1. Discuss different ways of power supply to the sensor nodes in WSN.

Traditional batteries - The power source of a sensor node is a battery, either non-rechargeable (primary batteries) or, if an energy scavenging device is present on the node, also rechargeable (secondary batteries).

Energy scavenging

- Some of the unconventional energy sources like fuel cells, micro heat engines and radioactivity – convert energy from stored secondary form into electricity in a easy way than a normal battery would do.
- The entire energy supply is stored on the node itself once the fuel supply is exhausted, the node fails.
- The energy from a node's environment must be tapped into and made available to the node – energy scavenging should take place.
- **Photo-voltaics** The solar cells can be used to power sensor nodes. The available power depends on whether nodes are used outdoors or indoors, and on time of day.
- **Temperature gradients** Differences in temperature can be directly converted to electrical energy.
- **Vibrations** Walls or windows in buildings are resonating with cars or trucks passing in the streets, machinery often has low- frequency vibrations, ventilations also cause it, and so on.

2. Define cognitive radio network and highlight the Beaming of spectrum sensing and spectrum sharing.

Cognitive radio (CR) is a form of wireless communication in which a transceiver

- intelligently detect which communication channels are in use and which ones are not.
- The transceiver then instantly moves into vacant channels, while avoiding occupied ones.
- Helps to optimize the use of the available radio frequency (RF) spectrum.
- minimizes interference to other users, by avoiding occupied channels, it increases spectrum efficiency and improves the quality of service (QoS) for users.

spectrum sensing

  - CR devices track the spectrum bands in their neighborhoods to identify users licensed to operate in that band.
  - look for unused portions of the RF spectrum known as white spaces or spectrum holes.
  - These holes are created and removed dynamically and can be used without a license.

spectrum-sharing

  - Several RANs share the same frequency band.
  - They also coordinate with each other to use unoccupied sub-bands intelligently and optimally.

3. What are the limitations of various paging techniques in location management

Simultaneous paging

- Implementations of simultaneous paging favour networks with large cells and low user population and call rates.
- Not favourable in large networks

Sequential Paging

- The number of cells per paging area is a factor which needs to be optimised and may lead to excessive call delays, particularly in large networks

Intelligent Paging

- efficient ordering of paging areas requires a comprehensive knowledge of user residence probabilities

4. Discuss the location management parameter in detail.

1. Paging

- Simultaneous Paging-
  - every cell in the user's LA is paged at the same time in order to find the user
  - Quicker
  - Cost wise inefficient
- Sequential Paging-each cell within an LA is paged in succession
  - poll the cells nearest to the cell of the most recent LU, and then continue outward if the user is not immediately found.
- Intelligent Paging
  - calculates specific paging areas to sequentially poll based upon a probability matrix.
  - optimized version of Sequential Paging

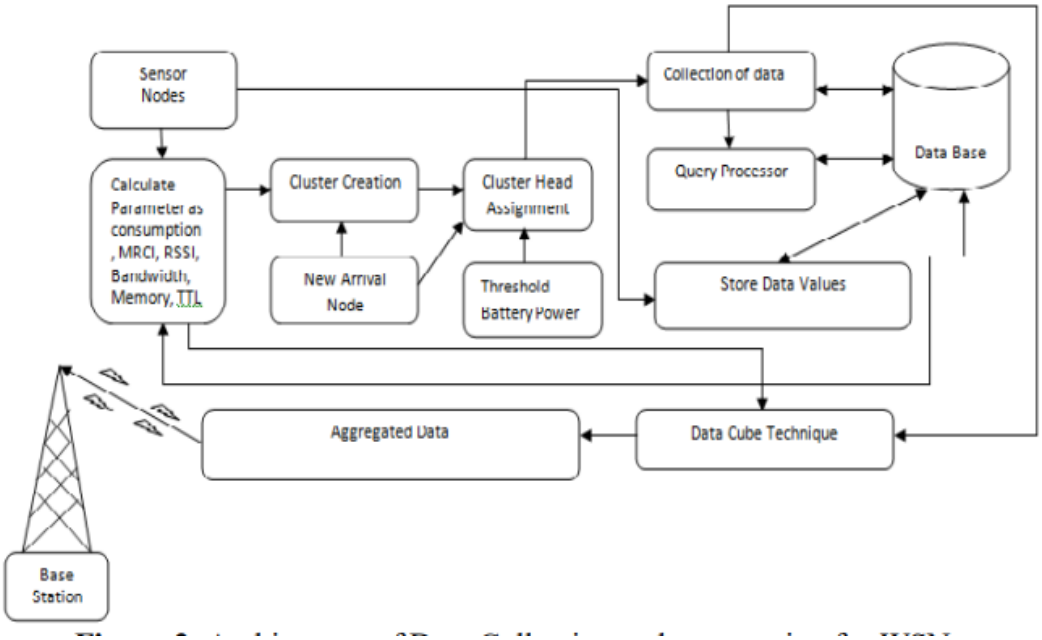
2. Mobility Models

Mobility Model is **a model that describe the movement of mobile users and how their location, velocity and acceleration change over time**.

- **Random Walk** is a part of Indoor Mobility Models.
  - Indoor Mobility model, there are 3 parts- Random Walk, Random Way-Point, Random Direction.
  - 2D Random Walk is widely used in mobility.
  - It is memory-less mobility pattern.
  - Current speed is independent of its past.
  - This also generates unrealistic movements such as sudden stops and sharp turns.

- Gauss-Markov mobility model – Outdoor mobility model
    - Probabilistic version of Random walk
    - The model adapts to different levels of randomness.
        - In indoor mobility models, there are fixed simulation areas in which we can do whether random walk or random way-point or random direction.
        - In outdoor mobility model, there is no concept of the simulation area. It is purely random.
    - each mobile node is assigned a current speed and direction. It means that every node has its initial direction and initial speed and it can change itself randomly. It can move freely in and out.
    - The Gauss Markov model has both memory and variability.
    - The tunable alpha parameter determines how much memory and randomness you want to model.
- **Fluid Flow model -** modelling users as a fluid; free particle (pedestrian) flow and the continuum (large crowd) flow approach
    - use of fluid mechanics and transport theory to represent user mobility.
    - A model based on viscous free irrotational fluid mechanics
    - Empirical data from pedestrian and vehicular studies provide a means of creating realistic group movement characteristics with smooth non random trajectories and smooth continuous velocity.
    - The model is used in an example to provide boundary crossing rates for users in a cellular network and optimising the size of cellular location areas.
- **Activity Based Model** – Extension of Markovian model
    - parameters such as time of day, current location, and predicted destination are also stored and evaluated to create movement probabilities.
    - a mobility model was developed with the goal of providing realistic mobility patterns for individual subscribers.
    - The model is based on activity pattern theory borrowed from related work in traffic engineering and social science and using raw data from regional planning travel surveys.
    - The principle behind the model is that, through statistics derived from travel surveys, there are certain probabilities associated with one activity following another activity, based on certain parameters such as time of day and socioeconomic status.

5. Explain the process of data collection and aggregation in WSN with the neat diagram.



Data Aggregation: Working Principle

- starts working by choosing selecting of nodes and divided into clusters. These clusters can satisfy the intended parameter requirements and conditions. The parameters like RSSI, TTL, MRIC, bandwidth, battery consumption are accustomed verify the amount of nodes that will be considered in a cluster.
- a cluster head (CH) is selected among nodes lies within the each cluster. CH are going to be responsible for administration of all different nodes inside several cluster and collecting the data} from the nodes within the cluster and transferring the information to the neighboring cluster head for more information exchange and updation .
- The newly arrived nodes will be assigned as cluster head if the global cost of arrived node is minimum , otherwise other cluster nodes are going to be given opportunity to participate and global cost is once more recalculated.
- thereafter the data aggregation approach is presumed as the collection of data and numerous queries from the user end are checked and transformed into low level schemes by a query processor.
- All data collected and aggregated is stored at a storage location in database server.