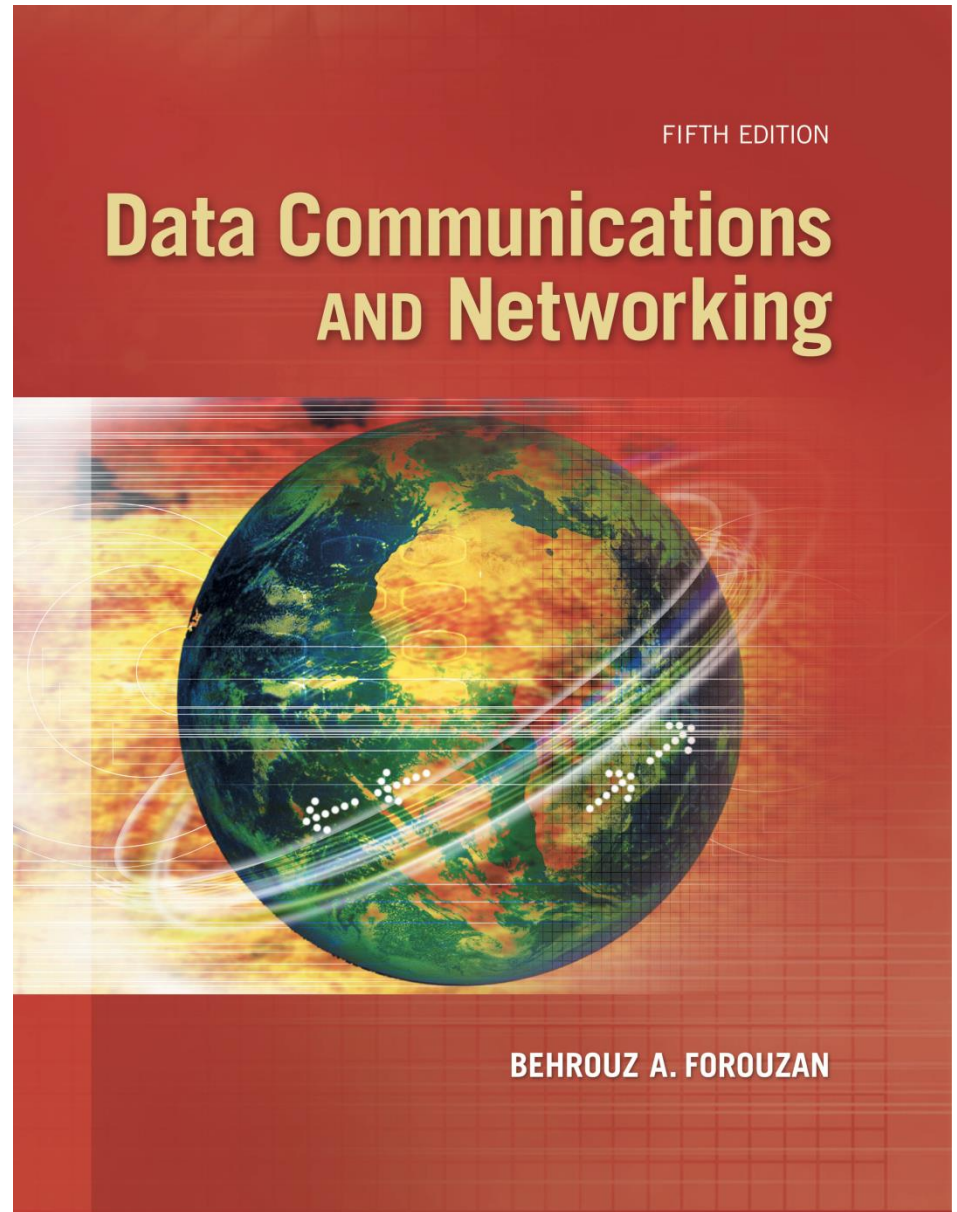
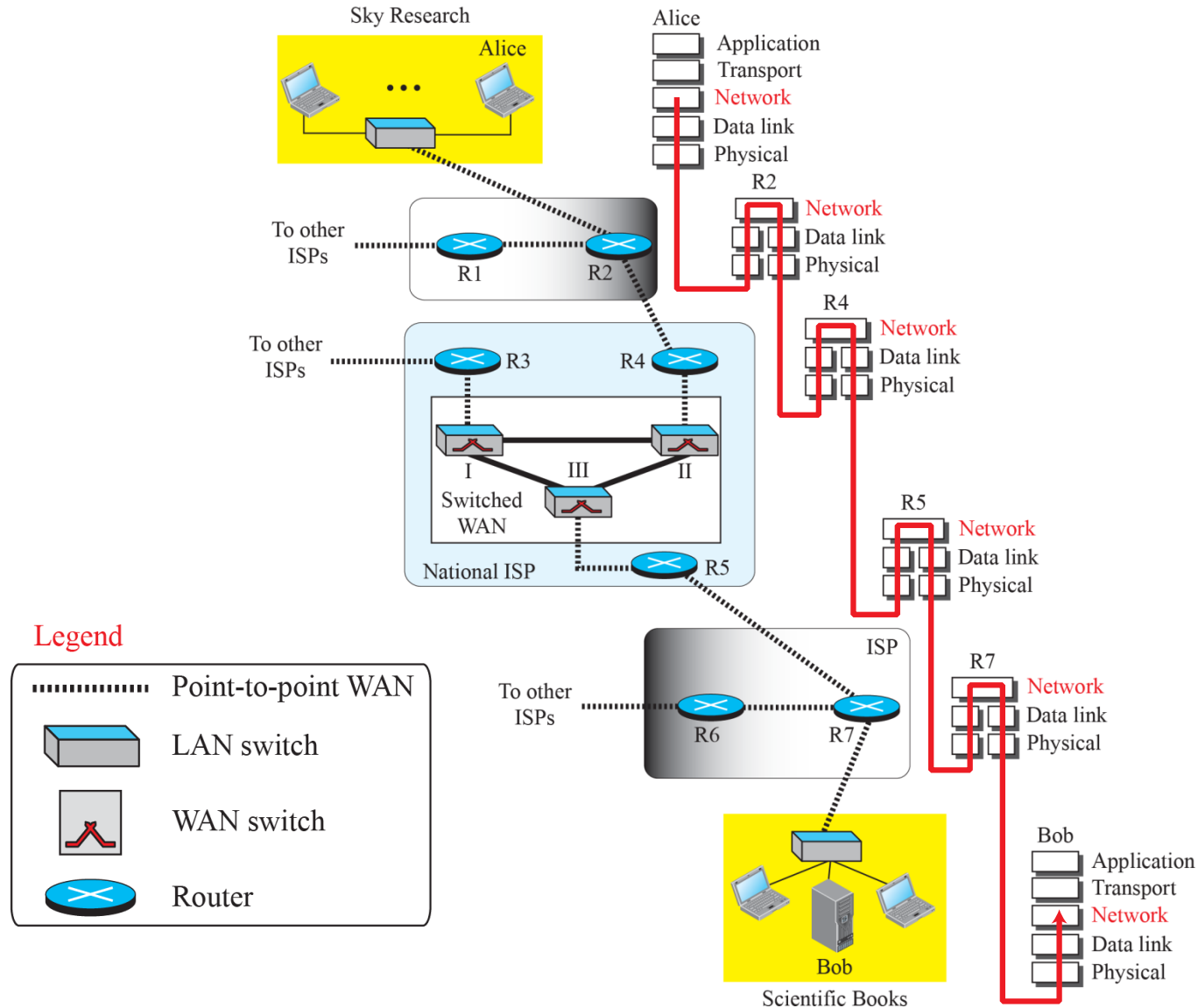


# *Chapter 18*

## *Introduction to Network Layer*



# Communication at the Network Layer



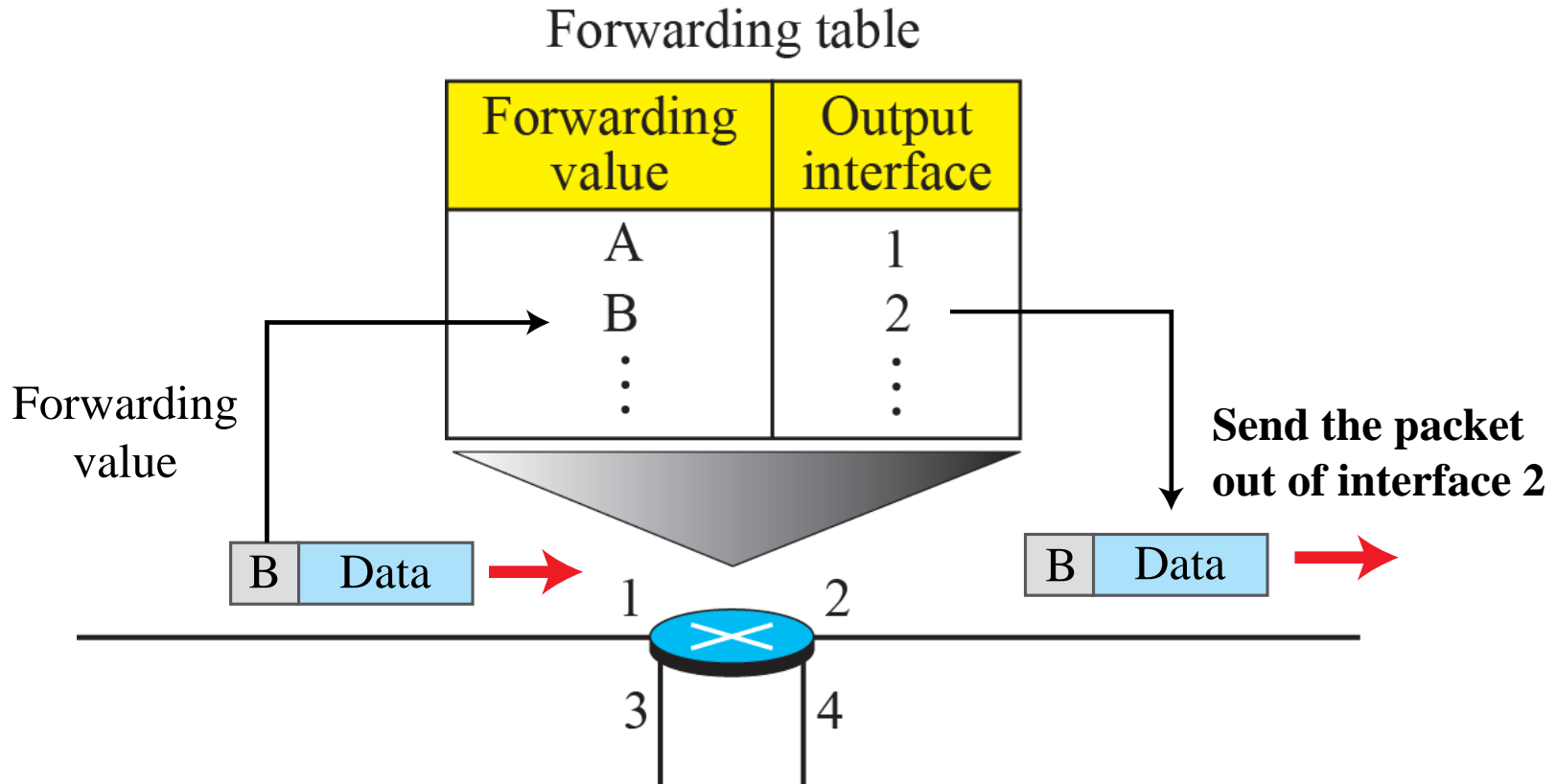
# *Packetizing*

- *Encapsulating the payload in a network-layer packet at the source and decapsulating the payload from the network-layer packet at the destination.*
- *In other words, one duty of the network layer is to carry a payload from the source to the destination without changing it or using it.*
- *The network layer is doing the service of a carrier such as the postal office, which is responsible for delivery of packages from a sender to a receiver without changing or using the contents.*

# *Main Duties*

- *Routing*
- *Forwarding*

# *Forwarding Process*



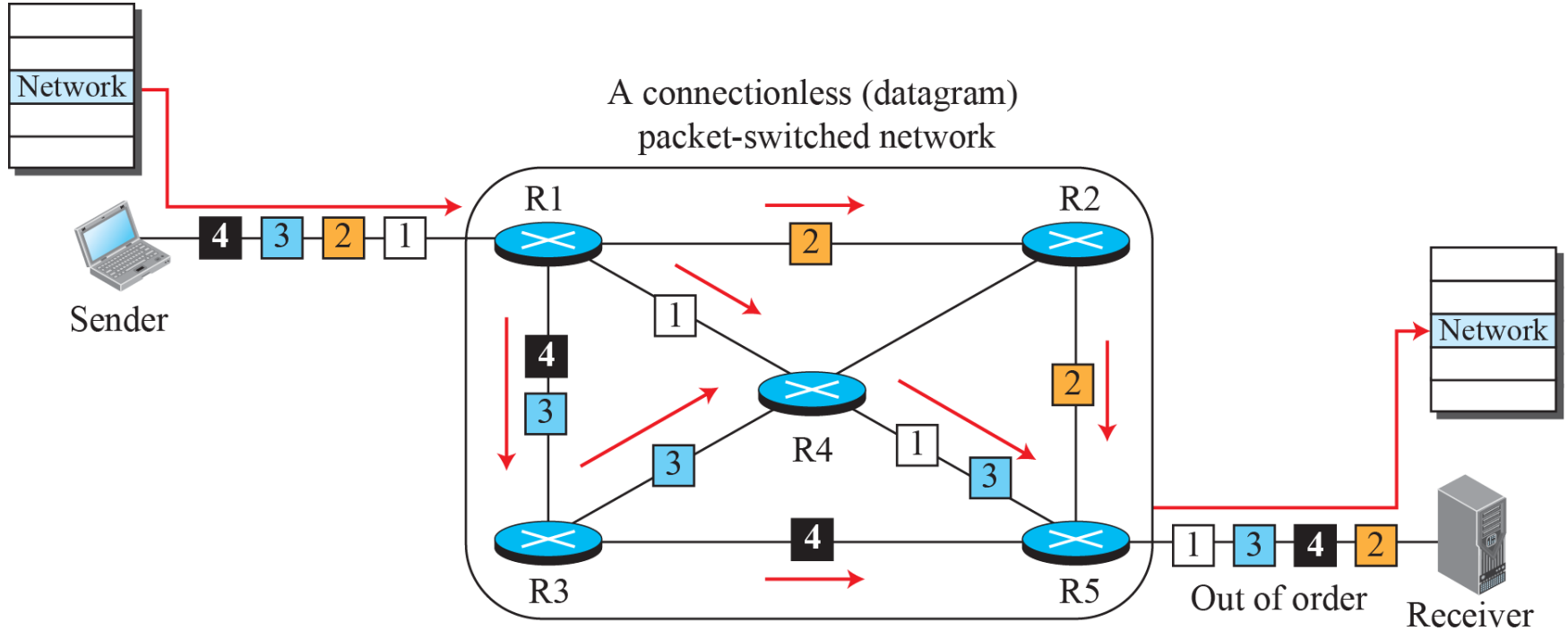
# *Packet Switching*

- *Switching occurs at the network layer.*
- *A router is a switch that creates a connection between an input port and an output port (or a set of output ports)*

# ***Datagram Approach: Connectionless***

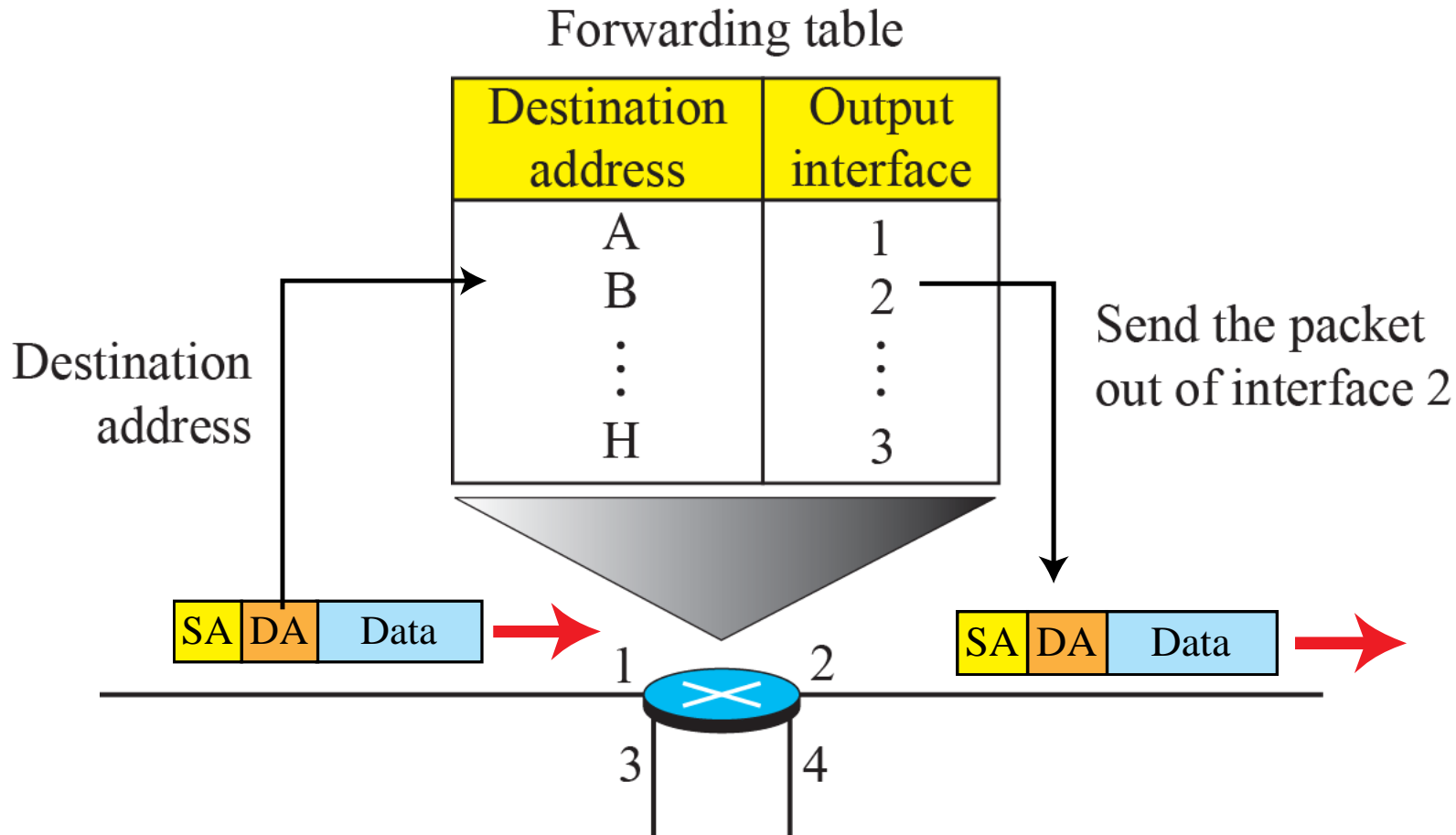
- *The network layer was designed to provide a connectionless service in which the network-layer protocol treats each packet independently, with each packet having no relationship to any other packet.*
- *The idea was that the network layer is only responsible for delivery of packets from the source to the destination.*
- *In this approach, the packets in a message may or may not travel the same path to their destination.*

# *A Connectionless Packet Switched Network*





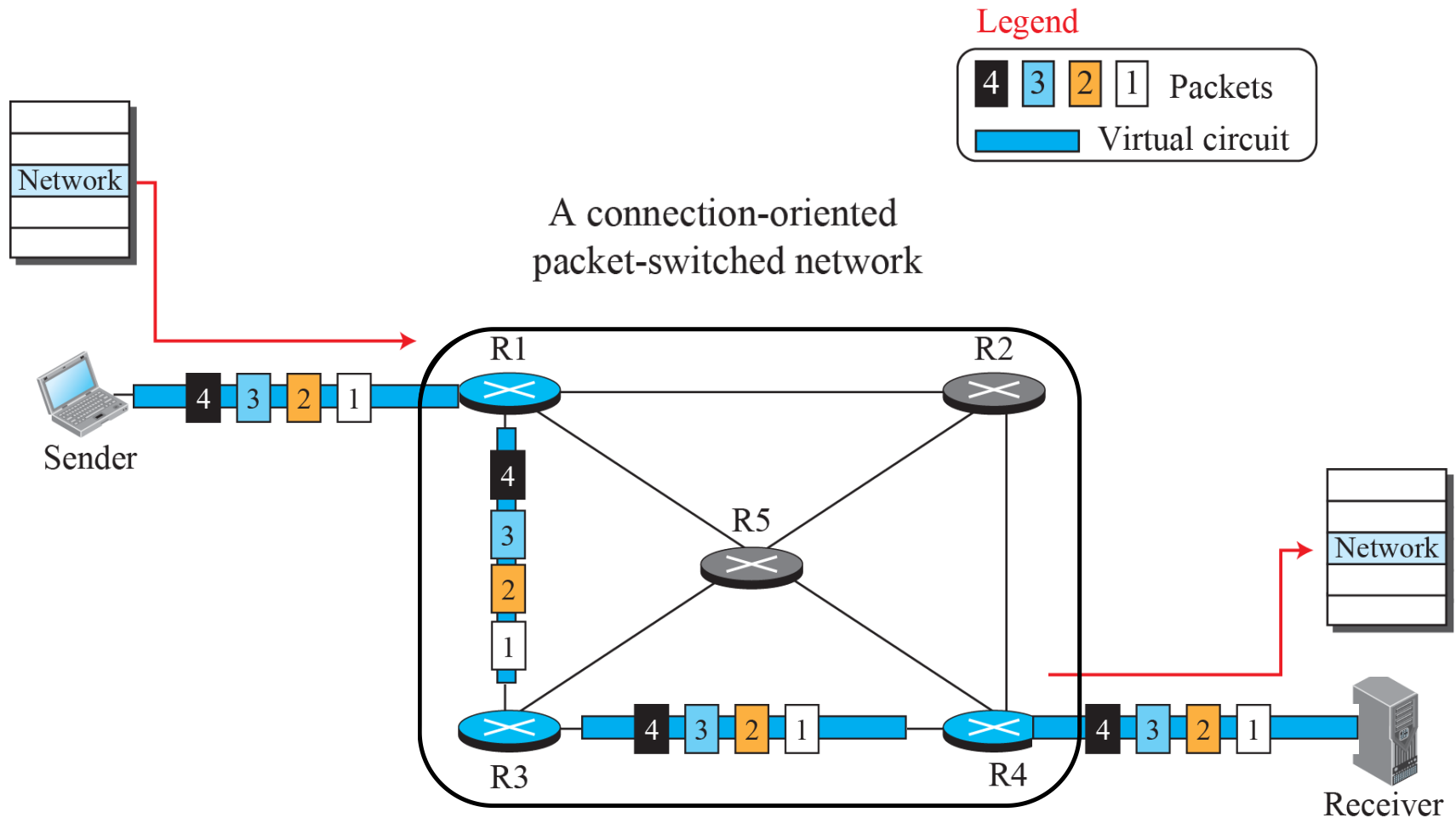
# *Forwarding Process: Connectionless network*



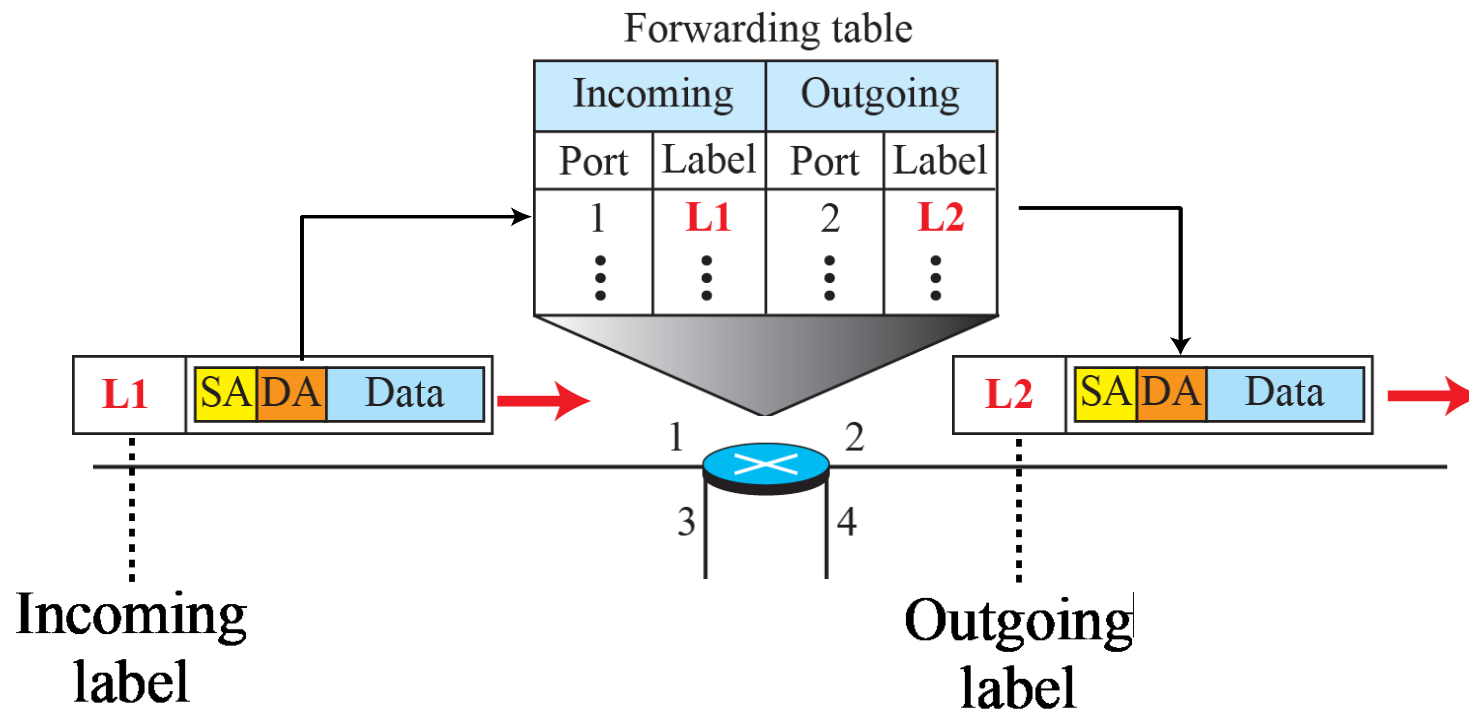
# ***Virtual Circuit Approach: Connection-oriented***

- There is a relationship between all packets belonging to a message.*
- Before all datagrams in a message can be sent, a virtual connection should be set up to define the path for the datagrams.*
- After connection setup, the datagrams can all follow the same path.*
- In this type of service, not only the packet contain the source and destination addresses, it must also contain a flow label, a virtual circuit identifier that defines the virtual path the packet should follow.*

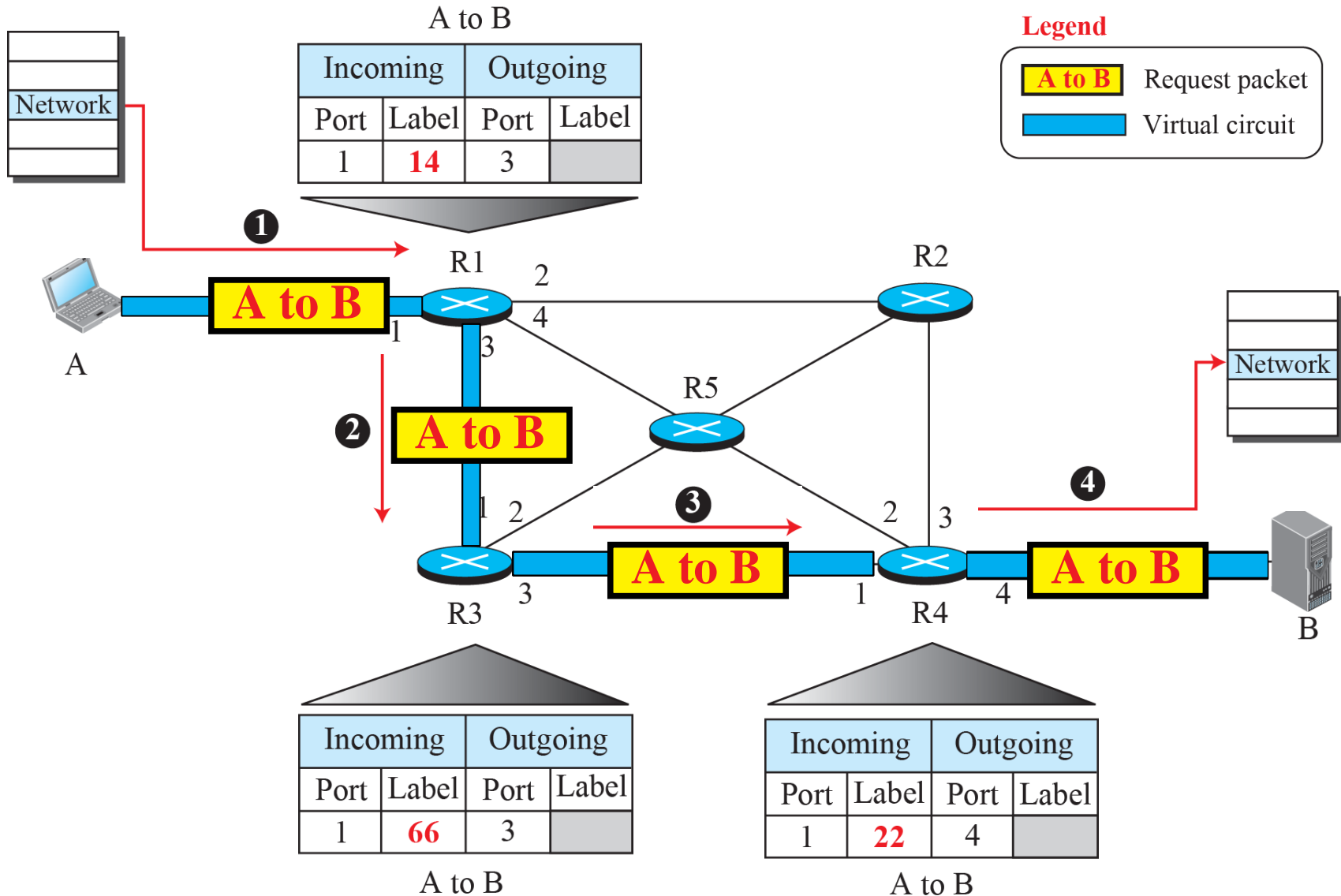
# *A Virtual Circuit Packet Switched Network*



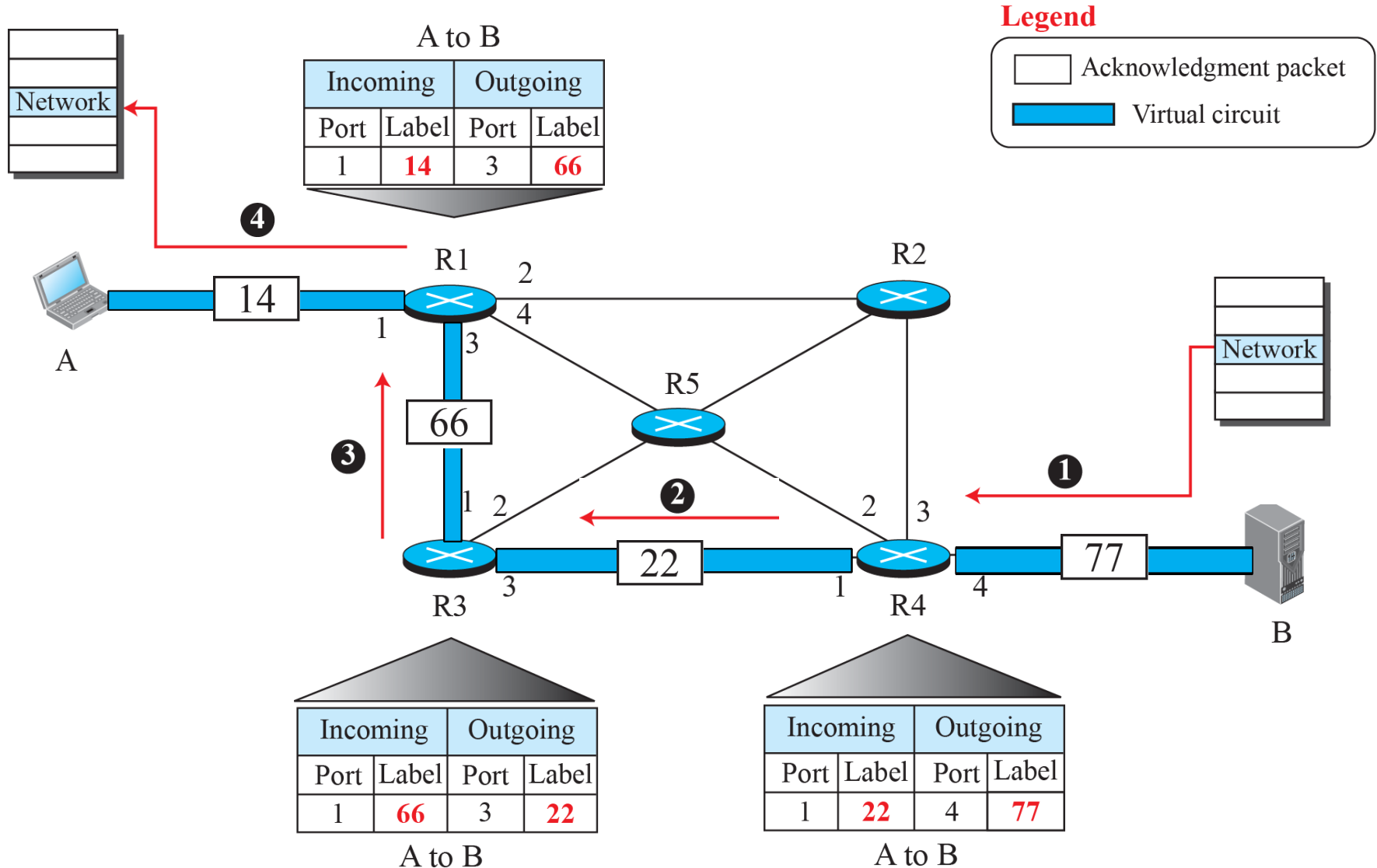
# *Forwarding Process: Virtual Circuit Packet Switched Network*



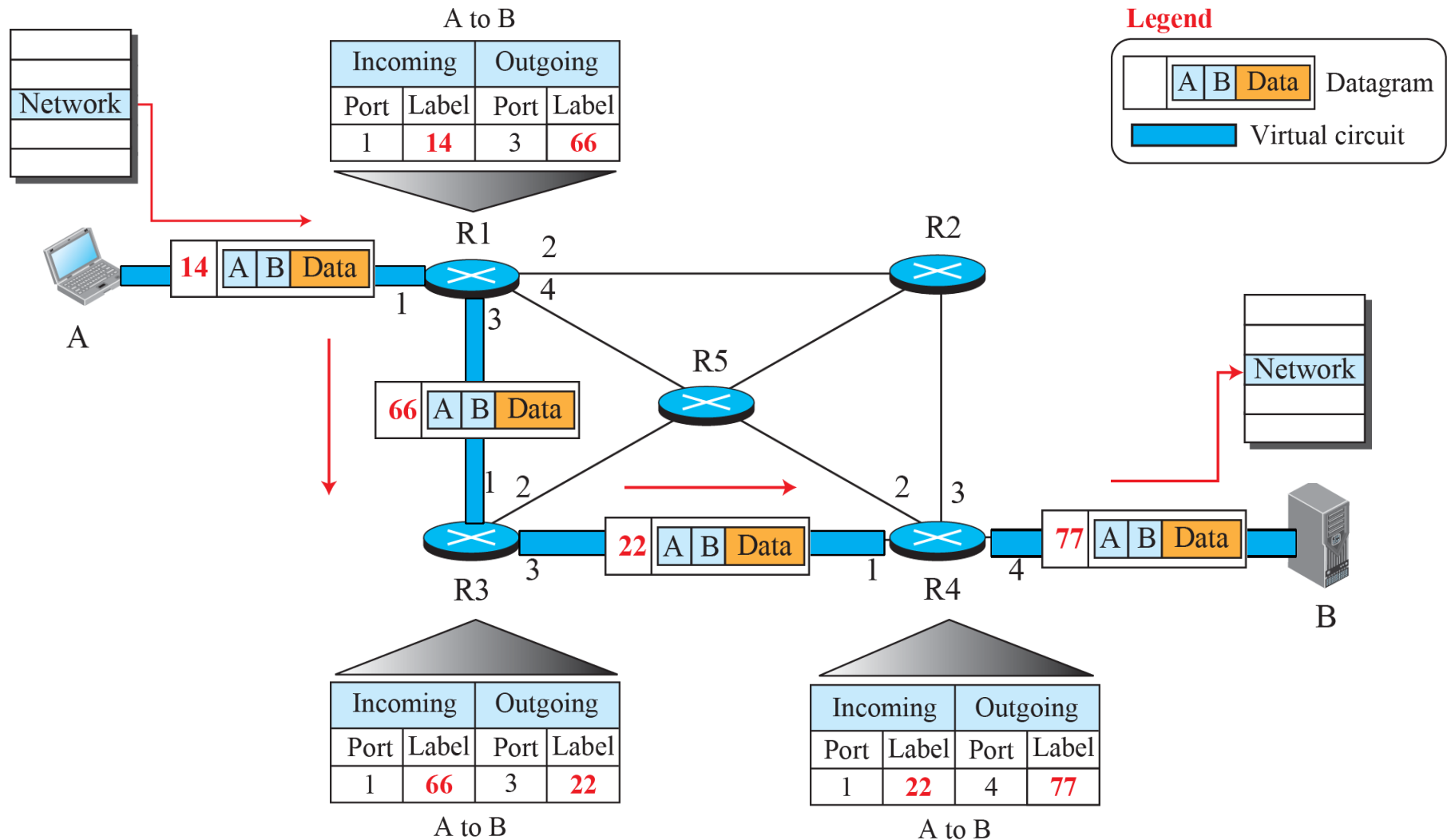
# ***Sending Request packet: Virtual Circuit Packet Switched Network***



# ***Sending Acknowledgements: Virtual Circuit Packet Switched Network***



# Flow of one packet in an established Virtual Circuit Packet Switched Network



# *Network Performance*

*The performance of a network can be measured in terms of **delay**, **throughput**, and **packet loss**.*



# *Delay*

*The delays in a network can be divided into four types:*

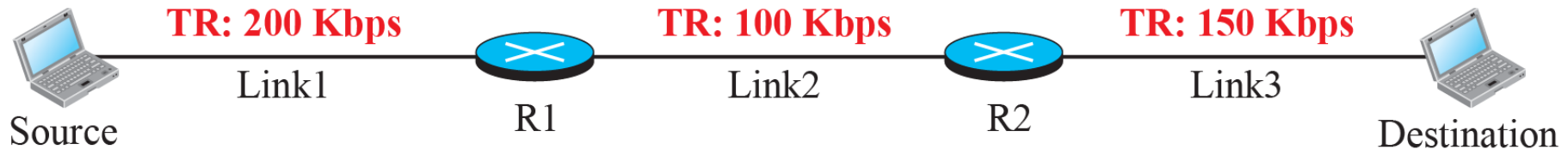
- *Transmission delay,*
- *Propagation delay,*
- *Processing delay, and*
- *Queuing delay.*

# *Throughput*

- *Defined as the number of bits passing through the point in a second, which is actually the transmission rate of data at that point.*
- *In a path from source to destination, a packet may pass through several links (networks), each with a different transmission rate.*
- *How can we determine the throughput of the whole path?*

# *Throughput in a path with three links in a series*

TR: Transmission rate

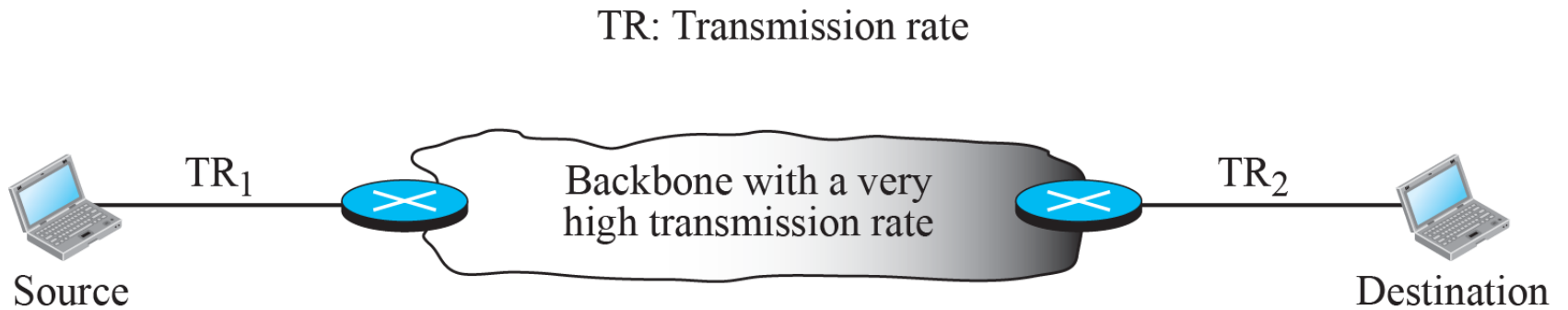


a. A path through three links



b. Simulation using pipes

# *A path through the Internet Backbone*



# ***Packet Loss***

- *Another issue that severely affects the performance of communication is the number of packets lost during transmission.*
- *When a router receives a packet while processing another packet, the received packet needs to be stored in the input buffer waiting for its turn. A router, however, has an input buffer with a limited size. A time may come when the buffer is full and the next packet needs to be dropped.*
- *The effect of packet loss on the Internet network layer is that the packet needs to be resent, which in turn may create overflow and cause more packet loss.*