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Optimized Channel Decision & Secure Data Transmission for Health Monitoring using Wireless Body Area Network through Cognitive Controller

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ABSTRACT

Remote monitoring system has been applied in different applications such as agriculture, industrial automation, defence, telecommunication and health care. In health care applications, wireless networks get the impact with Wireless Body Area Network (WBAN). WBAN is helpful in monitoring patients' health and it also possesses secure transmission and access control mechanism with different sensors. WBAN monitors the patient's health and transfers the information to data pool without influencing patient's daily routine activities. Further, the health report data are sent to the doctor over the network from the place of the patient without any data loss and delay. Due to increasing usage of wireless services, the available networks have been congested with heavy traffic which leads to miscommunication and delay. To overcome this scenario, solution has been proposed with help of Cognitive Radio Networks (CRN). Collected information are transferred to cognitive controller which acts as central node. Cognitive controller selects the channel to transfer the information with QoS as well as without any delay. Based on the input parameters, the channel selection process is optimized and it will also improve the system performance with secure transmissions. Using Fuzzy Inference System (FIS) optimizing, the channel selection process has been carried out and it also provides more accurate solution to choose the channel. For the optimization of the proposed approach Mamdani and Sugeno methods have been used. These methods yield the best results with minimum error probability of 0.9 compared to the

existing methods and these methods have achieved efficiencies of 98% and 99%, respectively.

Keywords: Sensors, Cognitive Controller, Encrypted Information, Fuzzy Inference, Network Selection, Sensor Networks, Wireless Communication.

1. INTRODUCTION

Development in wireless communication has created much interest in all the fields particularly in medical applications to communicate the information related to treatment and patient's history. There has been continuous development and inventions for the enhancement of human life with more smart automations. Many developments in biomedical applications provide accurate and efficient health care. The biomedical applications are not only used in hospitals but also in personal health caring facilities by including the Internet of Things (IoT) technology. Moreover, sensors also play dominant roles in the field of medical applications. The Wireless Sensor Network (WSN) [01] & [02] consists of different or similar sensors which are capable of sensing the environment and transferring the information to the central node over wireless medium. Based on the observed information and the physical phenomenon, the sensor nodes process the observed or the received information and then, transfer the information to the next sensor node which is very near to it. Thus, WSN forms the group of sensors and transfers the data within the group through wireless medium.

The keen interest of WSN has also been contributed in various applications such as smart home, smart vehicles, surveillance, agriculture, disaster management and underwater communications. The process of observing, processing and transferring the information over a wireless medium will impact on developing a tiny product for low computational and high energy efficient applications. The current research focuses on Ultra Wide Band (UWB) technology for blood pressure and cancer detection in human beings with non-invasive

sensor. In this work, the usage of tiny low power sensors has been focused and one of the advanced low powered tiny sensors is WBAN. WBAN collects the information from the human beings or patients and communicates the sensed information to the hospital or medical assistance through wireless medium in a secure transmission mode.

Body Area Network (BAN) has the ability to communicate the data over wireless medium through a base station which is placed at the hospital and home. The sensor nodes observe the critical parameters of a patient and detect the symptoms of disease/ attacks such as heart attack, diabetes and asthma. They communicate the information of the patients to the doctor through mail services. Physiological sensors that are worn by the patients at their homes can help the doctors to suggest prescription to the regions where local health care staff are not available or the hospital beds are in scarce. These kinds of systems are much helpful for elder-care and also the patients who are paralyzed.

The sensors, which are utilized for analysing the changes in a patient's vital signs as well as for identifying emotions, must have basic electronic design complexity and long lasting battery life. WBAN is entirely different from WSN in view of secured protocol and the sensors in WBAN have limited power and memory. WBAN uses plug-n-play scheme for security purposes, and it gathers real-time medical data from different sensors with secure data communication and consumes less power [03].

Transmitter power control should ensure reliable communication in the fluctuating environment without any harmful interference. Dynamic Spectrum Access (DSA) is helpful for uninterrupted reliable communication. To improve the accuracy and efficiency of DSA, CRN has been introduced to improve the spectrum utilization and to increase communication quality, parameters [04] and [05] are introduced. The CRN is one of the promising techniques for spectrum underutilization. Spectrum sensing [06], [07] and [08] has been an essential

process in CRN to find the unoccupied channels for enabling DSA [04] and [09]. WBAN needs a unique quality of selecting the most suitable channel for medical monitoring purposes. CRN can be dynamically programmed and configured to utilize the best wireless channels in its vicinity for avoiding user interference and congestion. This radio automatically detects the channels that are available in wireless spectrum. Further, the radios change its transmission or reception parameters to allow more concurrent wireless communications in a given spectrum band at one location [10] and [11]. Recently, the concept of DSA has been emerged as a potential process for the improvement of spectrum utilization.

WBAN system is essential during large scale implementation. The present work has been concentrated on the paralyzed patients as well as the coma patients who need more attention than the normal patients as well as the patients who do not need medical assistants at all the time. The user should confirm the channel that best meets its goals for task execution. Hence, an efficient decision-making algorithm is essential to select the best channel among the networks that are available depending on the highest efficiency.

The rest of the paper has been outlined as follows: the background and the related works are presented in Section 2. In section 3, the system framework for the process of three tier architecture has been described. Section 4 depicts the proposed optimization techniques to select the optimum channel for secure transmission through BASE64 with two way encryption algorithm. The optimum channel selection and the decision results are analysed in Section 5 with help of simulated results and conclusion is provided in Section 6.

2. RELATED WORK

CRN is a wireless network which comprises several types of Primary Users (PU) and Cognitive Users (CU). These CUs deploy their cognitive abilities to communicate without harming the PUs [13]. The review has been performed to find the current status of the

unlicensed user device operation and it includes available spectrum, interference potential, types of devices, applications, and regulatory models, with a view of determining the changes or alternative approaches for regulating unlicensed devices that promote more efficient and productive use of spectrum. The FCC provides a legal right to the licensees and other users of the spectrum. It also manages and identifies alternate approach for promoting most efficient access of spectrum [09].

The application of fuzzy logic has been explained for telecommunications and a novel fuzzy inter-related scheme has been proposed by [14] for cooperative spectrum sensing in CRN. For identifying the unoccupied channel in low Signal to Noise Ratio (SNR) range, Cyclostationary Feature Detector (CFD) and Auto-correlation Detector (ACD) and for high SNR range, Energy Detector (ED) and Singular Value Detector (SVD) as multistage detection techniques have been adopted by [15]. They have achieved the minimum sensing time for the CUs.

The distribute spectrum sharing function used in CR provides two different types of users such as selfish user and co-operative user. It gives some learning algorithms for which the user has the priority to have channel allocation and this no-regret learning algorithm is suitable for non-cooperative scenarios as well as needs only a minimal amount of information exchange. The co-operative user improves network performance through different spectrum sharing techniques [16]. For the co-operative users, a comparative study has been performed to find the effects of probabilistic and deterministic global search method in artificial neural network using fully connected feed forward multi-layered perceptron architecture.

The open spectrum approach can achieve near optimal spectrum utilization by providing opportunity to the users to sense and utilize the available spectrum. The controlled access scheme has offered the user to collaborate the access and optimize the spectrum for the entire network. The above network environment is static. If the environment changes,

network wide spectrum allocation is performed. It provides low complexity scheme to achieve fast spectrum access and it has an opportunity in temporary variation [18]. An overview of three Artificial Neural Network (ANN) architectures such as FLN, FFRP and LVQ has been proposed. Those ANNs have been applied for the detection and classification of malfunction of wear and damage of a gearbox operating under steady state conditions. Three artificial defects are deliberately introduced to the gearbox. Vibration signals collected from the extensive experimentation are analyzed using time and frequency domain descriptors and they are used as feature vectors to feed the ANNs. The results show that the FLN learns more quickly and it is more accurate in operation than the FFRP and LVQ. The LVQ algorithm exhibits faster rate of convergence than the FFRP but suffers more from misclassifications [19].

In the upcoming environment, the CR systems require enriched decision making and environment aware processes. These techniques are helpful in handling multidimensional, conflicting and usually non-predictable decision making problems. Hence, fuzzy logic can be used in cooperative spectrum sensing to offer additional flexibility to the existing methods [14] and it uses three or more layers of neurons. Hence, it is more powerful than the perceptron as well as it can distinguish the data that are not linearly separable, or separable by a hyperplane.

The authors [01] have discussed how to choose channels, how to manage it and how to fix the channel with efficient data transmission within the transmission zone. For channel selection, it is concluded with exact decision by using fuzzy logic system. This work is based on Stone-Weierstrass theorem and an Interval Type-2 Fuzzy Neural Network (IT2FNN) is a universal approximation which uses a set of rules and Interval Type-2 Membership Functions (IT2MFs) are used for this purpose. Simulation results of nonlinear function identification using IT2FNN for one and three variables and for the Mackey-Glass chaotic time series

prediction are provided to define the concept of universal approximation.

CRN tomography obtains the required parameters at the link and the network levels for successful CRN operations. CRN tomography gives solution to the CRN to obtain intrinsic parameter and provides smooth CRN operation by the learning algorithm [20]. Neural computing is an information processing paradigm, which is inspired by biological systems composed of large number of highly interconnected processing elements working in union to solve specific problems [21]. Using Common Control Channel (CCC), the authors [22] have proposed the handoff scheme for the cognitive users. In their approach, based on the PU, free channel usage history is stored in both the transmitter and the receiver and it has been considered for the channel switching techniques. The authors have considered the least reappearance history of the PU channel as the prepared channel for the spectrum handoff for the cognitive users. To minimize the usage of battery of the devices used in CRN, the authors have proposed a new approach by adopting the cloud computing / geo location database techniques. The channel selection and the sensing operations have been moved to cloud and it is named as Spectrum Agent. To improve the system performance and to maintain a continuous stream network connection, a Critical Path Method for relay selection has been proposed [23].

To improve the performance, a novel vertical handoff decision algorithm based on fuzzy logic with the aid of grey theory and dynamic weight adaptation has been dealt. The GPT receives 4 sample Received Signal Strengths (RSS) as input parameters, and calculates the predicted RSS to reduce the call dropping probability. The fuzzy logic theory based quantitative decision algorithm takes 3 QoS, RSS, BW, and MC as input parameters. The weight of QoS metrics has been varied to trace the network condition. The final results demonstrate that the proposed algorithm provides high performance in heterogeneous as well as homogeneous network environments [24]. The work [04] follows IEEE 802.22 proposed

coexistence beacon protocol. This mechanism carries the information of dynamic resource renting and solves the problem of spectrum sharing for inter-BS. Due to high flexibility and low complexity, fuzzy rules based on empirical laws adjust the parameters to control the radio resources. The results reveal that the proposed scheme can meet the goals of the dynamic spectrum sharing to improve the resource utilization and fairness. Traditional spectrum sensing in cognitive radio system is not enough for multi-link operation and network function.

Standard multilayer feed forward networks with one hidden layer using arbitrary squashing functions are capable of approximating any Borel measurable function from one finite dimensional space to another for any desired degree of accuracy, provided sufficiently many hidden units are available. In this sense, multilayer feed forward networks are a class of universal approximations [12]. In this work, continuous mapping can be approximately realized. The output functions of multilayer neural networks with at least one hidden layer are sigmoid functions. The starting point of the proof for the one hidden layer case is an integral formula and from this, the general case can be proved by induction. The two hidden layers case has also been proved by using Kolmogorov- Arnold-Sprecher theorem and this proof has also provided non-trivial realizations [25].

Now days, the modern microelectronics will sense, monitor and control the environment. When it is applied in medical applications, it needs some quantity/ parameters such as the size will be small and operating time will be minimum and reliable [26]. DSA identifies the unused portion of the licensed spectrum and utilizes the spectrum in an efficient manner without affecting PU. It has the potential to increase the spectrum utilization by allowing CU (non-licensed user) opportunistically to re-use the spectrum in an interference limiting manner [27].

To increase the capacity of mobile network, the authors [28] and [29] have proposed a

algorithm namely a Predicted Mobility Based Profitable Relay Selection Algorithm (PMBPRSA) based on the mobile relay mobility. Budget constraint has been emphasized by this algorithm for different levels such as operator, mobile user and mobile relay. To predict the mobility, the authors have used Bayesian game theory and Graph Theory concepts [30]. To reduce the SU traffic, the authors [31] have proposed Moving Target Defense (MTD) mechanism for temporal and spatial diversities. During the transmission phase, providing runtime data, shuffling pattern and false data injection attack in time domain and multiple frequencies hopping in space domain mechanism have been used in their approach.

WBAN will cause electromagnetic interference to bio-medical device and select priority channel for priority access of device. CR, which controls EMI, improves the performance by incorporating multiple channels and limits the number of secondary user in a system, has been proposed [10]. Ultra Wide Band (UWB) radio signal makes less invasive medical application instead of traditional wireless sensor. But, inter-connect in between UWB and WBAN causes some interferences and they can be overcome by CR technique [11]. New system utilizes all the frequencies as efficiently as possible. DSA management provides an emerging technology with spectrum sharing models and dynamic spectrum access method. They researchers have mainly worked with spectrum sensing in MAC layer in CRN based on overlay spectrum sharing policy and it may raise an unlicensed user coordination problem [05].

Generally, automations depend on microelectronic components. Hence, the present works also approaches with WBAN which works economically and efficiently. In the proposed work, WBAN with sensors has been used in the field of medical applications. But nowadays, electronics components like sensors are used with lots of electromagnetic interferences and these interferences will cause problems. As a result, the performance of CRN as a promising solution with DSA has been used for efficient with less interference

environment and DSA also performs an efficient data transmission among the users.

MLP networks are general-purpose, flexible and nonlinear models consisting of number of units organized into multiple layers. The complexity of MLP network can be changed by varying the number of layers and the number of units in each layer. The performance comparison between multi-layer perceptron has been presented. The study has investigated the performance of three algorithms to train MLP networks and found that the Back Propagation (BP) algorithm is much better than the other algorithms [32]. A Back-Propagation Neural Network (BPNN) processes the experimental results of series of remotely sensed data. The generalization capacity of a trained BPNN can approximate the experimental results of similar data. The results indicate that BPNN provides a powerful tool for categorizing remote sensing data [33]. DSA for parallel channels, which have been occupied by PU, arises with a problem of frequent analyze of channel performance. Hence, Markov Decision Process (MDP) has been used to provide mathematical frame work for this model where as it requires more traffic model and accessing capabilities of two or more secondary users [34].

To improve the efficiency of WLAN the authors [35] have proposed an optimization algorithm based on the waiting time in both Uplink and Downlink. Non preemptive scheduling has been used to reduce the waiting time in Uplink where as to increase the waiting time in Downlink, they have adopted the preemptive scheduling.

The present work mainly focuses on three tier architectures to assist the paralyzed patients and to securely transmit their health information to the hospital concerned or for the medical assistance. In the first tier, the sensor node collects the information and the collected information are communicated to the central node known as cognitive controller which can select the optimized available channel using DSA for fast, secure and reliable communication. In the second and third tiers, the information is processed in more secure

manner and then, transferred to the end user part.

The proposed work propose a system architecture which includes WBAN networks, used for monitoring the patient's health report and a cognitive controller which selects the suitable channel among the heterogeneous networks for transmitting the information gathered from patients through the WBANs to end user may be a doctors, medical officials, emergency care, relative, etc., Ensuring high spectral utilization, efficiency and transferring information without any delay with fulfilling some imposed QoS requirements is the main goal of the proposed systems.

As well as to improve the efficiency of DSA, in the proposed work, the channel selection operation has been deployed using Fuzzy Interference System (FIS). Here, the Mamdani and Sugeno methods have been adopted to select the best and suitable channel to transmit the data through cognitive controller. For secure data transmission, a two way encryption algorithm has also been used.

3. SYSTEM ARCHITECTURE

Wireless communication plays a dominant role in networking technologies. Wireless data transmission has been used in various fields for digital norms and efficient results. In health care application, there has been an evolution of WSN. This WSN has some drawbacks such as number of access points, data loss etc and these constraints can be overcome through the way of WBAN. The WBAN comprises different connected sensors which are imparted in human body either inside or outside to monitor the health record information indirectly.

The existing WBAN system has comprised three component-based layers such as Intra-BAN, Inter-BAN and beyond-BAN layers. The intra-BAN layer consists of Bio sensors, Central node and cognitive controller and they act as a data extraction layer. The CR device in this layer communicates with the Access points or base station or satellites for node communication. The beyond-BAN layer acts as a bridge between the two layers, and it

transfers information to the medical personnel and database. This system selects the best network for communication, but it does not select the optimal network without data loss and network traffic. The best network must have the basic characteristics such as faster communication, no data corruption, efficient use of spectrum etc.

In the present work, three-tier architecture with some additional functionalities other than just transferring information to the destination has been proposed and it is shown in Fig. 1.

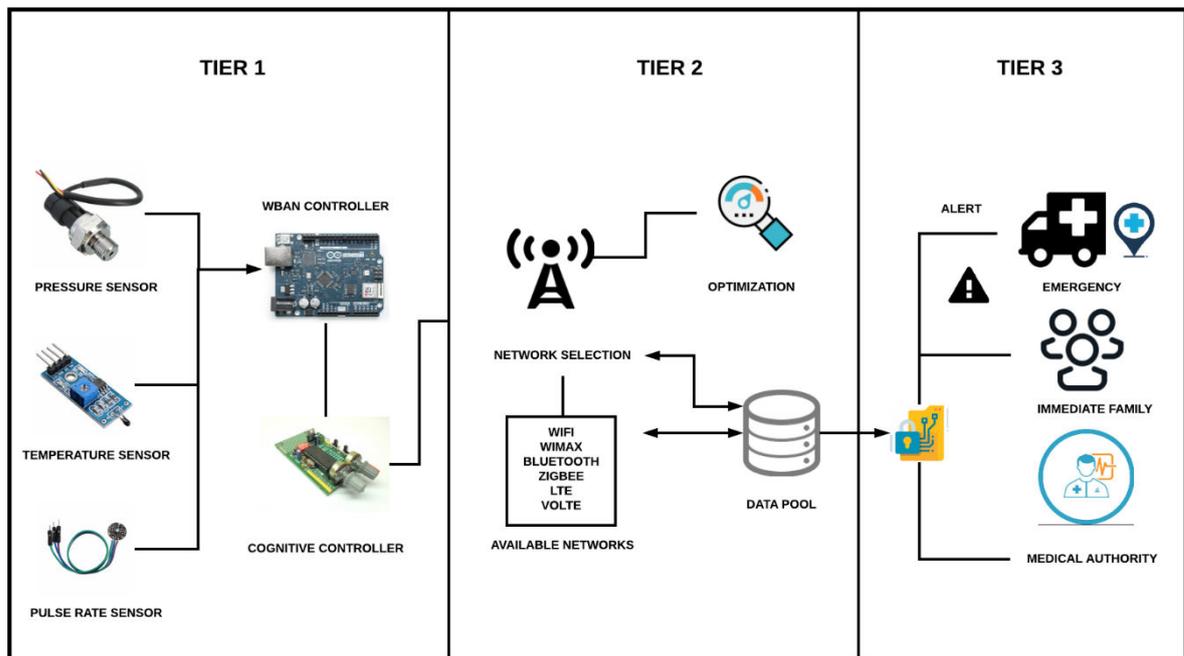


Figure 1: Three Tier Architecture

3.1 Tier 1: Data Extraction using CRC

Data Extraction layer comprises three sensors namely temperature sensor, blood pressure sensor and pulse rate sensor and these sensors are configured with central node to act as controller as shown in Fig.2. These sensors produce analog signals as output. The signals of the individual sensors are transmitted to the central node of WBAN controller. In the proposed work, Raspberry pi3 has been used as WBAN controller.

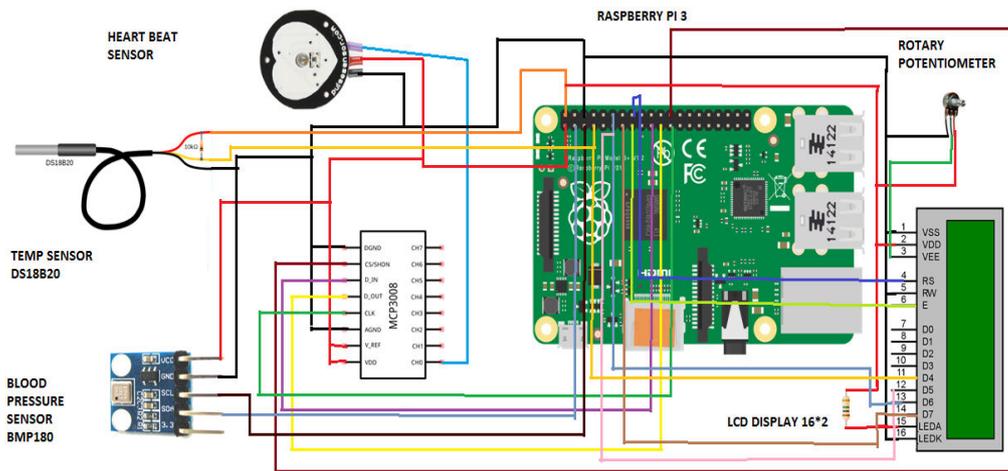


Figure 2. Configurations of Sensors

Fig. 2. shows the sensors connected over the patient's body transmitting the collected information to Raspberry PI board which is act as WBAN controller over wireless medium using WiFi communication. The data acquired by the sensors are stored in the WBAN controller. The copies values are stored for further reference in a separate data pool. Now, these data must be sent to the medical personnel and hence, a suitable network is needed based on the requirements. For efficient network selection, the concept of Cognitive Radio Controller (CRC) has been adopted. The CRC uses the dynamic spectrum access approach to achieve adaptive spectrum allocation and efficient spectrum access . The CRC has been connected using short-range network with WBAN controller and the examples are Bluetooth, Wi-Fi etc. In CRC, the presence of PU is checked, if the PU is idle and the CRC allows the CU to use the band until PU is inactive.

3.2 Tier 2: Channel Selection Layer

This layer is concerned with channel selection for transferring information to the end users. There are many networks such as Wi-Fi, WiMAX, LTE, VoLTE etc. available to transmit the data to hospitals. The selection of optimized channel is prior than selecting the suitable channel. For selecting the optimum channel, network attributes such as radio condition, bandwidth, coverage and handoff latency and user attributes such as residual

battery power, speed, power consumption and QoS parameters have to be considered. For selecting the optimized channel, FIS has been adopted in the proposed system. FIS is the major decision-making logic system which consists of member function, fuzzy rule set and surface curve. The Mamdani fuzzy inference process has been applied through four steps: Fuzzification of the input variables, rule evaluation, aggregation of the rule outputs, and finally defuzzification. Initially, the crisp inputs are taken and their degrees are determined. These inputs, which are fuzzified, are applied to the antecedents of the fuzzy rules. Since the fuzzy rule processes multiple antecedents, the fuzzy operator (AND) has been utilized to get a single number and it denotes the result of antecedent evaluation. To evaluate the rule antecedents, AND fuzzy operation intersection has been applied and then, this number (the truth value) is applied to the consequent membership function. The optimization is a simulation and in which, Mamdani and Sugeno methods have been adopted using MATLAB simulation window. After analyzing the channel selection efficiency by using both the methods, it is evident that Sugeno provides channel selection with an efficiency of 98% and Mamdani results in 99% efficiency.

After selecting the identified the optimal idle channels, then the CUs correlated the channel parameters with end user network for transferring the information over that network with DSA approach. The accumulated data are stored in the data pool for further reference and it acts as a storage house for all medical records. The results can be viewed through interface where the authority needs to give their personal information. For secure transmission of medical data to the medical personnel, it is dealt with encryption. The encrypted text is sent to the doctor in a hexadecimal format via E-mail. The proposed algorithm is Base64 which has been considered to be a two way encryption algorithm.

3.3 Tier 3: Application Layer

When the patient attains abnormal condition, the medical authority should immediately be alerted. A database server is necessary to track the previous medical records of the patient for better diagnosis. The data collected from the sensor are transmitted to a Xamp based database server to find the record or analyze the data of the patient. It will help the doctor for better diagnosis and to provide prescription. The data server can be accessed by the doctor at any time and the doctor can also know the current status of the patient's medical condition. The health record of patients is also maintained in the web portal for future perusal. The portal also possesses the option of maintaining and tracking the records of multiple patients. The patient can also refer especially his/her medical details on the web portal. Thus, this system proves to be an efficient and robust way to maintain and analyse one's medical record lively.

4. IMPLEMENTATION

To improve the efficiency of radio communication using cognitive radio (CR), spectrum mobility in cognitive radio network (CRN) is one of the important task which can occupy and use the unused channel or frequency band of the primary user (PU) to the cognitive user (CU) using the opportunistic manner in a dynamic environment. CR communication should assure that with out causing the harmful interference to the spectrum owner at any time frame and geo location because the PUs activites having the highest privillage. Sudden arrival of the PUs then the CUs has to vacat and handover the particular channel to the PUs. To improve the CR communication the CUs find out the next new target channel to continue the CR communication. This process is known as spectrum handoff (SH). There are many SH algorithms were developed by the researchers for CRNs to provide solution to the CUs for the arrival of PUs. To complete the unfinished CR communication, SH algorithms suggested a new target channels in addition, with some interrupt mechanism

for switching the CR data to the new target channel from the transmission buffer for the completion of on-going communication for the CUs.

The data are extracted from the sensors using the circuit diagram as shown in the Fig.2 and the extracted information is sent to the controller which is connected to the cognitive controller. The cognitive controller identifies the available network channel from the identified channel using the optimization technique and it selects the suitable channel as well as transmits the data about the patients in a more secure manner by using BASE64 with two-way encryption algorithm. The data are received by the corresponding medical representative in a more secure manner. The work flow is represented in Fig. 3.

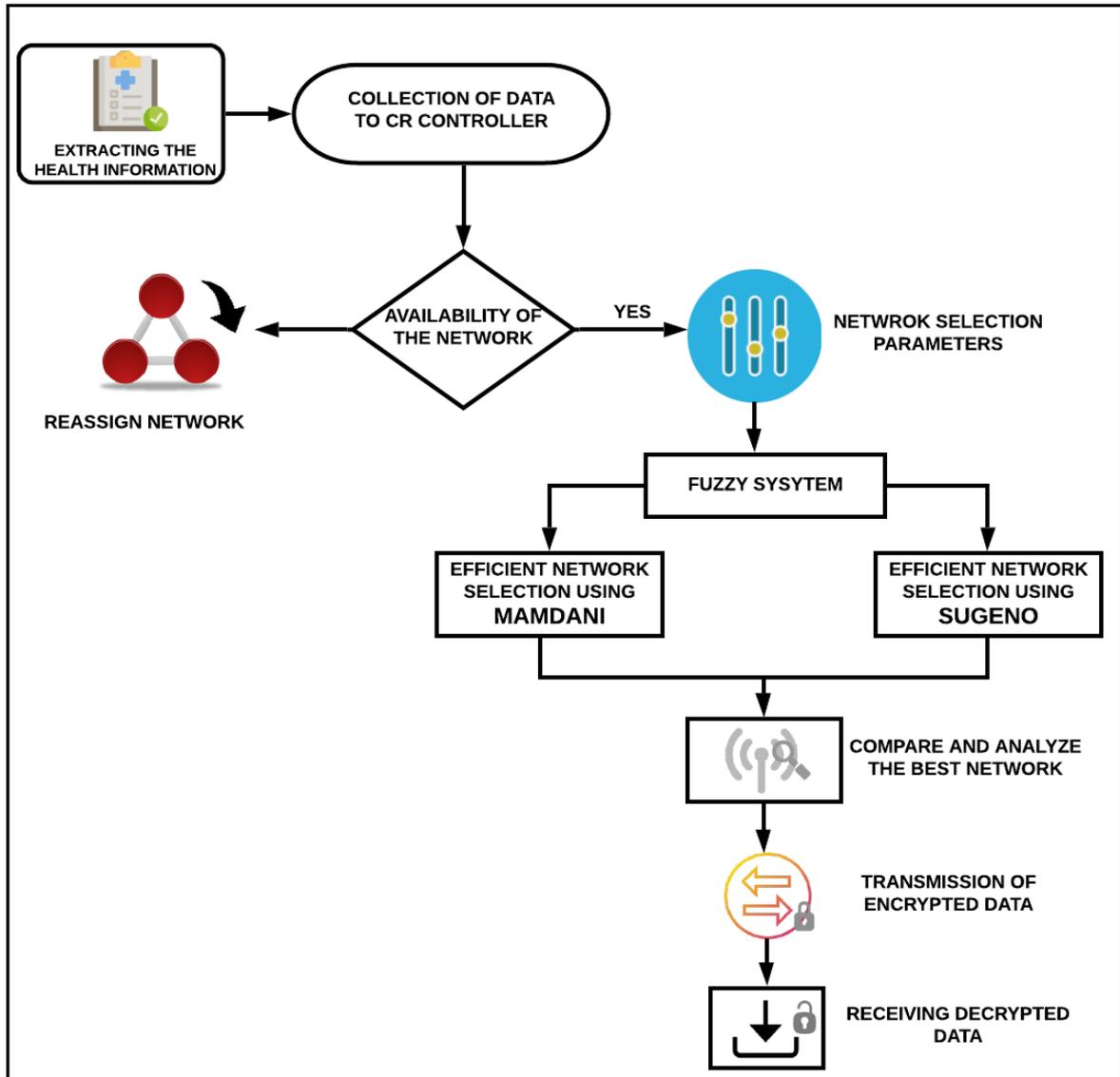


Figure 3. Process diagram

4.1 WBAN CONTROLLER

The proposed system has been designed with the idea of providing effective solution to the problems in medical domain using the latest technology. The process has been initiated from the sensors connected over the body of the patients and the sensors continuously monitor their physical condition. Hence, three basic sensors such as temperature sensor, pulse rate sensor and blood pressure sensors have been incorporated. The values of the sensors are rendered in the database in a time span of 10 seconds and an E-Mail is sent with 30 minutes

time interval to the doctor. The data that are collected from these sensors are accumulated in the central node. The sample data in each sensor are shown in Table 1,

Table 1 Sample Data Extraction

<i>Patient list</i>	<i>Temperature sensor</i>	<i>Pulse rate sensor</i>	<i>Blood pressure sensor</i>
<i>Person A</i>	34.2	65	125
<i>Person B</i>	32.0	72	140
<i>Person C</i>	33.4	63	132
<i>Person D</i>	32.8	78	121
<i>Person E</i>	32.5	86	141

Hence, each sensor in WSN needs data aggregation functions which include routing the data of all neighbour sensors to a central point, as they may be physically far away whereas for WBAN, this feature is not required. All the nodes are situated usually at relatively short distances and they are accessible to the central point. The main intention of the work is to send the medical history without any delay or data loss with fast communication. For this purpose, the optimal channel selection in best network has to be chosen to transfer the data. There are many networks available around the premises but an efficient transmitter is required.

4.2 COGNITIVE RADIO CONTROLLER

In wireless communication, efficient spectrum usage is the major constraint for using any network to provide efficient results. This part of the implementation work deals with WBAN controller to extract patient's data through sensors and the simulation part selects the best network with the phenomenon of optimizing the selection and securing the data using two way encryption algorithms. To overcome this constraint, there is an emerging technology called CR which is an adaptive, intelligent radio and network technology. It can detect the available channels automatically in a wireless spectrum and can change transmission

parameters for enabling more communications concurrently. CR also improves the operating behaviour of radio. The technology of CR involves the dynamic way of accessing the channels in the available spectrum. When the PU leaves the channel idle, then the SU uses that left-over channel until the PU comes into focus. The central node is connected with the cognitive controller through short-range wireless networks such as Bluetooth, Wi-Fi, Zigbee etc. For long range communication with the data pool, the network with QoS requirements is needed. The CR controller analyses the available network with the liable parameters. Since there are many networks and also to overcome the constraint of on-time delivery of information, the selection of network must be optimized. For the network selection optimization, FIS has been used for efficient results.

4.3 SECURE TRANSMISSION

Only the concerned doctor has been authorized to maintain the records. Since the present work deals with health care, it is important to secure the medical history of patients. Every person has the right to maintain his/her personal information confidentially and it especially includes medical records. Encrypting the patient's data by generating a static key value has already been known only to the doctor only. The E-mail is the proposed mode of communication between the sensors and the doctors. The data are encrypted while sending E-mails and in the other end, the history is shown only when the doctor enters the correct key value. In the proposed work, the encryption algorithm called BASE64 has been adopted with two way encryption algorithm. Base 64 is an encoding scheme which converts binary data into text format. As a result, the encoded textual data can be easily transmitted over network without any data loss. Problem with sending normal binary data to a network is that the bits can be misinterpreted by underlying protocols and hence, incorrect data will be produced at the receiving node. The reason for choosing Base 64 algorithm is resultant text. After encoding, the data those have characters are widely present in many character sets and so,

there is very less chance of data being corrupted or modified. Base64 has been utilized to generate printable text again after binary e-mail data which are generated during the e-mail encryption process.

4.3.1 Two Way Encryption

The focus of this work is maintaining confidentiality and data integrity in a database environment, particularly numeric data. Databases comprise a wide variety of sensitive data, including personal information as well as financial records. The quantity as well as the value of sensitive data has been constantly increasing, and this data must be safe guarded from unauthorized entry. This present work aims to provide confidentiality and integrity of data by an encryption scheme through Hash Message Authentication Code (HMAC) function and this encryption scheme extends and improves the HMAC based encryption scheme. The result is a symmetric encryption process and it can detect unauthorized updates of cipher text data, verify integrity and provide confidentiality. The encryption scheme has been implemented in a database environment and the process is known as “HMAC based Tamper Evident Encryption”.

Table 2 Comparison of Encryption Algorithms

Solution	Encryption Strength	Tamper Detection	Simple Usage	Encryption Efficiency	Decryption Efficiency
AES	High	No	Yes	Moderate	Moderate
AES & SHA-1	High	Yes	No	Moderate	Moderate
HTEE	Medium/High*	Yes	Yes	Fast	Slow

HTEE offers an alternative to standard approaches and it provides confidentiality and integrity of data such as combining the Advanced Encryption Standard (AES) algorithm with a hash digest. But, the HTEE can be difficult to implement, and it may not be ideal for all environments. The HTEE scheme also provides an efficient encryption which supports data

integrity in a straight forward processing order to investigate the use of HMAC for reversible encryption, key transformation, and to improve upon an existing method. To introduce the design, this encryption scheme processes positive integer values and decomposes them into components, or buckets, using modular arithmetic. These buckets or components are encrypted through HMAC-SHA1 function. Here, the authentication code represents cipher text. The secret key of HMAC has been modified for each plaintext value by a key transformation process. Decryption is performed with an exhaustive search for the authentication of code matching. Unauthorized changes to cipher text values or related data are detected during the decryption process, when the plaintext result cannot be found. The design of bucket decomposition makes the exhaustive search process feasible for large numbers. The key transformation process supports tamper detection and improves security.

Algorithm - Two Way Encryption

To create a secure data transmission portal, it is necessary to create mailing client by using a private database for message storage, and through which, more security on data can be achieved by the organisation.

Step 1 : *Create a mail user interface for quick access features.*

Initialize cipher key value for his account.

Step 2 : *After sending the message to the concern recipient, the message should to be encrypted with key called cipher.*

Step 3 : *The encrypted message is stored in database and ,this message is delivered using the user id. only the user who received can view the message in decrypted form.*

Step 4 : *The decryption is only possible when user shares his cipher key.*

5. SIMULATION AND RESULTS

5.1 NETWORK OPTIMIZATION

The proposed work uses FIS which is the prime unit of a fuzzy logic system with decision making as its primary work. It utilizes “IF...THEN” rules along with the connectors such as “OR” or “AND” for framing important decision rules as well as for mapping from a given input to an output through fuzzy logic. The process comprises membership functions, fuzzy logic operators, and if-then rules. The FIS is applied because of its multi-disciplinary nature. The FIS consists of rule and databases. The rule base has IF-THEN rules and the database has membership functions.

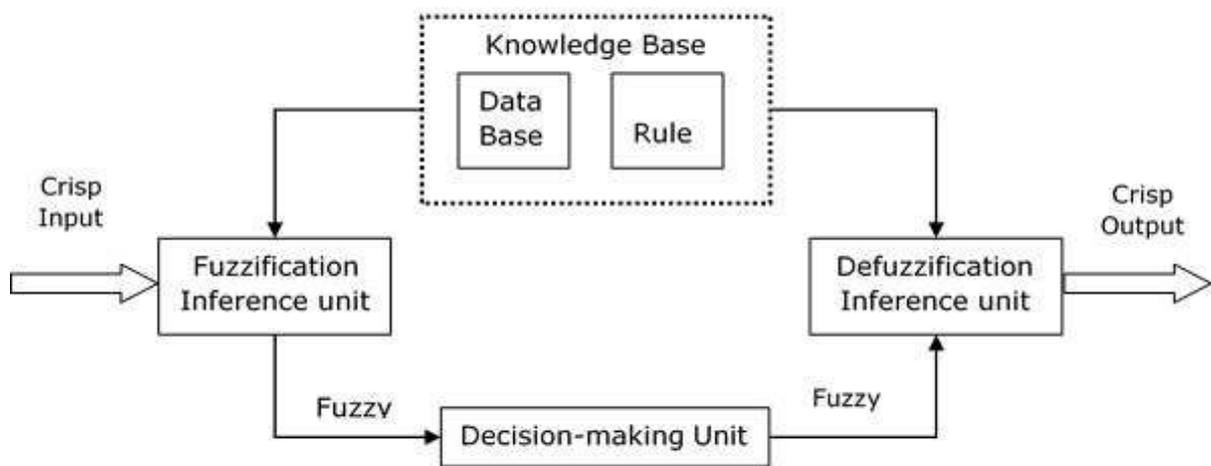


Figure 4 FUZZY INFERENCE SYSTEM

Fig. 4. possesses the following functional blocks

Rule Base – It consists of fuzzy IF-THEN rules.

Database – It denotes the membership functions of fuzzy sets used in fuzzy rules.

Decision-making Unit – It does the operation on rules.

Fuzzification Interface Unit – It changes the crisp quantities into fuzzy quantities.

Defuzzification Interface Unit – It converts the fuzzy quantities into crisp quantities.

Steps for Computing the Output

Following steps are required to compute the output from this FIS

Step 1. Set of fuzzy rules needs to be determined in this step.

Step 2. In this step, through input membership function, the input would be made fuzzy.

Step 3. Now establish the rule strength by combining the fuzzified inputs according to fuzzy rules.

Step 4. In this step, the consequent of rule is determined by combining the rule strength and the output membership function.

Step 5. For getting output distribution, all the consequents are combined

Step 6. Finally, a defuzzified output distribution is received.

5.2 FUZZY MEMBERSHIP FUNCTION:

Membership functions are graphically represented as a fuzzy set. The x axis denotes the universe of discourse, whereas the y axis denotes the degrees of membership in $[0,1]$ interval. Here, Triangular membership function has been used and it is defined by a lower limit a , an upper limit b , and a value m , where $a < m < b$.

$$\mu_A(x) = 0, \quad \text{when } x \leq a \text{ and } x \geq b \quad \text{----- (1)}$$

$$\mu_A(x) = \frac{x-a}{m-a}, \quad \text{when } a < x \leq m \quad \text{----- (2)}$$

$$\mu_A(x) = \frac{b-x}{b-m}, \quad \text{when } m < x < b \quad \text{----- (3)}$$

After the experimental analysis, the following membership function has been constructed for the implementation of two methods, namely Mamdani and Sugeno. The Mamdani method has been utilized with four input parameters such as Spectrum utilization, Degree of mobility, Distance to PU and Signal strength of PU and an output parameter for optimal spectrum utilization.

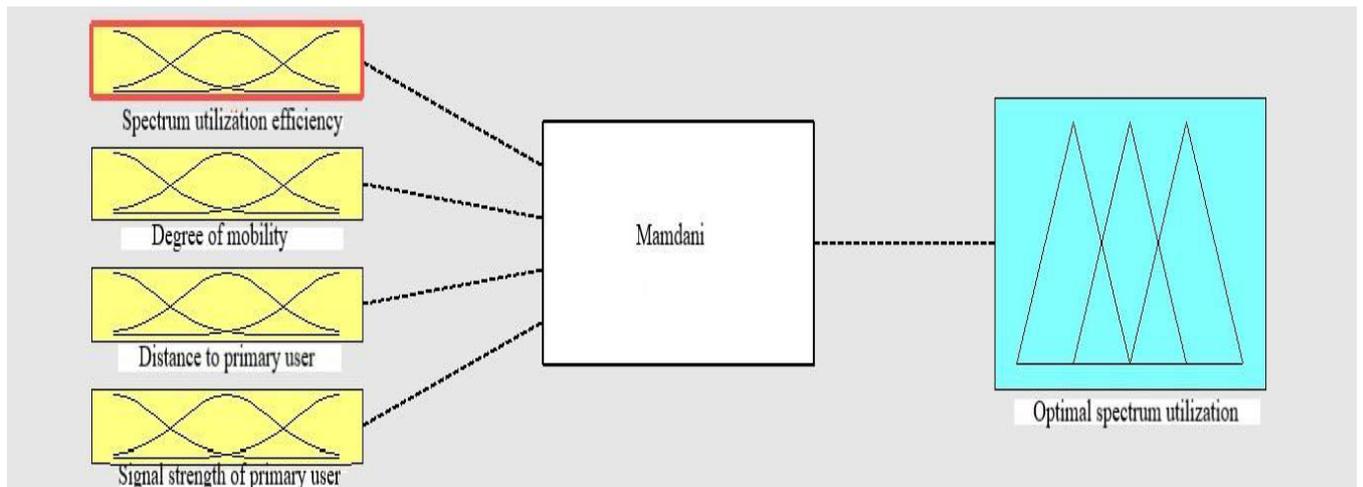


Figure 5 Mamdani method for Optimum Spectrum Utilization

Mamdani method has been used to derive the optimal spectrum utilization by considering the four input parameters such as spectrum utilization efficiency, degree of mobility, distance and signal strength of the PU and it is shown in Fig 5.

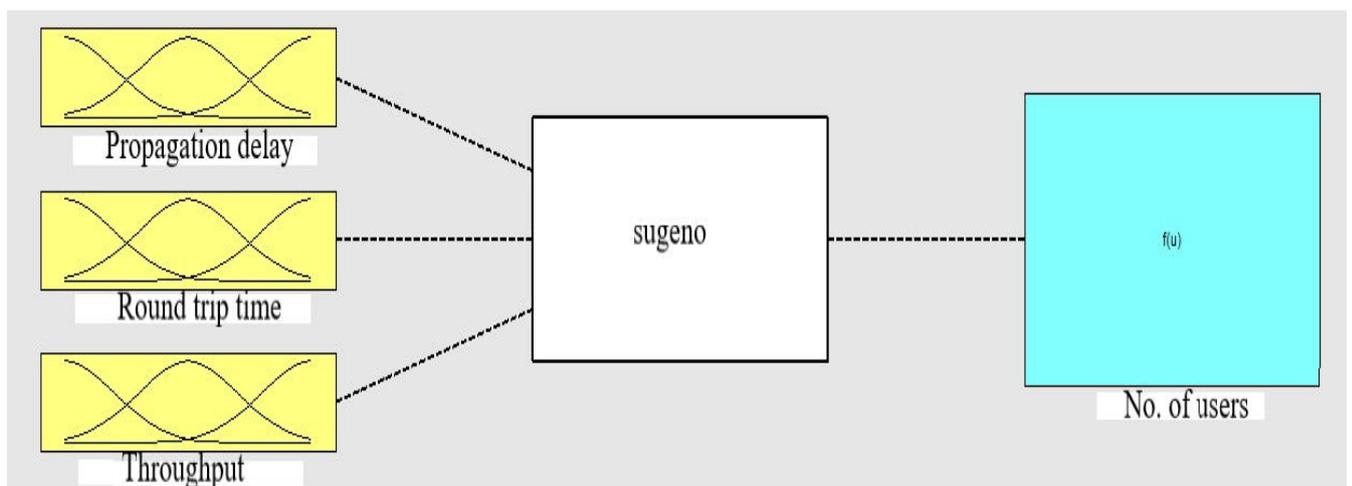


Figure 6 Sugeno methods for No. of Users

Sugeno method has been used to identify the number of user in the channel by considering the input parameters such as Propagation delay, Round trip time, Throughput and it is represented in Fig.6

The membership plot is drawn under three categories such as High, Low, and Medium, which are named as mf1, mf2 & mf3, respectively. Fig.7. shows the membership function plot for spectrum utilization efficiency of input parameters.

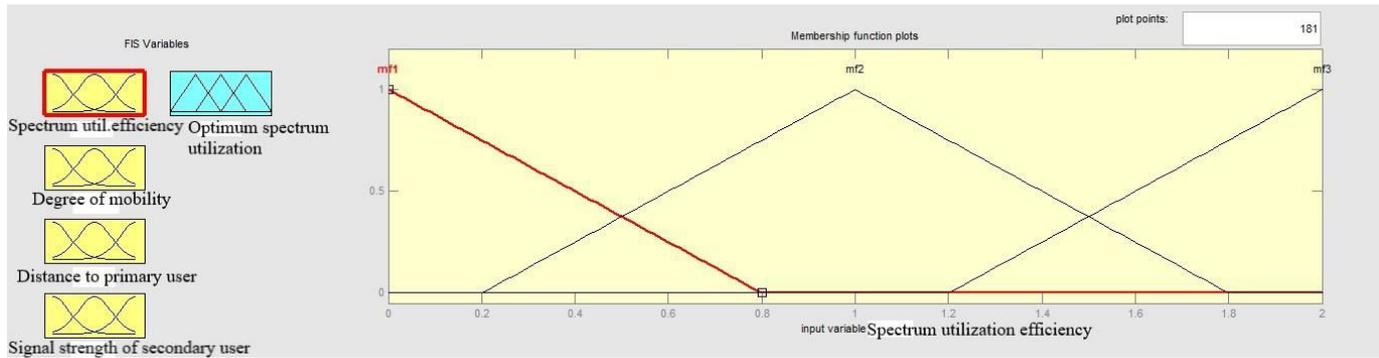


Figure 7 Membership plots for Spectrum utilization efficiency

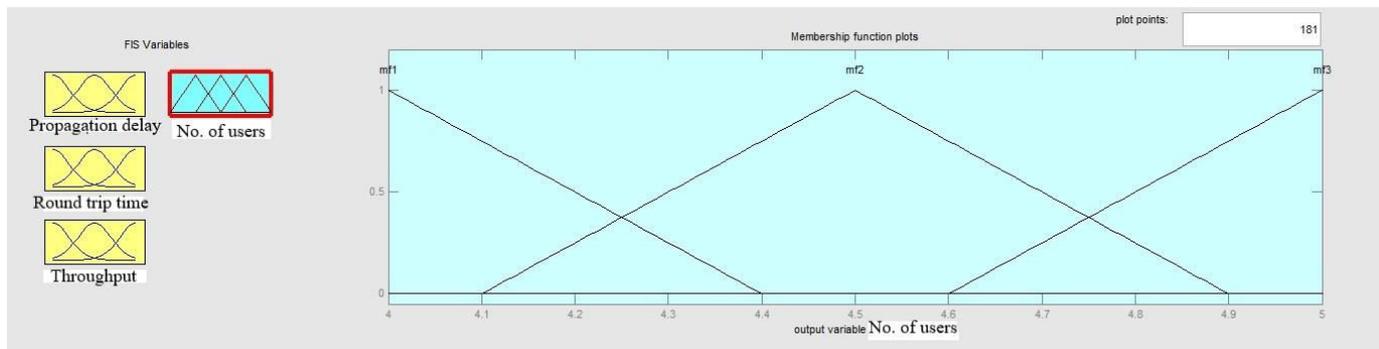


Figure 8 Membership plot for Number of users

Fig.8 describes an output parameter, number of users membership function plot which defines the degree of truth in fuzzy logic. After creating the membership function plot, the fuzzy rules set is generated. The fuzzy rules are the series of IF-THEN rules and they describe the decision making in current scenario. 27 input data are used and they consist of numerical values which indicate High, Low and Medium.

DATASET

Table 3 Dataset for Optimal spectrum utilization

Input				Output
PU's	Degree of mobility	Spectrum	Degree of mobility	CU's Spectrum
Spectrum		utilization		utilization
utilization		efficiency		efficiency
efficiency				

0	1	-1	2	-1
0	1	-2	0	-1
0	2	0	2	1
0	2	0	0	-1
1	2	-1	0	2
1	3	0	0	-2
2	1	-1	1	-1
2	2	0	2	1
2	2	0	0	-2

Table 4 Dataset for Number of users

Input			Output
Propagation delay	Round trip time	Throughput	Channels assigned for No. of users
0	1	0	4
0	3	2	3
0	1	2	5
1	1	0	3
1	2	1	3
1	3	0	2
2	1	0	2
2	2	1	2
2	3	0	1

The Mamdani fuzzy inference process comprises four steps as shown in Fig. 9 and they are Fuzzification of the input variables, rule evaluation, aggregation of the rule outputs,

and finally defuzzification. Initially, the crisp inputs are taken and their degrees are determined. According to fuzzification, the Spectrum utilization efficiency=1.02, Degree of mobility=2, Distance to primary user = -0.402, Signal strength of secondary user= 2.56 and Optimal spectrum utilization = 2.39

(or)

$$\mu_{A_1}(x_0) = 1.02, \mu_{A_2}(x_0) = 2, \mu_{A_3}(x_0) = -0.402, \mu_{A_4}(x_0) = 2.56 \text{ and } \mu_{B_1}(y_0) = 2.39$$

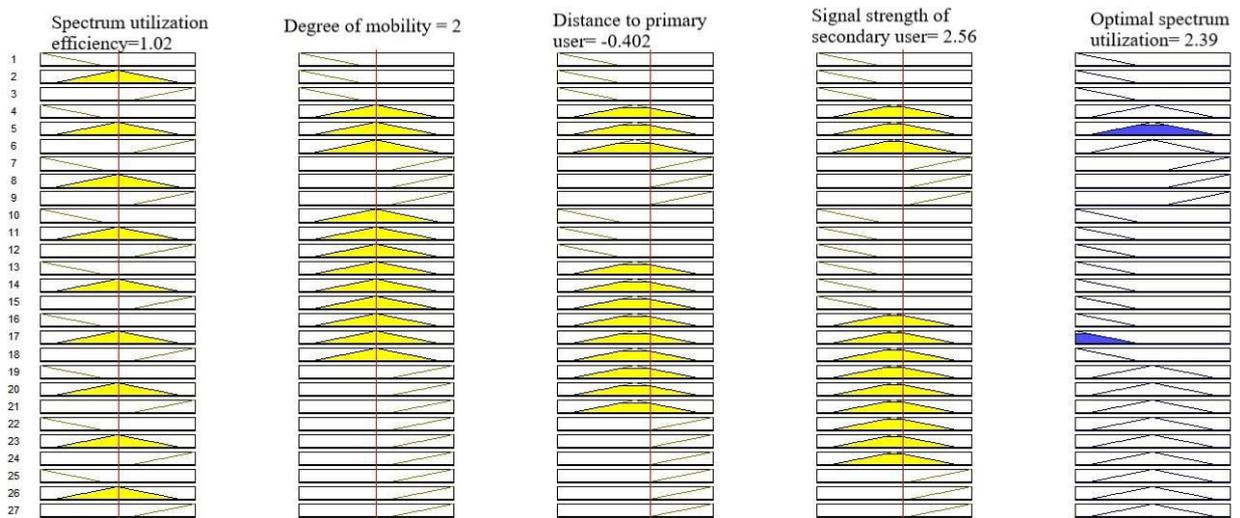


Figure 9. Parameter optimization for optimal spectrum utilization

The fuzzified inputs have been applied to the antecedents of the fuzzy rules as shown in Fig.

10. There are two methods in fuzzy and they are AND & OR methods. The fuzzy OR is written as:

$$\mu_{A \cup B}(x) = \max\{\mu_A(x), \mu_B(x)\} \quad \text{----- (4)}$$

If a given fuzzy rule possesses multiple antecedents, the fuzzy operator (AND or OR) has been utilized to get single number that quotes the antecedent evaluation result and to evaluate the conjunction of the rule antecedents, AND fuzzy operation intersection has been applied.

This number (truth value) is then applied to the consequent membership function.

$$\mu_{A \cap B}(x) = \min\{\mu_A(x), \mu_B(x)\} \quad \text{----- (5)}$$

1. If (input1 is mf1) and (input2 is mf1) and (input3 is mf1) and (input4 is mf1) then (output1 is mf1) (1)
2. If (input1 is mf2) and (input2 is mf1) and (input3 is mf1) and (input4 is mf1) then (output1 is mf1) (1)
3. If (input1 is mf3) and (input2 is mf1) and (input3 is mf1) and (input4 is mf1) then (output1 is mf1) (1)
4. If (input1 is mf1) and (input2 is mf2) and (input3 is mf2) and (input4 is mf2) then (output1 is mf2) (1)
5. If (input1 is mf2) and (input2 is mf2) and (input3 is mf2) and (input4 is mf2) then (output1 is mf2) (1)
6. If (input1 is mf3) and (input2 is mf2) and (input3 is mf2) and (input4 is mf2) then (output1 is mf2) (1)
7. If (input1 is mf1) and (input2 is mf3) and (input3 is mf3) and (input4 is mf3) then (output1 is mf3) (1)
8. If (input1 is mf2) and (input2 is mf3) and (input3 is mf3) and (input4 is mf3) then (output1 is mf3) (1)
9. If (input1 is mf3) and (input2 is mf3) and (input3 is mf3) and (input4 is mf3) then (output1 is mf3) (1)
10. If (input1 is mf1) and (input2 is mf2) and (input3 is mf1) and (input4 is mf1) then (output1 is mf1) (1)
11. If (input1 is mf2) and (input2 is mf2) and (input3 is mf1) and (input4 is mf1) then (output1 is mf1) (1)
12. If (input1 is mf3) and (input2 is mf2) and (input3 is mf1) and (input4 is mf1) then (output1 is mf1) (1)
13. If (input1 is mf1) and (input2 is mf2) and (input3 is mf2) and (input4 is mf1) then (output1 is mf1) (1)
14. If (input1 is mf2) and (input2 is mf2) and (input3 is mf2) and (input4 is mf1) then (output1 is mf1) (1)
15. If (input1 is mf3) and (input2 is mf2) and (input3 is mf2) and (input4 is mf1) then (output1 is mf1) (1)
16. If (input1 is mf1) and (input2 is mf2) and (input3 is mf2) and (input4 is mf2) then (output1 is mf1) (1)
17. If (input1 is mf2) and (input2 is mf2) and (input3 is mf2) and (input4 is mf2) then (output1 is mf1) (1)

Figure 10 Fuzzy rules

The final procedure in the fuzzy inference process is defuzzification. Fuzziness aids to evaluate the rules, but the final output of a fuzzy system must be a crisp number. The input of the defuzzification process is the aggregate output fuzzy set and a single number is the output. Mamdani method is an efficient method which deals with less number of input variables. If there are large numbers of inputs, then the number of rules increases exponentially and it becomes harder to find the rules that are suitable for the problem.

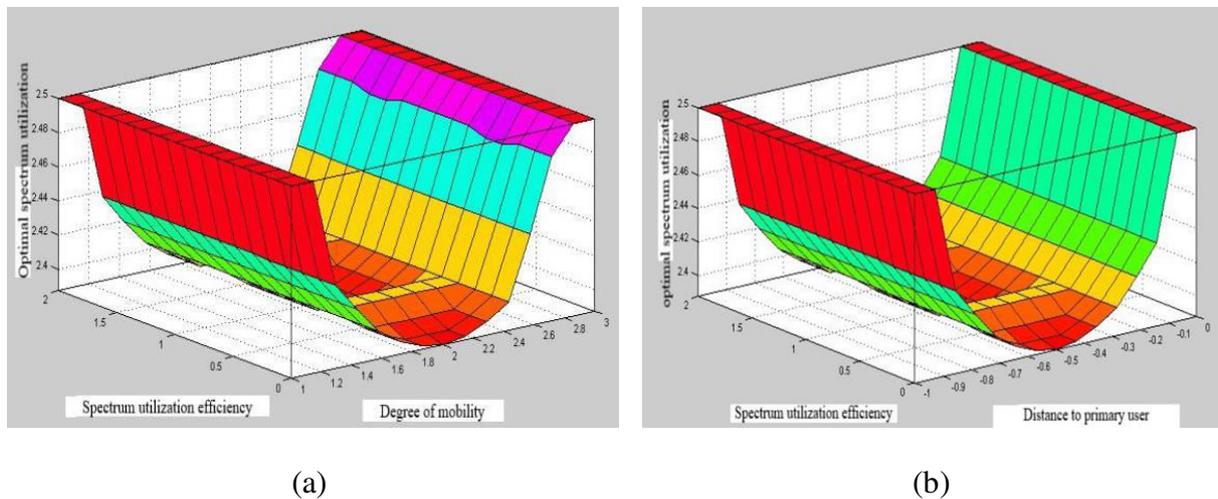
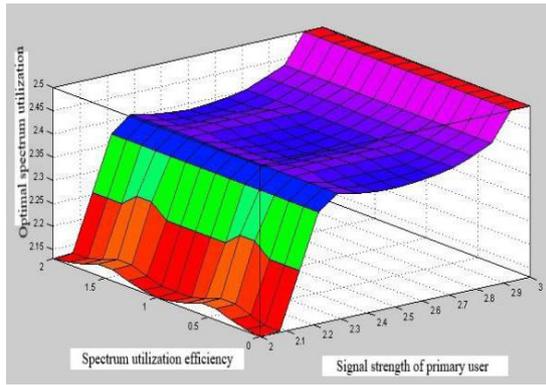
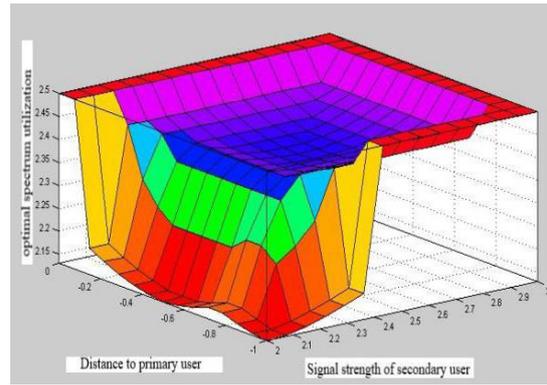


Fig.11 (a) & (b) Surface Diagram - Optimal Spectrum utilization by considering degree of mobility, distance and spectrum utilization



(c)



(d)

Fig.11 (c) & (d) Surface Diagram - Optimal Spectrum utilization by considering signal strength, distance and spectrum utilization

The results of rules are shown in Fig. 11 (a & b). If the Spectrum utilization efficiency is high, Degree of mobility & Distance to primary user are low, and Signal strength of secondary user is medium, and the optimal spectrum utilization is low. If the Spectrum utilization efficiency and Degree of mobility are low, Distance to primary user is medium, Signal strength of secondary user is high, and the optimal spectrum utilization is low.

If the Spectrum utilization efficiency is medium, Degree of mobility, Distance to PU and Signal strength of CU are high, as well as the optimal spectrum utilization is also high. The results are shown in Fig. 11 (c& d),. There are three linguistic variables for input parameters and five linguistic variables for output parameters. In Sugeno method, Sugeno fuzzy inference is similar to Mamdani method. Sugeno changes only a rule consequent. A mathematical function of the input variable is used instead of a fuzzy set.

The frame of the Sugeno fuzzy rule is given below:

IF x is A AND y is B, THEN z is $f(x, y)$ ----- (6)

Where x, y and z are linguistic variables, A and B are fuzzy sets on universe of discourses X and Y, respectively and $f(x, y)$ represents a mathematical function.

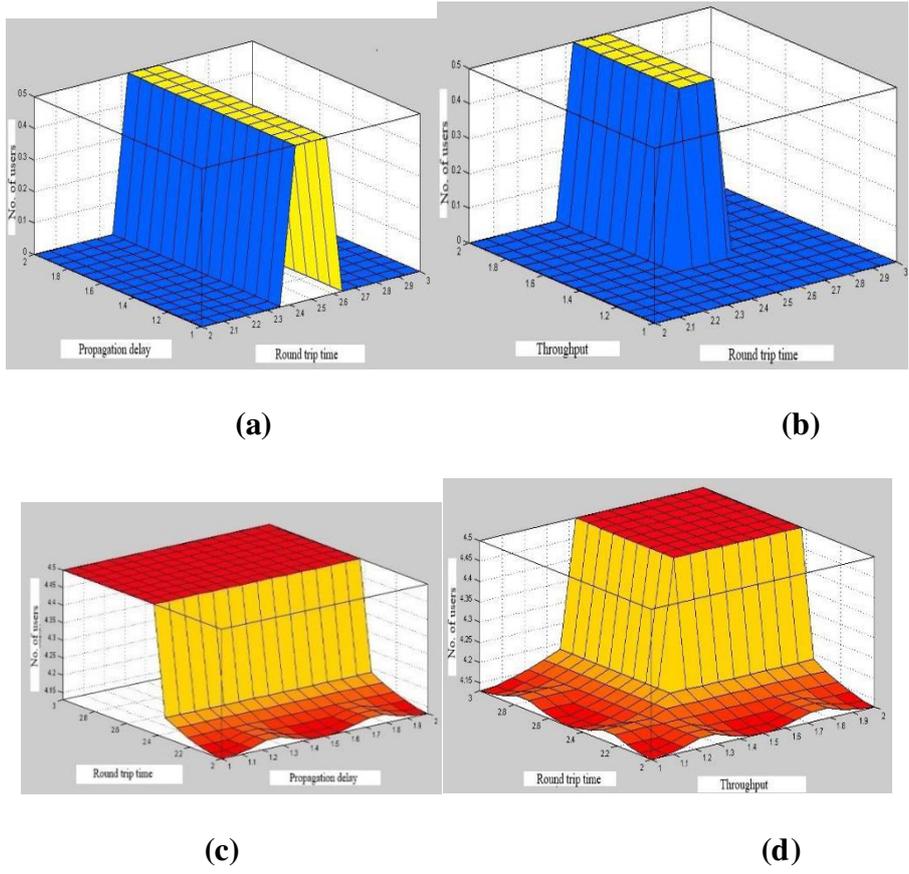


Fig.12. (a) Surface curve for input parameters 'Propagation delay' and 'Round trip time', Fig. (b) 'Throughput' & 'Round trip time', Fig. (c)'Round trip time' & 'Propagation delay', Fig. (d) 'Round trip time' & 'Throughput'

After the experimentation of the following rules, this surface curve has been displayed. If the propagation delay is high, then round trip time is medium. If the throughput is medium, then the number of users is high as shown Fig. 12 (a). Similarly as shown in Fig. 12 (b), if the propagation delay is high, round trip time is large and if the throughput is high, then the number of users is also high. If the propagation delay is low, round trip time is large. If throughput is low, then number of users is high as shown in Fig. 12 (c). If the propagation delay is medium, round trip time is small and the throughput is low, then number of users can be high as shown in Fig. 12 (d).

Sugeno method performs perfectly with the optimization and adaptive techniques and it guarantees continuity of output surface. When compared the inference methods, Sugeno

method produces 98% efficiency which is less than the Mamdani method with 99% efficiency.

5.3 Secure Transmission

```
4 function encrypt($text)
5 {
6     $key="123";
7     $iv = mcrypt_create_iv(
8         mcrypt_get_iv_size(MCRYPT_RIJNDAEL_128, MCRYPT_MODE_CBC),
9         MCRYPT_DEV_URANDOM
10    );
11    return base64_encode(
12        $iv .
13        mcrypt_encrypt(
14            MCRYPT_RIJNDAEL_128,
15            hash('sha256', $key, true),
16            $text,
17            MCRYPT_MODE_CBC,
18            $iv
19        )
20    );
21 }
22
```

Figure 13 Procedures for encryption

The procedures for encryption and decryption in two way encryption are represented in Fig. 13 and Fig. 14. As mentioned here, “123” is the key value and it can be changed based on the user choice during the account setting up. This unique encryption helps the users to get secure transmission over their data.

```

23 function decrypt($text)
24 {
25     $key="123";
26     $data = base64_decode($text);
27     $iv = substr($data, 0, mcrypt_get_iv_size(MCRYPT_RIJNDAEL_128, MCRYPT_MODE_CBC));
28
29     return rtrim(
30     mcrypt_decrypt(
31         MCRYPT_RIJNDAEL_128,
32         hash('sha256', $key, true),
33         substr($data, mcrypt_get_iv_size(MCRYPT_RIJNDAEL_128, MCRYPT_MODE_CBC)),
34         MCRYPT_MODE_CBC,
35         $iv
36     ),
37     "\0"
38 );
39 }
40

```

Figure 14 Procedure for decryption

This process can be automated by initializing, when the user wants to send a message to the recipient so that, he is not aware, when it is Encrypted or decrypted as shown in Fig. 15.

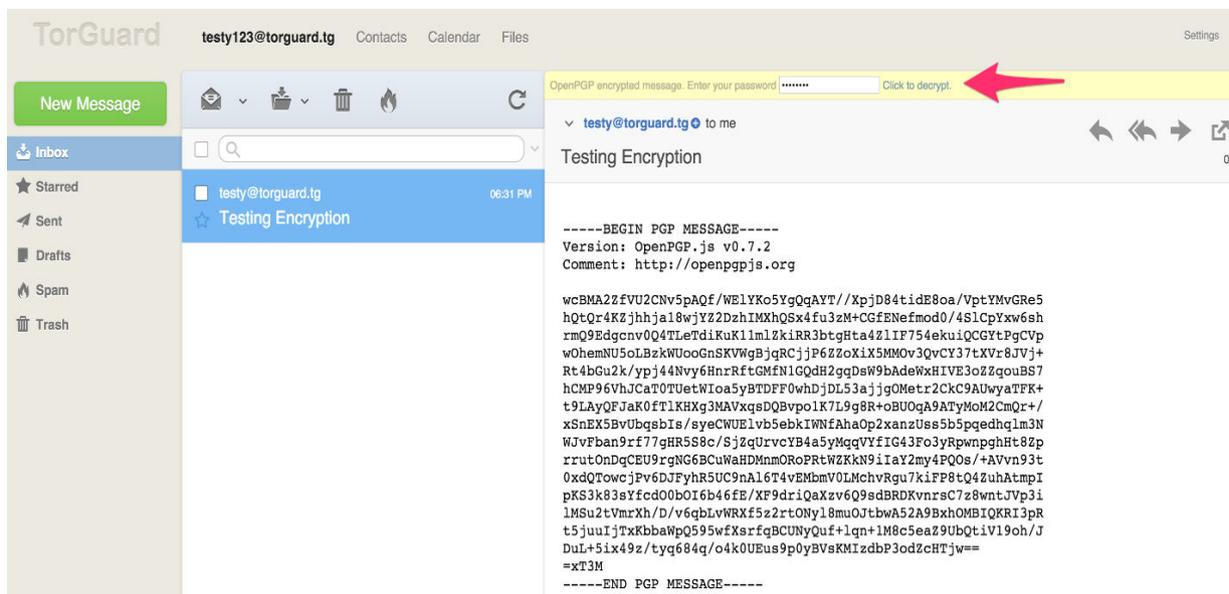


Fig. 15 Resultant Screen for Secure Transmission

6. CONCLUSION

The usage of WBAN in health monitoring system, which is especially related to paralyzed or coma patients, will provide enhanced performance. In the proposed experimental setup, the data pool collects the information from the patient's body with the help of sensors and transfers information to the application tier with the help of WBAN and CRC. The usage of cognitive controller will select the optimized channel and the selection is done using FIS. Based on the medical application, 98% and 99% of efficiencies have been achieved using Sugeno and Mamdani methods, respectively with the error rate of 0.9%. Further, the data of the patients have been secured using BASE64, a two-way encryption algorithm. The encrypted mail will be sent to the doctor every 30 minutes with the key value. The encrypted mail can be decrypted by the doctor. There is an interface between a new use sign-in and search options. The details of new patient are updated using sign in option. If the doctor needs to check the patients' details, the doctor can search through a search button with patient ID. This work can be extended further by implementing more complex and advanced encryption/decryption algorithms. It will be interesting, when the data are transferred using satellite communication and it will be efficient while communicating in remote areas.

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***Conflicts of interest/Competing interests**

No conflicts of interest with authors

***Availability of data and material**

Data sharing not applicable to this article as no datasets were generated or analysed during the current study

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