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1. (a)

(i) $$SNR_{decimal} = \frac{P_s\,[mW]}{P_n\,[mW]} = \frac{10^{\frac{-100}{10}}}{10^{\frac{-117}{10}}} \approx 50.119$$

$$C = \left(2 \times (40 \times 10^6)\right) \times log_2\,(1 + SNR_{decimal}) \approx 454.06\,Mbps$$

(ii) ● **Beamforming with MIMO**

Provides directional signal transmission and reception i.e. focus signal towards targeted device so that more data reaches the target through the manipulation of antenna arrays

● **Channel Bonding**

Throughput can be increased by bonding two 40 MHz 5 GHz separate non-overlapping channels together, making a channel width of 80 MHz

(iii) 80 Mbps

(iv) Binary signal → If channel has a bit rate $f_b = 80\ Mbps$, the Ideal Nyquist Bandwidth of the channel to send a binary signal is $B_N = 80\ MHz$

$$B_N = \frac{f_b}{log_2 M}$$ = Baud

$$log_2 M = 1$$

$$M = 2$$

Minimum no of bits used to encode each symbol:

$$N = log_2\,M = 1$$

(b)

Δ p = PRS – TRS

TMR = PMR – Δ p

= PMR – (PRS – TRS)

= PMR – PRS + TRS

2. (a)

Given: Repetition coding with a redundancy factor of 3,
Probability (any 1 bit gets inverted), $p = 0.01$

If the info bit is "0", send "000". If the received 3 bits have 2 or 3 bits that are "0", info bit is decoded to "0", else to "1"
Hence, "0" will be decoded to "1" only if 2 or 3 bits are inverted,
"000" is changed to:

111 → Probability: p^3
$011, 101, 110$ → 3 possibilities, each with Probability: $p^2(1-p)$

Total Probability of error $= p^3 + 3(p^2(1-p))$
$= 0.01^3 + 3(0.01^2(1-0.01))$
$= 0.000298$

Why such a code is effective?

– Receiver correct limited number of errors without re-transmission
– Lesser re-transmissions needed

(b)

$$f_C = \frac{1}{t} = \frac{1}{0.4 \times 10^{-6}} = 2.5 \times 10^6\ Hz$$

$$00: \quad 2\cos(2\pi\,(2.5 \times 10^6)\,t)$$
$$01: \quad 2\cos\left(2\pi\,(2.5 \times 10^6)\,t + \frac{\pi}{2}\right)$$
$$10: \quad 2\,cos\,(2\pi\,(2.5 \times 10^6)\,t + \pi)$$
$$11: \quad 2\,cos\left(2\pi\,(2.5 \times 10^6)\,t + \frac{3\pi}{2}\right)$$

(c)

Symbols = 00, 01, 10, 11 (2 bits)
Data rate = 3000 symbols/sec

Symbol Period $T_S = \frac{2}{3000}$

Bit Period $T_B = \frac{1}{3000}$

Energy per symbol $E_S = \frac{T_S}{2}\left[\frac{A^2 + A^2 + \ldots + A^2}{|A|}\right]$

$$= \frac{\frac{1}{3000}}{2}\left[\frac{2^2 + 2^2 + 2^2 + 2^2}{4}\right]$$

$$= \frac{1}{1500}$$

1 symbol comprises 2 bits, hence Energy per bit $E_B = \frac{E_S}{2} \approx 3.33 \times 10^{-4}\ \mathrm{J}$

(d)

If there is nothing to send = Wasted Slot

User 1	**User 2**	**User 3**	**User 4**	

5 Slots

Output Data Rate: $5\ Mbps \times 5 = 25\ Mbps$

3. (a)

Timeslots	**T0**	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**
Freq Channels	8	1	7	2	6	3	5	4
Freq (GHz)	2.407	2.4	2.406	2.401	2.405	2.402	2.404	2.403

AMA 1 – Slave A								
AMA 3 – Slave C								
AMA 5 – Slave B								

Slaves can only transmit in odd timeslots

Slave B: Slot 7 $f = 2.403\ GHz$

Slave C: Slots 3, 4, 5 $f = 2.401\ GHz$

(b)

Channel Reuse Factor = 1

– Interference from neighboring cell can't affect CDMA or DSSS
– Every user has a unique PN Code

No, there is too much interference and no unique PN code assigned for each user, thus it is impossible to differentiate between multiple transmissions (users) in same frequency range. Adjacent cells needs to be assigned different frequency channels to reduce crosstalk/interference.

(c)

$$Signal\ to\ Inteference\ Ratio\ (SIR) = \frac{S}{I} = \frac{(\sqrt{3N})^n}{i_0} \qquad i_0 = 6$$

$$15dB < 10\log\left[\frac{(\sqrt{3N})^4}{6}\right]$$

$$1.5 < \log\left[\frac{(\sqrt{3N})^4}{6}\right]$$

$$10^{1.5} < \left[\frac{(\sqrt{3N})^4}{6}\right]$$

$(10^{1.5} \times 6)^{\frac{1}{4}} < \sqrt{3N}$ [For calculators, <u>MUST</u> bracket $\frac{1}{4}$, i.e. ANS^(1r4) or just use 0.25]

$$4.591 < N$$

$N = 5$

$Q = \sqrt{3N}$

$= \sqrt{3 \times 5}$

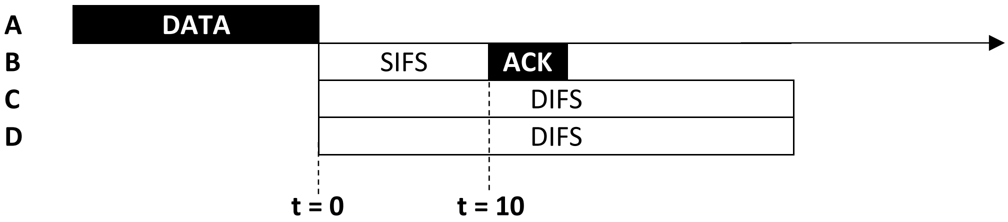
≈ 3.873

4. (a)

(i) DCF – Distributed Coordination Function

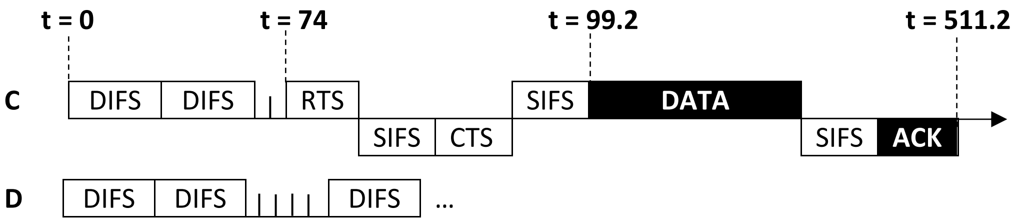
(ii) **SIFS** $= 10\ \mu s$ **DIFS** $= 10 + (9 \times 2) = 28\ \mu s$ **ACK & CTS** $= \frac{10 \times 8}{40} = 2\ \mu s$

RTS $= \frac{16 \times 8}{40} = 3.2\ \mu s$ **Data** $= \frac{2000 \times 8}{40} = 400\ \mu s$ **Back off** $= 9\ \mu s$



Station B will access the channel at 10 μs to send the **ACK** frame.

(iii)



Station C will gain access to the channel at 99.2 μs to transmit its **Data** frame.

Time channel is released $= 28 + 28 + (9 \times 2) + 3.2 + 10 + 2 + 10 + 400 + 10 + 2$

$= 511.2\ \mu s$

(iv) NAV – Network Allocation Vector

- MAC layer frame headers contain a Duration field that specifies the tx time required for the frame, during which the medium will be busy
- Stations listening on the wireless medium read the Duration field and set their NAV, which is an indicator for a station on how long it must defer from accessing the medium
- NAV may be thought of as a counter, which counts down to 0 at a uniform rate

(b)

(i) $10\ Mbps \times 4 = 40\ Mbps$

(ii)

$$\begin{array}{lr} & 0000 \\ \underline{\text{XOR}} & \underline{1010} \\ & 1010 \end{array} \leftarrow \text{Encoded bit 0} \qquad \begin{array}{lr} & 1111 \\ \underline{\text{XOR}} & \underline{0100} \\ & 1011 \end{array} \leftarrow \text{Encoded bit 1}$$

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Thank you and all the best for your exams! ☺