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A Survey on Device to Device Communication in Cellular Networks

Kamini Pandey
M.Tech Scholar (ECE)
JNCT, Rewa (India)
kaminipandey14@gmail.com

Sneha Singh
Asst.Professor (ECE)
JNCT, Rewa (India)
singhsneha1888@gmail.com

Sushil Kumar
Asst.Professor (ECE)
JNCT, Rewa (India)
ersushil.chaturvedi@gmail.com

Abstract: Device to Device communication has sought the attention of contemporary researchers due to the increase in the number of cellular users, higher bandwidth requirement for multimedia applications. The present scenario worsens with the limited availability of bandwidth. Hence a new paradigm has evolved which utilizes the fact that devices can communicate with each other in case the distance between the devices is less than a particular threshold. The distance should also take into account the effect of outage. The present paper presents a state of the art survey of Device to Device (D2D) Communication and its related parameters. The parameters focussed upon are Quality of Service (QoS), Optimum distance for switching from cellular to D2D mode and vice versa.

Keywords: Device to Device Communication (D2D) communication, Outage Probability, Optimum Distance, Quality of Service (QoS).

Introduction: Satisfying the basic demands of cellular users, such as voice calls and text messages, is not sufficient anymore. The cellular network operators face many problems in dealing with emerging mobile applications developed for the new generation of cellular devices, such as smart phones and tablets. These new cellular devices allow users to use services with high quality of service (QoS) requirements such as video/audio streaming, online gaming, video calls and social new technologies. Although the third and fourth) are designed to accommodate high speed data services, the operators are still struggling with the increased bandwidth demands of cellular users. These challenges need of new communication prototype that revolutionizing the existing cellular architecture. D2D communication represents a promising technology since it allows for direct and low power communication among devices thus contributing to reduce interference and system load and improving its overall performance.

D2D communications is one of such prototype that has been introduced to harness these increasing bandwidth requirements. D2D communication in cellular networks is capable of direct communication between two cellular devices located in vicinity of each other. One of the main functions of cellular base station (BS) in conventional cellular networks is to relay traffic between cellular users. In D2D communication, the data bypasses the BS and it is instead sent using a direct communication link between the users. By-passing the BS allows D2D communications to significantly increase the spectral efficiency of the dense cellular network.

The direct communication mode requires half of the resource as compared to cellular communication mode thus offering double spectral efficiency per connection typically. Also if devices in direct communication mode

are closer to each other than transmission power could be lower than in cellular mode which can be then turned into battery savings at the device and reduced interference levels in the system.

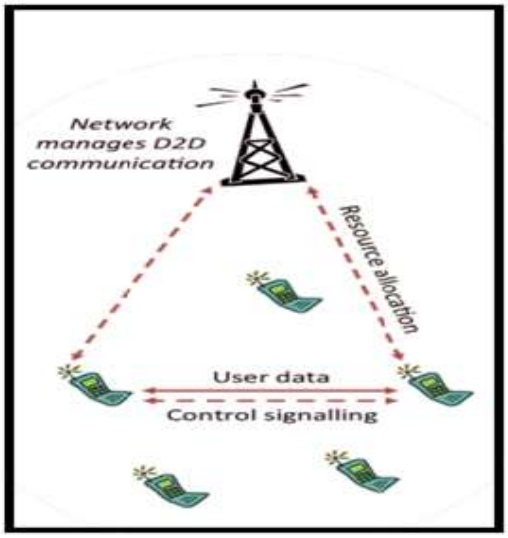

Fig.1 Model for D2D Communication

Further, reduced interference levels in system lead to higher system capacity and spectrum efficiency. Furthermore, D2D communications can improve the throughput, power efficiency and cell coverage. D2D users can either reuse the cellular network resources in the licensed spectrum (i.e., in band D2D) or use the resources from the unlicensed spectrum (i.e., out band D2D).

Related Work

Priyadarshi Ashok Dahat, Suvra Sekhar Das have provided Performance Analysis of D2D Communications in Cellular Networks under VaryingLoad Conditions in [1]. In this paper the performance of both mode under different load condition have been analyzed. In this paper the key parameters which have been analyzed are ratio of signal power to noise plus interference power, outage probability, effect of variation of transmitter power, capacity, mode selection, and D2D mode switching distance. The main aim of this paper is to find optimum distance for switching to D2D mode from cellular mode for loads with different power ratio. In this paper they considered downlink mixed D2D and cellular scenario, where D2D are underlying cellular network. In this paper they calculate number of UEs in the transmitter coverage area. They also calculated the expected distance for D2D interfering, SINR for D2D and Cellular mode, Outage probability, and channel capacity. The paper concludes the following results, when and how to optimally exploit D2D mode to enhance Cellular capacity. The paper concludes that with the increase in both Cellular and D2D load, link capacity of both modes falls, but the switching distance for D2D mode recedes away from BS with cellular load whereas it tends towards BS with increase in D2D load. The paper also concludes that bandwidth required for D2D mode is almost flat with the exception of locations near theBS and for higher cell load where the bandwidth required for D2D mode becomes verylarge.

Henrique de H.M. Barros, Marzio G.S. Rego have provided a Distance Based Study of D2D Communication for Improving Overall System Capacity in [2]. In this paper they

investigate potential sum rate gain of D2D communication underlying cellular network and conventional cellular system without D2D communication, all investigation in this paper has been done in Uplink. In this paper two communication mode has been used, D2D mode and Cellular mode. For investigating systems overall performance improvement by using D2D communication they have made two different analyses: without and with restriction concerning the distance between

D2D-Tx and D2D-Rx. The paper concluded that when user equipment (UE) is in the near base region the rates are higher than the UE is in the near cell region.

Xingqin Lin, Jeffrey G. Andrews and Amitabha Ghosh have provided a Spectrum Sharing for D2D Communication in Cellular Network in [3]. In this paper they addressed two fundamental issues in D2D communication underlying cellular networks, first one is how D2D user should access spectrum and second one is how D2D user should choose between communicating directly or via base station. To overcome these issues they proposed a tractable hybrid network model where the mobiles are positioned randomly following spatial Poisson point process. After that analytical rate expression has been applied to overcome the spectrum sharing issues. In this paper two spectrum sharing model has been described one of which Overlay in-band D2D and another one is Underlay in-band D2D. In Overlay in-band D2D uplink spectrum is divided into two orthogonal portions, a fraction 'n' is assigned to D2D communication and a fraction '1-n' is assigned to cellular communication. While in Underlay D2D communication, each D2D transmitter uses frequency hopping to randomize its interference to other links. The paper concludes how to apply the derived result in underlay D2D to study spectrum sharing from coverage prospective. It also concludes that there is a tradeoff between spectrum sharing and mode selection in D2D communication.

Hesham ElSawy and Ekram Hossain have provided Analytical Modeling of Mode Selection and Power Control for D2D Communication Underlying Cellular Networks in [4]. In this paper they presents a comprehensive and tractable analytical framework for D2D enabled uplink cellular networks with a flexible mode selection scheme along withtruncated channel inversion power control. They proposed a mode selection scheme for a UE which accounts for both D2D and cellular communication, and also different from the existing one which accounts only for D2D communication based on D2D link distance. In the paper with the help of numerical analysis they investigate the expected performance gain and provide guidelines for selecting the network parameters. The paper concludes a biasing – based mode selection for D2D enabled cellular networks. The paper provides a bias value for which D2D communication is enabled in cellular network and the amount of traffic offloaded to the D2D communication mode. The paper also concludes an analytical prototype to evaluate outage and rate in the proposed D2D enabled cellular network, it also concludes that underlay D2D communication is capable of improving system performance in terms of spatial frequency reuse, link capacity, and total network capacity.

K. Doppler and C.H. Yuhaveprovided Mode Selection for Device-to-Device (D2D) Communication under LTE-Advanced Networks in [5]. In this paper they analyzes the underlay and overlay mode selection of Device-to-Device (D2D) communication in the LTE-Advanced single-cell scenario. They mainly considered two cases, in one of which the cell contains the relay node and in the other the cell does not contains the relay node, and the study focuses on the location relationship between cellular UE and D2D UE. In the paper they proposed to preferred underlay mode when cellular user is closer to base station than the D2D user. In the paper they describe the different models of the network such as Infrastructural model in which

network contains a circular cell of radius R, where a BS equipped with Omni-directional antennas is in the center of the cell and three relay nodes are uniformly distributed in the cell with the distance D to the BS. User model in which two kinds of users has been considered in the system. A cellular user (CU) communicates solely through the BS. On the other hand Device-to-Device users are those who do not communicate via the BS but communicate directly with each other over one hop. The paper describes about Overlay and Underlay mode selection under the condition of a single cell without a relay node and with a relay node. The paper concludes that the simulation results shows that the system parameter affect thecondition of mode selection. By taking contradistinction between scenarios with and without relay nodes, it can conclude that the introduction of relay node will increase both chance and area of D2D pair using underlay mode.

Chia-Hao Yu, Klaus Doppler, Casio B. Ribeiro, and Olav Tirkkonen have provided the Resource Sharing Optimization for D2D Communication Underlying Cellular Networks in [6]. In this paper they analyses Optimum resource allocation and power control between the cellular and D2D connections that share the same resourcesfor different resource sharing modes. They discussed the Optimality under practical constraints such as minimum and maximum spectral efficiency restrictions, and maximum transmit power or energy limitation. In this paper resource sharing has been done between two types of communication, traditional cellular communication between a BS and a user and direct D2D communication. In this paper they assumed that a BS scheduler knows about the D2D communication need based on communication request between two potential D2D users, and the BS decides to offload that traffic to a direct D2D connection. Based on handover and other measurements provided by the cellular and potential D2D users, the BS may select by which way to reuse the resources of a specific cellular link for serving the D2D communication need. In this paper they have discussed Resource Sharing Mode, Optimization with Power and Energy constraints, Optimization with Spectral Efficiency Constraints. They have also discussed about the optimization for both Orthogonal and Non orthogonal sharing. The paper concludes the results that the 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, the optimal power allocation resides on a finite set of feasible solutions in all considered cases.With orthogonal sharing and cellular modes, the optimum radioresource allocation between D2D and cellular connections in closed form, except for the cellular mode when constrained by a maximum transmit energy.

Chia-Hao Yu, Olav Tirkkonen, Klaus Doppler and Casio Ribeiro have provided Power optimization of D2D communication underlying cellular communication in [7]. In this paper they address resource sharing of the cellular and D2D underlay communication assuming that the cellular network has control over transmit power and radio resources of D2D links. In the paper it is mentioned that by proper control of power, the interference between two services can be coordinated to benefit the overall performance. In the paper they considered a scenariowith prioritized cellular communication and upper limit on the maximum transmission rate of all links. In the paper they study the isolated cell where one cellular user and two D2D users share the available radio resources. They also assume

the channel state information (CSI) of all the involved links at the BS so that the BS is capable of coordinating the radio resources and transmit power. The BS assigns either Orthogonal or Non orthogonal radio resources to the cellular or D2D users. If D2D users occupy resources that are orthogonal to those occupied by the cellular user, they cause no interference to each other and the analysis is simpler. On the other hand, the resource usage efficiency can be higher in non-orthogonal resource sharing.

Xianghai Xu, Jun Sun, Shixiang Shao have provided the Transmission Capacity of D2D Communication under Cellular Networks in [8]. In this paper, The D2D reuse resources of cellular users near the base station, which bring greater improvements in the outage probability of cellular users, and then calculated the outage probability and the transmission capacity of D2D in cell system. In this paper, interference in the system is mainly divided into two categories: 1 D2D user multiplex orthogonal resources to the cellular user, means that the D2D communication will not cause interference to cellular users, interference exists only between the D2D pairs using the same resource. 2D2D users multiplex the same resources with cellular user, so the eNB receive interference from D2D transmitter, at the same time D2D receiver receives interference from cellular user. In this paper they have described two resource sharing method: D2D multiplex orthogonal resource and D2D multiplex Non-orthogonal resource. In this paper they calculate Outage Probability for cellular as well as D2D mode in terms of density. This paper concludes the proposed way to protect the successful communication of cellular user: the priority radius: D2D reuse resources of cellular users near the base station, which bring greater improvements in the outage probability of cellular users.

Conclusion:

It can be concluded that the concept of device to device communication is briskly catching up as the conventional cellular system mechanism is facing extreme loading due to increase in number of users and need for enhanced bandwidth. Future works may include enhancing the capacity of the system by effectively introducing MIMO and diversity concepts. The concept of channel bonding and cognitive radio can also investigate to improve upon the data transmission capacity of the designed systems. Thus device to device communication in conjugation with contemporary technologies will prove to the future of wireless communications.

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