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Efficient Resource Allocation for Overlay D2D Communication: A Comprehensive Review

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ABSTRACT

Device-to-device communication is the most crucial aspect of the fifth generation (5G) wireless networks. D2D communication is a technology that allows User Equipment (UE) to communicate with each other with or without the involvement of any base stations or any network infrastructures. In the overlay, there are dedicated resources for both cellular and D2D users thus there is no interference between them. Therefore, the in-band resources for D2D communication can be operated in overlay mode. But there is a wastage of resources in overlay D2D communication because the resources are dedicated to both cellular and D2D users. This paper gives critical review of previously published resource allocation algorithms of overlay D2D communication in terms of spectral efficiency, resource optimizations, outage probability, transmission capacity and power efficiency. The main contribution of this paper is to summarize the published work and future challenges in the field of overlay D2D communication that is linked with 5G.

Keywords – **5G, Overlay D2D, Resource Allocation, Resource Optimization**

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1. INTRODUCTION

With the growing number of mobile devices, multimedia applications such as mobile gaming, high definition (HD) movies, and video conferencing have triggered rapid advancements in cellular technology and services [1]. The cellular network is now four generations old. As new and more demanding applications arrive and the number of subscribers grows rapidly, more sophisticated techniques are urgently needed to increase data rates and reduce delays. D2D communication is a new prototype in cellular communication [2]. This allows the user's equipment (UEs) to communicate in proximity via a direct link instead of traveling their radio signal all the way through the base station (BS) or core network. One of its main advantages is the ultra-low latency in communication due to the short signal traversal route. Numerous short-range wireless technologies like: Bluetooth, Wi-Fi-Direct and LTE Direct (defined by the Third Generation Partnership Project (3GPP) [3]) can be used to enable D2D communication. For instance, Bluetooth-5 assists a maximum data rate of 50 Mbps and a range close to 240 m, Wi-Fi Direct grants up to 250 Mbps rate and 200 m range while LTE Direct provides rates up to 13.5 Mbps and a range of 500 m.

The organization of the comprehensive review is as follows: Following the introduction, background knowledge of D2D communication has been presented in Section II. In Section III, we categorize the available literature based on overlay D2D communication. Integrating D2D communication in existing cellular networks arouses several challenges, which have been discussed in Section IV. Lastly, the paper concludes in Section V.

2. BACKGROUND KNOWLEDGE

This knowledge provides background knowledge regarding the main characteristics of D2D communications. More specifically, types of D2D communication in the device tier, types of control in D2D communication, classification of D2D communication and structure of D2D communication.

2.1 Communication in the Device Tier

The fifth generation (5G) cellular network, which enables device-to-device (D2D) communication, is considered a two-tier network. The two tiers in these networks are called the macro cell tire and the device tire. Conventional cellular communication is supported by the macro cell tire, while D2D communication is supported by the device tire. These cellular networks are like existing networks. The difference is in the fact that loyal services can be obtained in the devices on the edges of the cell and congested areas inside the cell. As the devices in the device tire allow direct D2D communication, the base station can be partially controlled or the communication between the devices can be fully controlled. Thus, direct D2D communication in the device tier is categorized into two different types [4].

2.1.1 Device relaying with controlled link establishment from the device:

The two devices communicate via relays within cellular networks. Resource allocation, call configuration, intervention management, everything is distributed through the devices themselves. Control of the base station is missing. The architecture is as shown in Fig.1.

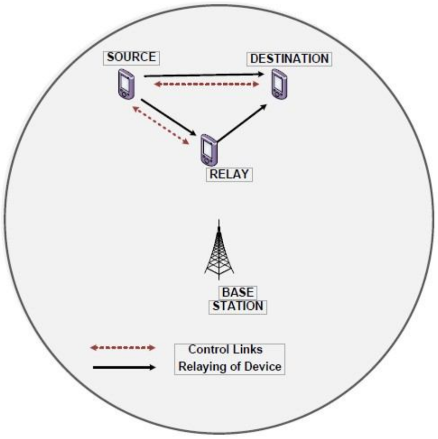

Fig.1. Relaying device with device-controlled link establishment

2.1.2 Direct communication between devices (Direct D2D) with controlled link establishment by the device:

Devices communicate directly without the help of a base station (BS). Call setup and management are handled by these devices themselves as in (1). The architecture is as shown in Fig.2.

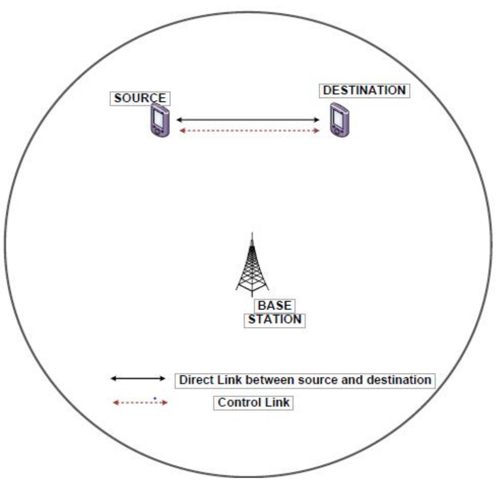

Fig.2. Direct communication between devices (Direct D2D) with device-controlled link establishment.

3. Types of Control in D2D Communication

The types of control that can be used for the foundation of D2D Communication links can be categorized as follows [5].

3.1 Centralized: Base Station (BS) monitors UE nodes completely even when they are communicating directly.

3.2 Distributed: D2D node management procedures are not obliged on any central entity but are performed by independent UEs themselves.

3.3 Distributed Artificial Intelligence (DAI): All control processes run in parallel and at the same time begin to collaborate in an intelligent way.

3.4 Semi-Distributed/Hybrid: A mix of centralized and distributed schemes.

4 Structure of D2D Communication

It consists of two structures.

4.1 Stand-Alone D2D: the term stand-alone D2D refers to D2D communication without the involvement of any network infrastructure.

4.2 Network-Assisted D2D: this refers to D2D communication with the involvement of infrastructure.

Although D2D communication provides us with many benefits at the same end there are certain limitations as well to improve the technology. D2D communications require well-established node discovery technologies, perfect mode selection (dedicated, cellular, etc) algorithm, methodologies used for resource management, mobility management, and security management [6].

5 Classification of D2D Communication

Device-to-device (D2D) communication can be classified into in-band D2D and out-band D2D and this classification is based upon the spectrum used while communicating [7]. High control over licensed spectrum is the key driving factor for selecting in-band D2D communications. On the other hand, the main motivation for using out-band D2D communication is its ability to eliminate interference between D2D connections [8]. Fig 3 will show its classification more clearly.

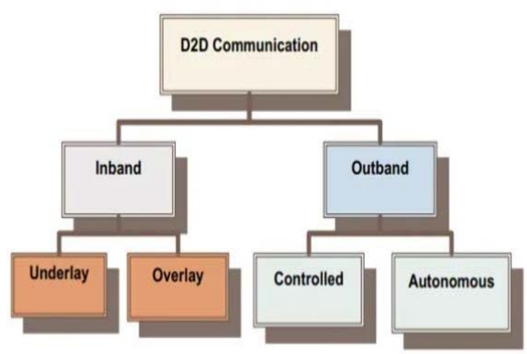

Fig 3. D2D classification

In this section, we present a formal definition for each category of D2D communication and an overview of the advantages and disadvantages of each D2D mode.

5.1 In-band communication

The literature in this category has been extensively researched and the use of cellular licensed spectrum for cellular and D2D links has been suggested. In-band communication is selected to achieve high and efficient

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use of spectrum because it enables high control over the cellular licensed spectrum [9-11].

The feasibility of D2D communication and its effects in the licensed spectrum are studied by simulating and analyzing different scenarios, and the authors show that tolerating the increase in interference in the licensed spectrum will make D2D communication possible [12].

To improve spectrum efficiency, D2D can reuse time and frequency resources by in-band D2D users (i.e underlay) or allocate time and frequency resources occupied by D2D users (i.e overlay) [13]. Under this, in-band communications can be divided into underlay and overlay categories.

The biggest disadvantage of in-band D2D is the interference in cellular communications caused by D2D users. This intervention can be mitigated by introducing high complexity resource allocation methods [8].

5.1.1 Underlay In-Band

In underlay in-band mode, cellular and D2D communications share the same radio resources [14-15]. To date, most of the papers in literature are dedicated to D2D communications underlaying cellular networks [16] [17] [18]. D2D and cellular users can use a solo channel utilizing mixed time slots [29]. Therefore, occasionally this communication system is also known as the mixed-mode communication [28]. However, it causes intervention in cellular communication by D2D communication and vice versa [30]. Underlay in-band can improve and enhance the performance of various targets such as spectrum efficiency, energy efficiency, and cellular coverage using a variety of techniques including diversification techniques, interference reduction, resource allocation, and by using network coding [19-24].

5.1.2 Overlay In-band

In this mode, cellular and D2D are given dedicated cellular resources, and these cellular resources are deducted from cellular users to eliminate the interference of D2D communications on cellular transmission [23],[26],[27]. The advantage of this scheme is that it improves scheduling and power control in direct D2D communication [31] and it offers better spectral performance and signal strength in relay assisted networks [23], [32]. One of the major limitations of overlay inbound communication is that the part of the cellular spectrum set aside for D2D communication cannot be used, leading to poor resource utilization and system throughput [23].

5.2 Out-band communication

In this category, D2D communications are performed in unlicensed spectrum such as ISM 2.4G which made interference between D2D and cellular communications impossible. On the contrary, out-band D2D suffers from the uncontrolled nature of my unlicensed spectrum. Exploiting spectrum without a license requires an additional interface that implements Wi-Fi Direct, ZigBee or Bluetooth [33-35].

However, out-band D2D has problems connecting two different bands because D2D communication takes place on another radio interface. There are two subcategories of out-band D2D communication: controlled D2D and autonomous D2D [30],[13]. Out band D2D communication has two subcategories: Controlled D2D and Autonomous D2D.

5.2.1 Controlled out-band communication.

In this mechanism, the cellular network operator controls the assignment of radio resources, indicating that BS controls the operation of the UE and is responsible for all functions related to the device communication system, such as resources allocation, power control and mode selection [37]. This system is simple because BS controls the overall system and has all the tools to reduce the conflicts caused by different devices and the dynamic system is handled efficiently [38]. This control system can cause the failure of the entire communication system with the failure of one [25].

5.2.2 Autonomous or distributed out-band communication.

In autonomous out-band, cellular links are controlled via the base station, while in D2D mode communication devices are responsible for controlling D2D communication. This approach significantly reduces the workload of cellular networks and since no major changes are required during BS deployment, it is also an attractive solution for operators and mobile service providers. The D2D network is responsible for allocating resources to new entrants, and which reduces system signaling overhead [37]. In [36] simulation results showed that delay performance can be improved by considering the above approach and the key performance requirement is to increase power expenditure.

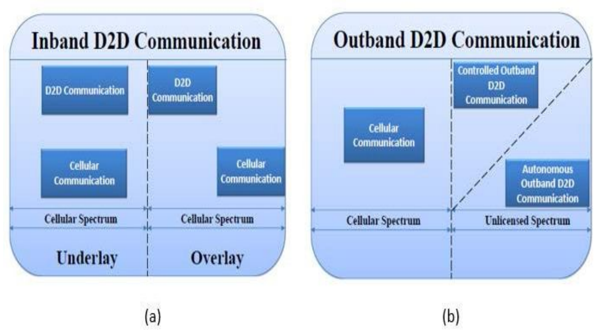

Fig. 4: (a) In-Band and (b) Out-Band Overview

6 LITERATURE REVIEW

In this section, some of the significant contributions made by different researchers in the domain of overlay architecture of D2D communication are discussed.

In the paper [39], the authors proposed a scheme of interference avoidance resource allocation. A graph-coloring algorithm was introduced by them to achieve the performance gain using spatial reuse in D2D systems. They assigned a single resource of D2D to the multiple pairs of D2D. Although by assigning a single resource to the multiple pairs of D2D, interference from the neighboring pairs of D2D is unavoidable and causes degradation of performance. To handle the problem of interference authors first proposed the feedback method which can be practically provided by the D2D pair. Then they applied a graph-coloring algorithm using the reported lists produced by the D2D pairs to avoid the interference completely. The reported lists are a set of lists that consist of dominant interferers. The simulation results of the proposed resource allocation scheme show that the performance is better than the conventional scheme used for the allocation of resources in terms of both sum rates and outage probability of D2D pairs.

In [41] the authors proposed a semi-distributed resource allocation scheme for the D2D communication where the BS assigns radio resources for cellular user and D2D user in a centralized manner while the modulation and coding scheme (MCS) level and the transmission power of D2D links are decided in a distributive manner by the device of each D2D link. To solve this problem authors proposed a sub-optimal greedy algorithm. They first addressed the issue of resource allocation. It aims to maximize local reuse of radio resources by allowing simultaneous transmission of D2D links on the same resources. The cellular network with the proposed scheme attains a higher network throughput as compared to the scheme used in [40] while reducing the control overhead more than the strategy used in [40].

In [42] a joint clustering and power control scheme for orthogonal frequency division multiple access (OFDMA) system is proposed. This is a modified version of the stepwise removal algorithm (SRA). This scheme comprises of two phases. In the first phase, an interference management scheme is proposed based on clustering, in order to guarantee the target outage probability of D2D communications. In the second phase, a power control scheme is proposed to further reduce the outage probability. The proposed strategy has a higher chance of transmission success than one that does not use a power control scheme.

Yang et al. [43] explore the issues regarding resource allocation of D2D in LTE systems. They developed an algorithm to achieve maximum spatial reuse in the domain of overlay D2D communication. An efficient resource allocation algorithm was proposed by them to achieve the maximum spatial reuse in orthogonal frequency division multiple access (OFDMA) systems. In the given set of D2D requests, a proposed algorithm (LIFA) minimizes the number of required RBs (Resource Blocks) and efficiently assigned multiple D2D pairs to reuse each RB (Resource Block) required. They further compared their results with simulation results of [41] and claimed that the proposed algorithm LIFA achieved better results in terms of the execution time, throughput per RB (Resource Block), and the number of required RBs (Resource Blocks). The proposed algorithm (LIFA) could save up to 18.6% RBs, improve the throughput per RB by up to 23.4% and reduce the computation time up to 67.9%. Two algorithms were used by the authors to evaluate the proposed algorithm (LIFA). The first is a Greedy Algorithm (GA) in [41] and the second one is a modified version of the Stepwise Removal Algorithm (SRA) in [42].

Marco Belleschi. [44] developed a model for a joint optimization of mode selection, resource assignment and power allocation for D2D communications. In such a scenario, resource management is particularly challenging, as there is a need to manage intracellular and intercellular interference between cellular and D2D layers. They used this model to develop a distributed single cell mode selection and resource allocation algorithm (S-MSRAP) which they benchmarked to the centralized optimal multi-cell algorithm.

In paper [45], the authors proposed an algorithm to intelligently assign a limited cellular spectrum for D2D in- band overlay communication to optimize the overall network spectral and energy efficiency. With the help of graph theory, the authors demonstrated that as the number of D2D nodes and frequency resources increases then the optimization problem exponential time complexity also increases. The authors solved the optimization problem in two phases. In the first phase, the authors aimed to minimize the required frequency resources whereas in the second phase, minimizes the required transmission power of the nodes programmed on those resource blocks. To evaluate the performance, they performed simulations using MATLAB. They analyzed the performance w.r.t the parameters such as spectrum efficiency, spectrum reuse, power efficiency, transmission capacity with outage constraints along with other performance trade-offs involved. The proposed strategies outperform other state-of-the-art strategies such as MinInterf [16] and FirstFit [32] in effectiveness.

Other authors considered millimeter wave (mmWave) channels for D2D communication [46]. They stated that in areas with high call traffic density, D2D communication can be implemented in overlay mode. This gives the advantage of low complexity interference avoidance technology. Complexity is reduced as resources for overlay mode are dedicated which results in no cellular user interference. D2D devices share the same radio resource, which plays a vital role in system performance. Spectrum wastage in overlay D2D mode is highlighted in this study. To improve the utility of spectrum, part of uplink resources is dedicated for the operations of the overlay operation based on history of call traffic. Two problems were addressed by the authors. First, assign resources to the overlay mode, which is solved using quadratic programming. After that, the second problem is to maximize system capacity in Overlay mode. It is solved using a simulated heuristic algorithm. The proposed scheme has the optimum performance for a dense network in a controlled overlay process for 5G networks. It also overcomes the problem of spectrum wastage in overlay mode by its selective process.

The author [47] explores the efficient allocation of resources in densely distributed 5G networks. For improving the allocation, they proposed a resource allocation algorithm. In which they first group D2D users according to their locations. Then modes are assigned to the users according to the priority order of communication need. Finally, to manage resource allocation, signal-to-noise ratio (SNR) is compared in all three modes (i.e. orthogonal, multiplex, and cellular). The throughput shown in their simulation results of single-cell multi-user scenario indicated that the proposed algorithm could allocate the best communication mode and resources to the users with the best throughput. Results of simulation proved that the proposed resource allocation algorithm will decrease the impact of unfriendly factors on the communication performance of both users and base stations, under the hybrid communication mode of cellular and D2D. Although it also improves the utilization of spectrum and throughput of the system.

Zhang et al. [48] describe that there are interference problems in the underlay mode of D2D communication. As the radio resources are shared by both cellular and D2D user. The authors suggested the use of overlay mode of D2D communication for the purpose of avoiding interference. In the paper [10] they adopted the overlay D2D mode in which resources of D2D are orthogonal to the resource of cellular. They proposed two D2D resource allocation algorithms based on the locations for broadcast services of vehicle-to- vehicle (V2V) (1) Location-based Centralized Scheduling Algorithm (LB-CSA) (2) Location-based Distributed Scheduling Algorithm (LB-DSA). They applied a centralized scheduler in (LB-CSA) so that all the users can be easily coordinated without any delay. The proposed algorithm performs well in major factors like resource utilization, communication accuracy, and time delay performances. On the other hand, distributed base stations are used in (LB- DSA) instead of the centralized scheduler. According to results shown by them in simulation, they concluded that the LB-DSA does not demand a centralized scheduler, but its communication performance is worse than the LB-CSA. Still, the communication performance of LB-DSA is at an acceptable level.

Mohamed Elsherief et al. in [49], have concentrated on resource and power allocation. Resource allocation is done by allocating subcarriers for the D2D pairs in such a way that each user gets the best subcarrier. The iterative Fairness Optimization Resource Allocation (FORA) algorithm has been used in this paper. FORA algorithm works based on fairness and not on channel quality. A water filling-based algorithm is used in this study for the power allocation among the spectrum resources allocated to the D2D links. The performance of the proposed algorithm (FORA) is compared with the “Best Subcarrier Channel State Information Resource Allocation (BSCR)” and with the “Subcarrier Achievable Data Rate algorithm (SAD)” in the matter of Jain’s fairness index and spectral efficiency. The allocation of subcarriers in the proposed algorithm (FORA)

depends on the maximization of the fairness index. The authors had concluded that the proposed algorithm (FORA) outperforms the other two algorithms (SAD & BSCR) in terms of fairness at the cost of spectral efficiency.

The authors [50] proposed a framework based on stochastic geometry for D2D multichannel overlaying uplink cellular networks. In this framework, cellular users can upload data to the nearest base stations via cellular channels and D2D users upload data to their relays via D2D channels, and then the relays communicate with the closest base stations through cellular channels. D2D users send data with the fixed transmit power while cellular users and D2D relays acquire the channel inversion power control with a full transmit power limit. This framework can design and evaluate how different parameters (minimum received power, relative deployment density, transmit Power control, and channel allocation) affect the coverage probability and periodic rate of users in the cellular network. Numerical results have indicated that there exists an optimal channel allocation to attain optimal network performance. Although overlay D2D communication avoids interference between CUEs and DUEs, interference among DUEs still plays a crucial role in overall performance degradation of entire network.

In [51] authors proposed an efficient resource allocation strategy that not merely curtailed the interference, but also enhanced the energy efficiency of the DUEs. We also examined that the FR PRB assignment scheme attains a good PRB reuse factor but at the cost of suffering huge interference. This led to high system blocking and low throughput. Whereas our PRB assignment technique reused PRBs among D2D pairs so that intervention among them was least.

The [52], provides a stochastic geometry-based theoretical framework for analyzing the coverage potential and ergodic rate for D2D overlapping multi-channel downlink cellular networks. Our results revealed that the developed framework is very beneficial for network designers to efficiently deduce the optimal network parameters at which point the best system performance can be attained. The network coverage can be considerably enhanced by stimulating the combined two-hop connection via an intermediate UE.

In [53] the main feature of D2D communication is that it enables direct communication between devices, thus effectively improving resource usage and reducing reliance on base stations, so it can effectively enhance the throughput of multimedia data. The author’s analyzed the intensive distribution of D2D links and proposed a user-centric approach to shared access control and time domain scheduling, which addresses the issue of maximizing the number of access links while ensuring quality of D2D link service. Simulation shows that the algorithm in this paper is an approximate best algorithm, which compromises between the performance and complexity of the algorithm.

In [54] authors proposed the joint uplink and downlink resource allocation scheme which maximizes the system capacity and ensures the signal-to-noise-and-interference ratio of both cellular users and device-to-device pairs. The optimization problem is developed as a mixed-integer nonlinear problem that is usually NP-hard. To attain reasonable resource allocation, the optimization problem is split into two sub-problems incorporating power allocation and channel assignment. It is demonstrated that the objective function of power control is a convex function, in which the optimal transmission power can be achieved. The Hungarian algorithm is generated to obtain joint uplink and downlink channel assignment. Simulation outcomes indicate that the performance of the proposed strategy of jointly uplink and downlink is better than that of the only reuse uplink resources (OU) [55] and only reuse downlink [56] (OD) resources schemes.

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References	Objective	Methodology	Results and discussions	Limitations
[39]	To implement an interference avoidance resource allocation scheme based on a graph-coloring algorithm to introduce performance gain using spatial reuse in D2D (Device-to-Device) system.	Graph-coloring-based resource allocation. 1) Feedback method. Graph Construction Based on Interference Avoidance	This shows that it performs well in terms of both sum rate and outage probability of D2D pairs.	The optimal solution of resource assignment is not practical to be applied in D2D systems.
[41]	To implement a resource allocation scheme for maximizing spatial reuse.	-Greedy Algorithm	-Higher network throughput than [2] -Reduction in control overhead more than [2] -Worst results in terms of the number of RBs required as compared to LIFA.	-No mode selection between direct or relay-based communication. -D2D links request the same transmission power regardless of uplink or downlink band. - Greedy uses an interference threshold as a reliability constraint.
[42]	To improve the reliability of D2D communication	-Stepwise Removal Algorithm (SRA)	- SRA produces the best results in terms of the number of RBs required -Highest group density than GA and LIFA	-Equal transmission power and does not consider the request sizes of individual links. - The reliability constraint cannot be guaranteed
[43]	To implement an efficient resource allocation algorithm that enables the maximum spatial reuse of OFDMA systems.	-Largest Aggregated Interference First Algorithm (LIFA).	-LIFA could save up to 18.6% RBs, improve the throughput per RB by up to 23.4% and reduce the computation time by 67.9% as compared to greedy algorithm [3].	-LIFA uses an SINR threshold as a reliability constraint
[44]	To develop a unified optimization problem that minimizes the used sum power in an OFDM system that may reuse physical resource blocks for D2D links	-Single Cell Mode Selection Resource Allocation Problem (S-MSRAP)	-Improves system capacity -Protects cellular layer from interference -Reduces overall power consumption.	-The advantage of the mode selection strategy over traditional cellular communications may be less efficient only for longer distances.
[45]	The objective is to come up with a resource allocation strategy that maximizes the overall frequency reuse with minimized transmission powers subject to maximum power and SINR constraints	-Joint power and spectrum allocation algorithm with different reuse strategies (GRP, FRP, RRP, MTPRP)	-GRP offers highest spectrum efficiency - MTPRP proves to be the best reuse strategy. - FRP and RRP offer a compromise between spectral and energy efficiency. GRP, FRP and RRP rely less on the CSI	In this network, a scheduler can only assign a single frequency resource block per D2D pair communication request.

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[46]	To control the problem of spectrum wastage in overlay mode by its selective operation.	-Quadratic programming -Resource Management Algorithm in Overlay	- Improves system performance -Decreases spectrum underutilization.	-The D2D connectivity is not taken into consideration if devices detachment is more than 20 m.
[47]	To improve the efficient distribution of resources in the scenario of densely distributed mobile terminals in 5G networks.	-Resource allocation algorithm based on D2D communication mode selection	-Improves the spectrum utilization -Increases the total throughput output of the network.	-System complexity increases -During downlink multiplexing, interference coordination and suppression will be difficult
[48]	To schedule D2D resource and improve resource utilization efficiency.	-Location-based Centralized -Scheduling Algorithm (LB-CSA) -Location-based Distributed Scheduling Algorithm (LB-DSA)	- Packet loss rate of LB-DSA is higher than that of LB-CSA - Time delay of LB-CSA is lower than LB-DSA. - Resource utilization ratio of LB-DSA is lower than LB-CSA LB-DSA performs slightly worse in communication	-In LB-DSA, resource reuse distance should be larger than 2r (Broadcast distance) in order to avoid co-frequency interference.
[49]	To improve the fairness of resources allocation while not degrading the individual users' performance	-Iterative fairness optimization resource allocation algorithm (FORA)	- FORA algorithm outperforms existing schemes, such as SAD and BSCR, in terms of fairness index.	- FORA algorithm doesn't incorporate channel conditions.
[50]	To develop a framework for modeling and analysis of uplink transmission in a single-tier cellular network	-Framework based on stochastic geometry	The framework can help us to find out the optimal channel allocation to attain the best network performance efficiently.	-The received signal power must be larger than a threshold, otherwise the transmission goes into outage.

[51]	To handle interference among D2D users without significantly affecting the spectrum efficiency.	Efficient resource allocation technique divided into two parts: -NADD Scheme -Heuristic Approach	- Our scheme performs better than FR (Full-Reuse) scheme in terms of spectrum reuse, energy efficiency and overall system blocking	-Considered uplink PRBs (physical resource blocks) only
[52]	To analyze the coverage probability and ergodic rate in a D2D overlaying multi-channel downlink cellular network	-Stochastic geometry based theoretical framework	- Improves the network coverage performance especially for the low SIR regime.	-Considered only one-tier BSs -Constants transmit power -Rayleigh fading for both cellular links and D2D links
[53]	To maximize the number of allocated resources in each scheduling period while ensuring the integrity of the D2D link service.	-Joint Access Control and Time Domain Scheduling	-The proposed algorithm effectively improved the resource distribution and overcome the co-channel interference as compared with existing algorithms.	-Tradeoff between algorithm performance and complexity
[54]	To maximize total system capacity.	-Joint Uplink and Downlink Resource Allocation Scheme	-Improves the system capacity and increases the spectrum efficiency	-Proposed algorithm performance decreases with the decreasing of maximum transmission power of D2D pairs. -As the distance of D2D pairs increases, improvement of system performance is limited.

7. FUTURE WORK AND CHALLENGES

Centralized solutions do have their downsides. If the base station goes down, then it is unable to process user requests. So, for reliable and ultra-low-latency communication, we should go for distributed resource allocation. Since distributed solutions rely on the local information around them that's why whatever solution people can propose will be suboptimal because each node in a distributed solution doesn't have the information of the complete knowledge of the network. We want to increase local information in the device-centric solution and that can be relay based in which nodes are somehow able to share the information of their local network to increase the overall network coverage of each node in the device tier. In [57] authors proposed distributed relay selection method for relay assisted D2D communication. In this method, they firstly manage the interference and eliminate the improper relays. Next, the best relay is chosen for sharing information using the distributed method. In [58] the authors proposed an auction- based algorithm to sovery network coverage and increased data rate respectively. Nodes use control channels to exchange information with each other. D2D communication comes with its own set of obstacles. A few of these are discussed in the following paragraphs.

7.1 Distributed Device Discovery*:*

In [59] the devices themselves do all the device discovery and connection establishment without the involvement of the Base Station. The device that wants to start a communication starts looking for other devices in its vicinity. The beacon signals are sent, and messages about the locale, channel state information, and device availability status for D2D communication are conveyed between the devices. There is a risk of interference and synchronization because there is no management from the central entity or Base Station.

7.2 Distributed Resource Allocation:

The distributed strategy does not include the Base Station in resource management. The devices oversee resource allocation and management. This type is also appropriate for networks with a larger number of devices. By exchanging messages, the devices gather information about their neighbors more frequently. Devices that want to communicate in D2D mode keep an eye on cellular resources and take advantage of licensed cellular communication resources as they become available. The devices monitor cellular communication to collect data on channel quality, SINR, and cellular resource availability [59].

7.3 Frequency Reuse Maximization: we are using overlay inband for d2d communication and dedicated resources are assigned for D2D communication. We must ensure that resources are efficiently used. Productive use of frequency spectrum is only possible if we reuse spectral resources to a great extent instead of introducing a new spectrum thus increasing spectral efficiency. Frequency reuse in a distributed manner is a big challenge.

7.4 Security and Privacy: Regardless of the numerous benefits, new applications for D2D communication emerge daily. In comparison to a traditional cellular network, the security issues of these applications cannot be overlooked. Directly connected devices, relay structure, handover, roaming, and privacy in social networks all pose security risks. If security concerns are addressed, it is possible that a successful deployment of D2D communication will be significantly hindered [60].

8. CONCLUSION

We have summarized the resource allocation papers for overlay in-band in two domains distributed and centralized. Although from Table 1 we can see that there is limited work done in the field of distributed resource allocation [44-46], [51], [53-54]. We cannot rely on a central entity for reckless communication. In a disaster or emergency, a central entity will not be able to meet the user's needs. For future work, researchers should work in distributed resource allocation so that devices can allocate frequencies according to their needs. D2D communication is a crucial technology of future networks, encouraging the researchers to endure the associated challenges to completely take benefit of its utility.

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