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A statistical Analysis of Wireless Body Area Network Using Clustering Based Routing Protocols

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Abstract

Recently, research on wireless body-area sensor networks (WBASN) or wireless body area networks (WBANs) has gained great importance in medical applications, and now plays an important role in patient monitoring. Clustering is the most important task in wireless sensor networks (WSNs) by data aggregation through each cluster head (CH). The development of technology has seen comfort in the domestic and professional life of an individual. However, such survival was not able to meet medical emergencies during the pandemic COVID-19 and other health surveillance scenarios. As a result, it is important to design an energy-efficient routing system for WBAN. Existing routing algorithms focus more on energy efficiency than security. A Secure Optimal Path-Routing (SOPR) protocol is proposed to identify and discover routes in WBAN that are secure against black-hole attacks.In this paperthe sensor's wireless capability has been tested with a simulator to detect and transmit signals across a wide range of frequencies and to ensure that data is transferred successfully. CARF reduces the maximum work done by relay nodes in case of overloaded nodes and thereby increases the energy distribution in the network. The proposed CARF design reduces packet loss and time delay, thereby increasing network lifetime compared to other fuzzy and heuristic methods used for routing in WSNs. The proposed algorithm maintains more than 75% of the residual energy in the network at a minimum initial energy level of 1 J to enable data syncing. A SAC-TA approach for data aggregation in WSNs is presented. False injection attacks are identified based on traffic analysis at the time of the route discovery process. One-time key generation algorithm is introduced to eliminate malicious nodes from the network. The presented paper proposes a congestion-free routing framework for data transmission from source to sink nodes in WSNs. Congestion-aware routing mechanisms modeled using fuzzy sets (CARF) include operations such as establishing non-localized nodes, by which more paths can be created for traffic distribution, and predicting an optimal congestion.

Keywords: Wireless Body-Area Network; Routing; Energy Efficiency; Black-Hole Attack.

INTRODUCTION

WSNs are increasingly deployed for applications such as battlefield monitoring applications in military, industrial control applications, wildlife habitat monitoring, health care monitoring, forest fire prevention, etc.Recently, the Wearable Internet of Things (WIoT) has gained increased interest in both academic and industrial fields due to its wide range of potential applications. WIoT enables a new dimension of wireless connectivity in Wireless Body Area Networks (WBANs), which helps improve remote health care systems and real-time health monitoring. WBANs can provide cost-effective health care system to senior citizens. WBAN could be a potential solution to the health care needs of an aging society, various chronic diseases and lack of medical facilities. Due to advances in microprocessors, Wi-Fi interfaces, global positioning systems (GPS), wireless charging, battery technology, smart watches, smartphones, wearable technology, unmanned aerial vehicles, and various sensors, modern health care systems have widely adopted WBANs. Therefore, communication costs are reduced. In the existing data aggregation process, nodes are formed as a fixed tree hierarchy on a BS. Non-leaf nodes act as data aggregators and collect data from child nodes of the tree structure before transmitting the collected data to the BS. Based on this process, data is processed and collected at each hop on the communication path of the BS. Thus, the communication overhead in the network is reduced to a great extent. WBAN can be classified into three levels of communication: intra-WBAN, inter-WBAN, and beyond-WBAN communication [5]. Tier-1 is intra-WBAN communication, which involves a set of sensors worn or implanted on the human body. Tier-2 is inter-WBAN communication using smartwatches, smartphones, and personal computers. Ad-hoc architectures are distributed to communicate at this level with random topologies. The function of Tier-2 is to transmit the information sent by sensors through 3G/4G/5G, WLAN and other wireless technologies. In recent years, wearable devices are becoming potential candidates for the centre of IoT and WBANs [6]. Wearable devices have become famous for health monitoring devices because they can collect data from biosensors of human body and transmit vital data while walking [7]. Wearable devices enhance the quality of human life and make our daily lives safer. Wireless body area network (WBAN) is an evolution of wireless sensor networks (WSN) consisting of small self-contained nodes equipped with a special parameter for transport interfacing and control unit communication. This exploratory study investigates energy management, which is an important quality of service parameter in WSN-assisted IoT. Apart from communication, the energy of a sensor node is consumed by other activities such as logging, processing, sensing and some others. The proposed EEDLAB routing protocol, which combines the above schemes, will reduce energy consumption, delay and improve network lifetime. The advanced nodes deployed in the proposed work have the characteristics and capability to transfer data without path loss and consume less energy in WBSN scenarios. Congestion prediction in wireless sensor networks (WSNs) enables packets to be dropped efficiently with minimal energy expenditure. The amount of traffic in each node is first estimated to find the non-collision path to follow. Wireless sensor networks (WSNs) consist of sensor nodes that are communicating with each other through wireless links for effective data collection and routing. In such networks, each sensor node is an autonomous device that detects other nodes.The purpose of the IEEE 802.15.6 BAN standard is to make low-power communications reliable and practical for in-body/on-body nodes to serve a variety of medical and non-medical applications. With the projected increase in the number of people using BANs, their coexistence will be a concern in the near future, especially in healthcare scenarios where reliable communication is critical. Wireless sensor networks (WSNs) have attracted worldwide attention in recent years, especially with the explosion in micro-electro-mechanical systems (MEMS) technology that has facilitated the development of smart sensors. Due to the random distribution of nodes and the nature of the terrain in which the nodes are deployed, some problems may occur. These problems include geographical constraints, node failures, inappropriate node density distribution, and uneven energy consumption of nodes. A routing protocol for discovering transmission routes to the sink node. Due to the location and mobility of the nodes, the sink node exists in a single-hop or multi-hop distance from the transmitting source. Traditional secure routing schemes are targeted at specific malicious or selfish attacks and are not suitable for multi-hop distributed WSNs because they mainly rely on encryption algorithms and authentication mechanisms. Multi-hop routing technology is one of the key technologies of WSN and mainly uses the data collected by sensor nodes according to the agreed routing protocol. Routing protocols in WSNs are application dependent, moreover their objectives change depending on different applications. Therefore, delay requirements must be met by the minimum energy cost routing protocol. WSN is considered an infrastructure-less network, consisting of inexpensive sensor nodes to monitor the WSN network. In WSN, sensor nodes are randomly allocated. WSNs are important in managing monitoring applications, including precision agriculture, environmental monitoring, smart cities, weather forecasting, disaster management, and natural disaster prevention. In most cluster routing algorithms, CHs consume more energy than CMs. This is hotspot problem in WSN. Uneven clustering approach is a good way to overcome the hotspot problem. In the unequal clustering approach, the size of the cluster that is closer to the BS is smaller. And the cluster size of CH which is far away from BS is larger. CHs with lower CM consume less energy in the aggregation phase and transmitting aggregated data. They use unnecessary energy to relay data packets away from the BS.

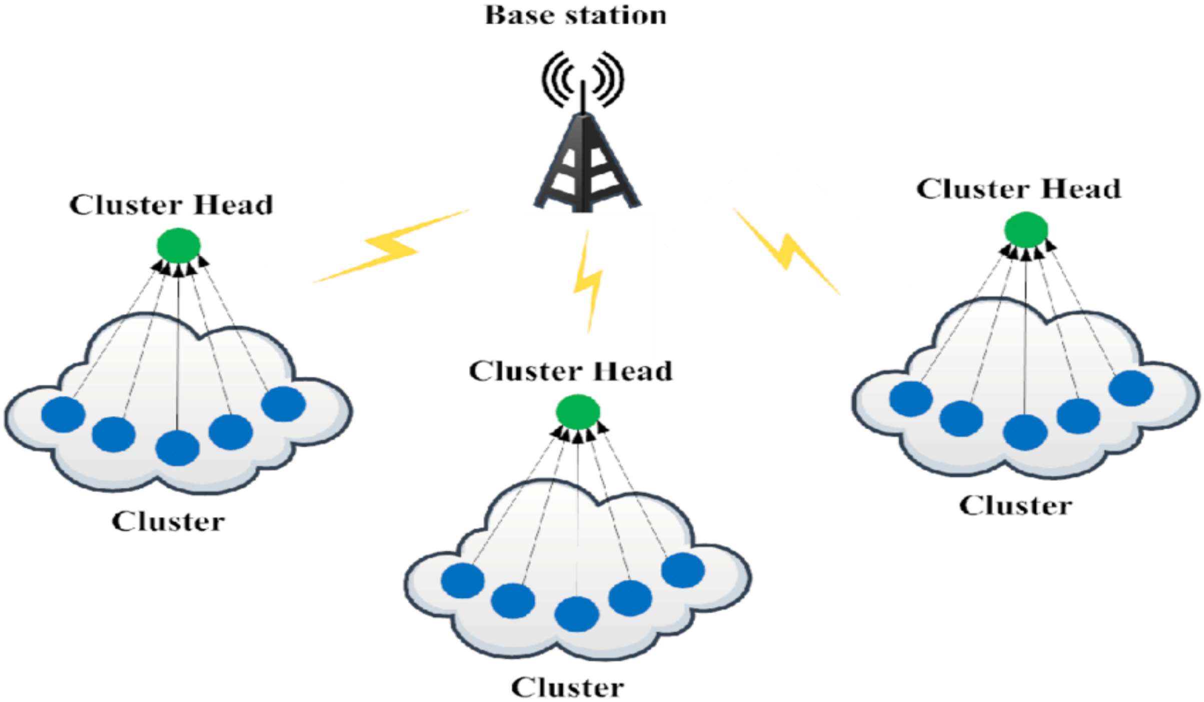


Figure 1. WSN without and with clustering.

Black-hole attacks are one of the most common attacks in WBANs, which involve malicious intruders taking over these nodes and reprogramming them to drop packets or create false packets to break the network. Therefore, it is imperative to propose a cluster-based and energy-efficient secure routing protocol to enhance the communication reliability in WBAN. To deal with the threats posed by malicious nodes through black-hole attacks, a new cluster-based energy-efficient and secure routing called Secure Optimal Path-Routing (SOPR) is proposed in this paper to provide reliable and secure routing in WBAN.

LITERATURE REVIEW

In [3], an energy-aware clustering algorithm and cluster-based routing algorithm EADC are designed under a non-uniform node distribution scenario where in a uniform cluster, the current cluster head forwards data to the next node with higher energy level. Selects and stabilizes the load among all nodes in the cluster to increase network lifetime [3]. Full Cluster Based Low Energy Adaptive Clustering Hierarchy (LEACH) represents a distributed clustering technique that minimizes the impact of random cluster head selection.

The authors of [6] proposed the CARF framework, congestion occurs when the number of incoming packets slowly exceeds the restricted buffer size of a node while routing data to reach the sink. Sudden event triggering causes the data traffic volume to increase, resulting in data congestion. This leads to more packet drops which need to be detected and repaired using congestion prediction algorithms. In addition to severe packet loss, traffic collisions can result in energy consumption and end-to-end delays that impact the entire network. There is a significant drop in network throughput which prevents sensitive data from reaching the sink. Our goal is to build a fuzzy set model to predict data traffic to sensor nodes to generate a reliable routing path to transfer packets to the sink node.

In [9], several studies have been focused on BANs for medical purposes. Some tasks concern global solutions for tens or hundreds of patients, each equipped with multiple sensor nodes, and are restricted to relatively small environments. We consider a two-tier network architecture composed of 10 co-located mobile BANs (ones with fitted wearable radios) deployed for experimental measurements, where the hubs of the BANs form tiers in a mesh (inter-BAN/BBN communication). Are in 2. and on-body sensor tier-1 of the respective BAN.

In [10], we consider three different areas of research related to this experimental study: multicast routing protocols for WSNs, machine learning based algorithms for WSNs, and testbeds or deployments using real sensor network hardware. The research community has proposed a large number of routing protocols targeting different application scenarios. Some of those multicast algorithms have emerged to route data from one or more sources to multiple, possibly mobile, sinks. Some approaches such as MSTEAM and GMR use geographic information, while others use hop-based metrics. An implementation of ADMR, a protocol initially designed for MANETs, is available for the MicaZ mote platform. Additionally, the relatively new idea of applying machine learning techniques to WSNs has received increasing attention. Some flexible, localized algorithms such as Antcolony Optimization or Reinforcement Learning for example efficiently implement selforganized behavior. Representative protocols implementing machine learning techniques on WSN hardware include a single source/single sink queue-routing protocol developed for Crossbow motes and an adaptation for routing schemes based on link quality estimation on MICAZ motes.

In [17], a lot of research has already been done in the field of energy-aware routing algorithms and reinforcement learning based routing algorithms. Nowadays, machine learning algorithms are widely used to solve problems related to wireless sensor networks. The reinforcement learning property of machine learning is very useful for developing routing algorithms. Several routing algorithms are discussed here.

An economical, on-body and user-friendly sensor and actuator for monitoring critical physiological sensors [13] with minimal human resources. The system incorporates sensors, communication methods, and intelligent retrieval to identify health information under different postures such as walking, sleeping, and running. IEEE standards for securing data communications are included in IEEE 802.15.6 for local area networks (LAN) and metropolitan area networks (MAN). Coordination of fixed hubs for medium access [14] and power management with a single hub in a BAN where the number of body nodes ranges from 0 to the maximum BAN Size. Secure communication in MAC goes through stages like orphan state – where hub security is zero, associated state – where the hub holds the master key for pairwise temporary key creation, secure state – nodes are secure and emphasize only security parameters and Finally the connection state to forward the data packet. Wireless sensor network (WSN) is an autonomous device mainly used to monitor various applications and environments using sensors. These sensors can be fixed or mobile and are widely distributed to collect information from time to time. Energy efficiency is one of the most important criteria that should be considered in the design of wireless sensor networks. Continuous monitoring is also a challenge for sensor design if battery power in the network is limited or interrupted. Precision farming is necessary to improve the productivity of farmers. In such a scenario, adoption of WSN can help farmers and other players in the field of agriculture i.e. government irrigation departments to take good decisions in a way that helps in predicting irrigation requirements and crop yield. Dong et al. [9] An autonomous precision agriculture based on center pivot irrigation systems was developed. The system uses an underground system consisting of a sensor network to monitor field conditions, including soil moisture and temperature. Data transmission in irrigation systems requires more energy and hence energy conservation is necessary to make irrigation more optimal. According to Sudha et al. [11], energy efficient data transmission in irrigation systems using WSNs can be scheduled more efficiently using time division multiple access (TDMA). Energy is conserved in two ways, namely by direct communication from node to sink node and then by data aggregation. The use of TDMA can improve the throughput of the network.

Finally, various deployments and testbeds have been set up and used for studies. General deployments, such as for habitat monitoring [12], [13] or environmental monitoring [14], have been established to better understand natural processes by collecting continuous data samples, but also sensors under harsh environments. The network is also set up to test hardware and software. conditions. On the other hand, collections of sensor nodes have also been used to evaluate isolated protocols, Which includes routing [9], [11], medium access [15], [16], event-based information processing [5] or transport for network reprogramming [17]. While the number of nodes used in a deployment depends on the application scenario, the sizes tested range from 2 to 60 nodes.

Huang et al. [11] proposed energy-aware dual-path geographic routing (EDGR) to address routing hole issues in WSNs. EDGR uses information about remaining battery power, energy expenditure, and geographic location of nodes to make routing decisions. It relies on disjoint paths crossing route holes for re-routing and is therefore able to achieve better packet delivery, network lifetime and lower latency. Routing decisions are instantaneous and lack continuous observation, leading to high independent overloading of nodes.

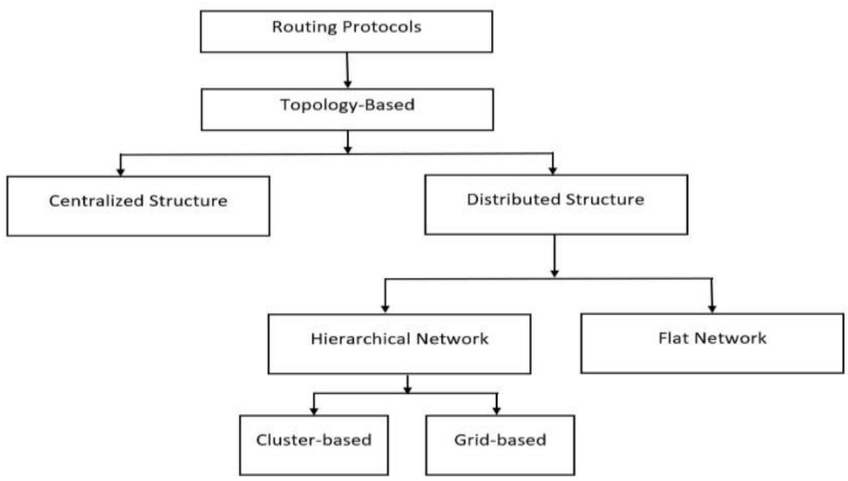


Fig 2. WBAN Topology based Routing Classification

TRADITIONAL TRUSTED ROUTING SCHEMES

Providing a reliable routing environment for WSN is an important and difficult issue. There are many related researches to implement reliable routing scheme. Lee et al. designed a new trust-based routing protocol by extending the widely used AODV (Ad-hoc On-Demand Distance Vector) routing protocol. The protocol implements a trust model to recommend reliable routing nodes and improve the security of the routing environment. Later, there was more research on trust-based routing schemes. Lu et al. proposed a secure routing scheme by quantifying and recording the algorithm-compliant behaviours of routing nodes. Sirisala et al. A QoS (Quality of Service) routing algorithm has been proposed to evaluate the reliability of routing nodes. The algorithm calculates the direct QoS trust of a 1-hop neighbour routing node, the indirect trust of a 2-hop neighbour routing node is calculated by a transitive rule (for example, A trusts B and B trusts C. If it is then it trusts AC). Some researchers embed trust mechanisms into routing paths, so that reliable routing paths can be determined. Most of this research is based on "reputation systems", which evaluate the reputations of
other nodes to make routing selections. However, building the reputation table requires the historical behaviour of routing nodes which cannot guarantee the real-time security of the WSN. Meanwhile, the reputation table maintained by each routing node may be tampered with, so that absolute reliability cannot be guaranteed.

Sert et al. propose a multi-objective fuzzy clustering algorithm (MOF-CA) to increase the lifetime of WSNs as well as satisfy the inadequacies of some of the mentioned methods that address energy hole issues in hotspots as well as in stable and evolving ones. Is concentrated. network. MOFCA selects the final CHs through energy-based competition between selected temporary CHs, and these are first revealed by a probabilistic model. The proposed approach is a distributed competitive algorithm that aims to allocate appropriate ranges to uncertain CHs. Performance analysis as well as evaluation is done with some clustering algorithms which are popular and from the experimental results it is found that the existing algorithms perform better than the proposed approach in terms of efficiency metrics, which are First Node Dyes (FND), in addition to the Total Remaining Energy (TRE) of Half Nodes Alive (HNA), the lifetime of the WSN is calculated as well as the efficiency of the protocol.

Table 1 Summary of Clustering and Routing Protocols in WBANs

Protocol	Architecture	Structure	Factor of CH selection	Advantages	Limitations
SDC [22]	Distributed	Cluster-based and single-hop	N/A	Self-organized clustering	Lack of analysis of CH selection process
E-HARP [26]	Centralized	Cluster-based and single-hop	Residual energy Transmission power and link quality	Utilized energy harvested technique	Not suitable for inter-WBAN Communication

DL QoS [27]	Centralized	Flat-based and Multi-hop	N/A	Delay efficient protocol	Control overhead may increase in large-scale WBAN
MT-MAC [28]	Distributed	Cluster-based and single-hop	N/A	User mobility-aware clustering method	Lack of analysis of mobility effect on network topology change
BBNs [29]	Distributed	Flat-based and Multi-hop	N/A	Low network latency	Higher protocol complexity
ALOC [31]	Distributed	Cluster-based and single-hop	N/A	Minimize the Number of Transmissions	Network topology change may reduce the cluster lifetime
EHCRP [32]	Distributed	Flat-based and Multi-hop	N/A	Energy-efficient approach	Routing overhead may affect the protocol performance
DHCO [33]	Distributed	Hierarchical and Multi-hop	N/A	Increase network lifetime	Applicable for WSN
uRLLWSNs[36]	Distributed	Cluster-based and multi-hop	N/A	Low latency approach	Applicable for static large-scale WSN

STATISTICAL ANALYSIS

The average path loss of the EEDLABA routing protocol in contrast to LAEEBA and DARE is given in Figure 3a–c. From this point, it is clear that the proposed EEDLAB routing protocol has achieved significantly better performance. Path loss refers to the communication loss that occurs during transmission from one sensor node to another. The simulations have been run for 9000 seconds, with each round representing different values. The proposed EEDLABA routing protocol has achieved better performance in contrast to all the routing protocols. The main factor for this is the use of advanced node deployment and clustering mechanisms. This clustering mechanism can maintain stable communication between sensor nodes. This value is calculated and measured in decibels (dB). Path loss is also related to the power of nodes; If they have strong and sufficient power from one sensor node to another sensor node, communication can occur efficiently. Path loss, or path attenuation, is the reduction in the power density of an electromagnetic wave as it propagates through space. Path loss is a major component in the analysis and design of link budget of a telecommunication system. The term is commonly used in wireless communications and signal propagation. The path loss of EEDLAB is calculated with the lowest value, the lower the path loss, the better the communication. Therefore, it is observed that the proposed protocol has achieved better performance in path loss by introducing minimum path loss value.

SHORTEST PQTH Q-ROUTING ALGORITHM

Various shortest path algorithms are available to route data packets in wireless sensor networks. Dijkstra's algorithm is widely used for routing data packets in networks. We have developed a shortest path queue-routing algorithm to route data packets. Thi algorithms based on reinforcement learning techniques and is used to find the shortest efficient path from source to destination. The shortest path queue-routing algorithm is designed as follows:

$$M(i,j) = \sqrt{[(x(j) - x(i)]^2 + [y(j) - y(i)]^2}$$

Where, (i, j)= Number of nodes for $i \neq j$

This algorithm starts from the source node and spreads network. At every node in the network algorithm finds the shortest path to the destination selects the optimal path from node and source destination. we have implemented this algorithm here heterogeneous, homogeneous and hybrid technologies compare network lifetime performance results.

Q-RC ALGORITHM

Q-routing with compression attempts to aggregate messages as early as possible in the routing process and tries to compress them together before sending them to a single sink. Q-learning techniques are used to learn the best compression path towards the sink. The algorithm is fully distributed and its concepts can be applied to the field of Wireless Sensor Networks.

LEARNING DECISION MAKING

In this decision making process, the conditions based on distance, lifetime and buffer are estimated. For a reliable solution, distance is less, lifetime and buffer space is high. This decision consists of two outputs differentiating distance entity and lifetime, buffer entity. If the distance condition is not satisfied by the node, then it is discarded. If distance condition is satisfied, then both the lifetime and buffer conditions are verified. Now, the pruning process is instigated. In the first transmission, the distance factor is considered for selecting a neighbour. This is the same as in the route construction process. The pruning process is instigated for disjoint and same sink connecting routes. It continues for all the transmission rounds r.

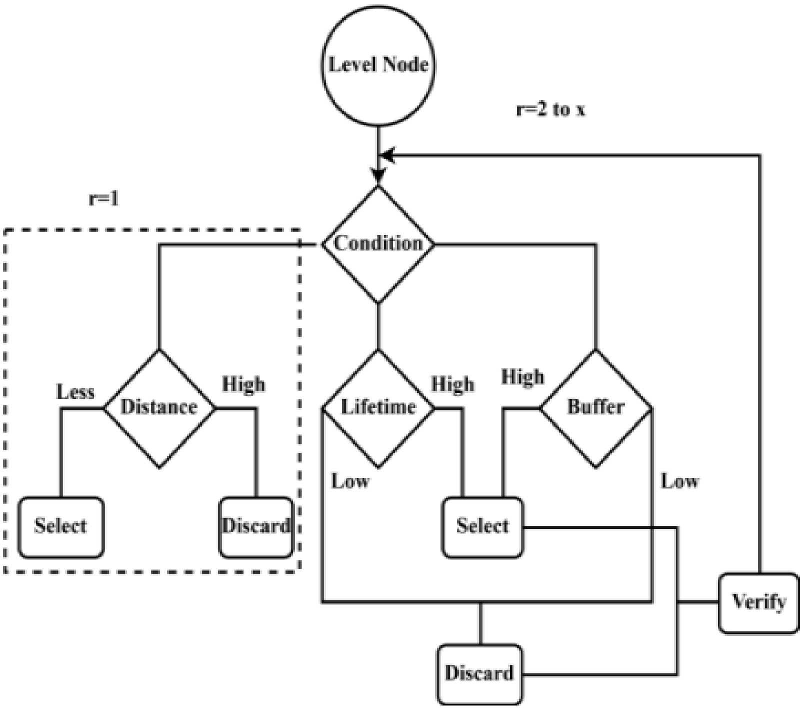
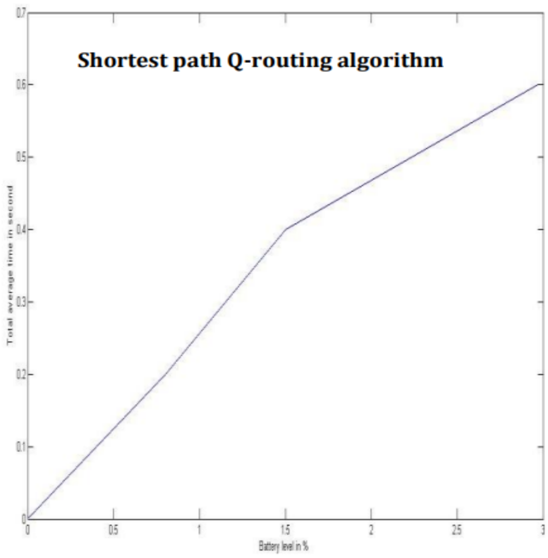


Figure 3 Learning Decision Making

Results

4.1.1 Network Lifetime Measurements for Homogeneous Topologies



We ran several simulations in our simulation environment to evaluate and compare the algorithms. We have implemented both the shortest path queue-routing algorithm and the energy aware queue-routing algorithm on various topologies. All lifetime results are averaged over 15 independent runs using the shortest path Q-routing algorithm. We separate the results based on the type of topology on which the experiment was conducted, because our results show that the performance of an algorithm can vary significantly on different topologies.

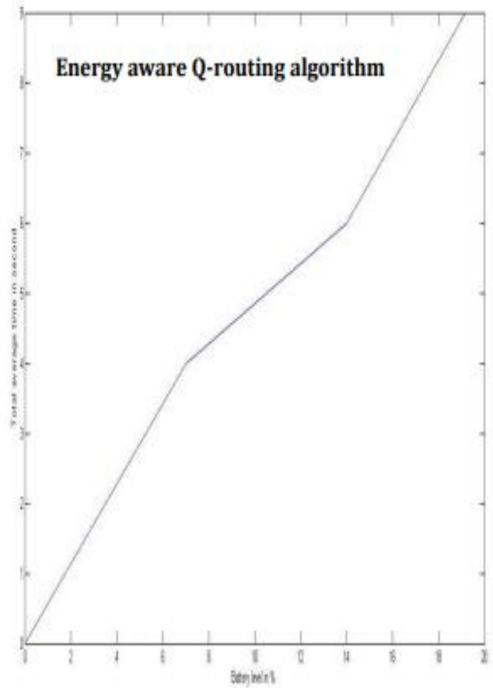


Figure 4.1 Network Lifetime Measurements for Homogeneous Topologies

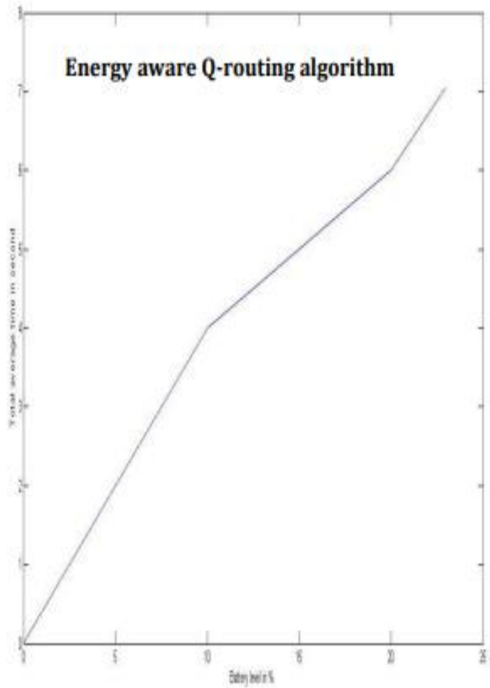


Figure 4.2 Network Lifetime Measurements for Heterogeneous Topologies

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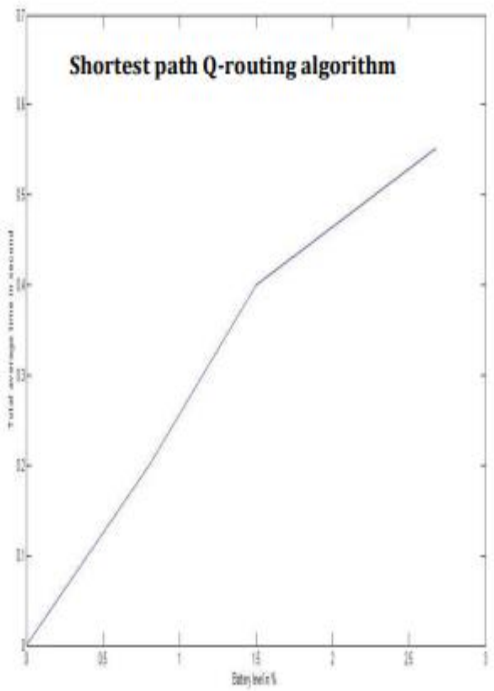
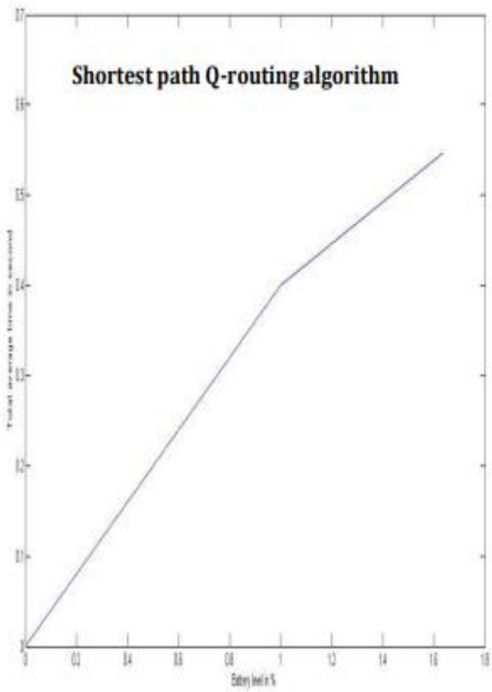


4.1.3 Network Lifetime Measurements for Hybrid Topologies



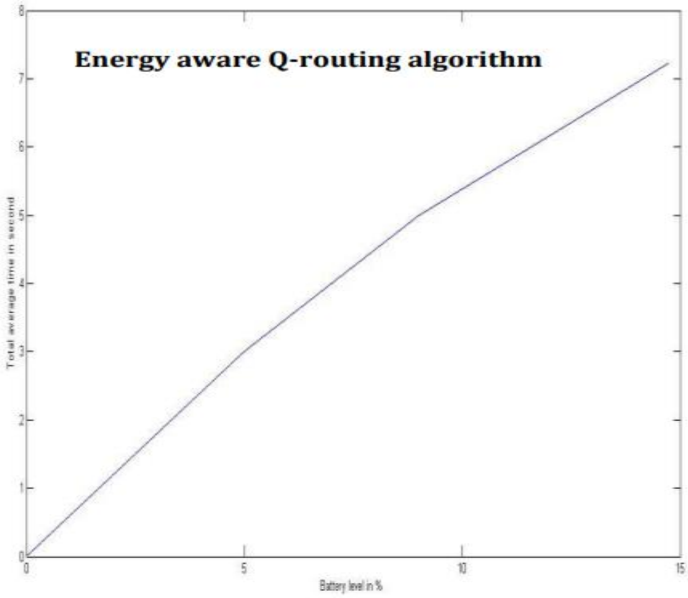


Figure 4.3 Network Lifetime Measurements for Hybrid Topologies

4.1.4 Comparison of Simulation Results in Tabular Form

Types of Topology	Types of Algorithm	Number of Nodes	Number of Paths	Consumed Battery Level in %	Total Average Time in Second
Homogeneous	Shortest path Q-routing algorithm	36	15	2.9703	0.6
	Energy aware Q-routing algorithm	36	15	19.1800	9
Heterogeneous	Shortest path Q-routing algorithm	36	15	2.6758	0.5523
	Energy aware Q-routing algorithm	36	15	22.9571	7.0358
Hybrid	Shortest path Q-routing algorithm	36	15	1.6349	0.5459

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	Energy aware Q-routing algorithm	**36**	**15**	**14.7256**	**7.2256**

PERFORMANCE ANALYSIS

In this section, the performance of the proposed secure area based clustering for data aggregation using traffic analysis (SAC-TA) is analyzed and compared with the existing secure data aggregation technique (SDAT) [29]. For the analysis, 200 sensor nodes are deployed, and the results are taken for simulation time up to 100 s and tested in NS2 tool.

THE PROPOSED EEDLABA PROTOCOL

In the proposed model, the first step is system initialization, also known as system configuration and initialization phase, as shown in Figure 1, followed by the deployment phase of nodes in different positions on the human body. The scheme is divided into clusters and nodes with sensors connected to these CHs, as shown in Figure 2. Here are several situations illustrated where conditional steps use yes/no statements. CH and body sensor location have been measured in the given scenario. Doing so leads to the path loss (PL) phase in which two PL models are used with conditional statements; It states that if distance D1 is greater than D2, follow the PL1 model or if distance D2 is greater than D1 then follow PL2. Finally, transmit the data in a mutual perspective and store all the measured parameters.

ANALYSIS AND EVALUATION OF AVERAGE PATH LOSS

The average path loss of the EEDLABA routing protocol in contrast to LAEEBA and DARE is given in Figure 3a–c. From this point, it is clear that the proposed EEDLAB routing protocol has achieved significantly better performance. Path loss refers to the communication loss that occurs during transmission from one sensor node to another.The simulation is run for 9000 seconds, with each round representing different values. The proposed EEDLABA routing protocol has achieved better performance in contrast to all the routing protocols. The main
factors for this are advanced node deployment and use of clustering mechanism. This clustering mechanism can maintain stable communication between sensor nodes. This value has been calculated and measured in decibels (dB). Path loss is also related to the power of nodes; if they have strong and sufficient power from one sensor node to another sensor node, then the communication can be done efficiently.

THE PROPOSED CARF FRAMEWORK

Congestion occurs when the number of incoming packets slowly exceeds the node's restricted buffer size while routing data to reach the sink. Due to sudden event triggering, data traffic volume increases resulting in data jam [26, 27]. This leads to more packet drops which need to be detected and repaired using congestion prediction algorithms. In addition to severe packet loss, traffic collisions can also result in energy consumption and end-to-end delays that extend across the network. There is a significant drop in network throughput which prevents sensitive data from reaching the sink. Our goal is to build a fuzzy set model to predict data traffic to sensor nodes to generate a reliable routing path to transfer packets to the sink node.

KEY METHODOLOGY OF CARF FRAMEWORK

The presented paper proposes a congestion-free routing framework for data transmission from source to sink nodes in WSNs. Congestion-aware routing mechanisms modeled using fuzzy sets (CARF) include operations such as establishing non-localized nodes, by which more paths can be created for traffic distribution, and predicting an optimal congestion. After the path to sync is eliminated by pre-estimation. The level of traffic congestion occurring at network nodes. Here, non-localized or unknown nodes refer to hidden unobserved node vertices in the sensor network. The point where the event is triggered is important to know because there are a large number of sensor nodes in the deployed area and this is the reason for detecting non-localized nodes.

FUTURE WORK

The sensor's wireless capability has been tested with a simulator to detect and transmit signals across a wide range of frequencies and to ensure that data is transferred successfully. Deploying and testing a real-time environment is planned as future work. Furthermore, we plan to use fuzzy rules for trust modelling for security and effective clustering in WBANs. A SAC-TA approach for data aggregation in WSNs is presented. False injection attacks are identified based on traffic analysis at the time of the route discovery process. One-time key generation algorithm is introduced to eliminate malicious nodes from the network. The efficiency of the proposed data aggregation scheme is evaluated by comparing it with the existing secure data aggregation scheme (SDAT). Node deployment with QoS optimization, reliability with energy, geographic and node scalability, andshock and heat-absorbing sensor nodes can be generated. To solve these issues, proper and robust routing techniques are required. It is suggested that since clustering with path loss has shown good results, in the future, congestion control with these two parameters will be used and tested in new conditions.

CARF reduces the maximum work done by relay nodes in case of overloaded nodes and thereby increases the energy distribution in the network. The proposed CARF design reduces packet loss and time delay, thereby increasing network lifetime compared to other fuzzy and heuristic methods used for routing in WSNs. The proposed algorithm maintains more than 75% of the residual energy in the network at a minimum initial energy level of 1 J to enable data syncing. When CARF is compared with other fuzzy and nonfuzzy congestion prediction methods, it has a better packet delivery ratio of 92%. The above findings show that CARF is a well-established algorithm in terms of good packet delivery and maintains maximum network lifetime compared to existing methods. A new intelligent energy efficient routing algorithm using fuzzy rules called Terrain Based Routing has been proposed for precision agriculture. This algorithm works in three stages, terrain formation stage, terrain head selection stage and terrain based routing stage. In the first stage, agricultural land is divided into small areas of equal size called tracts. In the second step, the TH is selected using fuzzy rules considering the distance to the base station and the remaining energy. Transmission of information from source to sink is done by TH which acts as a relay node.

CONCLUSION

In this paper, a Secure Optimal Path-Routing (SOPR) protocol is proposed to identify and discover routes in WBAN that are secure against black-hole attacks. In this case, the proposed protocol adopts cryptography techniques for symmetric keys while finding secure paths. Additionally, the protocol is integrated with Balanced Energy-Efficient and Reliable (BEER) algorithms to provide reliable and secure data transmission. Most black-hole attacks are exposed only locally, except for cluster heads, which work together with other nodes to carry out black-hole attacks. Therefore, attacks are detected very fast and with minimal message overhead. The simulation results show that the proposed protocol, Pro-SOPR-BEER, has improved performance in protecting against black-hole attacks when searching for secure routes, when compared with the AttempT, M-AttempT, and algorithms proposed in techniques.

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