ICS 351: Today's plan

- OSPF
- BGP
- Routing in general
- routing protocol comparison
- encapsulation
- network dynamics

OSPF

- OSPF generally used within a single Autonomous System (AS), i.e. within an organization (IGP, Interior Gateway Protocol)
- reliably finds shortest paths quickly
- divides AS into areas, including a backbone area
- all areas are connected to the backbone area
- all routing information is disseminated over the backbone area
- routers in OSPF play different roles, for example a backbone router is connected to the backbone, an area border router is connected to more than one area (and is usually also a backbone router), and an internal router is only connected to routers in the same area
- every area has one Designated Router which receives then rebroadcasts link-state updates
- defined in *RFC 2328* (and in *RFC 5340* for IPv6)

RIP compared to OSPF

- both RIP and OSPF find optimal paths
- OSPF generally finds them much more quickly
- OSPF can use multiple metrics
- RIP generally sends less data (somewhat lower overhead)
- OSPF is more complex: more configurable, more code

More OSPF details

- each router has a list of all link states
- an algorithm such as Dijkstra's shortest path algorithm can be used to build a directed acyclic graph (DAG) with the router at the root, and all other networks reachable through the DAG
- multiple equal-cost paths can be used for each destination
- OSPF supports authentication among routers (null authentication is an option)
- link-state advertisements expire if they are too old

OSPF areas

- areas can be used in larger networks to minimize the amount of information exchanged among routers
- routers outside an area don't have all the link state information of routers inside the area
- areas form a 2-level hierarchy with the backbone at the root, and all the other areas below it

BGP brief summary

- Border Gateway Protocol is an Exterior Gateway Protocol (EGP) used to route between Autonomous Systems
- BGP uses a variant of distance-vector routing in which the entire path to reach a destination is distributed
- BGP might use different criteria for advertising routes and for using routes
- these criteria may be set by the network administrator to define policy
- BGPv4 is defined in *RFC 4271*

some BGP properties

- a router configured to run BGP is a BGP speaker, as opposed to other routers which might not run BGP
- BGP uses TCP for reliable transmission of data, so timeouts can be faster

Why routing matters

- the routing protocol builds the routing tables, which are essential to correct routing of packets
- incorrect routing tables can lead to packets:
- o being dropped
- o being sent in a loop
- o being sent over slow links
- o being sent over congested links
- all of these cause network "malfunction", even when the hardware is working well!

routing responsibilities

- establish routes to destination networks
- maintain routes in the face of changing configuration: link loss, router loss, new links, new routers
- be trustworthy, do not advertise routes to which we don't know how to deliver

routing possibilities

- blacklist attacking hosts/networks as close to the source as possible
- route depending on packet (flow) type, e.g. low latency, high throughput, constant bit rate (CBR)
- smart routing, based on packet content (may conflict with net neutrality)

what routing is not:

- Ethernet switching does not use IP addresses in any way, and only connects Ethernet segments with the same network number
- Network Address Translation (NAT) allows a single IP address to be used as a "front end" for a number of systems that use TCP/IP or UDP/IP
- A firewall blocks access to most TCP/UDP ports, only allowing selected ports to connect to or from the outside world
- each or all of these may be combined in the same box with a routing function, but they are logically separate

Comparison of Routing Protocols

- IGPs vs. EGPs: within an Autonomous System (RIP, OSPF), or among different Autonomous Systems (BGP)
- routing algorithms:
- o distance vector: RIP
- o path vector (modified distance vector): BGP,
- o link-state: OSPF
- link-state distributes the state of the router's links
- distance-vector distributes the routing table distance to each destination -- if that is optimal, the sender is used as the direction (vector) in which to send the data
- OSPF and RIP are optimal, BGP finds acceptable routes

Protocol Encapsulation

- protocols are layered
- packets in one layer are encapsulated within packets in the lower layer
- for example, a UDP header is added to a RIP packet, to support directing to a specific UDP port number
- this UDP packet gets an IP header which includes the destination address (224.0.0.9) and the source address as well as protocol number 17 (UDP)
- the IP packet receives an Ethernet header (and a CRC "trailer") with the local ethernet address as source, and ff:ff:ff:ff:ff:ff as destination
- in this case, we say that RIP is layered over UDP, UDP over IP, and IP over Ethernet
- what protocol is OSPF layered over? BGP? Ping? Telnet?

Network dynamics

- a wired network can be modeled of as a graph
- a router or host is a node in the graph
- the links between them are the edges of the graph
- however, this model does not quite capture all the interesting features, for example, a local area network may connect many computers
- when adding a router or a link, all the routing protocols take some time before all the routing nodes recognize the new resource
- what happens during this time? In RIP, in OSPF, in BGP?
- when removing a router or a link, again the routing tables are inconsistent for some time
- what happens during this time?