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Energy Efficient Vertical Handoff Model for Wireless Body Area Networks (WBANs) in Ubiquitous Healthcare System

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Abstract: Present day's network technologies play a very important role in ubiquitous healthcare systems (UHS).Healthcare technologies have now been equipped with Wireless Body Area Networks (WBANs) where the sensors are less invasive yet gather sensory information equally well. These network sensor nodes' life is highly dependent on the battery of the coordinating sensory nodes. The development of Internet on Things (IoT) technology improves the coordination of WBANs in heterogeneous wireless networks which transfer the physiological information to the remote terminals in the stipulated time. As the monitoring is continuous, the quantity of the event-driven activities enormously increases the energy consumption in the nodes. Hence, we introduce Modified Content-Centric Networking (MCCN) model approach which minimize all unnecessary events driven and handoff activities during network selection. This function enables to reduction in overall energy requirement and make network is energy efficient. The results of the simulation proved that the proposed network model outperforms the Received Signal Strength indicator Vertical Handoff (RSSI-VHD), Fuzzy Logic (FL) based and Game Theory (GT) based techniques in terms of the number of handovers, Quality of Service (QoS) and energy consumption.

Keywords—WBANs; Heterogeneous Wireless Network; Modified Content-Centric Networking; Network Selection; Quality of Service; Ubiquitous Healthcare System; *Vertical Handoff.*

1. INTRODUCTION:

The growing populations in many developing and developed nations and the cost of human health care increasing rapidly. This have been motivated the introduction of many technology-driven enhancements and updating in the current healthcare applications and practices[1].Presently, the tremendous growth in the use of different wireless networks and further rapid miniaturization of electronic devices has encouraged the development of Wireless Body Area Networks (WBANs). WBANs are special purpose Wireless Sensor Networks (WSNs). They provide effective means of services in much many promising application in various domains. Particular, WBANs are uses in real life applications such as healthcare, medicine, patient monitoring, sport and multimedia, interactive gaming, entertainment etc. In e-health care system these networks are used to provide Ubiquitous Healthcare services, where various sensors are equipped on clothing or on the body or even implanted under the skin to collect continuously patientvital parameters and send to remote concern medical server, physician or any medical staff [2],[3].This activityparticularly uses for a continuous health monitoring of a patient without any constraint on his/her normal daily life activities. Carried out the same thing using wired network is to be too much complexity, which leads to a high cost for implementation and maintenance [4].

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The e-health users experience a good physical mobility and are no longer force or oblige to stay in a hospital. This situation can be considered to take up to the next level of personal health care and to face the costs of the health care system. Basically,e-Healthis exemplified as the healthcare practice supported by electronic signal processes and network for communication, the e-health care is now going a step aided by becoming mobile called as m-Health [5].

With their ubiquitous functions in healthcare, WBANs help to screen the status of patients over the long haul without confining day by day exercises. WBANs can be utilized to analyze incessant conditions, oversee restoration from a surgery and screen in physiotherapy. Likewise, WBANs can help in immediately dealing with crisis occasions through remote instruments. Along these lines, this innovation gives benefits by lessening pointless hospitalizations, decreasing the number of specialists required and diminishing the time required for quick investigation and diagnosis WBANs enhance the level of patient administer to a convenient mediation from doctors and crisis therapeutic expert staff through information analysis and storage. However, the effectiveness of real-time trials in remote ubiquitous healthcare network systems can be significantly affected by the existing different wireless networks condition, the power usage of mobile equipment and user requirements on the Quality of Experience (QoE) in terms of user mobility, required Quality of Service (QoS) of healthcare and personalized customized interaction.

However, to limit these impacts and enhance the transmission efficiency in heterogeneous networks with energy efficient, use multimode wireless access technologies with appropriate protocolsintegrate with WBANs.

2. RELATED WORK:

Many proposals and approaches have been made for integration of WBANs with other large-scale wireless technologies. Energy consumption and vertical handoff are the critical issues to enable the patient mobile node to select the best network seamlessly during data transmission. Energy efficient handover and data transmission approach needed to provide ubiquitous healthcare services.

The authors in [1] explain the use of WBAN for patient monitoring application. They discussed the physical layer, network protocols, cross-layer and QoS. Further focused on posting of sensors nodes, secured data transfers and issues and challenges are pointed out for research. The authors in [2] explain theroadmap for implementation of WBAN with considering the parameters like the service type, node energy are evaluate during vertical handoff. This work does not evaluate the node energy. In particular, [3] introduce an architecture integration of WBAN with web services for seamless healthcare service provisioning. Here they proposed the prototype Service-Oriented Wireless Body Area Networks (SOWBAN) architecture for service provisioning. An integrated wireless sensor networking environment for remote healthcare explicitly mentioning the reliability as well as privacy-preserving patient data during transmission [6].The solution provider fulfill diverse application requirements in an accurate and timely manner With its flexibility, and large-scalenetworks like the Internet, WLAN and Cellular networks 2G, 3G, and LTE are being used in WiMoCA[8], whereas is a smart architecture for mobile terminals and is optimized for flexibility and low-power short-range radios[7].

The authors [10], [11] proposed handoff decision making with network parameters, where parameters are considered are bandwidth and received signal strength at which mobile node stay in the network. In[9], Elaheh Arabmakki et all present handover scheme using Media independent handover services which results in terms of throughput, latency, packet drop. The author of the [12] presents the decision based on different parameters with threshold values and provides the performance optimization of handover between the 2g, 3g, and WLAN. The author in [13] presents Optical net modeler based on the vertical handoff decision for WLAN and UMTS. The paper [14] provides the RSS based decision model for voice and data application are considered and [15] considers a different real-time application for the analysis of decision algorithm. The author in [16] gives the different algorithm for applications and its analysis for VHD. The paper [17] gives the algorithm based on QoS and consumer choices andprovidespolicy-based solution i.e. PROTON MIPv6 based network selection method. In the [18] decision is based on the network condition, QoS requirement and service cost and [19] presents the decision based on mobile node request to avoid wastage of network resource, based on these study here proposed VHD by RSS based and dynamic and extended vertical handoff mechanism.

User preference based VHD schemes, including User-Centric [20], Fuzzy Logic [21], MADM and Game Theory [18] have been proposed and verify their performance terms of complexity, flexibility and reliability and other attributes.In the paper [21]describes the vertical handover between body area networks and LAN based on multi attributes and explains how unnecessary handoff can be reduced.

3. NETWORK ARCHITECTURAL MODEL AND TRAFFIC TYPES

The conceptual network architectural model and needed traffic types are describe in this section. These are specifically nessaryto reduce energy consumption while data transfer for remote e-healthcare patient monitoring.

3.1. Network architectural model

The network model, which is shown in figure 1 consists of two communication networks, namely intra-body communication and extra body communication network zones. Here we consider a 'μ' number of a patient each one of them using WBANs and set ofa β number of heterogeneous networks used for extra body communication. To obtain the benefits of lowpower, high reliability and support of dynamic range of data rates, Zigbee wireless technology (IEEE 802.15.6 standard) areseamlessly integrating with other extra body communication networks.

In the outer body communication use one of the reliable overlays large coverage networks from WiFi, WiMAX, UMTS (3G), LTE (4G) for data transfer to remote locations. Different sensors are used to collect the vital biological parameters from the patients' body. These

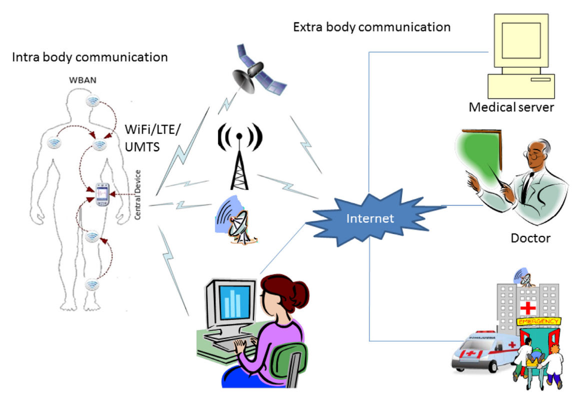

Fig. 1: The Conceptualarchitecture of WBAN network.

collected data to and then ubiquitously deliver to medical staff's Personal Device (PD) through WBANs network nodes, further, it passes to coordinating devices equipped with the reliable interface of 802.16 or other wireless technologies Wi-Fi, 3G,4G etc. Since the most of the time e-health care patient mobile in condition, the coordinating device in the associated WBAN network is always best connected seamlessly to one of the overlays networks. Hence WBAN is integrated with a multi-access node of extra-body communication, such as AP of Wi-Fi, BS of UMTS and E-NodeB of 4G. The core work of this paper is to select one of the best network interfaces seamlessly for extra body communication.

3.2. WBAN Traffic types

Following are the three traffic classes defined for data transmission in WBANs healthcare application.[29]

- Normal traffic (NT): This data traffic carries patients' dataduring the normal condition of a patient. Compare to other categories of traffic, use of periodical traffic for data analysis. This enables to minimize the unnecessary data transmission and this traffic can be easily handled by all the candidate networks.

- Emergency traffic (ET): It is initiated by sensory nodes when they measured data over cross a normal preset threshold or in an emergency situation. Such type of traffic is totally unpredictable. These data strictly required in terms of reliability with low latency. Hence, need to set high QoS attributes in the network.

- On-demand traffic (ODT): This data traffic is triggered by the concern people like doctor or medical staff to acquire certain information for a diagnosticpurpose. Including, Table 1. Shows in detail the requirement of some commonly used medical sensor's data traffic. Thereby, to meet the required efficiency in healthcare service, design WBAN protocols to handle heterogeneity and change in QoS requirements for healthcare traffic.

Table 1: Typical Bit rate and delay requirement for healthcare data (IEEE standard 11073)

Data source	Bit rate [bps]	Delay [s]	Sampling rate [Hz]
Electrocardiogram (ECG)	10 –100k	<10	63 –500
Blood pressure [mmHg]	10 –30	>120	63
Non invasive cuff	0.05	30 –120	0.025
Cardiac output [L / min]	1k	<10	63
CO 2 concentration	1k	30 –120	63
Temperature (°C)	0.3	>120	0.02
Patient ID Band	0.05	>120	0.0002
Inter cranial brain pressure [mm Hg]	16	10-30	1

Firstly obtain traffic information from the table 1. And assign priority as per the application. In viewpoint of that NT traffic has to assign low priority and ET traffic with the highest priority.

4. MODIFIED CONTENT-CENTRIC NETWORKING (MCCN) APPROACH:

In this section, introduce an energy efficient approach. This approach will encounter following main challenging issues:

- Ensure seamless switching and selection of best network during vertical handoff.
- How to reduce unnecessary handoff?
- How to satisfy require quality of service in low power WBAN network environment?
- How to enable event-driven sensor node to reduce energy consumption?

4.1. Quality of Service Attributes and User Preferences

Best network selection during handover buildsupon a set of attributes which comprise the node energy, traffic type, user preferences, network conditions, and applications. In our work, we focus on some QoS attributes like RSSI, latency, velocity of nodes etc. Some of the attributes calculate by using following relations

The basic parameter, the RSSI in radio propagation environments computed as follows

$$RSSI_{dBm} = P_t - 10\eta \log\frac{d}{d_0} - X \quad (1)$$

$$f_x(x) = \Delta_x^{-1} \times e^{\frac{x+\Delta x}{\Delta x}} \times e^{-e^{(\frac{x+\Delta x}{\Delta x})}} \quad (2)$$

Where P_t is the transmitter power level of the sender node in dBm, path loss coefficient is η(η=2 for outdoor), distance between the transmitter and the receiver nodes is d, $d_0$is a far field distance and X is a Gaussian distribution random variable. Typically normal range of RSSI for data networks -45dBm to -87dBm…

The percentage of Utilization is given by Equation (3)

$$U_{Utilization}(\%) = \frac{Data(bit)}{B.W(\text{Hz}) \times \text{Time(s)}} \times 100 \quad (3)$$

The following equations (4), (5) and (6), respectively shows the latency in the 802.11x, UMTS and LTE [21]

$$L_{WiFi} = T_{difs} + T_{sifs} + T_{boff} + T_{data} + T_{ack} \quad (4)$$

Where T_{data} is data transmission time,T_{boff}isback-off slots time and acknowledgement time T_{ack}aregiven by the following relations

$$T_{data} = \frac{L_{phy} + L_{machdr} + L_{macfrt} + payload}{R_{data}} + \frac{d}{s}$$

$$T_{boff} = bo_{slot} \times T_{boslots}$$

$$T_{ack} = \frac{L_{phy} + L_{machdr} + L_{macfrt}}{R_{data}}$$

Latency for UMTS and LTE is given by

$$L_{UMTS} = 5ms + X \times 10ms + \frac{l}{\alpha} \times 10ms$$

$$L_{LTE} = T_{up} + T_{Buff} + T_{re} + T_{U\_sch\_r} + T_{U\_sch\_g} + T_{UE} + T_{eNodeB} + T_{core} \quad (5)$$

The parameters used in this paper are listed in Table 2.

Table 2. Notation and Definition

L_{phy}	*Length of Physical header*
L_{machdr}	*Number of MAC headers*
L_{macfrt}	*Size of MAC footer*
R_{data}	*Data rate of the network*
d	*Distance from the sender to the receiver*
s	*Speed of light*
bo_{slot}	*Number of back-off slots*
$T_{boslots}$	*Time for a back-off slot*
T_{difs}	*Distributed inter-frame space time*
T_{up}	*LTE uplinks transmission time*
T_{Buff}	*LTE buffering time*
T_{re}	*LTE retransmission delay*
$T_{U\_sch\_r}$	*LTE uplink scheduling request*
$T_{U\_sch\_g}$	*LTE uplink scheduling grant*
T_{UE}	*UE delay estimated time*
T_{eNodeB}	*e_NodeB delay estimated time*
T_{core}	*Core network delay time*
l	*Payload length of the data packet*
α	*Length Factor*

4.2. Evaluation of Energy Consumption

Evaluation of total energy budget, first we analyze and calculate the additional energy requirement in the total energy for each application during handover execution. This technique help us to compute the energy best aspect of the proposed MCCN+MADM approach and compare with the other three handover approaches. Following is the relation to calculate the total energy consumption of wireless networks $E_{WiFi, UMTS, LTE}$(mJ)

$$E_{WiFi,UMTS,LTE}(mJ) = \sum (E_{pro} + E_{transfer} + E_{tail} + E_{idle})_{WiFi,UMTS,LTE} + E_{handover} \quad (6)$$

Further, the additional energy requirement during handover execution calculated as follows:

$$E_{handover} = E_{turn\_on} + E_{associating} + E_{promotion\_state} + E_{turn\_off} \quad (7)$$

Where E_{turn_on} is the energy for new network interface turn on, $E_{associating}$ **is the** energy of the new network $E_{promotion\_state}$ **isthe energy for** promotion state to establish a new connection and $E_{turn\text{-}off}$ energy for the network turn off.

Table 3shows the measured value of promotion energy consumption (E_{pro}), (E_{tail}) and (E_{idle}) are the tail and idle energy requirement respectively.

Table 3. Network ranking order with respect to the ranking values [21].

Parametres	**WiFi**		**UMTS**		**LTE**	
	Power (mJ/s)	**Duration (s)**	**Power (mJ/s)**	**Duration (s)**	**Power (mJ/s)**	**Duration (s)**
WiFi turn on	**24**	**--**	**24**	**-**	**24**	**-**
WiFi turn off	29	-	29	-	29	-
Associating	120	2	250	1	250	1
Promotion	124.4	0.08	659.4	0.058	1210.4	0.026
Tail	119.2	0.24	601.3	0.824	1060	0.1
Idle on	72.4	0.0074	374.2	0.055	594.3	0.0432
Idle off	0	-	0	-	0	-
Idle cycle	-	0.308	-	5.112	-	1.2802

From the above Table 3, the data transmission energy takes a large part of the total energy consumption. The magnitude of this mainly depends on the transmission duration t (in sec) and the up/downlink throughput (Mbps). The data transfer energy for WiFi, UMTS and LTE is computed as follows:

$$\begin{cases} E_{WiFi(mJ)} = \{218 \times Thro,put(\text{Mbps}) + 132\} \times \text{time} \\ E_{UMTS(mJ)} = \{869 \times Thro,\text{put}(\text{Mbps}) + 721\} \times \text{time} \quad (8) \\ E_{LTE(mJ)} = \{438 \times Thro,\text{put}(\text{Mbps}) + 1311\} \times \text{time} \end{cases}$$

We use equations (6)–8), to compute the total energy consumption for each application based on the throughput. Finally use the equation 9 to calculate energy consumption efficiency

$$E_{percentage} = \frac{E_{Max} - \sum(E_{WiFi,UMTS,LTE} + E_{handoff})}{E_{Max}} \times 100 \quad (9)$$

Where E_{max} is the maximum energy consumption.

5. Simulation Results

The proposed MCCN model is simulated by using NS2 event-driven simulator, considered thenetwork topology which is shown in figure 1. Deploying two eNodeBs, two BSs, Two RANs and four APs, MCCN module with a total coveragerange of 2000 sq meter. The patient monitoring deployed within the coverage range.

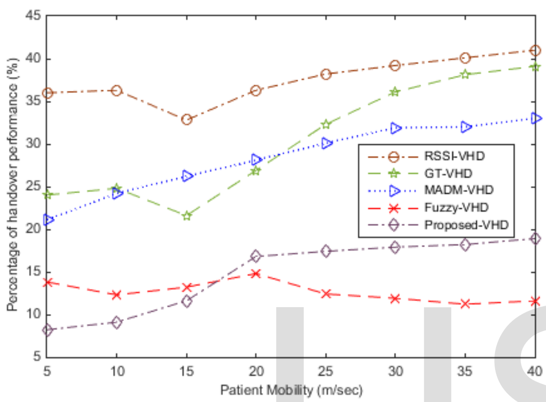

Fig. 2 : Handover efficiency for different handover approaches

The percentage of handover per unit time (consider per 1 hour) experienced with different handover approaches are shown in Fig. 2. It includes MADM-VHD, RSSI-VHD, GT and Fuzzy approaches versus proposed MCCN+MADM during a WBAN's user mobility. The obtained results evidence that MCCN+MADM approach gives enhanced performs compared to others and it reduces the ping-pong effects which lead to reduce 28% of unnecessary handoff compare to RSSI method. Further, the handover decision excited is only if it is needed. Indeed, if the presently serving network still meets the minium application requirements, the handover doesn't taken place, even if a better network exists in the coverage area.

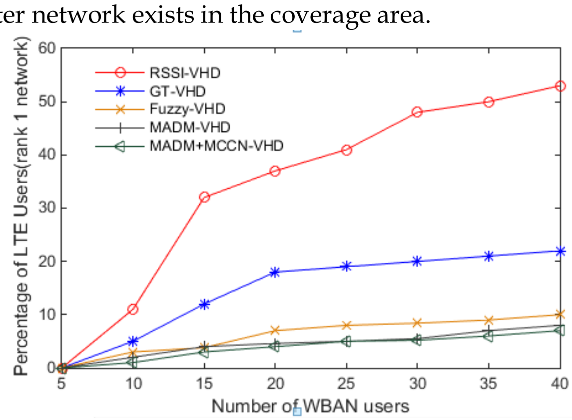

Fig 3: Percentage use of LTE in an overlay networks zone.

5.1. The Number of Handovers and No. of LTE user

The performance analysis and evaluation as per the simulation setup as mentioned above as describe in this section.In most of the research papers considered few matrices for evaluation, mainly RSSI, mobility throughput etc. For user's preference, we considered QoS and energy consumption along with basic parameters and investigate the effectiveness of the proposed approach.

WBANs sending critical traffic in real time, hence best outer body network are mandatory to pass the data to e-healthcare monitoring system. Since we focus mainly on energy saving criteria enables to use low energy operating network. The simulation result in Fig 3 shows the WiFi is least power hungry compared to other networks.LTE has the large cover range and consumes more power; it limits the usage of LTE by the proposed approach.

5.2 Energy efficiency

The fundamental objective of the proposed MCCN_MADM vertical handover decision is energy efficiency approach compared to other five handover approaches. The simulation result proves that in Fig 4. Wi-Fi has the least power consumption compared to UMTS and LTE. Hence, initially, WiFi is the default network for WBAN users. For ET traffic, the user node connected to the LTE immediately from the default WiFi network by handover operation. Therefore, the total energy consumption of LTE is the maximum consumption in this case. The energy consumption of WiFi is approximately 32mJ against to 148mJ of LTE over the simulation duration of 100 seconds. Additional transmission energy needs due to packet overhead and simulation result is shown inFig.5.

During handover processes time 't', the additional energy consumed may be calculated as follows:

$adding\_t = ER\_overhead + ER\_switch$ (10)

Where $ER\_overhead$ is the packet overhead additional energy needed while handover operations time t.ER_switch is the switching interface additional energy during the period t.In the simulation result notice that the RSSI-VHD handover consumes 29.8% of the total packet energy this is due to extra packet overhead during handoff time. The proposed method takes only 11.2% of the total packet energy.

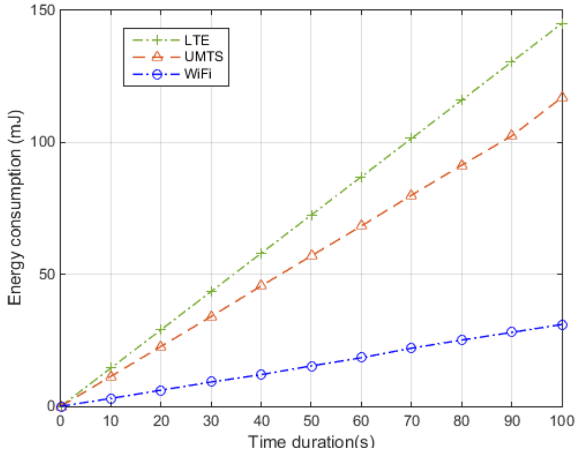

Fig 4. Energy consumption of different networks

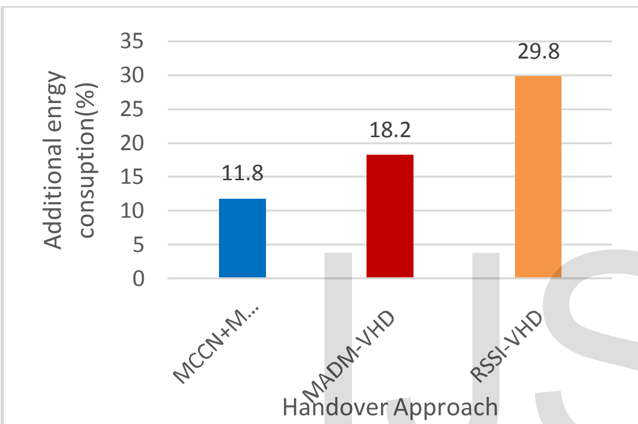

Fig 5.The additional energy requirement for handover approaches

The type of selected network for sensory data transmission and the total number of handovers are two main issues are responsible for more energy consumption for each application and this are proved in the previous analysis. Fig.6 and Fig.7 shows that the energy usage of the802.11x, 3G, and LTE networks is considerably different for WBAN traffic. The energy needed for ET traffic is more and essentially it increases for real-timescenario. It takes the least Energy for normal traffic (NT). Further both the cases meet the required QoS. MCCN approach drastically minimizes the unnecessary handoff with the presence of different QoS and user preferences. Finally, as a result of all basic performance parameters, the proposed MCCN_MADM approach performs well (which attains to (43.6%) in terms of energy efficiency compared to RRSI-VHD(18.6%), Fuzzy-VHD(only 13.4%) and MADM_VHD (28.9%).

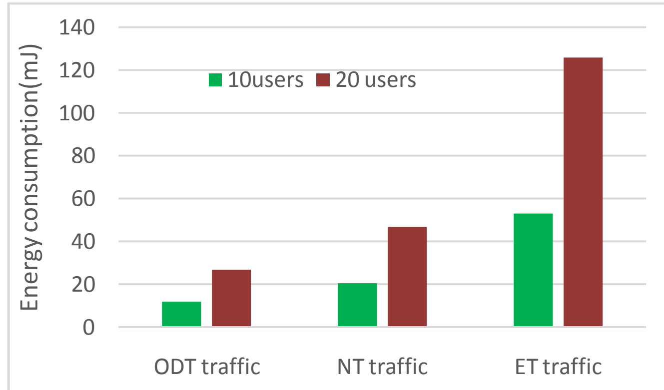

Fig 6. Energy requirement of different WBAN traffic

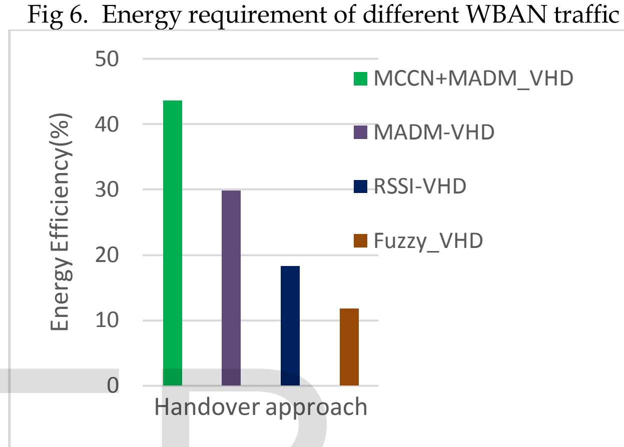

Fig7. Total energy efficiency for different approaches

6.CONCLUSION:

The fundamental design objective of WBAN networks is energy efficiency. The life duration of each sensor node is highly depending on the energy level of the battery. In this paper, we focused on the hand over and energy conservation issues in Wireless Body Area Networks. The number of handovers and retransmission policy are directly complemented in the energy consumption in the node. The proposed technique mitigates these issues. In particular, handover decision module uses the MADMA technique to enhance the handover performance with least energy budget. WBAN users select the best network for data transmission with reliability and QoS. Eventually, the proposed method outer performance compares to previous approaches and increases the energy efficiency. Future scope forworklies in adaptive energy consumption technique with more networks attributes.

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