CHANNEL ALLOCATION FOR WIRELESS NETWORKS BASED ON INTELLIGENT METHOD

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ABSTRACT

In this paper, will be presented actual research of the intelligent channel allocation. The intelligent channel allocation is based on combination of fuzzy logic method and game theory attributes to increase quality of link in network. The channel allocations will become an important phenomenon in different types of networks such as 5G technology, wireless networks (IEEE 802.11xx), Z-Wave, LoRa, 3G, 4G, etc. In the near future, new network technologies, Internet of Things (IoT) and Smart Cities will need to have intelligent channel allocation to prevent interference on the channels used for data transfer. These networks along with IoT are considered as promising technology, that interconnects different types of networks into one fully functional network. The aim of this paper is to present the concept of a methods for channel allocation in wireless networks, where channels work as communication medium based on IEEE 802.11xx technology. The simulations prove, that proposed method is able to provide lower interference, improve data rates and increase quality of links.

Keywords: *fuzzy logic, channel selection, intelligent management, radio resource management, spectrum sensing, wireless networks*

1. INTRODUCTION

The 5G technology, mobile ad-hoc networks or other types of wireless networks take into account communication control information between devices and obtain these informations to select more suitable channels and increase the quality of network. The main aim in these networks are to effective allocate channels and improve quality of services to improve speed, decrease interference. Efficiency is used for optimal channel selection in wireless networks and improve device connection quality, which is important. Available spectrum in the way, that is used today is not effective. It is more effective to use a free channel for communication without interference (trying to minimize interference) to serve a huge number of wireless devices. It is also a method of cognitive radio technology, that enables spectrum switching based on a set of measurable parameters. Parameters are used to evaluate the quality of each channel, that can be used by the device. Also, cognitive radio allows a channel to be changed even, if communication on the selected channel is insufficient due to interference caused by an adjacent device communicating on an inappropriate communication channel.

2. SPECTRUM SENSING

Wireless networks, multi layer networks or any type of networks need to communicate. When two devices want to use the wireless communication they need to select suitable channel (frequency) and technology of connection to create a link, where they can communicate. Channel management in network is related with spectrum sensing, where devices can obtain information about devices in radio range [1], [2]. Devices should select the right channels for each devices in radio range to decrease interference between selected channels and increase quality of link. Radio resource management concerns selection of the best channel based on input parameters. Similar problem is in the wireless networks with limited number of channels, but many devices and data streams are connected to the same access point with same selected channel [3]. When designing the method for allocation of individual channels, it is necessary to take into account spectrum sensing to obtain available information from the radio environment by each device. The device can obtain information from the transmission of control informations between devices, where all basic settings necessary for communication between two devices are exchanged [4]. Spectrum sensing helps device to measure parameters such as intensity of received useful signal (Received Signal Strength – RSS), interference from radio range of device [5]. Another important parameter is the SIR value, which is the ratio of the useful signal and the interference signal caused by the transmission of other devices in the radio range. Quality of channel describes also traffic, which influences the speed of data frames. It is not effective to use a channel with high traffic, but it is more suitable to use a channel with normal, low or with no traffic. An important parameter to characterize the quality of the connection is the SIR ratio and according to this parameter, it is most important to focus selection to this parameter.

3. FUZZY LOGIC FOR CHANNEL ALLOCATION

A method based on fuzzy logic (FL) is used for more accurate evaluation of individual channels, where individual parameter values are defined from an interval of values. FL also works with a partial truth from the interval [0, 1] (can be changed) and not only with a Boolean value of 0 or 1. The advantage of FL is the interval of values and not just suitable or non-suitable [6]. We use in fuzzy logic method *RSS_value* parameter, *SIR_value* parameter and *traffic_value* parameter to rank quality of link for each devices [7]. Fig. 2 shows proposed fuzzy logic method with these selected input parameters. We focus rules more to *SIR_value* as priority parameter, that defines, if channel can be used or not. If *SIR_value* is suitable, then channel is suitable and can be used. Other parameters (RSS, traffic) only defines how

suitable is this channel to use. Fig. 2 shows process of channel selection. The fuzzification is the process of changing a real scalar value into a fuzzy logic value. This is achieved with the different types of functions (membership functions) [8], [9]. These types of membership functions are shown on Fig. 1.

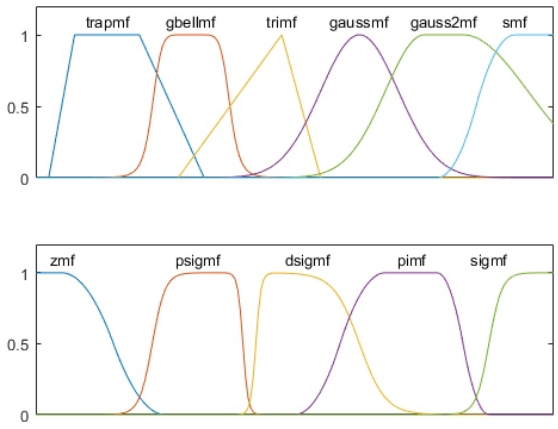

Fig. 1 Types of functions available to describe membership of parameter for fuzzy logic

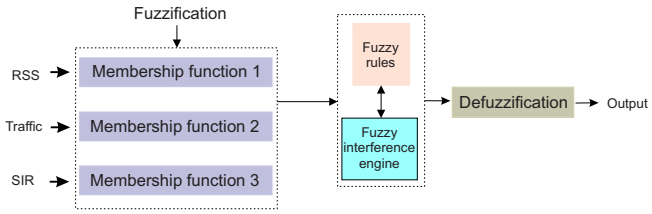

Fig. 2 Fuzzy logic with input parameters used for channel allocation

4. INTELLIGENT METHOD FOR CHANNEL ALLOCATION

Intelligent method for channel allocation is based on combination fuzzy logic and some attributes of game theory, that increase quality of the link between two devices. There exist many different types of games, that can be used for channel allocation. Also many information can improves channel selection to increase quality of link between devices in the network [10]. The main purpose of game theory attributes in intelligent method is to reach the sufficient agreement for every player. The main attributes from game theory principle are cooperation and more iterations to obtain optimal channel for each devices in network topology. Method based only on fuzzy logic changes channels only once for each device in one time slot. Fuzzy logic with more iterations as one is fuzzy logic method with game theory attribute. The intelligent method has more iterations for channel change to obtain optimal channels for network. Game theory is based on more iteration, means more moves (game moves – by players to win the game) and this attribute is also suitable to use in intelligent method. Another attribute suitable to use in channel allocation is cooperative strategy to obtain gain in allocation for quality of link in network [11]. When we have more iterations we can optimize quality of links in network by channels change. Change the channel to the one with the highest rank value in every iterations is not very effective. Due to this fact there needs to be a threshold value to change the channel. Obtain the optimal channel is not only for the device, but also to optimize network communications and quality of links. The process of this method is autonomous on each device in one time slot, where devices are not moving. The devices move in the simulation area, but within one time slot step simulation complete evaluation to verify, which channel is suitable to select. Final channel selection is at the last iteration of this method. Threshold value defines, when it is suitable to make a change and improve channel rank. It is not very effective to change channel in every iteration, when pay-off is similar or only a little bit better as previous value. Device needs some time to set this connection and with same channel this time can be used more effective. If the channel is same for more than one iteration, that means, that there is no more suitable channel to improve channel rank with higher value as threshold value. This value is expressed as a percentage, because the FL output values range is from 0 to 100. FL can very accurately defines values of each parameter with sets by membership functions. The disadvantage of this method with more than one iteration is time, that is needed to complete all iterations in one time slot in simulation area. More iterations can reevaluate selection to select more suitable channel at each iteration. The suitability of channels are reevaluated, and thus more appropriate channel is chosen, if it is possible to change channel to more suitable one from a network perspective.

5. SIMULATION RESULTS

Proposed algorithms for channel allocation based on IEEE 802.11xx technology we simulate in simulation program MATLAB. This program is suitable to use FL toolbox and evaluate our definition of rules and parameters for simulations. Also this environment is suitable to use game theory attributes for channel selection. Our proposed methods for channel allocation need to have initial parameters so for every link in the network topology we select channel 1. This channel is used to share control informations and also we need initial allocation channels to evaluate channel rank of first iteration. Next iterations are about the channel allocation and optimization of quality links in network based on selected allocation method and comparison actual and previous channel rank. During these iterations, the optimum channel for link between two devices is selected. Another attribute is final channel allocation for each device, which is selected at the last iteration of each method. Fuzzy logic method uses best available channel between two devices. This selection is also based on informations obtained from spectrum sensing and data sharing with other devices. Intelligent method has similar principle with some difference in channel process selection, where we use more iterations (21 iterations) to obtain optimal channel for connec-

tion between two devices. Also another attribute from game theory we use cooperation to share informations with other devices in radio range. Next Tab. 1 shows initial simulation parameters used to allocate channel for proposed methods.

Table 1 Parameters used to optimise channels

Area [m]	500 x 500
Radio range of device [m]	100
Number of nodes	40
Regular deployment	–
Static movement	–
Devices cooperate	–
Number of iterations for fuzzy logic	2
Number of iterations for intelligent method	21

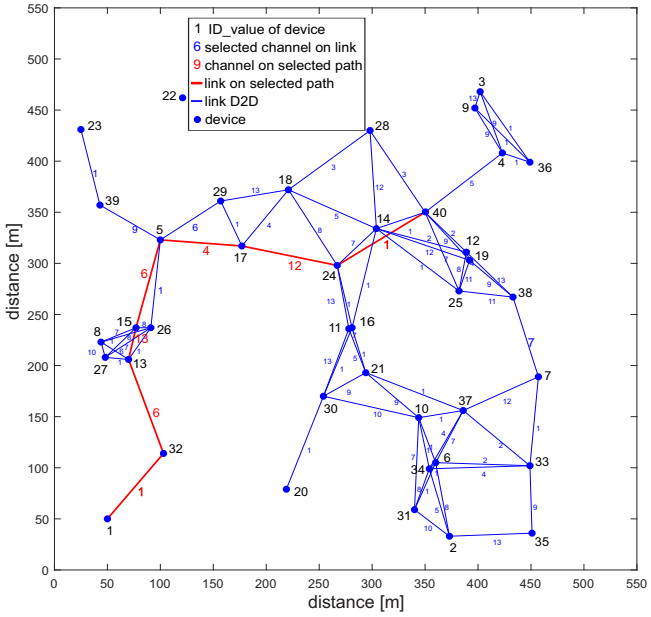

Fig. 3 The channels allocated by fuzzy logic (red line represent path from Source to Destination)

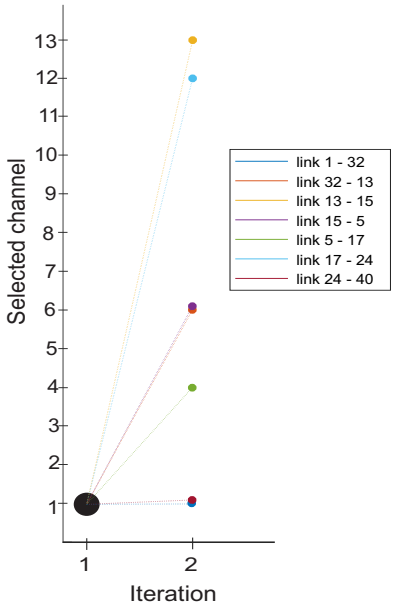

Fig. 4 Channels determined (allocated) by fuzzy logic on selected path

5.1. Allocation by fuzzy logic method

The topology of the network shows Fig. 3 with selected channels for each device by fuzzy logic method. Device can communicate only with one device at one time slot. Other channels are ready for possible communication with neighbours. The membership functions use a triangular form or other forms of the functions to define individual values in extreme cases of the interval, and the trapezoid form function is used in other parameter values. The types of these functions shows Fig. 1. The logic uses rules to determine whether a statement is true or false. In this case, we are considering rules based on the values of RSS, traffic, and SIR. Mobile devices can measure and determine the RSS value based on the received signal strength. So we assume, that the device is able to determine this value. Therefore we only use the distance of two devices to define the value of this parameter for simulation process. The *output_value* of the fuzzy logic based on the rules is *very suitable*, *more suitable*, *suitable*, *less suitable* or *non suitable*. Fig. 4 shows channel allocation after process of selection by fuzzy logic method. Fuzzy logic method is method with one iteration to optimise channels selection based on information obtained from spectrum sensing.

Next Fig. 5 shows channel rank of links between two devices on the selected path from source (S) to destination (D) device. The channel rank is low, if there are a large number of interference devices in the radio range. Channel changes to more suitable one leads to obtain a higher output value of channel rank in the next iteration. In the proposed method we use an interval to define the quality of the channel and not just a boolean-type of evaluation.

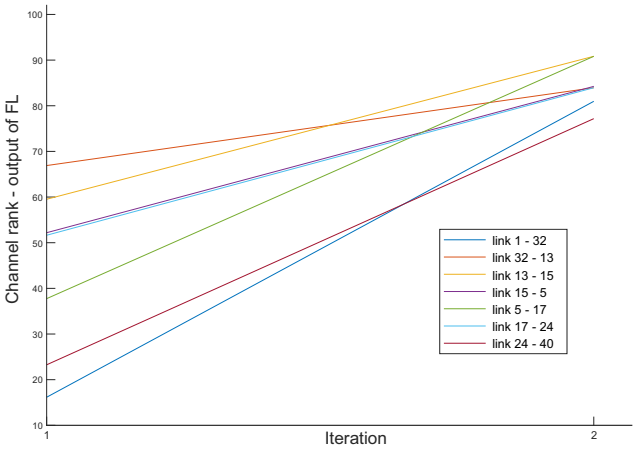

Fig. 5 Channel rank based on fuzzy logic on selected path

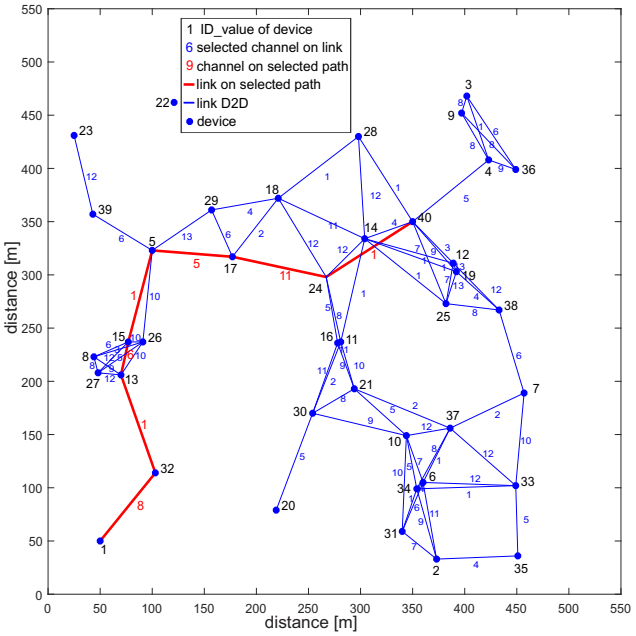

Fig. 6 The channels allocated by intelligent method on selected path

5.2. Allocation by intelligent method

Some type of game theory uses boolean logic to define parameters of link quality. Fuzzy logic on the other side uses membership functions to define these parameters with mathematical functions with different shapes. Change the type of membership function from one type to another one means change the result of output value for each defined parameter. Same *threshold_value* of difference, same input parameters, but different type of membership function means a lower number of iterations to obtain the same result for the channel allocation. The intelligent channel allocation method of simulation uses 20 iterations to make changes of selected channels in one time step, when devices don't change their location. The channel allocation is a process, that evaluates channel allocation between movement of each device. Method needs time to get the input parameters, but subsequent decision-making is performed within one time step. The repetition of simulation shows, that the number of iterations doesn't have to be large, as repetition do not result in such a drastic increases in channel rank, if an appropriate decision value is selected. The biggest jump is at the second iteration, when the allocation of the communication channel 1 is changed according to the parameters to a more appropriate one using fuzzy logic as the method for channel selection. Subsequent rating of possible channels being used decreases the rate due to the use of all 13 channels for each device and will not achieve such low interference. Output from intelligent method is channel allocation for each device in network, which shows Fig. 6.

Each link of two devices has a channel for communication, but in one time slot device can connect only to one device. So other channels are only to be ready, if there will be demand to create a new connection to another device in radio range. Red line is path from source (S) device to the destination (D) device. This path is selected by the dijkstra algorithm by links between devices in the network. The intelligent method uses channel rank by fuzzy logic, while also taking into account shared information between devices and set of the strategy for devices to cooperate. Fig. 7 shows channel selection at each iteration of links between two devices on selected path from source (S) to destination (D). It is obviously based on this figure how channels stop change their channels at the tenth iteration. After this iteration, there is no channel changes based on threshold value. Many changes are made before the eighth iteration, where devices select a more suitable channel for communication link. Only one link needs more iterations in this selected path to select optimal channel for communication. After the tenth iterations, there are no more changes so we can say, that ten iterations is enough to select optimal channel for communications in this type of the network. Link between devices 5 – 17 needs ten iterations. The device is capable to change the channel only if the pay-off is more as selected *threshold_value*, which is set to 20%. Threshold is a difference of channel rank previous selected channel and actual more suitable channel. The channel is ranked by value from interval 0 to 100, so difference set to 20 can be considered as percent of change due to fact, that channel rank is a without dimensional number. When we set *threshold_value* lower at 15 it means more channels selection and also more iterations for optimal channel selection in a network. Higher value of threshold such as 30 or more means a lower number of total iterations for optimal channel selection. Total number of iterations will be five or lower to allocate final channel of link.

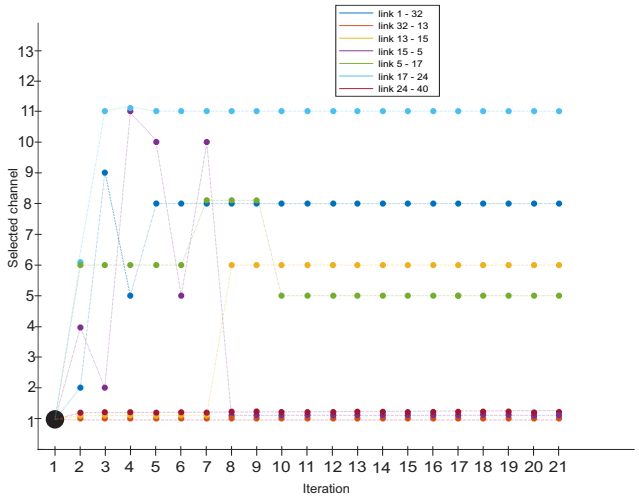

Fig. 7 Channels determined (allocated) by intelligent method on selected path

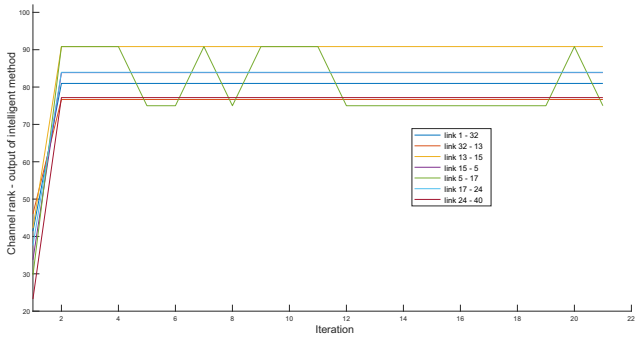

Fig. 8 Channel rank based on intelligent method on selected path

6. CONCLUSIONS

The effective channel division is done through fuzzy logic and intelligent method as combination of the fuzzy logic and some attributes from the game theory. For the proper function of channel allocation management, it is necessary to select the appropriate parameters, that characterize the quality of the connection to a sufficient degree. We use strategy set to cooperation in the simulations with intelligent method to improve channel allocation rank. Intelligent method with more then two iterations shows, that with more iterations it is possible to optimise channel allocation of the network, not only to increase channel rank for one device. When using FL, the accuracy of defining individual parameters are same as in intelligent method, but evaluation period is shorter, since FL needs only two iterations and intelligent needs 10 iterations in our scenarios. FL needs more time to obtain input parameters and to be defined due to fact, that FL can use parameters, that is partially truth and not defined just by a binary value. In one iteration management is faster, than the intelligent method, since we only need to change the connection channels only once. If the number of entries increases, so does the evaluation process.

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