

Device-To-Device (D2D) Data Communications in 5g Networks

Nkolika O. Nwazor and Victory K. Ugah

Electrical/Electronic Engineering Department, University of Port Harcourt, Nigeria

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ABSTRACT

The Device-to-Device (D2D) communication technology in the 5G network is a futuristic design with world-changing potential. Its known applications include; cellular offloading, machine-to-machine (M2M) communication, content distribution, and relay communication. These will increase the speed and throughput of communication, improve the energy efficiency for communication, extend base stations (BS) coverage capability, and lower communication latency. 5G D2D has the potential of creating and maintaining a localized communication network, without the need for BASE STATION. This work reviewed D2D communication in the 5G network. It highlighted the expectations for 5G communication, especially the D2D architecture. The different 5G D2D classifications – in-band mode, out-band mode, and relay communication mode – are discussed, together with their applications and limitations. Some of the challenges faced by the D2D architecture include intelligent device discovery, interference management, resource management, mode selection, and security, which are open research areas. The work recommends the mode selection solutions that involve the default use of in-band mode but with options to manually switch to out-band or relay mode. The relay mode could also be activated automatically in special cases. The recommended security solutions involve the use of interference management and cellular/wireless communication security measures.

I. INTRODUCTION

In the past, to increase the data transfer speed and capability for communication, some brilliant methods have been applied. Methods such as the use of frequency division multiplexing (FDM), time division multiple access (TDMA), code division multiple access (CDMA), global system for mobile communications (GSM), general packet radio service (GPRS), universal mobile telecommunications system (UMTS), high-speed

packet access (HSPA), evolved high-speed packet access (HSPA+), long term evolution (LTE), evolved packet system (EPS), multiple-input multiple-output (MIMO), orthogonal frequency division multiple access (OFDMA), single carrier frequency division multiple access (SC-FDMA), coordinated multipoint (CoMP), carrier aggregation, evolved multimedia broadcast multicast service (MBMS), and frequency division duplex-time division duplex carrier aggregation (FDD-TDD CA). These communication architectural evolutions were engineered to increase the bandwidth, efficiency, and overall speed while reducing the latency in electronic communication. These advancements did not happen overnight, starting from the 1980s, telecommunication has had great improvements which led to the first generation (1G), second-generation (2G), third-generation (3G), and fourth-generation (4G) evolutions (Opeoluwa et al, 2018).

Still, the fifth generation (5G) evolution in telecommunication is here in the spirit of constant improvement. In addition to several great telecommunication techniques such as CoMP, SC-FDMA, OFDMA, and FDD-TDD CA, 5G also includes filter bank multicarrier (FBMC), non-orthogonal multiple access (NOMA), universal filtered multi-carrier (UFMC), and multi-radio access technologies (multi-RATs) amongst others. Another additional telecommunication evolution in 5G is the device centricity aspect. Device centricity design uses direct communication between devices, thereby avoiding wasting the energy and time needed to go through a network infrastructure. This device-centric design, such as the device-to-device (D2D) communication promises better human communication, machine type communication (MTC), machine-to-machine (M2M), and internet of things (IoT) communication capabilities (Opeoluwa et al, 2018).

Gupta, Jain and Chan (2016) described 5G as a network for the future. 5G network is seen as a network that will provide limitless access from

anywhere, for anyone, at any time, for anything (Gupta and Jha, 2015). These definitions show how anticipated and important the 5G network is. As (Opeoluwa et al, 2018) puts it, 5G would create a unified air interface in establishing end-to-end connectivity between things such as smartphones, cars, wearable gadgets, utility meters, fridges, freezers, boilers, and many more. Farzamiyan (2019) expressed that 5G was designed to successfully handle all the demands for higher data rates and to support several applications that 4G cannot handle.

II. 2.0 DEVICE-2-DEVICE DATA COMMUNICATION IN 5G

Rupendra and Dharma (2015) referred to the D2D future in the 5G network, and its application in M2M and IoT communication, as a futuristic scenario for smart living. D2D communication was initially proposed as a new paradigm in cellular networks, to enhance network performance (Arash, Qing, and Vincenzo, 2014). Mohd and Zuriati (2020) expressed D2D communication as a new dimension in the mobile environment which eases the data exchange process between physically neighbouring devices, thereby enabling effective utilization of available resources, reducing latency, improving data rates, and increasing system capacity. Device-to-device (D2D) is a radio communication technology that allows devices to directly exchange data without the need for base stations or access points (Gharaibeh et al, 2017). Simply put, Device-to-Device communication is the direct communication between devices without traversing a Base Station (BS) or core network.

2.1 Classifications of 5G D2D

The D2D communication architecture in the 5G network is designed to function in three modes, namely; in-band, out-band, and D2D relay communication (Omar, Razali, and Yasser, 2019). They are also referred to as in-coverage, out-of-coverage, and relay-coverage respectively (Farzamiyan, 2019).

2.1.1 In-band D2D Communication

This involves the use of licensed spectrum for device-to-device communication. In this mode, the devices are supervised and controlled by a base station. Therefore the devices must be located within the coverage area of the base station. This location limitation is a disadvantage to this mode of D2D communication, but it has the advantages of better-managed and organized D2D communication.

2.1.2 Out-band D2D Communication

This involves the use of an unlicensed spectrum for device-to-device communication. This kind of D2D

communication is like that in Wi-Fi, ZigBee, and the like. It has no base station coverage limitation, but this also means that general control and management of this mode of D2D communication will be harder to achieve.

2.1.3 D2D Relay Communication

This is the use of D2D communication as an extension to increase the base station coverage of a network. In this kind of D2D communication, devices that are not within the base station coverage can communicate with the base station via other devices which are within the base station coverage. So essentially, the devices within the base station coverage act as sub-base stations and help in cellular offloading, content distribution, and range extension of the network.

Several mode selection studies have been researched (Park, Kim, Kim, and Hur, 2017), but it is recommended that 5G D2D enabled devices should be in in-band mode by default, but with options to manually switch to out-band mode if required. The relay mode should also be a manually switched option but could be set to automatic activation for special cases such as smart vehicle communication. The default in-band mode should inherently handle cellular communication, while the manually switched out-band mode should not. The manually/automatically switched relay mode should have cellular communication capability which activates when within the base station coverage area. The automatic mode selections should consider the energy demand and necessity of service. The active mode should be indicated together with the signal strength display of the device.

In terms of security in in-band mode, present security measures for cellular communication are good for a start. Network over-provisioning and reservation of network resources would be helpful. The base stations will need improved monitoring and resources sharing capability. For out-band mode, password protection, enhanced encryption and improvements on existing wireless communication security measures will be sufficient. For relay mode, a combination of in-band and out-band mode security measures should be applied to reduce interference.

It is recommended that all 5G D2D communication modes use licensed spectrums. This would help reduce interference, signal jamming, and would also encourage special study focus on the spectrum to improve the bandwidth, bitrate, reliability, availability, integrity, accessibility, authenticity, and overall quality of the service.

2.2 Merits of 5G D2D Communication

The design features of D2D communication in 5G networks comes with a lot of favourable packages. Some of these merits include;

- i. Improved privacy and anonymity.
- ii. Enhanced energy efficiency.
- iii. Ultra-low latency.
- iv. Offloading of cellular traffic.
- v. Increased overall throughput.
- vi. Enhanced communication coverage.

The 5G D2D communication technology has the potential of opening the door to new, yet imagined, communication discoveries and advancements.

2.3 Demerits of 5G D2D Communication

Being a relatively new architecture for network communication, D2D communication has many challenges that should be tackled in order to successfully execute the planned communication system. These challenges include (Farzamiyan A, 2019; Udit K. and Debarshi S, 2017);

- i. Effective peer discovery
- ii. Synchronization of devices
- iii. Proper resource allocation
- iv. Efficient mode selection
- v. Interference management

As pointed out by Mohd and Zuriati (2020), a successful D2D communication technology requires;

- i. Complex resource management techniques.
- ii. Efficient device discovery mechanisms.
- iii. Intelligent mode selection algorithms.
- iv. Robust security protocols.
- v. Mobility management procedures.

2.4 Applications of Device-2-Device Communication

Some forms of direct interconnection between devices have existed for some time. Earliest forms of which were the wired interconnection, then the wireless interconnections such as; Bluetooth, Wi-Fi, ZigBee, Near-Field Communication (NFC) and others. These are all used to enable communications between devices without the need for a base station, but they are different for the D2D communication for the 5G network. According to (Omar, Razali, and Yasser, 2019), D2D has over ten times more range, about a thousand times faster bitrate, and better quality of service.

Some of the current applications of D2D communication include:

- i. IoT applications like; smart refrigerators, smart alarm systems, smart doors, Amazon Echo, Google Home, smart vehicles, etc.
- ii. Wearables like; smartwatches, AI hearing aids, Google glasses, etc.

According to (Kar and Sanyal, 2018), it supports information sharing, and data and computation offloading.

III. CONCLUSION

The Device-to-Device (D2D) communication technology in 5G architecture is an important feature with world-changing potential. It has numerous applications such as offloading of cellular traffic, content distribution and relaying, and machine-to-machine communications. It is designed to improve the throughput, reduce delay, and enhance the energy efficiency of communication. But this promising technology faces some challenges. It requires improved methods for peer discovery, resource allocation, mode selection, and security. Some mode selection and security design solutions are recommended in this work.

The recommended mode selection solutions involve the use of in-band mode as the default D2D selection, with options to switch to out-band or relay mode. Relay mode could also be activated automatically in special cases. The recommended security solutions involve the use of cellular/wireless communication security measures, passwords, encryptions, and interference management measures.

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