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Performance analysis of effective communication technologies in sports management

Dr. MB Palanikumar and Dr. K Kumaravel

Abstract
The Wireless technologies played a vital role in all applications which leads an Effective Communication for maintaining in sports and fitness in life. In this paper, through research and analysis of the communication network of the physical activity monitoring system, we combine wearable technology and identification technology and design a physical health monitoring bracelet that integrates multifaceted physical data collection and an effective identity-matching function. We match the identity through the chip and collect the physical fitness data generated in the process of exercise and centralized tests by the sensor in real-time. Finally, the data transmission is realized through the WIFI communication function to achieve the purpose of monitoring physical exercise and improving physical quality. To ensure the continuity and stability of information transmission, the joint transmission method of direct transmission and indirect transmission is essential. Besides, considering the energy causality limitation of sensor nodes and relay nodes, a collaborative transmission model of a wireless body area network based on wireless cognitive network is constructed. And, a power allocation algorithm based on maximum ratio merging and wireless cognitive network is proposed, which puts forward a new idea for the future research of wireless body area network resource allocation.

Keywords: ICT, information and communications technology, sports and physical education

1. Introduction
In the current decade, technology-supported training and teaching methods have brought revolutions to sports training and physical education. The approach offers an innovative and modern way to overcome the usual limitations and difficulties in traditional training and teaching methods. The methodological changes can be visible in every part of modern-day training and teaching in sports and physical education. Now day's uses of ICT have a significant effect on training program preparation as well as on the outcome of the training program (Khan, Khan, & Khan, 2011) [9]. Modern technology like sensor-based wireless devices, high speed internet, innovative software, video sharing platform, and social networking sites have been highly contributing to the innovation in sports training as well as to class room teaching (S. & V., 2007). The easily available technological devices make it easier for the trainer and coaches to design and plan innovative and effective training programs on the other hand it also helps the physical educators to prepare effective and easily understandable teaching lessons. The Rapid development in the use of technology in sports have set the level of performance at height. Using these advanced technologies and innovative training, performance level continues to grow exponentially in the field of sports and physical education.

As most of the sensor nodes in the body area network have the characteristics of miniaturization. The energy density of the battery in the node is limited, and the energy that the battery can carry is very limited; once the battery energy is exhausted, the network will stop monitoring the human body, which endangers the life and property safety of users [4]. However, it is extremely inconvenient to replace the battery and charge it repeatedly regularly, especially for the sensor nodes placed inside the human body, and it is very difficult or even infeasible to replace the battery, which seriously limits the working life of the infinite body area network [5]. In addition to hospital patient use, wireless body area networks can also monitor the health of normal people, such as sports athletes, and can monitor their sports heart rate, pulse, fatigue level, and other important data in real-time, which can not only improve the efficiency of the athletes' professional training but also make the athletes' training more planned [6].

Also, the wireless body area network has important applications in the daily life of the masses. In this paper, we design a physical health monitoring bracelet that combines multifaceted physical health data collection and effective identity matching in one, which can collect data generated from students' exercise process and centralized testing in real-time in many aspects to achieving the purpose of reducing accidents during sports exercise and preventing data falsification during sports testing.

Because the TCP/IP protocol is very simple and reliable, their combination determines most of the current communication methods (from wired backbone networks to hybrid networks). Now the TCP protocol has become the de facto standard for most applications. The TCP protocol was originally designed for wired networks. In wired networks, the random bit error rate is negligible. Congestion is mainly caused by packet loss. Although this mode of transmission ensures the reliable nature of network transmission, many influencing factors are redundant to consider, such as the paths that must be available for transmission from end to end and the relatively long prep time for information transmission. Wireless networks have developed rapidly in the past few years, and different intelligent classes of terminal devices have emerged one after another [7]. Mobile nodes in a mobile self-organizing network can perform various calculations independently and can communicate with each other within a known range. In addition to the above advantages, this network cannot guarantee the reliability and rate of information and data transmission compared with TCP/IP nodes, mainly due to the nature of the nodes themselves, communication range, and environment, which causes various transmission delays.

1.1 ICT Tools for Sports and physical education

Now day's coaches and trainers have many available technical options to use as ICT tools. The majority of these tools can be easily accessed or integrated into training programs. Here we will discuss about the usage of some of the popular ICT tools in modern-day sports training and physical education.

1.2 Field-based ICT tools

These are the kind of ICT tools which are used in on-ground/field situations. One of the major field-based ICT tools is GPS-based tracking devices. The study on GPS-based tracking devices itself is a huge chapter. Along with technological advancement precision of this kind of device has been improving. Nowadays using these devices data can be easily obtained and analyze for performance improvement (Lynch & Borno, 2018) [11]. Dedicated sports-specific GPS-based devices have been developed to improve and monitor the performance of the players (Fox, Scanlan, & Stanton, 2017). Most of the outdoor activities, like hiking, fishing, paragliding etc. rely on precision navigation. Using these devices, a player can be tracked irrespective of on land or in water or in air. Long-distance runners use these devices to navigate their routes. Swimmers use these devices in open-water long-distance swimming competitions, where there is a high chance of getting distracted from the actual path. In team sports like soccer, rugby, kabaddi, hockey etc. multiple GPS devices are used to track every team member throughout the whole training sessions or even in match situations. In every outdoor racing sport, GPS is a mandatory device to be attached with the player. It helps the officials to keep track of the players as well as for the players, it helps to track their route and progresses.

2. Current Status of Research

The continuous development of electronic information technology has brought about more advanced wearable devices with features such as portability, high sensitivity, and low cost, which can be more easily used by people in their daily lives [8]. Wearable devices can also be called wearable computers because they can collect various data generated from people's physical activities, including motion data and physiological data, just like microcomputers [9]. Wearable devices were first invented in 1960, and the inventor was the Media Lab of MIT in the U.S. The technology was invented to facilitate people's lives, so the original wearable technology is a combination of various sensors and a master controller that allows data to be processed in a portable space and converts analogue information back to digital information [10].

Pavithran, *et al.* designed a Markov chain–based model for energy harvesting nodes in wireless body area networks based on the movement state of the human body and calculated the rate of loss of human activity information with energy consumption to provide requirements for the design of future energy harvesting nodes in wireless body area networks [11]. Yingling *et al.* proposed an application for cross-layer design to maximize the energy consumption of different topologies [12]. Wang *et al.* designed an energy-efficient data transmission strategy for wireless body area networks based on energy harvesting techniques, by which sensor nodes can select the optimal transmission power for data transmission [13]. On the basis of the above research, based on the characteristics of the small wireless body area network, combined with the limited energy during wireless body area network transmission and the low efficiency of energy information transmission [14], we consider introducing the delayed transmission mode into the wireless body area network. After derivation, analysis, simulation, and other processes, it is verified whether it can solve the problems of wireless body area networks and whether it is suitable for wireless body area networks [15].

Cui, *et al.* propose a convex optimization-based combination of minimum parametric sparse arrays in wireless body area networks (WBANs) the combination of wireless energy and information transmission in WBANs and develop three application models to highlight key design challenges, solutions, and opportunities [7]. Bacco *et al.* analyze the reliability of WBANs and quantify the reliability of WBANs based on the network life cycle. The reliability of WBAN is quantified based on the network life cycle and a general formula for reliability expressed in terms of the number of sensors and Group Characteristic Parameters (GCP) and upper and lower bounds for reliability are derived. Based on the monotonicity of reliability, an algorithm using the average GCP is proposed to calculate the minimum and maximum number of sensors for a given network lifetime and the optimal number of sensors for given reliability.

2.1. Communication Network Design

Cognitive radio networks contain two types of users, primary and secondary users. Users with spectrum access licenses are primary users, which have priority to use the communication channel and do not have cognitive provisioning. Secondary users are users who are not licensed for spectrum access, are cognitive users and have cognitive provisioning. They can access the spectrum and use the communication channel only if there is no primary user, without causing any interference to the primary user, who leaves the channel when the primary

user reappears. Cognitive radio users select the vacant part of the spectrum that can satisfy their transmission quality requirements.

After sensing the available spectrum bands, the sub-user selects the best available spectrum band for transmission to meet its quality-of-service requirements, which is called spectrum decision. This process consists of three steps: in the first step, the spectrum is classified according to the detection data of the sub-user, the interference level of the primary user's terminal receiver, and the path distance loss at the primary and secondary user's end; in the second step, the information is collected in a processing centre, which prepares a list of available channels according to the activity requirements of the primary and secondary users; in the third step, the best channel is broadcast to the cognitive user, who adjusts its transceiver parameters to achieve communication in the available frequency bands [9].

The first type of spectrum sharing is based on spectrum type sharing and is divided into two subcategories: the first is unlicensed spectrum sharing, where all users have the same priority and secondary users can only access spectrum that is not licensed, or if the spectrum is free, the user can access the spectrum. The second type of spectrum sharing is authorized spectrum sharing, where channel access in the network is based on priority, and the primary user has a higher priority for accessing the channel, while secondary users can only access the channel without the primary user. The second type of spectrum sharing is based on network architecture sharing, which is divided into two subcategories: the first is centralized sharing, where the network processor controls spectrum access and allocation, and each user in the network forwards its requirements and information to the network processor, which thus makes spectrum allocations. The second type is distributed sharing, where distributed spectrum sharing is used where infrastructure is not available, and each node is responsible for spectrum access and allocation. The third type of spectrum sharing is the access of scheme-based sharing, which is divided into two subcategories: the first is coexisting spectrum access sharing, which allows secondary users to transmit simultaneously with primary users without causing any interference to the primary users in spectrum sharing. Usually, secondary users use spread-spectrum techniques to fully utilize the spectrum and need to keep their power below an interference threshold to minimize interference to the primary user, which is obtained by the primary receiver measuring its own received power. The second type is opportunistic spectrum access sharing, in which the secondary user opportunistically accesses the empty spectrum when the primary user is not in the spectrum. Since the secondary user uses the spectrum only in the absence of the primary user, it minimizes the impact of interference and spectrum utilization on the primary user [4-7]

A cognitive radio network architecture is given in Figure 1, which is divided into two parts: the authorized network and the cognitive network, including the primary user base station and the cognitive user base station, in addition to the primary and secondary users. The primary user in the network generally can operate certain spectrum bands, and only the primary base station can access and manage the operation, while the cognitive user has routing, transmission, MAC protocol functions, and the ability to communicate with other cognitive users. The primary base station generally cannot achieve the effect of sharing spectrum with cognitive radio users, and the cognitive user base station provides cognitive radio access services to various subusers without spectrum licenses.

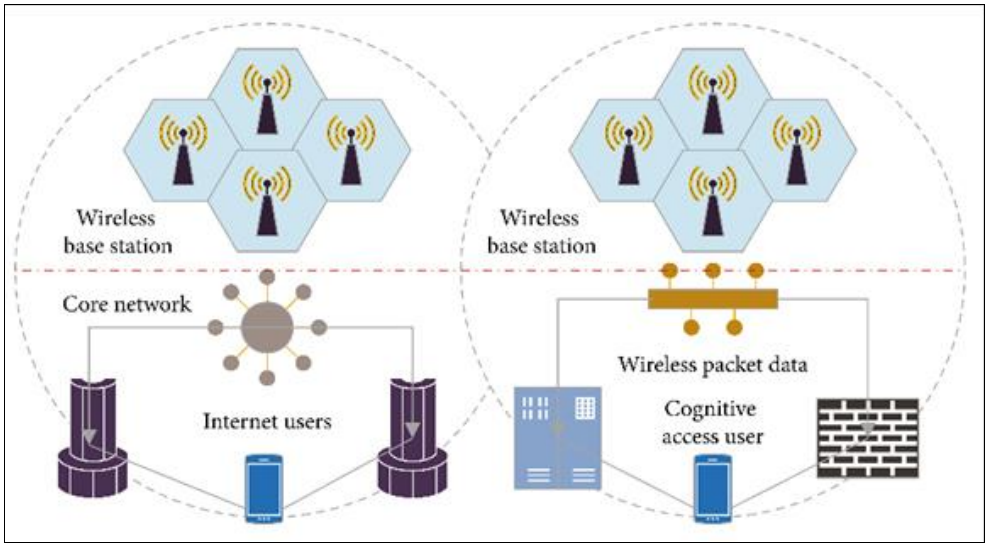

Fig 1: Wireless Applications using Cognitive Radio

Wireless communication network architecture.

The openness and broadcast characteristics of wireless channels make the secure transmission of information face serious challenges. Traditional secure communication mainly encrypts data through the upper layer of the network protocol stack, and this method has inherent difficulties and weaknesses in the distribution of keys. As a supplement to the traditional encryption technology, physical layer security technology has been widely studied and printed in recent years. Physical layer security technology uses the physical layer characteristics of the channel to ensure the secure transmission of confidential information from the basic principles of information theory. Compared with traditional cryptography, physical layer security technology has the advantage of not relying on the complexity of computing, so that even if the eavesdropper is equipped with powerful computing devices, it can still ensure safe and reliable communication.

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2.2. Design of the Physical Activity Monitoring System

The software design includes the program design of the main control module and the program design of each functional module, as shown in Figure 3, which shows the software workflow of the system. Based on the NRF51822 on-chip interface, the main control module is designed to collect and process physiological data, establish WIFI communication with the application side, send and receive data packets, and update the display of the bracelet in real time.

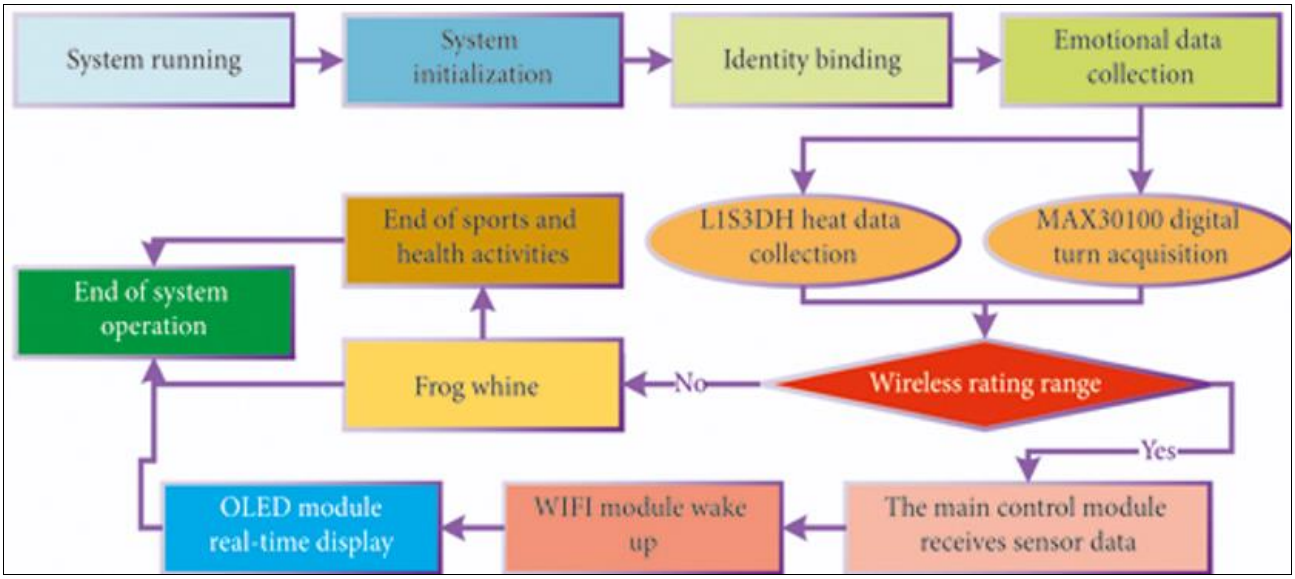

Fig 2: Physical Monitoring System using WIFI & Relay Nodes

2.3 System workflow diagram

In this model, relay nodes use time allocation protocols or power allocation protocols to decode information and collect energy and then use the collected energy to assist in the forwarding of information. Collaborative transmission not only extends the network transmission distance but also increases the system throughput and capacity. It is an important transmission technology of great interest to both academia and industry. Relay nodes applied in wireless body area networks are usually responsible for the bit-by-bit transmission of information on the physical layer between the destination and source nodes in case of poor channel state or uneven resource allocation of multiple sensor nodes. In this paper, the decode-and-forward collaborative transmission will be used as the relay transmission method. Wireless body area networks are short-range communication networks, so the introduction of relay transmission will greatly increase the channel state originating from between relay nodes, and it can also avoid the interference caused by signals from multiple sensor nodes to the source node to a certain extent.

To solve the partial collision phenomenon of the PA algorithm, the SA algorithm was developed, which divides the time into many discrete time slots based on the PA algorithm and divides the time slots into three types of time slots: successful time slots, collision time slots, and idle time slots according to the number of signals returned by the tag. The length of the time slot must be greater than the time required for data transmission. The tag is successfully recognized in the success time slot, and the tag sends data in the idle time slot; in the collision time slot, the tag collision occurs due to multiple tags sending data at the same time, and the system randomly delays several time slots before the collision resends data until all tags are successfully recognized by the reader, and the algorithm ends.

In a wireless body area network, all sensor nodes are placed inside or on the surface of the human body, and the nodes are not far from each other, so the distance between all sensor nodes and RF energy towers or handheld devices is almost the same, and the inequity problem seems to be eliminated on the surface. However, it should be noted that the unfair problem arises fundamentally because of the difference in channel conditions between nodes, and in wireless body area networks, human organs, extremities, and clothing all produce more severe shadow fading, making the channel conditions of sensor nodes vary greatly. Therefore, unfairness still exists in wireless body area networks, and the unfairness of throughput distribution among sensor nodes can affect user experience and even threaten the life safety of users, so it is an urgent problem to be solved.

3. Results and Analysis

The data values are displayed on the ICD display, while an alarm is triggered if the data is out of the normal range. The stored values are sent to the server with help. All the values are stored on the server in chronological order, and the monitor can log in to view the data of the monitored person through the login credentials, and then it can grasp the athlete's body temperature and heart rate during exercise in real-time, monitor his physical condition during exercise, and effectively avoid sports accidents. This data can also be used to develop individual training plans to achieve the best sports training results.

3.1. Analysis of Communication Network Performance Test Results

In this section, the proposed throughput is simulated and verified by MATLAB in the delay-tolerant transmission mode. Besides, the optimal system throughput is derived and the system performance is optimized by comparing and analyzing with the delay-tolerant and delay-limited transmission modes under the same simulation conditions, provided that the delay-tolerant and delay-limited transmission modes are known to be different. In all the following simulations, for multiple equidistant sensors, we set the distance between AP and sensor U; for multiple unequal distance sensors, we simulate based on the data provided; AP uses a mid-waist node and other ten parts nodes as sensor nodes. The channel model $Q = 10^3$, path loss index $\alpha = 2$, and energy harvesting efficiency $n = 0.6$.

Figure 3 plots the relationship between the average AP throughput and AP transmit power for different numbers of antennas under a single sensor. For the delay-tolerant mode, the asymptotic throughput rapidly approaches the exact throughput as the AP transmit power increases, although there is a gap between the two when the transmit power is low. The figure also shows that the system throughput in the delay-tolerant mode improves as the transmit power or the number of antennas increases.

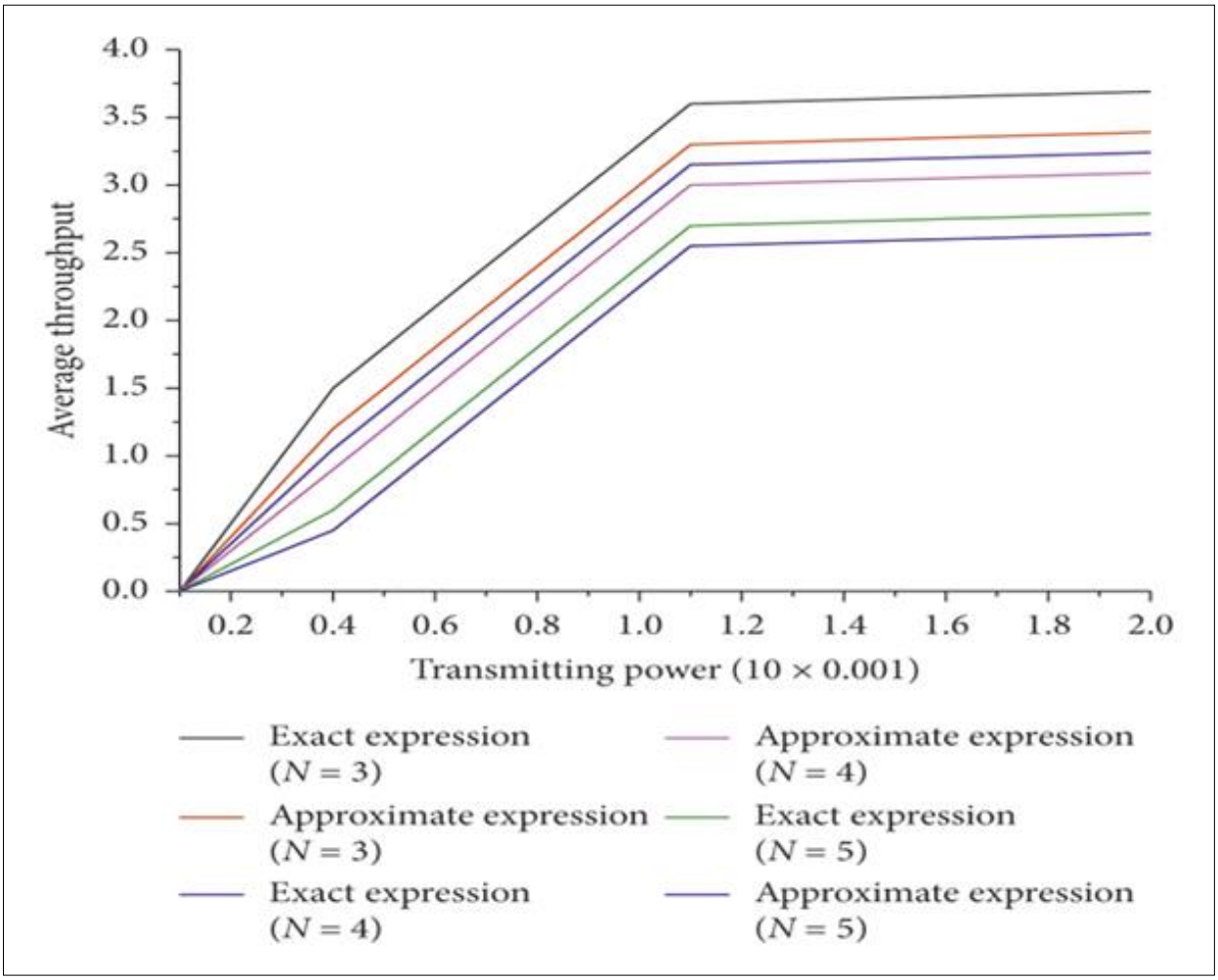

Fig 3: Ratio Analysis of Throughput & Energy Transmission Rate

3.2. Software and applications

Software is a set of instructions which tells the computer what to do once instructed. There are various kinds of software and applications available in the market. The usage of software and applications in sports and physical education can further be classified according to their performed task. Most of the biomechanical analysis software is integrated with number of video cameras. Some of this software are manual in nature and some of them are automatic. Three-dimensional biomechanical analysis software is much more complicated compared to the two-dimensional analysis software. Match analysis software is another important component of sports training tools in the recent times. Recorded videos can be analyzed in post-match conditions or in live situations. Live feedback and report of analysis can be explained to the players even in ongoing match situations. Nowadays, these match analysis software are very important to achieve the desired goal for most the team games or sports.

3.3. Analysis of Monitoring System Performance Test Results

The heart rate measurement method used in the MAX30100 sensor is a photoelectric transmission, which uses the difference in light absorption between oxygen-carrying haemoglobin and non-oxygen-carrying haemoglobin in the blood vessels to achieve the measurement. The light source generally consists of two types of LEDs: a visible red light with a wavelength of 660 nm and near-infrared light with a wavelength of 940 nm. The LED light emitted inside the sensor will pass through the body's light-transmitting layer and the light transmission rate will change with the arterial pulsation filling volume changes; at this time the MAX30100

built-in photoelectric converter will receive the light reflected by the body's tissue and will be converted into electrical signals and then amplified and output. Figure 7 is the haemoglobin absorption spectrum.

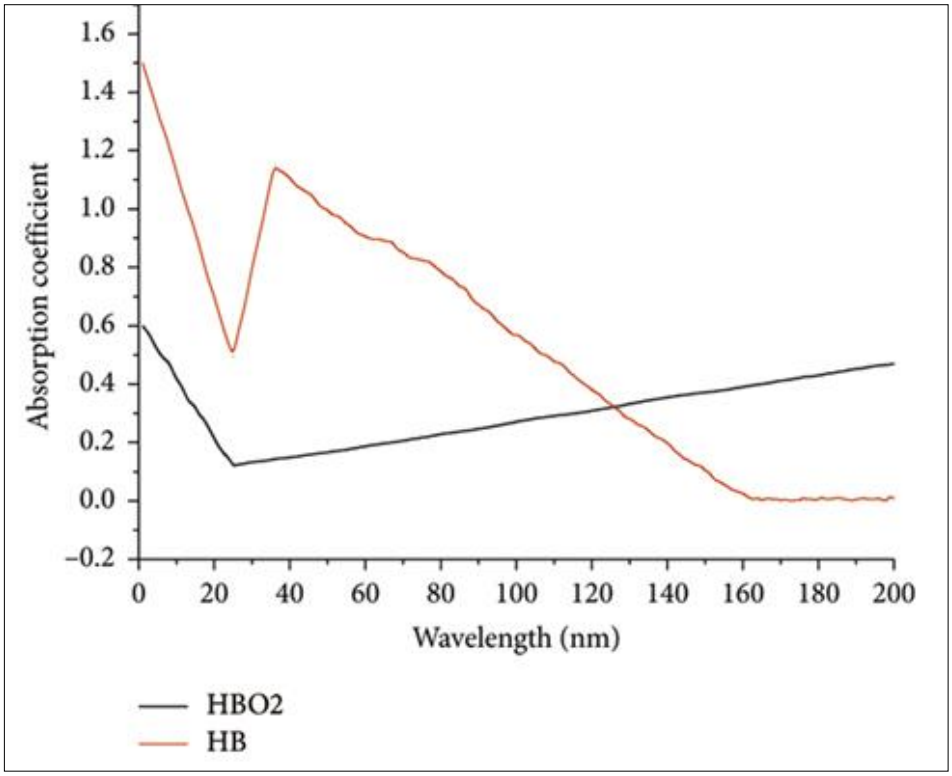

Fig 4: Average Wavelength & Bandwidth Consumption

4. Conclusion

This paper focuses on the problem of network resource allocation in multipoint classified wireless body area networks based on RF energy transmission. Considering the shadow fading generated by the human body and clothing, a multi-sensor node wireless body area network that communicates only through direct transmission is prone to interruption of communication. For wireless body area networks with high requirements for reliability and continuity of information transmission, a system model of multisensor node wireless body area network with a combination of direct transmission and relay transmission is more practical. In this paper, From a medical point of view, a new type of classified wireless body area network model is proposed by grouping multiple sensors according to the detected signals and according to the location of the human body where the same group of sensors can transmit common information. A pricing-based method for allocating energy resources in cooperative cognitive wireless energy supply communication networks is proposed.

ICT-based training methods have brought revolution to sports training. The revolution can be easily observed and recognized in modern training programs, training strategies, assessment strategies and in the way of relationship between trainers and trainees. The use of ICT makes it possible to bring the science of sports to the ground and is helping to connect physical activities with mental activities (50 Innovative Teaching Methods in Science, 2019). ICT is not only helping the sports persons in the practical field but also helping to educate them in theoretical works. It helps players to better understand their own bodies (Playing, And Even Watching, Sports Improves Brain Function, 2008). ICT brings motivation and enthusiasm to a sports person's mind and is helping to convert the dull and boring training sessions into attractive and interesting ones. It is found as one of the most effective ways for the overall development of a sportsperson. ICT helps the trainers to easily collect and store training-related data. Players can easily access their database and can see their progress report. Based on the stored and recorded data, predictions and hypotheses can be formulated relating to the performance of that sportsperson. (Lamsal & Choudhary, 2018) [10]. Using ICT players can get live feedback of their performance on the ground itself. They can analyze their performance using available software and applications and appropriate remedial can be taken for wrong technique or tactics. There are many advantages of using ICT in the field of sports training but the primary advantage remains the general improvement in performance and it can only be achieved by applying ICT in an innovative way.

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