CHAPTER - 2

LITERATURE REVIEW

2.1 Introduction

Device-to-device (D2D) communication, which is being used in boosting information speeds, decrease connection delay, and enhance bandwidth and efficiency of energy, is considered to be one of the emerging technologies in cellular wireless networks. According to published research, D2D resource optimization schemes are being used more often to handle interference effectively and improving efficiency of various network across a wider range of projects [111]. The transition of cell communication networks from 1G to 5G was brought about by expanding network capacity to satisfy users' expanding requirements [114]. A single data centre must be used to host both the training data and the inference procedures for the majority of the machine learning methodologies as well as solutions for communication networks now in use [119, 121]. Yet, it becomes not feasible for all of the communication equipment which are involved in learning to send every bit of their gathered data to an external data center or a cloud that can then use a centralized learning algorithm for data analysis due to privacy restrictions and constrained communication facilities for transfer of information in connections. To expand, centralized algorithms for machine learning include intrinsic drawbacks that restrict utilization, such as a considerable signaling burden, a rise in technical difficulty, as well as elevated delay when addressing problems with communication. Furthermore, new wireless networking paradigms such as cognitive radio networks, industrial control networks, D2D communications, and swarming networks based on unmanned aerial vehicles (UAVs) are inherently utilized for enhanced communication. In addition, given potential applications, centralized methods might not be appropriate for tasks requiring fast response times, such operating a self-driving car or directing a robotic surgeon [134]. Thus, the D2D communication based on cellular networks is consider for the efficient communication between the users.

2.2 Categorization of 5G Communication techniques

The categorization of the D2D communication techniques is devised based on the methods utilized for enhancing the performance of the model. Three various categorization of the conventional cellular communication in 5G networks are Machine learning based techniques, D2D communication techniques and Cooperative communication techniques. Figure 2.1 illustrates the categorization of 5G Communication Techniques.

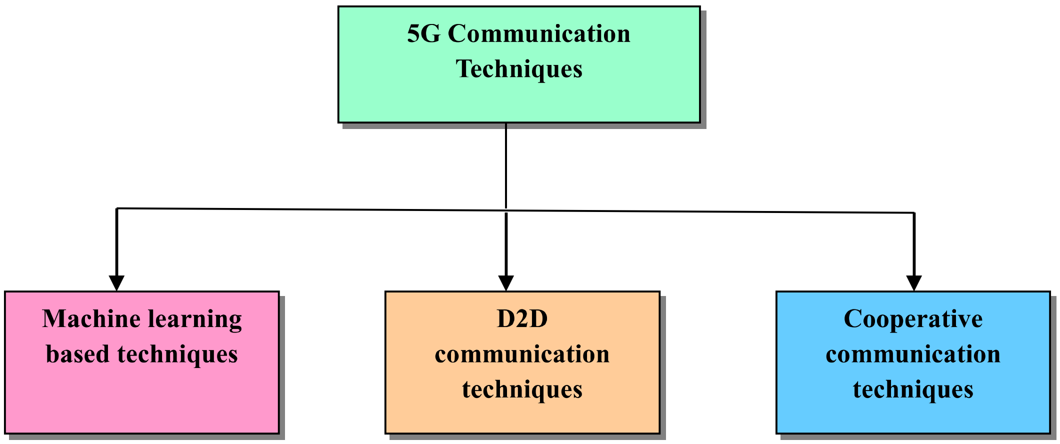

Figure 2.1: **Categorization of 5G Communication Techniques**

2.2.1 D2D Communication Techniques

Some of the D2D communication techniques are explained in this section.

Distributed Artificial Intelligence Solution: Routing problems in various D2D communication was solved by Belief-Desire-Intention (BDI) agents that utilized the designing of an AI-based D2D communication system by [110]. Without altering the hardware at user equipment or BSs, the agents were already integrated at the user equipment. The expectations or intentions concerning the planned responsibilities, wants or desires concerning the motivational approaches and convictions or beliefs concerning the informative states of mind were considered as three various fundamental mental structures considered by the BDI software agents while designing the agents. In its simplest form, the BDI model depends on two basic criteria's like mean transmit thinking and thought. While mean send thinking has series of activities to perform, as an effort to satiate desires, thought processes are the means by which the agent produces its aim on the basis of its desires and convictions. The D2D needs were defined together in the created model. Hence, the designed method considers the transmission mode of each user device and constructs the optimum routes to the BS via clusters and relays using the proof-of-concept algorithm. It was depicted that the devised system would guarantee both the minimal computing burden and enhanced spectral efficiency using the simulations.

Mixed Strategy: [112] developed a mixed strategy-based algorithm for D2D communications that allocates resources efficiently while using both the energy and spectrum. The designed method minimizes the power consumption of user equipment while increasing the efficiency of the entire spectrum. As an interpretation of a mixed strategy non-cooperative game, a distributed algorithm based on a novel mathematical game theory model was introduced, in contrast to earlier works on resource allocation issues that exclusively took centralized strategies. By reducing power consumption and interferences through intelligent resource block (RB) allocation, the solution provided by the designed model improves the joint spectrum efficiency/energy efficiency (SE/EE) trade off. According to the random network behavior, the designed model enables users to adopt more precise assumptions to maximize its utility. The outcome of the method shows that the suggested method outperforms earlier methods based on the convergence time and number of users supported by the method for communication. As an example, the method can be followed by a supplementary strategy to enable multi-hop D2D, in which relays must be carefully chosen for obtaining the sustained and effective data transmission with improved communication capabilities.

EMBLR: For solving the issues and improve network performance in D2D communication a novel approach based on energy, mobility, queue length, and link quality-aware routing (EMBLR) strategy was developed by [115]. Additionally, to choose the relay equipment in an ideal path, a multi-criteria decision making (MCDM) method was used. The hybrid and Dijkstra algorithm multi-path concept of routing was utilized by the developed EMBLR routing approach irrespective of the existing routing approaches. Besides, the designed method to select the best route was designed in accordance with the full combination of device parameter metrics like devices queue length, quality of link, consumption of energy and mobility. Here, for the selection of the optimal best route from the enormous routes identified based on link cost parameter that was measured according to the evaluated relay equipment's parameter value through the MCDM decision factor. Consequently, the choice of the best route between the equipments was made using the MCDM measure for enhancing the energy efficiency. The suggested routing strategy considerably improves network performance, as shown by extensive simulation that was done.

MBMQA: For the IoT 5G networks based on D2D communication, a Mobility, Battery, and Queue length Multipath-Aware (MBMQA) routing strategy was developed by [116] to address these major issues in routing. The device selection estimated value was employed using the back-pressure algorithm approach to reroute flow of packet. For the load balanced best route identification in the designed D2D communication framework, a Multiple-Attributes Route Selection (MARS) metric was utilized. In case of limiting the energy consumption of individual devices and assures the mobility would not affect packet routing, the designed model found many final routing pathways to the destination while distributing workload across all devices. By considering accessible factors for each node such as the size of device queue length, mobility details, and battery's energy level was considered for the route computation. The offered information was quantified in order to choose the optimum path among several paths to the target equipment. A multiple characteristics route selection metric is also provided. The developed MBMQA routing method therefore seeks to choose the best route from source to destination devices that eliminates consumption of energy, traffic loads were balanced among the equipments and acquired the route stability and enhances network while transmitting the data. The acquired simulation outcomes, demonstrate that the introduced MBMQA routing approach eventually elevates quality of service (QoS) and performance of the network when compared with conventional approaches.

NARA: While considering the 5G cellular infrastructures, an efficient routing approach for the D2D communication was developed by [118] using the Network Assisted Routing and Allocation technique (NARA). While considering the D2D communications, NARA increases network coverage and minimizes interference through the new resource block allocation technique. When determining routes for mobile devices, NARA takes into account the channel quality between nearby active D2D interactions while using a graph coloring technique to simulate the resource block (RB) allocation issue and interference minimization. Using the shortest path Dijkstra algorithm, NAR builds multi-hop routes to the user request from the BS. NAR actively chooses several paths before settling on the optimal best path using the CQIs of the user equipment neighbors. The NAR routing strategy considerably decreases the overall volume of messages and eliminates flooding criteria, which also lowers power usage. To assess the behavior of routing and resource allocation, the developed model made use of the Rayleigh fading channel and the UMa propagation model concerning the UMa channel model.

FINDER: While considering the disaster area for reducing the loss of damage and life to property a novel framework was designed by [122] using the Finding Isolated Node using D2D for Emergency Response (FINDER) to find and link the remote Mobile Nodes (MNs). A crucial D2D network was created if the cellular link was lost due to an emergency and the MNs under the damaged BS utilizing the concept of D2D communication. A nearby Wi-Fi access point or a BS can connect the MNs for providing an active network in the disaster area. To improve the energy efficiency of individual nodes and to enhance the lifetime of the network, a multi-hop D2D communications by considering the optimization was implemented. Furthermore, the number of nodes that are actively participating in the network was minimized through the dynamic clustering criteria, and the quantity of packets in the network was minimized through the data aggregation. It was advantageous to get help from the Software-Defined Networking (SDN) controller during disaster scenario at the BS for obtaining the reliable and intelligent to the MNs. The best path to use for maximization of efficiency was the path chosen with fewest hops and the highest link quality. In picking the neighbor node two various factors like the hop-count and connection quality were therefore taken into account from the list of the available paths. The likelihood of choosing a node as a neighbor node was higher for those with fewest hops and strong network quality. The short description of the cooperative communication method is presented in Table 2.1.

Table 2.1: Short description of the D2D communication techniques

Reference	Technique Used	Performance Measures	Advantages	Disadvantages
Ioannou, I., Vassiliou, V., Christophorou, C. and Pitsillides, A. **[110]**	Distributed Artificial Intelligence Solution	Computation time, Spectral Efficiency, and Total power	Numerous problems like routing issues including interference management, and power control were resolved by developed method.	The performance of the model analysis using a dynamic network scenario was not evaluated to depict the robustness.
Sawsan, S. and Ridha, B. **[112]**	Mixed Strategy	Average interference, Spectral efficiency, and Energy efficiency	For converging the algorithm, the designed model utilizes only fewer iterations.	As power consumption for data routing elevates, the energy efficiency first elevates with spectral efficiency and then declines. Energy efficiency first raised while attempting to cut down on energy, but it then starts to decline monotonically since power reduction has a negative impact on spectral efficiency.

Tilwari, V., Dimyati, K., Hindia, M.N., Mohmed Noor Izam, T.F.B.T. and Amiri, I.S. **[115]**	EMBLR	Convergence time, energy, packet delivery, delay, and throughput	The recommended structure was extremely favorable for public life, for instance in the event of a calamity when the communication for survival may be formed with the extra installation of drone-based disaster response models.	Due to interference prevails in the spectrum-sharing communication, which lowers the outcome of the model as the D2D link interferes with cellular links and other equipments that use the similar spectrum resources.
Tilwari, V., Hindia, M.N., Dimyati, K., Jayakody, D.N.K., Solanki, S., Sinha, R.S. and Hanafi, E. **[116]**	MBMQA	Throughput, delay, PDR, and energy	Higher energy efficiency was achieved by the MBMQA system that acquired the reduced quantity of loss of packets and provided a larger quantity of packets using the specified amount of energy.	The challenging aspect of the model was its lower system data rate.
Bastos, A.V., Da Silva, C.M. and da Silva Jr, D.C. **[118]**	NARA	Number of routes	The outcome of the devised model reveals that NARA acquired minimal message loss.	Resource allocation, power management, fairness, in sectored cell areas, and other route loss situations were not examined, nor were the resource allocation procedure improved to strengthen the

				integrality of the factors and provide the best possible outcome.
Thomas, A. and Raja, G. **[122]**	FINDER	Delivery probability, overhead ratio, average residual energy	According to the outcome of the deployment, designed model FINDER increases network lifetime and decreases energy usage during routing.	The network lifetime and energy efficiency may be further increased by extending to enable wireless energy harvesting from radio frequency.

2.2.2 Cooperative Communication Techniques

Some of the cooperative communication based methods are detailed in this section.

Relay Probing: [123] introduced a multi-hop relay probe strategy for mmWave D2D routing by considering relay nodes concerning the multi-band mmWave. To estimate the likelihood of the dispersed relay nodes SNR of the mmWave based on both non- line-of-sight (NLOS) and LOS route availability. The gathered μW signals received signal strengths (RSSs) of the relay nodes were employed in this technique. Here, the potential multi-hop path's relay nodes detection simultaneously using hierarchical search technique based on a probabilistic metric. The spectral efficiency of the route from the source to destination among the several paths was enumerated to maximize the efficiency. The relay nodes positioned inside the previously chosen multi-hop paths were devised to employ online relay probing in the offline phase. In order to demonstrate the value of multi-hop routing and the connection among improved amount of explored paths and improving the resulting spectral efficiency, the assessment was carried out. The superiority of the introduced route probing approach over the introduced method was devised to validate the mathematical conclusions acquired by the simulation analysis. The unmanned aerial vehicle (UAV) network was considered as one application for which the designed approach may be employed. Due to the UAV's high degree of dynamicality and its excessively low power capacity, multi-hop UAV-to-UAV routing with low energy consumption and high throughput was accomplished by the introduced model.

DSPA: Using the cellular communication and dual connectivity of D2D among cluster head for solving the problem of link disconnection was addressed in a cellular D2D-assisted relay strategy was introduced by [124] to forward data. The relay selection was employed using Maximum Weight Bipartite Matching in the suggested technique named D2D Relay Node Selection and uplink Power Allocation (DSPA). When data was being sent to BS via DSPA from active low-battery CHs, the CHs' uplink transmission power requirement was reduced. The initial step was to create a technique with energy usage criteria with or without D2D interaction. By considering the KM technique for the active CHs, a bipartite matching problem was then solved to determine the optimum D2D relay nodes. By considering both with and without D2D communication, the estimation of the CH's energy usage was estimated through the numerical value. In this, the BS can identify any CH with low battery levels at any particular time. Here, the DRNs were utilized for transmitting the data with multi-hop interaction. Same modulation and coding scheme (MCS) index were retained to conserve CH's transmission power; still, maintaining same throughput. According to the presumption concerning the data transmission by considering the inactive CH that provides assistance to the others in sending data to the BS, wherein the inactive CHs will be changed depending on the schedule period using the cooperative communication system. The overall transmission energy gets saved through the optimal D2D coverage range calculation for each sensor node density.

Adaptive relay selection algorithm: The multi-relay network model with cooperative out-bands technique using the concept of the adaptive method formulation was designed by [125]. Here, for a cooperative model, connection distance and channel gain were considered by the introduced adaptive relay selection (ARS) strategy for the efficient communication. A Rayleigh fading channel was utilized with QF protocol employing multi-relay was used to establish the framework for the design of introduced technique. Additionally, the suggested scheme's precise closed-form energy efficiency and throughput formulations have been developed for optimal communication. Based on the findings, it was summarized that the introduced ARS method acquired minimum distance, maximum channel gain and better throughput. Additionally, the introduced ARS has the potential to lower overall usage of energy that directly affects the final degree of energy efficiency. Besides, with regard to power distribution or connection space, the designed ARS design delivers the maximum energy efficiency.

PPP realistic model: To precisely analyze the arbitrary operation of the cooperative communication, the Poisson point process (PPP) approach with stochastic geometry was adopted by [126]. Since transmitters and receivers are components of stochastic point processes, they must be taken into account in stochastic modeling. While considering the variable cell size, the stochastic modeling was ineffective for topologies where, the hexagonal approach was not appropriate for the construction of heterogeneous network topologies. In order to forecast the probabilistic factors such as SINR, BS mapping, coverage probability, load distribution, and cell interference employs stochastic geometry as a suitable method for a randomly built heterogeneous network. While considering homogeneous random models as a network, the D2D and cellular users were used in the realm of relay nodes (RNs) design. Poisson and independent were considered as the two related phenomena in choosing the relay node. The outage probability, ergodic capacity, success probability, and SINR considered by the introduced technique during the cellular network simulation. In order to create an interference-free network, the suggested approach makes use of the D2D user, cellular user, relay node, and BS for the placement of the model. As metrics for assessing the outcomes with regard to densities of node and different SINR pre-defined values outage probability, ergodic capacity, and success probability of the D2D users.

Markov chain framework: D2D relays that already existed in the network were considered as the state of the Markov chain in a framework for D2D cooperative relay created by [127]. The assumption based on the premise of probabilistic D2D cooperation, the calculation of the network's long-term average D2D relays number as a function of the switching probability of the devices was employed. The objective was to evaluate ideal switching probability of the uplink D2D cooperative transmission and to acquire the highest possible levels of dependability and throughput using the designed D2D-relay configuration. The findings demonstrate that the network's average throughput and reliability may be maximized by using optimal switching possibilities and an average amount of D2D relay. The level of collaboration, density of network, and area of coverage all has a significant impact on the achieved outcomes. In general, equipment likes changing from one category to an alternative if the total throughput and dependability were higher than they would be if it remained in that group. With the objective to maximize the network's throughput and dependability, the ideal switching probabilities, which mean the number of device in every group were often affected by congestion in the network, disruption, orthogonality factor, transfer of power, and equipment batteries.

A Stackelberg Game Approach: A two-hop D2D relay selection was proposed by [128] using a Stackelberg Game Approach for obtaining energy and spectral efficiency in communication. The connection of out-of-coverage (OOC) devices was the primary objective of the model. A distributed two-stage approach has been created depending on the Stackelberg game to incorporate each of the participating equipment, in contrast to earlier systems where the relay was chosen either centrally or privately. Initially, the spectral efficiency of the intermediaries has been maximized by matching the OOC devices (OCDUs) with them, and then the bandwidth needed for every device was identified. To determine the ideal management of power, a power control stage was then evaluated. A superior result was obtained when the performance of the suggested strategy was analysed in terms of number of devices in the cell, spectral efficiency, and energy efficiency. Comparing the simulation findings to current approaches, considerable improvements were evident. Gains in energy and spectral efficiency were always maintained at the optimum distance and power level. The interferences among the co-channel interactions was obtained smaller as a result of energy mitigation and acquired spectral and energy benefits. The spectral and energy loss brought on by the usable signal gain decline cannot be made up for below the ideal value. Thus, the better outcome was offered by the introduced model when the transmitter and receiver were closer.

Inter-clustering: In order to enhance the outcome of the model for boost energy efficiency in cooperative D2D networks, [129] developed a relay selection approach utilizing the two inter-clustering model. Two various inter-clustering techniques were created by providing the appropriate methods for each model. To build a multi-relay network, simultaneously delivers training bits to several relays by the source of each cluster. The max-min strategy was used at this stage to choose a relay from the group. Next, the source transmitted this data to the top relay, which subsequently relayed to the CH. The CH that was most near the BS had been meant to be identified. After that, the CH transmits the data to the BS, which in turn passes it on to a different CH. The data passes according to the idea of a D2D multi-hop immediately after the most effective route has been chosen. Different clusters are present in the mobile network in the inter-clustering paradigm according to the second technique, in contradiction. The progressive relay-selection approach is used to pick several relays as cluster heads from among an extensive amount of types of equipment operating as senders. Following the selection of the CH, the source sends data to the destinations of the BS and CH of other clusters. For information to be transferred from one cluster to the intended cluster, inter-clustering model II needs minimal operations. As per the investigation, Inter-clustering Model II had the best throughput performance and was the most energy-efficient. The application of this concept was therefore appropriate while considering5G overlay D2D interactions.

Delay Aware Hybrid Routing: Geographic routing and clustering routing were combined to create a hybrid cluster based D2D cooperative routing strategy [130]. The algorithm's major goal was to create communication between devices with comparable levels of mobility in order to lessen the impact of mobility since there was a solid connection between those moving at the same speed. In this routing, we form a cluster with nodes of equal velocity to lessen the effect of mobility on the link reliability. Based on the node's location, we then chose the cluster head for the subsequent hop, which is the node that is within the source's transmission coverage area and close to the destination. When the SNR within the CH being lower compared to the established threshold due to travelling and route circumstances, cooperative interactions was employed to improve the network efficiency. An individual of the equipment in the group was chosen as the CH since it has a number of equivalent mobility modules. To enhance the efficiency of the system, the CH assignment was established using threshold-based and geographic routing cooperative communication was made available inside the cluster. Based on the findings of the simulation, it was determined that the suggested routing strategy performed better in terms of outage probability, energy usage, and end-to-end transmission latency.

CEETHCoR: In order to create a lightweight paradigm with the goal of lowering transmitting energy, [131] presented the channel aware energy efficient two-hop cooperative routing protocol (CEETHCoR). CEETHCoR derives the properties of cross-layer protocols. Three levels make up the protocol design: network, MAC, and physical layer. Additionally, unlike other research that modify data transmission in a one-hop way, our work performs data delivery in a two-hop transmission by using an integrated relaying for 2 successive one-hop cooperative conversations. In order to decrease packet collisions, handshaking of RTS/CTS interchange was carried out at the MAC layer. For example, by fully using the broadcast aspect of wireless signals, the connection quality was routinely evaluated to enable more precise relay selection. Here, the broadcast aspect of radio signals (both data as well as control signals) was completely used for two key goals: determining the connection quality and cooperatively coordinating between two subsequent one-hop communications. The goal of an optimization methodology developed to find the most effective approach was to reduce the communication efficiency for every network pathway. While the ideal cooperative protocol for routing has been discovered, it proved unworkable due to the required a lot of processing, involving gathering two-hop neighbor data as well as regulation. Using the path consciousness along with the energy efficiency criterion obtained using the lemma, the lightweight technique CAEECR was developed to overcome the problem. Because the selection of relay method was focused on establishing reliable and resilient connections for control signals and information packets, the ideal latency efficiency was achieved to its minimized packet retransmission.

EH-UWSN: The Energy Harvesting in UWSN (EH-UWSN) protocol for routing concept was presented by [132]. An efficient, high-performance, as well as small-footprint networking system called EH-UWSN took into account the coordination of data packet transfers across relay nodes to save energy. The devices had the capacity to recharge the batteries directly their external environment via harvesting energy, which served the dual purposes of reducing energy use and extending network lifespan. A Signal-to-Noise Ratio Combination (SNRC)-based mixing strategy was used at the sink node. The hand-off sensor and the receiver both receive data from the source nodes. The hand-off node strengthens the acquired signal to produce an instantaneous copy repetition of transmitted data. The main concept is to transmit copies of data using several techniques. Additionally, which is referred to as a beneficial diverse assortment. The system's capability and unwavering state are both improved by this cooperative arrangement. As a result of longer network lifetime and better throughput at the destination, simulation findings demonstrate that EH-UWSN has spent much less energy than Co-UWSN.

IACR: The Interference Aware Cooperative Routing (IACR) was described by [133] by considering the cost of the route as an outcome of the signal disruption that a network node generates and receives. The weighted total of the interference that was both generated and obtained has been employed to determine the metric value. The reception interruption component in the suggested routing measure guarantees that the information gets transmitted over a minimal interfering route, providing strong SINR on the destination. On contrary, the produced interruption concept chooses the data connection that delivers lowest disruption to the network. QoS for each network user gets better because a consequence of the aforementioned approach. According to the design, while units were added to the network, the system's consumption of energy rises. Still, IACR required less power than conventional methods since the devices cooperate as well as produce minimal interference to one another, hence lowering network-wide disturbance. Nodes in the network may communicate at a reduced rate of resource, which reduces the amount of energy they use since disruption in the system lowers.

Co-DLSA: [135] has developed two relaying techniques for the information transmission approach: Cooperative Delay and Link Stability Aware (Co-DLSA) and Delay and Link

Stability Aware (DLSA). Being a modification of the previous DLSA path detection scheme, Co-DLSA incorporated the relaying technique of cooperative routing along with the fair-relay-strategy (FRS) and red-black (R-B) routing tree to boost network efficiency. The major goal aimed to reduce the network reliability score by means of an interrupted node with minimizing loss of transmission and latency. In conclusion, all procedures produced results at various percentage levels of difficulty; however, its efficacy was inadequate in comparison to the recommended task. The relay method was deployed to accomplish cooperative routing through partitioning the relay nodes within the system as well as introducing a three-layered technique with relay, aerial, and ground strategy to act as a link separating them in minimizing the evaluation of the network reliability; in this case, the smallest number was regarded as to be optimal since it signifies the least amount of discontinuations have taken place. Likewise to this, the smallest transmission loss generally denotes the highest efficiency. The least amount of latency and packet loss, when compared to other factors, imply the highest performance. The top protocol overall was Co-DLSA, which excelled in every assessment criteria.

Hybrid K-Means Clustering: For cluster-based networks, a technique for cooperative collection of information and relay that increases lifespan has been put forth by [136]. Employing an innovative K-means clustering method incorporating K-means clustering and Huffman coding techniques, the suggested lifetime-enhancing cooperative collecting information and relaying method divides each node into cluster. Decreased information transmission costs across multiple cluster sections to the central BS have been obtained by making optimal use of specialized relay cooperative multi-hop interaction via network coding methods. In terms of transmission lengths and remaining energy measures, the choice of the relay node is presented as an NP-hard task. Relaying node location and remaining energy were employed to frame the node's relay allocation as an NP-hard issue. An approach based on the gradient descent technique has been suggested to address the NP-hard issue. The resulting region's accumulated packets have been jointly routed in multi-hops through the centralized BS during the last stage, where the data was cooperatively processed using random linear coding. Applying this methodology will improve relaying node identification and increase transmits success rates in a variety of cluster-based systems. Additionally, devoted collaborating relay nodes continually help the CH nodes to transmit their collected information by having advantageous locations and sources of energy. The payload packets are furthermore randomly network encrypted at every single hop between the points of origin to the recipient. The findings demonstrate that the suggested approach enhances throughput and durability while reducing delay and consumption of energy.

Multiple-Relay Cooperative Networks Using Hamming Coding: By employing Hamming codes, [137] gave an examination of cooperative networks with multiple-relay for enhancing the energy effectiveness. In this, Quantize-and-Forward (QF) and Amplify-and-Forward (AF) protocols were taken into consideration for multiple-relay networks. The multiple-relay networks used three different forms of Hamming codes with varying lengths. The system characteristics and network model were taken into account for evaluating the consumption of energy, which was assessed based on energy for depicting the efficacy of the model based on the energy. The energy efficiency of hamming code increased with the number of bits enhancement. For the acquisition of the lower BER, a longer Hamming code was employed in a cooperative network since it has a more adaptable minimum distance between the code-words and was resistant towards transmission noise.

CEER: By introducing the Cooperative energy-efficient routing (CEER) technique by [138] hoped to elongate the life of network and build a trustworthy one. By resolving the hotspot problem, the sink mobility strategy was used to cut down on the consumption of energy. To transport information to the intended node, the recommended approach employs the sink portability mechanism. As a result of the information being transmitted directly, consumption of energy could be reduced. The nodes would transport information immediately to the intended node if it was within range of communication. Dependability of information was not guaranteed when it was sent over a single link. Thus, the suggested technique makes advantage of the cooperative transmission of information system to decrease end-to-end latency and improve reliability of the network. The intake nodes were placed in every sector of the territory, which had been separated by several pieces enabling more accurate installation. For the purpose of cutting down on consumption of energy, nodes with sensors produce information and transfer it to the intended node. The network's dependability has been established by using a cooperative method. The maximum remaining energy and the shortest route are both significant factors that were used to choose the sender's location and receiver. By using direct communication to send information from sender to receiver that consumes less energy and retains the nodes active for an extended amount of time, the CEER technique reduces the overall amount of participating nodes.

TSCR: An energy-efficient two-stage cooperative routing (TSCR) system was put out by [139] to lengthen the lifespan of the network and increase energy efficiency simultaneously. This work utilized a core helper to choose the helper set and hence it was significant and unique because it initially investigates a two-stage cooperative (TSC) communication approach for cooperation. The model contrasts with the current methods due to the various design objectives. The incorporation of residual energy's coefficient of weighting into the cooperative transmission based on the two-stage link cost formulation impact the accomplishment of desired goal. The optimization of each link's two-stage link cost by choosing the best assistance set. At last, a distributed TSCR scheme was developed by considering two-stage link cost with optimization in reducing the cost of path and to determine the minimal distance route among sender and indented user. Here, in the designed approach, the sender shares the source packet to the destination via the path identified by the TSCR approach. The various demands concerning the flexibility of the model was accommodate through the consideration of fading conditions. Through simulation result, the advantages of the TSCR protocol were compared to the other schemes in terms of energy efficiency, delay, network lifetime, and network residual energy. The short description of the cooperative communication techniques is presented in Table 2.2.

Table 2.2: Short description of the cooperative communication techniques

Reference	Techniques Used	Performance Measures	Advantages	Disadvantages
Mohamed, E.M., Elhalawany, B.M., Khallaf, H.S., Zareei, M., Zeb, A. and Abdelghany, M.A. **[123]**	Relay Probing	Coverage probability, SNR, throughput, spectral efficiency		To further enhance the mmWave multi-hop relay probing procedure, reinforcement learning-based machine learning technologies must be explored.
Barik, P.K., Singhal, C. and Datta, R. [124]	DSPA	Energy efficiency, hop gain, and churn rate	The intended DSPA approach achieved the lowest battery energy usage of the low-battery active CHs employing an alternate cluster head with superior signal reliability to transmit information.	The designed method acquired minimal network lifetime.
Raziah, I., Yunida, Y., Away, Y., Muharar, R. and Nasaruddin, N. [125]	Adaptive relay selection algorithm	Energy efficiency, energy consumption, and throughput	In cooperative out-band D2D multi-relay infrastructure, the developed Adaptive relay selection strategy uses fewer resources compared to the highest channel gain or shortest path techniques.	The BPSK modulation was used to get the improved throughput efficiency since the throughput assessment utilising M-QAM was complicated. To enhance the reliability of a cooperative D2D

				network, M-QAM modulation was recommended for throughput study.
Qamar, F., Dimyati, K., Hindia, M.N., Noordin, K.A. and Amiri, I.S. [126]	PPP realistic model	Outage probability, and success probability	To ensure more dependable communications, a powerful interference control system was developed.	Adjacent-channel interference and device noise degrades the performance of the model.
Driouech, S., Sabir, E. and Bennis, M. [127]	Markov chain framework	Throughput, and switching probability	The optimal transition possibilities and typical quantity of D2Drelays were utilized to maximise efficiency and dependability.	The cost of improving dependability nevertheless involves an increase in delay.
Selmi, S. and Boullègue, R. [128]	A Stackelberg Game Approach	Energy Efficiency	Based on the results of simulations, it can be shown that the suggested architecture improves overall capacity, spectrum efficacy, and energy utilisation with a manageable computation.	High power transmissions from the BS cause substantial interference to close D2D conversations.
Nasaruddin, N., Yunida, Y. and Adriman, R. [129]	Inter-clustering	Throughput, and Energy Efficiency	According to simulation findings, the inter-clustering architecture was boosted by favourable connection path circumstances and had a low data	The network architecture impacts the network's energy use since only the best relay node was chosen to carry signals through the relay to the

			transfer error rate.	intended location, rather than every relay node.
Devulapalli, P.K., Pokkunuri, M.S. and Babu, M.S. [130]	Delay Aware Hybrid Routing	Delay, Energy consumption, number of hops, and bit error rate (BER)	The information and beacon signals were both compressed using an approach called compressed sensing, which significantly reduced the node's energy usage.	Failed to consider the effect of imperfect synchronization for enhancing the performance.
Tran-Dang, H. and Kim, D.S. [131]	CEETHCoR	Packet delivery ratio, energy consumption, end-to-end delay, energy efficiency	The received SNR may be significantly enhanced even when same transmission power was applied for both relay and direct link, it has been demonstrated that the cooperative transmission strategy was useful in improving reception quality of the information.	Considered only one or two relays for communication
Ahmed, S., Ali, M.T., Alothman, A.A., Nawaz, A., Shahzad, M., Shah, A.A., Ahmad, A., Khan, M.Y.A., Najam, Z. and Shaheen, A. [132]	EH-UWSN	Network stability, lifetime, energy consumption	When compared to Cooperative Routing Scheme for UWSNs (Co-UWSN), the developed has used up to three times as minimal energy during data transfers.	Minimal Network lifetime was accomplished by the method.

Waqas, A., Mahmood, H. and Saeed, N. [133]	IACR	Energy consumption, throughput	When there are a lot of nodes in the framework, the efficacy of the suggested approach gets better. Considering dense edge computing-enabled 5G networks, the suggested approaches could thus provide an effective interference-aware routing option.	The basic SINR at the lowest interference paths cannot meet the threshold level at because the efficiency of the paths has been impacted by the path-loss factor; thus, a significant outage was detected.
Hussain, A., Shah, B., Hussain, T., Ali, F. and Kwak, D. [135]	Co-DLSA	Delay, Throughput, Network stability, and packet drop	Due to the usage of a relay approach as a cooperative system, routing schemes have the capacity to function in cooperative environments.	Strong routing techniques were necessary for both airborne and terrestrial nodes, as well as for obtaining node regional security, scalability, and QoS optimization.
Agbulu, G.P., Kumar, G.J.R. and Juliet, A.V. [136]	Hybrid K-Means Clustering	Delay, Energy Consumption	Achieved superior results with regard to of decreased consumption of energy with longer lifespan and higher information transmission rates with decreased delay.	

Nasaruddin, N., Adriman, R. and Afdhal, A. [137]	Multiple-Relay Cooperative Networks Using Hamming Coding	Energy Efficiency	As a result, adding Hamming coding into the multiple-relay Quantize-and-Forward technique proved an effective way to boost effectiveness while boosting energy efficiency.	As the relay distance ratio rises, the Amplify-and-Forward network has to use more reinforcement power to avoid having its power consumption level rise along with it.
Ahmad, I., Rahman, T., Zeb, A., Khan, I., Othman, M.T.B. and Hamam, H. [138]	CEER	Number of alive nodes, delay, energy consumption, throughput	While the receiver remained out of transmission spectrum, CEER chose the closest neighbour node having the highest resource and bit error rate (BER) during transmitting information to the destination that reduces the system's consumption of energy.	Failed to consider the significant attributes during the relay node selection that enhances the energy efficiency.
Cheng, J., Gao, Y., Zhang, N. and Yang, H. [139]	TSCR	Residual energy, network lifetime, end-to-end delay, energy efficiency	Comparing the new TSCR system to the existing ones, simulation results further demonstrate that it may increase energy utilisation and longevity of the network.	Interference between different data flows was higher for the designed model.

2.2.3 Machine Learning based Techniques

Some of the machine learning based approaches is detailed in this section.

RL-ID2D: Rather than a direct uplink communication, the proposed method leverage two-hop communication protocol for narrowband Internet of Things (NB-IoT) applications that were applicable for healthcare-IoT services based delay-sensitive measure [113]. To attain best end-to-end delivery ratio (EDR), the optimum potential relay set (optPRS) optimization challenge is put forth. Additionally, the introduced model uses reinforcement learning (RL) based on Q-Learning to choose the best cellular relay, which helps to upload sensitive data to BS through the NB-IoT user device. Here, the eventual increase in energy efficiency is accomplished by choosing the best relay with the highest EDR using the designed RL-intelligent-D2D (RL-ID2D) method. The agent was acted depending on the Q-value, which was increased to allow for further exploitation. Here, while maximizing the immediate payoff, the agent to behave greedily in the exploitation phase to elevate the reward. The ambiguity in exploration was acquired from the fact that action was unknown and will result in a higher reward. Still, it was preferable to investigate non-greedy action while considering several time steps, in which exploitation was utilized that was represented in its outcome, which is that elevating the exploration improves the EDR.

CenTri: In 5G network scenarios, CenTri was developed by [117] utilizing a integrated path selection approach utilizing heterogeneous nodes concerning the small-cell from macro-cell BS for traffic offloading of white spaces. The ultra-densification, heterogeneity, and availability of dynamic channel were considered as only a few of the significant aspects of 5G network that it supports. Using the dynamic reinforcement learning (DRL) and conventional reinforcement learning (CRL) techniques, the D2D communication was designed. The constant learning rate was utilized by the CRL; but, the dynamic learning rate was utilized by the DRL that fluctuates in response to main user activity levels. Eleven USRP/GNU radio sets were used as test subjects in the designed protocol. In order to give more realistic circumstances, each USRP unit comprises a minicomputer named RP3. The findings of the analysis demonstrate improvements in many qualities of service (QoS) measures when compared to TRL, including a route breakage with minimal number, a smaller end-to-end latency, and higher packet delivery ratio. Despite having a lower throughput and packet delivery ratio, routes with more intermediate nodes also have greater end-to-end delays.

I-D2D: When it comes to information distribution based on improved in-depth coverage, enormous MTC's necessitates the ultra-reliability [117]. Data transmissions and repeating control allows NB-IoT to meet the need concerning the reliability. One of the main features of NB-IoT was its ability to use less energy. Still, the basic approach of more frequent repeats of the data and control signals uses higher power. For elevating the information transmission, a unique D2D communication connection was utilized as a routing strategy that provides the user equipments with minimal repeats and two-hop route. In this case, to access the best relay by considering the best PDR was performed through the identification of the relay using the dynamic intermediate node selection technique. A Multi-Arm Bandit (MAB) system may be used to perform the learning process for choosing an ideal relay. Based on the channel conditions and relay's location such the Signal-to-Interference-Noise power Ratio (SINR), the relay’s quality variations was examined. In order to get the least amount of latency and a trustworthy PDR while using less energy, the best relay was chosen.

CRP-GR: The clustering-based routing protocol (CRP-GR) [120] was crucial in heterogeneous 5G-based smart healthcare because it ensures quick data transmission to the BS from the sender. Energy optimization and QoS were acquired using game theory to choose an energy-efficient CH and reinforcement learning (RL) to choose the optimal multipath route. In order to identify equilibrium criteria, clustering game theory based CH selection was designed with a mixed strategy that considers several characteristics. While selecting the CH, several factors like mobility speed of the node, remaining energy, spacing between the BS and nodes were considered. The idea behind the information sharing was to use RL with Q-learning to create an energy-efficient multipath routing. Using a deduced iterative approach for the Q-table, multipath routing based on Q-learning identified for obtaining energy-efficient distance and pathways. The ideal cluster head (CH) and path (path of least resistance) for data transmission was chosen using the designed approach for sharing information from nodes to BS through CH. Conversely, the energy wastage in the network exists due to the consideration of arbitrary CH and path selection strategies that require additional computation and a long transmission range, which was avoided in the designed model. The suggested strategy reduces the network nodes and energy consumption as a result. The devised model enhances the effectiveness of the nodes based on energy-saving efforts and minimizes energy dissipation.

Fast Connectivity Construction: In order to meet the low latency requirement concerning the mobility, a smartphone has the capability of intelligent actions, DNN computation, and can process the context acquisition [140]. A small-scale neural network that was trained using a small batch of data and requires little computational effort using the introduced DNN. Signal state and connectivity context were considered as the two types of context utilized in the training phase of the introduced DNN training data set. The information concerning the links MAC layer like network layer routing path and MAC layer link were employed for the connectivity context. Radio signal strength (RSS) values were used to measure the signal status context. A light-weight multi-layer neural network (LMK) was utilized for the data learning. Here, the data gathered from the social networking domains or from the smart industry was utilized for learning the LMK for joining the mobile device in the network. After gathering the data acquired from the network, the LMK learns the data. By this way, the LMK was updated to the current scenario through the learned data. By considering the RSS value acquired from the real world issues, the contexts like signal and connectivity were considered for making the communication between the devices. The pre-trained LMK receives requests from the mobile device for forecasting the route based on the updated routing table for making the connection. Followed by, the execution of the networking control plane was devised by the mobile device in the network layer based on the updated table. At last, the information was ready to send data to other equipment through the established connection through the D2D communication. Based on evaluation results, it can be concluded that the introduced framework offers low latency data transfer and reliable communication.

Optimal DQN: An agent can choose the optimum action for a given state with the help of the Deep Q-network (DQN), which was designed based on DNN and reinforcement learning [141]. In order to increase flying ad hoc energy efficiency, longevity, and network stability, this method introduces an intelligent cluster-based routing strategy. To provide a balanced improvement in the performance of the local and global networks, the introduced strategy provides the recency of information among the distributed controller (DC) and central controller (CC). In order to forecast state action values, DNN gives agents the ability to learn the states based on mobility of agent and residual energy. The

DNN learns in real time using small batches of experiences. Improved convergence rate was acquired for the most appropriate path by considering the three characteristics based on the lower mobility and residual energy. While considering the dynamic environment for enhancing the prediction of state-action values, training was first conducted using the delayed reward concerning the replay memory. In addition, when the episodes rises, the fading variable employed was shifted to the tendency towards intensification away from diversification. Third, to train and minimize a loss function, replay memory with run times small batches were considered for the state estimation. It has been demonstrated that the introduced system improves energy efficiency when compared to random approaches and conventional reinforcement learning.

RLbR: The strain on the 5G cellular network was greatly reduced by a unique reinforcement learning-based V2V routing (RLbR) architecture developed by [143]. The V2V network was designed by considering the non-real time traffic offloads. The concentration on RA of 5G in the suggested architecture enhances the efficacy of communication. The figuring of presence or absence of the real-time traffic was performed by the SDN controller. The V2V network carries non-real-time traffic and cellular network carries real-time traffic. On top of an SDN controller, the relevant algorithms and strategies may be installed as an application, making it simple to upgrade owing to its plan. The application of the reinforcement learning in the routing algorithm to assess the nearby device's quality was utilized for choosing the best path. While considering the environmental conditions, the Q-Table's convergence rate was accelerated through the forward packets by considering the position factor PF. Several simulated conditions were used to evaluate efficacy of the model. The outcomes show that the suggested structure offloads traffic from the designed framework. There were also evaluated more comparisons with the available routing techniques to depict the superiority of the outcome. In terms of average latency, delivery ratio, average energy consumption, and network longevity, the findings demonstrate the effectiveness of the RLbR algorithm.

Improved D2D MIMO Deep Learning Model: With the use of artificial intelligence, [144] developed a mode selection method with highly effective and low complexity for D2D mmWave communications. The best mode in the event of mmWave transmission blockage or a small mmWave coverage area was estimated using deep learning strategy. The best mode for information relaying was then predicted with highly reliable using the suggested deep learning model. Here, nearly usage cases in the offline phase were utilized for training the model. Possible D2D transmitters choose their method of transmission during the mode selection process based on a number of factors. It utilizes the cellular uplink or specialized D2D communication, wherein the intermediate node utilized for the transmission was considered as BS. A high-efficiency and low-complexity based optimum mode selection problem was addressed by the developed deep learning model.

Resource allocation and power control method: By considering a complex D2D communication scenario, [145] suggested a DRL based approach for solving the issues using a combined power control and resource allocation approach. In this, the power management and channel selection concerning the surroundings were considered as joint optimization issue in the introduced model for training the transmitter of D2D model. Here, the consideration of channel reuse led to an increase in transmission power from D2D users and an increase in interference for cellular users. For satisfying service expectations and maximizing system capacity, the introduced model utilizes power control techniques and multi-channel selection approaches for learning the introduced model. With the inclusion of the RL approach, the issue concerning the decision-making was solved effectively. The decision-making issue was considered as a more challenging task by the D2D user's ability to choose a best path among several channels in a communication situation. This was because the state and action spaces were a quite wide task in reinforcement learning. The introduced deep RL (DRL) approach was designed particularly for situations with large state and action spaces to choose the best route that may greatly speed up learning process. Additionally, the algorithm's speed does not suffer as more multiplexed channels were considered by the introduced model. In order to send services as quickly as feasible without interfering with cellular users' regular interaction, D2D users can choose from a variety of channels depending on the different types of Mission-critical communication (MCC) service needs. Each agent may learn from the outcomes of simulations to meet the cellular communication requirement while maximizing the overall system capability and minimizing D2D communications disruption.

APERAA: The underlay Inband D2D communication model's uplink resource allocation was carried out in [146] with the optimization of transmit power by considering various restrictions such as SINR, BER, and so on. Using the BER constraints, the power control and resource allocation were assured by the introduced model for solving the transmit power limitations. Autonomous Power Efficient Resource Allocation Algorithm (APERAA), performs effectively by solving the issues in power regulation and resource allocation utilizing the Lyapunov optimization along with an iterative strategy. The uplink D2D connection based on frequency band distribution was provided autonomously by the SVM-based ML algorithm. The outcome of the method show that, in comparison to the most widely used algorithms, the system's total capacity was higher. The considerable separation between BS and D2D users along with the separation between the D2D users were supported by the introduced model. The test results for the random data set with SVM-based training demonstrate exceptional accuracy, and also demonstrated in the assessment based on simulation depicts that the accuracy in terms of resource allocation elevates with the elevation in number of D2D devices. In order to offer autonomous resource allocation for IoT healthcare applications and services, the devised approach may be used in 5G networks.

Joint Deep Reinforcement Learning: [147] suggested a hybrid approach that combines an unsupervised learning network and a deep Q network (DQN) using the distributed resource allocation approach to efficiently improve wireless spectrum utilization, boost network capacity, and decrease interference. The channel allocation in the unknowable and dynamic environment was first solved using a DQN algorithm in a distributed way. In order to provide a channel power management system in an optimal manner to elevate the sum-rate of the spectrum transmit by considering relevant constraint processing, power control based on unsupervised learning method was built using a deep neural network. Using a small amount of state information gathered locally, the suggested algorithm utilized each transmitter to make power control and channel selection as a learning agent. In contrast to conventional centralized methods, the devised approach utilizes the information concerning the network that was gathered instantaneous global criteria. The distributed algorithm's transmit power was within the permitted range, demonstrating the model's dependability.

Improved DRL: An innovative dynamic reinforcement learning-based slicing framework and optimization solutions were created by [148] for vehicular communications applications by considering low latency and bandwidth-hungry needs. In order to facilitate effective V2V communication, appropriate resource provisioning approach was used in the model. For several slices, it was intended to strike a compromise between degrees of QoS acquisition and resource use. The three layers and stages of the slicing structure were created in the virtualized network. As an initial step, various resources to slices was allotted by the suggested model for allocating virtual resources using a dynamic deep reinforcement learning strategy. For processing the particular application, slicing was devised in the mobile virtual network operators (MVNOs) by dividing it into several segments in its physical infrastructure. To achieve optimal resource management, adjustments were devised on the MVNOs' resources using a DRL agent. Additionally, it balances the QoS fulfillment and use of resources for slices for better communication. To create the D2D pool, the resources concerning the D2D components were combined together. The slice resourced resource integration using its specified portion was made in the second stage of the method. Using the distributed algorithm based on multipliers, problem concerning the physical resource allocation based on signaling overhead and computing complexity was transformed into a convex optimization in the third step. Here, the vehicular network's extremely dynamic character issue was addressed by the designed framework. Besides, operational needs, QoS, and performance of the slicing framework were optimized efficiently by the introduced model.

QSPCA: [149] suggests a two-stage power control method called the Two-stage transmit power control approach (QSPCA) for effective communication. The cellular users and several D2D users were taking into account for creating the dataset offline at the initial stage. The attributes like cellular user, D2D location, RB, and D2D user were considered while creating the datasets. To enhance the cellular usage based on the resources allotted by D2D users and the BS utilizing the spectrum were accessible with the help of the offline construction of training datasets. The obtained dataset was employed for the classification purposes using the SVM classifier during the second phase. The data was transformed using the kernel approach to provide the best separation between the results that could be produced. Industrial IoT applications such as mining, production, and factory automation in 5G networks might make use of the D2D transmit power control and minimum delay. The introduced method might potentially be used extensively in areas such increased ultra-reliable minimum delay and time-sensitive networking. The description of the literatures along with the advantages and challenges is depicted in Table 2.3.

Table 2.3: Short description of machine learning based techniques

Reference	Technique Used	Performance Measures	Advantages	Disadvantages
Raja, S., Logeshwaran, J., Venkatasubramanian, S., Jayalakshmi, M., Rajeswari, N., Olaiya, N.G. and Mammo, W.D. [4]	RL-ID2D	End to end delivery ratio	RL-ID2D chooses the cellular relay through an elevated likelihood of demand and excellent EDR, based on simulation outcomes.	The NB-IoT adds a greater quantity of control packet and data retransmissions, which lowers the method's average throughput and energy efficiency while increasing the reliability and coverage area of the connected device.
Gupta, D., Rani, S., Singh, A. and Mazon, J.L.V. [8]	CenTri	Route breakage, Throughput, PDR, and Delay	Load balancing was achieved by offloading traffic from the macrocell layer to the small-cell layer.	With the goal of concentrating on paths with minimal congestion, the delay created by multi-hop connectivity had not been taken into account. Furthermore, the suggested CenTri necessitates additional testing with a greater variety of paths and relay nodes.
Zhang, Y. [11]	I-D2D	PDR, and delay	The developed model chooses the cellular user equipment relay that has	

			the best likelihood of being provided with lowest latency and maximal PDR.	
Kazmi, S.H.A., Qamar, F., Hassan, R., Nisar, K. and Chowdhry, B.S. [31]	CRP-GR	Throughput, packet delivery ratio, residual energy, End-to-end delay, Network Lifetime	Realistic demands increase lifetime of the network and decrease latency by selecting an required learning rate and QoS factor value.	The developed method was not applicable to deal with the emergency situation due to the in-flexibility of the model.
Mangipudi, P.K. and McNair, J. [32]	Fast Connectivity Construction	Latency, Delivery Time, Packet Delivery Ratio	With 100% of the packets delivered, the designed technique can send data more quickly than the usual connectivity scheme.	Higher battery consumption and latency makes the network to degrade its outcome in D2D communication.
Barakabitze, A.A. and Walshe, R. [33]	Optimal DQN	Network lifetime, Energy consumption	Increased network stability leads to increased throughput and less route formation-related signaling overhead.	The model's performance was diminished by an overestimation of Q-value devised through choosing actions with the greatest Q-values.
Sylla, T., Mendiboure, L.,	RLbR	Network lifetime, Energy Consumption, Delivery	The delay associated with the network	The network's overall energy will grow as the quantity of devices participating

Maaloul, S., Aniss, H., Chalouf, M.A. and Delbruel, S. [34]		Ratio, and Latency	was minimal when the number of devices in the network was smaller; because, the path finding within the smaller network was considered as a easier task.	in information transmission increases as well.
Ogbodo, E.U., Abu-Mahfouz, A.M. and Kurien, A.M. [35]	Improved D2D MIMO Deep Learning Model	MSE, Throughput, Energy Efficiency, and Coverage Probability	The designed deep learning based optimal mode selection criteria accomplished an increase in reliability while communicating with the device.	In the event of direct path blockage or significant interference, the developed approach does not ensure that the link between the BS and devices was the optimal link.
Dangi, R., Lalwani, P., Choudhary, G., You, I. and Pau, G. [36]	Resource allocation and power control method	Sum rate, system capacity	The strategy for power selection and resource allocation had the advantage of increasing system capacity overall in accordance with the various MCC functions.	Slower convergence rate

Ioannou, I., Christophorou, C., Vassiliou, V. and Pitsillides, A. [37]	APERAA	Accuracy, SNR, Spectral Efficiency, System Capacity	For devices based on the Internet of Things having independent capability for live care or uninterrupted health monitoring of an individual without experiencing an interruption or latency when connecting to services, the designed model offers an innovative approach in the environment of communication.	The method considered only the uplink channel for resource allocation.
Laguidi, A., Hachad, T. and Hachad, L. [38]	Joint Deep Reinforcement Learning	Spectral Efficiency, and Energy Efficiency	For arbitrary assignments, the technique proved to be more adaptable in terms of average transmit sum-rate.	To directly reduce channel interference between users of mobile devices and BS, the suggested algorithm found it challenging to be implemented.
Khan, R., Tsiga, N. and Asif, R. [39]	Improved DRL	Convergence, resource utilization	Multiple experiments showed that, as compared with current methods, the	Failed to consider the significant features that enhance the efficiency of the model while designing the virtual

			new techniques may increase throughput, slices satisfaction, and resource utilization benefits.	model.
Guo, L., Zhu, Z., Lau, F.C., Zhao, Y. and Yu, H. [40]	QSPCA	SINR, Throughput, and Power	By guaranteeing that the regulated transmission power stays within the restrictions, the newly implemented technique increases the throughput of D2D users.	When the BER rises, the throughput falls as well. But when the BER value increases, throughput gradually declines. Increased SINR is necessary to lower BER. In order to properly analyse the efficacy of the network, the BER factor must be taken into account.

2.3 Research Gaps

D2D communication based on cellular network is an emerging topic of research among researchers nowadays. A lot of research has been done on the D2D communication, but major proposals were faced challenges in obtaining the efficient network model. Some of them are:

- ***Interference***: The main issue with D2D cellular networks that underpin D2D is interference among D2D users and cellular users. D2D connections involving D2D users and cellular users, commonly referred as cross-tier interference, which are considered as the source of unwanted interference. To improve the receipt of intended information at the point of reception, interference has to be significantly reduced. Due to the eNB's strong broadcast strength, D2D users that reuse downstream RBs will experience interference. The communication reliability of a D2D network is reduced when interference accumulates and SINR values declines. In contrast, reduced interference is seen whenever users of D2D reuse upstream RBs since upstream management signalling being weaker than downstream so there is more congestion overhead in cellular networks. Reusing the upstream frequency offers less interference than reusing the downstream spectrum, for this reason.
- ***Device Recovery***: Equipment identifying to connect the communication is an important issue in communication between D2D devices. In D2D technology, there are several device-finding techniques. The two primary methods of device discovery are prosteri and priori and eNB started functioning through interaction with users. Prior to the initiation of interactions among D2D users, the user broadcasts a beacon signal regularly certain times to begin the process of discovery. In order to maximise system gain, eNB finds prospective D2D pairings based on user IP address information and gives users the option to pick D2D connection options. Numerous research publications on device discovery in D2D communication were published. In the cellular network, an integrated approach for full, partial, and off-coverage scenarios are explored.
- ***Mobility***: A thorough examination of the network's mobility system for management is detailed along with an analysis of it impacts on the system's efficiency. Reliability of interaction between devices is significantly impacted by

mobility management. Users of wireless communication systems have allowed roaming about; therefore managing portability becomes an important issue that has to be solved. The wireless cellular technique's operational equipment may relocate, making it impossible to maintain communication uninterrupted. To maintain the infrastructure without disruption an effective algorithm must be developed using the aid of flexibility management. A higher information throughput, reduced latency, and less power consumption are characteristics of the D2D cellular network that underlies it for enhanced mobility.

- ***Security***: It is crucial to consider privacy and security issues thoroughly while adopting and deploying communication between devices on cellular networks. It occurs primarily a result of the integration of several user devices, network architecture, and interfaces to carry out the tasks on one system. To guard from many types of attacks on networks including reply attacks, man-in-the-middle, denial of service, etc., secure wireless communication has to meet the criteria of authenticity, privacy, and availability, as well as confidentiality. During exchange, data has to be secured using an encryption method to prevent attackers.
- ***Energy Consumption***: To increase the total handling capacity and spectrum efficacy of D2D-enabled mobile communications platforms, radio resource management (RRM) problems have to be correctly resolved following device detection and mode selection. To increase the efficiency of the system, a variety of radio resource management strategies were put forth. Upcoming cellular networks will be equipped with the capacity to support a lot of equipment. A 50 billion equipment prediction has been made. The unfortunate result of more communication devices being used is more energy being utilised. The atmosphere's CO2 concentration will rise as a result, harming the ecology and the environment worldwide. Additionally, BSs and access points consume a tremendous amount of energy and emit a significant quantity of radiation, all of which have an impact on human health and the global economy. The environment is therefore taught to hate wireless communication networks. Due to these factors, green communication networks are frequently implemented in 5G networks. In order to be "green," communication must use as little energy as possible and extend battery life. The next generation of 5G cellular networks is predicted to increase energy efficiency by a factor of 1,000. The basic goal of a green network may be achieved by

utilizing a variety of components, including power control, energy harvesting, cloud RAN, and femtocells. D2D technology is one of the key elements that helps green networks. It can take some of BS's energy off of it. The consumption of electricity by devices is also reduced via close-proximity networking. D2D render radiation from BSs obsolete. Also improving energy efficiency is the use of relays with DUs. Due to the fact that battery-powered devices are an evolved kind of D2D user in such networks, energy consumption is one of the key problems that cooperative D2D networking faces.

2.4 Summary

The review of conventional methods concerning the 5G cellular communications is elaborated in this chapter for identifying the challenges faced by the methods while enhancing the efficiency of the network. Here, the three various mechanisms like Machine learning based techniques, D2D communication techniques and Cooperative communication techniques are reviewed. Finally, the research gaps identified based on the review is detailed to develop a novel framework by fulfilling the challenges faced by the conventional methods.