A Survey Of Routing Protocols Of Wireless Sensor Network With Mobile Sinks

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***Abstract*— Wireless sensor network can be used in military application for monitoring militant activities like tracking enemies, force protection and monitoring the vital signs of the soldiers who are in a battlefield. Wireless sensor network has set of distributed sensor nodes which are connected to each other. These sensor nodes are low powered, low cost, small in size with limited amount of battery supply. While designing the wireless sensor network for sensing and data reporting task limiting the utilization of power resources of the sensors is the important concern in order to extend the lifetime of the wireless sensor network. The nodes which are selected as a mobile sink will quickly consume more battery power and degrade the network lifetime. Sink relocation is the most powerful method to extend the network lifetime without consuming more battery energy. In this paper, a survey of the existing distributed mobile sink routing protocols and the techniques for relocating sink to maximize the network lifetime with respect to the mobile sink routing protocol design requirements and its challenges are explained. With respect to the target applications ways to increase the battery efficiency and selecting the path with low cost by selective routing protocols are also discussed.**

Keywords—wireless sensor network, mobile sink, energy consumption

I. INTRODUCTION

Wireless sensor network (WSN) consists of group of spatially dispersed and dedicated sensors which will monitor and record the physical conditions of the environment and organize the collected data at a central location. WSNs measure environmental conditions like sound, temperature, pollution levels, humidity, wind speed direction and pressure, etc. Wireless Sensor Network is the one which combines many technologies such as the computer, communication and new technology of the information acquisition and processing. The WSN can be widely used in medical, military defense, manufacturing, environmental monitoring, water/waste water monitoring- agriculture, traffic management and other fields. WSNs were initially designed to facilitate military operations but its application has since been extended to health, traffic, and many other consumer and industrial areas.

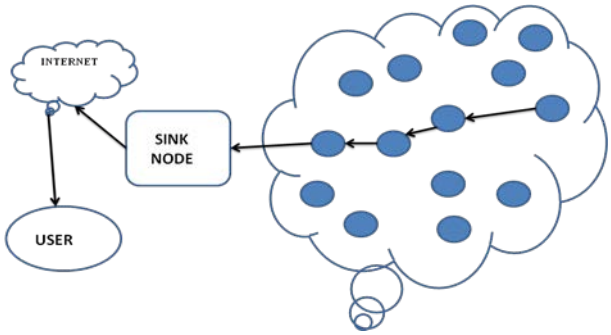

Fig.1 .Wireless Sensor Network

Most of the sensor nodes suffer limited battery supply. Energy efficiency is the most important factor in WSN. Replacing the batteries of sensor nodes is very difficult. So wireless sensor network have to be able to operate without human

intervention for a long time. In WSNs the nodes close to the sinks are easily drain their battery supplies than other nodes in case of static (immobile) sinks because of intersection of multihop routes and concentration of data traffic towards the sinks. This is called as hotspot problem [1], [2] and this cause the death of the node which reduces the sensing area because of disruption of the topology. Also it causes the sink to be isolated from the topology and affects the data collection from the sink. To overcome this problem, mobile sink concept is introduced [3], [4]. Mobile sink provides the load balancing and achieve uniform energy consumption in the network. But the fresh advertisement of the change in location of the sink through the network is not that easy. The overhead of this operation should be limited to make use of the advantage of energy savings using the mobile sinks. The real time examples are, WSN's with mobile sink is applicable for fire detection systems [5]. In a fire detection system more number of sensors is laid on a forest area along with one or more mobile sinks. These sensor nodes are used to get the periodic notification of temperature and humidity. The mobile sink also may be placed on a robot to collect the information from different places of a large field [6]. Battlefield surveillance can be done by using mobile sink as the static sink may be compromised by the adversary [7]. The other examples are traffic monitoring, hospitals and smart houses, rescue mission and pollution control [8]. The design of routing protocols for mobile sinks has to be incorporated with load-balancing in order to achieve uniformity of energy consumption throughout the network so that no node will be allowed to die and hence no information will be lost

II. LITERATURE SURVEY

The novel sensor communication model and a novel protocol for multiple static sink [9] is proposed to support the remote users outside the sensor network and the mobile user inside the sensor network. The multiple static sink is placed at a location within the legacy network and divides a sensor field into more number of multiple sinks, so the sink can communicate with other nodes directly through legacy network. Because of the legacy networks, the sharing queries and data from the multiple static sinks provide high throughput while gathering the data and provides low latency by data delivery. The static sinks deliver the aggregated data to the remote users through legacy networks and mobile sink receives data from the static sink. It also solves hot spot problems and increases the network lifetime by reduced consumption energy. The advantage of this paper includes high data delivery ratio, low delay and reduces hotspot problem.

A framework is designed for improving the network lifetime by making use of mobile sink and delay tolerance. This framework [10] is useful in the application that has a small amount of delay tolerance. Each node in the given delay tolerance level does not need to send the data as soon as it available. As an alternative it stores the data temporarily and transmits it when the sink is in favorable location. This helps to achieve the network lifetime.

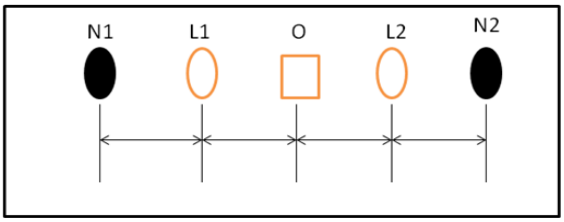

Fig .2.Dt-Msm Architecture

In Fig.2 N1 and N2 are two sensor nodes and L1 and L2 are the candidate stops of the mobile sink. The nodes N1 and N2 produce the data at 1 bps and each node have 100 units of energy primarily. If the sink is located at O in the SSM (static sink model), both nodes spend 4 units of energy for sending a bit of data. It is obvious that the optimal lifetime is 25 seconds. In the MSM (mobile sink model) with sink locations L1: L2, due to the symmetry of the structure, the sink stays at both L1 and L2 for the same amount of time to achieve the maximum lifetime. Each node spends 1 or 9 units of energy for sending 1 bit of data depending whether the sink is at L1 or L2. The average energy consumption per bit is 5 units. Thus, the lifetime is 20 seconds. In the DT-MSM, we assume that the sink alternates between the two stops stays for 1 second at each stop in each cycle. When the sink stays at L1, the node N1 only sends 2 bits of data to the sink; when the sink moves and reaches the L2, node N2 only transmits 2 bits of data. Hence both nodes spend 2 units of energy every 2 seconds or 1 unit of energy per second on average. Thus, the lifetime is 100 seconds, a significant increase compared to the ssm and msm.

Results shows that framework has better quality than other models. Also it increases the lifetime gain of the network than others. Increase in the mobile sink increases the optimal network lifetime. The advantages are this framework is useful in the application which accepts the delay tolerance. Proposed system increase the lifetime of the network compared with other models and can be applied for both practical solutions and benchmark for analyzing the energy efficient protocol. No efficient algorithms to solve optimization problems are proposed. Also algorithm for finding the location or to stop the sink to collect the data is not discussed.

Increasing the network lifetime of the sensor node is achieved by many research methods. Track based methods and the Anchor points based methods are proposed for operating the sinks. But these methods decrease the Quality of the Service (QoS) and also produce the hotspot in the network .Because they use the static mobile path which does not consider the query position and the data priority. Hence the proposed method uses the novel mobile sink operation [11] which will reduce the existing problem, the probing priority of the mobile sink is determined with the data priorities for increasing the QoS and the mobile features are used for reducing the routing hotspot. Results show that the proposed method increases the lifetime and reduces hotspot when compared with the other methods.

Design of Distributed Partition Detection and Recovery Algorithm (PADRA) [12] a local, distributed, and movement-efficient protocol which handle the failure of any node. Connected Dominating Set (CDS) is the technique which is used to find the node failure which is responsible for the partitioning of network.CDS finds whether the node is cut vertex or not before failure happens. If the node is cut vertex, it ask the neighbor node to perform the failure recovery. The failure recovery is done by selecting the neighbor node and the selected node is replaced with failed node in a cascaded manner.

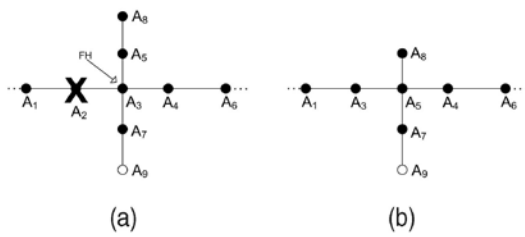

Fig.3. Illustration of PADRA

In the fig.3 Black nodes are dominators and white nodes are dominatees. In case if node A2 fails the failure handler, A2 starts its recovery process.A3 is the failure handler of A2. So A3 replaces A2 and A5 replaces the A3 and A8 replaces the A5. This stops the node from failure and increases the lifetime.

PADRA is extended to MPADRA which will handle the multiple node failures in the network. The nodes that are present on the path closest to the dominate node are reserved before the replacements are performed. These nodes are reserved because disconnections and race conditions occur in the network when it is requested by both failure handlers. State diagram is maintained to eliminate the race condition. When the node is reserved the replacement can be done easily. Result shows that the PADRA performs closer to the optimal solutions in terms of travel distance and this minimizes the message complexity. The MPADRA needs the knowledge of 2 hops for each node and hence it can replace the node in distributed manner. This system will also minimize the message complexity and there is no need of whole network topology in MPADRA. But the system has Coverage and connectivity issues.

Power-aware data dissemination protocol (PADD) protocol [13] that constructs a grid structure for grid based WSNs with mobile sinks. Only the dissemination nodes located at grid points need to acquire forwarding information. The other sensor nodes just fall into sleep mode to conserve energy. PADD selects the sensor node with minimum cost as dissemination node to avoid repeatedly performing the selection of another new dissemination node. Besides, dissemination nodes with the most residual energy are selected to build a robust data dissemination path and to evenly distribute energy load in the sensor field. A data dissemination path is maintained by caching a Query Information Table (QIT) in each dissemination node, so that sensed data can be efficiently and successfully transmitted from the source to the sink. Simulation results shows that the proposed PADD is more energy efficient and has longer network lifetime compared with TTDD.

An Energy-Balanced Routing Protocol (EBRP) is designed [14] by constructing a mixed virtual potential field taking depth, energy density, and residual energy into an account. EBRP is the data gathering algorithm and it does not look into data dissemination and point to point communication. It mainly focuses on moving the packets near to the sink using the dense area energy which will protect the nodes to maintain low residual energy. The proposed mechanism detects the routing loop problem and eliminate loop that emerging in the basic algorithm. Detection of loops can be done by validating the source addresses of the packets received and also by measuring the length of the local queue.Fig.4 shows the detection of loops in the high dense area.

Three types of loops can be detected in the high dense field namely one hop loop, origin loop, queue loop. One hop loop occurs between the parent and local node. In Fig.4 nodes in Area 3 selects each other as their parents and hence causes the one hop loop. This can be easily detected by the source address of the header packet. Routing loop that involves with one or more sampling node causes the origin loop. In Fig.4 three nodes in Area 4 forms the origin loop. This can be detected by the origin address of the packet. Once the packet is received by the local node it will check the origin address of the received node, if address is same for two received nodes, the local node declares it as the origin loop. Queue loop is the special multihop loop chain and it relates with relaying node not with the sampling nodes. In Fig.4 nodes in Area 1 falling into the queue loop. This loop can be detected by drastic increase in the queue of the nodes in the chain.

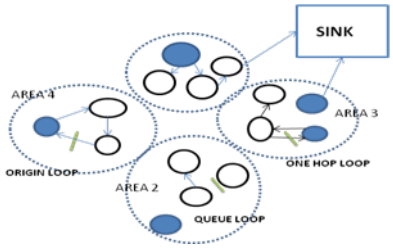

Fig. 4.Detection Of Loops

After detecting a loop, EBRP protect the current parent and selects the new neighbor in the next hop node. Lack of efficient understanding of time varying potential field is main constraint in EBRP. The proposed method significantly improves the balanced energy consumption, network lifetime, and throughput. But there is no deal with data dissemination and point-to-point communication. Also lack of sufficient understanding about the dynamics of time-varying potential field.

In Wireless Sensor Network (WSN) maximizing the network lifetime is the fundamental issue due to the limited battery power of the sensor node in the network. To overcome this challenge, many techniques like network protocols, some data fusion algorithm mainly focuses on low power, energy efficient routing and locating optimal sink position is developed over few years. The main focus is on the optimal sink relocation. Introduction of relay nodes in conjunction with sensor nodes moderate the geometric deficiencies of the network because the sensor nodes near to the sink involves in data forwarding in more times makes their battery to get depleted quickly. A particle swarm optimization (PSO) [15] algorithm is used to locate the optimal sink position with respect to the relay node makes the network more efficient. PSO uses the relay node to communicate with the sink instead of sensor nodes, which saves the battery power of each sensor node. This algorithm is based on the social behavior of bird flocking. It uses initializing population of random solutions and it searches for the optima by updating the generation. In PSO each solution is consider as a particle and PSO uses several particles to represent a solution and searches the best particle position according to the given fitness function. The main advantage of the proposed system is it uses the relay node which solves the connectivity issue. Also increases the lifetime without any damage in the network. No efficient routing protocol is discussed.

MobiCluster, a protocol [16] that uses urban buses as Mobile Sink (MSs) to retrieve information from isolated parts of WSNs. Main objective of the MobiCluster is to employ the MSs for collecting the data from the isolated urban sensor islands. The objective also includes prolonging the lifetime of the selected peripheral rendezvous nodes (RNs) that is present on the passing range of MSs and these nodes are used to deliver sensory data from remote source nodes. MobiCluster mainly aims at maximizing connectivity, data throughput, and also balanced energy expenditure among sensor nodes.

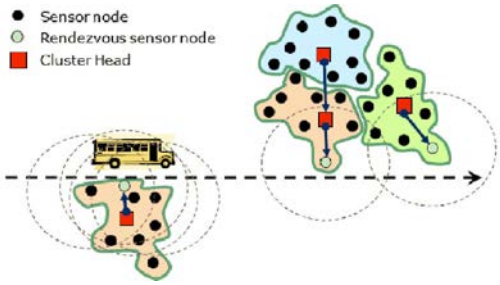

Fig.5.Mobicluster Architecture

By regulating the number of RNs to deliver their buffered data in an adequate time will increases the data throughput and also prevents the data loss. Mobi Cluster gives the balanced energy consumption across the WSN by its cluster structure that provides the high redundancy of data that is collected from the neighbor nodes and also minimize inter cluster data overhead when compared with other approaches. The performance gain of MobiCluster over alternative approaches has been validated by extensive simulation tests.

During the data transmission in wireless sensor network (WSNs), the nodes which are closer to the sink use their energy more and quickly when compared with other nodes. So there will be energy imbalance between the sensor nodes in the network leads to connectivity holes and a coverage hole which causes the network failure. This problem can be tackled by means of technique called optimal relocation of the mobile sink which will balance the load between the sensors. Relocation [17] is achieved by using the bio-inspired digital hormone model. This model guides the sink nodes to move towards the optimal location which will increase the network lifetime and reduces the energy imbalance. Results obtained from the simulation shows that the proposed model increases the lifetime better than the other models. In future the proposed model not only increases the lifetime but also increases the performance of the network such as latency, bandwidth, and end to end delay.

Increasing the network lifetime of the sensor node is achieved by many research methods. In case of mobile sink there are the track based methods and the anchor points based methods for operating the sinks. The static mobile path does not consider the query position and the data priority decreases the Quality of the Service (QoS) of the network and also produces the hotspot in the network. The novel approach explains the collection of data by relocating the hybrid sinks using the scheduling strategy [18]. The proposed method collects the data from sensor node by using both stationary and mobile sink sensor nodes. The separation of nodes depends on the power and packet ratio. The nodes with low power and high packet production rate are defined as “vital” node and the nodes having high power and low packet rate are defined as “non-vital” nodes. Data from the vital node is collected by the stationary nodes. The group of forwarding nodes is selected based on their power and data from the vital node is send to the stationary node through the forward node. The data from the non vital node is collected by the moving sink. Power efficient algorithm is used to relocate the sink and TDMA is used as a Mac layer protocol states which results in the sinking of the state transitions and the energy utilization. The proposed system increases the overall energy consumption and extends the lifetime of sensors and the whole network.

Virtual Line based Data Dissemination (VLDD) is the energy efficient [19] and reliable data dissemination protocol mainly focus on energy efficient and reliable data delivery. In VLDD instead of flooding Virtual Line Structure (VLS) is used for data storage in the specified region. Each source stores its data in the VLS and from VLS sink collects data required for it in its location when it needs. It uses both individual and group mobility scheme to support the mobility of the group sinks. The system avoid overhead occur due to flooding and also decreases the energy consumption although increase in large group region. But VLS is constructed every time when sink moves to new location. This increase the communication over head.

A survey of the existing distributed mobile sink routing protocols are discussed [20]. With respect to the rationale and concerns of a mobile sink routing protocol, requirements needed for design and challenges associated with the problem of mobile sink routing are determined and explained. The advantages and drawbacks of the protocols are also discussed. Each determined classes of protocols have different benefits which act as a motivation for new solutions. In hierarchical approach, a virtual structure is used which is the important one and this serves as a rendezvous region for the sink advertisement and data packets. It also reduces the overhead of the sink advertisement by confining it to a subset of the network, but the high-tier nodes constituting the structure are become hotspots because they carry more traffic. Virtual structures like Grids, clusters and backbones have high accessibility because they have uniform distributed structure which will cover the whole network, but the hotspot mitigation strategy requires more effort because high overhead happens while modifying these complex and dense structures. Non-hierarchical approaches also have both the benefits and the drawbacks of a virtual hierarchy and also the non-hierarchical approaches are able to operate without position-aware sensors since the employed mechanisms rarely rely on a geographic coordinate space. In spite of these advantages, the mechanisms employed by the non-hierarchical approaches are usually inefficient or costly.

In wireless sensor network depletion speed of battery energy of each sensor node will affect the network lifetime significantly. So many researchers designed the energy-aware routings which will conserve the usage of the battery energy to

prolong network lifetimes [21]. A relocatable sink is an approach which will increases the network lifetime by avoiding staying at a certain location for too long which may harm the lifetime of nearby sensor nodes. This approach not only solves the problem of the hot-spot, but can also integrate the energy-aware routing to enhance the performance of the prolonging network lifetime. In this paper, an energy-aware sink relocation method (EASR) is proposed which adopts the energy-aware routing maximum capacity path (MCP) as the underlying routing method for message relaying.

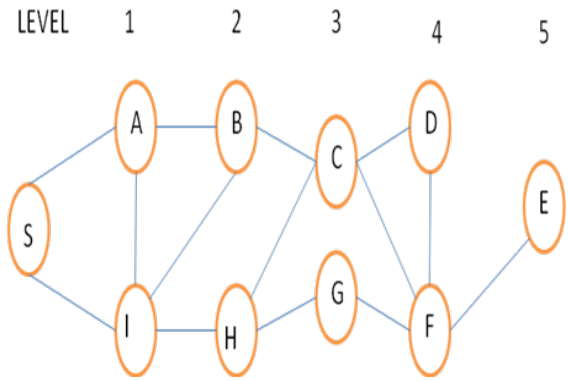

Fig.6. Maximum capacity path(1)

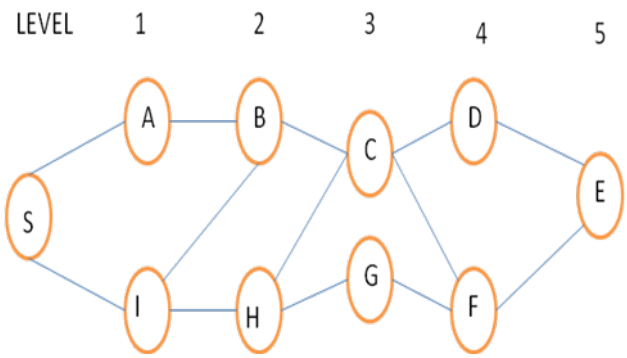

Fig.7. Maximum capacity path(2)

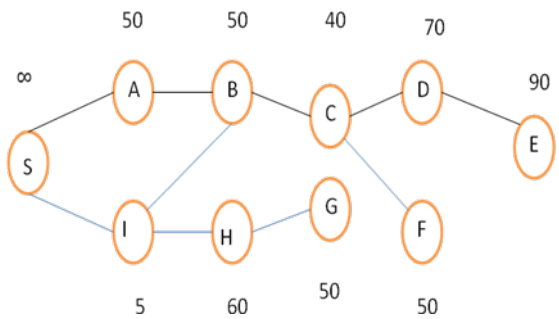

Fig.8.Maximum capacity path(3)

The Fig.6, Fig.7, Fig.8 explains the MCP algorithm. The fig 6 shows WSN and its current residual battery energy state of sensor node can be modelled by a capacity graph $G = (V,E)$, where set V denotes the collection of sensor nodes and E denotes all of the possible direct communication between sensor nodes. And let $r: V \rightarrow R+$ be the residual battery energy function to represent each sensor's residual battery energy. In fig 7 layering graph G into a layered network N using the condition uu = uv+1. In Fig.8 maximum capacity path for data transmission is decided. If node E wants to transfer the data to sink the maximum capacity path is E-D-C-B-A-S. Although the path E-D-C-B-I-S is also available for data transmission but

its capacity is very less when compared with other path. The proposed mechanism uses information about the residual battery energy of sensor nodes and adaptively adjusts the transmitting range of each sensor nodes and the mechanism to relocating the sink. The proposed system solves the hotspot problem and Prolong the lifetime by relocating the sink before its reaches the failure but it has the Time complexity

A mobile sink based obstacle avoidance routing protocol is proposed to monitor the environment of the smart homes [22]. In recent times sink mobility place vital role in smart environment. The sensor node which is deployed on the smart environment will detect the obstacles that are present by using the infra red signal coupling and also improve the transmission of data to the mobile sink using ZigBee. Moreover, the mobile sink implements obstacle avoidance to find the shortest path to collect data from static deployed sensor nodes. The results obtained from the research shows that the network lifetime can be increased 30% when compared to the previous static sink based data collection schemes. This implementation is mainly designed to work with the intelligent pervasive consumer products and services that include robotic vacuum cleaners and personal security robots.

Mobile Sink Based Reliable and Energy Efficient Data Gathering technique (MSREEDG) for single mobile sink and Efficient Routing Protocol [23] for Multiple Mobile Sink Based Data Gathering (ERMMSDG) technique for multiple mobile sink are proposed for efficient data transmission. The main differences between the two protocols are the usage of routing protocol by multiple mobile sink. The next position of the sink is determined by the biased random walk method. The optimal data transmission path is selected by means of rendezvous point selection with splitting tree technique. If the sink moves inside the rendezvous point it collects the received data from the source otherwise it selects the relay node from the neighbours to relay packets from the rendezvous point. In second case sink acts as a vehicle and collect the data from sensor. The system supports sink mobility with low overhead and delay with increase in reliability and delivery ratio. Also sensor transmits the data to the sink by encoding it using RS coding technique. The sink decodes the received data to get the original bundle of data. Pause time between the data depends on the node density and received encoded data. This will improve the performance of the nodes. Some advantages of the proposed are it Increase in reliability also increases the energy efficiency and reduces the signal overhead. Triangular routing problem is the important issue of the proposed system.

A novel Virtual Grid based Dynamic Routes Adjustment (VGDRA) scheme that will decreases the communication cost by maintaining the nearly best possible routes to the current location of the mobile sink is proposed [24]. In VGDRA scheme partition of the sensor field into a virtual grid is done and a virtual backbone structure is constructed which is comprised of the cell header nodes. When the mobile sink crosses the sensor field keeps on changing its location and interacts with the closest border-line cell-header for data collection. Route reconstruction process will take place by limited number of cell headers by using a set of communication rules, which will reduces the overall communication cost and also increases the energy efficiency by route reconstruction. But the node selected as cell header drains the network and break the transmission.

Based on the survey done in the routing, security and trust systems mechanisms of the vehicular networks and ad hoc networks two layer trust based information dissemination framework called FACT is proposed according to their application needs[25]. FACT will support the broadcast, multicast, and unicast communication in vehicular networks. FACT will maintain a list which contains the trusted list of neighborhoods to check the trust worth of the message. After receiving message from the trusted nodes it will select the best routing path to carry the message. This will increase the scalability of the protocol and also effective communication cost. FACT supports the delivery of message in a safe path in a short period of time with increase in the reliability of the network. FACT is an application framework so designers can incorporate their own routing scheme and transmit the data in a safe way.

An adaptive scheme is proposed to increase the efficiency of the nodes that are present in the network [26]. The main idea behind the scheme is to change the routing strategy adaptively based on the quality of the channel. Then the mathematical analysis of the adaptive protocol is done by using the medium access procedures of the IEEE 802.15.6 standard and also the analytical model is determined through simulations. When compared with other existing scheme, adaptive scheme provides 54% reduction in energy cost information bit. The investigation of BSN nodes which supports the activity recognition models [27] and the methodology which supports the model is designed and proposed. The methodology designed uses the randomized trees based on the collaborative training strategy. In the collaborative training phase, each nodes share their data and their models according to the randomized trees to the other nodes of the network. The recognition performance is based on the junk. The methodology uses three datasets with multiple sensor nodes. The node is replaced by a new node in the same position or a node is replaced by a new node from new unknown position. The evaluation can be done

using the k-folds cross validation protocols with different amount of junk data for each node. The minimum of 17% junk data and maximum of 80% is used for evaluation.

III. CONCLUSION

In this paper a comprehensive survey of different mobile sink relocation techniques for increasing the lifetime of the wireless sensor network was carried out. Also different energy efficient routing protocols for mobile sinks are discussed. Much work still needs to be done in this field to achieve high performance by increasing the lifetime and finding the efficient transmission for data transfer in WSNs.

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