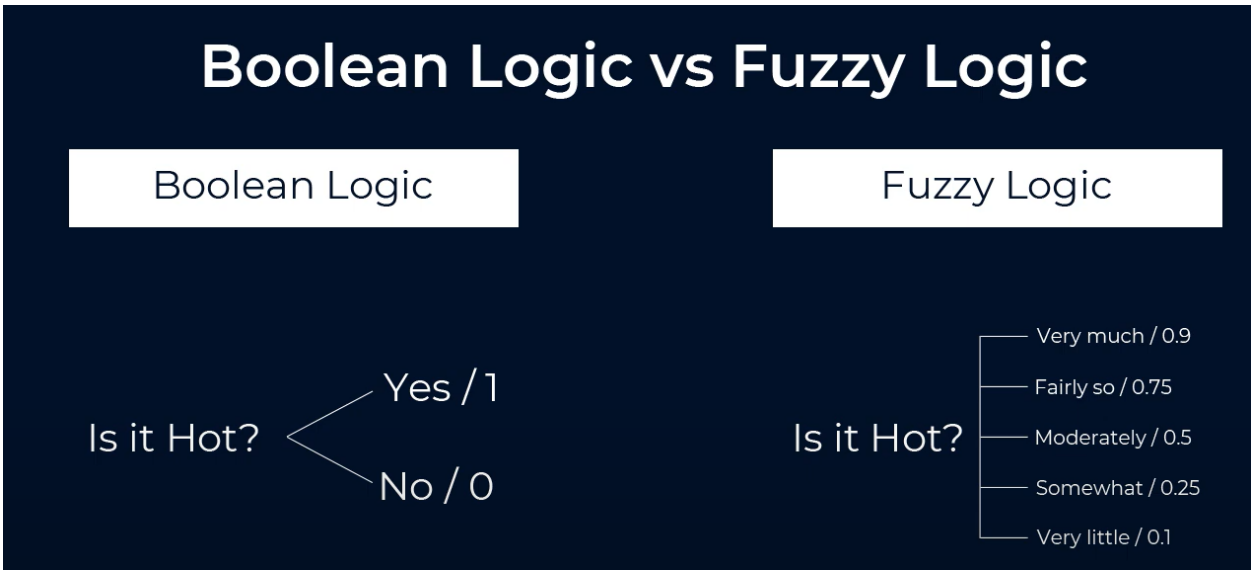
Hybrid Fuzzy-Genetic Algorithm

What is fuzzy logic ??



Applications of fuzzy logic in AI

1. Medicine Ex: Anesthesia to patient
2. Transport System
3. Industry
4. Defense
5. Naval Control

What is Genetic Algorithm ??

Inspired by natural evolutions

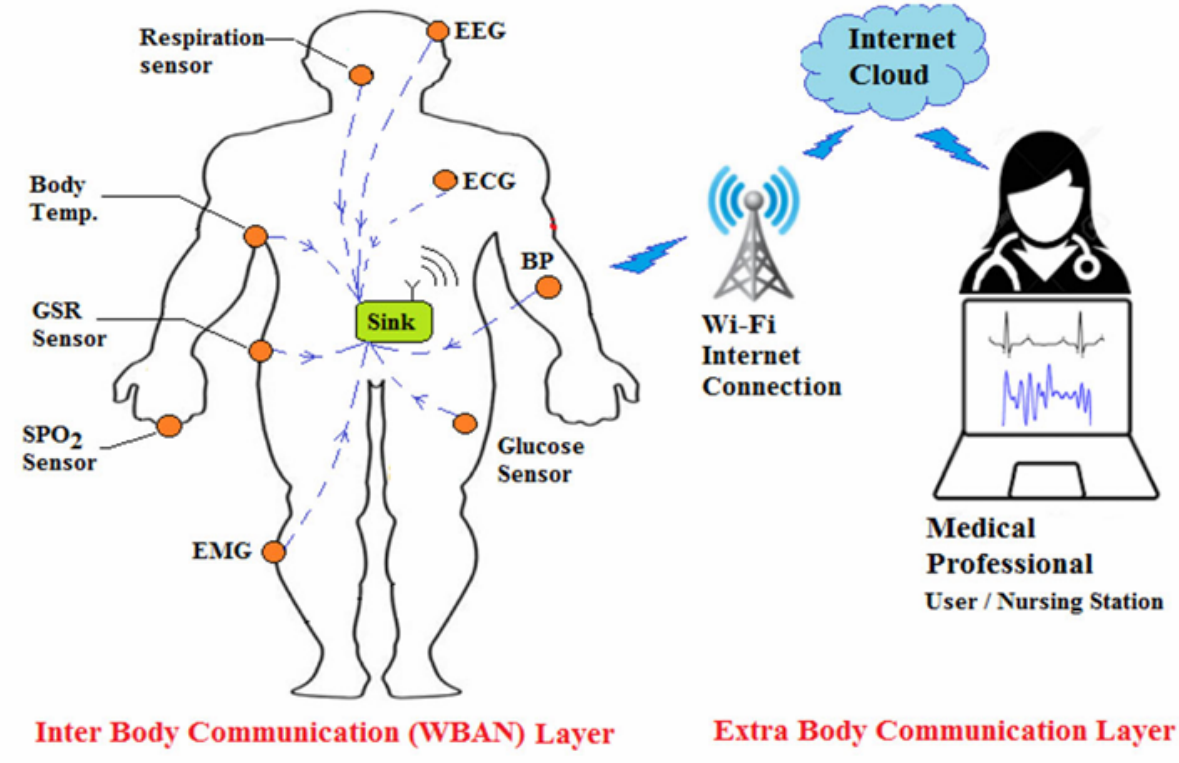
uses techniques like selection, crossover, and mutation to evolve solutions over generations. (Effective for optimization problems).

Hybrid Fuzzy - Genetic Algorithm :

A hybrid fuzzy genetic algorithm combines the principles of fuzzy logic and genetic algorithms to create a powerful tool for solving complex problems.

A Hybrid Fuzzy-Genetic Algorithm for Performance Optimization of Cyber-Physical Wireless Body Area Networks

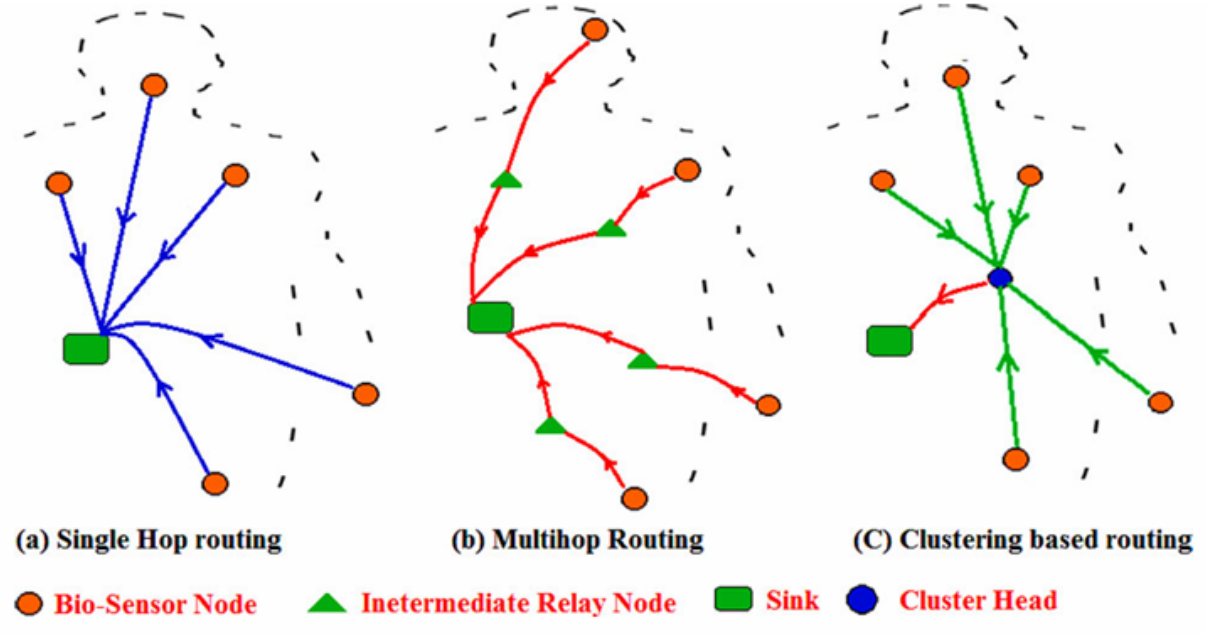
This paper is about fuzzy logical-based clustering protocol for data routing in Wireless Body Area Networks(WBAD).



All the data will be stored in SINK and it will share the data using WIFI or internet connections and that data will be transferred to the User/ Doctor using interact

cloud.

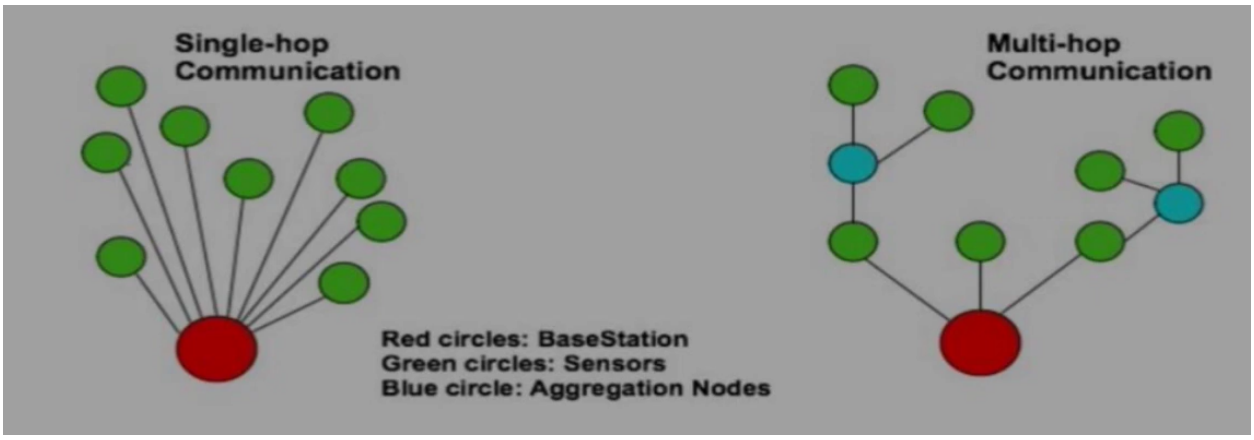
Different Routing Schema for WBAN



Single Hop Routing: In single-hop routing, a sensor node communicates directly with the sink node, the central node in the network responsible for collecting and aggregating data from the sensor nodes. (Simple and Efficient)

However, single-hop is limited to a relatively small distance.

Multi-Hop Routing: In Multi-hop communication, the sensor node can communicate with other sensor nodes that are with in a range, and these nodes can then relay the data to different nodes until the data reaches the sink node. This allows the data transmitted over large distances as the signal can be forwarded from node to node



Clustering approach-based routing protocols are appropriate for WBAN systems. Based on a predefined grouping criterion, nodes are clubbed into different clusters. A suitable cluster member node is selected as a cluster head (CH node). Thus, the cluster member nodes are considered as candidates for the job of CH node. CH node collects data packets from the cluster node in a single hop manner, aggregates them into a single datum packet and transmits the datum to the sink node. Overall, two hop data trans mission provides affordable data packet loss rates for boundary nodes with an acceptable end to end delay. Data aggregation compresses the transmitted data. It saves node transmission energy

Multi-Attribute Decision-Making (MADM) Algorithms

MADM algorithms are used to select the best candidate for a specific role, such as a cluster head in a network. These algorithms compare multiple attributes of candidate nodes and rank them based on their suitability. Attributes might include factors like residual energy level and distance from the sink. The node with the most desirable attributes is chosen as the cluster head.

Conventional MADM Approaches

- **Precise Values Required**: Traditional MADM methods need exact values for each attribute, which can be difficult to obtain in real-time environments.
- **Challenges**: Evaluating precise values for each node attribute is tedious and often impractical.

Fuzzy Logic-Based MADM Techniques

- **Handling Uncertainty**: Fuzzy MADM techniques are effective when attribute information is insufficient, missing, or vague.
- **Fuzzy Linguistic Grades**: These techniques convert attribute values into fuzzy linguistic grades (e.g., low, medium, high).
- **Fuzzy Mapping Rules**: Nodes are ranked based on the desirability of their fuzzy attribute grades.
- **Benefits**: Fuzzy MADM approaches can significantly increase network lifetime and ensure a consistent distribution of routing load among nodes compared to conventional MADM techniques.

Application in Wireless Sensor Networks (WSNs)

- **General WSNs**: Most existing fuzzy logic-based routing protocols are designed for general wireless sensor networks.
- **Limitations**: These protocols are not efficient for Wireless Body Area Networks (WBANs).

In summary, MADM algorithms, especially those using fuzzy logic, are crucial for dynamic cluster head selection in networks. They offer a robust solution for environments where precise attribute values are hard to obtain, enhancing network performance and longevity.

MADM Approaches for Cluster Head Selection

FORMULA _ BASED

Classical MADM approaches

▼ **OCER Protocol**:

- **How it works**: Chooses the best node to send data based on its energy, link quality, and distance.

- **Benefit**: Evenly shares the data load.

▼ **iM-SIMPLE Protocol**:

- **How it works**: Picks nodes based on how much energy they have left and how close they are to the end point.
- **Benefit**: Balances the load and adapts to body movements.

▼ **LAEEBA Protocol**:

- **How it works**: Chooses nodes based on a formula involving their energy and distance.
- **CO-LAEEBA**: Uses different paths for urgent vs. regular data, focusing on energy efficiency and fewer hops.

▼ **M-ATTEMPT Protocol**:

- **How it works**: Picks paths with the fewest hops and changes if node temperatures get too high.
- **Drawback**: Doesn't consider how much energy nodes have, which can lead to uneven load.

▼ **Relay-Based Strategy**:

- **How it works**: Uses small relays on the body to send data, choosing the closest relay to save energy.

▼ **Tripe-EEC Protocol**:

- **How it works**: Chooses paths based on the type of data—normal data gets routes with fewer relays and lower temperature rise, while critical data gets the fastest paths.

▼ **Clustering-Based Routing**:

- **EERP Protocol**: Picks cluster leaders based on energy and distance.
- **SIMPLE Protocol**: Chooses the leader with the most energy and closest to the end point.
- **DSCB Protocol**: Uses two end points to improve reliability but can be more expensive.

▼ **AMRP Protocol**:

- **How it works**: Uses special methods to weigh different factors and choose the best node for sending data.
- **Benefit**: Can consider many factors to pick the best option.

Fuzzy MADM approaches

▼ **Fuzzy Logic Basics**:

- **Fuzzy Logic**: A way to handle things that are not black and white, like "high," "medium," or "low" rather than exact numbers. It helps in making decisions when information is uncertain or vague.

▼ **LEACH-ERE Protocol**:

- **How it works**: Chooses cluster heads (CHs) based on their current energy and expected future energy. It turns these energy levels into fuzzy terms like "High," "Medium," and "Low." Nodes with "High" in both categories are picked as CHs.
- **Benefit**: Evenly distributes the data load and makes the network last longer.

▼ **SCHFTL Protocol**:

- **How it works**: Uses a three-level fuzzy system. First, it picks nodes that are good candidates. Then, it chooses the best CHs from these candidates. Finally, it picks a top CH (super cluster head) to oversee the other CHs.
- **Benefit**: Reduces packet loss and makes the network more reliable.

▼ **FBECS Protocol**:

- **How it works**: Uses fuzzy rules to evaluate nodes based on their energy, distance to the sink, and how many neighbors they have. Nodes with high energy, far distance, and many neighbors are prioritized.
- **Benefit**: Balances the load and improves node lifetime.

▼ **Type-1 Fuzzy Sets**:

- **How it works**: Chooses CHs based on trust and distance to the sink. Nodes with high trust and short distance are preferred.
- **Benefit**: Increases network lifetime and reduces overhead.

▼ **FHRP Protocol**:

- **How it works**: Used in farming technology. Critical nodes send data directly to the sink, while normal nodes use a cluster-based approach. Fuzzy logic helps pick CHs and sends data only when necessary.
- **Benefit**: Reduces the number of data transmissions and extends network life.

▼ **FEEC-IIR Protocol**:

- **How it works**: Combines fuzzy logic with other methods to select CHs based on energy, quality of service, and location.
- **Benefit**: Improves network performance and extends its lifetime.

▼ **Fuzzy-TOPSIS Approach**:

- **How it works**: Uses fuzzy logic to select CHs based on energy, number of neighbors, and distance to the sink.
- **Benefit**: Flexible and considers many factors to pick the best node.

▼ **Bilal et al. Approach**:

- **How it works**: Considers five factors (energy, energy usage rate, neighbor density, average distance to neighbors, and distance to the sink) to select CHs.
- **Benefit**: Comprehensive and precise CH selection.

Bio-inspired MADM approaches

▼ **Genetic Algorithm (GA)**:

- **How it works**: GA mimics natural evolution. It starts with a bunch of possible solutions (like sets of nodes). It then tweaks these solutions through processes like mixing and changing them to find the best one.
- **Example**: **GAHN Protocol**: Uses GA to organize nodes into clusters. It reduces the total communication distance, making the network last longer.

▼ **Particle Swarm Optimization (PSO)**:

- **How it works**: PSO is inspired by how birds flock. It tests different possible solutions (like possible relay positions) and updates them based on what's working best.
- **Example**: **PSO-LSMR Protocol**: Finds the best relay nodes for data transmission by considering how much power they use and their position. It helps minimize power consumption but can have issues with static relays.

▼ **Ant Colony Optimization (ACO)**:

- **How it works**: ACO is inspired by how ants find the shortest paths to food. It uses multiple paths to find the best way to route data by evaluating various options.
- **Example**: **CRT2FLACO Protocol**: Combines ACO with fuzzy logic to choose the best cluster heads (CHs). It balances the load and improves network life by considering factors like node energy and distance to the sink.

Project Idea

Cluster Head Selection Simulation
Objective: To create a simulation that selects cluster heads (CHs) using a combination of Fuzzy Logic and Genetic Algorithms (GA) to optimize energy efficiency and network lifetime in a Wireless Body Area Network (WBAN).

Steps to Implement the Project

1. Define Fuzzy Rules
   Objective: Implement fuzzy logic to evaluate nodes based on their attributes (e.g., energy and distance) to determine their suitability as cluster heads.