Research on Intelligent Routing Metric for Wireless BAN: A Survey

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***Abstract*-Wireless Body Area Network (WBAN) is a kind of wireless sensor network (WSN) which can be wearable or implantable in the human body. WBAN is an emerging technology in the field of healthcare system. WBAN has received great attention due to its applications in the field of health, medical, entertainment services and many more. The main idea behind WBAN technology is to deploy them in the medical system to replace wires with the help of sensor nodes implanted into the patient's body or placed around the patient body. Not only it gives more comfort to the patient, but also patient can be treated remotely by the healthcare system staff. It is very helpful to the elderly people or people with any disability to provide medical facility at home or in any emergency condition. Body Area Networks are an effective solution for communication in ubiquitous health systems. BAN's can be applied into fields of military, defense, telecomm etc. Such networks are thus being researched to provide better routing techniques in and around the body. WBAN has been a vast area for researchers in recent years. In this Paper, we have carried out survey of various existing approaches of WBAN and describe the future scope for further research in the field. The literature survey depicts that the existing schemes can be further modified to devise more reliable solutions for WBAN schemes.**

Keywords - Wireless Body Area Network, Sensor network, Healthcare, Existing Approaches.

I. INTRODUCTION

Wireless Body Area Network (WBAN) ensures innovative solutions for E-Health. It is composed of a number of tiny devises called "sensors" attached to the human body. These sensors continuously monitor the patient health state, while he is doing his daily activity, to be communicated to the specialized medical server or entity (doctor, emergency, laboratory…). Some patients need a long term and real time supervision of their vital signs like ECG (electrocardiography) and glucose level. WBAN, then, allows the early detection and intervention to save the patient life. The introduction of the Wireless Body Area Network (WBAN) grows significantly regarding its flexibility, accuracy, costs efficiency and mobility. It supports a huge range of innovative applications that improve the quality of life and enhance services. In the health care system, the majority of WBAN applications are responsible of handling critical data in order to monitor the patient health state and to save his live in many cases. That's why WBAN should efficiently deliver patient's vital signs to specialized medical entity (doctor, emergency). However, the particular architecture of WBAN and the movement patterns of the body part affect the communication quality.

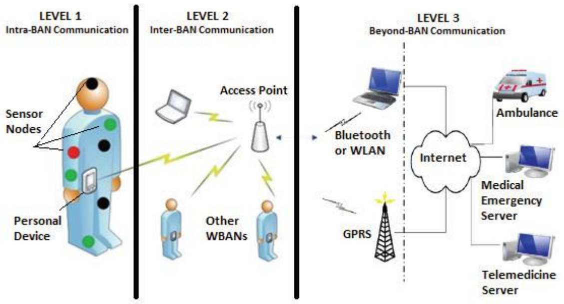

Figure 1. The general architecture of Wireless Body Area Networks (WBANs)

Wearable sensors: the subject is equipped with multiple miniature wearable sensors. These sensors can be located in, on or around the human body and collect physiological information from the human body such as heart rate, pulses, blood pressure, temperature, etc. The collected data is then transferred wirelessly to a nearby coordinator for further processing and data transmission. It should be noted that some wearable sensors are not completely wireless because they may be connected to other nodes through wires and may have huge electronics. Coordinator device: The wearable sensors forward the collected data to the coordinator device which is in the patient's proximity using short range wireless communications. This equipment is similar to the sink nodes in traditional Wireless Sensor Networks (WSNs). In most cases, the coordinator device is a smart device, such as a wrist watch, tablet, smart phone or laptop, depending on the application needs. It has more power and computing resources than the sensor nodes. All the collected data is then forwarded using long-range communications (e.g., through 3G/4G or Wi-Fi) to remote servers, which can be the clinical back-end system or the emergency service, etc. This coordinator device may include professional software to process the vital signals, reveal in real time the patient's situation and send a notification if an abnormal signal has been detected during the measurement. Clinical back-end server: All the data forwarded by the coordinator devices is received, processed and stored at a clinical back-end server. Depending on the system's application, the data can be analyzed continuously in real time. It is possible for a doctor or a nurse to take action depending on the received data (e.g., reminds the patient to take their medication via phone or message). For an urgent situation (e.g., an elderly who has falling down), the intermediate family or the emergency service can be notified and the required assistance is provided to the patient.

II. LITERATURE SURVEY

Many routing metrics with different performance goals has been proposed in literature so far, still new routing metrics are required to be discovered and utilized to improve the performance of routing protocols for highly dynamic wireless networks. De Couto *et al.* [1] presented that Minimum Hop Count metric (HOP) which is a simple routing metric that selects a minimum hop count path between source and destination is not adequate for link selection. It states that there are several minimum hop count paths available between each pair of sensors in a multi hop wireless network. The minimum hop count routing metric does not consider QoS and energy consumption issues and often selects long distance path with significantly less capacity than the best route and resulting in poor performance. It is further proposed that instead of using minimum hop count, link quality of paths must be considered while selecting a path in wireless networks.

Samaneh Movassaghi *et al.* [2] presented a review of routing protocols in WBANs. They have classified routing protocols in BANs into five categories: temperature based, cluster-based, cross layer, cost-effective and QoS-based routing. It states that QoS-based routing protocols aim to accomplish the required QoS metrics.

Gang Zhou et al. [3] submitted that Quality of service (or QoS) is one of the aspects of any application and this kind of research is not new; prior research has focused on managing and reserving resources in the Internet, wireless networks, and ad hoc networks.

M.A. Ameen et al [4] presented that QoS has emerged as a major concern and research area in sensor network applications such as WBANs and suggested more QoS specific WBAN research. There is also need to have some MAC as well as routing protocols that can handle QoS in WBAN specifically so as to improve the overall performance. They favored of using some mechanism for monitoring of QoS in WBAN itself. They want to include Energy efficiency, as a QoS metric, as a major focus of research.

Maalej et al. [5], proposed a WSN routing protocol for wildfire monitoring. Cooperative communication is applied to counter the effects of shadowing and to improve network lifetime. By sharing the resources between nodes the transmission quality is improved. A Received Signal Strength Indication (RSSI) based reinforcement learning technique is proposed by opponent modeling, optimizing a cooperative communication protocol based on node's energy consumption. Their proposed protocol is energy and quality-of-service aware cooperative routing protocol. Ibrahim et al. [6] stated that minimum-power routing problem is solved by proposing the Minimum Power Cooperative Routing (MPCR) procedure which employs cooperative communication in wireless networks. Routes with minimum transmission power are defined as optimum routes, guaranteeing some certain level of throughput. Routes are constructed as a cascade of the minimum-power single-relay building blocks from the source to the destination.

Chen et al [7] submitted an energy efficient fuzzy routing protocol in WBANs based on traffic load, battery power and link usages. The lifetime of a node depends on: (1) the traffic load the node is routing, (2) the energy consumed rate while transmitting or receiving the traffic load, and (3) the residual energy on the node.

Djenouri et al. [8] have proposed LOCALMOR algorithm for biomedical sensor applications. The protocol design relies on traffic diversity of different applications and ensures a differentiation routing using QoS metrics. It is based on modular and scalable approach, where the protocol operates in a distributed, localized, computation and memory efficient way. Apart from different QOS metrics, scalability is not measured through this algorithm.

Razzaque et al. [9] have proposed DMQoS, a data centric multi objective QoS aware routing protocol which provides customized QoS services according to different types of traffic generated for each traffic category differentiated according to the generated data types. It uses modular design architecture wherein different units operate in coordination to provide multiple QoS services.

Liang et al.[10] have proposed Reinforcement Learning based Routing Protocol with QoS support. In this protocol, concept of geographic location is considered for routing. All the nodes individually implement reinforcement learning algorithm for selection of routes'.

Kumar et.al [11] presents a routing framework to evaluate the Integrated Link Cost (ILC) in Wireless Mesh Networks (WMNs) based on some Quality of Service (QoS) parameters. This approach was based on Fuzzy Logic and the input parameters considered are Throughput, Delay and Jitter.

Viittala et.al [12] Presents Routing in WBAN which are focusing on routing occurring in personal and native areas of WBAN. They used Fuzzy logic for optimal resolution which needs less procedure power than typical ways. Zone routing protocol is proposed protocol that is hybrid protocol, combination of reactive and proactive routing protocol. WBAN communication architecture will be divided into 3 communication tiers are intra-WBAN, inter-WBAN and beyond-WBAN based on the communication occur on the body.

S Sharma et al. [13] present a fuzzy logic based routing framework for wireless networks. This routing metric is further used in Wireless Mesh Networks (WMNs) to present three new nature inspired approaches.

Kim et.al [14] proposed a Multi hop WBAN construction theme that has 3 operations: (1) the clustered topology setup, (2) mobility support, (3) transmission efficiency improvement. Existing schemes work on 1-hop based star network that is helpful just for short vary network on the opposite hand multi hop network have immeasurable benefits.

He et.al [15] proposed Body topology model was made primarily based on the particular spatial distribution of the medical sensors. They used two Ad- hoc routing protocol AODV and DSDV for this model. Both of this protocol, AODV is more appropriate for transmission of knowledge below form setting.

Tsouriet al. [16] presented a reinforcement learning based routing protocol with QoS support in biomedical sensor networks. By using the approach of machine learning, sensor node can estimate the QoS properties of all available routes and find the optimal routing policy through experiences and rewards. It was shown that RL-QRP performs well in respects of QoS metrics and its well in highly dynamic environments.

Liangtet al. [17] proposed a prediction-based secure and reliable routing framework (PSR) for WBANs. This frame work requires each sensor node to locally maintain a prediction model and obtain the neighborhood conditions in the immediate future. With the prediction results, the nodes can choose the incidental links of the best quality for packet relay to improve routing reliability and adaptively enable/disable source authentication function to resist data injection attacks.

III. WBANS NETWORK DESIGN ISSUES

Data transmission reliability and latency are very important in any WBAN which collect non-critical and critical data from the various part of the human body. The reliability and latency of a WBAN will mainly depend on the design of the Medium Access Control layer and it physical design. The MAC layerhelps to determine the network efficiency and utilization issues which mainly determine a system and operating costs of a WBAN. the design of the MAC layer also helps to determine the power consumption of a WBAN which is an important design issue. The physical layer also determines the reliability of the WBAN simultaneously.

A. Power efficiency

Power management is always an important operational issue in any design especially in WBAN. the power management in WBAN can be optimize by the PHY (physical) and the MAC (medium access control) layer processes. MAC layer introduces a much higher level of power saving by using several techniques such as packet transmission scheduling and channel access techniques it implements the use an intelligent signaling techniques and an optimal packet structure. By selecting appropriate modulation and coding techniques the PHY layer can increase the probability of successful transmissions. End to end packet delays and the power budget of a WBAN node can be reduce through a higher packet transmission probability.

B. Reliability

The reliability of WABN is directly proportional to the packet transmission delay and the packet loss probability. The probability of the packet loss is influence by the Bit Error Rate (BIR) of the MAC layer transmission procedures and that of the channel. by using an adaptive modulation and coding techniques which suites the channel conditions in which the transmission takes place the PHY layer of a WBAN can reduce the effective bit error rate of a transmission link. However the effective bit error rate can be reduce by implementing a forwards correcting error (EFR) technique. The use of this technique requires transmission of additional redundant bits which could increase the power budget of the WBAN node due to the transmission of extra bits. The situation of a network can also affect the can also affect the reliability and power budget of a WBAN. in order to transmit packets successfully when the interference and noise floor of a network is high a node needs to transmit at a very high transmitting power level.

C. Scalability

Scalability is very essential for a patient monitoring system such as WBAN because it is quiet often necessary to change the number of nodes and collect different physiological data from the patient body. when a WBAN is scalable it is easy for healthcare staffs to add or remove some nodes without affecting the entire WBAN operation. Since the PHY layers are fixed the scalability of WBAN is largely dependent on MAC layer this MAC layer plays a vital role in maintaining reliability under variable transmission and traffic conditions MAC layer also helps to maintain a good quality of service.

IV. VARIOUS APPROACHES TO ROUTING IN WBAN

Frequent network partitioning due to postural mobility of the on-body sensors, low transmission power of the sensors, high propagation loss across the human body and low reliability of end-to-end path from source to sink are the principal characteristics of a Wireless Body Area Network (WBAN) that make design of a routing protocol necessary. [1] Studied the Link layer behavior of WBANs at 2.4 GHz and observed the following:

(i) Environments do have an impact on PDR. In a lab setting more than 70% of links have PDR 90% or more; while in an open setting (on the roof) about 50% of links have 90% or more PDR.

(ii) Increasing transmission power at regions with low multipath increases PDR even more.

(iii) Average packet delivery ratio (PDR) increases with increase in transmission power.

The authors also found that channel symmetry is better in environments having more reflective surfaces (more multipath). Conventionally, there are mainly two approaches to routing in BANs. One approach is to design a routing layer on top of the MAC layer, where link qualities are measured based on selected parameters and taken into path computation the other is to implement the routing functions with the MAC layer, with a cross-layer approach.

The first approach has been investigated in [9] where the authors have proposed a probabilistic packet routing protocol, Probabilistic Routing with Postural Link Cost (PRPLC),using a stochastic link cost. The topology is being developed in the laboratory with on body sensor nodes using about 900 MHz Mica2Dot Motes operating in TinyOS. The motes consist of MTS 510 sensor cards from Crossbow Technologies and Chipcon’s Smart RF CC1000 radio chips. The radio chips’ transmission powers are decreased to set the range of transmission between 0.3 to 0.6 meters. The proposed protocol is based on postural link cost formulation using a time-varying cost, formulated for each link based on the area in the connectivity patterns of the links. The protocol uses postural link costs to compute probabilistic forwarding of data packets. The second approach has been studied and proposed in [3] Have proposed a cross-layer CICADA protocol that sets up a spanning tree and uses time slots for controlling each node's transmission and reception cycles. Each node tells its children about their turns for sending their data. Data transfer takes place in a sequence of cycles: a data cycle and a control cycle. In the control cycle all nodes are informed about the order in of transmission. When all nodes receive their control schemes, that data cycle starts. In the data cycle each data scheme has two parts: a data period, and a waiting period. The data period also provides a contention slot to allow nodes to join the tree. This can provide mobility support for the network which helps nodes to get disconnected due to postural mobility also. The authors have also discussed the energy efficiency of the algorithm, which depends on the network topology. As the nodes have to spend time on idle listening and overhearing during the control cycle, depth of the tree plays a significant role in controlling the energy efficiency of the protocol.

V. FUZZY LOGIC

Fuzzy-logic theory has been mainly applied to industrial problems including production systems. There has been significant attention given to modeling scheduling problems within a fuzzy framework. Several fuzzy logic based scheduling systems have been developed, although direct comparisons between them are difficult due to their different implementations and objectives. In general, a Fuzzy Logic System (FLS) is a nonlinear mapping of an input data vector into a scalar output. Figure 7 depicts a FLS that is widely used in fuzzy logic controllers. A FLS maps crisp inputs into crisp outputs, and this mapping can be expressed quantitatively as $y = f(x)$. It contains four components: fuzzifier, fuzzy rules, inference engine, and defuzzifier. Here, we have designed a FLC system for health monitoring services, which is one of component in our pervasive computing prototype health status. The FLC system receives context information from sensor (sensor data stored in data base) equipment as the inputs of the FLC and the fuzzification module converts inputs into fuzzy linguistic variable inputs.

VI. CONCLUSION

Because the WBAN has environmental characteristics vastly different from that of WSNs, the existing technologies for conventional sensor networks cannot be applied to the WBAN. This study examined the characteristics of WBANs that are different from that of existing WSNs and classified WBAN-related technologies that have been studied recently. WBAN is an emerging technology in field of medical and provides comfort to human and makes work easy for medical staff. In this survey paper, we have carried out survey of various existing approaches for WBAN. We studied various mechanisms based upon MAC layer, physical layer, and transport layer along with various security mechanisms. WBAN has vast number of applications and based on the application various mechanisms are devised to optimize its performance. Each of the proposed mechanisms performs well under specific scenarios and assumptions, but each has its own limitations. Therefore, we can conclude that no mechanism performs exceptionally well in all scenarios, but it proves to be exceptional in certain environments.

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