HO CHI MINH CITY UNIVERSITY OF SCIENCE
FACULTY OF ELECTRONICS AND TELECOMMUNICATIONS
DEPARTMENT OF TELECOMMUNICATIONS AND NETWORKS

COURSE

COMPUTER NETWORKS

Chapter 03

Packet

Reference: Peter L Dordal, "An Introduction to Computer Networks," Feb 05, 2022

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1 Packet Delay

1. Packet Delay

❖**Bandwidth delay**

➢The time needed for a sender to get the packet onto the wire.

➢Ex: 1500-byte packet on 100 Mbps Ethernet,

- Bandwidth delay $= \frac{12\,000\ bits}{\frac{100\ bits}{\mu s}} = 120\ \mu s.$

❖**Propagation delay**

➢The time it takes for the head of the signal to travel from the sender to the receiver.

➢The distance divided by the x speed of light.

1. Packet Delay

Medium	Propagation speed
Thick Coax	0.77c (231,000 km/sec)
Thin Coax	0.65c (195,000 km/sec)
Twisted Pair	0.59c (177,000 km/sec)
Fiber	0.66c (198,000 km/sec)

❖**Propagation delay**

➢Ex: 1,000 m of Ethernet using twisted pair

- Propagation delay $= \frac{}{} = \ \mu s.$

1. Packet Delay

❖ **Store-and-forward delay**

➢ The time spent reading in the entire packet before any of it can be retransmitted.

❖ **Queuing delay**

➢ Depend on competing traffic and/or the system specifications.

- Other words, is a delay based on how long the packet has to stay around in the intermediate device (e.g., router).

1. Packet Delay

Assume:

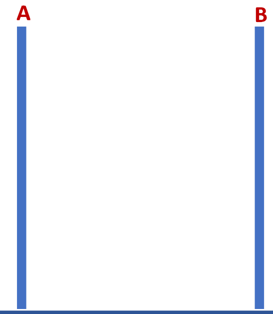
- Queuing delay = 0
- Store-and-forward delay = 0

❖ **Delay examples.**

➢ **Case 1: A-------------------B**

- Propagation delay is 40 μsec
- Bandwidth is 1 byte/μsec (1 MB/sec, 8 Mbit/sec)
- Packet size is 200 bytes (200 μsec bandwidth delay)

→One-way transmit time = μsec



1. Packet Delay

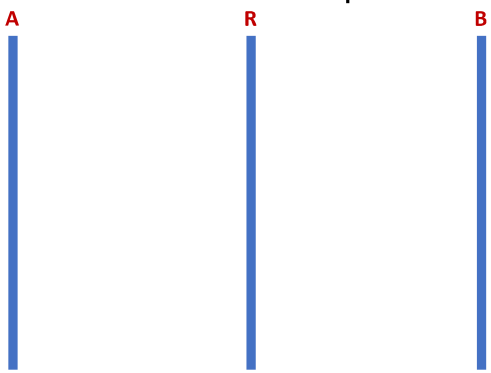
Assume:

- Queuing delay = 0
- Store-and-forward delay = 0

❖ **Delay examples.**

➢ **Case 2: A --------- R ---------- B**

- Two links, each with propagation delay 40 μsec; bandwidth and packet size as in Case 1.
- →One-way transmit time = μsec



1. Packet Delay

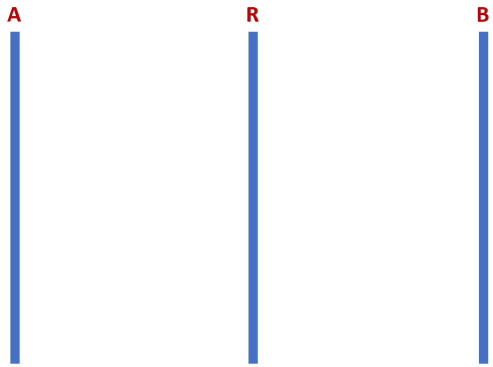
Assume:

- Queuing delay = 0
- Store-and-forward delay = 0

❖ **Delay examples.**

➢ **Case 3: A --------- R ---------- B**

- The same as 3, but with data sent as two 100-byte packets.
- →One-way transmit time = μsec



❖Round-trip time (RTT)

- At most non-LAN scales, the delay is typically simplified to the RTT.
  - The time between sending a packet and receiving a response.
- Different delay scenarios have implications for protocols:
  - If a network is bandwidth-limited then protocols are easier to design. Extra RTTs do not cost much, so we can build in a considerable amount of back-and-forth exchange.
  - However, if a network is delay-limited, the protocol designer must focus on minimizing extra RTTs.
    - As an extreme case, consider wireless transmission to the moon (0.3 sec RTT), or to Jupiter (1 hour RTT).

❖Bandwidth x Delay

- Represents how much we can send before we hear anything back.
- (Delay: usually involving RTT)
- Ex:

RTT	bandwidth	bandwidth × delay
1 ms	10 Mbps	1.2 kB
100 ms	1.5 Mbps	20 kB
100 ms	600 Mbps	8 MB
100 ms	1.5 Gbps	20 MB

❖Packet Delay Variability

- **RTT is variable.**
  - On Ethernet and Wi-Fi networks there is an initial "contention period" before transmission actually begins.
  - Different packets are routed via slightly different paths.
  - Different packets are handled differently by different queues of a parallel-processing switch.
  - Mobile nodes are involved, then the distance and thus the propagation delay can change.

❖Link's bandwidth, too, can vary dynamically.

- Shared bandwidth
- QoS (Quality of Service)
  - E.g., routers reserve a varying amount of bandwidth for
    - High-priority traffic
    - Depending on demand
    - Best-effort traffic
- ***RTT_{noLoad}*** to be the time it takes to transmit a packet from A to B, and receive an acknowledgment back, with no queuing delay.
- We will usually assume that ***RTT_{noLoad}*** **is fixed and well-defined**

2 Packet Size

2. Packet Size

- **How big should packets be?**
  - Should they be large (*e.g.,* 64 kB)
  - or small (*e.g.,* 48 bytes)?
  - Large packets would not allow other senders timely access to transmit.
  - Large packets waste a smaller percentage of bandwidth on headers.
  - In store-and-forward switches, smaller packets have much better throughput.

2. Packet Size

- **Packet Size vs. Error Rates**
  - For relatively high error rates, it turns out to be better to send smaller packet, because when an error does occur then the entire packet containing it is lost.
    - Choose the packet size small enough that most packets do not encounter errors.
  - To be fair, very large packets can be sent reliably on most cable links (e.g., TDM and SONET).
  - Wireless, however, is more of a problem.

2. Packet Size

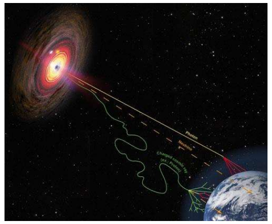
- **Packet Size vs. Real-Time Traffic**
  - It is common to commingle bulk traffic on the same links with real-time traffic.
    - Real-time traffic has higher priority than bulk traffic.
      - Router does not begin forwarding a bulk-traffic packet if there are any real-time packets waiting.
      - However, once a bulk-traffic packet has begun transmission, it is impractical to interrupt it.
- Limited to the maximum **Ethernet packet size.**
  - IPv4: 1500 bytes
  - IPv6: 2 MB

3 Error Detection

3. Error Detection

❖Packet error detection is to **add some extra bits** (or called error-detection code)

- ➢Allow the receiver to determine if the packet has been corrupted in transit.
- ➢A corrupted packet will then be discarded by the receiver.



❖**Reasons:**

- ➢Low-frequency bit errors due to things like cosmic rays.
- ➢Interference errors, typically generated by nearby electrical equipment.

3. Error Detection

❖**Single parity bit**: this will catch all one-bit errors.

- ➢Ex:
  - ○Data: **1001**
    - ▪ → parity bit = 1^0^0^1 = **0**
  - ○Send: **10010**
  - ○Receive: 10<u>**1**</u>10
    - → Check: 1^0^1^1^0 = 1 ≠ **0**
    - → Data is corrupted.

3. Error Detection

❖**Internet checksum**: used by IP, TCP and UDP

- ➢Taking the **one's-complement sum** of the 16-bit words of the message.
  - ○One's-complement sum:
    - ▪ Take the sum A+B.
    - ▪ If there is an overflow bit, add it back in as low-order bit.
- ➢A weakness of any error-detecting code based on sums is that transposing words leads to the same sum, and the error is **not detected**.
  - ○In particular, if a message is fragmented and the fragments are reassembled in the wrong order, the ones-complement sum will likely not detect it.

3. Error Detection

❖Cyclical Redundancy Check (CRC)

- ➢Ethernet frame.

3. Error Detection

❖Error-Correcting Codes (also called forward error correction)

- ➢That allows the receiver in many cases to figure out which bits are corrupted, and fix them.

- ➢Mostly used in the Physical layer.

QA

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