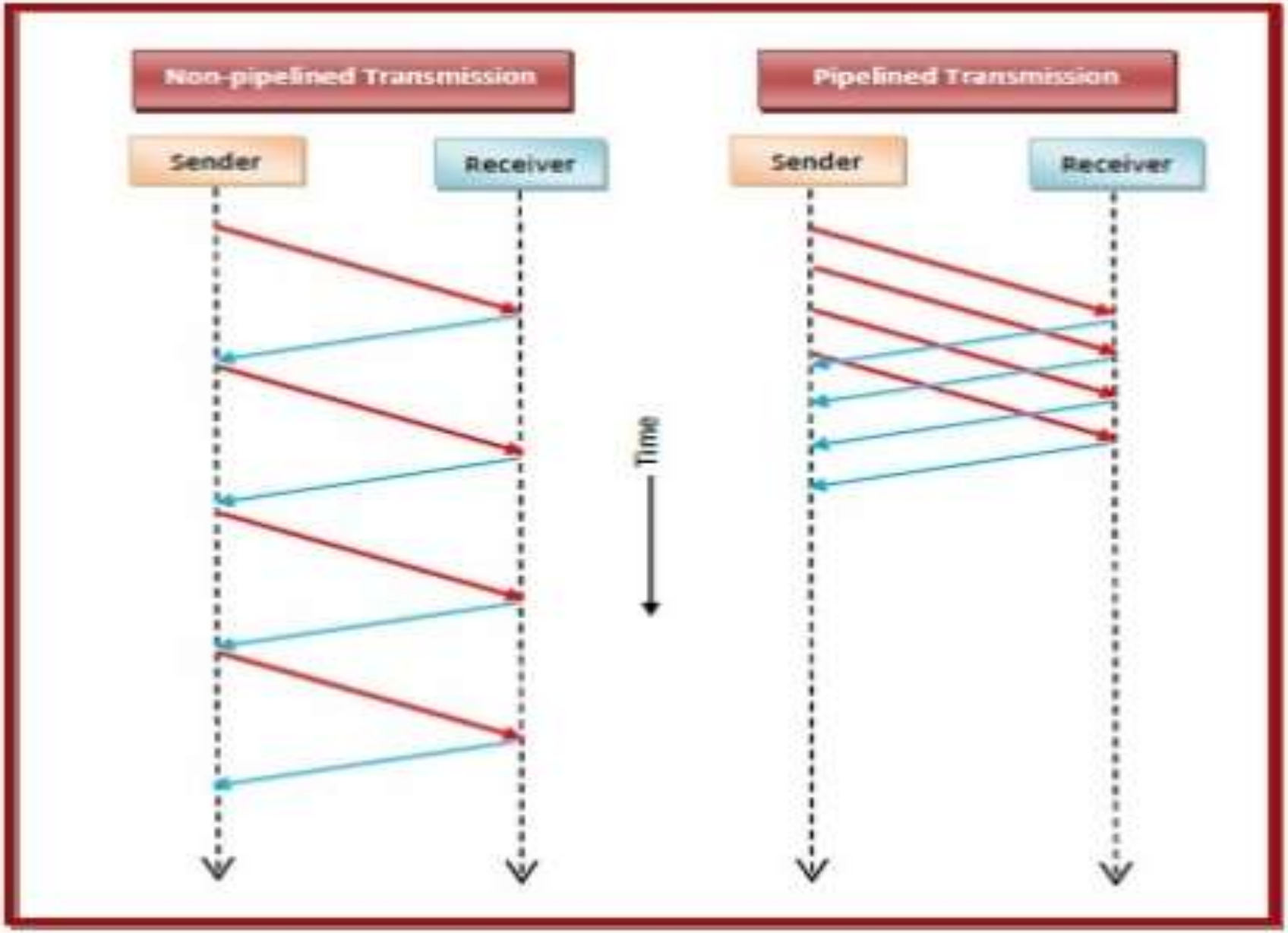
What is pipelining?

- In computer networking, pipelining is the method of sending multiple data units without waiting for an acknowledgment for the first frame sent. Pipelining ensures better utilization of network resources and also increases the speed of delivery, particularly in situations where a large number of data units make up a message to be sent.

- Flow Diagram of Pipelined Data Transmission
- The following flow diagram depicts data transmission in a pipelined system versus that in a non-pipelined system. Here, pipelining is incorporated in the data link layer, and four data link layer frames are sequentially transmitted.


Non-pipelined Transmission
Sender
Receiver
Time
Pipelined Transmission
Sender
Receiver

- **The Data-Link protocols that use pipelining are as follows:Go-Back-N:** Go-Back-N(GBN) is a ‘Sliding Window Protocol’ that ensures pipelining. It first checks the window size of the sender and receiver, and then it sends multiple data frames at the same time. It will retransmit all the frames starting from that failed data frame.
- **Selective Repeat:** Selective Repeat is also a sliding window protocol implementing pipelining. It makes use of a buffer at the receiver’s side for its implementation. It is the same as GBN, except that it retransmits only the failed data frame selectively.

- Pipelining can also be used in the Application layer of the OSI and TCP/IP reference layer. In the application layer, the sender's request and the receiver's response can be pipelined. It enhances the protocol performance, mainly in the network connections with very high latency. It also reduces the process of waiting time.
- The protocols that can be used in the Application layer are HTTP, SMTP, FTP, etc. In these protocols, multiple requests can be sent over a single TCP connection without waiting for the corresponding responses.

- **Following are the functionalities of pipelining in the computer networks:**
- High Performance
- Efficient use of resources
- Time Efficiency
- Fast Data Delivery
- Reduces the process waiting-time