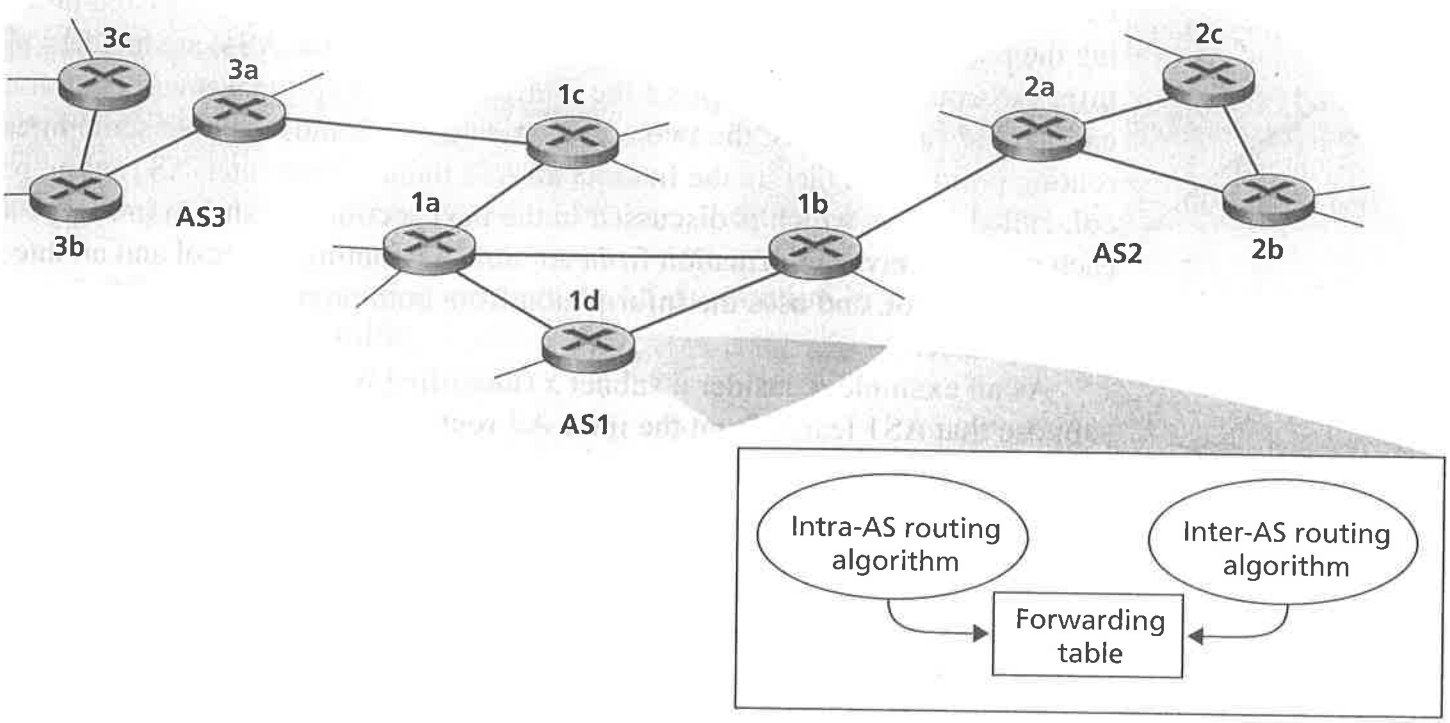


ure 4.32 ♦ An example of interconnected autonomous systems

rnal router knows how it should forward the packet. The gateway router, upon iving the packet, forwards the packet on the one link that leads outside the The AS on the other side of the link then takes over the responsibility outing the packet to its ultimate destination. As an example, suppose router n Figure 4.32 receives a packet whose destination is outside of AS2. Router vill then forward the packet to either router 2a or 2c, as specified by router forwarding table, which was configured by AS2's intra-AS routing protocol. packet will eventually arrive to the gateway router 2a, which will forward packet to 1b. Once the packet has left 2a, AS2's job is done with this one ket.

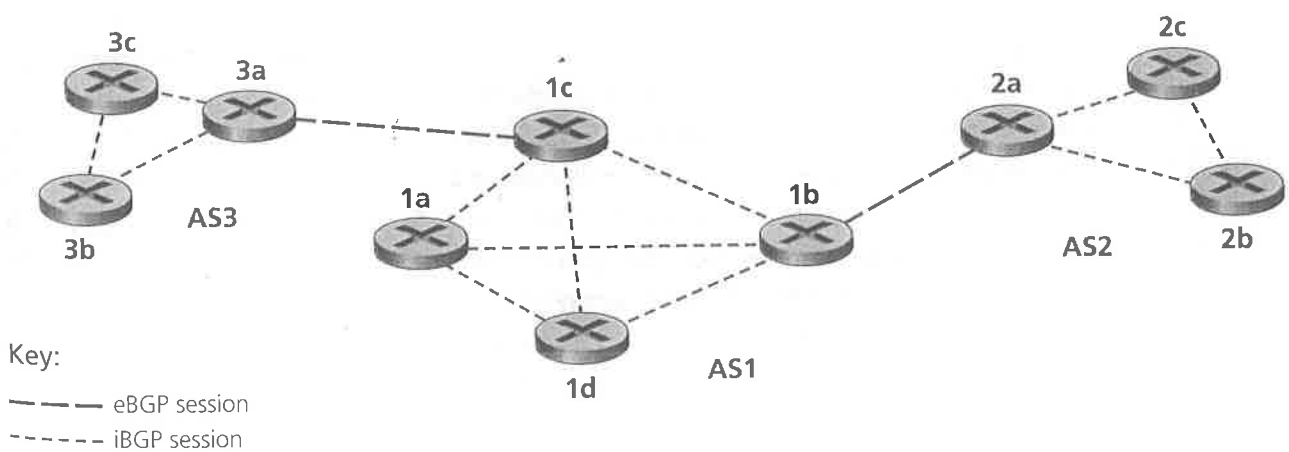
So the problem is easy when the source AS has only one link that leads outside AS. But what if the source AS has two or more links (through two or more gate- routers) that lead outside the AS? Then the problem of knowing where to for- d the packet becomes significantly more challenging. For example, consider a er in AS1 and suppose it receives a packet whose destination is outside the AS. router should clearly forward the packet to one of its two gateway routers, 1b or out which one? To solve this problem, AS1 needs (1) to learn which destinations reachable via AS2 and which destinations are reachable via AS3, and (2) to pagate this reachability information to all the routers within AS1, so that each er can configure its forwarding table to handle external-AS destinations. These st importantly, BGP allows each subnet to advertise its existence to the rest of Internet. A subnet screams "I exist and I am here," and BGP makes sure that all ASs in the Internet know about the subnet and how to get there. If it weren't for P, each subnet would be isolated—alone and unknown by the rest of the Internet.

P Basics

VideoNote
Gluing the Internet together

P is extremely complex; entire books have been devoted to the subject and many es are still not well understood [Yannuzzi 2005]. Furthermore, even after having l the books and RFCs, you may find it difficult to fully master BGP without hav- practiced BGP for many months (if not years) as a designer or administrator of ıpper-tier ISP. Nevertheless, because BGP is an absolutely critical protocol for Internet—in essence, it is the protocol that glues the whole thing together—we d to acquire at least a rudimentary understanding of how it works. We begin by cribing how BGP might work in the context of the simple example network we lied earlier in Figure 4.32. In this description, we build on our discussion of hier- hical routing in Section 4.5.3; we encourage you to review that material.

In BGP, pairs of routers exchange routing information over semipermanent P connections using port 179. The semi-permanent TCP connections for the net- rk in Figure 4.32 are shown in Figure 4.40. There is typically one such BGP TCP ınection for each link that directly connects two routers in two different ASs; s, in Figure 4.40, there is a TCP connection between gateway routers 3a and 1c l another TCP connection between gateway routers 1b and 2a. There are also nipermanent BGP TCP connections between routers within an AS. In particular, ure 4.40 displays a common configuration of one TCP connection for each pair routers internal to an AS, creating a mesh of TCP connections within each AS. r each TCP connection, the two routers at the end of the connection are called **GP peers**, and the TCP connection along with all the BGP messages sent over the



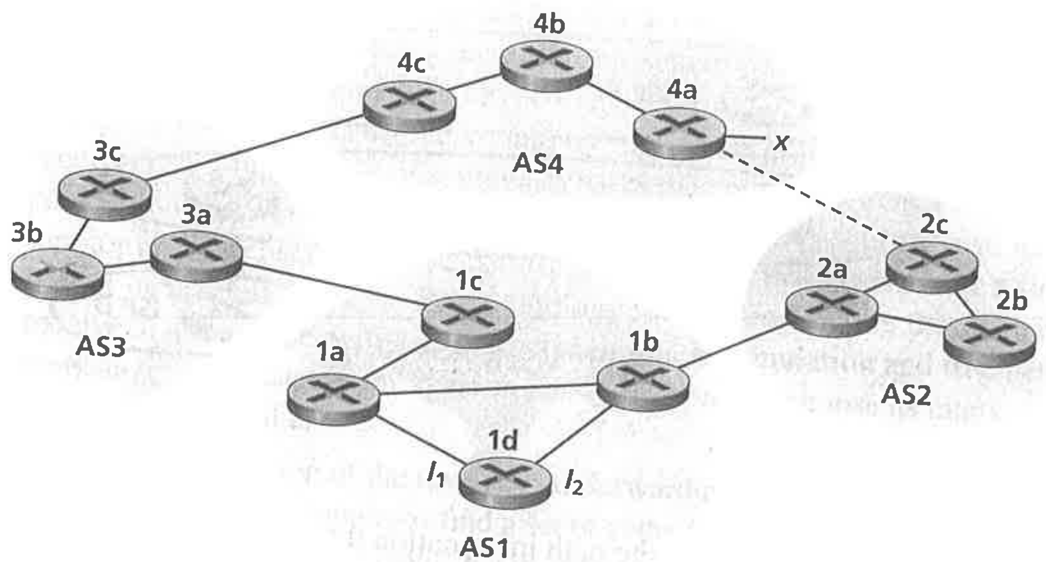
igure 4.40 ♦ eBGP and iBGP sessions

a. Router 3c learns about prefix x from which routing protocol: OSPF, RIP, eBGP, or iBGP?

b. Router 3a learns about x from which routing protocol?

c. Router 1c learns about x from which routing protocol?

d. Router 1d learns about x from which routing protocol?



P38. Referring to the previous problem, once router 1d learns about x it will put an entry (x, I) in its forwarding table.

a. Will I be equal to I_1 or I_2 for this entry? Explain why in one sentence.

b. Now suppose that there is a physical link between AS2 and AS4, shown by the dotted line. Suppose router 1d learns that x is accessible via AS2 as well as via AS3. Will I be set to I_1 or I_2? Explain why in one sentence.

c. Now suppose there is another AS, called AS5, which lies on the path between AS2 and AS4 (not shown in diagram). Suppose router 1d learns that x is accessible via AS2 AS5 AS4 as well as via AS3 AS4. Will I be set to I_1 or I_2? Explain why in one sentence.

P39. Consider the following network. ISP B provides national backbone service to regional ISP A. ISP C provides national backbone service to regional ISP D. Each ISP consists of one AS. B and C peer with each other in two places using BGP. Consider traffic going from A to D. B would prefer to hand that traffic over to C on the West Coast (so that C would have to absorb the cost of carrying the traffic cross-country), while C would prefer to get the traffic via its East Coast peering point with B (so that B would have carried the traffic across the country). What BGP mechanism might C use, so that B would hand over A-to-D traffic at its East Coast