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ENERGY EFFICIENT PATH DETERMINATION IN WIRELESS SENSOR NETWORK BY CRITICAL PATH METHOD

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Abstract:

Wireless sensor network (WSN) is defined as a network of devices denoted as nodes that sense the environment and communicate the information gathered from the monitored field through wireless link. These tiny sensor nodes, which consist of sensing, data processing and communicating components, leverage the idea of sensor networks based on collaborative effort of a large number of nodes. Sensor networks also introduce severe resource constraints due to their lack of data storage and power. Both of these represent major obstacles to the implementation of traditional computer energy efficient techniques in a WSN. Energy consumption in WSNs is of paramount importance, which is demonstrated by the large number of algorithms, techniques and protocols that have been developed to save energy and extend the lifetime of the network. One way to cope with the energy challenge is to power down the radio transceiver during periods of inactivity. In particular, it has been shown that sensors operating at a two percentage duty cycle can achieve lifetimes of 6-month using two AA batteries. The traditional networks aim to achieve high quality of service (QoS), so the provisions or protocols must focus primarily on power conservation. They must have inbuilt trade-off mechanisms that give the end user the option of prolonging network lifetime at the cost of lower throughput or higher transmission delay. The critical path method (CPM) is an optimal research technique of analysis to find the critical path, i.e., the sequence of activities with the minimum energy in wireless sensor node. CPM uses activity oriented network estimate with fair degree of accuracy and control both time and energy in network.

I INTRODUCTION

Wireless Sensor Networks (WSN) are intended for monitoring an environment. The main task of a wireless sensor node is to sense and collect data from a certain domain, process them and transmit it to the sink where the application lies. However, ensuring the direct communication between a sensor and the sink may force nodes to emit their messages with such a high power that their resources could be quickly depleted. Therefore, the collaboration of nodes to ensure that distant nodes communicate with the sink is a requirement. In this way, messages are propagated by intermediate nodes so that a route with multiple links or hops to the sink is established.

Taking into account the reduced capabilities of sensors, the communication with the sink could be initially conceived without a routing protocol. With this premise, the flooding algorithm stands out as the simplest solution. In this algorithm, the transmitter broadcasts the data which are consecutively retransmitted in order to make them arrive at the intended destination. However, its simplicity brings about significant drawbacks. Firstly, an implosion is detected because nodes redundantly receive multiple copies of the same data message. Then, as the event may be detected by several nodes in the affected area, multiple data messages containing similar information are introduced into the network. Moreover, the nodes do not take into account their resources to limit their functionalities.

One optimization relies on the gossiping algorithm [1]. Gossiping avoids implosion as the sensor transmits the message to a selected neighbor instead of informing all its neighbors as in the classical flooding algorithm. However, overlap and resource blindness are still present. Furthermore, these inconveniences are highlighted when the number of nodes in the network increases.

Due to the deficiencies of the previous strategies, routing protocols become necessary in wireless sensor networks. Nevertheless, the inclusion of a routing protocol in a wireless sensor network is not a trivial task. One of the main limitations is the identification of nodes. Since wireless sensor networks are formed by a significant number of nodes, the manual assignation of unique identifiers becomes infeasible [2]. The use of potentially unique identifier such as the MAC (Medium Access Control) address or the GPS coordinates is not recommended as it forces a significant payload in the messages [3]. However, this drawback is easily overcome in wireless sensor networks since an IP address is not required to identify the destination node of a specific packet. In fact, attribute-based addressing fits better with the specificities of wireless sensor networks. In this

case, an attribute such as node location and sensor type is used to identify the final destination.
Once nodes are identified, routing protocols are in charge of constructing and maintaining routes between distant nodes. The different ways in which routing protocols operate make them appropriate for certain applications.

Design Constraints for Routing in Wireless Sensor Networks

Due to the reduced computing, radio and battery resources of sensors, routing protocols in wireless sensor networks are expected to fulfill the following requirements [5]:
Autonomy: The assumption of a dedicated unit that controls the radio and routing resources does not stand in wireless sensor networks as it could be an easy point of attack. Since there will not be any centralized entity to make the routing decision, the routing procedures are transferred to the network nodes.
Energy Efficiency: Routing protocols should prolong network lifetime while maintaining a good grade of connectivity to allow the communication between nodes. It is important to note that the battery replacement in the sensors is infeasible since most of the sensors are randomly placed. Under some circumstances, the sensors are not even reachable. For instance, in wireless underground sensor networks, some devices are buried to make them able to sense the soil [6].
Scalability: Wireless sensor networks are composed of hundreds of nodes so routing protocols should work with this amount of nodes.
Resilience: Sensors may unpredictably stop operating due to environmental reasons or to the battery consumption. Routing protocols should cope with this eventuality so when a current-in-use node fails, an alternative route could be discovered.
Device Heterogeneity: Although most of the civil applications of wireless sensor network rely on homogenous nodes, the introduction of different kinds of sensors could report significant benefits. The use of nodes with different processors, transceivers, power units or sensing components may improve the characteristics of the network. Among other, the scalability of the network, the energy drainage or the bandwidth are potential candidates to benefit from the heterogeneity of nodes [7].
Mobility Adaptability: The different applications of wireless sensor networks could demand nodes to cope with their own mobility, the mobility of the sink or the mobility of the event to sense. Routing protocols should render appropriate support for these movements.

Classification of Routing Protocols in Wireless Sensor Networks

Taking into account their procedures, routing protocols can be roughly classified according to the following criteria.

Hierarchy Role of Nodes in the Network

In the flat schemes, all sensor nodes participate with the same role in the routing procedures. On the other hand, the hierarchical routing protocols classify sensor nodes according to their functionalities [8]. The network is then divided into groups or clusters. A leader or a cluster head is selected in the group to coordinate the activities within the cluster and to communicate with nodes outside the own cluster. The differentiation of nodes can be static or dynamic.

Data Delivery Model

Depending on the application, data gathering and interaction in wireless sensor networks could be accomplished on several ways. The data delivery model indicates the flow of information between the sensor nodes and the sink [7]. The data delivery models are divided into the following classes: continuous, event-driven, query-driven or hybrid. In the continuous model, the nodes periodically transmit the information that their sensors are detecting at a pre-specified rate. In contrast, the query-driven approaches force nodes to wait to be demanded in order to inform about their sensed data. In the event-driven model, sensors emit their collected data when an event of interests occurs. Finally, the hybrid schemes combine the previous strategies so sensors periodically inform about the collected data but also response to queries. Additionally, they are also programmed to inform about events of interest.

Optimization Techniques for Routing in Wireless Sensor Networks

The particular characteristics of wireless sensor networks and their constraints have prompted the need for specific requirements to routing protocols. When compared to mobile ad hoc networks routing protocols, the algorithms in wireless sensor networks usually realize the following specifications:

Attribute-based

In these algorithms, the sink sends queries to certain regions and waits for the response from the sensors located in this area. Following an attribute-value scheme, the queries inform about the required data. The selection of the attributes depends on the application. An important characteristic of these schemes is that the content of the data messages is analyzed in each hop to make decisions about routing.

Data Aggregation Data collected in sensors are derived from common phenomena so nodes in a close area usually share similar information. A way to reduce energy consumption is data aggregation. Aggregation consists of suppressing redundancy in different data messages. When the suppression is achieved by some signal processing techniques, this operation is called data fusion.

Addressing Scheme

Wireless sensor networks are formed by a significant number of nodes so the manual assignation of unique identifiers is infeasible. The use of the MAC address or the GPS coordinates is not recommended as it introduces a significant payload [3]. However, network-wide unique addresses are not needed to identify the destination node of a specific packet in wireless sensor networks. In fact, attribute-based addressing fits better with the specificities of wireless sensor networks. In this case, an attribute such as node location and sensor type is used to identify the final destination. Concerning these identifiers, two different approaches have been proposed [3]. Firstly, the ID reuse scheme allows identifiers to be repeated in the network but keeping their uniqueness in close areas. In this way, a node knows that its identifier is unique in a k-hop neighborhood, being k a parameter to configure. On the other hand, the field-wide unique ID schemes guarantee that the identifiers are unique in the whole application. With this assumption, other protocols such as routing, MAC or network configurations can be simultaneously used.

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Quality of Service

The network application business and its functionalities prompt the need for ensuring a QoS (Quality of Service) in the data exchange. In particular, effective sample rate, delay bounded and temporary precision are often required. Satisfying them is not possible for all the routing protocols as the demands may be opposite to the protocol principles. For instance, a routing protocol could be designed to extend the network lifetime while an application may demand an effective sample rate which forces periodic transmissions and, in turn, periodic energy consumptions. Figure 1 shows the relation of QoS and its dependence to the routing protocol goal and to the routing protocol strategy.

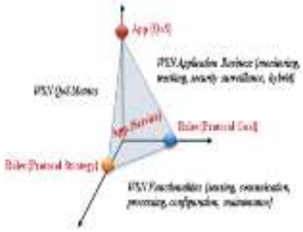

Figure 1. Relation of QoS and Routing Protocol Goal and Strategy.

ACQUIRE (Active Query Forwarding in Sensor Networks)

This algorithm [13] also considers the wireless sensor network as a distributed database. In this scheme, a node injects an active query packet into the network. Neighboring nodes that detects that the packet contains obsolete information, emits an update message to the node. Then, the node randomly selects a neighbor to propagate the query which needs to resolve it. As the active query progress through network, it is progressively resolved into smaller and smaller components until it is completely solved. Then, the query is returned back to the querying node as a completed response.

Geographical Routing Protocols

These algorithms take advantage of the location information to make routing techniques more efficient. Specifically, neighbors exchange information about their location so when a node needs to forward a packet, it sends it to the neighbor which is assumed to be closest to the final destination. To operate, the source inserts the destination's coordinates in the packets. The location information used in geographical algorithms can be derived from specific devices such as GPS or it can be modeled by virtual coordinates [14].
Concerning geographical protocols, geocasting is the process by which a packet is delivered to the nodes placed in an area. This primitive is especially suitable in wireless sensor networks since the sink usually demands information from the nodes that are in a zone. The zone can be statically determined by the source node or it can be constructed dynamically by the relaying nodes in order to avoid some nodes that may cause a detour.
On the other hand, in geographic-based rendezvous mechanisms, geographical locations are used as a rendezvous place for providers and seekers of information. Geographic-based rendezvous mechanisms can be used as an efficient means for service location and resource discovery, in addition to data dissemination and access in wireless sensor networks [15]. The most popular forwarding

techniques in geographical routing protocols are:

GAF (Geographic Adaptive Fidelity)

This protocol aims at optimizing the performance of wireless sensor networks by identifying equivalent nodes with respect to forwarding packets [19]. Two nodes are considered to be equivalent when they maintain the same set of neighbor nodes and so they can belong to the same communication routes. Source and destination in the application are excluded from this characterization. To identify equivalent nodes, their positions are necessary. Additionally, a virtual grid is constructed. This grid is formed by cells whose size allows to state that all the nodes in one cell can directly communicate with the nodes belonging to adjacent cells and vice versa. In this way, the nodes in a cell are equivalent.

Nodes identify equivalent nodes by the periodic exchange of discovery messages with the nodes in their cells. With the information contained in these messages, the nodes negotiate which one is going to support the communications. The other nodes will stay powered off. With this procedure, the routing fidelity is kept, that is, there is uninterrupted connectivity between communicating nodes. However, the elected node periodically rotates for fair energy consumption. To do so, the nodes wake up periodically.

Hierarchical Routing Protocols

The main objective of hierarchical routing is to reduce energy consumption by classifying nodes into clusters. In each cluster, a node is selected as the leader or the cluster head. The different schemes for hierarchical routings mainly differ in how the cluster head is selected and how the nodes behave in the inter and intra-cluster domain.

LEACH (Low Energy Adaptive Clustering Hierarchy)

In LEACH the role of the cluster head is periodically transferred among the nodes in the network in order to distribute the energy consumption. The performance of LEACH is based on rounds. Then, a cluster head is elected in each round. For this election, the number of nodes that have not been cluster heads and the percentage of cluster heads are used. Once the cluster head is defined in the setup phase, it establishes a TDMA schedule for the transmissions in its cluster [20]. This scheduling allows nodes to switch off their interfaces when they are not going to be employed. The cluster head is the router to the sink and it is also responsible for the data aggregation. As the cluster head controls the sensors located in a close area, the data aggregation performed by this leader permits to remove redundancy.

A centralized version of this protocol is LEACH-C [21]. This scheme is also based on time rounds which are divided into the set-up phase and the steady-phase. In the set-up phase, sensors inform the base station about their positions and about their energy level. With this information, the base station decides the structure of clusters and their corresponding cluster heads. Since the base station posses a complete knowledge of the status of the network, the cluster structure resulting from LEACH-C is considered an optimization of the results of LEACH.

PEGASIS (Power-Efficient Gathering in Sensor Information Systems)

It is considered an optimization of the LEACH algorithm. Rather than classifying nodes in clusters, the algorithm forms chains of the sensor nodes. Based on this structure, each node transmits to and receives from only one closest node of its neighbors. With this purpose, the nodes adjust the power of their transmissions [22]. The node performs data aggregation and forwards it the node in the chain that communicates with the sink. In each round, one node in the chain is elected to communicate with the sink. The chain is constructed with a greedy algorithm.

TEEN (Threshold Sensitive Energy Efficient Sensor Network Protocol)

TEEN [23] is other hierarchical protocol for reactive networks that responds immediately to changes in the relevant parameters. In this protocol a clusters head (CH) sends a hard threshold value and a soft one. The nodes sense their environment continuously. The first time a parameter from the attribute set reaches its hard threshold value, the node switches on its transmitter and sends its data. The nodes then transmits data in the current cluster period if the following conditions are true: the current value of the sensed attribute is greater than the hard threshold, and the current value of the sensed attribute differs from sensed value by an amount equal to or greater than the soft threshold. Both strategy looks to reduce energy spend transmitting messages.

The main drawback of this scheme is that, if the thresholds are not reached, the nodes will never communicate; the user will not get any data from the network at all and will not come to know even if all the nodes die. Thus, this scheme is not well suited for applications where the user needs to get data on a regular basis.

DirQ (Directed Query Dissemination)

DirQ [24] aims at optimizing the propagation of queries in a wireless sensor network. The main objective is that the queries are just propagated by the minimum number of nodes that ensure that the queries arrive at the nodes that are able to service the query. To do so, certain information is exchanged in the network. The periodicity of the update messages depend on the rate of variation of the physical parameters that the network is sensing. Then, each node autonomously maintains its own threshold (δ). If a sensor node has a value V of a desired parameter and the next measurement period gets the same or a similar value in the interval between (δ − V, V + δ) then it decides not to send anything to sink. However, if the sink does not receive any message from a specific node then it assumes that this node has a measured value that has not changed much from what has been reported recently. To allow a precise delivery of applications, all network nodes must be capable of storing information which can be considered a disadvantage depending on the amount of information stored in the topology and the number of nodes. DirQ is a protocol suitable for situations where the number of requests is high and times of transmission of requests are known.

Multipath Routing Protocols

In these protocols, a source knows multiple routes to a destination. The routes can be simultaneously used or one of them can be active while the others are maintained for future needs.

SAR (Sequential Assignment Routing)

SAR [25] is one of the first protocols for wireless sensor networks that provide the notion of QoS routing criteria. It is based on the association of a priority level to each packet. Additionally, the links and the routes are related to a metric that characterizes their potential provision of quality of service. This metric is based on the delay and the energy cost. Then, the algorithm creates trees rooted at the one-hop neighbors of the sink. To do so, several parameters such as the packet priority, the energy resources and the QoS metrics are taken into account. The protocol must periodically recalculate the routes to be prepared in case of failure of one of the active nodes.

Maximum Lifetime Routing in Wireless Sensor Networks

This algorithm combines the energy consumption optimization with the use of multiple routes [26]. In this algorithm an active route (also called the primary route) is monitored to control its residual energy. Meanwhile other routes can be discovered. If the residual energy of the active route does not exceed the energy of an alternative route, the corresponding secondary route is then used.

Energy Aware Routing in Wireless Sensor Networks

Once multiple paths are discovered, this algorithm associates a probability of use to each route [27]. This probability is related to the residual energy of the nodes that form the route but it is also considers the cost of transmitting through that route.

M-MPR (Mesh Multipath Routing)

This protocol presents two operation modes [28]. Firstly, in the disjoint MPR (D-MPR) with Selective Forwarding each packet is individually analyzed by the source and it is routed through different routes. Secondly, the D-MPR with data replication is based on the simultaneous emission of multiple copies of the same packet through different routes. Specifically, all the known routes that communicate the source and the destination propagate the packet. For the route discovery, information about the position of the nodes and about their residual energy is exchanged.

Beacon-less Geographic Routing Protocols

The geographic routing protocols were initially conceived to operate with the periodic exchange of messages that inform about the position of nodes in the network. These messages or beacons incurs in an additional overhead, which represents the main disadvantage of this kind of protocols. In [29] the suitability of suppressing the beacon messages in the geographic routing protocols [29] is analyzed. The beacon-less algorithms are then supported by the reactive exchange of location information just when the nodes need to route data. The paper analyzes five beacon-less routing protocols: IGF (Implicit Geographic Forwarding), GeRaF (Geographic Random Forwarding), CBF (Contention Based Forwarding), BLR and BOSS, which was proposed by the group.

QoS Routing Protocols based on Artificial Intelligence

In [30] a routing protocol that guarantees some QoS requirements by means of an artificial intelligence technique is presented. Neural networks are then introduced into the sensor nodes and a self-organized map is used. The simulation results show its ability to reduce the end-to-end delay and the network overhead compared to the Directed Diffusion protocol.

CHAPTER 2

LITERATURE SURVEY

The integration of WBANs and the IoT brings a new concept to the arena of sensor networks.WBANs fall under the WSN umbrella but differ as they have some unique characteristics. With thepassage of time state-of-the-art techniques have been adopted to remove deficiencies in the internalworking structure of WBANs. In different references numerous energy-efficient routing protocols havebeen anticipated for WBANs for diverse purposes such as thermal-conscious schemes, congestioncontrol techniques and maximizing battery efficient to extend the network lifetime. WBANs aremostly used in health-related applications that sense human body data, which in most cases is critical.

Therefore, its timely transmission for further analysis to medical-related servers is of the utmostimportance. Among all other technologies, routing is one of the main technologies, because the SNs'sensed data needs to be forwarded to the medical-related server efficient and in no time. Furthermore,due to resource constraints, such as limited battery capacity and transmission power due to the smallsize of the SNs, the network lifetime is compromised. Therefore, researchers nowadays are morefocused on developing energy-efficient routing mechanisms along with other means of providingenergy for WBANs. The aim of developing an energy- efficient routing mechanism is to enhance thenetwork lifetime, network stability, and throughput and reduce end-to-end delay among others. A fewstate-of-the-art routing protocols are discussed below.

Rahat et al. [26], presented an efficient and reliable routing protocol for wireless body area sensornetworks. It is claimed to be stable efficient in terms of power consumption. A total of eight sensornodes are deployed at different positions of human body which gather normal and critical data. Out ofthe total number of sensor nodes, two of the sensor nodes do not take part in multi-hop communication,but rather directly send data to the sink node. The remaining six sensor nodes forward the data tothe best forwarder node, which is selected best on the calculated cost function. The parameters toselect the best forwarder node are distance to the sink node and residual energy of the entire network.Extensive simulations are performed to prove the stable results.Ullah et al. [27] presented a routing scheme known by the name "Energy- efficient Harvested-awareClustering and cooperative-based routing protocol for WBAN (E-HARP)". E-HARP is amulti-attribute-based harvested energy routing protocol, which takes different network-relatedparameters into consideration and selects an optimal forwarder node towards the sink node. In thisscheme the sensed data is transmitted in case of need. It is duty of the cost function to select a clusterhead (CH) that uses four main parameters such as SNR, residual energy, total energy and transmissionpower. The duplicated data is not forwarded by the SN to CH. Before transmitting the data forward,it is checked for its possible duplication with the previous rounds. Hence much of the network energyis saved by the removal of any duplicated data from the transmission pool.Awan et al. [20] proposed a technique named Priority-based Congestion-avoidance RoutingProtocol (PCRP). This algorithm is grounded on IoT technology, which is used for medical purposes.It uses multi-hop communication for data transmission and chooses a congestion-free path for qualityof service (QoS) and emergency data to be forwarded for the purpose of increasing the efficiency. In thisalgorithm the authors have used a fitness function on the basis of residual energy (RE), node congestionlevel (NCL) and SNR. For highly important data they have supposed a priority bit.Guangsong et al. [28], proposed an energy- efficient routing protocol for WBANs. In the proposedprotocol the routing decision is based on the sensor node's remaining energy, communication type,path-loss in the communication link and some other relevant parameters. It works based on threesteps. In the first step, i.e., the initialization phase, a channel competition procedure is done. In thenext step, i.e., the routing setup phase, routes having energy abundant are selected. Finally in the thirdstep, time slots are assigned for data communication. Extensive simulations show that the proposedprotocol achieved better results as compared to its counterpart in terms ofminimizing the energyconsumption along with efficient utilizing the communication channel.Zahid et al. [29], focused in their research work on two very important WBAN issues, prolongingthe network lifespan and efficient communication. A complete novel scheme is proposed for WBANsnamed "Robust and Energy Harvested-aware Routing Protocol with Clustering Approach in BodyArea Networks (EH-RCB)". The authors targeted many WBAN network issues such as throughput,network lifespan, end to end delay, etc. They have proposed a system in which tiny sensors nodesare placed on the human body. These tiny sensors sense the important health-related parametersand forward it to two sink nodes. The two sink nodes are positioned on the front and back side ofthe human body. The highly critical data is sent directly to the

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sink node. Forwarder node selectionis based on the optimal cost function (CF) value, which is calculated based on different parameters,such as residual energy, required transmission power, link SNR and distance from the sink node.Energy harvesting technique is adopted to provide additional energy to the sensor nodes in order tohelp out in prolonging the network lifetime.

JitumaniSarma et al. [30] proposed a robust solution for WBANS. It works for one of the importanthealth-related parameters, ECG. In order to save energy, the ECG signals are divided into acute andnon-acute. The overall technical system is controlled and monitored by an IoT controller named LightWeight Power Management Controller.

CHAPTER 3

SYSTEM MODEL

Energy harvesting is the process by which a SN can power itself.The SNs can be equipped with many types of techniques which help the node produce energy fromthe environment automatically. A summary of energy harvesting sources and the used mechanisms. Due to the small size of the SN, the available resources in it is also limited, such assmall batteries having less available energy. The initial energy of the SN is 0.5 Joule which is verysmall. Due to this limitation, the energy available for the operation of the SN, such as transmissionand reception of data, is limited [43–51]. In order to use a WSN, practical efforts have been madeworldwide to resolve problem of supplying energy to SNs through reliable and efficient techniques.The efficient of power supply is ensured during the design of an integrated circuit; the capacitanceprovided is a critical aspect which is used for the regulation of operating clock frequency [44]. It hasgreat effects on the energy depletion of the circuit. A high clock rate means more power usage. It istherefore recommended to design a low clock frequency circuit as shown in Equation (1) $R = K*V$ (1)

where, R represents the total quantity of charge, K represents the magnitude of capacitance, and Vrepresents the current of the capacitor. The capacitor current is directly proportional to the quicknessof the voltage change inside the capacitor. The voltage of the capacitor rises if the current is harvestedduring input mode. The integrated circuit (IC) should check the voltage more often in cases where thevoltage of the capacitor changes rapidly.

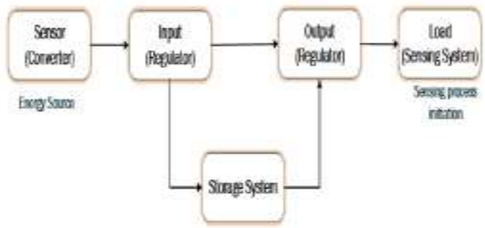

Figure 3.1 Proposed architecture for WSN system

In WSN, temperature and energy are the main factors to be evaluated. Cluster-based routing is the type of WSNrouting which aims to decrease the energy consumption and maximize the life-cycle of a network. In cluster-based routing, the node energy consumption is minimized by breaking the networks into portions, and each portion represents a cluster. These clusters are used for a communication head using a cluster head (CH). The CH is responsible for forwarding, aggregating, and collecting the data. The existing cluster routing protocols discussed in the literature include hybrid indirect transmission (HIT) [46], AnyBody [47], Cluster-based body are protocol (CBBAP) [48].

Cross Layered Routing

The cross-layer routing protocol is mainly used for the development of wireless sensors networks. The fundamental responsibility of the cross-layer approach is to provide synchronization among the layer without affecting the MAC layer functionality. Moreover, cross-layer routing protocols significantly enhance the network performance and resolve issues related to network and MAC layer. Cross-layer routing protocols are divided into four categories, i.e., Biocomm and Biocomm-D [49], TICOSS [50], CICADA [51], and WASP [52].

System Model

Reliable and stable data transmission with low energy consumption and the least temperature-rise of each sensor node is significant in WSN. One of the primary goals of this research is to intelligently operate single-hop and multihop transmission to enhance the network efficiency in domains of energy and temperature. In our proposed model, the sink is planted in the middle of the human body, as shown in Figure 1.

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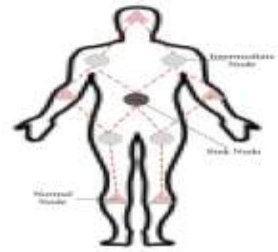


Figure 1. Deployments of nodes and their communication.

PROPOSED ALGORITHM

1. HP = Hello Packet
2. T.E = Total Energy
3. L.E = Link E_ciency
4. H.C = Number of hop-count between sink node (CNC) and leaf node (BSN)
5. d = distance between SN to the sink CNC
6. D = distance between leaf nodes
7. (NT) = information included in Neighbor Table
8. (HP) = information included in Hello Packet
Input: Hello Packets from neighboring nodes 'i' and 'j'
9. Start
10. For each HP do
11. If HP (TEi, LEi,j, HCi,CNC, di,j) = NT (TEi, LEi,j, HCi,CNC, di,j)
12. Ej (NT) TE (HP)
13. LEi,j (NT) LEi,j (HP)
14. di,j (NT) di,j (HP)
TE (HP)
13. LEi,j (NT)

To solve the issues of energy limitation and WSNlifetime enhancement a new scheme isproposed, named "Energy Harvested and Cooperative enable Routing Protocol" or EHCRP. In thisprotocol, energy harvesting is integrated inside the SNs to provide additional energy that enhancesthe network lifetime. Furthermore, link statistics are taken into consideration while forwarding thedata to the next hop, which achieves better throughput and less end-to-end delay. This schemeworks on the basis of multi-hop communication. The node with greater path cost estimation (PCE)will be nominated as data forwarder. In this solution, the data packets are divided into two types(normal and emergency). The path cost estimation function is used to calculate the cost of normalpackets based on signal-to-noise ratio (SNR), total energy (TE), hop-count (HC), distance (d) fromthe central node coordinator (CNC) and node congestion level (NCL). The PCE technique balancesthe use of SN resources which increases the overall network performance. The second type of datapackets (emergency data or life life-threatening data) is labeled as priority label. Each node in thenetwork schedules data transmissions based on the priority label. Highest priority label packets areselected first for transmission. This is clearly depicted in the flowchart of the proposed scheme andalso in Algorithm 1, 2 and 3. The presented technique includes:

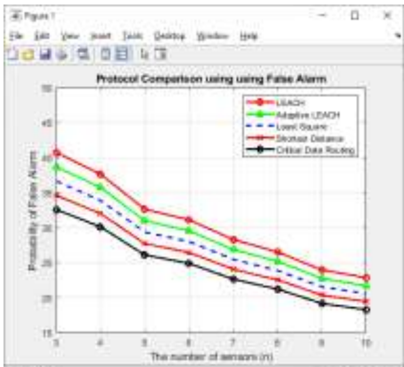
(1) Link efficiency network model is presented which calculates the capability of the forwardernode in terms of its ability to send the received/sensed data. Link efficiency is based on four linkquality parameters which are link quality indicator (LQI), packet reception ratio (PRR), SNRand received signal strength indicator (RSSI).

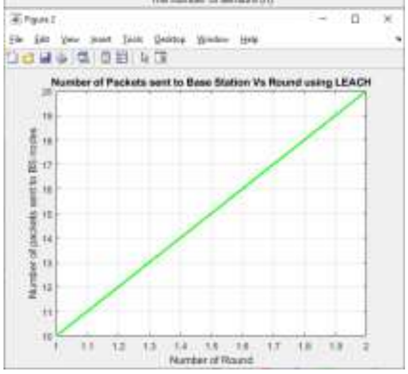
(2) The proposed protocol selects the forwarder node by calculating its PCE function derived fromenergy aware link efficiency of the selected node compared to non-selected ones.

(3) Supportive efforts communication has been used in which duplicated data is being discarded insuccessive transmission and not sent to CNC. In the proposed protocol the SN checks thesensed data for possible redundancy. If the sensed data (not in the case of critical situations) issimilar to the prior sensed data, it is discarded otherwise it forwards the data to the sink.

CHAPTER 4

RESULTS AND DISCUSSION





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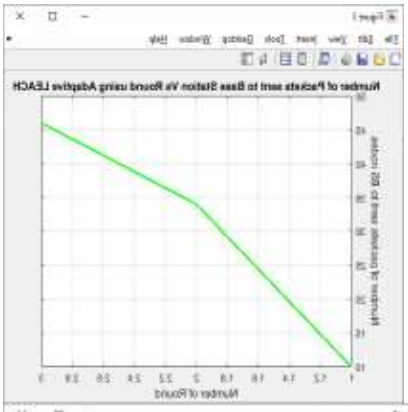

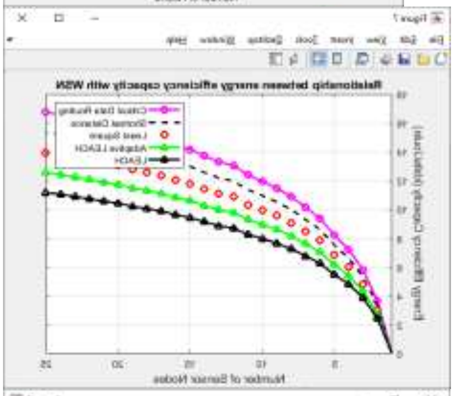

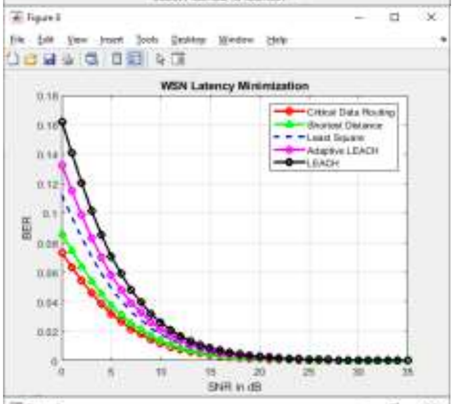

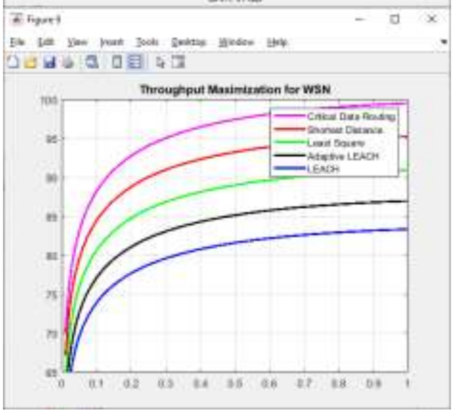

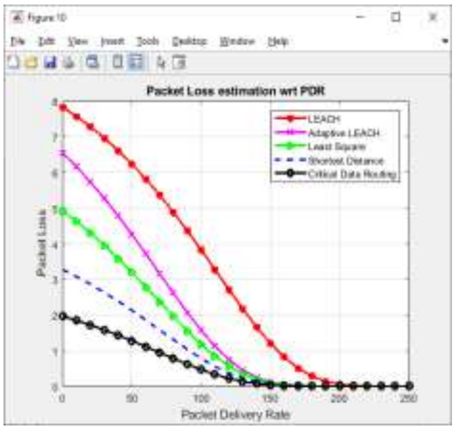

CHAPTER 5

CONCLUSION AND FUTURE WORK

In this project, the proposed protocol is used for routing the critical data from sensor node to the sink node (body controller) in WSN. We are using a new mechanism of implantation of the bio-medical sensor node inside the human body, in which we are placing all the medical sensors at equidistant from the body controller, that's why there is no need to employs any forwarder node to pick the data from the sensor nodes which is placed at a distance from the body controller and then route the data to the controller. The Wireless Sensor Network (WSN) is a wireless network consisting of ten to thousand small nodes with sensing, computing and wireless communication capabilities. WSN are generally used to monitor activities and report events, such as fire, overheating etc. in a specific area or environment. It routs data back to the Base Station (BS). Data transmission is usually a multi-hop from node to node towards the BS. Sensor nodes are limited in power, computational and communication bandwidth. Primary goal of researchers is to find the energy efficient routing protocol. This study highlights the recent routing protocols for sensor networks and presents a classification for the various approaches pursued. The three main categories explored in this paper are data-centric, hierarchical and location-based. The emergence of WSN technology has brought hope and dawn to solve the problems of population aging, various chronic diseases, and medical facility shortage. The increasing demand for real-time applications in such networks, stimulates many research activities. Designing such a scheme of critical events while preserving the energy efficiency is a challenging task, due to the dynamic of the network topology, severe constraints on the power supply, and the limited computation power. The design of routing protocols becomes an essential part of WSNand plays an important role in the communication stacks and has a significant impact on the network performance. In this paper, we briefly introduce WSNand focus on the analysis of the routing protocol, classify, and compare the advantages and disadvantages of various routing protocols.

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