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RPRP: Routing Protocol to Ensure the Reliability in Health Care System

[1]Obaid Ullah Owais Khan, [1]Adnan Nadeem, [1]Kamran Ahsan, [2]Nadeem Mehmood

[1]Federal Urdu University of Science& Technology, University of Karachi, Pakistan
[2]International Islamic University, Malaysia

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ABSTRACT

Wireless Body area sensor networks (WBASN) are an interesting and emerging application of wireless sensor networks. WBASN has a wide range of applications but health care is most beneficiary of this technology, which requires uninterrupted and reliable communication between sensors, Sinks and outside WBASN. This paper introduces the reliability aspect in intra-BAN communication system at network layer. The proposed routing protocol is based on single hop for non-critical nodes while multi-hop for critical nodes and this routing protocol adopt pro-active reliable routing technique with manageable updates, Reliable Proactive Routing Protocol (RPRP). The methodology of RPRP is to build and maintain a routing table at each node in which two multi-hop path entries are present from critical nodes to sink device while single-hop is used for non-critical nodes. The selection of primary and alternate path for multi-hop scenario is based on the Received Signal Strength Indicator "RSSI" derived by Link Quality Indicator "LQI". The reliability is introduced for critical nodes and can be observed in RPRP, if primary path fails due to intermediate node die, the communication will take place with the help of alternate path without any interruption. To evaluate the performance of WBASN with the proposed routing protocol scenario, we have implemented it on Castalia simulator and the result clearly indicates that the reliable and effective communication occurs with critical and non-critical sensors along with the improvements of throughput and packet delivery ratio.

KEYWORDS:WBASN Routing, Reliability, Proactive Routing Protocol, multi-hop, single-hop

1. INTRODUCTION

The Wireless Body Area Sensor Network (WBASN) has been recently growing an emerging research area for researchers. There are several applications of WBASN like healthcare, entertainment, sports, military operations etc. where implementation of the wearable sensors based network is productive in terms of monitoring, assistance, emergency response, and enhancement of performance.

Human physiological monitoring [1, 2] is one of the major beneficiaries of this emerging technology. The role of the WBASN has been very useful in the health care sector especially the increase in the chronic disease patient [3], doctor's community feels burdened. This technology helps the patients of the developing countries and remote areas where access to the clinical staff is difficult. This technology also helps in physical rehabilitation and assists the disable persons in performing their daily routine task [4]. Due to the wearable smaller size and embedded sensors, the WBASN can provide uninterrupted physiological conditions of the patient under supervision, and can provide real-time feedback or treatment in case of any critical health situation. The bio-sensors are continuously gathering patient's data and transmit it to the actuator or Sink device which is responsible for transferring the aggregated data to the patient's display device using wireless or Bluetooth technology or can also be transferred to the clinical staff or caregiver for further assessment and instantaneous support in case of any emergency.

The Wireless Body Area Sensor Network (WBASN) system is used by the physician for diagnostic, treatment, maintenance of chronic condition, supervised recovery from a surgical procedure and can handle emergency events like heart attack [19].

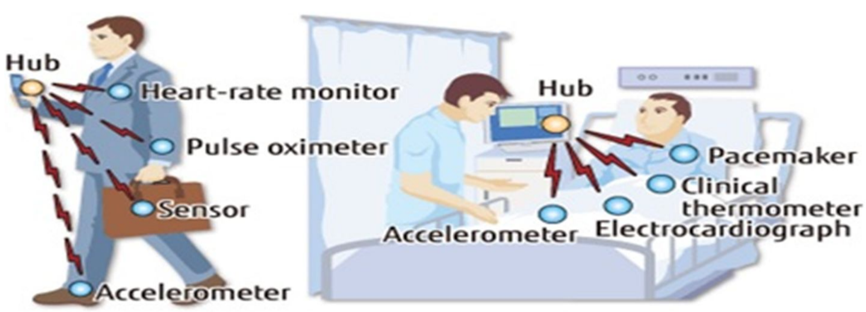

Fig. 1: Patient Monitoring using bio-sensors

The WBASN scenario in which intra-BAN communication is involved can be observed in Fig: 1, this figure illustrate that the different bio-sensors are placed on the patient's body to gathered vital signs information at centrally located device i.e. sink or hub, the sensory information can be used by physician or doctor in-order to real time monitoring

Corresponding Author: Obaid Ullah Owais Khan, Federal Urdu University of Science & Technology, University of Karachi

of patient's health status. The importance of reliable communication between sensors and sink is much needed in the case of critical sensors like ECG sensor is involved.

The critical environment especially in the health care sector, there are some serious efforts required to make WBASN model works with smooth and uninterrupted communication between different sensors and Sink. There are several routing protocol has been proposed to ensure the effective and reliable communication between wireless bio-sensors while considering the delay, energy, position and other security parameters [5, 6]. The majority of the proposed routing techniques for the WBASN are based on star or single hop based model while its alternatives are multi-hop architecture such as mesh, tree or cluster. The multi-hop communication from different sensors to sink can strengthen the communication as well as reduce the power required by individual sensors to transmit data packet to sink but in comparison the complexity of the system increases.

There are numerous routing protocols has been proposed for the traditional Wireless Sensor Networks in keeping view of the limited energy, bandwidth, security and other resources of the sensors [7,20]. These routing protocols efficiently utilize the bandwidth and energy to increase the life capacity of the network [8, 9]. However, these routing protocols cannot be employing on the WBASN system due to their different nature of applications environment and small area as compare to Wireless Sensor Network. To deal with short range, limited energy and small area like unique characteristics in WBASN, there are several routing protocol have been proposed [10–12]. Most of the existing routing protocol is based on reactive routing techniques as selecting the static optimal path from sensor node to Sink device this cause the unbalanced energy consumptions of nodes and also limit the network life of WBASN [13]. The reactive routing protocol is based on two major phases i.e. route discovery and route maintenance [21]. The routes in reactive routing techniques established on-demand and the Destination Sequence Numbers are applied to find the latest route to the destination. The route discovery phase is depend on Route Request packet is generated to search for the destination by source node and in response Route Reply packet is generated if the message has reached the intended destination. The Route maintenance phase starts on the event of fatal transmission caused due any hardware or network failure on the particular node. The reactive approach eliminates the need to periodically flood the network with table update messages which are required in a table-driven approach (proactive). The main reason to introduced the partial proactive routing approach over reactive in WBASN is to route maintenance mechanism does not locally repair a broken link while the connection setup delay is higher than table driven routing protocol. The high mobility nature of WBASN environment also does not support by the mechanism used by reactive routing so that's why we have relayed on partial proactive base routing with limited updates.

In this paper, the Reliable Proactive Routing Protocol (RPRP) is proposed using multi-hop strategy, this approach of discovering route for forwarding sensory data to sink is quite efficient then already proposed single-hop routing techniques. This proposed routing protocol uses Received Signal Strength Indicator (RSSI) and hop-count as a metric for selecting the primary and alternate path to ensure the increase of individual sensors and overall system life in terms of energy and reliability. The Castalia simulator is use for simulating and testing the scenario for WBASN, the results produced during the simulation run shows improvement in overall energy consumption and reliability of the system.

2. RELATED WORK

There have been several routing protocols proposed for efficient and reliable single or multi-hop routing protocol for WBASN. In Reactive virtual Coordinate Routing protocol (RVCR) [14], the author uses body coordinates based routing technique. The x-coordinate specifies the front/back side of the body, y-coordinate defined left/right side of the body and Z is used for the position of the body like head, neck, elbow, knee and waist using number digit 0 and 1. This routing approach works with the calculation of shortest distance between source and destination using distance equation, which referred as a basic greedy forwarding technique. When the Source node starts the route discovery process it will generate route request packet containing destination or sink device address. The intermediate nodes received the request packet and check its 1-hop neighbor list, if it is found the destination directly connected it will send acknowledgment to the source else send a hello request message to its neighbors and wait for a neighbor's response.

In [15] author assumes that all sensor nodes know other nodes information and Sink position. The proposed routing algorithm is based on the sensor's priority which have been given to the sensors based on their critical functions and also categories the sink's data in three categories i.e. on-demand, normal and emergency traffic. Author also claims that less energy is used for selection of the route as it assumes all the censors knows each other's position. The highest priorities sensors are placed near to Sink i.e. single hop away and others will be at the multi-hop. The route establishment of this routing protocol consists of an initialization phase in which all sensors broadcast "HELLO" message contains neighbor's information and distance to the sink node in the form of hop counts. In the routing phase nodes establish path based on less no. of hop and less energy consume during packet reached to the sink node. This routing protocol also addresses the node's temperature, when any node reaches to its threshold temperature it breaks all the associated links and stop participation in any communication until reaches to its normal temperature meanwhile the connected nodes marks this link as a "Hot-Spot". In the data transmission phase, sink node aggregates the received data and sends it to the external server for transfer to the clinical staff. The author also adds Invitation phase for mobility support if any of the sensor nodes disconnected from its parent node it will reestablish the path from the other node based on pre-defined parameters.

In [6] the author first proposes a network model that is based on number of hop counts. The network model based on the backbone link, which creates between any two sensors, expected to remain in communication range like the one sensor placed on the elbow and wrist of the same hand. The backbone link alone connects all the nodes together and a shortest path tree rooted at the data sink node using established backbone links. In the further proceedings author also discuss about the quality of service introducing a protocol base on collection of every node link quality and produce a metric for the comparison after a definite period. The sending node uses the quality metric model to predict the link quality with every other node and it chooses a neighbor that has the best predicted link quality among those closer to the Sink than itself as the next hop (greedy forwarding). If an expected ACK does not arrive from a designated receiving node, it will consider the corresponding link quality measurement to be -∞. The autoregressive (AR) model is use for understanding and predicting a time series of data for the link quality [16]. The last section cover in this paper is suggested security features in routing protocol for both source and data authentication. The set of secrets token shares among the sender and receiver and while initiating the transmission, if token validate, it ensures the authenticity of both data and source.

EBRAR [17] is an energy efficient routing protocol, which construct a routing tree stand on the residual energy and hop-count metric. The technique is to establish no fixed path rather changes according to the sum of the residual energy of the link called path energy (PE) to the Sink. This routing strategy is built on the assumption that all the nodes in the network enters one by one and each node choose its parent, from the neighbor which renders the smallest path-degree among all other neighbor nodes depend on PE. Using the hop-count metric enables rapid convergence (Hop-Count), but not necessary to establish a short path because it contains bad link quality or low residual energy sensors as compare to alternate one.

2.1 Research Challenges

During the study, it has been observed that the several routing model have been proposed to increase the network life of the WBASN by using different routing and data transmission protocol which mainly rely on the efficient use of sensor node energy [14]. In addition, some of the presently proposed routing protocols have focused on the energy balance, network lifetime and utility [17] while other routing protocols focuses on reliability and energy consumption with priority based single-hop method [15] and used link quality with time based prediction to established, providing reliability and improves the overall system performance but somehow we have focused on reliability feature while observing critical nodes and apply partial pro-active technique. The reliability in WBASN system is one of the most important features for monitoring the sensitive domain like health care. For example in WBASN, the monitoring of ECG or EKG of the heart patient is more complex and risky, it could be a life threatening, if the system comprises of bio-sensors are not guaranteed the reliable and stable communication between bio-sensors, sink and to its caregiver or physician.

The implementation of the proposed routing algorithm in section 4 not only proves the addition of reliability feature while maintaining the throughput but also improves the packet delivery ratio after introducing the alternate path method in multi-hop environment for transferring the data from sensor node to sink. The proposed routing protocol also provides alert facility to the sink device about failure or movement of sensor node. The proposed routing algorithm is based on proactive routing approaches which generally have higher overhead as comparison to reactive approach however keeping in view of small network and limited resources we have focused to provide reliability with manageable overheads. The features introduced in RPRP will increase the traffic of control packets but comparatively it has more beneficial in physiological monitoring of a person especially in monitoring of chronic or life threatening disease's patient.

3. Reliable Proactive Routing Protocol for Wireless Body Area Sensor Network

In this section we will discuss in detail the design and implementation of proposed routing protocol "RPRP".

3.1 Methodology

The methodology of RPRP is based on partial pro-active routing technique. On the first phase the critical sensor nodes is selected based on their sensory data nature like monitoring of ECG sensor of the body is need more attention than temperature sensor. After selecting the critical nodes, all nodes starting route discovery process and during this process critical nodes choose their intermediate nodes based on Received Signal Strength Indicator "RSSI" derived by Link Quality Indicator "LQI" to reached destination. The critical nodes constructs routing table and enters two optimal valid paths i.e. primary and secondary with restricted one hop away communication to destination. Once the route has been established between sensors to sink device, the sensors start to send sensory data to sink device while in case of any intermediate node failure, the route maintenance phase starts and select the alternate path to send sensory data. The route discovery process starts after the route maintenance to find and update the routing table with next alternate route towards destination. To consider the small environment and energy issue, we have restricted the number of hops and limited updates on the network in order to preserve the energy and increases the overall reliability of the WBASN.

3.2 Assumptions

The rapid growth in physiological sensors, low-power integrated circuits, and wireless communication has enabled a new generation of wireless sensor networks, now used for the purpose such as monitoring of health status. Presently, the information level provided and energy resources capable of powering the sensors are limiting and the technology is still in its primitive stage but exponential growth is expected to be a breakthrough in the availability of intelligent sensors very soon. In this proposed routing algorithm, it has assumed that the bio-sensors are fully functional with sensing and high processing capabilities along with their basic functions in order to accommodate the overall routing protocol mechanism. All sensors have same transmitting power, initial energy and also same amount of energy consume while transmitting and receiving the packet. The cell phone centric device or PDA will act as a sink. The proposed routing protocol will establish path on the basis of Received Signal Strength Indicator "RSSI" derived from Link Quality Indicator "LQI" with the assumption that higher the RSSI value predicts lesser the distance and there is no mobility involved during simulation testing.

3.3 Routing Metrics

The routing protocol developed with generally considering the parameters of routing loops, route acquisition, delay, and routing packet (overhead). The proposed routing technique partially based on pro-active multi-hop strategy instead of single-hop because during the study and simulation results it has been observed that as the distance increases, more power required to transmit data, cause quickly drain the node's battery [18]. The Fig: 2 define the proposed routing protocol algorithm which comprises of several steps in order to introduce reliability in WBASN system. The RPRP routing is based on the distance parameter between sensors, sensors to sink and the distance measured by the value of RSSI, as more the RSSI value, more the distance required to cover from sensor node to sink device. The energy consumed by sensors during the transmission is also directly related to the distance covered towards sink device, as more the distance to cover, required more energy consumed by sensors to reach its destination. This proposed routing protocol RPRP using multi-hop technique considering the RSSI value, and restricted no. of hop-count, so that route does not contain many intermediate nodes which cause delay and high processing, resulting increase in overall energy and instability of the system. The focus of this routing protocol is to achieve reliability in case of any intermediate node failure i.e. when primary link break seen in Fig: 3(c), instant convergence occurs to the alternate path present in sender node's routing table. The major routing metric terms are defined as follows:

Received Signal Strength Indicator (RSSI): is the measurement of the power in a received radio signal, the use of RSSI is to ensure the selection of shortest distance node as ideally higher value of RSSI indicates lower distance.

Link Quality Indicator (LQI): is a metric of the current quality of the received signal. LQI is best used as a relative measurement of the link quality (a low value indicates a better link than what a high value does).

Node's Energy: is the energy use by node for processing, transmitting, and receiving the packet/data. The source of energy is using the limited power built-in battery. The higher the energy use means shorten the overall system life.

Hop-count: is the number of intermediate nodes involved in transmitting the packet/data from source to destination i.e. Sink device.

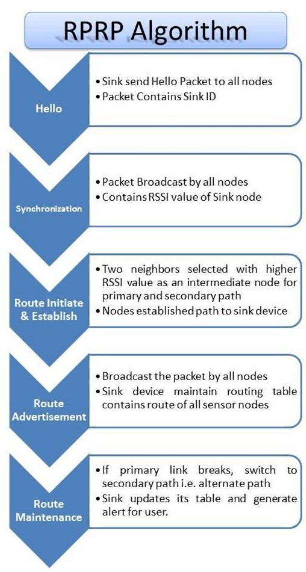

Fig. 2: RPRP Algorithm

3.4 Route Discovery Process

The route discovery process contains six phases. In the first phase, after deployment of all sensor nodes "SNi " where "i" is the number of sensor node and "SD" is called sink device, SD broadcast the "Hello" packet containing node ID to all SNi so that every node must aware the address and received signal strength of its final destination i.e. SD.

In response to the Hello packet, the second phase "Synchronization" begins. In this phase all SNi broadcast a packet so that each SNi records RSSI value of its neighbor's sensor node and construct a table based on these values for selecting their next-hop intermediate node.

After constructing the table "Route Initiate and Establish" phase start, each SNi sends route initiated packet to its selected two neighbors based on higher RSSI value. This packet contains the RSSI value of SD from particular node. When the neighbor's node received the packet, they will compare received SD's RSSI value with its own value of SD's RSSI. If RSSI value of sink is greater than the sending node, it will positively acknowledge the sender otherwise the receiving node returns the packet with negative acknowledgment. In case of sending node does not find any node's SD RSSI value lesser than its SD's RSSI then the node will establish the direct communication connection with SD. In this partial multi-hop routing technique, the maximum number of hop is restricted to "1" and routing table consists of two routes from source node "SNi" to destination "SD". The decision on restriction of number of hops and routes is to stop further potential intermediate nodes to become a part of the route because it cause high processing, more storage, increase of control packets resulting increase in overall energy consumption and delay to reach packet from source node SNi to SD. The comparison of received node's and sending node's RSSI value of the sink is necessary because absence of this check might cause routing algorithm to select longer distance path which consume more energy and delay to reach destination.

The "Route Advertisement" starts when all the SNi completes their previous phase. After selecting primary and alternate path with different intermediate nodes by SNi, all nodes send its routing table to SD, so that SD save all SNi's routes in its routing table in order to observes the nodes status. After completion of this process all nodes will have established and aware about their path towards sink device and sensor nodes starts communication with sink device using primary path.

3.5 Route Maintenance

In "Route Maintenance", if source node wants to start communication with sink device but source sense that signal is not getting from its primary intermediate node, it means primary intermediate node is die due to energy and other hardware failure so it means intermediate node will fails to deliver the sender's packet to the SD, source node SNi switch to alternate path or selecting the alternate intermediate node to start communication with SD. Meanwhile, source node SNi repeat the process of synchronization, route initiate and establish and route advertisement to fill-up the routing table with alternate path.

One of the prominent features of this routing algorithm is to aware sink about every node status. When sink node received source data packet from alternate path it assumes that the primary route is fail or intermediate node involve in delivering packet becomes die. The design of this routing protocol algorithm is based on proactive approach which have high overhead in terms of control packet used to manage and update the routing table but RPRP is designed to use limited updates and restricted network topology so that sensors can efficiently use their resources and the reliability is introduced in terms of less number of data packet lost using RPRP as compare to normal multi-hop scenario. The reliability aspect should introduce on the critical sensors which are used to gathering the critical and complex vital sign body functions like ECG, Glucose etc. so that caregiver or doctor will receive un-interrupted sensory data of life threatening diseases.

3.6 Case Study Based Evaluation of RPRP

To understand the working of RPRP routing protocol, we have graphically illustrate the scenario based on several sensors including critical sensors and apply RPRP to understand the functionality in WBASN system.

The actual WBASN simulation scenario which will discuss in section 4 is implemented in Castalia simulator and comprises of one sink device and seven bio-sensors node in which two sensors node are critical which are for example used to monitoring the ECG & Glucose level of the patient. In this section we are illustrating the overall process of RPRP using one critical sensor node to show and understand the functionality of RPRP. As mentioned in section 3.3, "SD" denotes sink device while all other sensor nodes denotes with "SNi " where "i" is the number of node, all "SNi " are placed according to the position shown in Fig: 3(a). We have taken Node SN7 as a critical node and display the implementation of RPRP process on this node. The RPRP starts with the process of sending "HELLO" packet by SD that contains the Node ID of sink node "SN0" so that all SNi records their final destination address i.e. sink device in routing table.

In the "Synchronization" phase SN_7 initiate the packet and broadcast it to all SNi to hear RSSI value of all SNi. To achieve the reliability and immediate convergence on alternate route, two neighbors will select based on higher RSSI value i.e. SN_5 and SN_2. After selecting neighbors, SN_7 will initiate the "Route Initiate and Establish" phase and send route initiate packet contains RSSI value of SD from SN_2 to both intermediate nodes SN5 and SN2. The SN_5 and SN_2 examine the packet and compare the value of RSSI of SD, in both cases RSSI value of SD from SN_5 and SN_2 is lower than RSSI value of SD from SN_7, both neighboring intermediate nodes are qualify and returns positive acknowledgment to SN_7. The process of route finding is complete with primary path with solid line having next hop SN_5 and secondary or alternate path with the dash line having SN_2 to SD shown in Fig: 3(b).

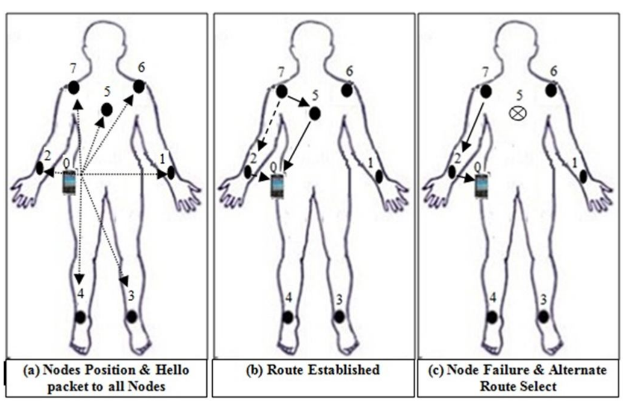

Fig. 3: RPRP Process

After completion of previous phase, SN_7 will broadcast its route to SD to update the status of node. The communication of WBASN system starts and SN_7 starts sending sensory data to SD using its primary path i.e. $SN_7 \rightarrow SN_5 \rightarrow SD$.

In Fig: 3(c), the node SN_5 die and fails to forward the packet of SN_7 to the SD so SN_7 uses alternate path i.e. $SN_7 \rightarrow SN_2 \rightarrow SD$. When this packet reached to the SD it compares the present route from the SN_7 routing table and observed that SN7 uses secondary path, so SD assumes that the primary intermediate node die and updates the entry in its table .

The algorithm of this routing technique implement through simulating the environment on WBASN based simulator called Castalia (OMNET++). The section 4, in detail deal with the implementation and describe the parameters on which proposed routing protocol consist.

4. Experimental Evaluation

To study the experience and observing the experimental results, Castalia simulator is used. In Table1, the simulations parameters are mentioned for simulating the proposed routing protocol model in WBASN environment.

The simulation study consist of 1000sec using eight nodes including sink and having constant packet rate of 5pkt/sec and each packet contains 105bits of data. The basic WBASN simulation module of Castalia simulator only supports single hop data communication and there is no participation of control packets during the simulation test. We have done modifications in basic Castalia WBASN module and add provision of multi-hop scenario along-with the initiation of control packets to implement proposed routing protocol. We have also increased the number of sensor nodes and its corresponding path loss map in order to properly investigate and verified the reliability aspect of WBASN system using RPRP. The placement of sensor nodes and its position can be observed through Table 2. The transmitting power of each node is set to -15 dBm and the initial energy of SNi is constant.

Parameters	Values
No. of nodes	8 nodes
Transmit power	-15dB
Simulation time	1000 sec
Start-up delay	1 sec
Packet rate	5 pkt/sec

Table 1: Simulation Parameters

The Castalia simulator is used for simulating the WBASN environment which is especially designed to simulate the low power operational sensors. To analyze the performance of proposed routing protocol we have simulated the WBASN environment using eight sensors node in which two nodes declared as a critical node which has a function to sense vital sign of the body's like ECG & Glucose while one node acts as a sink.

Node	Position
0	R-hip
1	L-wrist
2	R-wrist
3	L-ankle
4	R-ankle
5	Chest
6	L-Shoulder
7	R-Shoulder

Table 2: Nodes Position

We have introduce multi-hop scheme and alternate path on critical nodes in order to observe the performance of the system in-terms of number of packets drop by all nodes especially critical nodes and packet delivery ratio. The each simulation run with and without RPRP having same node's position and same amount of time while we have changed the consumed energy of critical nodes and their intermediate nodes in order to observe the number of packets received at sink.

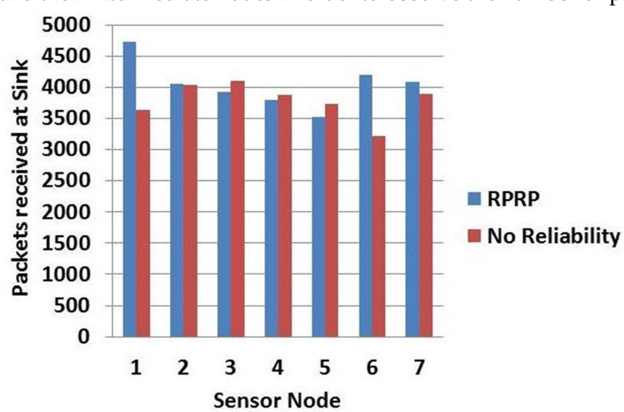

Fig. 4: Number of Packets received by Sink node from each Sensor node

The results obtained by performing the simulation run with simple scenario when no alternate path used for communication and when RPRP features introduces, the design of this proposed routing protocol constructed to keep view of improvement in terms of reliability of the system. The use of alternate path feature with multi-hop strategy with critical nodes, if primary path fails, helps in increase of number of data packet received at sink. In this simulation scenario we have marked two sensor nodes critical i.e. SN_6 & SN_1, these two nodes have their intermediate node in primary path is SN_2 & SN_4 respectively while SN_5 & SN_3 act as an alternate intermediate node of critical source sensor node.

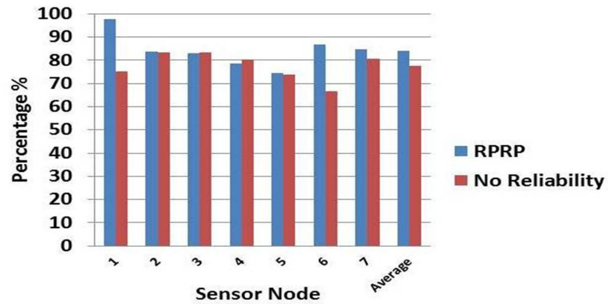

Fig. 5: Packet Delivery Ratio of Sensor node

After the simulation the results shown in Fig: 4 clearly support our argument because critical nodes SN_1 & SN_6 packet drop ratio and the number of packets received at sink by critical nodes is increased. It can also be observed that the number of packets received at sink decrease from SN_5 & SN_3 and this is logical as these two nodes are involved in delivering of critical node packets as an alternate intermediate node but the decrease of these nodes packet is much leaser as compare to increase in packet received at sink by critical nodes. The Fig: 5 also indicates that using RPRP mechanism there are some improvement can be seen as well in the packet delivery ratio of overall system.

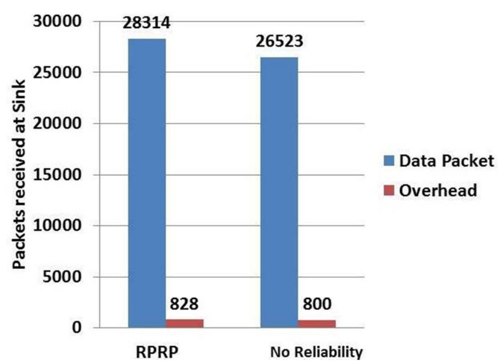

Fig. 6: Overhead Comparison between existing and RPRP protocol

The overhead or control packet could be increase disastrously by using proactive routing approach but as we have discussed that using restricted no. of hops and partial network topology, limited updates are used which can reduce the control packets overhead as confirm from Fig: 6 that data packet increase more as comparison to marginal increase in control packets or overhead using RPRP. The cumulative results in Fig: 4, 5 & 6 indicates that reliability is introduced using RPRP as number of received packet at sink increased as well as packet delivery ratio increase while overhead is manageable.

5. Comparison

A Wireless body area sensor network is used for monitoring the patient in hospital environment and for standalone patient monitoring. On the basis of environment, we can categorize the WBASN in Inter-BAN and Intra-BAN. The former provides the WBASN to WBASN communication or the communication between the WBASNS's while the second aggregates the vital signs of the patients inside each WBASN or it is the communication between entities within a WBASN. We have developed the routing protocol for Intra-BAN environment and in this section we are comparing our proposed routing protocol model RPRP with other existing model.

The proposed RPRP is based on partial-proactive technique while the AMR [22], M-ATTEMPT [15] and EBRAR [17] used reactive as a routing technique. We believe partial-proactive approach with fraction network topology at each node will take less convergence time in case of route failure. The limitation on network topology at each node is to keep manageable updates/overheads for WBASN environment. We have achieved reliability in terms of increasing overall system life especially for the critical nodes and increase the throughput and packet delivery ratio. The faulty or die node detection mechanism is also distinctive feature of this proposed routing algorithm. Unlike other similar work, we have built this scenario and implement on Omnet ++ based Castalia Simulator which is especially designed to simulate low power wireless sensors architecture like WBASN.

Comparing Parameter	AMR [22]	M-ATTEMPT [15]	EBRAR [17]	RPRP
Routing Technique	Reactive	Reactive	Reactive	Partial-Proactive
Communication	Multi-Hop	Single-hop /Multi-Hop	Single-hop /Multi-Hop	Single-hop /Multi-Hop
Performance Metrics	Throughput, Energy	Energy	Energy	Throughput, Packet Delivery Ratio
Routing Metrics	RSSI, Residual Energy	Priority, Residual Energy	Residual Energy, Hop-count	RSSI
Network Overhead	Not Considered	Not Considered	Not Considered	3% of the total traffic
Faulty Node Detection	No	No	No	YES
Communication Environment	Inter-BAN	Inter-BAN	Inter-BAN	Inter-BAN
Simulator	14 TelosB testbed	Matlab	VC++ Simulator	Castalia

Table 3: Comparison of RPRP with other related routing protocol

6. Conclusion and Future Work

The WBASN system comprises of low power and limited energy bio-sensors. The un-interrupted communication between sensor nodes and sink device is very important and there was much need of routing protocol on network layer which address the reliability issue in WBASN system. In this paper we have introduced routing protocol “RPRP” with reliability features using alternate path option from source node to sink in multi-hop scenario. This routing protocol is based on pro-active routing technique with restricted number of hops and limited network topology to reduce the control traffic overhead and make it efficient and robust for small scale wireless body area sensor Network. In future there are further several features can be introduced in RPRP to make it more reliable and effective for WBASN environment like mobility and efficient energy utilization scheme.

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Author’s Biography

Engr. Obaid Ullah Owais Khan is working as an Assistant Director (IT) and Deputy Secretary (IT/ICT) at Pakistan Standards and Quality Control Authority. He has done his BE (IT) from Hamdard University. He is currently enrolled in MS Leading to Ph.D (CS) program at Federal Urdu University of Arts, Science and Technology, Karachi, Pakistan. He is also a visiting lecturer in Federal Urdu University of Arts, Science and Technology. He is an active member of JTC1 of the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC). He is involved in the standardization process of IT/ICT in Pakistan. His research areas include mobile ad hoc network and its security, wireless sensor network, wireless body area network and mobile applications for Health Care.

Dr. Adnan Nadeem received his bachelor’s degree BSc and master’s degree MCS in computer science, both from the Faculty of Science, University of Karachi. He gained his PhD at the University of Surrey, UK. His principal research interests include security issues in Mobile ad hoc networks, intrusion detection & prevention, and routing in Body are Sensor Networks. He is an assistant professor in the Department of Computer Science, Federal Urdu University of Arts Science & Technology, Pakistan. He is a member of IEEE and a fellow of Higher Education Academy, UK.

Dr. Kamran Ahsan is an assistant professor at department of computer science Federal Urdu University of Arts Science & Technology. He has served as PhD researcher and lecturer in FCET (Faculty of Computing, Engineering and Technology) and, web researcher in Centre for Ageing and Mental Health, Staffordshire University, UK since 2005. He has an MSc in Mobile Computer Systems from Staffordshire University in Computer Science from University of Karachi. He is Visiting Faculty at University of Karachi. He is a consultant to businesses in IT applications, software development and web tools. His research interests are mobile technology applications in healthcare including knowledge management.

Dr. Nadeem Mahmood has obtained his Ph.D. in Computer Science from University of Karachi in 2010, with specialization in temporal and fuzzy relational model for health management system. He is currently enrolled in Postdoctoral Research Fellow at KICT, International Islamic University, Malaysia. He participated in international conferences and has published more than 15 research papers in international journals and conference proceedings (IEEE and ACM). He is a professional member of ACM and IAENG.