Study of Routing Schemes and its Contribution in Evolution of Sink

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Abstract : With the evolution in the technology of the sink from static sink to mobile sink has improved the network durability and efficiency to a large extent. Various routing methods has been evolved to increase the lifetime of network ,energy efficiency, stability period and to decrease the waiting time depending on the requirement. Clustering technique has contributed a lot in improving the network parameters. From predetermined path to optimized path to be followed by sink has brought tremendous advancement in all the features of the wsn network whereas it has also made the network complicated to handle and costly. Mobile sink speed, routing strategy, trajectory design, sojourn time and position has to be taken care of in designing the network with mobile sink. It has also been concluded that with low duty cycle static sink is efficient while mobile sink is much efficient with high duty cycle.

Index Terms **-** Wireless sensor networks, Sink Mobility, Multi hop routing, Routing techniques.

I. INTRODUCTION

The WSN systems are required to observe and check the progress or quality of something over a period of time. Sensors are deployed to sense the different parameters. The sensor nodes have four main components that define the profile for any node. A sensor node has battery, microcontroller, transceiver and sensing unit. The battery has limited energy and irreplaceable. The energy harvesting is another option to build up the provision to supply the power to the nodes which are in operation [1] [2]. These options normally work through the solar energy, wind energy and many others. These sensor nodes are cost inexpensive and the topology of WSNs may affect the whole operation of the network [3]. The propagation technique used in-between the hops of the network can be routing or flooding. The different routing techniques for the sensor network could be employed these may be stated as flooding; hierarchical routing, location-based routing [4].

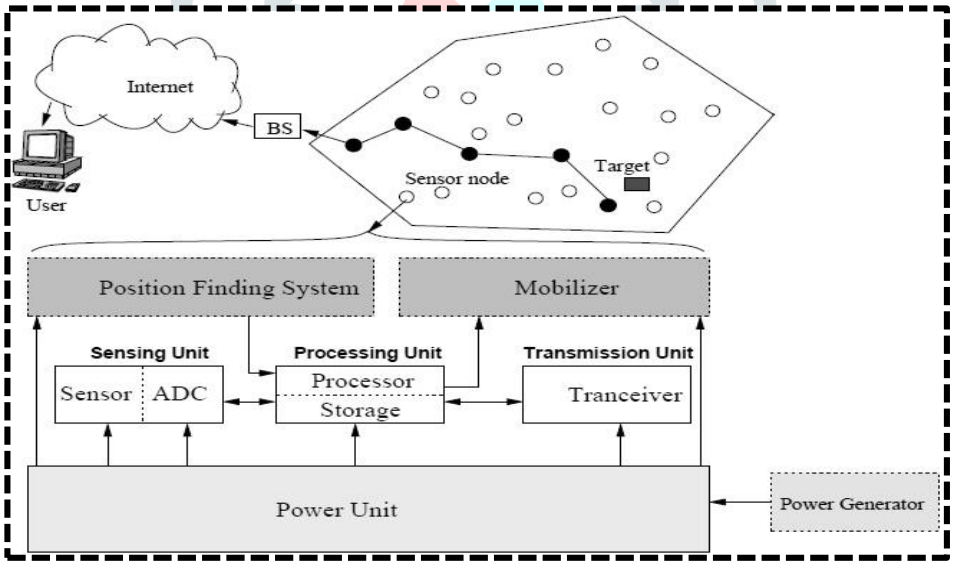

Fig. 1. WSN architecture [1]

1.1 Military Applications

It is inspired from the military applications for which the sensor network used to be deployed in the battlefield. The activities of enemies or intruder are observed while using the sensor network in such military applications. The rapid installation, complacence and fault resistance attributes of sensor networks mould them to a very optimistic sensing technique in military application such as commanding, controlling, communications, computing, intelligence, supervision, reconnaissance and targeting systems. Senor network is deployed in the battle field in. Since sensor nodes possess self-organization capability and rapid deployment so the network is set up in a very less amount of time without need of any fixed infrastructure.[4] Wireless sensors nodes can be rapidly deployed in a war or harsh region without any infrastructure in order to detect and gain maximum information that could be collected about rivalry movements, explosions, and other activities of interest, such as battlefield surveillance, biological, nuclear and chemical attack detection and reconnaissance. It helps to detect every moment in the target area [5]. Apart from the military applications, nowadays, smart cities projects make use of wireless sensor networks for surveillance, waste management, health monitoring, arresting pollution etc.

1.2 Health Applications

Some of the health applications for sensor networks are providing interfaces for the person with disability; Patient monitoring; diagnosis of the patients; medication management in hospitals; monitoring movements; tele-monitoring the human's physiological data; and to keep a track on and monitor health status of patient's and track doctors status inside a hospital[6]

II. ROUTING

The routing deals with sending the data packets to the sink in a single hop or in a multi hop manner. It saves the energy of the nodes and makes them survive for much longer duration. Various types of routing protocols are: hierarchical, location based, and flat routing. The first type i.e., hierarchical routing makes it possible for WSN to conserve the energy of the nodes. The routing is the only way to make the communication efficient enough so as the network could be operated for the longer duration of time [7].There are few challenges that are faced by the researchers while adopting the routing techniques in WSN. In order to resolve the concerns for the routing protocols, many researchers have proposed numerous solutions [8]. There are following challenges that are faced while designing the routing protocols, some of them are discussed below.

The nodes have limited stock of energy. Therefore, routing protocol must be designed in a way that the energy consumption of the nodes is minimized. Some users deploy nodes manually in a random fashion and some follow the deterministic way of deploying the nodes in the network. The scalability is the most striking feature that helps the WSN in giving the promising performance for any particular application. The scalability must be considered as there might be chance to enhance the dimension of the network area at some occasions. As the nodes are deployed, they are assigned the unique IDs that create their individual profile, which is known to the sink. The overheads should be reduced while developing the routing protocol. The routing scheme must not generate more number of overheads. It must be designed in a way that it stands still in the case of any node failure. It should never be dependent upon any individual node for its operation. That signifies its robustness. The routing protocol is always dedicated to specific applications. Therefore, while developing routing protocol, the requirement of monitoring of the surrounding is a decisive factor. In some event-based applications, the routing occurs based on those events. Therefore, routing protocol must be dynamic in nature. Node has the capability to sense the data and also it performs the data aggregation of data. However, while developing routing protocol, these capabilities must be explored in a way that a particular application is served. Reducing redundant data ensures the reduced energy consumption and effective data forwarding to the sink. Some of the other challenges that makes the routing more efficient are QoS (Quality of Service), coverage area and others [9].

Networks are of two types: a) Homogeneous: In homogeneous network all the nodes have same energy in the beginning. E.g., LEECH and HEED are routing protocols for clustering of homogeneous nodes.

b) Heterogeneous: In heterogeneous network, nodes are initialized with different energy level. SEP (two level), DEEC (two level), EDEEC (three level), BEENISH (four level), iBEENISH (four level) [11, 12, 13]

Sink mobility usage in BEENISH and iBEENISH schemes gives better results than static sink [13]

III. LITERATURE REVIEW

Tian et al. in [14] proposed a routing protocol Energy-efficient Chain-cluster Routing protocol (ECR) for wsn. This convention utilizes the focal control and appropriated calculation to frame a topology with two progressive chain arrangements. ECR includes a simple and systematic cluster-head selection guidelines, which lengthen the lifetime and improves the energy effectiveness. This protocol ECR performs better than LEACH and PEGASIS in terms of network lifetime.

Hu et al. in [15] proposed a novel algorithm of cluster-head based on LEACH. For removing the disadvantages of leach, leach-imp is proposed. This algorithm improves non uniform consumption in nodes. In this algorithm CH is appointed at the center of each section then neighboring nodes near CH make cluster. By this way communication radius is decreased and transmitted power is also decreased. In this proposed algorithm simulation result indicates that throughput and residual energy is improved compared to Leach.

Jang et al. in [16] proposed an EECCH algorithm to remove the shortcomings of Leach and Leach-C. EECCH (Energy-Efficient Clustering scheme with Concentric Hierarchy) is centralized clustering scheme, based on multi-hop routing. In this algorithm Toward drawing circles with those build station Concerning illustration its center, those base station separates organize hubs under some levels At that point we make diverse number of cluster part to kill those imbalance over energy efficiency. Here we attain the reasonable dissemination for cluster head Furthermore diminishing that energy dispersal.

Salim et al. in [17] proposed a clustering, routing protocol IBLEACH that is intra balanced leach for wireless sensor network. It improves Leach by balancing the energy utilization in the network. IBLEACH uniformly distributes the work between the CHs and CMs which increases the lifetime of the wireless sensor network and also it distributes the network workload, it means even energy dissipation. So, in terms of network lifetime and minimum energy consumption simulation results indicates that IBLEACH perform better than LEACH.

Younis et al. in [18] proposed HEED (Hybrid Energy-Efficient Distributed clustering), that recurrently selects cluster heads according to a hybrid of the node residual energy and a secondary parameters, such as node proximity to its neighbours or node degree.[19] It exploits the availability of multiple transmission power levels at sensor nodes and it ended in a consistent number of cycles, free of system measure. Simulation results demonstrate that proposed approach is effective in prolonging the network lifetime and supporting scalable data aggregation.

Yang et al. in [20] Recommended an energy productive Clustering algorithm EECA for remote sensor system. It Hosting two venture cluster head Choice component. The node for higher lingering energy gets family cluster-head Furthermore hopeful CH contend with make the cluster-head utilizing Postponed show system. This algorithm balances those dissemination from claiming energy around CH. Algorithm enhances lifetime against LEACH.

Zhao et al. in [21] proposed multi-hop routing protocol based on grid optimization (MhRPGO) to improve network's performance in wsn. The current energy of nodes and location information of each node calculated is used to find cluster head and to balance the energy utilization of the network. The cluster head changing mechanism is applied when the energy of cluster is below than the other nodes or the energy threshold. Other node is introduced as a new cluster head which have highest energy amongst the cluster nodes. Simulation results show that MhRPGO improves the clustering feature of network that increases network's lifetime and throughput that was hampering because of the dying of nodes.

Chen et al. in [22] proposed an Unequal Cluster-based Routing (UCR) protocol to mitigate the hot spot problem. It is an energy-efficient multi hop routing protocol for the inter-cluster transmission. It groups the nodes into clusters of unequal number of nodes and unequal area.

Cluster heads near by the sink or base station have compact cluster area than those at distance from the sink, so that they can utilize their energy in inter-cluster data forwarding. UCR unmistakably enhances the organize lifetime over HEED.

Tang et al. [23] proposed a chain cluster based mixed routing protocol (CCM) which takes advantages of Leach and PEGASIS and provide raised performance by removing weaknesses of both. It divides the work into few chains and works in two stages. In the first stage sensor nodes that are the member of each chain send data to the chain head using chain-based routing. In second stage, all the chain heads form a cluster and send the data to the voted CH. Proposed CCM algorithm proves that it is better than LEACH and PEGASIS in terms of residual energy, delay metrics.

Tashtarian et al. in [24] presented a cluster-based algorithm named as EELTC which stands for Energy efficient level-based time-based clustering. The reported algorithm performs better than LEACH, EEUC as number of unequal size clusters area created, and the overheads are made low. In this algorithm, level is set by receiving message from BS and sets a time to start broadcasting its advertisement message. Since it has lower msg overhead than EEUC, it saves more energy in setup phase which results improvement in network lifetime compared to EEUC and Leach.

Yuan et al. [25] proposed an unequal clustering algorithm UCA for prolonging the lifetime of network and mitigating hotspot problem. Here clusters near to the base station are of smaller size than farther clusters. In this algorithm there is rotation of cluster head and choosing CH having more residual energy same as EEUC. By this way network having uniform energy dissipation among cluster-head. Simulation results indicates improved network lifetime over M-LEACH.

Saranya et al. [26] presented an algorithm named as EECS that decides about the network lifetime by the bits that are sent and the selection of CH. The CH is selected in a way that in the waiting time, the throughput can be made maximum. Finite State Machine (FSM) is idealized for a node having CH, CM and different IDLE stages. The node which has the maximum residual energy and it is capable enough to send the greatest number of bits during the static interval of sink, is selected as CH. Markov model is used to estimate the transition within the inter-state. However, the algorithm has some limitations that cannot be afforded in the long survival of WSN. Only two parameters used for selection as CH are not sufficient for the optimal CH selection for any node.

Khan et al. [27] presented the improvement in energy conservation of the network using mobile sink rather than static sink. Extensive comparison between mobile sink and static sink has been shown experimental analysis. Duty cycle and mobility path are the important parameters focused on. It is shown that duty cycle is more important parameter than mobility to focus for achieving better energy efficiency.

3.1 Static sink

Firstly in the network static sink was commissioned in which all the nodes were transferring data to the sink via. Single hop, that made the network die so early then multi-hopping technique was employed that has little bit improved the network performance but introduced the hotspot and energy hole problem because the nodes near to the sink died earlier in relaying data towards the sink. Then multiple static sinks were installed which reduces the distance between source and sink as each node send its data to the nearest sink. This has divided the area into sub-areas. In deployment of multiple sinks optimal position of the sinks was an issue, so that all the sinks are equally burdened [28]. Clustering was another feature that has implemented by using heterogeneous nodes. In a cluster, a cluster head is assigned which collects data from other nodes and sends the processed data to the sink. Cluster heads have higher capacity in comparison to other nodes in the cluster [29].

3.2 Mobile sink

To overcome the flaws of static sink mobile sink was introduced. Mobility of the sink can be homogeneous when more than one mobile sink is used and they follow the same mobility model for their movement. While it can be heterogeneous when mobility models used for mobile sink are different and also when single mobile sink is used. Here also single hop data collection and multi hop data collection are used. It pursues different mobility patterns i.e. random mobility, predetermined path mobility or controlled mobility. In Random mobility, random path is followed by the sink and it is not sure whether it will reach every node to collect data or not and that results incomplete data collection. There is always a trade-off between energy consumed and coverage time. Multiple sinks random movement can be used in effective way. Each sink leaves a mark where it goes from and other sinks changes their direction when they detect the marks. In fixed mobility, sink is fed with a predetermined path.[28]

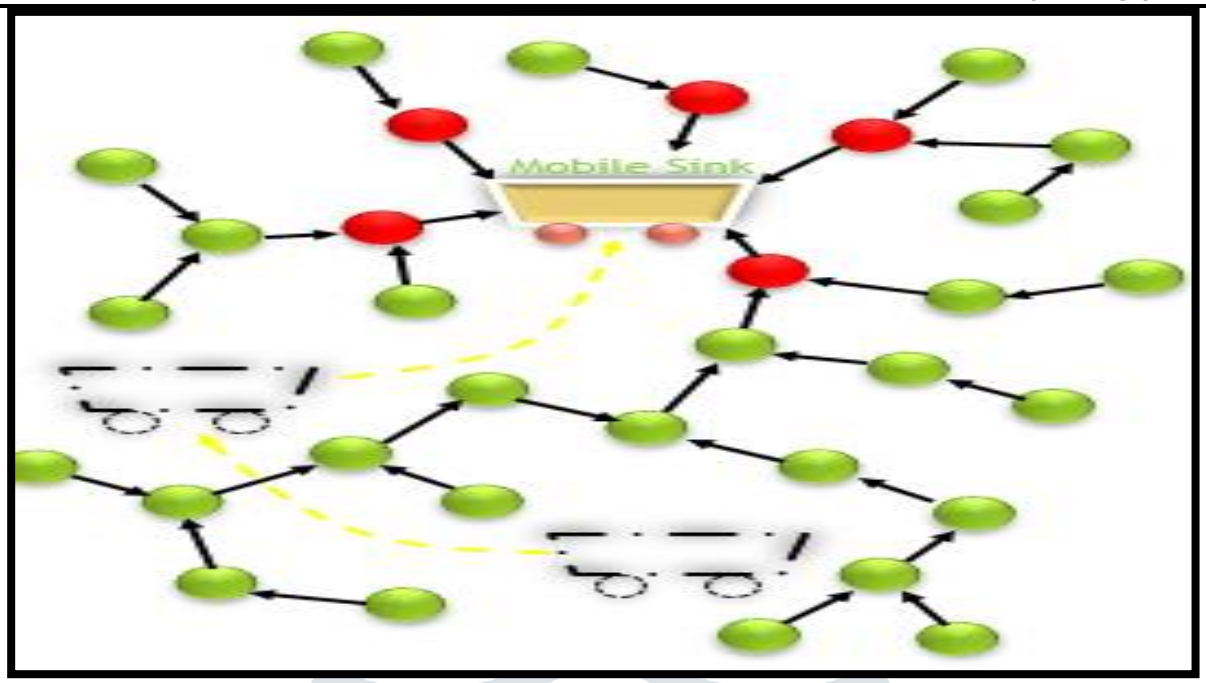

Fig shows sink mobility in the network

All the parameters are predefined which are not affected by the network behavior during the process. In controlled mobility, Mobility of the sink is guided by controlling some parameters such as residual energy, node density, inter-node distance and network congestion. Optimized path is followed by the mobile sink It has been observed that consideration of duty cycle is more important than mobility path. In case of small duty cycle, static sink gives optimal results while in case of large duty cycle, mobile sink gives better results in energy efficiency [27].

IV. RESULTS AND DISCUSSION

Reference Study	Algorithm	Parameters	Work done	Drawbacks
Wang et al. (2005)	Novel linear programming formulation for determining movement of the sink linear optimization model	network lifetime, Data gathering precision	Guaranted data collection from all the nodes, Energy efficiency, Ensures fairness in data collection	Establishing coordination b/w sink and nodes was tricky. No emphasis on Residual Energy.
Marta et al. (2008)	Using Sink Mobility to Increase Wireless Sensor Networks Lifetime	Depleted Energy, Network Lifetime	Energy Holes, Network Lifetime, Movement of sink on predefined hexagonal path	Localized and Distributed sink movement is better
Basagni et al. (2008)	A Mixed Integer Linear Programming (MILP) analytical model. Our Greedy Maximum Residual Energy (GMRE) and Random movement defined	Energy holes, Optimal sink routes, Sojourn time	Comparison between the uncontrolled, random sink movement and Controlled sink movement.	Enhancement of stability period is not considered
Luo et al. (2010)	Efficient primal-dual algorithm to solve the sub-problem involving a single sink	network lifetime, Sink Mobility	graph model on sink mobility	Energy holes not discussed.
Nakayama et al. (2011)	Set packing algorithm and traveling salesman problem	Efficiency, fairness index, average number of clusters	Control over the sink using mobile sinks as actuators	The time for collecting data or reducing the consumed energy of the mobile sink need to be minimized
Khan et al. (2013)	CSMA/CA protocol at MAC layer, Static sink and Controlled sink mobility	Mobility path or radius of the sink, Duty cycling value of nodes	Interrelation of duty cycle and mobility radius of mobile sink with energy efficiency in homogeneous network	Effect on throughput and Density of WSN is not considered
Salarian et al. (2014)	Weighted rendezvous planning, the optimal tour of sink	Min Energy consumption with-in delay bounds, Network Lifetime, Sink mobility pattern for better efficiency,	a hybrid moving pattern with rendezvous points, weighted rendezvous planning is used, Required packet delay time	Different delay time is same for each sojourn location, does not depend on data to be transmitted.
Tunca et al. (2015)	Ring Routing(energy-efficient mobile sink routing protocol)	Energy consumption and Packet delays	Minimize overheads, Fast Data Delivery, Stable avg. energy consumption and less avg. Reporting delays	Only one mobile sink can be used with Ring Routing
Gu et al. (2016)	Uncontrollable mobility (UMM), location-restricted mobility (LRM), path restricted mobility (PRM), and unrestricted mobility (URM).	Sink speed, Motion control, Energy efficiency	mobility management schemes	The mobility administration in duty-cycled WSNs remains unexplored
Maurya et al. (2017)	LBRR: Load Balanced Ring Routing Protocol for Heterogeneous Sensor Networks with Sink Mobility	Energy Efficiency, Sink Mobility, Network Lifetime, Load Balancing, Packet Drop Ratio	Belittle energy consumption, load balancing, and throughput increases. monitor a very large wsn	Energy Efficient Routing Protocols for Large field is nor developed. Single sink is used.
Rostami et al.	Clustering methods	scalability, energy efficiency, and reducing routing delay	Comparison between homogeneous and heterogeneous clustering of nodes	Heteogeneous clustering have uneven operation which leads to complexity

Kumar et al. (2018)	A novel Location Aware Routing for Controlled Mobile Sinks (LARCMS)	Average Energy Consumption per node nodes, Average Reporting, Lifetime	Enhances network lifetime, reduces reporting delay, Ring routing protocol	Controlled mobile sinks decreases the pertinence of the proposed protocol. Increases the execution cost.
Mitra et al. (2018)	An efficient virtual grid based hierarchical routing approach	Sink neighbourhood problem, data path delay, disconnected networks problem	Reduces Average control packets overhead, Average energy consumption, data path delay. Increases Network Lifetime and Throughput.	
Saranya et al. (2018)	Energy Efficient Clustering Scheme (EECS) algorithm	The energy hole, Cluster head Rotation, the HOT SPOT issues,	Comparison between EECS algorithm, MOD-LEACH and MOD-GEAR Finite State Machine realizes role of the node, Markov Model realizes state transition	Suitable for small areas. Multiple sinks may be required for larger areas.

V. CONCLUSION

Static to mobile sink evolution advantages and shortcomings are discussed. Deployment of optimized mobile sink has bought evolutionary changes and made critical monitoring to happen(better fairness index), while the static sink is cost efficient. Mobile sink increases lifetime, energy efficiency. Duty cycle is the important parameter for energy efficiency in mobile sink as high duty cycle is more efficient. Hotspot and energy hole problems has also removed with mobile sink and unequal clustering.

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