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Examination of Wireless Body Area Network Using Mobile Sinks

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Abstract— In the last few years, postural mobility has been seen as a significant barrier to the successful deployment of Wireless Body Area Networks (WBAN), and several mobility models have been put out to overcome this problem. Due to the sink node's fixed location in such topologies, WBAN performance was declining. The domains of other wireless networks including MANET, VANET, and FANET have successfully used Mobile Sink as a solution. The network lifespan and other QoS metrics like average end-to-end latency, PDR, throughput and energy consumption are significantly influenced by sink mobility. The random movement of the sink node is taken into account in this study effort to cope with the heterogeneity of network nodes and their movement pattern. Static and mobile sinks (Controlled and Random movements) are used to test both mobility models using Network Simulator NS2.35, and it was shown that mobile sinks improved WBAN performance for all QoS criteria.

Keywords- Wireless Body Area Networks, Quality of Service, Sensor Nodes, Packet Delivery Ratio, Average End-to-End Delay.

I. Introduction

A Wireless Body Area Network often comprises sensor nodes that may be worn within the body or implanted there. These sensor nodes will serve as network nodes when we require two-way communication, that is, communication from sensor to sensor and sensor to coordinator. Since a few decades ago, wireless broadcasting has been playing an increasingly important part in our everyday lives[1)]. It helps in a number of ways since it is a necessary component of many real-world applications, including monitoring, automation, and the tracking of appliances and gadgets. Because of the world's constantly expanding population, average life expectancy has grown, particularly in wealthy nations as Australia, Germany, Japan and Italy etc. With a sharp increase in residents comes an increase in the average age of those 60 and older, who require more care for their physical condition and hence cost more for medical treatments[2)]. Unfortunately, chronic and dangerous illnesses including cancer, asthma, and cardiovascular conditions are frequently detected too late, which raises the average mortality rate among those who receive a diagnosis. Early detection of these diseases may allow us to lessen their effects and lengthen the life expectancy of those who are affected[3)].

Furthermore, the Conventional Monitoring Systems in hospitals do not reveal the complete picture of the patient's health status due to infrequent monitoring of body functions. Due to this scenario, average healthcare expenses surge, so the overall load on healthcare management of a country also grows. This acts as a catalyst to upgrade current healthcare systems in order to detect diseases at an early stage.

II. Related Work

Jingwei Liu et al. [4] to guarantee the privacy of remote WBAN users, two remote authentication techniques for strong and lightweight certificates have been proposed. These authentication methods are based on a novel certificate less signature (CLS) technique that has been shown to be secure from existential falsification on adaptively selected communication assaults and computationally efficient in the random oracle model. Additionally, these protocols make guarantee that neither apps nor facility sources have the authority to reveal the true identity of customers. Furthermore, the system administrator, which assists as a secretive key producer in the certification procedures, is not allowed to pretend to be a valid user. Results from simulations show that these approaches work. The work in [5] has presented an effective poll-based MAC protocol (PMAC), which focuses on energy conservation and delay factor, to get over the limitations of IEEE 802.11 and 802.15.4. The limitation of 802.15.4, which employed CSMA-CA and TDMA mode for channel access in the beacon-enabled and contention-free time, is solved by using a polling-based channel access method. In the suggested work, the whole amount of traffic has been distributed into four groups. Additionally, polling has been divided into many categories, including planned, delayed, and unscheduled polling. The suggested approach performs well in terms of channel access; however it does not take into account node mobility. The total performance of

WBAN is significantly influenced by MAC layer protocols. To talk this matter, K.S Kathe et al. [6] suggested a thermal aware routing system that prioritizes patient important information (such as high blood pressure, low blood sugar, etc.) above other traffic. In order to prevent unexpected hotspots during the transmission of emergency data, this study focuses on a number of sensor node factors, including the space of the forwarding nodule from a sink and the current temperature condition of the nearby node. In this work, sensor node mobility is not taken into account. (E-HARP) protocols for WBAN have been proposed by the author in [7] The proposed protocol carries out two main functions, namely choosing a cluster head from a group of candidates based on their determined Cost Factor (CF) and Signal to Noise Ratio (SNR), and then routing data using E-HARP with cooperative routing. The suggested technique uses very little energy to function. Mehmood, G et al. [8] focused on the impacts of body fading in WBAN, which disrupts node connection and lengthens network latency. Therefore, the author has proposed an energy-efficient fault tolerance technique that employs the accommodating message and system coding policy in order to decrease the overall delay and node failure caused by body fading. The focus of the work that was presented was on developing monitoring indicators that would use cooperative communication to reduce hospital readmissions and, in turn, lower morality rates; however, the study was limited by its geographic scope (it only covered a small geographic area) and the number of WBAN nodes, so scalability was not taken into account. Agarkhed et al. [9] provided a mathematical model for a routing protocol (network architecture) in a WSN with certain resource constraints. The connection sensors' separation from one another and their energy consumption are two different kinds of restrictions that are engaged into justification. The suggested models seek to pinpoint energy-saving routes that reduce the network's energy consumption from the home device to the sink location. The computational outcomes demonstrate the efficacy of the provided models and their applicability to former system strategy situations with source restrictions (e.g., to multi-level source series systems).David Carels et al. [10] check for issues that prohibit RPL-based normal traffic from transferring to mobile devices. The descending route is modernized by utilizing a ground-breaking method. It is shown that it is possible to enhance the PDR of mobile nodes from 30% to 80% without using position information while lowering the total RPL signaling cost. Yu et al. [11]evaluated various 3rd layer protocols for WSN. Some of the mobility-aware routing strategies were discussed in this work but his survey for the same was very limited. Nazib, R.A et al. [12] worked on unmanned aerial vehicles (UAV) for data gathering in WSN where a sink node takes an aerial route to collect the data from sensor nodes in WSN, unlike a ground-based sink node. Even though data collection has improved significantly, the overall cost and performance of the system still need to be improved because a separate controller is required all of the time to manage UAV and this type of technology cannot be used for WBAN because sensor node movement is not fixed. Di Francesco et al. [13] worked on a mobile robot-based sink node for data gathering in WSN along with its challenges and advantages. The movement trajectory of the mobile robot sink was discussed with all possible paths. Since the approach in this paper is related to the controlled movement of the sink node, it will not be the best in WBAN because sensor node movement in WBAN is random. Furthermore, the overall energy of the system architecture used will be higher in this case. Basagniet al. [14] proposed a controlled sink mobility movement pattern for WSN where the upcoming position of the sink node can be determined based on its energy value. The author has used mixed-integer linear programming (MLIP) to find out the position where the sink node visits maximum time as per its energy and its application in WSN are discussed in this work. This type of scenario will not work better in terms of WBAN as the mobility of the sensor is much higher and predicting the sink movement will be much more difficult in the case of WBAN. Mini et al. [15] analyzes the effect of several system constraints such as number of SNs, detecting range, and sensor letdown rate on the k-coverage performance of the system. Palak Shandil et al. [16] show that speediness and remoteness are the utmost frequent and flexible metrics in a process. Vandana Jindal et al. [17] studied a variety of reasons for converting from a wired system to a wireless system, such as sharing internet, archives, and copiers, playing games, and reducing the need for tangled connections. The only practical choice for a more mobile explanation when a client has to access network resources while on the fly is radio technology. In addition, more and more individuals are utilizing their devices every day to get online news and other data. The number of individuals using their devices steadily increased from 10.8-22.4 million between January 2008 and January 2009. Khalil and Attea [18] The author developed a method that produces findings that are more reliable than the current heuristic and meta-heuristic methods in terms of system stability, longevity, and energy use by reconsidering the approach of the most important component of the EA (i.e., the objective function). A proposed evolutionary-based routing protocol can ensure a better trade-off between the network's stability and lifespan while utilizing less energy. Jamal Toutouh et al. [19] this artefact considers a series of exemplary meta-heuristic algorithms (PSO, GA, and SA) to uncover automatically the best plans for this routing procedure.

Belghachi Mohamed and Feham Mohamed [20] offer communication delay and energy usage as a direction-finding measure in the RPL protocol's procedure for selecting the next hop. Associate test results with the RPL based on ETX after projecting an independent task based on ACO for this metric. H. Santhi et al. [21] delivered a brand-new, highly efficient routing system for usage in mobile node networks with several hops that have a compact E2E delay and enhanced throughput. Meer M. Khan et al. [22] suggested that in order to enhance network performance, RPL requires a management framework that may specify message exchanges between several sink nodes. It is designed to use the RPL's recurring route repair messages to inform nearby sinks of the network state detected at a particular sink. Weisheng Tang et al. [23] suggest CA-RPL,

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a congestion prevention multipath direction-finding method that employs numerous routing metrics based on RPL. The average time around the DAG root is decreased by a direction-finding metric for RPL, and four metrics are used to determine the weight of all pathways. HosseinFotouhi et al. [24] describe how topology management and effective hand-off techniques may be utilized to promote inter-operability between fixed and mobile node containers. Describe a motion-controlling framework (called mRPL+) that makes use of two different hand-off types: (a) hard hand-off, in which a portable node must cut off an existing connection before identifying a fresh connection, and (b) soft hand-off, in which a movable device can choose a fresh linking earlier severing from the current one. Patrick Olivier Kamgueu et al. [25] examination of current RPL work emphasizes key offerings to its development, particularly those pertaining to topology adjustment, protection, and movement. Hanane Lamaazi et al. [26] in three different settings—compound sink, scalability, and movement models—evaluate the RPL. The results demonstrate that nodes count, sink nodes count, and smartness of movement greatly subjectively impact the RPL results.

III. PROPOSED WORK

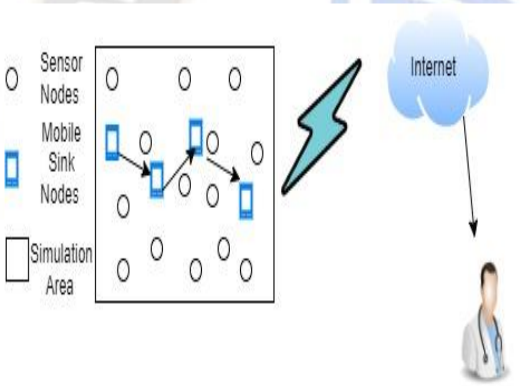

Figure 1: Proposed WBAN Architecture with Movable Sink in WBAN

Sink mobility has been introduced in conventional WBAN architecture along with different possible movement patterns of sink nodes. Irrespective of the drive of sensor devices in WBAN, Sink node movement patterns can be classified into three different categories.

A. Fixed/ Predictable Sink Movement

One of the simplest mobility patterns a sink node exhibits is that the sink node followed a fixed trajectory. In this type of sink movement, the sensor node transfers the data to the sink node as per the availability of the sink node to their nearest point of contact. This type of sink movement is not efficient in the case of WBAN as the movement pattern of mobile sensor nodes is not fixed. Due to unstable network topology fixing of sink trajectory will not help in making efficient WSN.

B. Controlled Sink Movement

This type of sink mobility requires a special observer to control the movement pattern of a sink node. For example, if we attach the sink to a robot that can be controlled easily, the direction and speed for the same can be changed as per the requirement of the network. This type of sink movement is successful in a case where the future position of nodes can be evaluated easily according to which the controlled movement of a sink can be planned, but in the case of WSN as the sensor node's movement is not at all predictable it is always difficult to manage the controlled sink node movement.

C. Random/ Unpredictable Sink Movement

Due to its random mobility, it is extremely difficult to judge or forecast the upcoming movement pattern of a sink node. The path will take the speed it will exhibit and the pauses it will take at a certain point before changing its direction are all unpredictable. In the case of delay-tolerant applications, this type of sink movement is highly recommended and this sink movement is ideal for the WBAN environment because sensor node movement is unpredictable. In this study, we have also considered the random movement of a sink node in our simulation area for WSN.

IV. RESULTS

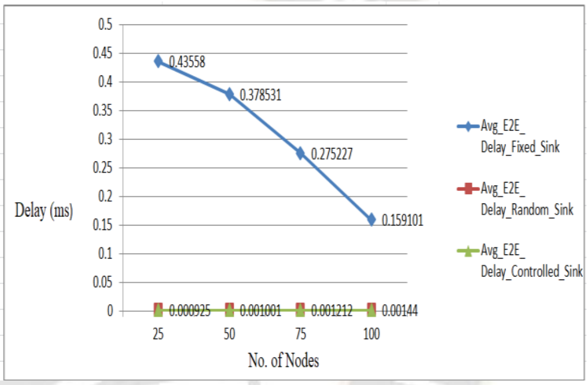

Figure 2: Average E2E (ms) Delay Fixed vs. Random/Controlled Sink

According to figure 2, the Average E2E delay by RPL with a fixed sink node for 25 nodes is 0.43558 ms, while the Average E2E delay by RPL with a random movable sink node is 0.00092 ms and Average E2E delay by RPL with a controlled movable sink node is 0.00092 ms. The Average E2E delay by RPL with a fixed sink node for 50 nodes is 0.378531 ms, while the Average E2E delay by RPL with a random movable sink node is 0.001001 ms and Average E2E delay by RPL with a controlled movable sink node is 0.001011 ms. The Average E2E delay by RPL with a fixed sink node for 75 nodes is 0.275227 ms, while the Average E2E delay by RPL with a random movable sink node is 0.001212 ms and Average E2E delay by RPL with a controlled movable sink node is 0.001151 ms. The Average E2E delay by RPL with a fixed sink node for 100 nodes is 0.159101 ms, while the Average E2E delay by RPL with a random movable sink node is 0.00144 ms and Average E2E delay by RPL with a controlled movable sink node is 0.00134 ms.

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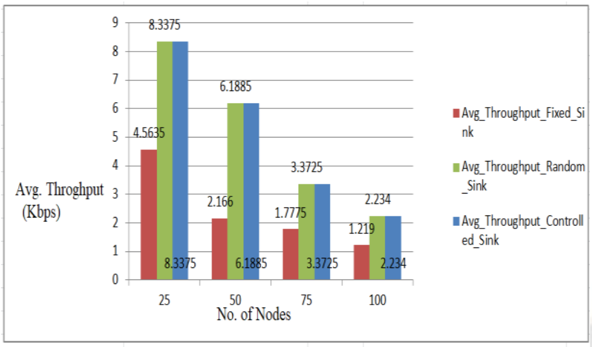

Figure 3: Average Throughput (Kbps) Fixed vs. Random/Controlled Sink

According to figure 3, the Avg. Throughput by RPL with a fixed sink node for 25 nodes is4.5635kbps, while the Avg. Throughput by RPL with a random movable sink node is 8.3375kbps and Avg. Throughput by RPL with a controlled movable sink node is 8.3375 kbps. The Avg. Throughput by RPL with a fixed sink node for 50 nodes is2.166kbps, while the Avg. Throughput by RPL with a random movable sink node is 6.1885 kbps and Avg. Throughput by RPL with a controlled movable sink node is 6.1885 kbps. The Avg. Throughput by RPL with a fixed sink node for 75 nodes is 1.7775 kbps, while the Avg. Throughput by RPL with a random movable sink node is 3.3725 kbps and Avg. Throughput by RPL with a controlled movable sink node is 3.3725 kbps. The Avg. Throughput by RPL with a fixed sink node for 100 nodes is 1.219 kbps, while the Avg. Throughput by RPL with a random movable sink node is 2.234 kbps and Avg. Throughput by RPL with a controlled movable sink node is 2.234 kbps.

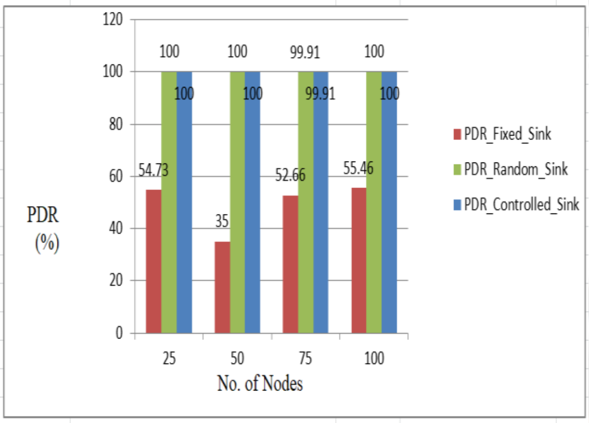

Figure 4: PDR Fixed vs. Random/Controlled Sink

According to figure 4, the PDR by RPL with a fixed sink node for 25 nodes is54.73, while the PDR by RPL with a random movable sink node is 100 and PDR by RPL with a controlled movable sink node is 100. PDR by RPL with a fixed sink node for 50 nodes is 35, while the PDR by RPL with a random movable sink node is 100 and PDR by RPL with a controlled movable sink node is 100. The PDR by RPL with a fixed sink node for 75 nodes is52.66, while the PDR by RPL with a random movable sink node is 99.91 and PDR by RPL with a controlled movable sink node is99.91. The PDR by RPL with a fixed sink node for 100 nodes is55.46, while the PDR by RPL with a random movable sink node is 100 and PDR by RPL with a controlled movable sink node is 100.

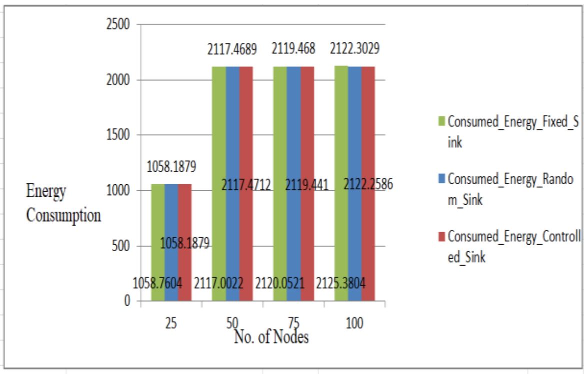

Figure 5: Energy Consumption Fixed vs. Random/Controlled Sink

According to figure 5, the Consumed Energy by RPL with a fixed sink node for 25 nodes is1058.7604 j, while the Consumed Energy by RPL with a random movable sink node is1058.1879jand Consumed Energy by RPL with a controlled movable sink node is1058.1879 j. Consumed Energy by RPL with a fixed sink node for 50 nodes is2117.0022 j, while the Consumed Energy by RPL with a random movable sink node is2117.4689 j and Consumed Energy by RPL with a controlled movable sink node is2117.4712 j. The Consumed Energy by RPL with a fixed sink node for 75 nodes is2120.0521 j, while the Consumed Energy by RPL with a random movable sink node is2119.468 j and Consumed Energy by RPL with a controlled movable sink node is2119.441 j. The Consumed Energy by RPL with a fixed sink node for 100 nodes is2125.3804 j, while the Consumed Energy by RPL with a random movable sink node is2122.3029 j and Consumed Energy by RPL with a controlled movable sink node is2122.2586 j.

V. CONCLUSION AND FUTURE SCOPE

In the IoT age, WBANs have become an essential component, focusing on several applications such as Intelligent Transportation Systems (ITS), home automation, agriculture, and autonomous driving. Because of the short battery life of sensor nodes, energy efficiency and system longevity become major issues throughout the communication process between nodes and sink. Devices which are adjacent to the fixed sink appear to be transmitting data constantly. As a result, the devices neighboring to the sink uses up its energy significantly faster than nodes farther away. The solution to the aforementioned problem is sink mobility. Wireless networks with limited energy resources may manage node mobility with ease because of RPL's architecture. Estimating the RPL protocol's performance with both a fixed and mobile sink node is among the work that is planned. The simulation tool is NS 2.35. Measurements for assessment include Average E2E interval, Packet Transmission, Average Throughput, and Spent

Energy. Results from simulations demonstrate that a moveable sink improves system performance as a whole.

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