PATIENT MONITORING QOS-AWARE PEERING ROUTING PROTOCOL FOR DELAY-SENSITIVE DATA

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***Abstract*: A novel modular QoS-aware routing protocol (QPRR) is developed to handle ordinary and reliability-sensitive data for BAN communication in hospitals. The modular architecture of QPRR includes five modules: a reliability module, a packet classifier, a Hello protocol module, a routing services module, and a QoS-aware queuing module. The proposed mechanisms for end-to-end path reliability calculation and data transmission using redundant paths ensure more reliable BAN communication. This paper proposes innovative and novel mechanisms for the reliable transmission of patient data in Body Area Network (BAN) communication, which simultaneously ensure high throughput, low data latency, and low energy consumption by implementing energy and QoS aware routing protocols.**

***Keywords*: BAN, QPRR, Routing, Protocol, WSN.**

Introduction

Body Area Network (BAN) is an emerging field which is used to monitor a patient's vital signs as well as other contextual information. The challenges and characteristics of BAN are different than the conventional Wireless Sensor Network (WSN) due to the specific requirements of its architecture, density, data rate, latency, and mobility requirements. These challenges include the high level of data reliability required in the communication of critical information such as blood pressure (BP), electrocardiography (ECG), and electroencephalography (EEG) readings. Other challenges include the small size of implanted body sensors, access to sensors due to their implanting in the human body, the very low power supply to implanted sensors, and mobility of the sensors when a patient is moving. Reliable communication of patient data in real-time and efficient routing are some of the challenges that need to be addressed. The projects like SMART, CareNet, AID-N, and ALARM-NET provide different methods to monitor patient data. In these mechanisms, the implanted or wearable sensors transmit the BAN data to the central database server and the central database allows the users to monitor BAN data. However, techniques to increase the reliable monitoring of real-time display of BAN data in hospital environment have not been considered by these methods. The mobility of the patient in the hospital may require a change to the dedicated display unit which is used to display patient data.

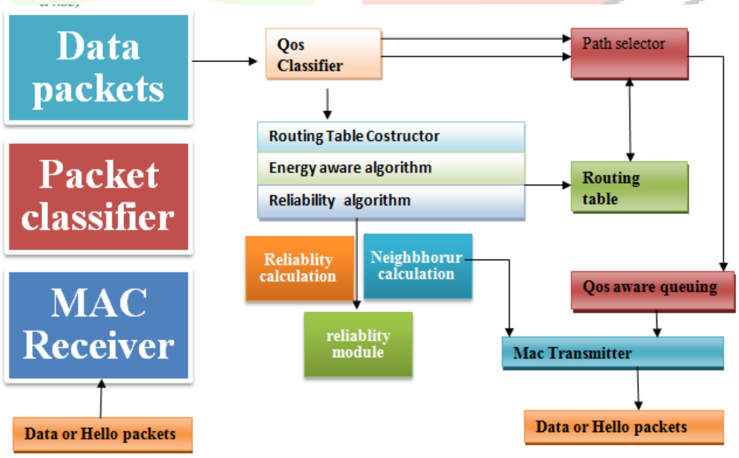

Figure 1: QPRR Protocol Architecture

In order to resolve these problems, a new QoS based routing protocol for reliable BAN communication is required in order to display real-time patient data in such environment. The proposed BAN routing protocol is designed to reliably communicate and display real-time BAN data, and dynamically discover the dedicated medical display device even when the patient is transferred from one room to another within an indoor hospital environment. The proposed QPRR is deployed in the ZK-BAN peering framework discussed and uses both centralized and distributed approaches. In the centralized approach, the information of BANs and display units are stored in a central computer which helps to improve privacy and better control on BAN communication. On the other hand, since the BAN data is displayed on the display unit in a distributed manner, this reduces overall network traffic and helps to improve the reliable monitoring of vital signs even when the patient is moving.

Literature Survey

Author name	Method	Advantages
Geneva	The budget for health care now accounts for a significant portion of several economies around the world. In the United States (U.S.) alone, $2.5 trillion dollars were dedicated to health care in 2009, amounting to approximately 17% of the gross domestic product (GDP)	The 17% of GDP spent by the U.S on health care is almost double that of the GDP spent by much of the rest of the world (approximately 9%), even though the U.S utilizes fewer doctors and nurses per person
Leape, LL; Berwick, DM.	Factors not only contribute to rising health care costs, but may also play a role in health care related preventable deaths, which account for approximately 44,000 to 98,000 deaths per year in the U.S., as estimated by the Institute of Medicine (IOM).	Technology has always presented ways of improving and enhancing our lives. Thanks to the continued realization of Moore's law, innovation in the area of sensor technology has allowed the integration of tiny, low-power, and wearable smart medical sensor devices (e.g., pulse oximeters
Ko, J; Lu, C; Mani, SB; Stankovic, JA; Terzis, A; Welsh	Therefore mentioned challenges are analyzed in detail, including the review of several research projects that have been conducted in an effort to overcome these challenges. This paper differs fundamentally from in that it reviews existing techniques that have been proposed in the literature for HCWSNs with the goal of identifying the gaps between their capability and desired HCWSN performance, and then motivate further research to close the gaps.	The techniques that were reviewed in this paper span multiple layers including data link (MAC), network (routing), and transport (end to end reliability). The treatment presented in does not encompass multiple layers.
Lin, P; Qiao, C; Wang, X	The Mobility-Aware Dynamic S-MAC (MD-SMAC) protocol is a combination of the mobile version of S-MAC (MS-MAC and the previously described DS-MAC	The main objective of MD-SMAC is to provide mechanisms to satisfy the constraints posed by delay sensitive applications while also handling mobility conditions in an energy efficient manner.
Yuan, X; Bagga, S; Shen,	Patients admitted to health care institutions typically have illnesses or injuries of different severity. Therefore, the manner in which traffic is characterized for medical updates from patient to doctor must garner special consideration.	The Differential Service Medium Access Control (DS-MAC protocol accounts for the different traffic types by contextualizing them as normal (Class 2—routine data), warning (Class 1—high priority), and emergency traffic (Class 0—highest priority).
Pereira, P; Grilo, A; Rocha, F; Nunes, M; Casaca, A; Chaudet, C; Almstrom, P; Johansson,	The scarce bandwidth, energy constraints, and unpredictable characteristics of the wireless medium in WSNs, end-to-end reliable transport protocols like the transmission control protocol (TCP) are not suitable	Several reliable transport protocols have been proposed for WSNs. The protocols can be categorized in terms of the direction (*i.e.*, upstream or downstream) in which reliability can be obtained.
Kargl, F., Lawrence E., Fischer M., and Lim Y	The standard intends to address both medical/healthcare applications and other non-medical applications with diverse requirements	The MAC layer in the standard intends to define short range, wireless communication in and around the body area. The standard aims to support a low complexity, low cost, ultra-low power and highly reliable wireless communication for use in close

		proximity to, or inside, a human body (but not limited to humans) to satisfy an evolutionary set of entertainment and healthcare products and services. The project will also address the coexistence issue with other WBAN and similar networks
Zhen, B., Li, H. -B., and Kohno	security issues must be resolved while designing the healthcare applications for sensor networks, or else they may give rise to serious social problems as discussed earlier. Authors argued that in the light of modern concepts of security, the safety should accompany the availability, scalability, efficiency and the quality parameters of inter-node communication.	WBAN scenario, where a person wears various devices, centralized control device can be used for data transmission from in and out of the network. This control device can also act as the gateway between internal network and outside world communication
Vaudenay S.	Authentication mechanisms can be used to ensure the data is coming from the person/entity it is claiming to be from	We feel that even if the network is unattended for longer time, security measures should be always in highest priority mode. Discuss unattended network security in detail
Ng, H. S., Sim, M. L., and Tan	Issues for personal health monitoring. We have found that most published works address the security issues for sensor networks applications. These include works by authors such as [6] and	Security issues are major concern raised by most authors. Privacy issue or other social implications are not discussed extensively regarding this field. We have mentioned the works done by various authors related to particular issues in the subsequent sections of this paper.

QOS-AWARE PEERING ROUTING PROTOCOL FOR RELIABILITY-SENSITIVE DATA (QPRR)

The devices used in indoor hospital BAN communication are divided into three types by considering their energy levels. The Nursing Station Coordinator (NSC) is type 1 device which is connected directly with the power source. The Medical Display Coordinators (MDCs) are considered to be type 2 devices which use replaceable batteries. The BAN coordinators have limited energy availability and are considered to be type 3 devices. In the ZK-BAN peering framework, the information of BAN coordinators and their respective peer MDCs are stored at the NSC. The BAN coordinator needs to first connect with NSC for getting peer information and then it starts displaying the real-time data on the peer MDC. An Energy-aware Peering Routing protocol (EPR) is provided in Chapter 5 for choosing the best next hop for Ordinary Packets (OPs) by considering the energy availability and geographic information of the devices.

The EPR results in better performance than other protocols in terms of reduced network traffic, successful data transmission rate, reduced number of packets forwarded by intermediate nodes, and overall lower energy consumption. However the mechanism for sending Reliability-Sensitive Packets (RSPs) has not been considered. The DMQoS classifies the data into four types: Ordinary Packets (OPs), Critical Packets (CPs), Reliability-driven Packets (RPs), and Delay-driven Packets (DPs). The performance of DMQoS for reliability-driven packets is better than several state-ofthe-art approaches in terms of successful transmission rate, traffic load, and operation energy overload. DMQoS determines the next hop by considering the highest reliability of the device, and then determines the other most reliable next hop towards destination. The disadvantage of this hop-by-hop reliability proposed in DMQoS is that the source node depends only on the neighbor node's reliability information. It is possible that the source node sends the packets to the neighbor node with highest reliability, but the neighbor node doesn't find the required reliability among its neighbor nodes, resulting in dropped data packets. In this case the source is getting acknowledgements from neighbor node that the packets are successfully transmitted but in reality the packets are dropped by upstream nodes instead of being forwarded to the destination. Moreover, by using the hop-by-hop reliability, the network traffic is increased and endto-end reliability is not ensured by DMQoS. Also, the high transmit power of the devices and the stationary natures of the nodes are other shortcomings of the DMQoS approach. The proposed protocol QPRR addresses these shortcomings by considering a low transmit power of -25dBm, and both stationary and movable nodes, and more importantly, by choosing the next hop device based on the most reliable end-to-end path(s) from the source node to the destination.

Experimental Results

To test the scalability of the proposed QPRR protocol in Case 5, a larger area of 16m by 39m is considered. This area models a hospital unit that contains 46 patient rooms. All the BANs send a total of 108.5K reliability-sensitive packets. The calculation of different parameters are done first at 6K packets and then after every 11.5K packets sent by the source nodes. To achieve a 97% confidence interval for the illustrative results, the average of three runs are simulated in every experiment which may introduce a maximum error of 3x10-3 , based on the error calculation.

Throughput

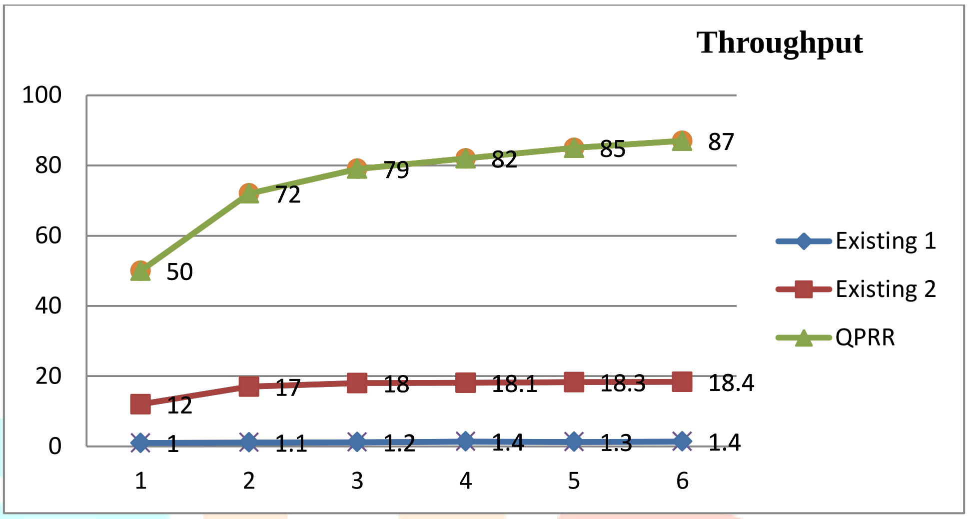

Figure 2: Throughput

From Figures 2 is seen that the reliability of QPRR are initially 50% and then reach to 86% with higher offered traffic loads for respectively. The figure show that DMQoS can deliver only on average 1% reliability-sensitive packets to the destinations for respectively. The performance of no Routing is slightly better than DMQoS but very poor when compared with QPRR. The successful transmission rates of no Routing protocol are 15% for respectively.

Reliability Packets

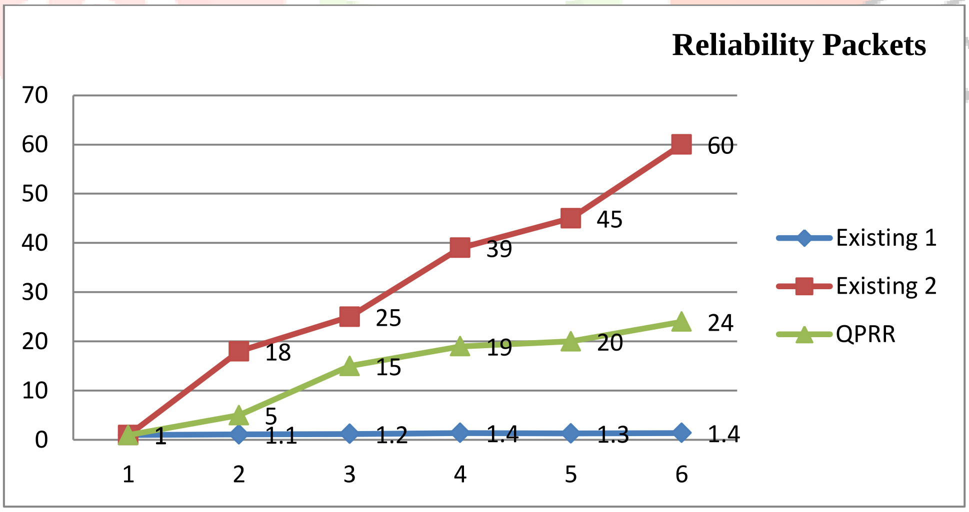

Figure 3: Reliability Packet

Figure 3 shows the performance of QPRR is about 3 times better than existing systems. QPRR resolves this problem by using the end-to-end path reliabilities. Also the use of three redundant paths in QPRR ensures maximum transmission rates.

Mac buffer Overflow

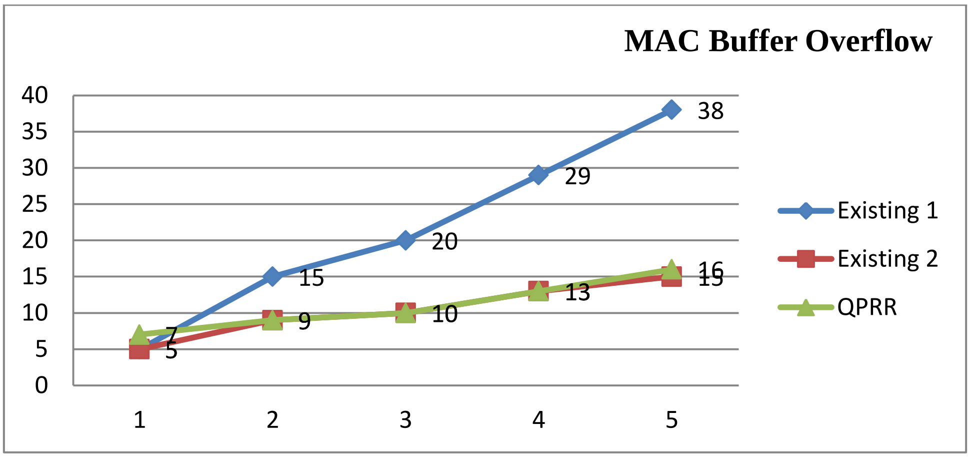

Figure 4: MAC Buffer Overflow

QPRR performs well initially but then after 4K packets sent by source nodes, it drops more packets than existing protocols. Figure 4 represented path reliability calculation mechanism used in QPRR helps to send the data through a path or over several redundant paths in order to ensure much higher rates of data delivery to the destination.

Network Traffic

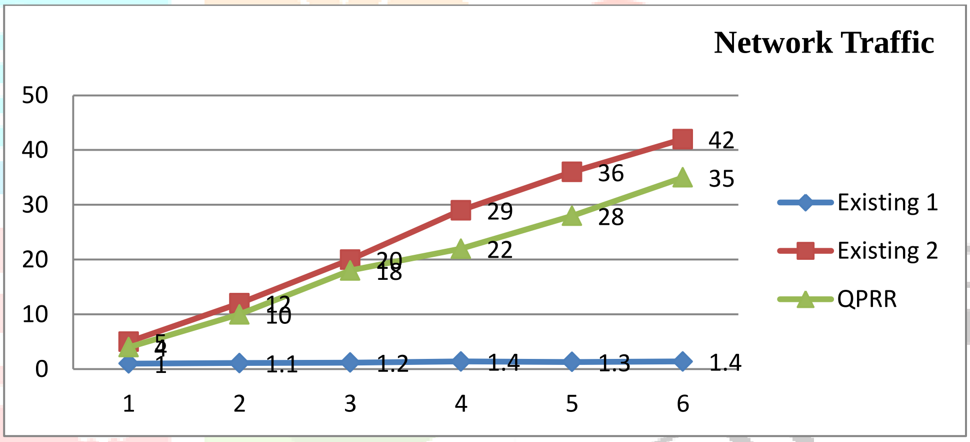

Figure 5: Network Traffic

The QPRR ensures better reliable data delivery, but this superior performance comes with a corresponding increase in the overall network traffic. Figure 5 represented into increase in the network traffic at higher offered traffic loads can be ascribed to the use of multiple redundant data paths for the reliable transfer of data.

Energy Consumption

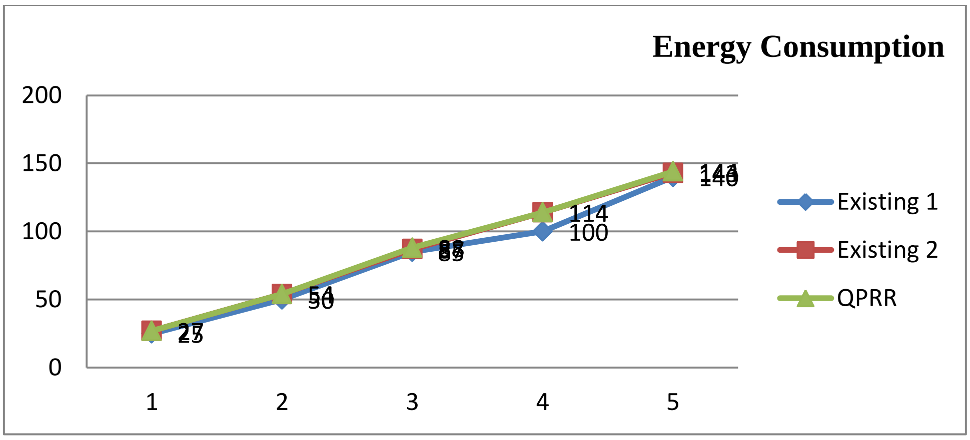

Figure 6: Energy Consumption

Figure 6 considers a real hospital with 93 nodes. It is observed from the Figure 6 that the energy consumption in QPRR is 0.37% more and 1.1% less than the DMQoS and no Routing protocols respectively.

Latency

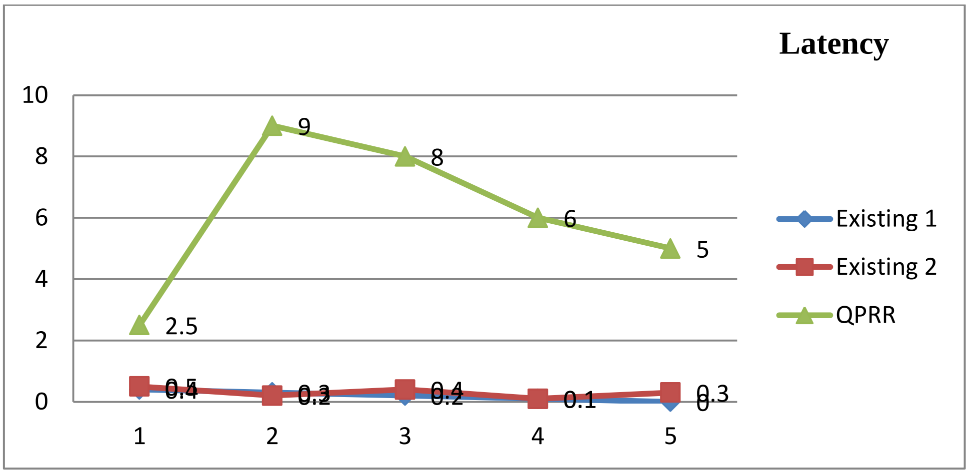

Figure 7: Latency

QPRR continues to outperform DMQoS and no Routing in terms of number of packets delivered reliably to the destination as shown in Figure 7. QPRR delivers on average 10 times more packets in comparison to DMQoS and no Routing protocols during all time intervals.

Conclusion

A mechanism is proposed to calculate the end-to-end path reliabilities of all possible paths from source to destination and then decide the degree of path redundancy required to meet the requested data reliability. The simulation results prove that QPRR provides more consistent performance for both movable and stationary patient scenarios with lower device transmit power of -25dBm. With 93 nodes, it is observed that QPRR provides an average of 80% reliability; whereas, the average reliabilies of DMQoS and no Routing are 2% and 15%, respectively. the transmission of critical data packets with stringent reliability requirements, QPRR outperforms DMQoS and no Routing in terms of having a much higher successful data transmission rate, with lower network traffic overhead and lower latency, while consuming the same power as the other comparable protocols.

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