# A SURVEY OF DATA COLLECTION TECHNIQUES IN WIRELESS SENSOR NETWORK

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***ABSTRACT***

*The challenges in wireless sensor network (WSN) are detecting the relevant quantities, controlling and merging the data, allocating and estimating the information, formulating significant user displays, and performing decision-making etc. Existing work had the intention of reducing the completion time of converge cast. Data collection is one of the most important operations of wireless sensor networks. Various data collection techniques designed for sensor networks and many practical applications require the real-time data transmission, such as controlling, tracking, etc. In this paper, we represent a survey of data gathering techniques to get the increasing capacity, routing protocols along with algorithms proposed for remote wireless sensor networks. We find, these schemes usually try to discover the least amount energy path to optimize energy usage at a node. Our goal is to provide a better understanding of the current research issues in this field. We also try to investigate of its various designing constraints and the use of certain tools to meet the design objectives.*

***KEYWORDS:*** *Wireless Sensor Network, Routing Protocol, Data Gathering, Data Collection Techniques*

## I. INTRODUCTION

The objective of the data-gathering problem is to send out the sensed data from every sensor nodes to a base station. One thing is defined as the base station collecting data from every one of the sensor nodes only one time. The goal of algorithms which perform data gathering is to increase the number of rounds of communication earlier than the nodes die and the network becomes inoperable. This means minimum energy should be consumed and the transmission should take place with minimum delays, which are disputed requirements. Hence, the combination of energy with delay metric is used to comparing different algorithms, since this metric measures speedy and energy-efficient data gathering. Convergecast, that is the gathering of data from a set of sensors en route for a common sink over a tree based routing topology, is a most important operation in wireless sensor networks (WSN) [1].

In numerous applications, it is fundamental to make available assurance on the delivery time as well as increase the rate of such data gathering. For example, in security and mission-critical applications everywhere sensor nodes are deployed to sense oil/gas leak or structural destroys, the actuators and controllers require to getting data from all the sensors within a specific deadline, failure of which might lead to unpredictable and disastrous events. This falls under the class of one-shot data collection. In this survey, we consider such applications and focus on the following fundamental question: “On tree based topology how faster data can be streamed from a set of sensors to the sink” Here we are discussing two types of data collection methodology: (i) aggregated (ii) raw-data convergecast. Aggregate convergecast is suitable when tough spatial association presents in the data, or the purpose is to gather summarized information such as the maximum sensor reading. On the other hand, raw data convergecast is applicable when every sensor reading is uniformly significant, or the correlation is minimal. One of the basic operations of a sensor network is data aggregation. During the data aggregation, sensed data is gathered from different sensors (data source), combined at intermediate nodes, and eventually transmitted to the base station (data sink) for more processing. One of the most significant challenges in designing an efficient data aggregation scheme is the energy constraint—sensor nodes carry limited, irreplaceable, power supply. These energy-efficient routing algorithms can achieve the goal of either minimizing energy utilization, or maximizing the network lifetime [11].

The rest of the paper is prepared as follows: In Section 2, we examine the possible data gathering schemes in WSNs by identifying the limiting factors. Section 3 we learn what is the wireless sensor network. In Section 4 we give arrangement of presented data collection technique in wireless sensor network. Section 5 introduces a related work and classification method to learning the existing protocols. In Section 6, we analyze the critical analysis with existing dissimilar data gathering methods on WSNs. Section 7, we represent the conclusions.

## II. RELATED WORK

The increasing awareness about wireless sensor networks and the general upcoming out of new architectural techniques motivated some earlier efforts for surveying the distinctiveness, applications and communication protocols for such a technical area. In this part we highlight the features that distinguish our survey and hint the difference in scope. Large scale dense wireless sensor networks (WSNs) will be gradually more deployed in different classes of applications for great monitoring. In this survey, we can go further and propose a latest algorithm, called Efficient Data Collection Aware of Spatio-Temporal Correlation (EAST), which uses straight routes for forwarding the gathered data in the direction of the sink node and fully develop both spatial and sequential correlations to perform near real-time data gathering WSNs [2].

A routing protocol must present fast and reliable techniques for data transmission. Mainly routing solutions for wireless sensor networks utilize static sinks to gather data from the whole network. This approach outcome in high traffic load in the sink's vicinity. The nodes placed near the sink will be more requested than other nodes under the network. Consequently, these nodes will be consuming more energy and face high congestion in a large scale network. In this survey, we found a propose solution to the problem of deploying mobile data collectors in order to improve the high traffic load and resultant bottleneck in a sink's surrounding area caused by static approaches [4].In this survey, we examine the following primary question - how fast can information be gathered from a wireless sensor network prepared as tree? Our survey is latest focused and can provide those who similar to deeper approaching for data collection and routing techniques in wireless sensor networks. To the best of our knowledge, our paper is the first job to build a classification of different data collection techniques in wireless sensor networks.

Many practical applications need the real-time data transmission, such as monitoring, tracking, etc. In his survey, we introduce and define the topology control problem for delay-constraint data collection (TDDC), and then formalize this problem into an integer programming problem. Because of NP-Hardness problem, we represent a load-aware power-increased topology control algorithm (namely LPTC) to heuristically resolve the problem. [5].

For data-gathering applications in wireless sensor networks, it is essential to ensure base station receives a whole picture about the monitored area. Converge cast is an essential communication model commonly used to gather continuous data. The prior broadcast trees are not appropriate for converge cast, because converge cast is a reverse transmit process. The tree protocol constructs an approximate load-balancing convergecast tree. Moreover, the change algorithm dynamically adjusts tree structure to avoid breaking tree link. The tree change only needs localized information and operations at the sensors [6].

We present a capable data reporting control scheme in a cluster-based hierarchical wireless sensor network, which has two mechanisms: (i) intra-cluster data reporting control (IntraDRC) method and (ii) inter-cluster control (InterDRC) method. The IntraDRC method controls the quantity of traffic generated in a cluster by selecting a definite number of data coverage nodes based on the preferred throughput particular by the end system. In other word, the InterDRC system offers differentiated coverage paths beginning from a cluster to a sink node based on the traffic characteristics [7]. A data gathering tree is generally created as a sub network of a wireless sensor network. Power maintenance is of vital importance in such networks, and with periodic sleep–wake cycles for sensor nodes is one of the most efficient methods for power maintenance. In this survey addresses the problem of scheduling the sleep–wake cycles of nodes in a data gathering tree below deadline constraints [8].

In this survey, we study that the energy capable routing for data gathering in wireless sensor networks to maximize the lifetime of the network, known the energy constraint on each sensor node. Using linear programming (LP) formulation, we represent this problem as a multi commodity flow problem, wherever a commodity presents the data generated from a sensor node and delivered to a sink node [11].

In-network gathering has been designed as one technique for reducing energy consumption in wireless sensor networks. Here, we discover two thoughts associated to encourage reducing energy consumption in the context of in-network gathering. The primary is by influencing the creation of the routing trees for wireless sensor networks with the goal of decreasing the amount of transmitted data. To this end, we recommend a group-aware network configuration method that “clusters” along the similar path sensor nodes that belong to the similar group. The next idea involves magnificent a hierarchy of production filters on the wireless sensor network among the goal of both decreasing the size of transmitted data and decreasing the number of transmitted messages [12]. We observe that existing methods approve effectively a two phase approach, consisting of, first, a tree creation and second, a scheduling phase. Following a similar approach, we suggest two latest developments, one to each of the two phases. The tree creation phase consists of solutions to instances of bipartite graph half matchings. The scheduling phase is a weight-based priority technique that obeys dependency (tree) and interference constraints [13]. We think the problem of gathering associated sensor data by an only sink node in a wireless sensor network. We imagine that the sensor nodes are energy-constrained and design competent distributed protocols to increase the network lifetime. It represents first effort on network lifetime maximization that together considers the three layers. We first assume that link access probability are identified and consider the combined optimal design of power control and routing. We illustrate that the formulated optimization problem is convex and recommend a scattered algorithm, JRPA, for the resolution. We also discuss the convergence of JRPA [16].

We study the trade-off between two communally contradictor performance objectives throughput and delay for fast, periodic data gathering in tree-based sensor networks randomly deployed in 2-D. Two major factors that have an effect on the data collection rate (throughput) and timeliness (delay) are: 1) efficiency of the link scheduling protocol, and 2) composition of the routing tree in terms of its node degrees and radius. In this survey, we utilize multiple frequency channels and design an efficient link scheduling protocol that gives a constant factor approximation on the best throughput in deliver aggregated data from every node to the sink [17].

Many represent approaches focus on optimizing the routing layer simply, other than in fact the routing strategy is commonly attached with power control in the physical layer and link access in the MAC layer. It represents a first effort on network lifetime maximization that together considers the three layers [15]. To solve the slow congestion detection and rate convergence problem in the present rate control based fair data collection schemes, a new fair data collection scheme is planned, which is named the enhanced scheme with fairness or ISWF for short. In ISWF, a fast congestion detection method, which combines the queue length with traffic changes of a node, is use to solve the problem of slow congestion recognition, and a new solution, which adjusts the rate of sending data of a node by controlling the channel utilization rate, is used to resolve the slow convergence problem. Compared with the existing tree-based fair data collection schemes, ISWF can get better fairness in data collection and reduce the transmission delay successfully, and at the same time, it can increase the average network throughput by 9.1% or more [16].

We examine contention-free *Time Division Multiple Access* (TDMA) based scheduling protocols for such data gathering applications over tree-based routing topologies. We categorize the algorithms according to their common design objectives, identify the following four as the most basic and most studied with respect to data collection in WSNs: (i) minimizing schedule length, (ii) minimizing latency, (iii) minimizing energy consumption, and (iv) maximizing fairness [15]. Data aggregation is a basic operation in Wireless Sensor Network. For an application which is concentricity in nature such as environment controlling system or health controlling system, the tree based data aggregation is the most competent technique, in terms of energy and data collection time. But, when one of nodes stop respond due to energy loss or hardware malfunction or external cause such as fire, flood etc, then the other nodes under that node will not be able to send their data even if the case of other path [18].

# III. DATA GATHERING SCHEMES

Here, we are discussing some multiple partition algorithms that implement data gathering they are-

## 3.1 Direct Transmission

All sensors nodes broadcast their data openly to the base station. This is extremely expensive in terms of energy consumed, because the base station possibly extremely remote away from some nodes. Also, nodes must take turns whereas transmitting to the base station to avoid conflict, so the media access delay is also large. Hence, this scheme performs weakly with respect to the combination of energy with delay metric.

## 3.2 Power-Efficient Gathering for sensor information systems

Power-Efficient Gathering for sensor information systems (PEGASIS) is a Data-gathering protocol who states that a sensor node knows the location of all other nodes, that is, the information routing topology is presented to the each node. As depicted in Fig. 1, how to perform data gathering with PEGASIS scheme with the help of BS, Leader and sensors nodes. The goals of PEGASIS are as follow:

-reduce the distance over which each node transmits.
- reduce the broadcasting overhead
- reducing the total number of messages that require to be sent to the base station
- Distribute the energy utilization uniformly across all nodes

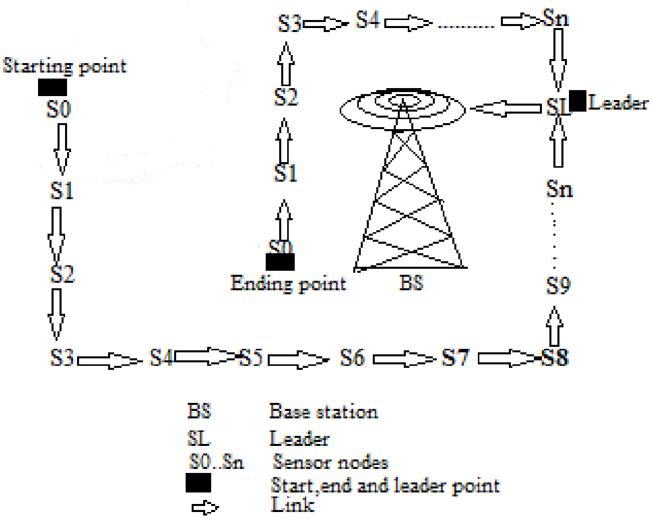
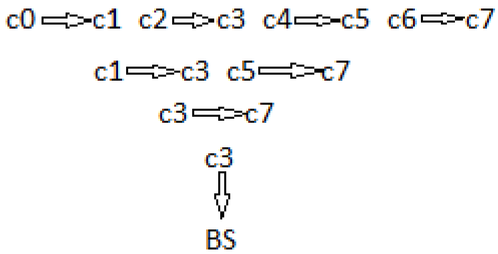



**Figure 1** Data gathering with PEGASIS

## 3.3 Binary scheme

This is also a chain-based scheme similar to PEGASIS, which separates nodes into various levels. All nodes which gather messages at one level rise to the next. The amount of nodes is just halved beginning from one level to the next (see Fig. 2).




BS Base Station
C0-C7 Node

**Figure 2** binary scheme

### 3.4 Chain- based Three- Level Scheme

Fig.3 presents, the chain-based three - level schemes, in this situation, again a chain are constructed as in PEGASIS. The chain is separated into several groups to space out simultaneous transmissions in order to minimize interference. Within a group, nodes broadcast single at a time. One node out of every group aggregates data beginning from all group members and rises to the subsequent level. The index of the leader node is decided apriori. In the second level, each and every one node are separated into two groups, and the third level merge of a message swap over between one node from each group of second level. In conclusion, the leader transmits a single message to the BS.

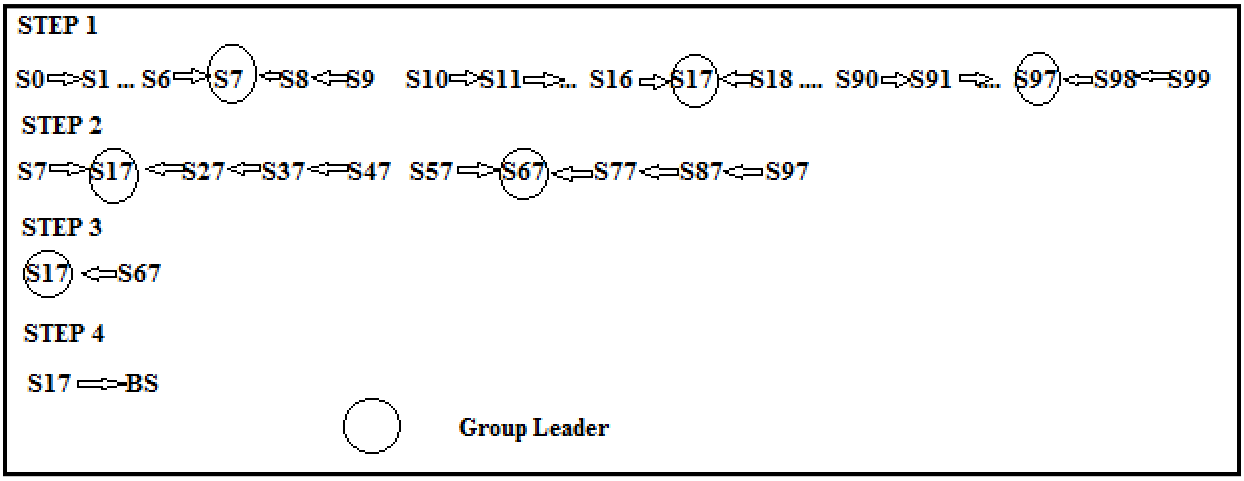



**Figure 3** chain based three level schemes

## IV. Wireless Sensor Network

A wireless sensor network (WSNs) is a cooperative network of small battery-operated, wireless sensor nodes whose main goal is twofold: to observe their surrounds for limited data and to encourage the gathered data en route for a sink node (base station) using typically multi-hop communication. This sink node (base station) will then be responsible for processing all of the received data from numerous source nodes and exposure them to a monitoring facility. One of the main restrictions of the WSNs is the battery-operated (freestyle) nature of their sensor nodes, which makes this type of network highly energy-constrain [2]. In wireless sensor network; Multi-channel communication is a proficient method to ease interference and conflict on the wireless medium by enabling parallel transmissions over dissimilar frequency channels and to improve network throughput the use of multi-channel communication to ease the effects of ‘‘competitive communication environment’’ and to get better capacity in WSNs[9].
Therefore, energy equalization is very important for increasing the network lifetime. Several cluster-based and chain-based protocols are proposed on this point, such as the low-energy adaptive clustering hierarchy (LEACH), the hybrid, energy efficient, distributed clustering approach (HEED***),*** and the PEGASIS. To obtain a better energy equalization performance, many of these suffer higher delay when setting up the network topology and gathering data to sink [3].Fig. 4, shows that the wireless sensor networks (WSNs) can be seen as a huge collection of small wireless devices that can categorize themselves in an ad hoc network proficient of sensing environmental conditions within their range and have constrain energy, processing and communication resources. However, a wireless sensor network typically lacks infrastructure and sensor nodes must manage themselves in order to create routes that lead to a sink [4].

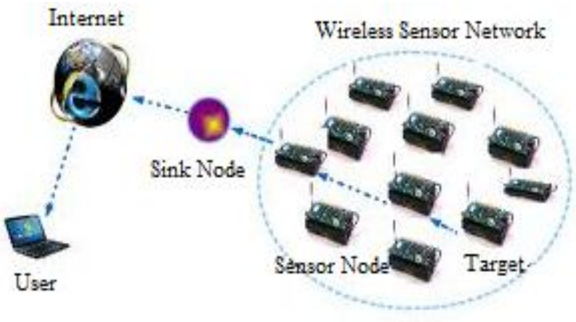



**Figure 4** wireless sensor networks

In large scale WSNs, sensor nodes may use a cluster based approach in which a cluster-head is in charge for collecting data from its cluster nodes. Hierarchical or cluster- based routing is a well-known approach that aims at provided that scalability and energy efficiency in WSNs. A mobile sink approach will not only remove the load of the nodes closer to a sink, but it will provide a mechanism to reach and collect data from network areas that are disconnected, as well as to increase network lifetime. In the monitoring network, each node will report the sensed data to the sink node at times. There are generally two processing methods for this type of All-to-One communication scheme. One is with the data aggregation, in which some packets can be combined into one packet with the same length through the fusion function. The other is without data aggregation, also called as data collection. Though data aggregation method can save the power consumption by reducing the number of transmitted packets, this scheme would be inappropriate in many practical applications. Obviously, this necessity can be easily realized under the data collection scheme [5]. When a huge amount of nodes initiate reporting data, wireless sensor networks simply obtain overwhelmed by high contention and interference along closest multi-hop routing paths and in the neighbourhoods of data collection points such as the sink [10].

## V. DATA GATHERING TECHNIQUES IN WSN

Data gathering process is performed by particular routing protocol. Our goal is gathering data to reduce the energy utilization. So sensor nodes are supposed to route packets based on the data packet content and select the next hop in order to promote in network gathering. Basically routing protocol is separated by the network structure, because of this reason, routing protocols is based on the considered approaches [19]. Data collection techniques in Wireless Sensor Net-works (WSN) suffer from heavy congestion particularly at nodes closer to the sink node. In order to conflict this problem, either co complex MAC layer protocols have been proposed or non-scalable data collection solutions have been designed. The introduced approach uses multiple disjoint gathering trees, rooted from sink, with non-overlapping duty cycles [14].

### 5.1 Tree-Based Technique

The tree based technique is defining data gather from constructing an aggregation tree. Fig.5, shows that this is the form of hierarchy is least amount spanning tree, sink node (base station) consider as a root node and source node consider as a leaves nodes. Information flowing of data initiate from leaves node up to sink (base station). Disadvantage of this technique, as we know like wireless sensor network are not free from collapse in case of data packet failure at any level of tree, the data will be misplaced not only for single level but also for entire related sub tree as well. This technique is appropriate for designing optimal gathering techniques [20]. The functioning of tree based technique is depending on two segments –

#### 5.1.1. Distributed segment

In distributed segment, in which collection query are pressed down into the network.

#### 5.1.2. Gathering segment

In gathering segment, where the collection values are constantly routed up from leaf nodes to parents nodes. Remember that our queries semantics division time epochs of interval, and that we must generate a single collection value (when not group) that combines the sense of every one devices in the network through that epoch.

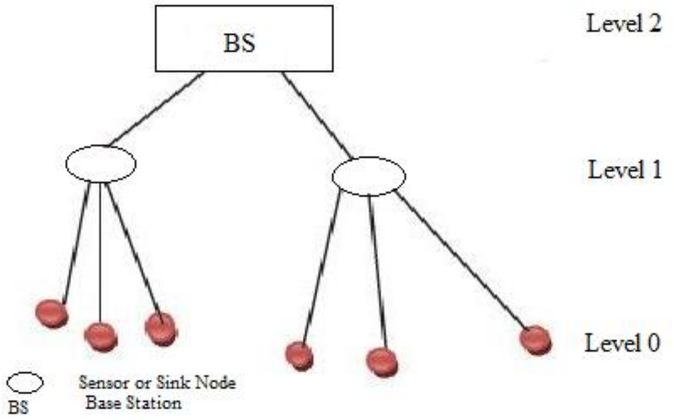



**Figure 5** Tree-based techniques

## 5.2 Cluster-Based Technique

In energy-constrained sensor networks of large size, it is incompetent for sensors to broadcast the data directly to the base station. In such scenarios, Cluster based technique is hierarchical technique. Fig.6, show cluster-based technique, in this technique complete network is separated in to numerous clusters. Each cluster has a cluster-head which is chosen among cluster members. Cluster-heads do the role of data collectors which collect the data received from cluster members locally and then convey the result to base station (sink). Recently, numerous cluster-based network organization and data-gathering protocols have been proposed for the wireless sensor networks. The cluster heads is capable to communicate through the Base station directly via lengthy range transmissions or multi hopping through other cluster heads.

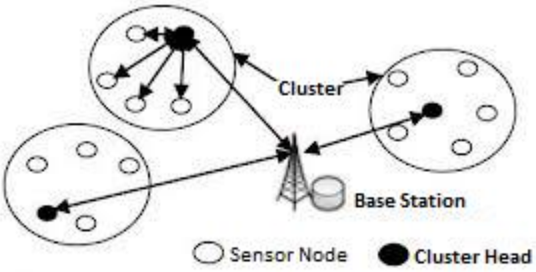



**Figure 6** Cluster based technique

### 5.2.1 Low-Energy Adaptive Clustering Hierarchy (LEACH)

LEACH is a clustering-based protocol that minimizes energy dissipation in wireless sensor networks. LEACH arbitrarily chooses nodes as cluster-heads and performs periodic reelection, that's why the high-energy dissipation qualified by the cluster-heads in communicating with the BS is spread across all nodes of network. Each iteration of selection of cluster-heads is called a round. The function of LEACH is divided into two phases: set-up and steady. In the set-up phase, all sensor nodes select a random number between 0 and 1. If this is less than the threshold for nodes n, T (n), the sensor node occurs a cluster-head. The threshold T (n) is defined as

$$T(n) = \begin{cases} \frac{P}{1-P\{r*mod(\frac{1}{P})\}} & \text{, if } n \ \varepsilon \ G \\ 0 & \text{, otherwise} \end{cases}$$

Where P is the desired gain of nodes which are cluster-heads, r is the current around, and G is the collection of nodes that has not been cluster-heads in the past 1/P rounds. This insures that all sensors nodes finally spend equal energy. After selection, the cluster-heads publicize their selection to all nodes. All nodes choose their nearest cluster-heads when they receive advertisements based on the received signal strength. The steady phase is of longer period in order to reduce the overhead of cluster formation. In the steady phase, data communication takes place depended on the TDMA schedule and the cluster-heads execute data aggregation/fusion throughout the local computation. The base station collects only aggregated data from cluster-heads, important to energy preservation. After a few period of time in the steady phase, cluster-heads are chosen again through the set-up phase [20].

### 5.3 Multi-path Technique

The disadvantage of tree based technique is the imperfect robustness of the system. To overcome this disadvantage, a new technique was proposed by many researchers .in which sending partially gathered data to single parent node in aggregation tree, a node could send data over numerous paths. Fig. 7, illustrates the multipath technique, in which each and every node can send data packets to it's possibly numerous neighbors. Hence data packet flow from source node to the root node along numerous paths, lot of intermediate node between leaves node to root node so gathering done in every intermediate node. The instance of this technique like ring topology, where network is separated in to concentric circle with defining level levels according to hop distance from root.

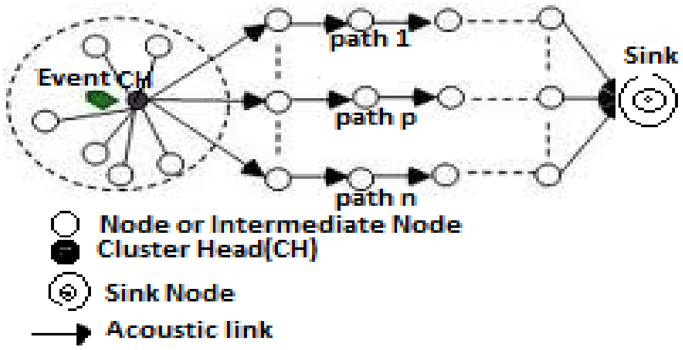



**Figure 7** Multi-path Technique

These strategies have both issues: energy efficiency and robustness. In which solitary path to connect every node to the sink node it is energy saving but high risk of link collapse. But on the other head multipath technique would require more nodes to participate with consequent waste of energy.

### 5.4 Hybrid Technique

Hybrid technique followed among tree, cluster based and multipath method. In which the data gathering structure can adjusted according to particular network situation and to some performance statistics.

## VI. Critical Analysis

The review of the fundamental individuality of the major data gathering methods for WSN are analysed below in the table 1.

**Table 1:** Analysis of data gathering methods for WSN

| Method | Path formation | Aim | Spatial relationship | Temporal relationship | Overhead | Scalability | Disadvantage |
|---|---|---|---|---|---|---|---|
| EEDC[21] | Single hop | Reduce control overhead | Yes | No | Extremely Low | Extremely Low | central and only single-hop network |
| CAG[22] | Tree-based cluster | Reduce data Redundancy | Yes | No | Extremely High | Average | preservation data-centric |
| GSC[23] | Tree-based cluster | Reduce data redundancy | Yes | No | High | Low | It is not applied to multi-hop members |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| SBR[24] | Tree-based | Reduce data redundancy | No | Yes | Average | High | Sink node can obtain outdated information |
| SCCS[25-26] | Tree-based cluster | Reduce data redundancy | Yes | Yes | Average | High | Sink node can obtain outdated information |
| DQEB[6] | Dynamic query-tree | Reduce broadcast cost | _ | _ | Average | Average | Prevents the structure of a disconnected tree |
| LEACH [3] | Cluster-based | Periodic re-election | _ | _ | High | _ | Suffer high cluster set-up overload |
| PEGASIS [3] | linear-chain scheme | Reduce the broadcasting overhead | _ | _ | Low | Average | consume more energy |

## VII. CONCLUSIONS

The flexibility, fault tolerance, low-cost and quick development characteristics of wireless sensor networks creates many latest and exciting application areas for remote sensing. In further, this broad choice of application areas will construct wireless sensor networks an integral part of our lives. In this paper, we studied various data collection methods and routing protocols in Wireless Sensor Network. Many schemes are more efficient in terms of eliminating interference but to achieve power consumption, Qos, fault tolerances, scalability, estimated cost, hardware, topology change, power consumption, fast data transfer etc some different new wireless ad hoc networking techniques are required.

We have explored a number of techniques to improve the aggregated data gathering over a tree topology in wireless sensor network. With the help of this survey, we also evaluate the efficiency of dissimilar channel assignment schemes and interference models, and recommend schemes for both constructing specific routing tree topologies that improve the data gathering rate for both aggregated and raw-data converge cast.

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