⏱ **20 minutes**

[L3] Quiz 2

This quiz covers the types of media, EM spectrum, and fundamentals of digital communication (signal representation and channel capacity).

Due to its high bandwidth, Millimeter waves is suitable for static (b) dense setups, (c) point-to-point communication, and (d) high-speed transmissions. However, its physical properties only allow directional transmissions covering a more limited area. Therefore, it is not a good strategy for covering transitting mobile users (e.g., in buses, trains, etc.), who might enter and leave the coverage area too fast.

* Required

* This form will record your name, please fill your name.

1. [Transmission Media] Internet's core is made of interconnected routers switching millions of billions of packets from and to ISPs' access networks. In order to support this workload, this infrastructure must be reliable, resilient, cover long distances, and achieve ultra high data rates. Given this scenario, what kind of media is more suitable for effectively making Internet core's links? * (4 Points)

- Twisted pairs
- Coaxial cables
- Fiber optics
- Microwave radio over the air

In short:

Fiber optics can achieve higher transmission rates than Twisted Pairs or Coaxial Cables.

Moreover, it is more resilient against interference than other wireless transmission media.

2. [SNR and Shannon Capacity] In an interference-free Wi-Fi channel, typically with a bandwidth of B=22 MHz, a transmitting node sends a signal with power S=100mW. The thermal noise in the wireless medium has power N=1mW. What is the maximum achievable transmission rate? * (4 Points)

- Rmax=96 Mbps
- Rmax=146 Mbps
- Rmax=96 Mbps
- Rmax=1.17 Gbps

You have to know that SNR = S/N and apply Shannon capacity equation, i.e.,

$$
\begin{aligned}
Rmax &= B \log2(1 + SNR)\\
&= B \log2(1+S/N)\\
&= 22.0\text{x}10^6 \log2\,[1 + (100.0\text{x}10^{-3} / 1.0\text{x}10^{-3})]\\
&= 146.0\text{x}10^6 \text{ bps}
\end{aligned}
$$

22/03/2023 15:35 [L3] Quiz 2

3. [Nyquist Theorem] What is the minimum required bandwidth of an ideal channel (no thermal noise) for a signal carrying 8 discrete voltage levels to achieve a rate of 1 Gbps (approximately)? * (4 Points)

- B=500.0 MHz
- B=250.0 MHz
- B=166.7 MHz
- B=125.0 MHz

We know that the maximum transmission rate is Rmax=1.0x10^9 bps and the number of discrete levels is V=8.

Now, we apply Nyquist theorem directly, i.e.,

$$
\begin{aligned}
&Rmax = 2 B \log2(V) \iff\\
&\iff B = Rmax / 2 \log2(V)\\
&\iff B = 1.0\text{x}10^9 / 2 \log2(8)\\
&\iff B = 166.7\text{x}10^6 \text{ Hz}
\end{aligned}
$$

4. [Signal Representation and Bandwidth] For a given type of transmission, it was observed that 8 harmonics are used to reconstruct any signal containing up to 10000 bits at the receiver with enough quality to be successfully decoded. Which of the cut-off frequencies below is **not** able to perform base-band transmissions at 100 Mbps? (4 Points)

- fc=320 kHz
- fc=160 kHz
- fc=80 kHz
- fc=40 kHz

Transmission period is $T = N/R = 10^4/10^8 = 1.0\text{x}10^{-4}$ s
Frequency is $f = 1/T = 1 / 10^{-4} = 10.0 \text{ x } 10^3$ Hz = 10.0 kHz

To be able to successfuly recover the signal, we need to send at least 8 harmonics, i.e., we need to send at least n=1,2,...,8 waves, whose frequencies are 10.0 kHz, 20.0 kHz, ..., 80.0 kHz, respectively.

Any cut-off frequency smaller than 80.0 kHz would not allow the required number of harmonics to be correctly transmitted.

5. [Wireless Transmission and EM spectrum] Millimeter waves (a sub-type of **microwaves**) have been widely adopted in modern wireless communication systems. Which of the following options is **not** an example of applications that may benefit from transmissions using this frequency band? * (4 Points)

- Provide Internet access to mobile users with **high mobility level** (e.g., users commuting in urban environments)
- Provide Internet access to **dense crowds** of mobile users (e.g., audience in stadiums or dense IoT deployments)
- Provide **point-to-point (direct) communication** between 5G base stations (e.g., for exchanging control packets)
- Provide **high-speed Internet access** to mobile users consuming demanding applications (e.g., augmented reality and cloud gaming)