Routing Protocols

- The IP protocol forms connections between separate Layer 2 networks
- When sending data, a host sends an IP datagram to the router which in turn might send it to another router on the same Layer 1 network, and so on
  - Each host sends the datagram with the network address of the router, yet the IP address of the destination
- Each router needs to select the next hop device to send the datagram to
- A basic routing table will contain information about the locally connected networks
- A more complete routing table will contain information about remote networks as well

Routing Protocols (cont.)

- A routing protocol is a protocol that is used to update the routing tables of each router
  - A routing protocol will maintain the least expensive route to a destination
  - When a network topology changes, the routing protocol will update the tables automatically
- A routing protocol needs to maintain constraints that were determined in the *static* routing table
- The routing protocol acts at the application layer and also at the internetwork layer.

Autonomous Systems

- An Autonomous System (AS) is a logical portion of a larger IP network
- An AS is administered by a single management authority
- An AS may connect to other AS's or other public or private networks
- An Interior Gateway Protocol (IGP) allow routers to exchange information within a single AS (ex RIP and OSPF)
  - Within a single AS, multiple IGPs may be used yet an AS must present to other AS's a single coherent and consistent view
- An Exterior Gateway Protocol (EGP) exchanges summary information between separate AS's (ex BGP)

IP Routing

- To build a routing table one can use
  - Static Routing: The routing table is entered manually
    - Simple to configure
    - Need to be reconfigured for every network change
  - Dynamic Routing: The routers automatically discover and maintain paths to other routers
    - Distance Vector Protocols
    - Link State Protocols
    - Hybrid Protocols
- There are several protocols due to
  - Different security, stability and scalability requirements
  - Simple protocols are used to small networks, allowing less demands on the router.
- For dynamic routing, whenever there is a topology change in the network, the amount of time for every router in the network to produce an accurate routing table is known as the *convergence time.*

Static Routing

- Each of the paths required is manually entered in each router in the AS
- The routers never communicate with each other unless they are forwarding datagrams
- Very simple to administer in networks of no redundancy
- Extensive coordination and maintenance in non-trivial networks
- Static routers cannot dynamically change when network topology changes
- Wrong entry will result in lost data, never reaching destination
- Mainly used for explicit reasons
  - Define a default route
  - Define a route that is not normally advertised
  - When one requires advertisements to stop at the required router
  - When one requires a specific path to be traversed
  - To ensure secure paths
  - Provide more efficient resource utilization since static routes use less processor and memory utilization on the router

Distance Vector Routing

- Each router maintains the distance or cost from itself to every known network
  - Path with smallest cost becomes the path of choice for datagrams
- This information is stored in a *distance vector table*.
- Each distance vector table is ***periodically*** advertised to each directly connected router
  - Each router will then process this table to determine best path through the network
- These protocols are easy to implement and debug
  - Useful in small networks with limited redundancy

Distance Vector Routing (cont.)

- During topology changes, the convergence time can be quite long
- To limit convergence time, one usually limits the maximum number of hops allowed in the distance vector table
  - Paths exceeding this limit are obviously unusable
- Distance Vector tables are sent periodically to neighbouring routers, regardless of any changes. This obviously uses up network bandwidth.

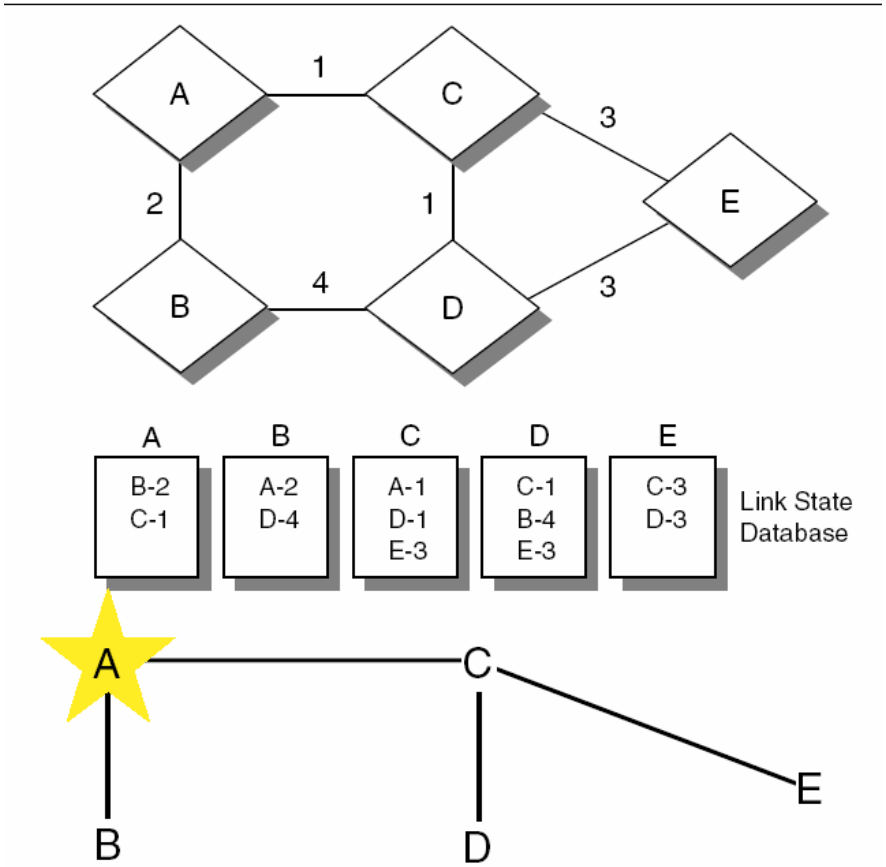
Link-State Routing

- These mainly address short-comings of the Distance-Vector Routing, yet are much more complicated.
- A *link state* is defined as a description of an interface on a router and its relationship to neighbouring router
- A collection of link states is known as a link state database
- The algorithm works as follows:
  - Each router identifies all other routers on the same Layer 1 network
  - Each router advertises a list of all directly connected network links and the cost of each link. This is an exchange of link state advertisements (LSAs)
  - Using these LSAs each router builds an internal picture of the current network topology. Each router has the same picture.
  - Each router uses this information to compute the most desirable path to each destination network. This path is then used to update the routing table.

Link-State Routing (cont.)

- To process the information in the topology database the Shortest-Path First (SPF) algorithm is used
- SPF build a tree structure with each node representing a specific routing device.
  - The root of the tree is the router holding the tree structure.
- The output of the SPF algorithm is a list of shortest-paths to each of the destination networks.
- Link State Advertisements are event-driven upon topology change
  - LSAs tend to be quite large thus further using up network bandwidth
- OSPF is one example of a popular link-state routing algorithm

SPF Tree Representation



Hybrid Routing Protocols

- These combine the advantages of both link-state and distance vector protocols
- Hybrid protocols
  - Use metrics to assign preference to a specific route
  - Metrics are more accurate than distance vector-protocols
  - Updates and advertisements are event-driven
  - They tend to converge much more quickly
  - They try to reduce the overhead of both link-state and distance-vector protocols
- Only hybrid protocol in use in the proprietary EIGRP algorithm developed by Cisco Systems.