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Original Article

Comparative Study on Clustering Approach Based Data Routing

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Abstract **-** *Wireless sensor network is wieldy used for IoT applications. The sensor node considers a physical device in IoT architecture. All sensor nodes are operated with a battery, so the power consumption is very high during the data communication and lows while sensing the environment. Without proper planning of data communication, the network might be dead very early, so the primary objective of the cluster-based routing protocol is to enhance the battery life and run the application for a longer time. In this paper, we have comprehensive twenty research papers related to clustering based routing protocol. We have taken basic information, network simulation parameters and performance parameters for the comparison. In particular, we have taken clustering manner, node deployment, scalability, data aggregation, power consumption, and implementation cost many more points for the comparison of all 20 protocols. Along with basic information, we also consider the network simulation parameters like the number of nodes, simulation time, simulator name, initial energy and communication range as well energy consumption, throughput, network lifetime, packet delivery ratio, jitter and fault tolerance parameters about the performance parameters. Finally, we have summarized the technical aspect, and a few common parameters must be fulfilled or considered for the design of an energy-efficient cluster-based routing protocol.*

Keywords **-** *Internet of Things (IoT), wireless sensor networks (WSN), Clustering, Routing protocol, Energy consumption.*

I. INTRODUCTION

A wireless sensor network is one of the most components of any Internet of things application. There are many applications like home automation, healthcare, smart cities, environment/agriculture monitoring and transportation and many more [1].In IoT, the ratio of connected devices per person is about 6.5. The 5 billion smart devices are already connected, and by 2020 about 50 billion devices to be connected [2]. The major role in IoT application is to collect data from the environment. The environment in wsn depends on the IoT application[3]. The wsn contain the various sensor nodes in one network, and all sensor nodes are battery operated. All nodes are deployed in such areas where humans can't easily reach that location. The location might be like water, forest and hazard location. The battery of those sensor nodes has been limited. Once the node energy level has been reaching the low level or might be dead, then the replacement of that node is very difficult. A main key issue of the wsn is energy consumption. Using any technique, we can reduce the power consumption in a network so we can run the network very longer time and achieve longer time reliability.

The need for cluster-based routing protocol is for reducing the energy consumption in the network. Few things can be observed most of the protocols are sensor nodes that have been distributed or deployed randomly throughout the network with the same initial energy level of every node. The base station node location is fixed in a network. After the deployment of the node, they form the group based on the location of the node, and the group is called a cluster. There are depends on the number of nodes for a number of clusters. Every cluster contains the number of nodes that belong to the same categories. Once the cluster formation the next task is to select the cluster head from the member nodes. The most common approach for the election of CH is the highest energy, and the best location can become the cluster head (CH) node. The Cluster head is responsible for the overall communication between the cluster member nodes to a base station. Many types of research also work with double CH nodes in a cluster like one is cluster head and other node act as back up cluster head node. Once the Ch form, the next is to data routing approach to the base station. There are single hope and multi hope communication in a network. The is direct communication between a node with a base station is called single hope communication. In communication, there are a few intermediate nodes is called multi hope communication. Routing is a key component in WSNs. The routing is difficult in wireless sensor networks comparing adhoc networks [6,7]. We consider many parameters like the clustering approach, network simulation parameter and QoS[4] parameters for the comparisons of all existing protocols.

The paper is arranged as follow section II indicate the background theory of the cluster-based routing protocol wsn. Section III discuss a review of 20's research article based clustering based routing protocol. Section IV discusses the comparison of all protocols based on basic information, network simulation parameters and performance parameters. Section Vindicate the conclusion and future scope of the research.

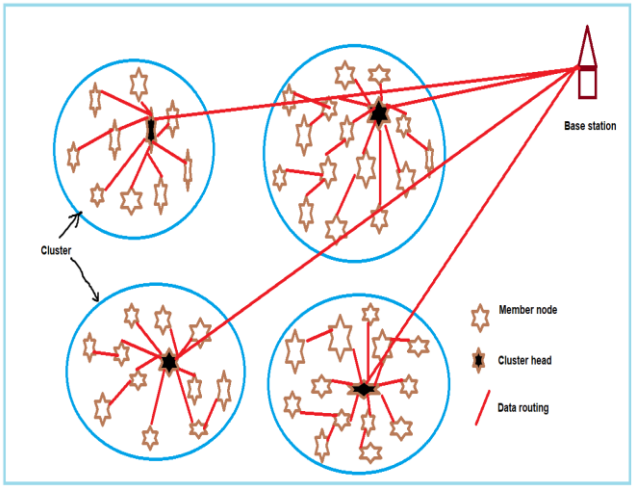

Fig. 1 Clustering-based Routing Protocol

II. BACKGROUND THEORY

Wireless sensor networks consist of the number of sensor nodes along with server or base station nodes. All nodes can deploy in the network randomly. The communication or data transmission between member nodes to the base station required energy. Even sensing the data from the network need some power. So main aim of any cluster-based routing protocol is to require very little energy consumption during the communication. The transmission range of a sensor node can be changed by adjusting the power level of the node[8]. For that, we have to divide any protocol into three different phases Clustering, Cluster head selection, Routing process.

Clustering: The number of nodes deployed in the network randomly. In the initial phase, there is no coordination between the nodes. The clustering process is nothing but a group of sensor nodes, and all sensor nodes are under one umbrella. There are many types of clustering processes like hierarchical, tree-based, grid-based, PSO based and flat clustering. Clustering is a key component of any protocol because we achieve efficiency and reliability[9]. In the cluster, all nodes consider as cluster member nodes and one representative of that cluster is called cluster head. In fig 1, the big circle indicates the group of nodes or clusters. The cluster contains sensor nodes.

Cluster head selection: Once the cluster has been forming, the next step is to select the representative of the cluster. Every cluster has its own CH node. The representative node is selected based on the criteria, and it depends on the protocol. The main criteria for the selection of any cluster head are residual energy and the location of that node. Most of the cased highest energy level node and centred location node can become the cluster head. But in a few protocols, they used fuzzy-based, approximate algorithms, genetic algorithms or bio-inspired techniques for the cluster head selection. The main goal of the CH is to collect the data from the member nodes and transmit it to the base station. In fig. 1, the dark black colour node is cluster head.

Routing: Once the cluster has been forming and CH elected now, the main task of the protocol is data routing to the base station from the cluster member node. Several methods have been proposed for communication in FANET, which typically consists of either proactive or reactive routing mechanisms [5]. There are two types of routing intracluster and inter-cluster routing. Intercluster data routing, the data of anyone sensor node is going to send the data to the cluster head through single-hop or multi-hop is called inter-cluster routing. One CH node can send to the other CH or directly to the base station is called intracluster routing. There are many protocols proposed for data routing only, among them minimum spanning tree, shortest path, genetic algorithm, any colony and mouth flam are famous protocols for routing. In this fig. 1, The data transmitted from the member node to BS via red line is called routing.

III. LITERATURE REVIEW

The review of 20 recent research papers related to clustering based routing protocol in IoT based WSN is listed below.

Padmalayaal.[10] has proposed a protocol based on Fuzzy logic for clustering and with this approach to enhance the network lifetime. Cluster head election is one of the important or key things in cluster-based routing protocols. In this research, CH selection based on the LEACH probability of the highest residual energy level but along with CH there is Super CH(SCH) is collecting the data from the CH and is responsible for transmitting to the base station. This research used a simple method for clustering and two cluster head approach, Data routing in internal and external transmission with single hope communication. For selecting super CH among the CH who is best to send or forward the fuzzy information to the BS like energy level, mobility of BS and cluster central point. It can carry out the work on NS-2 Simulator with few fixed network parameters. As a result, FLCA performs better compared to traditional approach LEACH protocols in reference to network lifetime, No of nodes alive, stability and energy consumption.

Xiaoyongal.[29] has proposed a lightweight and dependable trust system for clustered wireless sensor networks, which can mainly focus on the clustering algorithm. So this approach is proposed based on the node

identification in the network through lightweight trust decision making. Due to high energy consumption for the node to transmit and receive the acknowledgement from the other nodes or CH, This approach removes the acknowledgement as well improve the efficiency while reducing the communication of malicious nodes. Using the enhanced dependability trust-based CH evaluating approach for identification of faulty, selfish and malicious CHs. LDTS was simulated in Netlogo trust simulation software. They also define the role and classification of the node in simulation-based node behaviour. It also evaluates the performance of LDTS based on intra and inter-cluster communication. As a result, they compared the LDTS with GTMS with CM ot CM communication overhead, CH to CH communication overhead, avg storage overhead at each CM and CH. Finally, the simulation result shows that its use has very little memory and communication overhead compared to GTMS.

Leandro al.[11] has proposed a protocol DRINA lightweight and reliable routing. In routing based protocols, energy consumption is a key parameter in WSN. With data fusion and data, aggregation give more advantages for energy saving. In this main protocol, the motive is to reduce data communication in this protocol data aggregated at the intermediate node in a network. It can help reduce network communication and energy consumption. DRINA has three-phased for data aggregation, Phase 1 for building the HoP tree, cluster formation and routing formation and HOP tree updates. DRINA has some key points such as minimizing the number of messages, data routing overlapping, high data aggregated and accurate data transfer between nodes. This protocol has been comparing two different data routing protocols, InFrA and SPT. The DRINA has been compared based on the following points PDR, control overhead, packet loss, data routing cost, loss of raw data and aggregate data. The result shows that DRINA is the best aggregation quality compared to InFRA and SPT.

Rejinaal.[12] has been proposed the swarm optimization based clustering protocol mainly protecting the residual energy of node in a network. The existing optimization protocols do not consider all nodes for the cluster formation and head election. This protocol mainly considers all nodes without left any node in-network for the cluster formation and head election. This node is generally used for the data forwarding the data directly to the base station or sending via multiple hope to increase the network lifetime and reduce the energy consumption of individual nodes. This E-OEERP can eliminate direct communication to BS. It's always through multiple hope. It can achieve through swarm optimizer and gravitational search algorithm used for cluster formation. In the cluster, there is a cluster assistant along with a cluster head, so it reduces the overhead on the cluster head. GSA algorithm finds the best routing path from the cluster head to BS. The result of proposed protocols compared with existing protocols like LEACH, DRINA and BVDCP with energy consumption, throughput, PDR and network lifetime.

Hai al.[13] has been proposed energy-efficient clustering protocol for large scale wsn network. He believed the clustering based protocol is the best selection for the energy-efficient in wsn. In this research, he proposed FCS (fan-shaped clustering) to partition a large scale network. This paper identifies the key points that are clustering, cluster head election, Re-clustering, and relay routing and hotspot issues. Fan-shaped clustering, the nodes are uniformly deployed. For the entire node, the data transmission rate is fixed. For the cluster head selection, they only consider the central node only. Intra-cluster communication can be reduced to this strategy. Re-clustering did when there is no node in a central area or capable. In routing, data is sent to the neighbour node, and the neighbour node is sent to the BS. The performance analysis of FCS can be compared with HEED. It gives good results compared to HEED based on energy consumption and packet delivery ratio.

Yuan al.[14] has proposed the hierarchical clustering protocol for wsn using the particle swarm optimization method. This protocol considers all the parameters like energy consumption, data transmission distance and the intermediate node for routing. The approach of the protocols is simple CH is responsible for collecting data from the cluster member or relay nodes, and CH forwarded the same data to BS. The nodes deployed in the network randomly. The CH selection from the cluster is based on the highest residual energy and node location. PSO help to data efficiently transmission between nodes. The protocol is simulated in MATLAB. The protocol is compared with a traditional approach like LEACH, LECP-CP, HEED and Hausdorff with a number of nodes alive and network lifetime. The simulation results showed good results comparatively traditional protocols.

Subramanian al.[15] has been proposed SNR based dynamic clustering technique for routing protocol for wsn. The proposed protocol ESRPSDC has been combining the clustering formation, CH Selection and intra and inter-cluster data routing. For cluster head selection, simply check the node energy level must be above the threshold value and select the node with the highest energy level from the cluster. For the backup or next CH election, we also consider the second-highest energy node as Next CH. Suppose the node energy is less than the threshold level than its used SNR value-based CH selection. CH initiated or collected data from the members through TDMA. All data received from the member's node CH perform the data aggregation function, and later it is forwarded to a base station. For simulation performed on GloMOSim global mobile simulator 2.03 version. Comparison based on PDR, end to end delay versus a number of packet load and network size with traditional protocols like LEACG, RPSDC and PEGASIS.

Wenboal.[16] has been proposed E2HRC Energy-efficient heterogeneous ring clustering based routing protocol. This protocol is based on ring topology for communication. In-network used node location is fixed all the members and BS. In this process, only one cluster has been formed during the network operation. Energy consumption of the head node is greater than normal member nodes. Cluster head selection process based on highest residual energy. Once head node energy has been reducing the threshold, then event trigger and elects a new cluster head. Based on RFC and RPL used for the message communication in clustering. The simulation result has been compared with traditional approaches like RPL based on energy consumption and the number of the node control message.

Trupti al.[17] has been introduced residual energy based cluster head election process in a wireless sensor network for IoT application. All sensor has been deployed at a different location in-network, so the replacement of a dead sensor is a very tedious task. Cluster formation and cluster head selection can help to prevent the energy in communication and sensing. In this research, they focus on the selection process of cluster head based on the highest residual energy and rotation of CH among the network. For the cluster head selection, consider the initial energy, residual energy and best value of CH for the next level of CH. The protocol simulated in MATLAB and simulation result performance better than LEACH throughput by 60% in a lifetime by 66% and energy level by 64%.

Yunquanal.[18} has been proposed the DEARER protocol based on distance and energy reservation and harvesting for wsn. This protocol motive to select the best cluster head from the cluster member nodes and server longer time in clustering. DRARER protocol selects the node with the highest residual energy and nearest to the base station for the CH Selection. If it's near to BS, so communication cost for transmission is very low compared to other techniques. Also, the protocol provides the facilities for the non-CH node to prevent their residual energy for future use. The comparison based on the theoretical analysis and numerical experiments suggests that the DRARER protocol is outperformed compared to other traditional protocols.

Hassan al.[19] has been proposed Enhanced clustering hierarchical approach for wsn. This algorithm has been improved the energy efficiency in a network through the hierarchical process. For the cluster formation, they used a hierarchical approach and data transmission done through the highest energy node in a network. In this paper, they consider the collection of redundant data collected from the adjacent node as well overlapping to each other. They used sleeping and walking mechanisms for the data collection from the network with this approach, they can minimize the redundant data from the node and improve the network lifetime. The difference between previous literature and ECH is In all previous papers they consider all the nodes can collect and transmit the data but In ECH only waking nodes can do the process. Simulation results suggest that the ECH has been far better than LEACH, TEEN, SEP and DEECwith energy consumption, network load, and packets received.

Jain al.[20] has been proposed EECRP Energy-efficient centroid based routing protocol for wsn assisted ioT network. The node deployment in-network is randomly distributed over the network. The location of every node is available when deployed. Every node knows the position of every node as well as the BS node in a network. For the clustering process, they perform the three-step process like Initialization, cluster head selection and rotation or re-structuring. In the initialization phase, every node sent its location message to BS. The format contains message type, sender ID, X, Y coordinate and energy level. The CH selection is based on the highest energy level from the cluster. Once it identifies the CH, then it broadcasts the message to every node and BS about the information of CH in a network. For the rotation phase, all member nodes send the information about location and energy level to CH, and CH calculates the centroid of the cluster based on the centroid next nearest to it elected as CH. The simulation result shows the EECRP outperform traditional protocol like LEACH, LEACH-C and GEEC based on the quality of service parameters.

Fakhri al.[21] has been developed AZ-SEP hybrid and multi-hop zonal based election protocol for wsn. The protocol is mostly proposed for heterogeneous routing. Its advanced version of Z-SEP mostly focuses on reducing the transmission cost from cluster head to base station. In this protocol, sensor networks divide in zonal form rather than cluster. Every zone defines the small group of sensor nodes is called zonal clustering. Among the cluster highest residual energy, threshold value and centre location node become the CH. It directly communicates to the base station. MATLAB 14a tools were used for the simulation. The result suggests the AZ-SEP perform very good compared to Z-SEP and SEP with the Number of alive nodes, Energy consumption and PDR in different conditions like BS changing their position, node are skewed, and node changing energy level.

Seyyital.[22] has been proposed fuzzy logic based two-tier distributed and efficient data aggregation multi-hop routing protocol for wsn. The clustering member node transmits the data to the CH node, and the CH node relays the packets to a base station through a multi hope communication way. Due to multi-hop communication terminology, hotspots issues and energy hole problems may arise. TTDFP used two-tier, In first-tier fuzzy clustering algorithm used for the cluster head selection to maximize network efficiency and second-tier used for best routing path identification from CH to BS. Performance evaluation of TTDFP compared with traditional approach LEACH, CHEF,

EEUC, MOFCA-original and MOFCA-Optimized in two different scenario fuzzy clustering and routing cases. For the simulation, used MATLAB or Castalia platform and deployed 1000X1000 m area with randomly deployed. The comparison with the existing protocol is based on the Number of nodes alive, fuzzy computation, remaining energy and avg link remaining energy.

Quan al.[23] has been proposed EECSR energy-efficient compressive sensing based clustering routing protocol. The protocol is a combination of clustering strategy and compressive sensing based scheme. The cluster formation used a simple approach in optimal cluster formation. In this protocol, additional backup CH along with CH. They do a rotation in CH and BCH intern by tern and preserve the energy of the cluster node. The simulation result suggested outperforming EECSR compared to existing clustering-based and CS-based algorithms like LEACH, TEEEN, PEGASIS, CDG and HCDG in terms of energy efficiency and network lifetime.

Muhammad al.[24] has been introduced QoS aware based routing protocol (QERP) for underwater wsn network. Data reliability is the biggest challenge of underwater wsn. All the sensor nodes are deployed randomly in a network. So the capacity of all nodes for data transmission and energy level is the same. Node directly communicates to the Sink node at the sea surface. There are seven steps procedure for the routing starting initialization, cluster formation, parent node selection, crossover, mutation and fitness function. The performance of QERP was measured and simulated in MATLAB 7.0 platform with some static parameters. QERP achieves outperform in terms of the following parameters like Packet delivery ratio, energy consumption and end to end delay.

Jenn al.[25] has been proposed fault-tolerant routing protocol based on Bipartite flow graph modelling. In IoT, application wsn is a key component because sensor nodes are deployed in the network for collecting information or interesting data. Cluster-based routing is a very efficient way for data transmission. In this routing mechanism, cluster formation generally makes a group of nodes for smooth communication. The cluster head is responsible for the data packet forward to the base station. So if any node might be dead or CH failed due to energy level reaching to 0 level so how to forward network data to the BS. In this protocol, they have created a virtual CH for the backup plan. In a cluster, any CH might be failed to send data to BS, then virtual CH act as the main CH and forward the data to BS and create a smooth communication. The performance of the protocol is excellent compared with existing fault tolerance protocols.

Ali al.[26] has been proposed a Bio-inspired clustering scheme for FANET (BICSF). In-network energy consumption or limited battery and node mobility is a key issue for routing. If node moving in-network so every time we have to create a re-clustering approach for cluster formation and CH election process also do same. BICSF protocol can minimize this issue with the help of properly cluster formation and a hybrid combination of GSO and KH mechanisms for routing. GSO algorithm also helps for the cluster head selection. Using the krill herd behaviour for the cluster management. For the data, the transmission uses a genetic approach like path detection from one node to another or CH based on energy level and distance between nodes. The BICSF performance is higher compared with grey wolf optimizer and ANT colony clustering algorithm with cluster building time, quality of service parameters like energy consumption, network/cluster lifetime and packet delivery ratio.

Mahdi al.[27] has been proposed energy-efficient cluster-based routing protocol based on centralized clustering approach and grey wolf optimizer. For the clustering-based routing hierarchical approach. With this approach, it can divide the cluster into two-part for better communication. Grey wolf optimizer is used for the best cluster head selection from the cluster nodes. The GWO is behaviours based intelligent characteristic based algorithm for the CH selection. Along with GWO, it also uses two different points like the energy level of nodes and energy consumption for transmission. For routing, it also depends on the distance between a node to CH and CH to BS. If the distance is less than they communicate in single-hop or distance is far than multi-hop communication for data transmission. The protocol performs excellent results compared with the existing traditional bio-inspired based routing algorithm based on energy consumption and network lifetime.

Trupti al.[28] has been proposed I-SEP improved routing protocol for a heteronomous network for environmental IoT application. This research is an extended version of the existing protocol stable election protocol(SEP). In this protocol, nodes are deployed randomly throughout the network. The cluster head selection is mainly addressed in this paper. Cluster head selection is based on the highest energy level with above fix threshold level along with the centroid location of the cluster. The threshold value decides the network communication through the same CH node or might need re clustering process. If the residual energy value is less than a threshold level, then this node is always a member node. Due to this need extra energy for the cluster formation and new CH broadcasting message to member node. The simulation was carried out in MATLAB platform with 100 sensor nodes. The performance of I-SEP compared with an existing traditional protocol like SEP and DEEC with different parameters like throughput network lifetime with a different threshold level.

IV. COMPARISONS

In this paper, we have taken an analysis of 20 different clustering based routing protocols for the wsn network. For the comparison, we consider the major categories like basic

protocol information, network simulation parameters and performance parameters of all 20's protocols. In the clustering based routing protocol, the initial step is forming the cluster, so in every protocol, they used a different approach to clustering. Once cluster forms, we have to elect one of the responsible nodes in the cluster is, called cluster head. There are many strategies for selecting the cluster head, and the last step is routing in inner and outer clusters. Inner cluster, the member node can send data directly or via intermediate node to the cluster head, and the cluster head can aggregate the data from all members and send it to the base station. There is a number of approaches for inter and intracluster data routing in an efficient manner.

In table 1, we have a comparison of all 20 protocols based on basic information.

- Cluster types: The protocols used which types of a cluster for grouping the sensor nodes.
- Cluster manner: Cluster types belong to which categories of clustering like hierarchical, Flat or tree-based.

Table 1. Comparison of protocol vs basic information

Sr No	Protocol Name	Cluster type	Cluster manner	Node Mobility	Data aggregation	Power consumption	Scalability	BS fixed /mobile	Load balancing	Complexity	Hardware implemented	Implementation cost
1	FLCA[10]	Simple	Fuzzy	Fixed	Yes	Moderate	Yes	Fixed	No	Moderate	No	Low
2	LDTS[29]	LDTS	Simple	Fixed	Yes	Less	Yes	Fixed	No	Low	No	Low
3	DRINA[11]	Tree	Hierarchical	Fixed	Yes	Moderate	No	Fixed	Yes	Moderate	No	Medium
4	EOEERP[12]	PSO	Simple	Fixed	Yes	Moderate	Yes	Fixed	No	Low	No	Low
5	FSC[13]	FCS	Fan shaped	Mobile	Yes	Less	Yes	Fixed	NO	Moderate	NO	Low
6	CHIPSO[14]	Simple	Simple	Fixed	Yes	Less	Yes	Fixed	Yes	Less	No	Medium
7	ESRPSDC[15]	SNR	Dynamic	Fixed	Yes	High	Yes	Fixed	No	Moderate	Yes	High
8	E2HRC[16]	Simple	Ring formation	Mobile	Yes	Low	Yes	Mobile	No	Low	No	Low
9	RECHS[17]	Simple	Hierarchical	Fixed	Yes	Low	No	Fixed	No	Low	No	Low
10	DEARER[18]	Simple	Hierarchical	Fixed	Yes	Moderate	Yes	Fixed	No	Low	No	Low
11	ECH[19]	ECH	Hierarchical	Fixed	Yes	Moderate	Yes	Fixed	Yes	Moderate	No	Medium
12	EECRP[20]	Simple	Dynamic	Fixed	Yes	Low	Yes	Fixed	No	Low	No	Low
13	AZ-SEP[21]	Zone	Zonal	Fixed	Yes	Moderate	Yes	Fixed	No	High	No	Low
14	TTDFP[22]	Simple	Fuzzy	Fixed	Yes	Low	Yes	Fixed	Yes	Moderate	No	Low
15	EECSR[23]	Simple	Sensing based	Fixed	Yes	High	No	Fixed	Yes	Low	No	Medium
16	QERP[24]	Simple	Hierarchical	Fixed	Yes	Low	No	Fixed	No	Low	Yes	High
17	VCHFBG[25]	Simple	Hierarchical	Fixed	Yes	Moderate	Yes	Fixed	Yes	Low	No	Low
18	BICSF[26]	GSO	Location	Fixed	Yes	Moderate	Yes	Fixed	No	Moderate	No	Low
19	E2RGWO[27]	Simple	Flat	Fixed	Yes	Low	Yes	Fixed	No	Low	No	Low
20	I-SEP[28]	Simple	Hierarchical	Fixed	Yes	Moderate	Yes	Fixed	Yes	Low	No	Low

- Node mobility: The sensor nodes can be moved in-network or not. If it's not moving, that means its fixed mobility or moving nodes is called a mobile node.
- Data aggregation: The protocol can be aggregate the data as well as pre-process the data or not. The value yes indicate its support the aggregation, and no means they do not support it.
- Power consumption: The protocol can consume the energy for running the network. So we have classified the level as high, moderate and low based on the consumption
- Scalability: The protocol can be expanded or scaled for large. The value yes indicates we can extend up to a certain level, and no means we can't get scalable the network.
- BS fixed/mobile: The base station node can be movable or fixed at one location.
- Load balancing: The protocol can balance the load in the network or not.
- Complexity: The complexity level of the protocol.
- Hardware implementation: The protocol can be implemented in any real application or not.
- Implementation cost: The calculation of the simulation as well hardware implementation cost of the protocol.

We also consider the network simulator parameters for the comparison of all protocols. These all parameters are considered for the simulation environment only. In table 2, we have a comparison of all 20 protocols based on simulation parameters.

- No of nodes: The protocols simulated in any simulator at the same time they deployed a number of nodes in a network.
- Simulation time: The protocol takes some time for the one cycle of simulation is called simulation time.
- Area: The network can be deployed in a certain location with an area is called a network area.
- Simulator: The protocol that can be implemented or simulated in the platform is called a simulator. In wsn, MATLAB and Ns2 both are popular simulators.
- Node placement: In-network, the node can be placed randomly or fixed location.
- Initial node energy: The energy level at the time of node deployment in-network is called initial energy.
- EC per bit(Eelec): In-network, The cost of one node communicating to the other nodes is called EC per bit.
- Energy for Data aggregation: The protocol can consume the energy for the data aggregation or not.
- Transmission range: The protocol that can transmit the data in some range is called transmission range.
- Datagram Length: The maximum length of a packet transmitted from one node to another node is called datagram length or message length.

Table 2. Comparison Based on Protocol Vs Network Simulation Parameters

Sr No	Protocol Name	Network simulation parameters									
		No. of nodes	**Simulation time**	**Area**	**Simulator**	**Node placement**	**Initial node energy**	**EC per bit(E_{elec}) (nj/bit)**	**Energy for Data aggregation**	**Transmission range(m)/ Rate(kbps)**	**Datagram length**
1	FLCA[10]	40	2000s	100x100	NS-2	Random	2J	50	Yes	50 m	500 bytes
2	LDTS[29]	160-1800	1000s	100x100	Netlogo	Random	5J	56	Yes	100 m	650 bytes
3	DRINA[11]	1024	3	700x700	SingalGo	Random	2J	50	Yes	80 m	425 bytes
4	EOEERP[12]	100	30	200x200	Ns2	Random	200J	40	Yes	36m/409kbps	512 bytes
5	FSC[13]	3000	600s	700m	MATLAB	Random	2J	0.2J	Yes	150m	2000 bit
6	CHIPSO[14]	500	20	100x100	MATLAB	Random	2J	50	Yes	75m	512 bytes
7	ESRPSDC[15]	500	600	1000x1000	Glomosim	Random	0.5J	0.25j	Yes	75m	70 bytes
8	E2HRC[16]	120	3600	500x500	Cooja	Random	2j	50	Yes	50	1000 bytes
9	RECHS[17]	100	80	100 x 1000	MATLAB	Random	0.5J	0.13J	Yes	100 m	4000 bits

10	DEARER[18]	400	100	500 x 500	Ns2	Random	2J	50	-	75 m	512 bytes
11	ECH[19]	100	80	100 x 100	MATLAB	Random	5K	50	Yes	10 m	3000 bytes
12	EECRP[20]	100	100	100 x 100	Ns2	Random	2	50	Yes	150 m	500 bit
13	AZ-SEP[21]	100	300	150 x 150	MATLAB	Random	5J	0.8J	Yes	300 m	512 bytes
14	TTDFP[22]	100	60	1000 x 1000	MATLAB	Random	2J	50	Yes	100 m	4000 bits
15	EECSR[23]	100-400	200	100 x 100	MATLAB	Random	5J	0.25j	Yes	75m	512 bytes
16	QERP[24]	350	300	1000 x 1000	MATLAB	Random	3.5J	0.4J	Yes	50m	1024
17	VCHFBG[25]	1000	100	100 x 100	MATLAB	Random	10 J	50	Yes	50m	500 bytes
18	BICSF[26]	35	120	1500 x 1500	MATLAB	Random	2J	50	Yes	Dynamic	1000
19	E2RGWO[27]	100	100	200 x 200	C++	Random	0.5J	50	Yes	87m	4000 bits
20	I-SEP[28]	100	60	100 x 100	MATLAB	Random	0.13	50	Yes	87m	4000bits

Table 3. Comparison Based on Protocol Vs Performance Parameters

Sr no	Protocol Name	Year	Clustering approach	CH selection approach	Routing	Performance parameters							
						E	T	N	P	B	J	D	F
1	FLCA[10]	2016	Simple	Fuzzy based SCH	Single hop	Y	-	Y	-	-	-	Y	-
2	LDTS[29]	2013	The lightweight, dependable trust system	Residual energy	Multi-hop	Y	Y	Y	-	-	-	Y	Y
3	DRINA[11]	2013	Tree-based	Residual Energy, location	Shortest path tree	Y	Y	Y	Y	Y	-	-	-
4	EOEERP[12]	2015	PSO	PSO,GSA	Single	Y	Y	Y	Y	Y	-	-	-
5	FSC[13]	2015	Fan-shaped	Highest energy	Single-hop	Y	-	Y	Y	-	-	Y	-
6	CHIPSO[14]	2017	Simple	Location, higher residual energy	Multi-hop	Y	Y	Y	Y	-	-	-	-
7	ESRPSDC[15]	2013	SNR dynamic	Residual energy	Multi-hop	Y	Y	Y	-	-	-	Y	-
8	E2HRC[16]	2017	Ring based formation	Event driven	Multi-hop	Y	Y	Y	Y	-	-	Y	-
9	RECHS[17]	2019	Hierarchical	Residual energy, centroid location	Multi-hop	Y	Y	Y	-	Y	Y	Y	-
10	DEARER[18]	2016	Hierarchical	Highest energy	Multi-Hop	Y	Y	Y	Y	-	-	-	-
11	ECH[19]	2019	Hierarchical	Higher energy	Single hop	Y	Y	Y	Y	-	-	Y	Y
12	EECRP[20]	2017	Dynamic	Centroid , Highest energy	Multi-hop	Y	Y	Y	-	Y	Y	-	-
13	AZ-SEP[21]	2019	Zonal	Highest energy	Multi-hop	Y	Y	Y	-	-	-	-	-

14	TTDFP[22]	2018	Fuzzy based	Residual energy	Multi-hop	Y	Y	Y	Y	-	-	-	-
15	EECSR[23]	2019	Sensing	Residual energy CH,BCH	Single hop	Y	-	Y	Y	-	-	Y	-
16	QERP[24]	2018	Hierarchical	Location and Energy	Multi-hop	Y	Y	Y	Y	Y	-	Y	Y
17	VCHFBG[25]	2019	Hierarchical	Flow graph	Single hop	Y	Y	Y	-	-	-	Y	Y
18	BICSF[26]	2019	GSO	GSO and KH	Path detection	Y	Y	Y	Y	-	-	-	-
19	E2RGWO[27]	2019	Flat	GWO and residual energy	Single hop	Y	Y	Y	-	-	-	-	-
20	I-SEP[28]	2020	Hierarchical	Stable election	Multi-hop	Y	Y	Y	Y	-	-	-	-

*CH: Cluster head, E: Energy consumption, T: Throughput, N: Network lifetime, P: Packet delivery ratio, B: Bit error rateJ: Jitter, D: Delay, F: Fault tolerance

In table 3, we have a comparison based on the performance parameters along with information about the clustering types, cluster head selection approach and routing. The performance of any protocol can be measured with a few parameters like energy consumption, throughput, network lifetime, packet delivery ratio, error bit rate, jitter, packet delay and fault tolerance.

- Energy consumption: The node consumes the energy during the sensing and communication, or transmission of the data to the BS is called the energy consumption of that node.
- Throughput: The number of packets successfully transmitted to the destination is called throughput.
- Network lifetime: The number of rounds successfully completed from the network has to start.
- Packet delivery ratio: The ratio of the number of packets delivered to the destination and transmitted from the source node.
- Bit error rate: The ratio of the number of wrong bits delivered over the network.
- Jitter: The variation of delay at the packet receiving side is called jitter.
- Delay: The difference between a packet that has been sent from the source and is received at a destination is called packet delayed.
- Fault tolerance: The protocol can work continuously throughout the network even some node is dead.

V. CONCLUSION

A wireless sensor network is applicable in a variety of domains like healthcare, automation, manufacturing unit and military surveillance and many more applications. The main aim of this application is to fulfil by robust, energy-efficient and reliable protocol. In this paper, we have addressed a variety of twenty different protocols with their many different parameters based on basic information, network simulation and performance parameters. We have concluded the following points from all 20 papers and their comparison parameters.

1. In the network, the Node deployment is random in all protocols.
2. The base station location is fixed in every research article.
3. 70% of Research has been carried out in hierarchical clustering formation.
4. All the protocols provide the data aggregation and scalability feature.
5. Very few less than 8% of papers have implemented their protocol in a real-time scenario.
6. The number of nodes varies from 100 to 1000 nodes in a network.
7. Maximum protocols have been simulated in MATLAB and NS2 simulators.
8. Transmission range and message length are different in every protocol.

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