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# Interference Reduction In D2D Communication Underlying LTE-A Using(OFSR) Optimized Frequency Spectrum Reuse

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***ABSTRACT:****The increasing demands for high data-rate for a proximity-based social/commercial services and applications as online gaming and video streaming causes to search for a way to achieve it.Device–to–Device (D2D) communi-cation in LTE-A cellular network have been considered as a promising technology tosupport high data rate requirements within the existingevolved Node B (eNB). D2D communication, it would offer higher achievable data rates, reduced power consumption and spectrum efficiency etc. Although, a new challenge will occur as interference among D2D nodes and cellular users. In this paper, we present how to mitigate interference, in some pervious work the authors used allocation resource technique that allowed D2D users to share the same radio resources at the same area resulting in severe performance degradation. This work introduces an enhanced spectrum reuse technology, which is referred to as OFSR, which aims to reuse the spectrum band of cellular users (CUs) in D2D communication when the D2D users located in another eNB area, that insure the interference wouldn't occur between D2D users themselves, between D2D users and legacy cellular network. This could increase spectrum efficiency and throughput that would guarantees the reliability of D2D and cellular communication and mitigate outage probability.*

***KEYWORDS****: -D2D Communication ,OFSR, Underlay, Interference Mitigation.*

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## I. INTRODUCTION

Dou to continuously increasing in data demand and huge growth in mobile devices the Long Term Evolution (LTE) developed byThird Generation Partnership Project (3GPP), which aims to achieve high data rates, low latency and packet optimized radioaccess technology (RAT). D2Dcommunication is under investigation by the 3GPP as Proximity Services (ProSe), which proposed as a Release 12 of 3GPP future.Device to Device (D2D) communications is new technology that offer wireless peer-to-peer services and improve spectrum utilization in LTE-advanced network [1].While the communicationbetween users in the legacy cellular network was relaying through the base station (BS), D2D communication is a radio access technology that provides users with the ability to communicate directly between them when they are in close proximity, without traversing traffic through the network infrastructure [2]. In D2D the small distance between the two devices reduces the energy consumed in the communication, so the power efficiency and spectrum efficiency can be improved significantlywith proximity gain (high bit rate, low delays and low power consumptions) and hop gain [3].D2D communication reuses cellular network resources that called reuse gain and when D2D shares the same spectrum, interference will occur on D2D, CUs, and eNB, this will cause to increase outage probability and reduce QoS of CUs.Tthe authors have provided many solutions and techniques to reduce this drawback,most of these techniques fall under theradio resource allocation and power control.

Many of the challenges were caused by enabling D2D communication in existing cellular network device discovery, mode selection, interference management, radio resource management, power control, security, mobility management.

## II. RELATED WORK

There has been a lot of research on spectrum sharing between cellular networks and non-infrastructure wireless networks [4][5].Several wireless standards have addressed the need for D2D to operate in the same frequency spectrum as the eNB like WALAN and TETRA [6] standards.Although, sharing the band gives high efficiency in the use and optimal utilization of available resources, it causes a real dilemma, which is the interference on CUs, eNB and D2D devices themself that causes a decrease in the quality of cellular users' service.

There are several researchers who have talked about radio resource management (RRM) to reduce the mutual interference resulting from sharing the same radio sources by the D2D and the cellular network users, some of the papers offered solutions by controlling the transmitted signal power [7][8],While some papers have developed techniques to reduce interference mode selection [9][10],other researchers used resources allocation to be used as a solution to minimize interference [11][12].

some authors proposed that the D2D users can sharing UL spectrum resources of the legacy cellular network, due to only eNB is exposed to interference form D2D users during UL frame [13], where the traffic overhead and control signaling of uplink are much lower than that of downlink this makesgenerates less undesirable interference to the D2D users.

The aim of radio resource allocation is to optimize the resource usage between legacy cellular users and D2D link.However, there exist a basis drawback with this technique is underutilization of radio resources and reducing multi–user diversity.

## III. D2D COMMUNICATION

D2D communication in cellular network is divided into two types In-band and Out-band. Also the two types are divided into another categories, whereIn-band have two mode Underlay and Overlay, the Out-band type have two mode Controlled and Autonomous.The difference between In-band and Out- band is the frequency spectrum band which used in D2D. In this papers we discussed In-band mode only, Figure 1 shows the types of D2D communication.

### 1. In-Band Mode

In this mode all D2D users and Cellular users share the same frequency band. There for, the eNB can control D2D users, discovering and link establishment, etc. [14][15].Although In-band mode provides high control over licensed spectrum. However, it causes interference between legacy cellular network and D2D users. In-band mode has two categories Underlay and Overlay.

### 1.1 Underlay In-Band

In underlay in-band mode the cellular users and D2D devices share the same frequency spectrum, although underlay mode offer a reliable controlling, It cause an interference between cellular users and D2D when ruse downlink channels and interference between eNB and D2D devices when reuse uplink channels, In this paper we chose the uplink's channels to reuse in D2D communication but these channels must be from another cell; this will observably decrease the interference between D2D and eNB links.

### 1.2 Overlay

In overlay D2D communications, the cellular and D2Dlayers maintain resource orthogonality and do not cause anyinterference to each other, at the expense of losing the reusegain [17]. Although, overlay doesn't allow for interference to occur, ItCausing disabling the purpose of the D2D, which means increasing the cellular network capacity and raising the efficiency as-well-as causing the high price of the service because the frequencies used in the cellular network is limited and expensive, It is therefore not useful to use it while cellular networks are experiencing increasing number of users while sources are limited, especially frequency.

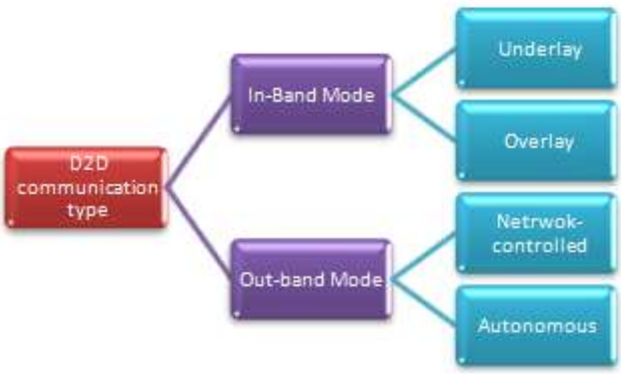


**Figure 1.** illustrate classification of D2D communication.

## IV. RESOURCE ALLOCATION

We assumed that UEs select D2D mode, so we did not go into the mode selection.

Radio resources are simultaneously allocated to the D2D and cellular links, the eNB allocates the RBs under centralized allocation scheme, that procedure allow eNB to control and manage resource allocation in effective manner to decrease and mitigate interference. UEs can reuse DL (Downlink) or UL (Uplink). Although, reuse DL it is desirable on the one hand that it does not add any complexity to the user's device, but it cause interference to CUs devices. This is why the use of UL is mandatory to eliminate the impact of interference on cellular users even if this leads to increased complexity in D2D devices; because UL requires UEs to be equipped with single carrier frequency-division multiple access (SC–FDMA), The authors also observed that sharing ULis more beneficial when the D2D terminals is farther away from the eNB. But when the D2D pair is closer to the eNB, the DL resources sharing performs better [18].D2D devices can select resource mode based on UEsdistribution and resource usage mode[16].

**System Model**

In this paper, we consider D2D communication underlying cellular networks where cellular and D2D users share the same frequency bandwidth but only at uplink channels because eNB is typically capable of dealing with the co-channel interferences; which mean there is no intra-layer interference, and only inter-layer interference will happen.

Users can communicate to each other directly over the D2D links after eNB established the D2D connection, which allow eNB to control the interference. On the other hand, the eNB allocate the resource to legacy cellular and D2D users.

## V. PROBLEMDEFINITION

When any two users in cellular network want to communicate to each other in D2D link, will share the same radio frequency with primary cellular network, when devices of users are closeinterference not occur if the transmitted power is lower and UEs part away from eNB and cellular users, but when thedistance between D2D is too long that's mean the transmitted power must be high, actually this will affect performance of cellular network, Fig.2 .Show the interference problem when eNB and D2D share the same frequency resource.

Some researchers have presented strategies to solve the interference problem by controlling the signal power sent when usingUL [19][20],but for the previous reason, the control of the transmitted signal power to reduce interference is not feasible whileit can mitigate the interference on the CUs, but on the other hand, the interference effect will remain on D2D links because the CUs will affect the D2Dreceivers when the CUs and D2Dshare the same UL of the same cell.

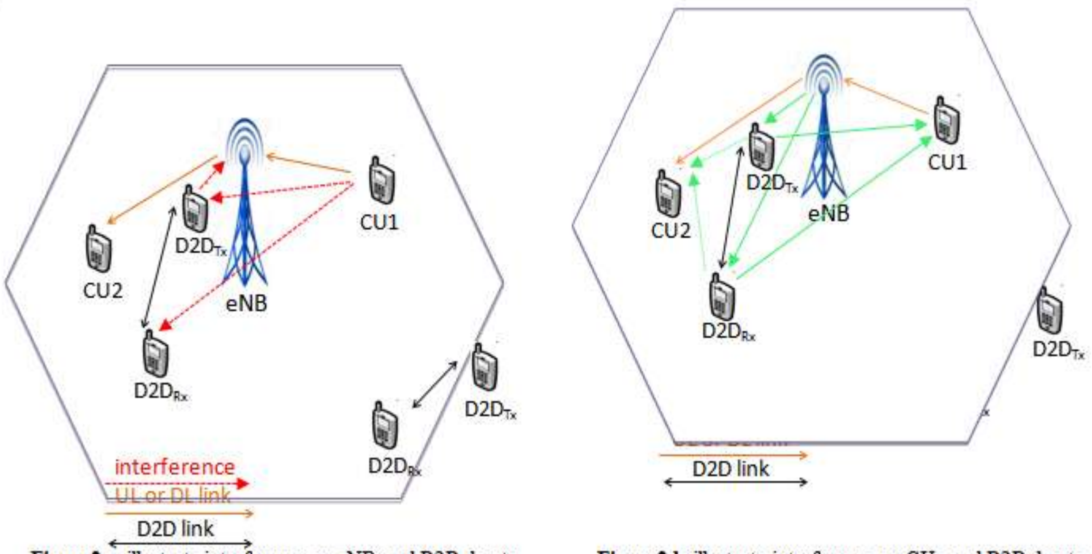


**Figure2.a.** illustrate interference on eNB and D2D duo to sharing UL resources.

**Figure2.b.** illustrate interference on CUs and D2D duo to sharing DL resources.

## VI. OBJECTIVES

The objective of this paper is to:

- Reduce the interference of D2D devices.
- Study propagation model in different environment for different SINR.
- Grouping an optimization algorithm based on power control andresource allocation

**Optimized Frequency Spectrum Reuse**

Selecting the right frequency for both terminals of the D2D connection is a somewhat complex process, many researchers have gone toradio resource management and power control as approaches to reduce interference [21][22].When the transmission power was controlled, the problem of interference was reflected again depending on the distance between terminals of D2D communication andeNBon the one hand, and between D2D device and the CUs on the other. Although,UL used to prevent interference to cellular network users, interference still continuously from the D2D devices to the eNB and from users of the cellular network to the D2D receivers.The power control approach became impractical in mitigate interference if the two D2D devices at long distances from each other, or close to the users of the cellular network or base station itself, because all devices in cell area (eNB, D2D, CUEs) share the same spectrum simultaneously.In this paper, we used the same power control technique as well as the reuse of the UL or DLchannels based on the interference valueon this channel, but the idea we worked on helped to reduce the interference clearly, we assumed that D2D devices can use the frequency of another cell,and not the one in which it exists. This procedure prevents the interference of the D2D devices on the eNB as well as the interference on D2D receivers due to cellular user’s transmitters, whereas UL channels used by the D2D is different from which eNB uses in the same cell area. Figure 3 shows the scenario of using the UL frequency of cell 1 in cell 2

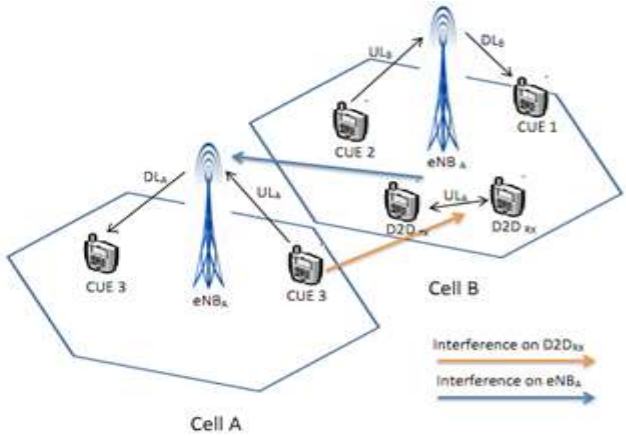


**Figure 3.** illustrate reuse UL of cell A to D2D communication in cell B

Figure 3 shows that D2Dpairs in cell B use the same cellular frequency spectrum of cell A, assuming that the transmission power of D2Dpairs is appropriate to ensure the quality and efficiency of the communication, through the figure we note that there will be no interference between D2D pairs and eNB as well as there will be no interference of cellular users on D2D.so the interference between the cell components of the eNB which exist in its area, but unfortunately if one of the D2D devices at edge of the cellit will be affected by the spectrum of the adjacent cell.As shown in Fig.3, the D2D receiver was affected by CUs devices of cell Awhich use the same channels as well as the effect of D2D transmitter on the eNB of the cell A.There is no need to worry about this,we have developed the proposal to accommodate this overlap,we have used two methods to reduce it and to make the solution highly effective and efficient to eliminate interference permanently:

The first method is to use the joint power to control power of the transmitter device that position at the edge of the cell. This technique will help us prevent interference from the D2D transmitter on the eNB,suppose that before D2D pairs start data exchange, it must get a RBs from eNB and allocate a subbandin UL or DL based on SINR value, when eNB allocate RBs and subbandfor D2D pairs, the D2D devices listen for the same subbandfrequency from all neighbor cellular devices, if interference under the allowed level the D2D pairs can establish connection and communicate with each other,we can calculate SINR of D2D and CU on DL as follow respectively:

$$SINR_{DL}^{D2D} = \frac{P_d G_{dd}}{N_o + P_c G_{cd}} \quad (1)$$

$$SINR_{DL}^{CU} = \frac{P_c G_c}{N_o + P_d G_{dc}} \quad (2)$$

where $P_d$ isthe D2D transmit power, $P_c$ isthe eNB transmit power to the DL UE,$G_{dd}$ denote theD2Dchannelgain,$G_{cd}$ is the interference channel gain from cellular transmission to D2D, $N_o$ denote the noise. When share UL link Only the eNB is exposed to interference, sothe SINR of D2D on UL formulate as:

$$SINR_{UL}^{D2D} = \frac{P_d G_{dd}}{N_o + P_{CU} G_{CUd}} \quad (3)$$

$$SINR_{UL}^{eNB} = \frac{P_{CU} G_{CUB}}{N_o + P_d G_{dc}} \quad (4)$$

Where $G_{CUd}$ is the interference channel gain from eNB to D2D, $P_{CU}$ is cellular users transmit power, $G_{CUB}$ is the interference channel gain from CU to eNB, We can detect D2D transmitting power to mitigate interference at the expense of data ratevalue, requiredD2Dtransmit power when share DL band can be calculated as:

$$P_D = SINR_{DL}^{D2D} \cdot \frac{(P_c . G_{cd} + N_o)}{G_D} \quad (5)$$

non-convex function (Tadrous et al) formulatetheDL power optimization problem with Shannon capacity expression (6):

$$P_D = \arg\max \left[ \ln(\frac{P_d G_{dd}}{N_o + P_c G_{cd}} + 1) + \ln(\frac{P_c G_c}{N_o + P_d G_{dc}} + 1) \right] \quad (6)$$

although, adjust power reduce interference on eNB, the interference occurs on D2D receivers due to nearby cellular users is still occur. To avoid that's drawback we supposedIn the second method that the cellular network system consisted of 7 cells(cluster size 7), so that we re-used the frequency of the cells around cell 1 for use in the D2D communication, as shown in Figure 4, we divided cell 1 into three sectors, each sector containing several frequencies band (UL & DL) to use by the D2D devices, this ensures that no

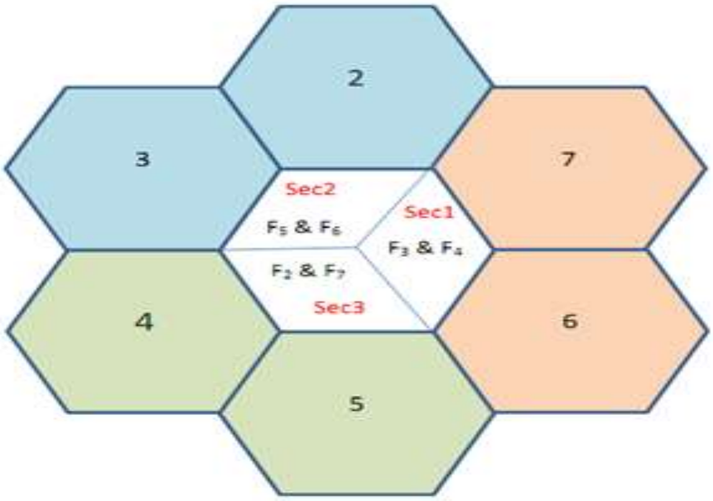


**Figure 4** illustrate reuse bands of the cells around cell 1 for use in the D2D communication

interference between D2D users and cellular network users even when the DL band is shared because the channels used by legacy cellular network users and by D2D are orthogonal with the existed frequencies in the same cell as well as with neighboring cells.

| **Frequency Selective Allocation Algorithm** |
|---|
| 1. Divide the cell area into three sectors |
| 2. Get the information of UL and DL bands used in allthe surrounding cells |
| 3. Determining UL and DL bands for each sector |
| 4. Receiving D2D dial request |
| 5. Locate D2D pairs in any sector |
| 6. Share DL band |
| 7. Once RB number for each D2D pair is decided Estimate SINR in each RB |
| 8. take RB which has highest SINR first |
| 9. If the interference on DL is high share UL band |
| 10. return to step 7th |
| 11. return to step 4th |
| 12. end |

**Performance Evaluation**

Simulation Variables

| **Parameter** | **Value** |
|---|---|
| Center Frequency | 2GHz |
| Spectrum allocation(UL/DL) | 20 MHz |
| Number of subcarriers per RB | 12 |
| Neighboring subcarrier spacing | 15KHz |
| RB bandwidth | 180 kHz |
| Number of active users per cell | 50 |
| Number of D2D link per cell | 20 |
| Cell layout | Hexagonal, 3-sector sites |
| Cell radius | 1000m |
| Distance between D2D | 100m |
| Transmission power of cellular user | 100mW |
| Transmission power of D2D | 0. 1mW |
| Transmission power of base station | 45dBm |
| Tolerable outage probability | 0. 2 |
| Noise figure | 5 dB at BS / 9 dB at device |
| Noise spectral density | 174 dBm/Hz |
| Antenna gains | BS: 14 dBi Device: Omnidirectional 0 dBi |

We implemented the proposed algorithm by extending Matlab that supports D2D communication underlying the LTE system. We analyzed its performance by assuming that the cluster size of the system k = 7 was made up of only seven cells each cell had three sectors.D2D pairs are randomly located in an area at least 100 m away from the eNB. In our simulations, a single cell network is considered. The maximum distance allowed between the transmitter and receiver of a D2D pair is 15 meters, as some researchers assume the D2D pair to be in the same room [39] and a larger distance cancels the benefits gained from D2D communication. As the macro cell radius typically starts from 1000 m [21], the cell radius is chosen to be 1000 m. The target system sum rate T is uniformly distributed between the system sum rate without sharing RBs with any of the D2D pairs and the maximum achievable sum rate. It should be noted that, the maximum achievable sum rate can be calculated by using the weighted bipartite matching algorithm from [12]. In reality the value of T can be set by the network operator.We fix the total number of cellular UEs to 250 and 350, and vary the number of D2D pairs from 10 to the number of cellular UEs. Each of the simulation results presented is an average of 20 different runs for a particular scenario. Please note that we also simulate the algorithm for various numbers of cellular UEs and the results are consistent in all the cases. We compared the results of the algorithm with adjusting power technique. As well we compared TAFIRA and MIKIRA algorithms.Finallywe analyzed the performance of algorithm when using the UL alone and when using the DL alone.

As shown in figures 5 (a, b, c, and d) it can be noticed that the curves of the simulation graphs are neither smooth nor monotonic but consistent. As the locations of the D2D pairs and cellular UEs are generated randomly in each run, the results are not monotonic. Furthermore, some random cases are generated where the results change verymuch (from high to low and vice versa), generating spikes in the curves in both upward and downward direction.

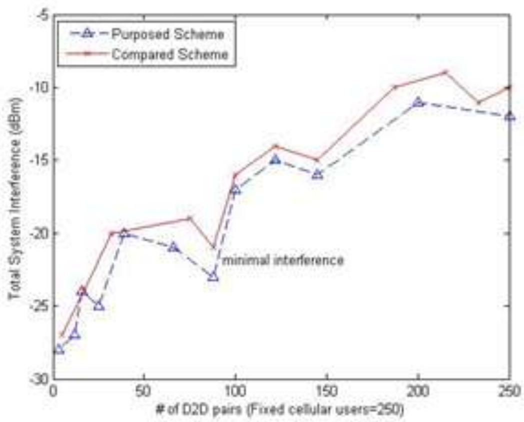


**Figure 5.a.** Total system interference with number of D2D pairs (250 users).

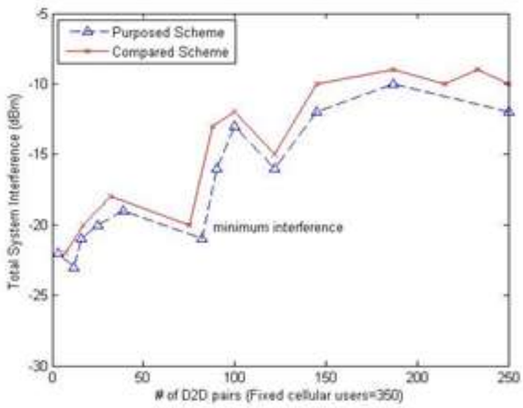


**Figure 5.b.** Total system interference with number of D2D pairs (350 users).

This graphs also prove that multiple scenarios are accumulated in one place, which saves us from number of graphs for each scenario. In summary, our proposed algorithm returns the assignment which introduces interference very close to the optimal interference.

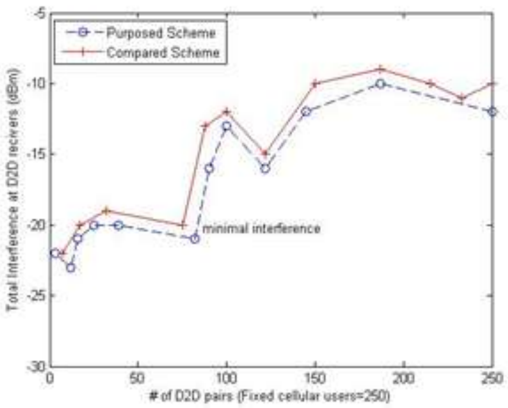


**Figure 5.c.** Total interference at D2D receiver (dBm) with number of D2D pairs (250 users).

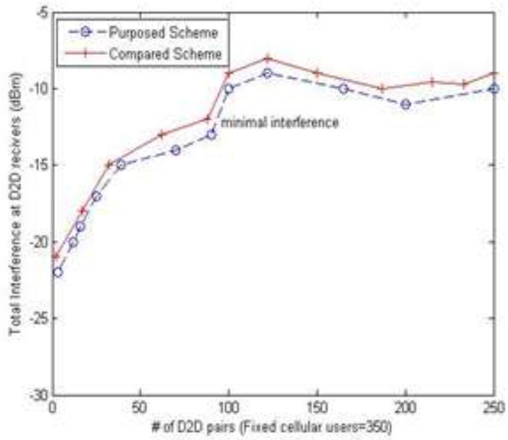


**Figure 5.d.** Total interference at D2D receiver (dBm) with number of D2D pairs (350 users).

In addition, our proposed algorithm returns better system sum rate than TAFIRA and MIKIRA while introducing less amount of total systeminterference. Unlike TAFIRA and MIKIRA, our algorithm guarantees a solution provided that such solution exists and also introduces less interference than TAFIRA and MIKIRA at D2D receivers.

## VII.CONCLUSIONS

In this paper we propose an optimization algorithm based on power control andresource allocation. we use an adjust power technic to limit the transmit power of D2D within a reasonable range, providing favorable conditions for D2D access successfully and reuse the spectrum band at a good manner to prevent the interference.It has been shown via simulation that the proposed algorithm is superior to the traditional algorithms in the performance.

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