**Conceptual Mobile Computing - Task for - 14th Jan 2025 – 8 – 10 AM**

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1. **Explain the multiplexing method that uses - "common frequency channel".**

Ans: The multiplexing method using a common frequency channel refers to Code Division Multiple Access (CDMA). In this method, all users transmit their signals over the same frequency band simultaneously. CDMA achieves this by employing a technique called spread spectrum and distinguishing users based on unique codes.

**Key Concepts of CDMA**

* **Spread Spectrum:**
  + Each user’s signal is multiplied by a high-rate pseudo-random code, spreading the signal across a wider frequency band than the original data requires.
  + This results in a low-power signal spread across the entire bandwidth, making it robust against interference and eavesdropping.
* **Orthogonal Codes:**
  + Each user is assigned a unique code (often Walsh codes or Gold codes) that is orthogonal to the codes of other users.
  + Orthogonality ensures minimal interference between users' signals.
* **Decoding at the Receiver:**
  + The receiver uses the same unique code to extract the desired user’s signal from the combined transmission.
  + Signals not matching the desired code appear as noise and are ignored.

**How CDMA Works**

* **Transmission:**
  + Each user's data is multiplied by a unique spreading code.
  + The spread signal is transmitted over the same frequency channel used by other users.
* **Reception:**
  + At the receiver, the incoming signal is correlated with the unique code assigned to the intended user.
  + Due to the orthogonality of the codes, the desired signal is extracted, while signals from other users are treated as noise.
* **Capacity:**
  + The number of simultaneous users is limited by the level of interference and the noise threshold of the system.
  + The capacity can be increased by using advanced interference management techniques.

**Advantages of CDMA**

* **Efficient Spectrum Utilization:**
  + Since all users share the same frequency band, CDMA makes optimal use of the available spectrum.
* **Robustness to Interference:**
  + The spread spectrum technique and code-based separation make CDMA resilient to interference and noise.
* **Scalability:**
  + Adding more users increases noise but does not require additional frequency bands, unlike Frequency Division Multiple Access (FDMA).
* **Security:**
  + The pseudo-random spreading codes add a layer of security, making it harder for unauthorized parties to decode the signal.
* **Resistance to Fading:**
  + Spread spectrum techniques reduce the impact of multipath fading and signal attenuation.

**Applications of CDMA**

* **Cellular Networks:**
  + Widely used in 2G and 3G mobile communication systems, such as IS-95 and CDMA2000.
* **Satellite Communications:**
  + CDMA is employed in satellite systems for efficient bandwidth sharing and robustness to interference.
* **Military Communication:**
  + Its security and resistance to jamming make CDMA suitable for military applications.

1. **How does CDMA differ from other multiplexing techniques in handling multiple user access?**

Ans:

**Shared Frequency Spectrum:**

* Unlike Frequency Division Multiple Access (FDMA), where users are assigned distinct frequency bands, CDMA allows all users to share the same frequency band.
* Time slots, as used in Time Division Multiple Access (TDMA), are not needed in CDMA.

**Signal Separation:**

* CDMA uses orthogonal codes or spreading codes to encode user data.
* Receivers decode data using these codes, enabling multiple users to coexist without severe interference.

**Interference Management:**

* CDMA inherently mitigates interference using spread spectrum techniques, spreading the signal over a wider bandwidth than required.

**Scalability:**

* Adding users in CDMA increases noise but does not require additional frequency bands or time slots, unlike FDMA or TDMA.

1. **What are the key advantages of SDMA over traditional multiplexing methods?**

Ans: Space Division Multiple Access (SDMA) leverages spatial separation to distinguish between users, often using directional antennas or beamforming.

* **Efficient Spectrum Utilization:**
  + SDMA allows multiple users to use the same frequency and time resources in different spatial regions.
* **Higher Capacity:**
  + By focusing signals in specific directions, SDMA reduces interference and increases the number of users that can be served.
* **Enhanced Signal Quality:**
  + Directional beams minimize interference and improve the signal-to-noise ratio.
* **Compatibility:**
  + SDMA can be combined with FDMA, TDMA, or CDMA for even greater efficiency.

1. **Analyze Which multiplexing technique would be most suitable for:**
   1. A crowded urban area with high-rise buildings
   2. Rural areas with sparse population
   3. A business district requiring high data security

Ans:

**Crowded Urban Area with High-Rise Buildings:**

* Recommended: SDMA and CDMA
* High-rise buildings create multipath propagation and dense user populations.
* SDMA can manage spatial separation, while CDMA's ability to handle interference makes it ideal.

**Rural Areas with Sparse Population:**

* Recommended: FDMA
* Fewer users and large cell sizes reduce the need for advanced interference management.
* FDMA's simplicity and reliability are well-suited for rural coverage.

**Business District Requiring High Data Security:**

* Recommended: CDMA
* CDMA's spread spectrum and unique codes offer inherent data security.
* Its robustness against eavesdropping and interference is crucial in sensitive environments.