International Journal For Advanced Research In Science & Technology
A peer reviewed international journal
www.ijarst.in
ISSN: 2457-0362

JOINT MODE SELECTION AND RESOURCE ALLOCATIONUSING EVOLUTIONARY ALGORITHM FOR DEVICE-TO-DEVICECOMMUNICATION

S.APARNA [1], N.VARALAKSHMI [2]
[1]PG Scholar, Dept of ECE, SIR C.V. RAMAN Institute of Technology & Science, AP, India
[2] Assistant Professor, Dept of ECE, SIR C.V. RAMAN Institute of Technology & Science, AP, India

ABSTRACT
Device-to-device (D2D) communications have been recently proposed as an effective way to increase both spectrum and energy efficiency for future cellular systems. In this paper, joint mode selection, channel assignment, and power control in D2D communications are addressed. We aim at maximizing the overall system throughput while guaranteeing the signal-to noise-and-interference ratio of both D2D and cellular links. Three communication modes are considered for D2D users: cellular mode, dedicated mode, and reuse mode. The optimization problem could be decomposed into two sub problems: power control and joint mode selection and channel assignment. The joint mode selection and channel assignment problem is NP-hard, whose optimal solution can be found by the branch-and-bound method, but is very complicated. Therefore, we develop low-complexity algorithms according to the network load. Through comparing different algorithms under different network loads, proximity gain, hop gain, and reuse gain could be demonstrated in D2D communications.

1. INTRODUCTION

As the smart mobiles got much popularity because of its applications the usage of it raised anonymously. Due to sharing of audio, video, image and documents... Etc might be for personal use or commercial use, recently the traffic of data is rising. In next to no time it catches the capacity of the present cellular networks which are using 4G. The spectrum requirement is high there by data traffic growing; thereby mobile user's faces difficulties in getting channel for communication. To congregate the intense demand, network bulkiness is the common method to increase the spectrum capacity which needs to be raised by 1000 times for now to meet the desire. However, the increase of access points and user traffic put a heavy burden on backhaul links, which connect base stations (BSs) with the core network. To reduce the backhaul burden, one promising approach is to cache popular contents at BSs and user devices, so that mobile users can get the required content from local BSs or nearby user devices without utilizing backhaul links. Such local access can also reduce the download delay and improve the energy efficiency.

Most previous investigations on wireless caching networks assumed fixed network topologies [8], [12]–[19]. However, user mobility is an intrinsic feature of wireless networks, which changes the network topologies over time. Thus, it is critical to take the user mobility pattern into account. On the other hand, user mobility can also be a useful feature to exploit, as it will increase the communication opportunities of moving users. Mobility-aware design has been proved to be an effective approach to deal with lots of problems in wireless networks. For example, exploiting user mobility helps improve capacity in ad hoc networks [20] and reduce the probability of failed file delivery in femto-caching networks [21]. In this project, we will propose an effective mobility-aware caching strategy in device-to-device (D2D) caching networks to offload traffic from the cellular network.

Cellular communication has changed the dimensions of communication by offering the ease of ubiquity to the users. The bandwidth available for a cellular system is always limited. With the increase in multimedia applications and ever increasing demand of wireless devices supporting higher data rate flow, cellular systems, in general, always face scarcity of channels. In cellular systems, utilization of channels has been one of the very important areas of research along with power management, location tracking etc. Efficient and effective allocation of channels for cellular networks has become an extremely important topic of recent research. The different types of emerging services require real time support and uninterrupted communication, having more strict QoS requirements.

2. LITERATURE SURVEY

Video transmission is currently the main driver for the increase of both wired and wireless data traffic. In wired networks, movie streaming currently accounts for 50% of all internet traffic during evening hours and further growth is expected. A similar trend has observed for wireless networks. Wireless data traffic has expected to increase by a factor of 40 over the next five years, from currently 93 Petabytes to 3600 Petabytes per month [1]. This explosive demand has fueled mainly by video traffic, which has expected to increase by a factor of 65 times, and become the by far dominant source of data traffic. This trend is accelerated by the proliferation of mobile devices that allow comfortable viewing experiences (tablet computers, large-screen phones), the higher content quality, and the proliferation of social networks. Concurrently, the emergence of on-demand video streaming services involves repeated wireless transmission of videos that are viewed multiple times by different users in a completely asynchronous way. Since the relative delay at which two users may stream the same video is generally much larger than the duration of the video itself, a conventional network architecture treats each streaming session as independent data, and it is therefore incapable of exploiting either the redundancy in the demands (the same file requested over and over) or the intrinsic multicasting capability of the wireless medium (unlike live streaming, for which the multicasting capability has been exploited in several system proposals and system implementations such as Media flow increases. This increasing demand offers new business opportunities but also poses an enormous challenge from a technical and economical perspective. Anecdotal user experiences, as well as statistics from many countries, show that current wireless networks are bursting at the seams. As demand is growing, operators have to reduce the cost per transferred

International Journal For Advanced Research In Science & Technology
A peer reviewed international journal
www.ijarst.in
IJARST
ISSN: 2457-0362

bit without relying on increasing wireless spectrum. Absent such developments, traffic-decreasing measures (caps on data per user, throttling the data rate of high–usage customers) would have to be taken, stymieing the positive developments.

3. EXISTING METHOD

The inter-contact model can capture the connectivity information in the user mobility pattern, and has been widely investigated in wireless networks [32], [38]–[40]. Thus, it is adopted in this project to model the mobility pattern of mobile users. In this model, mobile users may contact with each other when they are within the transmission range. Correspondingly, the contact time for two bile users is defined as the time that they can contact with each other, i.e., they may exchange files during the contact time. Then, the inter-contact time for two mobile devices is defined as the time between two consecutive contact times. Specifically, we consider a network with Nu mobile users, whose index set is denoted as $D = \{1,2,..,N_u\}$of contact times in the timeline for any two users i and j as a Poisson process with intensity as$\lambda_{i,j}$. For simplification, we assume that the timelines for different device airs are independent. We call $\lambda_{i,j}$ as the pair wise contact rate between users i and j, which represents the average number of contacts per unit time. The pair wise contact rate can be estimated from historical data, and we will test our results on real-life data-sets in the simulation.

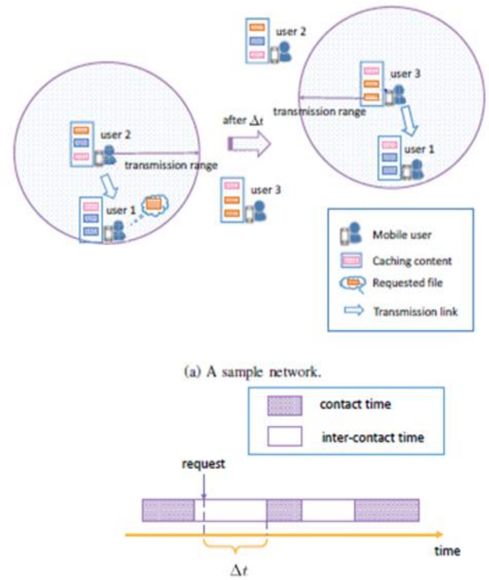

Figure 1: The timeline of user 1 and user 3

Characterizing the contacts between nodes is of utmost importance when evaluating mobile opportunistic networks. The most common characterization of inter-contact times is based on the study of the aggregate distribution of contacts between individual pairs of nodes, assuming a homogenous network, where contact patterns between nodes are similar. The problem with this aggregate distribution is that it is not always representative of the individual pair distributions, especially in the short term and when the number of nodes in the network is high. Thus, deriving results from this characterization can lead to inaccurate performance evaluation results. The inter-contact times distribution having a higher representativeness and, thus, increasing the accuracy of !%the derived performance results. Furthermore, these new characterizations require only a moderate number of contacts in order to be representative, thereby allowing performing a temporal modification of traffic traces. This a key issue for increasing accuracy, since real-traces can have a high variability in terms of contact patterns along time. The experiments show that the new characterizations, compared with the established one, are more precise, even using short time contact traces.

4. PROPOSED METHOD

In [10], mode selection taking into account the quality of both D2D and cellular links has been proposed to mitigate interference caused by D2D communications. Mode selection in [11] considers network information such as link gains, noise levels, and signal-to-noise-and-interference ratio (SINR). In [12], an opportunistic mode selection and subchannel scheduling algorithm has been developed for orthogonal frequency division multiple access (OFDMA) based D2D systems. Joint mode selection and power control has been investigated in [14]– [16] for further performance improvement. However, the above works consider the dedicated mode and the cellular mode only. For the reuse mode, the main challenge is how to properly assign the reusing channel and control the transmit power to mitigate the co-channel interference between the D2D links and the cellular links. To this end, joint channel assignment and power control has been considered for D2D systems. Optimal resource allocation and power control for a single D2D pair and a single CU has been investigated in [17]. An interference-aware graph-based resource sharing algorithm has been developed in [18], which is nearly optimal but with low computational complexity. Interference can be further mitigated by exploiting the multiuser diversity inherent in the cellular network [19] or by reusing the proper CU resources [20]–[22]. Recently, joint power control and reuse partner selection have been investigated in [23] and [24]. However, the works mentioned above only address the resource allocation for the reuse mode, without jointly considering mode selection for further performance improvement. Although a joint mode selection and resource allocation to maximize the system throughput and guarantee the fairness is proposed in [13], the optimality of the method cannot be guaranteed since it is based on the evolutionary algorithm. In this paper, we consider joint mode selection, channel assignment, and power control to maximize the overall system throughput. First, for each D2D pair, the optimal communication mode should be determined. Second, if a D2D pair works in the reuse mode, the reusing channel and the corresponding transmit powers of the DU and the co-channel CU should be carefully chosen to guarantee the quality-of-service (QoS) for both. Based on the above idea, an optimization problem is formulated, which is a nonconvex problem with 0–1 variables and NP-hard in general. To make the problem better tractable, we first decompose it into two subproblems: power control, and joint mode selection and channel assignment. Then, standard optimization methods can be used to solve the power control problem and the branch-and-bound (BB) method can be utilized for model selection and channel assignment. To further reduce the computational complexity, we propose

International Journal For Advanced Research In Science & Technology
A peer reviewed international journal
www.ijarst.in
IJARST
ISSN: 2457-0362

two lowcomplexity heuristic algorithms based on the network loads: heavy load, medium load, or light load. The computational complexities of the proposed algorithms are analyzed and their sub-optimality is demonstrated by numerical simulations. Through the comparison of different scenarios, the proximity gain, the hop gain, and the reuse gain are demonstrated by D2D communications. The main contributions of this paper are twofold. First, we consider all the three modes mentioned above while other papers only consider resource allocation for one or two modes. Secondly, we will develop different low-complexity algorithms based on the network loads to achieve three types of gain. We will demonstrate that more throughput gains can be achieved if more communication modes are available.

5. SYSTEM MODEL AND PROBLEM FORMULATION

In this section, we first introduce the system model and various D2D communication modes, then formulate the joint mode selection, channel assignment, and power control problem for D2D systems.

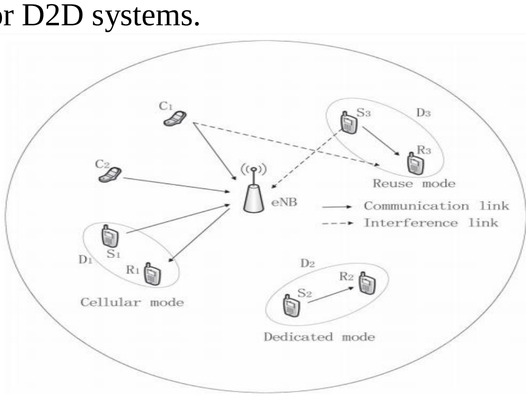

Fig. 1. System model for D2D communications.

Consider a single cell with M cellular users, {C1, C2,..., CM}, connecting to the eNB. There exist K pairs of potential DUs denoted by {D1, D2,...,DK}. Let Sk and Rk denote the transmitter and the receiver of D2D pair k, respectively. The D2D communication could be established by a certain neighbor discovery algorithm. Denote r as the maximum distance between each D2D pair, which is limited by the capability of neighbor discovery. As in [7], [21], [23], we further assume that the number of D2D pairs is smaller than that of CUs, i.e., K mode is chosen, the D2D pair uses one of the ND downlink channels and one of the NU uplink channels. If the dedicated mode is chosen, only one dedicated channel (either downlink or uplink) will be assigned to the D2D pair. If the reuse mode is selected, the D2D pair only reuses the uplink channels of CUs since interference to the cellular network can be better handled in uplink than in downlink from [25], [26]. In this case, the transmit powers of both DUs and CUs should be appropriately controlled to guarantee their QoS. Due to severe co-channel interference, the scenario that more than one D2D pairs reusing a same channel rarely happens and therefore is not considered. This is also reasonable since the number of D2D pairs is less than that of CUs and channel reusing among D2D pairs is unnecessary. We further assume that the eNB has full acquisition of the instantaneous channel state information (CSI) of links to all users, including the CSI of D2D links, which can be estimated by the D2D receiver and then feed back to the eNB via control channel. The joint mode selection, channel assignment, and power control is performed at the eNB based on available channel CSI. Our developed

International Journal For Advanced Research In Science & Technology
A peer reviewed international journal www.ijarst.in
IJARST
ISSN: 2457-0362

algorithms work in a centralized fashion, which require much control signaling overhead. However, the centralized algorithm generally achieves better performance than distributed one, and can be served as a benchmark for distributed algorithm. All links are assumed to experience independent block fading. Hence, the instantaneous channel gain of the interference link between CU m and the receiver of D2D pair k can be expressed as hk,m = Gβk,md−α k,m, where G is the path loss constant, α is the path loss exponent, βk,m denotes the channel fading component, and dk,m is the distance between CU m and the receiver of D2D pair k. Similarly, we can express the channel gain between CU m and the eNB as hC m,B, the channel gain between D2D pair k as hD k , and the channel gain between the transmitter of D2D pair k and the eNB as hD k,B.

6. JOINT MODE SELECTION AND RESOURCE ALLOCATION ALGORITHM

In this section, we will solve the optimization problem formulated in (6). It is non-concave and contains binary variables, thus could not be solved directly. Therefore, we will decompose the problem into two subproblems and then solve them individually. We can observe that the original optimization problem could be reformulated as (p∗ , x∗) = arg maxx K k=1 x(1) k Q1 +K k=1 x(2) k Q2 +K k=1 M m=1 x(3) k,mQ3+M m=11− K k=1 x(3) k,m Q4 , (7)

where Q1 = arg max p(1) k log 1 + p (1) k hD k,B σ2 N , Q2 = arg max p(2) k log 1 + p (2) k hD k σ2 N , Q3 = arg max p(3) k,m,pc k,m log 1 + p (3) k,mhD k pc k,mhk,m + σ2 N + log 1 + pc k,mhC m,B p (3) k,mhD k,B + σ2 N , Q4 = arg max pc m log 1 + pc mhC m,B σ2 N . From (7), we see that the optimization problem consists of two layers. The inner one is power control, denoted by Q1, Q2, Q3, and Q4 in (7), and determines the optimal transmit powers of DUs and CUs in each mode. The outer one is the decision process of communication mode and channel assignment. From (7), the two layers could be decoupled. Therefore, we can separately optimize both inner and outer layers to obtain the optimal solution. Since there is no co-channel interference between DUs and CUs in the cellular mode and the dedicated mode, the maximum throughput could be achieved when both DUs and CUs transmit with their maximum powers, i.e., P D max and P C max, respectively. That is, P D max = p (1)∗ k = arg max p(1) k log 1 + p (1) k hD k,B σ2 N , P D max = p (2)∗ k = arg max p(2) k log 1 + p (2) k hD k σ2 N , P C max = pc∗ m = arg max pc m log 1 + pc mhC m,B σ2 N , for problems Q1, Q2, and Q4, respectively. Power control in the reuse mode, Q3, is a little bit complicated and can be reformulated as p (3)∗ k,m, pc∗ k,m

---

= arg max p(3) k,m,pc k,m fk,m p (3) k,m, pc k,m

, (8) subject to 0 ≤ p (3) k,m ≤ P D max, (8a) 0 ≤ pc k,m ≤ P C max, (8b) p (3) k,mhD k pc k,mhk,m + σ2 N ≥ ξmin, (8c) pc k,mhC m,B p (3) k,mhD k,B + σ2 N ≥ ξmin, (8d)

International Journal For Advanced Research In Science & Technology
A peer reviewed international journal
www.ijarst.in
ISSN: 2457-0362

where fk,m p (3) k,m, pc k,m

= log 1 + p (3) k,mhD k pc k,mhk,m + σ2 N + log 1 + pc k,mhC m,B p (3) k,mhD k,B + σ2 N . The optimal power control vector (p (3)∗ k,m, pc∗ k,m) for the above problem can be obtained from the algorithm in [23]. With the optimal transmit powers, the optimization problem in (6) can be converted into x∗ = arg maxx K k=1 x(1) k γk+ K k=1 x(2) k θk+ K k=1 M m=1 x(3) k,mηk,m + K k=1 M m=1 x(3) k,mλk,m + M m=1 1 − K k=1 x(3) k,m τm , (9) subject to (6a), (6b), (6c), (6d), (6e), where, γk = log 1 + P D maxhD k,B σ2 N , θk = log 1 + P D maxhD k σ2 N , ηk,m = log 1 + p (3)∗ k,mhD k pc∗ k,mhk,m + σ2 N , λk,m = log 1 + pc∗ k,mhC m,B p (3)∗ k,mhD k,B + σ2 N , τm = log 1 + P C maxhC m,B σ2 N . In (9), the binary variables x(1) k , x(2) k , x(3) k,m are the only remaining variables to be optimized. Thus, it turns out to be a 0–1 integer optimization problem, which is NP hard in general. An effective way to solve this problem is using the BB method [30]. However its computational complexity is very high. Therefore, in the follows, we will develop some low computational complex algorithms, with the help of network load information. We first classify the system into three categories based on the network load: heavy load, medium load, and light load, as shown in Table I. The heavy load case corresponds that all channels have already been occupied by CUs, that is, max{NU, ND} = 0. In this case, only the reuse mode could be selected by D2D pairs and the optimal channel assignmentproblem can be solved by Hungarian algorithm [23]. In the medium load case, there are empty channels, but the number of D2D pairs is larger than the number of empty channels, i.e, K>NU + ND. Therefore, some of the DUs can use dedicated channels while others must work in the reuse mode and share channels with CUs. In the light load case, the number of empty channels is larger than that of D2D pairs, i.e, K ≤ NU + ND. In this case, channel reusing is unnecessary. Each DU can work in either the cellular mode or the dedicated mode and use orthogonal channel to avoid co-channel interference with CUs. Inspired by this, we propose two heuristic algorithms for the problem (9).

7. CONCLUSION

In this paper, we investigate the joint mode selection, channel assignment, and power control problem in D2D communication underlaying cellular networks. We optimize the overall system throughput while guaranteeing the SINR of both cellular and D2D links. The optimization problem is decomposed into two subproblems: transmit power control for both DUs and CUs, and joint mode selection and channel assignment for each DU. Joint mode selection and channel assignment is NP hard and usually very complicated to obtain the optimal solution. We then develop low-complexity algorithms according to different network loads. Through numerical simulation, we find that the proposed low-complexity algorithms perform very closely to the corresponding optimal algorithms. They can be effectively used in D2D communications to obtain the proximity gain, the hop gain, and the reuse gain. For the future work, we will develop distributed algorithms and consider the scenario where different D2D pairs can reuse the same channel of a CU.

REFERENCES

[1] J. G. Andrews, S. Buzzi, W. Choi, S. V. Hanly, A. Lozano, A. C. Soong,and J. C. Zhang, "What will 5G be?" IEEE J. Sel. Areas Commun.,vol. 32, no. 6, pp. 1065–1082, Jun. 2014.

[2] Y. Shi, J. Zhang, and K. B. Letaief, "Group sparse beamforming forgreen Cloud-RAN," IEEE Trans. Wireless Commun., vol. 13, no. 5, pp.2809–2823, May 2014.

[3] Y. Shi, J. Zhang, K. B. Letaief, B. Bai, andW. Chen, "Large-scale convex optimization for ultra-dense Cloud-RAN," IEEE Wireless Commun.,vol. 22, no. 3, pp. 84–91, Jan. 2015.

[4] V. Chandrasekhar, J. Andrews, and A. Gatherer, "Femtocell networks:A survey," IEEE Commun. Mag., vol. 46, no. 9, pp. 59–67, Sep. 2008.

[5] N. Golrezaei, A. F. Molisch, A. G. Dimakis, and G. Caire, "Femtocaching and device-to-device collaboration: A new architecture for wireless video distribution," IEEE Commun. Mag., vol. 51, no. 4, pp.142–149, Apr. 2013.

[6] X. Wang, M. Chen, T. Taleb, A. Ksentini, and V. Leung, "Cache in theair: exploiting content caching and delivery techniques for 5G systems,"IEEE Commun. Mag., vol. 52, no. 2, pp. 131–139, Feb. 2014.

[7] X. Peng, J.-C. Shen, J. Zhang, and K. B. Letaief, "Backhaul-awarecaching placement for wireless networks," in Proc. IEEE Global Commun.Conf. (Globecom), San Diego, CA, Dec. 2015.

[8] M. Ji, G. Caire, and A. F. Molisch, "Wireless device-to-device cachingnetworks: Basic principles and system performance," IEEE J. Sel. AreasCommun., vol. 34, no. 99, pp. 176–189, Jul. 2015.

[9] X. Peng, J. Zhang, S. Song, and K. B. Letaief, "Cache size allocationin backhaul limited wireless networks," in Proc. IEEE Int. Conf. onCommun.(ICC), Kuala Lumpur, Malaysia, May 2016.

[10] M. A. Maddah-Ali and U. Niesen, "Decentralized coded caching attainsorder-optimal memory-rate tradeoff," IEEE/ACM Trans. Netw., vol. 23,no. 4, pp. 1029–1040, Aug. 2015.

[11] E. Bastug, M. Bennis, M. Kountouris, and M. Debbah, "Cache-enabledsmall cell networks: Modeling and tradeoffs," EURASIP J. on WirelessCommun. and Netw., vol. 2015, no. 1, pp. 1–11, Feb. 2015.

[12] K. Shanmugam, N. Golrezaei, A. G. Dimakis, A. F. Molisch, andG. Caire, "Femtocaching: Wireless content delivery through distributedcaching helpers," IEEE Trans. Inf. Theory, vol. 59, no. 12, pp. 8402–8413, Sep. 2013.

[13] N. Golrezaei, K. Shanmugam, A. G. Dimakis, A. F. Molisch, andG. Caire, "Femtocaching: Wireless video content delivery through distributed caching helpers," in Proc. of IEEE Int. Conf. on Computer Commun. (INFOCOM), Orlando, FL, Mar. 2012.

[14] ——, "Wireless video content delivery through coded distributed caching," in Proc. IEEE Int. Conf. on Commun.(ICC), Ottawa, ON, Jun. 2012.

[15] N. Golrezaei, A. F. Molisch, A. G. Dimakis, and G. Caire, "Femtocaching and evice-to-device collaboration: A new architecture for wireless video distribution," IEEE Commun. Mag., vol. 51, no. 4, pp. 142–149, Apr. 2013.

[16] N. Golrezaei, A. G. Dimakis, and A. F. Molisch, "Scaling behavior for

device-to-device communications with distributed caching," IEEE Trans. Inf. Theory, vol. 60, no. 7, pp. 4286–4298, Apr. 2014.

[17] M. Ji, G. Caire, and A. F. Molisch, "Optimal throughput-outage tradeoff in wireless one-hop caching networks," in Proc. IEEE Int. Symp. Information Theory (ISIT), Istanbul, Jul. 2013.

[18] ——, "The throughput-outage tradeoff of wireless one-hop caching networks," IEEE Trans. Inf. Theory, vol. 61, no. 12, pp. 6833–6859, Oct. 2015

[19] M. Ji, G. Caire, and A. Molisch, "Fundamental limits of caching in wireless D2D networks," IEEE Trans. Inf. Theory, vol. 62, no. 2, pp.849 – 869, Feb. 2016.

[20] M. Grossglauser and D. Tse, "Mobility increases the capacity of ad-hoc wireless networks," in Proc. of IEEE Int. Conf. on Computer Commun.(INFOCOM), Anchorage, AK, Apr. 2001.

[21] K. Poularakis and L. Tassiulas, "Exploiting user mobility for wireless content delivery," in Proc. IEEE Int. Symp. Information Theory (ISIT),Istanbul, Turkey, Jul. 2013.

[22] J. Liu, B. Bai, J. Zhang, and K. B. Letaief, "Content caching at the wireless network edge: A distributed algorithm via brief propagation,"in Proc. IEEE Int. Conf. on Commun. (ICC), Kuala Lumpur, Malaysia,May 2016.