Switching
Computer Networks(CS31204)

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Switching Techniques

- In large networks there might be multiple paths linking sender and receiver. Information may be switched as it travels through various communication channels.

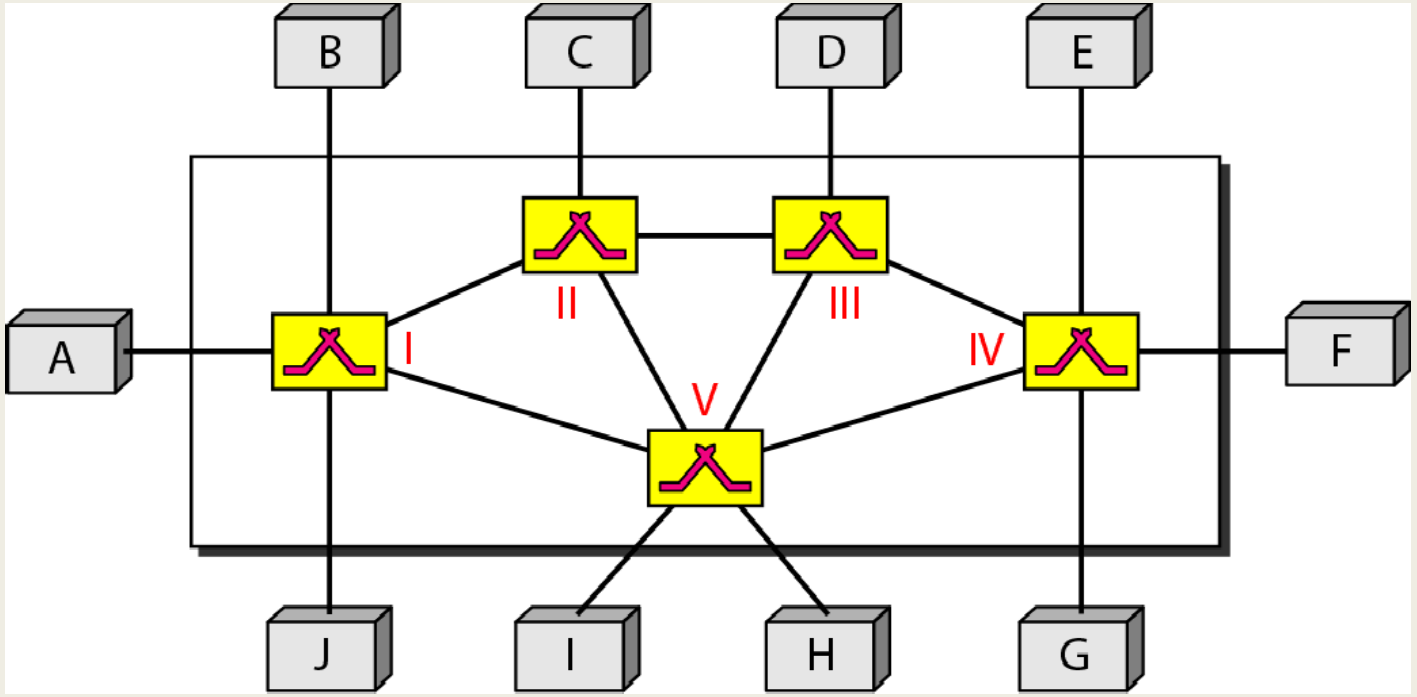
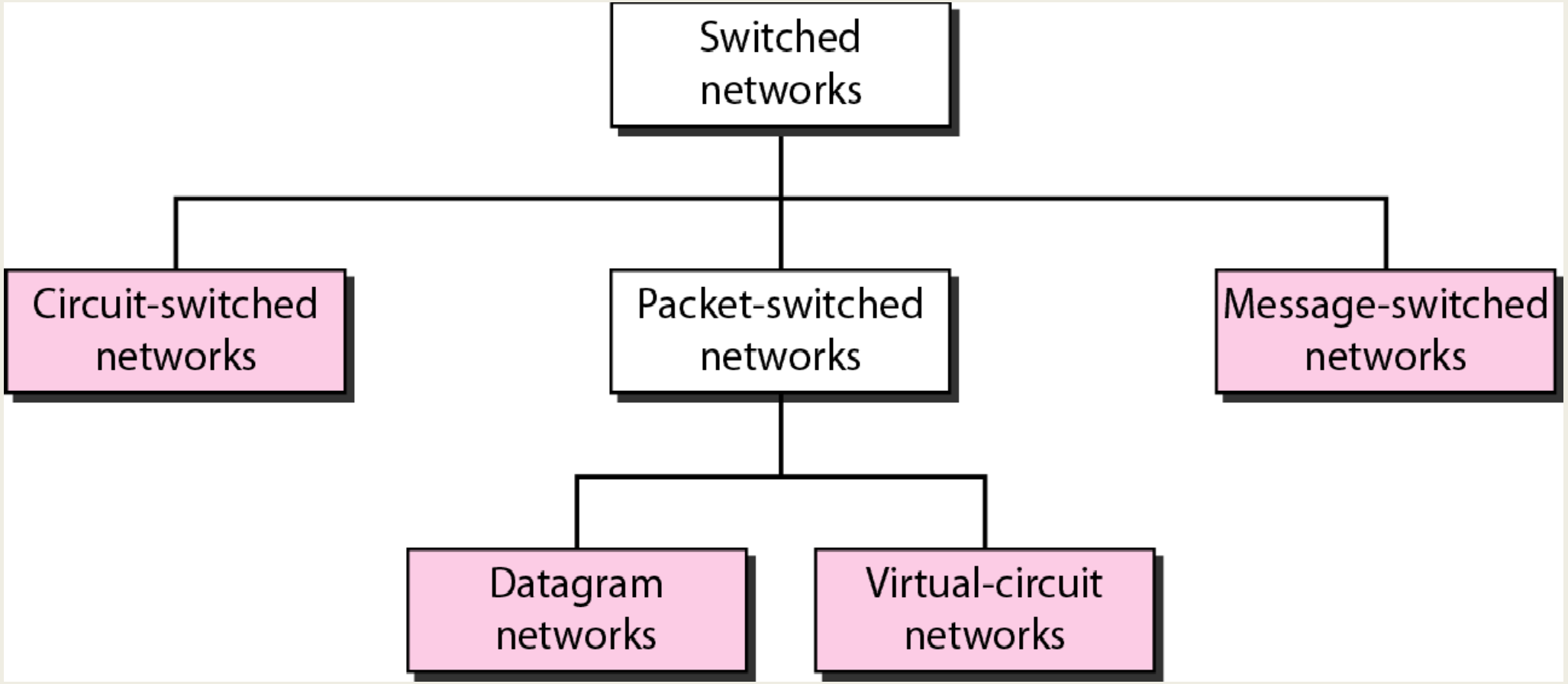


Fig. Switched Network

Source: B. A. Forouzan, " Data Communications and Networking ," *McGraw-Hill Forouzan Networking Series*,5E.

Switching Techniques



Source: B. A. Forouzan, " Data Communications and Networking ," *McGraw-Hill Forouzan Networking Series*,5E.

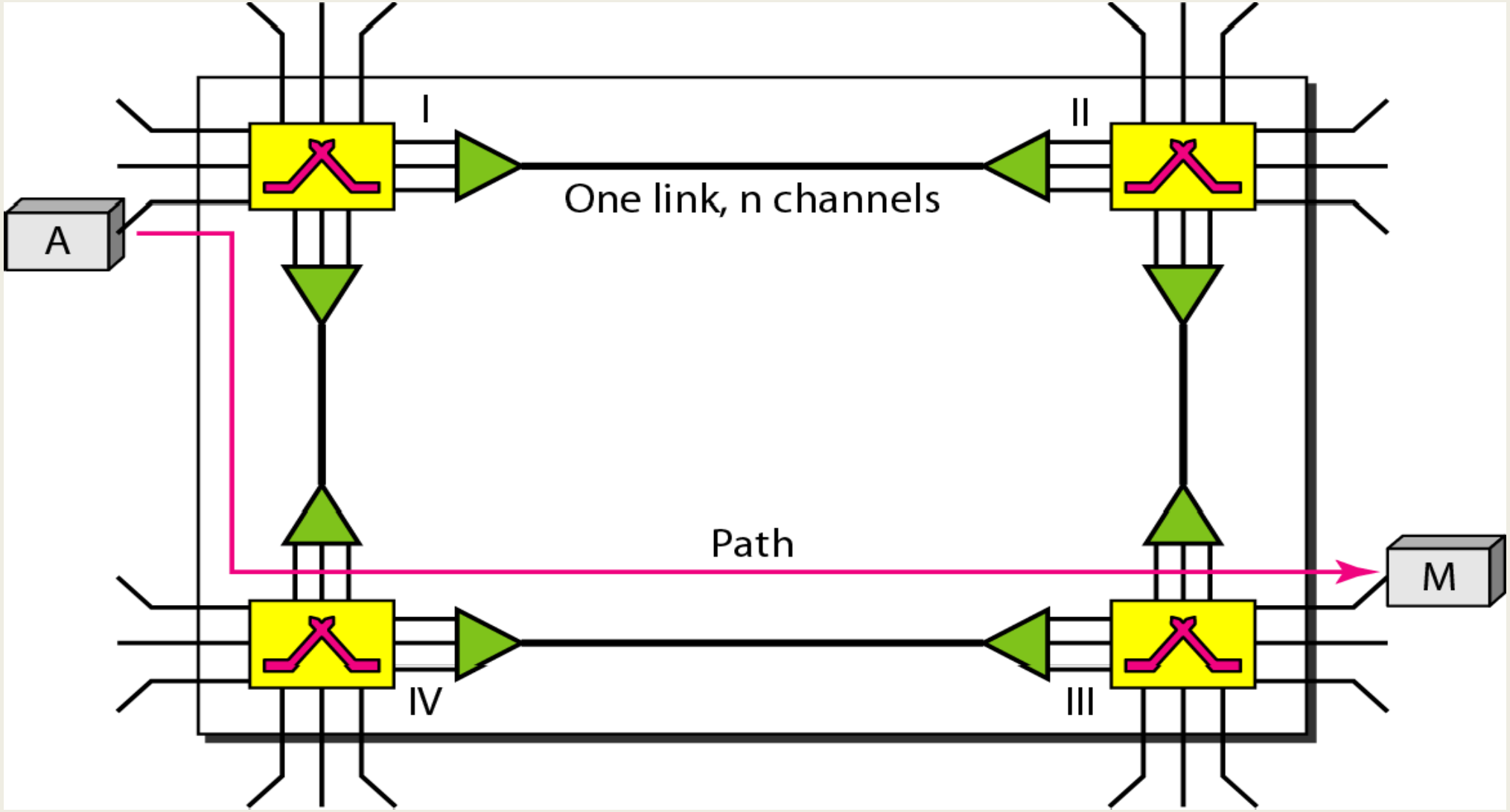
Circuit Switching

- **Circuit switching** is a technique that directly connects the sender and the receiver in an unbroken path.
- Telephone switching equipment, for example, establishes a path that connects the caller's telephone to the receiver's telephone by making a physical connection.
- With this type of switching technique, once a connection is established, a dedicated path exists between both ends until the connection is terminated.
- Routing decisions must be made when the circuit is first established, but there are no decisions made after that time.

Circuit Switching

- **Circuit switching** in a network operates almost the same way as the telephone system works.
- A complete end-to-end path must exist before communication can take place.
- The computer initiating the data transfer must ask for a connection to the destination.
- Once the connection has been initiated and completed to the destination device, the destination device must acknowledge that it is ready and willing to carry on a transfer.

Circuit Switching



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Circuit Switching

- **Advantages:**

  - The communication channel (once established) is dedicated.

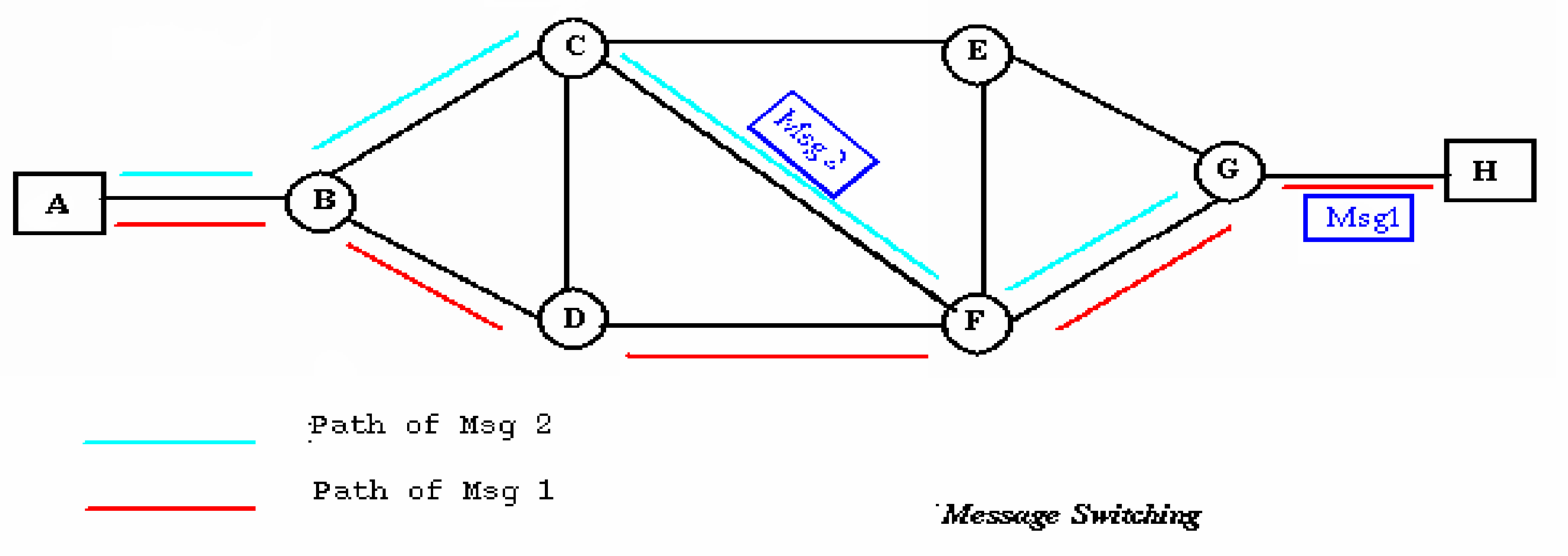
- **Disadvantages:**

  - Possible long wait to establish a connection, (10 seconds, more on long-distance or international calls.) during which no data can be transmitted.
  - More expensive than any other switching techniques, because a dedicated path is required for each connection.
  - Inefficient use of the communication channel, because the channel is not used when the connected systems are not using it.

Message Switching

- With message switching there is no need to establish a dedicated path between two stations.
- When a station sends a message, the destination address is appended to the message.
- The message is then transmitted through the network, in its entirety, from node to node.
- Each node receives the entire message, stores it in its entirety on disk, and then transmits the message to the next node.
- This type of network is called a store-and-forward network.

Message Switching



- A message-switching node is typically a general-purpose computer. The device needs sufficient secondary-storage capacity to store the incoming messages, which could be long. A time delay is introduced using this type of scheme due to store- and-forward time, plus the time required to find the next node in the transmission path.

Source: Ecomputers "Switching-Techniques", [Online], Available: https://ecomputernotes.com/computernetworkingnotes/switching/message-switching

Message Switching

Advantages:

- Channel efficiency can be greater compared to circuit- switched systems, because more devices are sharing the channel.
- Traffic congestion can be reduced, because messages may be temporarily stored in route.
- Message priorities can be established due to store-and-forward technique.
- Message broadcasting can be achieved with the use of broadcast address appended in the message.

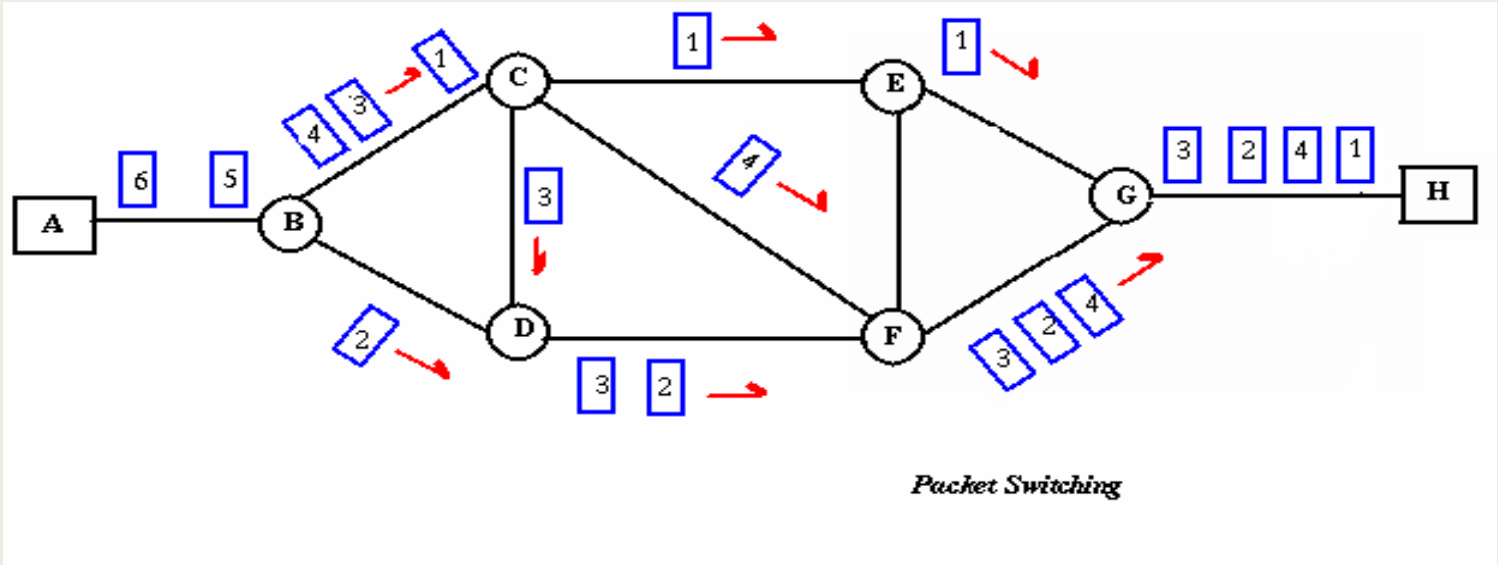
Message Switching

Disadvantages

- Message switching is not compatible with interactive applications.
- Store-and-forward devices are expensive, because they must have large disks to hold potentially long messages.

Packet Switching

- Packet switching can be seen as a solution that tries to combine the advantages of message and circuit switching and to minimize the disadvantages of both.
- There are two methods of packet switching: Datagram and virtual



Source: Kataria, "Modem-Switching-Techniques", [Online], Available: https://codes.pratikkataria.com/modem-switching-techniques/

Packet Switching

- In both packet switching methods, a message is broken into small parts, called packets.
- Each packet is tagged with appropriate source and destination addresses.
- Since packets have a strictly defined maximum length, they can be stored in main memory instead of disk, therefore access delay and cost are minimized.
- Also the transmission speeds, between nodes, are optimized.
- With current technology, packets are generally accepted onto the network on a first-come, first-served basis. If the network becomes overloaded, packets are delayed or discarded.

Packet Switching : Datagram

- Datagram packet switching is similar to message switching in that each packet is a self-contained unit with complete addressing information attached.
- This fact allows packets to take a variety of possible paths through the network.
- So the packets, each with the same destination address, do not follow the same route, and they may arrive out of sequence at the exit point node (or the destination).
- Reordering is done at the destination point based on the sequence number of the packets.
- It is possible for a packet to be destroyed if one of the nodes on its way is crashed momentarily. Thus all its queued packets may be lost.

Packet Switching : Datagram

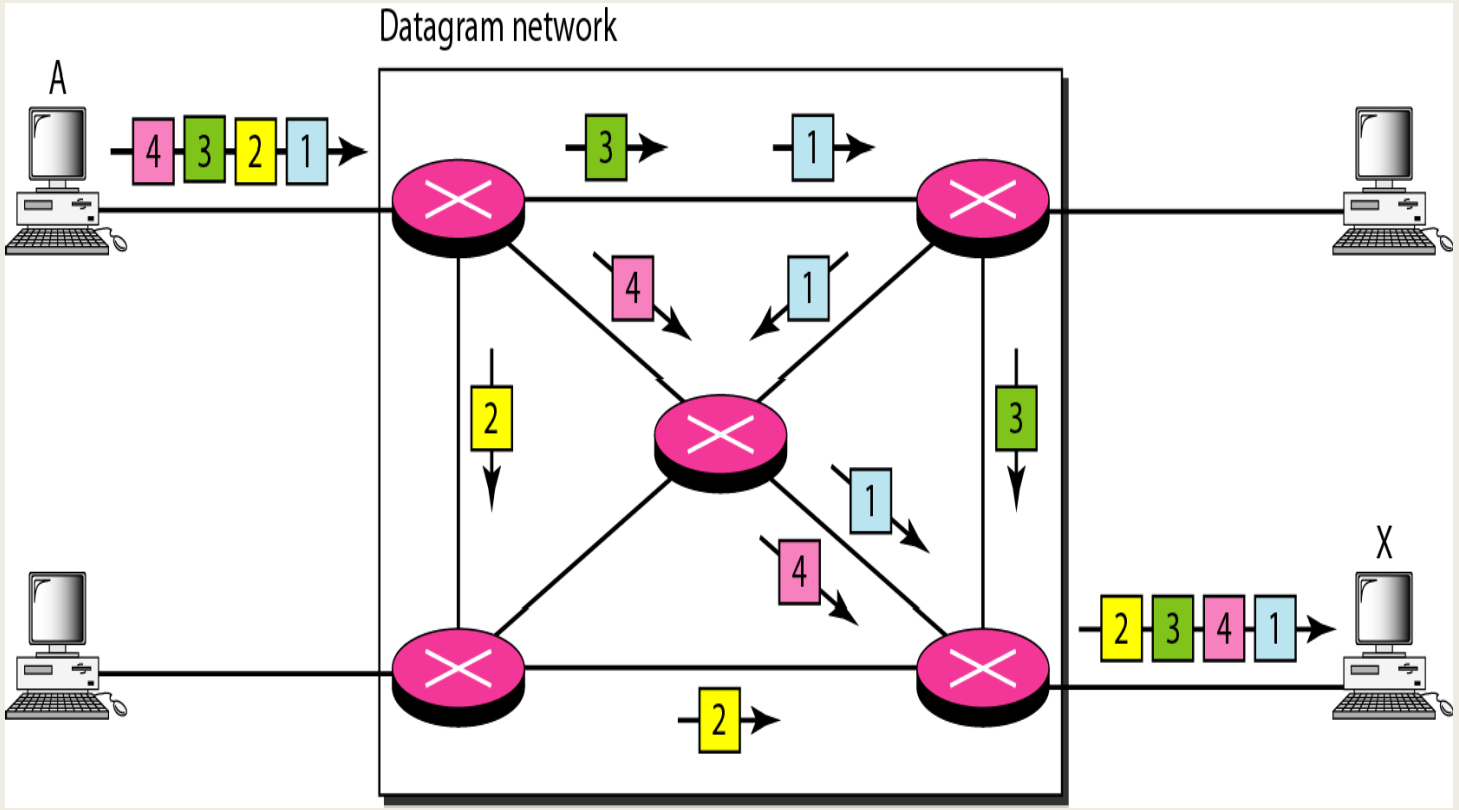


Fig. Datagram Networks

Destination address	Output port
1232	1
4150	2
⋮	⋮
9130	3

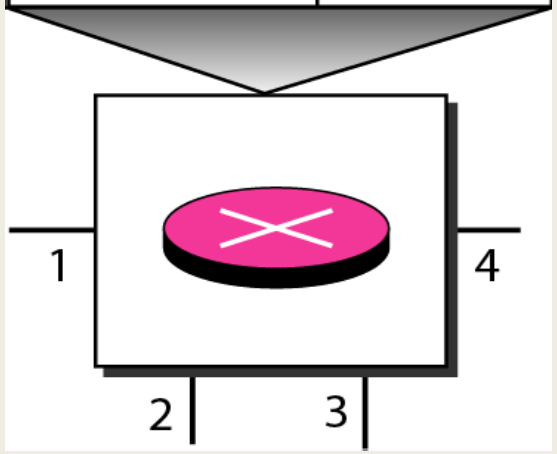


Fig. Routing Table in Datagram Networks

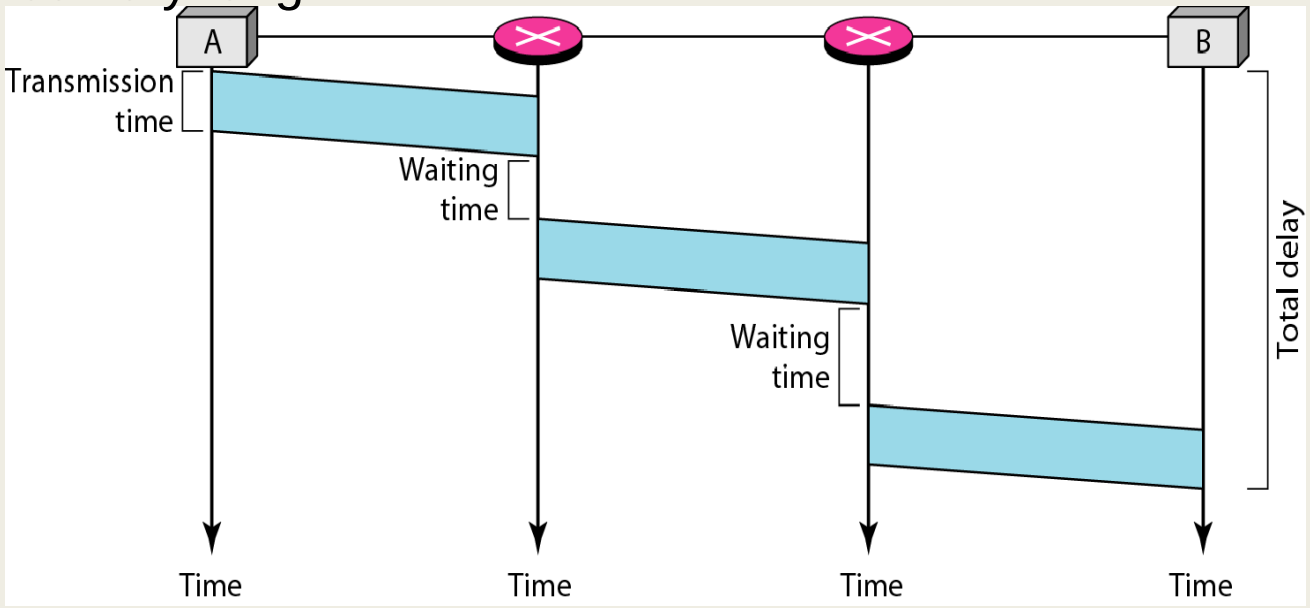
Source: B. A. Forouzan, " Data Communications and Networking ," *McGraw-Hill Forouzan Networking Series*,5E.

Delay in Datagram Network

The total delay is due to the time needed to create the connection, transfer data, and disconnect the circuit.

Delay caused by the setup is the sum of four parts: the propagation time of the source computer request, the request signal transfer time, the propagation time of the acknowledgment from the destination computer, and the signal transfer time of the acknowledgment.

The delay due to data transfer is the sum of two parts: the propagation time and data transfer time, which can be very long.



Source: B. A. Forouzan, " Data Communications and Networking ," *McGraw-Hill Forouzan Networking Series*,5E.

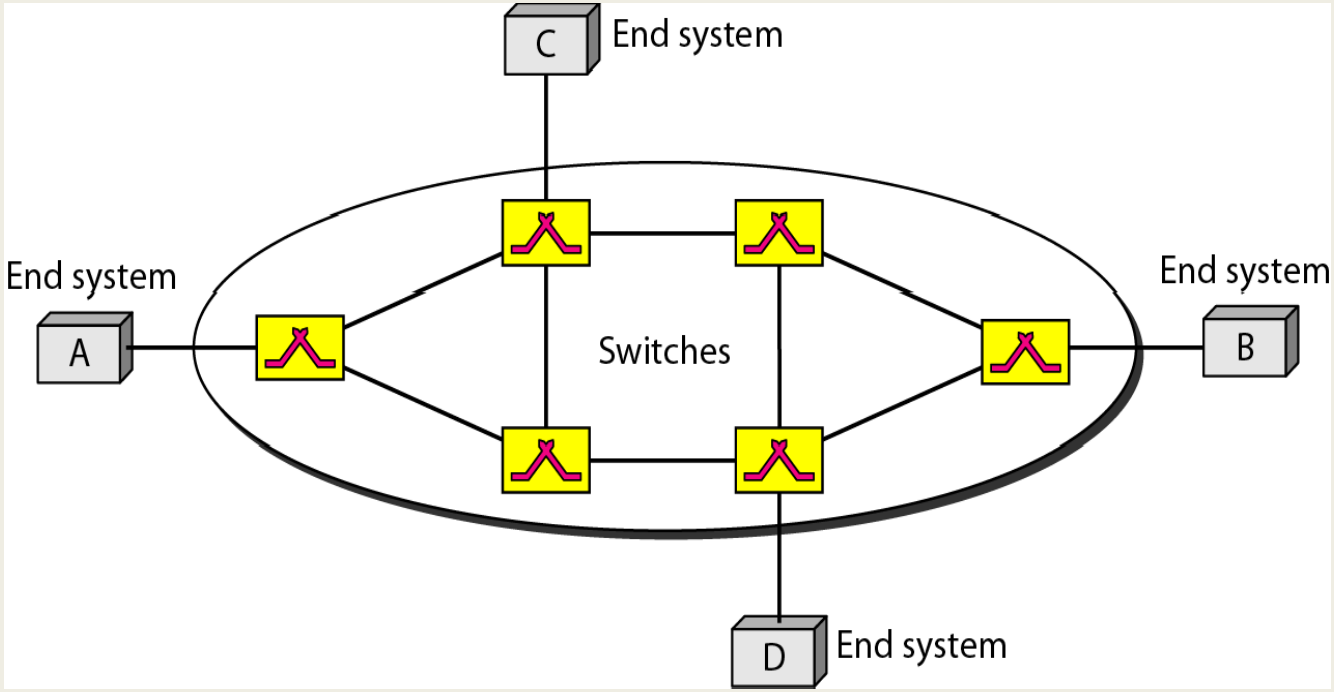
Packet Switching : Virtual Circuit

- In the virtual circuit approach, a preplanned route is established before any data packets are sent.
- A logical connection is established when
  - a sender send a "call request packet" to the receiver and
  - the receiver send back an acknowledge packet "call accepted packet" to the sender if the receiver agrees on conversational parameters.
- The conversational parameters can be maximum packet sizes, path to be taken, and other variables necessary to establish and maintain the conversation.
- Virtual circuits imply acknowledgements, flow control, and error control, so virtual circuits are reliable.
- That is, they have the capability to inform upper-protocol layers if a transmission problem occurs.

Packet Switching : Virtual Circuit

VC's offer guarantees that:

- the packets sent arrive in the order sent
- with no duplicates or omissions
- with no errors (with high probability) regardless of how they are implemented internally.



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Addressing in Virtual Circuit

In a virtual-circuit network, two types of addressing are involved: global and local.

Global Address

Global address in virtual-circuit networks is used only to create a virtual-circuit identifier.

Virtual-Circuit Identifier

The identifier that is actually used for data transfer is called the virtual-circuit identifier (Vel)

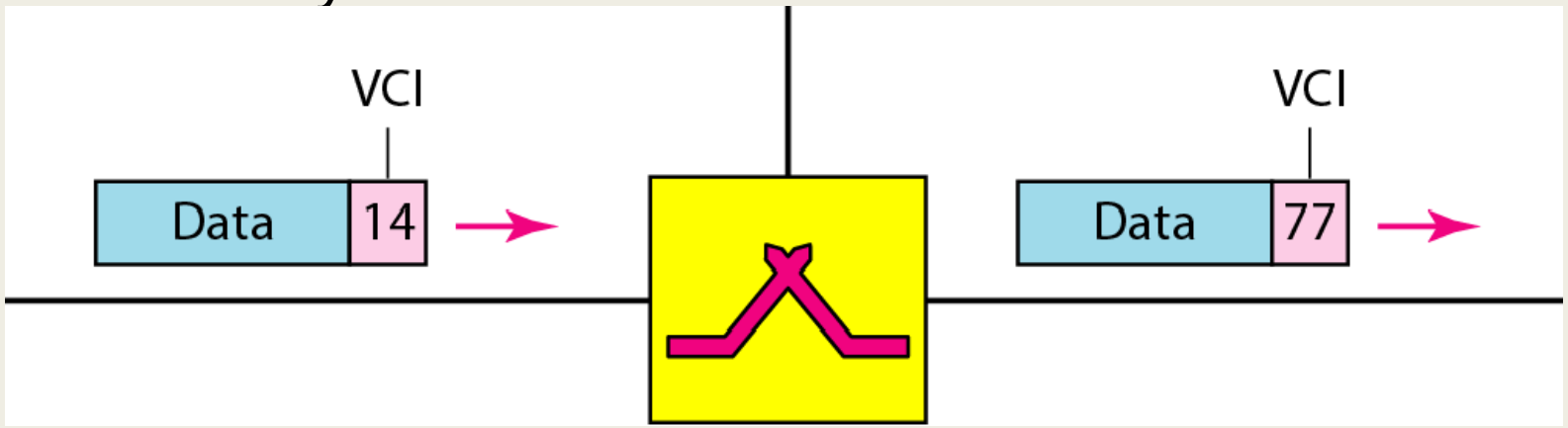


Fig.: Vel

Source: B. A. Forouzan, " Data Communications and Networking ," *McGraw-Hill Forouzan Networking Series*,5E.

Three Phases

- Source and destination need to go through three phases in a virtual-circuit network: setup, data transfer, and teardown.
- In the setup phase, the source and destination use their global addresses to help switches make table entries for the connection.
- In the teardown phase, the source and destination inform the switches to delete the corresponding entry.
- Data transfer occurs between these two phases.

Setup Phase

- In the setup phase, a switch creates an entry for a virtual circuit.
- For example, suppose source A needs to create a virtual circuit to B.
- Two steps are required: the setup request and the acknowledgment.

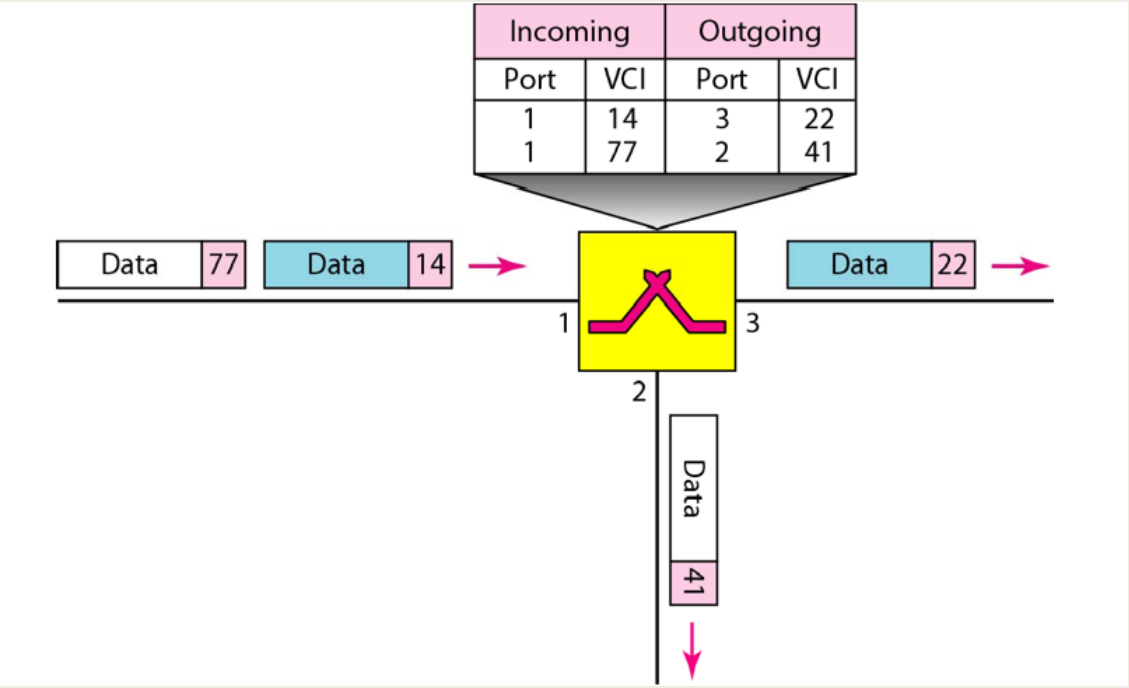
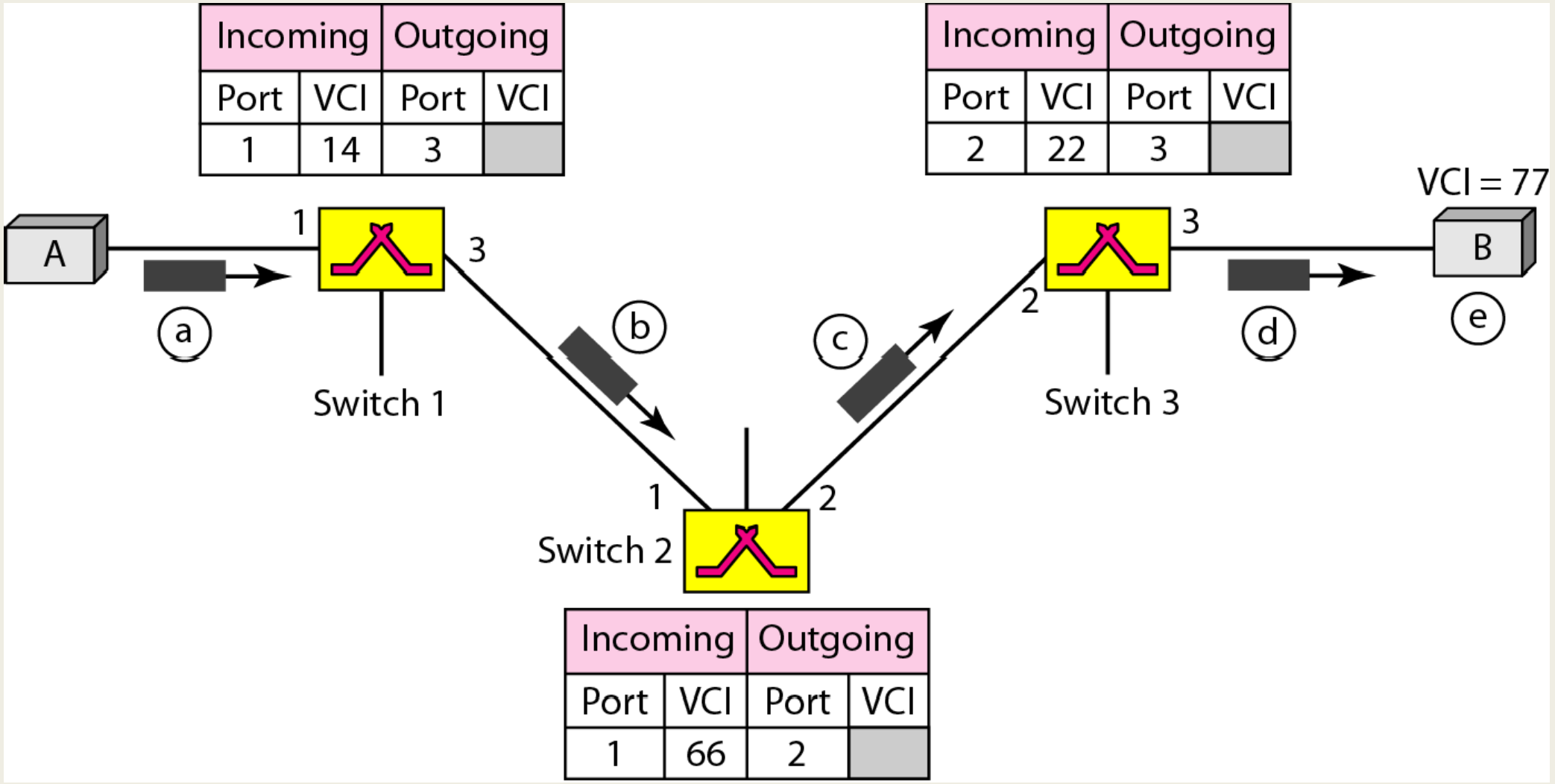


Fig.: Switch and tables in a virtual-circuit network

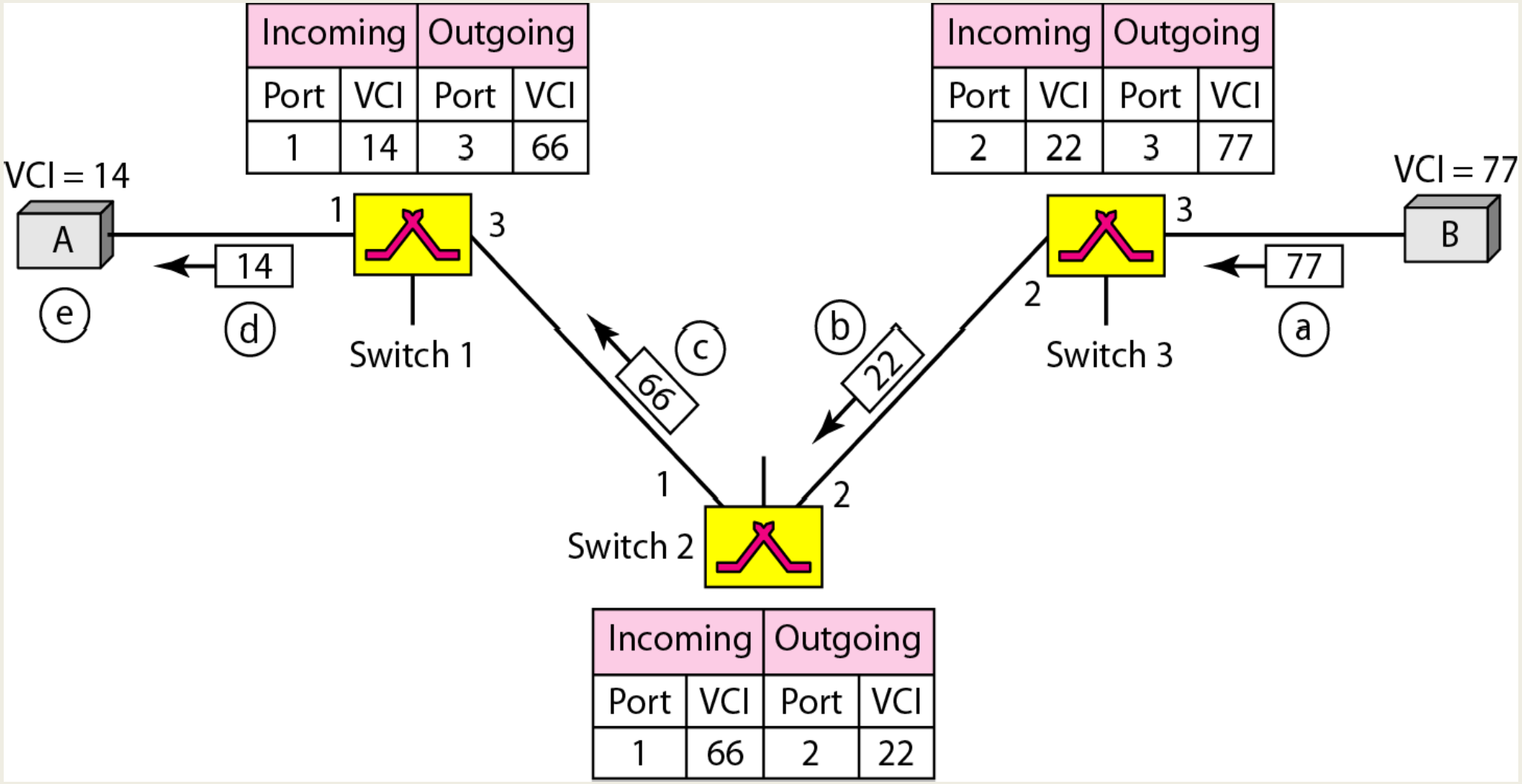
Source: B. A. Forouzan, " Data Communications and Networking ," *McGraw-Hill Forouzan Networking Series*,5E.

Setup Request



Source: B. A. Forouzan, " Data Communications and Networking ," *McGraw-Hill Forouzan Networking Series*,5E.

Setup Acknowledgement



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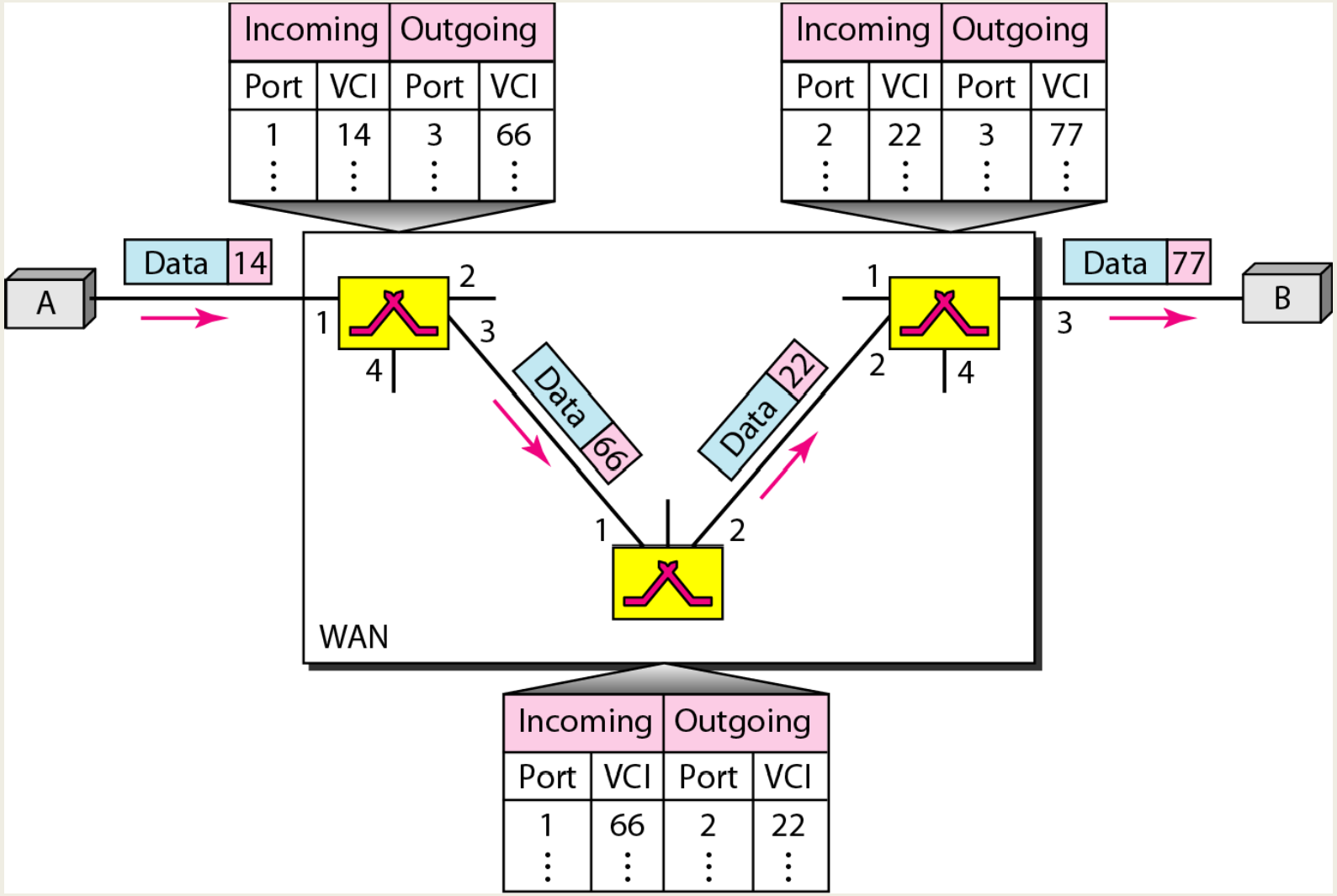
Data Transfer Phase

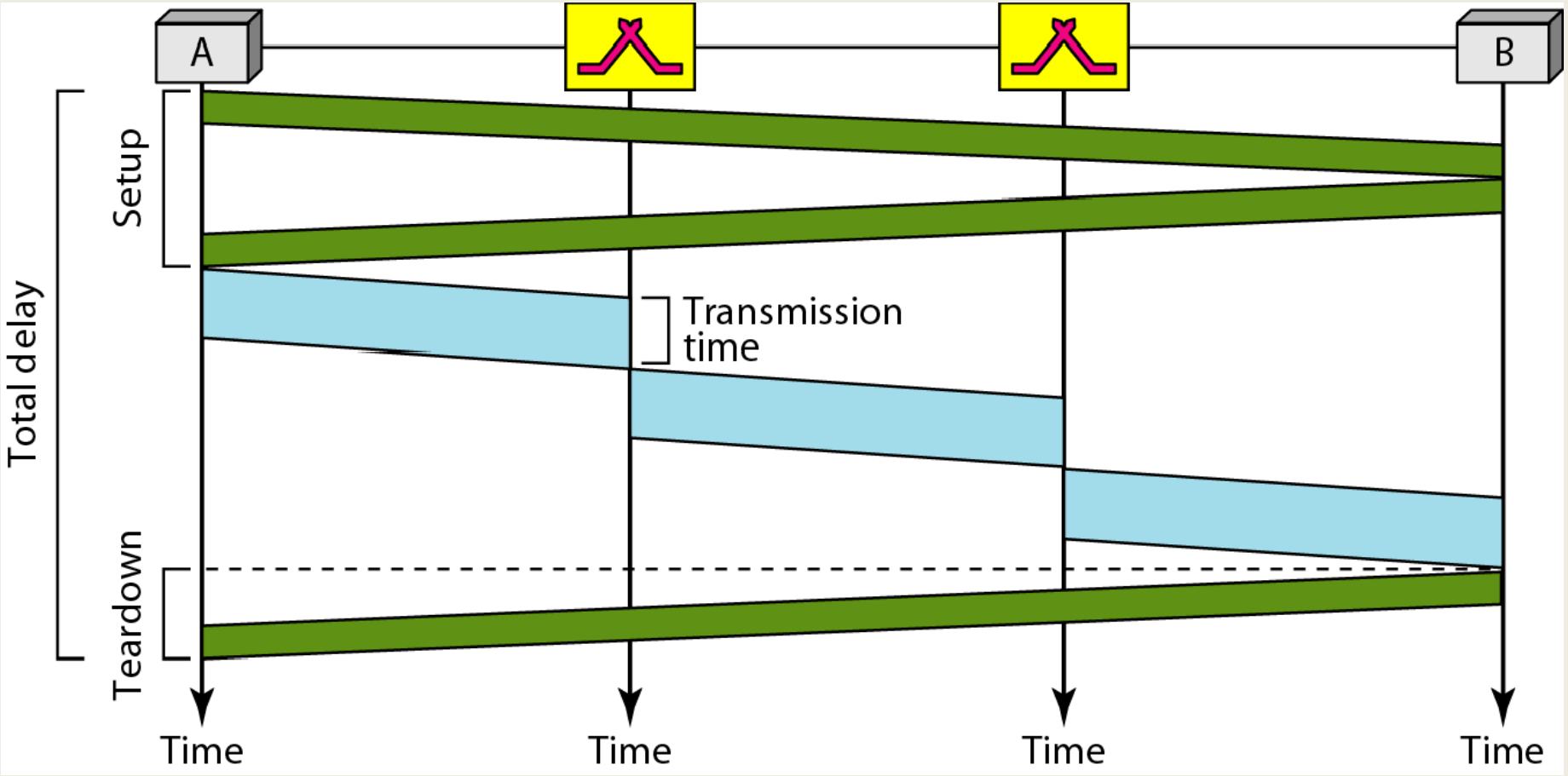


https://docs.google.com/viewer?a=v&pid=sites&srcid=ZGVmYXVsdGRvbWFpbnxlZWJhaHJpYTV8Z3g6MjE2MzY2MjcxMGU3MmQ4Nw

Data Teardown Phase

- In this phase, source A, after sending all frames to B, sends a special frame called a teardown request.
- Destination B responds with a teardown confirmation frame.
- All switches delete the corresponding entry from their tables.

Delay in Virtual-Circuit Network



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Packet Switching

Advantages:

- Packet switching is cost effective, because switching devices do not need massive amount of secondary storage.
- Packet switching offers improved delay characteristics, because there are no long messages in the queue (maximum packet size is fixed).
- Packet can be rerouted if there is any problem, such as, busy or disabled links.
- The advantage of packet switching is that many network users can share the same channel at the same time. Packet switching can maximize link efficiency by making optimal use of link bandwidth.

Packet Switching

Disadvantages:

Protocols for packet switching are typically more complex.

It can add some initial costs in implementation.

If packet is lost, sender needs to retransmit the data.

Another disadvantage is that packet-switched systems still can't deliver the same quality as dedicated circuits in applications requiring very little delay - like voice conversations or moving images.

Thank You!!!

Appendix

Space Division Switch

In space-division switching, the paths in the circuit are separated from one another spatially.

Crossbar Switch: A crossbar switch connects *n* inputs to *m* outputs in a grid, using electronic microswitches (transistors) at each cross point

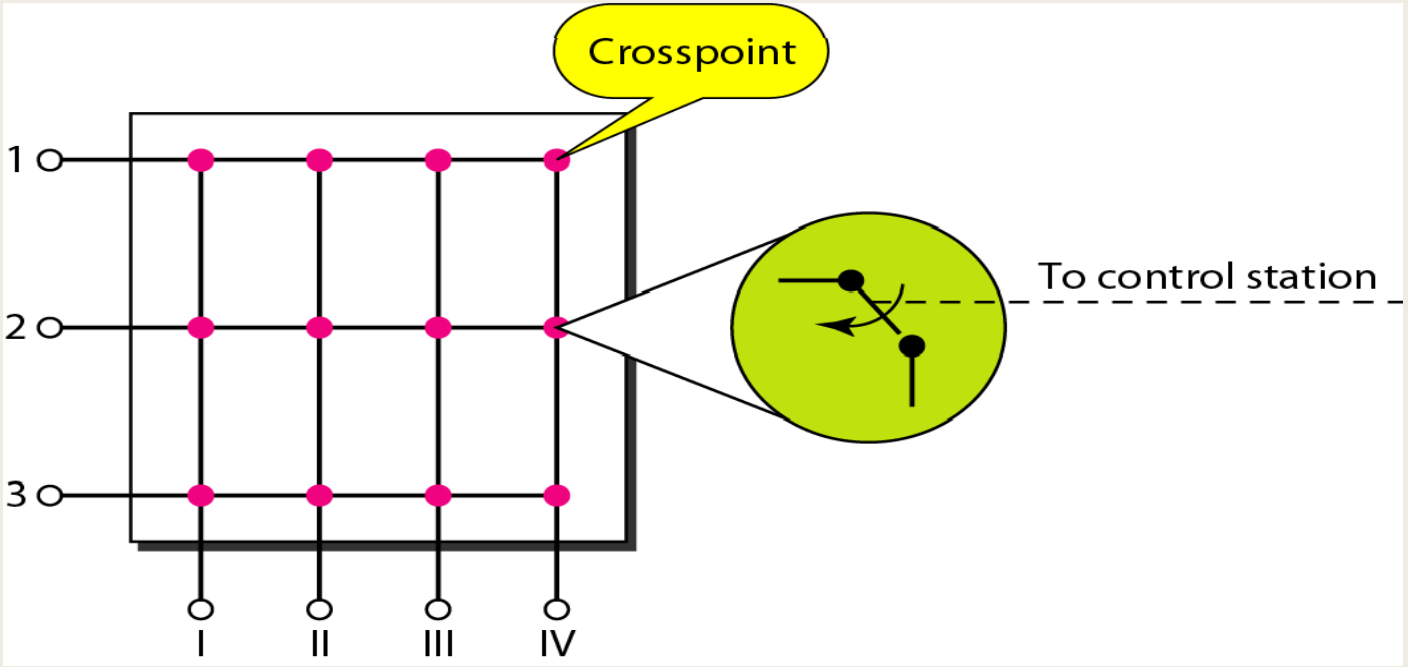


Fig.: Crossbar switch with three inputs and four outputs

Source: B. A. Forouzan, " Data Communications and Networking ," *McGraw-Hill Forouzan Networking Series*,5E.

Multi Stage Switch

Combines crossbar switches in several (normally three) stages

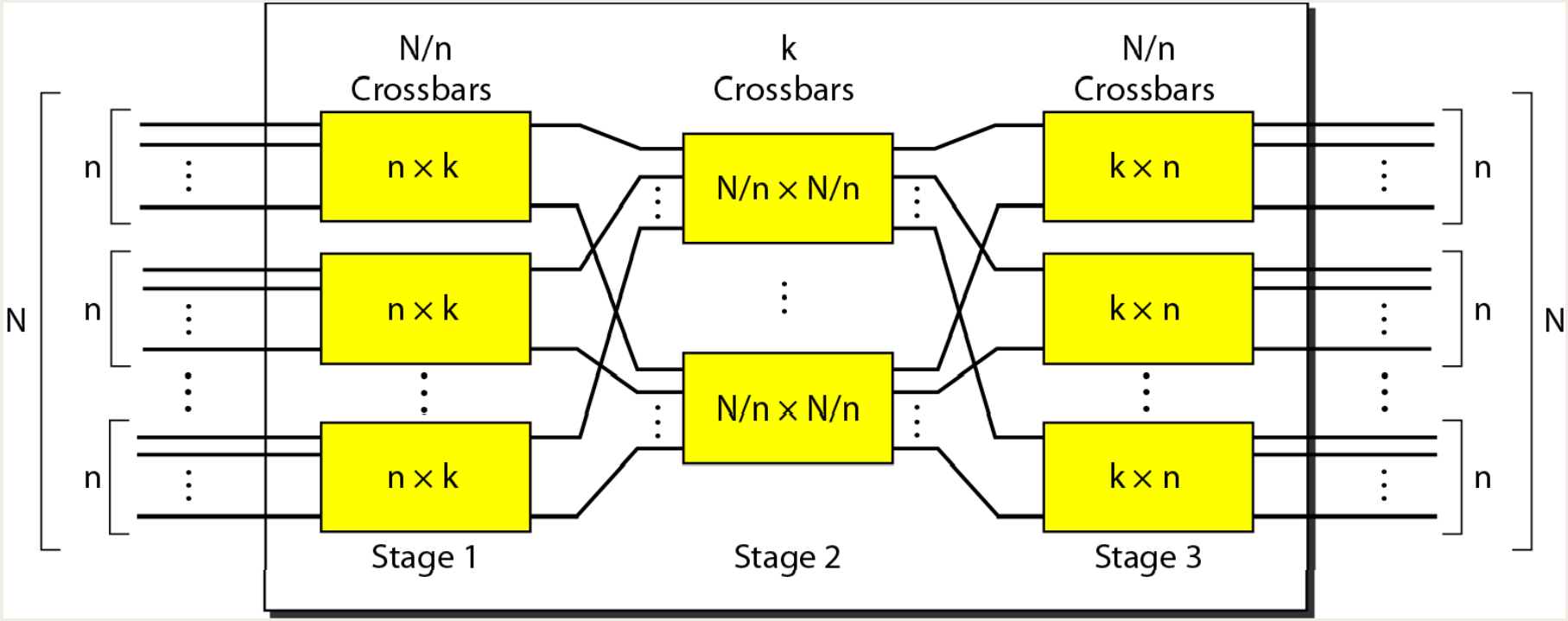


Fig.: Multistage switch

Source: B. A. Forouzan, " Data Communications and Networking ," *McGraw-Hill Forouzan Networking Series*,5E.

Designing Three Stage Switch

- To design a three-stage switch, we follow these steps:
- We divide the *N* input lines into groups, each of *n* lines. For each group, we use one crossbar of size *n* x *k,* where *k* is the number of crossbars in the middle stage
- We use *k* crossbars, each of size *(N/n)* x *(N/n)* in the middle stage.
- We use *N/n* crossbars, each of size *k* x *n* at the third stage.
- In a three-stage switch, the total number of cross points is:

$$\mathbf{2kN + k(N/n)^2}$$

which is much smaller than the number of cross points in a single-stage switch (N^2).

Time Division Switch

- Time-division switching uses time-division multiplexing (TDM) inside a switch.
- The most popular technology is called the time-slot interchange (TSI)

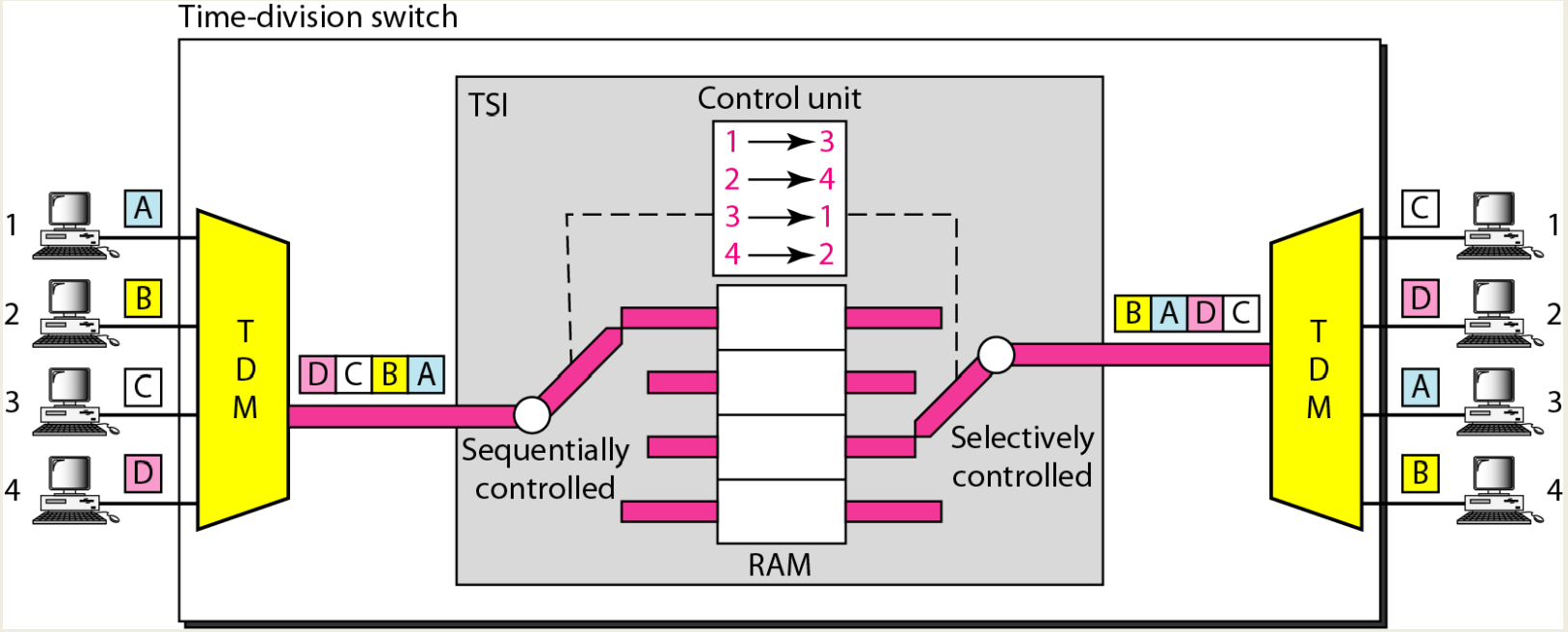
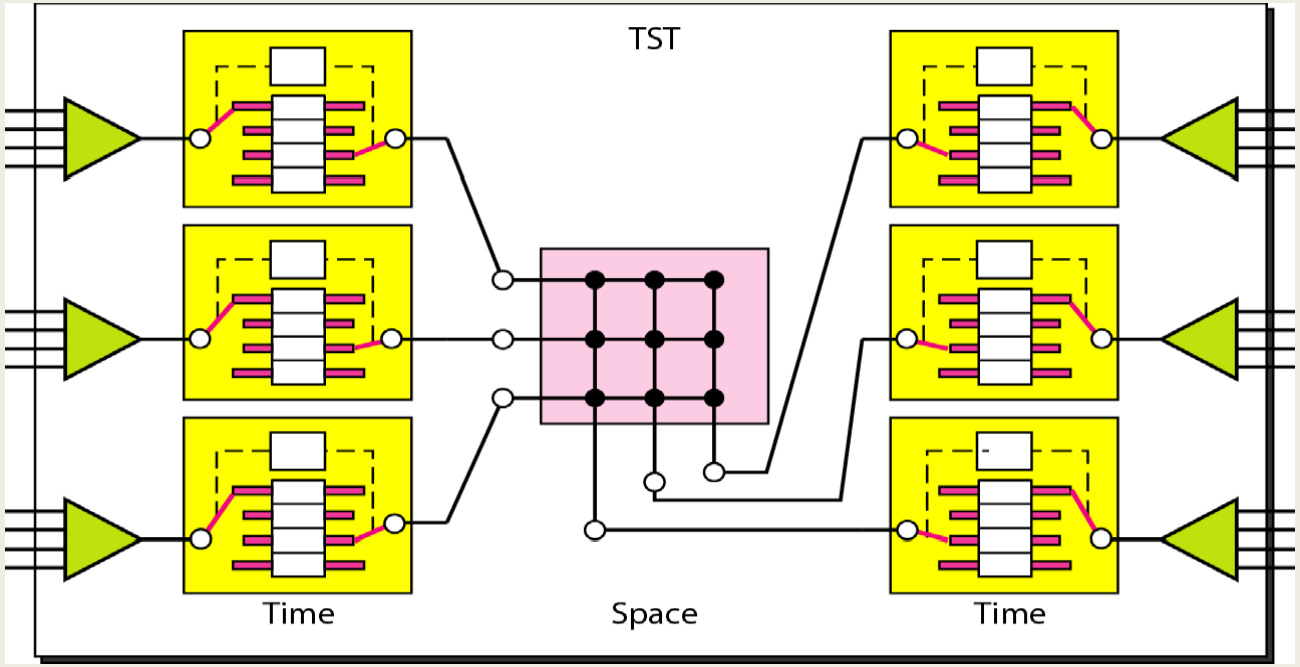


Fig.: Time-slot interchange

Source: B. A. Forouzan, " Data Communications and Networking ," *McGraw-Hill Forouzan Networking Series*,5E.

Time Space Time Switch

- It divides the inputs into three groups (of four inputs each) and directs them to three timeslot interchanges.
- The result is that the average delay is one-third of what would result from using one time-slot interchange to handle all 12 inputs.



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