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QoS-Aware D2D cellular networks with spatial spectrum sensing: A stochastic Geometry view

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ABSTRACT

Spectrum access and interference management are amongst the most challenging issues in device-to-device (D2D) cellular networks. In order to address these issues, this paper introduces Spatial Spectrum Sensing (SSS) for D2D cellular networks to facilitate cellular spectrum sharing by D2D users while providing a Quality of Service (QoS) guarantee for cellular users. In order to assess the performance of the proposed scheme, we adopt a stochastic geometry approach in which the locations of base stations and D2D devices are modeled as independent Poisson Point Processes (PPPs). Assuming that the locations of the active cellular transmitters form another independent PPP, we characterize the area spectral efficiency (ASE) of D2D networks under cellular users' outage probability constraint. The use of SSS prohibits D2D transmissions around the active cellular users because of which the locations of the active D2D transmitters are modeled as a Poisson Hole Process (PHP) driven by the PPP of active cellular user locations. Our analysis carefully accounts for this spatial separation between active cellular users and active D2D devices. Extensive simulation and numerical results are presented to verify our analysis and demonstrate the advantages of SSS-based D2D cellular networks

Index Terms— Stochastic geometry, D2D cellular networks, spatial spectrum sensing, Poisson hole process, outage probability, area spectral efficiency

I. INTRODUCTION;

Recent years we have seen an explosive growth in data demand which requires an evolution of current cellular network. As a result, a wide range of new wireless technologies have been developed for such challenge. Millimetre wave mobile communication is proposed to enable cellular user equipment (UE) to communicate at an extreme high frequency (30GHz – 300GHz), so that it may utilise more bandwidth and thus improve the system throughput [14]. Hyper-dense small cells deployment is under test to meet the "1000x mobile data traffic challenge" by Qualcomm and other institutes [15]. Massive MIMO is proposed as an evolution from conventional point-to-point MIMO in order to help concentrate energy into ever smaller regions of space to manifestly improve the throughput and radiated energy efficiency [16]. LTEunlicensed is developed to allow cellular UE sharing unlicensed frequency bands with Wi-Fi [17]. Finally, device-todevice (D2D) communication is

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proposed to offload local data traffic from cellular base stations (BSs) and improve cellular spectrum efficiency by enabling two UEs in proximity to communicate with each other directly reusing cellular radio resources. In this thesis, we focus on developing advanced technologies to improve the performance of D2D communications, which is one of the key technologies in the next generation network as aforementioned. In this chapter, we would first introduce the concept of D2D communications, following by concluding the paramount challenges in D2D communications. Then we discuss the state-of-art researches in D2D communications. Finally we summarise our achievements and present the structure of this thesis.

II. EXISTING METHODOLOGY:

2.1 Introduction

Remind in the previous chapter, we demonstrate how optimal QOS may significantly boost the performance of D2D communications while guaranteeing the performance of CC communications. The proposed algorithms require accurate channel state information of multiple channels and solving an NP-hard mixed integer nonlinear programming (MINLP) problem. However, the impact of user location on both the QOS and the resulting D2D–CC coexistence performance has not been sufficiently studied. In this chapter, we propose a novel location-based analytical framework for D2D com- munication reusing UL cellular resources, where inter-cell interference is modeled using SPPP. The proposed analytical framework gives insights in how the D2D transmitter's location in a cell may affect its performance and the optimal QOS for it. We first identify the key constraints (i.e., the maximum transmit power and transmission distance) of D2D communications as a function of the D2D's transmitter's location in a cell, so that the QoS of CC UL UEs can be guaranteed. Then we propose two low complexity QOS schemes, which jointly optimise the channel allocation and power control of D2D communications for maximizing the D2D throughput and energy efficiency. Finally, we demonstrate that the D2D throughput and the energy efficiency highly depend on the location of its transmitter in a cell and we discuss the trade-off between throughput and energy efficiency for D2D communications sharing the UL cellular resources

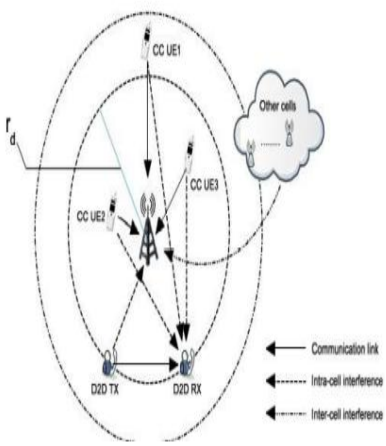

Fig. 4.1 System model.

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There are NC = 3 CC UEs and one D2D pair in the center macro cell. The distance from D2D transmitter to the center BS is rd. the constraints of the usable channels and the maximum radius of D2D communications. We propose two optimal location-based QOS mechanisms for D2D communications and analyse the performance in terms of throughput and energy efficiency.

III. PROPOSED METHODOLOGY:

3.1 Introduction

In the previos Chapter, we focus on the fundamental optimisation problems in D2D communications. However, D2D communications can not directly benefit users without a proper application protocol. Few research works considering a proper application protocol for D2D communications. And to our best knowledge, it is lack of published works considering joint application and physical layers optimisation for D2D communications. Nevertheless, we believe these are important for D2D communications that can be actually deployed and leveraged by massive users. Thus we develop PHP: a Poisson Point Processes (PPP) system based on multi-hop D2D communications. A Poisson Point Processes (PPP) system enables two or more clients communicate with each other without the help from a dedicated server. Although some PPP systems (e.g., BitTorrent) require a central server to facilitate one client to find other clients, the server is not involved in actual data transmissions. Conventional PPP systems usually focus on the design of application layer mechanisms without incorporating the underlaying network or physical layer characteristics. In the authors proposed a contextaware proximity- based PPP (CA-PPP) protocol, which considers the context of physical layer transmission. However, some critical information in the application layer (e.g., how data files are stored in the PPP system) is missing in CA-PPP. The infrastructureless nature of D2D communications makes it easy to integrate into the conventional PPP systems. The wireless PPP systems proposed in are based on WiFidirect, with which efficient interference management is not available. FlashlinQ [24], [25] is a prototype PPP system based on D2D communications without considering an optimised QOS for D2D communications and an efficient PPP protocol for the system. A multicast PPP streaming application based on D2D communications was proposed in where the authors focused on the node selection problem for PPP multicast considering the characteristics of D2D communications. However, many critical details, including the PPP protocol, QOS scheme and multi-hop routing algorithm are still 43 missing in the above works. In the authors proposed a D2D assisted video transmission system including an optimised physical layer and an application layer model, but they only considered one single- hop D2D pair. A power control scheme for multi-hop D2D communications to maximise the throughput of D2D links without affecting the performance of conventional cellular (CC) UEs was proposed in where a distributed routing protocol was used for multi-hop route discovery. However, the fully distributed routing protocol restricts the route discovery efficiency and the coverage area over which power control can be optimised. Moreover, there is a lack of optimised QOS for multi-hop D2D communications. The PHP system optimises D2D communications for PPP local file sharing, improves user experience, and offloads traffic from the BSs. The PHP system features: 1) a wireless PPP protocol based on Bittorrent protocol in the application layer; 2) a simple centralised routing mechanism for multi-hop D2D communications; 3) an interference cancellation technique for conventional cellular (CC) uplink communications; and 4) a QoS-Aware D2D cellular networks with spatial spectrum sensingscheme to mitigate the interference between CC and D2D communications that share the cellular uplink radio resources while maximising the throughput of D2D communications.

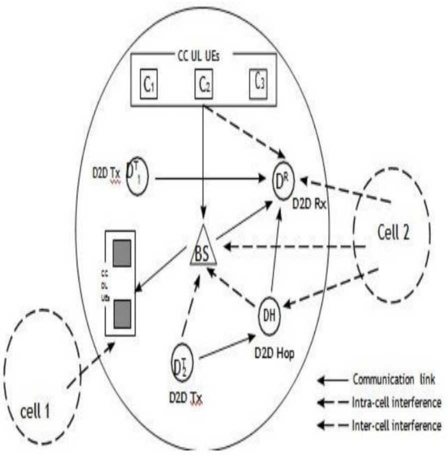

Fig. 3.1 System model of PPP framework

The intra-cellinterference includes the interference from D2D transmitters to the BS and the interference from the CC UEs to the D2D receivers. We also consider the inter-cell interference in our system model.

3.2 Network Architecture

3.2.1 Network Model In this work, we consider a frequency division duplex (FDD) cellular system consisting of multiple cells, as depicted in Fig. 5.1. A BS equipped with an omnidirectional antenna is deployed at the center of each cell. For BS assisted D2D communications, we assume that the inter-cell interference plus noise power can be estimated at the D2D receivers and the BSs [29]. The UL and DL channels each have a bandwidth of B, which is divided into K orthogonal subchannels. D2D communications may fully reuse the UL radio resources. A signal-to-interference-plus-noise ratio (SINR) of ΓD is required for a reliable link to be established between a D2D transmitter and a D2D receiver.

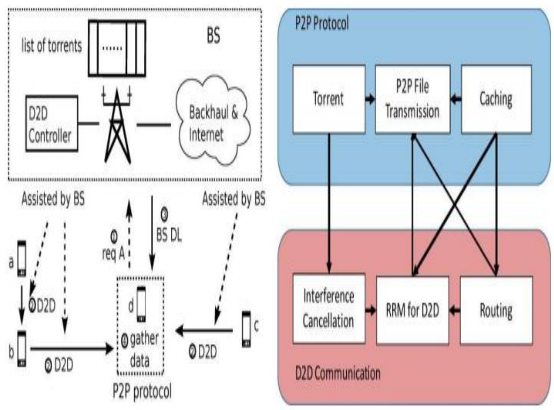

Fig. 3.2.1 PHP system model.

3.2.2 System

Fig. 3.2.1 shows the PHP system architecture, which consists of a spatially distributed cache system to provide local file caching services. PHP subscribers, i.e., the UEs par- ticipating in the PHP system, would cache a list of pre-selected files. Each of these files can be fully or partially cached in PHP. How each file is divided into chunks and stored at different subscribers is described by a torrent. Each

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BS maintains a list of torrents and has full knowledge of the data stored in each PHP subscriber associated with it. As wecan see in Fig. 3.2.1, a subscriber can receive a locally cached file through the following four subroutines:

1.Request: A PHP subscriber requests a file through the PPP protocol from the BS.

2.D2D: The BS then requests proper PHP subscribers to transfer the data to the requesting subscriber via BS assisted D2D communications, where the BS chooses the route from the D2D source to the D2D destination.

3.BS DL: For any partially, locally cached file or any failed end-to-end transmission, the BS transmits the remaining parts of the file to the requesting subscriber.

4. Data gathering: The requesting subscriber gathers the data from multiple D2D sources and the BS DL through the PPP protocol. Note that PHP subscribers would act as CC UEs when they either do not request any locally cached files or are not involved in D2D communications as sources or relays.

IV.RESULT:

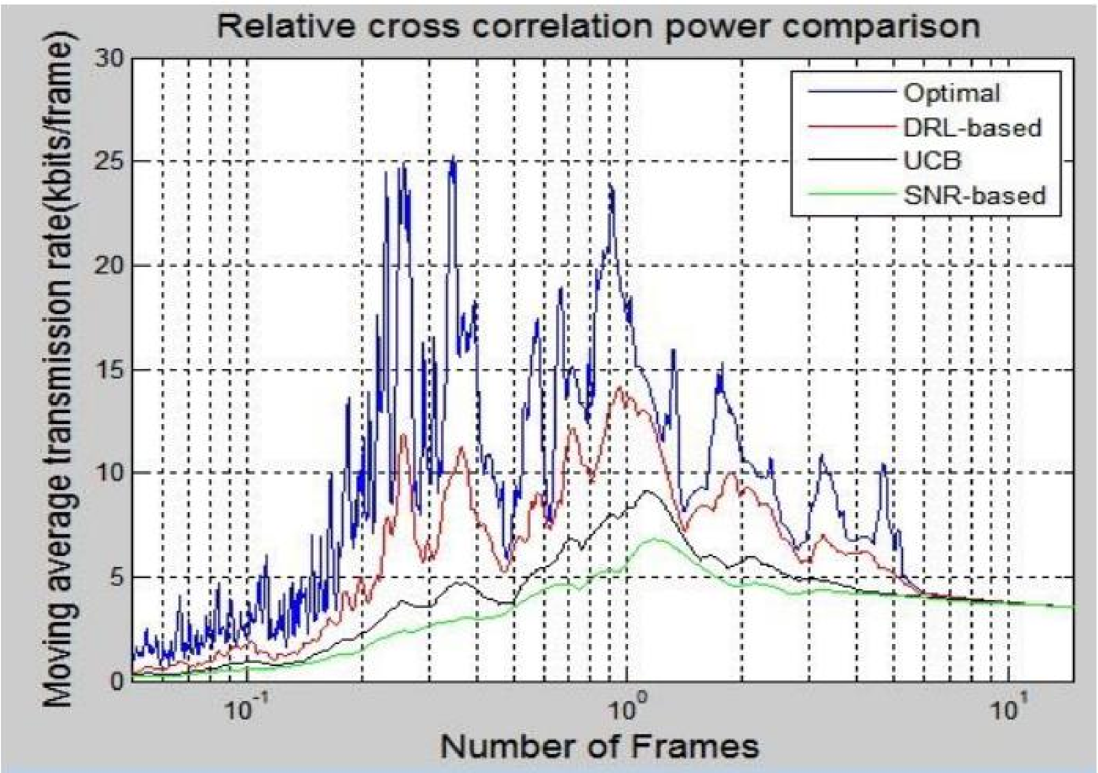

Fig 4.1 No of frames vs avg Transmission rate

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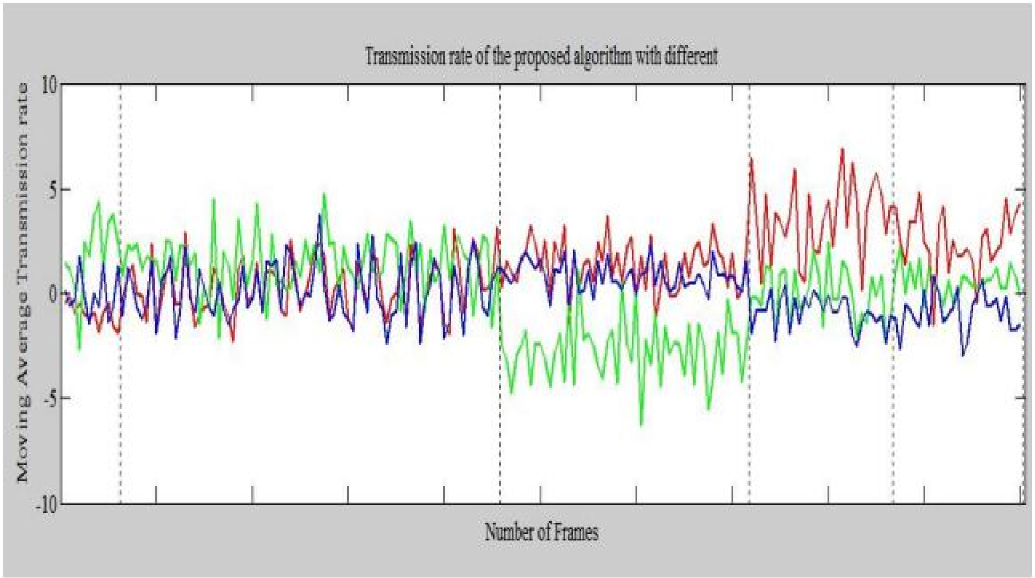

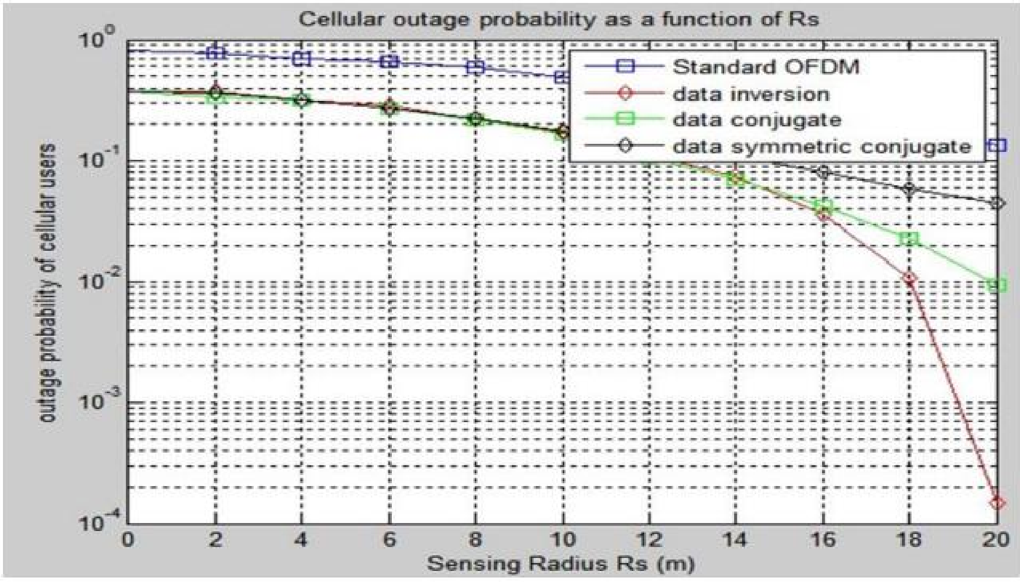

Fig 4.2 sensing radius vs outage probability of cellular users

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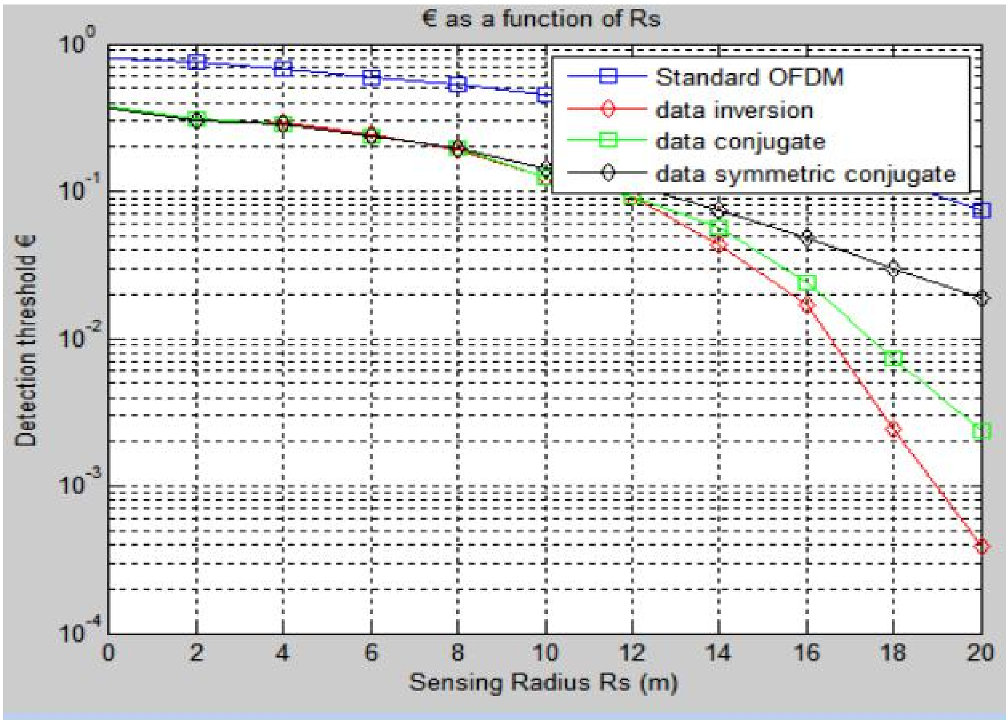

Fig 6.2 sensing radius vs detection threshold

Fig 4.3 sensing radius vs detection threshold

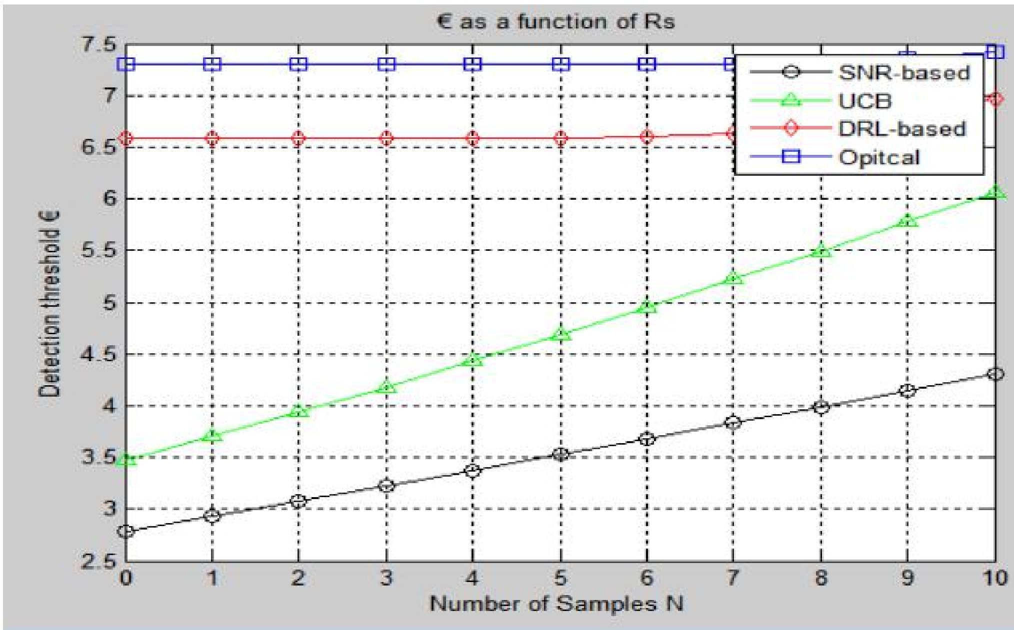

Fig 4.4 No of samples vs dectection threshold

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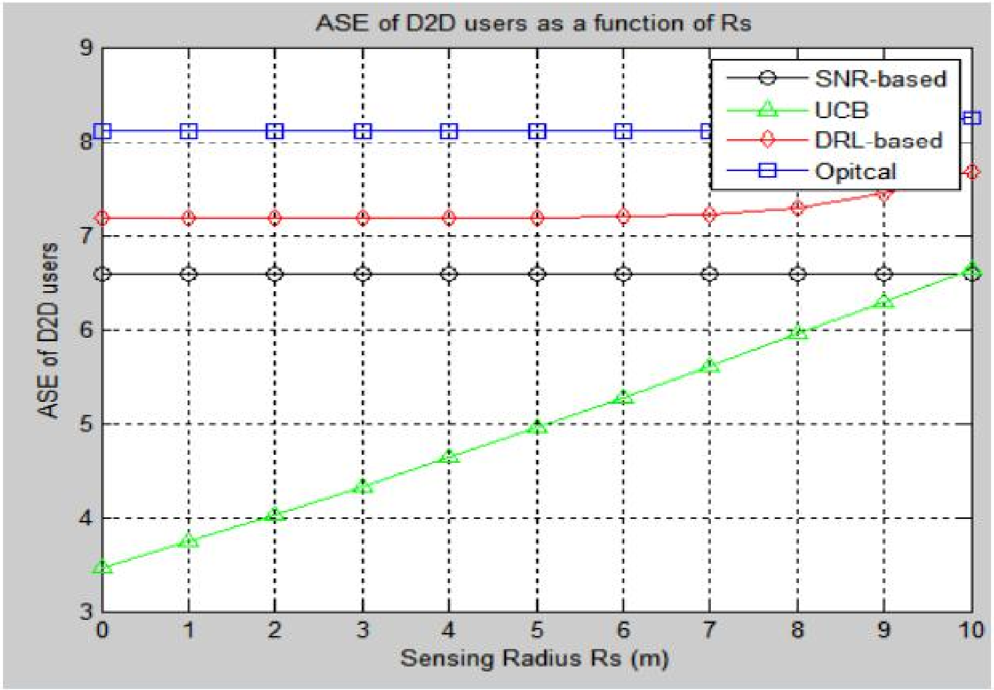

Fig 4.5 sensing radius vs ASE of d2d users

V.CONCLUSION:

In this project, the performance of SSS-based D2D under cel-lular users' QoS constraints is investigated. Analytical resultson both cellular users' outage probability and D2D users'ASE in spatial spectrum sensing-based D2D cellular networksare accurately characterized. The optimal sensing radius ofspatial spectrum sensing is characterized to maximize the ASEunder cellular users' outage probability constraint as well asD2D users' spatial false alarm constraint. Simulation resultsdemonstrate the advantages of SSS-based D2D networks andshow that the new analytical results obtained in this paperprovide a much more accurate performance characterizationthan existing PPP-based approximation for SSS-based D2Dnetworks. Our future work will focus on extending SSS toclustered cellular networks using Poisson cluster process.

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