CPE348: Introduction to Computer Networks

Lecture #13: Chapter 4.1

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Chapter 4 – Advanced Networking

- How do we build a system that can
  - handle hundreds of thousands of networks,
  - host billions of end nodes?
- How to enhance the functionalities of Internet?

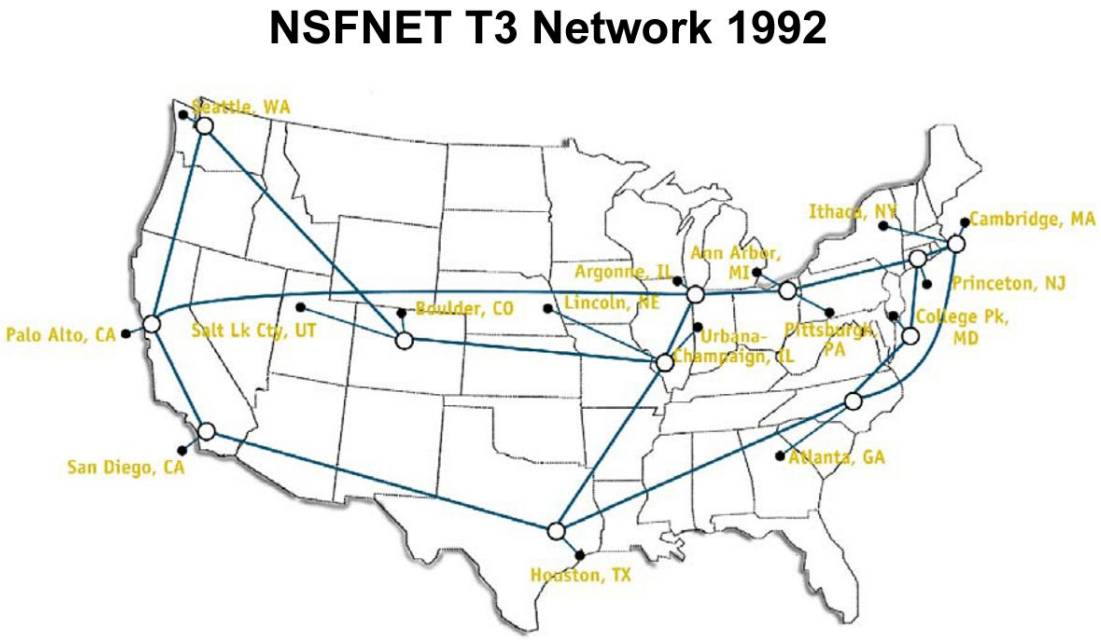
Chapter Outline

- Global Internet
- Multicast
- Mobile IP

Chapter Goal

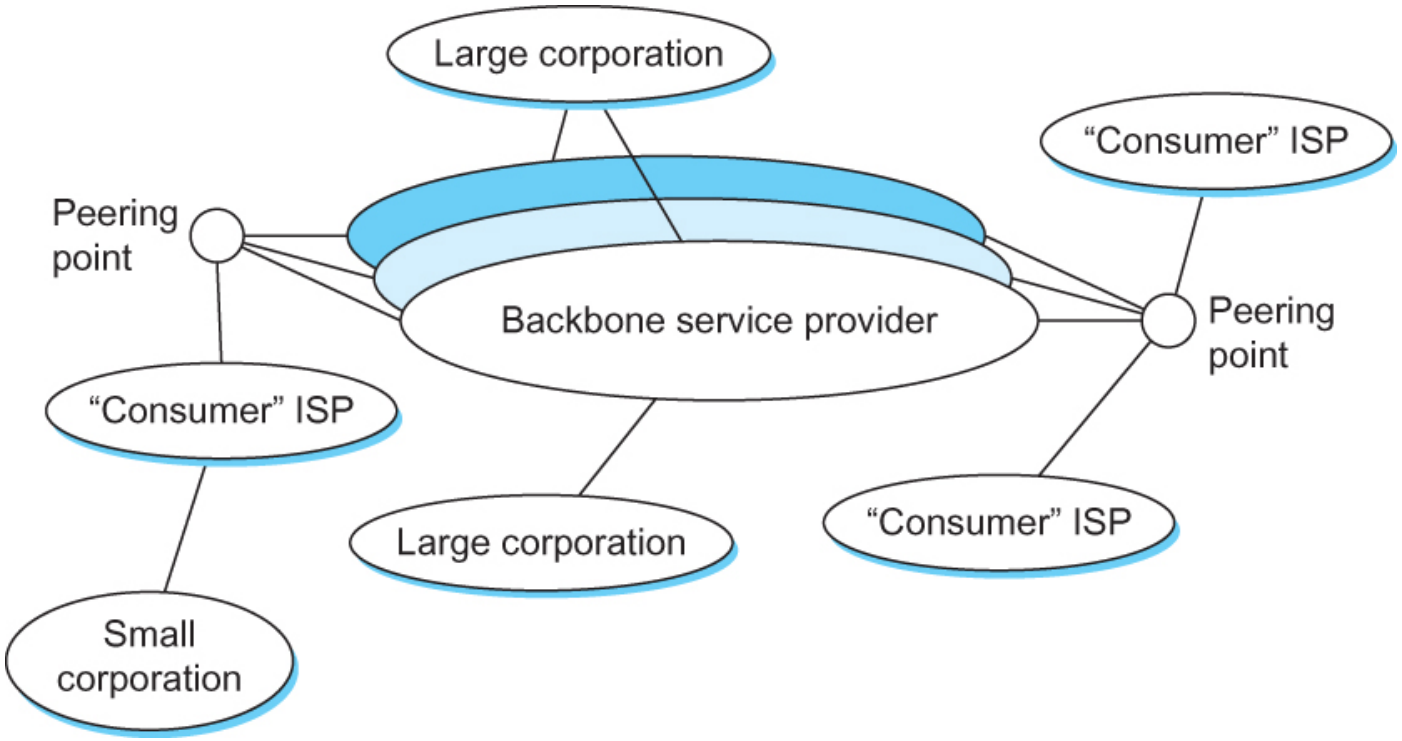
- Understanding the scalability of routing in the Internet
- Discussing IPv6
- Understanding the concept of multicasting
- Discussing Mobile IP

The Global Internet – history



National Science Foundation Network (NSFNET) program
1988-1992

The Global Internet

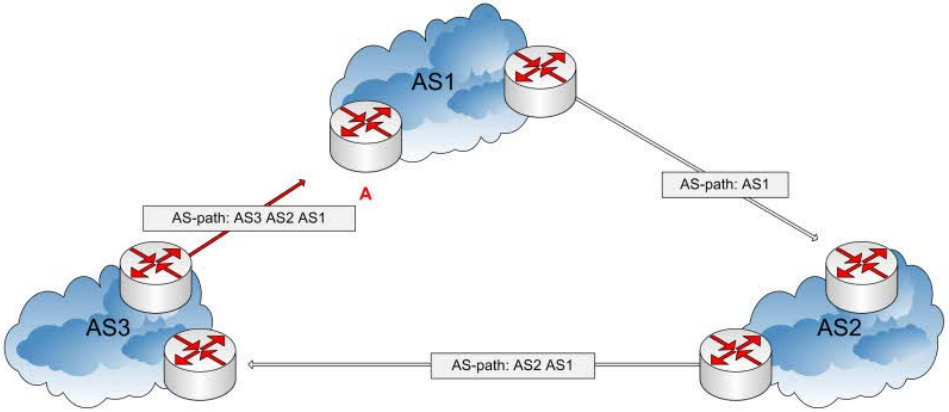


Global Internet has a tree structure and operated by multiple service providers.

Interdomain Routing

- Internet is organized by interconnected autonomous systems.

- Autonomous System (AS)
  - corresponds to an administrative domain
  - examples: University, company, backbone network



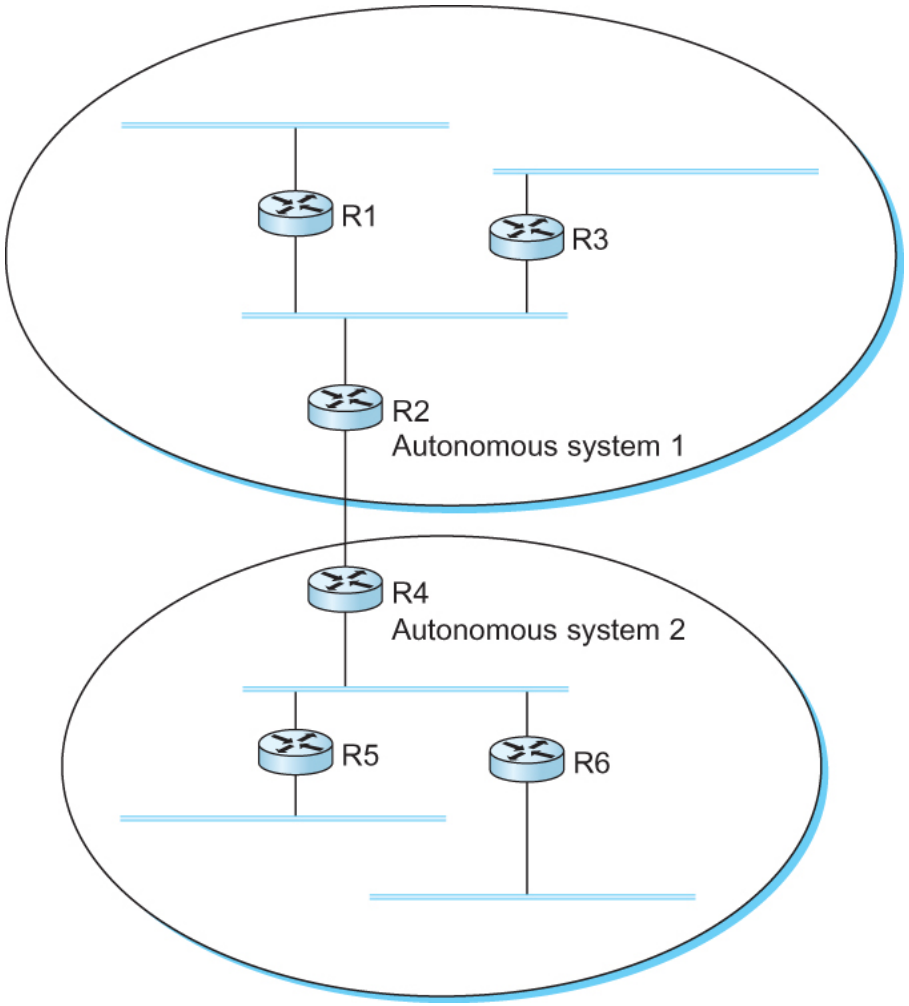
Interdomain Routing

What is the difference between a ISP and an AS?

ISP: Cogent, AT&T, etc.

AS: UAH, Intel, etc.

Interdomain Routing

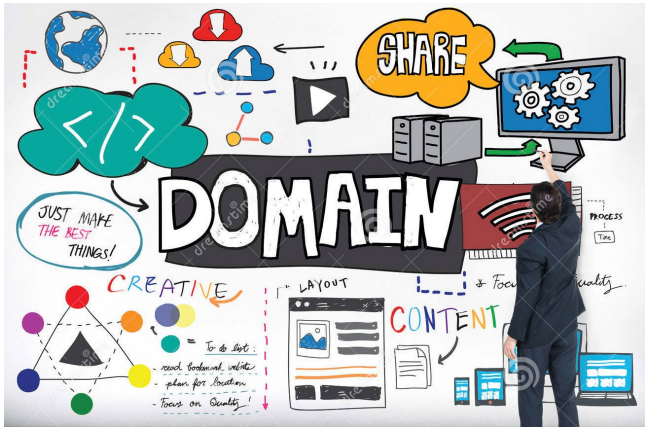


A network with two autonomous systems

Route Propagation

- Idea: a hierarchical way to disseminate routing information to a large internet.
  - Improves scalability WHY NOT if non-hierarchical?

- Divide the routing problem into:
  - Routing within a single AS - Intra-domain routing protocol
  - Routing between ASs - Inter-domain routing protocol

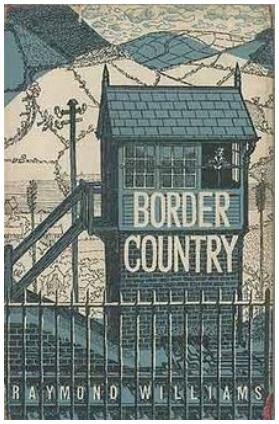


Intra-domain routing

We've studied it in the previous chapter!

Inter-domain routing

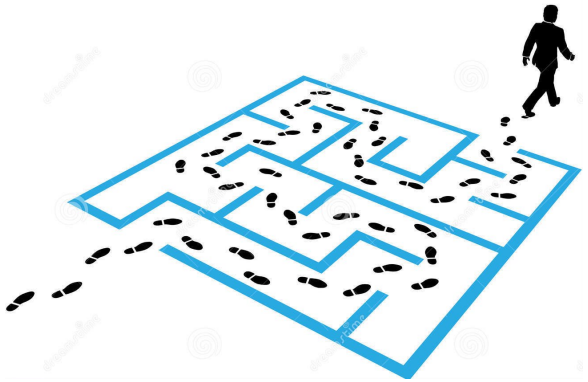
- Inter-domain Routing Protocols
  - Exterior Gateway Protocol (EGP) – first attempt
    - Forced a tree-like topology onto the Internet
    - Did not allow for the topology to become general
      - Tree-like structure: a single backbone and ASs are connected only as parents and children and not as peers.
  - Border Gateway Protocol (BGP) – replaces EGP
    - Assumes that the Internet is an arbitrarily interconnected set of ASs.



BGP: Border Gateway Protocol

The goal of BGP

- To find one path to the dest. that is loop free
  - Reachability more than Optimality
  - Optimal path is hard to find. WHY?



BGP: Border Gateway Protocol

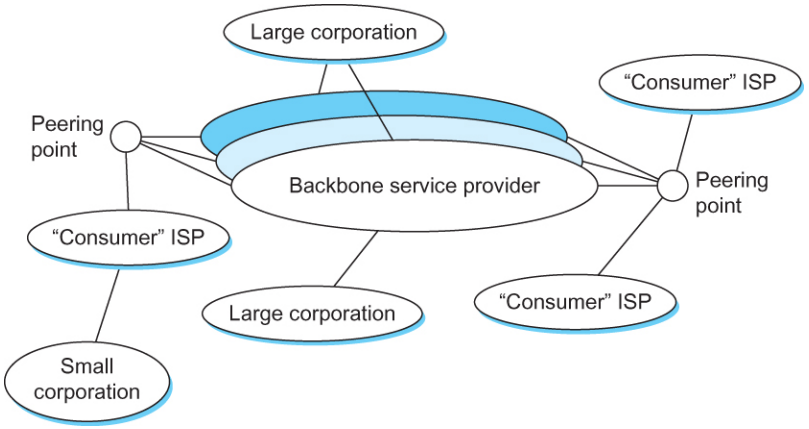
Design foundations for BGP:

- Define local traffic as traffic that originates at or terminates on nodes within an AS.
- Define transit traffic as traffic that passes through an AS.

BGP: Border Gateway Protocol

Depending on the traffic type:

- *Stub AS*: only connect to one other AS; only carry local traffic (e.g., *small corporation*).
-
- *Multihomed AS*: connect to more than one other AS; only carry local traffic (e.g., *large corporation*)
- *Transit AS*: connect to more than one other AS; carry both transit and local traffic (e.g., *backbone providers)*



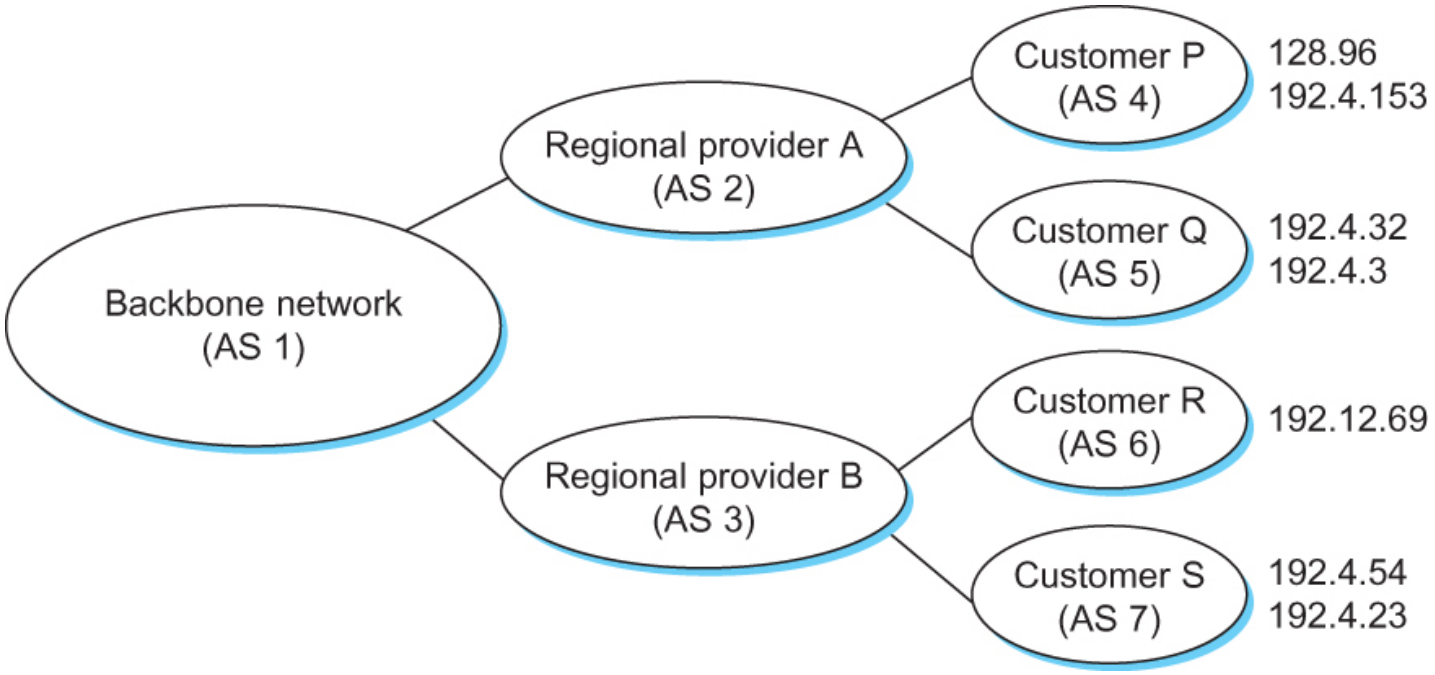
BGP: Border Gateway Protocol

Each AS has:

- One BGP *speaker* that advertises:
  - local networks
  - other reachable networks (transit AS only)
  - gives *path* information – uses a path vector
- One or more *border gateways*
  - routers through which packets enter and leave the AS

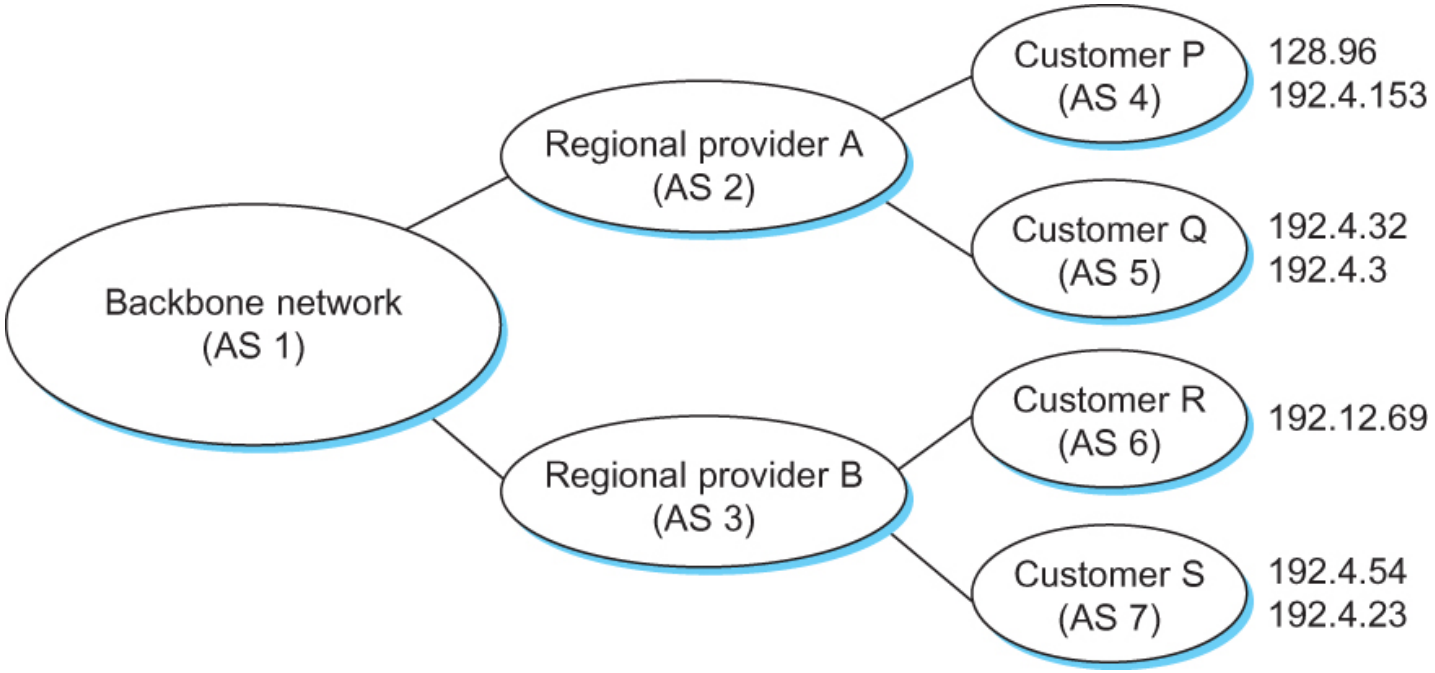
BGP: Example

- Speaker for AS 2 advertises reachability to
  - Networks 128.96, 192.4.153, 192.4.32, and 192.4.3, directly from AS 2.

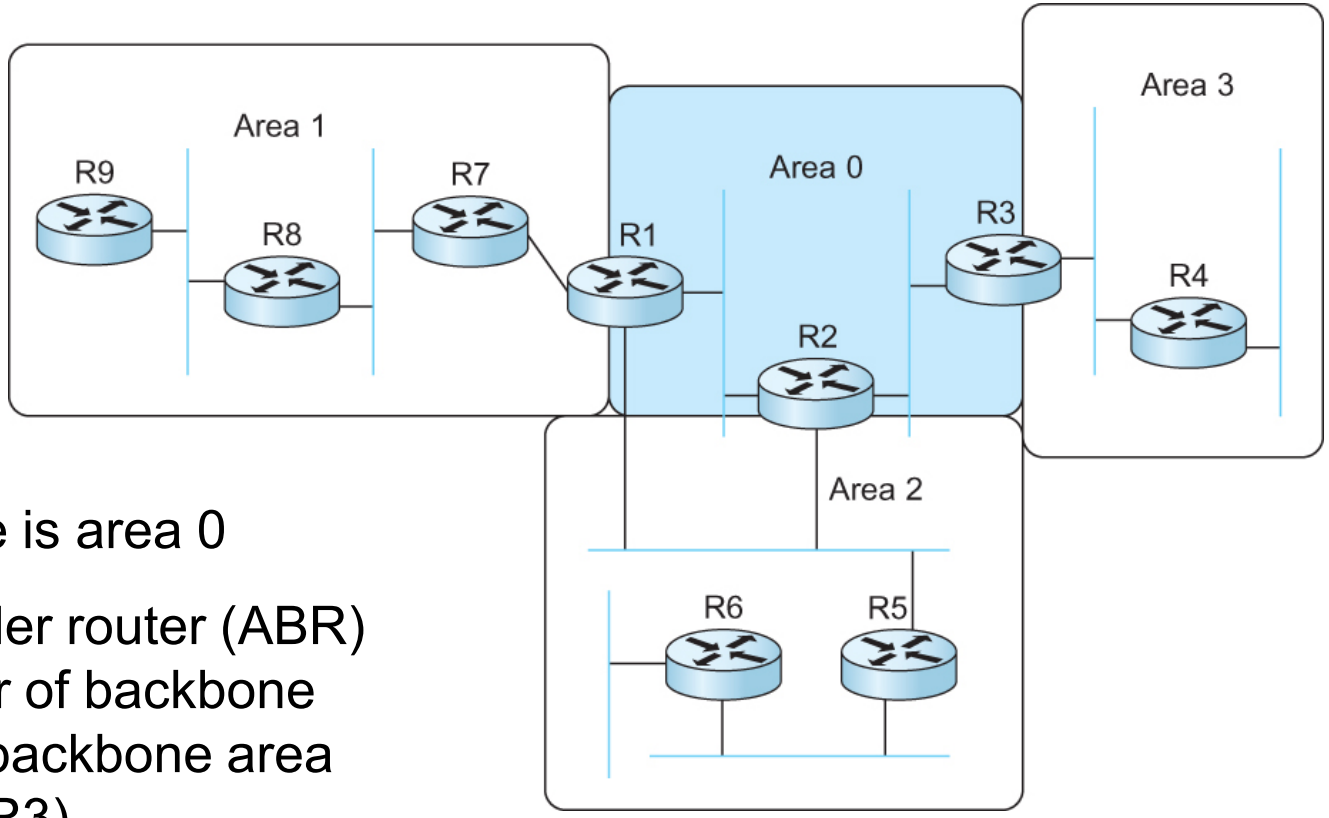


BGP: Example

- Speaker for AS 1 advertises reachability to
  - Networks 128.96, 192.4.153, 192.4.32, and 192.4.3 along the path <AS 1, AS 2>.



BGP: router area



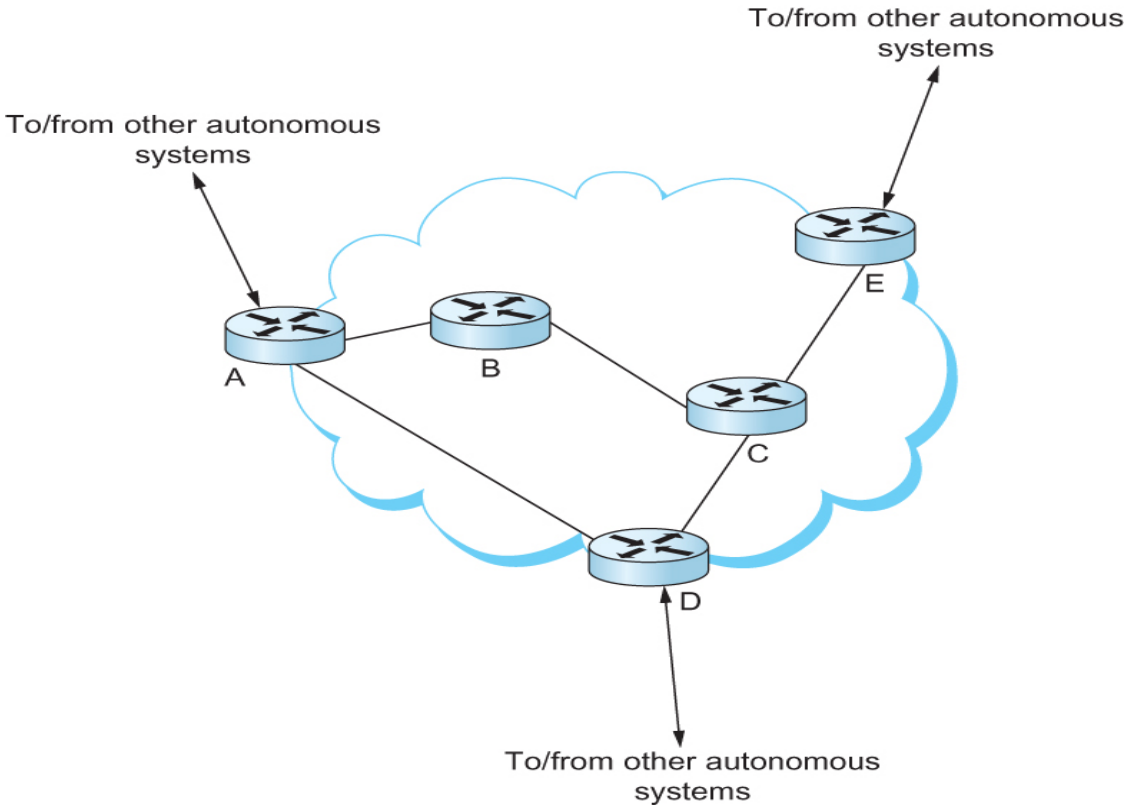
Backbone is area 0

Area border router (ABR) – member of backbone and non-backbone area (R1, R2, R3)

ABR's send other areas link-state information on all networks in their area

A domain divided into areas

Integrating Interdomain and Intradomain Routing



All routers run iBGP (interior BGP) to border routers;

Border routers (A, D, E) also run eBGP (Exterior BGP) to other ASs.

Integrating Interdomain and Intradomain Routing

Prefix	BGP Next Hop
18.0/16	E
12.5.5/24	A
128.34/16	D
128.69./16	A

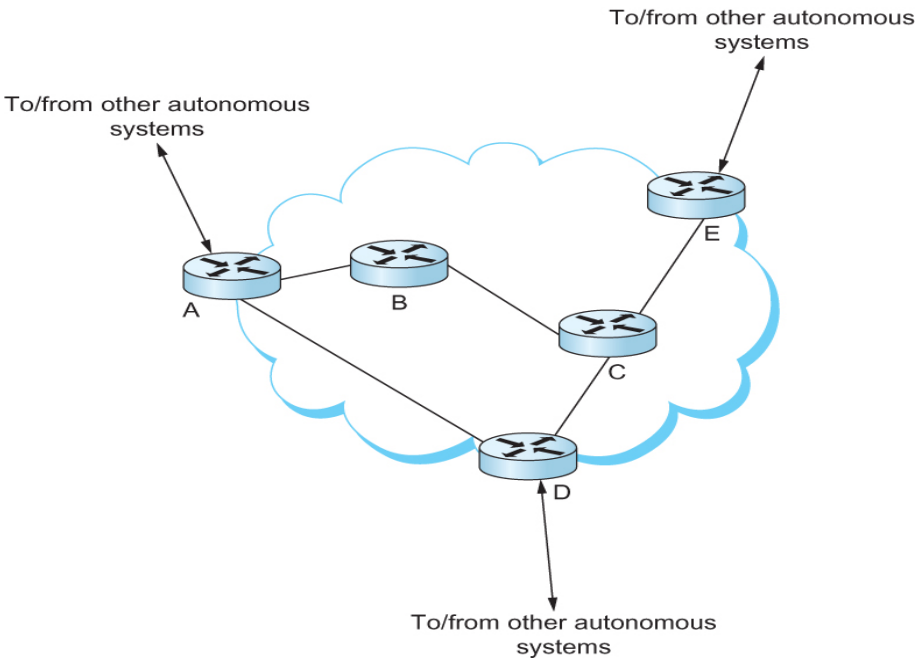
BGP table for the AS

Router	IGP Path
A	A
C	C
D	C
E	C

IGP table for router B

Prefix	IGP Path
18.0/16	C
12.5.5/24	A
128.34/16	C
128.69./16	A

Combined table for router B



BGP routing table, IGP(IBGP) routing table, and combined table at router B

Further Reading

Keycdn: https://tools.keycdn.com/bgp-looking-glass

Ping, DNS lookup, BGP looking glass, etc.

Cogent: http://www.cogentco.com/en/network/looking-glass

Internet service provider

Its served ASs, network map, BGP looking glass, etc.