

WORKSHOP ON
Advanced Networking Topics: BGP, BGP Hijacking, MPLS,
MPLS-based VPNs, Segment Routing, and others

University of South Carolina, Cyberinfrastructure Lab
<http://ce.sc.edu/cyberinfra/>

WASTC 2021 virtual Faculty Development Weeks (vFDW)
June 14, 2021

Introduction

USC – CI Lab

- Members



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Associate Professor
Integrated Information Technology



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Department of Computer Science and Engineering



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Ph.D. Student (01/2019 - present)
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M.S. Student (09/2019 - present)
Integrated Information Technology Department

Agenda

- The agenda and other material can be found in the workshop's website:
http://ce.sc.edu/cyberinfra/workshop_2021_wast.html

USC – Promoting Hands-on

- The IEEE and ACM are the main societies which guide IT education
- According to them, the IT curriculum should emphasize “learning IT core concepts combined with authentic practice” and “use of professional tools and platforms”
- The University of South Carolina (USC) – Cyberinfrastructure Lab (CI) promotes hands-on education, training, and research
- URL: <http://ce.sc.edu/cyberinfra/>

Virtual Labs

- USC works closely with the Network Development Group (NDG) (www.netdevgroup.com)
- NDG provides a scalable platform the labs can run on
- USC's lab libraries incorporate performance and realism along with NETLAB's features

Feature	Description
Performance	Virtual labs emulate high-performance systems (e.g., high-speed networks running at 40 Gbps)
Functional realism	Virtual labs have the same functionality as real IT hardware in a real deployment, and execute the same code
Traffic realism	Devices within the virtual lab environment are capable of generating and receiving real, interactive network traffic to and from the Internet
Presentation layer	Navigating through an experiment is easy for an inexperienced learner
Topology flexibility	It must be easy to create an experiment with any topology, including inter-connecting heterogeneous virtual machines (VMs)

USC – Lab Libraries

- The learning-by-doing approach is essential in networking; textbooks and lectures are not sufficient
- Insight and appreciation of how technologies operate in practice can only be achieved via first-hand experience, hands-on experiments
- Laboratory experience allows learners to see networking in action, to understand each component, and to appreciate details
- All laboratory experiments include a background reading section before undertaking the experiments
- Then, experiments are described step-by-step

USC – Lab Libraries

- List of USC's lab libraries can be found online:
<http://ce.sc.edu/cyberinfra/cybertraining.html>
- Network Tools and Protocols
- SDN
- Introduction to BGP
- MPLS and Advanced BGP Topics
- Open vSwitch
- Introduction to perfSONAR
- Zeek/Bro Intrusion Detection System

Border Gateway Protocol (BGP) Lab Series

Border Gateway Protocol (BGP)

- BGP is one of the most important protocols
- Consider the observations raised during the 2019's Internet2 Technology Exchange Conference¹

“Breakdowns in BGP policy are splashed across the headlines on a now weekly basis... High profile incidents like the June 2019 Cloudflare event highlight how hard it is to manage the distributed and interconnected networks of the world, and how easy it is for a mistake to impact large populations...”

- Consider ZDNet article²

“CenturyLink outage led to a 3.5% drop in global web traffic... US internet service provider CenturyLink has suffered a major technical outage on Sunday after a misconfiguration in one of its data centers created havoc all over the internet... Due to the technical nature of the outage -- involving both firewall and BGP routing...”

1. <https://meetings.internet2.edu/2019-technology-exchange/detail/10005600/>

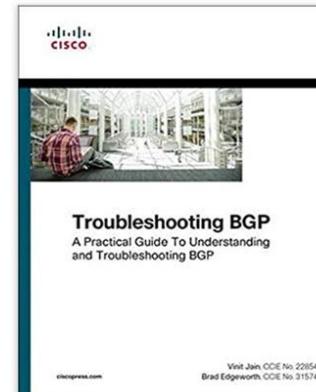
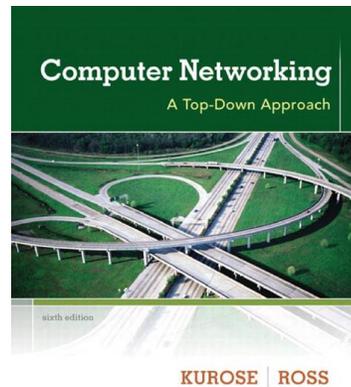
2. <https://www.zdnet.com/article/centurylink-outage-led-to-a-3-5-drop-in-global-web-traffic/>

Border Gateway Protocol (BGP)

- How can routers direct packets over a set of independently run networks?
- BGP was invented to solve this problem and is now the “glue” that makes independently run networks appear as a coherent system to the end user
 - Note that the “glue” here does not refer to the need of masking low-level compatibility of network technologies (IP); instead, it refers to the need of routing through independent networks
- BGP is a topic taught at different levels
 - Professional certifications, two-year technical colleges, four-year universities, graduate school

Border Gateway Protocol (BGP)

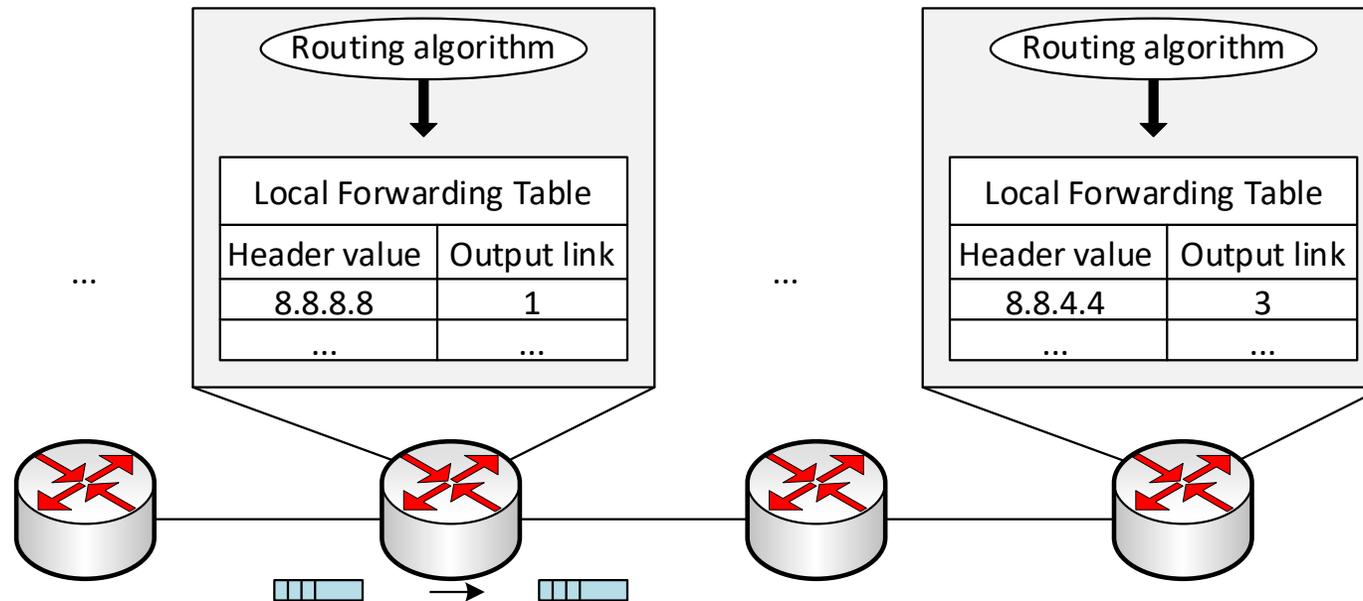
- BGP is very complex
- Even after having read books and RFCs, students (instructors) may find it difficult to fully master BGP without having practiced it
- As critical protocol for the Internet, it is important to understand it



BGP Historical Background

Routing Algorithms

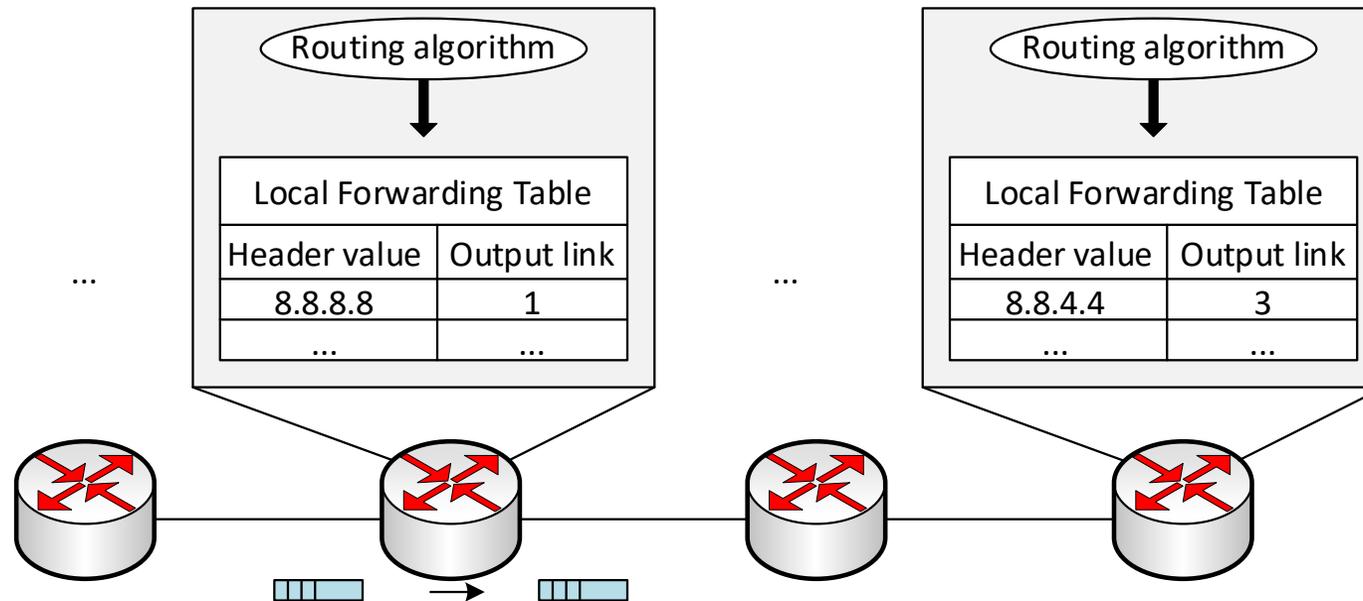
- When a packet arrives to a router, the router looks up in its forwarding table to match the incoming packet and determine the corresponding action (e.g., forward the packet to port 1)



J. Kurose, K. Ross, "Computer networking, a top-down approach," 7th Edition, Pearson, 2017

Routing Algorithms

- Given a set of routers with connected links, routing algorithms determine a good path from a source to a destination

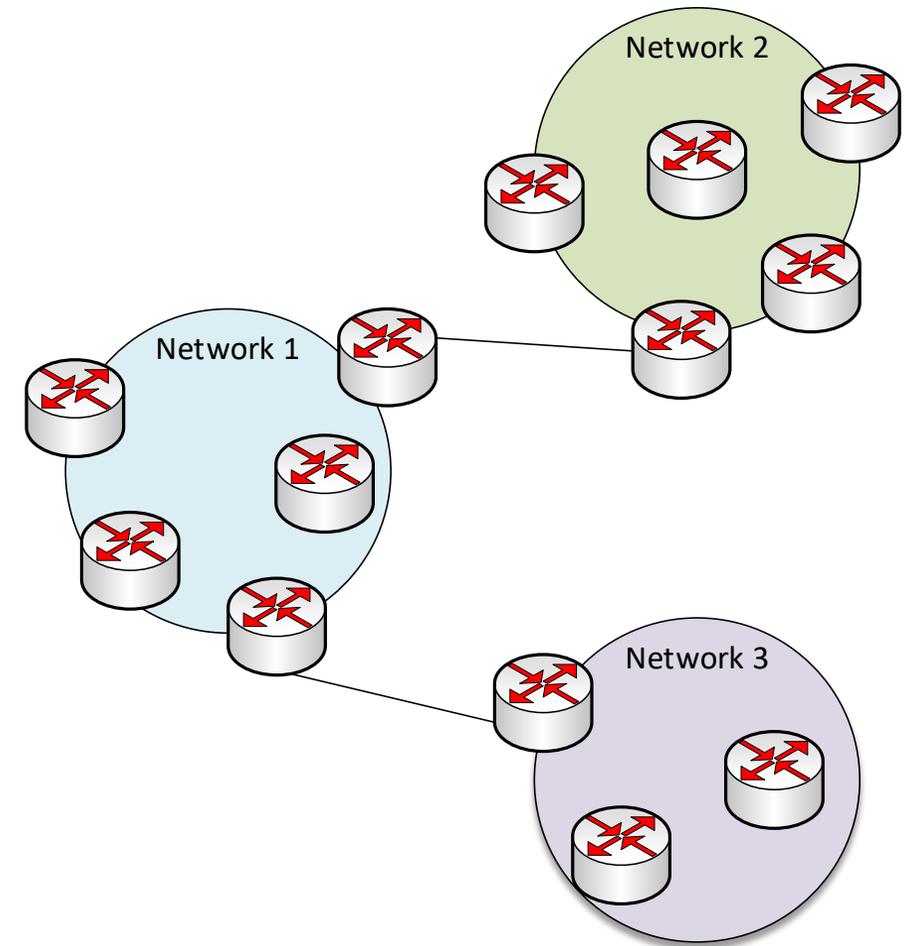


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Internetwork Routing

- Routers are organized into Autonomous Systems (ASes or ASs)
- What is an AS (RFC 1771)?

“A set of routers under the single technical administration, using an IGP and common metrics to route packets within the AS, and using an EGP to route packets to other ASs.”



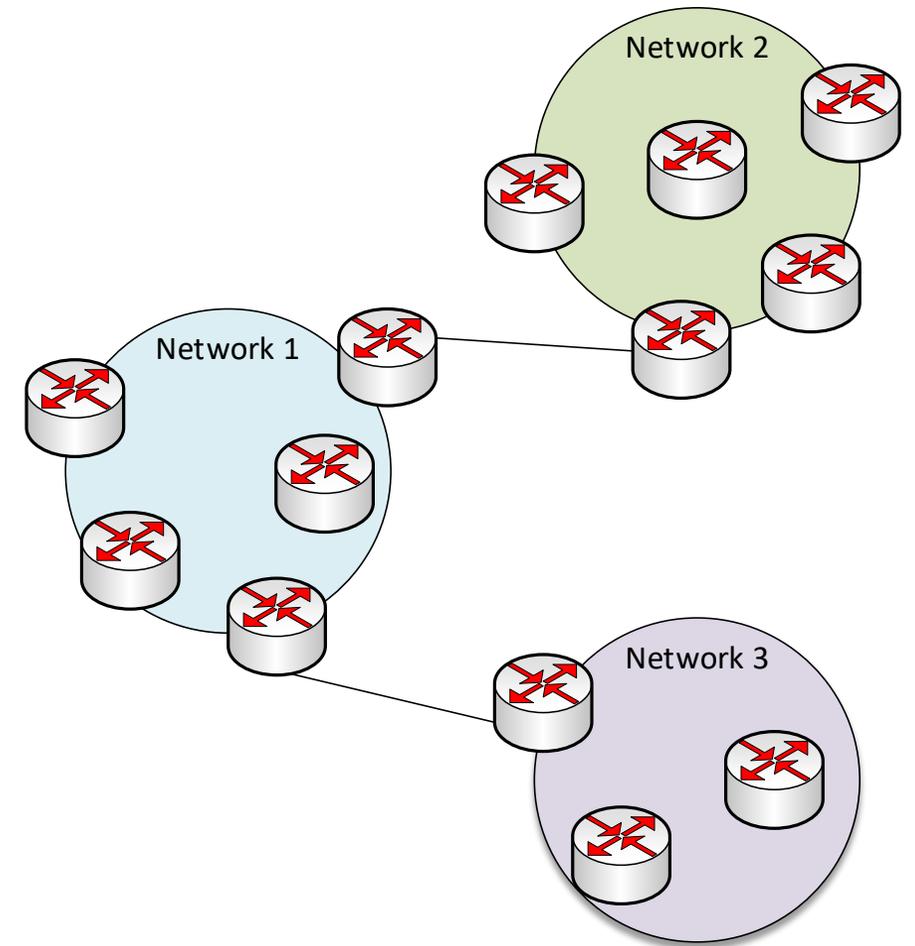
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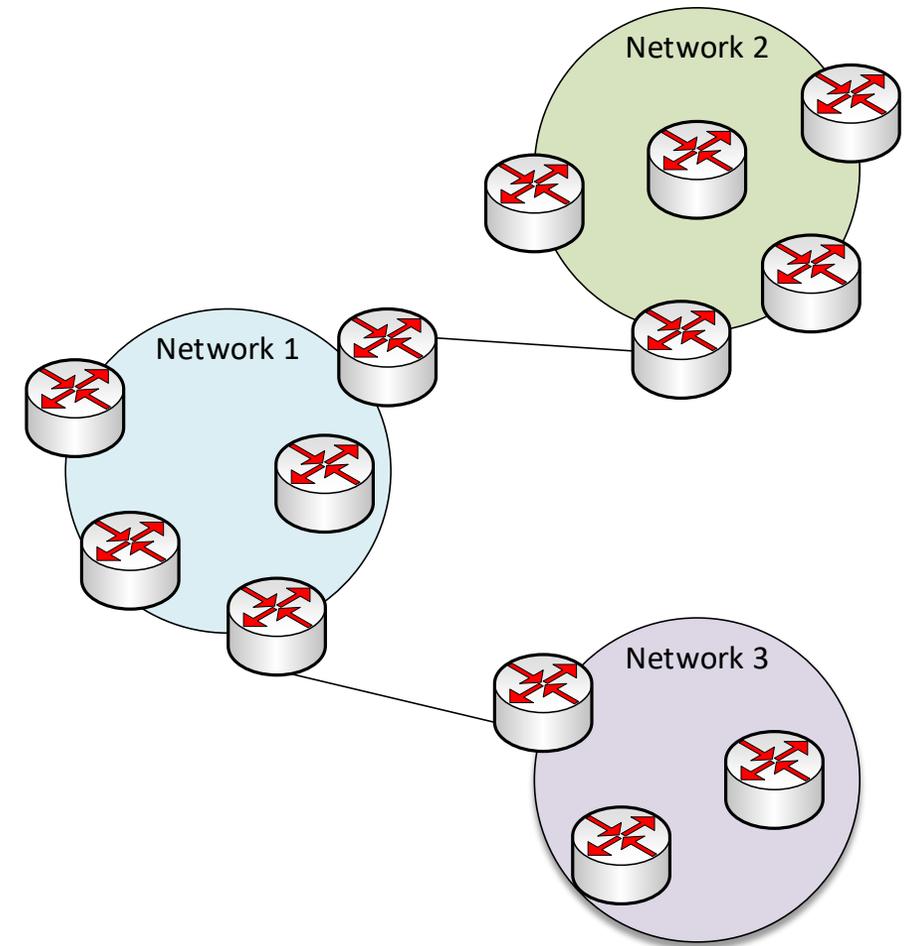
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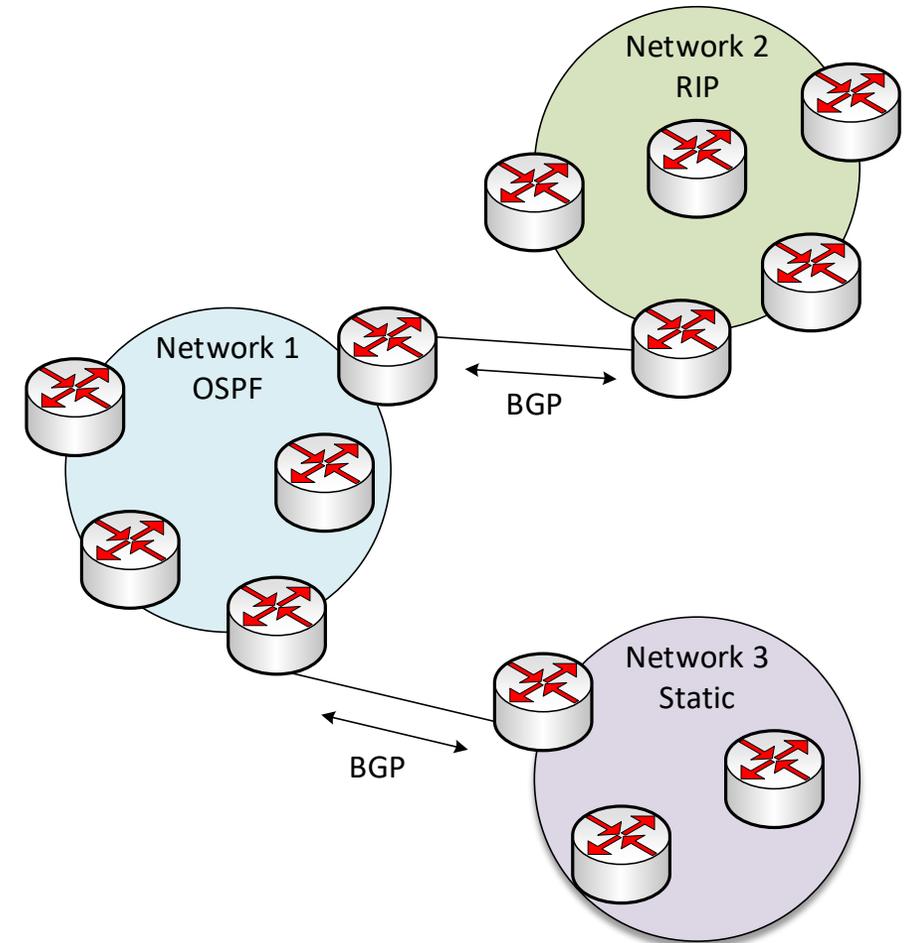
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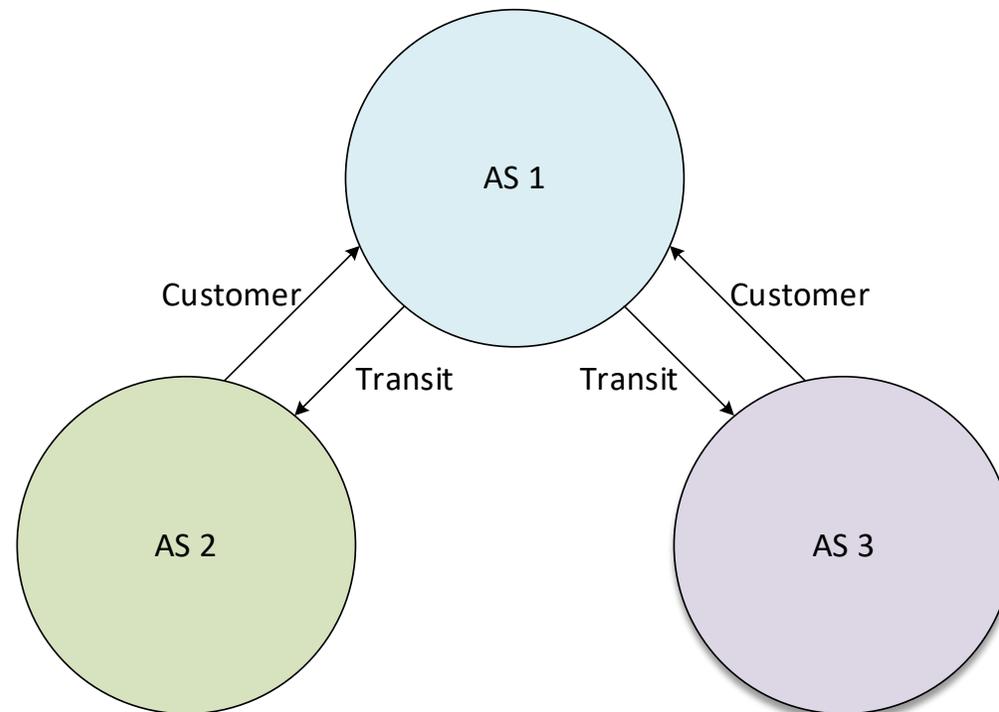
Why BGP?

- An IGP moves packets as efficiently as possible from the source to the destination within an AS
- A IGP does not worry about politics, i.e., not many routing policies can be enforced in the network
 - A corporate AS is not willing to carry traffic originating from a foreign AS, i.e., does not want to be a transit AS, however, telephone companies might be willing to carry traffic for their customers
 - Carrying commercial traffic on the educational network
 - Traffic starting or ending at Apple should not transit Google, etc.
- BGP is designed to handle all these cases and enforce routing policies between ASes

A. Tanenbaum, and D. Wetherall, "Computer Networks," Prentice-Hall international Edition, 2011

Routing Policies – Transit Service

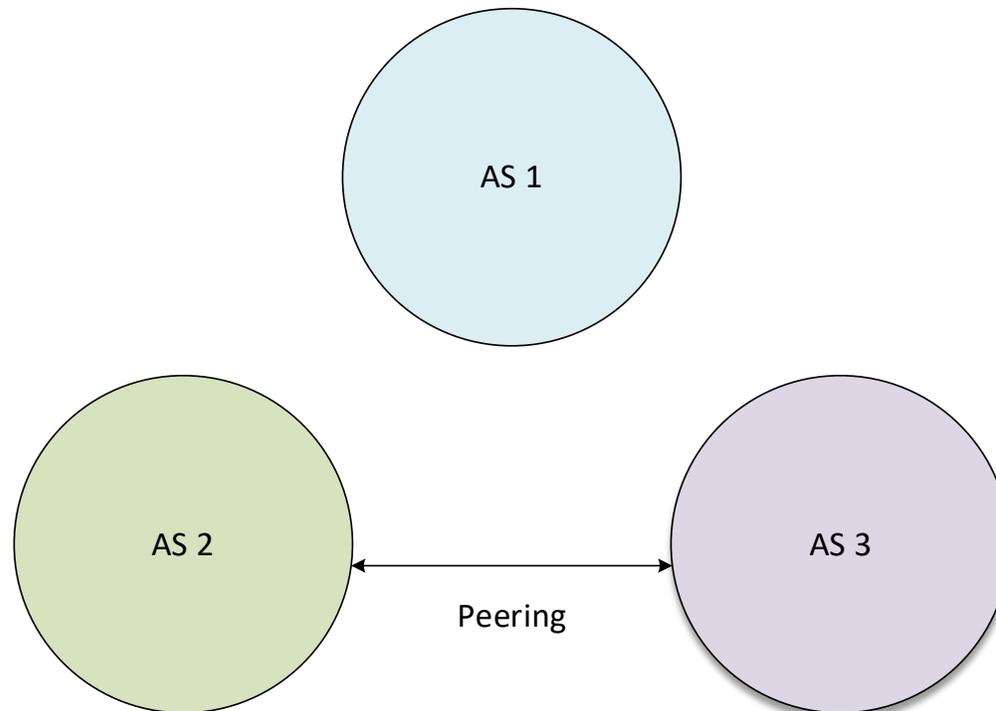
- A common routing policy is when a customer Internet Service Provider (ISP) pays another provider ISP to send and receive packets from and to any other destination in the Internet



A. Tanenbaum, and D. Wetherall, "Computer Networks," Prentice-Hall international Edition, 2011

Routing Policies – Peering

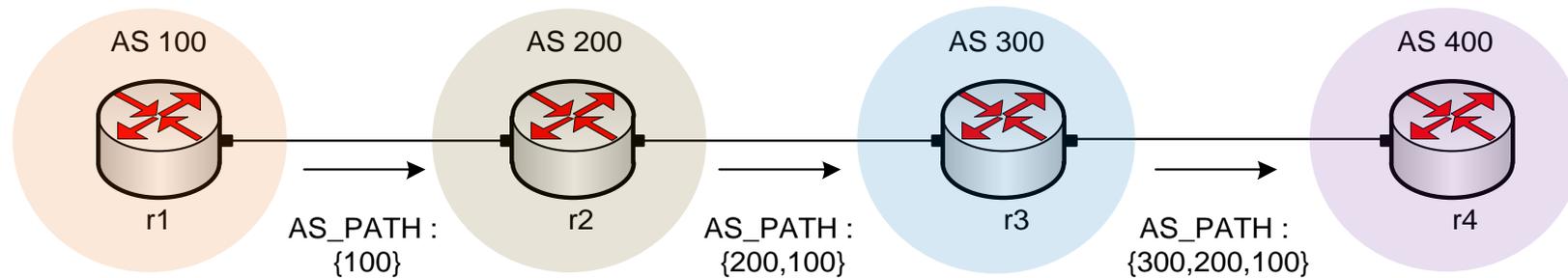
- If the ASes are already connected and they tend to exchange a lot of traffic, they can send traffic directly without having to pay for the transit service



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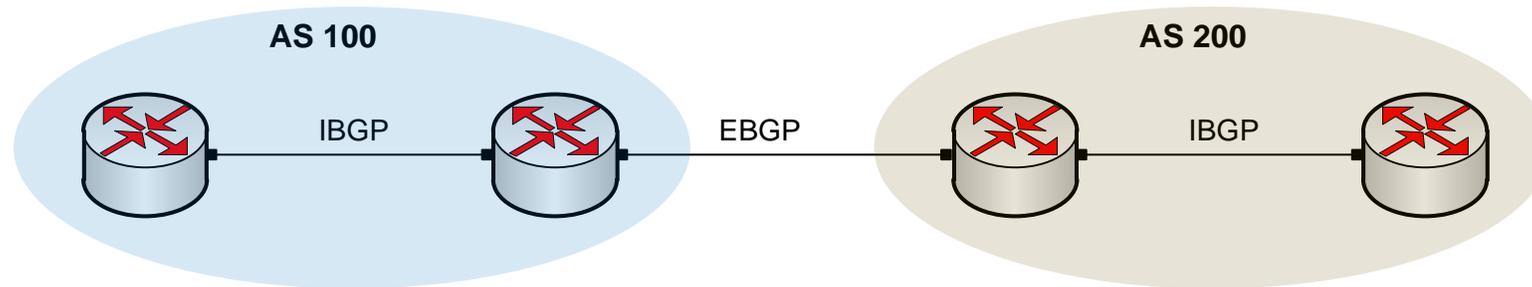
BGP Route Advertisements between ASes

- In BGP route advertisements, each border router prepends its own AS number to the route before advertising the route to the next AS



BGP Route Advertisements within an AS

- Propagating BGP route advertisements from one AS to another is referred to as External BGP (EBGP)
- Propagating BGP route advertisements within an AS is referred to as internal BGP (IBGP)



Workshop and Lab Information

Workshop and Lab Information

- Workshop website:

http://ce.sc.edu/cyberinfra/workshop_2021_wast.html

- NETLAB URL:

<https://netlab.cec.sc.edu/>

- NETLAB Credentials:

Username: **email** (example: jcrichigno@cec.sc.edu)

Password: **wastc2021** (lowercase)