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**DCAN202 Week 10 Tutorial – Data Communication and Networking**

**1. What types of applications might use frequency division multiplexing? Time division multiplexing? Dense wavelength division multiplexing?**

Ans: **Applications of Multiplexing Techniques-**

**Frequency Division Multiplexing (FDM):** FDM divides the available bandwidth into non-overlapping frequency bands, each carrying a separate signal. This technique is widely used in **broadcast radio** (AM/FM stations), where each station operates at a distinct frequency. **Television transmissions** similarly allocate specific frequency bands to different channels over coaxial cables. **Cable TV** leverages FDM to deliver hundreds of channels simultaneously, with each channel modulated onto a unique carrier frequency. In **cellular telephone systems**, FDM separates uplink and downlink frequencies to enable bidirectional communication. Modern applications include **DSL broadband**, where FDM splits telephone lines into voice and data channels, allowing internet access without disrupting phone service.

**Time Division Multiplexing (TDM):** TDM assigns time slots to multiple signals in a cyclical manner, making it ideal for digital systems. **T-1 telephone networks** use TDM to aggregate 24 voice channels (each sampled at 8 kHz) into a 1.544 Mbps data stream. **SONET/SDH networks** rely on TDM for high-speed optical communication, synchronizing data streams across long distances. Applications extend to **ISDN** (Integrated Services Digital Network), where Basic Rate Interface (BRI) and Primary Rate Interface (PRI) services multiplex voice and data. TDM is also foundational in **GSM cellular networks** and tactical data links like Link 16, enabling efficient digital signal sharing.

**Dense Wavelength Division Multiplexing (DWDM):** DWDM combines multiple optical signals (wavelengths) on a single fiber, maximizing data capacity. It is critical in **long-haul fiber-optic networks**, where transmitting terabytes of data across continents or undersea cables requires minimal signal degradation. Telecommunications providers use DWDM in **metro aggregation networks** to consolidate traffic from multiple cities and in **core backbone networks** for intercontinental data routing. **Data center interconnects** (DCIs) also employ DWDM to link geographically distributed facilities, supporting cloud services and hyperscale computing.

**2. What is the primary advantage of TDM over FDM?**

Ans: TDM’s key advantage lies in its use of **digital signaling**, which enhances efficiency and noise resilience compared to FDM’s analog approach. Digital signals are less susceptible to interference, as they encode data in discrete binary values (0s and 1s) rather than continuous waveforms. This allows TDM systems to regenerate signals accurately over long distances. Additionally, TDM eliminates the need for guard bands—unused frequencies required in FDM to prevent overlap—freeing bandwidth for data transmission. For example, in T-1 systems, time slots are precisely synchronized, ensuring no wasted capacity

**3. Where is discrete multitone commonly used?**

Ans: DMT is the backbone of **Digital Subscriber Line (DSL)** technologies, such as ADSL and VDSL. It divides the available frequency spectrum into hundreds of subchannels (or "tones"), each modulated independently using quadrature amplitude modulation (QAM). This enables high-speed internet over existing copper telephone lines by dynamically allocating bandwidth based on signal quality. DMT mitigates interference and crosstalk, optimizing data rates up to 100 Mbps in VDSL2 systems. Its adaptability makes it suitable for environments with variable line conditions

**4. How does code division multiplexing work?**

Ans: CDMA assigns a unique **spreading code** (e.g., a 64-bit sequence) to each user. To transmit a binary **1**, the device sends the code itself; for a **0**, it transmits the code’s inverse. Signals from multiple users overlap in frequency and time but are separated at the receiver using **correlation**. The receiver multiplies the incoming signal by the intended user’s code and sums the results. If the sum matches the code length (e.g., +64), it decodes as a 1; if it matches the inverse (e.g., -64), it decodes as a 0. This spread-spectrum technique is central to **3G/4G cellular networks**, allowing simultaneous communication with minimal interference

**5. How many examples of lossless compression can you think of? Lossy compression?**

Ans:

**Lossless Compression:**

* **Run-length encoding (RLE):** Replaces repeated data (e.g., pixels in an image) with a count and value.
* **Huffman coding:** Uses variable-length codes based on symbol frequency, prevalent in ZIP files.
* **Lempel-Ziv (LZ77/LZ78):** Found in GIF images and the DEFLATE algorithm (used in PNG).
* **FLAC (Free Lossless Audio Codec):** Compresses audio without quality loss, ideal for archiving music.

**Lossy Compression:**

* **JPEG:** Discards high-frequency image details imperceptible to the human eye.
* **MPEG:** Uses motion prediction and discrete cosine transform (DCT) to compress video.
* **MP3:** Removes inaudible audio frequencies and exploits psychoacoustic masking.

**6. List three common examples of frequency division multiplexing.**

Ans:

**Broadcast Radio:** AM (530–1600 kHz) and FM (88–108 MHz) stations each occupy distinct frequencies.

**Cable Television:** Channels like HBO or CNN are transmitted simultaneously via separate 6 MHz bands.

**Cellular Networks:** 4G LTE divides spectrum into frequency blocks for uplink/downlink traffic.

**7. Frequency division multiplexing is associated with what type of signals?**

Ans: FDM traditionally handles **analog signals**, such as AM/FM radio waves and analog TV broadcasts. Modern implementations, like DSL, use **discrete analog signals** (digitally modulated carriers) to transmit data over copper lines. Guard bands ensure separation between adjacent channels, preventing crosstalk

**8. In what order does synchronous time division multiplexing sample each of the incoming signals?**Ans:Synchronous TDM samples input signals in a fixed round-robin sequence. For example, a T-1 frame collects one 8-bit sample from each of 24 voice channels in succession, creating a 192-bit frame (24 × 8) transmitted at 8,000 frames per second. This cyclical sampling ensures uniform latency and synchronization across all channels