National Journal of Advanced Research
Online ISSN: 2455-216X; Impact Factor: RJIF 5.12
www.allnationaljournal.com
Volume 3; Issue 2; May 2017; Page No. 17-25

A survey on energy efficient techniques in WSN "leach protocol"

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Abstract
Recent technological advances in communications and computation have enabled the event of low-priced, low-power, tiny in size, and multifunctional device nodes during a wireless device network. Since the radio transmission and reception consumes lots of energy, one in all the necessary problems in wireless device network is that the inherent restricted battery power inside network device nodes. Therefore, battery power is crucial parameter within the formula style to extend period of time of nodes within the network. Additionally to maximising the period of time of device nodes, it's preferred to distribute the energy dissipated throughout the wireless device network so as to maximise overall network performance. Abundant analysis has been worn out recent years, investigation completely different aspects like, low power protocols, network institutions, routing protocol, and coverage issues of wireless device networks. There are a unit numerous routing protocols like location-aided, multi-path, knowledge centrical, mobility-based, QoS based, heterogeneity-based, hierarchical routing, hybrid routing, etc., during which best routing is achieved within the context of energy. During this paper, the main target is especially driven over the energy-efficient hierarchical cluster-based LEACH protocol beside the reviews of varied technologies introduced for Wireless device Network.

Keywords: wireless device networks, cluster head, cluster-based routing, hierarchical bunch, base station

Introduction

Due to recent technological advances, the manufacturing of small and reasonable sensors has become technically and economically doable. These sensors live shut conditions at intervals the setting shut them therefore transform these measurements into signals which will be processed to reveal some characteristics regarding phenomena located at intervals the house around these sensors. Associate in Nursing outsized form of those sensors area unit typically networked in many applications that require unattended operations, thence applications of WSNs ar quite numerous. As an example, WSNs have profound effects on military and civil applications like target field imaging, intrusion detection, producing a wireless device network (WSN). In fact, the weather looking at, security and branch of knowledge investigating, distributed computing, investigating shut conditions like temperature, movement, sound, light, or the presence of sure objects, control, and disaster management. Preparation of a device network in these applications area unit typically in random fashion (e.g., born from Associate in Nursing heavier-than-air craft in an exceedingly disaster management application) or manual (e.g., fireplace alarm sensors in an exceedingly facility or sensors planted underground for exactitude agriculture). Making a network of those sensors will assist rescue operations by locating survivors, distinctive risky areas, and creating the rescue team additional attentive to the scenario in an exceedingly country.

Typically, WSNs contain tons of or thousands of those device nodes, Associate in Nursingd these sensors have the power to speak either among one another or on to an external base station (BS). A larger range of sensors permits for sensing over larger realms with larger accuracy. Figure one shows a schematic diagram of device node elements. Basically, every device node includes sensing, processing, transmission, mobilizer, position finding system, and power units (some of those elements area unit facultative, just like the mobilizer). A similar figure shows the communication design of a WSN. Device nodes area unit typically scattered in an exceedingly device field, that is {an area unita a neighborhood a district a region locality a vicinity apart a section} wherever the device nodes are deployed. Device nodes coordinate among themselves to supply high-quality data concerning the physical setting. Every device node bases its selections on its mission, the knowledge it presently has, and its information of its computing, communication, and energy resources. every of those scattered device nodes has the aptitude to gather Associate in Nursingd route information either to alternative sensors or back to an external BS(s).1 A Bachelor of Science could also be {a fixed|a hard Associate in Nursingdfast|a set} or mobile node capable of connecting the device network to an existing communications infrastructure or to the net wherever a user will have access to the rumored information.

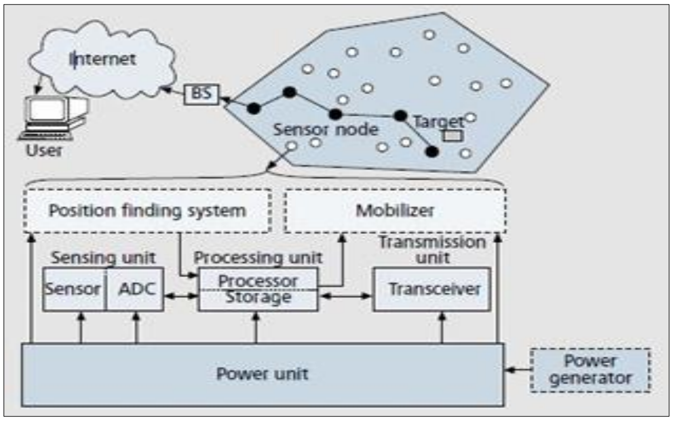

Fig 1: The components of a sensor node

Routing Challenges and Design Issues in WSNs

Despite the innumerable applications of WSNs, these networks have several restrictions, such as limited energy supply, limited computing power, and limited bandwidth of the wireless links connecting sensor nodes we summarize some of the routing challenges and design issues that affect the routing process in WSNs.

Node deployment

Node deployment in WSNs is application-dependent and might be either manual (deterministic) or irregular. In manual readying, the sensors square measure manually placed and knowledge is routed through planned ways. However, in random node readying, the device nodes square measure scattered every which way, making a ad hoc routing infrastructure. If the resultant distribution of nodes isn't uniform, best bunch becomes necessary to permit property and modify energy-efficient network operation. Inter sensor communication is generally inside short transmission ranges as a result of energy and information measure limitations. Therefore, it's presumably that a route can carries with it multiple wireless hops

Energy consumption without losing accuracy

Sensor nodes will assign their restricted offer of energy acting computations and sending info in an exceedingly wireless surroundings. As such, energy-conserving types of communication and computation ar essential. Sensing element node time period shows a robust dependence on battery time period

Data reporting method

Data coverage in WSNs is application-dependent and conjointly depends on the time criticality of the info. Information coverage may be categorised as either time-driven, event driven, query-driven, or a hybrid of these ways. The time-driven delivery methodology is appropriate for applications that need periodic information observation

Node/link heterogeneity

In several studies, all detector nodes were assumed to be homogenous (i.e., have equal capability in terms of computation, communication, and power). However, counting on the appliance a detector node will have a unique role or capability. The existence of a heterogeneous set of sensors raises several technical problems associated with knowledge routing. These cluster heads are often chosen from the deployed detectors or be additional powerful than alternative sensor nodes in terms of energy, bandwidth, and memory. Hence, the burden of transmission to the baccalaureate is handled by the set of cluster heads

Fault tolerance

Some sensing element nodes might fail or be blocked as a result of lack of power, physical harm, or environmental interference. The failure of sensing element nodes shouldn't have an effect on the general task of the sensing element network. If several nodes fail, medium access management (MAC) and routing protocols should accommodate formation of recent links and routes to the info assortment BSs. this could need actively adjusting transmit powers and signal rates on the prevailing links to cut back energy consumption, or rerouting packets through regions of the network wherever additional energy is on the market. Therefore, multiple levels of redundancy is also required in a very fault-tolerant sensing element network.

Scalability

The number of sensor nodes deployed in the sensing area may be on the order of hundreds or thousands, or more. Any routing scheme must be able to work with this huge number of sensor nodes. In addition, sensor network routing protocols should be scalable enough to respond to events in the environment. Until an event occurs, most sensors can remain in the sleep state, with data from the few remaining sensors providing coarse quality.

Network dynamics

In many studies, sensor nodes are assumed fixed. However, in many applications both the BS or sensor nodes can be mobile [6]. As such, routing messages from or to moving nodes is more challenging since route and topology stability become important issues, in addition to energy, bandwidth, and so forth. Moreover, the phenomenon can be mobile (e.g., a target detection/ tracking application). On the other hand, sensing fixed events allows the network to work in a reactive mode (i.e., generating traffic when reporting), while dynamic events in most applications require periodic reporting to the BS.

Transmission media

In a multi-hop sensor network, communicating nodes are linked by a wireless medium. The traditional problems associated with a wireless channel (e.g., fading, high error rate) may also affect the operation of the sensor network. In general, the required bandwidth of sensor data will be low, on the order of 1–100 kb/s. Related to the transmission media is the design of MAC. One approach to MAC design for sensor networks is to use time-division multiple access (TDMA)-based protocols that conserve more energy than contention-based protocols like carrier sense multiple access (CSMA) (e.g., IEEE 802.11). Bluetooth technology [7] can also be used.

Connectivity

High node density in sensor networks precludes them from being completely isolated from each other. Therefore, sensor nodes are expected to be highly connected. This, however, may not prevent the network topology from being variable and the network size from shrinking due to sensor node failures. In addition, connectivity depends on the possibly random distribution of nodes.

Coverage

In WSNs, each sensor node obtains a certain view of the environment. A given sensor’s view of the environment is limited in both range and accuracy; it can only cover a limited physical area of the environment. Hence, area coverage is also an important design parameter in WSNs.

Data aggregation

Since sensor nodes may generate significant redundant data, similar packets from multiple nodes can be aggregated to reduce the number of transmissions. Data aggregation is the combination of data from different sources according to a certain aggregation function (e.g., duplicate suppression, minima, maxima, and average). This technique has been used to achieve energy efficiency and data transmission transfer optimization in a number of routing protocols. Signal processing methods can also be used for data aggregation. In this case, it is referred to as *data fusion* where a node is capable of producing a more accurate output signal by using some techniques such as beamforming to combine the incoming signals and reducing the noise in these signals.

Quality of service

In some applications, data should be delivered within a certain period of time from the moment it is sensed, or it will be useless. Therefore, bounded latency for data delivery is another condition for time-constrained applications. However, in many applications, conservation of energy, which is directly related to network lifetime, is considered relatively more important than the quality of data sent. As energy is depleted, the network may be required to reduce the quality of results in order to reduce energy dissipation in the nodes and hence lengthen the total network lifetime. Hence, energy aware routing protocols are required to capture this requirement.

Energy- Efficient Routing algorithms

Energy efficient routing algorithm can be categorized as follows: data centric routing algo-rithm, location based routing algorithm and hierarchical routing algorithm. Data centric routing algorithm uses Meta data to find the route from source to destination before any actual data transmission to eliminate redundant data transmission Location based routing algorithm requires actual location information for every sensor node. Hierarchical routing algorithm divides the network into clusters. Cluster head (CH) is elected in each cluster. CH collects data from its members, aggregates the data and sends to sink. This approach is energy efficient but relatively com plex than other approaches (Akkaya and Younis [2005]).

Data centric

Data centric protocols are query based and they depend on the naming of the desired data, thus it eliminates much redundant transmissions. The BS sends queries to a certain area for information and waits for reply from the nodes of that particular region. Since data is requested through queries, attribute based naming is required to specify the properties of the data. Depending on the query, sensors collect a particular data from the area of interest and this particular information is only required to transmit to the BS and thus reducing the number of transmissions. e.g. SPIN was the first data centric protocol.

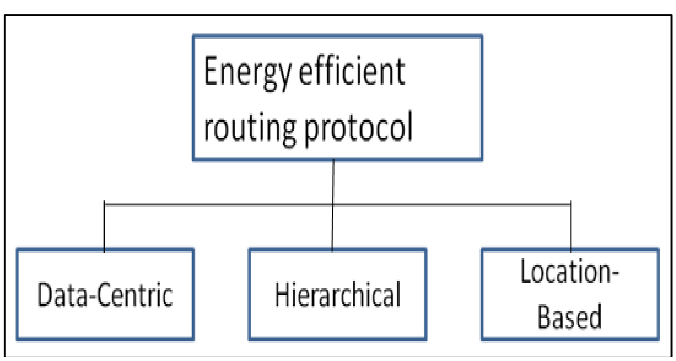

Fig 2: Classification of routing in WSNs

Hierarchical

Hierarchical routing is used to perform energy efficient routing, i.e., higher energy nodes can be used to process and send the information; low energy nodes are used to perform the sensing in the area of interest. e.g. LEACH, TEEN, APTEEN

Location based

Location based routing protocols need some location information of the sensor nodes. Location information can be obtained from GPS (Global Positioning System) signals, received radio signal strength, etc. Using location information, an optimal path can be formed without using coding techniques. e.g. Geographic and Energy-Aware Routing (GEAR)

Technology

Low-energy adaptive clustering hierarchy (LEACH)

LEACH [3, 7] is the first and most popular energy efficient hierarchical clustering algorithm for WSNs that was proposed for reducing power consumption. In LEACH, the clustering task is rotated among the nodes, based on duration. Direct communication is used by each CH to forward the data to the base station (BS). It is an application-specific data dissemination protocol that uses clusters to prolong the life of the wireless sensor network. LEACH is based on an *aggregation* (or *fusion)* technique that combines or aggregates the original data into a smaller size of data that carry only meaningful information to all individual sensors. LEACH divides the a network into several cluster of sensors, which are constructed by using localized coordination and control not only to reduce the amount of data that are transmitted to the sink, but also to make routing and data dissemination more scalable and robust. Given that energy dissipation of the sensor depends on the distance and the data size to be transmitted, LEACH attempts to transmit data over short distances and reduce the number of transmission and reception operations. The key features of LEACH are: (i) randomized rotation of the CH and corresponding clusters, (ii) local compression to reduce global communication, (iii) and localized coordination and control for cluster set-up and operation. LEACH uses a randomize rotation of high-energy CH position rather than selecting in static manner, to give a chance to all sensors to act as CHs and avoid the battery depletion of an individual sensor and dying quickly. The operation of LEACH is divided into rounds, each of which has mainly two phases namely (i) a setup phase to organize the network into clusters, CH advertisement, and transmission schedule creation and (ii) a steady-state phase for data aggregation, compression, and transmission to the sink. Cluster heads (CHs) use CSMA MAC protocol to advertise their status. Thus, all non-cluster head sensors must keep their receivers ON during the setup phase in order to hear the advertisements sent by the CHs. These CHs are selected with some probability by themselves and broadcast their statuses to the other sensors in the network. The decision for a sensor to become a CH is made independently without any negotiation with the other sensors. Specifically, a sensor decides to become a CH based on the desired percentage P of CHs (determined *apriori*), the current round, and the set of sensors that have nor become CH in the past $1/P$ rounds. If the number of CHs $<T(n)$, a sensor n becomes a CH for the current round,

where *T(n)* is a threshold given by where *P* is the desired percentage of cluster heads, *r* is the current round, and *G* is the set of nodes that have been cluster- heads (CHs) in the last *1/P* rounds. The sensor nodes that are CHs in round. 0. Cannot be a CH for the next *1/P–1* rounds. Once the network is divided into clusters, a CH computes a TDMA schedule for its sensors specifying when a sensor in the cluster is allowed to send its data. Thus, a sensor will turns its radio ON only when it is authorized to transmit according to the schedule established by its cluster head, therefore yielding significant energy savings. Furthermore, LEACH enables data fusion in each cluster by aggregating the data in order to reduce the total amount of data and then sends them to the sink. The sensors within a cluster transmit their sensed data over short distances, whereas CHs communicate directly with the sink. LEACH achieves over a factor of 7x and 8x reduction in energy dissipation compared to direct communication and a factor of 4x and 8x compared to the minimum transmission energy (MTE) routing protocol. The nodes die randomly and dynamic clustering increases system lifetime in case of LEACH as compared to direct transmission, MTE routing, and static clustering. LEACH is completely distributed and requires no global knowledge of network. LEACH reduces energy consumption by (a) minimizing the communication cost between sensors and their cluster heads and (b) turning off non-head nodes as much as possible [38]. It has major characteristics such as (i) it rotates the cluster heads in a randomized fashion to achieve balanced energy consumption, (ii) sensors have synchronized clocks so that they know the beginning of a new cycle, (iii) sensors do not need to know location or distance information, (iv) the time duration of the set-up phase is non-deterministic, and if the duration is too long due to collisions, sensing services are interrupted. In such cases, LEACH may be unstable during the set-up phase depending on the density of sensors. LEACH uses single-hop routing where each node can transmit directly to the cluster-head and the sink. Therefore, it is not applicable to networks deployed in large regions. Furthermore, the idea of dynamic clustering brings extra overhead, e.g. head changes, advertisements etc., which may diminish the gain in energy consumption. While LEACH helps the sensors within their cluster dissipate their energy slowly, the CHs consume a larger amount of energy when they are located farther away from the sink. Also, LEACH clustering terminates in a finite number of iterations, but does not guarantee good CH distribution and assumes uniform energy consumption for CHs.

Enhanced Low-Energy Adaptive Clustering Hierarchy (ELEACH)

E-LEACH [7] further improved LEACH in two major aspects. E-LEACH proposes a cluster head selection algorithm for sensor networks that have non-uniform starting energy level among the sensors. However, this algorithm assumes that sensors have global information about other sensors. Remaining energy. E-LEACH also determines that, under certain assumptions, the required number of cluster heads has to scale as the square root of the total number of sensor nodes to minimize the total energy consumption. Other aspects of E-LEACH are the same as LEACH.

LEACH-Centralized (LEACHC)

LEACH-C uses a centralized clustering algorithm and same steady state protocol. During the set-up phase of LEACH-C, each node sends information about current location and energy level to base station (BS). The BS will determine clusters, CH node and non-CH nodes of each cluster. The BS utilizes its global information of the network to produce better clusters that require less energy for data transmission. The number of CHs in each round of LEACH-C equals a predetermined optimal value, whereas for LEACH the number of CHs varies from round due to the lack of global coordination among nodes.

Multi-hop LEACH (M-LEACH)

M-LEACH [39] modifies LEACH allowing sensor nodes to use multi-hop communication within the cluster in order to increase the energy efficiency of the protocol. Other works define special nodes (called gateways) that are able to send the information generated inside the cluster directly to the sink [40]. This work extends the existing solutions by allowing multi-hop inter-cluster communication in sparse WSNs in which the direct communication between CHs or the sink is not possible due to the distance between them. Thus, the main innovation of the solution proposed here is that the multi-hop approach is followed inside the cluster (messages from sensor nodes to the CH) and outside the cluster (from CHs to the sink using intermediate sensor nodes). CHs can also perform data fusion to the data receive, allowing a reduction in the total transmitted and forwarded data in the network.

LEACH with Fixed Cluster (LEACH-F)

LEACH-F [42] is the further development of LEACH, which is based on clusters that are formed once and then fixed. Then, the cluster head position rotates among the nodes within the cluster. The advantage with this is that, once the clusters are formed, there is no set-up overhead at the beginning of each round. To decide clusters, LEACH-F uses the same centralized cluster formation algorithm as LEACH-C. The fixed clusters in LEACH-F do not allow new nodes to be added to the system and do not adjust their behavior based on nodes dying.

Power-Efficient Gathering in Sensor Information Systems (PEGASIS)

PEGASIS [41] is an extension of the LEACH protocol, which rather forming multiple clusters, forms chains from sensor nodes so that each node transmits and receives from a neighbor and only one node is selected from that chain to transmit to the base station (sink). The data is gathered and moves from node to node, aggregated and eventually sent to the base station. The chain construction is performed in a greedy way. Unlike LEACH, PEGASIS avoids cluster formation and uses only one node in a chain to transmit to the BS (sink) instead of using multiple nodes. A sensor transmits to its local neighbors in the data fusion phase instead of sending directly to its CH as in the case of LEACH. In PEGASIS routing protocol, the construction phase assumes that all the sensors have global knowledge about the network, particularly, the positions of the sensors, and use a greedy approach. Specifically, it starts with the furthest sensor to sink to guarantee that sensors farther away from the sink have close neighbors. When a sensor fails or dies due to low battery power, the chain is constructed using the same greedy approach by bypassing the failed sensor. In each round, a randomly chosen sensor node from the chain will transmit the aggregated data to the BS, thus reducing the per round energy expenditure compared to LEACH. Thus, PEGASIS is a near optimal chain-based protocol. The basic idea of the protocol is that in order to extend network lifetime, nodes need only communicate with their closest neighbors and they take turns in communicating with the BS. To locate the closest neighbor node in PEGASIS, each node uses the signal strength to measure the distance to all neighboring nodes and then adjusts the signal strength so that only one node can be heard. When the round of all nodes communicating with the BS ends, a new round will start and so on. This reduces the power required to transmit data per round as the power draining is spread uniformly over all nodes. The objectives of PEGASIS routing protocol are (i) to increase the lifetime of each node by using collaborative techniques, and (ii) allow only local coordination between nodes are close together so that the bandwidth consumed in communication is reduced. Simulation results showed that PEGASIS is able to increase the lifetime of the network twice as much the lifetime of the network under the LEACH protocol. Such performance gain is achieved through the elimination of the overhead caused by dynamic cluster formation in LEACH and through decreasing the number of transmissions and reception by using data aggregation. Although the clustering overhead is avoided, PEGASIS still requires dynamic topology adjustment since a sensor node needs to know about energy status of its neighbors in order to know where to route its data. Such topology adjustment can introduce significant overhead especially for highly utilized networks. Moreover, PEGASIS assumes that each sensor node can be able to communicate with the BS directly. In practical cases, sensor nodes use multi-hop communication to reach the BS. Also, PEGASIS assumes that all nodes maintain a complete database about the location of all other nodes in the network. The method of which the node locations are obtained is not outlined. In addition, PEGASIS assumes that all sensor nodes have the same level of energy and they are likely to die at the same time. PEGASIS introduces excessive delay for distant node on the chain. In addition, the single leader can become a bottleneck. Finally, although in most scenarios, sensors will be fixed or immobile as assumed in PEGASIS, some sensors may be allowed to move and hence affect the protocol functionality.

Hierarchical PEGASIS

An extension to PEGASIS, called Hierarchical-PEGASIS was introduced in [43] with the objective of decreasing the delay incurred for packets during transmission to the BS. For this purpose, simultaneous transmissions of data are studied in order to avoid collisions through approaches that incorporate signal coding and spatial transmissions. H-PEGASIS proposes a solution to the data gathering problem by considering energy × delay metric. In order to reduce the delay in PEGASIS, simultaneous transmissions of data messages are pursued. To avoid collisions and possible signal interference among the sensors, two approaches have been investigated. The first approach incorporates signal coding, e.g. CDMA. In the second approach only spatially separated nodes are allowed to transmit at the same time. The chain-based protocol with CDMA capable nodes, constructs a chain of nodes, that forms a tree like hierarchy, and each selected node in a particular level transmits data to the node in the upper level of the hierarchy. This method ensures data transmitting in parallel and reduces the delay significantly. Such hierarchical extension has been shown to perform better than the regular PEGASIS scheme by a factor of about 60.

Energy Balancing PEGASIS (EB-PEGASIS)

EBPEGASIS [44] is an energy efficient chaining algorithm in which a node will consider average distance of formed chain. If the distance from closest node to its upstream node is longer than distance thresh (the distance thresh can obtain from average distance of formed chain), the closest node is a "far node". If the closest node joins the chain, it will emerge a "long chain". In this condition, the "far node" will search a nearer node on formed chain. Through this method, the new protocol EB-PEGASIS can avoid "long chain" effectively. EB-PEGASIS can guarantee approximately the same in consumed energy of sensor nodes, and avoid the dying of some nodes early than other nodes to prolong the lifetime of sensor networks. It not only save energy on sensors, but also balance the energy consumption of all sensor nodes.

Hybrid, Energy-Efficient Distributed Clustering (HEED)

HEED [25, 26] extends the basic scheme of LEACH by using residual energy and node degree or density as a metric for cluster selection to achieve power balancing. It operates in multi-hop networks, using an adaptive transmission power in the inter-clustering communication. HEED was proposed with four primary goals namely (i) prolonging network lifetime by distributing energy consumption, (ii) terminating the clustering process within a constant number of iterations, (iii) minimizing control overhead, and (iv) producing well-distributed CHs and compact clusters. In HEED, the proposed algorithm periodically selects CHs according to a combination of two clustering parameters. The primary parameter is their residual energy of each sensor node (used in calculating probability of becoming a CH) and the secondary parameter is the intra-cluster communication cost as a function of cluster density or node\ degree (i.e. number of neighbors). The primary parameter is used to probabilistically select an initial set of CHs while the secondary parameter is used for breaking ties. In HEED, the clustering process at each sensor node requires several rounds. Every round is long enough to receive messages from any neighbor within the cluster range [29]. As in LEACH, an initial percentage of CHs in the network *Cprob*, is predefined. The parameter *Cprob* is only used to limit the initial CH announcements and has no direct impact on the final cluster structure.

In HEED, the distribution of energy consumption extends the lifetime of all the nodes in the network, thus sustaining stability of the neighbor set. Nodes also automatically update their neighbor sets in multi-hop networks by periodically sending and receiving messages. The HEED clustering improves network lifetime over LEACH clustering because LEACH randomly selects CHs (and hence cluster size). which may result in faster death of some nodes. The final CHs selected in HEED are well distributed across the network and the communication cost is minimized. However, the cluster selection deals with only a subset of parameters, which can possibly impose constraints on the system. These methods are suitable for prolonging the network lifetime rather than for the entire needs of WSN.

Threshold Sensitive Energy Efficient Sensor Network Protocol (TEEN)

TEEN [45, 46] is a hierarchical clustering protocol, which groups sensors into clusters with each led by a CH. The sensors within a cluster report their sensed data to their CH. The CH sends aggregated data to higher level CH until the data reaches the sink. Thus, the sensor network architecture in TEEN is based on ahierarchical grouping where closer nodes form clusters and this process goes on the second level until the BS (sink) is reached. TEEN is useful for applications where the users can control a trade-off between energy efficiency, data accuracy, and response time dynamically. TEEN uses a data-centric method with hierarchical approach. TEEN is a clustering communication protocol that targets are active network and enables CHs to impose a constraint on when the sensor should report their sensed data. After the clusters are formed, the CH broadcasts two thresholds to the nodes namely (i) shard threshold (*HT*), and (ii) soft threshold (*ST*). Hard threshold is the minimum possible value of an attribute, beyond which a sensor should turn its transmitter ON to report its sensed data to its CH. Thus, the hard threshold allows the nodes to transmit only when the sensed attribute is in the range of interest, thus reducing the number of transmissions significantly. Once a node senses a value ator beyond the hard threshold, it transmits data only when the value of that attribute changes by an amount equal to or greater than the soft threshold, which indicates a small change in the value of the sensed attribute and triggers a sensor to turn ON its transmitter and send its sensed data to the CH. As a consequence, soft threshold will further reduce the number of transmissions for sensed data if there is little or no change in the value of sensed attribute. Thus, the sensors will send only sensed data that are of interest to the end user based on the hard threshold value and the change with respect to the previously reported data, thus yielding more energy savings. One can adjust both hard and soft threshold values in order to control the number of packet transmissions. However, both values of hard and soft thresholds have an impact on TEEN. These values should beset very carefully to keep the sensors responsive by reporting sensed data to the sink. Important features of TEEN include its suitability for time critical sensing applications. Also, since message transmission consumes more energy than data sensing, so the energy consumption in this scheme is less than the proactive networks. The soft threshold can be varied. At every cluster change time, fresh parameters are broadcast and so, the user can change them as required. However, TEEN is not suitable for sensing applications where periodic reports are needed since the user may not get any data at all if the thresholds are not reached.

Comparision in Various Types of Leach Protocols

Table 1: Comparison in various modified LEACH protocols

Author	Algo proposed	Comm pattern	Energy efficiency	Advantages	Limitations
Sharma and others	PEGASIS	Chain based	High	No of rounds are 100 to200% higher than LEACH	Excessive delay fordistant nodes
Khan and others	Ad-LEACH	Single hop	High	The network life time is66% more than LEACH. Increases the number of rounds around 1500-2500 rounds	Instability region is 40%more than LEACH
Dakshayini and others	LEACH-E	Single hop	Very High	Reduced the radio communication range by proper selection of CH. No of rounds are 200%higher than LEACH	The network should equipped with GPS for monitoring the position of the nodes and CH
Nguyen and others	LEACH-C	Chain based	Very High	Number of data receive dat base station is 8%more than LEACH	Not give good performance if the nodes are mobile
Dembla and others	EE-LEACH	Single hop	Very High	Energy consumed is reduced up to 43% for100 nodes and 44% for 200 nodes	CH need to be distributed uniformly
Taneja and others	TLHCLP	Multipath model	High	Life time is improved from 20-42% for 100nodes	Algorithm should ensure that all nodes become cluster members
Gupta and others	LEACH-A	Chain based	Very High	Life time of the network increases 80% and through put increases 1.2times than LEACH	A multi path route algorithm based on energy hops is proposed to reduce the energy consumption
Bhadeshiya and others	LEACH SUB CH	Single hop	High	Fixed number of CH increased throughput and reduced the energy consumption significantly	Optimum number of clusters must be selected for best results
Mao and others	EECS	Single hop	Very high	Life time increases 135% and energy utilization is 93% more than original LEACH	Future work should include multi hop communication
Nguyen and others	M - LEACH	Multi hop	Very High	Throughput is 8 times Greater than LEACH-C	Velocity threshold and round time models should be developed. Location monitoring is an overhead
Mu Tong and others	LEACH-B	Single hop	High	Residual energy of nodes is considered for CH selection and 25% efficient than LEACH	Other parameters like node degree, distance are yet to be considered for best CH selection

Routing In Wsns: Future Directions

We summarize some of these directions and give some pertinent references as follows:

- Exploit redundancy: Typically a large number of sensor nodes are implanted inside or beside the phenomenon. Since sensor nodes are prone to failure, fault tolerance techniques come into the picture to keep the network operating and performing its tasks. Routing techniques that explicitly employ fault tolerance techniques in an efficient manner are still under investigation
- Tiered architectures (mix of form/energy factors): Hierarchical routing is an old technique to enhance scalability and efficiency of the routing protocol. However, novel techniques of network clustering that maximize network life time are also a hot area of research in WSNs
- Exploit spatial diversity and density of sensor/actuator nodes: Nodes will span a network area that might be large enough to provide spatial communication between sensor nodes. Achieving energy-efficient communication in this densely populated environment deserves further investigation. Dense deployment of sensor nodes should allow the network to adapt to an unpredictable environment.
- Achieve desired global behavior with adaptive localized algorithms (i.e., do not rely on global interaction or information): However, in adynamic environment, this is hard to model (e.g., [12]).
- Leverage data processing inside the network and exploit computation near data sources to reduce communication (i.e., perform in-network distributed processing): WSNs are organized around naming data, not nodes' identities. Since we have large collections of distributed. The future vision of WSNs is to embed numerous distributed devices to monitor and interact with physical world phenomena, and to exploit spatially and temporally densesensing and actuation capabilities of those sensing devices., localized algorithms that achieve system wide properties in terms of local processing of data before it is sent to the destination are still needed. Nodes in the network will store named data and make it available for processing. There is a high need to create efficient processing points in the network (e.g., duplicate suppression, aggregation, correlation of data). How to efficiently and optimally find those points is still an open research issue (e.g., [27]).
- Time and location synchronization: Energy efficient techniques for associating time and spatial coordinates with data to support collaborative processing are also required [1].
- Localization: Sensor nodes are randomly deployed into an unplanned infrastructure. The problem of estimating spatial coordinates of the node is referred to as localization. GPS cannot be used in WSNs as GPS can work only outdoors and not in the presence of any obstruction. Moreover, GPS receivers are expensive and unsuitable for the construction of small cheap sensor nodes. Hence, there is a need to develop other means of establishing a coordinate system without relying on an existing infrastructure. Most of the proposed localization techniques today depend on recursive trilateration multilateration techniques (e.g., [46]), which would not provide enough accuracy in WSNs.
- Self-configuration and reconfiguration are essential to the lifetime of unattended systems in a dynamic and energy constrained environment. This is important for keeping the network up and running. As nodes die and leave the netn No No Low Good No Poss. Aggregate work, update and reconfiguration mechanisms should take place. A feature that is important inevery routing protocol is to adapt to topology changes very quickly and to maintain the network functions (e.g., [9]).
- Secure routing: Current routing protocols optimize for the limited capabilities of nodes and the application-specific nature of networks, but do not consider security. Although these protocols have not been designed with security as a goal, it is important to analyze their security properties. One aspect of sensor networks that complicates the design of a secure routing protocol is in-network aggregation. In WSNs, in-network processing makes end-to-end security mechanisms harder to deploy because intermediate nodes need direct access to the contents of the messages (e.g.,) [47, 48]. Other possible future research for routing protocols includes the integration of sensor networks with wired networks (i.e., the Internet).Most applications in security and environmental monitoring require the data collected from sensor nodes to be transmitted to a server so that further analysis can be done. On the other hand, the requests from the user should be made to the BS through the Internet. Since the routing requirements of each environment are different, further research is necessary for handling these kinds of situations.

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