CS144
An Introduction to Computer Networks

Routing

Routing in the Internet

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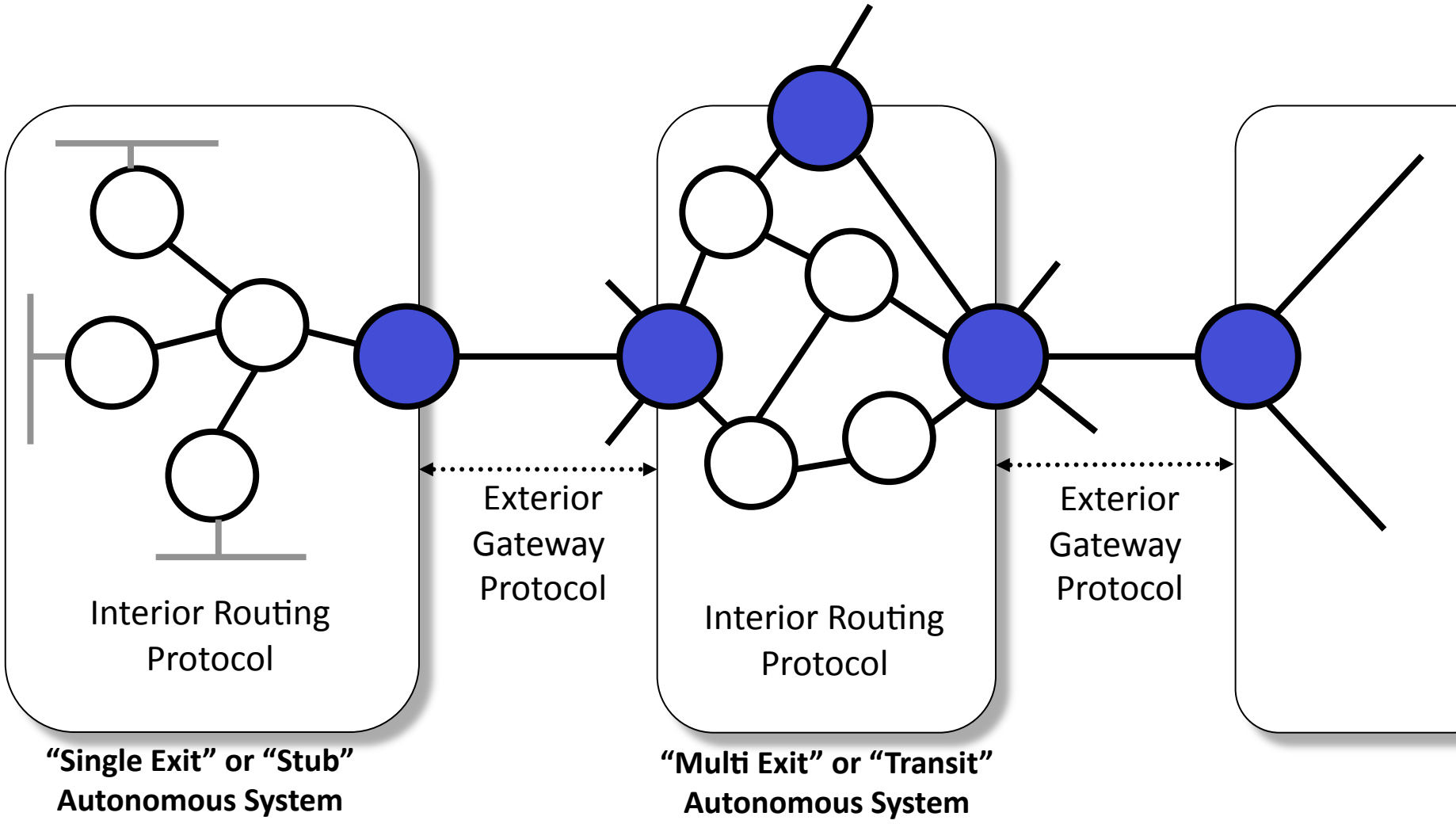
Outline

Hierarchy and Autonomous Systems (AS)

Interior Routing Protocols

The structure of the Internet

Hierarchy in the Internet



Autonomous Systems

The basic unit of hierarchy in the Internet.

- Within an AS, the owner decides how routing is done
- Between AS's, must use BGP-4 (Border Gateway Protocol, v4)*

Finding an AS number

- Query DNS to find IP address at Stanford: `dig stanford.edu`
  Returns: "`stanford.edu  1800 IN A 171.64.13.26`"
- Find AS for IP address: `nc whois.cymru.com 43`
  Enter: `171.64.13.26`
- Stanford (32), AT&T (797), Google (15169, 22859, 36039)
- `traceroute –a <destination>` will report AS numbers.

*Internet RFC 1771

Interior Routing Protocols

RIP

- Uses distance vector (distributed Bellman-Ford algorithm).
- Internet RFC 2453
- Updates sent every 30 seconds.
- No authentication for updates.
- Originally in BSD UNIX, `routed`.
- Widely used for many years; used less now.

OSPF

- Link-state updates sent (using flooding) as and when required.
- Internet RFC 2328
- Every router runs Dijkstra's algorithm.
- Authenticated updates.
- Autonomous system may be partitioned into "areas".
- Widely used, complex.
- IS-IS (RFC 1142) is similar, and is also widely used.

Routing to a single exit point

There is only one exit point, so routers within the AS can use *default routing*.

- Each router knows all prefixes within AS.
- Packets for another AS are sent to the default router.
- Default router is the border gateway to the next AS.

Routing tables in single exit AS's tend to be small.

Routing to multiple exit points

Used by multi-homed enterprises and transit AS's.

Each internal router must be told which exit point to use for a given destination prefix.

Requires large routing tables to route to every prefix.

Approach 1: Hot-potato routing – send to closest exit.

Approach 2: Pick exit closest to destination.

Exterior Routing Protocol

Every AS must interconnect using BGP-4.

Problems BGP-4 designed to solve

- Topology: The Internet is a complex mesh of different AS's with very little structure.
- Autonomy of AS's: Each AS defines link costs in different ways, so not possible to find lowest cost paths.
- Trust: Some AS's can't trust others to advertise good routes (e.g. two competing backbone providers), or to protect the privacy of their traffic (e.g. two warring nations).
- Policies: Different AS's have different objectives (e.g. route over fewest hops; use one provider rather than another).

Internet structure

Summary

The Internet consists of multiple AS's, each managed independently.

An AS runs its own interior routing protocol.

Stub AS's use simple default routing.

AS's with multiple exits must decide the best exit.

AS's must connect using the BGP-4 protocol.