Absolutely. I'll make your **DCCN (CS24305) Master Notes** in the same style as CD: **complete M1–M5 coverage, no syllabus topic intentionally skipped, exam-focused explanations, formulas, diagrams, active-recall prompts, memory hooks, and actual uploaded-paper questions clearly separated from syllabus/question-bank questions.**

Your uploaded study guide lists **52 DCCN topics: 13 + 6 + 8 + 9 + 16**.

One important distinction: the uploaded papers include **AI323/IT365 DCCN papers**, including 2025 mid/end papers, but they are not labelled CS24305 CSE papers. I'll therefore mark those as **[UPLOADED PYQ]**, rather than pretending they are your exact CSE paper. Your uploaded study guide also contains a DCCN question bank covering the syllabus.

📘 DCCN — COMPLETE MASTER NOTES

CS24305 | Data Communication & Computer Networks

🧠 0. THE ONE BIG PICTURE

Before memorizing anything, build this mental model:

```
DATA
 ↓
SIGNAL
 ↓
TRANSMISSION MEDIA
 ↓
ENCODING / MODULATION
 ↓
DATA LINK
 ↓
SWITCHING
 ↓
NETWORK / IP
 ↓
ROUTING
 ↓
TRANSPORT
 ↓
APPLICATION
```

Or think:

> **Key Insight**
>
> **Send → Encode → Carry → Detect Errors → Control → Switch → Route → Deliver → Application**

This single chain connects almost the entire syllabus.

MODULE I — DATA COMMUNICATION & NETWORKING OVERVIEW

13 topics

Your syllabus covers Communication Model, Data Communication, Networks, Internet, OSI, TCP/IP, standards/layers, applications, transmission concepts, analog/digital transmission, impairments and channel capacity.

---

1. Communication Model

Basic communication:



Components

Component	Meaning
Sender	Generates data
Receiver	Receives data
Message	Information being transmitted
Medium	Physical/wireless path
Encoder	Converts information into signal
Decoder	Recovers information
Protocol	Rules governing communication

Protocol

A protocol defines:

- syntax
- semantics
- timing
- sequence
- error handling

Memory hook

S-M-M-P

Sender → **M**essage → **M**edium → **P**rotocol

---

2. Data Communications

Data communication = exchange of data between devices through a communication medium.

Characteristics

Good communication should provide:

- delivery
- accuracy
- timeliness
- low jitter

Data representation

Data can represent:

- text
- numbers
- images
- audio
- video

Transmission modes

Simplex



One direction only.

Example: traditional television broadcasting.

Half-duplex



Both directions, but not simultaneously.

Example: walkie-talkie.

Full-duplex



Both directions simultaneously.

Example: telephone.

[UPLOADED PYQ] asks for the main transmission modes.

---

3. Networks

A computer network is a collection of interconnected devices that communicate and share resources.

Types by geographical size

```
PAN → LAN → MAN → WAN
```

PAN

Personal Area Network.

Small personal range.

Example:

```
Phone ↔ Earbuds ↔ Smartwatch
```

LAN

Local Area Network.

- building/campus
- high speed
- usually privately managed

MAN

Metropolitan Area Network.

Covers a city/metropolitan region.

WAN

Wide Area Network.

Covers large geographical regions.

Example: Internet.

Comparison

PAN	LAN	MAN	WAN
Personal	Building/campus	City	Country/world
Very small	Small	Medium	Huge

---

4. Internet

The Internet is a global **network of interconnected networks** using the TCP/IP protocol suite.

```
Device
  ↓
LAN
  ↓
Router
  ↓
ISP
  ↓
Internet
  ↓
Server
```

Important ideas:

- packet switching
- routers
- IP addressing
- TCP/UDP
- DNS
- application protocols

---

5. OSI Model

The OSI model contains **7 layers**.

```
7  Application
6  Presentation
5  Session
4  Transport
3  Network
2  Data Link
1  Physical
```

Memory trick

> **Key Insight**
>
> **All People Seem To Need Data Processing**

A → P → S → T → N → D → P

Layer 7 — Application

Provides network services to applications.

Examples:

- HTTP
- FTP
- SMTP
- DNS

Layer 6 — Presentation

Deals with:

- translation
- encryption/decryption
- compression

Example:

```
ASCII ↔ another representation
```

Layer 5 — Session

Manages sessions/dialogues.

Functions:

- establish session
- maintain session
- terminate session
- synchronization

Layer 4 — Transport

End-to-end delivery.

Important concepts:

- segmentation
- reassembly
- flow control
- error control
- reliability

Protocols:

- TCP
- UDP

Layer 3 — Network

Responsible for:

- logical addressing
- routing
- packet forwarding

Protocol:

- IP

Device:

- router

Layer 2 — Data Link

Responsible for:

- framing
- MAC addressing
- error detection
- flow control
- medium access

Devices:

- switches/bridges

Layer 1 — Physical

Transmits raw bits.

Deals with:

- voltage
- connectors
- cables
- bit transmission
- signal characteristics

---

6. TCP/IP Protocol Architecture

Your syllabus specifically includes TCP/IP architecture.

Common 4-layer representation:

```
Application
     ↓
Transport
     ↓
Internet
     ↓
Network Access
```

Application

HTTP, DNS, SMTP, FTP, DHCP etc.

Transport

TCP / UDP.

Internet

IP, ICMP etc.

Network Access

Physical transmission + data-link functionality.

OSI vs TCP/IP

OSI	TCP/IP
7 layers	4–layer representation
Reference model	Protocol architecture
Developed by ISO	Developed around Internet protocols
Session & Presentation separate	Usually part of Application
Data Link + Physical separate	Often combined as Network Access

[UPLOADED PYQ] directly asks to compare OSI and TCP/IP.

[UPLOADED PYQ] also asks TCP/IP architecture and layer functions.

7. Standards and Protocol Layers

Layering divides networking into manageable functions.

```
Application
_____________
Transport
_____________
Network
_____________
Data Link
_____________
Physical
```

Why layering?

- modularity
- easier design
- easier troubleshooting
- interoperability
- independent development

Encapsulation

Sender:

```
Application Data
      ↓
Transport Segment
      ↓
Network Packet
      ↓
Data-Link Frame
      ↓
Bits
```

Receiver performs reverse:

```
Bits
 ↓
Frame
 ↓
Packet
 ↓
Segment
 ↓
Data
```

8. Internet Applications

Application	Protocol
Web	HTTP/HTTPS
Email sending	SMTP
Email retrieval	POP3/IMAP
File transfer	FTP
Name resolution	DNS
Automatic addressing	DHCP
Secure remote login	SSH

9. Data Transmission Concepts & Terminology

Bit rate

Bits transmitted per second.

```
bps
```

Baud rate

Symbols transmitted per second.

If each symbol carries one bit:

```
baud = bit/s
```

Otherwise:

```
Bit rate = Baud rate × bits/symbol
```

Bandwidth

Frequency range available to a channel.

For analog channel:

```
Bandwidth = f_high - f_low
```

Throughput

Actual achieved data rate.

Usually:

```
Throughput ≤ theoretical data rate
```

Latency

Total delay experienced by data.

Major components:

```
Transmission delay
+
Propagation delay
+
Processing delay
+
Queuing delay
```

Transmission delay

Time to push bits onto link:

```
Ttrans = Packet size / Data rate
```

Propagation delay

Time for signal to travel:

```
Tprop = Distance / Propagation speed
```

Jitter

Variation in packet delay.

Especially important for:

- voice
- video
- real-time applications

10. Analog Data Transmission

Analog signal varies continuously.



Parameters:

- amplitude
- frequency
- phase

11. Digital Data Transmission

Digital signal uses discrete levels.



Typically represented using binary values.

Analog vs Digital

Analog	Digital
Continuous	Discrete
More susceptible to accumulated noise	Better noise regeneration
Uses continuous waveform	Uses discrete signal levels
Traditional radio/voice systems	Computers/data networks

12. Transmission Impairments

Three major impairments:

```
Attenuation
Distortion
Noise
```

Attenuation

Signal loses strength with distance.

Measured commonly in decibels.

```
Received power < Transmitted power
```

Distortion

Signal shape changes.

Different frequency components may experience different delays/attenuation.

Noise

Unwanted signal added to desired signal.

Types:

- thermal
- intermodulation
- crosstalk
- impulse

[UPLOADED PYQ] asks specifically about major transmission impairments and their effect on signal quality.

---

13. Channel Capacity

Maximum theoretical rate at which information can be transmitted reliably.

Nyquist theorem

For a noiseless channel:

$$C = 2B \log_2 L$$

where:

- B = bandwidth
- L = number of signal levels

Shannon theorem

For noisy channel:

$$C = B \log_2(1 + S/N)$$

where:

- C = capacity
- B = bandwidth

- S/N = signal-to-noise ratio

If SNR is in dB:

```
SNRlinear = 10^(SNRdB/10)
```

Key distinction

> **Key Insight**
> **Nyquist → noiseless**

> **Key Insight**
> **Shannon → noisy**

[UPLOADED PYQ] asks Shannon capacity directly.

🧠 M1 ACTIVE RECALL

Without looking:

1. What are the five basic components of data communication?
2. Simplex vs half-duplex vs full-duplex?
3. PAN/LAN/MAN/WAN?
4. Name all seven OSI layers.
5. What does each OSI layer do?
6. OSI vs TCP/IP?
7. What is encapsulation?
8. Bit rate vs baud rate?
9. Transmission vs propagation delay?
10. Attenuation vs distortion vs noise?
11. Nyquist formula?
12. Shannon formula?

MODULE II — TRANSMISSION MEDIA & SIGNAL ENCODING

6 topics

The uploaded syllabus lists Guided Media, Wireless Transmission & Propagation, Digital Signaling, Analog Signaling, Encoding and Modulation.

---

14. Guided Transmission Media

Signals travel through physical media.



Twisted Pair

Two insulated copper wires twisted together.

Types

UTP

Unshielded Twisted Pair.

STP

Shielded Twisted Pair.

Advantages

- inexpensive
- easy installation
- widely available

Disadvantages

- electromagnetic interference
- lower bandwidth than fiber
- attenuation

Coaxial Cable

Structure:



Better shielding than twisted pair.

Applications:

- cable TV
- broadband
- older Ethernet

Optical Fiber

Uses light instead of electrical signals.



Principle:

> **Key Insight**
>
> **Total Internal Reflection**

Advantages

- huge bandwidth
- low attenuation
- EMI immunity
- lightweight
- secure against electromagnetic interception

Disadvantages

- installation complexity
- higher equipment cost
- fragile compared with copper

Memory

> **Key Insight**
>
> **Copper carries electrons; fiber carries light.**

---

15. Wireless Transmission & Propagation

Unguided media:



Propagation methods

Ground wave

Follows Earth's surface.

Sky wave

Signal reflected/refracted by ionospheric region.

Line-of-sight

Direct path between antennas.



Used heavily by microwave communication.

Satellite Communication



Advantages

- huge coverage
- useful for remote regions
- broadcasting

Disadvantages

- high propagation delay
- expensive
- weather effects for some bands
- requires satellite infrastructure

[UPLOADED PYQ] asks the physical description/transmission characteristics of satellite microwave and satellite-vs-terrestrial microwave.

---

16. Digital Signaling

Digital data must be represented by physical signal patterns.

Important line codes:

- NRZ-L
- NRZ-I/NRZI
- Manchester
- Differential Manchester
- Bipolar AMI

NRZ-L

Signal level represents bit value.

Convention depends on specification.

Key issue:

> **Key Insight**
>
> Long sequences of same bits can cause synchronization problems.

NRZ-I

A transition represents one binary value; no transition represents the other.

The exact convention must be stated.

[UPLOADED PYQ] asks NRZI and Differential Manchester waveforms.

Manchester

Every bit has a transition in the middle.

This provides synchronization.

Typical convention:

```
1 → high-to-low
0 → low-to-high
```

But always follow the convention specified by your teacher/question.

Key advantage

Self-clocking.

Differential Manchester

There is always a transition in the middle.

The transition at the beginning determines the bit value.

Again, conventions may differ.

Bipolar AMI

```
0 → zero level
1 → alternating +V and -V
```

Example:

```
1 0 1 1 0 1
+ 0 - + 0 -
```

17. Analog Signaling

Digital data can be represented by changing a carrier wave.

Carrier:

```
c(t) = Ac cos(2πfct + φ)
```

Three fundamental parameters:

- amplitude
- frequency
- phase

Changing one creates modulation.

18. Encoding Techniques

Encoding

Maps data into a signal suitable for transmission.

```
Bits → Line Code → Signal
```

Important techniques:

Technique	Main idea
NRZ-L	Level represents data
NRZ-I	Transition represents data
Manchester	Mid-bit transition
Differential Manchester	Mid-bit transition + differential beginning
AMI	Bipolar representation

[UPLOADED PYQ]

For `001110011`, the paper asks you to draw:

- NRZ-L
- NRZ-I
- Bipolar AMI
- Manchester
- Differential Manchester

This is a **must-practice waveform question**.

19. Modulation Techniques

Modulation changes a carrier according to information.

ASK

Amplitude Shift Keying.

```
1 → carrier present
0 → carrier absent/different amplitude
```

FSK

Frequency Shift Keying.

```
1 → f1
0 → f2
```

PSK

Phase Shift Keying.

```
1 → phase φ1
0 → phase φ2
```

QAM

Quadrature Amplitude Modulation.

Changes:

- amplitude
- phase

simultaneously.

General comparison

ASK	FSK	PSK	QAM
Amplitude	Frequency	Phase	Amplitude + phase
Simple	Robust	Good noise performance	High data capacity

🧠 M2 ACTIVE RECALL

1. Twisted pair vs coaxial vs fiber?
2. Why is fiber resistant to EMI?

3. What is total internal reflection?
4. Ground vs sky vs LOS propagation?
5. Satellite vs terrestrial microwave?
6. NRZ-L vs NRZ-I?
7. Why does Manchester help synchronization?
8. What happens in AMI?
9. ASK/FSK/PSK/QAM?
10. Encoding vs modulation?

MODULE III — ERROR HANDLING, DATA LINK CONTROL & MULTIPLEXING

8 topics

The syllabus contains errors, detection, correction, flow/error control, HDLC, FDM and TDM.

---

20. Types of Errors

Single-bit error

Only one bit changes.

```
Sent:     101101
Received:101001
```

Burst error

Multiple bits in a sequence are affected.

```
Sent:     1100110011
Received:1101001011
```

Burst errors are particularly important in practical communication channels.

---

21. Error Detection Techniques

Goal:

> **Key Insight**
> Detect whether received data has been corrupted.

Main techniques:

```
Parity
Checksum
CRC
```

Parity

Add one bit.

Even parity

Total number of 1s becomes even.

Odd parity

Total number of 1s becomes odd.

Limitation

A single parity bit is not sufficient for detecting every possible error pattern.

[UPLOADED PYQ] directly asks what a parity bit is and how it detects errors.

22. Checksum

Basic idea:

```
Data words
   ↓
Add
   ↓
Complement
   ↓
Checksum
```

Receiver performs corresponding calculation.

Used historically/in various network protocols including transport/network contexts.

23. CRC

Cyclic Redundancy Check is one of the most important DCCN numerical topics.

Given:

```
Data = D
Generator = G
```

If generator degree = r:

1. Append r zeros to data.
2. Perform modulo-2 division.
3. Remainder = CRC.

4. Append remainder to original data.

```
Transmitted frame = Data + CRC
```

Modulo-2 arithmetic

Subtraction = XOR.

```
0 XOR 0 = 0
0 XOR 1 = 1
1 XOR 0 = 1
1 XOR 1 = 0
```

Receiver

Divide received frame by generator.

```
remainder = 0
```

means no detected error under the CRC test.

[UPLOADED PYQ] asks CRC for:

```
Data = 1010011110
Generator = 1011
```

Another uploaded paper asks:

```
Data = 1101011011
Generator = 10011
```

and requests the complete calculation and transmitted message.

🚨 Must practice

Do not memorize CRC.

Do the binary division repeatedly.

---

24. Error Correction Techniques

Error correction means recovering/correcting corrupted data.

Two broad approaches:

Forward Error Correction

Receiver corrects error without retransmission.

Useful when retransmission is expensive or slow.

Hamming Code

Adds redundant bits at carefully selected positions.

Hamming Code

For `m` data bits and `r` parity bits:

```
2^r ≥ m + r + 1
```

Parity positions:

```
1, 2, 4, 8, 16, ...
```

These are powers of two.

Example:

```
Position:
1 2 3 4 5 6 7
P P D P D D D
```

Parity bits cover different position groups.

Syndrome

The received parity-check results form a binary number.

If syndrome:

```
000
```

→ no detected single-bit error.

If:

```
101
```

→ error at decimal position 5.

Memory

> **Key Insight**
>
> **Hamming parity lives at powers of 2.**

---

25. Flow Control

Flow control prevents a fast sender from overwhelming a slow receiver.

```
Fast Sender ──────────► Slow Receiver
             CONTROL
```

Important methods:

- Stop-and-Wait
- Sliding Window

Stop-and-Wait



Only one outstanding frame.

Advantage

Simple.

Disadvantage

Poor link utilization on long-delay networks.

Sliding Window

Multiple frames can be outstanding.



Window moves as acknowledgements arrive.

Benefits:

- better utilization
- higher throughput
- supports pipelining

---

26. Error Control

Flow control:

> **Key Insight**
>
> **How fast?**

Error control:

> **Key Insight**
>
> **Was it received correctly?**

Error control uses:

- error detection
- acknowledgements
- retransmission
- sequence numbers
- timers

ARQ

Automatic Repeat reQuest.

Important forms:

1. Stop-and-Wait ARQ
2. Go-Back-N
3. Selective Repeat

Go-Back-N

If frame k is lost:

```
0 ✓
1 ✓
2 ✗
3
4
```

sender retransmits from frame 2 onward.

Selective Repeat

Only damaged/missing frames are retransmitted.

```
0 ✓
1 ✓
2 ✗
3 ✓
4 ✓
```

Retransmit only 2.

Comparison

GBN	Selective Repeat
Retransmits from error onward	Retransmits selected frames
Simpler	More complex
More waste	More efficient

[UPLOADED PYQ] explicitly asks Sliding Window and Stop-and-Wait ARQ vs Go-Back-N.

---

27. HDLC

High-Level Data Link Control

A bit-oriented data-link protocol.

Basic frame:



Flag

Identifies frame boundaries.

Common flag pattern:

```
01111110
```

Address

Identifies station.

Control

Defines frame type/control information.

Data

Payload.

FCS

Frame Check Sequence for error detection.

HDLC frame types

I-frame

Information.

Carries user data.

S-frame

Supervisory.

Used for control/acknowledgement.

U-frame

Unnumbered.

Used for management/control functions.

Memory

> **Key Insight**
> **I = Information**

> **Key Insight**
> **S = Supervisory**

> **Key Insight**
>
> **U = Unnumbered**

28. FDM

Frequency Division Multiplexing

Channel bandwidth is divided into frequency bands.



Each signal gets a different frequency band.

Applications:

- radio
- television
- analog communication

Guard bands

Prevent interference between adjacent channels.

29. TDM

Time Division Multiplexing

Users share the channel by taking turns in time.



Synchronous TDM

Fixed time slot allocated to each source.

Even if source has no data, slot may remain allocated.

Statistical TDM

Slots dynamically allocated to active sources.

Better utilization but requires more control.

[UPLOADED PYQ] asks TDM and explicitly asks synchronous vs asynchronous/statistical TDM.

🧠 M3 ACTIVE RECALL

1. Single-bit vs burst error?
2. Parity vs checksum vs CRC?
3. CRC steps?
4. What is `2^r ≥ m+r+1` used for?
5. Where are Hamming parity bits placed?
6. Flow control vs error control?
7. Stop-and-Wait?
8. GBN vs Selective Repeat?
9. HDLC frame?
10. I/S/U frames?
11. FDM vs TDM?
12. Synchronous vs statistical TDM?

MODULE IV — WAN & LAN

9 topics

Your syllabus lists switching, circuit/packet switching, cellular networks, generations, topologies, LAN architecture and VLANs.

---

30. Switching Network

Switching allows information to move through intermediate network nodes.

Main approaches:

```
Switching
├── Circuit Switching
└── Packet Switching
```

---

31. Circuit-Switching Networks

A dedicated path is established before communication.

```
A ── S1 ── S2 ── S3 ── B
      dedicated circuit
```

Three phases:

```
Setup
 ↓
Data transfer
 ↓
Teardown
```

Advantages:

- predictable path
- predictable delay after setup
- suitable for continuous traffic

Disadvantages:

- setup time
- inefficient for bursty traffic
- dedicated resources may remain unused

---

32. Circuit-Switching Concepts

Important characteristics:

- dedicated resources
- call setup
- fixed path
- circuit release

Traditional telephone systems are the classic example.

---

33. Packet-Switching Principles

Data is divided into packets.

```
Message
 ↓
Packet 1
Packet 2
Packet 3
 ↓
Network
 ↓
Destination
```

Packets may share links with other traffic.

Two major approaches:

Datagram

Each packet independently routed.

Virtual Circuit

Logical path established; packets follow that logical route.

Circuit vs Packet

Circuit	Packet
Dedicated path	Shared network
Setup	Usually no dedicated setup
Predictable path	Dynamic
Good for continuous traffic	Good for bursty traffic
Traditional telephony	Internet

[UPLOADED PYQ] explicitly asks circuit vs packet switching.

Another uploaded paper asks datagram vs virtual-circuit packet switching.

---

34. Principles of Cellular Networks

A cellular network divides a geographical region into cells.



Each cell has a base station.

Frequency reuse

Same frequency can be reused in sufficiently separated cells.

Goal:

> **Key Insight**
> Increase capacity without requiring unique frequencies everywhere.

Handoff

When a mobile moves from one cell to another:



The connection is transferred to another base station.

---

35. Cellular Network Generations

1G

- analog
- voice

2G

- digital
- voice
- SMS
- improved capacity

3G

- higher data rates
- mobile Internet

4G

- broadband mobile data
- LTE
- IP-oriented services

5G

- very high capacity
- low-latency applications
- massive device connectivity
- IoT-oriented use cases

Memory

> **Key Insight**
>
> **1 Voice → 2 Digital → 3 Internet → 4 Broadband → 5 Massive Connectivity**

---

36. Network Topologies

Bus

```
A — B — C — D
```

Cheap but backbone failure can affect network.

Star



Easy to manage.

Central device is critical.

Ring



Nodes form a ring.

Mesh

Every node has multiple connections.



Very reliable but expensive.

Tree

Hierarchical arrangement.



Comparison

Topology	Major strength	Major weakness
Bus	Cheap	Backbone failure
Star	Easy management	Central-device dependency
Ring	Predictable structure	Break can affect ring
Mesh	Reliability	Cost
Tree	Scalable hierarchy	More complex

---

37. LAN Protocol Architecture

IEEE LAN architecture is associated with the data-link layer and physical layer.

Data Link is commonly divided into:

```
Data Link
├── LLC
└── MAC
```

LLC

Logical Link Control.

Provides higher-level link services.

MAC

Medium Access Control.

Deals with:

- addressing
- access to shared medium
- frame handling

---

38. VLAN

Virtual LAN

A VLAN logically divides a physical LAN.

```
Physical Switch
  ├── VLAN 10 → Students
  ├── VLAN 20 → Faculty
  └── VLAN 30 → Admin
```

Devices can be physically connected to the same switches but logically separated.

Benefits

- segmentation
- security
- broadcast-domain reduction
- easier management
- flexibility

Memory

> **Key Insight**
> **VLAN = logical LAN, not necessarily physical LAN.**

🧠 M4 ACTIVE RECALL

1. What is switching?
2. Circuit vs packet switching?
3. Datagram vs virtual circuit?
4. Three phases of circuit switching?
5. Why does packet switching suit bursty data?
6. What is frequency reuse?
7. What is handoff?
8. 1G → 5G evolution?
9. Five network topologies?
10. LLC vs MAC?
11. Why VLAN?

MODULE V — ETHERNET, IP, ROUTING & APPLICATIONS

16 topics

The syllabus contains Traditional Ethernet, High-Speed Ethernet, Wi-Fi, IP, addressing, transport, routing, three routing approaches, congestion, traffic management and SMTP/DNS/HTTP/DHCP.

---

39. Traditional Ethernet

Ethernet is standardized under **IEEE 802.3**.

Traditional Ethernet:

```
10 Mbps
```

Historically used:

- coaxial cable

- twisted pair

Traditional shared-medium Ethernet used **CSMA/CD**.

---

40. High-Speed Ethernet

Important generations:

```
Ethernet       → 10 Mbps
Fast Ethernet  → 100 Mbps
Gigabit        → 1 Gbps
10 Gigabit     → 10 Gbps
```

Higher-speed Ethernet improves:

- throughput
- latency
- network capacity

---

41. IEEE 802.11 — Wi-Fi

Wireless LAN standard.

Common generations include:

- 802.11b
- 802.11a
- 802.11g
- 802.11n
- 802.11ac
- 802.11ax

Advantages:

- mobility
- easy deployment
- no cable to every endpoint

Challenges:

- interference
- shared medium
- security concerns
- variable performance

Ethernet vs Wi-Fi

Ethernet	Wi-Fi
Wired	Wireless
IEEE 802.3	IEEE 802.11
Dedicated physical connection typically	Shared radio medium
Generally more stable	More interference-sensitive

---

42. Internet Protocol — IP

IP provides logical addressing and packet delivery across interconnected networks.

Main versions:

```
IPv4
IPv6
```

IPv4

32-bit address.

Example:

```
192.168.1.10
```

IPv4 header includes fields such as:

- Version
- Header Length
- Total Length
- Identification
- Flags
- Fragment Offset
- TTL
- Protocol
- Header Checksum
- Source Address
- Destination Address

[UPLOADED PYQ] asks the structure and working of IPv4 and purpose of major header fields.

IPv6

128-bit addressing.

Example:

```
2001:db8::1
```

Advantages:

- enormous address space
- simplified base header
- better support for modern networking requirements
- extension-header architecture

IPv4 vs IPv6

IPv4	IPv6
32-bit	128-bit
Dotted decimal	Hexadecimal
Smaller address space	Huge address space
Broadcast exists	No conventional broadcast; multicast/anycast mechanisms
More dependence on NAT historically	Designed for vastly larger address space

43. IP Addressing

An IP address identifies a network interface logically.

Classful IPv4 addressing

Traditional classes:

Class	First octet range	Default mask
A	1–126	/8
B	128–191	/16
C	192–223	/24
D	224–239	Multicast
E	240–255	Experimental

Important special addresses

Private IPv4 ranges:

```
10.0.0.0/8
172.16.0.0/12
192.168.0.0/16
```

Subnetting

Splits a network into smaller networks.

Example:

```
192.168.1.0/24
```

If changed to:

```
/26
```

then:

```
2^(26-24) = 4 subnets
```

Each `/26` has:

```
2^(32-26) = 64 addresses
```

Traditionally:

```
62 usable host addresses
```

per ordinary subnet, excluding network and broadcast addresses.

Must know

```
Number of subnets = 2^borrowed_bits
Addresses/subnet = 2^host_bits
```

---

44. Transport Protocols

Main transport protocols:

```
TCP
UDP
```

TCP

Transmission Control Protocol.

Properties:

- connection-oriented
- reliable
- ordered
- byte-stream
- flow control
- congestion control

Three-way handshake



Connection established.

UDP

User Datagram Protocol.

Properties:

- connectionless
- low overhead
- no built-in reliability
- no ordering guarantee
- useful for real-time/latency-sensitive applications

TCP vs UDP

TCP	UDP
Connection-oriented	Connectionless
Reliable	Best-effort
Ordered	No ordering guarantee
More overhead	Low overhead
Flow/congestion control	No TCP-style mechanisms
Web/secure web/file transfer etc.	DNS, streaming/real-time uses, etc. depending on application

The uploaded DCCN question bank identifies **TCP vs UDP** as one of the highest-priority Module V questions.

---

45. Routing in Packet-Switching Networks

Routing determines a path from source to destination.



Routing algorithms use metrics such as:

- hop count
- delay
- bandwidth
- cost
- reliability

---

46. Distance Vector Routing

Each router maintains distance estimates to destinations.

Basic idea:

> **Key Insight**
> Router knows the distance through neighbors.

A classic recurrence is based on:

$$D_x(y) = \min_v \{ c(x,v) + D_v(y) \}$$

Characteristics

- neighbor-based information
- iterative updates
- simpler
- slower convergence in some situations

Example protocol:

> **Key Insight**
> **RIP**

Problem

Count-to-infinity.

---

47. Link State Routing

Every router builds a map of the network.

Steps:

```
Discover neighbors
       ↓
Measure link costs
       ↓
Create link-state information
       ↓
Flood information
       ↓
Build topology database
       ↓
Run shortest-path algorithm
```

Common algorithm:

> **Key Insight**
>
> **Dijkstra**

Example protocol:

> **Key Insight**
>
> **OSPF**

Memory

> **Key Insight**
>
> **Link State = Know the map.**

---

48. Path Vector Routing

Used especially for routing between autonomous systems.

Instead of simply advertising a distance, routers advertise path information.

Example:

```
AS1 → AS3 → AS7
```

A router can use policy and path information to select routes.

Main protocol:

> **Key Insight**
>
> **BGP**

Memory

```
Distance Vector → RIP
Link State      → OSPF
Path Vector     → BGP
```

---

49. Congestion Control

Congestion occurs when offered traffic exceeds network capacity.



Effects:

- delay
- packet loss
- retransmissions
- reduced throughput

Congestion vs Flow Control

Flow control

Protects the receiver.

Congestion control

Protects the network.

Congestion-control approaches

- traffic shaping
- admission control
- queue management
- congestion avoidance
- rate control

Leaky Bucket

Controls output at a relatively fixed rate.



Token Bucket

Tokens accumulate at a controlled rate.

Packets require tokens to transmit.

Allows controlled bursts.

50. Traffic Management

Goal:

> **Key Insight**
> Use network resources efficiently while maintaining acceptable service quality.

Includes:

- QoS
- queue management
- scheduling
- traffic shaping
- admission control
- congestion avoidance

QoS dimensions

- bandwidth
- delay
- jitter
- packet loss

Memory

> **Key Insight**
> **QoS = Bandwidth + Delay + Jitter + Loss**

51. SMTP

Simple Mail Transfer Protocol

Used primarily for sending/relaying email.

Typical ports:

```
25  → SMTP relay
587 → message submission
```

Basic flow:

```
Sender
  ↓
Mail Server
  ↓
Internet
  ↓
Recipient Mail Server
```

SMTP is primarily a **sending/transfer** protocol.

---

52. DNS

Domain Name System

Maps domain names to network information, especially IP addresses.

```
www.example.com
       ↓
      DNS
       ↓
    IP address
```

Hierarchy

```
Root
 ↓
TLD
 ↓
Authoritative domain
 ↓
Host
```

Important records

Record	Purpose
A	IPv4 address
AAAA	IPv6 address
MX	Mail server
CNAME	Canonical name
NS	Name server
TXT	Text/metadata

Port:

```
53
```

DNS commonly uses UDP for ordinary queries, with TCP also used in situations such as zone transfers and responses requiring it.

---

53. HTTP

HyperText Transfer Protocol

Used for web communication.

Basic model:

```
Client ── HTTP Request ──► Server
Client ◄── HTTP Response ── Server
```

Common methods

```
GET
POST
PUT
DELETE
```

Common status codes

```
2xx → Success
3xx → Redirection
4xx → Client error
5xx → Server error
```

Examples:

```
200 → OK
301/302 → Redirect
404 → Not Found
500 → Server Error
```

Ports:

```
HTTP  → 80
HTTPS → 443
```

---

54. DHCP

Dynamic Host Configuration Protocol

Automatically provides configuration such as:

- IP address
- subnet mask
- gateway
- DNS server

DORA

```
Client
  │
  │ DISCOVER
  ▼
Server
  │
  │ OFFER
  ▼
Client
  │
  │ REQUEST
  ▼
Server
  │
  │ ACK
  ▼
Client configured
```

Memory

> **Key Insight**
>
> **DORA = Discover → Offer → Request → Acknowledge**

Ports:

```
Server → UDP 67
Client → UDP 68
```

🌐 THE MOST IMPORTANT INTEGRATED CONCEPT

What happens when you type a URL?

Suppose:

```
https://example.com
```

Step 1 — Device needs network configuration

DHCP can provide:

```
IP
Subnet Mask
Gateway
DNS server
```

Step 2 — DNS resolution

```
example.com
     ↓
DNS
     ↓
Server IP
```

Step 3 — Transport connection

For HTTPS over TCP:

```
TCP 3-way handshake
```

```
SYN
SYN + ACK
ACK
```

Step 4 — HTTP/HTTPS request

```
GET / ...
```

Step 5 — IP routing

Packet travels:

```
Host
 ↓
Default Gateway
 ↓
Routers
 ↓
Server
```

Step 6 — Link-layer transmission

Locally:

```
Ethernet / Wi-Fi
```

Step 7 — Server response

```
HTTP response
 ↓
TCP
 ↓
IP
 ↓
Ethernet/Wi-Fi
 ↓
Browser
```

Step 8 — Browser renders webpage

```
HTML
CSS
JavaScript
Images
etc.
```

This single scenario connects **M1 + M4 + M5**.

The uploaded question bank specifically asks for this complete URL → webpage journey.

🔥 ACTUAL UPLOADED PYQ PATTERNS

These are not invented; they come from the DCCN papers available in your uploaded files.

2025 AI323 Mid

- Port vs logical vs physical address
- TCP/IP architecture
- Eb/No
- Half vs full duplex
- LAN vs WAN
- Communication vs transmission
- Transmission impairments
- Shannon capacity
- Satellite microwave
- NRZ-L / NRZ-I / AMI / Manchester / Differential Manchester

2025 AI323 End

- IPv4 header
- TCP/IP architecture
- PCM
- Satellite microwave
- Sliding window
- Stop-and-Wait ARQ vs Go-Back-N
- CRC numerical
- Multiplexing/access methods
- LLC
- Internetworking
- Circuit vs packet switching

2025 IT365 Mid

- Transmission modes
- Data communication components
- Data Link Layer
- OSI vs TCP/IP

- SNR
- Transmission impairments
- Guided vs unguided media
- Delta Modulation vs PCM
- Parity
- CRC

2025 IT365 End

- OSI vs TCP/IP
- Noise
- NRZI
- Differential Manchester
- PCM
- Unguided media
- CRC numerical
- TDM
- Synchronous vs statistical TDM
- Datagram vs virtual circuit
- Dijkstra
- ATM

🧠 ULTRA-HIGH-YIELD 20

Your uploaded study guide itself identifies these as the **20 highest-priority questions/topics**.

⭐⭐⭐⭐⭐

1. OSI Model
2. TCP/IP Architecture
3. OSI vs TCP/IP
4. Guided Transmission Media
5. Analog vs Digital Signal
6. Manchester Encoding
7. ASK/FSK/PSK/QAM
8. CRC
9. Hamming Code
10. Stop-and-Wait vs Sliding Window
11. HDLC Frame
12. FDM vs TDM
13. Circuit vs Packet Switching
14. Cellular Networks / 1G–5G
15. Network Topologies
16. VLAN
17. IPv4 vs IPv6

18. TCP vs UDP
19. Routing — RIP/OSPF/BGP
20. DNS/HTTP/SMTP/DHCP

📊 FORMULA SHEET

Transmission

```
Bandwidth = fH - fL
```

```
Transmission Delay = Packet Size / Data Rate
```

```
Propagation Delay = Distance / Propagation Speed
```

Nyquist

```
C = 2B log₂L
```

Shannon

```
C = B log₂(1 + S/N)
```

SNR conversion

```
SNR(dB) = 10 log₁₀(S/N)
```

Subnetting

```
Number of subnets = 2^borrowed bits
```

```
Addresses/subnet = 2^host bits
```

Hamming

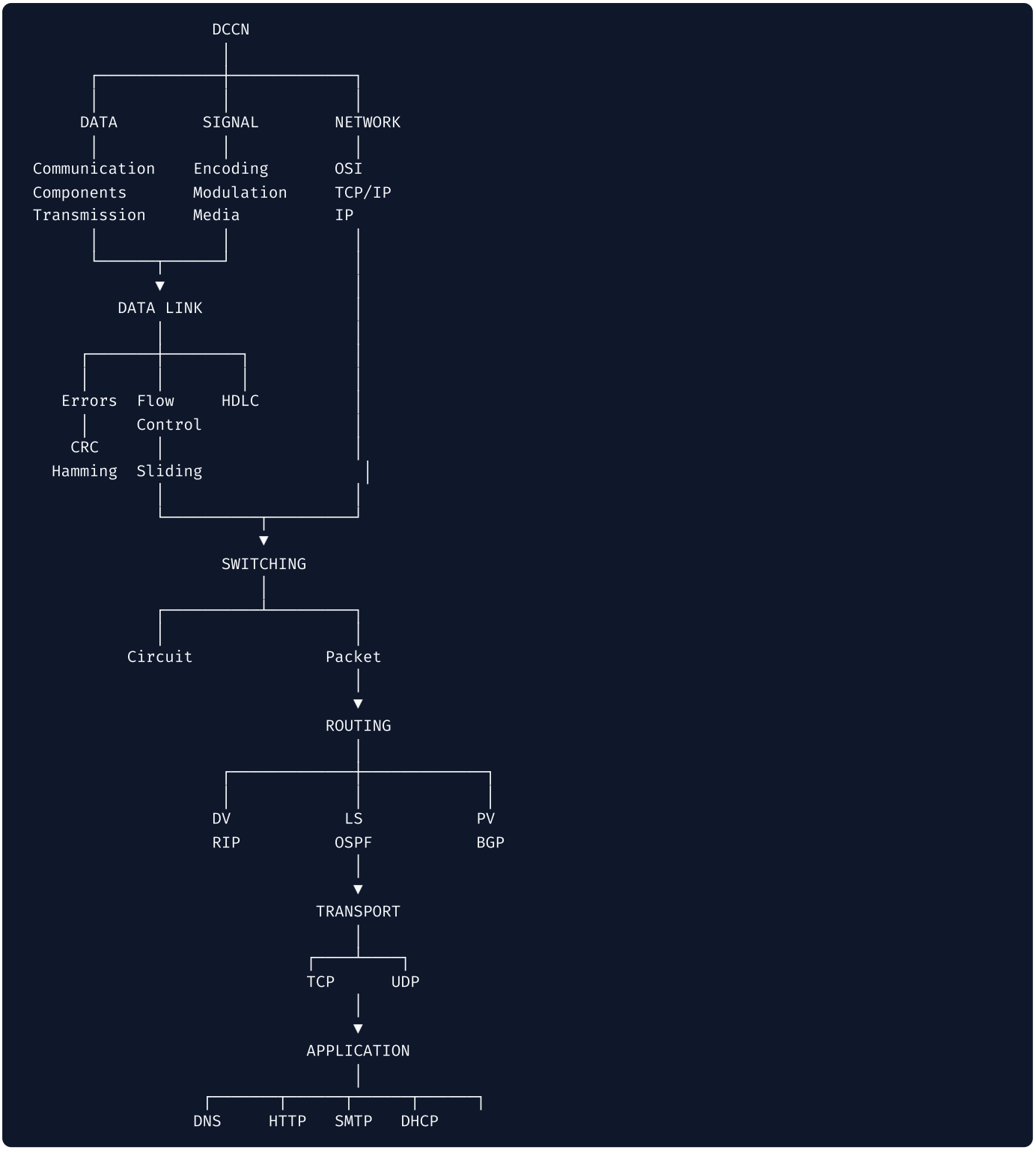
```
2^r ≥ m + r + 1
```

CRC

```
Append r zeros
→ modulo-2 divide
→ remainder = CRC
→ append CRC
```

🧠 MASTER MEMORY MAP

You should be able to reconstruct the whole course from this:



🧠 NEUROSCIENCE-BASED STUDY SYSTEM FOR DCCN

Don't read this entire thing repeatedly.

Use:

1. Retrieval before rereading

Close the notes and answer:

> **Key Insight**
> "What are the 7 OSI layers?"

Then check.

---

2. Generation

Before seeing a solution, try:

```
Data = 1010011110
Generator = 1011
```

and perform CRC yourself.

---

3. Dual coding

For every major concept, **draw it**.

Especially:

- OSI
- TCP/IP
- communication model
- satellite
- Manchester
- CRC division
- Hamming positions
- HDLC
- FDM/TDM
- switching
- cellular cells
- topologies
- VLAN
- Ethernet
- TCP handshake
- routing

---

4. Interleaving

Don't study:

```
CRC → CRC → CRC → CRC
```

Instead:

```
CRC
OSI
Hamming
TCP
Manchester
CRC
Routing
```

This improves discrimination between similar concepts.

---

5. Spaced repetition

```
Day 0 → Learn
Day 1 → Recall
Day 3 → Recall
Day 7 → Recall
Day 14 → Recall
Day 30 → Recall
```

🎯 DCCN EXAM ANSWER FORMULA

For a **5/10-mark theory question**, use:

```
Definition
   ↓
Diagram
   ↓
Working
   ↓
Components / Steps
   ↓
Advantages
   ↓
Disadvantages
   ↓
Application
   ↓
Comparison / conclusion
```

For a **numerical**:

```
Given
↓
Formula / rule
↓
Substitution
↓
Step-by-step calculation
↓
Final answer boxed
```

For a **comparison**:

```
Definition
↓
Table
↓
Example
↓
When to use which
```

🚨 TOP NUMERICALS YOU MUST MASTER

If your goal is high marks, don't treat DCCN as only theory.

Practice these **from scratch**:

1. ⭐⭐⭐⭐⭐ CRC
2. ⭐⭐⭐⭐⭐ Hamming Code
3. ⭐⭐⭐⭐⭐ Nyquist
4. ⭐⭐⭐⭐⭐ Shannon
5. ⭐⭐⭐⭐ Subnetting
6. ⭐⭐⭐⭐ Transmission delay
7. ⭐⭐⭐⭐ Propagation delay
8. ⭐⭐⭐⭐ Line-code waveform generation
9. ⭐⭐⭐ Dijkstra
10. ⭐⭐⭐ Sliding-window calculations

✅ COMPLETE 52-TOPIC TRACKER

M1 — 13/13

- [ ] Communication Model
- [ ] Data Communications
- [ ] Networks
- [ ] Internet
- [ ] OSI Model
- [ ] TCP/IP Architecture
- [ ] Standards & Protocol Layers
- [ ] Internet Applications
- [ ] Data Transmission Concepts
- [ ] Analog Data Transmission
- [ ] Digital Data Transmission
- [ ] Transmission Impairments
- [ ] Channel Capacity

M2 — 6/6

- [ ] Guided Transmission Media
- [ ] Wireless Transmission & Propagation

- [ ] Digital Signaling
- [ ] Analog Signaling
- [ ] Encoding Techniques
- [ ] Modulation Techniques

M3 — 8/8

- [ ] Types of Errors
- [ ] Error Detection
- [ ] Error Correction
- [ ] Flow Control
- [ ] Error Control
- [ ] HDLC
- [ ] FDM
- [ ] TDM

M4 — 9/9

- [ ] Switching Network
- [ ] Circuit-Switching Networks
- [ ] Circuit-Switching Concepts
- [ ] Packet-Switching Principles
- [ ] Cellular Network Principles
- [ ] Cellular Generations
- [ ] Network Topologies
- [ ] LAN Protocol Architecture
- [ ] VLAN

M5 — 16/16

- [ ] Traditional Ethernet
- [ ] High-Speed Ethernet
- [ ] IEEE 802.11
- [ ] IP
- [ ] IP Addressing
- [ ] Transport Protocols
- [ ] Routing
- [ ] Distance Vector
- [ ] Link State
- [ ] Path Vector
- [ ] Congestion Control
- [ ] Traffic Management
- [ ] SMTP
- [ ] DNS
- [ ] HTTP
- [ ] DHCP

Total: 52/52 topics.

The most important thing

For **DCCN**, your learning should be much more **problem-oriented** than CD:

> **Key Insight**
>
> **Understand → draw → derive → calculate → recall → solve PYQ.**

And the highest-value sequence is:

M1: OSI/TCP-IP + transmission + Nyquist/Shannon

→ **M2:** waveforms + media + modulation

→ **M3:** CRC + Hamming + ARQ + HDLC + TDM

→ **M4:** switching + cellular + topology + VLAN

→ **M5:** IP + subnetting + TCP/UDP + routing + application protocols.

Your uploaded material independently highlights essentially the same high-priority cluster, particularly **OSI/TCP-IP, CRC, Hamming, flow control, HDLC, FDM/TDM, switching, cellular networking, IP/TCP/UDP, routing and DNS/HTTP/SMTP/DHCP**.