INTERNATIONAL JOURNAL OF TECHNO-ENGINEERING
IJTE

ISSN: 2057-5688

RESOURCE ALLOCATION AND POWER CONTROL TO MAXIMIZE THE OVERALL SYSTEM SURVIVAL TIME FOR MOBILE CELLS WITH A D2D UNDERLAY

Dr. D. Bhasker **(professor)**

JODU SRINIVAS (188R1A0481), K DURGA PRASAD (188R1A0483), K SAI PRASAD GOUD (188R1A0484), K PRAKYANTH (188R1A0490)

Department of ECE, C M R Engineering College,Hyderabad, Telangana, INDIA

ABSTRACT

The limited battery life of user equipment (UE) is always one of the key concerns of mobile users and a critical factor that could limit device-to-device (D2D) communications. In this work, considering that UEs may have different residual battery energy levels, we define the overall system survival time as the minimal expected battery lifetime of all transmitting UEs in a cell. We then propose to maximize the overall system survival time by jointly optimizing the resource allocation and power control (RAPC) D2D links as well as conventional cellular (CC) links. Subject to the transmission rate requirement of each link, the joint optimization problem is formulated as a mixed integer non-linear programming (MINLP) problem, which is solved by a game theory based distributed approach. Simulation results demonstrate that our game theory based RAPC approach can enormously prolong the overall system survival time as compared with existing RAPC approaches.

I. INTRODUCTION

1.1 BACKGROUND

Wireless communication networks have seen a tremendous growth in the past decades. This trend might grow exponentially in the next decade. The technolo- gies improved to meet the increasing demand for wireless communication are far from satisfying the expectations.The achievement of wireless networks depends on network spectral efficiency (SE) and energy efficiency (EE) [1]. Radio Spec- trum must be efficiently used for assisting ever increasing wireless traffic growthand quality of services (QoS) demands from users. In order to meet capacity demands from the data traffic growth, network with base stations (BSs) are expected to achieve a higher spectral efficiency and energy efficiency. A typical network model consists of Macro-Base Station (MBS), Pico- Base Station(P-BS), Femto-Base Station (F-BS) and relay basestations (R-BS). An M-BS transmits high power, serves a larger coverage area; while other types of BSs transmit at a relatively lower power so their coverage area is smaller .A network with base station can improve the wireless link quality since the BSs are now much closer to UEs. Due to the existence of BSs with diverse transmit powers, the network can be more energy efficient and spectral efficient.

1.2 D2D Communication

Tremendous increase in demand for wireless communication technologies lead to overcrowding of radio spectrum. So efficient utilizing of radio spectrum is the 6 important task and new innovative technologies are required. A new paradigmsto revolutionize the existing wireless networking technologies is Device-to-device communication. Device-to-Device (D2D) communications in the wireless network are used to facilitate proximity-aware services and data traffic offloading, especially in local area communication services[2]. Device-to-device communication is a new technique in advanced wireless communication to improve the spectral efficiency of cellular systems. In D2D communication, devices in near proximity can communicate directly with each other without assistance of BS and can provide performance gain. The demand for higher data rates increased worldwide during the past few years. Todays user applications need higher data rates for serviceslike video sharing and gaming, offloading the data transfer from base station. Other application of D2D are machine-to-machine (M2M) communication and relaying[3]. D2D is classified into inband and outband. In case of outband ,D2D users utilize unlicensed radio spectrum for communication,Wi-fi or ZigBee are some examples of outband D2D .While in case of inband, D2D users utilize licensed ra- dio spectrum (cellular spectrum). To establish a connection in outband,D2D usesthe assistance of BS known as controlled outband or autonomous outband. In- band D2D can be further categorised into overlay inband and underlay inband.Inoverlayinband D2D users can have either dedicated radio resources for commu-nication. In underlay inband D2D users share the resources allocated for cellularusers. Figure 1.1 shows the categorization of D2D communications. The decisionon how D2D users communicate either through BS (cellular mode) or directly (D2D mode) should be taken sensibly. Further in case of D2D mode, BS should choose among controlled outband, overlay inband or underlay inband.Figure 1.1shows the classification of D2D communications.

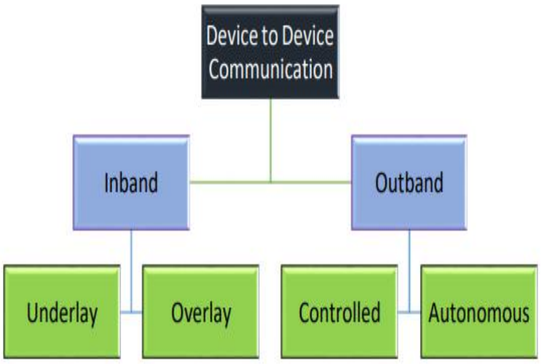

Figure 1.1: Classification of D2D Communication

1.2.1 Outband In general

D2D communication use unlicensed spectrum in which users establish the D2D connection.The BS doesn’t have the control over the D2D communication established between the devices which is not useful for cellular networks. But in case of controlled outband, BS has control on the D2D communication [4, 5].The advantage of this scheme as it uses unlicensed spectrum there is no chance of interference from cellular communications. The major disadvantage is the interference on D2D connections by other users accessing unlicensed spectrum.These disadvantages restrict user from using the outband in D2D communication.

1.2.2 Inband Overlay

Inband provides energy efficiency but doesnt provide spectral efficiency because it needs dedicated radio spectrum [6].UnderlayInband is the best mode which provides spectral efficiency [3, 7]. The main disadvantage in this method is sharing of the same radio resources for both D2D and cellular users, this will cause interference among the users.In uplink scenario when the D2D link shares the resources,BS experiences interference from D2D transmissions as well as from others D2D users accessing the uplink.Indownlink scenario when the D2D link shares the resources,cellular users experience interference from D2D transmission and D2D recievers will experience interference from users communicating with BS. To enhance the communication capacity and capabilities and to introduce new services research is performed on device-to-device (D2D) communications device-to-device (D2D) communications as an underlay to cellular networks 8 A D2D link is a direct connection between two communicating devices, using the spectrum provided for cellular networks. The D2D communication is recognized as one of the technology that enable User Equipments (UEs) to facilitate high data rate local communication without an infrastructure of Base Station (BS) [3, 9] (i.e) a UE can communicate with other UEs in the range using cellular network resources without involvement of base station.

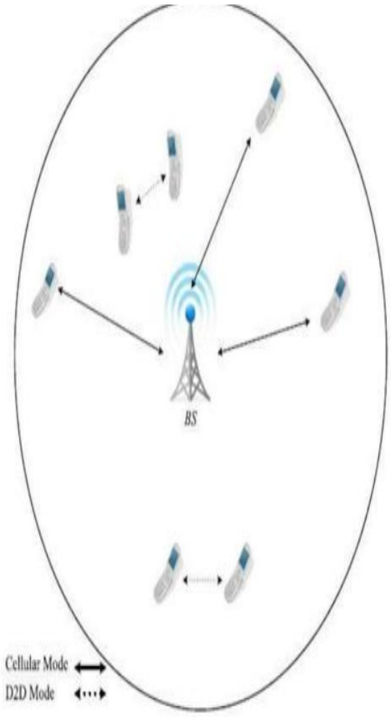

Figure 1.2: D2D and Cellular mode of communication

The concept of D2D communication is shown in Figure 1.2.The UEs communicating through direct links refers to D2D Mode and UEs communicating through the BS refers to cellular mode. The direct device communications, for example Bluetooth and Wi-Fi direct, use unlicensed spectrum for communication. The D2D communication uses licensed spectrum which improves the QoS and provides better coverage.The D2D communication underlying cellular network operates in a licensed spectrum allocated to the cellular users, the D2D users can access the licensed spectrum in two modes either in a dedicated mode or in a shared mode[10].

II. LITERATURE SURVEY

2.1 D2D Communication in Cellular Networks

In traditional method of cellular communication,two UEs communicate by relaying through BS.BS controls link establishment, resource allocation in a specific range served by that cellular system.If two UEs are in the proximity D2D communication can be established.If distance between two UEs can satisfy the constraints,then the UEs can form a D2D pair.This is first step in the method of Device Discovery.The conditions for mode selection will conclude whether D2D pair can communicate.The conditions include aspects like distance between the pairs in the cell,availability of resources for sharing,etc. The D2D communication can be implemented in three stages,the first stage deals with discovery of D2D candidates,the second deals with the mode selection and resource allocation and finally third stage is the communication of two UEs.

2.1.1 Device Discovery and Communication

In this device discovery stage, base station discovers a UE that wants to connect with another UE. During this discover phase UEs exchange lot of messages with BS and among themselves (i.e) UE and UE. These messages will provide the information about the links established among the UEs and the links between the UEs and the BS to the network. If a new D2D candidate is confirmed to bea D2D pair , then mode selection condition is applied. This condition decides whether a new D2D pair can communicate in D2D mode. If the pair satisfies conditions for D2D communication, D2D mode is assigned. If this D2D pair fails to satisfy the conditions, cellular mode is assigned to the pair.BS allocates the resource to the new D2D pair. After device discovery,mode selection and resource allocation ,the D2D can communicate and exchange information with each otherwithout the assistance of BS [14].

2.2 Device Discovery Process

In this section we suggest two protocols for device discovery in which the exchange of messages is set up by BS or UE based on information provided in [15].These outline of the protocols is described as following, Reactive protocol:In this scenario, a UE notifies the BS that It want to communicate with another UE. Then base station communicates with the devices to obtain information regarding the link. Proactive protocol:In this scenario,BS multi-casts request from time to timeto all UEs, even if there is no request for service from UEs. In these two cases, the BS assists for discovery of UEs. The entire process is controlled by BS. In this thesis we consider network assisted device discovery method, because BS can control the interference and entire process will be efficient and we can expect considerably better results.We compare these two protocols in terms of the performance computed from numerical simulations. This conditions for successful discovery of D2D candidates can be summarized as: If the transmitting device has the details of the receiving device, If the receiving device has the details of the transmitting device and if theywant to communicate with each other, If the pair satisfies the proximity condition.

2.3 SYSTEM MODEL

The system model consists of number of uniformly distributed UEs in the cell.The system model is shown in the Figure 2.1 .We assume a D2D communication in cellular networks coordinated by a BS.We also assume that the BS is positioned at the center with radius in the cell.BS coordinates traditional and D2D communications in the cell.Ues in the proximity can communicate with each by a direct D2D link.BS decides if the direct communication between the UEs can be established by observing the location of UEs. BS allocates the resource to the new D2D pair. After device discovery,mode selection and resource allocation ,the D2D can communicate and exchange information with each other without the assistance of BS.

2.4 PROTOCOLS FOR DEVICE DISCOVERY

We propose two protocols termed as reactive and proactive.In reactive protocol the process of device discovery is started by a UE,where as in proactive protocol BS starts the process of device discovery [16].

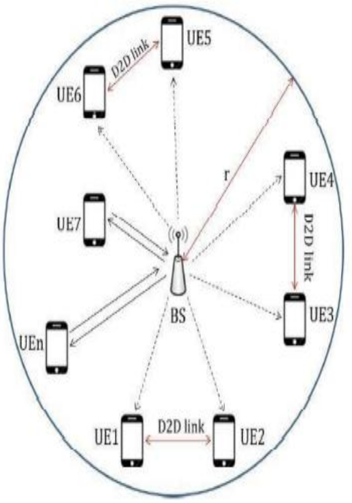

Figure 2.1: System model for Device Discovery

III. PROPOSED METHODOLOGY:

GAME THEORY BASED APPROACH A. The RAPC Game The optimization problem in (3) is an MINLP problem, which is NP-hard. To solve it, we develop a game theory based distributed approach in this section. Considering the UL CC inks and D2D links as non-cooperative players, we define vector si∗ = (δi∗ 1, δi∗ 2, ..., δi∗ K) as the strategy of player i∗ . Given other players' strategies, s−i∗ , player i∗ 's utility function, ui∗ (si∗ , s−i∗), is defined as the optimal solution of the following optimization problem in (9). Transparently, (si∗ , s−i∗) should satisfy the constraints in (5)-(7).

$$u_{i^*}(\boldsymbol{s}_{i^*}, \boldsymbol{s}_{-i^*}) = \max_{p_i,\, i \in \Gamma \cup \Lambda} OST_{sys} \qquad (9)$$

s.t.:

$$(4),\ (8) \qquad (10)$$

$$\delta_{i\_k} \text{ is given by } (\boldsymbol{s}_{i^*}, \boldsymbol{s}_{-i^*}),\ i \in \Gamma \cup \Lambda,\ k = 1, .., K \qquad (11)$$

Every scheduling period is divided into two phases. In the first phase, all the links are set to work in the control channel and participate in the RAPC game as non-cooperative players. Initially, the |Λ| UL CC links select |Λ| different UL subchannels while each D2D link randomly selects one UL subchannel. These links (players) then adjust their strategies iteratively. In each iteration of the RAPC game, all the players broadcast their current strategies. An individual player calculates its best response that will maximize its own utility function, according to the strategies of all the other players. This response will be the player's new strategy and be broadcast in the following iteration. The RAPC game keeps running until it reaches a Nash equilibrium or the iteration number exceeds a certain threshold, Nthd. In the second phase, each UL CC link or D2D link transmits in a certain UL subchannel and adjusts its transmission power based on the output of the RAPC game in the first phase. Definition 1: A set of strategies s for all the players participating in the RAPC game is a Nash equilibrium if no player can improve its own utility function by changing its strategy unilaterally, i. e.

$$u_i(s_i, s_{-i}) \geq u_i(s_i^{'}, s_{-i}),\ for\ \forall s_i^{'} \neq s_i,\ \forall i \in \Gamma \cup \Lambda \quad (12)$$

The Nash equilibrium is a stable outcome of a non-cooperative game. In the Nash equilibrium state, multiple players reach a condition where no player wishes to deviate. Also, we can prove Proposition 1: Proposition 1: Nash equilibrium exists in the constructed RAPC game. Moreover, the values of δi k, (i∈ Γ ∪ Λ, k = 1, ..., K) in the optimal solution of OPT in (3) is a Nash equilibrium B. Best Response of Each Individual Player From constraint (4), we can see that the transmission power needed of each link is influenced by all the other links allocated in the same subchannel. As the expected battery lifetime of a transmitting UE is inversely correlated to its transmission power, given (si∗ , s−i∗), ui∗ (si∗ , s−i∗) in (9) can be achieved if the transmission power of each link in Γ∪Λ is minimized. Assuming the links in set Ck are transmitted in subchannel k (δi k = 1, δi k 0 = 0, ∀k 0 6= k, ∀i∈ Ck), we can prove the following Proposition Proposition 2: For an arbitrary link i # in Ck, under the transmission rate constraint (4), its minimum feasible transmission power, pi#,min, can be achieved only when all the inequalities relevant to the links in Ck in constraint (4) become equality at the same time, i. e.

$$B \cdot \log_2\left(1 + \frac{p_i \cdot g_{ii}}{N_0 + \sum\limits_{(j \in C_k) \cap (j \neq i)} p_j \cdot g_{ji}}\right) = b_i,\ \forall i \in C_k \quad (13)$$

Proof. See Appendix B. Through equivalent transformation, (13) can be transformed into the following linear equations:

$$g_{ii} \cdot p_i + \sum_{(j \in C_k) \cap (j \neq i)} (1 - 2^{b_i/B}) g_{ji} \cdot p_j = (2^{b_i/B} - 1), \quad \forall i \in C_k \quad (14)$$

According to Proposition 2, we conclude that when transmission subchannels of the other links in Γ∪Λ are fixed (s−i∗ are given), the minimum feasible transmission power pi,min of each link i in Γ ∪ Λ is determined by which links are transmitted in its subchannel, and then determined by player i∗ 's strategy, si∗ . In order to achieve player i∗ 's best response given s−i∗ , the proposed algorithm will test every feasible strategy for player i∗ . In each testing, the algorithm first calculates the minimum feasible transmission power pi,min of each link i in Γ∪Λ if player i∗ choose this strategy. Then the algorithm calculates the utility function, ui∗ (si∗ , s−i∗), using (1) and (2), respectively. After all the testings, the proposed algorithm will finally acquire the strategy for player i∗ with the largest value of utility function. The proposed algorithm is given in Algorithm 1. Proposed Algorithm We proposed two algorithms in this section , mode selection Algorithm and Joint mode and relay selection Algorithm. Mode Selection Algorithm In this section we select appropriate communication mode i.e, D2D or cellular communication,which satisfies the QoS requirement and maximizes the overall system throughput. By selecting the mode we imply that the network chooses whether the UEs should communicate directly or through the BS. Each UE can operate either in Cellular mode or D2D mode of communication. In the proposed mode selection scheme, D2D link maximizes the throughput than cellular link. To establish a communication from UEi to UEj , the BS compares the ξ cd with xith .UEi is assigned in Uc or Ud upon the decision of comparison.

If the minimum SNR requirements are not met in both the cases ,thenneithe the modeis assigned to UEi Relay Selection Algorithm We suggest a mode selection algorithm to solve the problem stated. The suggested algorithm is Hungarian algorithm which achieves maximum weighted matching for bipartite graph.We further assume that the BS has acquisition SINR at UEs and the channel state information (CSI) of transmissions and this method can be executed at the BS. To assign the communication modes for every transmission we consider a weighted bipartite graph, G(X, Y, E), as shown in Figure 3.2. Our main motivation is to select a appropriate partner for every element in P corresponding to Rso that the overall system throughput is maximised with selecting the appropriate mode of communication. In bipartite graph X vertices denotes the transmitting UEs in P and Y vertices denotes the remaining users inside the cell , i.e., R (UEs other than the transmitters in cell). SINR is the important parameter in maximizing the overall system throughput.As shown in the figure the weights of the edges are the SINR values for particular transmission between the nodes.The weight of the each edge between a user xi in X and user yj in Y for (p, q) transmission, wi,j = ξij , ∀i∈ P if q = j. Else, i.e.,q /= j, the SINR of relay mode, (p, j, q) is calculated and assigned as weights, wi,j = min (ξpj , ξjq), ∀i∈ P.

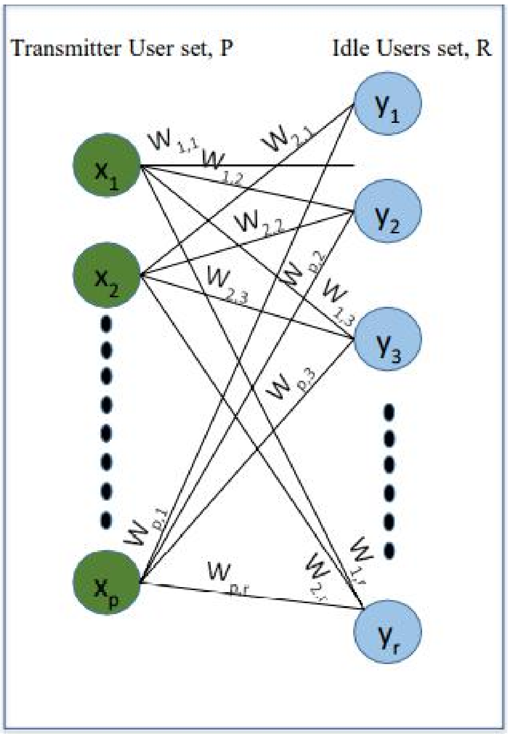

Figure 3.1: Weighted Bipartite graph matching scenario

IV. SIMULATION RESULTS

We evaluate the performance of the proposed game theory based approach and all results are averaged over 1000 random tests through Monte Carlo method. We compare our approach with the algorithm in [5], which maximizes the D2D links'energy efficiency, and a centralized random allocation RAPC algorithm (CRA-RAPC algorithm), which randomly allocates a UL subchannel (each of the K subchannels has the same probability) to an arbitrary D2D link. In the simulations, the energy consumption of control information exchanging is ignored as the data amounts of D2D links or UL CC links are much larger than that of control information. We consider a circular cell coverage area with the BS at the center. 54 CHAPTER-5

REFERENCES

[1] C. Fredembach, G. Finlayson,: Simple shadow removal", In Proceedings of International Conference on Pattern Recognition, (ICPR),pp. 832–835, 2006

[2] J.M. Wang, Y.C. Chung, C.L. Chang, S.W. Chen, "Shadow Detection and Removalfor Traffic Images", Proc. IEEE International Conference on Networking, Sensing and Control, volume 1, pp. 649 – 654, 2004.

[3] T. Chen, W. Yin, X.S. Zhou,D.Comaniciu, and T.S. Huang, "Illumination Normalization for Face Recognition and Uneven Background Correction Using Total Variation Based Image Models", Proceedings CVPR, volume 2, pp. 532-539, 2005.

[4] Y. Adini, Y. Moses, and S. Ullman, "Face recognition: The problem of compensating for changes in illumination direction", IEEE Transactions Pattern Analaysis Machine 5.Intelligence, volume 19, no. 7, pp. 721–732, 1997.

[5] G. Funka-Lea, "The visual recognition of shadows by an active observer", PhD thesis, Department of computer and information science, university of pennsylania, 1994.

[6] C. Jiang, M.O. and Ward, "Shadow segmentation and classification in a constrained environment", In CVGIP: Image Understanding, volume 59, no. 2, pp. 213-225, 1994.

[7] V.J.D Tsai, "A comparative study on shadow compensation of color aerial images in invariant color models [J]", IEEE Transcations on Geoscience and Remote Sensing, volume 44, no. 6, pp. 1661-1671, 2006.

[8] A.C. Hurlbert, "The computation of colour", Technical report, MIT Artificial Intelligence Laboratory.

[9] A. Cavallaro, E. Salvador, and T. Ebrahimi, "Detecting shadows in image sequences", 1st European Conference on Visual Media, pp. 199–212.

[9]. Dr. B Sankara Babu, Srikanth Bethu, K. Saikumar, G. Jagga Rao, "Multispectral Satellite Image Compression Using Random Forest Optimization Techniques" Journal of Xidian University, in Volume 14, Issue 5-2020.

[10]. G. Jagga Rao, Y. Chalapathi Rao, "Human Body Parts Extraction in Images Using JAG-Human Body Detection (JAG-HBD) Algorithm Through MATLAB" Alochana Chakra Journal, Volume IX, Issue V, May/2020.