

IT/CYBR 4323, Chapter 7:

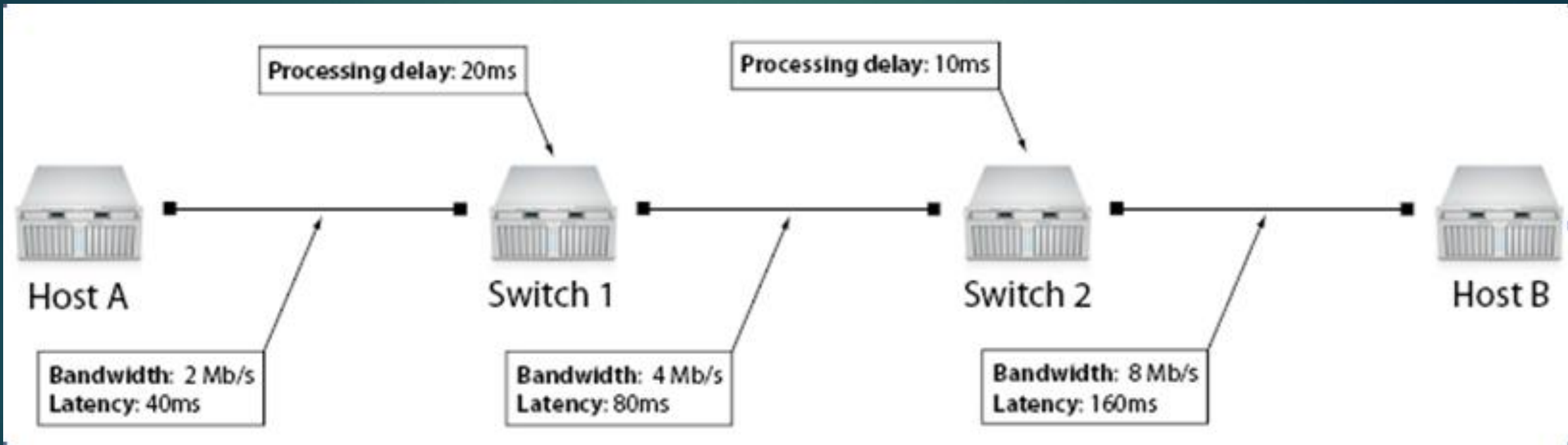
Packets

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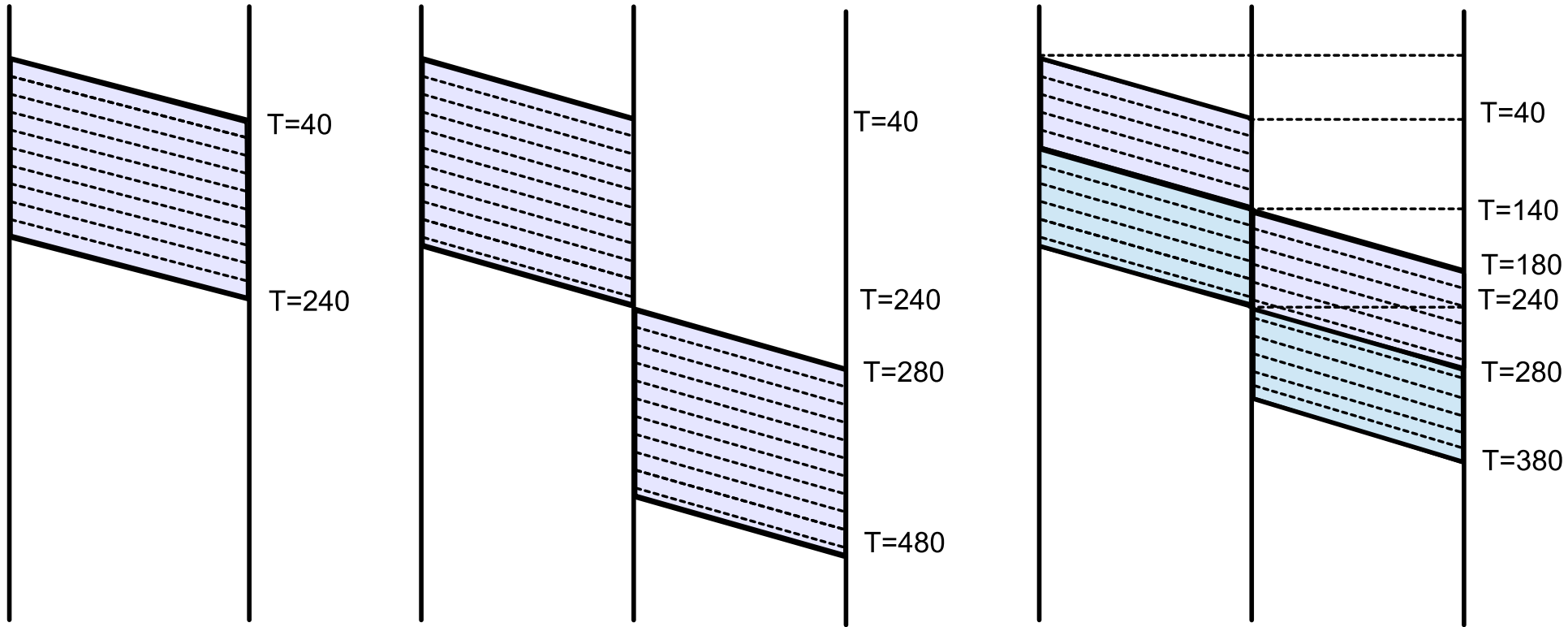
Packet Delays

- **Bandwidth Delay:** the time needed for a sender to get the packet onto the wire; the packet size divided by the bandwidth.
- **Propagation Delay:** relating to the propagation of the bits at the speed of light (for the transmission medium in question); distance divided by the speed of light.
- **Store-and-forward Delay:** the time spent reading in the entire packet before any of it can be retransmitted.
- **Queuing Delay:** depends on competing traffic.

Bandwidth Delay Illustrated



Propagation Delay Illustrated



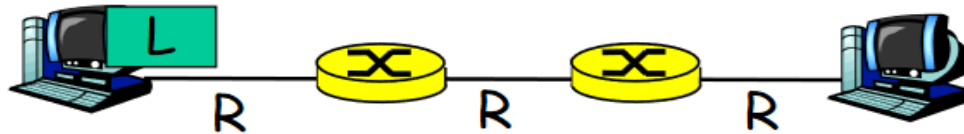
Case 1: one link

Case 3: two links

Case 4: two half-sized packets

Bandwidth delay 200 μ sec, per-link propagation delay 40 μ sec

Store-and-Forward Delay Illustrated

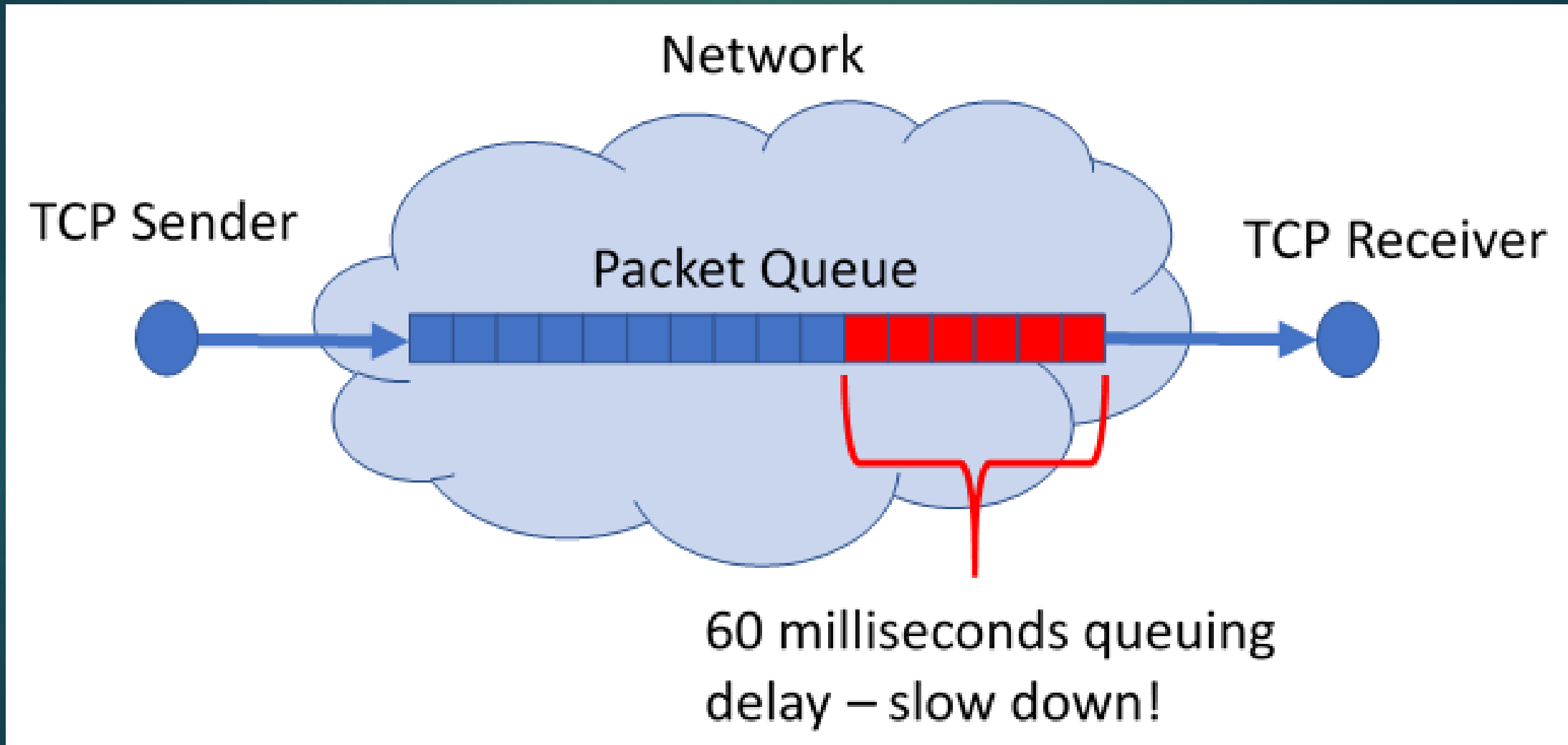


- Takes L/R seconds to transmit (push out) packet of L bits on to link or R bps
- Entire packet must arrive at router before it can be transmitted on next link: *store and forward*
- delay = $3L/R$

Example:

- $L = 7.5$ Mbits
- $R = 1.5$ Mbps
- delay = 15 sec

Queuing Delay Illustrated



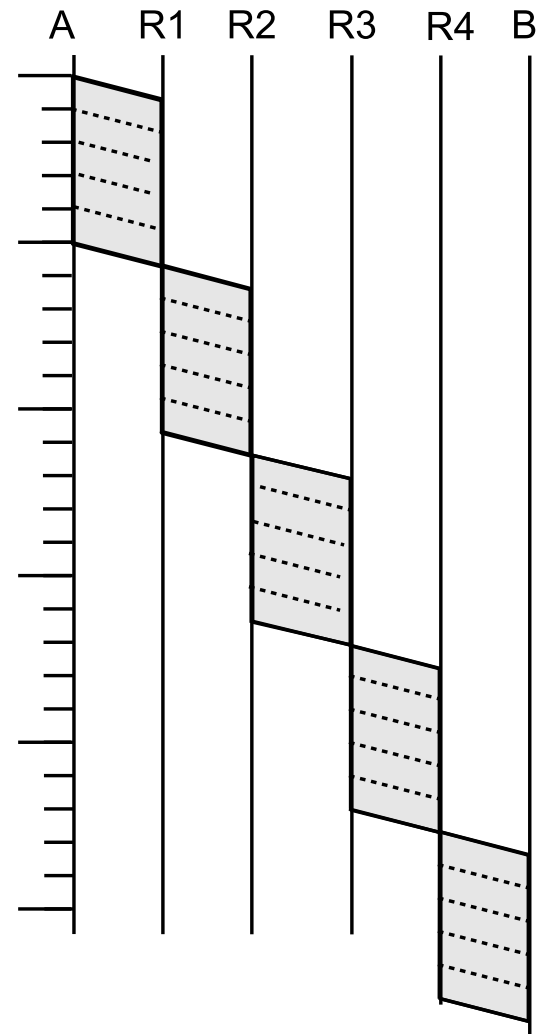
Effects of Packet Size

A path from A to B with four switches and five links:

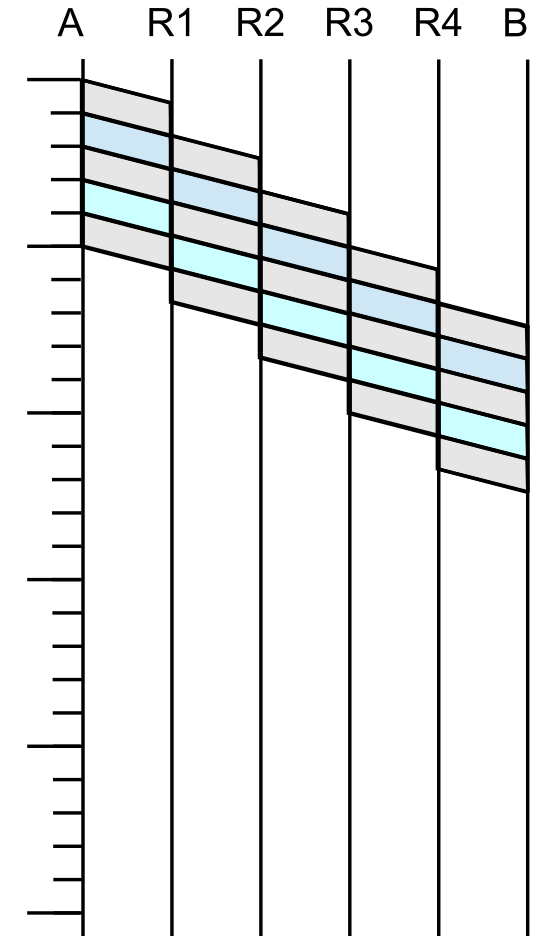


Suppose we send either one big packet or five smaller packets.

The relative times from A to B are illustrated in the accompanying diagram.



One large packet over five links



Five smaller packets over five links

Error Rates and Packet Size

- 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.
- Very large packets can be sent reliably on most cable links.
- Once a bulk-traffic packet has begun transmission, it is impractical to interrupt it.
- Most IPv4 packets are limited to the maximum Ethernet packet size of 1500 bytes, but IPv6 has an option for so-called “jumbograms” up to 2 MB in size. Transmitting one such packet on a 100 Mbps link takes about 1/6 of a second, which is likely too large for happy coexistence with real-time traffic. Therefore, jumbograms are suited for higher speed links only.

Errors

Packet Errors

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

Error detection

- Add some extra bits – formally known as an error-detection code – that will allow the receiver to determine if the packet has been corrupted in transit.

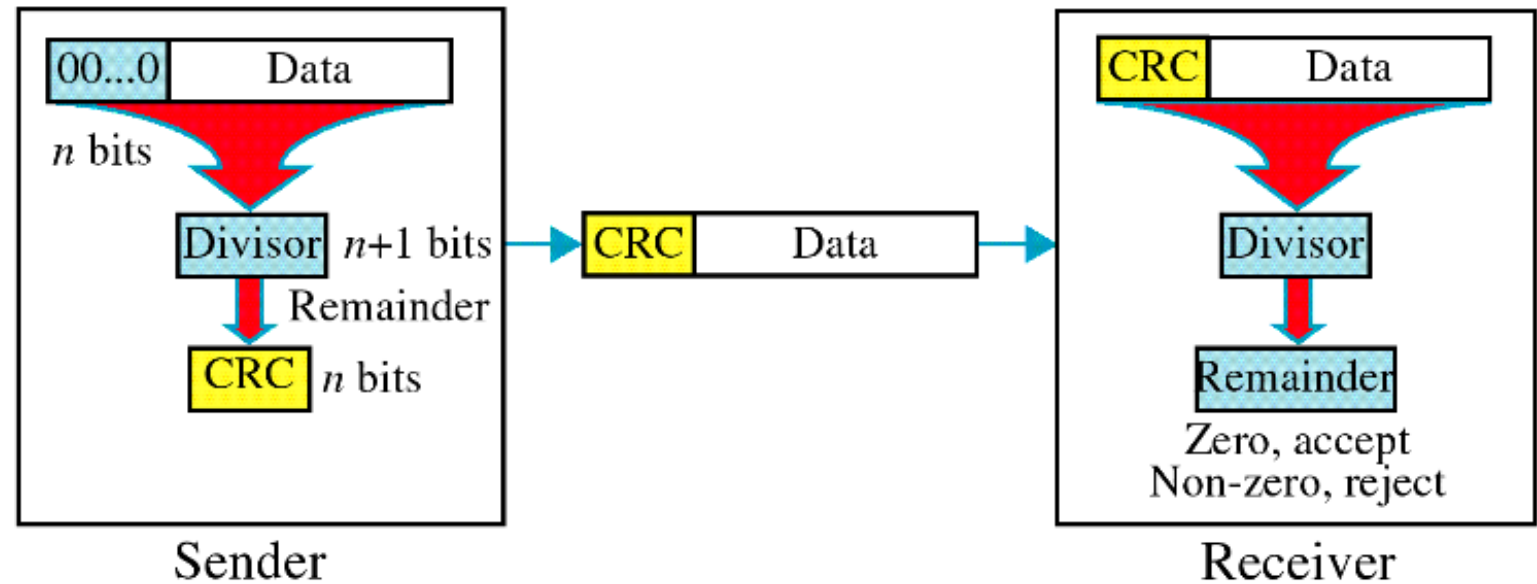
Internet checksum

- Used by IP, TCP and UDP, is formed by taking the ones-complement sum of the 16-bit words of the message. If a message is fragmented and the fragments are reassembled in the wrong order, the ones-complement sum will likely not detect it.

Cyclic Redundancy Check (CRC)

The CRC error code is based on long division of polynomials, where the coefficients are integers modulo 2.

Cyclic Redundancy Check CRC



Error Correcting Codes

- If a link is noisy, we can add an error-correction code (also called forward error correction) that allows the receiver in many cases to figure out which bits are corrupted and fix them.
- The addition of error-correcting codes can easily increase the size of a packet significantly; some codes double or even triple the total number of bits sent.
- Almost every LAN-level protocol, from Ethernet to Wi-Fi to point-to-point links, incorporates an error-detecting code chosen to reflect the underlying transportation reliability. Ethernet includes a 32-bit CRC code, for example, while Wi-Fi includes extensive error-correcting codes due to the noisier wireless environment.