1. Transport Layer Protocol

- The transport layer provides end-to-end segment transportation, where messages are segmented into a chain of segments at the source and are reassembled back into the original message at the destination nodes.
- Transport protocols are used to:
  - Mitigate congestion
  - Reduce packet loss
  - Provide fairness in bandwidth allocation
  - Guarantee end-to-end reliability

Examples of Traditional transport Layer Protocol

- Transport Control Protocol (TCP)
- User Datagram Protocol(UDP)
- Sequenced Packet Exchange Protocol (SPX)
- NWLink (Microsoft's approach to implementing IPX/SPX)

1.1 Challenges and Issues in Transport layer protocol

- WSNs should be designed with an eye to energy conservation, congestion control and reliability in data dissemination, security, and management.
- The congestion control may involve only the transport layer, but energy conservation may be related to the physical, data link, network, and perhaps all other high layers.
- Designing a new transport layer protocol for WSN should consider the following issues.

- **Induced traffic:** Unlike wired networks, ad hoc wireless networks utilize multi- hop radio relaying. A link-level transmission affects the neighbour nodes of both the sender and receiver of the link. In a path having multiple links, transmission at a particular link affects one upstream link and one downstream link. This traffic at any given link (or path) due to the traffic through neighbouring links (or paths) is referred to as induced traffic. This is due to the broadcast nature of the channel and the location-dependent contention on the channel. This induced traffic affects the throughput achieved by the transport layer protocol.

- **Induced throughput unfairness:** This refers to the throughput unfairness at the transport layer due to the throughput/delay unfairness existing at the lower layers such as the network and MAC layers.

- **Separation of congestion control, reliability, and flow control:** The transport layer flow can experience congestion with just one intermediate link under congestion. Hence, in networks such as ad hoc wireless networks, the performance of the transport layer may be improved if these are separately handled. While separating these, the most important objective to be considered is the minimization of the additional control overhead generated by them.

- **Power and bandwidth constraints:** Nodes in ad hoc wireless networks face resource constraints including the two most important resources: (i) power source and (ii) bandwidth. The performance of a transport layer protocol is significantly affected by these constraints.

- **Misinterpretation of congestion:** Traditional mechanisms of detecting congestion in networks, such as packet loss and retransmission timeout, are not suitable for detecting the network congestion in ad hoc wireless networks. This is because the high error rates of wireless channel, location-dependent contention, hidden terminal problem, packet collisions in the network, path breaks due to the mobility of nodes, and node failure due to a drained battery can also lead to packet loss in ad hoc wireless networks. Hence, interpretation of network congestion as used in traditional networks is not appropriate in ad hoc wireless networks.

- **Completely decoupled transport layer:** Another challenge faced by a transport layer protocol is the interaction with the lower layers. Wired network transport layer protocols are almost completely decoupled from the lower layers. In ad hoc wireless networks, the cross-layer interaction between the transport layer and lower layers such as the network layer and the MAC layer is important for the transport layer to adapt to the changing network environment.
- **Dynamic topology:** Some of the deployment scenarios of ad hoc wireless networks can lead to frequent path breaks, partitioning and remerging of networks, and high delay in reestablishment of paths. Hence, the performance of a transport layer protocol is significantly affected by the rapid changes in the network topology.

➢ Generally, transport control protocols' design include two main functions:

  - Congestion control
  - Loss recovery.

➢ The design of transport protocols for WSNs should consider the following factors:

- Perform congestion control and reliable delivery of data.
  - Since most data are from the sensor nodes to the sink, congestion might occur around the sink. WSNs need a mechanism for **packet loss recovery,** such as ACK and selective ACK used in TCP.
  - It may be more effective to use a hop-by-hop approach for congestion control and loss recovery since it may reduce packet loss and therefore conserve energy.
  - The hop-by-hop mechanism can also lower the buffer requirement at th e intermediate nodes

- Transport protocols for wireless sensor networks should **simplify the initial connection** establishment process or **use a connectionless protocol** to speed up the connection process, improve throughput, and lower transmission delay.
- Transport protocols for WSNs should avoid packet loss as much as possible since **loss translates to energy waste**. To avoid packet loss, the transport protocol should use an **Active Congestion Control (ACC)** at the cost of slightly lower link utilization. ACC triggers congestion avoidance before congestion actually occurs.
- The transport control protocols should **guarantee fairness** for a variety of sensor nodes.

  If possible, a transport protocol should be **designed with cross-layer optimization**. For example, if a routing algorithm informs the transport protocol of route failure, the protocol will be able to deduce that packet loss is not from congestion but from route failure. In this case, the sender may maintain its current rate.