Computer Network

B.Tech, Computer Engineering,

Department of Software Engineering

Delhi Technological University

Module 1: Physical Layer Transmission Medium

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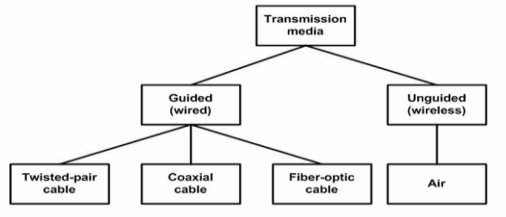
Roadmap

- Transmission media
- Wireless transmission
- Communication satellites
- Switching

Transmission Media

- Wired – Energy is contained and guided with a solid media
- Wireless – Energy propagates in the form of unguided electromagnetic waves



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Guided Transmission Data

- Magnetic Media
- Twisted Pair
- Coaxial Cable
- Fiber Optics

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Twisted Pair

- Two insulated copper wires twisted together
- Twisting – because two parallel wires constitute a fine antenna, twisting cancels waves
- Application in telephone system, DSL lines LAN (10Base-T and 100Base-T)
- Run for several km for larger distances need repeater

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Twisted Pair

•Data rates of several Mbps common.

• Spans distances of several kilometers.

• Data rate determined by wire thickness and length. In addition, shielding to eliminate interference from other wires impacts signal-to-noise ratio, and ultimately, the data rate.

• Good, low-cost communication. Indeed, many sites already have twisted pair installed in offices -- existing phone lines!

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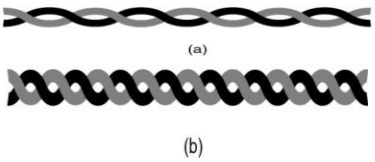
Unshielded Twisted Pair



(a) Category 3 UTP.

(b) Category 5 UTP. – more twists cancels crosstalk, offers better-quality signal over longer distances, better for high speed communication

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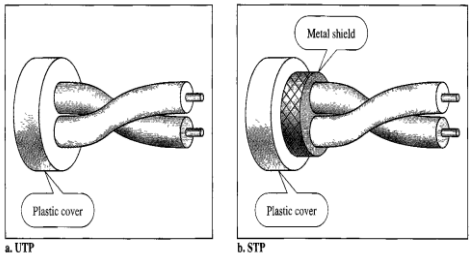
UTP and STP



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UTP and STP

- Improves quality of cable by reducing crosstalk penetration / noise

Disadvantage:
-Bulkier and heavy

-UTP connector – RJ45 (registered jack)

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UTP

Category	*Specification*	*Data Rate (Mbps)*	*Use*
1	Unshielded twisted-pair used in telephone	< 0.1	Telephone
2	Unshielded twisted-pair originally used in T-lines	2	T-1 lines
3	Improved CAT 2 used in LANs	10	LANs
4	Improved CAT 3 used in Token Ring networks	20	LANs
5	Cable wire is normally 24 AWG with a jacket and outside sheath	100	LANs
5E	An extension to category 5 that includes extra features to minimize the crosstalk and electromagnetic interference	125	LANs
6	A new category with matched components coming from the same manufacturer. The cable must be tested at a 200-Mbps data rate.	200	LANs
7	Sometimes called SSTP (shielded screen twisted-pair). Each pair is individually wrapped in a helical metallic foil followed by a metallic foil shield in addition to the outside sheath. The shield decreases the effect of crosstalk and increases the data rate.	600	LANs

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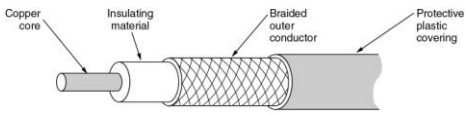
Coaxial Cable



•Better shielding than twisted pair hence used for longer distances at higher speeds
•Stiff copper wire as the core surrounded by a insulating material
•Shielding provides high bandwidth and noise immunity (1GHz)
•Used for cable TV
•Have been replaced by fiber optic cables in telephone system

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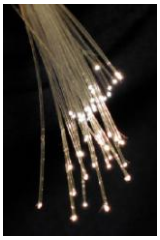
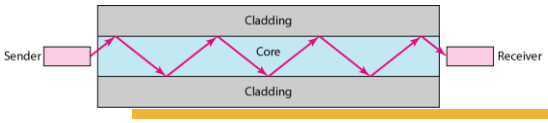
Fiber optics

- An **optical fiber** is made up of :
  i) core (carries the light pulses)
  ii) the cladding (reflects the light pulses back into the core)
  iii)buffer coating (protects the core and cladding from moisture, damage, etc.).
- Fiber optic carries up to 10 million messages at any time using light pulses.





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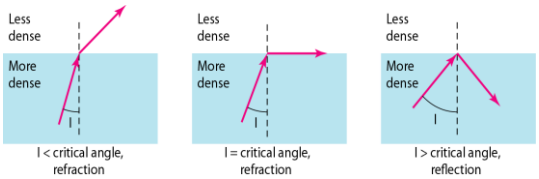
Fiber Optics



• *refractive index* (R.I.) of a particular substance is equal to = *c* (the speed of light in empty space) divided by the speed of light in that particular substance.

•Refractive index of cladding is kept high for total internal reflection

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Fiber Optics

- Three components: Light source at one end , transmission medium (ultra-thin fiber glass), detector on the other end
- Bit 1: Pulse of light, Bit 0: absence of light
- Detector generates electric pulse when light falls
- Fiber Optic Networks: Suitable for LANS though tapping is complex –so use a ring network

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Fiber Optics

- **Advantages:**
  - Higher bandwidth (1000 Mbps (1 Gbps) over distances of kilometers common)
  - Low error rates
  - Low signal attenuation
  - Immunity to electromagnetic interference
  - Resistance to corrosive material
  - Immunity to tapping
- **Disadvantages:**
  - Installation and maintenance
  - Unidirectional light propagation
  - One-way channel. Two fibers needed to get full duplex (both ways) communication
  - Cost

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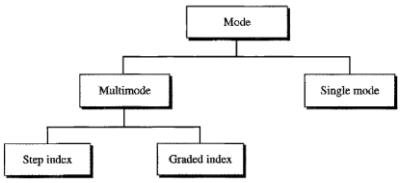
Propagation modes



• Multimode: multiple beams from light source move through the core in different paths

•Step index: refractive index of the core is uniform throughout and at the core cladding boundary there is an abrupt change in refractive index

•Graded index: refractive index of the core varies radially from the centre to the core-cladding boundary from n1 to n2 in a linear manner

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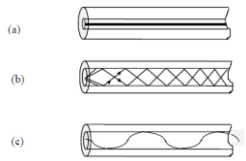

Schematics of three optical fiber types, (a) Single-mode step-index, (b) Multi-mode step-index, and (c) Multi-mode graded-index

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Comparison

•In a multi-mode fiber, the quality of signal-encoded light deteriorates more rapidly than single-mode fiber, because of interference of many light rays.
• Hence single-mode fiber allows longer distances without repeater.

•For multi-mode fiber, the typical maximum length of the cable without a repeater is 2km, whereas for single-mode fiber it is 20km.

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Fiber Optic Uses

Long distances – single mode

Multi-mode fiber is commonly used in LAN

•Long-haul trunks-increasingly common in telephone network (Sprint ads)
•Metropolitan trunks-without repeaters (average 8 miles in length)
•Rural exchange trunks-link towns and villages
•Local loops-direct from central exchange to a subscriber (business or home)
•Local area networks-100Mbps ring networks.

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Wireless Transmission

- The Electromagnetic Spectrum
- Radio Transmission
- Microwave Transmission

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The Electromagnetic Spectrum

- When electrons move they generate electromagnetic waves that propagate through space
- Using an antenna of appropriate size the electromagnetic waves can be broadcasted and received effectively

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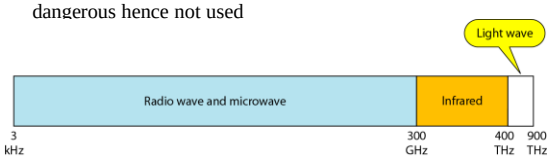
The Electromagnetic Spectrum

The electromagnetic spectrum and its uses for communication.

- Radio, microwave, infrared and visible light – used for transmitting information
- UV, X-ray and gamma rats are hard to produce and modulate , do not propagate through buildings and are dangerous hence not used



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Electromagnetic Spectrum

- Most transmission use narrow frequency band
- Wider frequency band used for Frequency Hopping Spectrum – transmitter hops from frequency to frequency hundred of time per sec – to make transmission detection hard

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Radio Transmission

- 3kHz to 1 Gz are ***radio waves***
- Easy to generate and travel long distances
- Easy penetration in buildings
- Omni directional
- At low frequency pass obstacles well, but power falls off sharply with distance from source
- At higher frequencies tend to travel straight and bounce off obstacles, absorbed by rain
- Since they can travel straight for long can interfere between users – hence license is controlled tightly

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Radio Transmission

- Types:

i) Short waves for AM radio

ii) VHF (Very High Frequency) for FM radio and TV

iii) UHF (Ultra High Frequency) used in TV

Radio bands regulated and licensed by a regulatory body

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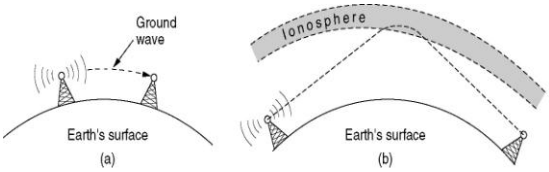
Radio Transmission



(a) In the VLF, LF, and MF bands, radio waves follow the curvature of the earth.

(b) In the HF band, they bounce off the ionosphere.

MF band used by AM radio, Military uses HF, VHF

Other uses: cordless phones, paging

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Microwave Transmission

- Between 1GHz to 300 Ghz waves travel nearly straight and can be narrowly be focused(unidirectional)
- Compared to RF they produce better throughput
- Repeaters required
- Do not pass through buildings
- Widely used for long distance telephone communication, mobile phones, TV distribution, wireless LANS
- Allocation controlled by government

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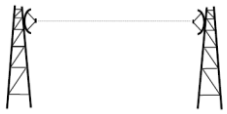
Microwave Transmission

Microwave signals commonly used for longer distances (10's of km). Sender and receiver use some sort of dish antenna



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Infrared communication

•Used for short-range communication.
•Eg: remote controls used on televisions, VCRs, and stereos.
•Are relatively directional, cheap, and easy to build but have a major drawback: they do not pass through solid objects

•Since they cannot pass through solid objects, problem of interference between signals across different rooms is not present and also adds to the security of the signal

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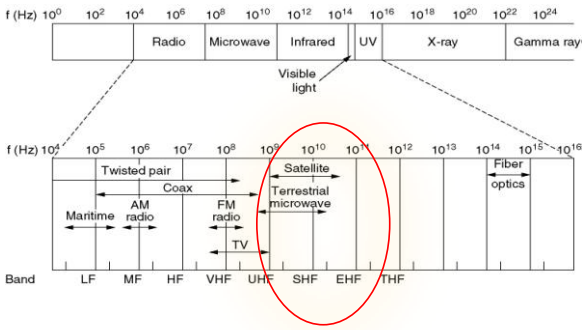

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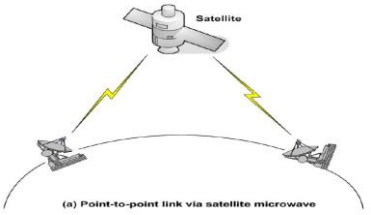
Communication Satellites

- Big microwave repeater in the sky with several transponders
- Each transponder listens to some portion of spectrum and amplifies the incoming signal and then rebroadcasts it at another frequency to avoid interference



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Communication Satellites

- Geostationary Satellites
- Medium-Earth Orbit Satellites
- Low-Earth Orbit Satellites
- Satellites versus Fiber

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Geostationary Satellite

- Satellite placed at an altitude of approximately 35,800 km ~ 36000 km over equator
- Revolves in the same direction the earth rotates with orbit at 24 hours.
- The term geostationary comes from the fact that such a satellite appears nearly stationary in the sky as seen by a ground-based observer.
- unwise to have geostationary satellites spaced much closer than 2 degrees in the
- 360-degree equatorial plane, to avoid interference. With a spacing of 2 degrees, there can only be 360/2 = 180
- of these satellites in the sky at once.

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Geostationary Satellites

- The principal advantages:

  - An earth bound directional antenna can be aimed and then left in position without further adjustment.

  - Since highly directional antennas can be used, interference from surface-based sources, and from other satellites, is minimized.

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Geostationary satellites

- Two major limitations

- Orbital zone is an extremely narrow ring in the plane of the equator, the number of satellites that can be maintained in geostationary orbits without mutual conflict (or even collision) is limited
- The distance that an electromagnetic (EM)signal must travel to and from a geostationary satellite is a minimum of 71,600 kilometers . One-way *propagation delay is roughly 270 ms. In interactive terms, propagation delay alone inserts a 1 second delay between typing a character and receiving its echo.*

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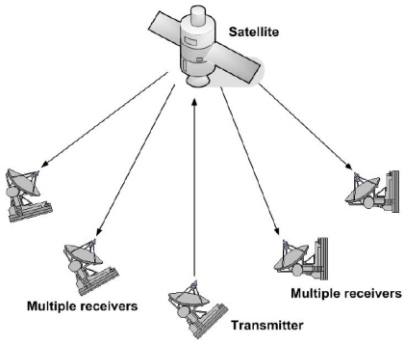

Broadcast a signal received from one station to many ground-based stations

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Satellite vs. Fiber

- Bandwidth of Fiber not available to all users
- Mobility
- Broadcasting
- Remote areas with poor infrastructure
- Good coverage and economical for a wider area

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Public Switched Telephone System

- Structure of the Telephone System
- The Local Loop: Modems, ADSL and Wireless
- Trunks and Multiplexing
- Switching

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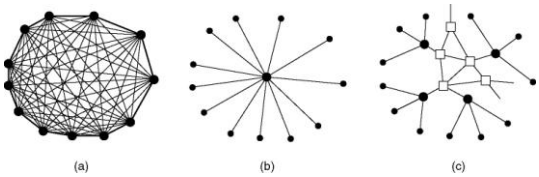
Structure of the Telephone System



(a) Fully-interconnected network.
(b) Centralized switch.
(c) Two-level hierarchy.

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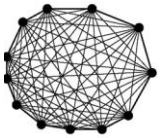
PSTN
Fully-interconnected network.

- Each user connected to the other
- Not scalable and complicate wiring



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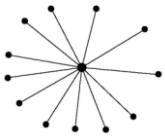
PSTN Centralized Switch

•Wiring from home to company office
•Customer dials up and attended by a operator who manually connected to the callee using a jumper cable
•Problem not scalable for long distance calls across cities



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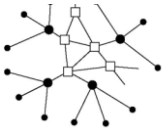
PSTN
Two-level hierarchy

•Interconnection of second level switching office
•Levels kept growing
•Three major parts –
1. Switching office
2.Wires between customer and switching office
3.Long-distance connections between switching offices



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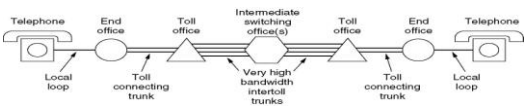
Structure of the Telephone System (2)



A typical circuit route for a medium-distance call.

- Two wires from subscriber telephone to the nearest end office - Local Loop
  Uses the twisted pair for distance up to 10 km
- If callee is at another end office connect to toll office using toll connecting trunk – digital fiber optics connection
- If toll offices are different switch to intertoll trunks (microwaves, fiber optics)

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Major Components of the Telephone System

- Local loops
  - Analog twisted pairs going to houses and businesses
- Trunks
  - Digital fiber optics connecting the switching offices
- Switching offices
  - Where calls are moved from one trunk to another

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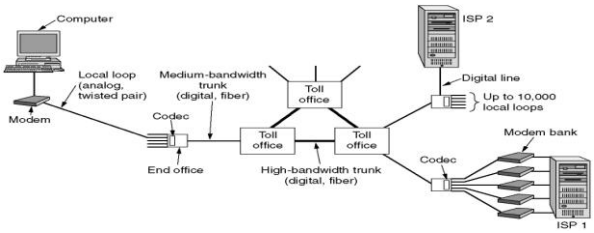
The Local Loop: Modems, ADSL, and Wireless

- The use of both analog and digital transmissions for a computer to computer call. Conversion is done by the modems and codecs.
- Local loop is the last mile uses analog signaling
- Digital data from computers is converted to analog signaling using modems



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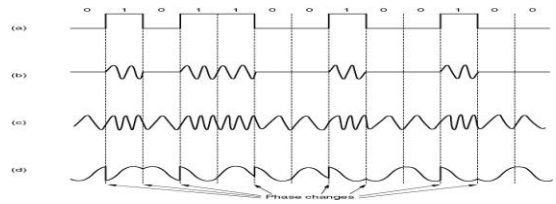
Modems



(a) A binary signal
(b) Amplitude modulation – different amplitudes used for 0 and 1 bits
(c) Frequency modulation – two different frequencies used for 0 and 1 bits
(d) Phase modulation – Different phase shift used carrier wave is shifted 0 or 180 degree at uniformly spaced intervals

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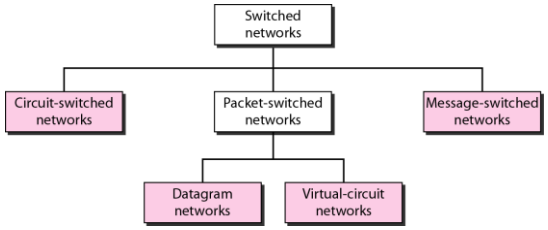
Switching

- Switched networks consists of interlinked devices called switches which are capable of creating temporary connections between two or more devies linked for communication

SWITCHED NETWORKS

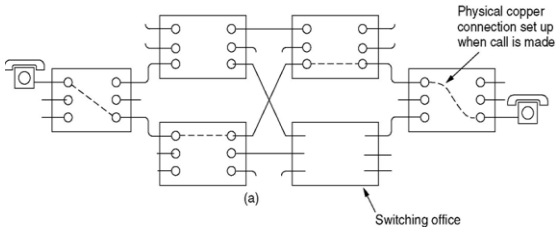


CIRCUIT-SWITCHED NETWORKS

•A circuit-switched network consists of a set of switches connected by physical links. A connection between two stations is a dedicated path made of one or more links.
•In which each link is divided into *n* channels.
•However, each connection uses only one dedicated channel on each link. Each link is normally divided into n channels by using FDM or TDM.

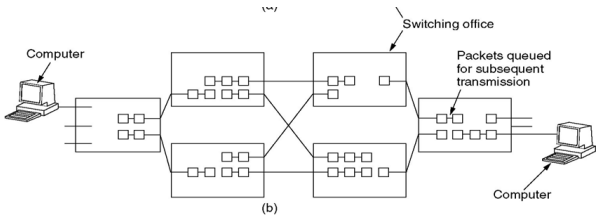
Circuit Switching

- Resource need to be reserved during the setup phase;
- Resources remain dedicated for the entire duration of data transfer until the teardown phase.



Packet switching

- Individual packets are sent as need be and no path is set up in advance
- Each packet finds its own way



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Message Switching

- No physical path between sender and receiver
- Sender sends a block of message which is stored in the switching office and then forwarded later.
- Also known as store-and-forward network

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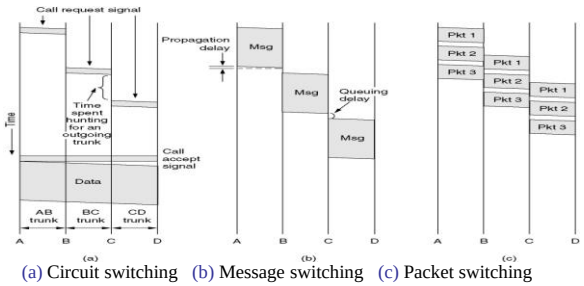
Comparison



(a) Circuit switching (b) Message switching (c) Packet switching

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Packet Switching

Item	Circuit-switched	Packet-switched
Call setup	Required	Not needed
Dedicated physical path	Yes	No
Each packet follows the same route	Yes	No
Packets arrive in order	Yes	No
Is a switch crash fatal	Yes	No
Bandwidth available	Fixed	Dynamic
When can congestion occur	At setup time	On every packet
Potentially wasted bandwidth	Yes	No
Store-and-forward transmission	No	Yes
Transparency	Yes	No
Charging	Per minute	Per packet

A comparison of circuit switched and packet-switched networks.

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References

- Chapter 7: Transmission Medium, Forouzan
- Switching: Chapter 2.5.5, Tanenbaum

THANKS