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# Device To Device Communication In Cognitive Cellular Network Using Wireless Mesh Network

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***Abstract:*** *Device-to-device (D2D) communications can potentially alleviate cellular network congestion by utilizing local available links, and have attracted intensive attention recently. Cognitive radio (CR) allows users to opportunistically access unused licensed spectrum. It thus serves as a great candidate technology for D2D communications, but has not been widely employed in cellular networks due to hardware development limitations. In this paper, we propose a new architecture, called cognitive mesh assisted cellular network (CMCN), in which several secondary service providers (SSPs) deploy CR routers to facilitate D2D communications among wireless users. To address the competition among the SSPs, we further construct a secondary spectrum auction market. Although a few works have studied spectrum auction, most of them are designed for single-hop communications, and it is usually not clear whom a winning user communicates with. Uncertain spectrum availability is not considered in previous schemes either. In this paper, we propose a transmission opportunity auction scheme, called TOA, which can address these problems. Extensive simulations are conducted to validate the efficiency of the CMCN architecture and that of the TOA scheme.*

***Keywords:*** *Device-to-Device communications, cognitive mesh assisted cellular network.*

## I. Introduction

The exploding growing of wireless devices like smartphones and tablets has determined the development of various applications, such as location-based social networking, mobile gaming, and mobile video services, but on the other hand, has exaggerated the congestion in wireless cellular networks. Device-to-device (D2D) communications deliver data traffic by applying local available links and bypassing the base stations (BSs), and hence can theoretically improve network congestion, improve network capacity, coverage, and robustness, enable new services, etc. Besides, recent studies show that many licensed spectrum blocks are not used in certain geographical areas and are idle most of the time.

Since Federal Communications Commission (FCC) opens the discussions on intelligently sharing licensed spectrum, there has been a flow of research activities on cognitive radios (CRs), which can be allowed to opportunistically access the unused licensed spectrum as long as they stand by the rules and regulations for such a usage. Thus, by integrating CR techniques, nodes under the D2D communication mode can borrow idle radio spectrums from extra networks without interrupting communications between the licensed users. In such a way, the capacity of D2D communications in cellular networks can be largely increased by improved spectrum efficiency. There have been some existing research exploring the resource allocation, connectivity and energy efficiency for CR-enabled D2D communication systems.

Device-to-device (D2D) communication that permits direct communication between nearby mobiles is an exciting and innovative feature of next-generation cellular networks. It will facilitate the interoperability between critical public safety networks and universal commercial networks. In a traditional cellular network, all communications must go through the BS even if communicating parties are in range for D2D (Device to Device) communication. Communication through BS suits conventional low data rate mobile services such as voice call and text messaging in which users are seldom close enough for direct communication. However, mobile users in today's cellular networks use high data rate services (e.g., video sharing, gaming, proximity-aware social networking) in which they could potentially be in range for direct communications (i.e., D2D).

Hence, D2D communications in such states can greatly rise the spectral efficiency of the network. The advantages of D2D communications go beyond spectral efficiency; they can potentially improve throughput, energy efficiency, delay, and fairness.

The greatest forgoing works commonly assume that a CR can operate across a wide spectrum range. Device-to-Device (D2D) communication based on cognitive radio (CR) technology can expressively improve the coverage and spectral efficiency. Existing research on D2D communications mainly focus on optimizing the network Quality of Service (QoS) in single-tier networks.

However, the exponential growth in data traffic has inspired the move from traditional single-tier cellular networks toward heterogeneous cellular networks (HetNets). Hence, in this paper, we consider a CR-based HetNet coexisting with cognitive D2D pairs and cellular users, where the cellular users are primary users (PUs) and D2D pairs are secondary users (SUs). Considering Quality of Experience (QoE) is an important metric to quantify and measure quality of experience from the user perspective, we focus on the QoE optimization of the D2D pairs via the BS association, the discrete power control, and the resource block (RB) assignment.

To do so, first formulate the cross-layer optimization problem to maximize the average QoE of the D2D pairs while satisfying the QoE requirements of cellular users. We then propose the centralized resource allocation, namely the genetic algorithm (GA), and semi-distributed resource allocation method, namely Stackelberg game based algorithm, to solve the non-convex optimization problem.

The GA is proposed to ensure the maximum achievable QoE with known channel state information (CSI), whereas the Stackelberg game based algorithm is proposed to cope with the strong needs for distributed D2D solutions with only local CSI of each D2D link. Innovative use of wireless devices such as smart phones in various mobile applications has exacerbated the congestion over cellular spectrum.

On the other hand, many licensed spectrum blocks are left unused. Although cognitive radios (CR) technology has emerged as an enabler for unlicensed users to opportunistically access the unused licensed spectrum, most previous works commonly assume that each user is equipped with a CR which can operate across a wide range of spectrum. This may be possible in theory, but may not be practical for light-weight devices such as cell phones.

In this paper, we propose a new network architecture, called cognitive mesh assisted cellular network (CMCN), which allows wireless users to take advantage of CR technologies while minimizing the complexity of their devices. We propose a new architecture, called cognitive mesh assisted cellular network (CMCN), in which several secondary service providers (SSPs) deploy CR routers to facilitate D2D communications among wireless users. To address the competition among the SSPs, we further construct a secondary spectrum auction market.

Although a few works have studied spectrum auctions, most of them are designed for single-hop communications, and it is usually not clear whom a winning user communicates with. Uncertain spectrum availability is not considered in previous schemes either. In this paper, we propose a transmission opportunity auction scheme, extensive simulations are conducted to validate the efficiency of the CMCN architecture scheme. To harvest the available spectrum bands and facilitate the accessing of **secondary** users without cognitive radio capability.

In this wireless communications, channel state information (**CSI**) refers to known channel properties of a communication link. This information describes how a signal propagates from the transmitter to the receiver and represents the combined effect of, for example, scattering, fading, and power decay with distance. The method is called Channel estimation. The CSI makes it possible to adapt transmissions to current channel conditions, which is crucial for achieving reliable communication with high data rates in multi antenna systems.

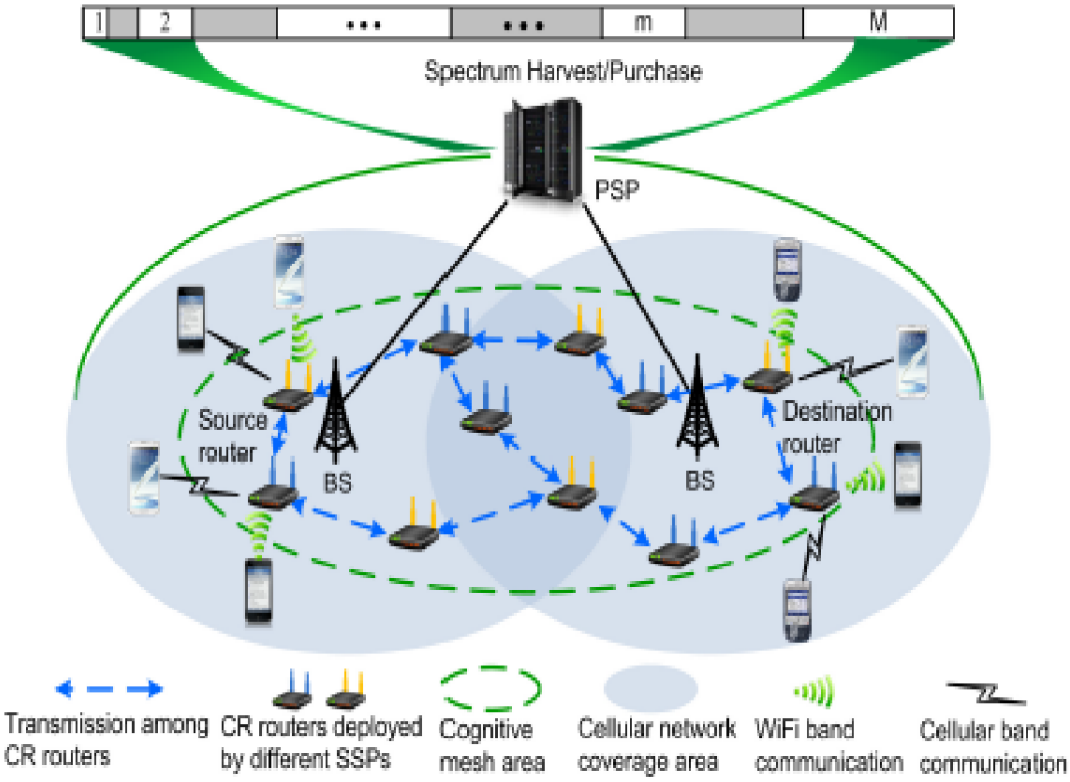


**Fig No.1.1**.The Architecture Of Cognitive Mesh Assisted Cellular Network.

**Fig.No.1.2**. Block Diagram Of Cognitive Mesh Assisted Cellular Network (CMCN).

## II. Performance Of The CMCN Architecture

In this section, we compare the maximum throughput of our proposed CMCN architecture with that of another two architectures, i.e., cellular network (CN) architecture and mesh network assisted cellular network (MNCN) architecture. In particular, in the CMCN architecture, we first utilize the cellular bands to carry users' traffic. Then, after all the cellular bands are exhausted, we employ the cognitive mesh to further support users' traffic demand. We assume that the CN architecture works in FDMA/FDD mode, i.e., each cellular band is completely allocated to one user for either upstream or downstream data transmissions in one cell, and each session requires two cellular bands, one for upstream transmissions and the other for downstream transmissions.

In addition, MNCN works in a similar way to that of CMCN, except that the mesh network in the MNCN only uses the cellular bands that are available locally. As we focus on the performance comparison among these three architectures, we do not employ the TOA scheme to allocate the spectrums in CMCN. Instead, we explore the joint scheduling and routing to find the maximum throughput of these three architectures6. Simulation results when the number of sessions L ranges from 3 to 10. We find that the maximum throughput of the CN architecture is the lowest among the three.

The maximum throughput of the MNCN architecture is up to 130% larger than that of the CN architecture. The performance gain is because the MNCN can utilize the available cellular bands for local transmissions. Moreover, comparing the performance of the CMCN architecture and that of the MNCN architecture, we can see that the average throughput of CMCN is much larger, i.e., up to 63% more, due to the utilization of secondary spectrum bands. We further evaluate the end-to-end delay performance of the three architectures. By applying the Little's theorem, the average delay a session experiences at a single node could be approximated by the ratio between the average queue length at that node and its average transmission rate. Then, for each session we count the number of hops/nodes it passes through from the source to the destination. Accordingly, the average delay of all sessions can be readily derived.

First, we find that the CN architecture has the lowest delay when $L < 9$. This is because all sessions in CN are carried out in two hops, one as the uplink connection and the other as the downlink connection. When L _ 9, its delta surpasses that of CMCN. It accounts to the fact that when the network becomes crowded, the base station becomes the bottleneck of data delivery, which causes some extra queuing delay, while CMCN can explore local links to accommodate more traffic.

Besides, part of sessions in CMCN can be delivered within a single hop with D2D communications, if the destination is within the transmission range of the source. We also find that the delay of MNCN is larger than that of CMCN, since CMCN also leverages secondary spectrums for data delivery which leads to a higher network capacity.

## III. D2D Communications In Cellular Networks

The concept of D2D communications as an underlay to an LTE-Advanced cellular network is firstly introduced in this section. After that, a few works have studied resource allocation and power control which aim to mitigate mutual interference between D2D and cellular connections. For example, Kaufman et al. proposed a route discovery scheme for D2D users, which keeps the interference to cellular users below an allowed threshold.

However, the interference from cellular users to D2D users is not considered. To address this problem, proposed interference management strategies to enhance the reliability of D2D communications or the overall capacity of D2D underlaying cellular networks.

Besides, Yu et al. studied a resource sharing mode selection problem, which decides whether the network shall assign D2D communication mode or not to a user pair and whether a pair of D2D users shall share resources with cellular users or use dedicated resources instead. Niu et al. discussed popular content downloading in mm Wave small cells.

Both D2D transmission in close proximity and concurrent transmissions are exploited to improve transmission efficiency. Meng et al. investigated a dynamic social-aware peer selection problem for cooperative D2D communications. Mozaffari et al. studied the performance of a UAV that acts as a flying base station in an area in which users are engaged in the D2D communication.

Tractable expressions for the coverage probabilities are derived. Notice that none of the above work is similar to ours, which discusses how a PSP offloads cellular users' data traffic to a cognitive mesh via a constructed spectrum auction market.

## IV. Parameters Measured

Efficiency-the efficiency is the energy Output divided by the energy input and expressed as a percentage. Packet loss-Packet loss is the failure of one or more transmitted packets to arrive at their destination.

**X Graphs And Comparison**


## V. Conclusion

In this paper, we have proposed a novel architecture, called cognitive mesh assisted cellular network (CMCN), to enable D2D communications and alleviate congestion in cellular networks. Moreover, we have found through simulations that the proposed CMCN architecture can achieve much higher throughput than the traditional cellular network (CN) architecture and the mesh network assisted cellular network (MNCN) architecture. Extensive simulation results also show that CMCN can lead to higher spectrum utilization under uncertain spectrum supply than other auction schemes.

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