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REVIEW ARTICLE

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A Review Article on Issues and Requirements of Wireless Body Area Network (WBAN) with Fuzzy Logic

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***Abstract*:** Wireless body area network (WBAN) is an emerging technology which is getting a lot of attention these days due to its application in medical field and health monitoring system. In this technology by using different bio-sensors which could be implanted or worn by patient, he/she get his/her health conditions at regular intervals. Wireless connectivity makes it more popular because of its patient could use it in his daily life activities also. There are various fields in WBAN where a lot of development could be made, as this field is still in its developing stages. Efficient energy utilisation techniques have been explained. Routing metrices which consists of residual energy, delay, packet collision, network lifetime, complexity, network traffic etc. is also an interesting area where we will be working to develop intelligent routing metrices for wireless body Area Network (WBAN).Fuzzy Logic(FL) is a powerful tool used to develop solution of various problems today which maps the crisps inputs to give corresponding outputs. Momdani Fuzzy Inference System (FIS) provides the atmosphere needed for Fuzzy Logics where depending on degree of membership functions maps the variables and a surface is generated with respect to various factors in routing metrics. In this paper we had reviewed its basic aspects like its constituents, layered architecture and Issues as well as requirements of WBAN with Fuzzy Inference System (FIS).

Keywords: Wireless Body Area Network, WBAN, Routing Metrices, Layered Architecture, Fuzzy Logic, Energy efficiency, Fuzzy Inference System (FIS).

I. INTRODUCTION

As we all know that aged population is increasing day by day and with them the problems regarding health are also increasing with a good pace. Demographers have predicted that the worldwide population over 65 will have doubled in 2025 to 761 million from the 1990 population of 357 millions [1]. Also, one of the leading causes of death is related to cardiovascular disease, which is estimated to be as much as 30 percent of deaths worldwide. Infact our living style, our environment, our food and our activities also affects our health. In today's world almost everyone is struggling to stay fit and healthy. In recent times although the health issues have increased a lot but corresponding to them medicines and doctors hasn't developed. Health issues are creating very serious problems for developed as well as developing countries. Patients and doctors ratio is very poor which tells about the state of healthcare system. Due to lack of doctors and good medicines people's health risks are increasing and if somehow these issues would be solved by doctors, then they are charging so much high that a common people are not able to pay that amount. But health is wealth as we all know it very well, so we can't put it at so much risk. Wireless body area network (WBAN) is an emerging technology which is making our lives somewhat safe by keeping us aware about our health on regular basis instead of going to a hospital for checkups regularly which consumes a lot of money and time as well. Technical advancements in the fields of sensors, communications, networking and electronic devices has led us to implement WBAN which act as a self monitoring and alert system for any patient or even for a healthier person also. Many medical devices as Electrocardiogram (ECG), Insulin Pumps, Pacemaker, Implantable Cardioverter Defibrillators (ICD), temperature and pulse sensors, all have been also moves to WBAN technologies[2]. Wireless body area network (WBAN) is a short range network which consists of various miniaturised biological sensors, actuators and communication technologies through which these devices communicate with each other for data exchange and it generally implemented over the human body. At initial stage of its development it was taken as wireless sensor network, but there are lots of differences between WSN and WBAN. Like coverage range of WBAN (in metres and centimetres) is very less as compare to WSN (in KM). Network topology in wireless sensor networks will be of fixed type or static type but in wireless body area network it is variable due to body movements. Data rates are also homogeneous in WSN while in WBAN data rates are heterogeneous. Both needs large powers but it is easier to provide power in WSN as compare to WBAN and additional measures are needed to ensure QoS and real time data delivery. This paper has been arranged in a manner that section (II) will review the constituents and workflow in Wireless Body Area network (WBAN), Section (III) will demonstrate the layered architecture of WBAN, section (IV) tells about some applications of WBAN, section (V) consists of issues and requirements of Wireless Body Area Network (WBAN), section (VI) would introduce about the Fuzzy Logic and Fuzzy Inference System(FIS) section (VII) will successfully conclude this review paper.

II. CONSTITUENTS AND WORKFLOW OF WBAN

(A). Biological Sensors and Actuators Nodes:

Biological sensors are the miniaturised electronic devices which will sense the certain biological parameters and convert those parameters' signals into electrical form or in a form

which could be easily read by the signal processing system. In WBAN these sensors could be worn by the person or could be implanted into or over the body of the person. Actuators are the electromechanical devices which performs action on the basis of the results of processed signals from sensors. For example, if glucose sensor provides a signal of above critical level, then a mechanism which is driving the insulin injector will get activated and it will put the insulin into the patient's body. A sensor or actuator node in WBAN will also consist of basic components like power supply unit and wireless transceivers as well. Following table 1 tells us about the various sensors and actuators used in WBAN with the required data rates and others parameters.

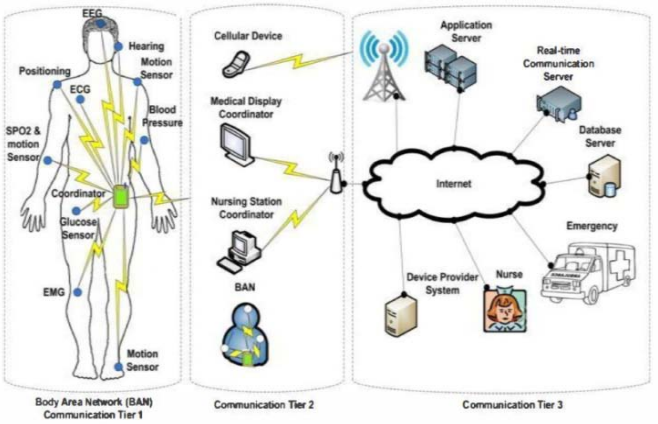

Fig.1 Wireless Body Area Network(WBAN)[3]

(B). Coordinator Node: The coordinator node connects external world's networks like cellular network, another WBAN, a trust centre or an access point to the WBAN over a human body. It is generally a personal digital assistant (PDA) through which all other nodes communicates.

Table 1: Sensors and Actuators with their characteristics[1]

Sensors Node	Data rate	Duty cycle(per device)% per time	Power consumption	Delay
Glucose sensor	<1 kbps	<1%	Very Low	<250ms
Pacemaker	Few kbps	<1%	Low	<150ms
Endoscope capsule	>2Mbps	<50%	Low	<250ms
ECG	3 Kbps	<10%	Low	<250ms
SpO2	32 Kbps	<1%	Low	<200ms
Blood pressure	<10 bps	<1%	High	<250ms
EEG	86.4Kbps	<10%	High	<250ms
EMG	1.57 Mbps	<26%	High	<225ms
Drug delivery	<16 Kbps	<10%	High	<250ms
Deep brain stimulation	<320 Kbps	<4%	High	<150ms

(C). Data Handling and Storage :

WBAN consists of several nodes (in form of different sensors /actuators), so they need to communicate properly with each other to make all WBAN setup of some useful applications. Communication in WBAN is divided into 3 main categories as shown in fig.1.

(i) Intra body communication (Tier 1): When the nodes of same body communicate with each other then such kind of interaction is known as Intra body communication. Generally range of such network is less than 2 meters or only limited to area around human body. Here all the data from all nodes of body will be sent to coordinator node.

(ii) Inter body communication (Tier 2): When the data from coordinator node or personal server node has to send to the access points (AP) s which is connecting the WBAN to various other networks like cellular network or the Internet. On the network type this communication categorised onto two categories: (a) infrastructure based in which deployment of network is dynamic in limited space and AP can act as database servers related to its applications. (B) Ad-hoc based architecture in which multiple APs will be sending information. APs are in a mesh construction by which deployment is fast and flexible. Through this approach coverage rang also get increased to 100 meters from 2 meters.

(iii) Beyond body communication (Tier 3): In this tier, a gateway is provided in form of some personal digital assistants (PDA) which creates a communication path between tier 2 and tier 3. The design of this tier is application specific. For example, through internet we are connected to the medical servers (MS) of some specific hospital where all our monitored is getting stored regularly. If some parameters get approaches towards the critical situations then the system will generates an alert signal and send it to the PDA in form of some emergency SMS or direct to the coordinator node over patient's body.

(D). Personal digital Assistant: These are the electronics devices which works as a coordinator for all nodes involved into WBAN. It could be an Android, windows or java base mobile phone. It will receive all the critical SMS or alert signals from medical servers and transmits the signal from WBAN towards the servers as well. PDAs' are armed with signal processing and feedback mechanism also.

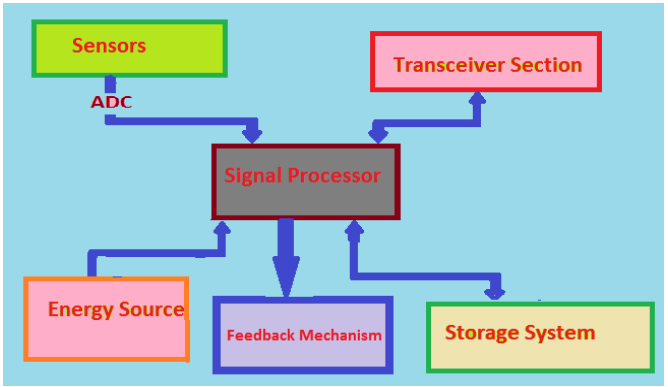

Fig: 2 Main Parts of WBAN

(E). Transceiver section: It will be the important part because it is always at front end of every node because they had send and receive the data. Transceivers play an important role in data rates, transmitting powers and errors of the signals and heating of body cells as well. But as the topology of WBAN changes with the motion of body. To overtake all issues like beamwidth, gain factor, type of antenna, compact size and low powered as well as efficient antennas with all desired parameters for WBAN, various researchers suggest certain types of antenna designs. Like Somayyeh Chamaani, Alireza Akbarpour suggested a miniaturised dual band omnidirectional antenna for wireless body area network in two frequency bands of 403.5 MHz (MICS) and 2.45 GHz(ISM). Miniaturization factor of 6.3 and 5.1 for MICS and ISM respectively[4]. The simulated azimuth gain for MICS ban is 1.11 dBi with 93^o beamwidth and 2.62 dBi for ISM band with 79^o beamwidth[4].

(F). Energy Sources: Like all other electronics system it also needs proper power supply for its functioning. WBAN is battery operated system. But as compare to other systems Like WSN, power supply to WBAN is difficult due to design of sensors, technologies for communication and most importantly due to their positioning in human body. Energy sources should be such that it could offer a very long lifetime, continuous supply and easily disposable as well. But still a lot of research in this field is required because we are not meeting our energy goals in WBANs. Most researches claim that ANT is technologies which consumes a LI-ion battery in 3 years but offers a very low data rates i.e. 1 byte in 5 minutes. IEEE 802.15.4 standard for low power Zigbee technology indicates a power consumption of 1mW which consumes a Li-ion battery in few hours when operating at 250 kbps continuously. So some ultra low power technologies are suggested by researchers which will includes IBC techniques with IEEE standards of 802.15.6.

III. LAYERED ARCHITECTURE OF WBAN

(A). PHY layer:

Most of the researchers worked over PHY layer and MAC layer. But layers like application layer, network layers don't get so much developed however some protocols for packets routing in network layer has been demonstrated.

IEEE 802.15.6 Technical Group 6(TG 6) standard has given three categories of PHY layer which are: Narrowband (NB) Layer, Ultra wideband (UWB) layer and Human body communication (HBC). Some authors also classify WBAN in two categories on basis of communication technologies used in it for data transmission as (i) RF WBAN (Narrowband (NB) and Ultra wideband (UWB)) and (ii) Non-RF WBAN (Human Body Communication).

(i) *Radio Frequency Based Wireless Body Area Network(RF-WBAN)*

RF WBAN consists of operations in Narrowband frequency bands (402-405 MHz, 420-450 MHz, 863-870 MHz, 902-928 MHz, 950-958 MHz, 2360-2400 MHz, 2400-2483.5 MHz) offering data rates of 100 Kbps-1000 Kbps and Ultra wideband frequency bands are also subdivided into two bands, Low (3.24-4.75 GHz) and High (6.6-10.25 GHz) giving 500 MHz bandwidth of use in each band and operates with data rates of 395Kbps-12.636 Mbps. UWB proves very handy in low powered applications. Some technologies with their characteristics which are in use in WBAN are given as:

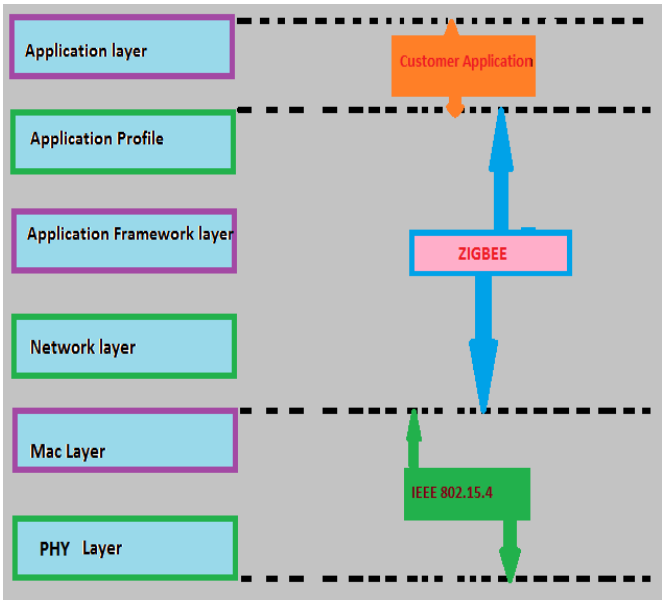

Fig: 3 Layered Architecture of WBAN

Bluetooth with frequency band of 2.4 GHz ISM offers a data rate of 1mbps using frequency hopping and time division multiple access techniques[2]. It operates with star topology giving a coverage area of 10 meters[2]. Bluetooth 3.0 with frequency band of 2.4 GHz ISM offers a data rate of 3-24Mbps using frequency hopping and time division multiple access/carrier sense multiple access(FH+TDMA/CSMA) techniques[2]. It operates with star topology giving a coverage area of 10 meters[2]. Ultra wideband (UWB-ECMA-368) with frequency band of 3.1-10.6 GHz offers a data rate of 480 Mbps by using carrier sense multiple access/time division multiple access (CSMA/TDMA) [2]. It operates with star topology covering a range of less than 10 meters[2]. Zigbee(IEEE 802.15.4) which uses the ISM frequency band offers 250 Kbps data rate by using carrier sense multiple access(CSMA) and also uses the star/ mesh topology for covering the range of 30-100 meters[2]. Insteon with frequency band of 131.65 KHz (powerline) or 902-904 MHz offers data rates of 13Kbps with mesh technology[2]. Z-Wave with frequency band of 900 MHz ISM generates data rate of 9.6k with mesh topology for 30 meters coverage area[2]. ANT with 2.4 GHz ISM generates 1Mbps by using TDMA and mesh/star topology over a short range local area[2]. RuBee (IEEE 1902.1) within frequency band of 131 KHz generates 9.6k data rate with peer to peer topology over a coverage range of 30 metres[2]. RFID(ISO/IEC 18000-6) within 860 MHz to 960 MHz frequency band offers a data rates of 10 to 100 Kbps with slotted Alloha/binary tress by using peer to peer topology over a coverage area of 1-100 meters[1].

(ii) Non-RF Technologies (Human Body Communication (HBC))

Wireless connectivity is the key feature of Wireless body area network which makes it portable and flexible but RF techniques are power consuming, susceptible to electromagnetic interference and have security issues. So body channel communication(BCC) or Human body communication(HBC) is a technique in which body is modelled as a communication channel and used for propagation of signals[5]. Some authors also termed this technique with the name Intra body communication(IBC) [5]. Researchers showed that this technology consumes a power below 1mW and could offer data rates of more than 100 Kbps[5]. Data rates of 164Kbps-1312.5 Kbps is achieved with frequency band centred at 21 MHz with high energy efficiency and coverage range of less than 2 metres and low signal attenuation[5]. At higher frequencies body could behaves as radiating antenna, so coupling of transmitting and receiving antennas in this approach is done in two ways[5]:

(a) *Capacitive coupling:* in this approach only signal electrodes of transmitter and receiver antennas attached to body and ground electrodes would remain floating. The induced signal is controlled by an electric potential. Channel gain and data rates are higher for this approach in which dominant signal transmission pathway is environment.

(b) *Galvanic coupling:* involves the control of induced signal by a current flow. Both electrodes of transmitting and receiver antennas are attached to human body and dominant signal pathway is through tissue where human body is modelled as waveguide but lower data rates are possible in this coupling. Cole-Cole equation suggested the Human Tissue parametric model[5]. Body channel circuit model has been suggested by Zimmerman to characterise it by RC model. Finite element model(FEM), Finite difference time domain (FDTD) model, theoretical Electromagnetic models are some other model analysed by some researchers with different assumptions[5]. On-off keying(OOK) and direct sequence spread spectrum(DSSS) are the digital modulation techniques used from which OOK technique with data rates of 2.4 Kbps is found to be most effective[6]. However due to higher frequency use higher data rates are achieved with some problems like heating effect over body and signal travelling through body also suffer insignificant channel variations[6]. Body channel communication (BCC) is a technique which offers a lot of research scope.

(B). Medium Access control (MAC)Layer

In wireless communication major concern is to utilise the power efficiently which is consumed mostly at the time of communication between nodes. Energy gets depleted in idle listening, network overheads handling, packets collision and varying traffic over the network. Low power listening(LPL), schedule contention based approaches, code division multiple access(CDMA), time division multiple access (TDMA) where polling of sensor nodes, sending data in small bursts are used to avoid idle listening and cut down usage of power sources. MAC layer offers a lot of work for researchers.

Okundu Omeni, A. Wong, A. J. Burdett, and C. Toumazou worked over a MAC protocol to increase energy efficiency in which a buffer system is allotted to sensor nodes so that whenever a node has something to send to master node and if it couldn't send it then it could data during its next time slot[7]. But it gives good performance for few nodes but performed badly for increased number of nodes[7]. N.F.Timmons and W. Scanlon developed Med Mac Protocol in which two approaches (i) Drift Adjustment Factor (DAF) (ii) Adaptive Guard Band Algorithm (AGBA) are proposed[8]. In this protocol a variable guard band is introduced between time slots to synchronise nodes and a guaranteed time slot (GTS) is used to avoid collision of packets[8]. S. J. Marinkovic, E. M. Popovici, C. Spagnol, S. Faul, and W. P. Marnane worked on low duty cycle MAC protocol where signal is converted to digital and digital signal processing is done, after which TDMA scheme is employed to smartly utilise energy[9]. But this protocol is not worked for dynamic network topologies [9].

Ta-MAC protocol consists of wakeup radio mechanism which uses fixed radio channel for emergency transmission and traffic based wakeup mechanism utilised for wakeup in which traffic pattern is used for node selection for packet transmission [10]. G. Fang and E. Dutkiewicz suggested T-Mac (time-out MAC) protocol in which a flexible duty cycle is utilised to minimize the idle listening whereas S-MAC (sensor MAC) uses the fixed duty cycle to reduce the delay in network communication [11].

(C). Network Layer

Network layer in wireless body area network (WBAN)performs the same functions as in other networks such as routing of packets, minimization of overheads of nodes, packetisation, of data, delay reduction, increase network lifetime etc. through the network from source to destination nodes. Researchers proposed several routing protocols for WBAN from conventional routing protocols and WBAN specific as well.

Routing protocols are categorised as:

(a) *Temperature based protocols:* Thermal aware routing algorithm (TARA), Least temperature routing (LTR), Adaptive least temperature routing(ALTR), least total route temperature(LTRT), Hotspot Preventing Routing(HPR) , Thermal aware shortest route hoping(TASRH) [12].

(b) *Hierarchical Routing algorithms:* LEACH, PEGASIS, HEED,TEEN, and APTEEN[12].

(c) *Cluster based routing:* Anybody algorithm, Hybrid indirect transmission(HIT) [12].

(d) *Cross layer protocols:* Wireless autonomous spanning tree protocol(WASP), Controlling access with Distributed slot Assignment Protocol(CICADA), Time zone coordinated sleeping mechanism(TICOSS), Cross layer MAC and routing

protocol co-design for biomedical sensor networks (BIOCOMM)[12].

(e) *Cost effective routing algorithms:* Opportunistic routing algorithm(OR), Prediction based secure and reliable Routing(PSR), Probabilistic routing with postural link costs(PRPLC), Distance vector routing with postural link costs(DVR-PLC), On body store and forward routing algorithm(OBSFR).

(f) *QoS based routing:* LOCOLMOR, Data centric multi-objective Qos-aware routing(DMQoS), QoS framework dependent Algorithm, Reinforcement learning based routing protocol with QoS support(RL-QRP) [12].

There are various types of issues with routing in WBAN which have to tackle like link quality degrades with the postural body movements, energy is limited so efficiently use of it and with low frequency signals signal disruption is another issue which is to address, body temperature changes, number of hopes count must be kept low for efficient use of resources available [12].

IV. APPLICATIONS OF WIRELESS BODY AREA NETWORK

Wireless body Area network offers numerous applications in various fields due to its regular development. Application areas of WBAN can be categorised into different categories which are medical, healthcare sector, defence, entertainment field, sports and fitness, electronics and research. Following table 2 suggests some of the applications of WBAN.

Table 2: Various Applications [1]

Sr.no	Categories	Applications
1.	Medical	
	Wearable WBAN	Sleep staging
		Asthma
		Wearable health monitoring
	Implantable WBAN	Cardiovascular diseases
		Cancer detection
	Remote control of medical devices	Ambient Assisted living(AAL)
		Patient monitoring(ECG,EEG)
		Tele-medicine system
2.	Defence	Assessing soldier Fatigue and battle readiness
		Aiding professional and amateur sport training
3.	Electronics	Media players and cell phones security system
4.	Entertainment	Emotion and Posture detection for animated movies
		Gesture and body movements in interactive games

V. ISSUES AND REQUIREMENTS OF WBAN

Implementing a wireless boy area network is very difficult. There are number of parameters which have to meet as suggested by IEEE TG6 group. However some of these parameters are analysed as below:

(A). Bit Rates: As WBAN involves various sensors which monitors different parameters of body so the signals transferred by them will also require different data rates which is varying from 1Kbps to 10 Mbps as shown in the list of sensors.

(B). Network Routing QoS: Network Lifetime, Minimum packet delay, low retransmission of packets and packet collision, efficient use of network resources like residual energy, bandwidth etc. These issues offers a huge area of scope for researchers in case of Wireless body area network(WBAN) which must be handled for successful deployment of WBAN.

(C). Quality of Services: low bit error rates, minimum end to end delay, minimum packet loss and reliable connection, lesser traffic overheads and congestions are defining the quality of service of WBAN. Very powerful methods for error correction and interference avoidance should be implemented over MAC and PHY layers.

(D). Topology and coverage range: star or Mesh topology is sufficient for WBAN but Dynamic Position of nodes due to the motion of body will be adding vulnerability to the network performance. WBAN is generally confined to 3 to 7 meters only due to its nature of operation. Multi-hop communication must be preferred for a robust and reliable network.

(E). Security: WBAN is mostly operating over power limitations so conventional techniques for encryption of data in this network will not be feasible so low powered but effective and powerful encrypting techniques must be implemented. Because Security of data is always an important aspect of every data transmission technology. A.Siva Sangari, J.Martin Leo Manickam suggested a polynomial based security in wireless body Area network where data acquisition phase, data transfer phase, data access phase employed and reliability improvement is achieved[13].

(F). Transmitting and Receiving Antennas designs: Antennas play effective role in data transmission, so highly efficient, low power consuming and compact size are the requirements. However a trade-off has to make but we have to use the most efficient one. Froehle, Patrick, Tyler Przybylski, Christopher McDonald, MiladMirzaee, SimaNoghanian, and Reza Fazel-Rezai researched for a flexible, bowtie, light weight and non-obtrusive antenna for university of North Dakota(UND) next generation spacesuit 2(NDX 2) [14].

(G). Power consumption: WBAN is battery operated network so battery lifetime must be of several years especially for implanted devices. PHY and MAC protocols must be used which would be low power consuming. Less power means delay in signal transfers, but a trade-off has to apply for efficiency and working life of network. However some of these are suggested in form of IEEE 802.15.4, IEEE 802.15.6 standards (ZIGBEE, Bluetooth, ANT And HBC(human body communication)). Although we can apply energy scavenging by body movements or body heat to provide power to devices

in WBAN. Power consumption related issues are major field of research in WBAN.

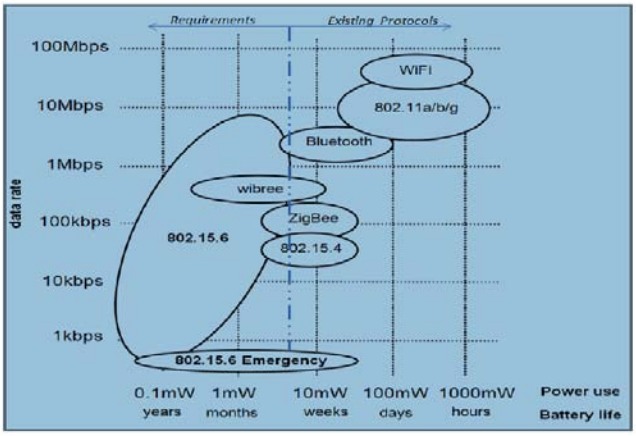

Fig.4 Power requirements in different technology

(H). Interference: WBAN-WBAN interference is as serious issue as interference from other application's frequency. A study has been done over WBAN-WBAN interference in an indoor environment at 60 GHz and 2.45 GHz with using monopoles antenna and Horn antennas for both carrier frequencies[15]. Median interference power levels get reduced by 20 dB with use of 60 GHz channel along with monopole antenna and a further reduction of 20 dB with Horn antennas. Instantaneous carrier to interference ration shows improvement of 30 dB with 60 GHz channel as compare to 2.45 GHz16].

(I). Frequency band: WBAN uses ISM band centred at 2.45 GHz whereas some others technologies are also using same frequency band like WIFI (802.11), Bluetooth (802.15.1), and Zigbee (802.15.4). So congestion is increasing in this band due to different application running in the same band. So at the time when emergency signals had to be sent then such communication must be very reliable, easily distinguishable and free from any kind of interference due to other application in same frequency band.

(J). Signal processing: WBAN is power limited and Radio circuits which are used to process the signals consume a lot of power. So power efficient techniques have to be developed. Compressed sensing (CS) is a low power consuming technique which samples the analog signal at sub-Nyquist rate. In this technique less data or say compressed data is sent to save the power. More about this technique can be seen in [17].

(K). Safety for body: The international commission on Non-Ionizing radiation protection (ICNIRP) Puts some rules and limits over use of time varying electromagnetic signals near body tissue for their safety issues. Specific Absorption ratio (SAR) tells about the heating effect created on the tissues due to RF signals. However Frequency which WBAN uses hasn't show much of such concerns but attention must be paid by measuring it on different parts of body after implementing it.

(L). Xiao-Qi Zhu, Yong-xin guo and Wen wu proposed a compact dual band antenna for WBAN through which bandwidth performance and radiation pattern is observed in both free space and on body to claim it a good choice for WABN. Performance is observed with antenna's operation in frequency bands centred at 24 MHz and 113 MHz. Fractional bandwidth of 1.2% and 2.0% is observed in both bands and radiation efficiency of 60% and 76% has been claimed. RT 5870 has been used as Substrate for antenna fabrication. Height and area of this antenna is 1.58 mm and 986 mm^2 respectively[18].

(M). Conventional power control methods are not performing up to the par level in WBAN. So lots of researches are going in transmission power control (TPC) fields. According to their mechanism they were classified into categories as network-level methods, neighbour-level methods, node-level method, and packet-level methods. Ali Hasan Sodhro, Ye li, Madad Ali Shah suggested a Novel energy-efficient adaptive power control(APC) algorithm in which power levels are controlled on the basis of base station signals as feedback. 40.9% savings in energy and lower complexity are some points of this algorithm[19].

(N). Wireless boy area network implemented over body suffers high channel variations and link losses due to different postures of human body. During movements position of sensor node keeps varying with respect to network which leads to extra energy consumptions and less reliable communication. BeomSeok Kim, Jinsung Cho, Seokhee Jeon, Ben Lee provides a analytical hierarchy process(AHP)-based flexible node selection approach in which factors like Signal to noise ratio(SNR), residual energy and load of traffic would be considered for appropriate node selection to increase the reliability and energy efficiency of communication[20].

(O). Chunqiang HU, Hongjuan Li,Xiuzhen Cheng, Xiaofeng Liao proposed a communication architecture in which data is made secure by using applying Cipher text-Policy Attribute Base Encryption (CP_ABE)[21]. Two policies were designed based on it and analysed for good authentication, collusion resistance and energy efficiency.

(P). Soumaya Bel Hadj Youssef, Slim Rekhis, Noureddine Boudriga conducted a research on Wireless body area network (WBAN) for fire-fighters for evaluating the physiological parameters of commander and soldiers of fire-fighting team and as well as of combat area. A clustered based topology and hierarchical approach of communication developed using two models (i) angle based model (ii) random sector based model are used to coordinate the activity of team against the failure and combat it with suitable strategy which could be developed after looking up the parameters like intensity of fire, position of soldiers, condition of soldiers[22].

(Q). Weilin, Zang and Ye Li suggested a motion aware transmission power control algorithm in which body motion activity is taken into account to control the transmission power. 43.27% reduction in power consumption and increase in reliability are main results of this scheme with Zigbee platform having CC2530 radio[23].

(R). Ramlall, Rohan proposed some changes in the timestamp free synchronisation process suggested by R.Brown to give a

modified approach to synchronise the coordinator and sensor nodes[24].

(S). Antonio Pereira, Nelson Nunes, Daniel Vieira, Nuno Costa,Hugo Fernandes, Joao Barroso developed a Body Area Network based system for blind people to avoid collision against walls or obstacles around them. Ultrasound sensors are used with polling of these sensors in every 800ms. Based on the reflected signal from obstacles computations are made to make a decision [25].

(T). Sen Yan, Ping Jack Soh proposed a dual band magneto-electric dipole antenna which could be worn and simulation results based on IEEE C95.1 provides a specific absorption ratio is 0.045 W/kg(well below 2 W/kg) [26].

VI. FUZZY LOGIC (FL) AND FUZZY INFERENCE SYSTEM (FIS)

Fuzzy Logic (FL) is aimed at formalization of modes of reasoning which are approximate rather than exact. In this logic a fuzzy set which consists of a class of objects of continuum degree of grade of membership is formed and various kind of operations like union, intersection, complement, relational, logical are performed and depending on these various industrial problems are solved[27].

Fuzzy logic has four important part as shown in the fig.5 (i) FL/L (logical) consist of a logical system where truth is a matter of degree. (ii)FL/E(epistemic) focuses on knowledge representation, natural language, semantics, expert system, probability of modes of reasoning as well. (iii)FL/S (Set theoretic) consists of theory of fuzzy sets or mathematical literature of fuzzy logic. (iv)FL/R (relational) consists of practical application of fuzzy sets. It focuses on granulation, fuzziness dependencies, linguistic variables and fuzzy rule sets.

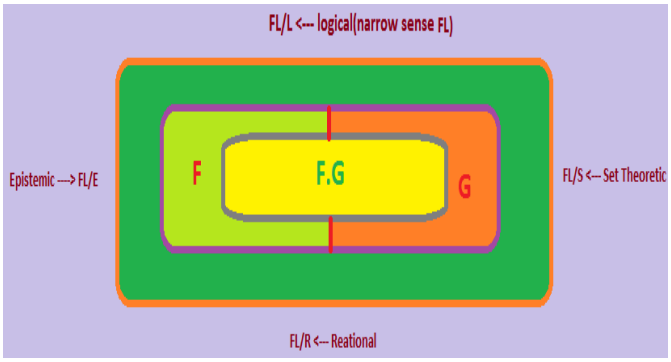

Fig.5 Facets of Fuzzy System[31]

Fuzzy inference system (FIS) is a tool designed over these fuzzy logics where IF-THEN rules are used to formulate the logic rules for the input variables which are crisp in nature and after processing through this system it will give an output which is also a crisp one but it will be the solution of input problems[28].

$$Y=F(x)$$

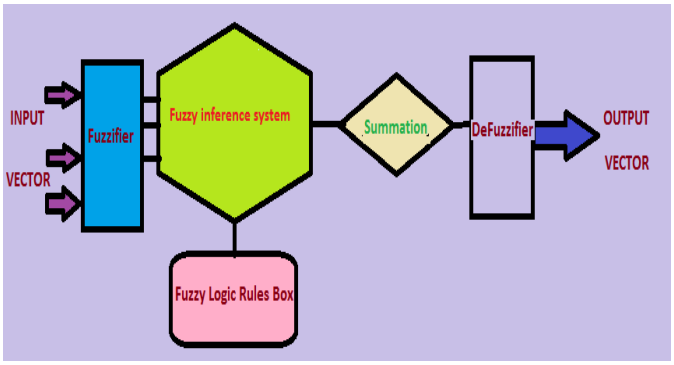

Fig.6 Block Diagram of Fuzzy Logic System

VII. CONCLUSION

Wireless Body Area Network offers a wide scope of area of further studies and improvements due to various issues stated as in this paper. Energy utilisation in a smart manner is the task where we will be working by using the Fuzzy Inference System logics to develop routing metrics consisting of parameters like residual energy, traffic types, throughput, delay, link cost, route availability etc. Fuzzy logic uses the logic which is a mathematical model of somewhat human decision making system. Depending on these parameters routing of packets through network is examined and reviewed for reliable and maximum packet delivery rates with minimum delay and packet losses in this paper.

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