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Uplink and downlink Resource Allocation to Improve Capacity for Cognitive Radio Networks

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Abstract— *Efficient spectrum management algorithms are necessary to achieve immense success in wireless communications. Cognitive radio seems to be a panacea for increased utilization of licensed spectrum. Investigate the ergodic uplink resource allocation problem for secure communication in relay-assisted orthogonal frequency-division multiple access (OFDMA)-based cognitive radio networks (CRNs) in the presence of a set of passive eavesdroppers where relay nodes assist the legitimate users to transmit their messages. andmaximize the system goodput of the CRN while satisfying the interference constraints of the PU bands both probabilistically and for the worst case scenario. The original probabilistic optimization problem is approximated and transformed into a convex deterministic form, and a closed-form analytical solution for power allocation is derived. The closed-form power allocation solution helps us to develop an efficient relay selection scheme based on Hungarian algorithm. In this project, consider uncertainty on the estimated values of CSI between different transmitters and receivers, e.g., CSI between each legitimate transmitter and its corresponding receiver and CSI of each legitimate user and each eavesdropper. Utilize the worst-case robust formulation to find power and sub-carrier allocations in such a way that under the worst condition of error, the regulatory constraints imposed to CRN are satisfied and the secrecy rate of each secondary legitimate user is stabilized. It is well known that the robust approaches impose a high computational complexity to the system and reduce the system performance as they conservatively consider the error in the maximum extent.*

Keywords— Cognitive radio networks; Ergodic resource allocation; OFDM;PU; Perfect channel state information; physical-layer security; relay-assisted transmission; robust optimization theory.

I. INTRODUCTION

Spectrum sharing through Cognitive Radio Networks (CRNs) is a promising approach first proposed by Ian C. Wong [2] 2005. Increase the spectrum efficiency for next generation of wireless communication networks where the unlicensed/Secondary Users (SUs) are allowed to access the spectrum of Primary Users (PUs) subject to Quality of Service (QoS)[1].Constraint of PUs, e.g., in underlay CRNs, the interference threshold constraint. In Orthogonal Frequency-Division multiple access (OFDMA)-based cognitive radio network CRNs, resource allocation (RA) plays a key role to increase the system performance with the intelligent assignment of transmit power to each SU on each sub-carrier In the literature, there exist two categories of RA problems:

1) Instantaneous resource allocation (IRA) where allocation of the resources is performed for any new set of channel state information (CSI) values to maximize the instantaneous objective function, e.g., sum-rate subject to constraints that have to be satisfied instantaneously, and

2) Ergodic resource allocation (ERA) where allocations are made based on the long-term channel distribution information (CDI) to maximize the objective function, e.g., sum-rate, in the average sense subject to constraints that have to also be satisfied in the average sense. In general, the ERA problems are solved in two phases: an off-line phase where based on the long term Channel Distribution Information (CDI) of different links, Lagrange multipliers are derived, and an on-line phase where based on the exact values of CSI and the parameters obtained from the off-line phase, the power and sub-carrier foreach user in each hop are determined. As the CDI varies much less infrequency than CSI, the computational complexity of the ERA is considerably less compared to the IRA problems. In this project, consider three types of uncertain CSI parameters: 1)the CSI between SU transmitters and PU receivers referred to as the interference

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CSI (I-CSI), 2) the CSI between secondary transmitter and receiver referred to as the secondary CSI (S-CSI), and 3) The CSI between SU transmitters and eavesdroppers referred to as the eavesdropper CSI (E-CSI).

Then, introduce the robust counterpart of the ERA problem for our setup. Note that in contrast, the resources are allocated so as to maximize the secrecy sum rate of SUs rather than the sum-rate itself. This significantly affects the corresponding formulations and solutions. Moreover, inclusion of relays adds more constraints to the problem which makes the solution more involved and challenging. To solve the corresponding robust ERA problems, several issues arise which are addressed in this paper as follows:

II. PARAMETER DESIGN AND SYSTEM MODEL

2.1 Computational Complexity

Generally, the robust resource allocation problems are non-convex optimization problems which suffer from high computational complexity and generally the closed-form solutions are not available for them. Recently, there have been efforts to derive closed-form solutions for robust counterpart problems in CRNs and to introduce trade-off parameters to moderate the effects of the worst-case approaches on throughput without considering security issues. In this project, follow this track for secure ERA problem and show how by utilizing the D-norm uncertainty region and reformulation of robust counterpart problems can derive a tractable formulation for the uncertain parameters on secrecy rate of each SU. For constraints involving the uncertain parameters, also propose well-behaved safe approximation functions. Then show how the robust ERA problem can be solved with tolerable additional calculations.

2.2 Trade-Off between Optimality and Robustness

It is well known that the worst-case approach might be too conservative since the error is assumed to be in its maximum extent which leads to the reduction of the total secrecy rate of SUs compared to that of the nominal ones. Therefore, it is very desirable to develop algorithms that can provide trade-off between optimality and robustness. Adjustable robust optimization theory is a new area of robust optimization where uncertain parameters are assumed to be bounded in the uncertainty region and of stochastic nature. By these two assumptions, a proper robust optimization can be defined where under the worst-case condition of error, the violation probability of each constraint and each user's utility is kept below a given threshold. Compared to the existing literature, the novelties of our paper can be summarized as follows:

The system model of this project is based on joint OFDMA transmission and relay-assisted model which can jointly increase the secrecy rate of SUs considerably;

The resource allocation problem is based on ergodic formulation which was not considered in the relay-assisted secrecy rate formulations in the existing literature.

2.3 System Model MIMO- OFDM Design

A MIMO-OFDM signal has three stages as summarized in below equation. The first stage groups subcarriers and frames to maximize the number of observations for a fixed channel matrix. The second stage applies an ICA algorithm to estimate the inverse channel matrix **H**-1 and thus separate the MIMO signals. Finally, in the third stage, modulation classification methods are applied to the separated data streams.

The ICA and modulation classification stages are discussed below in detail by the equation

$$H^\wedge = HPD \tag{1}$$

Where $H^\wedge$is the channel estimate obtained by ICA, **D** is a diagonal, complex-valued matrix accounting for phase ambiguities, and **P** is a permutation matrix?

2.4 Comparison Of MIMO OFDM With OPSK

Orthogonal frequency-division multiplexing is a multicarrier digital modulation system that has been employed as a modulation system for terrestrial digital broadcasting. Compared with single-carrier digital modulation, OFDM can lengthen the symbol period while maintaining the same error-rate characteristics and band efficiency. The OFDM signal multiplexes multiple digitally modulated waves that are mutually orthogonal in a certain signal interval. Referring to Figure 1, if, for baseband frequencies, let carrier- 1 be the base wave and arrange subsequent carriers at integral multiples of 2, 3, and so on of the base frequency, then any set of these carriers will be mutually orthogonal within one period of the basic wave. A guard interval is formed for each effective symbol period by taking a section of waveform data from the end of the symbol in question and simply attaching it to the front of the symbol, as shown in Figure 2. Transmit symbols of period Tu+Tg are obtained in this way. A MIMO-OFDM system can be considered a set of instantaneous mixtures of transmitted signals. The problem of separating MIMO-OFDM signals becomes a blind source separation problem (BSS) at each subcarrier. But rather than having to solve multiple BSS problems, we exploit the coherence bandwidth and time coherence of the channel, assumed known at the receiver.

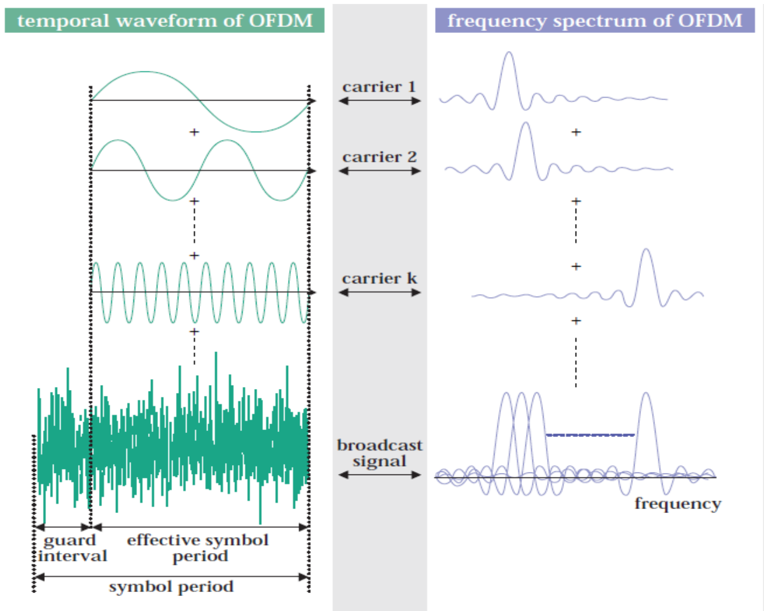

FIG 1: OFDM TIME SPECTRUM AND FREQUENCY SPECTRUM

Modulation and demodulation in an OFDM system can be performed for all carriers collectively by using an Inverse Discrete Fourier transform (IDFT, IFFT) and a Discrete Fourier Transform (DFT, FFT). On the transmit side, the transmit bit stream is input data for the IFFT. As an example, consider the case of 16QAM-OFDM modulation. As shown in Figure 4, each carrier is divided into 4-bit units. If the four bits allocated to symbol number l and carrier number k happen to be 1001, the I-axis value will be 1 and the Q-axis value -3 in the 16QAM constellation. Accordingly, data C(l,k) input to the IFFT can be expressed as complex data in the following manner.

$$C(L,K) = A(L,K) + JB(L,K) = \ 1 + J(-3)C \qquad (2)$$

This input-data conversion is performed for multiple carriers and the result is subjected to the IFFT: this constitutes the 16QAM-OFDM modulation process. The output from one IFFT pass constitutes the temporal waveform data of one (effective) symbol. On the receive side, the inverse operations of those on the transmit side are performed to obtain the received bit stream. The above forms the basis for OFDM modulation/demodulation using FFTs.

That the number of subcarriers of the OFDM frame matches the coherence bandwidth of the channel, implies a flat channel signal vectors $\mathbf{s}(k,n)$, and noise vectors $\mathbf{z}(k,n)$ associated with channel **H**, are re-indexed SK,HK,YK. by using this formula. and obtained the secure value. A modulation classification bound obtained based on data-aided channel estimates is looser than the bound obtained based on blind channel estimation.

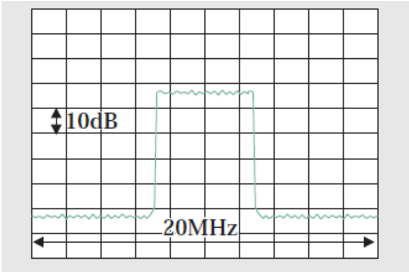

FIG 2: OFDM TRANSMISSION SPECTRUM

III. PROPOSED SYSTEM BLOCK DIAGRAM

Consider a MIMO-OFDM system with transmit antennas and receive antennas. Identifiability conditions of the MIMO channel require. $M_t < M_r$. The system transmits frames of OFDM symbols, $s^{(i)}(k,n)$ where $s^{(i)}$ is a length M_t vector of symbols belonging to a constellation Ω is the subcarrier index n and k is the frame index.

A frame is an OFDM block of data symbols. The transmitted symbols are of unknown PSK/QAM modulation, but are assumed statistically independent between antennas, subcarriers and frames. In addition, ideal time synchronization as well as ideal carrier frequency synchronization is assumed at the receiver side. A block diagram of the MIMO-OFDM system is shown in Fig.

$$Y(K,N) = H(K,N)S(K,N) + Z(K,N) \tag{3}$$

where $\boldsymbol{H}(\boldsymbol{K},\boldsymbol{N})$ is the MIMO channel matrix associated with subcarrier index *n* and frame index K, and Z(K,N) is additive white Gaussian noise. The noise is complex-valued, zero mean, has known variance $\sum^2$ for both real and imaginary parts,and is independent between receive antennas, subcarriers, and frames.

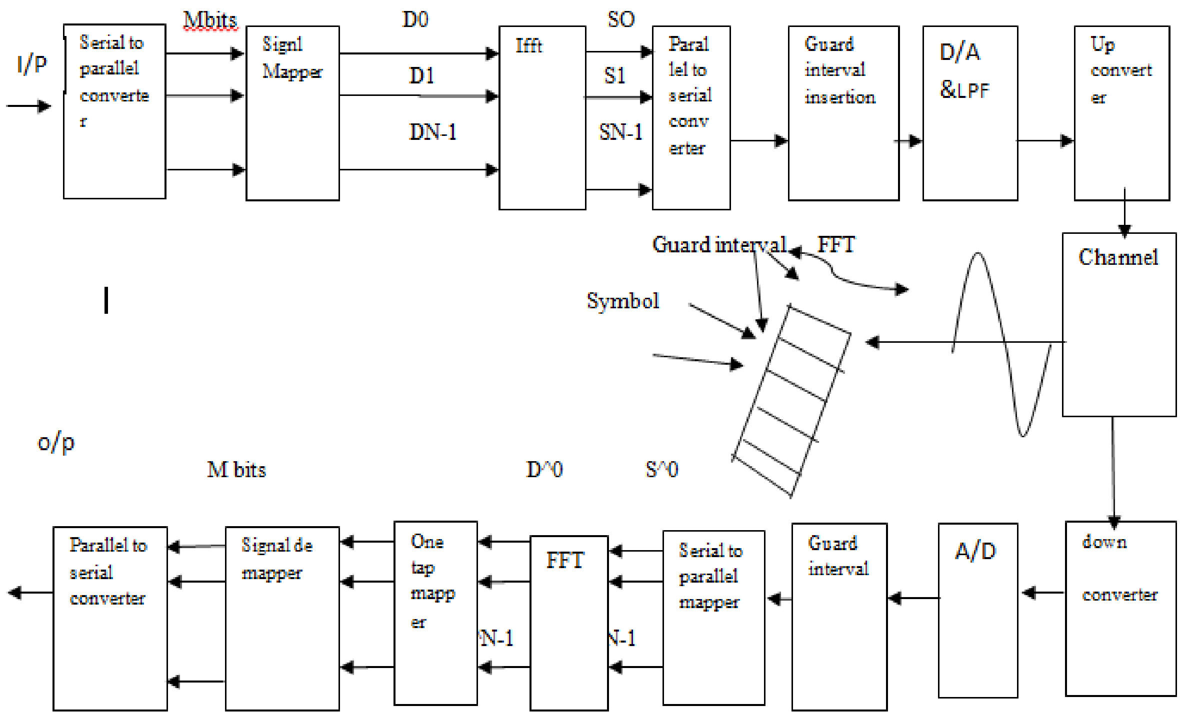

FIG 3: BLOCK DIAGRAM OF THE MIMO-OFDM SYSTEM

3.1 Input Data

The input Data to the OFDM is given in terms of high bit stream with 9.6KHzbaudrate.The high bit streams are converted to low bit stream by applying data segmentation technique.

3.2 Serial to Parallel Conversion

The input serial data stream is formatted into the word size required for transmission, e.g. 2 bits/word for QAM, and shifted into a parallel format. The data is then transmitted in parallel by assigning each data word to one carrier in the transmission.

3.3 Modulation of Data

The data to be transmitted on each carrier is then differential encoded with previous symbols, then mapped into a Phase Shift Keying (PSK) format. Since differential encoding requires an initial phase reference an extra symbol is added at the start for this purpose. The data on each symbol is then mapped to a phase angle based on the modulation method.

3.4 Inverse Fourier Transform

After the required spectrum is worked out, an inverse Fourier transform is used to find the corresponding time waveform. The guard period is then added to the start of each symbol. OFDM uses the available spectrum efficiently by spacing the channels much closer together. For that, after choosing the spectrum required, we have to convert it back to its time domain signal using an Inverse Fourier Transform

3.5 Guard Period

One way to avoid the inter symbol interference is to set a small gap equal to the duration of delay spread between the symbols. So, each symbol does not affect the next one. We will all later this interval plays an important role in the implementation. The guard period used was made up of two sections. Half of the guard period time is a zero amplitude transmission. The other half of the guard period is a cyclic extension of the symbol to be transmitted. This was to allow for symbol timing to be easily recovered by envelope detection. After the guard has been added, the symbols are then to a base and then determining the block diagram.

IV. RESULTS

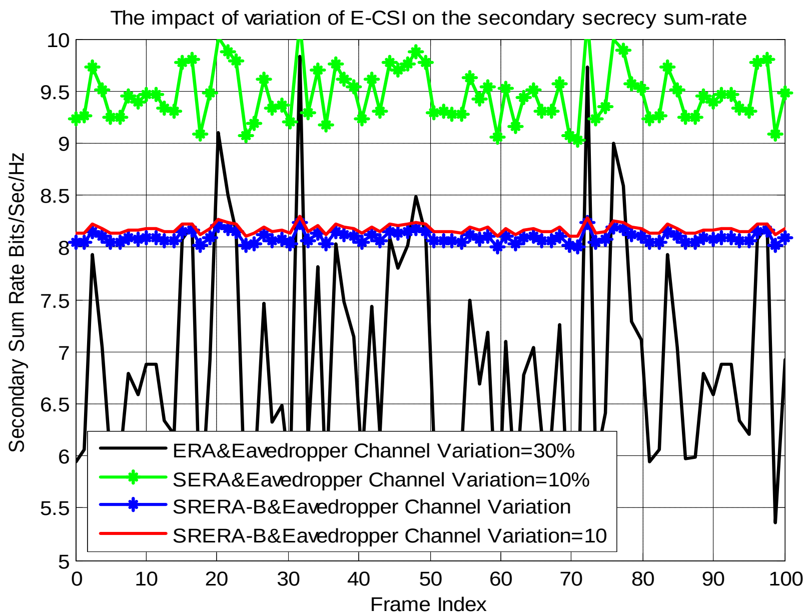

FIG .4.THE IMPACT OF VARIATION OF E-CSI ON THE SECONDARY SECRECY SUM-RATE.

In fig. 4 eavedropper is concerned with how well OFDM performs when transmitted over an Additive White Gaussian Noise (AWGN) channel only. E-CSI values are varied up to 10% and 30% of their nominal values in each time frame. The system cannot obtain a high secondary secrecy sum-rate even for large values.The signal then passes through a channel, modelled by a finite-length impulse response limited to the interval [0,1].have plotted the instantaneous secondary secrecy sum-rate for SERA and SRERA where we again assume that I-CSI and E-CSI variations are upto 10%, and 30%, respectively. Both of these figures show that SRERA can stabilize the secondary secrecy sum-rate .

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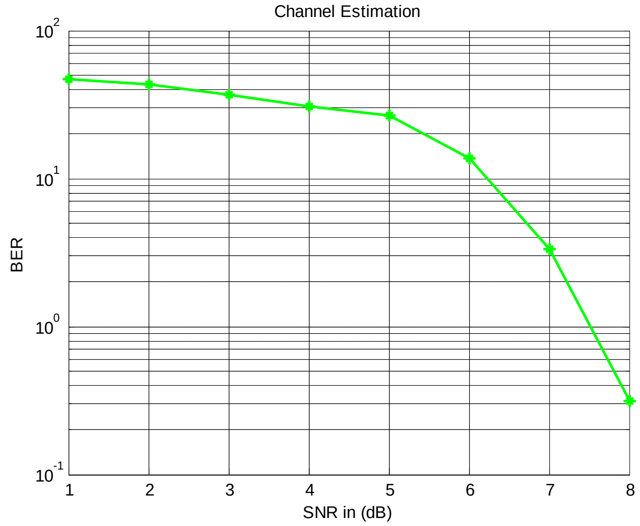

FIG .5.THE IMPACT OF VARIATION OF E-CSI ON THE SECONDARY SECRECY SUM-RATE.

In Fig.5 First compare the performance of SERA and SRERA where the uncertainty is assumed to be on the value of E-CSI. For Fig .4 in the simulations, first assume that at , the proposed problems are solved and the Lagrange multipliers are derived for the upcoming time instants. For each new instant of time, based on the Lagrange multipliers at and new CSI values, new allocations are made for power and sub-carriers. However, E-CSI values are varied up to 10% and 30% of their nominal values in each time frame.

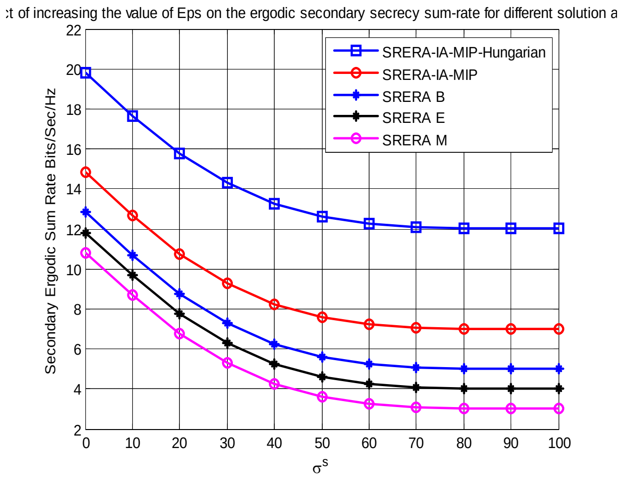

FIG.6.THE EFFECT OF INCREASING THE VALUE ON THE ERGODIC

In the fig .6 contain the ergodic sumrate and the performance of the different relay values.

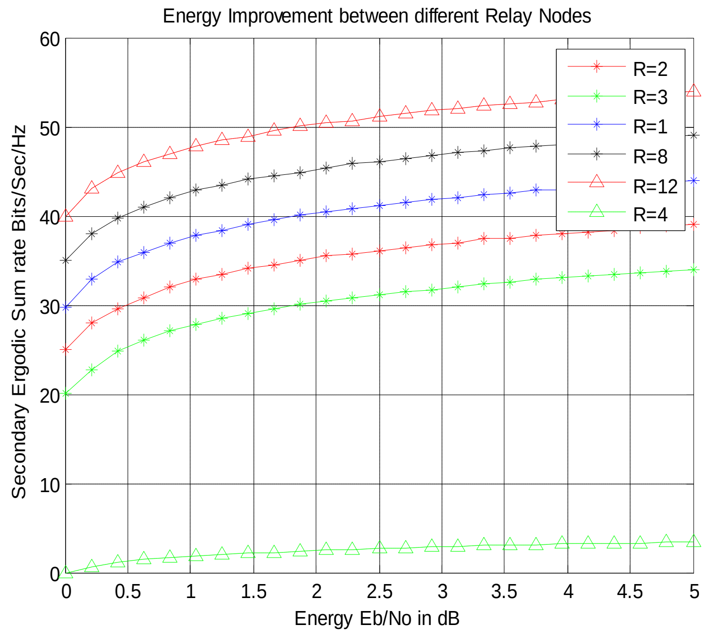

FIG 7 THE EFFECT OF THE NUMBER OF RELAY NODES ON THE PERFORMANCE OF THE SYSTEM

The effect of the number of relay nodes on the system performance is shown in Fig. 6.when IA-MIP is used to solve the SRERA problem. Modulation classification generally entails a step of blind channel estimation.

Simulation results confirm the effectiveness of the proposed robust approaches in stabilizing the secrecy rate. A simple division by the channel frequency response gets back the transmitted signal. E-CSI values are varied up to 10% and 30% of their nominal values in each time frame Modulation and demodulation in an OFDM system can be performed for all carriers collectively by using an Inverse Discrete Fourier transform (IDFT, IFFT) and a Discrete Fourier Transform.

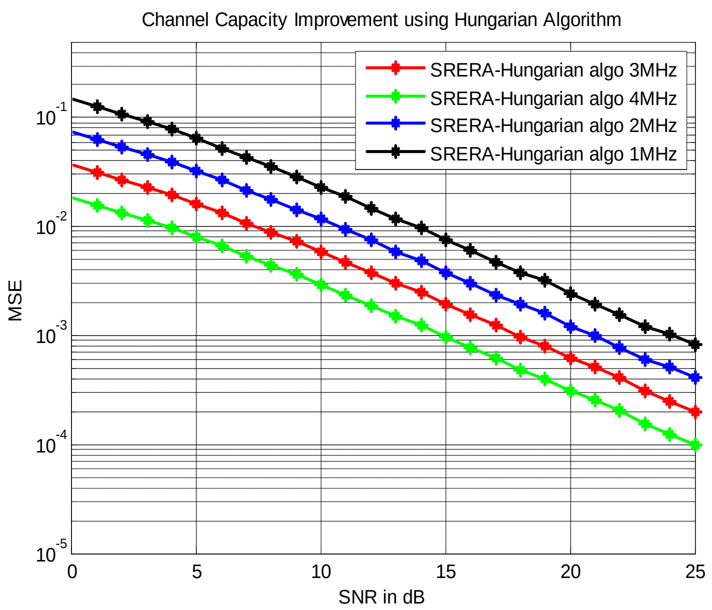

FIG .8.THE EFFECT OF THE NUMBER OF MSE SYSTEM

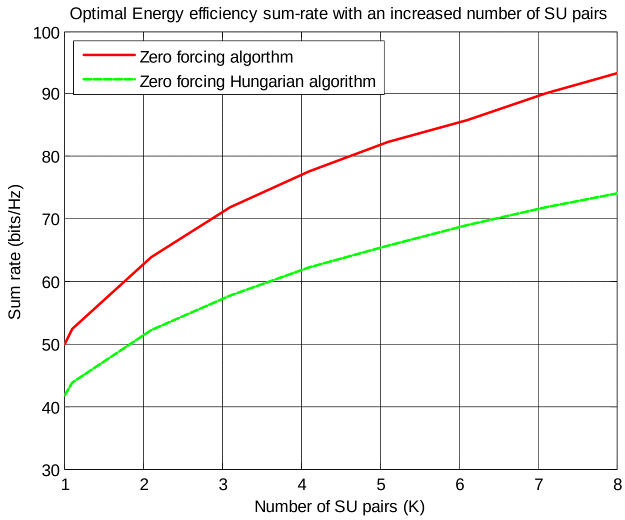

FIG .9.OPTIMAL ENERGY EFFICIENCY SUM RATE

The secure sum-rate of secondary users in SRERA decreases by increasing the percentage of uncertainty on S-SCI The accuracy of estimated channel matrix affects the modulation classification. Based on the accuracy of the estimated channel, an upper bound on the performance of modulation classification will be obtained in this paper.

V. CONCLUSION

On considering the raising the impact of WSNs on real-time civil and military applications. In this context, it is common to assume that the exact and instantaneous values of CSI between different transmitters and receivers, including those corresponding to the eavesdropper, are available to solve the SERA problem which is an unrealistic assumption. Among the proposed methods, iterative algorithms outperform other approaches, and the proposed method based on the Markov inequity as well as the Ellipsoid method offer the worst secrecy rate. The performance of the Bernstein approach falls between these two extremes. Simulation results confirm the effectiveness of the proposed robust approaches in stabilizing the secrecy rate. The proposed group power allocation algorithm adaptively assigns the transmit power to the subcarrier groups according to the effective signal-to-noise ratio (SNR) of each subcarrier group based on greedy algorithm. The proposed joint optimization algorithm can maximize the CR systems spectrum efficiency at an extremely low primary user SNR regime with low complexity.

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