Welcome to

CS 3516: Computer Networks

Prof. Yanhua Li

Time: 9:00am –9:50am M, T, R, and F Zoom Lecture Fall 2020 A-term

Some slides are originally from the course materials of the textbook "Computer Networking: A Top Down Approach", 7th edition, by Jim Kurose, Keith Ross, Addison-Wesley March 2016. Copyright 1996-2017 J.F Kurose and K.W. Ross, All Rights Reserved.

Project 2 and Quiz 8: Graded!

<u>Lab 3</u> starts from today and due this Thursday 10/15

<u>Final exam</u>: this Friday 10/16 Sample questions are available in Canvas

<u>Review session</u>: Tomorrow 10/13, an offline video will be posted!

Hierarchical routing

- aggregate routers into regions, "autonomous systems" (AS)
- routers in same AS run same routing protocol
 - "intra-AS" routing protocol: RIP, OSPF.
 - routers in different AS can run different intra-AS routing protocol

gateway router:

- * at "edge" of its own AS
- has link to router in another AS

Interconnected ASes



- forwarding table configured by both intraand inter-AS routing algorithm
 - intra-AS sets entries for internal dests
 - inter-AS & intra-AS sets entries for external dests

Inter-AS tasks

- suppose router in ASI * receives datagram destined outside of ASI:
 - router should forward packet to gateway router, but which one?

ASI must:

- Learning: learn which Ι. dests are reachable through AS2, which through AS3
- Announcement: 2 propagate this reachability info to all routers in ASI



X

Example: setting forwarding table in router 1d

- suppose ASI learns (via inter-AS protocol) that subnet x reachable via AS3 (gateway Ic), but not via AS2
 - inter-AS protocol propagates reachability info to all internal routers
- router Id determines from intra-AS routing info that its interface e is on the least cost path to Ic
 - installs forwarding table entry (x,e)



Example: choosing among multiple ASes

- now suppose ASI learns from inter-AS protocol that subnet
 x is reachable from AS3 and from AS2.
- to configure forwarding table, router 1d must determine which gateway it should forward packets towards for dest x
 - hot potato routing: send packet towards closest of two routers.



Intra-AS Routing

- also known as interior gateway protocols (IGP)
- * most common intra-AS routing protocols:
 - **RIP:** Routing Information Protocol-- DVR
 - **OSPF:** Open Shortest Path First-- LSR
 - •••

Internet inter-AS routing: BGP

- BGP (Border Gateway Protocol): the de facto inter-domain routing protocol
 - "glue that holds the Internet together"
- BGP provides each AS a means to: (external vs interior)
 - eBGP: obtain subnet reachability information from neighboring ASs.
 - iBGP: propagate reachability information to all ASinternal routers.
 - determine "good" routes to other networks based on reachability information and policy.
 - allows subnet to advertise its existence to rest of Internet: "1 am here"

BGP basics

- BGP session: two BGP routers ("peers") exchange BGP messages:
 - advertising paths to different destination network prefixes

- when AS3 advertises a prefix to ASI:
 - AS3 promises it will forward datagrams towards that prefix
 - AS3 can aggregate prefixes in its advertisement



BGP basics: distributing path information

- session between 3a and 1c, AS3 sends prefix reachability info to AS1.
 - Ic can then use iBGP do distribute new prefix info to all routers in ASI
 - Ib can then re-advertise new reachability info to AS2 over Ib-to-2a eBGP session
- when router learns of new prefix, it creates entry for prefix in its forwarding table.



Path attributes and BGP routes

- advertised prefix includes BGP attributes
 - prefix + attributes = "route"
- * two important attributes:
 - AS-PATH: contains ASs through which prefix advertisement has passed: e.g., AS 67, AS 17;
 - AS numbers are maintained by ICANN;
 - NEXT-HOP: indicates specific internal-AS router to nexthop AS. (may be multiple links from current AS to nexthop-AS)



Chapter 4-5: outline

- 4.1 introduction
- 4.4 IP: Internet Protocol
 - datagram format
 - IPv4 addressing
 - IPv6

4.5 routing algorithms

- link state
- distance vector
- hierarchical routing
- 4.6 routing in the Internet
 - RIP
 - OSPF
 - BGP

Questions?

Network Layer 4-14