COMP3203 Final Exam Notes

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Contents

1 Test 1 Stuff (Brief and Important Only)

1.1 Units

prefix	base 10 conversion	base 2 conversion
pico	10^{-12}	2^{-40}
nano	10^{-9}	2^{-30}
micro	10^{-6}	2^{-20}
milli	10^{-3}	2^{-10}
—	10^{0}	2^{0}
kilo	10^{3}	2^{10}
mega	10^{6}	2^{20}
giga	10^{9}	2^{30}
tera	10^{12}	2^{40}
peta	10^{15}	2^{50}

- $Hz \implies$ cycles per second
  - $GHz \implies 10^9$ cycles per second
  - etc.

1.2 Equations

1.2.1 Frequency and Period

- $T = \frac{1}{f}$
- $f = \frac{1}{T}$

1.2.2 Wavelength

- $\lambda = vT$
- $f = \frac{v}{\lambda}$, since $f = \frac{1}{T} \implies \lambda = \frac{v}{f}$
  - for electromagnetic waves in a vacuum, $v = c$

1.2.3 Bandwidth

- $B =$ lowest frequency $-$ highest frequency
  - Hz
  - bps
  - or any scalar of the above two

1.2.4 Delay

- propagation delay $= \frac{\text{distance}}{\text{speed of light in medium}}$
- transmit delay $= \frac{\text{packet size}}{\text{bandwidth}}$
- queue delay = buffering and switching delays at nodes
- **total delay** = propagation + transmit + queue
- **RTT** or round-trip-time = $2 \times$ delay

1.2.5 Delay Bandwidth Product

- # of bits $= B \times D$
  - e.g., # of bits $= 10bps \times 10s = 100b$
- this is the number of bits of data that can be sent before the first bit arrives
- we can send $2(B \times D)$ bits before we receive the first reply bit

1.2.6 Shannon Capacity

- maximum theoretical capacity
- $C = B\log_2\left(1+\frac{S}{N}\right)$, where $\frac{S}{N}$ is the signal/noise ratio
  - high $\frac{S}{N} \implies$ good capacity
  - low $\frac{S}{N} \implies$ poor capacity $\because \log_2(1+0) = 0$
- $\frac{S}{N}$ should be in Db

1.2.7 Redundancy

- redundancy $= \frac{n+r}{n}$
- r redundancy bits must cover $n+r$ bits for errors
  - in other words, 2^r must be able to express $n+r$ bits
  - this means $2^r > n+r$
  - or, $n < 2^r - r$

1.3 Error Checking

- VRC
- LRC
- **CRC**
  - *this is usually used before ARQ*
- checksum

2 ARQs

- **(A)**utomatic **(R)**epeat Re**(Q)**uests
- strategy to handle errors detected by the CRC
  - or whatever other detection method
- main types
  - **stop and wait**
  - sliding window
    - **go back N**
    - **selective reject**

2.1 Sliding Window

2.1.1 Go Back N

- most commonly used sliding window
- sequential frames numbered $n \mod N$
- send up to $N-1$ frames **before an ACK is received**
- **unbounded sequence numbers** is a hurdle for sliding window in **non-FIFO** channels

<u>*ACKs and NAKs*</u>

- if no error
  - send RR (ACK) for frame[n]
- if error
  - send REJ (NAK) for frame[n]
- if frame lost, send a NAK
- if no ACK or NAK received before *timeout*, **assume lost**

When Sender Receives a NAK[n]

- resend frame[n] and all frames sent since

When a Sender Receives No ACK or NAK

- go back to the previous ACK and resend all frames sent since

2.1.2 Selective Reject

- similar to go back N
- **BUT** we only resend the **lost frame**
  - out of order!
  - receiver needs *sorting logic* to store frames after a NAK
- in general, smaller window size

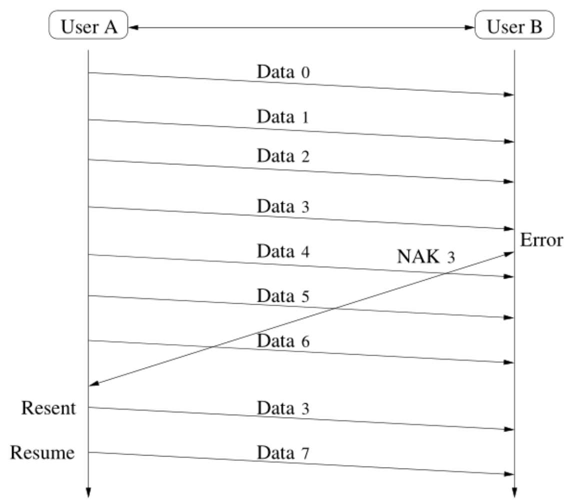


Figure 1: An example of the Selective Reject protocol.

2.2 Stop and Wait

- also called an **ABP**
  - *alternating bit protocol*
  - because the label bits alternate between `0` and `1`
- you can think of it as sliding "window" with a **window size of 1**
- works only in **FIFO queues**
  - suitable for **data link layer**

2.2.1 Errors in Stop and Wait

- two main types
- **frame** errors
  - damaged frame
- **ACK** errors
  - damaged acknowledgement

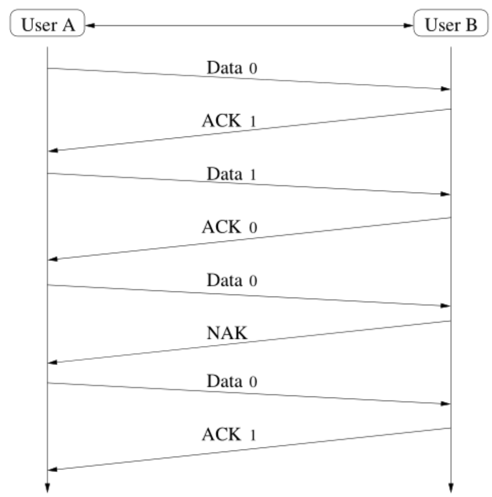


Figure 2: A diagram of the Stop and Wait ARQ protocol.

Frame Errors

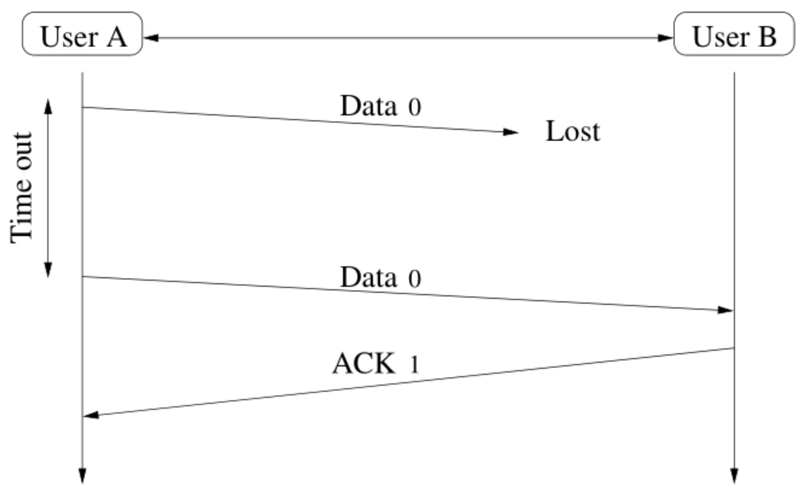


Figure 3: A lost frame error in the Stop and Wait ARQ protocol.

- frame is damaged
  - one or more bits have been altered
- discard the frame
- source waits for ACK
  - if it doesn't receive one, it will resend

ACK Errors

- frame is received but ACK is damaged
- sender will resend message
- receiver will accept the same message twice
  - so we need to label frames
  - and label ACKs

  - use a bit for this
    - ACK[b] acknowledges frame[$b + 1 \mod 2$]
    - says receiver is ready for frame[b]

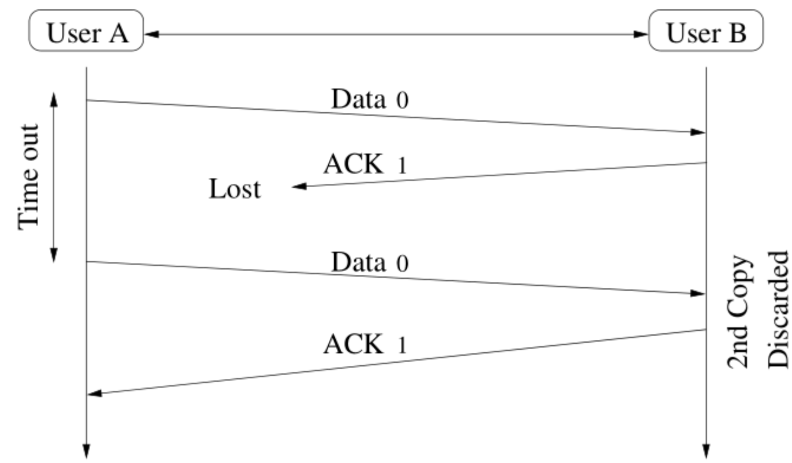


Figure 4: An ACK error in the Stop and Wait ARQ protocol.

2.2.2 Correctness

- satisfies:
  - safety
    - algorithm never gives an incorrect result
    - always results in a "corrected" error
  - liveness
    - never enters a deadlock condition

3 Multiaccess

3.1 LANs

- two types
  - **switched**
    - lines, multiplexes, switches
    - hierarchical addressing scheme
    - routing tables
  - **broadcast**
    - no routing
    - flat addressing scheme
    - **(M))**edium **(A))**ccess **(C))**ontrol to coordinate transmissions
    - **preferred over switched** due to **simplicity**

3.2 The Problem with Shared Channels

- in *point-to-point* networks we have signal as a function of one transmitted signal
- in *shared* networks, we may have **more than one** transmission contributing to a signal

3.3 MAC Protocol

3.4 Uncoordinated Access Control

3.5 Ethernet

3.6 Coordinated Access

3.6.1 Tree Algorithm

3.6.2 Binary Countdown

3.6.3 Bitmap

4 Wireless

4.1 Cellular

4.2 Ad Hoc

4.2.1 UDG

4.2.2 Compass Routing

4.2.3 Face Routing

4.3 Bluetooth

5 GPS

5.1 Three Techniques

5.2 Satellites

6 Routing

6.1 Distance Vector (RIP)

6.2 Link State Protocol (LSP)

6.3 MSTs

6.4 Dijkstra

7 IP

7.1 IPv4

7.1.1 Classes of Address

7.1.2 Subnets

7.1.3 Subnet Masks

7.2 IPv6

7.3 DHCP

7.4 ARP

7.4.1 RARP

8 TCP

8.1 How it Works (Sliding Window)

9 Sample Test

1

A system has an n-layer protocol hierarchy. Applications generate messages of length M Bytes. At each level of the layers, an h-Byte header is added.

1.1

[**3 pts**] What fraction of the network bandwidth is filled with headers? (Give the formula.)

$$\text{overhead} = \frac{nh}{nh+M}$$

1.2

[**3 pts**] Now assume $M = 20h$. What should the max number n of layers be so that the fraction in previous Question 1 does not exceed 10 % of the total?

$$\begin{aligned}
\text{overhead} &= \frac{nh}{nh+M} \\
10\% &\geq \frac{nh}{nh+20h} \\
\frac{1}{10} &\geq \frac{n}{n+20} \\
(n+20)\frac{1}{10} &\geq n \\
(n+20)\frac{1}{10} &\geq n \\
\frac{n}{10}+2 &\geq n \\
n+20 &\geq 10n \\
20 &\geq 9n \\
n &\leq \frac{20}{9}
\end{aligned}$$

1.3

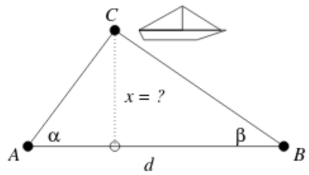
Two CDMA users are assigned the 9-bit vectors $A = 110011011, B = 100101111$, respectively. Are they orthogonal? (Prove or disprove!) **Hint:** Recall $0 \to -1$ and $1 \to +1$.

Take inner product of vectors in $\mod 2$.

$$\begin{aligned}
\langle \vec{A}, \vec{B} \rangle \mod 2 &= 1+0+0+0+1+0+0+1+1 \mod 2 \\
&= 0 \qquad \iff \text{orthogonal}
\end{aligned}$$

2

You are observing a ship from two base stations A, B. Assume that at this time of observation $\alpha = \pi/3, \beta = \pi/4$ and $d = 1000\ m$.

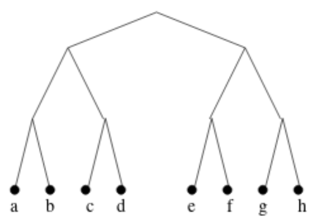


Derive a formula for the unknown distance x (You are not required to evaluate the trigonometric functions of $\pi/3$ and $\pi/4$).

$$x = d\frac{\tan\alpha \tan\beta}{\tan\alpha + \tan\beta}$$
$$x = 1000\,\mathrm{m}\frac{\tan\frac{\pi}{3}\tan\frac{\pi}{4}}{\tan\frac{\pi}{3} + \tan\frac{\pi}{4}}$$

3

Ethernet stations a, b, c, d, e, f, g, h contend for a channel. Assume a, e, f, g, h become ready at once and that they use the tree resolution protocol to resolve contentions.



for each contention slot give in the table below the winning stations.

Slot	Station
1	a e f g h
2	a
3	e f g h
4	e f
5	e
6	f
7	g h
8	g
9	h

4

5

6

7