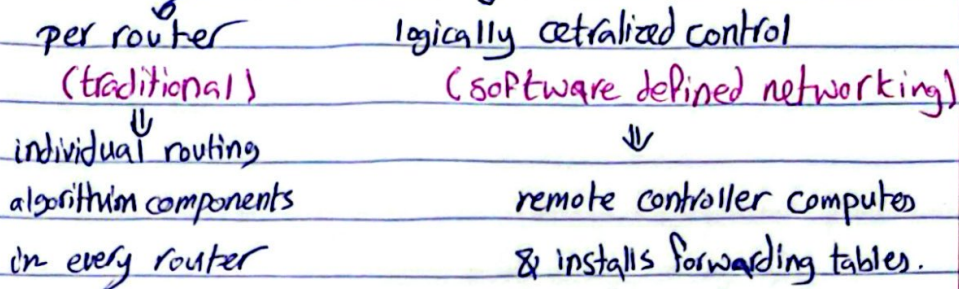


chapter 5 : control plane

Data plane \leftarrow - forwarding : move packets from router's input to output.
control plane \leftarrow - routing : determine routers taken by packets (route) from source to destination.

structuring control plane



Routing protocols

\rightarrow Goal : find best path from sending host to receiving ones
 \rightarrow by cost, fastest, least congested

Routing Algorithm classification

- ① global : all routers have complete topology & link costs (e.g. link state)
- ② decentralized : iterative computation & exchange of info with only neighbors (e.g. distance vector)
- ③ static : routes change slowly over time. (user manually adds an algorithm to each router)
- ④ dynamic : routes change more quickly.

Dijkstra's Link-state

→ centralized (network topology known to all nodes)
→ iterative

• if x is a neighbor of y then initially $C_{xy} = z$ else $C_{xy} = \infty$

* complexity: $O(n^2)$ (not most efficient)

* message complexity also $O(n^2)$

⇒ oscillations possible when link costs depend on traffic.

Distance vector

↳ based on Bellman ford equation (dynamic programming)

$$D_x(y) = \min_v \{ C_{xv} + D_v(y) \}$$

↳ to go from x to y first find the minimum cost through a vector (v) + your cost to v

- iterative, asynchronous, an iteration can be caused by:

① local link cost change

② DV update message from neighbors.

- distributed, self stopping: each node notifies neighbors only when its DV changes only if necessary
(if something changed) - neighbors then notify their neighbors.
- nothing changes if no notification.

- initially a node has distance estimates to its neighbors only.

"good news travel fast" "bad news travel slow"

	"LS"	"DV"
message complexity	$O(n^2)$	Varies
speed of convergence	$O(n^2)$ for both messages & algorithm. - oscillation can happen	varies - may have routing loops & count to infinity
robustness ↓ if router malfunctions	- router can advertise wrong link - routers compute only their own table	- router can advertise wrong path cost. ⇒ black holing - errored DV propagate through network

- intra-AS : routing among router within same AS (Network).

↳ routers in same AS must run same Intra-AS protocol.

↳ gateway router: router at edge of an AS that is linked to other ASes.

- inter-AS : routing among ASes.

- in gateway routers they have both intra & inter domain routing

intra-AS

Protocols : → RIP (DV) (no longer used) (RFC 1723)

→ EIGRP (DV) (RFC 7868)

→ OSPF (LS) (IS-IS protocol) (not RFC standard)

(RFC 2328)

↳ a protocol similar to OSPF

OSPF

- open & public - LS

- secure : all message authenticated (to prevent malicious intrusion)

hierarchical OSPF

2 level hierarchy → backbone
↳ local areas.

- LS advertisements only in the area.

- area border router : advertizes the distances to destinations of its own area to backbone

- boundary router : connects to other ASes

- backbone router runs OSPF to backbone.

- local routers → flood LS in area only
↳ compute routing within area
↳ forward packets outside of area via area border router

BGP (Border Gateway Protocol)

↳ Inter-AS protocol

(eBGP)

- used to :
- ① obtain reachability to a destination info from neighbor ASes.
 - ② determine routes to other network based on reachability & policy.
 - ③ propagate reachability to all AS internal routers (iBGP)
 - ④ advertise to neighbors reachability info

* gateway routers run eBGP & iBGP

* BGP is a "Path vector"

* BGP session : 2 BGP routers exchange messages over semi-permanent TCP connection.

* BGP Messages :

* open : opens a TCP connection to remote BGP peer & authenticates sending BGP peer.

* Update : advertises new path or removes old one.

* Keep alive : keep connection alive when no updates & acks OPEN.

* Notification : reports errors in previous msg & used to close connections.

* BGP advertised route → prefix : destination being advertised

↳ attributes ⇒ AS-PATH : list of ASes which

prefix advertisement has passed

NEXT-HOP : indicates specific internal-AS router to next-hop AS.

* routing can be policy based more than cost effective.

* Hot potato routing : when a ~~router~~ router chooses the least intra-domain cost local gateway router without worrying about inter-domain cost.

* route selection based on

① policy

② shortest AS-path

③ closest Next-Hop

④ additional criteria

(hot potato)

* intra focuses on performance while inter focuses on policy.