# A Joint Band Jamming and Tone Suppression Technique using CSI for Wireless Networks

Pooja Patel[#1], Mahendra Patel[#2], Mayank Bhatt[#3]

[#1]*PG Scholar, Department of CSE, LNCTS (RIT), Indore, MP-India*
[#2]*Assistant Professor, Department of CSE, LNCTS (RIT), Indore, MP-India*
[#3]*HOD, Department of CSE, LNCTS (RIT), Indore, MP-India*

***ABSTRACT:*** *Digital data transmission in wireless networks has seen various types of attacks by adversaries on the data stream transmitted. Although several encryption algorithms have been employed, yet none can ascertain complete security of classified data. [1] Therefore a countermeasure in terms of band jamming has been proposed here which makes the data for intended users undetectable to adversaries. This paper shows the results band jamming can achieve under constraints of selective channel response in practical wireless networks. Finally a comparative analysis in terms of the Bit Error Rate (BER) has been carried out which depicts the effectiveness of the jamming technique under variable channel state response under practical situations for required Quality of Service (QoS).*

***KEYWORDS:*** *Band Jamming, Outage Probability, Quality of Service (QoS), User Equipment (UE), Additive White Gaussian Noise (AWGN), Signal to Noise and Interference Ratio (SINR), Bit Error Rate (BER), Channel State Information (CSI.).*

## I. INTRODUCTION

Spread spectrum is a means of transmission in which the signal occupies a bandwidth in excess of the minimum necessary to send the information; the band spread is accomplished by means of a code which is independent of the data, and a synchronized reception with the code at the receiver is used for de-spreading and subsequent data recovery.” Under this definition, standard modulation schemes such as FM and PCM which also spread the spectrum of an information signal do not qualify as spread spectrum. [1] There are many reasons for spreading the spectrum, and if done properly, a multiplicity of benefits can accrue simultaneously. Some of these are [2]

Securing Wireless Networks
Anti jamming
Anti interference
Low probability of intercept
Multiple user random access communications with selective addressing capability in High resolution ranging.
Accurate universal timing.

The means by which the spectrum is spread is crucial. Several of the techniques are “direct-sequence” modulation in which a fast pseudo randomly generated sequence causes phase transitions in the carrier containing data, “frequency hopping,” in which the carrier is caused to shift frequency in a pseudorandom way, arid “time hopping,” wherein bursts of signal are initiated at pseudorandom times. Hybrid combinations of these techniques are frequently used. Although the current applications for spread spectrum continue to be primarily for military communications, there is a growing interest in the use of this technique for mobile radio networks (radio telephony, packet radio, and amateur radio), timing and positioning systems, some specialized applications in satellites, etc. Spread spectrum is a class of modulation techniques developed over the past 50 years. In order to qualify as a spread spectrum signal, the following criteria must be met:

1) The transmitted signal bandwidth is greater than the minimal information bandwidth needed to successfully transmit the signal.
2) Some function other than the information itself if being employed to determine the resultant transmitted bandwidth.

Most commercial spread spectrum systems transmit an RF signal bandwidth in the neighborhood of one to two orders of magnitude greater than the bandwidth of the information that is being sent. Transmitted bandwidth can be as large as three orders of magnitude above the bandwidth of the information. There are a number of benefits that are obtained from spreading the transmitted signal bandwidth. First, because the spread spectrum signal is being spread over a large bandwidth, it can coexist with narrow-band signals with only a slight increase to the noise floor in a give slice of spectrum. This coexistence is possible because the spread-spectrum receiver is "looking" over such a large range of frequencies that it does not see the narrow-band frequency. Even if the spread-spectrum receiver does detect the narrow band signal, it does not recognize the signal because it is not being transmitted with the proper code sequence. There are a number of incarnations of spread spectrum modulations. We will concentrate our attention on two popular forms of spread spectrum modulation, Direct Sequence and Frequency Hopping, making note that a third hybrid form of the two presented here does exist in practice. The basic spreading action can be seen through the following diagram

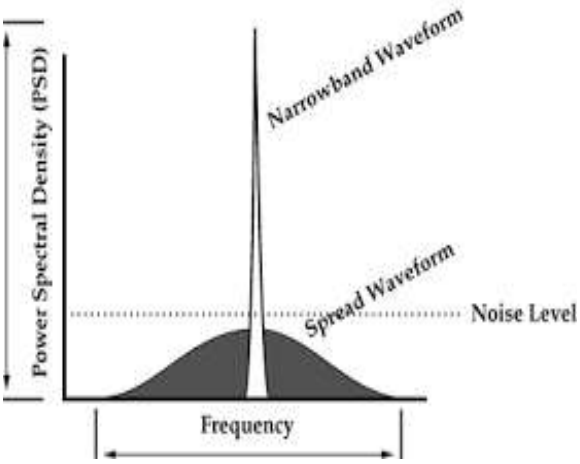


Fig.1 Basic Idea behind Spread Spectrum

## II. IMPLEMENTATION OF BAND JAMMING

Band jamming can be achieved in the desired spectrum of operation by means of direct pseudorandom sequences or frequency hopping. Here, fast frequency hopping has been employed for the purpose of jamming the desired spectrum. The specific order in which the hopping occurs is determined by a hopping table generated with the help of a pseudo-random code sequence. The rate of hopping is a function of the information rate. The order of frequencies that is selected by the receiver is dictated by the pseudo-random noise sequence. The frequency hops over different values decided by the pseudo-random (PN) sequence which creates the impression of a randomly changing frequency usage for data transmission. Even if one of the n frequencies generated by the frequency synthesizer is deciphered by the adversaries, the systems quickly hops to a different frequency for data transmission.

Mathematically the technique employed can be expressed as:

Let the signals generated for jamming be given by:

xbase1=[exp(j*4*pi*rand(Lh*n,1))]; (1)

xbase0=[exp(j*2*pi*rand(Lh*n,1))]; (2)

The final frequency hopped signal can be expressed as:

X(t)=f(s_data, xbase0, xbase2) (3)

Here,

s_data is the binary transmitted data stream

xbase0 and xbase1 represent the hopping signals

Lh represents the length of the Hopping Sequence n is the length of the binary message sequence. The addition of Noise in the Wireless Channel is modelled under AWGN conditions as under:

$$(PSD)_{Noise} = A_0 \ \forall \ f \quad (4)$$

Here

PSD stands for the Power Spectral Density;

$A_0$ stands for the value of PSD

f stands for the spectrum under consideration.

## III. SUPPRESSION OF WEAK TONES USING CHANNEL STATE INFORMATION (CSI) FOR ACHIEVING DESIRED QUALITY OF SERVICE (QOS)

Consider a discrete impulse response of the channel given by h (n) [6]
Obtain the frequency response of the channel using the FFT

I.e. H(f)=fft(h(n)) (5)

Generate the random message signal which would eventually modulate the sub carriers of to generate a random signal.
Let the random data signal be x(t) which is expressed as

$$x(t) = \sqrt{\frac{2E_s}{T}}[I(t)cos(2\pi f_c t) - Q(t)sin(2\pi f_c t)] \quad (6)$$

Where $I(t) = \sum a_n^x v(t - nT) \rightarrow$ In phase amplitude
$Q(t) = \sum a_n^Q v(t - nT) \rightarrow$ Quadrature amplitude
Representing the complex phaser as $Q_1$ (t) and $Q_2$ (t).
Random QAM signal can be expressed as

$$s_i(t) = a_1 Q_1(t) + b_1 Q_2(t) \quad (7)$$

Channel has impulse response h (t).
Therefore, output of channel is given as

$$y(t) = s_i(t) * h(t) \quad (8)$$

The Time Domain OFDM signal needs to be analyzed under 3 cases:

1) $S_1$ (t)=ifft[x(t)] where all the sub carriers are utilized for modulation.
2) $S_2$ (t) after the suppression of weak sub carriers. Weak sub carriers can be decided based on some threshold value which may vary from system to system. Here the threshold values is chosen as 50% of the maximum amplitude of the sub carriers.
3) $S_3$ (t) which is the case where all the sub carriers have equal strength due to ideal or flat nature of the channel frequency response.

Obtain the output of the channel by convolving the OFDM signal and the impulse response of the channel. Do this for all the three cases.
Generate and add random noise to the signal after the channel. Such a noise addition emulates the noise addition in the channel.

Obtain the scatter plots of the signals to analyze the effect of sub carriers with:
1) High strength
2) Average Strength
3) Weak Strength

The scatter plots depict the signalling points of the signal. In case of poor sub carriers, the scatter plots would show maximum deviation from the ideal signalling points, while the strong sub carriers would show minimum deviation from the ideal signalling points. The average sub carriers would show the deviations in between the two extremes.
Subsequently the received signal has to be obtained using x' (t) =fft [y (t)]
Finally the Probability of Error or Bit Error Rate can be estimated as:
Here we assume n (t) corresponds to zero mean white noise signal having double sided psd of $\frac{N_0}{2}$ watts/ Hz and possessing Gaussian pdf.

## IV. OUTAGE PROBABILITY FOR BASED QUALITY OF SERVICE (QOS) ESTIMATION

The user kind in cellular system is indicated for $\phi = \{C, D\}$, C is cellular communication and D is D2D communication. It is also assumed that the distribution of D2D nodes of system follows a stationary Poisson point process (PPP) with density of $\lambda_D$in the finite two-dimensional plane. [3], [24]The channel model includes path loss and Rayleigh fading. Therefore, the power of the node i received from j can be expressed as: $P_i \delta_{ij} |X_{ij}|^{-\eta}$, $i, j \epsilon \phi$, $P_i$is the power of node i, $\delta_{ij}$ is the Rayleigh fading indexbetween i and j, and it has an exponential distribution with unit mean,$X_{ij}$is the distance between node i and j,$\eta$is the path loss exponent. Signal to interference plus noise ratio at the receiver k is given as:

$$SINR_k = \frac{P_k \delta_{k0} R_k^{-\eta}}{\sum_{j\epsilon\phi} \sum_{X_{ji} \epsilon \pi_j} P_j \delta_{ji} |X_{ji}|^{-\eta} + N_0} \quad (9)$$

Where $\delta_{ji}$ is the fading factor on the power transmitted from the desired transmitter to the receiver, $N_0$ is the psd of the channel under interest.

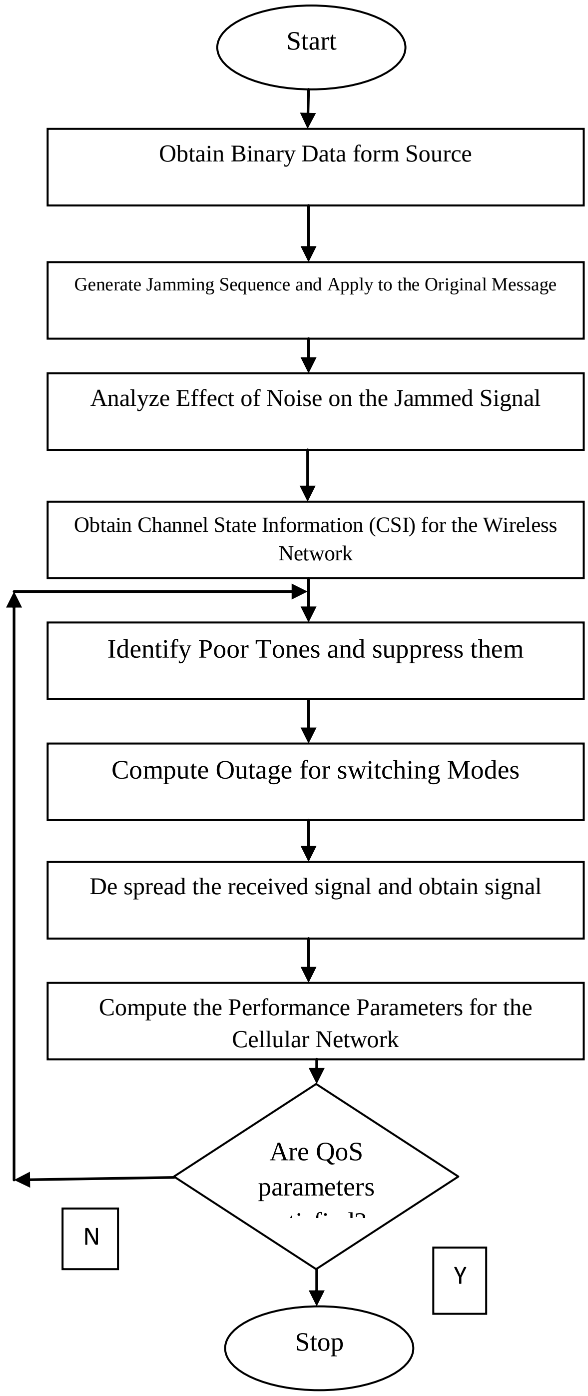


Fig.2 Flowchart of Proposed Methodology

## V. RESULTS:

The results of the proposed method can be analyzed using the sequential implementation of the steps mentioned. A clear description of the various steps involved in the culmination of results has been shown along with the inferences that need to be drawn from each step. The original data assumed here is in the form of random binary data. The network and the channel have been modelled according to aforesaid parameters.

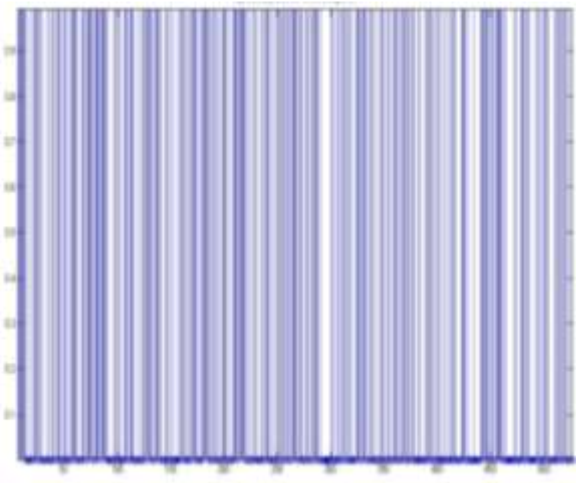

Fig. 3 Input Binary Data Signal

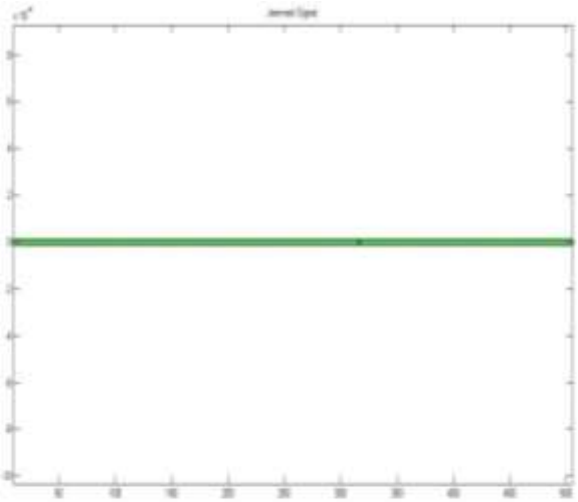

Fig. 4 Jammed Signals

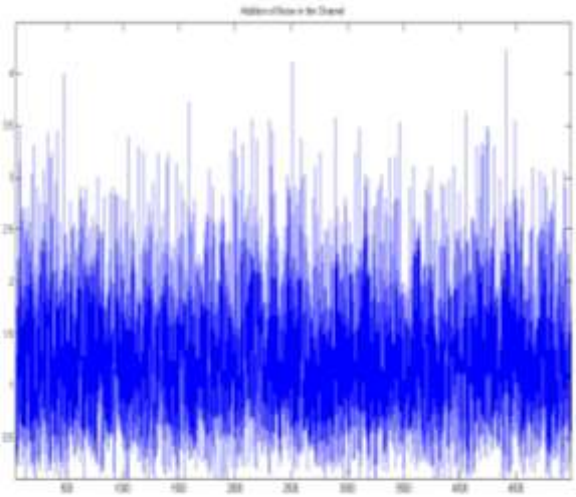

Fig. 5 Addition of Noise in the Channel

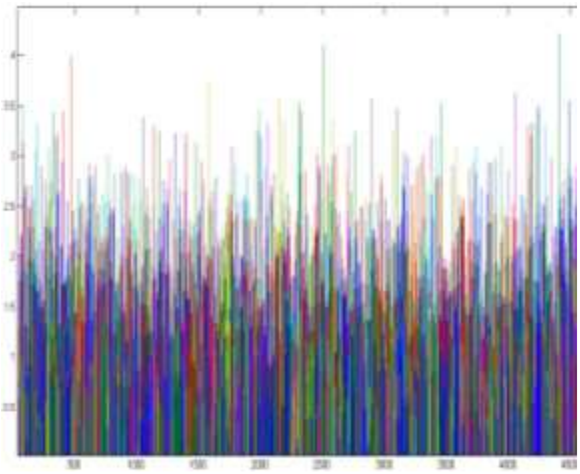

Fig. 6 Noise Added to the Jammed Signal

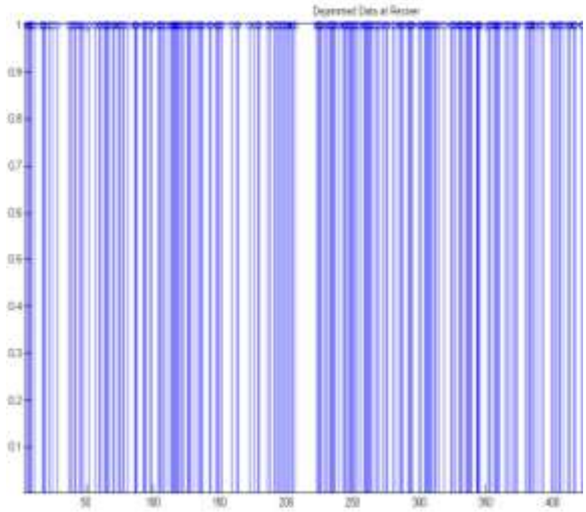

Fig. 7 De-jammed Received Signal

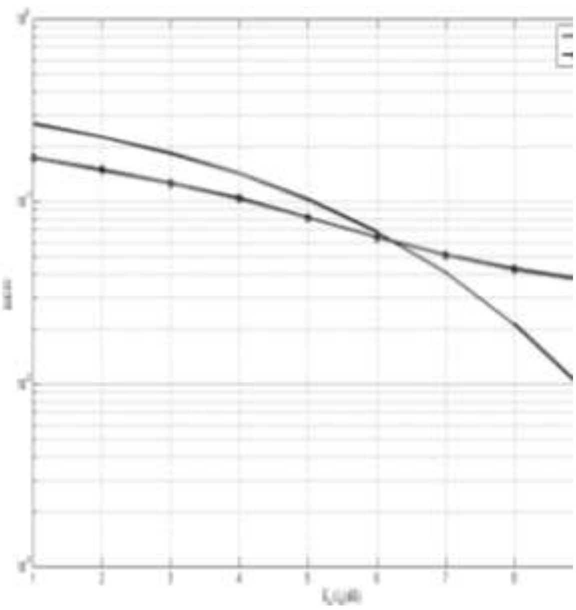

Fig. 8 BER performance of the Proposed Technique

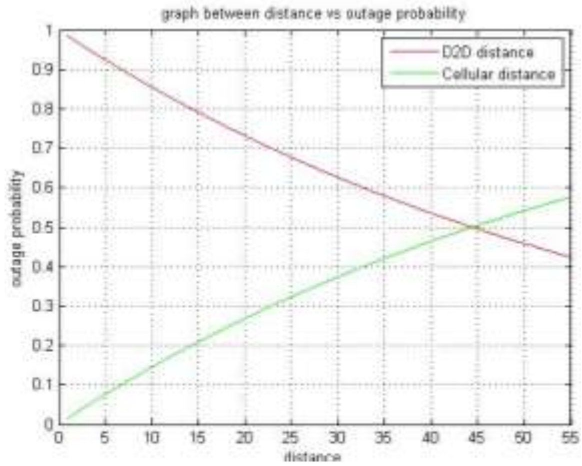


Fig. 9 Outage Probability of the Cellular Network for both Cellular and D2D modes under various shadowing effects

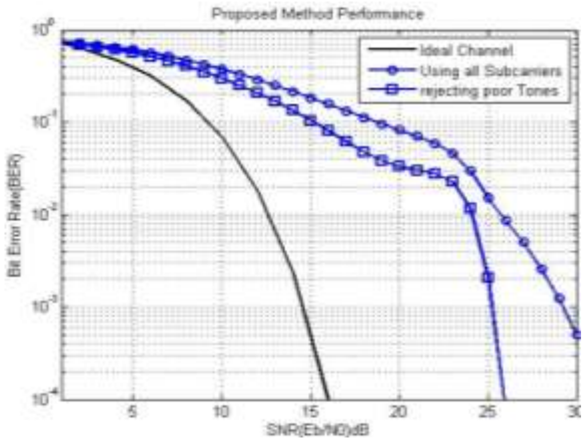


Fig. 10 BER performance of the system using Channel State Information (CSI) of the Cellular Network

| **S.No** | **BER** | **Ideal Channel** | **Using all carriers (tones)** | **Proposed System** |
|---|---|---|---|---|
| **1.** | **$10^{-1}$** | **9 dB** | **19 dB** | **15 dB** |
| **2.** | **$10^{-2}$** | **12.5 dB** | **26 dB** | **24 dB** |
| **3.** | **$10^{-3}$** | **14 dB** | **28 dB** | **25 dB** |

Table.1 Comparative Performance Evaluation of the Proposed System with respect to previously existing system

The above table clearly illustrates that with tone suppression, the BER falls more steeply compared to the normal scheme which uses all the carriers. The ideal channel obviously shows a steeper fall in the BER curve. Conversely, it can be said that more SNR is needed to attain the same BER in case of the conventional scheme as compared to the proposed scheme. The ideal channel is one in which we assume no signal strength degradation even after passing through the channel. This can be attributed to be the reason for the better BER performance compared to the proposed and conventional schemes.

## VI. CONCLUSION:

It can be concluded from the above results and discussions that the proposed technique efficiently jams the band under consideration. The jammed signal resembles noise which makes adversaries get deceived in assuming the transmitted data as noise. The BER or Probability of Error curve augments the result as the BER falls much steeply for non-jammed signals. Also the proposed technique clearly yields the distance at which the system should switch from D2D to Cellular Mode and vice-versa. Finally suppressing poor tones utilizing the channel state information (CSI) helps in improving the reliability of the cellular network by reducing the probability of error for common values of Signal to Noise Ratio (SNR).

## REFERENCES


[1] Coordinated Jamming and Communications in an MC-CDMA Systems by Wang et al, IEEE 2015

[2] Partial Band Noise Jamming Rejection with S-CFFH/16-QAM Optimum and Suboptimum Maximum-likelihood Receivers over Rayleigh Fading Channels with Imperfect CSI by Yishan He, IEEE 2015

[3] Priyadarshi Ashok Dahat, Suvra Sekhar Das, "Performance Analysis of Device-to-Device Communications in Cellular Networks under Varying Load Conditions", Springer Science, Business Media New York 2015

[4] Henrique de H.M. Barros, Marzio G.S. Rego, "A Distance based Study for D2D Communication Underlying a Cellular System", SymposiaBrasileiro Telecommunication, September 2012.

[5] K Doppler, CH Yu, "Mode selection for D2D Communication underlying an LTE-Advanced Network", WCNC 2010.

[6]Chia-Hao Yu, Klaus Doppler, Cassio B. Ribeiro, and Olav Tirkkonen, "Resource Sharing Optimization for D2D Communication Underlying Cellular Networks", IEEE Transactions on Wireless Communications, AUGUST 2011

[7] Chia-Hao Yu and Olav Tirkkonen,Klaus Doppler and Cassio Ribeiro, "Power optimization of device-to-device communication underlying cellular communication", IEEE International Conference on Communication, 2009.

[8] Xianghai Xu, Jun Sun, Shixiang Shao, "Transmission Capacity of D2D Communication under Cellular Networks", International Conference on Computer, Networks and Communication Engineering (ICCNCE 2013)

[9]Muhammad Naeem Bacha, Jamie S Evans and Stephen VHanly, "Capacity of cellular networks with MIMO links",IEEE, 2006

[10]Klaus Doppler, Mika Rinne, Carl Wijting, Cassio B. Ribeiro, and Klaus Hugl, "Device-to-Device Communication as an Underlay to LTE-Advanced Networks". IEEE Communications Magazine, December 2009

[11]Yu, Tirkkonen, Doppler, Ribeiro, "Power optimization of D2D communication underlying cellular communication",IEEE international conference on communication, 2009

[12] Sami Hakola, Tao Chen, Janne Lehtom aki and Timo Koskela, "Device-to-Device (D2D) Communication in Cellular Network - Performance Analysis of Optimum and Practical Communication Mode Selection", IEEE Communication Society, 2010.

[13] S. Hakola, T. Chen, "Device-to-Device (D2D) Communication in Cellular Network-Performance Analysis of Optimum and Practical Communication Mode selection", WCNC 2010

[14] Gabor Fodor, Erik Dahlman, Gunnar Mildh, "Design Aspects of Network Assisted Device-to-Device Communications", IEEE Communications Magazine • May 2011

[15] Fodor, G., & Reider, N. "A distributed power control scheme for cellular network assisted D2D communications", In IEEE global telecommunication conference on communication system 2011

[16] Akkarajitsakul, K., Phunchongharn, P., Hossain, E., & Bhargava, "Mode selection for energy efficient D2D communications in LTE-advanced networks: A coalitional game approach", In IEEE international conference on communication systems 2012

[17] Akhilesh Kumar, Anil Chaudhary, "Channel Capacity Enhancement of Wireless Communication using Mimo Technology",International Journal of Scientific and Technology Research, March 2012

[18] Erturk, M. Mukherjee, S. Ishii, H, & Arslan, H. "Distributions of transmit power and SINR in D2D networks", IEEE Communication, 2013.

[19] Wang, J. Zhu, D., Zhao, C., Li, J., & Lei, M. "Resource sharing of underlying D2D and uplink cellular communications", IEEE Communications 2013

[20] A. Asadi, Qing Wang, "A survey on device-to-device communication in cellular networks". Communication Survey Tutorial, IEEE, 2014.

[21] Kiran Vanganuru, Steven Ferrante, "System Capacity and Coverage of a Cellular Network with D2D Mobile Relays", IEEE 2013

[22] Rawan Alkurd, Raed M. Shubai, "Survey on Device-to-Device Communications: Challenges and Design Issue", IEEE 2014

[23] Ying -Dar Lin and Yu -Ching Hsu, "A multi hop cellular: A new architecture foe wireless communication". IEEE JNFOCOM, 2000.

[24] A. Mawira, "Estimate of mean C/I & capacity of interference limited mobile ad-hoc networks", IEEE, 2002.