ICS 351: Today's plan

- OSPF
- BGP
- Routing in general
link-state routing

- in distance-vector (Bellman-Ford, Ford-Fulkerson, RIP-style) routing, each router distributes its routing table to its neighbors
- an alternative is for each router to broadcast its neighborhood connectivity to all routers
- once a router has heard from every other router, it can puzzle the network together from the pieces
- once a router has a network map, it can find routes in the map (using a shortest path graph algorithm), and build its routing table accordingly
- in practice, this process runs incrementally
- the neighborhood connectivity describes the state (up or down, and perhaps bandwidth and load) of all the links to which a router is connected, so this algorithm is called Link-State
- in wireless ad-hoc networks, OLSR stands for Optimized Link-State Routing protocol
- in wired IP networks, OSPF stands for Open Shortest Path First
- IS-IS (Intermediate System to Intermediate System routing) also uses link-state routing
link-state routing game

1. prepare a list of all neighbors and the links to them (HELLO protocol)
2. make a copy for every router in the network
3. distribute a copy to every router in the network (by sending it to the neighbors, and letting them distribute it)
4. build the network map
5. find the shortest path to each router
6. build the routing table
Flooding Link State Advertisements

- each router is responsible for distributing copies of every link-state advertisement that it gets
- if there are loops, this means each router will get multiple copies of each LSA
- so LSAs are only forwarded if they are new
- LSAs are acknowledged to the sender, and LSAs are resent if there is no acknowledgement, so that the transmission is reliable
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.
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.