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ENHANCING USER EXPERIENCE IN 5G NETWORKS THROUGH DYNAMIC MODE SELECTION IN D2D MOBILITY MANAGEMENT SCHEME

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ABSTRACT

The neediness of cordless apps and offerings with high bandwidth requirements over the years has increased the demand for high-speed internet and data volumes exponentially. Current wireless networks like 4G LTE technology face issues from this increase in demand as they battle to keep up with users' growing demands. To satisfy the rising demand for wireless data, 5G cellular networks have been created as a solution to this issue. D-2-D communication has emerged as a brand-new cellular communication paradigm. This technology enables the User Equipment (UE) in 5G cellular networks to instinctively communicate without going through the evolved Node-B (eNB). D2D communications enhance the efficiency and capacity of wireless networks and play a crucial part in ensuring the level of service quality (QoS). However, several unresolved issues, such as mode selection, need to be addressed and mobility management for better performance. It should be managed wisely so that it provides lower latency, less complexity, lower power consumptions, and minimum potential data continuity connection which are primary for cell phone networks of the future. In this paper, we proposed an updated D-2-D mobility management protocol that is performance-based and enhances the user experience in 5G networks utilizing mode selection. The proposed scheme considers the user's travel between different locations which is the mobility patterns of devices and dynamically selects the optimal mode of communication to minimize the handover delay.

Index terms: D2D communication, 5G, mode selection, handover, mobility management.

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1. INTRODUCTION

In the context of mobile technology, the fifth-gen (5-G) is the upcoming important advancement in technology of communicating through mobile is beyond the IMT-Advanced/4-G standards now in use. The 5-G network is expected to meet all of the key telecommunications data service demands as well as a new wave of developing applications, including automated vehicles, VR tech, and the Internet of things.

One key feature of 5G, Device-to-Device (D-2-D) communication is an upcoming tech where two neighbouring mobile U-Es (User Equipment) convey within them without any Ground Station (BS) or main network. D-2-D communication offers multiple benefits in terms of spectrum efficiency, throughput, area expansion, delay, and capacity enhancement by re-utilizing radio's network resources and permitting network main functions to the devices due to the short range of communication between the D2D duo.

In addition to this, D2D communication also makes new possible services such as sharing files, videos, or pictures, games, public safety, location-based commercial proximity, connectivity extension, and traffic off-loading [1]. Owing to the mentioned benefits, D2D communication is regarded as one of the fundamental technologies in next-generation networks. Spectral Efficiency, Bandwidth, and Cell Size are the three main parameters that affect cordless communication capability. Yet, the group of cells that can be in an area and available licensed spectrum is constrained as a result of different cost considerations. Thus, the 5th gen communication(5G) [2], [3] exploits the under-utilized high-frequency millimeter to address this problem wave (mmWave) band.mmWave technology is expected to provide a century times greater speed and capacity compared to the current Long Term Evolution (LTE) mobile spectrum.

However, as devices move in and out of coverage areas, managing mobility in D2D communication poses a significant challenge and conventional cellular communication may still be necessary for certain scenarios. Therefore, to ensure seamless connectivity and reduce handover delays, mobility management strategies for D2D communication are crucial. Mode selection is another important aspect of mobility management in 5G D2D communication. Based on the state of the network at the time, such as signal strength and interference levels, mode selection assists devices in choosing between direct communication and conventional cellular communication. This feature significantly enhances the performance of D2D communication by enabling devices to switch between communication modes dynamically depending on the network conditions.

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2. REVIEW OF RELATED WORK

A. D-2-D in 5-G

A device can directly connect with another device through wireless means in a D2D communication system to boost total bandwidth and spectrum effectiveness. Hence, traffic in ground stations is offloaded. It is an interaction technique that allows any direct communication device during data transmission without the assistance of significant infrastructure, such as a ground station. Only the devices must be controlled by base stations for them to communicate. D2D communication can be used in a variety of ways to enhance performance in general. If a device is situated outside of a base station's coverage area, the Signal Interference plus Noise Ratio (SINR), a measurement of the quality of the received signal at a given receiver about the interference and noise levels present in the environment, is often poor. As a result, it's possible that the gadget cannot communicate with other devices using base stations. However, if the device is close to another device, using the second device as a relay could help to increase the overall coverage area. Then, there is an increase in overall spectrum utilization.

Yet, enabling D-2-D communication on a network could dramatically improve its overall energy efficiency. When a device is utilised as a relay, the ground station does not require communication with full power because the device sends and receives from a relatively small distance, using less power to deliver data to another device.

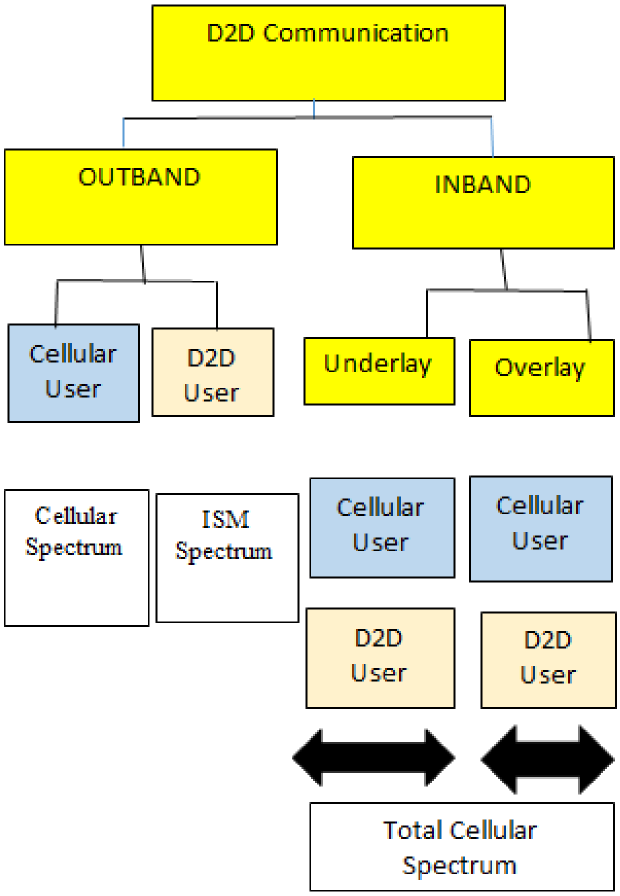

Figure-1. Major classification of D2D communications.

In [4] the authors emphasise 5 disruptive technological ways to use the 5-G network, including gadget-based design, massive MIMO, mmWave, smarter devices, and improved mobile broadband (eMBB) (D2D). The primary component of 5G networks, Massive MIMO, was created to increase efficiency; however, this enhancement is not possible without expanded BS densification. The purpose of this study does not extend to a description of all D-2-D communication capabilities and opportunities. The overview paper [5] covers all the fundamentals of D2D communication. Nonetheless, Figure-1 outlines each of the main D2D classes. It is also outside the purview of this text to provide a comprehensive summation of each category of them.

B. Mobility Management

Mobility management is a significant problem for any wireless communication system. While two devices are active, either one or both of them may shift location, but when they are using a cell phone, it is easy to maintain service. Mobility management becomes essential in D2D mode, though, as an appropriate algorithm is still being developed that can handle it without crashing. It is still difficult to build low-latency, reliable data transmission between two moving devices. Very few studies have so far tackled this. The latency for exchanging the controlling signal may rise when multiple base stations are involved in the handover, rendering D2D communications impractical when traveling. Seamless mobility management is essential because, in addition to the sentient-based use cases, one of the key uses is vehicle-to-vehicle connectivity (V2V), where a slight increase in latency could have catastrophic effects. In the paper [6], certain mobility management strategies are proposed, along with predicted small all-network gains. A mechanism for improving vehicle-to-vehicle quality of service and vehicle-to-infrastructure (V2I) links was also developed by the author in [7] and is based on performance parameters. Yet as more networks are used in the future, such a system won't be able to handle the demand on the networks. Mobile devices that are not easily portable are hardly ever accepted. Using cellular inband underlay D2D communication, a smart mobility system should have shorter latency, less battery consumption, and better data speeds. To guarantee lower signaling overhead, lower delay, well as uninterrupted D2D connection for the 5G cellular communication system, our idea is to assess the LTE's Advanced technology which presents a roaming management system.

An explanation of handoff and roaming management for the heterogeneous environment network (4-G) in LTE-A on a technical level is provided in papers [8], [9]. The events that influence the whole handover parameters are looked into by the authors in this research. Typically, a user's mobility is described in terms of three separate states, namely the idle, active, and detached modes. To provide the user with an uninterrupted service when the UE travels from one area to the next, a new ground station is required, this is when handover occurs.

The usual handover is not, however, applicable to D2D communication because it requires that both devices satisfy additional parameter requirements. Every communication's primary goal is to reduce latency. Two alternative types of solutions that could significantly minimize the delay were examined in Paper [7]. With certain simulation findings, the authors supported their solutions. These two smart solutions fall into two categories: D2D-triggered handover solutions and D2D-aware handover solutions. The authors suggest using a single BS to control all devices. That's because the extra overhead required to interact with two different base stations results in a significant increase in latency when different eNodeBs operate them. The performance suffers as a result. In our paper, we suggest a D2Daware handover under the proviso that source eNodeB will delay the handover until target eNodeB2 can satisfy the controls of both devices.

C. Mode Selection

In Device-to-Device (D2D) networks, the process of choosing an appropriate mode for communication between D2D user equipment (UE) is referred to as mode selection. This process is based on several variables, including channel quality, interference level, social relationships between users, and energy consumption. By choosing the best communication mode, it is possible to increase network throughput generally, lessen interference, and use less energy.

In [10] a mode selection strategy for D2D communications on cellular networks is suggested. The system chooses the best mode for D2D communication based on a threshold value, taking into account the channel quality and interference level. The research uses simulations to assess the proposed scheme's performance and demonstrates how it can increase total network throughput. [11] outlines a cooperative mode selection and resource distribution plan for D2D communications supporting cellular networks. The suggested plan maximises network throughput by carefully choosing modes and allocating resources. The research uses simulations to assess the proposed scheme's performance and demonstrates that it can significantly increase network throughput.

[12] presents a mode selection strategy for socially conscious D2D communications. The approach determines the ideal mode for D2D communication by taking into account the social relationships between users and their preferred communication channels. Using simulations, the paper assesses the efficacy of the suggested strategy and demonstrates how it might increase overall network throughput while lowering energy consumption. [13] proposes a method of mode selection for D2D communications in the unlicensed spectrum. The plan takes into account the cohabitation of Wi-Fi networks and D2D communications and chooses the proper mode to prevent interference. Using simulations, the article assesses the effectiveness of the suggested method and demonstrates how it might increase total network throughput and decrease interference.

3. PROPOSED METHOD

We offer a novel D-2-D communication mechanism in this section for use in next-generation networks. The plan uses mobility management to improve Quality of Service (QoS) while lowering costs, latencies, and energy usage. We concentrate on signaling cost, an important research area, to address these problems. A similar method was discussed in [14]. Our strategy consists of the following steps:

- A call is started by the user equipment.
- The UE and the destination node or cellular node are connected by the eNBB, which also gathers user-provided channel information.
- The UE and eNBB begin exchanging information. • A duo of resources pooling and a D-2-D duo within the cell converse simultaneously.
- The UE and C-N are calculated by the network.
- D2D communication occurs via a side-link when the UE and CN are in the same cell.

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- It is handed over. As a result, one of the main goals of our suggested approach is to lower the cost of signaling during D2D communication.

4. SIMULATION RESULTS

In this section, we'll concentrate on the pertinent computations and the suggested workings. The proposed scheme was evaluated using the conventional Lengthy Evaluation technique and has indeed been created using statistical data computations. It is predicted that mobility in D-2-D communication for mobile next-generation networks will interact frequently and play a significant role in moving users.

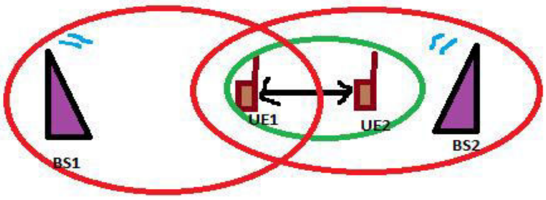

Figure-2. Proposed scheme of D2D Communication.

Consider two user equipment, When a consumer (UE2) travels swiftly between cells at a certain pace, the distance between the ground station (BS1) and UE2 is maximized, increasing the likelihood that its signal will be dropped as well as the cost of transmission. To resolve this problem with the proposed work, during the time of handover, seeing as UE1 is nearer to B-S-1 and U-E-1 conveys the signal to U -E-2 and B-S-1. So, the D2D mode of exchange of info occurs between the two user equipment (U-E-1 and U-E-2) and meanwhile, the ground station (BS2) is delayed until that point. Therefore, a device to-device crowd is created and side signal exchange happens without a ground station. We also had the factor that none of the devices are initially out of the network's coverage region and if any of the device moves away from It could serve as a repeater if it is beyond the broadband service zone but yet close to another D-2-D pair.

We outlined five potential operational scenarios that could happen about the best Mode Selection. These include calling mode, D-2-D mode, Relay option, Handover option, and Holdback option. Algorithm 1 shows the simplified manner in which modes are selected through the algorithm. The main variables that affect the improved decision-making are the selected lower limit and the total path degradation from the traveling gadget to the ground station. The simulation results are shown in Fig. 5, and it amply demonstrates the D-2-D mode's dominance over all five scenarios, which is the main objective of our model. We have implemented the design with MATLAB (R2016a) Using the L-T-E Organization's Toolbox; to create a simulated design based on the method.

The technique can be used when a user device is a part of a D2D group that changes over time due to mobility. We can come across two different scenarios in this instance, first within a cell and then in a different cell. The mobility management procedure takes into account the signal strength, overall latency, and needed efficient energy. Based on the distance from the source to the destination site, where the observer is the base station, and using the performance metrics we shall be able to determine the best possible values.

The service strength for traveling users is tested to ensure a reliable connection, which is discussed in [15] and derived as:

$$SS_m = SS(M_p) + 2SS(\bar{S}T) \quad (1)$$

Where, SS_m is the signal potency as users are moving about (mobility), and D-2-D connectivity is used to join to the desired node. M_p demonstrates ability metrics from the intended origin. While ST⁻ is the signal strength between the user and to ground station. We can use $SS(M_p)$ is,

$$SS(Mp) = F_{ss}C_i\left[\prod_m^n \sum_{i=1}^3 P_t^2\, dt + \prod_m^n \sum_0^{\varphi} t\right] \quad (2)$$

Where, F_{ss} is the spectral response aspect, which is affected by the bandwidth needed, the skipping frequency, the size of the data packet being sent, and the size of the packet itself.

$$F = \left[\frac{d_p + SS_r + SS_{rp}}{BW}\right]\varphi + \theta + \theta_{\varphi-1}(\varphi - 2) \quad (3)$$

Signal power between the corresponding source and target has been calculated to be,

$$SS(\bar{S}T) = F_{ss}C_i\left[\sum_{i=1}^3 P_t^2 + \sum_0^{\varphi} t\right] \quad (4)$$

We have the formula given for a high Signal Noise Ratio and complete load,

RSRP (dBm)= RSSI (dBm) -10*log (12*N) (5)

Here, R-S-R-P is the Reference Signal Receive Power and R-S-S-I shows the strength of the transmitted signal Index, which is further calculable using the equation beneath.

RSSI = wideband power = noise + serving cell power (6)

+ interference power

Reference Signal Received Quality (RSRQ) is done by the following equation.

RSRQ = n x RSRP / RSSI, where, n denotes the (7)

number of physical resource blocks (PRBs).

Total path loss is calculated according to the paper [16].

$$Pathloss(PL) = \alpha.PL_{LOS} + (1-\alpha).PL_{NLOS} \quad (8)$$

where α is the proportion of D-2-D consumers on aggregate in areas with line of sight (LOS) and areas without line of sight (NLOS). PL_{LOS} and PL_{NLOS} are the path loss for the line of sight and non-line of sight distance respectively and calculated by

$$PL_{LOS/NLOS} = K_1 + K_2.log10.d \quad (9)$$

where K_1 and K_2 are the path loss coefficients calculated from the receiving and transmitting antennas along with the usage of the frequency. d determines the distance between the D-2-D users.

The total of calculated shadowing loss is as follows:

$$\mathrm{L(r)} = \mathrm{R}(\Delta\mathrm{r}).\mathrm{L}(\mathrm{r} - \Delta\mathrm{r}) + \sqrt{1 - \left(\mathrm{R}(\Delta\mathrm{r})\right)^2}.\sigma.\mathrm{X} \quad (10)$$

where X is a zero-mean, unit variance Gaussian random variable. α is the standard deviation. The calculation of R(Δ r) is in the paper [17] which shows the de-correlation distance of shadow fading and the distance between the two areas.

Multi-path fading is calculated using the equation:

$$ML = 10\log(-\log Y) \quad (11)$$

where Y is a random variable with uniform distribution.

The next generation of cellular systems, such as 5G, are taking network handling practices into account rather than manually handling and the same mobility management concepts are applied. All call connections inside a cellular network, including call arrival and departure rates, are based on the network's mobility rate and the amount of available bandwidth.

$$\gamma(x) = \xi(x)/ v(x) \quad (12)$$

Where the numerator and denominator denote the call arrival and departure ratio concerning its time and x represents the location of the user. The coordinates of D-2-D users can be known by using the technique of direction of arrival estimation [17] [18].

DATA:

All loss within D-2-D according to data collected from the base station = SrcBD2D,
D-2-D's threshold = SrcThreshD2D,
All losses within the D-2-D Transmitter and ground station = SrcLDTransBS,
Threshold from D-2-D Transmitter to ground station = SrcThreshDTransBS,
All losses from D-2-D Receiver to ground station = SrcLDRcBS,
Threshold within D-2-D Receiver to ground station = SrcThreshDRcBS.
Destination Base station:
Every loss within D-2-D = DtLD2D,
D-2-D pair's threshold = DtThreshD2D,
All loss from D-2-D Transmitter to base station = DtLDTransBS,
The threshold from D-2-D Transmitter to Base station = DtThreshDTransBS,
All losses from D-2-D Receiver to BS = DtLDRcBS,
The threshold from D-2-D Receiver to BS = DtThreshDRcBS.
If SrcLD2D <= SrcThreshD2D and SrcLDTransBS <= SrcThreshDTransBS and SrcLDRcBS <= SrcThreshDRcBS:
then
Choose Mode called D2D;
else
Check up on the new practical method;
end
if SrcLD2D SrcThreshD2D and SrcLDTransBS SrcThreshDTransBS and SrcLDRcBS SrcThreshDRcBS:
then
choose a Mode called cellular;
else
Check up on the new practical method;
end
if SrcLD2D SrcThreshD2D and SrcLDTransBS SrcThreshDTrans BS and SrcLDRcBS SrcThreshDRcBS:
then select the hold back option to observe how the UE is altering direction;
else
Check out the new practical method;
end
if SrcLDTransBS SrcThreshDTransBS and DtLDTransBS DtThreshD2D and DtLDRcBS DtThreshDRcBS:
then
start the handover process;
else
Check up on the new practical method;
end
if SrcLDTransBS SrcThreshDTransBS and DtLDTransBS DtThreshDTransBS and DtLDRcBS <= DtThreshDRcBS and DtLD2D DtThreshD2D:
then
choose a Mode called Relay;
end

Algorithm 1: Mode selection algorithm.

Table-1. Simulation parameters values.

Parameter	Value
Total loss	path loss + shadow fading + multi-path [16]
Handover trigger	D-2-D aware
Handover type	Group handover
Handover Threshold	114dBm
Duplexing	TDD
Walking	model Random
Resource used	Uplink
Types of D-2-D	Underlay Inband
Network Layout	2 Sites and no grid maintained
K1	17.6 dB (N-L-O-S) and 39.8dB (LOS)
K2	43.2 dB (N-L-O-S) and 16.8dB (LOS)
σ(for urban areas)	3dB (L-O-S and N-L-O-S)
Number of resource blocks	100 resource block/20KHz (Full)
MATLAB version	2016a
Total simulation performed	200

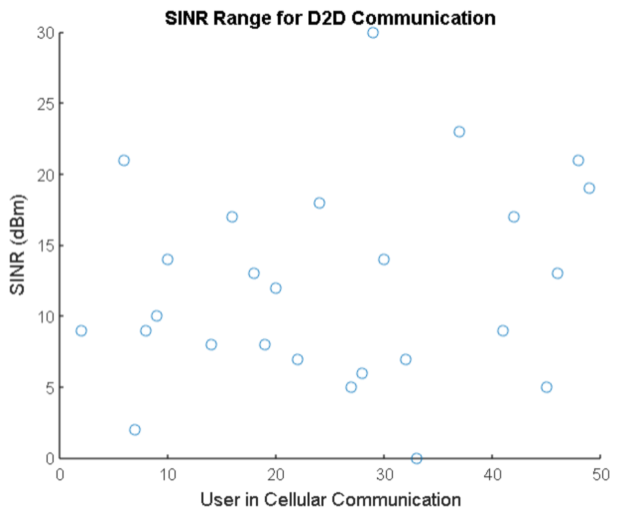

Figure-3. SINR range for cell network D-2-D communication.

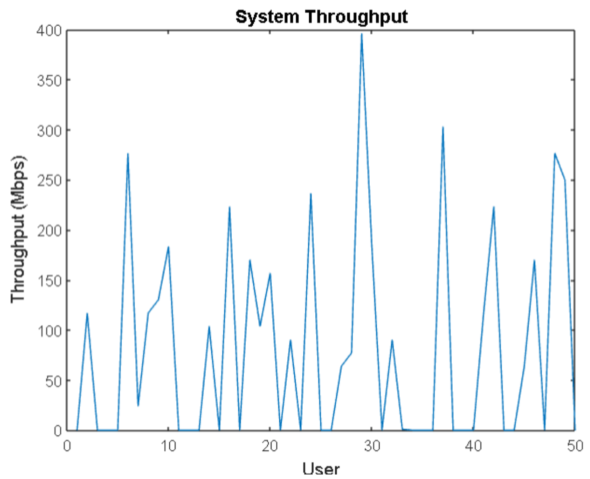

Figure-4. System throughput.

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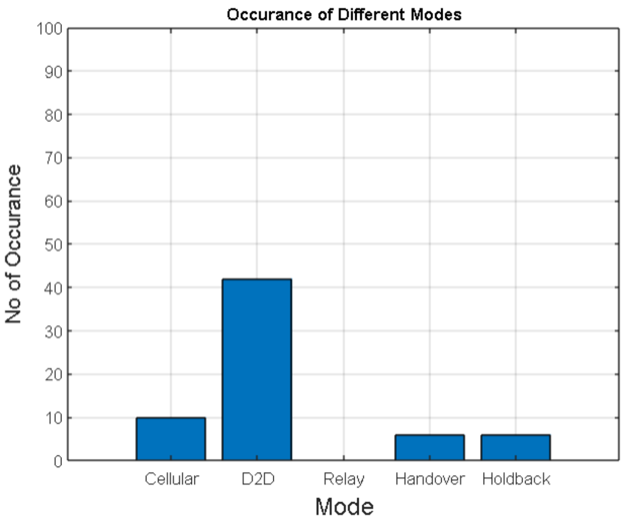

Figure-5. Plot of mode occurrences (percentage).

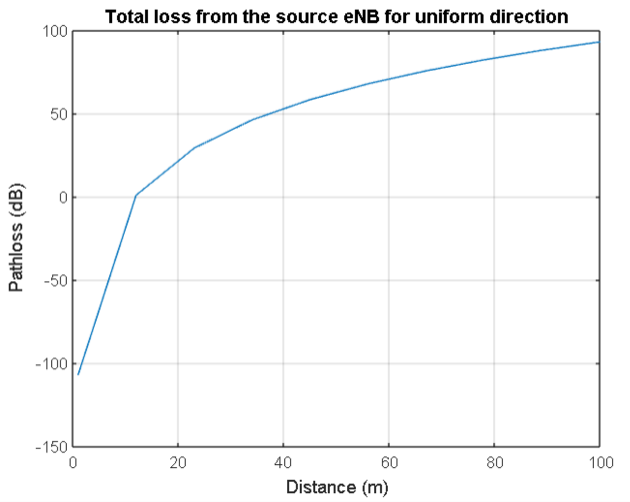

Figure-6. Plot for the pathloss.

5. CONCLUSIONS

The D2D communication system has been evaluated in this work, where mobility management is a significant problem that needs to be resolved. The new approach was suggested to overcome the difficulty of mobility management for future generation networks. The following algorithm shows how the mode was chosen. According to simulation results, D2D mode occurs the most frequently when the mobile station is traveling in various scenarios with the suggested model. The figure shows that the suggested solution meets the users' requirements and is helpful for D2D communication. Larger SINR values are reflected for users closer to the transmitter, and the proposed approach increases throughput. Our further study will compare this suggested model to the Markovian Chain model to thoroughly validate the technique.

REFERENCES

[1] X. Lin, J. G. Andrews, A. Ghosh, and R. Ratasuk. 2014. An overview of 3GPP device-to-device proximity services. IEEE Communications Magazine. 52: 40-48.

[2] M. Agaiwal, A. Roy, and N. Saxena. 2016. Next Generation 5G Wireless Networks: A Comprehensive Survey. In IEEE Communication Surveys and Tutorials. 18(3): 1617-1655.

[3] A. Gupta and R. K. Jha. 2015. A Survey of 5G Network: Architecture and Emerging Technologies. In IEEE Access. 3: 1206-1232.

[4] F. Boccardi, R. W. Heath, A. Lozano, T. L. Marzetta and P. Popovski. 2014. Five disruptive technology directions for 5g. Communications Magazine, IEEE. 52(2): 74-80.

[5] A. Asadi, Q. Wang and V. Mancuso. 2014. A survey on device-to-device communication in cellular networks. Communications Surveys and Tutorials, IEEE. 16(4): 1801-1819.

[6] O. N. Yilmaz, Z. Li, K. Valkealahti, M. A. Uusitalo, M. Moisio, P. Lund´en and C. Wijting. 2014. Smart mobility management for d2d communications in 5g networks. In WCNCW, IEEE. pp. 219-223.

[7] U. Ali Khan and S. S.Lee. 2019. Three-Dimensional Resource Allocation in D2D-Based V2V Communication. Electronics, 8, 962. doi:10.3390/electronics8090962.

[8] J. Lim and D. Hong. 2013. Mobility and handover management for heterogeneous networks in lte-advanced. Wireless personal communications. 72(4): 2901-2912.

[9] P. Ghosal, S. Barua, R. Subramanian, S. Xing, and K. Sandrasegaran. 2014. A novel approach for mobility management in lte femtocells. International Journal of Wireless and Mobile Networks. 6(5): 45.

[10] T. Chen *et al.* 2014. Mode Selection for Device-to-Device Communications.

[11] S. Zhang *et al.* 2015. Mode Selection and Resource Allocation for Device-to-Device Communications Underlaying Cellular Networks.

[12] Y. Li *et al.* 2017. Mode Selection for Device-to-Device Communications with Social Awareness.

[13] S. Li *et al.* 2018. Mode Selection for Device-to-Device Communications in Unlicensed Spectrum.

[14] Pallavi Sapkale and Uttam Kolekar. 2021. Modified Performance Based D2D Mobility Management Scheme using Mode Selection for Next Generation. 2021 6th International Conference for Convergence in Technology (I2CT) Pune, India. Apr 02-04.

[15] Shouman Barua and Robin Braun. 2017. Mobility Management of D2D Communication for the 5G Cellular Network System: A Study and Result. 17th International Symposium on Communications and Information Technologies (ISCIT).

[16] G. Jaheon, S. J. Bae, S. F. Hasan and M. Y. Chung. 2013. A combined power control and resource allocation scheme for d2d communication underlaying an lte-advanced system. IEICE Transactions on Communications. 96(10): 2683-2692.

[17] S. Barua, S. C. Lam, P. Ghosa, S. Xing and K. Sandrasegaran. 2015. A survey of direction of arrival estimation techniques and implementation of channel estimation based on scme. In Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology (ECTICON), 2015 12th International Conference on. pp. 1-5.

[18] S. Barua and R. Braun. 2016. Direction of arrival (doa) and channel estimation. In Self-Organized Mobile Communication Technologies and Techniques for Network Optimization, pp. 216-235, IGI Global.