Device to Device Communication Underlaying Cellular Networks Using Energy Efficiency Optimization

G Rameshreddy [1]
Associate Professor
ECE Department
St.Martin's Engineering College
Secunderabad, Telangana-500100.

Suresh Penchala[2]
Assistant Professor
ECE Department
Kamala Institute of Technology
& Science, Telangana-505468.

ABSTARCT

In this paper we discuss about the D2D communication which is used to improve the communication rapidly. To maximize the EE, we use D2D in 5g networks which is key in D2D. It also reduces the throughput latency. We use D2D in overlay or underlay, in this we choose underlaid over overlaid because of high spectral efficiency. However, we give much attention to single cell scenario to which are existing technologies and we give less attention to maximize the EE of whole cellular network underlaid with D2D communication. By using successful transmission probability and AVSR reduces the interference problem which is introduced by D2D and cellular. The optimization problem is formulated with algorithms they are Branch and Bound and proposed derivative algorithm. To solve non-convex problem, we proposed a derivative algorithm, compare both algorithms which shows the propose derivative is lower than the BB. Finally, we perform simulation results by using MATLAB software which demonstrated that the EE with much better performance.

1 INTRODUCTION

In present scenario we are finding a better communication through wireless smart devices and the demand grows at an un known speed ever [1]. In this we use the method that is device to device communication to increase the energy efficiency to consume less power while transmitting the information without loss[2].Thedevice to device communication is a key for future 5G networks[3].The device to device communication which connects the devices directly and it also improves the quality of network through put and reduces the latency and it is good at improving the spectral efficiency and energy efficiency[4]. The D2D communication it again uses frequencies in cellular networks [6]. The D2D communication is divided into two types they are in band and out band, in this we use in band and again the in band is divided into two types they are underlaid and overlaid [7]. In underlaid cellular and D2D share same resources. In overlaid the cellular and D2D they use separate resources. In this we choose underlaid over overlaid because it has high spectral efficiency.

At present we mainly focusing on energy efficiency maximization and mostly based on better performance we choose this technique which is device to device communication underlaying cellular networks. The existing technologies only works on single cell scenario. In this we use uplink or downlink to transmit and receive the information [8]. At present We give more attention to single cell scenario, we do not give much attention to multiple bands because in multiple bands it takes lot of power so they were still trying to increase the energy efficiency to consume less power than only we get the desired output.

In this paper, we Also discussed about algorithms. If we want the maximum energy efficiency firstly, we have to use the energy efficiency optimization [9]. The energy efficiency optimization problem is the best solution for getting maximum EE (energyefficiency) [10]-[12].The optimization means finding the best solution for a problem [10]. In this we use branch and bound algorithm and we also use successful transmission probabilities and average sum rate [11]. The transmission probability is used because after getting maximum energy efficiency the interference will be occurred due to this we may loss information we can't send the packets through transmitter to overcome this we use transmission probability and average sum rate is going to find theaverage sum of values to get the maximum value[12].

The optimization is based on two types they are convex and non-convex. The convex is better than non-convex but we used non convex because in the process finding maximum energy efficiency, we proposed a derivative algorithm to solve non-convex problem. After performing we compare both algorithm and we choose better algorithm which shows less computational complexity. We done this process by using simulation, we generate the graph by using MATLAB software after generating the graphs we compare the graphs and choose the best one.

II SYSTEM MODEL

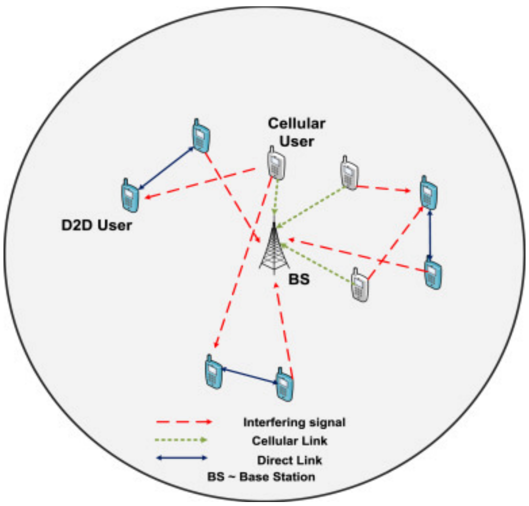

Figure 1: system model of whole cellular network underlaid with D2d communication

In this paper the figure shows the whole cellular network underlaid with D2D communication [13]. The D2D users are distributed on a 2-dimensional plane R2 and cellular users share the same bandwidth in uplink direction. In this the Base station is used to allocate the resources to the whole cellular network underlaid with D2D communication.

At present we are seen that the existing works only on single cell scenario, but at present we are trying to get work on multiple bands that means at a time it transfers the data to multiple devices. The C and D denotes the cellular and device to device to communication and the total bandwidth of ith band is Wi and it is divided in to M sub bands. The bandwidth of each sub band is Wi i=1,2,3…M, having these parameters the channel fading may vary ad the power transmission is adjustable and it also improves the energy efficiency [14]. The both cellular and D2D is divided in to sub bands so they can use these subs and with density lambda Ci and lambda Di. For each there is a different density and if we use more bandwidth for both users, the multiple users are allowed to transmit and the density is also increased.

The transmission power allocation for ith band for cellular users $P_{c,i}$and the total transmission power Pc.

$$\sum_{i=1}^{k} P_{c,i} = P_c$$

Similarly, the transmission power for ith band for D2D users$P_{d,i}$and total transmission power for D2D Pd.

$$\sum_{i=1}^{k} P_{d,i} = P_d$$

We consider the channel model as a channel path loss and small-scale channel fading, which represents the Rayleigh fading. To observe the performance of cellular and D2D of whole network we focus on typical receiver without los, the typical receiver for D2D and typical base station for cellular [15]. Whatever the received power for both devices obtained by considering small and large scale fading it is expressed as

$$P_r = P_t \delta R^{-\alpha}$$

Where Pt is the power transmission,δ represents the Rayleigh fading, R represents the distance between transmitter and receiver,PR represents the power received for cellular and D2D users and α denotes the path loss exponent.

IIIEEOPTIMIZATION PROBLEM

In this the optimization is used with other formulations they are successful transmission probability and average sum rate. By using those expressions, we remove interference problem, then we get the formulation for energy efficiency optimization.

A. **Successful transmission probability**:

When we transfer the information the interference problem will be occur in receiver, the interference will be introduced by both cellular and D2D communication. By analysing the network performance is characterized by successful transmission probability which is the receiver receive the information successfully without loss [16].Thus, signal to interference plus noise ratio to base station for ith band.

$$SINR_{C,I} = \frac{P_{c,i}\delta_{c,00}\, R^{-\alpha}{}_{c,00,i}}{\sum_{J\varepsilon\phi_{c,i}} P_{c,i}\,\delta_{c,j0} R_{c,j0,i}^{-\alpha} + \sum_{J\varepsilon\phi_{d,i}} P_{d,i}\,\delta_{d,j0} R_{d,j0,i}^{-\alpha} + N_0}$$

Where $\delta_{c,00}$ and $R^{-\alpha}{}_{c,00,i}$ denote the Rayleigh fading coefficient and the distance between the typical BS and the corresponding cellular user in the ith band, respectively. Similarly, $\eth_{c,j0}$ and $R^{-\alpha}_{c,j0,i}$ stand for the Rayleigh fading coefficient and the distance between the jth cellular user and the typical BS in the ith band. $\eth_{d,j0}$ and $R^{-\alpha}_{d,j0,i}$ are the counterparts for D2D communication. Finally, N_0 is the thermal noise.

B. Average sum rate:

The average sum rate is obtained by using energy efficiency,[17] the EE is defined by dividing the average sum rate by total power consumption the total power consumed in D2D communication for ith band which is expressed in

$$\mathrm{EE_{d,i}} = \frac{\mathrm{ASR_{d,i}}}{\lambda_{\mathrm{d,i}}\mathrm{P_{d,i}}}$$

C.EE optimization problem

In this we formulate the EE optimization problem and we obtain the maximum energy efficiency.

To obtain the better quality of communication, the probabilities should be less than the threshold values.

$$1 - \Pr(\mathrm{SIR}_{c,i} \geq T_{c,i}) \leq \theta_{c,i},$$

$$1 - \Pr(\mathrm{SIR}_{d,i} \geq T_{d,i}) \leq \theta_{d,i},$$

Where $\theta_{c,i}$ and $\theta_{d,i}$ are the probabilities for cellular transmission and device to device to communication for ith band. But the power transmission for D2D it can't hold interference much longer in that case the network is very difficult to coordinate [18]. In that situation the base station will reduce the D2D users to access until the probabilities become small.

When the sum of power for D2D communication should be equal to total transmission power then only it should be satisfied.

The power in the ith band should not be less than zero and it should not be greater than upper bound and it is represented as $P_{d,i,up}$.

Then we get

$$0 \leq P_{d,i} \leq P_{d,i,up}.$$

The optimal resource allocation mainly is used for to maximize the energy efficiency, finally we obtain the maximum EE.

IVBRANCH AND BOUND ALGORITHM

In this we used branch and bound algorithm on the purpose of how to maximize the energy efficiency for device to device to communication underlaying cellular networks [19].

Branching:

In this we initially check the device to device users nearby base station by determining the distance between the user and the user terminals, if the user in the line of the sight region then we considered as them as a device to device users [20]. After that we form the network with base station and we choose the node then we transmit those nodes. After finding the optimal solution it is formed as a tree with levels, each level comparable to one cellular link and each node form sub nodes and it distributes to cellular link [21]. After that we take away the underlaying sub nodes if the new node is smaller than the upper bound and it will be done in the non-decreasing order [22].

Bounding:

In this we calculate the lower bound of current node, if node is empty and upper bound larger than the lower bound, then we replace the upper bound with lower bound. All branching procedures are completed and upper bound is zero.

Flow chart for branch and bound

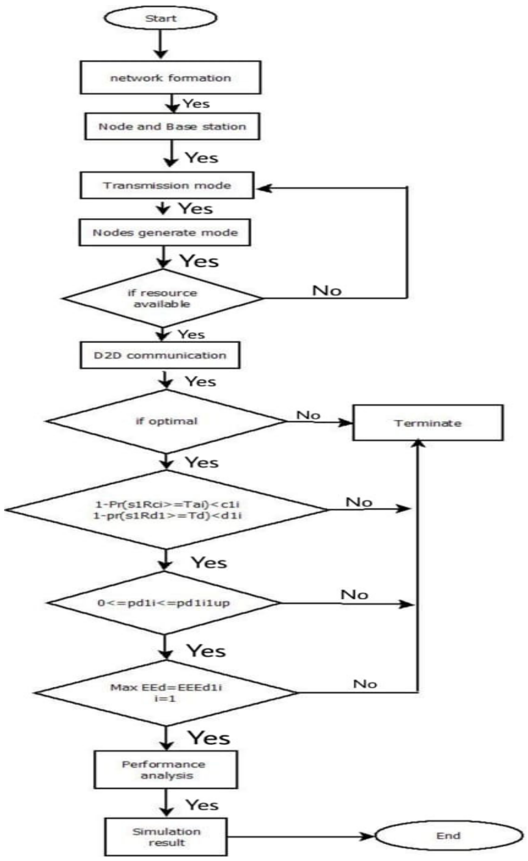

Figure 2: Flowchart for Branch and Bound

Flow chart description

Step1 first we form a network transformation

Step 2 after network transformation with base station we chose the node

Step 3 in this we transmit the nodes directly

Step 4 the nodes will be generated

Step 5 If resources are available then goes to the D2D communication

Step 6 If the solution is optimal then it goes to the next step otherwise it goes to termination state.

Step 7 In this the power transmission for cellular and D2D probabilities should be less than the threshold values

Step 8 If above condition is true then it goes to the next step in that it should not be less than zero and not more than upper bound.

Step 9 Then we obtain the maximum EE and finally in performance analysis the receiver will receive the information without loss and we obtain the graph by using MATLAB software. This is the end of the process.

PROPOSED DERIVATIVE ALGORITHM

To solve the non-convex problem, we proposed a derivative algorithm. Then we compare both algorithms to get the better solution.

Flow chart for proposed derivative

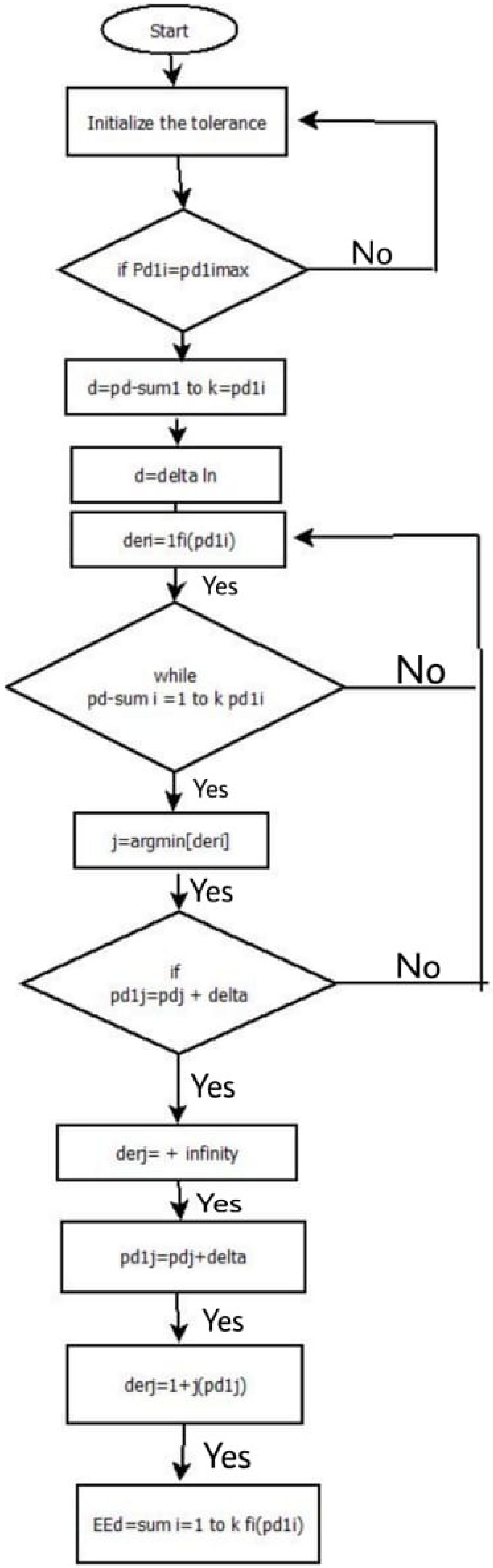

Figure 3: Flowchart for Proposed Derivative method

Flow chart description

Step1 initialize the threshold value

Step2 calculate the power transmission of D2D users for ith band.

Step3 after calculating we get the maximum Pd,i. (Pd,i=Pdmax)

Step4 in order to achieve the least reduction in EE we have to adjust the value of Pd,i to meet the equality constraint.

Step 5 consider 'n' as a parameter which checks the balance between computational and performance. Hence according to the practical requirements, we can adjust the value.

Step6 we consider deri variable to set a value to save. it is used to select appropriate value for Pd,j in further steps.

Step 7 we set a threshold value instead of a counter to exit the loop. Because if Pd,j is selected in current iteration it may exceed the feasible region in such case we need to go for another Pd,j to adjust another iteration. This situation is unpredictable and iterations are not determined either.

Step 9 and 10 after the all adjustment if Pd,j is overstepping the feasible region then we set derj to infinite such that j will not be chosen in step 8. Such that we prevent the occurrence of an endless loop.

Step 13 in this we update derj variable instead of every deri variable because for i=1,2,3…k and not equal to j deri remains unchanged after adjusting Pd,j.

V. SIMULATION RESULTS

In this we perform the simulation results using MATLAB software, we perform the EE of D2D communication with different network parameters. The parameters are bandwidth of ith band Wi and total transmission power Pd are included in table.

TABLE: Simulation Parameters

Parameter	Value
K	5
Wi	20MHz
A	4
θc,i	0.1
θd,i	0.1
Tc,i	0db
Td,i	0db
[Rc,00,1,Rc,00,2,….,Rc,00,5]	[50,60,70,80,90]m
[Rd,00,1,Rd,002,…Rd,00,5]	[10,20,30,20,10]m
[λc,1, λc,2, · · · , λc,5]	[10,1,10,10,10]x 10−5user/m2
[λd,1, λd,2, · · · , λd,5]	[10, 1, 10, 10, 10]x10−4user/m2
Pc,i	100mW
Pd	60mW
Pd,i,up	20mW
E	1 × 10−3

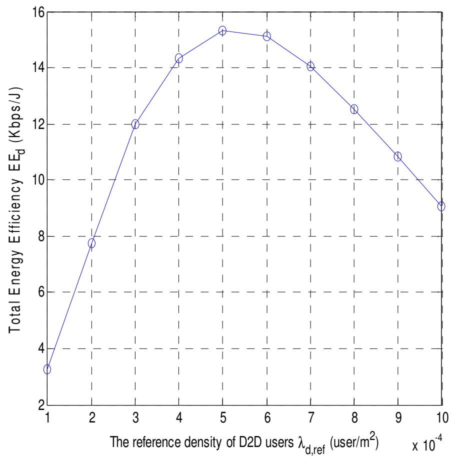

Fig 2 The EE of D2D communication against the reference density of D2D users.

This figure is achieved by proposed derivative algorithm. Which is EE of D2D communication against reference density of D2D users. The EE raises and then it slowly decreases and D2D users increases. The D2D users increases because, the interference is introduced while sharing the spectrum. In this Case the interference is not much effected and it results in higher EE. But when reference density of D2D users increases rapidly, the chance of interference becomes severe and EE is also decreasing due to more power consumption. We can also absorb that in graph if cellular users increase the EE decrease. This leads to more occurrence of interference. The EE decrease when more power is consumed.

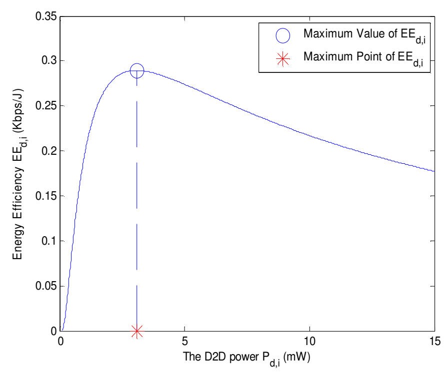

Fig 3 EE against D2D power

This fig illustrates that the graph between D2D power and EE. at first the D2D power for ith band feasible region increases and it is considered as maximum point. This situation is divided in to 3 categories. In first, the feasible region is on the left of dash line. Then the feasible region of D2d power for ith band increases and it reaches maximum point. In second, the global maximum point is within the feasible region. In third the feasible region is on right side, and its starts decreasing on feasible region. hence, we get maximum D2D power.

REFERENCES

[1] M. N. Tehrani, M. Uysal, and H. Yanikomeroglu, “Device-to-devicecommunication in 5G cellular

networks: Challenges, solutions, and futuredirections," IEEE Commun. Mag., vol. 52, no. 5, pp. 86-92, May. 2014.

[2] X. Lin, J. G. Andrews, A. Ghosh, and R. Ratasuk, "An overview of 3GPPdevice-to-device proximity services," IEEE Commun. Mag., vol. 52, no.4, pp. 40-48, Apr. 2014.

[3] J. Liu, N. Kato, J. Ma, and N. Kadowaki, "Device-to-device communication in LTE-advanced networks: A survey," IEEE Commun. Surveys Tuts.,vol. 17, no. 4, pp. 1923-1940, Nov. 2015.

[4] L. Wei, R. Q. Hu, Y. Qian, and G. Wu, "Enable device-to-devicecommunications underlaying cellular networks: Challenges and researchaspects," IEEE Commun. Mag., vol. 52, no. 6, pp. 90-96, Jun. 2014.

[5] E. Datsika, A. Antonopoulos, N. Zorba, and C. Verikoukis, "Greenco-operative device-to-device communication: A social-aware perspective,"IEEE Access, vol. 4, pp. 3697-3707, Jun. 2016.

[6] D. Feng, G. Yu, C. Xiong, Y. Yi, G. Li, G. Feng, and S. Li, "Modeswitching for energy-efficient device-to-device communications in cellular networks," IEEE Trans. Wireless Commun., vol. 14, no. 12, pp.6993-7003, Dec. 2015.

[7] L. Wei, R. Hu, Y. Qian, and G. Wu, "Energy-efficiency and spectrumefficiency of multi-hop device-to-device communications underlayingcellular networks," IEEE Trans. Veh. Technol., vol. 65, no. 1, pp. 367-380,

Jan. 2016.

[8] Y. Wu, J. Wang, L. Qian, and R. Schober, "Optimal power control forenergy efficient D2D communication and its distributed implementation,"IEEE Commun. Lett., vol. 19, no. 5, pp. 815-818, May. 2015.

[9] A. Abrol and R. K. Jha, "Power optimization in 5G networks: A steptowards green communication," IEEE Access, vol. 4, pp. 1355-1374, Mar.2016.

[10] Y. Jiang, Q. Liu, F. Zheng, X. Gao, and X. You, "Energy efficient jointresource allocation and power control for D2D communications," IEEETrans. Veh. Technol., vol. 65, no. 8, pp. 6119-6127, Aug. 2016.

[11] Z. Zhou, M. Dong, K. Ota, J. Wu, and T. Sato, "Energy efficiency andspectral efficiency tradeoff in device-to-device (D2D) communications,"IEEE Wireless Commun. Lett., vol. 3, no. 5, pp. 485-488, Oct. 2014.

[12] T. D. Hoang, L. B. Le, and T. Le-Ngoc, "Energy-efficient resourceallocation for D2D communications in cellular networks," IEEE Trans.Veh. Technol., vol. 65, no. 9, pp. 6972-6986, Sep. 2016.

[13] Y. Yang, Y. Zhang, K. Shi, and J. Li, "Optimal power control forenergy efficiency of device-to-device communication underlaying cellularnetworks," in Proc. IEEE INDIN'16, Jul. 2016, pp. 1-4.

[14] M. Haenggi, Stochastic geometry for wireless networks. CambridgeUniversity Press, 2012.

[15] F. Baccelli and B. Blaszczyszyn, Stochastic geometry and wirelessnetworks. Now Publishers Inc, 2009.

[16] Q. Ye, M. Al-Shalash, C. Caramanis, and J. G. Andrews, "A tractablemodel for optimizing device-to-device communications in downlink cellular networks," in Proc. IEEE ICC'14, Jun. 2014, pp. 2039-2044.

[17] S. Shalmashi, E. Bjornson, M. Kountouris, K. W. Sung, and M. Debbah, "Energy efficiency and sum rate when massive MIMO meets device-to-device communication," in Proc. IEEE ICCW'15, Jun. 2015, pp. 627-632.

[18] Y. Kwon, T. Hwang, and X. Wang, "Energy-efficient transmit powercontrol for multi-tier MIMO hetNets," IEEE J. Sel. Areas Commun., vol.33, no. 10, pp. 2070-2086, Oct. 2015.

[19] T. Cormen, C. Leiserson, R. Rivest, and C. Stein, Introduction toalgorithms. MIT press, 2009.

[20] W. Kuo and S. Chu, "Energy efficiency optimization for mobile ad hocnetworks," IEEE Access, vol. 4, pp. 928-940, Mar. 2016.

[21] R. Bartle and D. Sherbert, Introduction to real analysis. New York:Wiley, 2011.

[22] S. Boyd and L. Vandenberghe, Convex optimization. Cambridge univer-

sity press, 2004.