Lecture 18: Network Layer – Control Plane II

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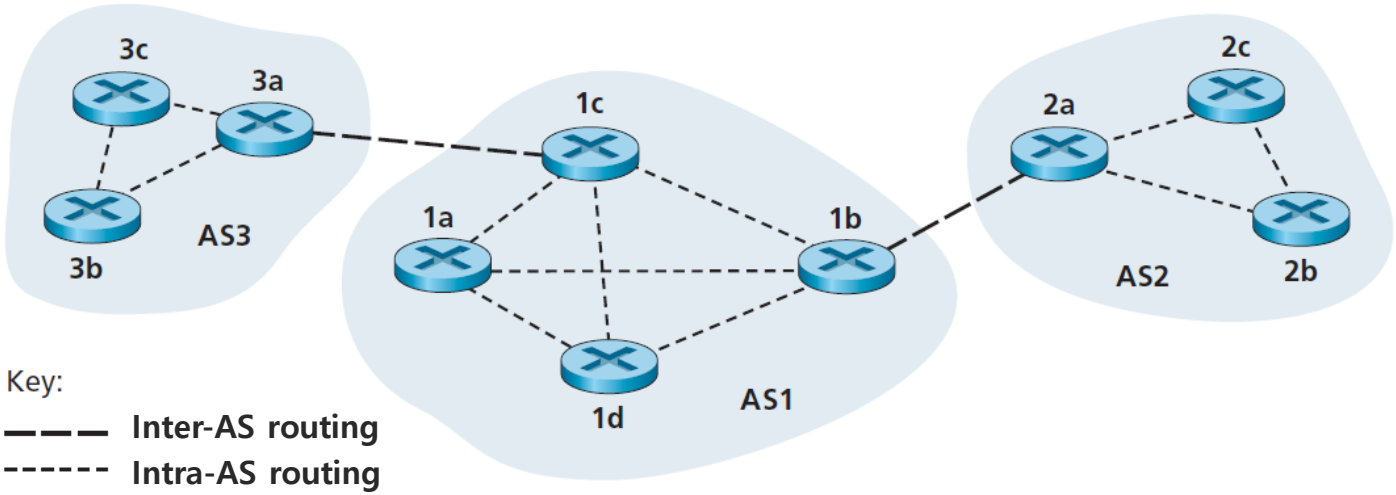
Intra-AS Routing in the Internet: OSPF

- **In practice,**
  - As the number of routers becomes large, the overhead involved in communicating, computing, and storing routing information becomes prohibitive.
  - An organization should be able to operate and administer its network as it wishes.

Intra-AS Routing in the Internet: OSPF

Autonomous systems (ASs)

- Routers are organized into ASs, with each AS consisting of a group of routers that are under the same administrative control
- An AS is identified by its globally unique AS number (ASN) assigned by ICANN regional registries.

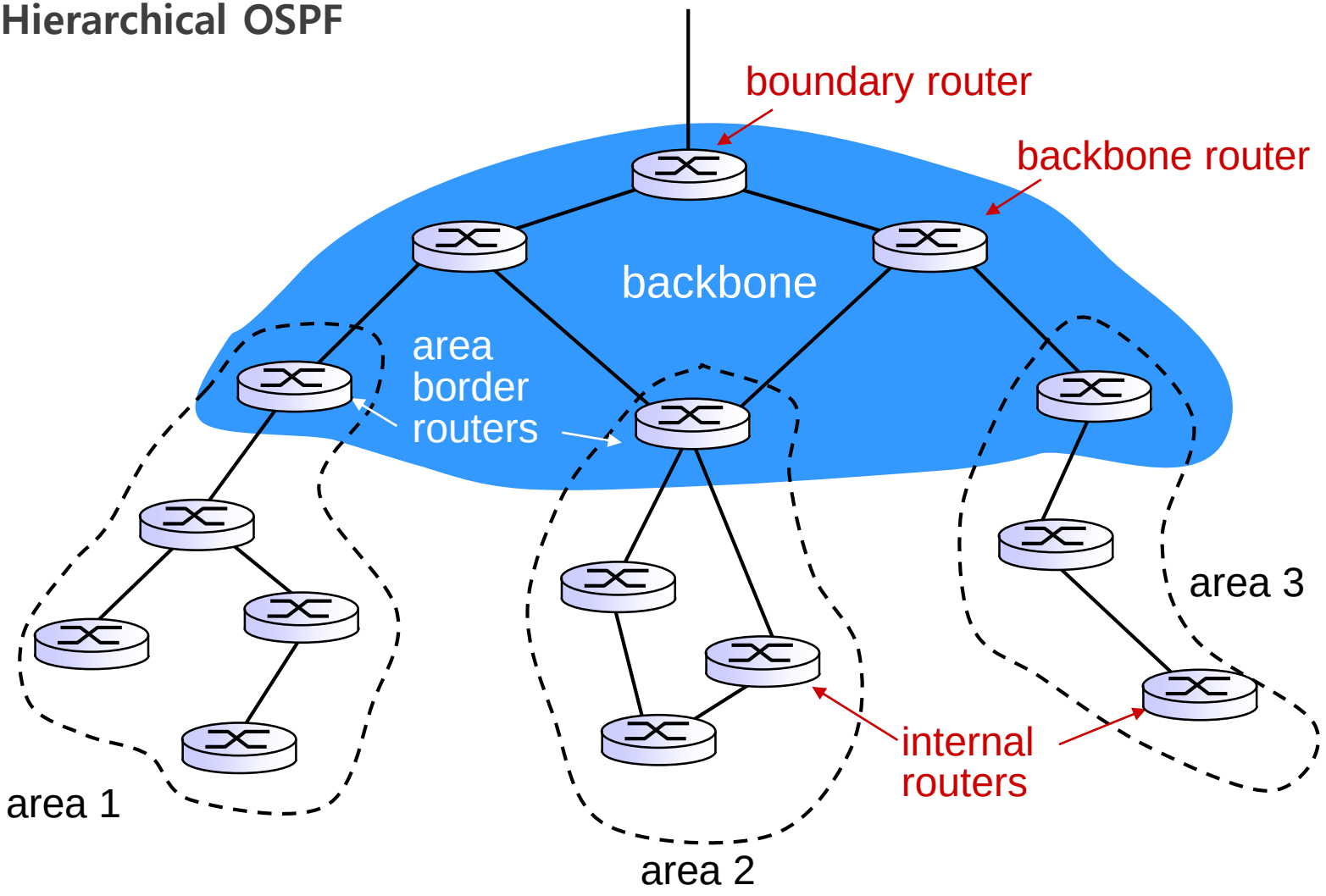


Intra-AS Routing in the Internet: OSPF

- **Open shortest path first (OSPF) routing**
  - "Open": Publicly available
    - Cisco's EIGRP protocol was only recently became open, after roughly 20 years as a Cisco-proprietary protocol.
  - Link-state protocol that uses flooding of link-state information
  - Dijkstra's least-cost path algorithm
  - Each router
    - Construct a complete topological map, i.e., a graph of the entire AS system
    - Locally run Dijkstra's shortest-path algorithm to determine a shortest-path tree to all subnets, with itself as the root node
    - Broadcast routing information to all other routers in the AS system

Intra-AS Routing in the Internet: OSPF

- Hierarchical OSPF

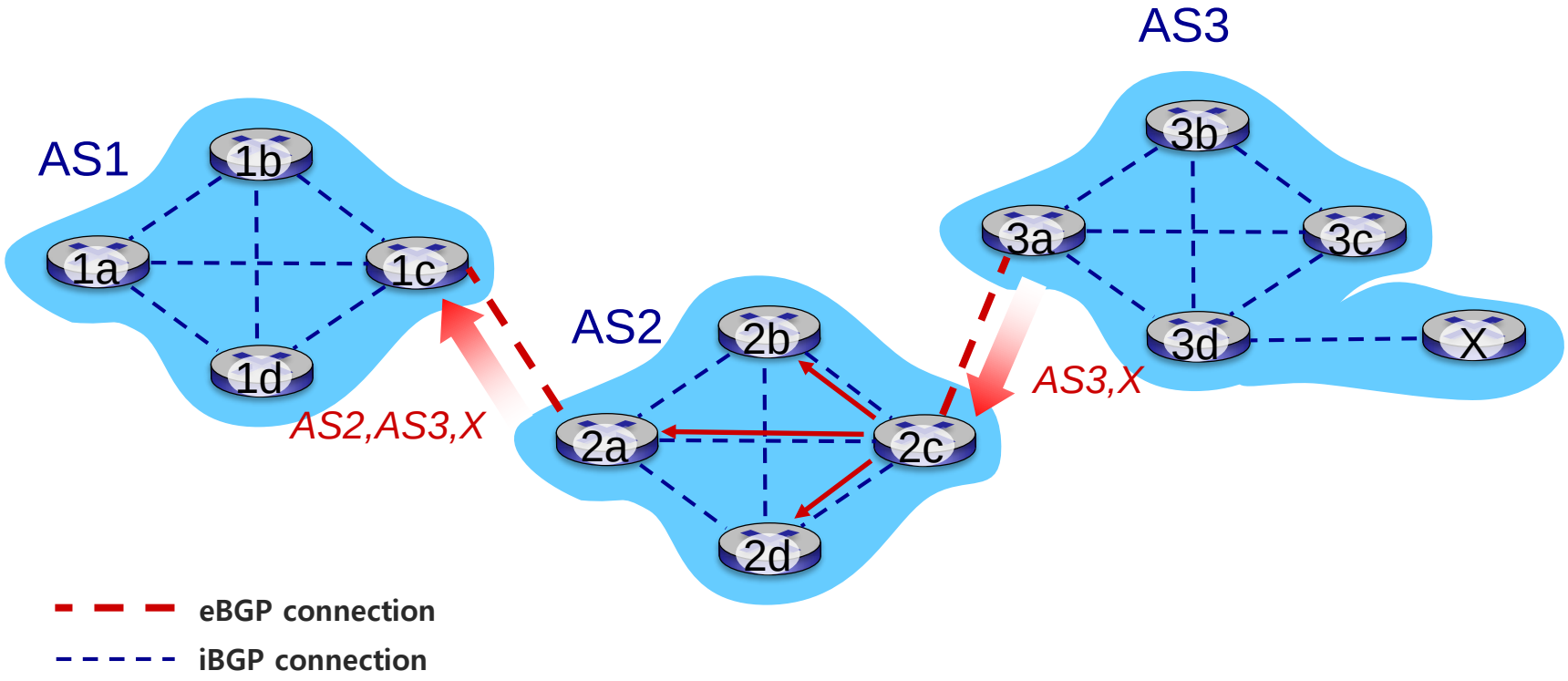


Routing Among the ISPs: BGP

- **Border gateway protocol (BGP)**
  - In the Internet, all ASs run this inter-AS routing protocol.
  - Decentralized and asynchronous
  - Packets are routed to CIDRized prefixes, e.g., 138.16.68/22
  - External BGP (eBGP)
    - Obtain prefix reachability information from neighboring ASs
  - Internal BGP (iBGP)
    - Determine the best routes to the prefixes

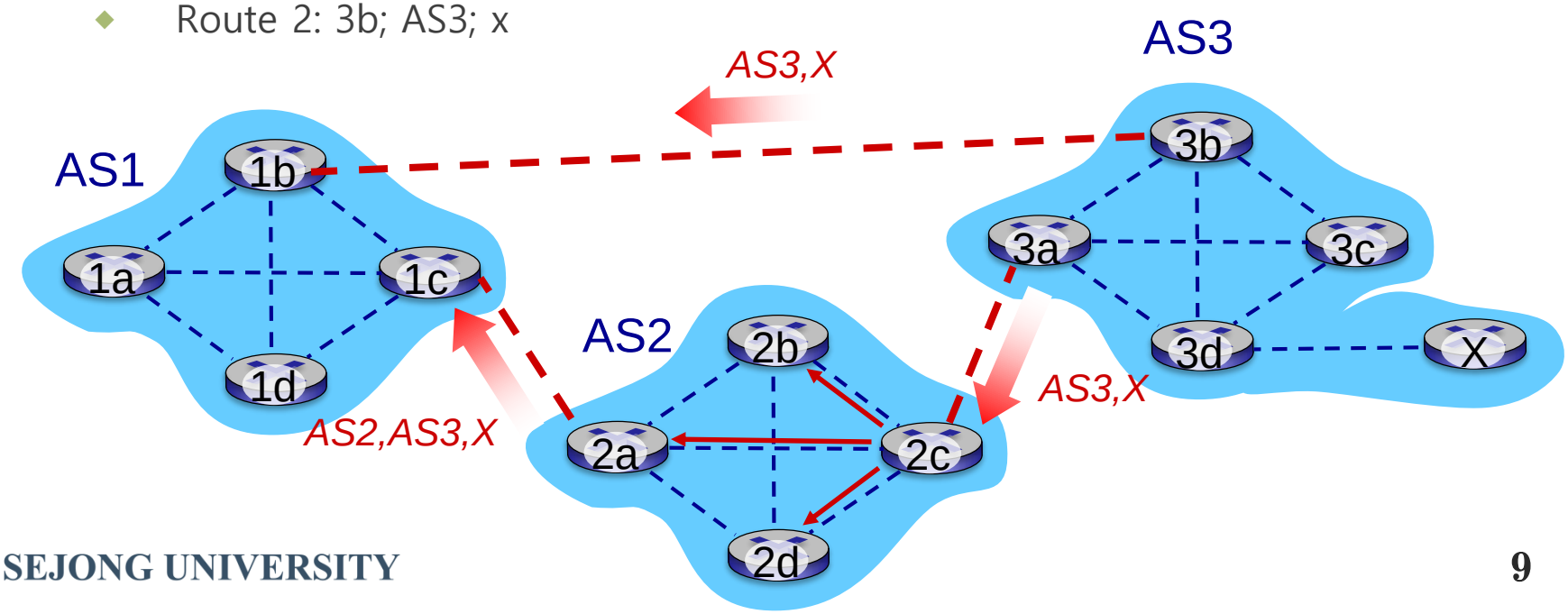
Routing Among the ISPs: BGP

- **Advertising BGP route information**
  - Gateway router: 1c, 2a, 2c, 3a
  - Internet router connects only to hosts and routers within its own AS.



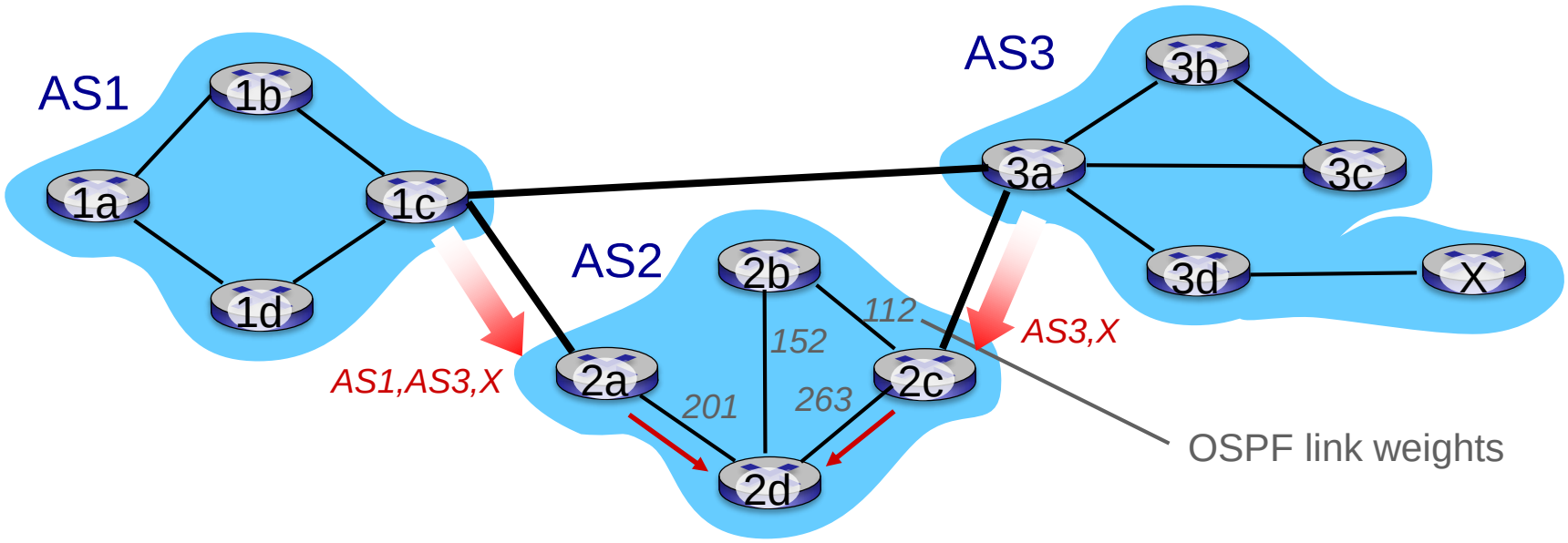
Routing Among the ISPs: BGP

- **Path attributes**
  - AS-PATH: The list of ASs through which prefix advertisement has passed
  - NEXT-HOP: The IP address of the router interface that begins the AS-PATH
- **"route" = prefix + attributes**
  - Route 1: 2a; AS2 AS3; x
  - Route 2: 3b; AS3; x



Routing Among the ISPs: BGP

- **Hot potato routing**
  - A selfish algorithm that chooses a local gateway that has least intra-domain cost



Routing Among the ISPs: BGP

- **Route-selection algorithm**
  - BGP sequentially invokes the following elimination rules until one route remains:
  - 1) The routes with the highest local preference values (policy decision) are selected.
  - 2) The route with the shortest AS-PATH is selected.
  - 3) The route with the closest NEXT-HOP router is selected (hot potato routing)
  - 4) The router uses BGP identifiers, e.g., the lowest value, to select the route.

Routing Among the ISPs: BGP

- **Routing policy**
  - A, B, C are backbone provider networks
  - X, W, Y are access ISPs
  - All traffic entering an ISP access network must be destined for that network.
  - All traffic leaving an ISP access network must have originated in that network.