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Energy Aware Resource Allocation in Multi-Hop Multimedia Routing via the Smart Edge Device

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ABSTRACT Environment sustainability, energy efficiency and computational reduction of computation time are recent stressing issues for the information and communication technologies (ICTs). Energy efficiency (EE) in particular is accounted for practical use of device to device (D2D) communications which is optimistic, and alternative architectural network especially for the cases where the infrastructure based communication is not possible. As a consequence, resource allocation for D2D communication plays a key role to address the issues related to battery lifetime and application quality of services (QoS). In this paper, a novel multi-hop routing is proposed to increase the energy efficiency of the D2D communication systems. In order to obtain a plausible solution, a combinatorial optimization is formulated. The purpose of this problem formulation is to achieve improved energy efficiency, throughput rate, resource utility, and packet delivery ratio as well as to reduce the computation cost. Network simulation demonstrates the efficiency of the proposed routing as compared to other existing techniques.

INDEX TERMS Device to device communication, energy efficiency, multi-hop routing, optimization, quality of services.

I. INTRODUCTION

Economic and social developments have been influenced by the evolution of mobile communications and its integral features are in daily use of common people. This has evolved 5G architecture design to be a pillar of 2020 future society, which is aimed to offer various innovative services. 5G will bring an ecosystem for the business and technical innovation, which demands economic advantages for vertical markets, such as healthcare, energy, education, manufacturing and automobile. As a consequence, 5G must overcome some conditional demands, namely complex service, user scalability, traffic volume extendibility, device heterogeneity and price affordability towards feature update. Besides, 5G service access should be ubiquitous, as long as the convergence and integration is predominant in daily use. Since the new paradigm of 5G always changes the built-in component features of existing architecture not only in terms of the wireless channel interface, but also in the perception of flexible network management, the principles of SDN, MEC, NFV and FNM should be leveraged to deal with short-term network life-cycles. Table 1 defines the important abbreviation used.

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IoT has now become a daily use of common people due to the evolution of wireless communication technologies, such as 4G, RFID, WiFi, IEEE 802.15.x etc [1]. In IoT, the daily-use physical objects can be linked to the Internet not only to identify but also to be ubiquitous connection among each other. Internet specialists report that IoT will certainly have 50 billion physical objects by 2020 [2]. Using IoT, the electronic objects, such as television, smart phones, computers, cars etc. will collect the necessary information and send them back to the concerned object over wireless technologies, which will in turn accomplish the proper response [3]. The major contribution of IoT is to provide the advance connection establishment between the systems, devices and services, which always exceed the device-to-device communication to support various routing protocols, applications and domains. The interconnection of these physical devices will concern on the automation process and also provide some advanced supports, such as smart surveillance and grid computing system [4].

The term surveillance includes monitoring processes, such as behavior, activities and exchange of information for the purpose of human direction, management and protection. As a result, the term is meant for the remote monitoring process by means of electronic devices like CCTV camera or

TABLE 1. Important abbreviation used.

Abbreviation	Description
D2D	Device-To-Device
EE	Energy Efficiency
ICT	Information And Communication Technologies
QoS	Quality Of Services
SDN	Software Defined Networking
MEC	Mobile Edge Computing
NFV	Network Function Virtualization
IoT	Internet Of Things
RFID	Radio Frequency Identification
FNM	Flexible Network Management
M2M	Machine-To-Machine
MTC	Machine Type Communication
OFDM	Orthogonal Frequency Division Multiplexing
EHANT	Energy Harvesting Active Networked Tags
MD	Markov Decision
IoE	Internet Of Everything
WSNS	Wireless Sensor Networks
Q0E	Quality Of Experiences
LTE-A	Long Term Evolution – Advanced
OFDMA	Orthogonal Frequency Division Multiple-Access
FBC	Filter Bank Carrier
CD	Closest To Destination
AODV	Ad Hoc On-Demand Distance Vector
CUE	Cellular User Equipment
BS	Base Station
5G	Fifth Generation
RSSI	Received Signal Strength Indicator
I2D	Infrastructure-To-Device

the interception of electronic transmission streaming (such as phone calls, internet traffic etc.). The term smart surveillance system denotes the real time abilities to analyze the video in applicable with surveillance application [5]. The use of surveillance application is the video compression technology, which multiplexes the stored images effectively capturing from a large number of cameras into mass storage devices (e.g. disc, video tapes).

The surveillance system converts the video from the data acquisition and analyses the information through the tool of intelligence acquisition system. The purpose of real time video analysis is to analyze the activities on real time and to gather the significant information at higher resolution. M2M communication enables IoT as the base technology to form autonomous data transfer [6]. It is widely used in various application domains such as smart networking, grid, enterprise, telematics, e-Healthcare and security [7]. These application domains are situated at the center of cellular networks to evolve 5G network. This network involves experimental analysis to address the deployment and functionality issues such as traffic, time-controlled, energy requirement, dynamic mobility, quality transmission and device scalability. The critical requirement of MTC is energy efficiency that is difficult to provide a reliable battery backup during radio-resource management [5]–[14]. Therefore, the energy efficiency of smart computing devices should increase at least by the factor of 10 to achieve better battery lifetime.

Specifically, 5G deployment demands the requirements of communication systems such as less latency, more reliability, scalability, availability and interoperability. Moreover, the functionalities increase the battery capacities and security efficiencies [8]. The 5G enabling technologies provide network virtualization, heterogeneous networks, coding and congestion reduction techniques. To give certain properties of backhaul networks, a modulation technique known as OFDM is preferred in 5G. However, a new 5G deployment widely uses a filter bank multicarrier scheme to offer effective radio resource allocation. This scheme provides high spectrum sensing, where an efficient resource allocation plays a vital role to improve the performance of wireless networks. Several researches address the downlink resource allocation to restrict the energy efficiency of M2M communication system [15].

Unfortunately, M2M communication is uplink centric; and thus it is necessitated to construct a resource allocation technique in order to generate less traffic on downlink. Currently, resource allocation on M2M uplink network degrades other computation performance i.e. less M2M communication devices, higher delay and more signaling messages to accomplish better energy efficiency. As a consequence, a significant gap is addressed to provide a prominent solution. In literature, limited resource allocation techniques have been studied for the achievement of better energy efficiency of multimedia networks. Figure 1 shows the literature work of resource allocation mechanism in IoT networks. Tsai et al. [16] presented a SEIRA algorithm that uses metaheuristic technique to assess device computation resources in order to claim less communication overhead. Su *et al.* [17] proposed a resource allocation mechanism for wireless networks. This proactive mechanism utilizes power allocation technique and MD process to increase the network throughput rate.

Moreover, a service-to-communication interface uses a heterogeneous resource allocation technique [18] to reduce the service cost of networking systems. A resource allocation technique known as EHANT [19] is introduced to manage the power supply of M2M networks i.e. for IoE.

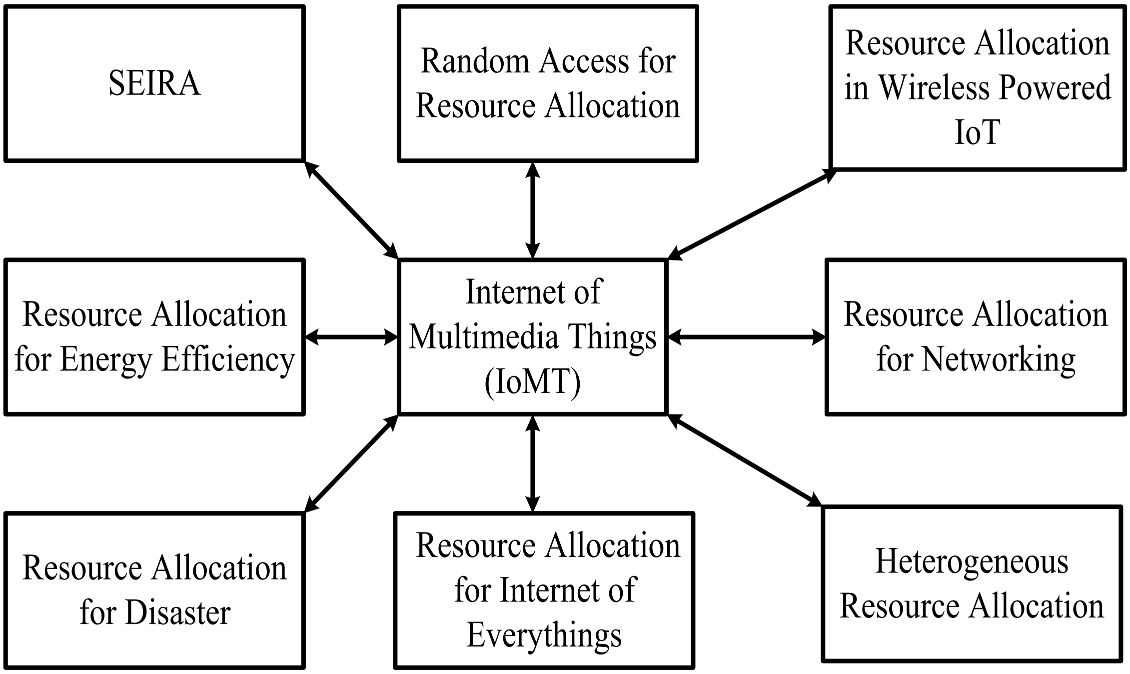

FIGURE 1. Recent resource allocation approaches in IoT.

Zhang *et al.* [20] introduced a collision-free resource allocation for uplink communication network that offers scheduling protocol. Avgouleas [21] provided a game-theory to imply a co-operative strategy. Li *et al.* [22] constructed an I2D to maximize the resource allocation of device-to-device communication. They implement an approach of weighted sum-rate to provide better resource allocation. Kumar and Zaveri [23] deployed a maximum bi-partite graph to assign a contiguous resource allocation in disaster environment.

WSNs are in fact tending to be integrated with IoT networks. They are generally an ad hoc network, which composes of several small sensor nodes with limited computational resources and one or more bases stations. In several cases, sensor nodes would have a built-in processing unit with limited power and computation capacity. WSNs are used to deploy in nature disaster environment, such as glacier, dense forest and mountain in order to gather the environmental information. Temperature, humidity and light are the key reading factors or environmental phenomena like climate change and their seasonal impacts. Though there are several advantages in the integration of WSNs in IoT, the integration schemes still carries several technical challenges [22] such as privacy issue [3]. The significant of smart city is to enhance the overall quality of life of the citizen. A smart city is often highlighted with six significant characteristics, which are built on smart endowment combination, independent, self-decisive activities and citizen aware. Lately, the European Commission has called for the proposal on smart city regarding energy efficiency, renewable energy and green mobility for the large urban cities [24]. Smart city citizen will be encircled by an environmental system, which frequently acquires and leads them to better QoE in terms of executing the user requisition. As relay based transmission can improve the longer distance D2D communication, most of the researchers give their attention for the multi hopping D2D communication. Wen *et al.* [25] dealt with spatial-density and power transmission to get better transmission capacity. However, it is declared without specifying a routing technique. Pingley *et al.* [26] proposed a multi hop routing technique to maximize the hop count of the networking systems. But then, it is proven undependable to minimize the distance between the users. Since the existing relay based techniques do not consider the energy efficiency for the D2D communication, this paper formulates a combinatorial optimization to improve the energy efficiency, throughput rate, packet delivery ratio, and resource utilization of communication systems.

The rest of the paper sections are organized as follows: Section 2 discusses the significance of existing works and its related challenges. Section 3 explains the system models constructing the spectrum-sharing model and the cellular-hybrid networks. Section 4 presents a heuristic algorithm for relay-based multi-hop routing. Section 5 discusses the simulation results. Section 6 concludes the research work.

II. RELATED WORKS

Several initiatives have been sufficed for the growth of M2M communication in IoT domains. To identify the significance of energy efficiency in recent publication, Figure 2 summarizes the related works towards the resource allocation mechanism in 5G networks. In [27], Zhou et al. presented a resource allocation technique that uses a method of contention-based access network to improve efficiency of machine type communication systems. This technique

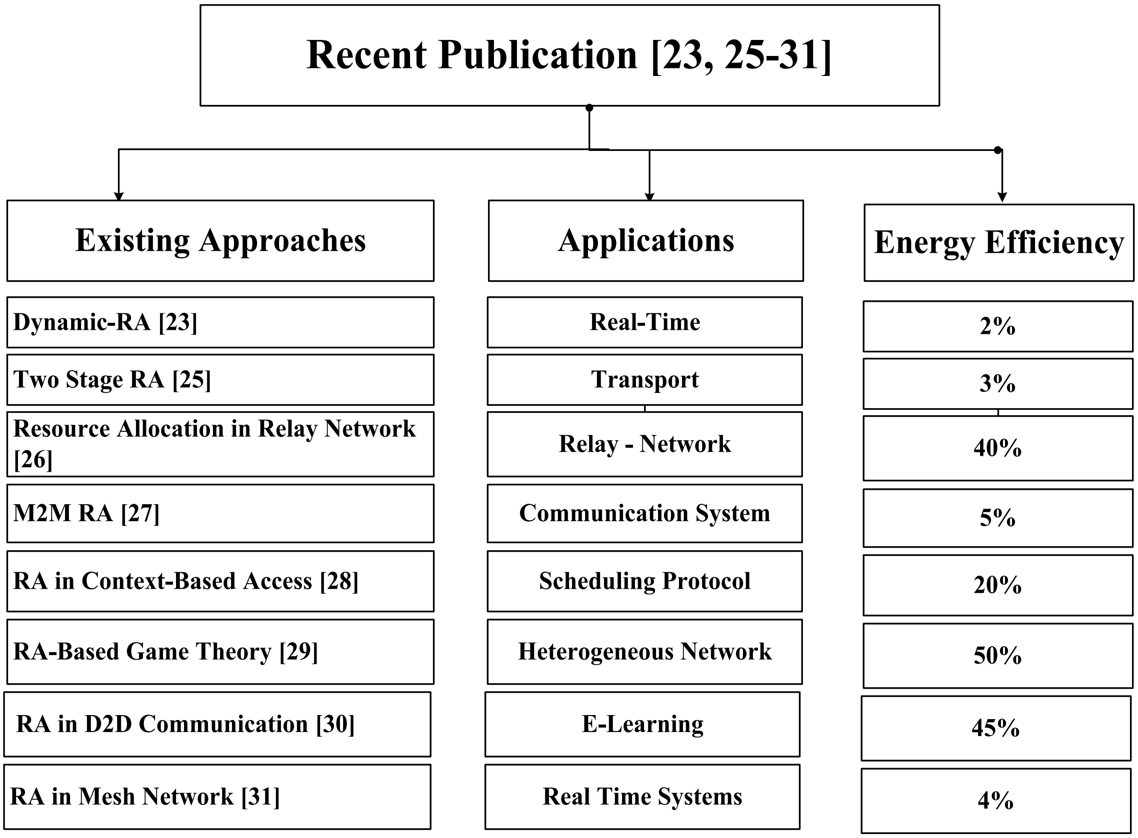

FIGURE 2. Recent publication based on resource allocation mechanism.

considers an event-occurring probability to estimate the transmission and latency. While latency is larger in any network access, then the contention-based network increases the resource allocation for the available computing devices. However, Morvari *et al.* [28] presented a two-stage resource allocation mechanism to estimate the computation resources of user equipment. In the first stage, a factor of access class barring is computed to assess the resource demand of user devices, whereas the second stage ignores the user devices to calculate new access class barring.

Chen *et al.* [29] examined the usage of energy efficiency for LTE-A with Type-I relay i.e. for uplink. To address the issue effectively, they proposed a heuristic approach. It utilizes the spatial spectrum reuse to achieve better energy consumption that ensures less reduction of modulation and coding scheme. It is noted that the proper use of reward calculation in game theory can select an expected modulation and coding level. It introduces the constraints of QoS requirement using a sum of power minimization problem to achieve energy efficiency. This minimization problem utilizes an inverse weed optimization to meet the QoS requirements of computing devices. The simulation result proved the co-existence of M2M communication in LTE-A networks. Shi *et al.* [30] proposed the context information of computing devices that uses a scheduling protocol to test 5G networks. The context information is based on LTE-A signaling architecture, which is implemented to work on priority scheduling in LTE-A to achieve better energy efficiency using two-layer game-theoretic approach. This proposed model allows each femtocell access point to maximize the usage of data-rate preferring the frequency-band between millimeter wave and sub-band 6 *GHz*. The proposed model applies the Nash equilibrium strategy to achieve the prominent solution. It ensures energy efficiency associating with minimum data-rate and maximum power-constraint using dual decomposition. Zappone et al. [32] showed the hybrid heterogeneous network to improve sum-rate and energy efficiency. Moreover, it is proposed to utilize the D2D communication architecture to improve the spectrum reuse better.

Most importantly, the resource allocation problem considers a case study application to mention the use of sequential fractional programming. It is mainly focused on downlink of OFDMA that coexists with I2D and D2D communication architecture. To address the issue effectively, Zappone et al. proposed two-key measurement techniques namely weighted sum-rate and GEE. Shi *et al.* [30] presented a channel assignment algorithm to improve the network performance, which uses interference of local multicasting and forwarding weight of each node. The network simulation shows the improvement of network allocation. However, there are still various issues addressing on computation delay and system complexity. Moreover, a wide gap is prevailed to present an effective resource allocation algorithm in order to provide an energy efficient M2M device. To the best of our knowledge, there is no efficient resource allocation algorithm for smart computing devices i.e. for narrowband IoT-network and LTE-M. Morozs *et al.* [35] proposed the distributed inter cell interference coordination for LTE cellular systems that uses Q-Routing technique to provide a robust cognitive spectrum management. Du *et al.* [39] developed a prioritized deep Q-Routing network to solve the resource allocation and joint routing problems. However, the above routing techniques [39], [40] were failed to consider the multi-hop routing networks in order to improve the network performance.

III. SYSTEM MODEL

This section builds the spectrum-sharing model and the cellular-hybrid networks to infer the channel, relay, transfer-rate model. In general, MTC system composes of smart computing devices that contain sensor and actuator to connect over wireless channel. This channel periodically invokes send and receive function to establish smart device communication i.e. M2M. Moreover, it has a cellular coverage to provide extensible services in 5G networks [33]. This system is further divided into massive-MTC and ultrareliable-MTC, which is set with 5G network properties to analyze the low-power communication devices. FBC is considered as a potential waveform modulator to access 5G networks. However, in data-link layer, it is primarily consisted of open-wireless architecture, lower and upper network link. Table 2 defines the important notation used.

In D2D communication, a small computing sensor uses a wireless channel $\mathrm{W_C}$ that allocates the resource block $\mathrm{RB_N}$, where n represents the subcarrier for each resource blocks. It is referred as a signaling power $\mathrm{S_P}$ [34] to compute the required radio resource allocation. This can be expressed as:

$$\mathrm{S_P} = \mathrm{P_e} - 10\log_{10}(\mathrm{q}\times\mathrm{S_C}) \tag{1}$$

where $\mathrm{P_e}$ represents the eNB signaling power and $\mathrm{S_C}$ is the number of subcarrier signal with $\mathrm{q^{th}}$ resource block. The total power computation $\mathrm{T_{PC}}$ can be further calculated from the path loss subtraction $\mathrm{P_L}$ to the signaling power $\mathrm{S_P}$. This can be used to estimate the power of MTC that computes the consumption rate of signaling power. It can be calculated as:

$$\mathrm{T_{PC}} = \mathrm{S_P} - \mathrm{P_L} \tag{2}$$

Using $\mathrm{q^{th}}$ resource block, the MTC devices compute signal-to-noise i.e. $\mathrm{SNR_q}$ [32]. It can be expressed as:

$$\mathrm{SNR_q} = \frac{\left(\mathrm{T_{PC}} \times |\mathrm{h_q}|^2\right)}{\delta^2} \tag{3}$$

In Equ. (3), $\mathrm{h_q}$ is the channel amplitude fading, δ^2 is the power of Additive White Gaussian Noise (AWGN) and $\mathrm{T_{PC}}$ is the total computation power of $\mathrm{q^{th}}$ resource block. The date rate $\mathrm{d_r}$ [30] can be expressed as:

$$\mathrm{d_r} = \mathrm{b_w}\times\mathrm{RB_N} \times \log_2\left(1 + \mathrm{SNR_q}\right) \tag{4}$$

where $\mathrm{b_w}$ is the effective bandwidth rate and $\mathrm{RB_N}$ is the allocated resource blocks assigned with particular devices.

TABLE 2. Important notation used.

Notation	Description
$\mathrm{W_C}$	Wireless channel
$\mathrm{S_P}$	Signaling power
RB	Resource Block
n	Subcarrier for each resource block
$\mathrm{P_e}$	eNB signaling power
$\mathrm{T_{PC}}$	Total power computation
$\mathrm{P_L}$	Path loss subtraction
$\mathrm{h_q}$	Channel amplitude fading
δ^2	Power of Additive White Gaussian Noise
$\mathcal{N}_0$	Additive White Gaussian Noise
$\mathrm{P_C}$	Power consumption
$\mathrm{E_E}$	Energy efficiency
T_{po}	Transmitted power
A	Constant gain
ρ	Small scale constant for fading factor
α	Path-loss exponent
D_{TR}	Cellular data transmission rate
C_G	Channel gain
θ	Value of channel noise
$\mathrm{o_i}$	Optimal reuse
C_k	Candidate-node
$cg^k_{D^j_h}$ and cg^k_{i,D^j_h}	Channel gains defined for $D2D$ link interfering to the $D2D$ receiver
$P^k_{D^j_h}$ and P^k_i	Power transmitter of $D2D$ transmitter
$Q^k_{D^j_h}$	Inter-cell communication interference obtained by $D2D$ receiver
$\mathcal{T}^t_{\mathrm{D}}$	Throughput
UE	User equipment
t_s	Time slot

The power consumption $\mathrm{P_C}$ can be measured as:

$$\mathrm{P_C} = \sum\nolimits_{m=1}^{M} \sum\nolimits_{k=1}^{RB} \mathrm{T_{PC}} \tag{5}$$

The main objective is to minimize the power consumption $\mathrm{P_C}$ to allocate the appropriate resource block i.e. for smart device communication. Finally, the energy efficiency $\mathrm{E_E}$ [in bits/Joule] can be calculated as:

$$\mathrm{E_E} = \frac{\mathrm{d_r}}{\mathrm{T_{PC}}} \tag{6}$$

A. NETWORK ARCHITECTURE

This paper prefers an infinite planer cellular network to provide two alternative transmission modes for UE. In cellular mode, the proximal UE directly communicate with D2D without the knowledge of base station $\mathrm{B_S}$,

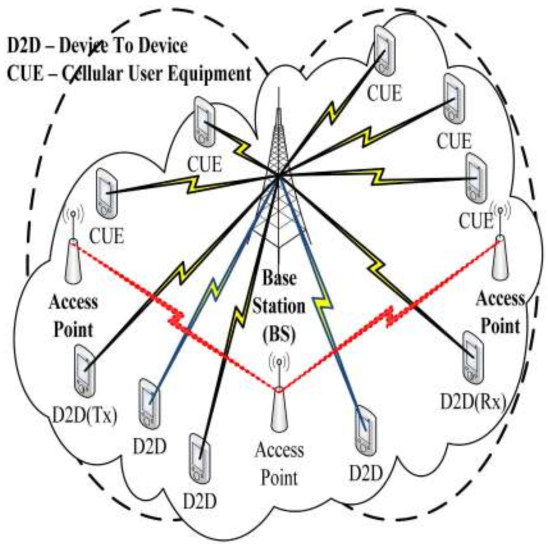

FIGURE 3. Relay based D2D communication using cellular network.

whereas in D2D mode, the adjacent UE can be discovered through the RSS i.e. passively observing from other UE. The UE always considers the adjacent UE as a neighbor if it the RSSI region from UE is beyond the threshold value. This method is much focused on the procedure of LTE discovery [36], [37]. It uses certain transmission mode schemes not only to offer better system performance, but also to select an optimal transmission mode [38]. D2D proactively uses spatial reuse to mitigate the interference and resource efficiency to proximal UE transmission, whereas communication link employs orthogonal resource to reduce the interference under various transmission modes.

B. SPECTRUM SHARING

A single-cell scenario is considered as part of $'N'$ simultaneous *CUE* and $'M'$ D2D communication node. Assume that the *D2D* nodes share the up-link spectrum with the cellular-users, whereas $D2D_{T_x}$ and $D2D_{R_x}$ are transmitter and receiver of the communication nodes that are communicating through one or more existing *D2D* as shown in Fig 3. As stated in the assumption, the CUEs of N communicate through N channels with the base-station B_S and the channel allocation to the respective CUE is unchanged. However, the *D2D* node may be allowed to reclaim one of the channels. It shows that BS can suffer from interference of all the signals received from $D2D_{T_x}$ significantly. Therefore, the interference of *D2D* user should be avoided in order to improve the transmission power efficiency.

C. CHANNEL MODEL

For defining the channel model, the transmitted power utilized by the *D2D* users are represented as T_{po} and the transmission range between *BS* and *D2D* user is represented as T_r. The expression of channel model can be provided as:

$$C_M = A\rho T_{P_0} T_r^{-\alpha} \tag{7}$$

where C_M is the transmission power of BS, A is the constant gain factor for power provided by antenna and amplifier gain, ρ is the small scale constant for fading factor and α is the path-loss exponent. The transmission range between the *D2D* nodes of i and j is denoted as $R_{ij}\,(i, j = 1, 2, 3, \ldots\ldots, N)$. Besides, the reuse channel transmission range is represented as Δ_i, the range for *D2D* nodes (i and j) and *BS* is denoted as r_i and the power transmission for node i is defined as p_i. The cellular-link interference is expressed as:

$$\mathrm{I_{BS}} = \frac{\mathrm{A}\rho \mathrm{T_{P_0}} \mathrm{T_r^{-\alpha}}}{\mathrm{A}\rho \mathrm{T_{P_i}} \mathrm{r_i^{-\alpha}}} \tag{8}$$

D2D Relay Model: The relay based decode and forward protocol use set of D2D nodes as the idle relay nodes excluding $\mathrm{D2D_{T_x}}$ and $\mathrm{D2D_{R_x}}$. Also we assume that each cellular-channel can reuse a single D2D pair for different channels of the cellular-users as explained in [25], [26]. As D2D link suffers from interference in different cellular network, D2D relay node acts as hitch-aware node to improve the energy efficiency of D2D link with less interference and more channel gain to reuse in order to achieve better throughput rate.

D. D2D TRANSFER RATE MODEL

To calculate the power consumption rate, D2D Tranfer Rate is modeled. Since the examination is targeted for 5G networks, it is therefore included of cellular or *D2D* communication for constant transmission rate. To examine the data transfer rate, it is modeled as:

$$D_{TR} = \sum\nolimits_{k=1}^{N} \log_2 \left[\frac{1 + \left(T_{P_0} \times C_G\right)}{\sum_{i=1}^{M} \left(P_D \times C_G\right) + \theta^2} \right] \tag{9}$$

where D_{TR} is the cellular data transmission rate, C_G is the channel gain, P_D is the required transmission power i.e. for $D2D_{T_x}$ and $D2D_{R_x}$ and θ is the value of channel noise.

Subsequently, D_{TR} of *D2D* communication can be computed as:

$$D2D_{TR} = \sum\nolimits_{i=1}^{M} \sum\nolimits_{j=1}^{N} 1 + \frac{\left(P_D \times C_G\right)}{T_{P_0} + \sum_{i=1}^{M} \left(P_D \times C_G\right) + \theta^2} \tag{10}$$

IV. HEURISTIC ALGORITHM FOR RELAY-BASED MULTI-HOP ROUTING

In each hop, the power transmission $\mathrm{T_{P_i}}$ ($1 < \mathrm{i} < \mathrm{P_N}$) and the channel reuse $\mathrm{r_i}$ ($1 < \mathrm{i} < \mathrm{N}$) must be assigned properly to resolve the energy efficiency problem; and thus, this short paper presents a non-convex combinatorial problem, given in Eq. (9).

$$\min_{P_S T_{P_i} r} \left\{ \sum\nolimits_{P_S} T_{P_i} P_S + \sum\nolimits_{P_S} \left(\sigma + \theta EE_{ij}\right) \right\} B_w \times \log\left(1 + \frac{A\rho T_{P_0} T_r^{-\alpha} T_{\pi(k),\pi(k+1)}^{-\alpha}}{\left(N_o + A\rho T_{P_0} \Delta_{\pi(k+1)}^{-\alpha}\right) t_{\pi(k)}^{-\alpha} \varepsilon_{th}}\right) \geq TR_{th} \tag{11}$$

$$\pi\,(1) = Src_{msg}, \quad \pi\left(Dest_{msg}\right) = D_M \tag{12}$$

It is an NP-hard problem, which has a prohibitive computational complexity not only to optimize the transmission power and channel reuse, but also to mitigate the computational cost of the networking systems. Where, σ denotes a static term of the circuit power and θ is the constant of the dynamic term of the circuit power [33]. Assume that the first (k − 1) route hops between the source message $\mathrm{Src_{msg}}$ and the destination message $\mathrm{Dest_{msg}}$ are ascertained for the determination of receiver node, denoted as $\mathrm{k^{th}}$ route hop that is from node π (k + 1). Initially, the candidate-node and channel reuse check whether the network has sufficient bandwidth $\mathrm{B_w}$ or not. By then, we calculate the transmission power $\mathrm{T_{Pi}}$ and maximum energy efficiency for the $\mathrm{k^{th}}$ hop of the network to determine the direct transmission rate ($\mathrm{D_M}$) using π (k + 1). At last, we consider the maximum energy efficiency for the $\mathrm{k^{th}}$ hop of the network and the direct transmission $\mathrm{D_M}$ using π (k + 1) to route the $\mathrm{k^{th}}$ hop.

A. TO DETERMINE CHANNEL-REUSE AND CANDIDATE-NODE

Interference from the cellular user equipment is chiefly concerned to enhance the energy efficiency of the multi-hop D2D networks. Thus, the hitch-aware channel is chosen to improve the performance of the networks. To achieve that, initially the $\mathrm{k^{th}}$ route hop determines the channel which is optimally reused, denoted as $\mathrm{o_i}$. The idle D2D nodes in the network are used to deduce the channel, which is in optimal reuse $\mathrm{o_i}$. To calculate the maximum transmission rate $\mathrm{TR_{th}}$ of the channel reuse for the $\mathrm{k^{th}}$ route hop, the idle D2D node expresses its equivalence as:

$$TR_{\pi(k),\pi(k+1)} = B_w \log\left(1 + \frac{A\rho T_{P_0} T_r^{-\alpha} T_{\pi(k),\pi(k+1)}^{-\alpha}}{\left(N_o + A\rho T_{P_0}\Delta_{\pi(k+1)}^{-\alpha}\right) t_{\pi(k)}^{-\alpha}\varepsilon_{th}}\right) \quad (13)$$

The node which satisfies the Eq. (10) would be included into the set of candidate-nodes; and thus, the set of candidate-nodes C_k can be expressed as:

$$C_k = \left\{ \begin{array}{l} S|S \in \mathbb{Z}, 1 \le \mathrm{S} \le \mathrm{N}, TR_{\pi(k),S} \ge TR_{th} \\ \mathrm{S} \neq \pi\,(1)\,, \pi\,(2)\,, \pi\,(3)\ldots\ldots\ldots\ldots \pi\,(k) \end{array} \right\} \quad (14)$$

B. TO CALCULATE THE MAXIMUM ENERGY-EFFICIENCY

As the objective of this paper is stated under the energy-efficiency for multi-hop D2D, the $\mathrm{k^{th}}$ route hop of the network should be maximized in its energy-efficiency. To accomplish such efficiency, the $\mathrm{k^{th}}$ route hop criterion for the total energy consumption per transmission rate can be formulated as:

$$EE_{\pi(k),S} = \frac{T_{P_i}P_S\sigma + \theta B_w \log\left[1 + \frac{A\rho T_{P_0} T_r^{-\alpha} T_{\pi(k),\pi(S)}^{-\alpha}}{\left(N_o + A\rho T_{P_0}\Delta_{\pi(S)}^{-\alpha}\right)}\right]}{B_w \log\left[1 + \frac{A\rho T_{P_0} T_r^{-\alpha} T_{\pi(k),\pi(S)}^{-\alpha}}{\left(N_o + A\rho T_{P_0}\Delta_{\pi(S)}^{-\alpha}\right)}\right]} \quad (15)$$

The value of $EE_{\pi(k),S}$ surges with the gain of the power transmission T_{P_i} which is provided in the derivation of Eq. (12), and then, $EE_{\pi(k),S}$ attains its peak value, while T_{P_i} is maximally allocated. From the Eq. (12), the maximal power transmission can be derived as:

$$T_{P_i} = \frac{T_{P0}}{\varepsilon_{th}}\left(\frac{r_i}{T_r}\right)^{\alpha} \quad (16)$$

From the expression of Eq. (12) and Eq. (13), the peak value of $EE_{\pi(k),S}$ and its proper power transmission T_{P_i} can be calculated for each of the *D2D* nodes in the set C_k.

C. TO ESTIMATE THE DIRECT TRANSMISSION-RATE

For the energy-efficiency of the $\mathrm{k^{th}}$ route hop, the complex transmission factor of π(k + 1) to $\mathrm{D_M}$ should be considered. For which $\mathrm{TR_{S,D_M}}$ is denoted as the standard for complex transmission factor of π(k + 1) to $\mathrm{D_M}$. This expression of direct transmission-rate is:

$$TR_{S,D_M} = B_w \log\left[1 + \frac{A\rho T_{P_0} T_r^{-\alpha} T_{S,D_M}^{-\alpha}}{\left(N_o + A\rho T_{P_0}\Delta_{D_M}^{-\alpha}\right) t_S^{-\alpha}\varepsilon_{th}}\right] \quad (17)$$

This expression proves that transmission rate utilization is reasonable for each D_M and not significant in terms of amount of cross-interference when compared with the other candidate nodes.

D. TO-DO MULTI-HOP ROUTE IN D2D COMMUNICATION

To show the consideration of maximum energy-efficiency for k^{th} route hop and the direct transmission rate factor for $\pi(k+1)$ to D_M, the destination node $\pi(k+1)$ of the k^{th} route hop is carefully chosen by:

$$\pi\,(k+1) = \arg\max_{S \in C_k}\left\{\tau EE_{\pi(k),S} + \omega TR_{S,D_M}\right\} \quad (18)$$

where τ and ω are assumed to be the weight of $EE_{\pi(k),S}$ and TR_{S,D_M}.

E. ESTIMATING RADIO RESOURCE MANAGEMENT SCHEME

To maximize the throughput rate of *D2D* links, a radio resource (RR) management is subjected. Assume that each *D2D* source $D_j^T \in D_T$ wants N_j hops i.e. $H_j = \{h_1^j, h_2^j, \ldots\ldots, h_{N_j}^j\}$ to extend the *D2D* services. For the given time slot t_s, T_h^j defines a data transmission rate of network hop $N_h^j \in H_j$, where D_h^j is a *D2D* transmitter. It can further be expressed as follows:

$$T_h^j = \frac{b_d}{k}\sum_{k=1}^{N} \mathcal{X}_{D_h^j}^k . \log_2\langle 1 + \mathcal{Y}_{D_h^j}^k\rangle \quad (19)$$

where b_d is the channel bandwidth separated into k orthogonal subchannels and $\mathcal{Y}_{D_h^j}^k$ is the signal-to-interference-plus-noise ratio (*SINR*) of the network hop N_h^j. It is given by:

$$\mathcal{Y}_{D_h^j}^k = \frac{cg_{D_h^j}^k . P_{D_h^j}^k}{cg_{i,D_h^j}^k . P_i^k + Q_{D_h^j}^k + \mathcal{N}_0} \quad (20)$$

where $cg^{k}_{D^{j}_{h}}$ and $cg^{k}_{i,D^{j}_{h}}$ are the channel gains defined for $D2D$ link interfering to the $D2D$ receiver, $P^{k}_{D^{j}_{h}}$ and P^{k}_{i} are the power transmitter of $D2D$ transmitter i.e. at the k^{th} orthogonal subchannel, $Q^{k}_{D^{j}_{h}}$ is the inter-cell communication interference obtained by $D2D$ receiver and $\mathcal{N}_0$ is the power of $AWGN$ respectively. A subchannel assignment indicator $\mathcal{X}^{k}_{D^{j}_{h}}$ may be expressed as:

$$\mathcal{X}^{\mathrm{k}}_{\mathrm{D^{j}_{h}}} = \begin{cases} 1, & \text{if a subchannel k is allocated to } \mathrm{D^{j}_{h}} \\ 0, & \text{Otherwise} \end{cases} \tag{21}$$

According to Equ.(16), the mutual interference between the two consecutives D2D links may be negotiable. At time slot $\mathrm{T^{j}_{h}}$, the D2D transmitters of active links form a group $\mathrm{D^{t}_{A}}$. Hence, a total throughput $\mathcal{T}^{\mathrm{t}}_{\mathrm{D}}$ of all active D2D links can be expressed:

$$\mathcal{T}^{\mathrm{t}}_{D} = \sum\nolimits_{D^{j}_{h} \in \mathcal{D}^{t}_{A}} \mathcal{T}^{j}_{h} \tag{22}$$

To maximize the total throughput rate $\mathcal{T}^{t}_{D}$, the joint resource allocation of all active $D2D$ links can be expressed as:

$$Opt_1 : \arg\max\nolimits_{P_C P_D \mathcal{X}_C} \mathcal{T}^{\mathrm{t}}_{D} \tag{23}$$

It is subjected to:

$$\begin{aligned} &\sum\nolimits_{C \in \mathcal{C}_i} \mathcal{T}^{C}_{i} \geq \varphi_i, \quad i = 1, \ldots\ldots, \mathcal{N}^{U}_{C} \\ &\quad 0 \leq P^{C}_{i} \leq P^{C}_{Max}, \quad i = 1, \ldots\ldots, \mathcal{N}^{U}_{C} \\ &\quad 0 \leq P^{k}_{D^{j}_{h}} \leq P^{D^{j}_{h},k}_{Max}, \quad \forall D^{j}_{h} \in \mathcal{D}^{t}_{A}, \ k = 1, \ldots\ldots, N \\ &\quad \mathrm{Y}^{k}_{D^{j}_{h}} > \urcorner_D, \quad \forall D^{j}_{h} \in \mathcal{D}^{t}_{A}, \ k = 1, \ldots\ldots, N \\ &\quad \mathcal{X}^{k}_{D^{j}_{h}} = \langle 0, 1 \rangle, \quad \forall D^{j}_{h} \in \mathcal{D}^{t}_{A}, k = 1, \ldots\ldots, N \end{aligned}$$

where the N - by - $\mathcal{N}^{U}_{C}$ be responsible for a matrix P^{C}, N - by - $|\mathcal{D}^{t}_{A}|$ be responsible for a matrix P_D and N - by - $|\mathcal{D}^{t}_{A}|$ be responsible for a matrix $\mathcal{X}_D$ that includes the power transmission for user equipment (UE) to assign the subchannel indicator i.e. specifically for the active $D2D$ transmitters. Assume that the k^{th} subchannel is z.

$$\begin{cases} P^{k,*}_{D^{j}_{h}} = P^{D^{j}_{h},k}_{Max} \\ \mathrm{X}^{k,*}_{D^{j}_{h}} = 1, \quad D^{j}_{h} \in \mathrm{D}^{t}_{A}, k = 1, \ldots\ldots, N \end{cases} \tag{24}$$

F. D2D DISTRIBUTED TRANSMITTED POWER

In a system of interconnections, D2D pairs and Cellular Users (CUs) influences several key parameters to improve the network performance. D2D pairs generally distribute the transmission power; however QoS cannot be maladjusted for cellular activities. Moreover, D2D transmission power is set to be static, where each D2D pair infers the transmission power not including neighbour coordination and conditional rule. As referred to [37], the maximum transmission power for D2D pairs can be expressed as:

$$\frac{\boldsymbol{P_{C_j} d^{-\alpha}_{j,A} |H_{j,A}|^2}}{\boldsymbol{\sum^{N}_{i=1} \beta^{CD}_{i,j} P_{D_i} d^{-\alpha}_{j,A} |H_{j,A}|^2 + N_C}} \geq \boldsymbol{\gamma_{min}(C)} \tag{25}$$

The maximum transmission power of D2D pair can be rewritten as:

$$\boldsymbol{P_{D_i} \leq P_{D_{i_{Max}}} = \frac{\frac{P_{C_j} d^{-\alpha}_{j,A} |H_{j,A}|^2}{(\gamma_{min}(C) - N_C)}}{\sum^{N}_{i=1} \beta^{CD}_{i,j} d^{-\alpha}_{j,A} |H_{j,A}|^2} \quad \forall i, \ j \in X} \tag{26}$$

It is noted that $\sum^{\mathbf{N}}_{\mathbf{i=1}} \boldsymbol{\beta^{CD}_{i,j}}$ can be set to $\mathbf{1}$, when the $\mathbf{j^{th}}$ CU shares the resource blocks (**RBs**) with $\mathbf{i^{th}}$ ***D2D*** pairs to establish the communication. Therefore, the maximum power transmission of D2D pair can be expressed as:

$$\boldsymbol{P'_{D_{i_{Max}}} = min_i \left(P_{D_{i_{Max}}}, P_{D\_Max}\right)} \tag{27}$$

A session of D2D pair connection can be established by the use of channel state information (CSI) and threshold gain $\boldsymbol{TG^{D}_{min}}$. It is known to all the transmitter and receiver nodes including D2D pairs, CUs and maximum power $\boldsymbol{P'_{D_{i_{Max}}}}$ with a transmission probability $\boldsymbol{P_i}$. The associated transmission signal uses maximum transmission power to utilize the uplink channel state (UCS). Therefore, the mean power transmission of D2D pairs can be expressed as:

$$\begin{aligned} \mathbb{E}(\boldsymbol{P_{D_i}}) &= \left(\boldsymbol{P'_{D_{i_{Max}}} \cdot p_i}\right) \\ &= \left(\boldsymbol{P'_{D_{i_{Max}}} \cdot p}\right) \left[\boldsymbol{d^{-\alpha}_{i,i} |H_{i,i}|^2 \geq TG^{D}_{min}}\right] \\ &= \left(\boldsymbol{P'_{D_{i_{Max}}}}\right) \left[\boldsymbol{exp\left(d^{-\alpha}_{i,i} \cdot TG^{D}_{min}\right)}\right] \end{aligned} \tag{28}$$

where the last equality is resulted in Rayleigh fading that determines the transmission power of D2D pairs to fix the path loss exponent of communication environment. Therefore, the transmission power of D2D pairs can directly affect the node distance $(\boldsymbol{d_{i,i}})$ between the transmitter and the associated receiver including the threshold gain $\boldsymbol{TG^{D}_{min}}$. This is to note that the transmission power could be so limited if the node distance and the threshold gain is set to be larger. Therefore, an appropriate threshold selection $\boldsymbol{TG^{D}_{min}}$ is more significant to improve the system performance.

G. D2D CLUSTERING PAIRS

D2D clustering pair receives signal-to-interference plus noise-ratio (SINR) to traverse the resource blocks (RBs) that cluster the CUs to calculate the network performance. It can be expressed as:

$$\boldsymbol{\gamma_{D_i} = \frac{P_{D_i} d^{-\alpha}_{i,i} |H_{i,i}|^2}{I^{i}_{cd} + I^{i}_{dd} + N_d}} \tag{29}$$

where $\boldsymbol{I^{i}_{cd} = \sum^{N}_{i,j=1} \beta^{CD}_{i,j} P_{C_i} d^{-\alpha}_{j,i} |H_{j,i}|^2}$ is the CUs interference to denote $\boldsymbol{I^{i}_{dd} = \sum_{k \in D_{U_i}, k \neq i} P_{C_k} d^{-\alpha}_{k,i} |H_{k,i}|^2}$ i.e. from the subchannel of neighbouring D2D pairs; $\boldsymbol{D_{U_i}}$ is the D2D clustering pair of i^{th} subchannel; D_i and D_k represent i^{th} D2D pair and k^{th} CUs; and P_{D_i} and P_{D_k} are the transmission power of i^{th} D2D pair and k^{th} CUs, respectively. The k^{th} CUs do not have any interference of i^{th} D2D pair since the CUs transmits the information with orthogonal spectrum of a cellular system. Therefore, the receiving SINR of a cellular-link i.e. at base-station B_S can be expressed as:

$$\gamma_{C_i} = \frac{P_C d_{i,B}^{-\alpha} \left|H_{i,B}\right|^2}{I_{dc}^i + N_C} \tag{30}$$

where $I_{dc}^i = \sum_{i,j=1}^{N} \beta_{i,j}^{CD} P_D d_{i,B}^{-\alpha} \left|H_{i,B}\right|^2$ is stated to maximize the throughput performance of a system. Moreover, it guarantees a reliable communication between CU and D2D pairs. According to Shannon capacity, a throughput system model can be expressed as:

$$R_B = R_{D2D} + R_{CU} \tag{31}$$

$$= \sum_{i=1}^{N} B_d \log_2\left(1+\gamma_{D_i}\right) + \sum_{i=1}^{N} B_d \log_2\left(1+\gamma_{C_i}\right) \tag{32}$$

It means that

$$\gamma_{D_i} \geq \gamma_{min}^{(D)}, \quad \forall i \in \gamma \tag{33}$$

$$\gamma_{C_i} \geq \gamma_{min}^{(C)}, \quad \forall i \in X \tag{34}$$

$$P_{D_i} \geq P_{D\_Max}, \quad \forall i \in \gamma \tag{35}$$

$$P_{C_i} \geq P_{C\_Max}, \quad \forall i \in X \tag{36}$$

where B defines the possible resource allocation; B_d represents a subchannel bandwidth; R_{D2D} and R_{CU} are the throughput of CU and D2D pairs respectively. Eq.(33) and Eq.(34) are the lower bound of CU and D2D pairs; Eq. (35) and Eq.(36) are the transmission power of CU and D2D pairs with limited power. This optimization problem is observed to be a NP-hard to perform exhaustive search.

H. RESOURCE ALLOCATION

In the network, each resource block selects a D2D pair to act as the intended actual user aiming to support better system performance. Most of the intended user may use multiple D2D pairs to comply with clustering rules, whereas some RBs may consume weak uplink transmission for fewer intended users. To minimize the algorithmic complexity, it has the following definition:

Definition 1: Each row and column of matrix coordination $\beta_{i,j}^{CD}$ have one resource allocation at most, whereby the resource allocation is not more than one for D2D pairs. It means that only one RB can be reprocessed by the D2D pairs at the same time in the scheduled period.

$$\sum_{i=1}^{N} \beta_{i,j}^{CD} \leq 1, \quad \forall j \in X \tag{37}$$

$$\sum_{j=1}^{M} \beta_{i,j}^{CD} \leq 1, \quad \forall i \in \gamma \tag{38}$$

The above scenario is evident that D2D pairs would never reprocess the allocated RB; and thus cannot experience any interference between the D2D pairs i.e. $I_{dd}^i = 0$. A set of cluster user is represented as U_j^D, which shall not be more than 1.

According to this definition, the optimization problem for system throughput i.e. from Eq.(32) can be expressed as:

$$max_{i,j} RB \tag{39}$$

TABLE 3. Proposed resource allocation algorithm.

IN/OUT	System Area S_A, CU's Transmit Power P_{C_j} and Intended Cluster Set U_j^D
Step1	Initialize $\gamma_{min}^{(D)}$, $\gamma_{min}^{(C)}$, and $\beta_{I,j}^{CD} = 1, \forall i \in \gamma, \forall j \in X$
Step2	Calculate P_{D_i} by Eq.(28)
Step3	Obtain γ_{D_i} and γ_{C_i} by Eq.(29) and Eq.(30) to calculate the network performance.
Step4	Set $\beta_{I,j}^{CD} = \beta_{I,j}^{CD} = 0$, if any of the Eq.(34) or Eq.(35) is not satisfied.
Step5	Find I_{cd}^i from $\beta_{i,j}^{CD}$
Step6	Calculate I_{dd}^i
Step7	For each ($j \in X$)do
Step8	If $\beta_{I,j}^{CD} = 1$, then
Step9	Set the performance matching matrix i.e. i^{th} row and j^{th} column to be 0
Step10	Else
Step11	Choose the D2D pairs with maximum weighted value to intended user i.e. keeping $\beta_{I,j}^{CD} = 1$
Step 12	End IF
Step 13	End For
Step14	Obtain U_j^D and $\beta_{I,j}^{CD}$
Step15	Return U_j^D

Table 1 represents the descriptive details of resource allocation. It is noted that D2D weighted pair is set to be 1 to signify the resource usage of intended cluster users. In this case, the intended cluster has a priority to reprocess the resource block i.e. resource fairness. As a result, the step ⟨8⟩ and ⟨9⟩ are incorporated of one D2D pairs i.e. for the intended cluster users. From Table 1, it is observed that the weighted value of D2D pair is unfixed to process different allocation periods. Assume that D2D pair is already allocated of one RB; and thus the other intended user would change the allocation of the resource in the next execution period. As a result, the RB's allocation can be effectively implemented to reuse most of the resource allocation at M times. An effective resource allocation can be denoted in the form of performance matching matrix to obtain the actual user set U_j^D i.e. for each RB.

V. RESULTS AND DISCUSSION

This section examines the novel multi hop routing technique using NS3 simulator. To analyse its combinatorial

TABLE 4. Parameters used in the simulation.

Parameters	Values
Carrier frequency	2.3 GHz
Frequency channel bandwidth B_w	5 to 10 MHz
Max. transmission power for cellular UE	0.25 W
Cell radius i.e. System area	500 m
Max. transmission power for $D2D$	40 W
Duration of frame time	1 s
Path gain for 1 m distance	5.7×10^{-4}
Power spectrum density for noise (σ^2)	-174 dBm/Hz
Exponent for path-loss (α)	3
Transmission rate requirement TR_{th}	2 $Mbit/s$
power of additive white Gaussian noise ($AWGN$) ($\mathcal{N}_0$)	120 dBm/Hz
Number of allotted subchannel	50
Max. Transmission power P^{C}_{Max}	23 dBms
Noise density i.e. spread spectrum	-174 dBm/Hz
Minimum SINR of Cellular-Link	-10 dB
Minimum SINR of D2D-Link	0 dB

optimization technique effectively, a single-cell with a base-station B_S, centric position c_p and omnidirectional antennal O_{md} are considered. A model is assumed for the path-loss channel as $P_{ij} = P_0 r_{ij}^{-\alpha}$, where r_{ij} is the distance between $D2D_{T_x}$ and $D2D_{R_x}$, P_0 is the channel gain at a distance of $1m$. To neglect the small-scale frequency fading, the channel uses a round-robin based mechanism. The important parameters used in the simulation are illustrated in Table 4. In case of single-link, the optimal mode of selection policy uses a geometrical interpretation to guarantee the minimum energy cost to fulfil the transmission rate requirement TR_{th} for the mode of CUE and $D2D$ as well. At first, CUE mode is considered to examine the energy efficiency of the $D2D$ communication. In the analysis, the $D2D$ proves that it has minimum energy cost, when $EE^{D2D}_{ll}(T_{Pi}) \leq EE^{CUE}_{ll}\left(t^*_{util}\right)$.

According to the path loss model, the optimal selection policy can be expressed as:

$$S_{ll} \leq \underbrace{\left(\frac{e^{B_W/T_{Pi}}-1}{e^{B_W/t^*_{util}}-1} * \frac{T_{Pi}}{t^*_{util}}\right)^{-1/\alpha}}_{kS_{0l}}$$
$$S_{l0} = k\left(S_{0l}\right) S_{l0} \tag{40}$$

where $k(.)$ is an optimal function of S_{0l}; since S_{0l} disturbs the data transmission rate TR^{max}_{0l}, the utilization of energy efficiency can be rewritten as $t^*_{util} = T_{Pi} - B_W/TR^{max}_{0l}$. Though the energy cost in the CUE is ignored over data-link D_L transmission, S_{0l} yet plays a significant role in selection of optimal nodes. As $D2D_{R_x}$ is positioned at the arc provided by the circle radius intersection S_{0l} where B_S is at the centre of disc radius $k(S_{0l}) S_{l0}$ along with $D2D_{T_x}$, the $D2D$ optimal distance can easily be traced out to show that energy utilization of $D2D$ node is optimal. The proposed heuristic routing algorithm compares its examination results with Dijkstra, Closest to Destination (CD), Ad hoc On-Demand Distance Vector (AODV) and Q-Routing and PD Q-Routing. In simulation, 35 $CUEs$ and 130 $D2Ds$ are provided to examine the energy efficiency and throughput rate of the cellular networks.

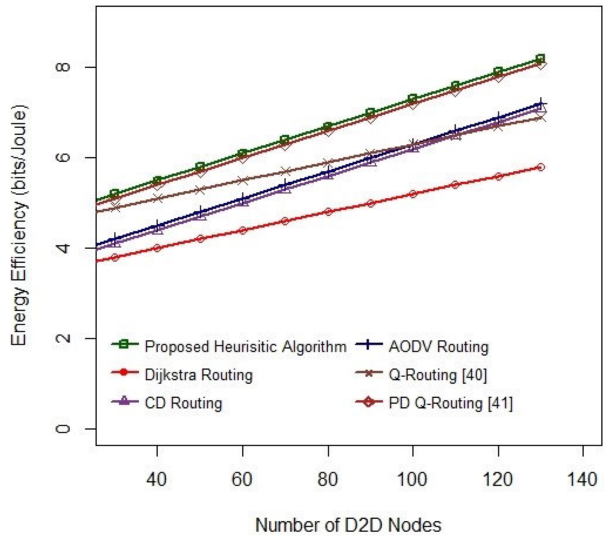

FIGURE 4. Energy efficiency [in bits/Joule]vs. number of D2D nodes.

Fig.3 illustrates the energy efficiency [in bits/Joule] versus the number of D2D nodes. The average results hold confidence intervals of no more than 5% of the average values at a 95% confidence level. The proposed heuristic routing algorithm always prefers the channel by means of minimum interference and maximum channel gain to reuse; and thus it is able to allocate different power transmission promptly for each D2D route hop. Besides, the proposed heuristic considers a direct-transmission from the up-to-date hop, which proves that the energy efficiency of proposed heuristic is better than the other techniques, such as Dijkstra routing, CD routing, AODV routing, Q-Routing [35] and PD Q-Routing [36].

Fig.4 illustrates the throughput rate of $D2D$ communication TP_{DL} i.e. throughput rate (Mbps) versus path-loss exponent (α), where the performance of proposed heuristic algorithm includes subscriber density $\rho = 700$ and 90% of file requisition has been cached consistently to examine the transmission rate of $D2D$ transmitter. The overall throughput rate is calculated as:

$$TP_{SYS} = \frac{1}{0.1/TP_{DL} + 0.9/TP_{D2D}} \tag{41}$$

From the Fig.4, it is observed that the $D2D$ communication with optimal RR management achieves much higher throughput than the other existing schemes specifically for the defined path-loss exponents. It is also perceived that Opt_1 optimizes the transmission power $P^{D^i_h,k}_{Max}$ to increase

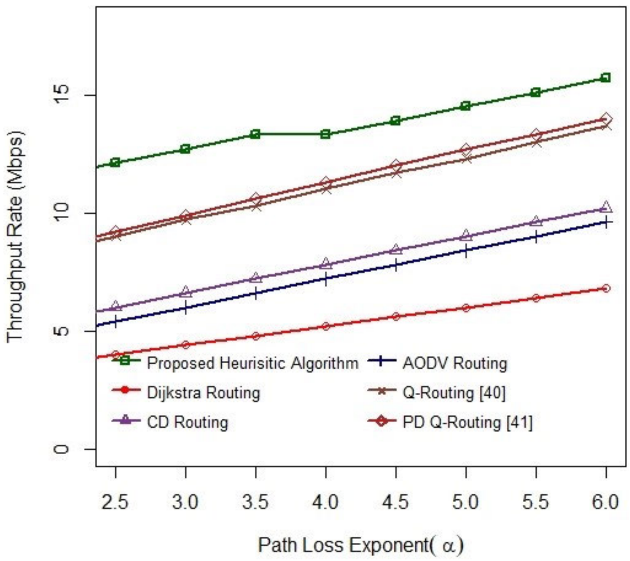

FIGURE 5. Throughput rate of *D2D* communication TP_{DL}.

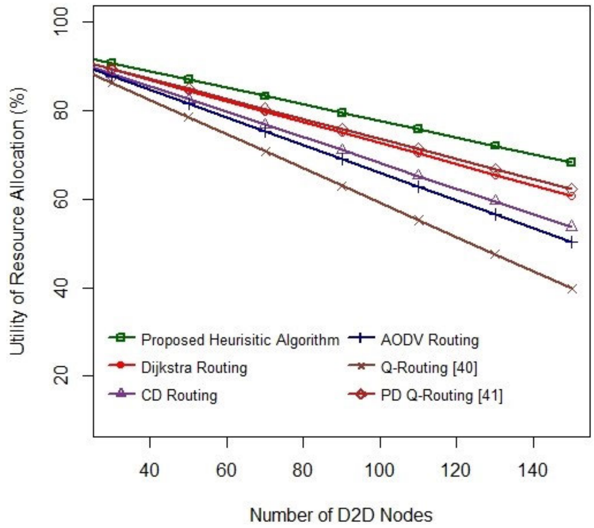

FIGURE 6. Utility of resource allocation (%) vs. number of D2D nodes.

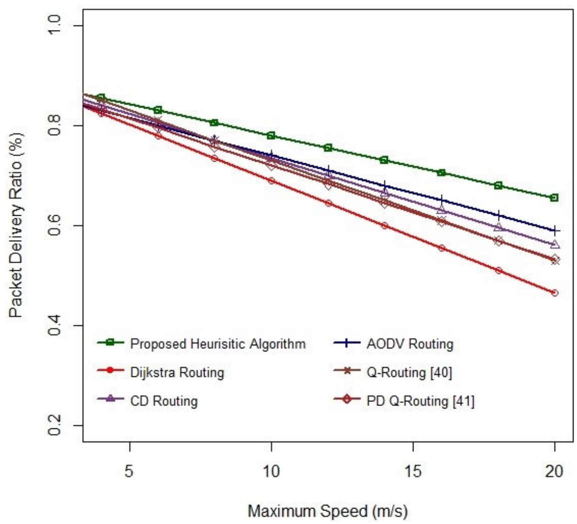

FIGURE 7. Packet delivery ratio (%) vs. maximum speed (m/s).

its transmission rate with path-loss exponent (α). Moreover, the optimal *RR* management moderates the path-loss, where *D2D* transmission isolates the user equipment from each other to increase the *D2D* throughput rate. Since *D2D* communication incurs less interference between the $UE's$ to optimize the radio resources, the overall throughput rate of proposed heuristic algorithm achieves higher transmission rate than the other existing schemes such as Dijkstra routing, CD routing, AODV routing, Q-Routing [39] and PD Q-Routing [40] in terms of *DL* throughput at the consistent use of α.

The utility of resource allocation is represented to integrate the efficiency of active D2D pairs. It is expressed as:

$$R_U = \frac{User(\beta^{CD})\times RB_{D2D}}{N \times RB_{Opt}}, \quad \forall \beta^{CD}_{I,j} \in \beta^{CD} \subseteq B \qquad (42)$$

where RB_{Opt} is the optimum system throughput to complete the exhaustive search i.e. between CU and D2D pairs; N is the number of D2D pairs; RB_{D2D} and RB_{Opt} are the system throughput between D2D pairs and total systems.

From Fig.5, it is observed that the performance of proposed heuristic algorithm performs better than other existing schemes specifically at the path loss exponent i.e. $\alpha = 5$. It shows that the resource utility is comparatively low when the number of D2D nodes is reported to be small as the CU's mainly concerns to improve the system throughput. However, the resource utility gradually decreases due to finite number of resource constraints with more D2D node pairs. Therefore, the downtrend of resource utility shows that the allocation of resource blocks would continuously decline in proportion to the number of D2D pairs.

In experimental analysis, a set of communication nodes is analysed to realise the effect of mobility, where the number of source connections is set to be $\langle 20 \rangle$ with a sending rate of 10 $packets/sec$. The nodes are dynamically set to conduct a mobility speed with respect to 2, 4, 6, 8, 10, 12, 14, 16, 18 and 20 m/s respectively. Fig. 7 shows the variation of delivery ratio i.e. as a function of node's mobility. When the node's mobility is recorded to be minimal, the proposed heuristic algorithm and other existing mechanisms experiences less probability of link failure which may in turn minimize queue buffering time i.e. quality of network congestion and packet collision. As a result, when the communication nodes are highly dynamic and increased link failures, the packets could not achieve better delivery ratio. However, the proposed heuristic algorithm achieves better delivery ratio in comparison with other existing mechanisms such as Dijkstra routing, CD routing, AODV routing, Q-Routing [39] and PD Q-Routing [40].

VI. CONCLUSION

A vision of smart environment necessitates an innovative framework model that comprises three-layered (consumer, cloud and sensor) model to provide the integral interfaces to emerge the key technologies as unified relay-based multi-hop routing model. The objective of this model is to grant the communication service upon smart illustrative workflow to-do decision making, computation, communication and storage cost in 5G networks to examine the communication metrics namely energy efficiency, throughput rate, resource utility, and packet delivery ratio. This proposed model optimizes the energy efficiency of the cellular network using combinatorial optimization problem. The result shows that the proposed heuristic routing achieves better performance than the other existing techniques, such as Dijkstra routing, CD routing, AODV routing, Q-Routing and PD Q-Routing.

In the future, the simulation results will be extended to reuse multiple RBs i.e. for one D2D pairs. In order to improve the spectrum resource efficiency, a suitable heuristic algorithm can be adapted. Moreover, a real case related to smart mining and agriculture can be chosen to realize the communication condition dynamically.

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