**CAT 1**

**1. Challenges in Localization:**

1. Signal Interference and Multipath Propagation: Problems such as obstructions, reflections or noise interfere with the accurate positioning signal making location estimation a challenge.
2. Environmental Factors: Natural conditions such as weather, or physical barriers and other physical condition factors make the process of localization to be inaccurate.
3. Energy Constraints: Sensor nodes are often restricted to finite energy source; thus, it is difficult to achieve a highly localized sensor network over long interval.
4. Scalability: Such big networks need fast methods that provide precise positioning and do not load the computational equipment heftily.
5. Cost: Both the hardware acquisition and algorithms adopted for localization can be costly when done for large networks.
6. Mobility: Updating of nodes that are in motion makes the system complex since the location information has to be updated continuously.
7. Non-Line-of-Sight (NLOS) Conditions: Since localization occurs by following signals that may curve due to obstacles, there may be a chance of errors.

**2. IEEE 802.15.4 MAC Protocol:**

IEEE 802.15.4 MAC is a standard mainly used for LR-WPAN and supports low power and low data rate communication. It prescribes how systems gain rights to the wireless medium, how to gain possession of the physical media and regulate data transfer.

**3. Sensor Node Clustering in WSNs:**

Concept:

Wireless Sensor Networks (WSNs) clustering is the process of dividing a set of connected nodes into clusters. Every cluster is headed by a node called the cluster head who is specifically charged with overseeing data collection processes from other nodes in the cluster or with the base station.

Benefits:

Energy Efficiency: Reduces energy consumption since the membership of each cluster only sends data to and receives data from the base station. Scalability: Ensures that the network is more scalable by addressing small clustered problems. Data Aggregation: Data received at nodes within a cluster may be consolidated by the cluster heads, thus curtailing the amount of information sent to the base station, hence optimum bandwidth attained. Load Balancing: Contributes to balance the communication load, which increases the total lifetime of the network.

**4. Four Operational Modes of the Radio Transceiver:**

i. Transmit Mode: The transceiver transmits information towards other nodes.
ii. Receive Mode: The transceiver is used to listening to the channel in order to receive data.
iii. Idle Mode: Transcribing, but not transmitting or receiving in this mode; power consumption is lower than in each active mode.
iv. Sleep Mode: The transceiver is said to be IEEE802.14.14 compliant and is powered off, thus is the lowest power consuming; It must wake up occasionally.

**5. Two Routing Protocols in WSN:**

A. LEACH (Low-Energy Adaptive Clustering Hierarchy): Each node is in a cluster in the network, and only the head of the cluster gathers data from the nodes then sends it to the base station to save energy.
B. Directed Diffusion: A messaging protocol in which data is labeled by attribute-value pairs. A point of interest expresses an interest in a certain data, and the information gets to travel through the network depending on these interests.