# Several Energy Efficient Routing Methods, Architecture and System Models used in WSN

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***Abstract*** **— with the advancement in technology, wireless sensor network is one of the main research areas. Wireless sensor networks are capable to sense and gather information from specific domain, develop and transfer data it to the sink hop. WSN is utilized in different applications areas such as military service, industries, agriculture, and healthcare. The small and low price sensor hops are capable to sense different types of the physiological and biological situations, processing information and wireless transmission. Though, features of WSN need most efficient techniques for progressing and handing out data. Sensor hops have inadequate communication range, dispensation and storage inabilities as well as power sources that are also inadequate. Generally, Wireless sensor networks are controlled by storing ability, power and calculating energy. Hence, it is necessary to establish reliable and power aware protocol to improve the lifetime of the network. Routing protocols are accountable for managing the route in system and need to confirm multiple node transmission under such situations. In this research, there is detailed survey about different routing protocols based on network structure in WSN. The classification of the routing protocols includes data centric, hierarchical, location based and motion based protocol.**

***Keywords— Wireless sensor network, Routing protocols, Communication range, Power aware protocol Introduction***

## I. Introduction

Wireless sensor network consists of maximum amount of the sensor hops that are interconnected to each other through wireless links. Some of the applications are industrial and health monitoring; automation at home-based applications and so forth. The structure of the internal and external structure should adapt a dynamic atmosphere [1].

### 1.1. Applications of WSN

***i) Agriculture*****:** WSN plays an essential role in agriculture. The data gathered from sensors is used to consider more suitable density, deduction fertilizer and internal requirements and expect crop yield in more accurate way.
***ii) Monitoring Environmental conditions*****:** Some of the application areas are recognition of the flood, leakage of the gas, earthquakes, coal mining, detecting the quality of the water and so forth.
***iii) Monitoring of Health applications*****:** Generally, sensors work on different biological parameters and after that diagnosis of the disease is done by medical experts. The monitoring scheme is based on the cognitive sensor system in which electronic devices can be detected. Moreover, in emergency condition, a button for patients is attached to the devices [2] [3].

### 1.2 Challenges of WSN

Some of the challenges are described as; (i) Energy (ii) Self-management and (iii) Safety in Road Traffic.

***i) Energy:*** The sensors need energy for operating and maximum amount of energy is consumed for collecting information, processing data and communication purpose [4]. The batteries are required to be modified and recharged for the consumption of the energy but, it is not easy to modify battery due to demographic atmosphere. An essential research challenge for sensor network is planned, establish and power reliable hardware and software for WSN.
***ii) Self-management:*** The deployment of the sensor network are capable to exert in absence of the social interaction. It should be capable to accomplish the system alignment, management, restored [5].
***iii) Safety:*** It is challenging approach in wireless sensor network and is used not only in deployment of battleground but also in serious conditions, alarm rate and investigation like as airfields and rest homes.

## 2. Architecture of Wireless Sensor Network

Wireless sensor network contains huge amount of the spatial scattered devices is called sensor hops which are sparsely deployed in surrounded environment where one wants to sense data. The location of the sensor hops in system is not required to be contrived and pre-arranged i.e. hops are randomly deployed in dangerous environment conditions. The system consists of the single hop is known as controller and other hops forwards the information directly and by multiple announcement [6]. The controller may be static or movable and present connection to the external atmospheric conditions. It is more accomplished than other hops in the system. The connection of more than one system that is paired or grouped in the form of the clusters is known as a network. The communication may be from node to node or from one node to another node lead to formation of new devices. The communication may be done through Wi-Fi and internet device. The resources linked through various kinds of the machine components and the alteration lead to the formation of the clusters. The type of the hop node leads to adaptable changes to main node such as computer systems, mobile phones and so forth [7].The structure of the wireless sensor network is given in fig 1.

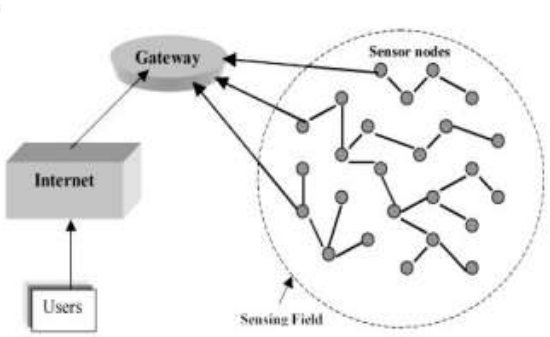


**Fig.1** Architecture of wireless sensor network [8]

The structure, arrangement of sink hop, other hops and globalised vision of the network. The independence and flexibility of the system is an essential factor. The sensors are organised in unrecognised region or bodily inaccessible and it

needs to operate at less energy from controller. Sensor network provide flexibility to operate in changed environmental situations. For instance, sensors may reduce the cycle for decreasing the energy consumption in sensors in which there is no specific alterations in the reading of sensor [8].Generally, sensor hop contains five elements which are sense, storage, processing, trans-receiver and battery-operated. Presently, hops are projected as low priced and small. Accordingly, the sources are inadequate (less battery, less storage and processing power). Due to constrained communication energy, sensor hops may connect with small amount of the native nearest hops. Hence, hops gathered to achieve the process such as sense, compute, route, locate and so forth. Usually, few number of the sink hops collect information and interconnects with external environmental conditions.

## 3. Prior Work

**Agnihotri, A and Gupta, I. K. et al., 2018 [9]** established a route method utilising nature inspiring optimisation method by combination of PSO and GA that enhance the lifetime of the network. In present research, they designed four route method which were shortest path method, GA, PSO, and hybrid method for smaller and larger sized system. This method links the advantages of both the algorithms that was maximum transmission vale of PSO(particle swarm optimisation) and issue to trap in local optimum was carried out by GA(genetic algorithm).Wireless sensor network have several issues such as inadequate power resource, inadequate storage of hops, restricted calculating energy and restricted width of interconnections of sensor hops. The main goal of this research was routing of wireless sensor network to transmit data efficiently with key approach to improve the system lifetime and degraded system by using an inspiring power management method for routing. Experimental analysis demonstrated that hybrid method improved network lifetime from 12% to 15% when comparison was done with shortest path method, GA, PSO, and hybrid method for complex network. Hybrid PSO-GA enhanced from 9% to 15% packet delivery ratio when compared to shortest path route, PSO and GA method. **Wang, X., Peng, Y and Huang, L. et al., 2019[10]** considered a power restrained clustered wireless sensor network and enhanced a routing protocol to acquire a globalised optimisation in power consumption for every CH hops. This decreases the effects on some of the hops nearest to sink hop and avoids the overhead during data transmission. A time aligned algorithm was used to choose the cluster head hops forreducing the dynamic topology of broadcast data between sensor hops irrespective of cooperation method that was designed for system traffic loads. In addition, detachment among the hops and sink hop as promotion directory were taken in to account to drop the incapable energy dispersion of cluster hops in wireless sensor network administrated by the protocols. The hops in cluster select the main hop by considering the detachment among data communication location and balanced dimension of the cluster. Generally, maximum energy was consumed because of the multiple tasks includes management and controlling of the intra cluster member hops, collection of information from associate hops, fusion of information and forwarding information to distribution hops. The new convention algorithm was verified by MATLAB simulation tool. The comparison was done between lowest energy adaptable cluster hierarchical algorithm (LEACH) and Energy efficient unsatisfactory cluster (EEUC) algorithm. The simulation outcome demonstrated the enhanced route protocol that was more static to reduce the maximum energy consumption of wireless sensor network with more balanced transmission loads and increases the lifetime of the network **Zhang, Y., Zhang, X., Ning, S., Gao, J. and Liu, Y et al., 2019[11]** proposed research on improved stable energy efficient system integrated super heterogeneous(improved-BEENISH) routing protocol by considering transmitted power consumption of clusters and maximum of power level in diverse wireless sensor networks. BEENISH was dependent on the weigh selection possibility of every hop to make cluster head in accordance to remained power and detachment from sink to main hop. In addition, they studied the effect of the differentiability of hop in form of power. They designed a simple algorithm that imagines detachment from main hop to sink hop. An issue occurs when a hop was detached from sink hop works as cluster head, an impulsive demise of the hop was missing from the controller due to impaired power consumption. Hence, they studied a static selection protocol that concludes heterogeneous factors catching energy inequality in the system and searched that the proposed protocol produces maximum stable area for appropriate weigh of power and distance. Experimental results demonstrate that this protocol enhance the network lifetime by the way of comparing dimension compared to clustered protocols. **El Hajji, F., Leghris, C. and Douzi, K. et al., 2018 [12]** presented a novel adaptable and dynamic multiple phase routing protocol. This protocol operates a multiple restrained environmental factor which has the maximum present output failed to investigate consecutive and regular alterations in stage of system and preferences of operator. The main issue was the high growth of the wireless applications, unrestricted range, and medicinal bands grow into oversaturated area. To overcome, a novel dynamic method was combined into wireless sensor network by retaining cognitive radios. This method presented a route method that provides a route tree dependent on assessment of different process. These standards can protect the regional metrics of closest hops, probable energy consumption to get every neighbour, route dimension and so forth. Such method was controlled by the detection criteria. Moreover, dynamic selection method was dependent on multiple value selection technique for updating the route tree. In contrast, modifications in system, preferences of operator and selection method presented finest routing neighbour among every hop and sink hop. **Li, L., and Li, D. et al., 2018[13]** proposed research on energy balanced route protocol (EBRP) for WSN. This protocol divided the system into different group of clusters by utilising k mean algorithm and selecting the CH (cluster Head) through FLS (fuzzy logic scheme). They proposed a genetic approach for acquiring fuzzy regulations. They programmed the regulations as chromosome and lifetime of the system was preserved as fit value. After that, best regulation for every system model was decoded by best offspring through selecting, crossover, and mutation method of both groups. An issue was less network lifetime and unbalanced energy because of inadequate resources, less battery and minimum data capacity. The main goal of proposed method was to improve the lifetime of the network. Simulation outcome and comparison was done present routing conventions like as LEACH, LEACH-C and SEP, EBRP. It was observed that lifetime of the network was increased by 57%, 63% and 63%. **Hamouid, K., Barkat, A. and Othmen, S. et al., 2019[14]** designed a safe and lightweight Hierarchical Cluster-based Routing protocol (SLHCR) for wireless sensor network. It was established to improve validity and legitimate key contract method. The amount of keys placed by every hop was decreased to particular stable secret key. The hops may utilise key to create an authenticate session secret key with other hop at the time of the route method without the involvement of the controller. Generally, hardware restraints of the sensor hops with unfriendly atmosphere may be deployed capable the kind of the system that can be positioned and visible to unidentified threats. This was the main issue that affects the security of the

network. During complex system, managing of the maximum amount of the keys may require additional storage memory that was not appropriate for small sensor hops. Experimental outcomes emphasized on the proposed method and comparison was done with the existing research. **Sreejith, V., Surve, R., Vyas, N., Anupama, K. R. and Gudino, L. J et al. ,2018 [15]** implemented a power efficient , region based route protocol for movable wireless sensor network . The planned method utilise related locations of the sender and controller to form and active area for routing. The movable hops in the system utilise as sleep wake up design to store energy. The motion vector data like as present position, way and speediness and also remained energy of hop was utilised to select neighbour which can deliver higher interconnection maintenance time. Motion vector data was also utilised to relief moveable hops that were stored in active area. The proposed technique followed sleep wakeup technology. This technology of the statistical hop assured power efficient of the whole system. The proposed technique was compared against ROF and GPSR protocol. The present method focused on applications in which single hop was interactive to stale sink hop. The proposed method was simulated and comparison was done in contradiction of same route protocols. **Kaur, M and Malik, A et al., 2018[16]** established a reliable and an organised protocol utilising bio inspirable method for regulating the congestion in the system. In planned method, a technique was computed to forward the data packets on novel path. The planned method had utilised three methods for searching the route that leads to congestion free route. In this research, hybrid congestion prevention protocol namely, a reliable and an organised protocol. This protocol was the combination of three protocols. An ad hoc on demand protocol was joined with bio-inspirable method that searched congestion free route for forwarding information form sender to destination. An issue in this research was congestion on the system due to large number of the data packets. This leads to decrease the throughput, delay in network and increase in packet loss and energy waste. Hence, it become necessary maintains the congested sources in WSN for improving the performance of the network. In this research, a novel method was discovered to control the issue of congestion. Experimental analysis was done through simulation and comparison was done with existing parameters in form of packet loss, delay and throughput.

## 4. Energy Efficient Clustered Routing Protocols in WSN

Routing is the method of different form predictable routing in static system in different manner. There is no structure, wireless connections are unpredictable, sensor hops may fail and routing protocols run into power saving needs. Various approaches were established for wireless system. Some of the routing protocols are described as [17],

### 4.1 Location-based Protocols

This protocol is determined by the location and data for sensor hops which is necessary for sensor system by various routing protocols to compute the distance among specific hops so that the power consumption can be valued.

A. ***Geographic Adaptive Fidelity (GAF):*** This protocol is used for the preservation of power so used in wireless sensor network.

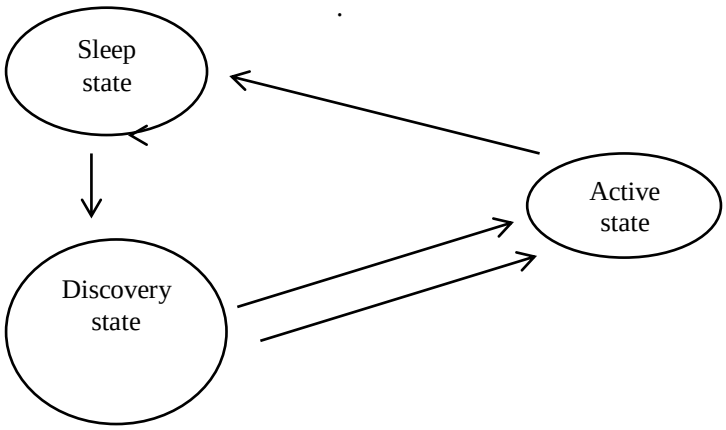


**Fig. 2** Geographic Adaptive Fidelity [18]

The structures of GAF is inspired by the power method that reflects power consumption because of the receiving and transferring of the data packets and idle when wireless sensor hops recognise the present data packets. It is dependent on the needless sensors whereas storing a continuous phase of route fidelity (constant connectivity between shared sensors).The fields of the sensors are distributed into grid squares and each square utilise positioned data which can represented by GPS or position method to connect with special grid where it is located [18].As given in figure, the state conversion method of GAF has three stages which are discovery state, active and sleep state. When sensor hop is in sleep state, it removes its radio for saving power. In discovery phase, sensor hop connects discovery data to determine other sensors in similar grid. Sensor forwards discovery data to notify parallel sensor about the condition even in active phase. The time consumed in every of the stage may be adjusted by the applications on various facts like as requirement and sensor movement. It purposes to increase the lifetime of the system while attaining a state in which every grid contain one lively device that is reliant on rank regulation. The rank of device is dependent on the remained power level. Sensor with maximum rank capable to cope up routing with the related grids

***B. Geographical and energy aware routing (GEAR):*** In this type of routing, route inquires to target area in sensor region. Sensors are imagined to get the positional hardware prepared, for instance, global positioning system able to determine the present locations. In addition, sensors are attentive about the remained power and also the position and remained power of every neighbour. It depends on the geographic data to choose sensor device to route data packets in direction of the received area [19].

### 4.2 Centroid information routing protocol

This protocol is different from out-dated address centric convention in which data sent from source to sink hop. Every basis sensor has suitable information reacts by forwarding its information to sink hop which is not dependent of other sensor devices. A middle sensor device accomplishes some accumulation on information creating from multiple resource and forward combined information towards the sink hop. The method leads to saving of the power due to low communication which is essential to forward information form source to sink hop.

***A. Sensor Protocols for Information via Negotiation (SPIN):*** This protocol is considered to enhance the definitive flood protocol. This protocol is reliable and adaptive about the resource. The sensors organise the protocol capable to calculate the power consumption need to compute, forward and obtain information over the system. This protocol is dependent on the two methods which is negotiation and resource variation. It facilitate the sensor to negotiate with

another before any data distribution take place to overcome introducing non required and terminated data in the system. It utilise multiple information as descriptor that the sensor needs to distribute. The concept of multiple data prevents the overlapping specified sensors [20]. The related sensor information should be more than the size of the multiple data.

***B. Directed Diffusion (DD):*** It is routing protocol for sensor inquiry distribution and dispensation. It encounters the major needs of sensor network as power efficiency, toughness and scalability. It is based on different components like as data mining, propagation of data. A sensing job can be described by the group of the attribute couples. During direct diffusion, sink hop recognises low information for received actions. In addition, sink hop supports specific sensor to forward actions with maximum information by again sending the actual data with less interval. In the same way, neighbouring sensor gets the concern data and searches that the sender concern with maximum information which is higher than gradient value [21].

***C. Energy aware data centric routing*:** It is new dispersed routing protocol that established computer generated backbone possessed of lively sensors which are accountable for inner system data processing and relay transmission. The system is determined through broadcast tree span tree where all devices in the system and fixed at the gateway. Specially, it builds a forwarding tree that estimates an optimum span tree with less mount of leaves, thus decreasing the size of the support generated by lively sensors. It is power aware and tends to enhance the network lifetime. The gateway plays an essential of information sink in which every sensor works as information resource.

**4.3 Hierarchical Protocol**

This protocol is based on the clustering approach. It is utilised by the sensors to record the sensed information to the sink hop. In the given figure, group of the layered protocol in which system consists of different clusters. Each cluster is achieved by specific hop, is called as cluster head [20]. In hierarchical structure, system is segmented into clustered layers. Hops are distributed into clusters along with cluster head that is responsible for routing from one group to another or towards the controller. The information transmitted from one layer to other layer or from hop to other hop. The clustering approach capable an essential optimisation capacity at cluster head [22].

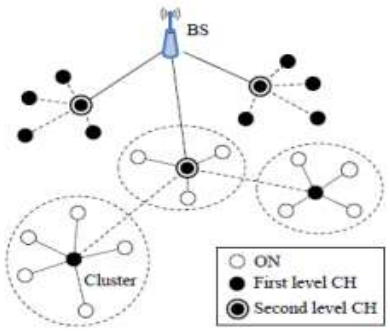


**Fig 3.** Hierarchical Protocol [22]

***A. Low-energy adaptive clustering hierarchy (LEACH):*** The cluster based routing protocol based on the cluster heads where the data is collected from the sensor nodes. The sensor nodes belong to the clusters and then data sends to the sink nodes after the collection process. The sensor nodes in the network consume equal energy and the lifetime of the network is extended. The cluster head in this network randomly changes where node belongs the clusters in every tie period [23]. The data collection sis done by the cluster heads and then sends to sink node to reduce the overall costs. The main objectives of the LEACH are:

- Lifetime of the network is extended.
- The energy consumption by each network sensor node is reduced.
- The communication messages are reduced using data aggregation.

The operations of the leach are based on the two phases. The first phase is the set up phase consists of the cluster head selection and the cluster formation. The second phase is the steady phase that focuses on the collection of data and delivery to the base station.

LEACH is totally circulated and requires no worldwide information of system. It lessens vitality utilization by (a) limiting the correspondence cost among sensors and their CH and (b) killing non-head hops however much as could be expected. LEACH uses single-node routing where every hop can transmit legitimately to the CH and the sink. Hence, it isn't relevant to systems conveyed in huge areas. Besides, the possibility of dynamic grouping brings additional overhead, for example head changes, commercials and so forth, which may lessen the addition in vitality utilization. While, LEACH enables the sensors inside their group to disperse their vitality gradually, the CHs spends a huge amount of power when they are found more distant away from the sink.

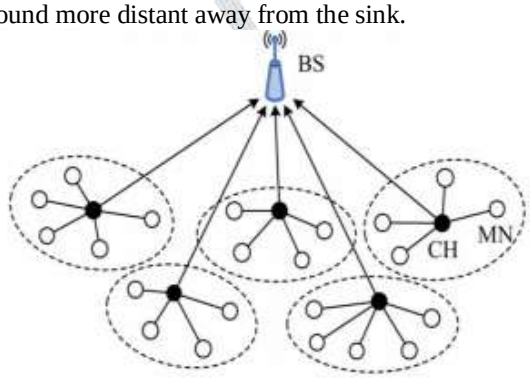


**Fig 4.** Structure of LEACH Protocol [30]

***B. Power Efficient Gathering in Sensor Information Systems (PEGASIS):*** This protocol generates a chain from sensor hops which are cluster 1 and cluster 2. Cluster 2 forwards and gets data from nearest hop and one hop is chosen from the chain to send to the controller. The information is grouped and gathered from one hop to other, combined and finally forwarded to the controller. The building of the chain is established in greedy manner. It prevents the formation of the cluster and utilise one hop in chain to forward to controller irrespective of the multiple hops. Sensor device forwards data to localised neighbour hop in fusion of information irrespective of forwarding data to cluster head. This protocol use greedy method when sensor expires due to less battery, a chain is built utilising similar greedy method by avoiding died sensors. A random sensor hop is selected in each cycle that may forward collected information to controller and decrease energy consumption per cycle [24].

***C. Threshold Sensitive Energy Efficient Sensor Network Protocol (TEEN)*:** The protocol in which sensors is divided into clusters and every cluster is followed by cluster head (CH). The sensor devices present in the cluster record the sensed information to the cluster head. Then, CH forwards collected information to maximum level unless information is forwarded to the sink hop. An architecture of the TEEN protocol is reliant on hierarchical structure in which nearest hops forms a clusters and this method proceeds unless reaches to controller. TEEN is helpful for applications where the clients can regulate an exchange off between vitality effectiveness, information precision, and reaction time powerfully [25].

**4.4 Motion Based Protocol**

The motion of sink needs power efficient protocol to assure information distribution created from sender to movable sink. System with stable sink have serious issue , known power sink hole issue, in which sensor positioned from stable sink are seriously utilised for sending information to sink. The overloaded sensors nearest to sink reduce the sink drain the battery more rapidly, and it separate the system. An issue take place in which static sink is positioned at optimum location related to centre of sensor ground. To overcome this issue, movable sink for collecting the sensed information from sender is determined. Sensor adjacent the sink alters over the time, all the sensor device in system works as information relay to movable sink and balance the loading of information route on every sensor[26].

## 5. Importance of Routing Protocol Used in WSN

Generally, routing protocols in WSN is the most challenging aspect because of the wireless system restraints. Some of the design issues in WSN are described as [29],

*i) In adequate power capacity:* - Though sensor hops work on powered battery, it has an inadequate power capacity. Power is the main challenge for designing the network. In addition , when the power of sensor have certain threshold vale, then sensor may have some error and may not able to function in proper way.

*ii) Position of sensor:* - The other challenge is at the time of the designing of the routing protocols for the management of the position of the sensor. Generally, protocols are prepared by GPS are determine about the position.

*iii) Inadequate hardware::*- Sensor hops contains an inadequate processing and loading ability and can perform only inadequate computing function. Such hardware restraints have various issues in development of the software and protocols.

*iv)Randomised hop deployment:*- Generally, sensor hop deployment is dependent on applications manually or in randomly the affect the presentation of the system. Sensor hops may be distributed in planned region.

*v) Network features and unpredictable conditions:*- Sensor system works in vigorous and unpredictable environmental conditions. Network topology is determined by the sensors and connections among the sensors , failure of the hops, damages, power consumption. In addition, sensor hops are connected by wireless connection that may have error, noisy or changeable with the time. Thus, route reflects the network conditions because of the inappropriate power and motion of the hops.

*vi)Accumulating information:* - Though sensor hops may produce specific reduced information, same data packets from multiple hops accumulate data so that the amount of the connections can be decreased.

*vii) Scalability:*- The routing protocols in WSN is capable to scale on the basis of the size of the system. In addition, sensors may not require power, sensing, handling. However, connection among the sensors may not e symmetrical, as the group of the sensors ay not able to communication in similar positions.

## 6. Basic Wireless Sensor Network System Models

The system models in wireless sensor networks are divided into two phases.

(i) Network and (ii) Adversary Model

**6.1 Network Model**

The measured heterogeneous multihop wireless network have the movable hops and disconnect confidential party in which public key is determined by whole hops. The movable hops have various hardware and power capacity. The system is utilised for inhabitant applications and it runs for long period and hops have extended connection in the system. However, each communication contains an approximation of further response. Every hop has specific identification and confidential key pairs with short period certificate delivered by transmission process. The hops may not connect or work as middle hop in absence of the valid certification. Confidential party manages the hops recognition records and confidential attributes. Every hop connects confidential party to stand up into payment incomes and confidential party is updating the present hops compensation and confidential attributes. This connection can take place through cellular system.

**6.2 Adversary Model**

An adversary method regulates the hops. It can alter the hops standard values and acquire the cryptographic identifications. An effort to threat the payment scheme to bargain, pay less value, connecting freely. Few of the adversaries may record inaccurate power ability to enhance the opportunity to be chosen by routing protocol, for instance, earning maximum credit values. An adversary may effort to threat the confidential scheme to incorrectly expand the confidential attributes to improve the opportunity to contribute in paths [27][28]. Intruders may introduce denial of service threats by violating the connected paths purposely. When hop B gets the data packet from C to again send it to next hop in path, D falls the data packet and place as a still record for B and C to go out of the communication range and connection between them is removed. Such threats may be established by co-operated, failed or less source hops. The movable hops are possible threats but confidential party are fully safe. The hops are automated and egocentric and inspired to disobey, but confidential party is operated by user that is involved in confirming the system safe Procedure.

## 7. Conclusion

In recent years, routing in sensor system involved a lot of consideration and presented specific issue compared to traditional data routing wired system. Wireless sensor system has an encouraging prospect in numerous civilian and soldierly applications such as ecological monitoring, safety investigation, and boundary defence and health systems. For better development and designing of these scenarios, architecture must be organised. Though architecture of the system is reliant on the applications so appropriate methods required to be monitored to guarantee maximum lifespan and power efficient. Generally, energy efficient clustered routing protocols in WSN are categorised as data centric, hierarchical, location and motion based protocol. Moreover, the protocols are categorised on the basis of the overhead, energy efficiency and QOS parameters. Though, routing method in WSN has many applications aspects still there some design challenges that are required to be resolved in sensor system. Some of the design challenges are described in this paper. Along with that, wireless system models are also described namely network system and adversary model. In network model, data is stored as confidential data whereas in adversary model, cryptographic authentication of the hops is done.

It can implement an encryption method such as DES, 3DES, RSA and ELGOMAL etc. These methods will improve the security levels in the network and data transmit one node to another node through 3rd secret key or 3rd party. It will enhanced the network parameters such as time, delivery rate and security factors etc.

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