Computer Networks

BCST -502 BCSP- 502

B.Tech (CSE) 5th Semester

Course Instructor: Dr Bishwajeet Pandey

New 2020 Syllabus

Unit –I

Computer Network: Definitions, goals, components, Architecture, Classifications & Types.Layered Architecture: Protocol hierarchy, Design Issues, Interfaces and Services, ConnectionOriented & Connectionless Services, Service primitives, Design issues & its functionality. ISOOSI Reference Model: Principle, Model, Descriptions of various layers and its comparison with TCP/IP. Principals of physical layer: Media, Bandwidth, Data rate and Modulations

Unit-II

Data Link Layer: Need, Services Provided, Framing, Flow Control, Error control. Data Link Layer Protocol: Elementary &Sliding Window protocol: 1-bit, Go-Back-N, Selective Repeat, Hybrid ARQ. Protocol verification: Finite State Machine Models & Petri net models. ARP/RARP/GARP

Unit-III

MAC Sub layer: MAC Addressing, Binary Exponential Back-off (BEB) Algorithm, Distributed Random Access Schemes/Contention Schemes: for Data Services (ALOHA and Slotted- ALOHA), for Local-Area Networks (CSMA, CSMA/CD, CSMA/CA), CollisionFree Protocols: Basic Bit Map, BRAP, Binary Count Down, MLMA Limited Contention Protocols: Adaptive Tree Walk, Performance Measuring Metrics. IEEE Standards 802 series & their variant.

New 2020 Syllabus

Unit-IV

Network Layer: Need, Services Provided, Design issues, Routing algorithms: Least CostRouting algorithm, Dijkstra's algorithm, Bellman-ford algorithm, Hierarchical Routing,Broadcast Routing, Multicast Routing. IP Addresses, Header format, Packet forwarding,Fragmentation and reassembly, ICMP, Comparative study of IPv4 & IPv6

Unit-V

Transport Layer: Design Issues, UDP: Header Format, Per-Segment Checksum, CarryingUnicast/Multicast Real-Time Traffic, TCP: Connection Management, Reliability of DataTransfers, TCP Flow Control, TCP Congestion Control, TCP Header Format, TCP TimerManagement. Application Layer: WWW and HTTP, FTP, SSH, Email (SMTP, MIME, IMAP), DNS, Network Management (SNMP).

About Course Instructor

- PhD from Gran Sasso Science Institute, Italy
- PhD Supervisor Prof Paolo Prinetto from Politecnico Di Torino, World Rank 13 in Electrical Engineering
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About Course Outline

- UNIT 1: Lecture No 1-4
- UNIT 2: Lecture No 5-11 (Including Lab on Vivado)
- UNIT 3: Lecture No 14-18
- UNIT 4: Lecture No 19-21, Lecture 12-13
- UNIT 5: Lecture No 22-28 (Including Lab on Packet Tracer)
- Lecture No 29-35: Discuss Previous Year Question of UKTU
- Out of 35 Lectures: Some will delivered by Professor From Foreign University

OUTLINE OF LECTURE 17-18

- Performance Measuring Metrics
- IEEE Standards 802 series & their variant.

Performance Measuring Metrics

- The most common performance metrics are delay and throughput.

- Although in certain cases, like sensor networks, power consumption might also be an important metric.

Performance Measuring Metrics

The following metrics are often considered important:

- **Bandwidth** commonly measured in bits/second is the maximum rate that information can be transferred
- **Throughput** is the actual rate that information is transferred
- **Latency** the delay between the sender and the receiver decoding it, this is mainly a function of the signals travel time, and processing time at any nodes the information traverses
- **Jitter** variation in packet delay at the receiver of the information
- **Error rate** the number of corrupted bits expressed as a percentage or fraction of the total sent

Bandwidth

- The available channel bandwidth and achievable signal-to-noise ratio determine the maximum possible throughput.

- It is not generally possible to send more data than dictated by the Shannon-Hartley Theorem.

Shannon-Hartley Theorem

When the SNR is large ($S/N >> 1$), the logarithm is approximated by

$$\log_2\left(1+\frac{S}{N}\right) \approx \log_2 \frac{S}{N} = \frac{\ln 10}{\ln 2} \cdot \log_{10} \frac{S}{N} \approx 3.32 \cdot \log_{10} \frac{S}{N},$$

in which case the capacity is logarithmic in power and approximately linear in bandwidth (not quite linear, since N increases with bandwidth, imparting a logarithmic effect). This is called the **bandwidth-limited regime**.

$$C \approx 0.332 \cdot B \cdot \mathrm{SNR\ (in\ dB)}$$

where

$$\mathrm{SNR\ (in\ dB)} = 10 \log_{10} \frac{S}{N}.$$

- If Signal power = Noise power then calculate SNR?
- If the SNR is 20 dB, and the bandwidth available is 4 kHz, calculate C?
- If the requirement is to transmit at 50 kbit/s, and a bandwidth of 10 kHz is used, then the minimum S/N required is?
- What is the channel capacity for a signal having a 1 MHz bandwidth, received with a SNR of −30 dB ?

Shannon-Hartley Theorem

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- At a SNR of 0 dB (Signal power = Noise power).

Shannon-Hartley Theorem

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where

$$\mathrm{SNR\ (in\ dB)} = 10\log_{10}\frac{S}{N}.$$

- If the SNR is 20 dB, and the bandwidth available is 4 kHz, which is appropriate for telephone communications, then C = 4000 $\log_2(1 + 100)$ = 4000 $\log_2 (101)$ = 26.63 kbit/s. Note that the value of S/N = 100 is equivalent to the SNR of 20 dB.

Shannon-Hartley Theorem

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- If the requirement is to transmit at 50 kbit/s, and a bandwidth of 10 kHz is used, then the minimum S/N required is given by 50000 = 10000 $\log_2(1+S/N)$ so C/B = 5 then S/N = $2^5 - 1$ = 31, corresponding to an SNR of 14.91 dB (10 x $\log_{10}(31)$).

Shannon-Hartley Theorem

When the SNR is large ($S/N >> 1$), the logarithm is approximated by

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$$C \approx 0.332 \cdot B \cdot \mathrm{SNR\ (in\ dB)}$$

where

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- What is the channel capacity for a signal having a 1 MHz bandwidth, received with a SNR of −30 dB ?
- That means a signal deeply buried in noise. −30 dB means a $S/N = 10^{-3}$. It leads to a maximal rate of information of $10^6 \log_2 (1 + 10^{-3}) = 1443$ bit/s.

Throughput

- *Throughput* is the number of messages successfully delivered per unit time.
- The *Time Window* is the period over which the throughput is measured.
- Choice of an appropriate time window will often dominate calculations of throughput,.
- Throughput is controlled by available bandwidth, as well as the available signal-to-noise ratio and hardware limitations.

GATE CS 2007 Exam

3) The distance between two stations M and N is L kilometers. All frames are K bits long. The propagation delay per kilometer is t seconds. Let R bits/second be the channel capacity. Assuming that processing delay is negligible, the minimum number of bits for the sequence number field in a frame for maximum utilization, when the sliding window protocol is used, is:

(A) $\left\lceil \log_2 \frac{2LtR + 2K}{K} \right\rceil$ (B) $\left\lceil \log_2 \frac{2LtR}{K} \right\rceil$

(C) $\left\lceil \log_2 \frac{2LtR + K}{K} \right\rceil$ (D) $\left\lceil \log_2 \frac{2LtR + K}{2K} \right\rceil$

Answer (C)

```
Distance between stations = L KM
Propogation delay per KM = t seconds
Total propagation delay = Lt seconds

Frame size = k bits
Channel capacity = R bits/second
Transmission Time = k/R

Let n be the window size.

UtiliZation = n/(1+2a) where a = Propagation time / transmission time
            = n/[1 + 2LtR/k]
            = nk/(2LtR+k)
For maximum utilization: nk = 2LtR + k
Therefore, n = (2LtR+k)/k
```

GATE CS 2006 Exam

11) Station A uses 32 byte packets to transmit messages to Station B using a sliding window protocol. The round trip delay between A and B is 80 milliseconds and the bottleneck bandwidth on the path between A and B is 128 kbps. What is the optimal window size that A should use?

(A) 20

(B) 40

(C) 160

(D) 320

Answer (B)

```
Round Trip propagation delay = 80ms
Frame size = 32*8 bits
Bandwidth = 128kbps
Transmission Time = 32*8/(128) ms = 2 ms

Let n be the window size.

UtiliZation = n/(1+2a) where a = Propagation time / transmission time
            = n/(1+80/2)

For maximum utilization: n = 41 which is close to option (B)
```

Latency

- The speed of light imposes a minimum propagation time on all electromagnetic signals. It is not possible to reduce the latency below s/c_m where s is the distance and c_m is the speed of light in the medium. This approximately means 1 millisecond round trip time (RTT) for 100 km/62 miles of distance between hosts.

- A telecom satellite in geosynchronous orbit imposes a path length of at least 71000 km between transmitter and receiver. Which means a minimum delay between message request and message receipt, or latency of 473 ms.

GATE CS 2012 Question

The first packet will take 6ms to reach D.

While first packet was reaching D, other packets must have been processing in parallel.

So D will receive remaining packets 1 packet per 1 ms from R2.

So remaining 999 packets will take 999 ms. And total time will be 999 + 6 = 1005 ms

1) Consider a source computer (S) transmitting a file of size 106 bits to a destination computer (D) over a network of two routers (R1 and R2) and three links (L1, L2 and L3). L1 connects S to R1;L2 connects R1 to R2; and L3 connects R2 to D. Let each link be of length 100km. Assume signals travel over each link at a speed of 10^8 meters per second. Assume that the link bandwidth on each link is 1Mbps. Let the file be broken down into 1000 packets each of size 1000 bits. Find the total sum of transmission and propagation delays in transmitting the file from S to D?

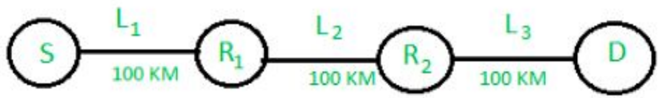
(A) 1005ms

(B) 1010ms

(C) 3000ms

(D) 3003ms

Answer (A)



Propagation delay to travel from S to R1 = (Distance) / (Link Speed) = 10^5/10^8 = 1ms
Total prorogation delay to travel from S to D = 3*1 ms = 3ms

Total Ttransmission delay for 1 packet = 3 * (Number of Bits) / Bandwidth = 3*(1000/10^6) = 3ms.

GATE CS 2005 Exam

4) Suppose the round trip propagation delay for a 10 Mbps Ethernet having 48-bit jamming signal is 46.4 ms. The minimum frame size is:

(a) 94

(b) 416

(c) 464

(d) 512

Answer (c)

Transmission Speed = 10Mbps.

Round trip propagation delay = 46.4 ms

The minimum frame size = (Round Trip Propagation Delay) * (Transmission Speed) = 10*(10^6)*46.4*(10^-3) = 464 * 10^3 = 464 Kbit

Error rate

- In digital transmission, the number of **bit errors** is the number of received bits of a data stream over a communication channel that have been altered due to noise, interference, distortion or bit synchronization errors.

- The **bit error rate** or **bit error ratio** (**BER**) is the number of bit errors divided by the total number of transferred bits during a studied time interval. BER is a unitless performance measure, often expressed as a percentage.

- How many IEEE standards are available for networks?
  - In 2017, IEEE had over **1100** active standards, with over **600 standards** under development.
  - One of the more notable are the IEEE **802** LAN/MAN group of standards, with the widely used computer networking standards for both wired (ethernet, aka IEEE **802.3**) and wireless (IEEE **802.11** and IEEE **802.16**) networks.

IEEE Standards 802 series & their variant

- **IEEE 802** is a **family of IEEE standards** dealing with local area networks and metropolitan area networks.

- The **IEEE 802 standards** are restricted to networks carrying variable-size packets, unlike cell relay networks, for example, where data is transmitted in short, uniformly sized units called cells.

Why do we need IEEE 802 standards?

- The **standards** such as **IEEE 802** helps industry provide advantages such as, interoperability, low product cost, and easy to manage **standards**.

- **IEEE standards** deal with only Local Area Networks (LAN) and Metropolitan Area Networks (MAN).

Why is Wi-Fi called 802.11?

- The first number, **802**, is simply the IEEE's number for the Committee of the IEEE that has been developing technical standards for local-area and metropolitan-area networks since February of 1980.

- 802.11a is 802.11a because it was the second standard to be developed by the Wireless LAN group (the first was 802.11).

IEEE Standards 802 series & their variant

IEEE 802 Standards

Institute of Electrical and Electronics Engineers

STANDARDS	PURPOSE
802.1	Bridging and Management
802.2	Logical Link Control
802.3	Ethernet Lan (CSMA/CD)
802.4	Token-Bus Lan
802.5	Token-Ring Lan
802.7	Broadband LAN
802.9	Isochronous LAN
802.10	Network Security
802.11	Wireless Networks
802.12	Demand Priority Access Lan (100 VG - Any LAN)
802.15	Wireless PAN
802.16	Broadband and Wireless MAN