Intelligent Routing Metric for Wireless Body Area Networks

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Abstract :- Routing in Wireless Body Area Networks (WBANs) is a critical requirement due to its dynamic behaviour. This paper proposes an intelligent framework for link cost evaluation. A suitable Quality of Service (QoS) parameters based function has been proposed. The sensors in WBANs would be capable of computing the Link Cost (LC) function based upon the current values of QoS parameters: throughput, delay of the link and residual energy of the sensor. A fuzzy logic based system is proposed at the sensor to evaluate the LC. Nodes of architecture evaluate a set of possible paths between source-terminal pairs. This LC is then used to evaluate the suitable path for the routing.

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I. Introduction

Recent years ago medical field has no more development in its medical devices and healthcare systems. Due to its lack of facility, patients put their lives on risk in emergency condition. Medical facilities were providing with full of wires and very complex to handle it for patient. Nowadays Medical field is very developing field and Wireless body area network (WBAN) is one of the emerging technology in the field of healthcare system which is able to change the landscape of the medical systems and its way of delivery [1]. Due to its variety of applications such as medical, health, and entertainment services, WBAN has received great attention [2]. Many medical devices such as Electrocardiography (ECG), Insulin Pumps, Pacemakers, Implantable Cardioverter Defibrillators (ICD), temperature and pulse sensors, all have been also moved to WBAN technologies. WBAN technology reduces the problem of wires in the healthcare system and increases the comfort of the patient and provides ability for healthcare system to monitor patient remotely [3].

Fig.1 shows a typical example of WBAN with various wearable and/ or implantable sensors to monitor vital parameters of a human being. The status of these parameters or critical measurements are collected at the Personal Server (PS).

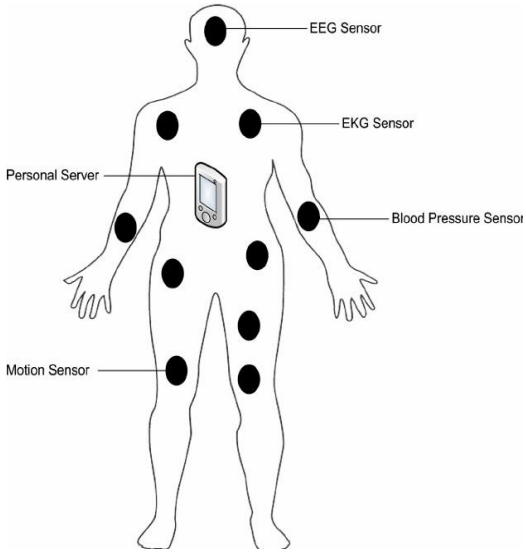

Fig 1. Architecture of Wireless Body Area Network

A Goal of Body area network is health-care system that guarantees the continuous, reliable gathering and objective analysis of physiological and behavioural aspects of a patient, and delivers this information to physicians. In WBAN sensor nodes are placed on the human body or placed on everyday clothing [4].

In WBAN the benefits at one hand, there are also various issues like interference and eavesdropping that Body area network should solve on other side. Energy efficiency related issues resolve by various MAC layer techniques. Use the human body as a communication channel is more energy efficient and reliable [4].

The rest of Paper is organized as follow: In section 2 related works on various WBAN approaches is mentioned and in final section paper is concluded.

II. Literature Survey

A thorough literature survey of the various WBAN approaches have been conducted which are described as follows.

Latre et al [1], Chen et al [2], Sana et al [3] and Movassaghi [4] presents various surveys on the various characteristics, applications and open research issues in WBANs.

De Couto*et al.* [5] 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.

SamanehMovassaghi et al. [6] 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. [7] 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 [8] 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.

Thamilarasu*et.al* [9] proposed an autonomous mobile agent primarily based intrusion detection design to deal with security in wireless body area networks. In this paper intrusion detecting in WBAN by mobile agent migration and cooperative performance. Every node in the WBAN behaves as computing node. In this paper, a multiple mobile agents based intrusion detection system is developed so, learning and decision creating is distributed among totally different nodes within network.

Kim *et.al* [10] a MAC protocol that applies on the delay limitation to MAC Protocol in medical signal observance to scale back the time delay and packet loss in TDMA primarily based CSMA/CA surroundings. In this paper WBSN surroundings is established as star and computer simulation is conducted in static environment within which range of node devices doesn't amendment. DTD-MAC Protocol is efficient additional than Bio-MAC.

S. 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.

Froehle et.al [12] gives plan concerning analysis on WBAN for area that provides safety of future astronaut throughout area Exploration, advance health industry and technology. In the spacesuit health watching system, Bluetooth module and sensors should be enforced on the interior aspect of the pressure suit to with efficiency live important signal and to shield instrumentation from worst surroundings and antenna must be connected to the Bluetooth. In the simulation Perfect Electric Conductor (PEC) was used because the ground plane material that improves the antenna output however having air gap is downside in pressure suit therefore to decrease this gap a folded ground style was enforced.

Kim et.al [13] 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 [14] 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.

Ramlall et.al [15] proposed a timestamp-free synchronization algorithmic rule. In this algorithm the sensors change once they transmit their messages to the central communication node. Central communication node knows the sensing element node's time offset is at intervals want level of your time accuracy and if time offset is exceeds the desire level of time accuracy at that point central communication node answer sensing element node.

Viittala et.al [16] 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. [17] presents a fuzzy logic based routing framework for wireless networks. This routing metric is further used in Wireless Mesh Networks (WMNs) to presentthree new nature inspired approaches.

Hamalainen et.al [18] gives plan regarding the European level customary proposal for sensible wireless body area networks. Smart BAN concept is primarily based on the heterogeneous multi-radio approach and Smart BAN hub act as a relay or bridge between devices operative with totally different radio standards. The proposed knowledge model is divided into 3 main parts: BAN, Nodes, Process and Measurements. The Smart BAN is using 2 totally different channels: a control channel, a data channel. At last we could say that Smart BAN is employed for monitoring specific phenomena.

Lahlou et.al [19] proposed on the energy optimization issue and the joint routing and MAC protocols in WBANs. In this paper author present their antecedent style model Energy-Aware Topology style for WBANs (EAWD), its weakness and extend the EAWD as Enhanced EAWD (EEAWD).EAWD is a mathematical framework supported the integer liner programming. It has two mathematical issues: the set covering and multi-commodity flow problems. Design of EEAWD framework is planned for people with low quality, like the elderly people.

Zang et.al [20] presents a new transmission power control theme, which is Motion aware transmission power control (M-TPC) theme in the dynamic WBAN state of affairs.TPC theme in WBAN area unit 3 sorts particularly real-time reactive scheme, dynamic postural position inference (DPPI) mechanism, and link-state-estimation-based transmission power control (LSE-TPC) protocol. In this paper author assume that physical activity recognition algorithm has already been applied and also the activity of walking is acknowledged effectively. The relationship between body movement and link quality is examined by the experiment.

Sangari et.al [21] presents the proposed scheme comprises 3 section: (1) Data acquisition phase, it performs monitoring and transferring the patient data. (2) Data transfer section, it performs transmitting the signals between the sensors and Hospital network. (3) Data access section, it performs accessing and monitoring the patient data. This proposed technique is combination of each symmetric and asymmetric cryptography mechanism. For transmission security of biomedical system authors use RC6 block cipher that is derived from RC5.

Ambigavathi et.al [22] proposed a Priority Queuing formula with using AODV protocol to differentiate varied sorts of data traffic supported vital data. Simulation result performs comparison between traditional AODV while not priority and planned AODV with priority. In traditional AODV traditional FIFO planning formula is used that is typically making drawback for emergency case. In proposed AODV this drawback is solved with the facility of pre-emption and Non pre-emption condition.

Nhan Le et.al [23] proposed a new theme Asynchronous Wake-up on Demand MAC protocol (AWD-MAC) supported the Receiver Initiated Cycled Receiver (RICER) protocol using nano-watt wake up radio (WUR) in star topology. Wake up radio is ultralow power hardware that receives awaken signals within the type of data or commands. The proposed protocol has 2 sections: the neighbor discovery section and the asynchronous communication phase.

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 signalling 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 (BER) 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 quite 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. [24] 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.

It has been 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.It has 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 [25, 26] 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 4 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. Result

The network architecture for 10 nodes are shown in Figure 2; clearly displaying the source and the destination sensor nodes of a WBAN.

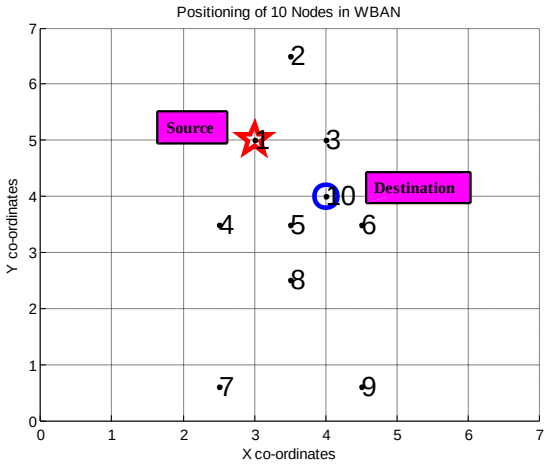

Fig.2: Positioning of 10 nodes in WBAN

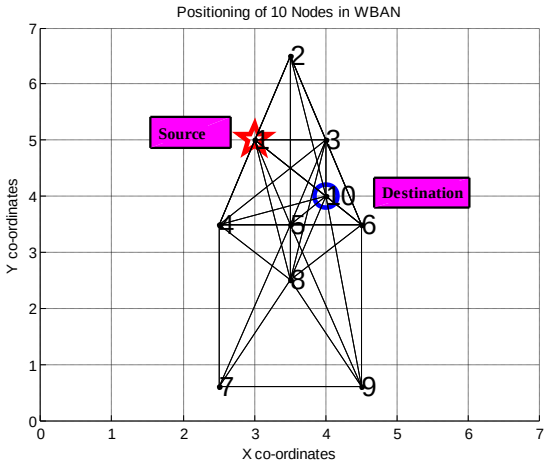

Figure 3: Positioning of 10 nodes in WBAN with possible paths

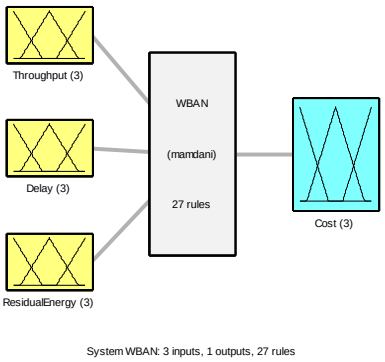

Figure 4: Fuzzy System to evaluate the Cost of a path in WBAN

Fig 4 presents a Fuzzy system for link cost evaluation between two sensor nodes in a WBAN. The input parameters are Throughput, Delay and Residual Energy. Each input is having three membership functions. This WBAN is based on mamdaniinferencing.

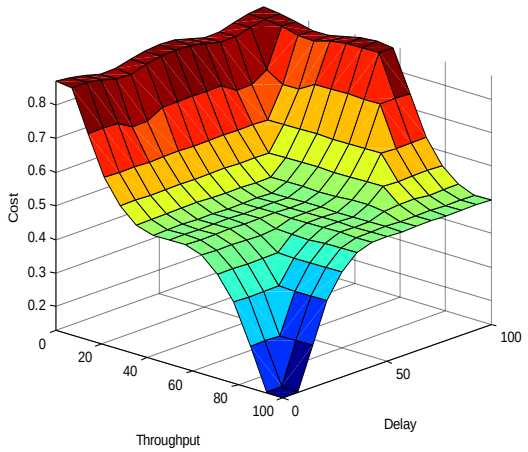

Figure 5: Plot of Surface between Throughput, Delay and Cost

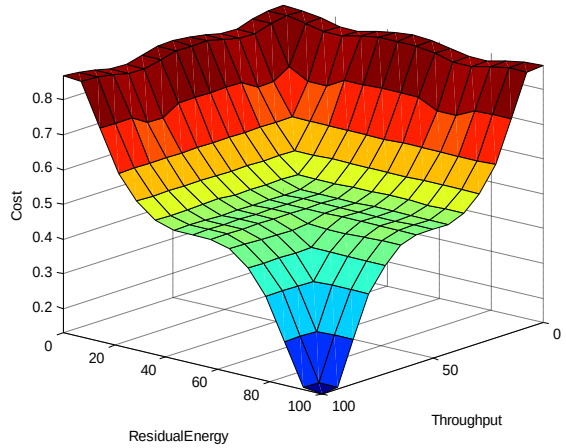

Figure 6: Plot of Surface between Throughput, Residual Energy and Cost

Surface plot of Throughput, Delay and Cost has been shown in Fig. 5 while Fig. 6 presents surface plot between Throughput, Residual Energy and Cost. It has been observed that the proposed FLC successfully computes the Link Cost in a typical WBAN. This Link Cost is then used to establish a routing path between source and destination nodes.

VI. Conclusion

A new routing metric based on Fuzzy Logic is proposed.The performance of this metric is compared with the minimum hop count based approach which is considering minimum number of hops only. The criteria of comparison of these two performance metrics is the Link Cost of the route.

This approach is applied to 5 and 10 sensors (nodes) WBANs with two inputs- throughput and delay as well as three inputs- throughput, delay and residual energy. From the results obtained from the two input fuzzy model and three input fuzzy model it has been observed that the proposed approach is providing more robust solutions in terms of QoS parameters.

After wide-ranging simulation rounds it has been observed that the proposed Fuzzy Logic based approach for performance metric calculation in WBAN was able to converge to the QoS parameters based Link Cost while the minimum hop count based approach converged to the minimum hops for the same communication link resulting in inferior paths for communication. Hence, it is concluded that Fuzzy Logic based approach is a suitable solution to enumerate the Link Cost for a path between source and destination nodes in WBAN.

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