Transport Layer - Additional Clarity Keywords

Study-Ready Notes

Compiled by Andrew Photinakis

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Contents

1 Transport Layer in Computer Networks

1.1 Core Definitions

- **Transport Layer:** Layer 4 of the OSI model responsible for end-to-end communication and data delivery between hosts.
- **Segment:** A unit of data encapsulated by the transport layer for transmission.
- **Port:** Logical endpoint identifying specific applications/services on a host.
- **Flow Control:** Mechanism to prevent sender from overwhelming the receiver.
- **Error Control:** Mechanism to detect and correct errors in transmitted data.

1.2 Keyword Breakdown

- **TCP (Transmission Control Protocol):** Connection-oriented, reliable, ensures ordered delivery.
- **UDP (User Datagram Protocol):** Connectionless, faster, but unreliable and unordered.
- **Three-Way Handshake:** Process to establish TCP connection (SYN, SYN-ACK, ACK).
- **Checksum:** Field used for error detection in segments/datagrams.
- **Sliding Window:** Technique for flow control and efficient data transmission.

1.3 Stepwise Mechanism

1. **TCP Connection Establishment:**
    - Client sends SYN.
    - Server responds with SYN-ACK.
    - Client sends ACK; connection established.
2. **Data Transmission:**
    - Segmenting large messages.
    - Sending segments with sequence numbers.
    - Receiver acknowledges received segments.
    - Retransmit lost or corrupted segments.
3. **Connection Termination:**
    - Four-way handshake: FIN, ACK, FIN, ACK.

1.4 Examples & Applications

- **Web Browsing:** HTTP/HTTPS over TCP.
- **Video Streaming:** UDP for live low-latency streams.
- **Email:** SMTP, IMAP, POP3 over TCP.
- **Gaming:** Real-time multiplayer using UDP.

1.5 Comparisons / Contrasts

- **TCP vs UDP**
  - TCP: Reliable, connection-oriented, slower.
  - UDP: Unreliable, connectionless, faster.
- **Flow Control vs Congestion Control**
  - Flow Control: Manages sender vs receiver speed.
  - Congestion Control: Manages network congestion to avoid packet loss.

1.6 Analogies

- Transport layer = postal service: ensures letters (data) reach the correct recipient (port) reliably (TCP) or quickly without guarantee (UDP).

1.7 Visual / Diagram Description

- TCP Three-Way Handshake diagram:
  - Client $\rightarrow$ SYN $\rightarrow$ Server
  - Server $\rightarrow$ SYN-ACK $\rightarrow$ Client
  - Client $\rightarrow$ ACK $\rightarrow$ Server
- Optional figure: Segmentation and reassembly of a large message using sequence numbers.

1.8 Concept Integration

- Interfaces with the Network Layer (IP) for addressing and routing.
- Provides reliable delivery for Application Layer protocols.
- Supports end-to-end communication across heterogeneous networks.

1.9 Summary & Study Aids

[Summary: The transport layer ensures end-to-end data delivery, providing reliability, flow control, and error management, mainly through TCP and UDP protocols.]

2 Multiplexing in Computer Networks

2.1 Core Definitions

- **Multiplexing:** Technique of combining multiple signals or data streams into one shared communication channel.
- **Demultiplexing:** Reverse process of separating combined signals back into their original individual streams at the receiver.
- **Channel:** A single communication path used to transmit multiple data flows.
- **Bandwidth:** The total data capacity of a channel shared among multiple users.

2.2 Keyword Breakdown

- **TDM (Time Division Multiplexing):** Allocates specific time slots to each data stream in sequence.
- **FDM (Frequency Division Multiplexing):** Allocates distinct frequency bands to each signal.
- **WDM (Wavelength Division Multiplexing):** Optical variant of FDM, using different light wavelengths.
- **CDM (Code Division Multiplexing):** Each sender uses a unique code to transmit simultaneously on the same frequency band.

2.3 Stepwise Mechanism

1. **Multiplexing Process:**
   - Multiple data sources are encoded or modulated.
   - Multiplexer (MUX) combines them into one composite signal.
   - Signal transmitted through a shared physical medium.
2. **Demultiplexing Process:**
   - Receiver uses a demultiplexer (DEMUX) to separate the composite signal.
   - Each original data stream is reconstructed and delivered to the correct application.

2.4 Examples & Applications

- **Telecommunications:** Combining multiple voice calls on a single trunk line.
- **Internet Links:** ISP backbone links use multiplexing to carry multiple data flows.
- **Fiber Optics:** WDM enables terabit-scale data transmission using different light wavelengths.
- **Satellite Communication:** TDM used for scheduling transmission times for multiple users.

2.5 Comparisons / Contrasts

- **TDM vs FDM**
  - TDM: Time-based sharing; all users use full bandwidth sequentially.
  - FDM: Frequency-based sharing; all users transmit simultaneously using separate frequencies.
- **Synchronous vs Statistical TDM**
  - Synchronous: Fixed time slots for each channel (can waste bandwidth).
  - Statistical: Slots assigned dynamically based on demand.

2.6 Analogies

- **TDM Analogy:** Like a round-robin conversation where each person speaks in turn.
- **FDM Analogy:** Like multiple radio stations broadcasting on different frequencies.
- **CDM Analogy:** Like multiple people speaking in different languages simultaneously; each listener understands only their language.

2.7 Visual / Diagram Description

- Typical multiplexing system:
  - Multiple sources $\rightarrow$ MUX $\rightarrow$ Shared Channel $\rightarrow$ DEMUX $\rightarrow$ Multiple Destinations.
- Time or frequency bands can be shown as parallel blocks labeled for each user.

2.8 Concept Integration

- Works closely with the **Physical Layer** for channel sharing.
- Used in **Transport Layer** via port multiplexing (identifying processes).
- Enables efficient utilization of bandwidth and scalability in communication systems.

2.9 Formulas & Performance Metrics

- **Bandwidth per User (FDM):** $B_u = \frac{B_{total}}{N}$ where N is the number of channels.
- **Efficiency (TDM):** $\eta = \frac{T_{useful}}{T_{frame}}$

2.10 Summary & Study Aids

[Summary: Multiplexing combines multiple data streams into one channel to optimize bandwidth and transmission efficiency; demultiplexing reverses the process at the receiver.]

[Mnemonic: **M.U.X. = Merge, Use, eXtract**: Merge signals → Use shared channel → eXtract original data at destination.]