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A Survey on Fuzzy Logic-Approach & Various Clustering Techniques in Wireless Sensor Network

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***Abstract*— An important application for the Wireless Sensor Network (WSN) involves remote control of the environment and target tracking. This has been made possible by the development of smaller, cheaper, and smart sensors, particularly in recent years. These sensors have wireless interfaces to communicate with each other to form a network. We evaluate latest developments in WSNs in this paper, containing their design constraints and applications as well as lifetime assessment models. Clustering is most common technology of energy efficiency and offers some advantages such as energy efficiency, scalability, lifespan & less time. Because of the execution needs, fuzzy logic (FL) is a good approach; sensor nodes can easily support it while enhancing overall network performance. The research addresses clustering approaches of fuzzy logic, which combine the benefits of localization, scalability, and energy conservation. The WSNs have employed fuzzy logic to enhance decision-making, minimize consumption of resources, also usually improve performance by efficient deployment, collection of clusters and cluster heads, localization, data aggregation, security, routing, etc.**

***Index Terms*— Wireless Sensor Network, Clustering, Fuzzy Logic, Multi-Hop Wireless Networks.**

I. INTRODUCTION

WSN contains autonomous spatially dispersed systems that communicate without wireless communication, collect information, and detect events in physical & environmental conditions that are significant. Each of these devices can be sensed, processed, and communicated simultaneously. These features offer a wide variety of convincing applications on a sensor device. For instance, one of the oldest fields of WSNs application is in environmental monitoring, ranging from animal tracking too hard to access monitoring. Possible application of WSN is also military battlefields, mainly in inaccessible or hostile territory, where WSNs are essential to the identification, surveillance, and detection of snipers, intruders. Also, WSNs deployment may be valuable for enhancing logistics to face the difficulties of managing transported goods, by tracking the containers' temperature, to mention only a few. [1].

The clustering mechanism is a crucial method utilized to extend existence of energy consumption sensor networks. By forming clusters, sensor networks can be scalable Cluster leader is often named CH. A CH can be selected by sensors in clusters or pre-assigned by NW designers. Several clustering algos for scalability and effective communication have specifically been developed for WSN. Cluster-based routing concept is also used for energy-efficient WSN routing. In hierarchical architecture, higher energy nodes (CHs) can be utilized to process, transmit information, as well as low-energy sensing nodes. Some of the clustering algorithms include LEACH, PEGASIS, TEEN & APTEEN. Energy efficiency clustering is the most effective method. In this technique, SNs are grouped into clusters [2].

Various components that serve as a guideline for conception of protocol or a sensor NWs algorithm influence sensor NW design. In several WSN fields, FL has been implemented widely & shown promising results. Energy is an essential element for WSNs because it is one of the key issues of this technology. Life of given network is primarily due to power constraint SNs. Literature studies found that much research has been completed as well as authors have paid careful attention to improvement of these main sensor NW design parameters, which is important for extending existence of whole sensor NW. Effective SNs are main factors for usage and clustering processes in sensor network lifespan and, ultimately, the precise event detection and decision making processes, including the aggregation and routing of data. This study provided special attention to the key architecture factors that are seen to be the most complex aspects of the WSN for the application of fuzzy logic and where positive results and substantial developments have already been accomplished [3].

Energy limitations impact communication methods for single-hop & multi-hop. In multi-hop approach, transmission range & power consumption are smaller. Generally, several factors will determine loss of energy; however, collisions, overheating as well as idle listening are key ones. Typically, model of data transfer is divided into 3 types: event-driven, query-driven & time-driven, respectively. For any node in time-driven model, data is obtained periodically. Nodes report the existence of event in event-driven Models. A request from BS is sent & nodes in query-driven model respond to this request.

II. WIRELESS SENSOR NETWORKS (WSNS)

WSN refers to set of spatially distributed sensors for monitoring & recording environmental physical conditions and centralization of data gathered. WSN measures factors such as temperature, sound, levels of pollution, wind, etc. To transportation sensor data wirelessly, wireless network is enabled by wireless networking and the random creation of networks. The sensor is smaller, more compact, and

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intelligent. WSNs have distributed sensors, for example, temperature, sound, and pressure, for physical or environmental monitoring. The more modern networks are two-way, which also require sensor activity monitoring.

A. TYPES OF WSNS

Types of networks are defined by environment to be underground, land, underwater, etc. WSNs include different types:

1. Terrestrial WSNs

It can contact BSs effectively and include hundreds to thousands of unstructured or structured wireless SNs. In unstructured mode, SNs have altered arbitrarily from target area dropped from fixed plane. Designed or organized mode takes grid placement, optimum placement as well as 2D 3D placement models into consideration.

2. Underground WSNs

More experience, maintenance as well as cost of equipment are underground wireless sensor networks and the planning should be very careful. The WSN networks contain a variety of SNs concealed in ground for purpose of monitoring underground conditions. Further sink nodes are placed over ground to transfer data from SNs to BS.

3. Under Water WSNs

70 percent of the world absorbs water. There are multiple SNs and underwater vehicles in these NWs. Data from certain SNs are obtained with underground vehicles. In underwater communication, a long bandwidth (BW) deletion and sensor failure is an issue.

4. Multimedia WSNs

It has been utilized to monitor & track events in multi-media forms, like images, audio & videos. NWs are made of low-cost microphone and camera SNs. These nodes are interconnected by a wireless data compression & data retrieval connection.

5. Mobile WSNs

Mobile networks include set of sensor nodes, which can be moved as well as interact with physical environment by them. Mobile nodes (MNs) are capable of sensing and communicating computers. The mobile WSN is far easier than static sensor networks.

B. WSNs LAYERS

1. Application Layer

It is responsible for traffic management, as well as offers tools for many applications that change data to meaningful data easily. In various fields such as agriculture, military, environment, and medical applications, sensor networks may be used.

2. Transport Layer

It is precisely needed when system is configured to access additional networks. Providing more energy-efficient robust loss recovery renders TCP less suited for the WSN one of the major reasons.

3. Network Layer

The network layer's main function is routing, with multiple applications-driven tasks, but main function is to maintain the universal ID for resources, buffers, sensors, and partial memory.

4. Data Link Layer

It is responsible to multiplex data frame detection, error control, MAC and data sources, verify point (or) point-multipoint dependency.

5. Physical Layer

It provides a boundary where bits are transmitted through the physical network. This layer has the responsibility for frequency selection, frequency generation, data encryption, signal detection as well as modulation.

C. ADVANTAGE

- WSNs are used where wireless networks cannot be deployed in these cruel and hostile environments.
- WSN is easily deployed.
- WSN is easily operated.
- Improved and better coverage, better channel capacity, and better energy efficiency are WSN's over static WSN.

D. DISADVANTAGES

- Only disadvantages of WSNs are restricted computation & communication resources.
- They have restricted battery power, limited storage, and computation capability, susceptible to attacks on safety and security.
- Have restricted bandwidth to communicate.

E. CHARACTERISTIC OF WIRELESS SENSOR NETWORKS

- Capacity to handle node failures
- Some mobility of nodes and Heterogeneity of nodes
- Power consumption limits for nodes with batteries
- Capability to ensure strict environmental conditions
- Scalability to large scale of distribution
- Cross-layer design
- Easy to use [4].

III. CLUSTERING

Clustering is the partitioning method into a collection of specific subclasses (called clusters) of data (or objects). It allows users to consider the normal structure or classification of a dataset. A good method of clustering can lead to high-quality clusters in which the interclass similarity is high (i.e. intra-cluster) and interclass similarity is low. The accuracy of the clustering outcome also depends on both how the process is identical and how it is implemented. The consistency of a grouping strategy is often calculated by ability to locate any or more hidden patterns. WSN clustering demonstrated considerable energy efficiency by improving NW lifetime, bandwidth, and energy consumption.

A. CLUSTERING TECHNIQUES

1. Hierarchical Clustering

It produces hierarchical decomposition of given set of data objects. It may be classified, depending on nature of hierarchical decomposition, as agglomerative or divisive. A cluster is separated into smaller clusters until finally each object has been separated.

2. Density-based Clustering

Cluster objects dependent on distance between objects several methods of partitioning. These techniques can only locate spherical clusters and are hard to discover arbitrary types of clusters. The notion of density is the basis for other

clustering methods. Clustering based on density requires no one, as opposed to k-means, to show no. of clusters in data priori. It's got notion of noise. This requires only two parameters also is mostly responsive to database order.

3. Grid-based Clustering

Grid-based clustering measure space of object into a small no. of cells representing a structure of a grid. Grid layout carries out all clustering operations. Key benefit is quick processing time, normally depending on no. of data items and no. of cells in each dimension in the quantified space.

4. Model-based Clustering

Assuming a model for each cluster and determining the data that is ideally matched to the given configuration. A model-based algorithm can find clusters by creating a density function that represents the range of data points.

5. Partitioning Method

In this method, a partitioning approach is used to create k partitions of the data in the database of 'n' objects, in which every partition is cluster and k<=n. It classifies data in 'k' classes that satisfy all requirements: at least one object must be in every category, and every object must exactly belong to one group [5].

B. CLUSTER PROPERTIES

Cluster requirements are specified as cluster properties including cluster size, cluster count, inter-cluster, & intra-cluster communication.

1. Cluster count.

No. of clusters produced shall be predefined or may vary depending on necessity of application. In certain instances, cluster number is 5% of overall no. of deployed nodes. No. of clusters varies with random collection of CHs in many applications.

2. Cluster size.

It can be divided into cluster sizes equal to and unequal. It is equivalent across whole network in similar grouping. It is determined by distance from BS for an unequal clustering. While the distance to BS is less and when distance from BS is larger, cluster size becomes smaller.

3. Intra – cluster communication.

It includes b/w CH & node data transfer within the network. Depending on the cluster methods, communication may be direct or multi-hop. Multi-Hop communication is required for large-scale WSN data transmission across community.

4. Inter – cluster communication.

It can be communicating directly or multi-hop. For transmission of energy-efficient data from CHs to BS through large intermediate CHs, Multihop Method is generally suggested. Communication between CH and BS in many small WSN applications is single-hop transmission [6].

IV. Overview of Fuzzy Logic

Fuzzy sets and logic were introduced by L. Zadeh in 1965. Since then, other fields have utilized their features. Information-based systems with system information are represented in Fuzzy rules by various rules of IF-THEN, which contain FL statements (fuzzy rules), namely input and output variables. The capability to combine knowledge of the individual by taking into accounts the lack of accuracy, incertitude, or imprecision is one of the key characteristics of these systems.

A. FUZZY LOGIC IN WSN

FL versatility, which benefits from partial membership before crisp membership or non-membership, made faded logic most effective technique for troubleshooting even in the absence of correct data. FL control consists of fuzzy, Fuzzy Inference Engine (FIE), defuzzifier, as well as fuzzy rules & linguistic variables result is made. Any input parameter is identified with membership function during process of fuzzification, which is then given to FIE. FIE generates output which is further defuzzified to get crisp value by inference mechanisms and fuzzy rules [7].

B. USE OF FUZZY LOGIC IN WSN

Different authors in WSNs utilized FL or fuzzy methods. FL is easy way to reach certain conclusions depending upon ambiguous, vague, noisy, and inconsistent or lack of input information. FL has been utilized in WSNs to enhance decision making, minimize resource consumption, as well as increase performance. Following procedures were carried out using fuzzy logic:

- Determination of the system input and output.
- Transforming numerical input variables to fuzzy.
- Choosing input membership function shape & boundaries.
- Determination & application of suitable rules on input.
- Choosing output membership functions' shape and boundaries.
- Converting fuzzy responses as output to numeric values [3].

V. Multi-hop Wireless Networks

Router is a so-called system used for network routing. When we study routing on multi-hop Wireless networks, efficient, secure routing protocols from current ones become extremely important. Our research aims to protect these wireless protocols on multi-hop networks. We attempted first to solve these protocols with separate routing protocols and numerous security attacks. After addressing attacks on routing protocol, we then defined security steps that could lead to network efficiency.

A. ROUTING IN MULTI-HOP WIRELESS NETWORKS

Utilization of broadcast transmissions is based on opportunistic routing to extend prospective forwarders to enable retransmission of data packets. To prevent repeat transmissions, receptors must be synchronized. This is generally accomplished by choosing those parameters in order of forwarding nodes. Proposed opportunistic routing protocols vary in order and coordination parameters for receptors.

B. ATTACKS ON MULTI-HOP WIRELESS NETWORKS

Wireless multi-hop NWs are commonly accepted also their implementations grow day by day. But, security of these networks is becoming major concern as these networks are broadly deployed. A competitor is a rival in a contest, a confrontation, or a dispute within a clear and general context. In wireless networking, an adversary is a node against or

challenging the network's protection that leads to poor network contact. These security attacks seek to improve the power over the contact between other nodes within NW of these adverse nodes. Adversaries are not physically present; however, by launching regular device attacks they aim at manipulating legitimate nodes.

1. **Route Disruption**

The adversary avoids the discovery of a path between two connected nodes when there is a route interruption. This attack aims primarily to reduce network service efficiency.

2. **Route Diversion**

Route diversion attack contributes to the creation of routes that are specific than those defined by the protocol because of the adversary's interference. The opponent is attempting to ensure that routes diverting monitor connection so that data sent b/w victim nodes may be eavesdropped or changed.

3. **Creation of incorrect routing states.**

In this attack, unsafe & adverse nodes seem secure and state seems right, yet they do not. If data packets are redirected using infected state then this corrupted node will not reach their desired destination.

4. **Generation of extra control traffic**

The purpose of this attack is to inject spoofed control packets into networks. Spoofing is practice for testing someone by manipulating or forging data that has an illegitimate benefit.

5. **Setting up a Gray Hole.**

Gray Hole Attacks (GHA) NW by losing packets randomly and leading nodes. This attack renders data either malicious or useless by dropping all UDP packets when sending TCP packets or by dropping packets with a probabilistic distribution. Gray hole is an attacker node but is right [8].

VI. LITERATURE SURVEY

Lipare et al. [2019] WSN consist of vast no. of wirelessly controlled, limited memory, and battery-powered SNs. Energy efficiency in WSN is also critical. Clustering is a professional network performance management enhancement technique. In every cluster, one of the SNs is known to be CH. Owing to multiple intra-cluster activities, CH loses energy faster. Therefore, adequate CH selection is required for WSN. A fuzzy inference approach is utilized to choose right CH in this function. Fuzzy input variables represent the node distance and capability for the sensor Node while two fuzzy output variables are the "competition radius" and "size." "Competitive radius" is used to describe CHs. The cluster is designed as per values of 'size.' SNs are distributed to their CH at adjacent distance & appropriate CH size. This technique exceeds EAUCF and LEACH algorithms in terms of performance parameters like energy consumption, active process sensor nodes, and network stability [9].

Randhawa et al. [2018] energy efficiency protocols are utilized by WSN to increase energy conservation as well as lifetime of system. Transmission is carried out using nodes in WSN before any physical medium. With VGDRA (Virtual Grid Dynamic Routes Adjustment) concept, we propose an energy-efficient genetically modified approach that improves overall performance of WSNs. Compared with LEACH, because a dynamic approach is not static, proposed method offers better energy efficiency, balanced load and optimization give a better chance of leading to fewer loops that are not possible in additional techniques. MATLAB simulates result of proposed approach [10].

Vinutha et al. [2017] With the integration of various low power, low cost, and compact sensor nodes used for short distance, multi-hop communications, the rapid development and efficient fusion of different technologies, such as wireless networking, Micro Electro Mechanical Systems (MEMS) and Digital electronics have made it probable to evolve idea of sensor networks. Our work improves the transfer of packets by estimating stable resources and near-by nodes in the data transmission path to the destination using the neural network backpropagation algorithm. With simulation results, we have shown the increase in the energy usage of batteries without exchanging the speed of data transmission obtained at low overhead costs.[11]

Benaddy et al. [2017] many wireless sensor network applications are important, like medical, crisis management, military, environment, emergency, transport & security. Such systems include the processing and analysis of accurate information. In this field, researchers have been studying several WSN reliability strategies, like retransmission or redundancy mechanisms or routing protocols, some of which are not for WSN resource constraints like energy consumption. In this article, we suggest multipath WSN routing algorithm for data transmission, about energy usage & distance restrictions [12].

Ahamad, F. et al. [2016] Routing is little more complex than traditional wired or wireless networks with this sort of NW. Protocols utilized for routing other networks of various kinds cannot be used here since nodes in WSN are operated by battery. WSN would also be energy efficient. Whole NW life is based on effective sensor network energy usage. Clustering is technique utilized to efficiently use NW resources. In exchange for volumes, this approach requires additional contact overhead to pick the correct cluster head. This node-to-node transfer requires more energy, which makes energy supplies unreliable. This work offers a method for extending the existence of the WSN using fuzzy rational CH collection, which offers a very impossible method. This method incorporates two fuzzy variables: angle between BS and SNs' residual energy. This strategy employs multi-hop coordination. One CH can also communicate with another CH and BS. The solution for simulation experiments proposed that the WSN network extended its lifetime [13].

Bolourchi et al. [2013] In remote areas are typically the multi-purpose integrated home surveillance security systems. Intelligent decision-making (IDM) is the main element in developing T / R architecture. IDM has simultaneous purpose. First of all, energy conservation is required as device operation is independent depending on solar energy available and accompanying battery reserve. Secondly, is it possible to activate the required actions based on the sensitivity thresholds described above? The present research concentrates on the second target with the pre-defined levels of sensitivity. We consider using WSN to gather information to be used as raw input data in our control system. To

represent IDM potential of network, fire detection has been selected. 5 membership functions such as smoke, temperature, humidity, light, and distance are used to create a Fuzzy logic algorithm. Fire probability simulation results based on the fuzzy rules based on membership status are given in the work [14].

Fei Gao et al. [2013] Two key strategies for enhancing lives of WSNs have been developed in past years. One is to equalize use of energy in networks also other is to increase NW energy efficiency. In this study, authors presented Multi-Hop routing protocol based upon LAR & cross-layer algorithms. Plan considers details on remaining energy of node as well as its distance from next-hop node with numerous equilibrium considerations. Results of study and relaxation indicate that our approach successfully integrates nodes in energy usage and that the loss rate of network packets. Network history has always been longer than LAR [15].

VII. Conclusion

Most of the WSNs are used in real-time. Because of its harsh environment, WSN requires high-security requirements. WSNs need energy-aware and real-time routing, security, and nodes solutions. This paper explains the fundamentals of fuzzy logic and different forms of WSNs using the fuzzy logic concept. Various fuzzy logic applications are mainly listed in WSNs. Clustering is most common energy-efficient process, however, it suffers from a problem with the hot spot and greatly decreases network lifespan. Unfair clustering spread load evenly removed the issue of hot spot and maximized the existence of the network.

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