ECE 356/COMPSI 356
Computer Network Architecture

Inter-domain Networking.
Border Gateway Protocol (BGP).

Wednesday October 2nd, 2019

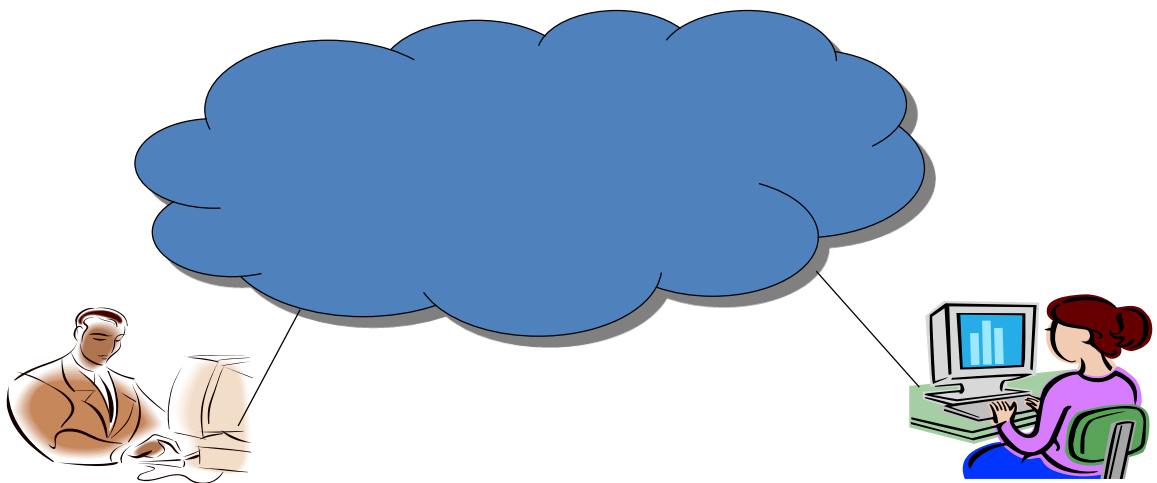Duke UNIVERSITY

Recap

- Last lecture: link state routing

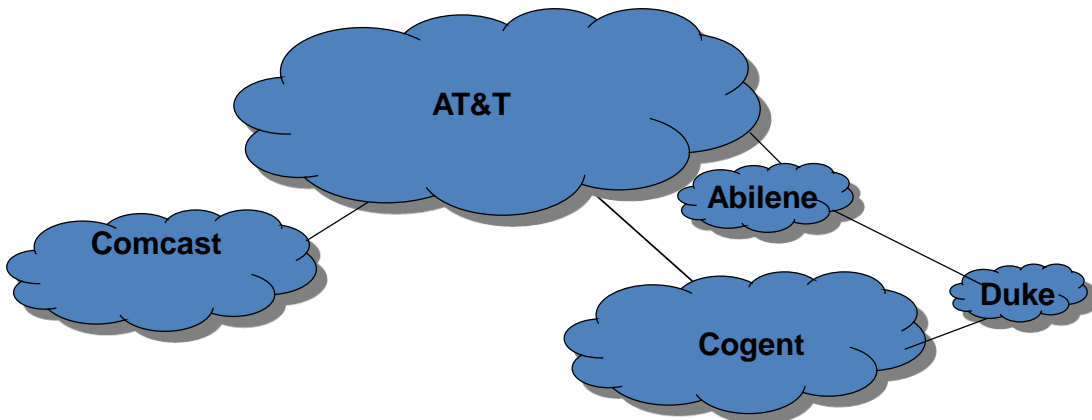- Readings for this class: **PD 4.1.1, 4.1.2**

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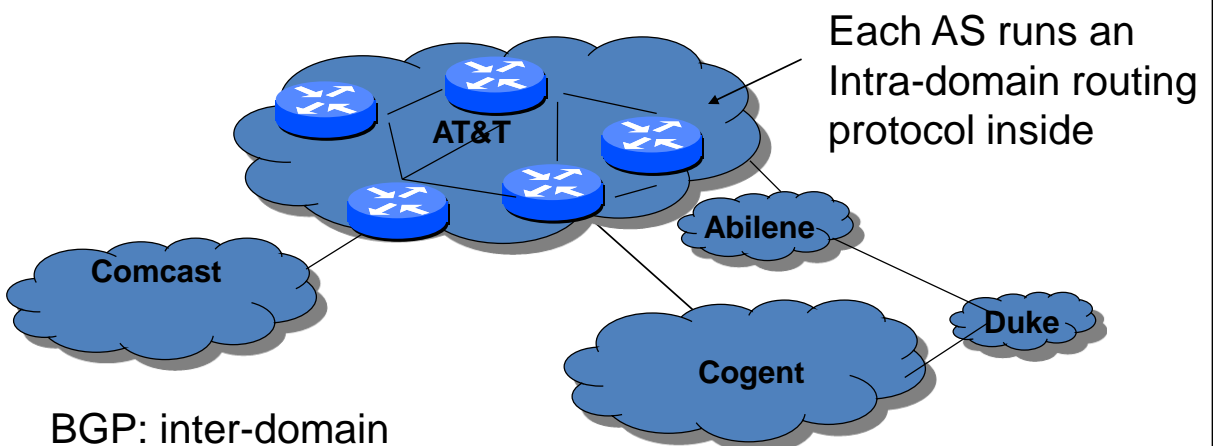
Lecture Outline

- Inter-domain routing
- BGP

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The Internet

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The Internet: Zooming In 2x

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Abilene

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Intra-domain vs. Inter-domain Routing

Each AS runs an Intra-domain routing protocol inside

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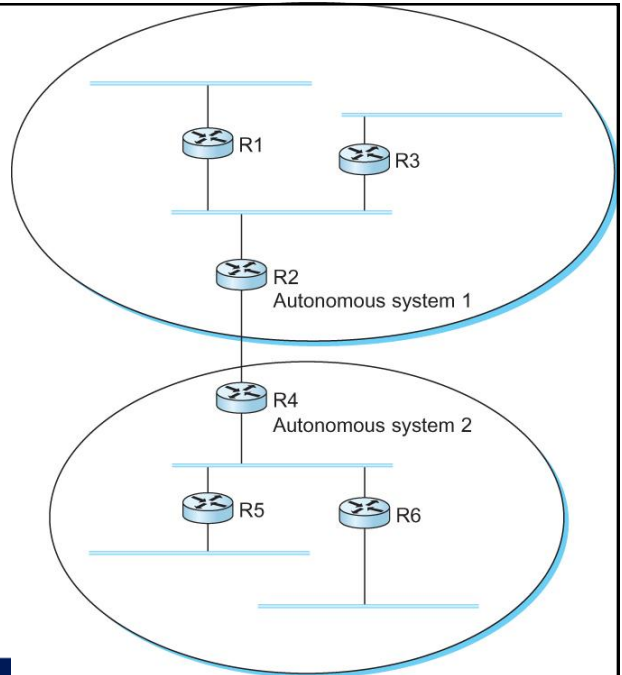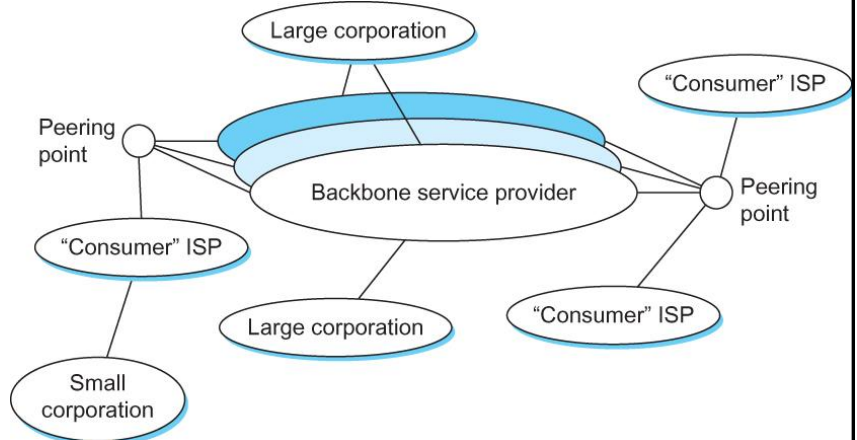BGP: inter-domain

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Inter-domain Communications

- Always through the designated points
- E.g., if R3 and R6 are directly connected, they still need to go through designated *Area Border Routers* (ABRs)
 - ➤ Also called *gateways*

Autonomous system 1

Autonomous system 2

R1, R3, R2, R4, R5, R6

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ASs Are Not Created Equal (1/4)

Large corporation
"Consumer" ISP
Peering point
Backbone service provider
Peering point
"Consumer" ISP
Large corporation
"Consumer" ISP
Small corporation

- Local traffic: traffic that originates at or terminates on nodes within an AS
- Transit traffic: traffic that passes through an AS
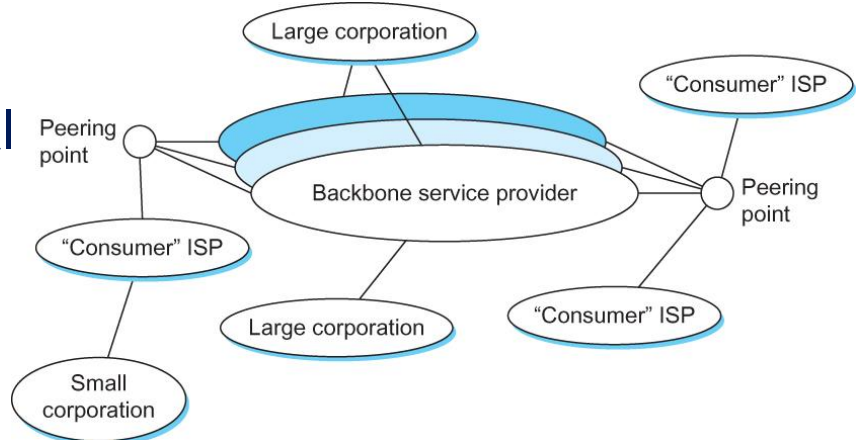
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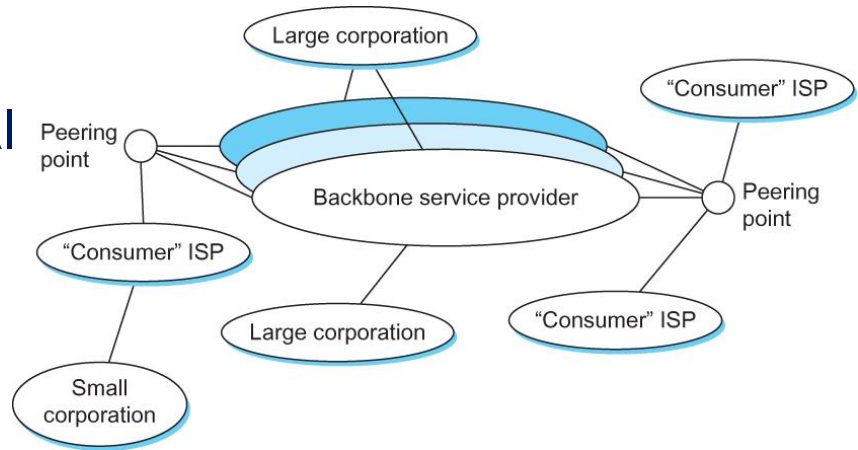
ASs Are Not Created Equal (2/4)
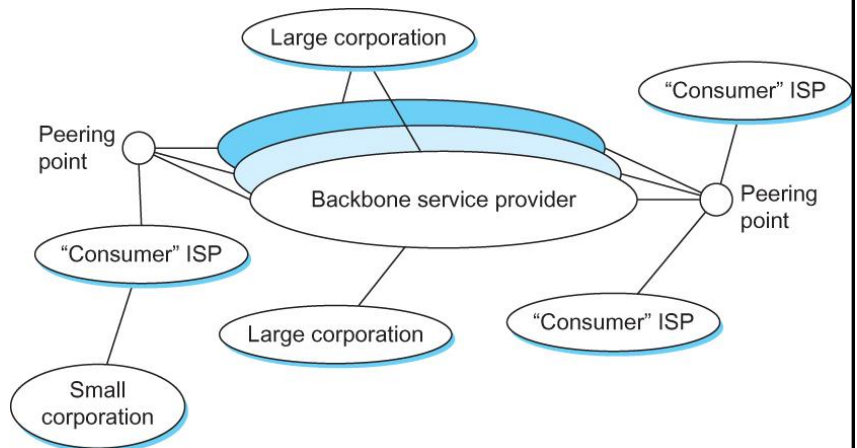
- *Stub AS*: an AS that has <u>only a single connection</u> to one other AS
  - ➤ Will only carry local traffic

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ASs Are Not Created Equal (3/4)

- *Multihomed AS:* an AS that has connections to more than one other AS, but refuses to carry transit traffic

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ASs Are Not Created Equal (4/4)

Large corporation

"Consumer" ISP

Peering point

Backbone service provider

Peering point

"Consumer" ISP

Large corporation

"Consumer" ISP

Small corporation
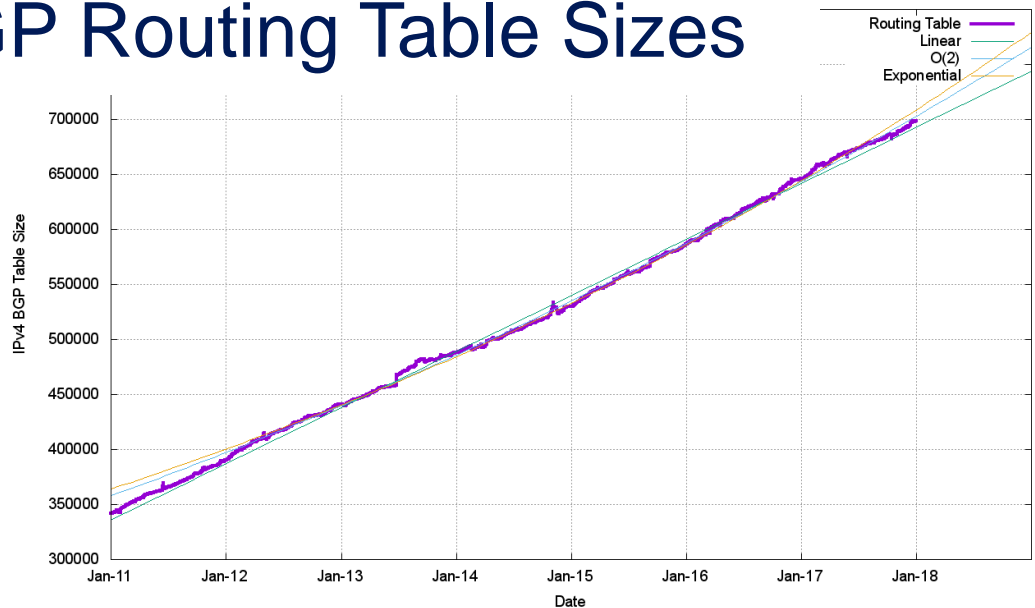
- *Transit AS:* an AS that has connections to more than one other AS, and is designed to carry both transit and local traffic

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Challenges in Interdomain Routing: Scalability

- An Internet backbone router must be able to forward any packet destined anywhere in the Internet
  - ➢ Having a routing table that will provide a match for any valid IP address

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BGP Routing Table Sizes

Challenges in Interdomain Routing

- Cannot find the true shortest path
  - ➢ Domains are autonomous and can use different routing metrics
- Find *a* path, advertise reachability
  - ➢ "Can reach this network through this AS"
- Paths must be policy-compliant, and policies can be complex
  - ➢ E.g., "*whenever possible, I prefer to send traffic via AS X than AS Y, but I'll use AS Y if it is the only path, and I never want to carry traffic from AS X to AS Y or vice versa*"

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Lecture Outline

- Inter-domain routing
- **BGP**

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BGP (1/4)

- BGP = Border Gateway Protocol
  - ➢ Currently in version 4, specified in RFC 1771 (~ 60 pages)
- Inter-domain routing protocol for routing between autonomous systems
- Uses TCP to establish a BGP session and to send routing messages over the BGP session

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BGP (2/4)

- BGP is a *path vector protocol*
  - ➢ Similar to distance vector routing, but routing messages in BGP contain complete paths
- Network administrators can specify routing policies
- BGP's goal is to find any path (not an optimal one)
  - ➢ Since the internals of the AS are never revealed, finding an optimal path is not feasible

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BGP (3/4)

Each AS has:

- One BGP *speaker* that advertises:
  - ➢ Local networks
  - ➢ Other reachable networks (transit AS only)
  - ➢ Gives *path* information
- One or more border "gateways"
  - ➢ The routers through which packets enter and leave the AS
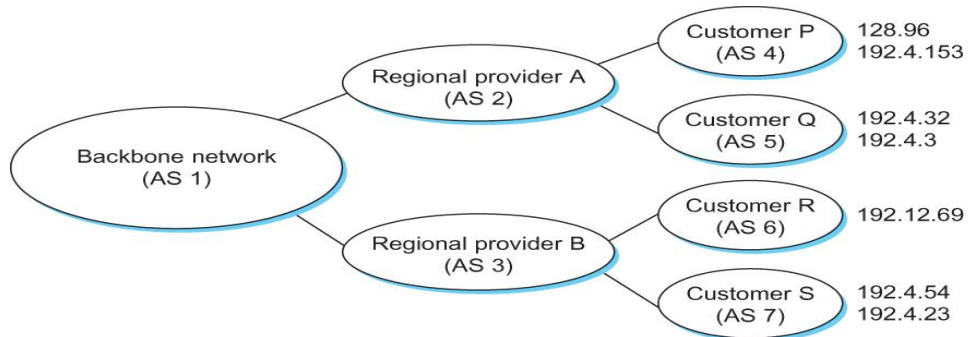 - ➢ Need not be the same as the speakers

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BGP (4/4)

- BGP advertises *complete paths* as an enumerated lists of ASs to reach a particular network

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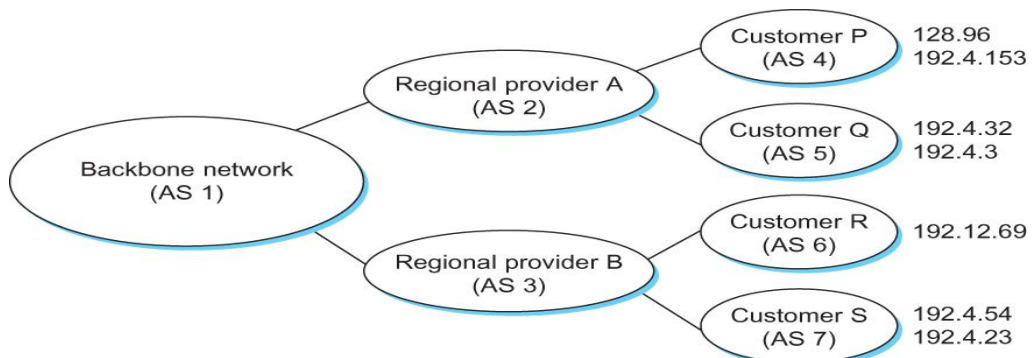
BGP Example (1/2)

- Speaker for AS 2 advertises reachability to P and Q
  - ➢ Network 128.96, 192.4.153, 192.4.32, and 192.4.3, can be reached directly from AS 2

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BGP Example (2/2)

- Speaker for backbone network then advertises
  - ➢ Networks 128.96, 192.4.153, 192.4.32, and 192.4.3 can be reached along the path <AS 1, AS 2>

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Loop Prevention in BGP

- ASs can see themselves in advertised paths
- AS numbers carried in BGP need to be unique
  - ➢ AS can only recognize itself in the AS path if no other AS identifies itself in the same way
- AS numbers are 16-bit numbers assigned by a central authority
  - ➢ Stub ASs do not need unique numbers

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Different ASs Use Different Routing Policies
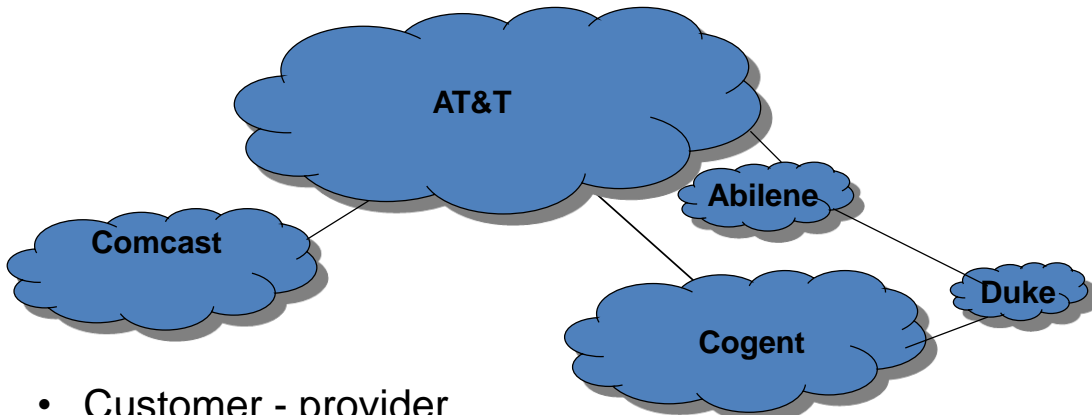
- E.g., BGP speaker does not have to advertise a route to a destination if it has one
  - ➤ This implements a policy of not providing transit
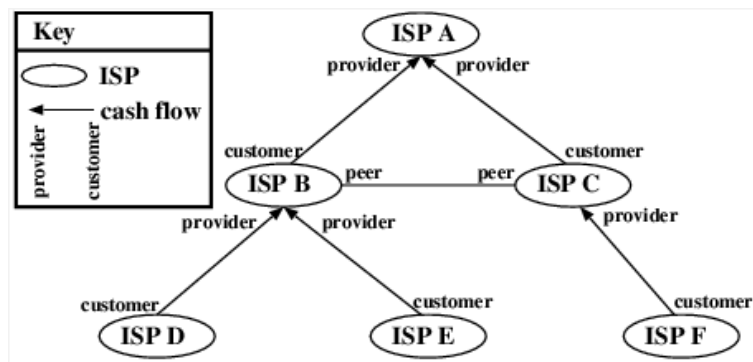
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Common AS Relationships (1/3)
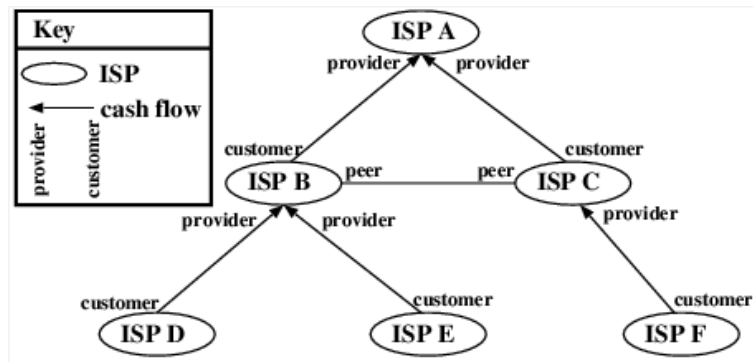
- Provider - customer
  - ➤ Advertise all routes I know about to my customer
  - ➤ Advertise routes I learn from my customer to everyone

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Common AS Relationships (2/3)

- Customer - provider
  - ➤ Don't advertise routes learned from one provider to another provider

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Common AS Relationships (3/3)

- Peer-peer
  - ➤ Advertise customer routes only
  - ➤ Don't advertise peer routes to a provider

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Lecture Summary

- Inter-domain routing
- BGP

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Next Lecture

- Miscellaneous IP topics
  - ➢ Host configuration (DHCP)
  - ➢ Network address translation (NAT)
  - ➢ IPv6
  - ➢ Tunneling

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