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DESIGN AND IMPLEMENTATION OF D2D COMMUNICATION NETWORKS TO IMPROVE BER & OUTAGE OF SYSTEM

Ravina Karma[1], Prof. Ganesh Mukati[2]

[1]PG Scholar, Department Of Electronics & Communication Engineering, JIT, Borawan, Khargone, India.

[2]Professor, Department Of Electronics & Communication Engineering, JIT, Borawan, Khargone, India.

ABSTRACT

Rapid increase in the number of users using cellular users has resulted in the increase of load on the cellular network. The base station which routes the data from devices is becoming more and more loaded with data. This has led to the concerns on the upcoming years when the number of users would increase manifold and so would be the data rate. With evolving technologies of 5G and 6G on the forefront, a new technical solution to the aforesaid problem is inevitable. One of the major contenders for the same is the Device to Device Network (D2D) model. In this model, the base station is completely bypassed and the data is communicated among the devices directly. In this scenario, the load is hence not subjected to the base station of the cellular system although it exists. Such a D2D network is also often called an underlay device to device network. However, such a methodology also has its associated problems since the base station is unavailable for routing the network traffic. The major blow is the decrease in the signal strength of the signal which gets weakened due to the fading effects. Hence the bit error rate takes a surge due to decreasing signal to noise ratio. To circumvent this issue, corrective measures need to be taken. In this proposed work, the channel response is sensed and then used to detect the frequencies which undergo severe fading and then utilize only the frequencies which do not undergo severe fading. This mechanism is then used to select frequencies for data transmission. Moreover, an equalization mechanism is used to further reduce the errors of transmission. A practical D2D channel model is designed by simulating a Poisson cluster model in which wave clusters at the receiving end cause interference effects synonymous with a real life fading model. It has been shown that the technique which is designed outperforms previously existing systems in terms of BER and system outage.

Keywords: Underlay D2D Network, Frequency Selective Channel, Frequency Dependent Fading, Channel Response, Frequency Selection, Equalization, BER.

1. INTRODUCTION

The present scenario of cellular systems in challenging era due to the increase in number of user and data requirement. The base station which routes the data from devices is becoming more and more loaded with data. This has led to the concerns on the upcoming years when the number of users would increase manifold and so would be the data rate. With emerging technologies on the forefront, a new technical solution to the aforesaid problem is inevitable. One of the major contenders for the same is the Device to Device Network (D2D) model. In this model, the base station is completely bypassed and the data is communicated among the devices directly. In this scenario, the load is hence not subjected to the base station of the cellular system although it exists

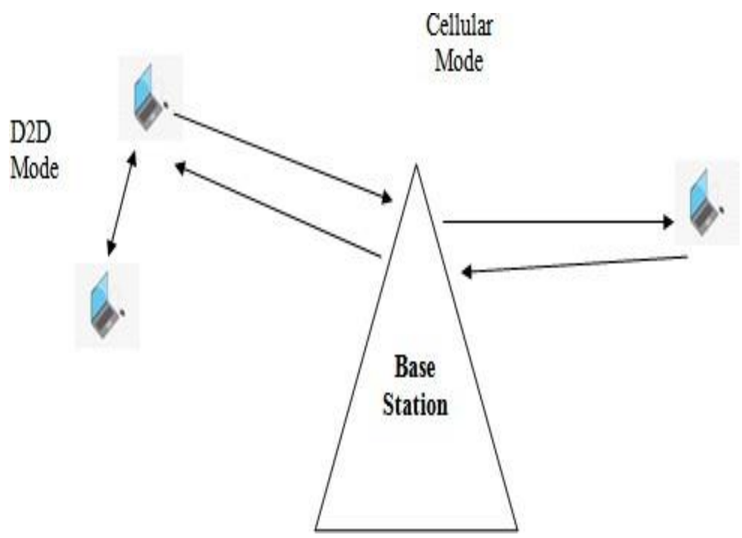

Fig 1: Underlay D2D Model

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1.2 Device to Device Communication in Cellular Networks: The large scale or large amount of data that is routed through a mobile network is shown in the figure below-

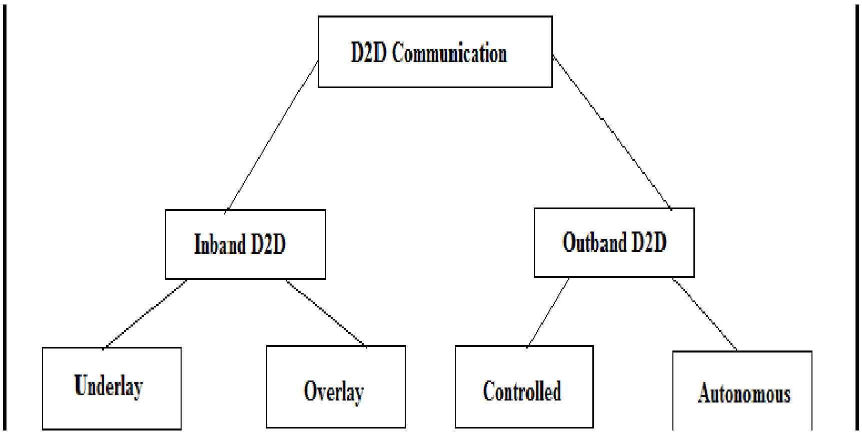

Fig 2: D2D Network data transfer

Typically, the concept of mobile networks is critical in the sense that there can be several mobile pairs forming the D2D mechanism. In this case, the D2D Model needs to the data traffic needs of the large scale mobile networks [2]. This being the case, the D2D network needs to utilize frequencies effectively to distribute the data of difference users in such a way that the data is distribute and also the effects of interference among users sharing big data is also mitigated. This is executed by employing the frequency re-use concept in which the frequencies are re-used in underlay networks with sufficiently large distances so as to avoid interference effects among the same pair of frequencies.

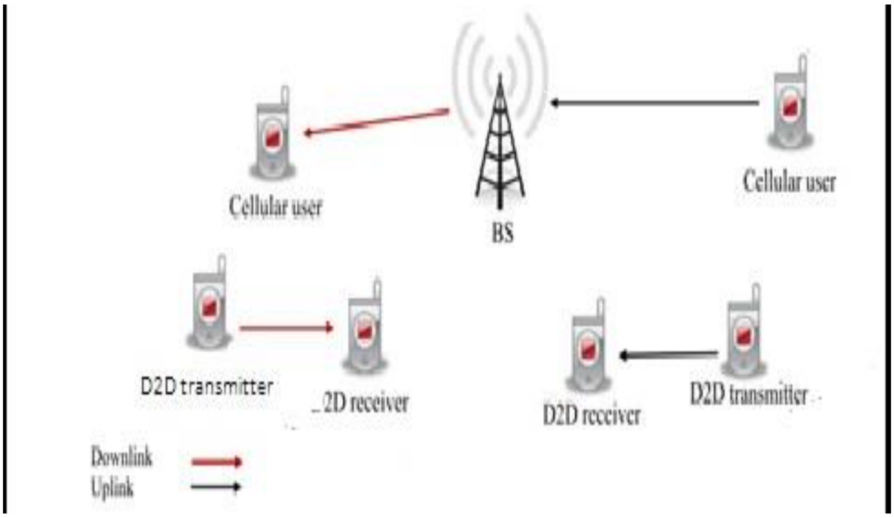

Figure 3: Categorization of D2D Networks

Channel Assignment in D2D Networks: The channel assignment in D2D networks is a serious challenge as discussed in [3]. It is always a challenge to mitigate the effects of partially overlapping channels in the D2D model of data transfer. In such a case, it becomes mandatory to design a mechanism to circumvent the possibilities of overlapping of user data for different D2D pairs and revert the effects of BER and Outage of the system. In such a case, the concept of game theory is useful to evaluate the chance of overlap among user data for different pairs. This is to be employed in both in-band and out-band systems to improve the performance of the system.

2. OBJECTIVE

The objective of the proposed work is to reduce the bit error rate (BER) and the system outage. Moreover, it is also envisaged to find out the distance to swatch from cellular to D2D and vice versa so as to figure out the coverage of the system. For the purpose, it is necessary to sense the channel and ascertain that the frequencies for transmission do not undergo severe fading. In this proposed work, the channel response is sensed and then used to detect the frequencies which undergo severe fading and then utilize only the frequencies which do not undergo severe fading. This mechanism is then used to select frequencies for data transmission. Moreover, an equalization mechanism is used to further reduce the errors of transmission.

3. LITERATURE SURVEY

1. In 2023 IEEE, Performance Evaluation of D2D Communications in of LTE-A Network, Mona Bakri Hassan, Rashid Saeed et al.: In LTE-Advanced, device-to-device (D2D) communication is a technology enables to increase the coverage and capacity coverage in metropolitan areas. Improvements in energy efficiency, throughput, latency, spectrum efficiency, and interference reduction have all been proposed. It is used in many domains, including applications, network traffic offloading, and public safety, and is recognized as one of the viable ways for the 5G wireless communications system. LTE advanced might perform worse in D2D communications because of multipath impact and delay dispersion. It is an essential and important element for the design of receivers in mobile communication systems. In this study, the spectrum efficiency, throughput, data rate, signal-to-interference-pulse-noise ratio, and latency of LTE-based D2D communications will be examined (SINR).

2. In 2019 IEEE, Coverage and interference in D2D networks with Poisson Cluster Process, Sandeep Joshi et al.: proposed a mathematical model in which it can be seen that the base station is completely bypassed. The major challenge which is associated with the D2D network is the loss of signal strength with the distance which the signal travels. The nature of fading also depends on the nature of the channel. Some frequencies undergo severe fading while the others do not. In this case it is often suggestible to utilize the interference pattern among different groups of waves often defined by a Poisson Cluster Model. the signal to noise plus interference ratio decides the system outage performance and the BER performance of the system. In general as the signal strength surges above the noise and interference levels, the BER and Outage is seen to dip and improve the Quality of Service (QoS) of the system.

3. In 2018 IEEE, Statistical QoS provisioning over D2D-offloading based 5G multimedia big-data mobile wireless networks", IEEE Infocom 2018 X Zhang, Q Zhu et al.: explained the concept of mobile networks is critical in the sense that there can be several mobile pairs forming the D2D mechanism. In this case, the D2D Model needs to the data traffic needs of the large scale mobile networks. This being the case, the D2D network needs to utilize frequencies effectively to distribute the data of difference users in such a way that the data is distribute and also the effects of interference among users sharing big data is also mitigated. This is executed by istance sunderlay networks with sufficiently large distances so as to avoid interference effects among the same pair of frequencies.

4. PROBLEM IDENTIFICATION

Computing Optimum Distance (d_0) The switching distance is necessary to ascertain the distance at which the strength of a particular mode of data transmission is higher in the underlay network. The two modes are the conventional cellular mode and the D2D mode. It is necessary to compare the strengths of the signal modes prior to choosing a certain one at a particular distance d‟. It is however not only dependent on the distance alone and also depends on other parameters such as shadowing effects and signal fading. Hence it is necessary to compute the optimum distance so as to gauge the coverage of the D2D network.

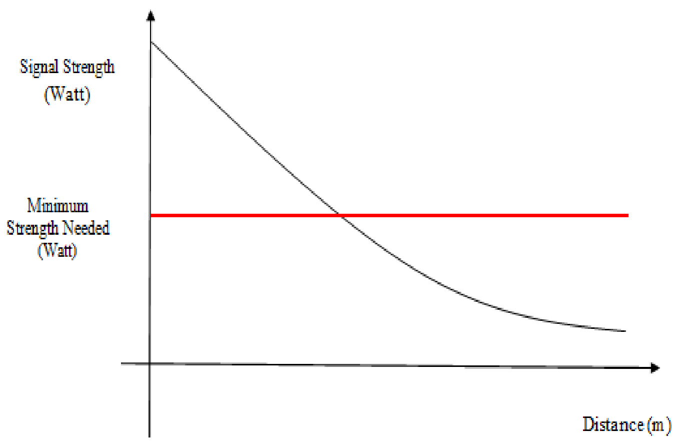

Fig 4: D2D Power w.r.t. D2D link distance

The decrease in strength of the D2D mode of transmission needs the D2D network to switch to the conventional cellular mode of transmission. This distance is often termed as optimum distance, "d_0".

The bit error rate (BER) is closely related to the signal strength of the D2D network.

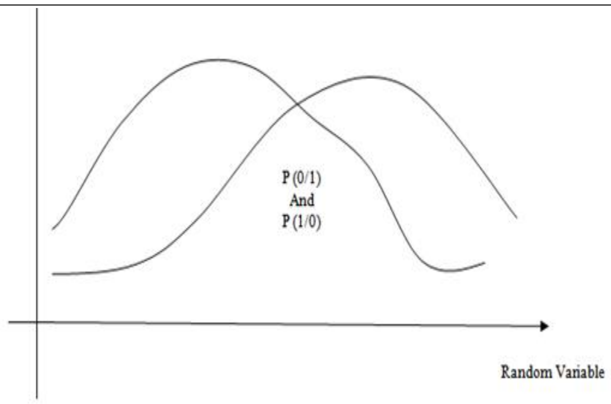

Fig 5: BER as a probabilistic approach

Obtaining low outage for the system

The outage of the system is measure of the quality of service of the systems. The outage means the chance of unacceptable quality of service. The outage primarily depends on the signal to noise ratio and the bit error rate of the system. The system outage often is represented in terms of the **Complementary cumulative distribution function** or the CCDF.

$$q(\lambda) = \exp\left\{-\frac{2\pi^2}{\sin\left(\frac{2\pi}{\eta}\right)} R_k^2 \mathrm{SINR}_k^{2/\eta}\lambda\right\}$$

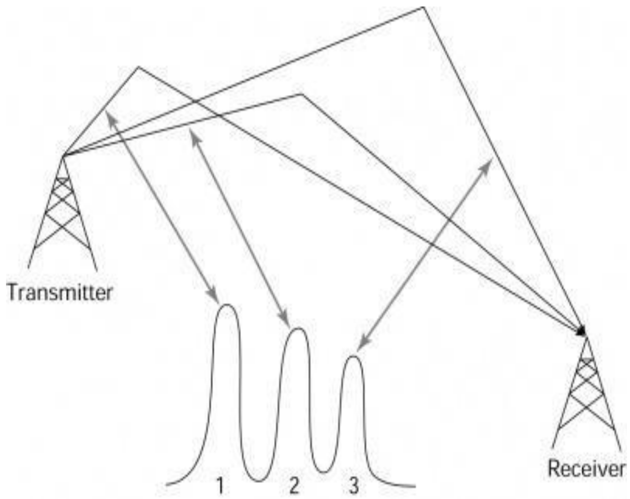

Fig 6: Multipath Propagation Model for D2D Networks

It is well known that wave clusters travel in different paths constituting a multi path propagation model. The mechanism is shown in the figure above.

Need for Channel Equalization

The need for equalization stems from the fact that wireless channel generally does not follow an ideal nature and tend to behave in a practical manner with a varying frequency response and non-linear phase response. The deviation of the channel response from the ideal characteristics results in the increase in the BER of the system and this further has a cascading effect on the outage of the system.

5. PROPOSED SOLUTION

The designed mathematical model shown in the figure below emulates the actual D2D environment scenario. It is basically an underlay D2D network in the presence of a cellular network. The D2D network is a part of a larger Cellular network and devices have the choice of connecting via the D2D mode or the cellular mode. A mathematical model for the device link establishment, transmitted power, receiver power, node density needs to be designed in order to investigate the performance of the D2D network. Another important aspect is the group scattering of the wave clusters which may create interference at the receiving end of the D2D Network. This is often designated as the Poisson cluster process.

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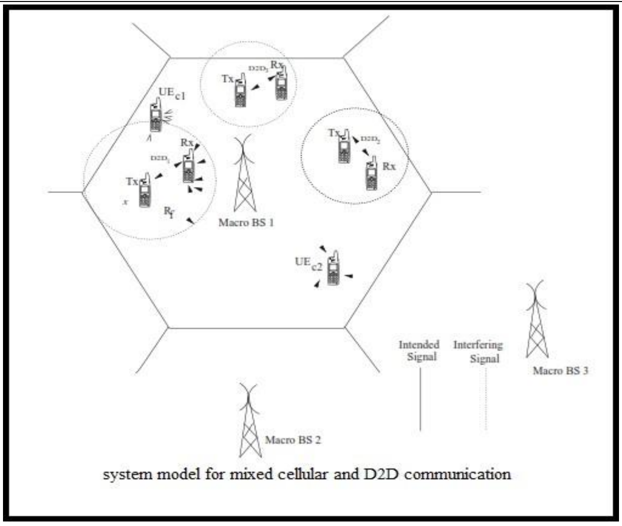

Fig7: D2D underlay network system model

The Channel State Information

Wireless Channels behave differently for different frequencies. The channel state information is the about the state of the channel. The state of the channel is generally a function of time. The practical wireless channels are generally functions of frequency and time both.

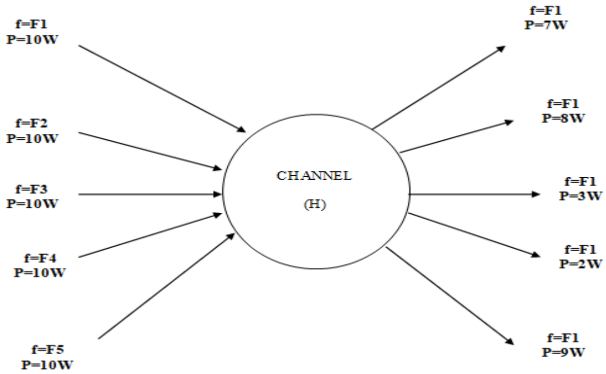

Fig 8: Physical Interpretation of Channel State Information

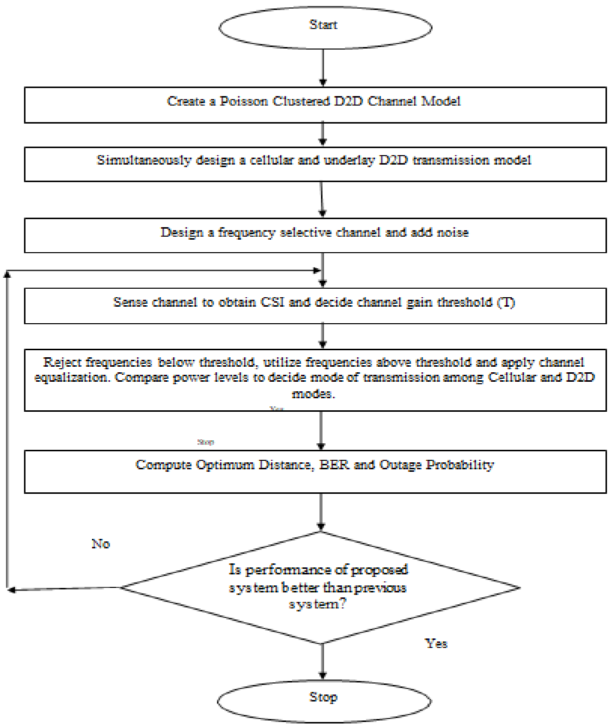

Fig 9: Implementation of Equalizers

The equalization is done based on the channel sensing information received after channel sounding.

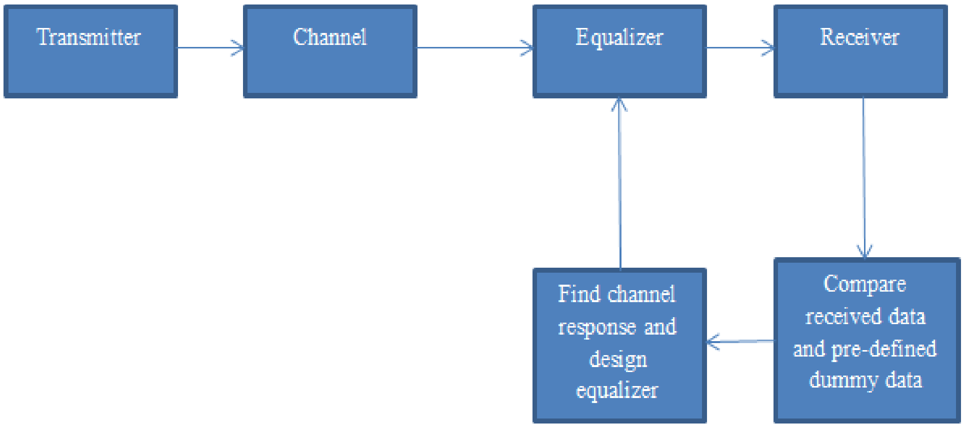

Fig 10: Flowchart of Proposed Approach

6. RESULTS AND DISCUSSION

The results obtained on the design and implementation of the proposed system is shown-

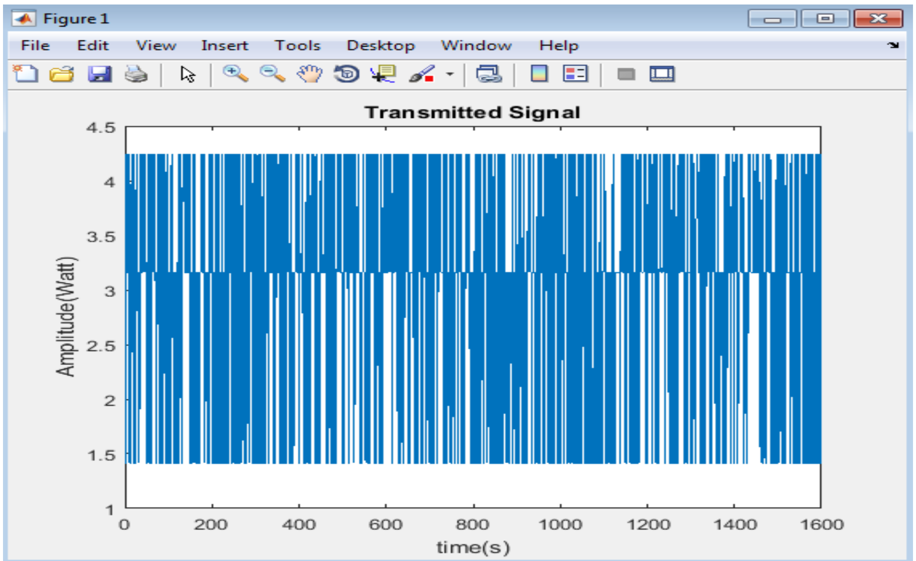

Fig 11: Random binary data transmission

The figure above depicts the generation of binary data for the purpose of transmission.

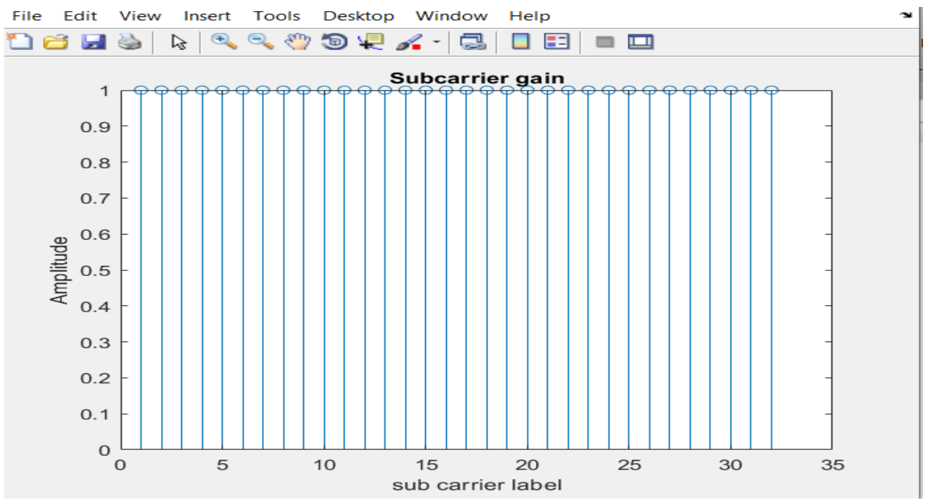

Fig 12: Ideal Channel CSI

The figure above depicts the Channel State Information of an Ideal Channel. It can be seen that the response of the channel is same for all frequencies. However, practical channel do not behave in this manner.

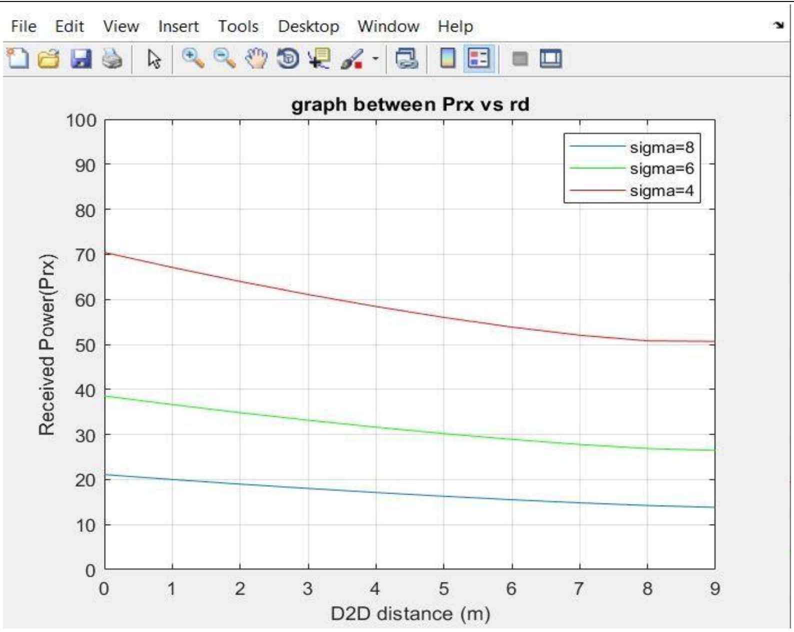

Fig 13: Power received in D2D mode vs D2D link length

The figure above depicts the received power strength as a function of distance of the devices and the shadowing factor.

Table 5.1: Received Power

S. No	Value of Shadowing	Power Received
1.	Sigma=4	50 W
2.	Sigma=6	28 W
3.	Sigma=8	12 W

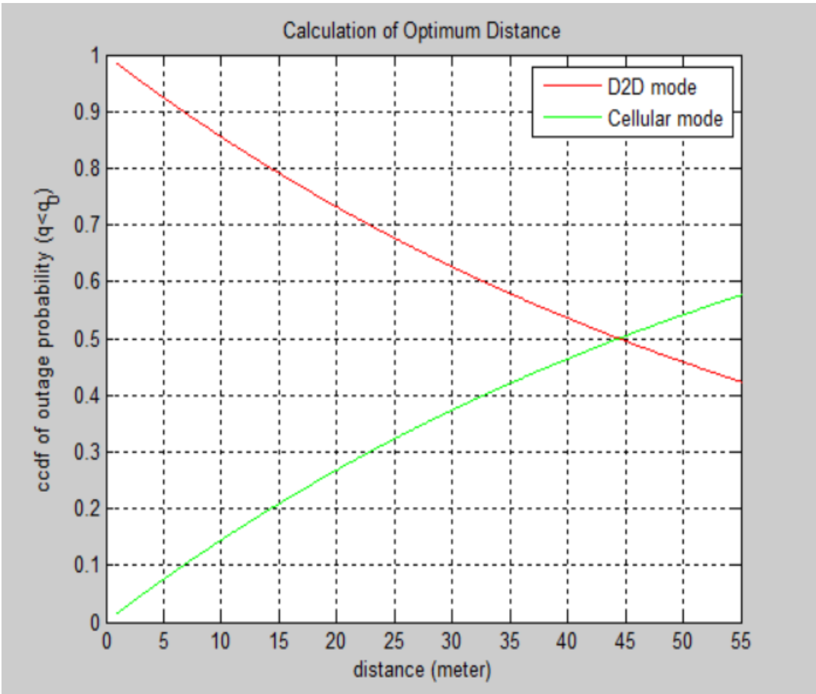

Fig 14: Computation of Optimum distance

The figure above depicts the computation of the optimum distance based on the power levels of the D2D and Cellular modes of transmission.

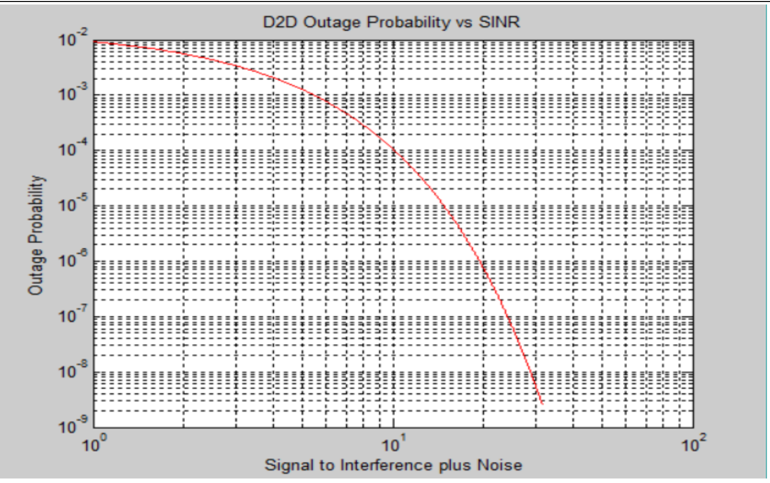

Fig 15: Outage Probability of System

The figure above depicts the outage of the system as a function of the SINR of the system for a Poisson Clustered D2D underlay network.

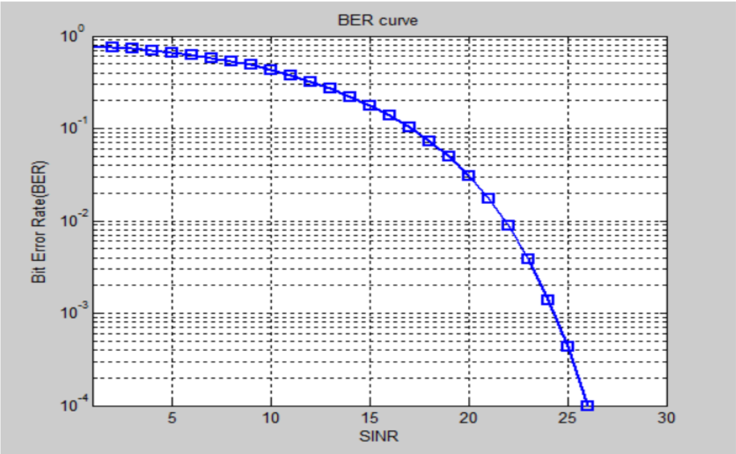

Fig 16: Obtained BER of the System

The figure above depicts the BER of the system as a function of the SINR of the system for a Poisson Clustered D2D underlay network. It can be seen that the BER decreases with increasing values of SINR.

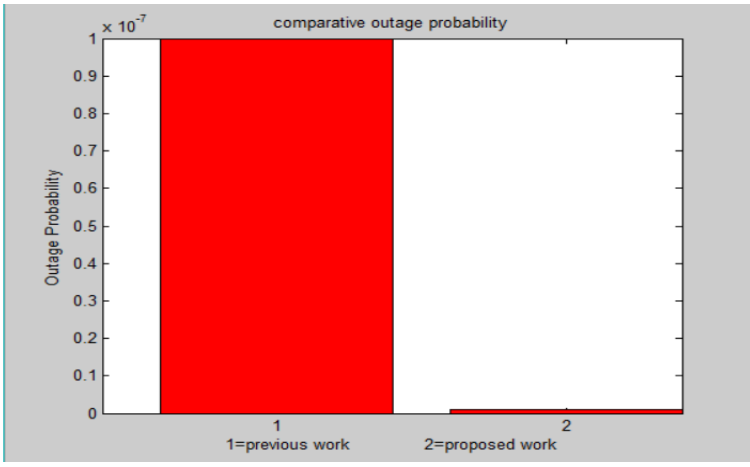

Fig 17: Outage Comparison

	Previous Work	Proposed Work
Outage Value	10^{-7}	10^{-9}

The figure and table above depicts the comparative outage w.r.t. previous work.

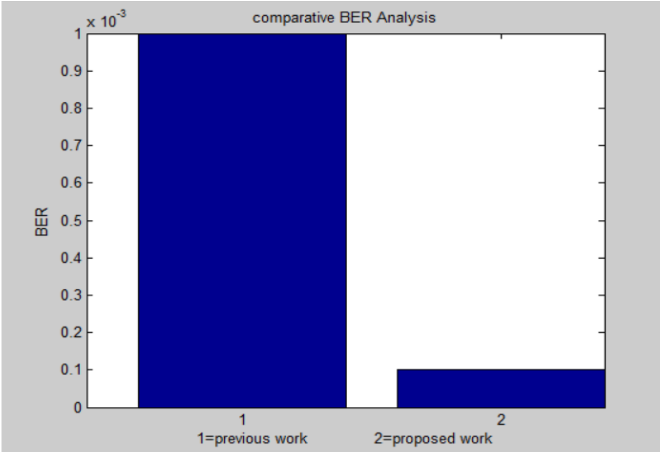

Fig 18: BER Comparison

BER	Previous Work	Proposed Work
	10^{-3}	10^{-4}

The figure and table above depicts the comparative BER w.r.t. previous work. The following remarks about the results obtained using the proposed system can be summarized as:

The system emulates a practical Poisson clustered process.
The network coverage can be estimated using the optimum distance.
The BER of the system and the outage are the metrics to evaluate the QoS of the system.
The simulation considers a typical underlay network with separate frequencies for cellular and D2D modes.
The performance of the system is improved compared to the existing technique.

7. CONCLUSION

It can be concluded from the previous discussions that Rapid increase in the number of users using cellular users has resulted in the increase of load on the cellular network. The base station which routes the data from devices is becoming more and more loaded with data. This has led to the concerns on the upcoming years when the number of users would increase manifold and so would be the data rate. With evolving technologies of 5G and 6G on the forefront, a new technical solution to the aforesaid problem is inevitable. One of the major contenders for the same is the Device to Device Network (D2D) model. In this model, the base station is completely bypassed and the data is communicated among the devices directly. An equalization mechanism is used to further reduce the errors of transmission. A practical D2D channel model is designed by simulating a Poisson cluster model in which wave clusters at the receiving end cause interference effects synonymous with a real life fading model. The tone rejection algorithm tries to find out frequencies which are suitable for transmission so as to obtain high signal to noise ratio and hence low BER values. The BER values also in turn govern the outage values of the system. The computation of the optimum distance is done based on the comparison of the power levels of the D2D and cellular modes of transmission. It has been shown that the technique which is designed. Out performs previously existing systems in terms of BER and system outage.

8. REFERENCES

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