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WBANs for Patient Monitoring Systems: A Survey and Outlook

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Abstract: ***The WBAN has become one of the most researched areas for developing more reliable, accurate and efficient patient monitoring systems. Many researchers have proposed different approaches and schemes for building such monitoring systems. But the reliable transmission, latency, fast path recovery and re-routing are still some of the major issues that occurs in WBANs.This paper presents the survey of some proposed methodologies used for building wireless patient monitoring systems, the WBANs for patient monitoring systems implemented with different approaches, their advantages and limitations. It also discusses about some protocols which have been devised to increase the reliability of the WSN systems.***

Keywords: Wireless Body Area Networks, latency, patient monitoring systems, reliable transmission, re-routing.

1. Introduction

The development of Wireless Body Area Network (WBAN) was started around 1995 revolving around the idea of using Wireless Personal Area Network (WPAN) technologies to implement communication on, near and around the human body. Then after six years, the term Body Area Network came to refer to the systems where communication is entirely within, on and in the proximity of the human body. However, WBANs can make use of the WPAN technologies for achieving longer ranges.

A Wireless Body Area Network (WBAN) may comprise of only sensor(s) and the sink, or it may comprise of sensor(s), actuator(s) and sink(s) that may be situated in the clothes, on the body or under the skin of a person. The network expands over the whole human body and the nodes are connected through a wireless communication channel. A wireless body area network is a networking technology based on radio frequency that connects the sensors or actuators and the nodes which are low powered and small sized to monitor the physiological changes occurring in the human body.

These days, we witness a lot of death incidents due to unavailability of doctors and treatments in the golden hours. These cases are most often with the ageing population and mostly the aged people suffer from chronic health related issues. There has always been a problem of sudden deaths of diseased persons because of increase or decrease of some vital compounds or fluids or chemicals in their bodies. The unavailability of treatment in the golden hours can cause the patients or diseased people fall prey to death. So knowing the importance of human lives researchers came up with the idea of deploying sensors on, in and over the body of patients to sense the vital signs and transmit these vital signs to a nearby doctor, hospital or an emergency centre over the internet wirelessly.

The idea, WBAN was originated from the Wireless Sensor Networks (WSNs) which involves deploying the sensor/actuators and tiny nodes on locations (where humans cannot stay and monitor the things continuously)and pass the sensed data over the wireless network to the base station, sink or the internet. So, with enhancements in the integrated circuits along with the electromechanical gadgets, the capabilities of WSNs have been explored to use them in the medical field for continuous monitoring of patients health. Thereon many researchers started gaining interest in developing the systems for monitoring the patients‘ health and trying to avoid deaths due to unavailability of treatment. These systems are the wireless body area networks of sensors/actuators (deployed on, in and over the patients‘ body) and the sink which co-operatively work and pass the vital signs sensed to the emergency centre or the doctor so that immediate actions could be taken in the golden hours.

The WBANs, now-a-days are being used in sports field to monitor the athlete‘s or sportsman‘s performance during work-outs and also in the military field for examining the soldiers on the regular basis.

The WBANs face the same issues as WSNs like the implementation, QoS, and other performance related issues. The QoS like the energy of sensors, the reliability of communication or transmission, re-routing in case of node failures or link failures, fast re-transmissions in case of packet loss, etc. must be taken care of while deploying such a network. The main objective of building WBANs for monitoring patient‘s health is to deliver all the vital signs sensed to the emergency centre or the doctor so that the patient can get the immediate treatment or he can be driven to the nearest hospital or the doctor available. So, it is necessary to work on the efficiency and the reliability of the transmission of vital signs. Many researchers are working on to improve the reliability, energy-efficiency, and other factors of the WBANs to build best possible patient monitoring systems.

The paper does present the explanation of various patients monitoring systems build with different approaches, their merits, demerits and the scope for improvements. Section II provides a brief explanation of each of the approaches. Section III gives the merits and demerits of each of the approaches along with the possible scope for improvement.

Section IV describes the transport layer protocols for reliable communication in WSNs which can also be included and implemented in WBANs designed for remote patient monitoring systems as reliable transmission is a major issue as well as the need of such systems. Finally, section V presents the conclusion.

2. Patient Monitoring Systems

As mentioned earlier, the patient monitoring systems face issues like unreliable transmission, re-routing in case of node or link failures, energy consumption, etc. So, many researchers, knowing the importance, have contributed and built such monitoring systems that avoid the mentioned issues at the most using different approaches, schemes and methodologies. Some of the approaches and methodologies are explained below:

A. Methodologies

Central server provides the function of coordinating data collection and video conferencing services with full security. This allows the patients and the clinicians to securely access the data from the central server [1]. The patient‘s hosts include the Mercury network that comprises of the sensors worn by the patient and a laptop with an 802.15.4 transceiver [1]. The wearable sensor nodes are the SHIMMER [2] nodes which are capable of self-recovery in case of software failures. The clinician‘s hosts provide the functions of collecting, storing, access to patient‘s data and the video conferencing between the patient and the clinicians [1].

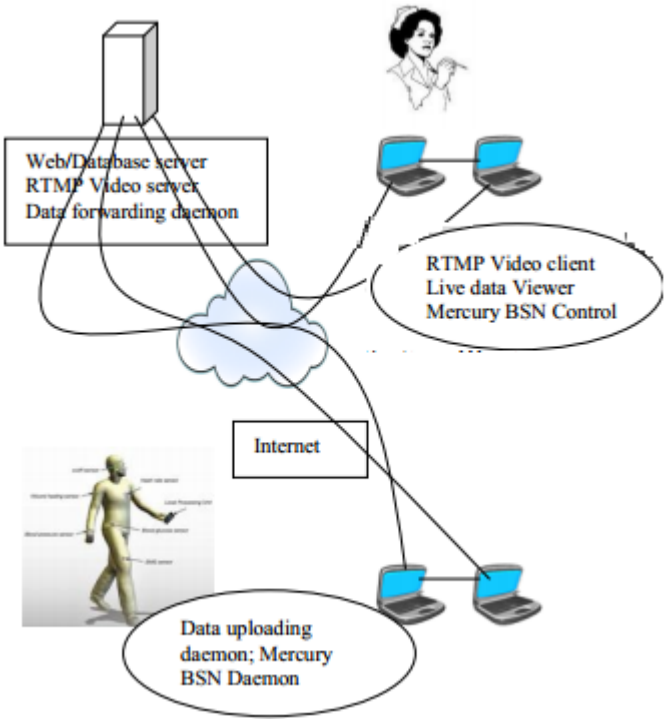

Figure 1: A general architecture of MercuryLive [1]

Bor-Rong Chen, Shyamal Patel, Thomas Buckley, Ramona Rednic, Douglas J. McClure, Ludy Shih, Daniel Tarsy, Matt Welsh, and Paolo Bonato have introduced a platform that made monitoring of the patients suffering from Parkinson‘s Disease (PD) sitting at home using warble sensors. The authors have named this platform as MercuryLive [1] which consists of three tiers: a resource aware of data collection engine that relies wearable sensors, web services for live streaming and storage of sensor data [1]. Along with data transmission, the proposed system also provides the feature of video conferencing and for having a user friendly GUI, the authors have also developed a web portal. The system allows the doctors or the clinicians to access the gathered data via the web portal thus making the clinicians to interact with the patients in the home setting and providing a quick and faster quality care to the patients suffering from PD [1].

The general architecture of Mercury Live mainly consists of three tiers- the central server, patient‘s hosts and the clinician‘s hosts with daemon processes running at each hosts for performing hosts‘ (tiers‘) specific programs [1].The

Finally, the authors conclude that their proposed is an integrated one which is suitable for monitoring the patients suffering from PD in home setting and to gather patients important information for providing the titration of medication in their last stages [1].

Gabriel E. Arrobo and Richard D. Gitlin have proposed a wireless body area network that leverages the Co-operative Network Coding (CNC), a networking technology to provide increased throughput and avoid single points of failure. The use of CNC in WBANs is considered to be a most likely solution for fighting loss of packets, reducing latency, avoiding single points of failure and successfully delivering the data at sink in real time applications [3]. In this paper, the authors have talked about the idea of enhancing the technology of Co-operative Network Coding from Single-input-single-output to multiple-input – multiple-output (MIMO) systems.

The CNC is a blend of two different technologies- Co-operative communication [4] and Network Coding [5]. The single receiver devices can leverage the advantages of the MIMO systems using co-operative communication and minimize the packet loss while network coding escalates the probability of correct reception of data packets [3].

The co-operative communication technology enables the receiver to receive data from multiple relays, combine the data properly and make reliable decisions on it [3]. While the network coding is that networking technology which provides capacity gain by combining the packets at each intermediate node and forming a linearly independent packet called a combination packet containing information about all original packets coming from the source. This combination packet is formed by multiplying the original incoming packet by a co-efficient which can be randomly chosen from a Galois FieldGF (2^q) and all the calculations are performed over the Galois Field (2^q). The resulted combination packet form the above calculation is then forwarded to the other intermediate nodes [3].

The mathematical equation for the network coding calculation is:

$$y_i = \sum_{l=1}^{m} c_{il}\, x_l \text{ where } i = 1,2,3,\ldots, m'$$

Where,

y_i–the combination packets or coded packets

x_l–the original packets

c_{il}– randomly chosen co-efficient from the Galois Field GF (2^q).

The Galois Field (2^q) – set of elements {0, 1, 2, …, 2^q -1}

The Co-operative Network Coding provides a synergistic combination of co-operative communication and network coding to increase the reliability of the system [3]. The authors have shown a single destination CNC model given below in figure (3) (where ―Dest‖ is the destination) which explains the complete working of the mechanism. The source creates the packet and forwards it towards the nodes in first cluster (group of nodes) then the nodes the first cluster use network coding and creates a combination packet from the original packets and using equation mentioned above and forwards it to the next cluster. The second cluster will perform the same operation using the equation:

$$y_i = \sum_{l=1}^{m_j} c_{ijl}\, y_{i-1,l} \text{ where } j = 1,2,,\ldots, n_i$$

Where, *i* represents cluster and j represents node in the cluster. The same process is then followed by each node in each cluster and finally transmits the packet to the destination using spatially different paths. The destination must receive at least m independent packets from the nodes in cluster *K* for the successful recovery of transmitted information [3].

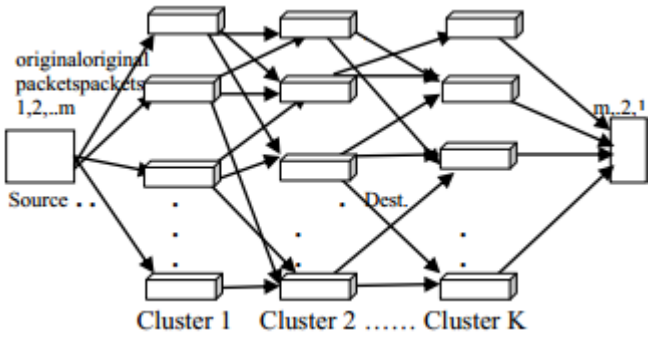

Figure 3: Single destination Co-operative Coding Model [3]

The authors have also given a CNC model for WBANs which is said to improve the reliability of the transmission. The CNC model for WBANS (see figure (4):

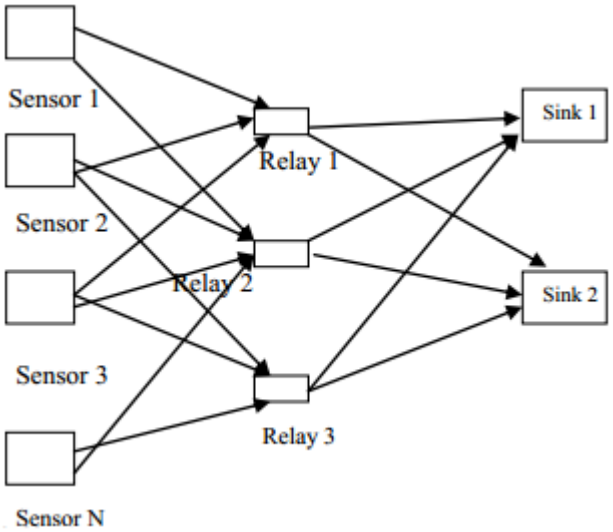

Figure 4: CNC model for WBANs [3]

The sensors or the sources send packets to the relays in the clusters which then perform network coding on the received packets pass the independent coded packets to the sinks using MIMO systems [3]. Because of the extended feature of CNC of MIMO, the packets will surely be received by sinks from one or the other route as all the routes cannot get failed at the same time to the sinks. Here, multiple sinks have also used to reduce the probability of losing packet loss. The sinks then communicate with each other and properly recollect the transmitted information [3].

Finally, the authors present the conclusion that using Co-operative network coding using multiple sinks improves the reliability of the Wireless Body Area Networks [3].

Shyr-Kuen Chen, Tsair Kao, Chia-Tai Chan, Chih-Ning Huang, Chih-Yen Chiang, Chin-Yu Lai,Tse-Hua Tung, and Pi-Chung Wang proposed a transmission protocol based on anycast routing for wireless patient monitoring. [6]. It is actually a hybrid approach that involves the amalgamation of a transmission protocol and a data forwarding mode to improve the reliability of WBANs. The authors first presented the need for developing a reliable wireless patient monitoring system and the related study which revealed that the earlier work on patient monitoring systems involves only two transmission modes viz. multicast and broadcast. They researched that these modes were increasing the network traffic and end-to-end transmission delay. So, the authors came up with an idea of using a new data forwarding mode called anycast to a reliable transmission in WBANs. The proposed system is a ZigBee based fall monitoring system which includes fall detection, indoor positioning and ECG monitoring [6].

The authors have also stated that their proposed scheme can also be integrated easily with the next generation technologies of wireless wide area network, worldwide interoperability for microwave access (Wimax) and long term evolution (LTE) for achieving patient monitoring in real time [6].

The architecture of proposed system is shown in the figure (5) which gives the overview of how the complete fall monitoring system would work along with knowing the

positioning of the patient indoor and how it can be integrated with the next generation networking technologies. The network architecture on the other hand, is divided into three types: sensor, router nodes (which form the multihop wireless mesh network (WMN)) and the data receiver [6]. For ensuring a successful transmission in the WMN, the authors have proposed a reliable transmission protocol based on the ad hoc On-Demand Distance Vector (AODV) routing protocol [7]. AODV has many advantages like it is self-starting, loop-free and scalable and thus can reliably transmit the data [6].

The sensor node has two modules: sensor and ZigBee which are connected through the RS-232 interface. The sensor node deployed or placed on or over the human body will sense the vital signs using the sensor module which are then transmitted to the ZigBee module. TheZigBee module has a data receiver list for storing the addresses of the data receivers. The ZigBee module will, then, broadcast the route request (RREQ) message to the router nodes. The router nodes reply with the Route reply (RREP) message. ZigBee will save the replies from the router nodes in its data receiver list as the data receivers and find the nearest router node using the anycast data forwarding mode.If the nearest node has the route to the destination or if itself is the destination or data receiver, then the ZigBee module will forward the packets to the router which in turn forwards the packet to the destination. Otherwise, the nearest router node will broadcast RREQ message to its neighboring nodes and find the next nearest router node using anycast scheme and the procedure continues till the ZigBee module doesn‘t get the path to the destination. The data receiver once gets the packet; it will extract the vital signs and transmit them to the computer to which it is connected through an USB interface (RS-232). The data receivers will also have a timer which will trigger an acknowledgment message to be sent to the sensor [6].

Each router node and the data receiver will be having a ZigBee module for broadcasting the RREQ messages in the case if they do not have the route to the destination. Each RREQ message coming to each router will be first tallied by the respective router in its routing table if the received RREQ message is already processed. If it is already received and processed by the routers then the received message will be discarded. The same goes with every data receivers. Each router node has the data receiver list stored in their internal memory because of the received RREP messages. The router nodes also includes a counter called AnycastGate which keeps the track of number of received RREP messages and it also specifies the number of data receivers. This counter gets incremented by one after receiving the RREP message and if the counter is greater than one than it directly discards the RREP message.

ZhaoyangZhang1, Honggang Wang1, Chong gang Wang2 and Hua Fang3 have proposed a power game based approach to mitigate the communication interference for WBANs based on people‘s social interaction information [7]. The authors have modeled the inter-WBANs interference, determined the distance distribution of interference through both theoretical analysis and Monte Carlo analysis, developed social interaction detection and prediction algorithms for people carrying WBANs and also developed a power control game based on the social interaction information in order to maximize the system‘s utility and at the same time, minimize the energy consumption of WBAN system [7].

For avoiding the intra-network collisions the authors have used a TDMA based media access control (MAC) control scheme to control message scheduling within the WBANs and assume that it solves the above mentioned problem [7]. The nearby WBANs rather the people (carrying WBANs) are close to each other, so the WBANs interfere with each other because their communication range overlaps. The authors have used the social interaction information for the mitigation of this interference and for the same purpose they have used social network as a tool to build a social interaction network (SIN) [7] for modeling the social interactions among people depending on their location data.

The proposed of work authors can be summarized as follows:

- Formulation of inter-network interference model based on data of social interaction between people carrying WBANs.
- Developing a Probability Density Function (PDF) about the interference distance distribution which is key factor to the SINR. The PDF is important for mitigating the inter-network interference.
- Developing social interaction detection prediction algorithms for the people carrying WBANs.
- Designing a co-operate power control game which includes the social networks information to solve the problem of inter-network interference mitigation.

As discussed earlier for mitigating the interference due to closeness of different WBANs, the authors have used SIN and for detecting the nearby WBANs they have used Bluetooth and acoustic wave technology, writing a specific algorithm for it. Then, to have a significant impact on the net interference level caused on the WBANs, the channel gain concept [8] is used which can be given as

$$q_{ij} = d_{ji}^{-4}$$

Where, d_{ji} is the distance between the person *j* (who is the transmitter)and the person *i*(who is the receiver). This is how the interference channel gain can be calculated. This is the area where the PDF is used for the distances (*d)* between the transmitters and the receivers.

Then the authors described about their proposed power game control to mitigate the inter-network interference for WBANs. It was necessary to decrease the capacity gains and as the WBANs were battery supported and for this the authors had defined the utility as

$$u_i = \log(r_i)$$

This gives the system utility as

$$U = \log \sum_{i=1}^{N} \log(r_i)$$

The authors had optimized the transmission power of the nodes to mitigate the interference based on the prediction of the interference distances. The authors wanted to maximize the system‘s performance and at the same time minimizing the net

$\max \sum \log(r_i)$
$\min \sum p_i$

where $0 < p_i < P$ is the maximum transmission power for each of the transmitter. Then the game theory was applied to solve the problem of power to maximize the system's performance and minimize the total power consumed for transmission.

Then the paper discusses about their power game control approach and the proposed algorithm (that makes use of the Nash Equilibrium specified as an equation in the proposed algorithm and the use of social interaction information proves it [7]) which says that each player holds its own transmission power initially and these players are also capable of updating their powers and prices at each turns and at the same these players also need to acquire minimum information.

In this proposed interference mitigation scheme, the authors have used 4 state predictors to predict the topology change based on the calculated information. This makes the system capable of adapting the network topology change and reducing the frequency of information collected regarding the topology.

3. Observations

3.1 Advantages

In [1], the proposed platform not only analyses the sensor data but also estimate the clinical scores according to the severity of the tumour, bradykinesia and dyskinesia. The proposed system also allows the patient to have a face to face communication with the doctor with help of video conferencing technology (included in the system). The SHIMMER sensors used are also capable of self-recovery and each of the main components of the system is working on the specific daemon processes which do not require any periodic checking or testing. The proposed platform also enables the clinicians to access the data sensed by the sensor, upload the dataset and most importantly to estimate the Unified

Parkinson's Disease rating Scale (UPDRS) scores. The proposed system had found to reduced latency in data uploading, and video streaming according to the authors simulation results.

In [2], the proposed system can support a variety of real time WBAN applications which can fight the unwanted packet loss and reduce the latency due to retransmissions. The system is also capable of avoiding single points of failure and provides improved probability of recovering the data successfully at the destination. The system helps in achieving the capacity gain and the throughput of the system is increased as it uses the CNC technology. The authors have enhanced the CNC to use MIMO feature which ensures the successful delivery of the transmitted information at the destination assuming that all the paths or links cannot be failed at the same time.

In [3], the authors have used the hybridization of an anycast data forwarding scheme and a reliable transmission protocol-AODV. The proposed system reduces the network congestion and end-to-end transmission delay problem that arises due to broadcasting or multicasting the data messages by using the anycast scheme. The proposed protocol reduces the path recovery latency by the intermediate routers in the chosen path to initiate the re-routing mechanism. It offers several advantages like scalability, auto-starting and it is also loop-free. The proposed system is also capable of integrating with the WWANs like worldwide interoperability for microwave access that helps in achieving real-time patient monitoring and LTE. The proposed system gives a good performance regarding the reduction of latencies in finding the nearest node, shortest path and eventually, the data delivery. The system is also said to have improved the reliability in transmitting the information from source to destination.

In [4], the proposed system minimizes the interference caused due to the overlapping ranges of the WBANs worn by the people dwelling or working nearby. It also maximizes the system's performance and at the same reduces the total power consumption. Due to the decreased interference the data collected by each WBAN can be sent reliably to the sink. It opens up a new research area to use social networks in monitoring the patients' health.

3.2 Limitations

In [1], the proposed is heavily dependent on fast internet connection. If the connection speed decreases the working of the system suffers. As the high bandwidth internet connection is only available in the main urban region and not in the remote rural locations, so the applicability of the proposed system is limited to the urban region only. It does not guarantee the reliable transmission of information.

In [2], the proposed system makes use of multiple router nodes and sinks. It just provides the guarantee that the data will be sent to the destination using any path if the chosen link gets failed. But it does not bother about the time frame within which the vital messages must be transferred. Most importantly the system is complex as it includes the calculation at each node which is also considered as a merit because this achieves capacity gain. But in terms of fast delivery continuous computation at each node is a drawback. The number hardware is also increased with the proposed scheme which cannot be considered as economic.

Though the proposed system in [3], provides fast re-routing, decreased latency and reliable transmission it does not bother about the packet loss. The proposed system does not put forth any scheme or solution to compute the packet loss.

In [4], the proposed system only focuses on mitigating the interference caused due to nearby WBANs and maximizing the system's utility with mining the power consumption but does not provide any scheme to improve the reliability, reduce latency and fasten the path recovery. The social networks inclusion in the system may prone to attacks or we can say that the sensed data is not secured.

The tables (a) and (b) gives a comparison of the methodologies discussed above in a brief way.

3.3 Challenge and issues of WBANs.

The WBANs face too many challenges and issues which still needs some proper solutions. The confidentiality of patient‘s data in the WBAN is the most critical ethical issue of WBANs which is still not correctly addressed yet [9]. Some of the major challenges of WBANs are as follows:

- **Scalability**: It deals with the human body [10].
- **Node size**: It deals with invasive monitoring and they are mostly required for minimization [10].

Table a: Summary of methodologies along with their advantages and limitations.

Paper Title	Methodology	Advantages	Limitations
A Web-based system for home monitoring of patients with Parkinson's Disease using wearable sensors	A platform named MercuryLive holding the capability to have video interaction with the clinicians.	Analyses the sensor data and estimates the clinical scores as per the severity. Allows the clinicians to access the sensor data, upload it and estimate UPDRS scores. Latency for data upload and video upload is reduced.	Heavily dependent on fast internet connection. Reliable transmission is overlooked. Applicability area is restricted.
Improving the reliability of WBANs	Cooperative Network Coding with MIMO systems	Fights packet loss Reduces latency due to re-transmissions. Avoids single points of failure. Increases probability of successful data recovery.	Complexity increases due to computation at each node. Requires large number of wireless tools, so not that much economic.

- **Number of Nodes**: Only required number of nodes is meant to use. No need of using extra unwanted nodes [10].
- **Data Security**: The patient‘s must be secured. It must not be prone to any attacks [10].
- **Contact**: Implantable sensor substitutes are difficult and they need biodegradability [10].
- **Event Recognition**: The early adverse effects must be recognized as the human tissue failure is irrevocable [10].
- **Wireless infrastructure**: The infrastructure used must be small enough and must have low power along with the capability of signal detection [10].
- **Bio Compatibility**: The implantable sensors must be human body friendly and they are likely to have huge market price [10].
- **Context Consciousness**: The WBAN set up on the body must be conscious to the changes in the context as the human is very sensitive to the context change [10].

Table b: Summary of methodologies along with their advantages and limitations.

Paper Title	Methodology	Advantages	Limitations
A Reliable Transmission Protocol for ZigBee-Based Wireless patient Monitoring	A hybrid approach of a reliable transmission protocol AODV and anycast message forwarding technique.	Reliably transfers data Fast re-routing Reduces network congestion Reduces end-to-end transmission delay or latency.	It does not take into consideration the problem of packet loss and its recovery.
Interference Mitigation for Cyber-Physical Wireless Body Area Systems using Social Networks.		Minimizes interference Improve the system's utility Reduce the total power consumption	Focuses only on interference mitigation. Does not bother about QoS

4. Protocols in WSNS for Improving

4.1 Reliability

WBAN is one of the application areas emerged from the

WSN‘s family, so some of the approaches, schemes and protocols of WSNs can also be utilized and implemented with WBANs and eventually in wireless patient monitoring systems. As mentioned earlier WBANs differ in the network setup and topology from WSNs while the working and inter-network communication and QoS are similar things to achieve in both. The following table enlists and summarizes some reliable transport layer protocols that can be used in WBANs for monitoring patients.

Table c: Enlisting some of the protocols for improving reliability in WSNs as well as WBANs.

Paper Title	*Protocol*	*Advantages and feasibility in WBANs*
SPEED: A stateless protocol for real-time Communication on in sensor networks.	SPEED.	It ensured desired delivery speed and real-time communication [11] [12]. This can help in WBANs for real-time patient monitoring with certain advancements
MMSPEED: Multipath Multi-SPEED Protocol for QoS Guarantee of Reliability and Timeliness in Wireless Sensor Networks.	MMSPEED	Provides packet routing decisions without a priori path setup and differentiated QoS options in timeliness and reliability domains [11][13]
ESRT: event-to-sink Reliable transport in wireless Sensor networks.	ESRT (end-to end)	Provides reliability and Minimizes energy consumption. It also provides event and packet reliability [11] [14]
STCP: a generic transport layer protocol for wireless sensor networks.	Sensor Control Protocol (end-to end)	Provides controlled variable reliability, congestion detection, its avoidance and multiple applications in the same network. It also provides event and packet reliability [11] [15].
RMST: Reliable Data Transfer in Sensor Networks.	RMST	Provides guaranteed delivery and fragmentation or reassembly to the needed applications [11] [16].

Table b: Enlisting some of the protocols for improving reliability in WSNs as well as WBANs.

Paper Title	Protocol	Advantages and feasibility in WBANs
Reliable Bursty Converge cast in Wireless Sensor Networks	Reliable Bursty Converge cast (RBC).	It addresses the issue of bursty converge cast .It improves channel utilization and reduce ack-loss. It also improves the packet delivery ratio and reduce end-toend delay [11] [17].

There other protocols also like GARUDA [18], PSFQ [19], etc. which also provides the mechanisms to improve the reliability of WSNs and can also do the same in WBANs. These protocols can be modified and used in WBANs for healthcare as well as other applications.

5. Conclusions

So from the above study we can conclude that there still exist a number of limitations in the WBANs for patient monitoring systems. Of all, reliable transmission and other factors like minimum energy consumption of sensors, reduced latency etc. are the most important factors are major needs in WBANs. The study also reveals that there are different approaches through which the better patient monitoring systems can be developed. This survey also clears that there are ideas coming in from every possible direction to enhance the functioning of wireless patient monitoring.

6. Future Scope

The WBANs for patient monitoring systems is a new popular research area which holds a big scope for improvement for different fields like computer engineering, biomedical engineering and others as well. The reliability of transmission is a major issue to focus on for the research people from computer. The development of low power yet highly reliable sensors can be a big part of the work to be done by people from electronics and communication stream. The Biomedical and telemedicine field has the ability to come up with new ideas to build wireless patient monitoring systems.

7. Acknowledgment

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