Anaylsis of Device to Device Communication Unlicensed Band for 5G System

Shruti Rajendra Upganlawar, Achala M. Deshmukh, .M. N. Kakatkar

ABSTRACT **-** Device to device communication which means direct communication between nearby device without any the participation of the Base station or the evolved node. D2D has a feature to improve spectrum efficiency. Device to device communication can be used in licensed as well as unlicensed band. Here, we proposed D2D communication in unlicensed band. In paper, our main objectives are to implement a algorithm for LTE and D2D user to use the unlicensed spectrum without degrading the performance of Wi-Fi system and to evaluate the interference to Wi-Fi networks introduced by LTE and D2D users. The analysis and simulation results show the improvement in system data-rate.

Keywords **-** *Resource allocation, Device to Device, Wi-Fi.*

INTRODUCTION

In recent year, there is rapid growth in wireless communication and information traffic, high demands of broadband mobile communication. Moreover 4th generation lags the demands of mobile users for data rate. Therefore 5th generation technology has been invented in that new technology is used which is called as Device to Device communication (D2D).D2D which used to improve spectrum efficiency and data rate, system capacity.

D2D communication allows communication between nearby two devices, directly without participation of base station or evolved node. Device can directly connect with each other through establishing direct links. It support power saving with network, due to small distance between D2D user this is not possible in conventional cellular system.

D2D communication is categories in licensed as well as unlicensed spectrum. In licensed called as in band and unlicensed spectrum called as out band. In band D2Dcommunication further classified as underlay and overlay. Underlay communication is communication in which cellular and D2D share same resource. Overlay communication is only for cellular resources. And out band communication uses unlicensed spectrum for formation of direct links and it is divided into two types i.e. autonomous and controlled. In controlled D2D, the radio interface in D2D managed by the evolved node, while in autonomous these are controlled by the user equipment.

LITERATURE SURVEY

The fifth generation (5G) of wireless communication is the next generation networks. 4G systems will soon be replaced by 5G in order to fulfill the increasing demands of the subscribers for higher data rates and support numerous applications. LTE-Advanced is one of the most promising commercialized wide-area wireless network standard for achieving 5G requirements D2D communication enables direct links between devices in 369*proximity using the cellular spectrum without passing through the base station(BS). There are two main advantages. First, the devices can transmit data with a higher throughput in a low power due to the shorter distance. Second, the BS can lighten its own load and serve more users if low transmission power between devices can make spectrum reusing possible. With these advantages, D2D is a rising star in LTE-Advanced systems.

Kalus Doppler[1] propose work on device-to-device communication as an underlay to an LTE-Advanced cellular network. Then he told how to control and limit the interference of D2D communications to the cellular network. In the analysis, explain D2D communication in a local area cellular network. the cellular network may be interference limited by the cellular communication alone, the D2D peers are still able to use the D2D communication, if they are close and located in the same room. By allowing D2D communication to underlay the cellular network, the overall throughput in the network may increase up to 65 percent compared to where all D2D traffic is relayed by the cellular network. In this way D2D communication may also serve cellular traffic, offloading for the eNBs in addition to its other benefits of fast and light session setup, low transport delay, and high instantaneous data rate.

Chia-Hao[2] has descrised about the analysis of D2D communication underlay cellular network. They considered selecting between a cellular mode, and orthogonal and non-orthogonal resource sharing modes where radio resources are shared between cellular and D2D communication. The main analysis focuses on the optimized sum rate by power control and resource allocation subject to spectral efficiency restrictions, and maximum transmit power or energy constraints. With non-orthogonal sharing, we showed that the optimal power allocation resides on a finite set of feasible solutions in all considered cases. With orthogonal sharing and cellular modes, we solved the optimum radio resource allocation between D2D and cellular connections in closed form, except for the cellular mode when constrained by a maximum transmit energy

SYSTEM MODEL

System description

In our scene, which is shown in fig.1 we have LTE, D2D and Wi-Fi system which uses both the licensed as well as unlicensed band. In our system model we have Base station represent as BS and Wi- Fi access point denoted by AP. We have take LTE users which is 2 and denoted by CU. Number of D2D user is 2 denoted by D, while Wi-Fi user are denoted by WU. In our case, one access point i.e. AP can access two Wi-Fi user. Suppose that we have unlicensed band which is IEEE 802.11 it has 23 channel in 5GHZ band. Here, BS will decide whether we have to select LTE user or D2D user.

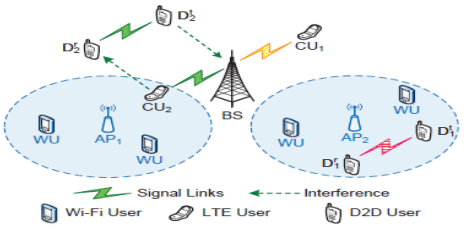

Fig. 1 System model for LTE, D2D and Wi-Fi coexistence in both licensed and unlicensed spectra

Evaluation of interference and optimization

When the unlicensed band is used by LTE and D2D user, the nearest Wi-Fi user cannot access it either it is partially or it can be fully so the it will degrade the performance of the Wi-Fi system. As the performance of Wi-Fi should not be degraded we introduced a interference range for the Wi-Fi networks. Then the Wi-Fi user can select the unavailable channel and do their transmission within defined interference range. For paradigm, LTE and D2D user interference range is defined the power threshold which is defined should exceeds by the received power.

The weight function defined for LTE and D2D are as follows:

$$f^{c}_{n=\min_{j,m\in C^{u}}}(f^{c}_{n,j},f^{c}_{n,m})$$

Where,

$f^{c}_{n,j}$: The increased area of interference between CU_n and CU_j i.e. the range of interference between two LTE users.

$f^{c,d}_{n,m}$: The increased area of interference range i.e. distance between CU_n and D_m

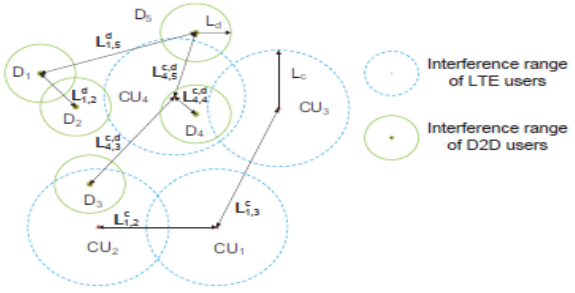

Fig.2 Interference range

The weight function for D2D can be given by:

$$f^{d}_{m}=\min_{j,n\in C^{u}}(f^{d}_{m,j},f^{d,c}_{m,n})$$

$f^{d}_{m,j}$: The weight functions between two D2D users. I.e. D_m and D_j.

$f^{d,c}_{n,m}$: The weight function distance between CU_n andD_m.

Evaluation of mutual interference between LTE and D2D users. For LTE and D2D The sub channel allocation matrix can be defined as:

For LTE,

$$\emptyset_{n,k}=\{^{1,when\ \ subchannel\ is\ used\ by\ CU_u}_{0,empty}$$

For D2D,

$$\theta_{m,k}=\{^{1,when\ subchannel\ is\ used\ by\ D_m}_{0,empty}$$

The data rate for CU_n and D_m over licensed sub channel given as:

$$R^{c}_{n,k}=B1log_2(1+\gamma^{c}_{n,k}),$$

$$R^{d}_{m,k}=B1log_2(1+\gamma^{d}_{m,k})$$

The data rate of CU_n and D_m over unlicensed sub channel given by:

$$R^{c,u}_{n,k}=B1log_2(1+\gamma^{c,u}_{n,k}),$$

$$R^{d,u}_{m,k}=B1log_2(1+\gamma^{d,u}_{m,k})$$

GAME THEORY

Algorithm 1. GameE

Begin
1. t :=1 ; // iteration number
2. Initialize=e player set **I** , $I^{s}_{i}:=0$ and $I_iP:=0$ ($|I^{t}|=N$, $0<1<N$) // Initialize player population for iteration
3. Evaluate **f(I);** // **for** each I_i of **I,** evaluate I^{obj}_{i}
4. **while t** > T_{max} **do**
5. select 2 different competitors I_i and I_j from I
6. Refresh the payoff of I_i and I_j :$I^{v}_{i}:=I^{a}_{i}+I_iP$, $I^{v}_{j}:=I^{a}_{j}+I_jP$;// the following steps are responsible to reproduce a new player I_i
7. **if** $I^{v}_{i}==0$ && $random()<P_1$ **then** Perform imitation operation: $I_i=imitation(I_i,I_j)$;
8. **else**
9. Calculate the expectation payoffs $E(I_i)$ of I_i using equation(3)
10. **if** $E(I_i)>0$ **then** Perform imitation operator $I_i=imitation(I_i,I_j)$;
11. **else if random()** <P_2**then** Perform belief learning operator : I_i = belief learning (I_i)
12. t: = t + 1;
13. **end while**

end

Game theory is set of mathematical tool which help to study a complex relation among interconnected ration players and they predict the selection of their technique. Hence, for D2D the best tool for model and evaluation the resource allocation problem is game theory. The game theory model for resource allocation can be classified as non cooperative and cooperative. In non-cooperative game, an individual player acts to maximize her own payoff while in cooperative game theory coalitions of players are formed and players have joint actions so it makes as mutual benefits.

In our scenario, the input of resource allocation game theory is data rate and sub channel allocation matrix i.e. interference according to that we get a probability results.

RESULT AND DISCUSSION

Results of device to device communication in unlicensed band in 5g systems algorithm implementation. Performance analysis is also done by implementing various optimization techniques. The two methods are present for resource allocation and reducing the interference: Game theory resource allocation method and greedy algorithm methods.

1. Simulation system model

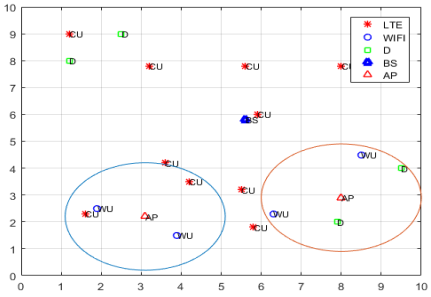

Fig. 3 Simulation system setup

For implementation we are considering a simulation system setup which is given in fig.5.1. Uplink scenario in a LTE networks is consider which consist of base station give by BS and Wi-Fi access points denoted by AP. We have taken 10 LTE users and 10 D2D users are denoted by CU and D respectively. For Wi-Fi system, assuming that there are L unlicensed channel to support different APs base station will select one of them to support LTE-U and D2D-U users. Each AP can access two Wi-Fi users.

2. Calculation of distance and interference

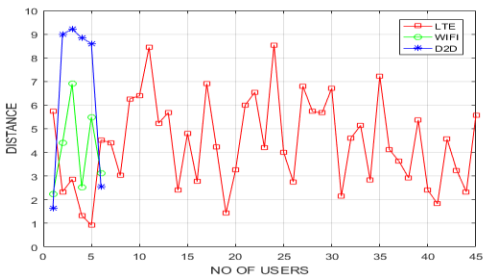

Fig. 4 Calculation of distances

In this graph, X input is distance and Y input is number of users. For wireless communication, the distances between the users are calculated for proper communication.

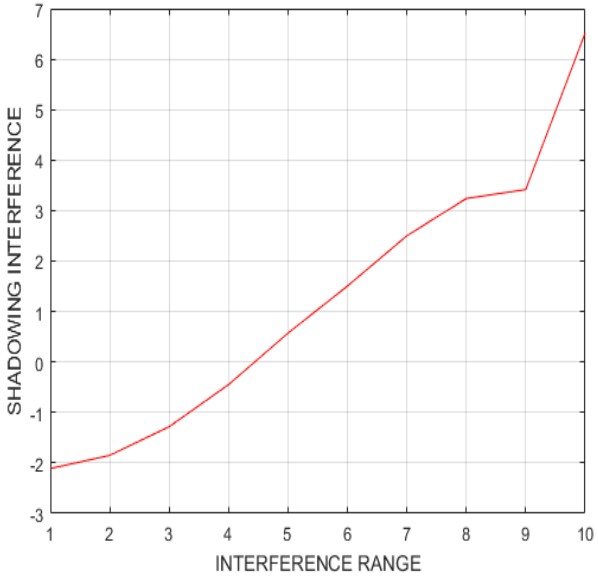

Fig. 5 Calculation of interference

In this above graph, X input is shadowing interference and on Y axis interference range. Free space model is used to calculate the shadowing effect so that we can evaluate the interference created by the building and other obstacles.

3. Optimization result for resource allocation

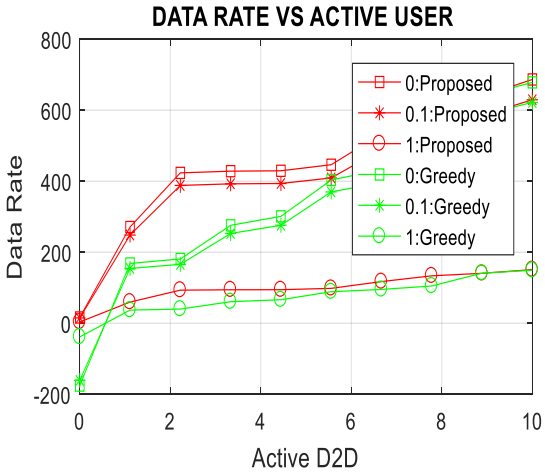

Fig. 6 Data rate vs. active D2D users, with LTE users

In this graph, X axis we have data rate and Y axis active D2D with 10 LTE users.. We observe the data rate decrease as the sensitivity factor increase. D2D and LTE users can use the unlicensed spectrum when the sensitivity factor is 0. It can be seen that subchannels are sufficient, the system s data rate is the maximum. λ = 1 means that almost all LTE and D2D users cannot use the unlicensed spectrum, and thus the system data-rate is the minimum.

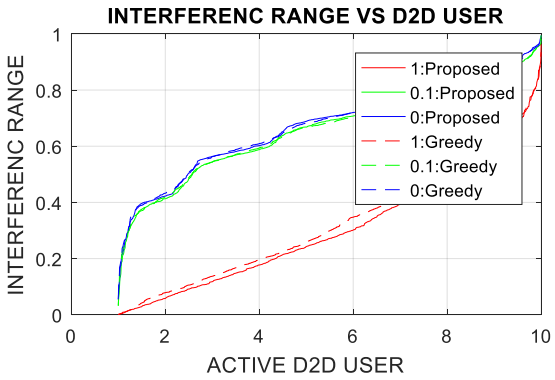

Fig. 7 Interference range vs. active D2D users with LTE users.

Fig.7 provide graph of interference range vs. active D2D users. For judgment of interference range we have uniform sampling done for the sampling point is in interference range. It's also show that threshold increase the interference range decrease with increasing the number of user.

CONCULSION

In our paper, we study the D2D technology which can be used in both licensed as well as unlicensed band. But it mainly focuses on unlicensed band which can be used by LTE and D2D Users. We estimate the allocation issue as a many-to-many matching game with externalities, and build up a low-complexity user sub channel allocation algorithm. Evaluation and simulation result shows that we can achieve maximum data rate by using D2D communication. We use a game theory which reduced then time complexity and it will achieve maximum the data rata. Here, we tackle with the interference problem created by the users.

REFERENCE

[1] H. Zhang, Y. Liao, and L. Song, "Device-to-Device Communications Underlaying Cellular Networks in Unlicensed Bands", in *Proc. IEEE ICC*, Paris, France, May 2017.

[2] D. Feng, L. Lu, Y. Yuan-Wu, G. Ye Li, S. Li, and G. Feng, "Device-to-device communications in cellular networks," IEEE Communications Magazine, vol. 52, no. 4, pp. 49–55, April 2014.

[3] Asadi, Arash, Qing Wang, and Vincenzo Mancuso. "A survey on device-to-device communication in cellular networks." IEEE Communications Surveys & Tutorials Vol.16, No.4, pp.801-1819, 2014.

[4] Lingyang Song, Dusit Niyato, Zhu Han, and Ekram Hossain "Game-theoretic Resource Allocation Methods for Device-to-Device (D2D) Communication".

[5]R. Yin, G. Yu, A. Maaref, and G. Y. Li, "A Framework for Co-channel Interference and Collision Probability Tradeoff in LTE licensed-Assisted Access Networks," *IEEE Trans. Wireless Commun.*, vol. 15, no. 9,p. 6078-6090, Sep. 2016.