Fuzzy-Logic based Selection and Switching of Channels in Cognitive-Radio Networks

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doi: https://doi.org/10.21467/proceedings.114.73

Abstract

In Wireless-Communication, quick increments of cell phones furthermore, the heterogeneous condition have expanded the prerequisite for extra spect-rum for information transmiss-ion. It is past the domain of imagination to allocate new bands to all networks, which is the explanation behind product-ive utilizat-ion of the adequately available spect-rum is the interest of the day. Cognitive-radio (CR) development is a promising response for compelling range use, where Cognitive-Radio devices, or optional clients (SUs), can keenly utilize void areas open in the authorized channels. Secondary-Users need to rapidly surrender the authorized channel and change to another available channel when they recognize the presence of the essential client. In any case, execution for the SU truly taints if constant channel exchanging happens. Likewise, taking the channel-turning choices subject to fresh rationale is certainly isn't sensible procedure in the brain empowered Cognitive-Radio networks (CRNs) where recognizing information isn't simply free and misguided at this point furthermore incorporates a huge vulnerability factor. We propose a Fuzzy-Logic Supportive System (FLSS) commonly oversees channel-choice and channel-changing to redesign general through-put of CRNs. Proposed plot decreases the SU channel-exchanging rate and channel-determination more adaptable. Assessment of execution is refined utilizing MATLAB Simulator. The results are promising in regards to the through-put and the num-ber of hand-offs subsequently, FLSS ends up being a fair candidate framework for SUs while making the judicious choices in Cognitive-Radio condition.

Keywords: Cognitive-Radio Networks; fuzzy-logic; Channel-Switching; Channel-Selection; Fuzzy-Logic Supportive system

1 Introduction

The segments of cognitive-radio network architecture, can be characterized two groups as the Primary-users and the Secondary-Users. Primary-users are known heritage network that has a prohibitive right to a specific reach band. Out of the blue, cognitive-radio doesn't have a lic-ense to work in ideal-band. Key empowering innovation of dynamic range access methods in Cognitive-radio (CR) advancement, which enables to share the distant direct with authorized client in a spearheading way. Cognitive-radio network are envisioned to give high bandwidth to versatile clients through hetero-geneous remote models also, dynamic range access strategies. This objective can be acknowledged uniquely through powerful and effective spectrum management procedures.

Factors which add uncertainty in Cognitive-radio networks:

- Fading
- Pathloss
- Noise

Comparison of Non-CR Networks with CR Networks:

Proceedings DOI: 10.21467/proceedings.114; Series: AIJR Proceedings; ISSN: 2582-3922; ISBN: 978-81-947843-8-8

Cognitive-Radio permits to change to other recurrence groups. Non-Cognitive Radio doesn't permit to change to other recurrence band. Thus, CR intelligently makes the utilization of the frequency-band.

Cognitive-Radio are craftily using the white spaces of the band while Non-Cognitive Radio networks are not able to make the best utilization of the band.

An important feature of Cognitive-Radio networks is channel selection and switching, whereby the delay is introduced during the process of decision making for Spectrum hand-off.

1.1 Cognitive radio network classified:

Interweave: This is interference avoidance strategy in which secondary user and Primary-user (PU) does not do the data transmission simultaneously. Whenever channel is free then the secondary-user (SU) uses it.

Underlay: In this data transmission is done parallelly for both PU and SU, rather than watching the PU action and using a channel just when it is free, the methodology contains sending information at low capacity to ensure that the obstruction with the PU doesn't increment over a predefined limit.

Overlay: The SU acts in an agreeable way by giving a sensible aspect of transmiss-ion capacity to expanding PU quality signal, and accordingly, can effectively encourage identification of Primary-User. It is not yet fully implemented approach.[1]

The Spectrum distinguishing limit recognizes the un-utilized openings in fundamental spect-rum reach and continually screens the spect-rum reach for PU area. Range sharing gives the co-appointment segment to partition open Spect-rum reach between various scholarly radio clients. Reach the board gives the instrument to pick the best open channel among the different profit capable channel. Right when PU correspondence is perceived in free roaming space by methods for a recognizing framework, the mental client needs to clear the channel to keep an essential separation with the PU. The Cognitive Radio changes to another channel subject to some quality limits. This segment of moving the correspondence to another channel band is known as reach movability or reach hand-off.

Cognitive-radio networks have many areas of Applications, some of the uses are listed as follows:

white Spaces in TV

Intelligent CR networking

For Public Safety and Emergency Applications

Vehicular Communications when applied with

Cognitive radio networks etc

Cognitive-Radio network are an answer for the issue of spectrum shortage in remote correspondence. Notwithstanding, CR networks force novel difficulties, taking the channel-exchanging and divert choice choices in CR networks (CRNs) where detecting data isn't just loose and erroneous yet additionally includes a significant vulnerability fact-or. Here, we are focussing on Channel-Selection and Channel-Switching..Figure1 Shows the Licensed and Unlicensed User Utilizing the Spectrum in Environment. Channel-Selection and Channel-Switching are Challenging in CRNs in light of the fact that the detected data in CRNs is uncertain, deficient, and dubious Channel-Switching is profoundly reliant on Channel choice choices so both oughts' to be managed together to upgrade the through-put of the CRNs. Through-put is important para-meter for the performance Evaluation in CRNs. More the Through-put, Better the performance of the CRNs. Throughput can be increased in various ways, some of them are Parallel Transmissions, by select-ing the channels which have higher channel acquire. Execution Evaluation can be performed by the number of number of Handoffs, Time utilized in channel Searching, Selecting, changing to continue suspended Transmissions and System Through-put.

Proceedings DOI: 10.21467/proceedings.114

Series: AIJR Proceedings
ISBN: 978-81-947843-8-8
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Remaining paper is coordinated in the accompanying way: segment II examines Fuzzy-Logic Approach next, in segment III, related work is talked about. Segment IV explains system-model and Segment V depicts the Fuzzy-based Proposed Channel-Switching and channel-Selection Decision Supportive System. At last, we finish up the paper by summing up with the Conclusion

2 Fuzzy-Logic

Fuzzy-Logic is about the overall significance of exactness: How significant is it to be spot on when non-exact answer will do? A Fuzzy-Logic Algorithm assists with taking care of an issue subsequent ponder-ing all open data. By then it takes the best decis-ion for the given information. FL technique mirrors the method of dynamic thinking about all the prospects.

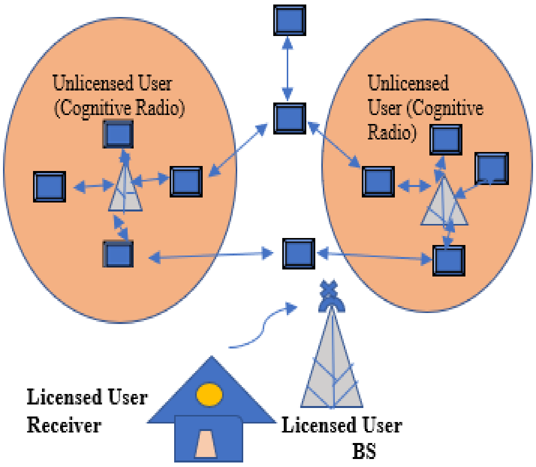

Figure 1: Cognitive Radio Network

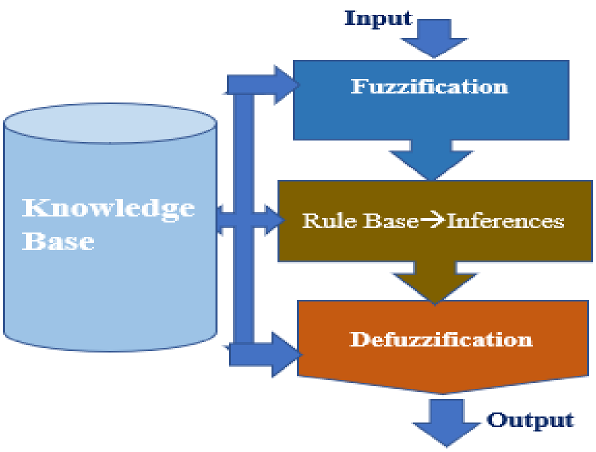

Figure 2: Fuzzy Architecture

2.1 Implementing Fuzzy-Logic

To Imple-ment the decis-ion making, Fuzzy-Logic Controll-ers are used which furth-er acknowledge fuzzy-sets as information boundaries. Fuzzy-Decision System is parceled into three interesting stages:

Fuzzification Phase: The information data regards are first fuzzified using the predefined cooperation limits

Fuzzy-Reasoning: Fuzzy-Input sets are dealt with into a data base,s and it produces fuzzy yield sets.

Defuzzification: Fuzzy-Output sets are defuzzied to get the last fresh Output.

Fuzzy-Logic is utilized when you need to de-al with the vulnerabilities and heterogeneity in the most ideal manner.

The focal point of the decis-ion technique is the inference engine which needs rules character-ized by an specialist of the field. The Infer-ence unit has different levels of utilization unpredictability dependent on the requirements.[2]

Figure 2. Summarizes the steps involved in the Fuzzy Based Approach implementation. The inferences are the core of the design which uses rules defined by the expert.[1]

3 Literature Review of Related Work

In Wireless-Networks, a ton of research work has been done for channel-selection, channel-switching and fuzzy-Logic base-d system. Utilizing channel and selecting them in cognitive-radio network plays a vital role in evaluating the performance of the system. In [3] many signal processing methods are demonstrated. Although, there is still requirement of improvement in various areas still for uncertain results and the errors sensed. In [4] Spectrum sharing scheme using the con-cept of fuzzy-logic in which cell phones operator shares the available spect-rum information with the one's who are interested to purchase the Spectrum license for own communication. This was proposed by Chatzikokolakis et al which helps in the best possible manner for the select-ion of suitable license channel which can satisfy the transmission necessities. Appropriate channel is chosen depending on the Licensed Spectrum access (LSA), range effectiveness, obstruction, load pattern, client versatility, and co- primary spectrum parameters of efficiency. After, Channel Selection another parameter which is to be taken care of in our work is Channel-Switching or Spectrum Hand-off. In [5] Fuzzy-based plan was proposed based on the con-cepts of fuzzy-logic, the plan was to make better and more productive channel handoff choices. This plan utilizes the bit error, interference, and strength of signal as para-meters for the decision. In addition, on bas-is of fuzzy-patterns channel gain is measured by utilizing a prepared neural network.

For Channel Selection, under IEEE 802.22 norm another plan was proposed, in that, by the past transmission conduct of the PUs candidate and backup chann-el list is made. Utilizing a Fuzzy-Logic controller, chann-el positioning is determined to focus on and categorize the chann-els as working, backup, candidate, ensured, involved, and un-classified to choose the best chann-el for SU transmiss-ion without disturbing with the PU transmiss-ions in [6].

Two distinct plans for best channel determination and better execution: the channel occupancy insights of the PU, and data about the level of rivalry between the SUs. In this plan, SUs finds out about their own serious conduct utilizing a two- step data trade measure. At that point, the SUs can choose the best channel for transmission utilizing a fuzzy Logic decision supportive network. This was introduced by Yao et al. [7]. The dynamic structure based on fuzzy Logic was proposed in [8] for collaboration among SUs and PUs, in which a various transfer conspire is utilized to choose the best channel for SUs transmissions without upsetting the QoS of the PUs.

In [9] plan empowers the SUs to choose a suitable direct in a conveyed way to limits the obstruction issues and to accomplish a serious level of reasonableness among the Secondary base stations (SBSs). Spectrum sharing in distributed manner was proposed by Hawa, A. Algorithm for Adaptive channel assignment calculation which can powerfully control the nature of service that outcomes in execution improvement was proposed by J. Wang [10]. In multiple cognitive radio performance measured in terms of throughput by the author in [11] packet delivery ratio is improved significantly on a wireless node.

In, [12] Cooperative plan for hopping arrangement is proposed to diminish the impact of channel blurring. In that, SUs is bunched into bouncing gatherings to detect the accessible range and send results to a combination community. The bouncing bunch results are at last used to allot the channels with high, medium, and low positions.

In [13] multiple attributes in Channel Switching are discussed for selection of optimal network. In [1],

Be that as it may, Hybrid approach can guarantee better channel usage with least handoff rates. Moreover, it can likewise guarantee the appropriate channel choice utilizing parameters that have extraordinary effect on these two settles the issue of restricting the channel trading rate by using two incredible method. In any case, we use the joint methodology by picking the best channel for transmiss-ion. Second, we use the underlay approach by restricting the SU's transmiss-ion capacity to extend the last throughput of the organization while restricting the channel hand-off rates.

4 System-Model

We are using a model which consists of secondary network as well as primary network. We are trying to use the characteristics of underlay channel as well as overlay channel models. Unlicensed User are the secondary networks which opportunistically or intelligently use spectrum. Licensed User are the privileged, primary networks present in model. This channel model is considered as error free, but due to collision between both licensed and unlicensed user there would be some data packet loss happening.

We are aware of the fact that Spectrum is being exploited by the secondary user in the absence of privileged users. In case interference caused by SU's exceeded the certain limit they have to leave channel and find some other channel as per their suitability for transmission purpose. Channel Selection decision is taken by the SUs by the parameters $Md_{Activity-PU}$ and Md_{TR} .

Here, this assumption is also made that Rayleigh-Fading which is quasi-static is present and channel coefficients of Secondary networks are independent variables which are Rayleigh distributed. Moreover, for representing properties of wireless networks next generation we are also using a random way point mobility model.

5 Fuzzy Logic Supportive System for Channel Switching and Selection

This Segment, will explain about the scheme that is proposed to resolve issues for reducing the rates of channel switching by using mainly two effective ways. One way is using the interweave technique in which we do transmission by selecting the best suitable channel. Second way, is the underlay technique in which we try to minimize the power transmission requirements by the unlicensed users and final increment in throughput which is achieved by reduction in switching rates. Moreover, we will discuss fuzzy logic and its working. Also, the parameters used in the process.

5.1 Fuzzy Logic

Systems which are Fuzzy Logic based have simple structure and are understandable. The fuzzy logic is broadly utilized for both commercial and non-commercial purposes.

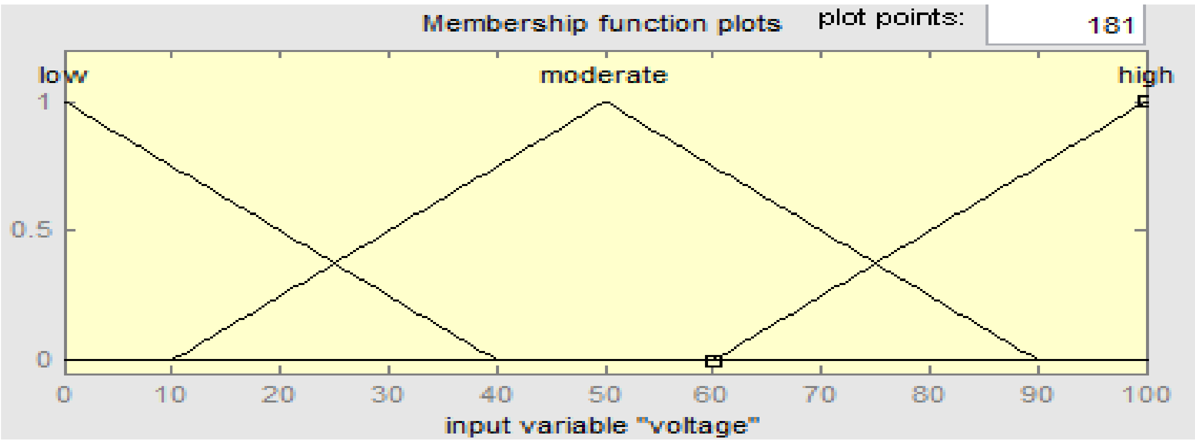

Figure3: Membership Function "Voltage" (A-ohm or Volt)

For example: All Z variable in fuzzy set is linguistic term named like as low, medium, high etc. Term P(Z) is called linguistic variable. To understand concepts of Membership functions and fuzzy set let us take Voltage as example. If voltage is linguistic variable, whose set can be defined as P(voltage) as P= {low, moderate, high,}, all the terms come under universal set [0,100]. These terms are called membership function and fuzzy-sets. Voltage considered as low(40v), as moderate(50v), high(95v). Here, v denotes unit of voltage volt.

5.2 Selection of the Parameters

We have some parameters which helps us in evaluating performance of the system. Here Let us know about four parameters for fulfilling the purpose.1) $Md_{Activity-PU}$(2) Md_{TR}3) $\mathrm{InterTemp_{PU}}$4) $\mathrm{SINR_{SURx}}$

1) $Md_{Activity-PU}$(Medium Activity -PU): $Md_{Activity-PU}$ can be Calculated as:

$$Md_{Rank} = \frac{TI_t^{ch}}{(TB_t^{ch} \times No.\,of\;Arr_t^{ch}) + TI_t^{ch}}$$

[1]. It helps to provide the availability of channel or medium according to the activities of Primary users. Here, $No.\ of\ Arr_t^{ch}$: demonstrates the whole regard for all sections of the PU distinguished through-out channel ch at time-frame t. TB_t^{ch}: Total Busy Time, TI_t^{ch} : Total idle time. This factor also decides selection of channel.

2) Md_{TR}(Transmission range of Channel): Various heterogeneous channels are available to secondary users in terms of error rates of channel and range of transmission.

This factor effect switching when it comes to mobility of SU.

electing channel based on this factor reduce the rate of switching on providing enough transmission range for the pair of Secondary users.

3) $\text{InterTemp}_{\text{PU}}$: $\text{InterTemp}_{\text{PU}}$ is radio frequency measure of available power at PU receiving antenna. ITPU can be calculated as:

$$\text{InterTemp}_{\text{PU}}(f_{ch,}\, BA_{Ch}) = \frac{\sum_{i=1}^{N_{SU}+1} Pavg_i(f_{ch,}\, BA_{Ch})}{KBA_{ch}}$$

[1]. Here, cent-ral frequency is mentioned as $f_{ch,}$. and Bandwidth mentioned as BA_{Ch}. Pavgi Power-Value referencing Average Interference (watts). Boltzmann's constant denoted by k whose unit is joules per kelvin. This parameter will help us in switching purpose.

4) $\text{SINR}_{\text{SURx}}$: $\text{SINR}_{\text{SURx}}$ is a parameter used for the purpose of reducing switching rate. Here SINR indicates measured value of SINR at receiving antenna of the SU (Secondary user). This helps in determining the transmission of SU Quality of Service.

$$\text{SINR}_{\text{SURx}} = \frac{|hg_{22}|_B^2 SUT_{SU-B}*}{\sum_{i=1, i\neq B}^{N} |hg_{22}|_i^2 SUT_{SU-i} + \sum_{J=1,}^{N} |hg_{11}|_J^2 SUT_{SU-j} + \boldsymbol{\sigma}_{SU-B}^2}$$

[1]. Here, hg_{22} is Fading channel coefficients power gain. SUT is Co-channel SUs transmission power. $\boldsymbol{\sigma}_{SU-B}^2$ is the AWGN Variance at Unlicensed user. Co-channel SU is denoted as K and Co-channel Pu number is denoted by N.

SUT denotes power that can transmit SU data at the receiving antenna of the un-licensed user.

5.3 Fuzz- Logic Controllers Proposed:

Fuzz-Logic Controller, basically used to control the working of system. We are using two Fuzzy-Logic Controllers:

1. FUZZY-LOGIC CONTROLLER1: fuzzy-logic controller1 is trying to reduce the rate of channel-switching. For this Controller we are taking these parameters as inputs $\text{InterTemp}_{\text{PU}}, \text{SINR}_{\text{SURx}}$ .Figure 4 shows FLC1 membership functions. Also, Table1 shows Inference rules of fuzzy. Figure 5 Shows the Channel-switching status function. Figure 6.1 Shows the Channel-Switching Decision Surface diagram. Figure 6.2 Effect on Channel-Switching Status in 2D

2. FUZZY-LOGIC CONTROLLER2: fuzzy-logic controller2 purpose is to do best and proper channel-selection. There are two inputs which are considered for channel-selection: $Md_{Activity-PU}, Md_{TR}$ .Figure 5 shows FLC2 membership functions. Also, Table2 shows Inference rules of fuzzy. Figure 7 Shows the FLC2 Membership functions. Figure 8 Shows the Surface Diagram for FLC2

Proceedings DOI: 10.21467/proceedings.114
ISBN: 978-81-947843-8-8
Series: AIJR Proceedings
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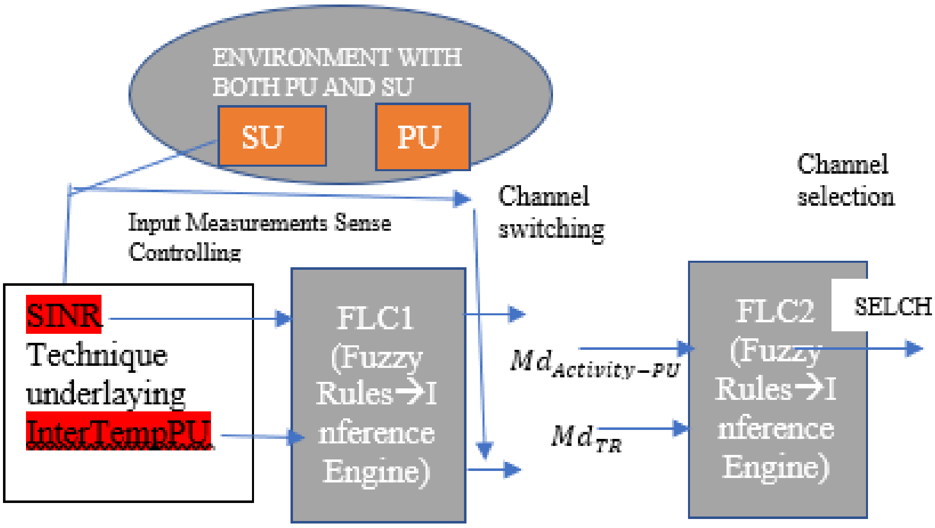
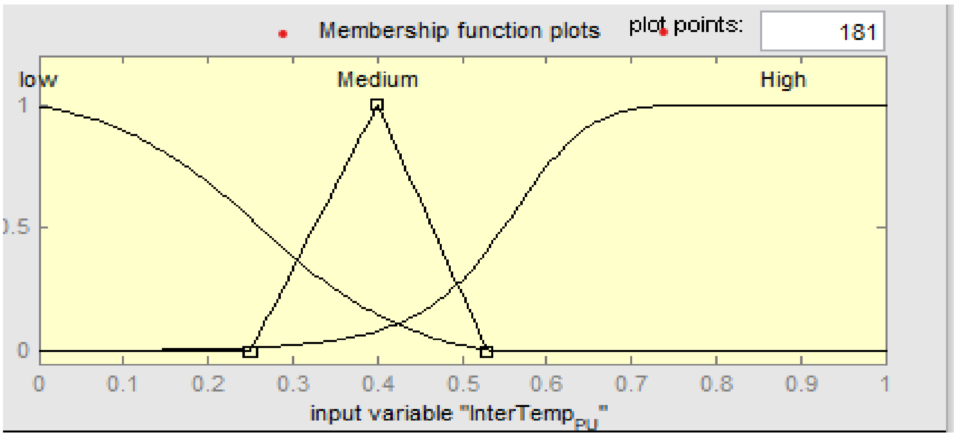
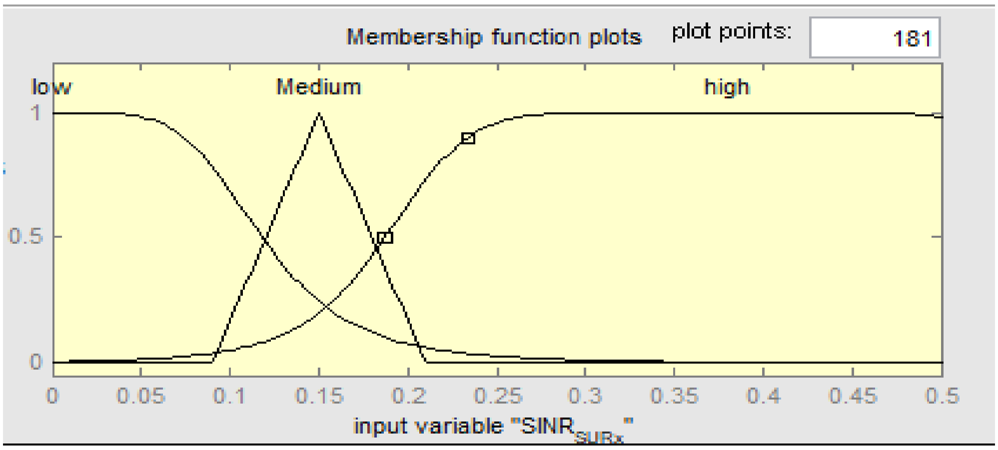


Figure 4: Proposed Fuzzy-Logic Supportive System(FLSS)



a) Membership Function $\text{InterTemp}_{\text{PU}}$



b) Membership function for $\text{SINR}_{\text{SURx}}$

Figure5:FLC1 Membership function

TABLE 1. FUZZY BASED CHANNEL SWITCHING RULES

	IF		THEN
Rule No.	$InterTemp_{PU}$	$SINR_{SURx}$	CHANNEL SWITCHING (Occurs (✔)/ Not Occurs ✗)
A.	Low	Low	✔
B.	Medium	Low	✔
C.	High	Low	✔
D.	Low	Medium	✗
E.	Medium	Medium	✗
F.	High	Medium	✔
G.	Low	High	✗
H.	Medium	High	✗
I.	High	High	✔

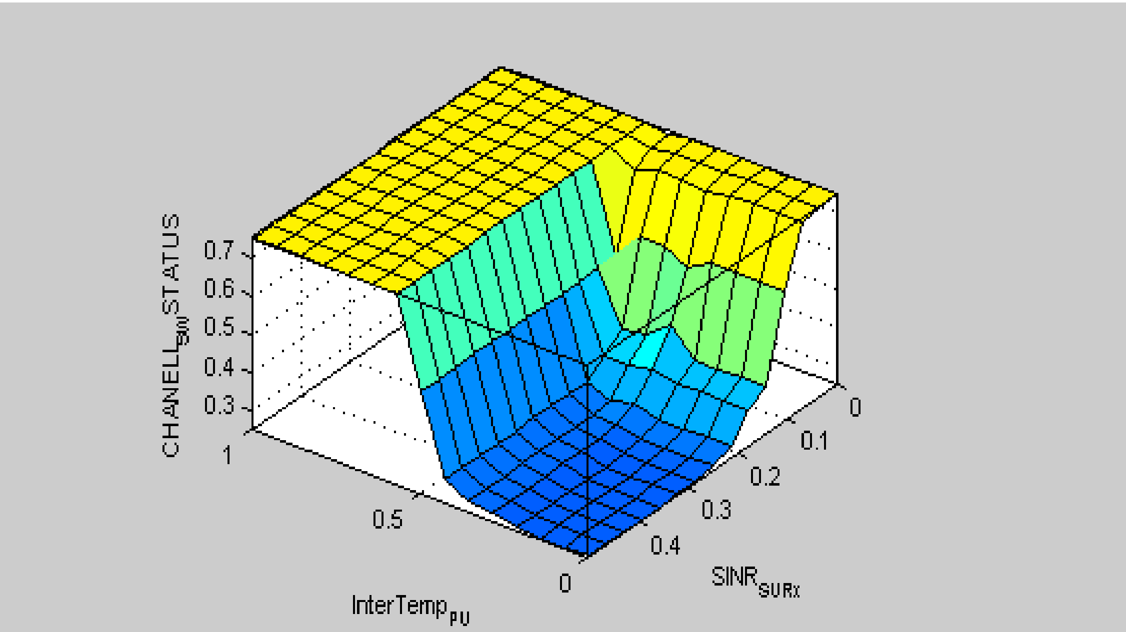
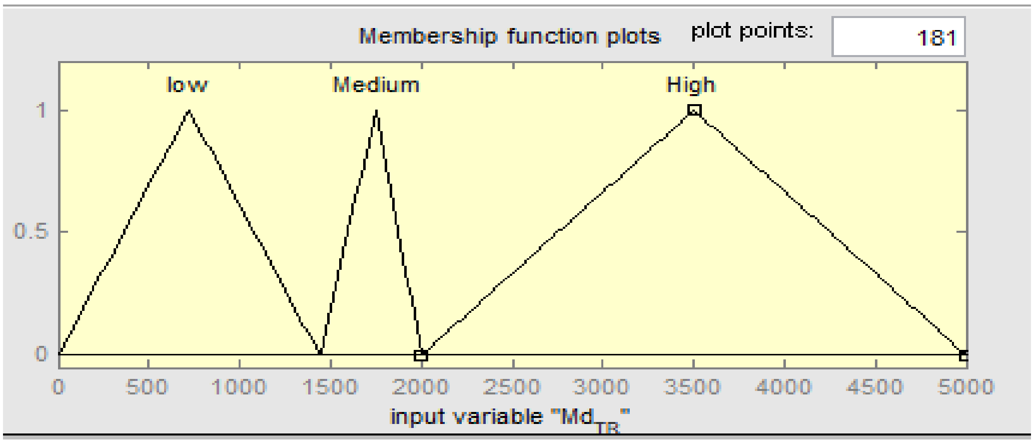


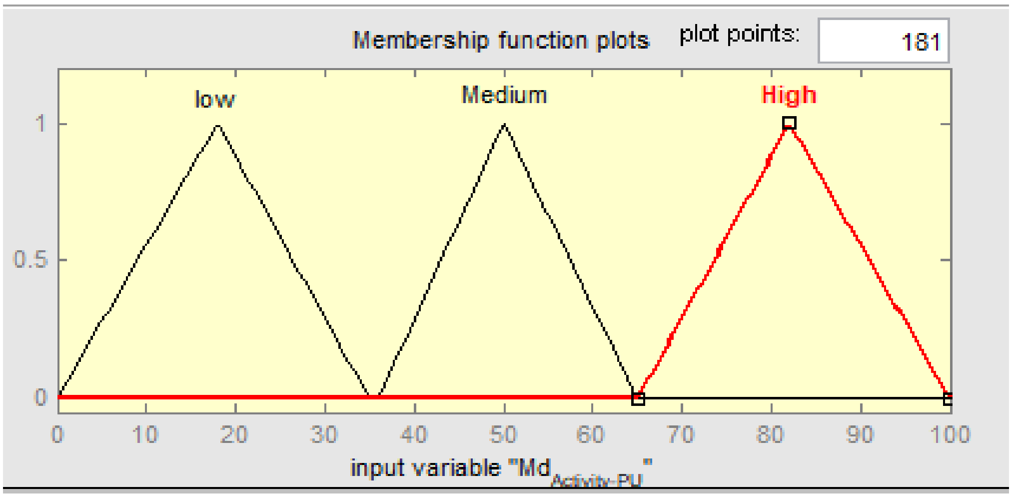
Figure 6: Surface Diagram for Channel Switching Decision

TABLE 2. FUZZY BASED CHANNEL SELECTION (SELCH) RULES

	IF		THEN
Rule No.	$Md_{Activity-PU}$	Md_{TR}	SELCH
A.	Low	Low	✗
B.	Low	Medium	✗
C.	Low	High	✔
D.	Medium	Low	✔
E.	Medium	Medium	✔
F.	Medium	High	✔
G.	High	Low	✗
H.	High	Medium	✔
I.	High	High	✔



a) Membership Function $Md_{Activity-PU}$



b) Membership Function Md_{TR}

Figure7:FLC2 Membership function

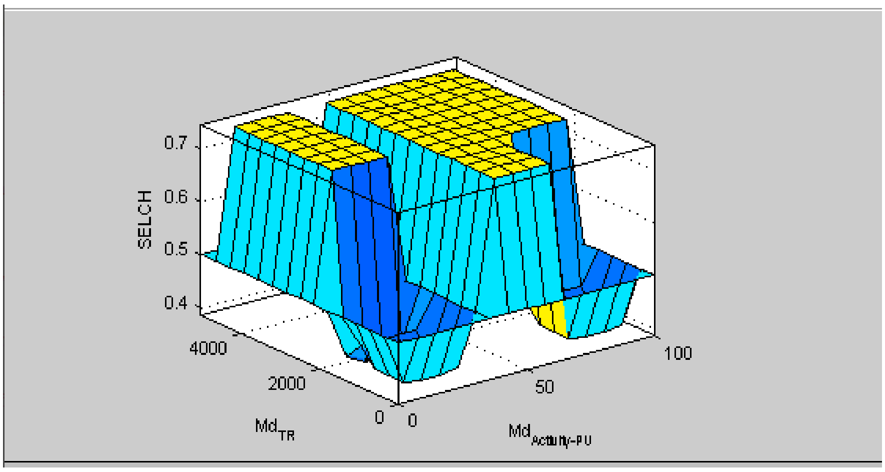


Figure 8: Surface Diagram for Channel Selection Decision

The Proposed Scheme is beneficial differently, for understanding this we need to comprehend what is deficient in the Conventional Scheme. There is more switching in conventional scheme as it selects only licensed channel for the communication purpose with SU and it does not consider some crucial parameters like the availability duration, susceptibility value of channel, range of coverage etc. In the Proposed Scheme the Channel Selection is done on the basis of $Md_{Activity-PU}$, Md_{TR}. It is helpful in using channel for more duration but also taking decisions of soft handoff. Moreover, in our proposed scheme the data is transmitted simultaneously by the SU, in the presence of PU by having a control on its generated interference's, in proposed scheme channel switching does not occur till the time operating channel (the one which is licensed) has sufficient required quality of transmission.

6 Conclusion and Future Work

This paper discusses about fuzzy-logic based proposed channel switching techniques and how they are helpful for increment in throughput. One of the foremost noticeable way for utilizing the Range is Cognitive-Radio systems . Here, we are attempting to make strides the execution of CRNs by enhancing the throughput of the Cognitive radio Networks. Typically accomplished by utilizing FLSS (Fuzzy-Logic Supportive System) which not fair focusses on constraining the channel exchanging rates however thinks about practically most genuine and best channel for the transmitting unlicensed use-r. Further, more ways can be plugged to enhance the performance of the system.

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