Review on Energy Efficient Clustering based Routing Protocol

Kanu Patel[1], Dr. Hardik Modi[2]

[1]Research scholar, Computer Engineering Department, CHARUSAT University, Changa, Gujarat,
[2]Assistant Professor, Electronic and Communication Department, CHARUSAT University, Changa, Gujarat,

Abstract
Wireless sensor network is wieldy use for IoT application. The sensor node consider as physical device in IoT architecture. This all sensor node are operated with battery so the power consumption is very high during the data communication and low during the sensing the environment. Without proper planning of data communication the network might be dead very early so primary objective of the cluster based routing protocol is to enhance the battery life and run the application for longer time. In this paper we have comprehensive of twenty research paper related with 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 protocol. Along with basic information we also consider the network simulation parameters like number of nodes, simulation time, simulator name, initial energy and communication range as well energy consumption, throughput, network lifetime, packet delivery ration, jitter and fault tolerance parameters about the performance parameters. Finally we have summarize the technical aspect and few common parameter must be fulfill or consider for the design energy efficient cluster based routing protocol.

Keyword:
Internet of Things (IoT), wireless sensor networks (WSN), Clustering, Routing protocol, Energy consumption

I. INTRODUCTION:

Wireless sensor network is one of the most components of any Internet of things applications. 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 device 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]. Major role in IoT application is to collect the data from the environment. The environment in wsn is depending on the IoT application[3]. The wsn contain the various sensor nodes in one network and all sensors nodes are battery operated. The all nodes deployed in such area where human can't easily reach to 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 reach to the low level or might be dead then the replacement of that node is very difficult. Main key issue of the wsn is energy consumption. Using any technique we can reduce the power consumption in network so we can run the network very longer time and achieve the longer time reliability.

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

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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 about review of 20's research article based clustering based routing protocol. In section IV discuss about the comparison of all protocols based on basic information, network simulation parameters and performance parameters. In section V indicate the conclusion and future scope of the research.

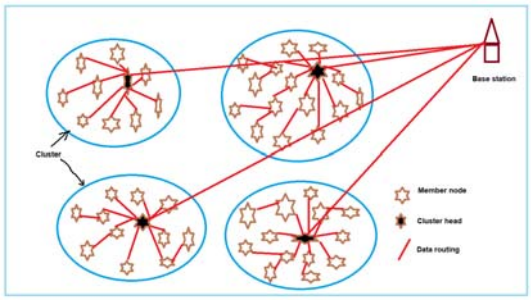

Fig 1 Clustering based routing protocol

II. BACKGROUND THEORY

In wireless sensor network consist the numbers of sensor nodes along with server or base station node. The all nodes can deploy in network randomly. The communication or data transmission between member node to base station required the energy. Even for sensing the data from the network need some power. So main aim of the any cluster based routing protocol is required very less 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 in three different phases like Clustering, Cluster head selection, Routing process.

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

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

Routing: Once the cluster has been form 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 one intra cluster and inter cluster routing. Inter cluster data routing, the data of any one sensor nodes 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 intra cluster routing. There are many protocol proposed for data routing only among them minimum spanning tree, shortest path, genetic algorithm, any colony and mouth flam are famous protocol 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 are 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 highest residual energy level but along with CH there is Super CH(SCH) is collecting

the data from the CH and responsible for transmitting to the base station. This research used 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 carried out the work on NS-2 Simulator with few fixed network parameters. As a result of FLCA performs the better compared to traditional approach LEACH protocols in reference of network lifetime, No of nodes alive, stability and energy consumption.

Xiaoyongal.[29] has proposed the lightweight and dependable trust system for clustered wireless sensor networks which can mainly focus on clustering algorithm. So this approach proposed based on the node identification in network through lightweight trust decision making. Due to high energy consumption for the node transmit and receive the acknowledgement from the other nodes or CH, This approach remove the acknowledgment as well improve the efficiency while reducing the communication malicious nodes. Using the dependability enhanced 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 simulate based on node behavior. Its also evaluate the performance of LDTS based on intra and inter cluster communication. As the 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 simulation result shows that its use very less 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 key parameter in WSN, With data fusion and data aggregation give more advantage for energy saving. In this protocol main motive is to reduce the data communication. In this protocol data aggregated at the intermediate node in network. It can help the reduce the 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 minimize the number of messages, data routing overlapping, high data aggregate and accurate data transfer between nodes. This protocols has been compare two different data routing protocols InFrA and SPT. The DRINA has been compared based on following points PDR, control overhead, packet loss, data routing cost, loss of raw data and aggregate data. The result shows the DRINA is best aggregation quality compared to InFRA and SPT.

Rejina al.[12] has been proposed the swarm optimization based clustering protocol mainly protecting the residual energy of node in network. In the existing optimization protocols do not consider the all nodes for the cluster formation and head election. This protocol mainly consider all nodes without left any node in network for the cluster formation and head election. This node generally use for the data forwarding the data directly to the base station or send via multiple hope to increase the network lifetime and reduce the energy consumption of individual node. This E-OEERP can be eliminate the direct communication to BS its always through multiple hope, it can achieved through swarm optimizer and gravitational search algorithm used for cluster formation. In the cluster there is cluster assistant along with cluster head so its reduce the overhead on cluster head. GSA algorithm find the best routing path from the cluster head to BS, The result of proposed protocols compare withexisting 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 best selection for the energy efficient in wsn. In this research, he proposed FCS (fan shaped clustering) to partition a large scale network. In this paper it's identify the key points are clustering, cluster head election, Re-clustering, and relay routing and hotspot issues. Fan shaped clustering the nodes are uniformly deployment. The entire node the data transmission rate is fixing, for the cluster head selection they only consider the central node only. Intra-cluster communication can be reduce this strategy, Re-clustering only done when there is no node in central area or capable. In routing data sent to the neighbor node

and neighbor node sent to the BS. The performance analysis of FCS can be compared with HEED. It's give good result compare to HEED based on energy consumption and packet delivery ratio.

Yuan al.[14] has proposed the clustering hierarchical protocol for wsn using particle swarm optimization method. This protocol considers all the parameters like energy consumption, data transmission distance and no of 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 network randomly. The CH selection from the cluster 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 traditional approach like LEACH, LECP-CP,HEED and Hausdorff with number of node alive and network lifetime. The simulation results showed good result 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 combine 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 highest energy level from the cluster. For the back up or next CH election we also consider second highest energy node as Next CH. If the node energy 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 members node CH perform the data aggregation function and later it forward it to base station. For simulation perform on GloMOSim global mobile simulator 2.03 version. Comparison based on PDR, end to end delay versus 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 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 form 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 reduce the threshold than event trigger and elect new cluster head. Based on RFC and RPL used for the message communication in clustering. The simulation result has been compare withtraditional approach like RPL based on energy consumption and number of node control message.

Trupti al.[17] has been introduce residual energy based cluster head election process in wireless sensor network for IoT application. All sensor has been deployed at different location in network so the replacement of dead sensor is very tedious task. Cluster formation and cluster head select 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 next level of CH. The protocol simulate in MATLAB and simulation result performance better than LEACH throughput by 60% in lifetime by 66% and energy level by 64%.

Yunquanal.[18} has been proposed 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 select the node with highest residual energy and nearest to the base station for the CH Selection. If its near to BS so communication cost for transmission is very low compare to other technique. Also the protocol provide the facilities for the non-CH node to prevent their residual energy for the future use. For the comparison based on the theoretical analysis and numerical experiments suggest that DRARER protocol is outperforms compare to other traditional protocol.

Hassan al.[19] has been proposed Enhanced clustering hierarchical approach for wsn. This algorithm has been improved the energy efficiency in network through the hierarchical process. For the cluster formation they used hierarchical approach and data transmission done through highest energy node in 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 mechanism 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 all literature and ECH is In all previous paper they consider all the node can collect and transmitted the data but In ECH only waking nodes can do the process. Simulation result suggest that the ECH has been far batter 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 randomly distributed over the network. The location about every node is available when they deployed. Every node know the position of every node as well BS node in network. For the clustering process they perform the three step process like Initialization, cluster head selection and rotation or re-structuring. In initialization phase every node sent their location message to BS. The format contain message type, sender ID, X,Y coordinate and energy level. For the CH selection is based on highest energy level form the cluster. Once it identify the CH then it broadcast the message to every node and BS about the information of CH in network. For the rotation phase all member node send the information about location and energy level to CH and CH calculate the centroid of cluster based on centroid next nearest to it elected as CH. The simulation result shows the EECRP outperform than traditional protocol like LEACH, LEACH-C and GEEC based on quality of service parameters.

Fakhri al.[21] has been developed AZ-SEP hybrid and multi hop zonal based election protocol for wsn. The protocol mostly proposed for the heterogeneous routing. Its advance version of Z-SEP which mostly focus on reduce the transmission cost from cluster head to base station. In this protocol sensor network divide in zonal form rather cluster. Every zone define the small group of sensor node is called zonal clustering. Among the cluster highest residual energy, threshold value and center location node become the CH. It directly communicate to the base station. MATLAB 14a tools used for the simulation. The result suggest the AZ-SEP perform very good compare to Z-SEP and SEP with 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. In the clustering member node transmit the data to the CH node and CH node relay the packets to base station through multi hope communication way. Due to multi hop communication terminology hotspots issue 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 evaluate 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 existing protocol based on Number of node 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 combination of clustering strategy and compressive sensing based scheme. In the cluster formation used simple approach in optimal cluster formation. In this protocol additional backup CH along with CH. They do rotation in CH and BCH in tern by tern and preserve the energy of cluster node. The simulation result suggested outperform EECSR compare to existing clustering based and CS based algorithm like LEACH, TEEEN, PEGASIS, CDG and HCDG in term of energy efficiency and network lifetime.

Muhammad al.[24] has been introduce QoS aware based routing protocol (QERP) for underwater wsn network. The data reliability is biggest challenge of underwater wsn. All the sensor nodes deployed in randomly in network. So the capacity of all nodes for data transmission and energy level are same. Node directly communicate to the Sink node at 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 measure and simulated in MATLAB 7.0 platform with some static parameters.

QERP achieves outperform in terms of the following parameters like Packet delivery ration, energy consumption and end to end delay.

Jenn al.[25] has been proposed fault tolerant routing protocol based on Bipartite flow graph modeling. In IoT application wsn is key component because sensor nodes deployed in network for collecting information or interesting data. Cluster based routing is very efficient way for data transmission. In this routing mechanism cluster formation generally make 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 reach to 0 level so how to forwarded network data to the BS. In this protocol they have created virtual CH for the backup plan. In cluster any CH might be failed to send data to BS than virtual CH act as main CH and forward the data to BS and create a smooth communication. The performance of protocol is excellent compare with existing fault tolerance protocols.

Ali al.[26] has been proposed Bio inspired clustering scheme for FANET (BICSF). In network energy consumption or limited battery and node mobility is key issue for routing. If node moiving in network so every time we have to create re-clustering approach for cluster formation and CH election process also do same. BICSF protocol can be minimize this issue with the help of properly cluster formation and hybrid combination of GSO and KH mechanism for routing. GSO algorithm also help for the cluster head selection. Using the krill herd behavior for the cluster management. For the data transmission use genetic approach like path detection from one node to other or CH based on energy level and distance between node. The BICSF performance higher compared with grey wolf optimizer and ANT colony clustering algorithm with cluster building time, quality of service parameter 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 be divide the cluster in two part for the better communication. Grey wolf optimizer use for the best cluster head selection from the cluster nodes. The GWO is behaviors based intelligent characteristic based algorithm for the CH selection. Along with GWO its also used two different points like the energy level of node and energy consumption for transmission. For routing it also depends on the distance between node to CH and CH to BS. If distance is less than they communicate in single hop or distance is far than multi hop communication for data transmission. The protocol perform excellent result compare with 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 heteronomous network for environmental IoT application. In this research is extension version from existing protocol stable election protocol(SEP). In this protocol nodes deployed in randomly through out the network. The cluster head selection mainly address in this paper. Cluster head selection based on highest energy level with above fix threshold level along with centroid location of cluster. The threshold value decide the network communication through same CH node or might need re clustering process. If the residual energy value less than threshold level then this node is always be a member node. Due to this need extra energy for the cluster formation and new CH broadcasting message to member node. The simulation carried out in MATLAB platform with 100 sensor nodes. The performance of I-SEP compared with existing traditional protocol like SEP and DEEC with different parameters like throughput, network life time with different threshold level.

IV. COMPARISONS

In this paper we have taken and analysis of 20 different clustering based routing protocol for wsn network. For the comparison, we consider the major categories like protocol basic 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 different approach about clustering. Once cluster form we have to elect on of the responsible node in cluster is called cluster head. There are many strategies for selecting the cluster head and last step is routing in inner and outer cluster. Inner cluster the member node can send data directly or via intermediate node to the cluster head and cluster head can aggregate the data from all members and send to the base station.

There are numbers of approaches for the inter and intra cluster data routing in efficient manner.

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

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

- Cluster types: The protocols used which types of cluster for grouping the sensor nodes.
- Cluster manner: Cluster types belong to which categories of clustering like hierarchical, Flat or tree based.
- 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 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.
- Power consumption: The protocol can consume the energy for running the network. So we have classified the level like high, moderate and low based on the consumption
- Scalability: The protocol can be expand or scale it for large. The value yes indicates we can extend up to certain level, and no means we can't 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 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.

Table 1: Comparison of protocol vs Basic information

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

- No of nodes: The protocols simulated in any simulator at same time they deployed number of nodes in network.
- Simulation time: The protocol take some time for the one cycle of simulation is called simulation time.
- Area: The network can be deployed in certain location with area is called network area.

- Simulator: The protocol can be implemented or simulated in platform is called simulator. In wsn MATLAB and Ns2 both are popular simulator.
- Node placement: In network the node can be placed randomly or fixed location.
- Initial node energy: The energy level at time of node deployment in network is called initial energy.
- EC per bit(Eelec): In network, The cost of one node communicate to the other nodes is called EC per bit.
- Energy for Data aggregation: The protocol can consume for the energy for the data aggregation or not.
- Transmission range: The protocol can transmit the data in some range is called transmission range.
- Datagram length: The maximum length of 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/40 9kbps	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	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 life time, P: Packet delivery ratio, B: Bit error rate J: Jitter, D: Delay, F: Fault tolerance

In table 3 we have comparison based on the performance parameters along with information about the clustering types, cluster head selection approach and routing. For the performance of any protocol can be measure with 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 numbers of packet successfully transmitted to the destination is called throughput.
- Network lifetime: The number of rounds successfully completed form the network has to start.
- Packet delivery ratio: The ratio of number of packet delivers to the destination and transmitted from the source node.
- Bit error rate: The ratio of number of wrong bit deliver over the network.
- Jitter: The variation of delay at packet receiving side is called jitter.
- Delay: The difference between packet has sent from source and received at destination is called packet delayed.
- Fault tolerance: The protocol can work continuous throughout the network even some node is dead.

V. CONCLUSION

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

1. In the network the Node deployment in random in all protocols.
2. The base station location is fixed in every research article.
3. 70% 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 real time scenario.
6. Number of nodes varies from 100 to 1000 nodes in network.
7. Maximum protocols have simulated in MATLAB and NS2 simulator.
8. Transmission range and message length are different in every protocols.

REFERENCES

[1]. J. A. Stankovic, “Research Directions for the Internet of Things,“IEEE Internet of Things Journal, vol. 1, no. 1, pp.3–9, Feb.2014.

[2]. J. Chase, “The evolution of the internet of things,” Texas Instruments, 2013.

[3]. M. Kocakulak, and I. Butun, “An Overview of Wireless Sensor Networks towards Internet of Things,“ 2017 IEEE 7th Annual Computing and Communication Workshop and Conference (CCWC), pp.1–6, Jan.2017

[4]. J. Gubbi, R. Buyya, S. Marusic, and M. Palaniswami, “Internet of Things (IoT): A vision, architectural elements, and future directions,” Futur. Gener. Comput. Syst., vol. 29, no. 7, pp. 1645–1660, 2013.

[5]. I. Jawhar, N. Mohamed, J. Al-Jaroodi, D. P. Agrawal, and S. Zhang, ``Communication and networking of UAV-based systems: Classication and associated architectures," J. Netw. Comput. Appl., vol. 84, pp. 93108, Apr. 2017

[6]. Sustainable Wireless Sensor Networks; Seah, W., Tan, Y. Eds.; InTech Open Access Publisher: Rijeka, Croatia, 2010.

[7]. Li, C.; Zhang, H.X.; Hao, B.B.; Li, J.D. A survey on routing protocols for large-scale wireless sensor networks. Sensors 2011, 11, 3498–3526

[8]. S. Lin, J. Zhang, G. Zhou, L. Gu, J. A. Stankovic, and T. He, “Adaptive Transmission Power Control for Wireless Sensor Networks,“ Proceedings of the 4th international conference on Embedded networked ensor systems, pp. 223–236, 2006.

[9]. M. C. M. Thein and T. Thein, “An energy efficient cluster-head selection for wireless sensor networks,” in Intelligent systems, modelling and simulation (ISMS), 2010 international conference on, 2010, pp. 287–291.

[10]. P. Nayak and A. Devulapalli, "A Fuzzy Logic-Based Clustering Algorithm for WSN to Extend the Network Lifetime," in *IEEE Sensors Journal*, vol. 16, no. 1, pp. 137-144, Jan.1, 2016, doi: 10.1109/JSEN.2015.2472970.

[11]. X. Li, F. Zhou and J. Du, "LDTS: A Lightweight and Dependable Trust System for Clustered Wireless Sensor Networks," in *IEEE Transactions on Information Forensics and Security*, vol. 8, no. 6, pp. 924-935, June 2013, doi: 10.1109/TIFS.2013.2240299.

[12]. L. A. Villas, A. Boukerche, H. S. Ramos, H. A. B. F. de Oliveira, R. B. de Araujo and A. A. F. Loureiro, "DRINA: A Lightweight and Reliable Routing Approach for In-Network Aggregation in Wireless Sensor Networks," in *IEEE Transactions on Computers*, vol. 62, no. 4, pp. 676-689, April 2013, doi: 10.1109/TC.2012.31.

[13]. J. RejinaParvin and C. Vasanthanayaki, "Particle Swarm Optimization-Based Clustering by Preventing Residual Nodes in Wireless Sensor Networks," in *IEEE Sensors Journal*, vol. 15, no. 8, pp. 4264-4274, Aug. 2015, doi: 10.1109/JSEN.2015.2416208.

[14]. H. Lin, L. Wang and R. Kong, "Energy Efficient Clustering Protocol for Large-Scale Sensor Networks," in *IEEE Sensors Journal*, vol. 15, no. 12, pp. 7150-7160, Dec. 2015, doi: 10.1109/JSEN.2015.2471843.

[15]. Y. Zhou, N. Wang and W. Xiang, "Clustering Hierarchy Protocol in Wireless Sensor Networks Using an Improved PSO Algorithm," in *IEEE Access*, vol. 5, pp. 2241-2253, 2017, doi: 10.1109/ACCESS.2016.2633826.

[16]. S. Ganesh and R. Amutha, "Efficient and secure routing protocol for wireless sensor networks through SNR based dynamic clustering mechanisms," in *Journal of Communications and Networks*, vol. 15, no. 4, pp. 422-429, Aug. 2013, doi: 10.1109/JCN.2013.000073.

[17]. W. Zhang, L. Li, G. Han and L. Zhang, "E2HRC: An Energy-Efficient Heterogeneous Ring Clustering Routing Protocol for Wireless Sensor Networks," in *IEEE Access*, vol. 5, pp. 1702-1713, 2017, doi: 10.1109/ACCESS.2017.2666818

[18]. T. M. Behera, S. K. Mohapatra, U. C. Samal, M. S. Khan, M. Daneshmand and A. H. Gandomi, "Residual Energy-Based Cluster-Head Selection in WSNs for IoT Application," in *IEEE Internet of Things Journal*, vol. 6, no. 3, pp. 5132-5139, June 2019, doi: 10.1109/JIOT.2019.2897119.

[19]. Y. Dong, J. Wang, B. Shim and D. I. Kim, "DEARER: A Distance-and-Energy-Aware Routing With Energy Reservation for Energy Harvesting Wireless Sensor Networks," in *IEEE Journal on Selected Areas in Communications*, vol. 34, no. 12, pp. 3798-3813, Dec. 2016, doi: 10.1109/JSAC.2016.2621378.

[20]. H. El Alami and A. Najid, "ECH: An Enhanced Clustering Hierarchy Approach to Maximize Lifetime of Wireless Sensor Networks," in *IEEE Access*, vol. 7, pp. 107142-107153, 2019, doi: 10.1109/ACCESS.2019.2933052

[21]. J. Shen, A. Wang, C. Wang, P. C. K. Hung and C. Lai, "An Efficient Centroid-Based Routing Protocol for Energy Management in WSN-Assisted IoT," in *IEEE Access*, vol. 5, pp. 18469-18479, 2017, doi: 10.1109/ACCESS.2017.2749606.

[22]. F. A. Khan, M. Khan, M. Asif, A. Khalid and I. U. Haq, "Hybrid and Multi-Hop Advanced Zonal-Stable Election Protocol for Wireless Sensor Networks," in *IEEE Access*, vol. 7, pp. 25334-25346, 2019, doi: 10.1109/ACCESS.2019.2899752.

[23]. S. A. Sert, A. Alchihabi and A. Yazici, "A Two-Tier Distributed Fuzzy Logic Based Protocol for Efficient Data Aggregation in Multihop Wireless Sensor Networks," in *IEEE Transactions on Fuzzy Systems*, vol. 26, no. 6, pp. 3615-3629, Dec. 2018, doi: 10.1109/TFUZZ.2018.2841369.

[24]. Q. Wang, D. Lin, P. Yang and Z. Zhang, "An Energy-Efficient Compressive Sensing-Based Clustering Routing Protocol for WSNs," in *IEEE Sensors Journal*, vol. 19, no. 10, pp. 3950-3960, 15 May15, 2019, doi: 10.1109/JSEN.2019.2893912.

[25]. M. Faheem, G. Tuna and V. C. Gungor, "QERP: Quality-of-Service (QoS) Aware Evolutionary Routing Protocol for Underwater Wireless Sensor Networks," in IEEE Systems Journal, vol. 12, no. 3, pp. 2066-2073, Sept. 2018, doi: 10.1109/JSYST.2017.2673759.

[26]. J. Lin, P. R. Chelliah, M. Hsu and J. Hou, "Efficient Fault-Tolerant Routing in IoT Wireless Sensor Networks Based on Bipartite-Flow Graph Modeling," in *IEEE Access*, vol. 7, pp. 14022-14034, 2019, doi: 10.1109/ACCESS.2019.2894002.

[27]. A. Khan, F. Aftab and Z. Zhang, "BICSF: Bio-Inspired Clustering Scheme for FANETs," in *IEEE Access*, vol. 7, pp. 31446-31456, 2019, doi: 10.1109/ACCESS.2019.2902940.

[28]. S. M. M. H. Daneshvar, P. AlikhahAhariMohajer and S. M. Mazinani, "Energy-Efficient Routing in WSN: A Centralized Cluster-Based Approach via Grey Wolf Optimizer," in *IEEE Access*, vol. 7, pp. 170019-170031, 2019, doi: 10.1109/ACCESS.2019.2955993.

[29]. T. M. Behera, S. K. Mohapatra, U. C. Samal, M. S. Khan, M. Daneshmand and A. H. Gandomi, "I-SEP: An Improved Routing Protocol for Heterogeneous WSN for IoT-Based Environmental Monitoring," in *IEEE Internet of Things Journal*, vol. 7, no. 1, pp. 710-717, Jan. 2020, doi: 10.1109/JIOT.2019.2940988.