

COMP 431

Internet Services & Protocols

Routing on the Internet

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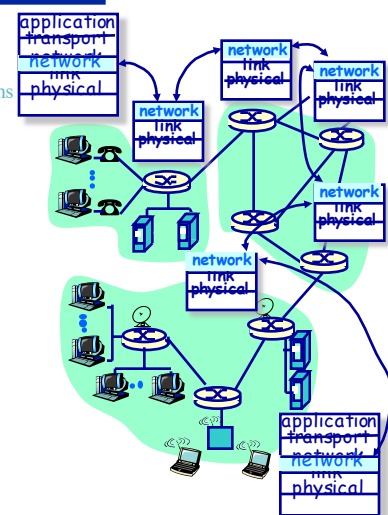
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The Network Layer: Routing & Addressing

Outline

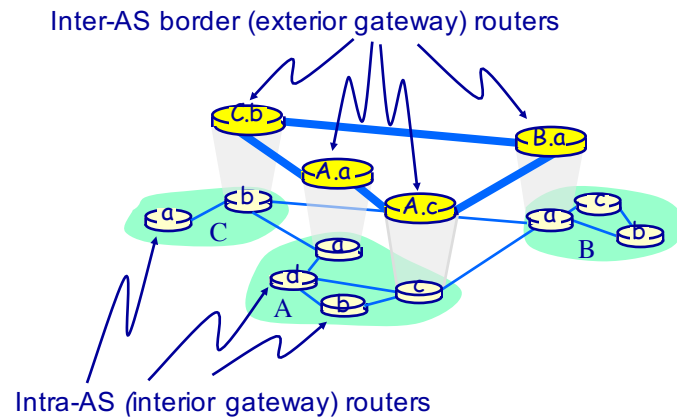
- ◆ Network layer services
- ◆ Routing algorithms
 - » Least cost path computation algorithms
- ◆ Hierarchical routing
 - » Connecting networks of networks
- ◆ IP Internet Protocol
 - » Addressing
 - » IPv6
- ◆ Routing on the Internet
 - » Intra-domain routing
 - » Inter-domain routing
- ◆ Router architecture



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Routing on the Internet

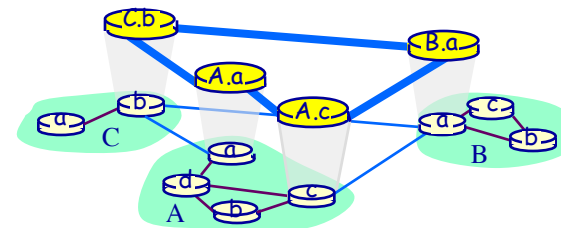
The Internet AS hierarchy



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The Internet AS Hierarchy

Intra-AS routing

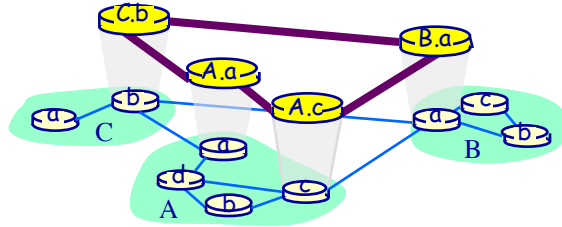


- ◆ Also known as “Interior Gateway Protocols” (IGPs)
- ◆ Most common IGPs:
 - » RIP: Routing Information Protocol (Distance-vector like routing)
 - » OSPF: Open Shortest Path First (Link-state routing)
 - » IGRP: Interior Gateway Routing Protocol (Cisco proprietary)

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The Internet AS Hierarchy

Inter-AS Routing



- ◆ Border Gateway Protocol (BGP) is the *de facto* standard
- ◆ *Path Vector* protocol:
 - » Similar to Distance Vector protocol
 - » Each Border Gateway advertises to adjacent nodes (peers) the *entire AS path* (i.e., sequence of AS numbers) to a destination
 - » e.g., Gateway X may send its path to destination Z:

$$\text{path}(XZ) = X, Y_1, Y_2, Y_3, \dots, Z$$
- ◆ BGP messages are exchanged using TCP

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Internet Inter-AS Routing

BGP

- ◆ Suppose gateway X sends a path to peer gateway W
- ◆ W may or may not select the path advertised by X
 - » Cost, policy ("don't route via competitor X 's network"), or loop prevention reasons
- ◆ If W selects the path advertised by X to Z , then:

$$\text{path}(WZ) = W + \text{path}(XZ)$$
- ◆ Note that X can control its incoming traffic by controlling its route advertisements to adjacent border gateways:
 - » If X does not want to route traffic to Z , then X will not advertise any routes to Z

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Putting It All Together

Intra-AS & Inter-AS Routing

The diagram illustrates the combination of intra-AS and inter-AS routing. It shows three Autonomous Systems (ASes) represented by green ovals: AS A, AS B, and AS C. Each AS contains several routers (represented by circles) and a host (represented by a laptop icon).

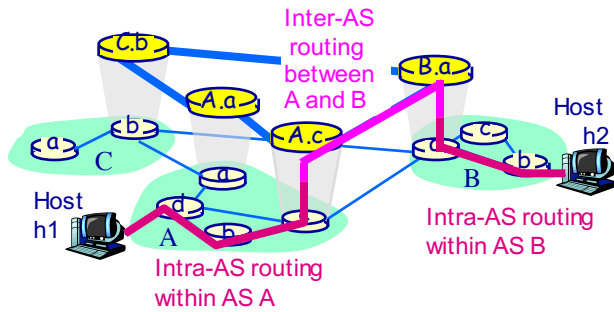
- AS A:** Contains routers labeled 'a', 'b', and 'd'. Host h1 is connected to router 'd'. A red line indicates intra-AS routing within AS A.
- AS B:** Contains routers labeled 'c' and 'b'. Host h2 is connected to router 'b'. A red line indicates intra-AS routing within AS B.
- AS C:** Contains routers labeled 'a', 'b', and 'c'. Host h1 is connected to router 'a'.

Inter-AS routing is shown by blue lines connecting routers across the different ASes:

- Router 'd' in AS A connects to router 'a' in AS C.
- Router 'a' in AS C connects to router 'b' in AS C.
- Router 'b' in AS C connects to router 'c' in AS B.
- Router 'c' in AS B connects to router 'b' in AS B.
- Router 'b' in AS B connects to router 'a' in AS B.
- Router 'a' in AS B connects to router 'c' in AS C.

Labels and annotations:

- Intra-AS routing within AS A:** Red line connecting Host h1 to router 'd'.
- Intra-AS routing within AS B:** Red line connecting Host h2 to router 'b'.
- Inter-AS routing between A and B:** Blue lines connecting routers across the different ASes.



The Internet AS Hierarchy

Why different intra- and inter-AS routing?

- ◆ Policy:
 - » Inter-AS: administration wants control over how its traffic routed and who routes through its network
 - » Intra-AS: single administration, 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

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