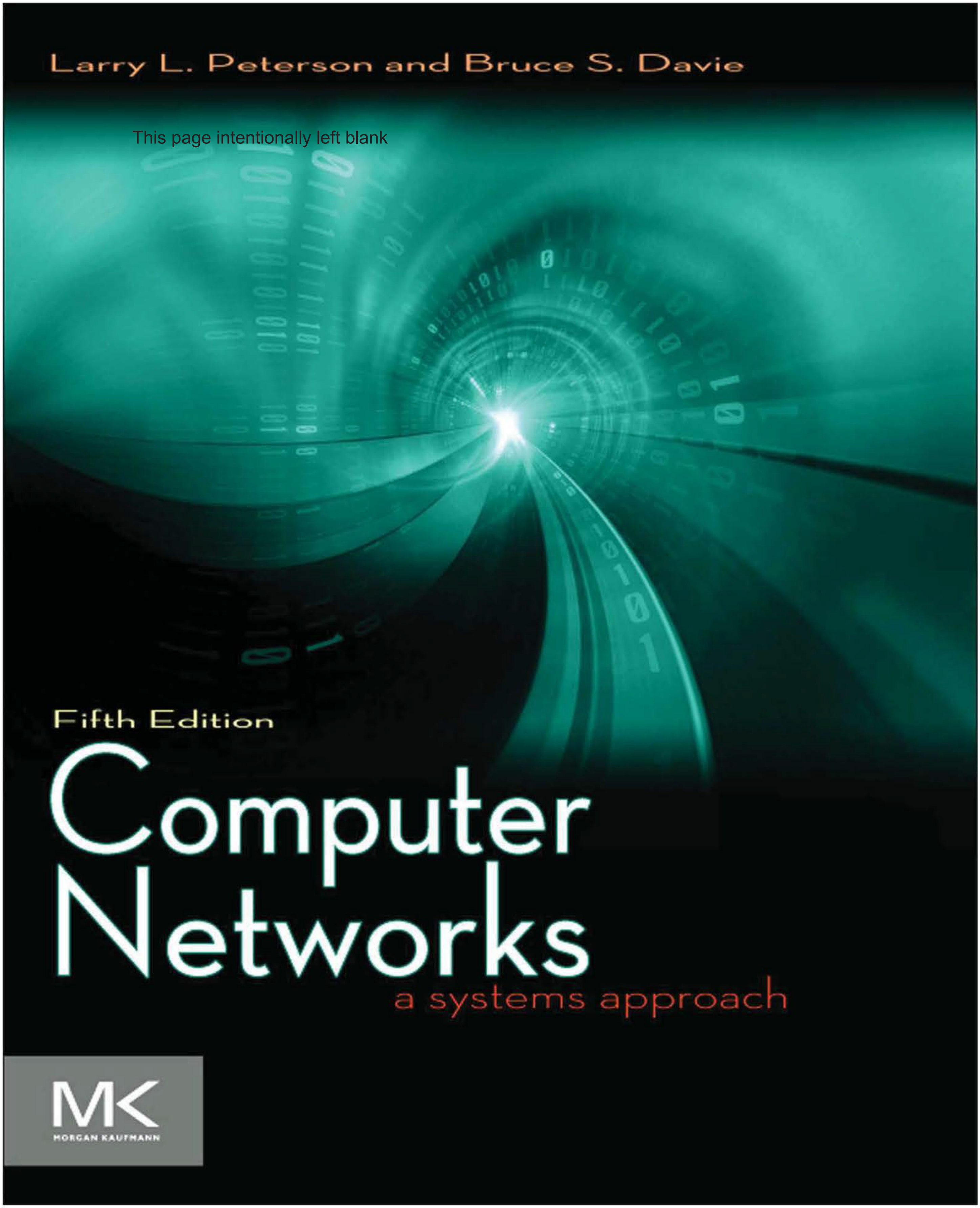
Larry L. Peterson and Bruce S. Davie
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autonomous systems. It is common to find that border routers are also BGP speakers, but that does not have to be the case.

BGP does not belong to either of the two main classes of routing protocols (distance-vector and link-state protocols) described in Section 3.3. Unlike these protocols, BGP advertises *complete paths* as an enumerated list of autonomous systems to reach a particular network. It is sometimes called a *path-vector* protocol for this reason. The advertisement of complete paths is necessary to enable the sorts of policy decisions described above to be made in accordance with the wishes of a particular AS. It also enables routing loops to be readily detected.

To see how this works, consider the very simple example network in Figure 4.5. Assume that the providers are transit networks, while the customer networks are stubs. A BGP speaker for the AS of provider A (AS 2) would be able to advertise reachability information for each of the network numbers assigned to customers P and Q. Thus, it would say, in effect, "The networks 128.96, 192.4.153, 192.4.32, and 192.4.3 can be reached directly from AS 2." The backbone network, on receiving this advertisement, can advertise, "The networks 128.96, 192.4.153, 192.4.32, and 192.4.3 can be reached along the path ⟨AS 1, AS 2⟩." Similarly, it could advertise, "The networks 192.12.69, 192.4.54, and 192.4.23 can be reached along the path ⟨AS 1, AS 3⟩."

An important job of BGP is to prevent the establishment of looping paths. For example, consider the network illustrated in Figure 4.6. It differs from Figure 4.5 only in the addition of an extra link between AS 2

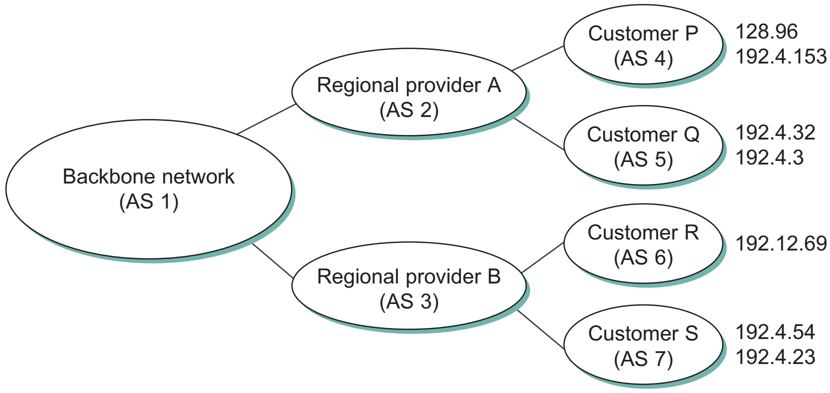

FIGURE 4.5 Example of a network running BGP.

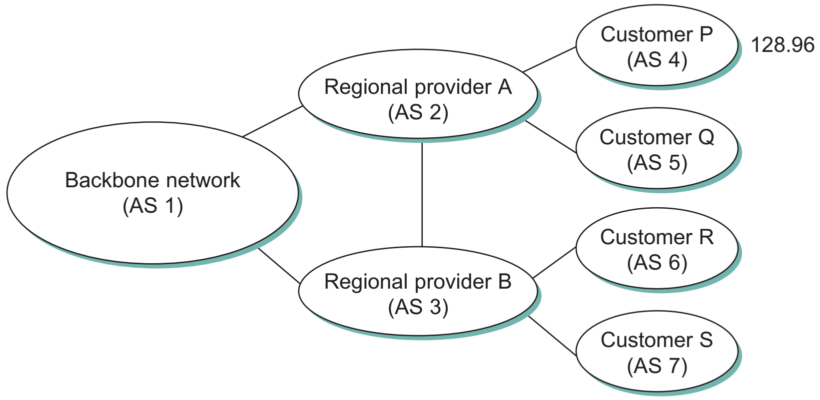

FIGURE 4.6 Example of loop among autonomous systems.

and AS 3, but the effect now is that the graph of autonomous systems has a loop in it. Suppose AS 1 learns that it can reach network 128.96 through AS 2, so it advertises this fact to AS 3, who in turn advertises it back to AS 2. In the absence of any loop prevention mechanism, AS 2 could now decide that AS 3 was the preferred route for packets destined for 128.96. If AS 2 starts sending packets addressed to 128.96 to AS 3, AS 3 would send them to AS 1; AS 1 would send them back to AS 2; and they would loop forever. This is prevented by carrying the complete AS path in the routing messages. In this case, the advertisement for a path to 128.96 received by AS 2 from AS 3 would contain an AS path of ⟨AS 3, AS 1, AS 2, AS 4⟩. AS 2 sees itself in this path, and thus concludes that this is not a useful path for it to use.

In order for this loop prevention technique to work, the AS numbers carried in BGP clearly need to be unique. For example, AS 2 can only recognize itself in the AS path in the above example if no other AS identifies itself in the same way. AS numbers have until recently been 16-bit numbers, and they are assigned by a central authority to assure uniqueness. While 16 bits only allows about 65,000 autonomous systems, which might not seem like a lot, we note that a stub AS does not need a unique AS number, and this covers the overwhelming majority of nonprovider networks.[2]

[2]32-bit AS numbers have also been defined and came into use around 2009, thus ensuring that AS number space will not become a scarce resource.