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Interference Reduction Between Device to Device (D2D) Communication Underlying Cellular Networks

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Abstract— Due to the popularity of intelligent phone devices, the demands for high data-rate wireless broadband services must be increased. The purpose of this paper is to reduce the interference between D2D communication underlying cellular networks and to study the log distance model in different environment with greedy grouping algorithm. All results are provided with three different SINR requirements, such as 6dB, 9dB and 12dB and the simulation is applied to lengths 500m, 250m, 100m and 50m for 150 links. For each group of links the free space, urban, sub urban areas are implemented. All simulation results of different areas are grouped by greedy algorithm and compared with each other; the results show that the log distance model is best in sub urban areas.

Index Terms— Interference, Device to Device (D2D), Cellular Networks

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1 Introduction

TODAY and future wireless networks are facing one of their greatest limiting factors: interference. This is due to the unprecedented increase in the number of connected devices [1].

A D2D link is a direct connection from D2D transmitter (D2D Tx) to D2D receiver (D2D Rx) in spectrum managed by cellular network. [2]. In a cellular network user data is transmitted via base station (BS) or other central network element when one user device is communicating with another user device [3], Device-to-Device (D2D) communication will become an important technology in future networks with the increase of the requirements of local communication services [4]

2 Problem Statement

The D2D pair share the same radio resource with the cellular users such as shown in figure 1, however, the coexistence of D2D communications in a cellular network poses many obstacles.

- The interference of D2D pairs could critically affect the performances of the communication.
- The minimum distance requirements for D2D communication need to guarantee the SNR

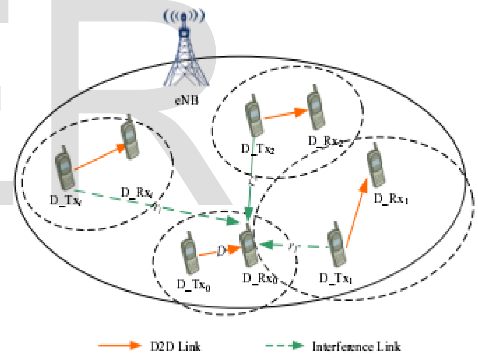

Fig. 1. model with one cellular and multiple D2D users.

2 Literature Review

Interference alignment techniques in a D2D underlay network is proposed to enhance spectral efficiency [5], A distance-based interference coordination scheme for D2D communication underlying a cellular network is studied. In order to mitigate the D2C interference [6], multiple device-to-device (D2D) users reuse the uplink resources of a cellular network is studied and The aggregated interference from the D2D users is limited by applying a threshold on the allowable interference in the base station.[7], D2D communication underlying the LTE-A

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cellular network is presented and two schemes are proposed[8], an interference management scheme based on ISA is proposed to manage the interference between the D2D communication at cell edge and cellular networks [9], radio resource allocation for D2D links based on interference avoidance approach is proposed. For system with multiple transmit antennas, beamforming technique based on signal to leakage criterion to reduce the co-channel interference[10], both intra-cell interference and inter-cell interference between D2D and cellular links are considered, and a new resource reuse algorithm that D2D users reuse the minimum interference uplink (UL) Semi-Persistent Scheduling (SPS) resources to reach the highest throughput is proposed [11], device-to-device (D2D) communication underlying a 3GPP LTE-Advanced cellular network is studied as an enabler of local services with limited interference impact on the primary cellular network [12], a D2D pair access strategy using the interference limited area of CUE is proposed to improve the performance of D2D communications underlying a cellular infrastructure.[13],

3 Path Loss Model

Path loss models describe the signal attenuation between a transmit and a receive antenna as a function of the propagation distance and other parameters [14], the log-distance path loss model is applied for the simulation and the path loss for urban wireless environments are calculated as follows:

$$PL_{dB}(d) = PL_{FSdB}(do) + 10n\log_{10}(\frac{d}{d0}) + X_{dB} \qquad 1$$

Where

$$PL_{FSdB}(do) = 20\log_{10} 4\pi do\frac{f}{C} \qquad 2$$

PL_{FSdB} (d_0) is the free space loss for a distance d_0 that is close to the transmitter, n is the path loss exponent, and X_{dB} is a zero-mean Gaussian random. This model is used for derivation the final equation of minimum distance requirements between D2D communications.

$$d_{min} = \left[10^{\left(\frac{\varphi+10\log_{10}(6)}{10n}\right)}\right]d_{D2Dmax} \qquad 3$$

Objectives

The objective of this project is to:

- Reduce the interference of D2D devices.
- Study propagation model in different environment for different SINR.
- Grouping the distance of D2D communication by using greedy grouping algorithm.

4 Result and Discussion

There are three scenarios (free space, urban area and sub urban area) have been implemented and the results are analyzed and compared. All these scenarios are applied to 150 links with greedy grouping algorithm.

Figure 2 show the cell distributed inside the cell for 300 nodes with different link lengths, The bar plots shown in figures (3 - 5) , explain the number of necessary groups such as minimum ,mean and maximum respectively (Min (M), Mean (M) and Max (M)) from the total number of links for all simulated scenarios and SINR requirements.

First scenario (free space): for very long links with a length of 500 meter, the minimum distance is 2443.7, 3451.8, 4875.8, where the radius of the cell is 1000 meter, in this case the minimum distance calculated is greater than the diameter of the cell, this cause severe interference to devices in other cells and also no links can be combined in a group.

Second scenario (Urban Area): for very long links with a length of 500 meter, few groups are created because the minimum distance requirement d_{min} for maximum D2D link length being 1238.0 1508.1 and 1837.2 meters.

Third scenario (Sub Urban Area): For very long links with a length of 500 meters, more links are placed in the same group because the minimum distance requirement d_{min} for maximum D2D link length being 943.1923, 1082.9 and 1243.4

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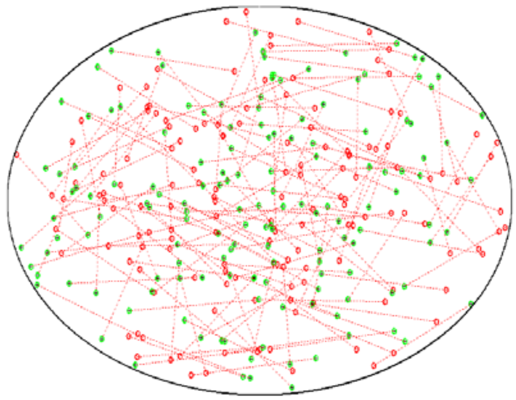

Fig.2. cell scenarios with fixed D2D link lengths (300 nodes) - (a) 500 meter links.

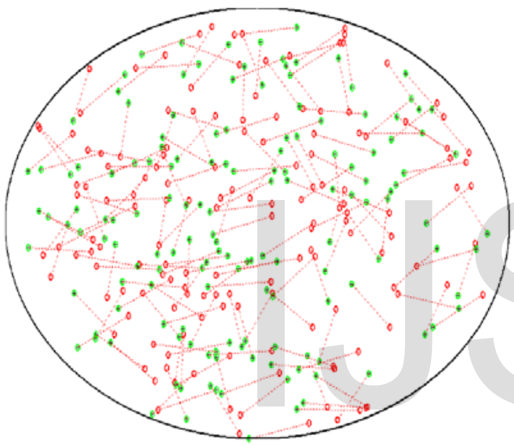

Fig.3. cell scenarios with fixed D2D link lengths (300 nodes) - (a) 250 meter links.

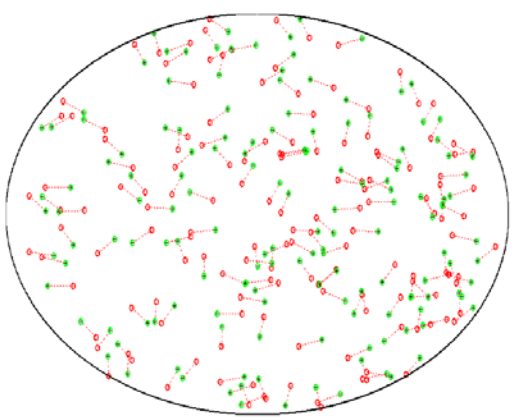

Fig.4. cell scenarios with fixed D2D link lengths (300 nodes) - (a) 100 meter links.

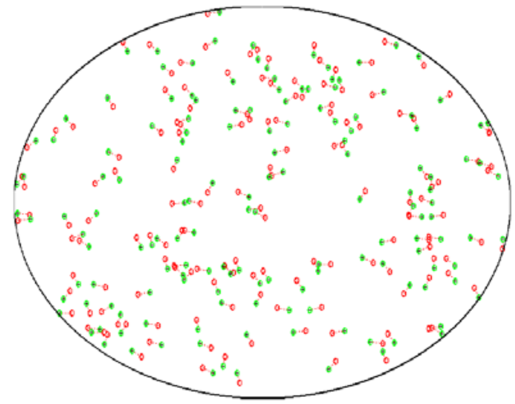

Fig.5. cell scenarios with fixed D2D link lengths (300 nodes) - (a) 50 meter links.

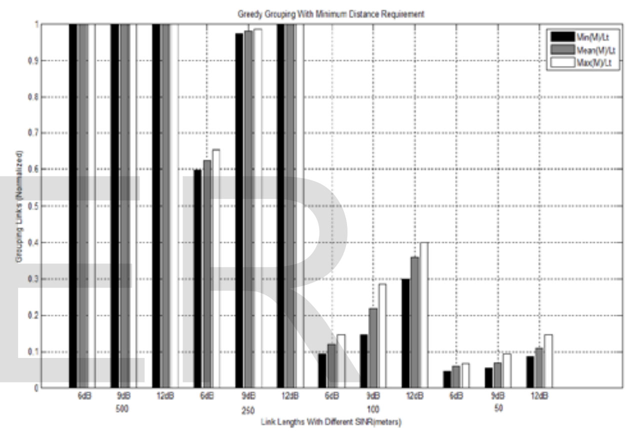

Fig.6. number of groups formed with 150 links in free space scenario

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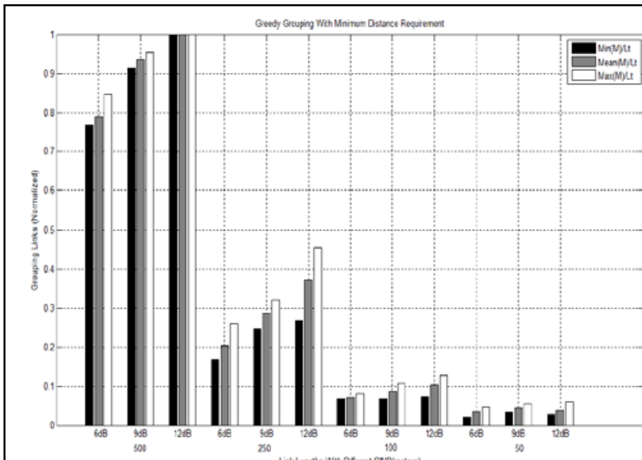

Fig.7. number of groups formed with 150 links in Urban Area scenario.

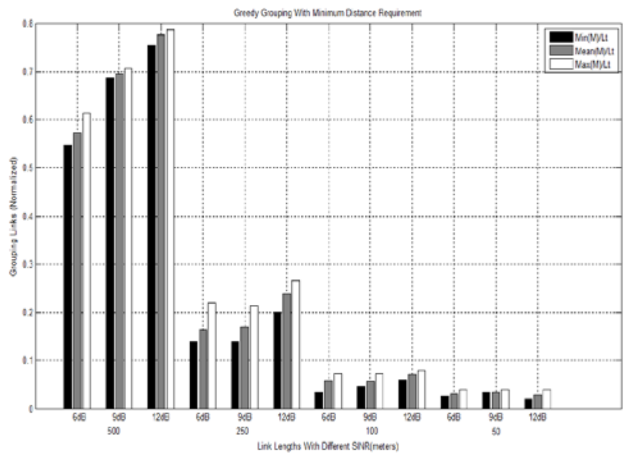

Fig.8. number of groups formed with 150 links in Sub Urban scenario

5 Conclusion

Different scenarios (Free Space, Urban Area, and Sub Urban Area) are constructed for D2D links with greedy grouping algorithm, and D2D links lengths are examined and implemented to evaluate the performance of interference reduction.

Also when the minimum distance d_{min} greater than the diameter of the cell D, it has causes severe interference with other nodes in others cells.

Comparing the free space, urban, sub urban areas models, it is found that the model used for derivation the minimum distance requirement d_{min} is more suitable in case of sub urban area compared to other areas because more links are grouped with less necessary groups.

In the future work it will implement a cluster concept in the cell to increase the cell capacity, and also propose different propagation model for d_{min} to reduce the severe interference.

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