Recent Advances on Energy Efficient Cluster Based Routing Protocols of Wireless Sensor Networks for Healthcare Systems

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Abstract

A number of hospitals and medical centres are exploring applications of wireless sensor network (WSN) technology to a wide range of medical applications, including pre-hospital, and in-hospital emergency care, disaster response, and stroke patient rehabilitation. Current Healthcare Wireless Sensor Networks (HCWSN) research trends focus on patient, reliable communication, patient mobility, and energy-efficient routing, among others. The studies focus on different cluster-based routing protocols which are used in increasing energy efficiency of WSN for healthcare application and to point out important issues in cluster-based routing (CBR) protocol that guide to improve them in order to extend their application range. Today, WSNs are becoming popular and many routing protocols have been proposed in the literature with a focus on the hierarchical routing. This paper surveys the WSNs energy-efficient CBR techniques that are used for Healthcare Communication system. Recent advancement and limitations of previous studies were highlighted. The routing protocols are categorized according to their respective energy efficiency. We intend for researchers to quickly identify areas that require more attention and to propose a novel methodology for improving the effectiveness of existing protocols.

Keywords: *Routing Protocols, Healthcare, Node, Sensor Nodes, Wireless Sensor Networks.*

1. Introduction

Recent technological advancement has enabled cost effective development of sensor nodes. Despite their relatively small size, they are extremely powerful in sensing, processing, and communication capabilities. The benefits arising from the collaborative use of such sensor nodes, which are wirelessly interconnected, find an ever growing number of applications. WSNs in healthcare and sensor network have attracted a lot of research effort in recent years. A group of spatially distributed sensor nodes, which are interconnected without the use of any wires, constitutes a wireless sensor network (WSN) [1, 2].

A WSN is a network consisting of numerous sensor nodes with sensing, wireless communications, and computing capabilities. These sensor nodes are scattered in an unattended environment (i.e. sensing field) to sense the physical world. The sensed data can be collected by a few sink nodes which have access to infrastructure networks like the Internet. Finally, an end user can remotely fetch the sensed data by accessing infrastructure networks as shown in Fig. 1.
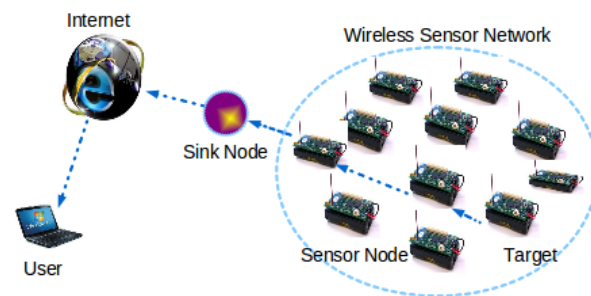

Figure 1: Illustration of Wireless Sensor Networks

Due to the recent and continued advancement in wireless communications, embedded micro sensing (MEMS) technologies, and WSN had grown extremely good in the past few years [3, 4]. This network, contained hundreds or thousands of sensor nodes, thus, attract much attention due to its ubiquitous capability to support a wide range of applications.

The application of WSNs in health is referred to as healthcare wireless sensor networks (HCWSNs) [5]. The difference between HCWSNs and other WSN technology application is the criticality of reliable data transmissions which have a number of characteristics that differentiate them from standard WSNs and Wireless Local Area Network (WLAN), therefore, reliability is very important. Since replacing batteries may be difficult or impossible in HCWSNs applications, and the lifetime of a sensor node depends to a large extent on the battery life time as well as the network coverage/connectivity. Therefore, it is important to adapt energy efficient strategies for these networks. The main challenge in WSN is to minimize energy consumption in each sensor node. Researchers mainly focus on the routing protocol that would consume less power, hence prolong network's life span.

The sensor nodes are deployed randomly in the sensing field; they are expected to perform their function without any maintenance, human attendance or battery replacement, which limits the energy available on the sensor nodes.

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Current routing protocols are designed for traditional networks, and they cannot be used in a Healthcare Wireless Sensor Networks (HCWSN) because the networks are application specific, high degree of redundancy in the sensed data, data collection in the sensor network is based on location, and sensor nodes are not mobile.

Not all the protocols are suitable in all situations; the performance differs from one WSNs application to another. Therefore, it is critical to asses routing protocols for health care monitoring applications.

This paper has critically examined cluster-based routing protocols which are used in increasing energy efficiency of WSN for healthcare applications. Also, the paper points out important issues in cluster-based routing protocols.

2. Background

Technology has always presented ways of improving the quality of lives in the society. This is as a result of continued realization of Moore's law, idea or methods in the area of sensor technology, which allowed the integration of tiny, low-power, and wearable smart medical sensor devices, for example e pulse Oximeters [5], electrocardiographs [6], and accelerometers [7] into commonly used wireless sensor devices. These sensor-equipped wireless devices form WSN that presently offer a potential solution to the inefficiencies that plague the health care industry. In recent years, WSN-based health care systems have been deployed for applications such as home monitoring for chronic and elderly patients [8], real-time continuous patient monitoring in hospitals [9], automated vital sign analysis to reduce the incidents of medical accidents due to human error [10], and emergency situations [11]. For most applications that requires the design, implementation, and deployment of WSNs, the following challenges inherent to almost all WSN applications must be overcome: low computational power, poor communication bandwidth, congested wireless medium and limited energy budget. However, health care related applications for nursing homes, emergency scenarios, or hospitals require more specific requirements to make the integration of WSNs successful. This is because the world's aging population is increasing at an unprecedented rate in the developed and developing countries. According to the aging World: 2008 report [12], in 2008 the number of aging people worldwide (*i.e.*, 65 years and older) was estimated at 506 million, and by 2040, that number will increase to 1.3 billion. Thus, in just over three decades, the percentage of older age people will increase two times from 7% to 14% of the total world population [12]. Though, the aging population signifies, a human success story of increased longevity, the steady, sustained growth of the older population also poses health challenges, thus the aging population desperately demands independent life and good quality of care without disturbing their comfort, while reducing their costs of maintenance. In this context, wireless sensor technology could provide highly useful tools for elderly people health monitoring and patients who need continuous monitoring.

A number of hospitals and medical centres are exploring applications of WSN technology to a range of medical applications, including pre-hospital and in-hospital emergency care, disaster response, and stroke patient rehabilitations. WSNs may be embedded into a hospital building to track and monitor patients and all medical resources. The WSNs have the potential to influence the delivery and study of resuscitative care by allowing vital signs to be collected and integrated automatically into the patient care record that may be used for real-time triage, correlation with hospital records, and long-term observations [9,14]. The WSNs permit home monitoring for chronic and elderly patients, facilitating long-term care and trend analysis; this in turn can sometimes reduce the length of hospital delays. WSNs also permit collection of long-term medical information that populates databases of clinical data; this enables longitudinal studies across populations and allows physicians to study the effects of medical intervention programs [15] Fig. 2 shows the HCWSNs applications.
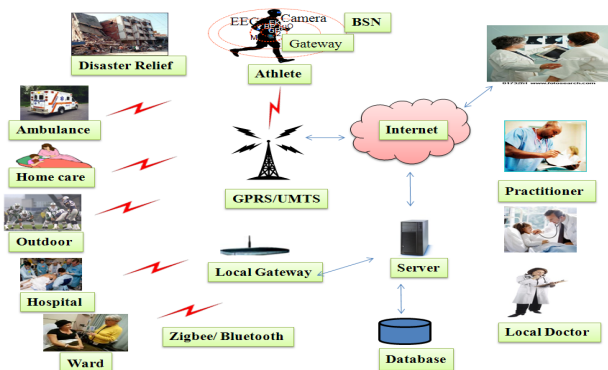

Figure 2 Healthcare Application using WSN

As shown in Fig. 2, Wireless Medical Sensor Networks (WMSNs) carry the promise of quality of care across wide variety of healthcare applications (e.g., ambulatory monitoring, vital sign monitoring in hospitals, elderly peoples' at home care monitoring, monitoring in mass-casualty disasters, clinical monitoring, etc.). In addition, other applications that also benefit from WMSNs include sportspersonels health status monitoring [10], and patients' self-care (i.e., a Body Area Network BAN on a diabetic patient could be helpful to auto inject insulin, though a pump, as soon as their insulin level declines).

So far several research groups and projects have started to develop health monitoring using wireless sensor networks, for example, CodeBlue (CodeBlue is a prototype HCWSNs that defines an architecture for hardware and a framework for software) [6,7,9], MASN (Medical Ad hoc Sensor Network) [7,15], MobiHealth (Mobile Healthcare System) [6,10,12,], Madison (Medical Ad hoc Sensor Network) [6,15]. Thus, healthcare systems are the most beneficial applications using wireless medical sensor technology that can take care of the patient within homes, hospitals, clinics, disaster sites, and the open environment.

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3. Applications Scenarios for Healthcare Wireless Sensor Networks

As we have seen, all the on-going healthcare monitoring projects enable automatic patient monitoring and provide excellent quality of healthcare without disturbing patient comfort. All the projects focus on the reliability, cost effectiveness and power consumptions of their prototypes. It is worthwhile to assume the scale of deployment of healthcare applications using WMSNs. In this regards, we have considered three wireless healthcare scenarios, namely, a nursing home, in-home monitoring, and in-hospital monitoring, as shown in Fig. 3.
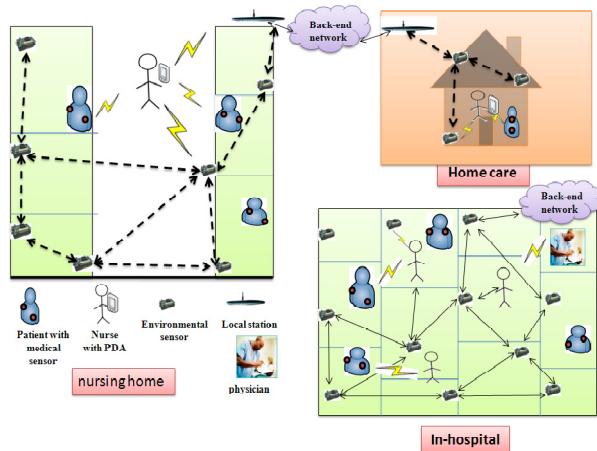

Figure 3.Applications Scenarios for a Nursing Home, Home Care, and In-hospital

Home care = fig.3 a, Nursing home = fig.3b, In-hospital = fig.3 c

The wireless healthcare applications use medical sensors (i.e., patient appropriateness) and environmental sensors (ES), mobile devices (e.g PDA, laptop and iPhone), and more especially wireless communications (e.g, IEEE 802.11, IEEE 802.15.4, Bluetooth etc.) protocols. Furthermore, a backend server is used for physiological healthcare information (PHI) storage, and for offline analysis of PHIs. According to the nursing home scenario (see Fig.3) medical sensors are placed on a patient's body and sense the physiological data of an individual and transmit it in a timely way to the PDA that is held by a nurse. A nurse can query the patient's sensors and analyze the real-time patient data conditions. Later, the nurse can send patient data to the central server by using the Internet or a wireless medium. Many ES are deployed in nursing homes that can form a wired or wireless network, sense the environmental parameters (e.g., ward temperature, humidity, etc.) and transmit the data to either a nurse or a remote center. In addition, the environmental sensors may forward an alarm to the remote server in an emergency situation (if a severe condition is detected), should one occur. In the home scenario(Fig. 3a), medical sensors are planted on a patient's body, and capture the health data from an individual and transmit it in a timely fashion to a PDA held

by a nurse or family member. In addition, environmental sensors are required when a patient is usually alone at home. The environmental sensors are placed at the corners of rooms, collecting the environmental conditions (e.g., room temperature, humidity, etc.), and patient movement data. Later they automatically send collected environmental and patient abnormal conditions to the PDA, which is held by either a nurse or a responsible family member. The home local station can directly communicate with environmental sensors using Zigbee modules. To analyze the patient physiological data an application program will be implemented in the backend network. In the In-hospital scenario(Fig. 3c), the same deployment and sensing scenario (e.g nursing home and homecare scenarios) is now applicable to the hospital environment, where groups of patients are temporarily monitored using a WMSN by nurses or physicians using their PDAs; for more details the reader may refer to [17].

4. Healthcare Wireless Sensor Networks

The three main requirements that the architecture for a HCWSN must satisfy includes:

i. Reliability: The ability to transmit accurate and diverse data while meeting stringent quality of service (QoS) requirements, in terms of high packet delivery ratio (PDR) and low end to end latency is of paramount importance in medical settings.

ii. Energy Efficiency: One key drawback of WSNs to health care applications is that many sensors do not require external power (i.e., they use battery power), so it is critical to extend the lifetime of these devices by minimizing energy consumption.

iii. Routing: The routing of data can directly impact the reliability, fault tolerance, and scalability of a HCWSN, and also the energy required by the system for communications.
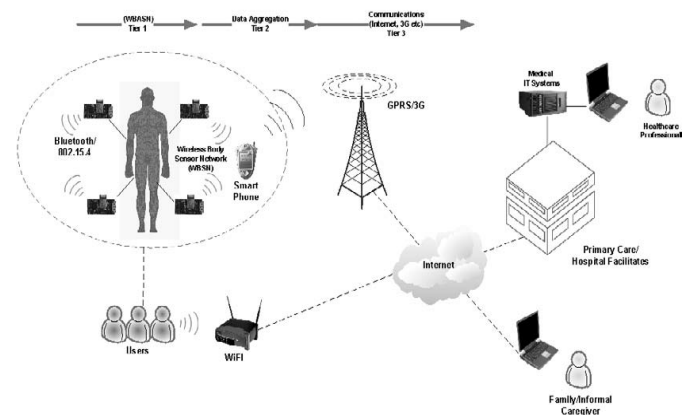

Figure 4 The architecture for HCWSN.

In Fig. 4, two kinds of network topologies are shown. The sensor nodes either form a flat network topology where sensor nodes also act as routers and transfer data to a sink through multi-hop routing, or a hierarchical network topology where

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more powerful fixed or mobile relays are used to collect and route the sensor data to a sink.

4.1 Design Considerations for Healthcare Monitoring Systems

The medical applications of wireless sensor networks aim to improve the existing healthcare and monitoring services, especially for the elderly, children and chronically ill as previously explained. There are several benefits achieved with these systems. To begin with, remote monitoring capability is the main benefit of pervasive healthcare systems. With remote monitoring, the identification of emergency conditions for risk patients will become easier and the people with different degrees of cognitive and physical disabilities will be enabled to have a more independent and easy life. The little children and babies can also be cared for in a more secure way whereas their parents are away. The special caregivers' dependability will be decreased.

In healthcare applications, a real-time system is referring to as soft real-time systems, in which some latency is allowed [18]. Identifying emergency situations like heart attacks or sudden falls in a few seconds or even minutes will suffice for saving lives considering the identified conditions. Therefore, providing real-time identification and action taking in pervasive healthcare systems is among the main benefits. Based on this observation, in a typical scenario, there are four different categories of actors other than the other users of the system such as administrators and developers.

Children: this group consists of young pupil who is not capable of taking care of themselves like babies, infants, toddlers or those who are more grown up but still needed to be constantly monitored.

Elderly and chronically ill: this group includes the chronically ill people who have cognitive difficulties or other medical disorders related to the heart, respiration, etc. and the elderly people who also may have these symptoms, besides, who are more susceptible to sudden falls.

Caregivers: this group comprised of the parents and the babysitters of the children's group and also the caregivers and other care network of the elderly and the chronically ill.

Healthcare professionals: these are the professional caregivers like physicians and other medical staff who are responsible for the constant health status monitoring of the elderly and the chronically ill people. Also, they are capable of giving the immediate response in case of an emergency situation.

These groups of actors constantly interact with the wireless sensor network healthcare system by using different subsystems. Five subsystems in such scenario have been identified which include:

(i) Body Area Network Subsystem, (ii) Personal Area Network Subsystem, (iii) Gateway to the Wide Area Networks, (iv) Wide Area Networks, and (v) End-user healthcare monitoring application. The design considerations of i and ii is power consumption and energy efficiency, whereas iii, and iv, are concerned with the reliability of routing protocol and scalability.

5 Design Issues of Routing Protocols for HCWSN

Initially WSNs was mainly motivated by military applications. Subsequently, civilian application domains of wireless sensor networks were considered, such as environmental and species monitoring, production, healthcare, smart home, etc. These WSNs may consist of heterogeneous and mobile sensor nodes, the network topology may be as simple as a star topology; the scale and density of a network vary depending on the application. To meet this general trend towards diversification, the following important design issues [4,19] of the sensor network have to be considered.

Energy: Sensor nodes have limited energy. The nodes may drain out while performing the tasks like calculating and transmitting the data in a wireless environment. The lifetime of a sensor node may depend on its battery lifetime. Depending on the energy, routing process should be reconfigured and routing algorithm is required to be highly flexible.

Fault Tolerance: Some sensor nodes may fail or be blocked due to lack of power, have physical damage or environmental interference. The failure of sensor nodes should not affect the overall task of the sensor network. This is the reliability or fault tolerance issue. Fault tolerance is the ability to sustain sensor network functionalities without any interruption due to sensor node failures.

Scalability: The number of sensor nodes deployed in the sensing area may be in the order of hundreds, thousands or more and routing schemes must be scalable enough to respond to events.

Production Costs: Since the sensor networks consist of a large number of sensor nodes, the cost of a single node is very important to justify the overall cost of the networks and hence the cost of each sensor node has to be kept low.

Operating Environment: We can set up a sensor network in the interior of a given healthcare environment, in a field of emergency situations services, in a home or a large building, attached to patients, attached to fast moving ambulance, etc.

Power Consumption: Since the transmission power of a wireless radio is proportional to distance squared or even higher order in the presence of obstacles, multi-hop routing will consume less energy than direct communication. However, multi-hop routing introduces significant overhead for topology management and medium access control. Direct routing would perform well enough if all the nodes were very close to the sink [22].

Data Delivery Models: Data delivery models determine when the data collected by the node has to be delivered. Depending on the application of the sensor network, the data delivery model to the sink can be Continuous, Event driven,

Query-driven and Hybrid [23]. In the continuous delivery model, each sensor sends data periodically. In event driven models, the transmission of data is triggered when an event occurs. In query driven models, the transmission of data is triggered when the query is generated by the sink. Some networks apply a hybrid model using a combination of continuous, event-driven and query driven data delivery.

Data Aggregation/Fusion: Since sensor nodes might generate significant redundant data, similar packets from multiple nodes can be aggregated so that the number of transmissions would be reduced. Data aggregation is the combination of data from different sources by using functions such as suppression (eliminating duplicates), min, max and average [22]. As computation would be less energy consuming than communication, substantial energy savings can be obtained through data aggregation. This technique has been used to achieve energy efficiency and traffic optimization in a number of routing protocols

Quality of Service: The quality of service means the quality service required by the application, it could be the length of lifetime, the data reliable, energy efficient, and location-awareness, collaborative-processing. These factors will affect the selection of routing protocols for a particular application. In some applications (e.g. some military applications) the data should be delivered within a certain period of time from the moment it is sensed.

Data Latency and Overhead: These are considered as the important factors that influence routing protocol design. Data aggregation and multi-hop relays cause data latency. In addition, some routing protocols create excessive overheads to implement their algorithms, which are not suitable for serious energy constrained networks.

Node Deployment: Node deployment is application dependent and affects the performance of the routing protocol. The deployment is either deterministic or self-organizing. In deterministic situations, the sensors are manually placed and data is routed through pre-determined paths. However, in self organizing systems, the sensor nodes are scattered randomly creating a Special Issue on Ubiquitous Computing Security Systems.

5.1 Classification of Routing Protocols for Wireless Sensor Networks

Different routing protocols are designed to avoid the weaknesses of the resource constrained nature of the WSNs. WSN Routing Protocols can be classified into four main categories based upon:

I.   The type of communication routes processed within the network for data transmission from the source to sink
II. The type of the network structure
III. The network operations carried out using these protocols
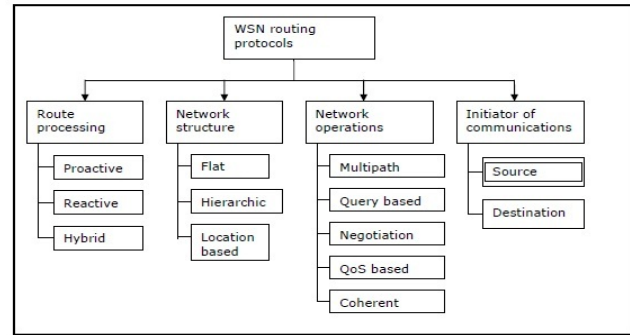IV. The initiator of communications

Figure 5 Classification of Routing Protocols for WSN

Proactive routing protocols: All the paths from sources to sinks are regularly computed before they are really needed and then these routes are stored in a routing table in each node so that routing information is kept for every node in the network. A certain amount of control traffic, is needed to keep routing tables up to date and consistent over the whole network. Example: Optimized Link State Routing (OLSR).

Reactive routing protocols: Paths are acquired by nodes on demand when data need to be forwarded and no path to the destination is currently known. Whenever a sink wants to contact a particular node, the path values are calculated and the best path is selected for data transmission. Example: Ad-hoc On-Demand Distance Vector (AODV).

Hybrid routing protocols: Combine features of proactive and reactive protocols. The network is divided into specified regions or zones. Data distribution within a zone is table driven (proactive) and when a node needs to send data to a node of another zone, it is accomplished through on-demand (reactive) routing protocol. Examples: Dynamic Zone Topology Routing protocol (DZTR) and Zone Routing Protocol (ZRP). Flat Routing protocols: All nodes participating in routing play the same role of collecting data and communicating with the sink. Example: Sensor Protocols for Information via Negotiation (SPIN).

Hierarchical routing protocols: The goal of the protocol is to perform energy-efficient routing in WSNs by avoiding an overload of sink nodes by too many received messages, as well as reducing the amount of overall message transmissions. To achieve this, nodes are grouped into clusters, where the high energy nodes are used to process and send the information while low energy nodes are used to perform the sensing in the proximity of the target. Example: Low energy adaptive clustering hierarchy (LEACH)

Location-based routing protocols: Sensor nodes are addressed by means of their locations. In most cases location information is needed in order to calculate the distance between two particular nodes so that energy consumption can be estimated. Each node calculates the distance to his neighbor node from the incoming signal strength. In some location-based schemes in order to save energy, the nodes must change their state from active to sleep if there is no activity.

Multipath routing protocols: Several paths are discovered between the source and the destination and are used to provide a backup route. When the primary path fails, the backup is used and this increases the network performance at the expense of increasing the cost of energy consumption and traffic generation. Example: Ad hoc On-demand Multipath Distance Vector routing (AOMDV).

Query based routing protocols: Destination node sends queries requesting certain data from the nodes in the network. If a node has the data that match the query, it sends them back to the requested node. This process is known as Directed Diffusion. Examples: Directed Diffusion (DD), COUGAR, Sensor Protocols for Information via Negotiation (SPIN).

Negotiation based routing protocols: The main idea is to suppress duplicate information and prevent redundant data from being sent to the next sensor or the base station by conducting a series of negotiation messages before the real data transmission begins. Examples: SPIN family protocols.

QoS based routing protocols: The network has to balance between energy consumption and data quality. In particular, the network has to satisfy certain QoS metrics (delay, energy, bandwidth, etc.) when delivering data to the base station. Example: SPEED (Stateless Protocol for Real-Time Communication in Sensor Networks).

Coherent based routing protocols: All the nodes within the network collect the data and perform minimum processing (time stamping or duplicate suppression). Then the data is forwarded to nodes that perform further processing on the data. These nodes are called aggregators.

Source initiated routing protocols: The nodes send data to the base station soon after they take new measurements. Source initiated protocols use either time driven or event driven data reporting.

Destination initiated routing: The nodes only send data in response to a request for data. Destination initiated protocols use query driven data reporting. The drawback of destination initiated protocols is the fact that requests are usually flooded through the network, draining the energy sources of nodes.

5.2 Cluster-Based Hierarchical Model

As shown in Fig. 6, a hierarchical approach breaks the network into clustered layers [24, 25]. Nodes are grouped into clusters with a cluster head that has the responsibility of routing from the cluster to the other cluster heads or base stations. Data travels from a lower clustered layer to a higher one. Although, it hops from one node to another, but as it hops from one layer to another it covers larger distances. This moves the data faster to the base station. Theoretically, the latency in such a model is much less than in the multi hop model.

Clustering provides inherent optimization capabilities at the cluster heads. In the cluster-based

Hierarchical model, data is first aggregated in the cluster, then sent to a higher-level cluster-head. As it moves from a lower level to a higher one, it travels greater distances, thus

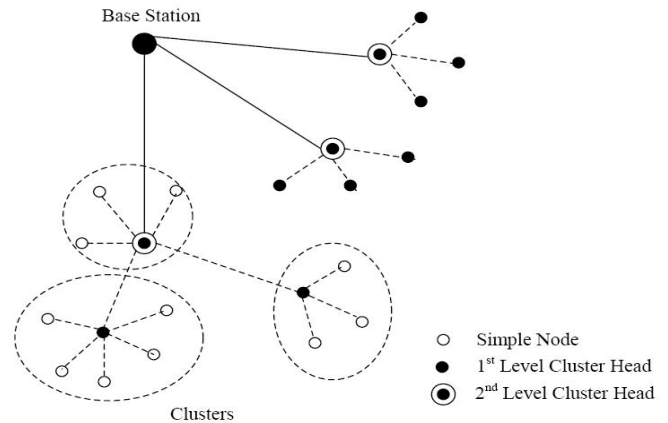reducing the travel time and latency. This model is better than the one hop or multi-hop mode.

Figure 6 Cluster-based Hierarchical Model

A cluster-based hierarchy moves the data faster to the base station thus reducing latency than in the multi-hop model. Further, in cluster-based model only cluster-heads perform data aggregation whereas in the multi-hop model every intermediate node performs data aggregation. As a result, the cluster-based model is more suitable for time-critical applications than the multi-hop model. However, it has one drawback, namely, as the distance between clustering level increases, the energy spent is proportional to the square of the distance. This increases energy expenditure. Despite this drawback, the benefits of this model far outweigh its drawback. A cluster based hierarchical model offers a better approach to routing for HCWSNs.

5.3. Cluster Based Routing Protocols for Healthcare

Clustering is the process of classifying the nodes into different groups by partitioning sets of data into a series of subsets called clusters. Clustering basically involved a set of cluster heads, which are selected as predefined criteria. The cluster heads carried out the other responsibilities like collecting data from all the sensor nodes in a cluster and transmits it to the base station. The role of each cluster head turns around after every round between all the nodes present in a cluster. It should be balanced, the energy level of the cluster head. It is assumed that each sensor node has an extensive range of communication and is able to reach CH directly and thereafter BS. The Cluster based wireless sensor network architecture is shown in Fig. 6.

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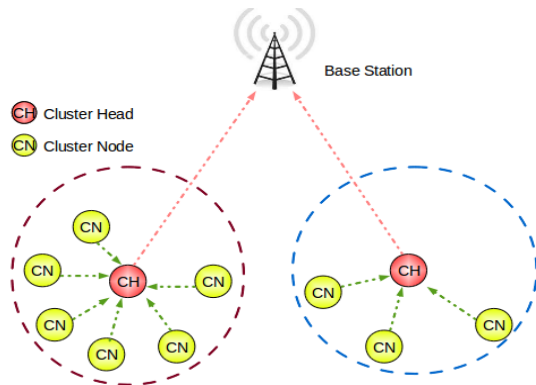ISSN (Print): 1694-0814 | ISSN (Online): 1694-0784
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Figure 7. Cluster-based wireless sensor network architecture

There are enormous activities of research has been carried out to provide energy efficient routing [2] for Mobile WSNs and quite a lot of solutions have been proposed for minimizing the energy consumption. This section briefly outlines the related work in CBR as related to hierarchical routing.

A hierarchical protocol is an approach to the balance between scalability and performance. In hierarchical routing, energy consumption of sensor nodes is drastically minimized when the sensor nodes are involved in multi-hop communication in an area of cluster and performing data aggregation and fusion so as to reduce the number of transmitted information to the sink. The cluster formation is based on the energy reserve of sensor nodes and its proximity to the cluster head [24]. In hierarchical routing, data moves from a lower clustered layer to higher regions, hopping from one node to another which covers larger distances, hence moving the data faster to the sink faster. Clustering provides the inherent optimization capability at the cluster heads. A view of the architecture of hierarchical network.

Traditional (or flat) routing protocols for WSN may not be optimal in terms of energy consumption. Clustering can be used as an energy-efficient communication protocol. The objectives of clustering are to minimize the total transmission power aggregated over the nodes in the selected path, and to balance the load among the nodes for prolonging the network lifetime. Clustering is a sample of layered protocols in which a network is composed of several clumps (or clusters) of sensors. As shown in Fig. 6, each clump or cluster is managed by a special node or leader, called cluster head (CH), which is responsible for coordinating the data transmission activities of all sensors in its clump. All sensors in a cluster communicate with a cluster head that acts as a local coordinator or sink for performing intra-transmission arrangement and data aggregation. Cluster heads in turn transmits the sensed data to the global sink. The transmission distance over which the sensors send their data to their cluster head is smaller compared to their respective distances to the global sink. Since a network is characterized by its limited wireless channel bandwidth, it would be beneficial if the amount of data transmitted to the sink can be reduced. To achieve this goal, a local collaboration between the sensors in a cluster is required in order to reduce bandwidth demands.

Low Energy Adoptive Clustering Hierarchy (LEACH), Energy Efficient sensor Network (TEEN), Adaptive Periodic Energy Efficient sensor Network (APTEEN), and Power-efficient gathering in sensor information systems (PEGASIS) [26, 27] are cluster based routing protocols they have similar features and their architectures are to some extent similar. They have fixed infrastructure.

The low-energy adaptive clustering hierarchy (LEACH) proposed by Heinzelman et al. [19] is a well-known hierarchical routing protocol applied in clustered wireless sensor networks. LEACH divides a wireless sensor network into a number of clusters, and sensor nodes in the same cluster can communicate with each other directly. A sensor node decides which cluster to join based on the strength of receiving signals. After joining a cluster, sensor nodes in the same cluster randomly select a cluster head for collecting and forwarding data to the base station (Figure 3). Since the cluster head will consume more energy, it has to be replaced regularly to reduce the power consumption.

To replace LEACH's distributed operation by a centralized control, LEACH-Centralized (LEACH-C) was proposed by Handy et al. [28] and it is more effective in extending the lifetime. In the deployment phase, each sensor node sends back its location to the base station. Then, the base station selects cluster heads according to their power conditions and positions, and the selected cluster heads start to transmit data to the base station afterwards. This approach can effectively extend the lifetime of LEACH, but its drawback is that distant cluster heads will consume power quickly.

The basic operations of LEACH are organized in two distinct phases. The first phase, the setup phase, consists of two steps, cluster-head selection and cluster formation. The second

phase, the steady-state phase, focuses on data collection, aggregation, and delivery to the base station. The duration of the setup is assumed to be relatively shorter than the steady state phase to minimize the protocol overhead.

Manjeshwar and Agrawal proposed the Threshold sensitive Energy Efficient sensor Network protocol (TEEN) [20], which can immediately react to unexpected events. TEEN is based on LEACH to send back sensor data to the base station periodically, and it sets two threshold values, i.e., hard threshold and soft threshold, to avoid the transmission of duplicated sensor data. This method can save electric power, but it is not applicable in the environment requiring periodical data as the threshold values may not be met on occasion

For the improvement of TEEN, Manjeshwar and Agrawal proposed the Adaptive Periodic Threshold sensitive Energy Efficient sensor Network (APTEEN) as a revision [21]. APTEEN remedies the drawback of TEEN by reporting data periodically, and the objective is to react to sudden events in real time. After the sensor network is established, each cluster head sends out four parameters:

I.   Attribute: information about data events.

II. Thresholds: including hard threshold and soft threshold.

III. Schedule of TDMA (Time Division Multiple Access): every sensor node will receive its own allocated time slot.

IV. Count Time: the time interval between two transmissions. When the count time is reached, the data will be transmitted as a periodical report.

PEGASIS [22] and its extension, hierarchical PEGASIS, are a family of routing and information-gathering protocols for WSNs. The main objectives of PEGASIS are twofold. First, the protocol aims at extending the lifetime of a network by achieving a high level of energy efficiency and uniform energy consumption across all network nodes. Second, the protocol strives to reduce the delay that data incur on their way to the sink.

The network model considered by PEGASIS assumes a homogeneous set of nodes deployed across a geographical area. Nodes are assumed to have global knowledge about other sensors' positions. Furthermore, they have the ability to control their power to cover arbitrary ranges. The nodes may also be equipped with CDMA-capable radio transceivers. The nodes' responsibility is to gather and deliver data to a sink, typically a wireless base station. The goal is to develop a routing structure and an aggregation scheme to reduce energy consumption and deliver the aggregated data to the base station with minimal delay while balancing energy consumption among the sensor nodes. Contrary to other protocols, which rely on a tree structure or a cluster-based

hierarchical organization of the network for data gathering and dissemination, PEGASIS uses a chain structure.

The performance of APTEEN lies between TEEN and LEACH with respect to energy consumption and longevity of the network. TEEN only transmits time-critical data, while APTEEN performs periodic data transmissions. In this respect APTEEN is also better than LEACH because APTEEN transmits data based on a threshold value whereas LEACH transmits data continuously.

5.4 Comparative Analysis of the Routing Protocols

Now we compare the routing protocols earlier mentioned, according to their performance on different parameters (Table 1 reported the comparisons). When analyzing the performance of a proposed clustering algorithm, there are two major areas that have to be examined Which includes: First, Power, energy and network lifetime. Due to the limited energy nature of the sensor nodes, network lifetime is dependent on the efficient use of this energy. The primary comparison measurement when looking at the efficiency of a given algorithm is the network lifetime. Second, Quality and Reliability of the Links: When comparing clustering algorithms, the quality of the links is an important comparison parameter. Each clustering scheme proposes various recovery mechanisms.

Table 1. Comparison of different routing protocols

Routing protocols	Power Management	Network Life Time	Scalability	Classification	Data Aggregation	Data delivery model
LEACH	Maximum	Very good	Good	Clustering	Yes	Custer-head
TEEN	Maximum	Very good	Good	Reactive/Clustering		
APTEEN	Maximum	Very good	Good	Hybrid	Yes	Active threshold
SAR	Maximum	Good	Ltd		Yes	Continuously
PEGASIS	Maximum	Very good	Good	Reactive/Clustering	No	Chain based
SPEED	Minimum	Good	Ltd		No	Geographic

LEACH, TEEN, APTEEN and PEGASIS have similar features and their architectures are to some extent similar. They have fixed infrastructure. LEACH, TEEN, APTEEN are cluster based routing protocols, whereas PEGASIS is a chain-based protocol. The performance of APTEEN lies between TEEN and LEACH with respect to energy consumption and longevity of the network [9]. TEEN only transmits time-critical data, whereas APTEEN performs periodic data transmissions. In this respect APTEEN is also better than

LEACH because APTEEN transmits data based on a threshold value whereas LEACH transmits data continuously. In addition, PEGASIS avoids the formation of the clustering overhead of LEACH, but it requires dynamic topology adjustment since sensor energy is not tracked. PEGASIS introduces an excessive delay for distant nodes on the chain. The single leader can become a bottleneck in PEGASIS. PEGASIS increases network lifetime twofold compared to the LEACH protocol. In order to deviate from the limitations, the

solutions for such environments is to have a mechanism for providing a reliable and fault tolerant communication, quick reconfiguration, and the minimum consumption of energy. Routing protocols have a critical role in most of these activities. Beside all these problems, the infrastructure, limited resources (in terms of power, memory and computing capabilities) nature of WSNs makes routing more complicated. Clustering is one of the basic approaches for adopting energy efficient, robust and highly scalable sensor networks. Clustered organization dramatically reduces the communication overhead, thereby minimizing energy consumption and interference among the sensor nodes. Moreover, by aggregating the sensor's data at a designated node called cluster head (CH), the total amount of data to the base station can be reduced, saving energy and bandwidth resources. Therefore, we have to be aware that energy efficient protocols are in high demand in order to prolong the lifetime of sensor networks. Actually, routing protocols can render the network useful by effectively saving energy consumption, whereas clustering provides a hierarchical organization of the network [6].

6. Conclusions and Further Work

Previous studies on the performance of the clustering algorithms in saving energy for healthcare wireless sensor networks showed that energy efficient clustering protocols for heterogeneous wireless sensor network have better performance than energy efficient clustering protocols for the homogeneous wireless sensor network in prolonging the network lifetime. We conclude that the heterogeneous wireless sensor networks are more suitable for real life applications as compared to the homogeneous counterpart. In future, in smart home environments, there may be multi-modal sensor solutions that incorporate the benefits is being described as a useful tool for elderly people health monitoring and patients who need continuous monitoring, However, there are still challenges in overcoming the achievement of context-aware, and pervasive healthcare applications. We intend for researchers to quickly identify areas that require more attention and to propose a novel methodology for improving the effectiveness of existing protocols. We intend to modify LEACH to improve its energy efficiency. In addition, the research will be extended to include energy efficiency in collaborative virtual environment [29], cyberspace [30], internet of things [31], security systems [32] and Cryptosystem [33].

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