Novel Spectrum Handoff scheme in Cognitive Radio with Multiple Attributes

RESHMI KRISHNA PRASAD (reshmiideepak@gmail.com)
VISTAS: Vels Institute of Science Technology & Advanced Studies
T Jaya
VISTAS: Vels Institute of Science Technology & Advanced Studies

Research Article

Keywords: SAW, TOPSIS, GRA, ETOPSIS, spectrum handoff, CR, ARODN

Posted Date: March 16th, 2022

DOI: https://doi.org/10.21203/rs.3.rs-1421281/v1

Abstract

Cognitive radio is a technology that can be used to detect accessible data transmission channels in the wireless spectrum. To avoid user interference and congestion, the cognitive radio is employed. Multiple parameters make up the network, which are used to choose the best network for transmission without delay. The goal of this paper is to investigate and develop a spectrum handoff scheme using MADM (Multiple Attributes Decision Making) methods like simple additive weighting (SAW), technique for order preference by similarity to ideal solution (TOPSIS), grey relational analysis (GRA), cost function-based method (CFB), and Enhanced technique for order preference (ETOPSIS). In two different circumstances, the research work has been implemented. In the first scenario, MADM methods were used to implement all four network selection strategies, as well as Enhanced TOPSIS (ETOPSIS). Voice, video, and data services, sometimes called as triple play services, are depending on CR preferences. In cognitive radio networks, the proposed MADM spectrum handoff system will be efficiently implemented to select the best network in line with triple play services. Spectrum management concerns such as spectrum sensing and sharing make CRN networks difficult to manage. As a result, ARODN (Adaptive Rider Optimization with Different Noise) is created in this study to increase energy efficiency for various spectrum sensing circumstances. As a result, in the second example, various noises such as AWGN, Rayleigh, and Nagakami noises are introduced to the receiver signal, and spectrum sensing and sharing are evaluated on the basis of which the bit error rate is depicted (BER). As a result, the suggested approach is used to calculate the bit error rate for three different noise scenarios. MATLAB is used to implement the proposed approach.

Introduction

Researchers looking for a solution to the spectrum shortage in wireless communication will find Cognitive Radio to be a viable option. According to research by the US Federal Communications Commission, the majority of spectrum bands are unused (FCC). Government agencies are in charge of allocating spectrum bands[1]. The use of frequency bands can be enhanced, and spectrum handoff can be done more efficiently as a result. When primary users appear in the licensed band inhabited by secondary users, this is known as spectrum handoff [2]. The purpose of spectrum handoff processes is to assist secondary users in vacating occupied licensed spectrum and locating a suitable target channel to resume unfinished tasks. Non-interference to PU receivers is the most critical restriction in a cognitive radio scenario. To avoid interfering with PU receivers, the SU must be aware of its location, which is a difficult research problem [3][10].

A secondary user's connection in a CR network may be interrupted several times by primary users during its transmission period. Because spectrum handoff processes are conducted anytime an interruption event happens, these disruptions result in a sequence of spectrum handoffs. As a result, for repeated handoffs, a succession of target channels will be selected progressively. Although spectrum handoff functionality can improve channel usage [14], these handoffs will clearly raise the secondary connections' extended data delivery time. The majority of the allocated spectrum is unused, according to the US Federal Communications Commission (FCC). This is primarily due to government entities' allotment of fixed spectrum bands [9].

Large numbers of spectrum holes, known as white spaces, have been discovered in various networks. CR will be able to choose the best network from among the available networks[16]. The ideal network is defined as one that can meet the user's need to be connected at all times. To choose the best network, CR must first discover and sense its properties, such as many dissimilar and conflicting network attributes. As a result, optimal network selection is a difficult problem that can be accomplished through spectrum handoff decisions.

The following is the format of this paper: The literature review in Section 2 is about better network selection in CR. Section 3 contains the spectrum hand-off for picking the best network utilising various attributes and different noises. The outcomes of the experiment are shown in section 4. Finally, the paper is concluded in Section 5.

Literature Review

G. Dinesh et al. [7] proposed the Modified Spider Monkey Optimization (MSMO) technique for spectrum sensing and recognising free spectrums, hence improving the energy efficiency of the available spectrum. This method will discover the best option while also increasing the likelihood of some selections being made. The load was scheduled using a modified round-robin method. Every packet flow in this method has its own packet queue in the network interface controller. Finally, criteria like throughput, handoff, success probability, and false alarm probability were used to evaluate the performance study. Circuit energy consumption has been highlighted by the author [14] as a key paradigm to consider when computing the energy efficiency of a network system. This approach, however, is only appropriate for short-range applications. The Hybrid PSO-GSA was presented by the author [9] for spectrum sharing and sensing in the CRN network. This algorithm, on the other hand, lacks global search, while the PSO algorithm lacks local search.

Yawada(2019)[8] Cognitive radio is a cutting-edge wireless communication system technology that attempts to drastically enhance radio spectrum usage while allowing secondary users to access the spectral band as-needed. The spectrum management system, which controls the efficiency of operation between the primary and secondary networks, ensures data transport. Spectrum management's main purpose is to ensure that secondary users get the most out of the spectrum while preventing interference with primary users. This research looks into the most important issues of spectrum mobility in cognitive radio networks.

In cognitive radio networks, Hoque et al. (2019)[9] suggested an analysis of handoff delay for proactive spectrum handoff scheme with PRP M/G/1/K queuing system. Using the PRP M/G/1/K queuing model with a finite number of allowable CU interruptions, investigate the performance of the proactive decision spectrum handoff scheme in terms of cumulative handoff delay (CHD) and TST (Cognitive user). CHD and TST analytical equations have been established for the proposed PRP M/G/1/K queuing network model [9].

Proposed System Model

The spectrum sensing efficiency and energy efficiency of the CRN in the 5G heterogeneous network are trade-offs. The spectrum sensing and spectrum sharing problems are solved by focusing on energy economy when developing the battery-powered CRN network[2, 3]. The existing solutions are primarily focused on using convex optimization to solve the energy efficiency optimization problem in spectrum sensing.

Real-time spectrum sensing, on the other hand, is a non-convex optimization issue. As a result, (ARODN) is created in this study to improve energy efficiency for various spectrum sensing scenarios. The (ARODN) method is used to achieve spectrum sensing and sharing in the CRN network. Figure 1 depicts the proposed algorithm block diagram.

3.1 Multiple Attribute Decision Making

MADM approaches are scientific decision-making procedures for choice issues involving a variety of decision qualities [3]. MADM methods are used to choose the best option out of a limited number of options. The option is chosen based on the information provided by each attribute in relation to each alternative. Several factors are known to influence the outcome. An MADM method specifies how attribute values are processed to arrive at a decision. SAW, TOPSIS, GRA, cost function-based, and ETOPSIS are some of the MADM approaches available.

3.1.1 Simple Additive Weighting Method

The weighted average is used to calculate the weighted linear combination or a scoring method [2, 3]. The normalized value of each attribute is multiplied by the weight of the linked network, then the weighted sum is added for each network to obtain an assessment score [2, 3]. It includes the following steps:

Step 1: Create a matrix with various attributes.

Step 2: Produce a normalized matrix with many attributes:

Step 3: Determine the weighted average

Step 4: Determine the network's ranking: In a cognitive radio network, the network with the highest value is chosen as the best network

3.1.2 Ideal Solution Technique For Order Preference By Similarity

When the characteristics have roughly identical values and their normalized values are relatively close to each other, the TOPSIS approach[3] is more precise than other methods. It entails the following procedures:

Step 1: Create a matrix with various attributes.

Step 2: Normalized values of numerous characteristics are computed.

Step 3: Formulation of a normalized multiple attribute matrix

Step 4: Finding the best positive and negative solution

Step 5: Using the Euclidean distance approach, calculate the distance from the ideal solution.

Step 6: Relative proximity

Step 7. Ranking the networks: In a cognitive radio network, the network with the greatest Hi value is chosen as the best network for spectrum handoff.

3.1.3 Grey Relational Analysis Method

The level of available information is employed in GRA for the system's analysis. A white system is one in which all of the information is known, while a black system is one in which all of the information is unknown[10]. The steps for GRA-based optimal network ranking are as follows:

Step 1. To classify the properties of the networks. Delay, data rate, PLR, and price per unit are all characterized as lower is better.

Step 2: Establish upper and lower bounds for attributes: X is a multi-attribute matrix made up of n networks (X1, X2, ..., Xn)

Step 3: Normalize the attributes: The following equation is used to construct the normalisation matrix of several properties such as delay, PLR, Price, and crosstalk.

$$X_i^* (j) = \frac{Y_j - X_i(j)}{Y_j - Z_j}$$

1

The Normalized matrix is represented as

$$A_{norm} = \begin{bmatrix} X_1^*(1) & X_1^*(2) & \ldots\ldots & \ldots\ldots & X_1^*(n) \\ X(1) & X_2^*(2) & \ldots\ldots & \ldots\ldots & X_2^*(n) \\ \ldots & \ldots\ldots & \ldots\ldots & \ldots\ldots & \ldots \\ \ldots\ldots & \ldots\ldots & \ldots\ldots & \ldots\ldots & \ldots\ldots \\ X_m^*(1) & X_m^*(1) & \ldots\ldots & \ldots\ldots & X_m^*(n) \end{bmatrix}$$

2

Step 4: Calculate the Gray Relationship: The Gray Relationship is calculated as follows:

$$GRc_i = \frac{1}{1 + \sum_{j=1}^{m} A_{norm} \left| X_j^*(n) - 1 \right|} \quad (3)$$

Step 5. Ranking the networks: In a cognitive radio network, the network with the greatest GRci value is chosen as the best network for spectrum handoff.

3.1.4 Cost Function Based Method

The cost function-based method [10] picks the best network in CR networks from a pool of feasible networks.

Step 1: Identifying attributes that are reliant on the cost function: The cost function is influenced by a number of factors, which are presented as

$$CFB_i = f(X_{iDR}Y_{iDR}, X_{id}Y_{id}, X_{iPLR}Y_{iPLR}, X_{iCT}Y_{iCT}, X_{iP}Y_{iP})$$

4

Where CFB_i is the cost function of multiple attributes such as $X_{iDR}, X_{id}, X_{iPLR}, X_{iCT}, X_{iP}$ are data rate, delay, PLR, Crosstalk, price. The weight are obtained by the entropy method.

Step 2: Calculate the cost: The cost is determined as follows:

$$CFB_i = \frac{X(Y_{iDR})}{max(Y_{iDR}....Y_{nDR})} + \frac{X_D(1/Y_{iD})}{max((1/X_{iD}),........(1/Y_{nD})} + \frac{X_{PLR}(1/Y_{iPLR})}{max((1/X_{iPLR}),......(1/Y_{nPLR})} + \frac{X_{CT}(1/Y_{iCT})}{max((1/Y_{iCT}),....(1/Y_{nCT})} + \frac{X_P(1/Y_{iP})}{max((1/Y_{iP})........(1/Y_{nP})} \quad (5)$$

Step 3: Determine the network's ranking: In a cognitive radio network, the network with the highest CFBi value is chosen as the best network for spectrum handoff.

3.1.5 Enhanced TOPSIS Algorithm

Consider the inclination estimations of voice, information, and video administrations while choosing the best framework for handoff range[2, 10]. Delay, Data Rate, PLR, Price, Jitter, Traffic Density, Direction, and Power Consumption are among the many attributes considered.

Step 1: Define the various properties grid

Step 2: Calculate standardised estimations for various traits:

Step 3: Estimation of entropy and deviance

Step 4: Calculate the normalised value of a number of properties.

Step 5: Determine the positive and negative optimum arrangements.

Step 6. The Euclidean distance associated to positive, negative solutions and relative closeness are represented as

Step 7.In an intellectual radio system, the system with the highest ETi estimation is chosen as the optimum system for range handoff.

3.2 Proposed Adaptive Rider Optimization with Different Noise Algorithm

The ARODN method is used to ensure that the CRN network's spectrum sensing is as accurate as possible. This section contains a general description of the ARODN. The rider optimization is based on the behaviour of the riders. A few cyclist groups in the ARODN travel to a shared objective location for the race winner [17]. The algorithm considers the four groups, with the number of riders in each group drawn at random from the total number of riders. The cyclists are divided into four groups: bypass rider, follower, overtaker, and aggressor. The bypass rider's motivation is to get to the end destination by bypassing the main route. The follower's motivation is to get to the ultimate destination by following the main route.

Performance Evaluation

Different methodologies are utilised in this research to assess the efficiency of spectral handoff in cognitive radio networks. We employ a variety of networks for testing, including UMTS, WiMax, Satellite, and WiFi. Data rate, Delay, PLR, Price, Jitter, Traffic Density, Direction and Power Consumption are the attributes employed in the selection criteria. The proposed method will be implemented in the MATLAB R2016b software package and tested in the CRN network to ensure the presence of ARODN-based spectrum sensing and sharing.

4.1 Performance analysis for Triple play services

The best network for handing off the spectrum can also be decided by taking phone, data, and video service preferences into account. Delay and data rate are the most important characteristics for phone and video services, respectively.

Based on the preference values, the subjective weight for each aspect of triple play services may be computed and Fig. 2 depicts the graphical representation of these subjective attribute weights.

4.1.1 Voice Service

The delay property is believed to be the leading attribute if the CR user requires voice services.

The weighted matrix for voice service is calculated by multiplying the normalised values of voice service by the selected weight. Figure 3 shows the network selection ranking for voice service based on several MADM approaches.

4.1.2 Video Service

When a CR user requires video service, the data rate is one of the most important factors to consider. On the basis of data rate, we can see that WiMAX is given more weight. Figure 4 shows a network selection ranking for video services using MADM techniques.

4.1.3 Data Service

When a CR user needs data service, the PLR and pricing are the most critical factors to consider. Wifi or satellite are the greatest solutions when pricing is the most crucial consideration.

4.1.4 Proposed ETOPSIS

Network Rank Selection in Voice, video and data is depicted in Fig. 6 with enhanced TOPSIS method and it shows better network selection than any other techniques with delay, data rate, PLR, Price, Jitter, Traffic density, direction and power consumption.

4.2 Different Noise (AWGN, Rayleigh, Nagakami) in Adaptive Rider Optimization

The three various sounds are incorporated in the receiver signal and assessed in this case analysis. The AWGN, Rayleigh, and Nagakami noises are added to the receiver signal, and the spectrum sharing and sensing are evaluated based on that as well. Figure 7 depicts the bit error rate of the three noise signals.

Three types of data are evaluated in the examination of the suggested methodology: text, video, and image. The BER is calculated by taking into account three different types of data and sounds. The AWGN, Rayleigh, and Nagakami error rates in this video data were 0.54, 0.539, and 0.538, respectively. The AWGN, Rayleigh, and Nagakami error rates in this image data were 0.527, 0.529, and 0.512, respectively. The AWGN, Rayleigh, and Nagakami error rates in this text data were 0.47, 0.48, and 0.468, respectively. According to the findings, the Nagakami has achieved a low error rate in the CRN network with various data transfers.

Conclusion

The Research work from our study devised an effective spectrum handoff for optimal network selection in cognitive radio using MADM techniques such as SAW, TOPSIS, GRA, Cost Function and ETOPSIS. The study has implemented the entropy approach which was used to calculate the weight features in cognitive radio, and CR preferences are based on triple play services such as voice, video, and data, according to the study. Because MADM techniques are effective, the research is limited to them. Because the values are used directly for spectrum handoff, the SAW methods are simple to implement. The GRA method has a very low chance of being inaccurate. The TOPSIS technique is the best for optimal network selection based on positive and negative ideal solutions. The value is directly reliant on the cost function technique. ETOPSIS method shows better network selection than any other network. Hence the network selection approach has been done by all the above-mentioned techniques using the triple play services. Once the network selection is done, the Proposed algorithm ARODN was created to increase energy efficiency in various spectrum sensing applications. The bit error rate was calculated using the proposed algorithm. Finally, Research shows the best network selection in CR networks and algorithm which is effectively used for spectrum sensing application.

Declarations

6.Compliance with Ethical Standards Statements

6.1 Ethical Approval

Adhered to the accepted ethical standards of a genuine research study. The submitted research work is original and it has not been published in any form or language.

6.2 Funding Details

No Funding

6.3 Conflict of Interest

The author declares that there is competing or conflict of interest

6.4 Informed Consent

Not Applicable

7.Authors Contribution

Author1 and Author2 designed and coordinated the research work. Authors collected the necessary information and designed the mathematical analysis. The interpretation and performance analysis carried out by the authors. Authors drafted the manuscript and approved the final manuscript which is to be published.

References

1. Mrs, Jaya T " Intellectual Radio architecture with Software Defined Radio and its functionalities",ICSCN 2019, LNDECT 39, pp. 517–522
2. Mrs RK, Prasad, Jaya DT " Optimal Network Selection In Cognitive Radio Network Using Saw Method With Multiple Parameters" IEEE Xplore Part Number: CFP19P17-ART; ISBN:978-1-7281-2119-2
3. Mrs RK, Prasad, Jaya DT " Optimal Network Selection In Cognitive Radio Network Using Saw Method With Multiple Parameters" IEEE Xplore Part Number: CFP19P17-ART; ISBN:978-1-7281-2119-2
4. Youness, Arjoune, Kaabouch N (2019) A comprehensive survey on spectrum sensing in cognitive radio networks: Recent advances, new challenges, and future research directions. Sensors 19(1):126
5. Ambaji S, Jadhav PB, Patil, Biradar S (2020) "Optimal feature selection-based diabetic retinopathy detection using improved rider optimization algorithm enabled with deep learning."Evolutionary Intelligence:1–18
6. Tianyi Xiong Y-D, Yao Y, Ren, Li Z (2018) Multiband spectrum sensing in cognitive radio networks with secondary user hardware limitation: Random and adaptive spectrum sensing strategies. IEEE Trans Wireless Commun 17(5):3018–3029
7. Dinesh G, Venkatakrishnan P (2021) Meena Alias Jeyanthi. "Modified spider monkey optimization—An enhanced optimization of spectrum sharing in cognitive radio networks. Int J Commun Syst 34(3):e4658
8. Yawada P, Semba (2019) and Mai Trung Dong. "Intelligent Process of Spectrum Handoff/Mobility in Cognitive Radio Networks." Journal of Electrical and Computer Engineering (2019)
9. Hoque S, Shekhar S, Sen D, Arif W (2019) "Analysis of handoff delay for proactive spectrum handoff scheme with PRP M/G/1/K queuing system in cognitive radio networks."IET Communications
10. Nandakumar S, Velmurugan TUtthara Thiagarajan, Marimuthu, Karuppiah Mohammad Mehedi Hassan,Abdulhameed Alelaiwi, and Md Motaharul Islam."Efficient Spectrum Management Techniques for Cognitive Radio Networks for Proximity (2019)Service." IEEE Access7 –43805
11. Fu Y, Yang F, He Z (2018) "A quantization-based multibit data fusion scheme for cooperative spectrum sensing in cognitive radio networks." Sensors 18, no. 2 : 473
12. Guohu Wang Y, Yuan, Guo W (2019) An improved rider optimization algorithm for solving engineering optimization problems. IEEE Access 7:80570–80576
13. Ambaji S, Jadhav PB, Patil, Biradar S (2020) "Optimal feature selection-based diabetic retinopathy detection using improved rider optimization algorithm enabled with deep learning."Evolutionary Intelligence:1–18
14. Umamaheswari K (2017) "An efficiently optimized handover in cognitive radio networks using cooperative spectrum sensing."Intelligent Automation & Soft Computing:1–8
15. Rachad Atat L, Liu H, Chen J, Wu H, Li (2017) "Enabling cyber-physical communication in 5G cellular networks: Challenges, spatial spectrum sensing, and cyber-security. IET Cyber-Physical Systems: Theory & Applications 2(1):49–54

16. Xin Liu M, Jia X, Zhang, Lu W (2018) "A novel multichannel Internet of Things based on dynamic spectrum sharing in 5G communication". IEEE Internet of Things Journal 6(4):5962–5970
17. Ali O, Ercan M, Oğuz, Sunay, Ian F (2017) Akyildiz. "RF energy harvesting and transfer for spectrum sharing cellular IoT communications in 5G systems". IEEE Trans Mob Comput 17(7):1680–1694
18. Guo H, Jiang W, Luo Wu (2017) "Linear soft combination for cooperative spectrum sensing in cognitive radio networks". IEEE Commun Lett 21(7):1573–1576
19. Geoffrey, Eappen, Shankar T (2020) Hybrid PSO-GSA for energy efficient spectrum sensing in cognitive radio network. Phys Communication 40:101091
20. Arturo Briones-Reyes (2020) Luis Alberto Vásquez-Toledo, Alfonso Prieto-Guerrero, and Rafael Aguilar-Gonzalez. "Mathematical evaluation of spectrum sharing in cognitive radio networks for 5G systems using Markov processes. " Comput Networks 182:107521
21. Nkalango SDaudiA, Zhao H, Song Y, Zhang T (2020) "Energy efficiency under double deck relay assistance on cluster cooperative spectrum sensing in hybrid spectrum sharing". IEEE Access 8:41298–41308
22. Xin Liu K-Y, Lam F, Li J, Zhao, Li W (2021) "Spectrum Sharing for 6G Integrated Satellite-Terrestrial Communication Networks Based on NOMA and Cognitive Radio." arXiv preprint arXiv:2101.11418

Figures

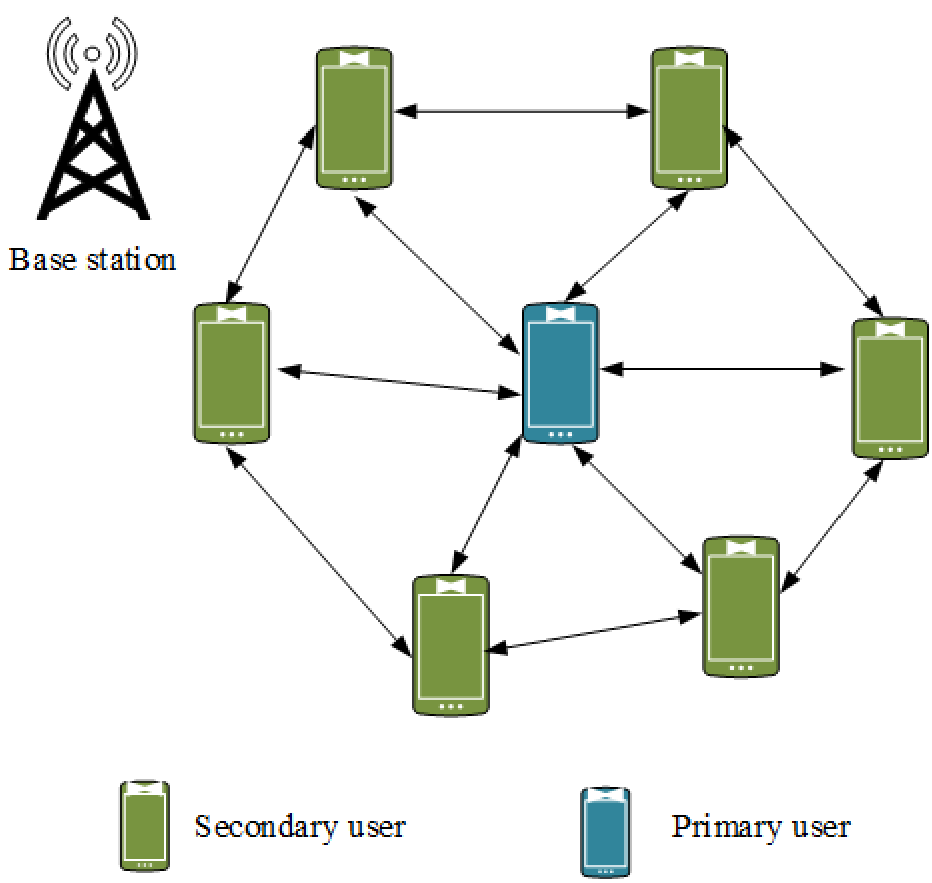

Figure 1

System Model

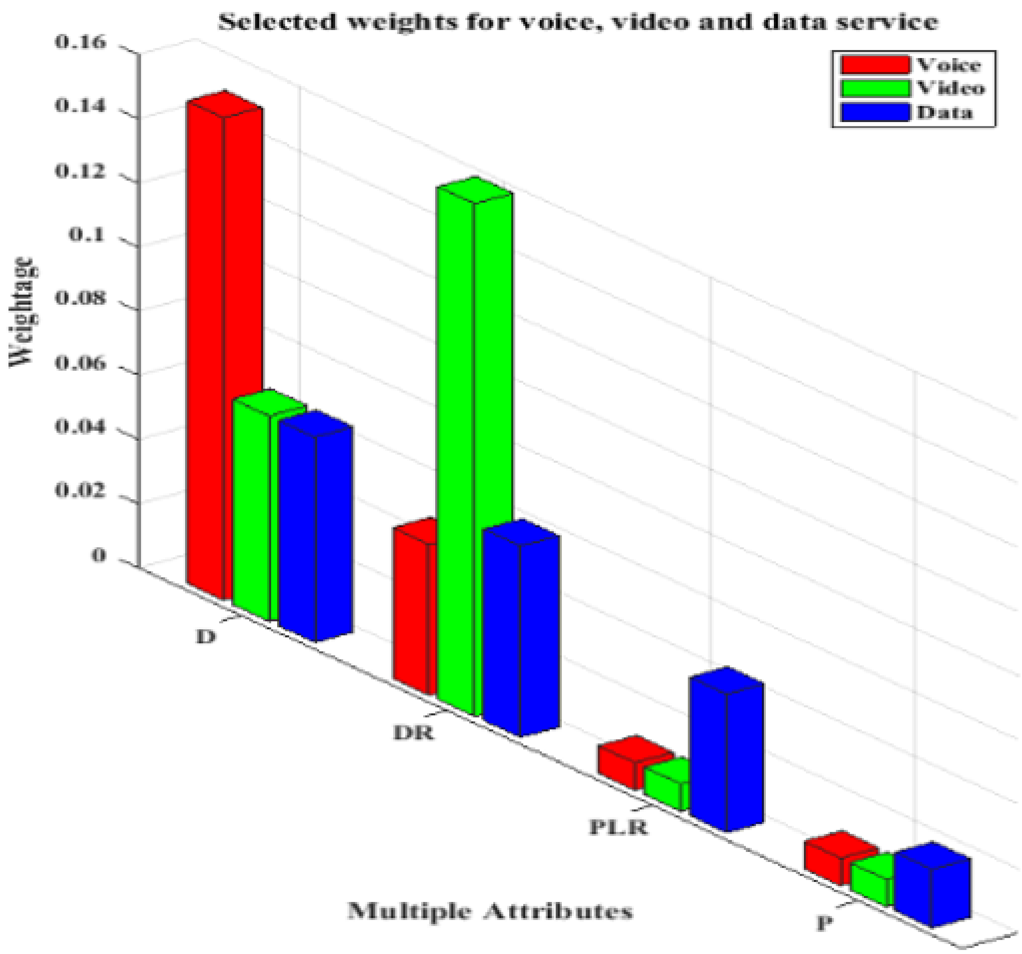

Figure 2

Illustration of voice, video, and data service weights

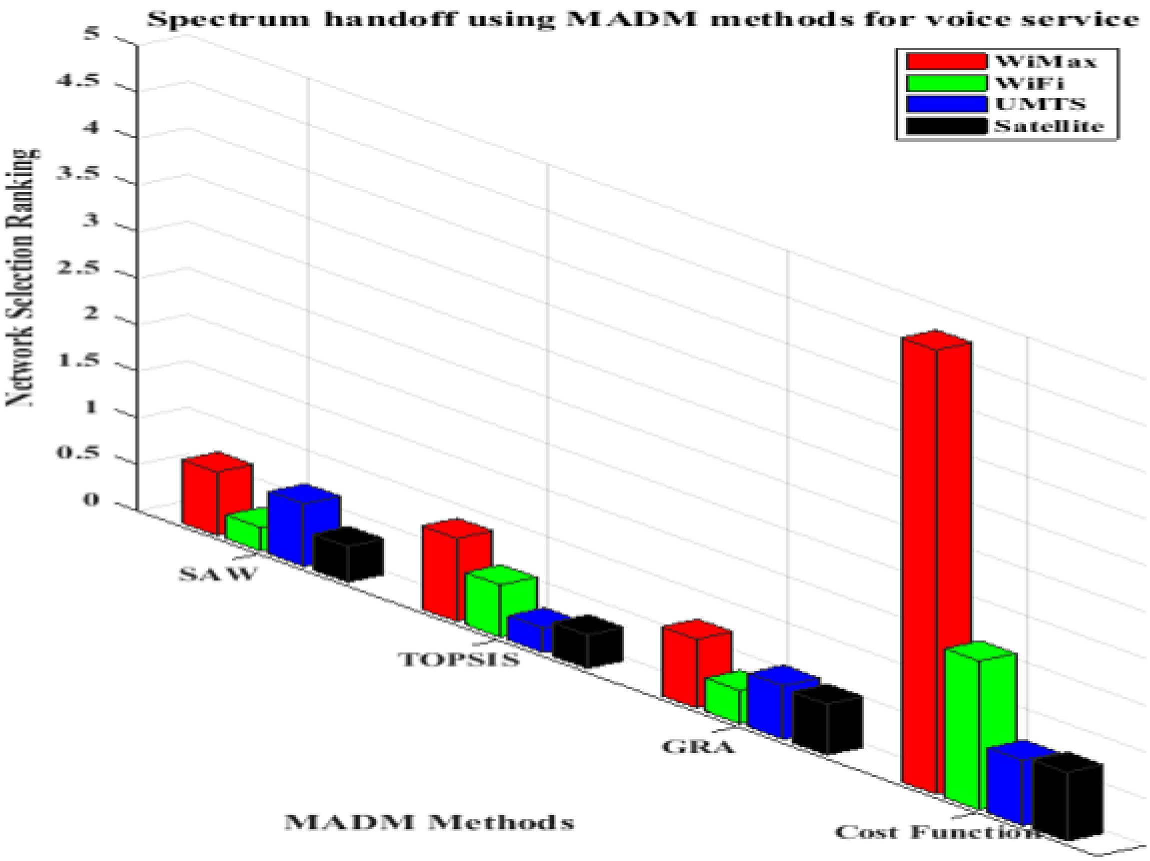

Figure 3

A representation of the voice service network selection rating.

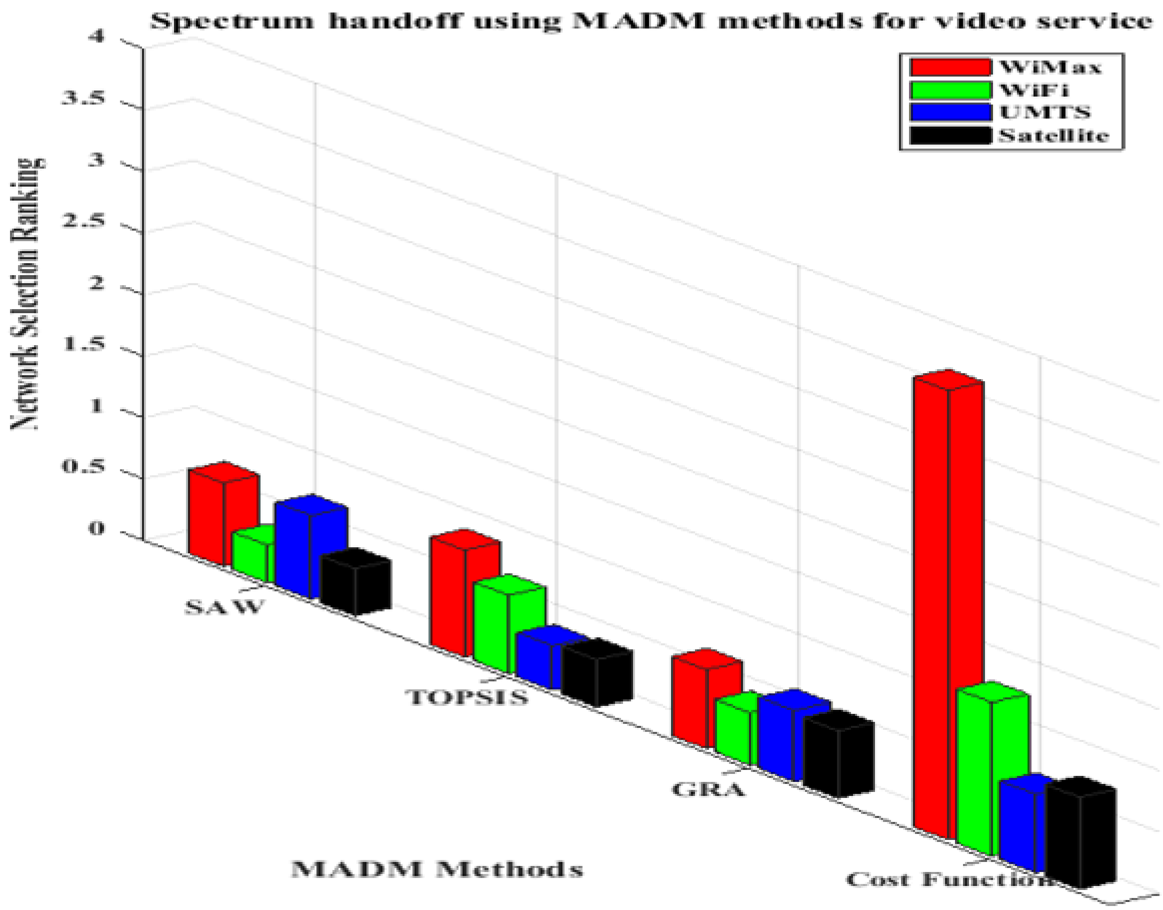

Figure 4

Illustration of network selection ranking for video services.

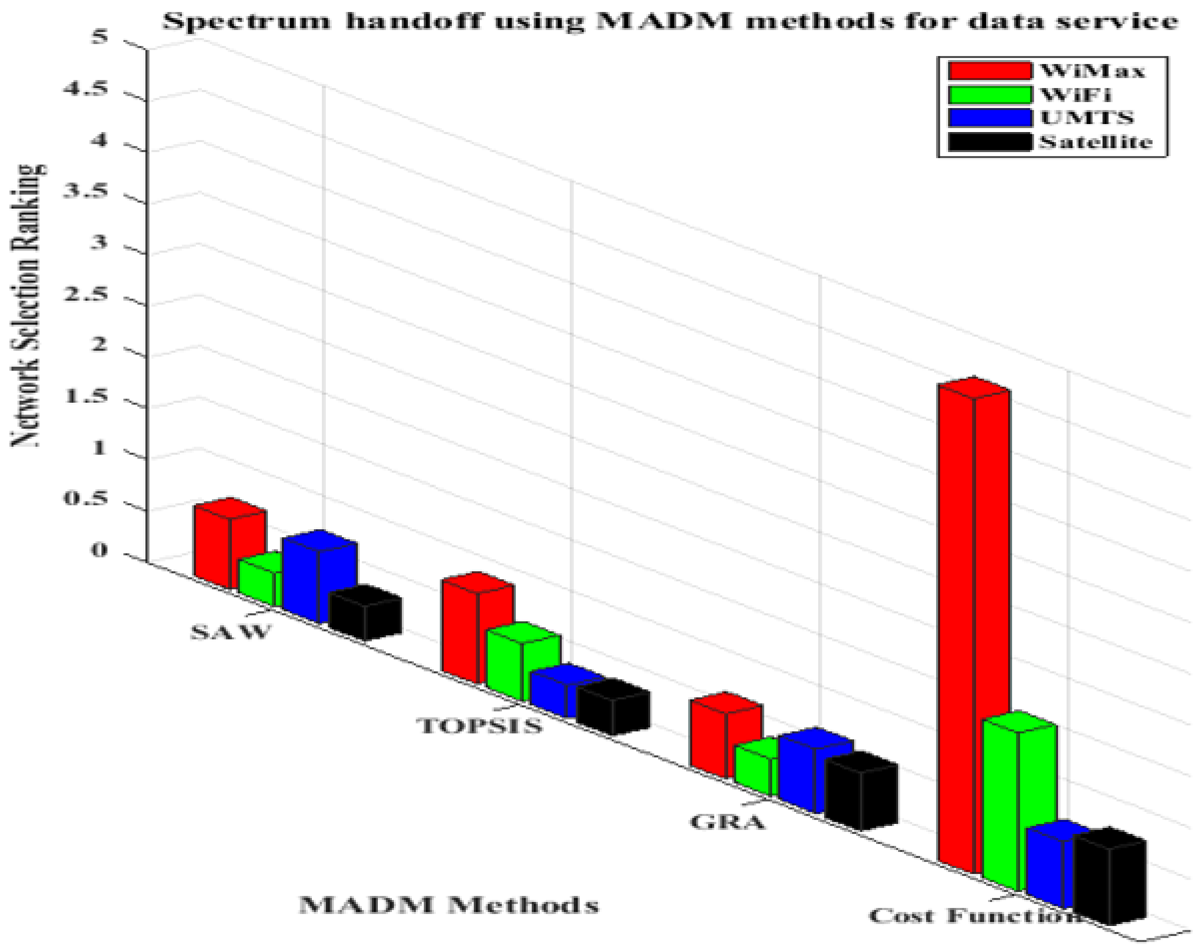

Figure 5

For data services, an illustration of network selection ranking

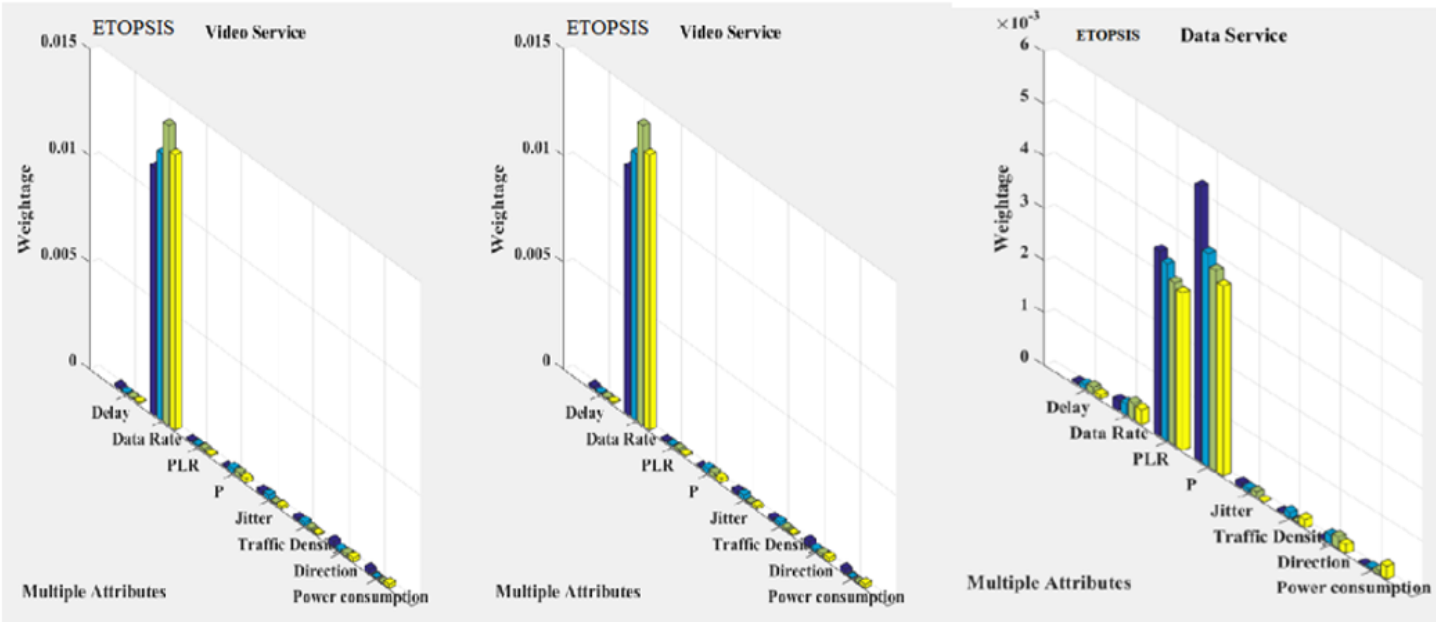

Figure 6

Network Rank Selection in Voice, video and data

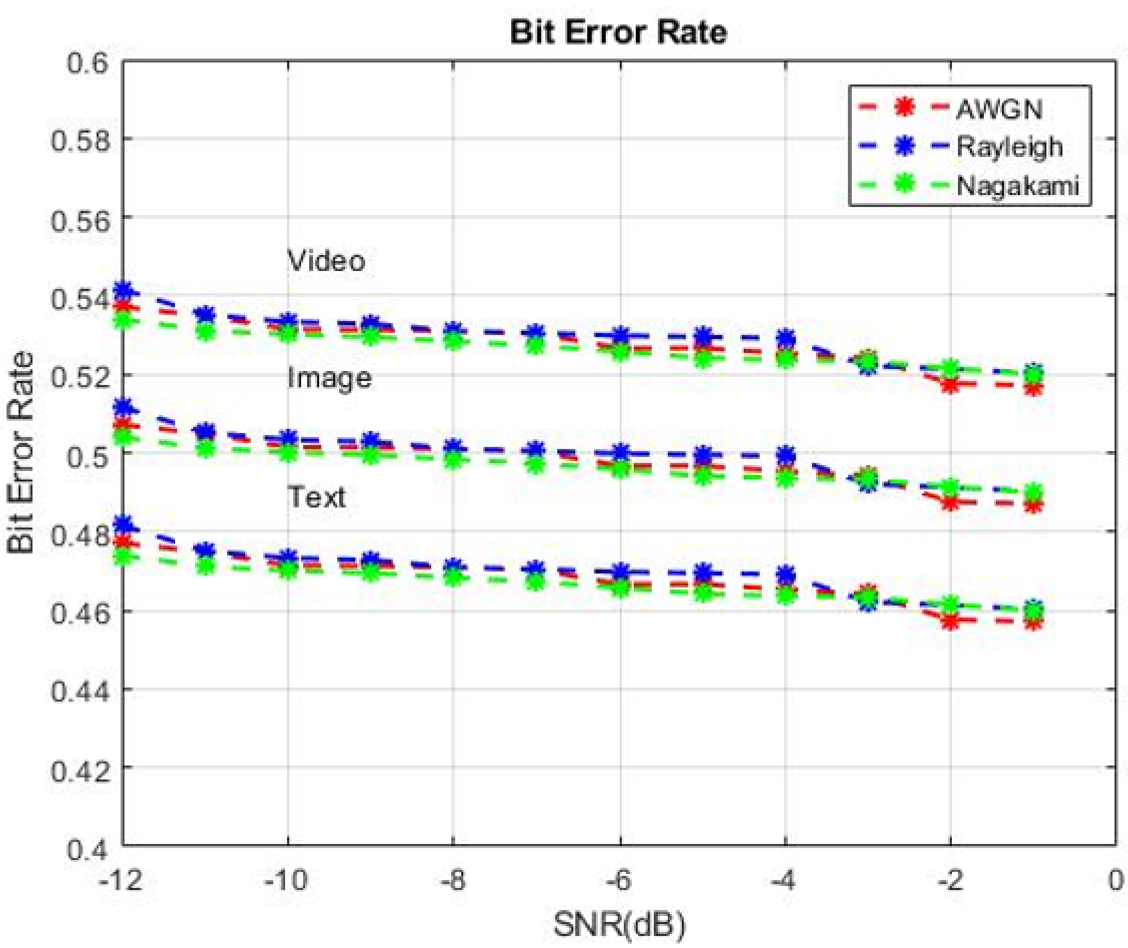

Figure 7

Analysis of BER