JEDIC Journal of Ethics and Diversity in International Communication

| e-ISSN: 2792-4017 | www.openaccessjournals.eu | Volume: 1 Issue: 4

Challenges and Key Issues in D2D Communication in 5G IoT Networks

Nozima Musaboyeva Bahtiyorqizi

Master of Telecommunication at "Tashkent University of Information Technologies named after Muhammad al Khwarizmi", Tashkent, Uzbekistan

ABSTRACT: Device-to-device (D2D) communication produces a new dimension in the mobile environment, easing the data exchange process between physically neighboring devices. To achieve an effective utilization of available resources, reduce latency, improve data rates and increase system capacity, D2D communication utilizes nearby communicating devices. The mobile operator's action to collect the short-range communications for maintenance of the proximity-based services and improve the performance of networks drives the development of D2D. The main goal of the research is to present an extensive review of the recent advances in various D2D domains such as the discovery process, mode selection schemes, interference management, power control techniques and finally the mode selection for D2D applications for 5G technologies.

Key words: device-to-device (D2D) communication; device discovery; interference management; power control; security; mode selection.

I. INTRODUCTION

New technologies fundamentally change the way people exchange information with each other, especially in wireless communication and mobile computing. Despite this, cellular mobile environment is still infrastructure-dependent. The mobile users' connection is restricted depending on the base station (BS) coverage, and does not permit direct communication among mobile devices. Even though the source and the destination are in close proximity to each other, the routing traffic is routed through the core network. As an alternative way for overcoming this problem is making D2D communication possible. However, there might be considered many vulnerabilities and weaknesses. For this reason, many challenges that should be tackled in order to successfully execute D2D communication. Specifically, D2D require complex resource management techniques, efficient device discovery mechanisms, intelligent mode selection algorithms, robust security protocols, and mobility management procedures.

This paper first provides a general view of the issues of D2D in 5G systems. Interference is a major problem for D2D, because non-regulated bands are being considered, as well as the coexistence of D2D communication with Bluetooth and Wi-Fi bands. Furthermore, resource allocation is also highlighted as a big issue. Finally, performance and applications are given, as well as the current state of D2D communication in 5G systems. Finally conclusions are given.

II. ISSUES IN D2D

1. Device Discovery

The device discovery process occurs when the devices transmit a discovery signal through a base station to discover the neighboring devices. There are several integrating technologies related to communication that are being considered by 5G as having potential in helping the discovery process. A device discovery procedure can be divided into centralized and distributed device discovery. These categories are the basis of all the remaining technique functions.

For the centralized device discovery, a centralized entity will assist the devices in discovering one another, usually at an access point or a base station. The intended device informs the base station about its purpose to connect with adjacent devices. The base station needs to acquire specific information such as channel conditions, power and also the interference control policy that depends on the system prerequisites. For the distributed device discovery, the devices have permission to discover other devices without including the BS.

2. Interference Management

The interference from cellular users is one of the major weaknesses affecting D2D communication.The coexistence of CUs and D2D pairs that use the same cellular resources leads to an interference issue.Depending on the D2D network's operation mode such as uplink and downlink situations, the D2D users will suffer from intracellular and intercellular interference. The transmission success can be damaged by interference that compromises the signal-to-interference-plus-noise ratio (SINR).Table 1 shows the brief summarization of the management of interference in D2D communications.

Table 1. **Brief summary of interference management in D2D communication**.

No.	Problem	Algorithm Used	Findings	Reuse Resources	Interference Control Level
1.	Utilize throughput to an interference temperature constraint	Stackelberg game theoretic optimization	Improves resource allocation and interference management in spectrum-sharing D2D communications	Uplink (UL)	Centralized
2.	Quality of Service (QoS) interference management	Graph theory-based solution for relay selection and power adoption	Improves QoS satisfaction with high energy efficiency	Uplink and Downlink (UL&DL)	Distributed
3.	Interference management and performance enhancement	Concatenated Bi-partite Matching (CBM) graph theory-based solution	Reducing the average number of cellular user equipment (CUEs) in outage	Uplink or Downlink (UL/DL)	Centralized
4.	Distribution of random devices in cellular networks lead to critical interferences	Novel greedy-based channel assignment algorithm	Increases the network capacity and improves the fairness among devices with low computational complexity	Uplink (UL)	Centralized
5.	Co/cross-tier resource sharing interferences problem	Matching theory-based distributed resource allocation algorithm	Achieves optimum network performance with much lower overhead and complexity	Downlink (DL)	Distributed
6.	Dependency on CSI and high signaling	Joint clustering and topological interference management (TIM) framework	Computation time is reduced	Uplink or Downlink (UL/DL)	Centralized

The interference management scheme can be broken down into three categories:

1. Interference Avoidance. This techniques used to avoid interference between D2D links and cellular links. The example might be the simultaneous D2D transmissions and proposed a multiuser D2D system that is called “MD2D”.
2. Interference Coordination schemes have significant advantages in In band D2D communication. For the Centralized Interference Coordination (CIC) scheme, this involves the monitoring from the BS.
3. Interference Cancellation techniques use advanced decoding and coding schemes for the cancellation of interference signals at the DUE or CUE. The techniques used can enhance the cellular network’s capacity.
4. Security and Privacy in D2D Communications

D2D communications offers a hybrid framework where the centralized and the distributed approaches are paired together. That is why it is risky to some of the privacy and security threats that are being identified by both the ad-hoc wireless and the cellular networks.

Table 2. **Overview of security issues and recently proposed solutions.**

No	Problem	Algorithm	Attack Addressed	Findings	Limitations
1.	Interference among LTE-U network, D2D users and channel access in existing Wi-Fi systems	User Sub-channel Matching Algorithm for LTE and D2D users	Address Spoofing	Significantly improve the system sum rate	Need to consider Wi-Fi performance degradation
2.	Lack of protection for cellular users against eavesdropping	Optimization-Based Access Assignment Scheme for D2D	Eavesdropping	Improves the physical-layer security of cellular	Consider protecting only single cellular

ISSN 2792-4017 (online), Published under Volume:1 Issue: 4 in September-2021

JEDIC Journal of Ethics and Diversity in International Communication
| e-ISSN: 2792-4017 | www.openaccessjournals.eu | Volume: 1 Issue: 4

		users		users and achieved maximum secrecy throughput with the optimal threshold	user in the presence of multiple eavesdroppers
3.	Lack of trusted devices to execute secure data aggregation without a base station	Security protection mechanism of private data based on homomorphic encryption	Packet Sniffing	Improves the security and optimizes the resources allocation in D2D network	Further studies on election factors and the impact of the dynamics of wireless devices on D2D networks
4.	Lack of privacy-preserving and secure scheme in D2D group communications	Key Agreement and two privacy-preserving authentication protocols	Replay Attack	Improves the security, efficiency, and effectiveness of the protocols	No real applicability evaluation in a 5G D2D communication
5.	Maturity of key generation in the physical layer security (PLS) technique	Secure Key Generation (SKG) scheme	Eavesdropping	Improves information confidentiality	Need to combine authentication of higher layer and information confidentiality
6.	Unassisted third-party devices mutual communication	Dynamic group key agreement protocol	Masquerade Attack	Achieves high entropy group session key for D2D group communication and improved the security	No real applicability evaluation in a 5G D2D communication

Some of the security threats faced by D2D communications can affect the confidentiality, authenticity, availability and also integrity of the network. Table 2 shows an overview of security issues and recently proposed solutions.

3. Power Control

Power control can be defined as the process of adjusting the BS's power levels during DownLink (DL) transmissions and the user equipment (UE) during UpLink (UL) transmissions. The need to increase the transmission power of a device exists because it can also increase the link capacity. However, this will lead to incremental interference among the devices that share the same resources. Table 3 describes a summary of power control issues and proposed solutions.

***Table 3.* Summary of power control issues and proposed solutions.**

No.	Problem	Proposed Method	Findings	Limitations
1.	Power control distribution	Theoretic framework using Mean Field Game (MFG)	Achieves higher energy efficiency compared with the blind power control scheme	Increasing the energy means increasing the interference power and decreases the spectrum efficiency
2.	Imperfect wireless Channel State Information (CSI) power control	Truncated channel inversion and ON-OFF power control scheme	Imperfect CSI and misinformation lead to the degradation of performance especially for high target SINR	Estimation error is a key parameter that should be consider during network design
3.	Contamination and training sequence overhead reduction in D2D underlay massive MIMO networks	Revised Graph Coloring-based Pilot Allocation (RGCPA) algorithm	Pilot overhead is reduced and the effect of pilot contamination is cancelled	The sum power monotonically decreases and converges rapidly for different value
4.	Sparse Code Multiple Access (SCMA) power allocation	Graph theoretic approach	Energy efficiency performance is enhanced and network capacity is upgraded	Need to compare the algorithms with different schemes
5.	Power control under	Power control	Achieves higher throughout	Combine the admission

ISSN 2792-4017 (online), Published under Volume:1 Issue: 4 in September-2021

JEDIC Journal of Ethics and Diversity in International Communication

| e-ISSN: 2792-4017 | www.openaccessjournals.eu | Volume: 1 Issue: 4

	different constraints	scheme using Particle Swarm Optimization (PSO)	than the optimal strategy	control into power control scheme and the joint channel allocation
6.	Power control is non-convex and intractable	D2D transmit power control schemes	D2D rates converge to a rate ceiling at high signal-to-noise ratio	The energy signal transmission is less effective when performance gaps are small

One of the benefits of power control techniques is its help protecting energy resources. These techniques allocate radio resources that have been used in resource allocation to different users or devices. Power control algorithms can be split into two broad categories, which are centralized and distributed.

4. Mode Selection

The user equipment can communicate with the BS directly in the D2D cellular network. This capability is beneficial, and it significantly improves the network performance in terms of delay and network throughput. Table 3 shows overview of mode selection issues and recently proposed solutions. Nevertheless, D2D also creates other new challenges in terms of resource management and network overloading.

Table 3. **Overview of mode selection issues and recently proposed solutions.**

No.	Problem	Solutions	Contributions	Limitations
1.	Joint mode selection, power control problem, and resource group (RG) assignment for D2D underlaid cellular networks	RG assignment, joint optimal mode selection, and power allocation design for D2D	Improves the system sum rate significantly compared to the conventional schemes	Focus more on optimizing the communications mode in relay-based D2D communication
2.	The effects of network interference profile to D2D mode selection and vice versa	IA-based coding strategy and DoF-based mode selection	Better performance than in high SNR regime, low interference environment, large MIMO systems, and small-cell networks	Further analysis on small/medium antenna systems and large-cell networks
3.	Link allocation and mode selection problem under coalition formation game	Distributed coalition formation algorithm	Achieves better performance for cellular users	Need to extend the single cell scenario to a multi-cell scenario, and implement some joint optimal solutions
4.	Problem in evolutionary game formulation in mode selection	Evolutionary game-based distributed D2D mode selection algorithm	Achieves higher utilities than the baseline schemes	Need to consider other D2D communication modes
5.	Spectrum partition and mode selection problem from physical layer	Theoretical framework for optimization of both D2D pairs and cellular users (CUs), and the performance modeling	PLS performances of the CUE and D2D pair can be flexibly controlled by mode selection and spectrum partition	Need to consider the performance evaluation for the case with two CUEs and two D2D pairs
6.	Resource allocation and joint relay selection problem for relay-assisted D2D	Greedy-based mode selection and channel allocation algorithm	Transmission data rates is maximized while guaranteeing the minimum QoS requirements for both CUs and D2D users (DUs)	Study the impact of social attributes among users on the performance of D2D communication networks

Generally, there are four modes of communication for the user equipment:

1. Pure cellular mode—used when low resources are available and there is high interference because there is no D2D communication. This does not allow D2D users to transfer their data;

ISSN 2792-4017 (online), Published under Volume:1 Issue: 4 in September-2021

2. Partial cellular mode—without sharing the co-channel spectrum, this mode allows the UEs to communicate through the BS;
3. Dedicated mode—allows the user equipment to communicate with other user equipment using dedicated spectrum resources;
4. Underlay mode—allows D2D users and cellular user equipment to share the uplink and downlink resources.

III. CHALLENGES IN D2D COMMUNICATION

There are various open issues and challenges which are neededan attention on D2D communication in 5G IoT environments. They are highlighted in the following discussion.

3.1. *Challenges in Device Discovery.* Some of the challenges identified in devices discovery are presented as open research issues:

- *Synchronization*. The synchronization in D2D communication occurs between devices in the system and the BS. The time frame and the scheduling will be shown by the BS. However, the device discovery will face a challenge when the secondary device that are associated with the primary devices are outside of the BS coverage. The devices in the asynchronous discovery situation require continuous searching for different devices in proximity.
- *Multicell Device Discovery.*
- *Discovery Messages Frequencies.*
- *Initial Device Discovery Signal.* This refers to the devices communicating with an initial discovery signal to discover the neighboring devices. However, any proximal device can effectively obtain this signal.

3.2. Challenges in Interference Management. This paper also highlights the challenges in interference management for D2D communications in the 5G environment for future studies.

- *Cell Densification and Offloading.* Network densification can be defined as a simple but important instrument that is used in increasing the capacity of network in 5G cellular networks. This approach has been used over several cellular generations to enhance the network capacities. Furthermore, ultra-dense networks make resource allocation more challenging because of the massive number of devices and the random device locations.
- *D2D in mmWave Communication.* One of the features that are considered crucial in 5G networks that recently gained notable attention is the mmWave band communication. It is fully anticipated that for future 5G cellular networks, mmWave mesh networks will replace the traditional structure that used copper or fiber, in order to offer mesh-like connectivity and rapid deployment.

3.3. Challenges in Security. Research challenges for D2D security that need to be highlighted in the future are highlighted below:

- *Balancing Security-Energy Trade-off.* It is impractical to utilize security techniques that use a lot of energy in a limited resource devices in D2D communication. Therefore, to ensure the optimal device resources usage, a secure energy-efficient protocol needs to be implemented.
- *Nonrepudiation*. In the D2D network, it is crucial to maintain nonrepudiation so that data integrity is preserved. However, the current research on D2D communication lacks a complete security architecture that can be used for the device authentication and users.
- *Lack of Standardization*. To ensure the secure communication of D2D user equipment, there are no global standards or policies available. Furthermore, the mechanism that is used to authenticate different applications could vary, which makes it is difficult to guarantee interoperability.
- *Decentralized Anonymity Schemes.* Due to the nature of D2D communications, which are peer-to-peer, opportunistic, and self-organizing, an anonymity scheme that is independent and not reliant on centralized third parties is required.
- *Privacy and Security*. Elliptic Curve Cryptography, AES-128, and access points are some of the cryptography techniques that are traditionally used for protecting privacy and security.

3.4. Challenges in Power Control. Several challenges of the power control aspect that can be used as a reference for future studies are identified as follows.

ISSN 2792-4017 (online), Published under Volume:1 Issue: 4 in September-2021

- *One Large Network or Multiple Small Networks.* The resource management challenges such as power control are associated directly with the user volume in the network. Power and frequency resources can be managed equally in small networks.

- *Optimal Transmission Power*. Making sure that the transmission power of D2D devices is well maintained is extremely crucial. For example, the transmission power should not be too low in order to attain a superior quality of D2D links.

3.5. Challenges in Mode Selection. Some of the research challenges in the mode selection of D2D communication is highlighted in below:

- *Mode Alterations Volume.* One of the specific challenges in mode selection is the frequencies of the mode alteration that have to be done. Due to the wireless channel random nature, the mode alteration can happen as frequent depending on the mobility of devices and the number of scatterers.

- *Mode Selection Overhead*. A high amount of overhead can be incurred by the mode selection process. The overhead includes control signaling and channel estimation. Channel estimation can be generated based on the CSI of the links.

- *Dynamic Mode Selection*. The majority of studies consider the static network scenario. These studies primarily focus on the downlink scenarios in which the BS becomes the mediator for the D2D pairs to communicate.

IV. CONCLUSION

There are many benefits that are expected to be provided by the D2D communication when compared to the traditional cellular networks. D2D technologies show great potential to be the most favorable and promising paradigm for future networks. We have highlighted, a detailed review of the current existing D2D technologies together with their characteristics, such as device discovery, interference management, security, mode selection, and power control. We review various proposed solutions with a goal to achieve a secure Device-to-Device (D2D) communication in 5G.

We summarize the existing solutions by highlighting the issues or problems of the research and the proposed solutions. Based on the comprehensive analysis, we further identified the open problems and challenges that deserve future research. Even though D2D communication is considered a relatively new idea, the remarkable amount of studies and research in D2D has triggered various aspects of related research problems and challenges that can be explored in the future.

V. REFERENCES

1. Goudos, Sotirios K.: “A survey of IoT key enabling and future technologies: 5G, mobile IoT, sematic web and applications.” // Wireless Personal Communications 97.2 (2017): 1645-1675.

2. Kh. Khujamatov, D. Khasanov, E. Reypnazarov, N. Akhmedov. Networking and Computing in Internet of Things and Cyber-Physical Systems // The 14th IEEE International Conference Application of Information and Communication Technologies, 07-09 October 2020, Tashkent, Uzbekistan. **DOI:** 10.1109/AICT50176.2020.9368793

3. Bahga, Arshdeep, Vijay M.: Internet of Things: A hands-on approach. Vpt, 2014.

4. SobiyaArsheen, Abdul Wahid, Khaleel Ahmad, Kh. Khujamatov. Flying Ad hoc Network Expedited by DTN Scenario: Reliable and Cost-effective MAC Protocols Perspective // The 14th IEEE International Conference Application of Information and Communication Technologies, 07-09 October 2020, Tashkent, Uzbekistan. **DOI:** 10.1109/AICT50176.2020.9368575

5. Bhavani, Satish T., Shameena B.: “Agriculture productivity enhancement system using IOT.” // Int. J. Theor. Appl. Mech 12.3 (2017): 543-554.

6. Halim Khujamatov,ErnazarReypnazarov, NurshodAkhmedov, DostonKhasanov. Blockchain for 5G Healthcare architecture // 2020 International Conference on Information Science and Communications Technologies (ICISCT), Tashkent, Uzbekistan – 2020. **DOI:** 10.1109/ICISCT50599.2020.9351398

7. Robot-R-Us-Singapore // https://www.robot-r-us.com

8. Halim Khujamatov, ErnazarReypnazarov, NurshodAkhmedov, DostonKhasanov. Industry Digitalization Consepts with 5G-based IoT // 2020 International Conference on Information Science and Communications Technologies (ICISCT), Tashkent, Uzbekistan – 2020. **DOI:** 10.1109/ICISCT50599.2020.9351468

ISSN 2792-4017 (online), Published under Volume:1 Issue: 4 in September-2021

9. Karunakanth M., Venkatesan R., Jaspher G., Kathrine W.: “IOT Based Smart Irrigation System for Home Based Organic Garden.” // International Journal of Pure and Applied Mathematics 119.12 (2018): 16193-16200.

10. Halim Khujamatov, TemurToshtemirov. Wireless sensor networks based Agriculture 4.0: challenges and apportions // 2020 International Conference on Information Science and Communications Technologies (ICISCT), Tashkent, Uzbekistan – 2020. **DOI:** 10.1109/ICISCT50599.2020.9351411

11. Kumar, Akshaya A., Kumar S.: “Comprehensive Review on pH and Nutrients Detection Sensitive Materials and Methods for Agriculture Applications.” // Sensor Letters 17.9 (2019): 663-670.

12. IlkhomSiddikov, KhalimKhujamatov,DostonKhasanov, ErnazarReypnazarov. IoT and Intelligent Wireless Sensor Network for Remote Monitoring Systems of Solar Power Stations //Advances in Intelligent Systems and Computing https://doi.org/10.1007/978-3-030-68004-6_24.

13. Rajeswari S., Suthendran K., Rajakumar K.: “A smart agricultural model by integrating IoT, mobile and cloud-based big data analytics.” // 2017 International Conference on Intelligent Computing and Control (I2C2). IEEE, 2017.

14. KhalimKhujamatov,DostonKhasanov, ErnazarReypnazarov, NurshodAkhmedov. IoT, IIoT, and Cyber-Physical Systems Integration // Advances in Science, Technology and Innovation. https://doi.org/10.1007/978-3-030-66222-6_3

15. KhalimjonKhujamatov, DostonKhasanov, ErnazarReypnazarov, NurshodAkhmedov. Existing Technologies and Solutions in 5G-Enabled IoT for Industrial Automation // Advances in Science, Technology and Innovation. https://doi.org/10.1007/978-3-030-67490-8_8.

16. Ashwini J.: “A study on smart irrigation system using IOT for surveillance of crop field.” // Brindavan college of engineering, Banglore, India, IJET 7.4.5 (2018): 370-373.

17. KhujamatovKhalimjonErgashevich,KhasanovDostonTurayevich, FayzullaevBayramArtikbayevich, ReypnazarovErnazarNurjamiyevich. WSN-based research the monitoring systems for the solar power stations of telecommunication objects // IIUM Engineering Journal, Vol. 22, No. 2, 2021. https://doi.org/10.31436/iiumej.v22i2.1464

18. Halim Khujamatov, ErnazarReypnazarov, NurshodAkhmedov, DostonKhasanov. IoT based Centralized Double Stage Education // 2020 International Conference on Information Science and Communications Technologies (ICISCT), Tashkent, Uzbekistan – 2020. **DOI:** 10.1109/ICISCT50599.2020.9351410

ISSN 2792-4017 (online), Published under Volume:1 Issue: 4 in September-2021