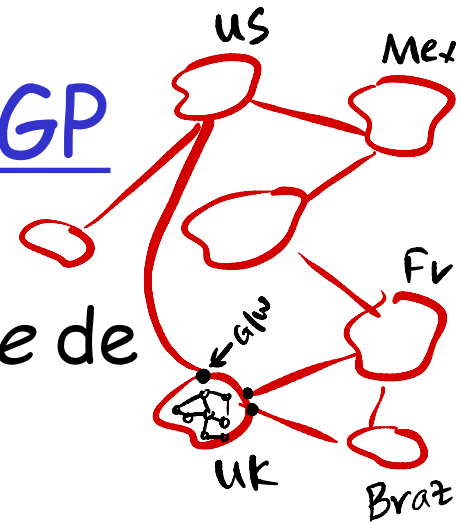


Chapter 4: Network Layer

- ❑ 4.1 Introduction
- ❑ 4.2 Virtual circuit and datagram networks
- ❑ 4.3 What's inside a router
- ❑ 4.4 IP: Internet Protocol
 - Datagram format
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 - Distance Vector
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- ❑ 4.6 Routing in the Internet
 - RIP
 - OSPF
 - BGP
- ❑ 4.7 Broadcast and multicast routing

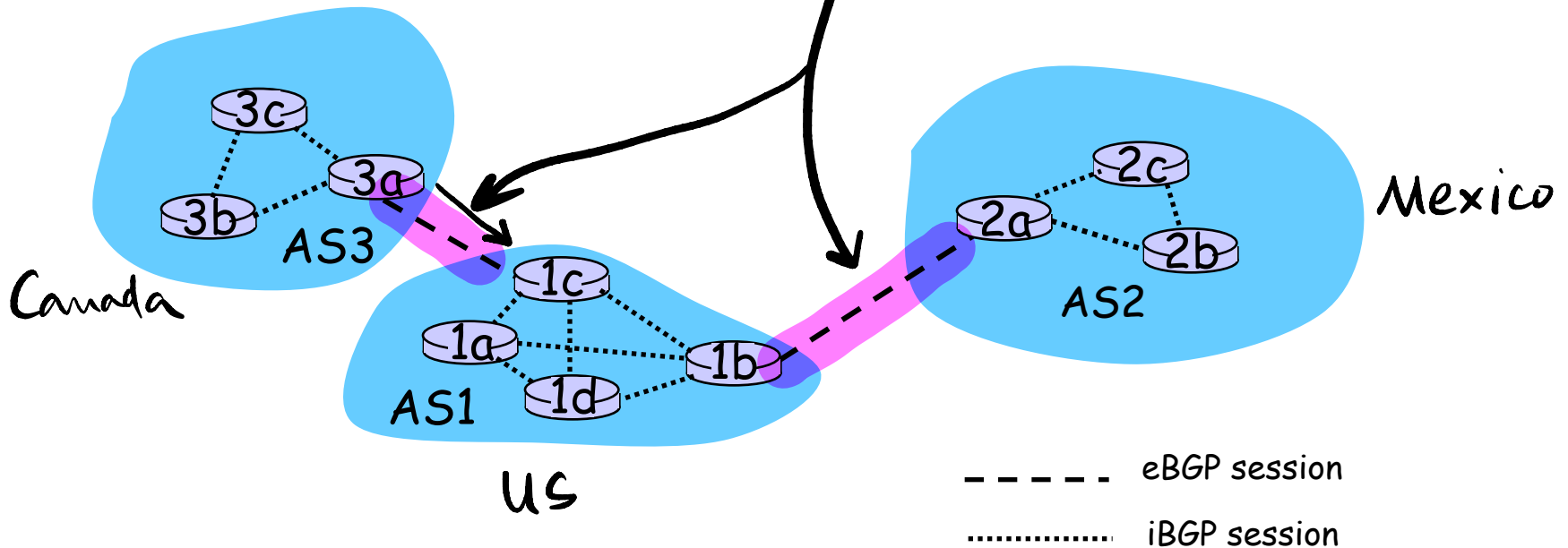
Internet inter-AS routing: BGP

- ❑ **BGP (Border Gateway Protocol):** *the de facto standard*
- ❑ BGP provides each AS a means to:
 1. Obtain subnet reachability information from neighboring ASs.
 2. Propagate the reachability information to all routers internal to the AS.
 3. Determine "good" routes to subnets based on reachability information and policy.
- ❑ Allows a subnet to advertise its existence to rest of the Internet: *"I am here"*



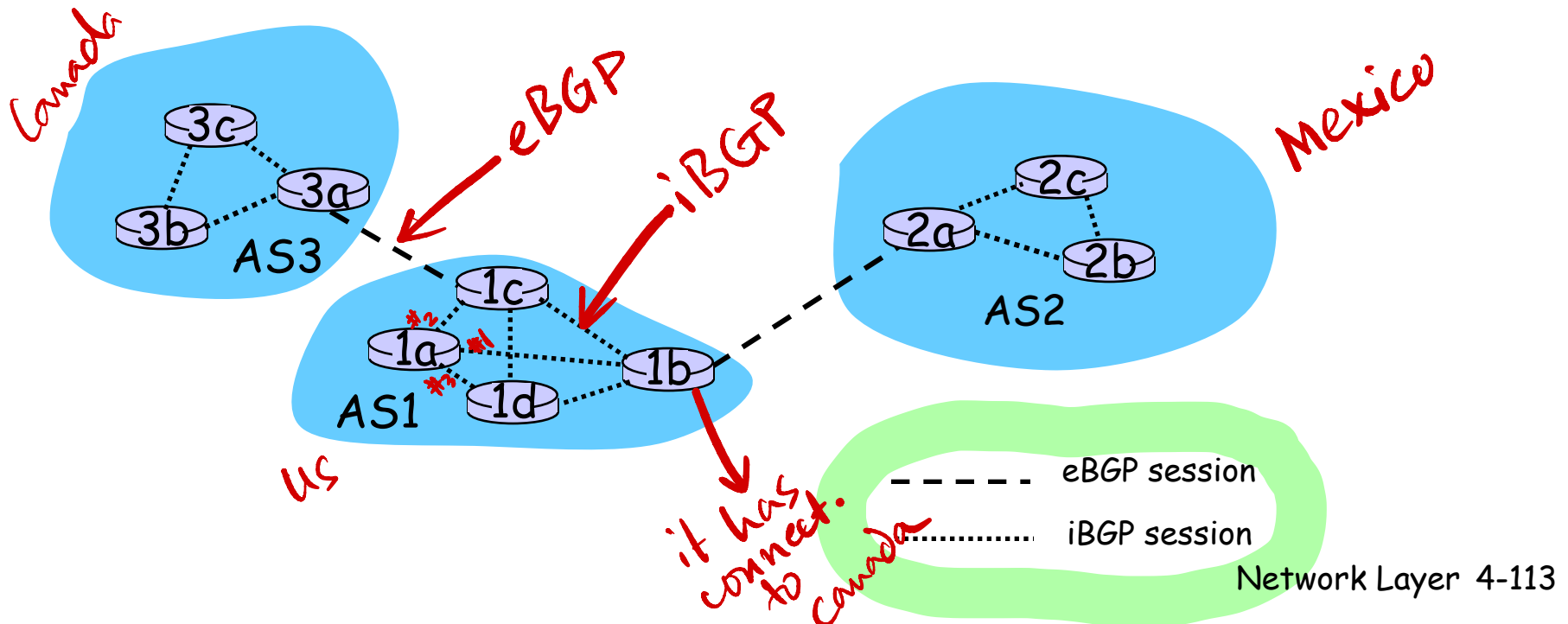
BGP basics

- ❑ Pairs of routers (BGP peers) exchange routing info over semi-permanent TCP conctns: **BGP sessions**
- ❑ Note that BGP sessions do not correspond to physical links.
- ❑ When AS2 advertises a prefix to AS1, AS2 is **promising** it will forward any datagrams destined to that prefix towards the prefix.
 - AS2 can aggregate prefixes in its advertisement



Distributing reachability info

- ❑ With eBGP session between 3a and 1c, AS3 sends prefix reachability info to AS1.
- ❑ 1c can then use iBGP to distribute this new prefix reach info to all routers in AS1
- ❑ 1b can then re-advertise the new reach info to AS2 over the 1b-to-2a eBGP session
- ❑ When router learns about a new prefix, it creates an entry for the prefix in its forwarding table.

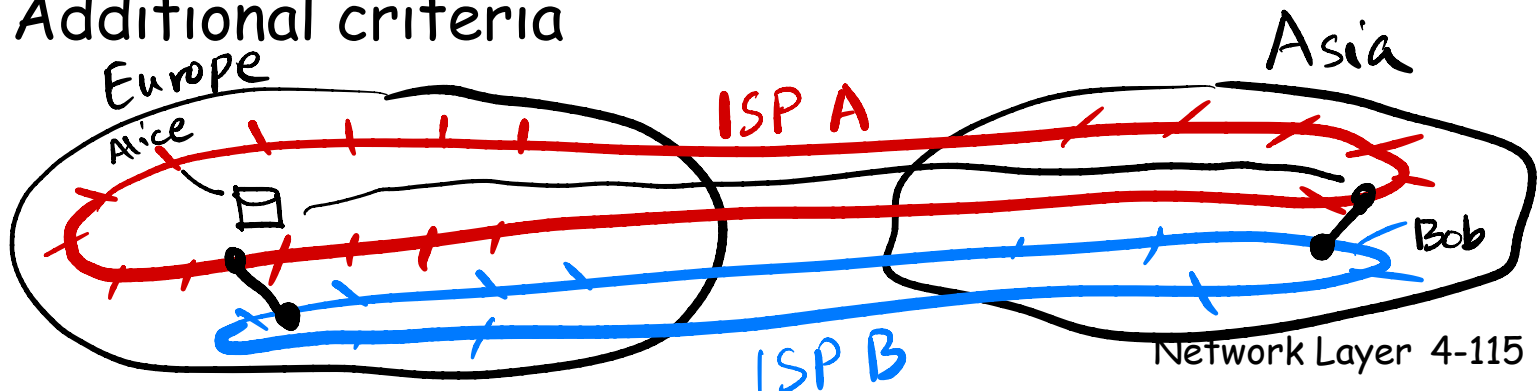


Path attributes & BGP routes

- ❑ When advertising a prefix, advert includes BGP attributes.
 - prefix + attributes = "route"
- ❑ Two important attributes:
 - **AS-PATH**: contains the ASs through which the advert for the prefix passed: AS 67 AS 17 }
 - **NEXT-HOP**: Indicates the specific internal-AS router to next-hop AS. (There may be multiple links from current AS to next-hop-AS.) }
- ❑ When gateway router receives route advert, uses **import policy** to accept/decline.

BGP route selection

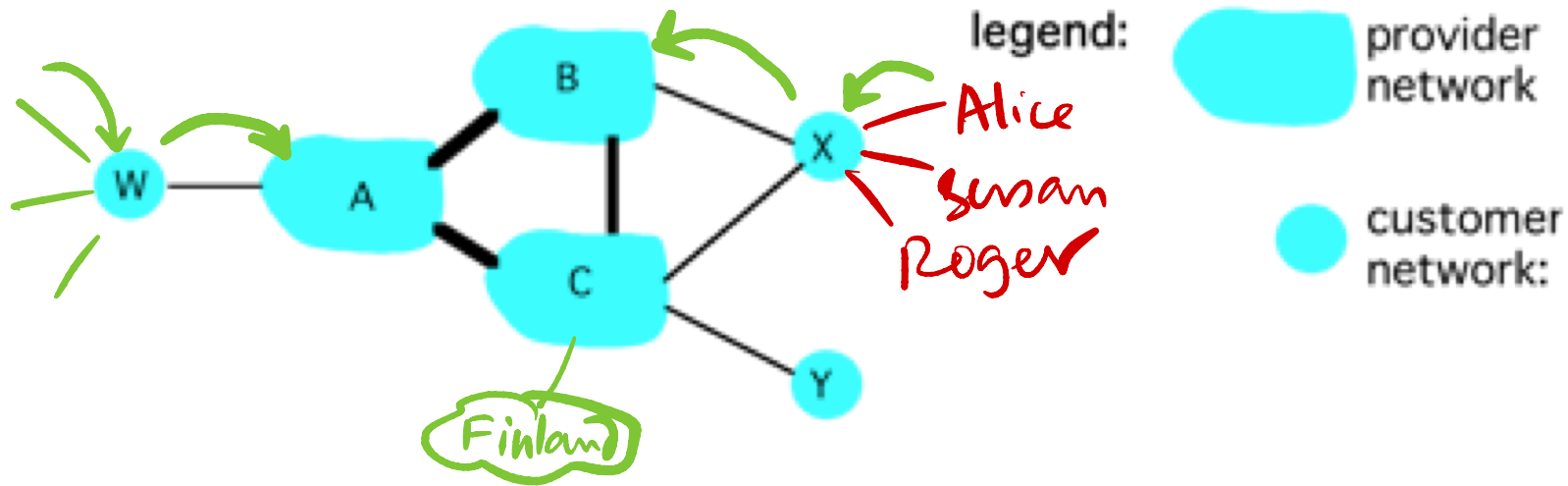
- ❑ Router may learn about more than 1 route to some prefix. Router must select route.
- ❑ Elimination rules:
 1. Local preference value attribute: policy decision
 2. Shortest AS-PATH
 3. Closest NEXT-HOP router: hot potato routing
 4. Additional criteria



BGP messages

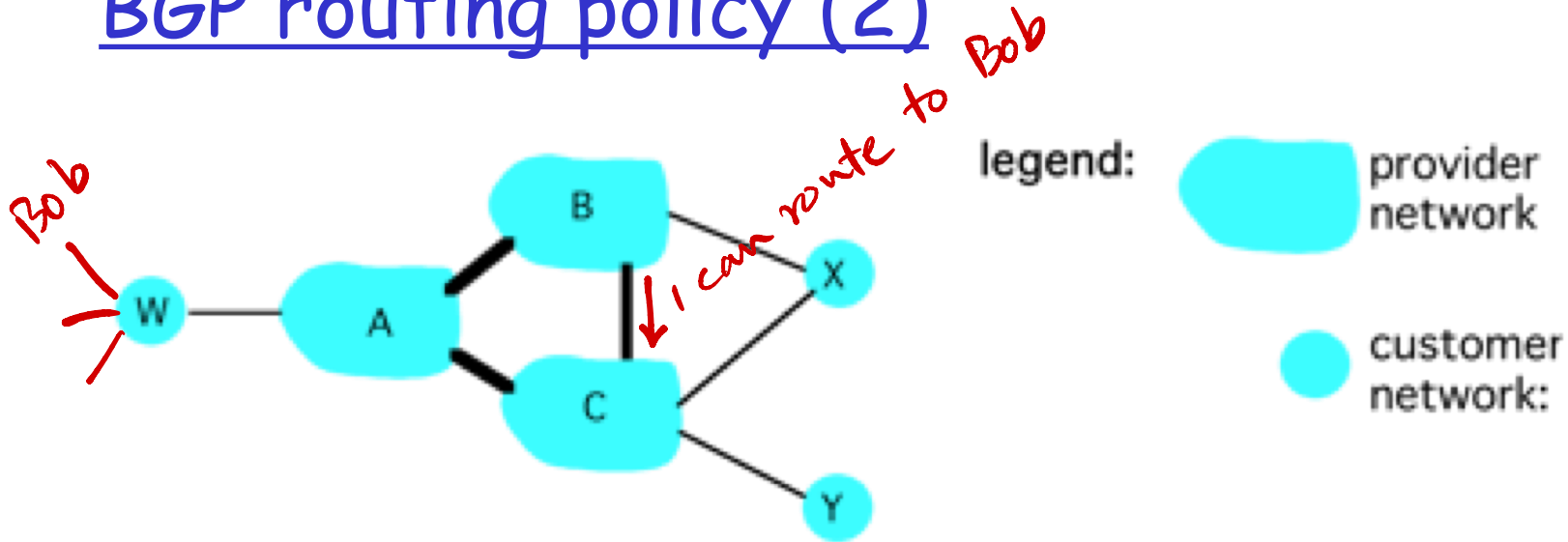
- ❑ BGP messages exchanged using TCP.
- ❑ BGP messages:
 - **OPEN**: opens TCP connection to peer and authenticates sender
 - **UPDATE**: advertises new path (or withdraws old)
 - **KEEPALIVE** keeps connection alive in absence of UPDATES; also ACKs OPEN request
 - **NOTIFICATION**: reports errors in previous msg; also used to close connection

BGP routing policy



- A,B,C are **provider networks**
- X,W,Y are customer (of provider networks)
- X is **dual-homed**: attached to two networks
 - X does not want to route from B via X to C
 - .. so X will not advertise to B a route to C

BGP routing policy (2)



- ❑ A advertises to B the path AW
- ❑ B advertises to X the path BAW
- ❑ Should B advertise to C the path BAW?
 - No way! B gets no "revenue" for routing CBAW since neither W nor C are B's customers
 - B wants to force C to route to w via A
 - B wants to route *only* to/from its customers!

Why different Intra- and Inter-AS routing ?

Policy:

- ❑ Inter-AS: admin wants control over how its traffic routed, who routes through its net.
- ❑ Intra-AS: single admin, so no policy decisions needed

Scale:

- ❑ hierarchical routing saves table size, reduced update traffic

Performance:

- ❑ Intra-AS: can focus on performance
- ❑ Inter-AS: policy may dominate over performance

Questions?