Data Dissemination in Wireless Sensor Networks: A State-of-the Art Survey

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Abstract

A wireless sensor network is a network of tiny nodes with wireless sensing capacity for data collection processing and further communicating with the Base Station this paper discusses the overall mechanism of data dissemination right from data collection at the sensor nodes, clustering of sensor nodes, data aggregation at the cluster heads and disseminating data to the Base Station the overall motive of the paper is to conserve energy so that lifetime of the network is extended this paper highlights the existing algorithms and open research gaps in efficient data dissemination.

Keywords: Data Dissemination, Clustering, Aggregation, Sensor Nodes, Wireless.

1. INTRODUCTION

Wireless Sensor Networks (WSNs) is the fast growing research area from more than a decade and the pace is still increasing. The latest trend in Micro-electromechanical systems (MEMS)-based sensor technology has enabled the development of relatively inexpensive and low power wireless sensor nodes. Wireless Sensor Networks (WSNs) are applicable in various areas including vehicle tracking, habitat monitoring, forest surveillance, earthquake observation, biomedical or health care applications, and building surveillance. In these applications sensors are usually densely deployed remotely and are made to operate autonomously. The conditions are generally harsh and the sensors are unattended, hence sensors cannot be charged, so energy constraints is the most critical problem that must be considered. Much of the work is being done on number of issues but still there is lot of gaps present in this area. Deployment of tiny nodes in any type of conditions is not an easy task when there is no source of power backup once the battery is drained out. These tiny nodes have to collect data in extreme conditions, process the data and further send it to the Base Station through intermediate cluster heads or neighboring nodes with single-hop or multi-hop communication. During communication there are many mile-stones i.e. how to collect data, which data needs to be discarded, how clusters are to be formed, how to set cluster boundaries, how data is aggregated at the cluster head, how data is transferred to the Base Station for further processing, how to secure this data at every step[1].
Network lifetime i.e. the time till network is alive and able to provide all the services to the application is the most dominant parameters considered in designing the protocols for WSNs. The considerable improvement in network lifetime can be achieved either by reducing the number of hops travelled by a packet to reach its destination (i.e., a BS) or by reducing the amount of energy consumed across all the nodes in the network [2].

The rest of the paper is organized as follows: In Section 2, we discuss about the clustering process, various clustering algorithms and open issues in the existing literature. Section 3 lists the various in-network data aggregation strategies and research gaps in the present literature. In Section 4 we discuss various Mobility models and research gaps. Finally, we conclude the paper in Section 5.

2. CLUSTERING

Heinzelman et al. [3] proposed LEACH algorithm i.e. Low-Energy Adaptive Clustering Hierarchy. It uses a distributed algorithm to form clusters and nodes make autonomous decisions without any centralized control. In this algorithm, a node decides to be a CH with a probability p initially and broadcasts its decision. Each non- CH node determines its cluster by choosing the CH that can be reached using the least communication energy. The algorithm provides a balancing of energy usage by random rotation of CHs. It forms clusters based on the received signal strength and uses the CH nodes as routers to the base-station. No overhead is wasted making the decision of which node becomes cluster-head. CDMA allows clusters to operate independently, as each cluster is assigned a different code. Each node calculates the minimum transmission energy to communicate with its cluster-head and only transmits with that power level. Changing the CH is probabilistic in LEACH; there is a good chance that a node with very low energy gets selected as a CH. When this node dies, the whole cluster becomes non functional. LEACH is not applicable if the CHs are far from the base station. Therefore, a large number of algorithms have been proposed to improve LEACH, such as PEGASIS [4], TEEN [5], APTEEN [6], MECH [7], LEACH-C [8], EEPSC [9].

Loscri et al. [10] proposed Two-Level LEACH (TL-LEACH) algorithm which is an extension of the LEACH algorithm. It utilizes two levels of cluster-heads (primary and secondary) in addition to the other simple sensing nodes. In this algorithm, the primary cluster-head in each cluster communicates with the secondary, and the corresponding secondary communicate with the nodes in their sub-cluster. Data-fusion can also be performed as in LEACH. In addition, communication within a cluster is still scheduled using TDMA time-slots. The organization of a round will consist of first selecting the primary and secondary cluster-heads using the same mechanism as LEACH, with the a priori probability of being elevated to a primary cluster-head less than that of a secondary node. The two-level structure of TL-LEACH reduces the number of nodes that need to transmit to the base station, effectively reducing the total energy usage. It might not be effective if the CH is far from the base station

Ye et al. [11] proposed an Energy Efficient Clustering Scheme (EECS) in which cluster-head candidates compete for the ability to elevate cluster-head for a given round. This competition involves candidates broadcasting their residual energy to neighbouring candidates. If a given node does not find a node with more residual energy, it becomes a cluster-head. Cluster formation is different than that of LEACH. LEACH forms clusters based on the minimum distance of nodes to their corresponding cluster-head [4]. EECS extends this algorithm by dynamic sizing of clusters based on cluster distance from the base station. The result is an algorithm that addresses the problem that clusters at a greater range from the base station requires more energy for transmission than those that are closer. Ultimately, this improves the distribution of energy throughout the network, resulting in better resource usage and extended network lifetime. However clusters closer to the base station may become congested which may result in early CH death.

Younis et al. [12] proposed a clustering algorithm i.e. Hybrid Energy Efficient Distributed Clustering (HEED). It is a multi-hop clustering algorithm for Wireless Sensor Networks. CHs are chosen based on two important parameters: residual energy and intra-cluster communication cost. Residual energy of each node is used to probabilistically choose the initial set of CHs, as commonly done in other clustering schemes. HEED is a distributed clustering scheme in which CH nodes are picked from the deployed sensors. HEED considers both energy and communication cost while selecting CHs. Unlike LEACH, it does not select cluster -head nodes randomly. Only sensors that have a high residual energy can become cluster-head nodes. HEED has three main characteristics: For a given sensor's transmission range, the probability of CH selection can be adjusted to ensure inter-CH connectivity. In HEED, each node is mapped to exactly one cluster and can directly communicate with its CH. The algorithm is divided into three phases: Initialization, repetition and finalization.

Li et al. [13] proposed Energy-Efficient Unequal Clustering (EEUC) algorithm. In multi-hop WSNs, there exists a hot-spot problem that CHs closer to the base station tend to die faster, because they relay much more traffic than remote nodes. EEUC (Energy- Efficient Unequal Clustering) proposed to balance the energy consumption among clusters, in which the cluster sizes near the sink node are much smaller than the clusters far away from the sink node in order to save more energy in intra-cluster communications and inter-cluster communications. Actually, EEUC is a distance based scheme similar to EECS and it also requires every node to have global knowledge such as its locations and distances to the sink node. It tries to prolong the network lifetime and to balance the load among the nodes. It solves the hot spot problems; cluster size is proportional to the distance to base-Station. However, the extra global data aggregation adds overheads to all sensors and degrades the network performance, especially for a multi-hop network.

Bandyopadhyay et al. [14] proposed a distributed, randomized clustering algorithm for WSNs i.e. Energy Efficient Hierarchical Clustering (EEHC). CHs collect data from the non cluster-head node in different clusters and send an aggregated report to the base-station. This technique is divided into two phases; initial and extended. In the first stage i.e. single-level clustering; each sensor node announces itself as a CH within its communication range with probability p to the neighbouring nodes. These CHs are named as the volunteer CHs. All nodes that are within k hops range of a CH receive this announcement either by direct communication or by forwarding. Any node that receives such announcements and is not itself a CH becomes the member of the closest cluster. Forced CHs are nodes that are neither CH nor belong to a cluster. If the announcement does not reach to a node within a preset time interval t that is calculated based on the duration for a packet to reach a node that is k hops away, the node will become a forced CH assuming that it is not within k hops of all volunteer CHs. The second phase, called multi-level clustering builds h levels of cluster hierarchy. The CHs closest to the base station are at a disadvantage because they are relays for other CHs.

Gong et al. [15] proposed distributed clustering scheme i.e. Multihop routing protocol with unequal clustering (MRPUC). It operates in rounds, and each round is separated into three phases: cluster setup, inter-cluster multihop routing formation and data transmission. Each node gathers the correlative information of its neighbour nodes and elects a node with maximum residual energy as the cluster-head. The cluster-heads closer to BS have smaller cluster sizes to save the energy for heavy inter-cluster forwarding task. The regular nodes join clusters where the cluster-heads have more residual energy and are closer to them. An inter-cluster routing tree is constructed as network backbone, and data is transmitted to BS via multi-hop communication. This algorithm prevents early CHs death because the inter cluster communication also depends on the residual energy. CHs route to the neighbouring CH having the highest residual energy. The Inter-cluster multihop routing formation may cause an additional overhead.

To solve the problem of existing clustering algorithms of energy consumption due to cluster formation overhead and fixed level clustering for densely deployed wireless sensor nodes; Yi et al. [16] proposed Power-efficient and adaptive clustering hierarchy (PEACH). PEACH minimizes the energy consumption of each node, and maximize the network lifetime. In PEACH, cluster formation is performed by using overhearing characteristics of wireless communication to support adaptive multilevel clustering and avoid additional overheads. In WSNs, overhearing a node can recognize the source and the destination of packets transmitted by the neighbour nodes. PEACH is applicable in both location-unaware and location-aware sensor networks. Based on its overhearing characteristics, PEACH saves energy consumption of each node and hence prolong network lifetime.

Hanh et al. [17] proposed Sensor Web or S-WEB which divide the sensing field into clusters bordered by two arcs of two adjacent concentric circles and two adjacent radii originating at the BS. Each cluster is identified by angle order (β) and the order of Signal Strength threshold (δ). To do so, the BS in S-WEB will send beacon signals for every α degree angle, one at a time. Sensors that receive the beacons at time slot i will measure their signal strength to determine their relative distances to the BS. Let T be a predefined distance (which is inversely proportional to the received signal strength). All sensors which receive beacon signals at angle order βi (=i*α) with signal strength of δj*T (within sector j) will be in the same group/cluster, denoted as (βi, δj). Nodes with the same (β, δ) or in the same cluster can select a CH based on its residual energy. Since nodes in the same cluster know about each other, the role of being a CH can be rotated to prolong the lifespan of CH. S-WEB is a hybrid technique since most tasks are performed by the nodes, except the beacons are generated from the BS.

2.1 Open Research Issues

For large scale wireless sensor networks, clustering is most convenient and a useful topology management approach to reduce the communication overhead and exploit data aggregation in sensor networks. Large number of clustering algorithms is present but energy consumption during cluster formation and maintenance is still high. There are lot of compelling challenges for clustering algorithms i.e. to schedule concurrent intra-cluster and inter-cluster transmissions, to compute the optimal cluster size, and to determine the optimal frequency for cluster head rotation in order to maximize the network lifetime, to handle heterogeneous network, to set boundaries of the cluster, rotation of the cluster head if mobility is applied, reorganizing clusters when some of the sensor nodes are dying.

3. DATA PROCESSING WITHIN THE NETWROK

In WSNs, aggregation techniques and routing protocols are not independent, rather interdependent. Routing protocol design takes into consideration the targeted data aggregation at some network nodes and accordingly decides packet routing mechanism. Similarly, while designing aggregation technique the routing protocol used underneath plays a vital role.

3.1 Data Aggregation within the network

In WSNs, data generated by different sensors can be jointly processed while being forwarded toward the sink. Data aggregation is the simplest type of in-network processing which combines data from different sources or nodes into a single entity. Data aggregation techniques are closely related to the way data is gathered at SNs as well as how packets are routed through the network. Data Aggregation has significant impact on energy consumption and overall network efficiency. However, data size reduction through in-network processing should not diminish required granularity of information about the monitored event. Also, apart from reducing many network overheads, it should be useful in enhancing network lifetime. According to [18], "in-network aggregation is the global process of gathering and routing information through a multi-hop network, processing data at intermediate nodes with the objective of reducing energy consumption, thereby increasing network lifetime".

3.2 Types of Data Aggregation in WSN

Data aggregation can be classified as in-network aggregation with data size reduction and in-network aggregation without data size reduction.

Aggregation With Data Size Reduction: This is a process of combining data from different sources to a data unit which is much smaller than the total size of individual data from different sources. The aim is to reduce the size of information to be sent over the network.

Aggregation Without Data Size Reduction: If data packets from different sources or nodes are combined into one packet without any processing like, average, min, max, median etc. For example, suppose SNs are programmed to measure two different event parameters namely temperature and pressure. A cluster-head node receives a packet comprising temperature reading from one node and pressure reading from another. These two readings cannot be averaged but surely can be put into one larger packet as such and instead of two separate packets cluster-head transmits single packet.

3.3 Data Aggregation Strategies

Though most data-aggregation protocols can be classified according to the network architecture, some protocols pursue a different approach where sensor network is represented as a graph. Such protocols where data aggregation is modeled as a network flow problem are classified as network-flow-based protocols. The main goal of network-flow-based protocols is optimization of network lifetime considering energy constraints on sensor nodes and flow constraints on information routed in the network[19].

Kalpakis *et al.* [20] studied the maximum lifetime data gathering with aggregation (MLDA) problem employing efficient data-aggregation algorithms. The goal of the MLDA problem is to obtain a data-gathering schedule with maximum lifetime where sensors aggregate incoming data packets. The sensor network is modeled as a directed graph. The edges of G have an associated capacity which indicates the number of packets transmitted from node i to node j. An optimal admissible flow network is obtained using integer programming with linear constraints. The integer program computes the maximum system lifetime T subject to energy constraints of the sensors and capacity constraints on the edges. To alleviate this problem, a clustering-based approach called greedy CMLDA has been proposed to obtain efficient data gathering schedules in large networks. Each cluster is referred to as a super-sensor. A maximum lifetime schedule is first obtained for the super-sensors which is then used to construct aggregation trees for the sensors. The initial energy of each super-sensor is equal to the sum of the initial energies of all the sensors within it. The time complexity of the approach is polynomial in the number of sensors, which involves solving a linear program with $O(m^3)$ variables where m is the number of clusters [21].

Xue *et al.* [21] have studied the data-aggregation problem in the context of energy efficient routing for maximizing system lifetime. The problem was modeled as a multicommodity flow problem, where the data generated by a sensor node is analogous to a commodity. The objective of the multicommodity flow problem is to maximize the network lifetime T (time until first node dies), subject to flow conservation and energy constraints. A Maxconcurrent flow (Maxlife) algorithm was proposed which computes a shortest path for one commodity at each iteration of the algorithm. This is followed by updating the weight of each sensor S_k which represents the marginal cost of using an additional unit of the sensor's energy reserve. Since all data sources share a common destination, a shortest path tree rooted at the data sink is eventually formed. For the multi-sink data-aggregation problem, a modification of Dijkstra's shortest path tree algorithm has been used. The objective is to compute an aggregation forest which is a unification of M trees routed at data sinks 1, 2, …, M [19].

Hong *et al.* [22] have formulated data gathering problem as a restricted flow optimization problem. The goal of maximal data gathering problem (MDG) is to maximize the number of data gathering rounds subject to the energy constraints of the sensors. The energy constraints on the nodes are transformed into edge capacitates. The quota constraint requires each node to generate a fixed number of packets in a given round. The MDG problem is reduced to a restricted flow problem with edge capacities (RFEC). The sensor network is modeled as a graph and the RFEC problem determines whether or not there exists a data flow which satisfies the flow constraints, quota constraint, and the edge-capacity constraints. The RFEC algorithm finds the shortest augmenting path P from the source to the sink. The RFEC algorithm obtains an integer valued solution that specifies the number of data packets to be transferred between two neighboring sensors for each round. The shortest path heuristic may not obtain the optimal solution because it searches over possible paths in the original graph instead of the residual graph. Examples have been presented in [22] where for networks with four or more sensors, the MLDA algorithm [20] achieves only 50 percent of the optimal system lifetime [19].

In sensor networks, the data gathered by spatially close sensors are usually correlated. Cristescu *et al.* [23] have studied the problem of network-correlated data gathering. When sensors use source coding strategies, then there is a joint optimization problem which involves optimizing rate allocation at the nodes and the transmission structure. Slepian–Wolf coding and joint entropy coding with explicit communication have been investigated in the context of data gathering. In Slepian– Wolf coding, optimal coding allocates higher rates to nodes closer to the sink and smaller rates to the nodes at the extremity of the network. In the explicit communication model, larger rates are allocated to nodes farther from the sink and smaller rates to nodes closer to the sink. The sensor network is represented as a weighted graph.

An optimal Slepain–Wolf rate allocation scheme has been proposed in [23]. In this scheme, the closest node to the sink codes data at a rate equal to its unconditioned entropy. All other nodes code at a rate equal to their respective entropies conditioned on all nodes which are closer to the sink than themselves. The main disadvantage of this scheme is that each sensor requires global knowledge of the network in terms of distances between all nodes. To overcome this problem, a fully distributed approximation algorithm has been proposed which provides solutions close to the optimum. In this scheme, data are coded locally at each node, and the conditioning is performed only on the neighbor nodes which are closer to the sink than the respective node.

3.4 Open Research Issues

Despite of lot of research in In-network data aggregation, there are still open research gaps present i.e. to build data management frameworks for various application-specific data aggregation schemes, data naming is another aspect of data management which needs ore exploration, disparity between the amount of data generated and actual data required for data transmission, In dense networks, significant correlation is expected which helps in reducing the size of data.

4. MOBILITY

Mobility can finally be used as a tool for reducing energy consumption. In a static sensor network packets coming from sensor nodes follow a multi-hop path towards the sink(s). Thus, a few paths can be more loaded than others, and nodes closer to the sink have to relay more packets so that they are more subject to premature energy depletion (funneling effect). If some of the nodes (including, possibly, the sink) are mobile, the traffic flow can be altered if mobile devices are responsible for data collection directly from static nodes

4.1 Mobile Sensor Nodes

Howard et al. [24] presented an algorithm for robotic sensors to maximize coverage while maintaining line-of-sight contact among robots. Howard et al. [25] in another paper presented a theory of potential field to distribute the mobile sensors throughout a given area. It also presents an algorithm to repel mobile sensors from obstacles and other nodes. Goldenberg et al. [26] presented an idea to have the sensors move into positions that minimize the energy cost of reporting streams of data to the sink, which is tactically placed. Wang et al. [27] proposed a protocol that aims at moving mobile sensors from densely deployed areas to areas with coverage holes, where for some sensors a limited number of sensors have been deployed. Wang et al. [28] in another paper suggests that nodes move logically to minimize energy consumption and maximum area coverage. Rao et al. [29] presented a mobility algorithm to reduce transmission power needed to send data to static sink. Positions of moving sensors are determined via "distributed annealing" [29].

4.2 Mobile Relays

The concept of Mobile Relays is proposed by Chatzigiannakis et al. in 2004. Shah et al. [30] introduced a scheme of MULEs i.e. forwarding agents with single hop networks. An algorithm is proposed for avoiding sensor nodes buffer overflow while minimizing the speed of mobile relays. The algorithm is extended by having "urgent" flag with the urgent messages. The investigation of controlled use of relay nodes for data collection and subsequent report to the sink is proposed by

Kim et al. [31]. It is proved that MULEs are effective for energy conservation in so-called delay tolerant networks i.e. energy is traded off for latency is explained by Small et al. [32]. It means that the energy needed to communicate a packet to the sink is decreased at the cost of waiting for a MULE to pass by and cost of waiting for the MULE to reach sink node. Song et al. [33] studied a model of sensor-o-sink transmission. Tirta et al. [34] stated that nodes send data to cluster-heads in a multi-hop fashion. Tirta et al. [35] in another paper states that unmanned Relays can only visit to cluster-heads. Relays are recharged at sink nodes. Different classes of nodes and controlled and uncontrolled movement of collectors are considered. Its goal was to schedule collector's visit to the nodes to minimize transmission energy consumption, data latency and nodal buffer requirements. Kansal et al. [36] discussed that how to include mobile relays into the network. An implementation with one mobile relay (robot) is presented with single-hop communication and network application priorities.

Jea et al. [37] Extended the work of Kansal et al. [36] with multiple controlled mobile elements. It considers two cases: first was to deploy nodes uniformly and randomly and second was to distribute nodes differently i.e. non-uniformly. In the first case, criteria is given to chose number of nodes by number of MULEs and in second case, a load balancing algorithm is introduced for distributed number of nodes to number of MULEs. MULEs travel in a straight line and gathers information. They elect a leader and sends whole of the data to the leader. The leader runs the load-balancing algorithm. It tackled the problem of scheduling visit to the sensor nodes of a single relay. Somasundara et al. [38] states that the corresponding Mobile Element Scheduling (MES) problem is proven to be NP – Complete and Centralized analytical model (ILP) and algorithms are given for solving the problem. Somasundara et al. [39] in another paper discussed on the advantages and challenges of controlled mobility.

Ekici et al. [40] discussed a new approach to exploit mobility (Morph) and benefits to sensor network sustainability. Wang et al. [41] in another paper addressed the use of controlled mobility and defined how mobility introduces improvements in wireless sensor networks performance. Giuseppe et al. [42] presented a systematic and comprehensive taxonomy of the energy conservation schemes. It also considered techniques for energy efficient data acquisition.

4.3 Mobile Sinks

Directed diffusion, TTDD, ADMR algorithms with static sink are presented in [43–45] respectively. Scalable Energy-Efficient Asynchronous Dissemination (SEAD) where a tree-like communication structure is built and maintained is presented. The sink moves randomly to sensor nodes in the tree. Communication between sink and the access points can be multi-hop. The trade offs are that the data latency and energy needed for tree reconfiguration. Tong et al. [46] states that this algorithm is best for data dissemination with mobile sink. The main contribution is towards energy efficient transmission to the passing sink [47–50]. Sinks move along the same route repeatedly. Hwang et al. [50] determines the transmission range needed to collect data from a predefined percentage of the sensor nodes, given the observer speed, the time required to transmit a packet, and different traffic patterns. Various methods for building and maintaining routes to a mobile sink are presented [51–53]. Hu et al. [51] presents local update techniques for detecting disconnections and performs route repair in "sink-oriented trees". Akkaya et al. [52] proposed ERUP protocol for conducting route rediscovery only in the vicinity of the damaged route. Xuan et al. [53] presents initial route building. Sink moves, if route is invalid, forwarded nodes are designated to extend the current. Sink moves according to the random waypoint model [46, 48, 54]. Sink (airplanes) are introduced where movement of sink is fully controlled.

Heterogeneous sensor networks with two types of nodes: Type 0 and Type 1. Type 0 does basic sensing; perform short-range communications partitioned into clusters are presented. Type 1 nodes are the cluster-heads. They do sensing, aggregation and perform long range communication. Kansal et al. [49] in another paper aims to determine the optimum node deployment nodal energy needed to achieve a given network lifetime while ensuring sensing coverage and radio connectivity with high probability. The inherent pattern of the sink movement for the design of robust and energy-efficient routing is exploited. Baruah at al. [55] states that the sensor nodes learn about sink whereabouts at given times via statistics techniques as well as methods from distributed reinforcement learning.

Network controlled sink mobility for reducing energy consumption and for maximizing the lifetime of a sensor network is presented. An ILP model is presented that determines the locations of multiple sinks as well as the routes from the sensors to the sinks. Time is divided into rounds. Each round calculates the next location of sink by considering minimum energy consumption parameter. ILP is solved at every round [55–58]. The problem of network lifetime maximization through controlled sink mobility for networks with single sink is addressed. Sink has no limitation for time spent at each node, no location constraint. The network lifetime is improved by five times. Sink moves at five positions in a grid. A solution that provides two times more lifetime than [57] is presented. It solves the problem of determining the sink sojourn times at the given sites. It also presents routing of the packets to the current position of the sink [59]. The idea of lifetime maximization as a min-max problem is proposed. Together sink mobility and data routing is considered. A load balancing solution is presented that, while keeping the sink moving along the external perimeter of the network, achieves lifetimes 500% higher than when the sink stays still in the center of the network [24]. Mixed Integer Linear Programming (MILP) considers data communication cost constraints of sensor network and sink mobility [60–61]. GMRE, heuristic approach, TTDD and SEAD are explained in [42].

4.4 Open Research Issues

In case of mobile sensor nodes, the cost associated with the sensor movement as well as the cost of transmitting sensed data is not yet explored. Lot of research is done in controlled mobility of relay nodes but there is a scope of improvement in case of uncontrolled mobility. Different network topologies and routing algorithms can be implemented in case of mobile relay nodes. Till now, static sinks are being deployed and proved to provide better network efficiency but more than one sink and mobility of sink needs to be explored more with different network topology and routing algorithms.

5. CONCLUSIONS

Wireless Sensor Networks is the fastest growing area and considered as the revolutionary concept of the present and future. Lot of work is reported on single-hop and multi-hop clustering. Due to which cluster-head nodes die faster and cluster-head nodes nearer to sink nodes become relay nodes for whole of the network. Very less work is reported on increasing the lifetime of those relay nodes. Lot of work in WSN study exists to reduce energy consumption in a WSN. Few of them are: to compress data before dissemination; to find optimal paths between source and sink for data transfer; to find proper aggregation points in the network; aggregate smaller units into larger units (fusion) for transmission from different sources or generated at different times. Lot of work is reported in the review about exploiting correlation to decide when to do aggregation and how to forward highly correlated data as well as unrelated data. However, insignificant work yet exists to block and isolate undesired/unnecessary data nearer to its source of generation based on its value. Blocking such data early in its journey towards sink can avoid many unnecessary inter-node transmissions resulting in energy savings. Lot of work is reported on sensor nodes movement but cost associated with the sensor movements and cost associated for transmitting sensed data is not considered. Lot of models have been proposed for Relay node’s movement by existing protocols but new routing protocols for sensors- relay nodes and relay-sink nodes need to be developed. Energy conservation is another area, which is not covered extensively so far. Very less work is reported on timely discovery of mobile elements and transmission scheduling at sensors. Very less work is reported on the possibility of collision, corresponding energy cost, cost of building and maintaining routes, impact on network lifetime in case of sink nodes.Our survey covers almost all the areas from data collection at sensor nodes to data dissemination to the sink nodes and discusses the research gaps at every step.

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