D2D Resource Allocation under the Control of BS

 Ran Xiaogang, Zhang Zhongpei, Wei Ning,

University of Electronic Science and Technology of China

Abstract-In order to mitigate the mutual interference caused by D2D system and cellular system, a scheme of D2D resource allocation under the control of BS is been proposed. The interference caused by cellular system will be detected by D2D system, then transmitted to the BS, as a factor to choose the resource allocated to D2D system. In order to mitigate the interference caused by D2D system, BS uses the information of power headroom reported by each cellular UE to determine the ability of tolerating interference of UE, so BS can allocate the resource of the UE which has the ability of tolerating interference from D2D UE. With the combination of the two kinds of information, BS can make the decision of D2D resource allocation to successfully mitigate the interference caused by each other.

*Index Terms-device to device, resource allocation, interference avoidance.*

# ⅠINTRODUCTION

More and more operators are deploying the LTE system to offer higher data rates, but it still hardly meet people’s need for wireless communication. Now Researchers place the hopes on the LTE-Advanced, which shall meet the IMT-Advanced requirements. Device-to-Device, as a technology component for LTE-Advanced, may give the promise of providing very high bit rates, low delays and low power consumption [1].

The Device-to-Device (D2D) system, reuses the spectrum resources of cellular system, thus improves the spectrum efficiency. But with the introduction of the D2D system, here comes the problem: D2D shares the same resources with cellular system, one system may cause interference to the other one. How to address the interference is a very important issue in the D2D research.

In order for D2D users not to cause severe interference to cellular users and improve the performance of the whole system, we must work out a realistic scheme of the resource allocation for D2D.there are two kinds of resource allocation schemes in general: one is BS assisted, the other is BS controlled. BS assisted means the resource allocation is determined by the D2D UE itself by using some strategies, it need less signaling between D2D user and BS[2].However, D2D is introduced as an underlay to LTE-Advanced networks, so we need to make sure D2D communication links won’t cause much performance loss to cellular system. It means our first priority is to guarantee the interference from D2D system to cellular system is under control. So it is suitable to let BS control the D2D resource allocation under the sacrifice of more signal exchange between BS and D2D UEs. But this resource allocation scheme can make sure D2D communication shares the resources that won’t cause severe interference to cellular communication and if severe interference occurs, BS can terminate the D2D communication or allocate other resource to D2D communication.

# ⅡSystem Model

D2D system can share the resource of LTE uplink or downlink. Compared with LTE downlink, uplink is underutilized by the cellular operators[3], and in the downlink, the scheduling mechanisms adopted by BS make one UE’s resource change very fast ,so it’s hard for D2D UE to share the resource of cellular UE. On the other hand, according to the LTE standard, uplink resource allocation is done by BS and informed to UE before a few subframes. Therefore, D2D UE may use this time interval to finish its resource allocation. So this paper is focused on how to address interference avoidance when D2D system shares resource with cellular uplink[4].

Here is a simple demonstration of the problem we are going to solve in the paper as shown in Figure 1, we assume D2D UE1 and D2D UE2 need communicate with each other directly, so D2D UE2, as the transmitter, will cause interference to BS. At the same time D2D UE1, as the receiver, will suffer interference from cellular UE, so there is the need for D2D UE to share the proper resource of cellular UE. First we should consider cellular UE suffering interference from D2D UE. To mitigate the interference, we should choose to share the cellular UE which D2D UE causes not much interference to. After Comparison, because UE1 is near the BS, it usually send data to BS with low power, even if suffering interference, it can increase the transmitting power to offset the interference from D2D, having the capability to guarantee the normal communication with BS. So we make cellular UE shares the resource with D2D UE. On the other hand, we consider how to solve cellular UE causing interference to D2D UE to guarantee D2D UEs’ communication. Because UE2 is far from D2D UE2, we assume it cause less interference than UE1. In reality, D2D UE can measure the interference level to determine how to share the resource. Certainly, the best solution to make the D2D system works properly with cellular system is to make sure, after the sharing of resources, D2D link and cellular link has good channel quality respectively. So we assume there is a UE3, which is near the BS and far from the D2D pair, then it can be the good choice to be chosen to share resource. Mitigating the mutual interference is the core ideal the paper is discussing on.



 Figure 1

# Ⅲ D2D Resource Allocation Scheme

Before D2D UE begins direct link communication, it can get the cellular UEs’ scheduling information from the BS, then measures the interference level from each cellular UE in the same site, so D2D UE can get the information about those UEs which cause severe interference to D2D UE. Then D2D UE sends the information to BS, which allocates resource to D2D using this as a basis. However, the information D2D UE sends to BS is used to mitigate the interference from cellular UEs to D2D UE, not able to mitigate the interference suffering by cellular UEs from the D2D UEs. Besides containing the transmitting power of D2D UEs[5], BS uses another way to mitigate the interference produced by D2D UEs. LTE uplink adopts the power control scheme, which means cellular UE’s transmitting power can change at some extend. And cellular UE will report power headroom[6] to BS through the MAC layer, so BS knows the scheduling cellular UEs’ power adjustment ability. Here we define the interval of cellular UE’s power, from the current using power to the maximum of the power, as the cellular UE’s interference-tolerant level. The bigger the power adjustment interval, the higher ability of interference-tolerant level. Otherwise, the lower ability of interference-tolerant level. Thus, BS got the information to mitigating both sides’ interference. Here is the scheme about how to share the resource of cellular UE to mitigate the mutual interference:

Step 1.D2D UE decodes the RRM (Radio resource management) information from the BS to get the cellular UE resource allocation information.

Step 2.D2D UE measures the interference from the cellular UE, and records the interference of each cellular UE.

Step 3.D2D UEs send the interference information to BS.

Step 4.BS allocates the resource to D2D

Step 5.BS sends the resource allocation information to D2D UE.

Step 6.BS instructs resource-sharing cellular UE to increase transmit power.

And the algorithm of BS resource allocation in step 4：

1．BS excludes the cellular UEs which can’t share resources based on the tolerance ability.

2．{D| D2D UE waiting to allocate resources}

3．{|set of cellular UEs causing severe interference to D2D UE D }

4．{|cellular UEs having not share resources}

5 . while  && 

 BS allocates resources to D2D UE d:

 BS gets the set of cellular cells which is near d based on the interference,，do difference sets, get 

 If 

 Choose a cellular UE ，randomly,D2D UE shares all the RBs of the cellular UE

 

 

 else

 don’t allocate RBs for D2D UE 

 

 end

 end

# Ⅳ Simulation and Analysis

The simulation builds on 7 sites, 3 sectors per site，based on 3GPP LTE Scenario. There are 10 cellular UEs randomly distributed in every sector, and 10 pairs of D2D UEs randomly distributed in two circles, the radius of the circle is 20 m, the distance from the center of the circles to the BS is 200 m, and the distance between sites is 500 m, the shadow fading correlation between sites and sectors is 1 and 0.5 respectively. The other parameters are listed in TableⅠ.

|  |  |
| --- | --- |
| Parameters | Values |
| Spectrum allocation(UL) | 5MHz |
| Carrier frequency | 2000MHz |
| Channel Model | TU |
| Number of available RBs | 25 |
| Max UE Tx Power | 200mW(23dBm) |
| Number of users per sector | 10 |
| Max D2D links per sector | 10 |
| UE to eNodeB distance attenuation | L=40\*(1-4e-3\*Dhb)\*log10(distance/1000)-18\*log10(Dhb)+21\*log10(frequency)+80;Dhb is the base station antenna height in meters |
| Scheduler of eNodeB | Round Robin |
| BS/UE antenna gain | 14dBi/0dBi(omni) |
| D2D distance attenuation | 128.1+ 37.6\*log10(distance/1000) |
| User speed | 5km/h |
| Cell layout | Hexagonal gird,3-sector sites,21 sector in total |
| Cell radius | 500m inter-site distance |
| Noise figure | 5dBm for base station/9 dBm for D2D receiver |
| Thermal noise density | -174dBm/Hz |

 TableⅠ

The cellular link and D2D link use Open Loop Power Control, D2D UEs measure the interference from the cellular UEs, then based on the predefined interference threshold, feedback the information of the UEs which can’t be shared with resources. When BS assigns resources to D2D UEs, first excluding the cellular UEs which can’t be shared in resources. Once the cellular UE has been chosen to share resource with D2D UE, BS instructs the cellular UE to increase the transmission power, in order to compensate the interference caused by D2D link. From figure 2, we can get the result: with the change of the interference threshold, the whole capacity also changes. When the threshold is set at -75dBm, we get the maximum capacity.



 Figure 2

If we don’t use the scheme of the interference avoidance, contrast to D2D the scheme of setting interference threshold to -75dBm,wo get the result from Table Ⅱ:

|  |  |  |  |
| --- | --- | --- | --- |
|  | Cellular link capacity (Mbps) | D2D link capacity (Mbps) | The whole capacity (Mbps) |
| No scheme | 7.6383 | 8.6691 | 16.3074 |
| With scheme | 8.2267 | 10.4743 | 18.7010 |

 Table Ⅱ

D2D link shares the cellular UE’s resources will cause interference to cellular UE, so BS instructs cellular UE to increase transmission power to compensate the interference.



 Figure 3

From figure 3, we can see, with the power compensation of the cellular link, the cellular system capacity increases, but the D2D system capacity decreases, so the whole capacity is almost unchanged. We can also get the idea that the interference from D2D UEs to cellular system can’t be ignored. In order not to cause too much interference to cellular system, there is need to increase cellular UEs’ power.

# Ⅴ Conclusion

This paper proposes a scheme to do D2D frequency resources allocation controlled by BS, mitigating the severe harmful mutual interference. BS receives the information about the cellular UEs causing severe information to D2D UEs and the PH of cellular UEs to make resource allocation for D2D system. Using this strategy, BS can easily guarantee the performance of cellular system. Then take full advantage of the character of D2D system’s short distance communication, to maximize the whole system’s performance.

# References

1. P. J¨ anis, C.-H. Yu, K. Doppler, C. Ribeiro, C. Wijting, K. Hugl,O. Tirkkonen, and V. Koivunen, “Device-to-device communication un-derlaying cellular communications systems,”International J. Commun.,Network Syst. Sciences, vol. 2, no. 3, June 2009.
2. T. Peng, Q. Lu, H. Wang, S. Xu, and W. Wang., "Interference avoidance mechanisms in the hybrid cellular and Device-to-Device systems, " in IEEE PIMRC, 2009, pp. 617-621.
3. M. Wellens, J. Wu, and P. Mahonen, Petri, “Evaluation of Spectrum Occupancy in Indoor and Outdoor Scenario in the Context of Cognitive Radio,” 2nd International Conference on Cognitive Radio Oriented Wireless Networks and Communications, 2007, Aug. 2007, pp. 420– 427.
4. A Osseiran, K Doppler, C Riberio, and et al, “Advances in Device-to-Device Communications and Network Coding for IMT-Advanced”, IIMC International Information Management Corporation , 2009
5. Chia-Hao Yu, Olov Tirkkonen, Klaus Doppler and Cássio Ribeiro, “On the Performance of Device-to-Device Underlay Communication with Simple Power Control”, IEEE Vehicular Techonlogy Conference (VTC)Spring , April 2009.
6. 3GPP TS 36.213 Physical layer procedures.