An Examination of Wireless Body Area Networks' Temperature and Reliability-Aware Routing Protocol

Meegan Scariah[1], Anu Eldho[2]

[1]Student, Dept. of Computer Science & Engineering, Mar Athanasius College of Engineering, Kerala, India
[2]Assistant Professor, Dept. of Computer Science & Engineering, Mar Athanasius College of Engineering, Kerala, India

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Abstract - *It is possible to see the Wireless Body Sensor Network (WBSN) as an affordable way to offer reporting and monitoring services for both non-medical and medical applications, hence enhancing quality of life. One requirement of WBSN's healthcare applications is the fast and trustworthy distribution of patient data. The crucial data packets are extremely sensitive to delays. Nevertheless, the advantage of these networks is compromised by these packets arriving at their destination after timeliness. A sufficient link must be maintained in order to deliver real-time health monitoring in terms of stability, dependability, and quality of service. The unique features of WBSN, however, provide a number of difficulties that must be overcome, including scarce resources, a short transmission range, and unstable wireless connectivity in terms of quality of service since low-power radios are susceptible to noise and interference. As a result, there is considerable congestion in some areas of the network, which puts stress on the available bandwidth, the communication links, the buffer space, the frequency of collisions, the packet loss rate, and the disruption of transmission. Consequently, it is critical to incorporate QoS awareness into routing decisions in order to enhance WBSN performance. TLD-RP (Temperature, Link reliable, and Delay-aware Routing Protocol) is a QoSaware routing protocol for WBSN that is proposed in this paper. Temperature, hop count, or energy are the three main routing metrics that are included in the majority of temperature-aware routing protocols that have been suggested for the WBSN. Nevertheless, the majority of earlier research on QoS requirements, including connection reliability, stability, and delay, has ignored optimized route finding. With these constraints in mind, the suggested TLD-RP thoroughly analyzes the crucial QoS needs for the WBAN before utilizing a multi-facet composite routing measure. The dependability of the link, path latency, and link asymmetry are key considerations in the design of the suggested TLD-RP method. These design factors enable the proposed TLD-RP scheme to make more informed decisions regarding dynamic channel conditions. The optimized links satisfying the QoS requirements are selected for routing data packets. The simulation results confirm the effectiveness and efficacy of the proposed TLD-RP strategy by improving WBSN performance along with throughput, packet delivery, network overhead, and link stability.*

Key Words: Link quality, quality of service, routing protocol, temperature awareness, wireless body sensor network

1.INTRODUCTION

Real-time data recording using nanoscale biomedical sensor nodes is now feasible thanks to advancements in wireless communication technology. The Wireless Body Area Network (WBAN) refers to the network of these nanoscale medical sensor nodes that are affixed to the human body. Typically, sensor nodes positioned throughout the body collect patient data to identify illnesses in their early stages.

Modern WBAN apps, however, are not patient-specific. WBANs are now commonly utilized to watch performances in real time of sportsmen and military personnel in combat. The individuals in a WBAN, information is wirelessly sent to a central location for diagnostic made by a doctor. Data must therefore arrive securely and reliably in the terminal. However, wireless communication is not historically prone to errors. Critical data packets being lost could lead to grave risks to the patient's life. Consequently, WBAN requires a secure method in order to send patient data to the final location. Among other things, wireless communication involves Routing protocols are essential to the equitable use of networks resources in addition to the secure data packet transit inside anticipated time limits. However, because of the particular difficulties associated with WBANs, routing protocols created for other networks, including WSN and MANET, cannot be utilized in their original form. As a result, in order to address the various issues that WBANs face, including overheating, the timely dissipation of crucial data packets, network longevity, and QoS requirements, new routing protocols must be developed.

Furthermore, in certain circumstances, recording physiological data necessitates the insertion of biomedical sensor nodes. Nevertheless, radio waves are absorbed by the human body and cause sensitive tissues near the sensor node to overheat. Long-term radio communication may be caused by tissue damage from implanted sensor nodes. As a result, it's important to monitor the amount of radiation absorption to prevent overheating of delicate tissues.

The Specific Absorption Rate (SAR) refers to the rate at which electromagnetic radiations can be absorbed by human body tissues. Equation 1, where T is the electrical conductivity of the tissues and E is the electrically induced field, provides the SAR per kilogram. On the other hand, the tissue's density is indicated by. Radiations from the antenna and circuit of the node implanted inside the human body are the two main causes of tissue overheating in WBAN. Equation 2 illustrates the application of the well-known Penne's bioheat equation [6] to determine the rate of temperature rise surrounding sensitive tissue. where the heat specific to a tissue is represented by Cp, the rate of temperature rise by dT dt, temperature rise resulting from thermal conductivity by K 2T, heat resulting from blood perfusion by b(T Tb), the absorption of antenna radiation by SAR, and heat resulting from the node circuitry by Pc.

Furthermore, because delayed packets may negatively impact network performance, WBAN solutions for the healthcare industry must distribute vital data packets to their intended destination immediately. Furthermore, network nodes may encounter a high degree of congestion and connection interference as a result of simultaneous data transmission and different data speeds. As a result, there is a frequent disconnection of the wireless links between nodes, which increases the amount of network resources needed to construct a new route.

The aforementioned limitations imply that stringent QoS requirements must be addressed by the routing protocols created especially for WBAN. Nevertheless, meeting WBAN's quality of service (QoS) requirements is difficult because real-time health monitoring services rely heavily on maintaining appropriate connection quality.

Designing an effective routing protocol with limited resources—such as frequency, transmission range, operating environment, data rate, and low-power wireless links that are unreliable in terms of QoS requirements—is therefore a difficult and exhausting task. This is because low-power radios are highly susceptible to noise and interference.

To solve QoS issues in WBAN, several QoS-aware routing protocols and techniques have recently been presented. Unfortunately, the majority of routing protocols fail to take into account different design criteria for optimal route selection, which leads to worsened network performance, including increased packet loss, longer end-to-end delays, and overheating of delicate bodily tissue. Additionally, the majority of routing algorithms include route-cost determined by just one parameter, i.e., either hop-count, temperature, or energy. However, it has been shown by pertinent research that choosing an end route solely based on hop-count may not be the best course of action because the routes that are chosen may have significant levels of interference, delays, and loss ratio.

However, it has been found that a workable option for packet distribution is end route selection based on composite routing metrics (i.e., temperature and energy, temperature and hop-count, energy and hop-count, or temperature, energy, and hop-count). Unfortunately, the majority of schemes based on composite routing metrics have failed to consider WBAN's QoS requirements, making them unsuitable for WBAN applications that are delay-sensitive. A more practical approach is required for delay-sensitive applications to ensure that essential data packets are distributed on time. Thus, the best option for WBAN is QoS awareness in the quest of connection stability and reliability.

1.1 LITERATURE SURVEY

This section is aimed to review the conducted research works which have addressed various methods for Temperature and Reliability Aware Routing Protocol for Wireless Body Area Networks.

Many routing protocols have recently been put forth to address the difficulties and stringent QoS requirements of the WBANs. Cross-layered routing, cluster-based routing, temperature-aware routing, and QoS-aware routing are the different types of these routing protocols [1], [9], and [10]. The main goal of temperature aware routing protocols is to prevent radio signals and power circuitry from raising body temperature in the vicinity of delicate bodily tissues. By expertly combining data from several routes, temperature-aware routing algorithms aim to reduce temperature rise surrounding biomedical sensor nodes and prevent hotspot nodes (hotspot nodes are identified when temperature readings surpass a predetermined threshold value). The first attempt to address the problem of temperature rise in the context of researchers' ongoing improvements to the WBAN model was put forth in [10]. This system uses a method of measuring the load (packet transmitted and received) to overhear nearby nodes' transmissions, which ultimately aids in measuring the targeted node's temperature rise. Until the temperature returns to normal, the packets are removed from the node whose temperature is higher than the threshold. For dependable data transfer in WBANs, a brand-new thermal and energy-aware routing (TEAR) protocol has been developed. The weighted average of the cost function—which takes into account the temperature, energy usage, and link quality of the nodes—is used to determine routing options. By assessing the link quality between communication nodes, the suggested protocol guarantees dependable data forwarding to the sink node and so minimizes the quantity of packet retransmissions, leading to reduced energy consumption.

To lower the average temperature, rise of implanted biomedical sensor nodes in the wireless body area network (WBAN), an adaptive thermal aware routing protocol (ATAR) has been proposed. The goal of the suggested plan is to lower temperature rise by distributing traffic load evenly over the whole network. A technique that uses multiple rings for routing is used to alleviate the temperature rise of implanted sensor nodes. When any relay node along the active route has a temperature that is higher than the threshold value at any given time, the source node will adapt an alternate route.

A temperature-aware routing strategy for WBANs has been suggested in [3]. Different priority levels have been allocated to the data in this method, with high priority data being sent straight to the sink node to guarantee a consistent temperature distribution across all network nodes. Based on the temperature, energy, and hop count of the node, a route cost metric has been established. The nodes that meet the routing cost metric are selected for data forwarding during the route building phase.

In order to solve temperature-related restrictions in the Intra body Nano Network (IBN), a unique temperature-aware routing protocol [TA-IBN] has been suggested in [4]. By lessening network congestion and halting temperature rise in the hotspot area, the suggested routing system seeks to stabilize the network's temperature. The network's temperature rise is managed by preventing packet forwarding and receiving from hot locations. In contrast to other systems, the outcome analysis verifies a consistent temperature rise throughout the network.

To combat temperature rise, a number of temperature-aware routing methods have recently been proposed, such as [5]. These schemes are built on this premise. Unfortunately, because they retransmit too many packets, most temperature-aware routing methods have high overhead, increased end-to-end delays, and rapid node depletion.

The second category, which deals with cluster-based routing, also focuses on lowering energy usage. The entire network is split up into smaller node clusters in this design, with a head node in the center of each cluster. The head node that oversees all traffic is selected from each cluster. Among the few well-known cluster - based routing techniques that have been put forth in recent decades are [6], [7]. Nevertheless, these methods' cluster head selection adds significantly to overhead and increases average packet delivery delays.

Another category of routing protocols that eventually combines the difficulties of the medium access layer and the routing layer is the cross-layered routing system. Compared to other methods, these designs produce relatively high throughput while consuming extremely little energy. Cross-layered plans, however, are limited to immovable BANs. Well-known cross-layered routing protocols specifically created for WBANs include PCLRP, CLDO [8]. Prioritizing higher packet delivery ratio, reducing end-to-end delay, and ensuring high dependability were the main considerations in the development of QoS-aware routing protocols. They are built using a modular methodology, in which several modules are created with consideration for various QoS criteria. The key modules of the routing protocols created with this method are the neighbor manager, reliability-sensitive, delay-sensitive, and power-efficient modules. Recently, several QoSaware routing methods have been proposed for WBANs in order to provide rigorous QoS requirements.

In order to meet the QoS criteria for WBANs, a strong next hop selection-based routing method known as ENSBAN has been developed in [9]. The best next-hop node forwards data packets to the sink node. where the hop counts and link costs of the nearby nodes are used to determine which next-hop node is the best. The leftover energy, queue size, and link reliability of an adjacent node determine its link cost. Every node in the network must choose an effective next-hop node that will take the fewest hops to reach the sink node with the highest cost function value. This scheme's routing algorithm operates in two stages: the network initialization phase and the routing phase. Every node regularly broadcasts a greeting packet to the sink node during the network activation phase, adding details about its remaining energy, queue size, and number of hops. A node builds its neighbor table by updating the data it got in the hello packet after receiving it. Data packets are forwarded by the source node to the sink node via a chosen next hop during the routing phase. Three metrics are used to assess the effectiveness of the ENSA-BAN: packet forwarding ratio, end-to-end delay, and energy usage. The authors assert a noteworthy enhancement in performance as compared to the examined method. Nevertheless, it might not be the best idea to use a hop-count technique in WBAN applications where latency is an issue. Reduced performance may arise from a node that is in the shortest path to the sink node but is subject to high levels of interference and congestion.

A further strategy to guarantee WBANs' quality of service is to give distinct data packet kinds differing priorities. P-AODV, a priority-aware routing protocol, was proposed in [10] to improve the QoS specifications for Adhoc networks. PAODV maintains distinct flows and gives each flow a priority according to its data rate in order to guarantee the quality of service. Similar to this, authors in [10] suggested a low latency traffic prioritization strategy (LLTPQoS) for WBANs that, by preventing congestion at the node and link levels, guarantees the transmission of crucial data packets at the end station.

In many QoS-aware methods, the end-route selection is determined by a composite routing metric mostly made up of temperature, energy, and hop-count. Unfortunately, the majority of these schemes' routing metrics choose unsuitable links that ultimately result in subpar QoS requirements because they fail to take into account changing traffic and channel conditions. Conversely, one of the shortcomings in QoS-aware routing that significantly impairs the network's throughput, latency, and dependability is channel interference. Because of this, the majority of these systems experience an excessive amount of packet retransmissions.

Table -1: Sample Table format

Reference	Proposed System	Advantages
S.Movassaghi et.al[1]	Wireless body area net works: A survey	Overcome temperature rise
A.R. Bhangwar et.al[2]	WETRP	Minimize temperature rise around biomedical sensor nodes
M. A. Ameen et.al[3]	An on-demand emergency packet transmission scheme	Overhear the transmission of neighboring nodes by calculating the load
M.Javed et.al [4]	TAEO	Ensures reliable data forwarding to the sink node.
Movassaghi et.al[5]	ETPA	Reduce the average temperature rise of implanted biomedical sensor nodes in the WBAN
I. Bangash et.al[6]	Bi-GAC	Reliability aware routing for intra wireless body sensor networks
C. Yi [7]	Transmission management of delay-sensitive medicalpackets	Reduce the number of packet retransmissions which results in low energy consumption
A. Ahmed et.al[8]	I-RP	High priority data is immediately forwarded to the sink node by ensures uniform distribution of temperature amongst all nodes in the network.
Movassaghi et.al[9]	Wireless body area networks for healthcare applications: Protocol stack	Addresses temperature-related constraints in IBN
Q. Tang et.a[10]	TARA	Stabilize the temperature across the network by reducing network congestion and preventing temperature rise in the hotspot region

3. CONCLUSIONS

The many studies on Temperature and Reliability-Aware Routing Protocol for Wireless Body Area Networks finished between the years 2014 and 2021 were the subject of the literature review. Researchers will find it useful to analyze and examine the benefits and drawbacks of the various methods used to conduct the survey in the future.

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