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SECTION 02

# NETWORK MODELS

02

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# WHY A NETWORK MODEL?

A shared blueprint so every vendor's gear interoperates

Early networking equipment used proprietary, vendor-specific rules — a router from router from one company could not talk to a switch from another, and a global network global network like the internet would have been impossible. A reference model is a model is a blueprint defining how devices should communicate. When every manufacturer follows the same blueprint, their products work together seamlessly. seamlessly.

**KEY TAKEAWAY**

A network model is not a physical device — you cannot buy one. It is a set of agreed standards standards that manufacturers follow so their products work together.

**THE TWO IMPORTANT MODELS**

| MODEL | FULL NAME | CREATED BY |
|---|---|---|
| **OSI Model** | Open Systems Interconnection | ISO |
| **TCP/IP** | Department of Defense (DoD) Model Model | US DARPA |

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# THE OSI MODEL — 7 LAYERS

Formalised by ISO in 1984 · data flows down, then back up

## REMEMBER THE ORDER

**Layer 1 → 7 (bottom to top)**

*"Please Do Not Throw Sausage Pizza Away"*

Physical · Data Link · Network · Transport · Session · Presentation · Application

**Layer 7 → 1 (top to bottom)**

*"All People Seem To Need Data Processing"*

### KEY TAKEAWAY

OSI has 7 layers. Each station does one job, like a factory line. Data flows down the layers on the sender on the sender and back up on the receiver.

| | |
|---|---|
| L7 | APPLICATION |
| L6 | PRESENTATION |
| L5 | SESSION |
| L4 | TRANSPORT |
| L3 | NETWORK |
| L2 | DATA LINK |
| L1 | PHYSICAL |

Sending: top → bottom  Receiving: bottom → top

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# UPPER LAYERS (5–7)

Application-level functions · mostly software

L7

## APPLICATION

Interface between user software and the network. The protocol — not the app itself — sits here: your browser invokes HTTP. Identifies partners, checks resource availability, synchronises communication. HTTP, FTP, SMTP, POP3/IMAP, SSH, DNS.

L6

## PRESENTATION

Formats data so sender and receiver understand each other other — the translator. Handles text/image/audio/video text/image/audio/video formats (ASCII, JPEG, MP3, MPEG) MPEG) plus encryption (security) and compression (size). (size).

L5

## SESSION

Establishes, manages and terminates sessions — the ongoing ongoing conversations between applications. Recovers Recovers interrupted sessions. Modes: full-duplex (phone (phone call), half-duplex (walkie-talkie), simplex (broadcast). (broadcast).

**IMPORTANT NOTE**

Modern TCP/IP has no true Session-layer protocol — connection management is handled by the Transport layer (TCP). The upper layers matter for understanding OSI, but engineers rarely troubleshoot them.

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# LAYER 4 — TRANSPORT

Reliable, end-to-end delivery · PDU = Segment

## KEY FUNCTIONS

- Segmentation — breaks large data into smaller segments
- Sequencing — numbers segments for correct reassembly
- Acknowledgments — confirms receipt; lost segments are resent
- Flow control (windowing) — negotiates rate so a fast sender does not overwhelm a slow receiver

### KEY TAKEAWAY

TCP = reliable but slower. UDP = fast but no guarantees. Layer 4 adds a header; the result is a result is a Segment.

## TCP vs. UDP

| PROTOCOL | TYPE | BEHAVIOUR |
|---|---|---|
| **TCP** | Connection-oriented | Reliable — acks, sequencing, flow flow control |
| **UDP** | Connectionless | Fast — no acks, no guarantees |

**Connection-oriented (TCP):** set up the connection first — like a phone call.

**Connectionless (UDP):** send immediately, no setup — like posting a letter.

**Use TCP** when reliability matters (web, files, email). **Use UDP** when speed matters (video calls, gaming, DNS).

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# NETWORK · DATA LINK · PHYSICAL

Where data actually moves — engineers live here

L3

## NETWORK

Communication between different networks — makes the internet possible. Logical addressing (IP identifies host + network) and routing (best path across networks). Protocol: IP. Device: Router. PDU = Packet.

L2

## DATA LINK

Moves data node-to-node within a single network. Sublayers: Sublayers: LLC (bridge to upper layers, error checking) and and MAC (controls medium access, uses MAC addresses). addresses). Adds a header + trailer (FCS). Ethernet, Wi-Fi. Wi-Fi. Device: Switch. PDU = Frame.

L1

## PHYSICAL

Transmits raw bits (0s and 1s) across the medium — electrical electrical signals (copper), light pulses (fibre) or radio waves waves (wireless). Defines voltages, connectors (RJ45), cable cable specs, distances. Devices: cables, NICs, hubs. PDU = Bit. PDU = Bit.

KEY TAKEAWAY

Router = Layer 3, reads IP addresses (Packet). Switch = Layer 2, reads MAC addresses (Frame). Physical = Layer 1, raw bits on the wire — no header added.

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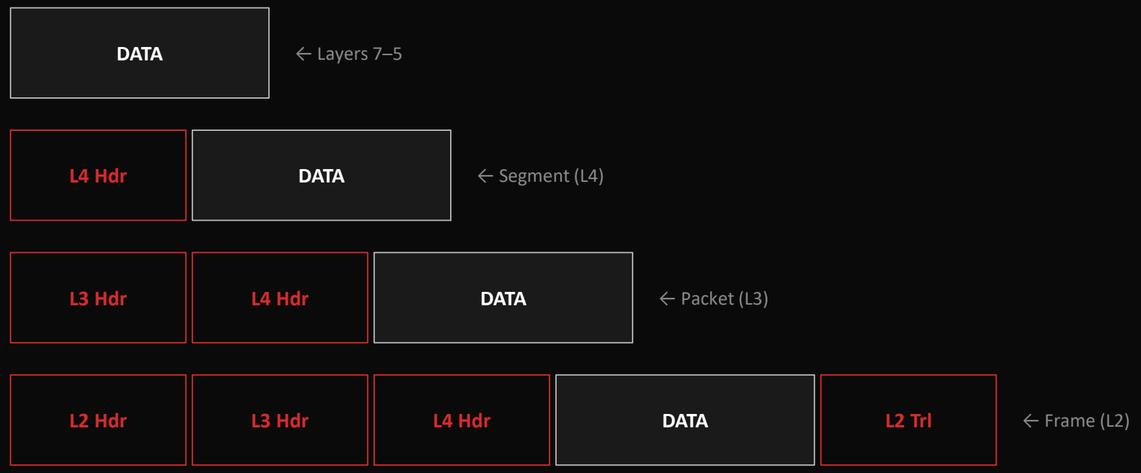
# PDUs & ENCAPSULATION

Each layer wraps the data above it with its own header

| OSI LAYER | PDU NAME | WHAT IS ADDED |
|---|---|---|
| **7 — Application** | Data | User data |
| **6 — Presentation** | Data | Formatting / encryption |
| **5 — Session** | Data | Session info |
| **4 — Transport** | Segment | L4 header (ports, sequencing) |
| **3 — Network** | Packet | L3 header (IP addresses) |
| **2 — Data Link** | Frame | L2 header (MAC) + trailer (FCS) |
| **1 — Physical** | Bit | Raw electrical / optical signals |

## ENCAPSULATION — DATA TRAVELS DOWN




**KEY TAKEAWAY**

Segment = L4 · Packet = L3 · Frame = L2 · Bit = L1

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# ENCAPSULATION & DE-ENCAPSULATION

Adding headers down · stripping headers up

## SENDING — ENCAPSULATE (DOWN)

1. App data → Transport adds L4 header → Segment
2. Segment → Network adds L3 header (IP) → Packet
3. Packet → Data Link adds L2 header (MAC) + trailer → Frame
4. Frame → Physical converts to Bits → transmitted on wire

## RECEIVING — DE-ENCAPSULATE (UP)

1. Physical receives bits → assembles a Frame → up
2. Data Link checks MAC, validates FCS, strips L2 → Packet
3. Network checks IP, strips L3 header → Segment
4. Transport checks sequencing, reassembles, strips L4 → Data

### THINK ABOUT IT

When a switch receives a frame it processes at Layer 2; when a router receives a packet it operates at Layer 3.

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# LAYER INTERACTION & TCP/IP

How layers talk · the 4-layer model the internet runs on

## TWO TYPES OF INTERACTION

**Adjacent-layer** — different layers on the same device. Transport takes data from Session, adds a Session, adds a header, passes the segment to Network.

**Same-layer** — the same layer on two different devices. Layer 4 on your laptop talks to Layer 4 on the server; they understand each other's headers. Layers are independent.

### KEY TAKEAWAY

TCP/IP is the model the real internet runs on. OSI is the model we use to think and talk about networking. You need both.

## THE TCP/IP (DoD) MODEL — 4 LAYERS

| TCP/IP LAYER | OSI LAYERS | PROTOCOLS |
|---|---|---|
| **Application** | 7, 6, 5 | HTTP, FTP, SMTP, DNS |
| **Host-to-Host** | 4 | TCP, UDP |
| **Internet** | 3 | IP |
| **Network Access** | 2, 1 | Ethernet, Wi-Fi |

*OSI upper layers collapse into one Application layer; the two lowest collapse into Network Access.*

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# BROWSING A WEBSITE

What happens at each OSI layer when you load a page

| LAYER | WHAT HAPPENS |
|---|---|
| **7 — Application** | Your browser invokes HTTP to request the web page |
| **6 — Presentation** | Page encoded as HTML / JPEG, etc.; HTTPS/TLS encryption may apply |
| **5 — Session** | A session is established with the server (handled by TCP in TCP/IP) |
| **4 — Transport** | HTTP uses TCP; connection set up, data split into numbered segments |
| **3 — Network** | IP picks the best path; source & destination IP addresses added |
| **2 — Data Link** | MAC addresses deliver the frame on each link (PC → Switch → Router) |
| **1 — Physical** | Electrical signals, light pulses or radio waves carry the bits |

**THINK ABOUT IT**

Page loads but some images are missing → Layer 6 (Presentation) handles image formats like JPEG and GIF.

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# DAY 2 — KEY CONCEPTS

Everything to remember

| | |
|---|---|
| **OSI MODEL** | 7 layers — Physical to Application |
| **TCP/IP MODEL** | 4 layers — what the real internet uses |
| **ENCAPSULATION** | Add headers travelling DOWN (sending) |
| **DE-ENCAPSULATION** | Strip headers travelling UP (receiving) |
| **SEGMENT / PACKET** | L4 PDU / L3 PDU |
| **FRAME / BIT** | L2 PDU / L1 PDU |
| **SAME-LAYER** | Layer N on Device A ↔ Layer N on Device B |
| **ADJACENT-LAYER** | Layer passes data up/down on one device |

| | |
|---|---|
| **L1 PHYSICAL** | Raw bits · cables, connectors, NICs |
| **L2 DATA LINK** | Node-to-node · MAC · Switch |
| **L3 NETWORK** | Network-to-network · IP · Router |
| **L4 TRANSPORT** | End-to-end · TCP (reliable), UDP (fast) |
| **L5 SESSION** | Establishes / manages / ends sessions |
| **L6 PRESENTATION** | Formatting, encryption, compression |
| **L7 APPLICATION** | User-to-network · HTTP, FTP, SMTP |