  - Remaining paths are scored by time

Multicast Routing

- Hosts send and receive data from a single multicast address.
- The routers:
  - Make sure members of the group get the data
  - Accept new members
  - Drop members leaving the group.
- Multicasting is not well supported over the Internet.