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Smart Backhauling for 5G Heterogeneous Network with Millimeter Wave Backhaul Links to Perform Switching Off, Interference Management and Backhaul Routing

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Abstract

Developments made in the fifth generation (5G) and the cellular networks have greatly influenced the lifestyle of the wireless users. Increased demand on higher data rates has also increased the network traffic. In the viewpoint of cellular networks, several Small Cells (SCs) are combined together with the help of microwave communications and millimeter wave communication models, in order to support the heterogeneous environments. In this paper, we have proposed a hybrid communication framework which can efficiently support the interference management, routings in backhaul links and the joint issue during on/off status of the mobile using 5G mmWave backhaul links. A novel cache-enabled technology is designed to develop backhaul links using heuristic search models. Along with that, an effective data access framework is also formulated using distance based cluster head selection that resolves the interference issues. Without modifying the content of the mobile users, the services are offered to the uses associated with backhaul links. Since a fast iterative model is developed, the throughput rate and the energy savings are maximized. A simulation analysis is carried out with a static number of mobile nodes which has proved the efficiency of the proposed framework.

Keywords 5G networks, Millimeter wave (mm wave) · BackHaul routing · Cache-enabled technologies and interference management

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1 Introduction

With the recent developments in the wireless industry, the communication network generation evolves from 1G to 5G that develops an evolution in terms of the data rates, mobility, capacity and the use of the application [1]. Due to the rapid and reliable communication exchange process, a growing interest has been developed among the researchers. The computational demand increases day by day in the aspects of data rates, quality of services and also ensures the availability [2]. Several load balancing and scheduling methods are incorporated to increase the load of the users and thus, the balancing of those load mechanisms are required. A survey states that the wireless traffic volume increases to a thousand-fold in which, the upcoming decades will be explored over 50 billion connected devices. A tremendous volume of devices is being mutually connected with each other and thus, the chance of different research problems [3] pertaining to this field have to be focussed.

Different forms of communication systems which are being supported by the development of the 5G networks such as ultra-dense networks, inter-cell interference coordination, massive multiple inputs multiple outputs and so on. The research on ultra-dense networks is still in a developmental stage which comprises Heterogeneous Networks (HetNets) [4]. The sharing of spectrum in User Defined Networks (UDN) imposes an intelligent inter-cell interference coordination, cancellation and exploitation. Centralized Radio Access Networks (CRAN) is one of the interesting research areas in UDN systems. The demand for integrating with the small cells of traffic patterns is a promising research problem. Since CRAN [5] involves the temporal as well as spatial, the concept of CRAN becomes very attractive. With the help of the baseband unit, the data placed in the shared pool of resources are migrated. It ensures the green aspects of 5G which are close to the proximity of cells and power requirements. In the aspects of mobility management, when the mobile users transfer from one cell to another, it makes use of the handover process in order to administer the entities in RAN. When the handover process is applied to the UDNs, the overheads are observed during signal cripples. Data splitting and managing near the control planes is one of the research challenges which is resolved by an emerging technique, known as 5G backhaul.

Motivated by the growth of different User-Equipment (UEs) devices and the data-intensive applications, the enhancement of spectral efficiency and the data rate needs to be addressed, so as to accommodate the data oriented applications. Priorly a large number of Base Station (BS) and the Small Cells (SCs) were deployed to increase the performance of energy consumption rate, network delays and so on. However, it remains a tedious task, when the network size increases. In some cases, the demand of UEs fluctuates the location as well as causes inefficient energy preservation models. To overcome this scenario, the deployment of Small Cells (SCs) are harnessed by the concept of backhaul link routing under 5G mmWave networks. In this digital world, the development of green network management systems and its operational policies are of prime importance. Thus, we incorporate the energy-efficient operation by using Access Networks (AN) and the Backhaul Link (BL). The main contributions of this study are presented as follows:

a) We present the green optimization policies that very-well suits and supports the mmWave mesh BH links.
b) We formulate a Mixed Integer Linear Programming (MILP) which makes a significant improvement in the User Equipment (UE) installation and allocating the BH links to on-

demand route traffic with an intelligent control over the switching ON/OFF mechanisms over the BackHaul (BH) links.

c) We develop an energy model between Base Station and the Backhaul link of the transreceiver region, especially in their mmWave spectral bands.
d) We develop a system model that demonstrates the working flow of the proposed mmWave network.
e) We develop a throughput and end-to-end delay model between Base Station and the Backhaul link of the transreceiver region, so as to resolve the interference issues. Finally, it is implemented in the NS2 simulator under pre-defined networks nodes

The rest of the paper is organized as follows: Section 2 presents the literature survey; Section 3 presents the research methodology; Section 4 presents the experimental results and analysis and atlast, conclusion is given in Sect. 5.

2 Literature survey

This section presents the review of existing techniques explored by other researchers. In [6], a multihop backhaul model was explored using cloud radio access networks. Compression strategies like the Decompress-Process-and-Recompress (DPR) backhaul scheme were designed to maximize the sum-rate under backhaul capacity constraints to reduce the performance gain during the recompression process and also increased the background noise. A novel routing scheme, named, anycast backpressure routing was suggested by [7] for the dense small cell deployments. It is observed that some small cells were acting as core aggregators which demands for the dynamicity of the backhaul routing. Thus, anycast backpressure scheme was introduced that optimized the usage of gateways, paths and the diversity by eliminating the uncongested gateways. The geographical information and the queue backlogs data of the neighboring nodes were encountered during the construction of the communication path. Finally, the deployment of multiple path and multi-gateway schemes resulted in an improvement of 40% in aggregated throughput and the 99% latency reduction. Some of the low-rate links that cause heavy traffic were limited for this study.

Software Defined Network (SDN) based CRAN model was developed by [8] that resolved the fronthaul/backhaul connectivity issue in the RANs using two optical-layer routing mechanisms such as static load balancing and the dynamic routing model. The suggested model enhanced the survivability rate of the data operations. Monte Carlo analysis was done to prove the robustness of the CRAN operation. The reliability measurements on large scale networks has lowered the control entities in the higher-layer. Author in [9] explored the Millimeter-Wave Backhaul Cellular Networks, so as to optimize the delay aware in proportional flow models. It explored two algorithms, namely, back-pressure and the Heat Diffusion which administered the mmWave backhauls that reduced the average time with minimized network delay. The suitability of the framework in a small-scale environment will impose different data control policies which is not focused here.

In [10], the authors have explored the minimization of traffic in backhaul links of 5G networks. Coordinated Multipoint Joint Transmission (CoMPJT) is one of the important techniques in the 5G networks. Cluster head formation during joint transmission is a complex task which incurred high bandwidth consumption. System aimed to reduce the backhaul traffic even under constrained radio sources. Here, a dynamic programming model was explored to optimize the subproblem solutions. Though the system has improved the network throughput rate yet, the interference caused during the deployment phase is not studied. As the growth of 5G network increases, it was also incorporated in the field of Fiber Wireless (FI-WI) broadband access networks [11]. Reliability is one of the performance metrics that lowered the functions of LTE-enabled technologies such as very low latency and the ultra-high reliability which was enhanced using 5 g networks. Along with the features of wifi offloading capabilities, the mobile networks under dense networks were studied. Some Passive Optical Networks (PONs) are failed due to the compression near the backhaul routing. And also, due to the lack of temporal and spatial relationships, an optimizer is unable to develop near the integrated algorithms.

In [12], they explored the link scheduling models using backhaul routing for smart manufacturing systems for edge gateways and the edge server. The deployment of mm-wave spectrum near the wireless channel has consumed higher bandwidth and also enlarged transmission delay. A novel directional routing and the link scheduling algorithm were explored to reduce the delay by ensuring fair allocation of bandwidth process. With the use of jain's fairness index, the developed scheme reduced the throughput rate, packet loss rate and the delay. However, the scalability of the network is compromised. Author in [13] has explored the cost optimization model for the 5 g wireless backhaul networks. Here, different backhaul routings were suggested to increase the cost efficiency. Variant types of short-lived routes are optimized which is very supportive to the local gateways. Along with the weighted directional links, the traffic rates from the multiple gateways are significantly reduced. Since a static Signal Noise Ratio (SNR) value is employed, the multiple gateways are supported which reduces the access cost. It is not a suitable framework for User Defined Networks (UDNs).

Robust and an efficient millimeter wave [14] was designed to support the hierarchical networks by increasing the efficiency of the spectral regions that supported the fiber lines with lowered bandwidth. Possible sets of base stations were collected to support the backhaul traffic, which is known as super- base-station. By doing so, the routing fluctuation near the traffic was reduced. Load balancing under different networks is not focussed which has improved the access cost. Ensuring connectivity via backhaul in macro and micro base stations in heterogeneous networks [15] is a challenging task which was resolved by the Radio Resource Management (RRM) using cross layer approaches. A hidden convexity based link scheduling was followed to eliminate the low signalling issues. The simulation results have ensured better performance gain improvement 40% than previous schemes.

In [16], the authors discussed a low-cost WSNs model in order to balance the loads, path length and the stability of the backhauls system. A joint routing system, ReduceBottleneck algorithm was suggested to optimize the routing and the channel assignments via on-demand local solution. It was experimented in NS3 which enhanced the aggregate as well as minimum throughput per flow, even under large-scale networks. As told, the system reduced the computational costs, even so, some cascaded effects and the signalling overheads are observed in the interference process. A small cell mmWave mesh backhaul network [17] was explored to schedule the network packets under a distributed environment. In the course of enhancing 5G network system, the authors have designed, Distributed Maximum QoS-aware (DMQ) scheduling algorithm which mainly aimed to enhance the throughput without compromising the Quality of Service (QoS) factors. It has improved the MAC contention window and thus, it has enabled a secured and strong transmission system. Lowered packet loss ratio with higher throughput was achieved under a smaller grid area. Some higher pattern interferences are omitted from the study.

Service oriented infrastructure plays a key role in the 5G networks especially in the cost optimization model. It is universally known that, when the network communication increases, the latency of the network also increases, which in turn incurs higher computational costs. Thus, a mathematical model for network placement problem is resolved by suggesting a Mixed-Integer Linear Programming model [18] that overcomes the data placement issue using heuristic strategies. Here, the location of network facilities was improved to optimize the cost systems. Since, tabu search technique was followed, the complexities of the algorithm are reduced in each network system. Similar work done by [19] using hierarchical cache networks which resolved the low-complexity distributed algorithm based on the available information. It has improved the stability and the convergence of the network problems by following a cooperative caching. In case of merging the global data, the system failed to meet the objectives.

Spatial and Energy aware routing algorithms [20] were performed to enhance the network lifetime of the wireless sensor networks. Along with that, a hierarchical trust method was also designed which efficiently detected the attacks by matching the data behavior patterns. This system has improved average packet transfer rate with reduced computational time. System has increased radio frequency among different cluster heads. Network Coverage is a universal barrier which is resolved by hub-and-spoke topology [21]. Here, three models, namely, an Integer Nonlinear Program (INLP), an Integer Linear Program (ILP) and Optimisation-via-Simulation (OvS) model were developed to yield optimal solutions. It has taken multiple sensor and target types, probabilistic detection function, sensor reliability, communication range, communication interference, network topology and budget constraints. System has reduced the discontinuity among different communication paths, yet, some complex locations do not detect the intelligent targets.

Multicast [22] is one of the technologies which helped to increase the throughput with minimal bandwidth rate. It ensured the reliability gain of different classes by minimizing the delays in group size, packet loss rate and the tree-depth of the multicast protocol via analytical models. Delay analysis at relay nodes have decreased the workload complexity. Typically, it increases the packet loss rate when the distance between source and destination increases. Reachability [23] is one of the significant parameters which assures the scalability as well as availability of the network path. In order to enhance the network throughput rate, an efficient scheduling as well as relay probing scheme were discovered. It is observed that the mmWave signals have the ability to control the free path loss and attenuation occurred by network blockages. Thus, by increasing the number of probes, the system has achieved the maximum throughput.

In [24], the authors have presented a Time-To-Live (TTL) based efficient forwarding backhaul links using nanonetworks. Here, the modification done in the data extraction stage by polling the beacons, the deployed nano-networks near the sink forwards the packets. Each packet is encountered with the TTL values which supported the recent network topologies. By doing so, the system has obtained a high end-to-end packet delivery and efficient energy consumption rate. During the polling process, poor network connectivity is observed in smaller sizes of networks. In the viewpoint in telecommunication systems, the deployment of backhaul links is to establish as well as recover the networks during any network disaster scenario. A wired and wireless network cooperation system was designed to improve the network throughput rate even with the recovery nodes. The NeCo system [25] was developed to bring up the communication flow between the leaf nodes.

With the baseline of the network controller, security of the leaf nodes were also assured. Since the routing problem is viewed as NP-hard, the findings of optimal solutions are not achieved. Previous study was extended by [26] for the Internet of Thing (IoT) domain. In case of fixed density, the deployment of random destination nodes and its communication rate are resolved. With the help of wireless backhaul communication systems, some hierarchical routing protocols were discovered to support the linear scaling of network sizes. The system has resolved the local communication cost and the path loss during network joint cooperation process, yet the communication process in smaller network size is still a challenging task. Variable link capacity in dynamic topology in the smart-grid applications was explored by [27]. Data capacity-aware channel assignment (DCA) was designed with the Fish Bone Routing (FBR) algorithm, so as to improve the stability of the channels under different spectrum bands. Since multi-hop data transmission was supported to devise the expenses in data transmission, and irrelevant network delays. Whilst, the network lifetime becomes short-lived which is a serious drawback of the system.

In order to explore an efficient wireless communication process, the concept of network virtualization was introduced [28]. Due to heterogeneity between wireless networks, a global optimal solution is unable to achieve it. Therefore, an Integer Linear Programming model was developed to support the virtual network providers. By doing so, the virtual algorithms have reduced the communication cost to some extent, but, at the other end, it lacks the security of those virtual networks. In [29], the authors have done a comparative analysis on access techniques in 5G mmWave cellular networks. Different iterative and the exhaustive search models were explored to overcome the network delay. It is well-said that due to the misdetection probability levels, trade-off among the network delays will be minimized. Then, a scheduling on-link under dual hop using mmWave networks was studied by [30]. Here, the Maximum Expected Delivery Time (MEDT) problem was minimized using PicoNet Coordinator. With the help of joint relay optimization, the MEDT problem was reduced with a sufficient amount of relay nodes.

3 Research Methodolgy

This section presents the working model of the proposed 5G backhaul networks. Here, we have provided a systematic model for switching off, backhaul link and the interference management during the joint issues. The proposed phases are explained as follows:

3.1 System Model

Our research study is focussed on 5G networks. Since Radio Access Technology (RAT) is combined, the designed 5g Networks compose a different set of Base Station (BS). The Base station comprises Small Cells (SCs) and the eNodeB (eNB). It is defined that each eNBs is associated with the SCs which is collectively represented as, β. In specific, Line of Sight (LoS) communication is assumed. LoS is one of the types of the propagation medium which send and receive the data among to its closer proximity regions. It also ensured that there are no obstacles during the communication process. Millimetre (mm) wave is one of the instances of LoS communication. Thus, mm-wave BackHaul (BH) links is employed which is denoted as L_{BH}. The chief responsibility of the L_{BH} is to develop an inter-communication between eNBs and the SCs. In the aspects of the small cells, the backhaul links are created, so as to facilitate the connectivity for the deployed small cells and its core network. It is deployed outdoors 3-6 m above street level with space of 50-300 m distant from each other. The main challenge is the coverage of connecting all small cells and thus, we have facilitated the mesh topology. Each eNBs are directly communicated with the SCs which also play a role of aggregators to their relevant eNBs. The possible set of aggregators is given as A where $A \subseteq \beta(\textit{Nodes associated with the small cell})$. The aggregators and the SCs are collectively known as User Equipment (UE). It is also assumed that the bit rate is fairly allocated for each UEs depending on its selected service. In order to serve the UEs and the BSs, a set of millimetre wave links are assumed which is given as ζ_{mmLink}. Then, the channels are assumed to slow fading and the power allocation is fairly done by its Physical Resources (PRs). It is important to assume that a UEs is associated with a BSs in a stipulated period of time. Since the mesh topology is followed, the flow of traffic is smooth between the aggregators and the UEs.

The deployment of mmWave link in UDNs takes place by distance estimation between small cells basestation (SBS) and the user equipment. It is a general rule that UE covers multiple SBS and thus, the density of SBS must be higher than UE density. Moreover, the probability of the existence of a Line of Sight (LoS) path between the SBS and UE in UDN is high because of the short distances. However, severe inter-cell interference occurs due to short Inter-Site Distance (ISD).

3.2 Mathematical Model

The objective of the study is to develop an optimized framework, so as to minimize the cost of the energy without compromising its efficiency during 5G backhaul links. As we told earlier, interference between links occurs due to the improper directivity of the transmission lines. In order to manage the interferences, proper initialization of the control variable of the power, coordination between the transmission lines and also ensuring simultaneous transmission by spatial reuse techniques. Here, a cache-enabled strategy is employed to preserve the content exchanged between eNBs in a peer -to -peer fashion. Caching of data is a distributed model that ensures the information is being exchanged based on the received request. It determines the placement of the new cache by estimating the previous cache drop time of the information. Certainly, it falls into the category of decision-making systems. The contents are shared to the nodes near the closest proximal regions which helps to eliminate the overhead.

An optimized data caching framework is proposed where the eNBs behave independently in the mesh mm-wave backhaul link. The proposed network model comprises different data content in which each content has its own server and the set of the clients accessing those data with a limited frequency. The source and destination eNBs are cautiously selected so that it cannot maximize the access costs. A centralized and localized distributed algorithm is formulated which can handle the mobility of the nodes and the dynamic traffic conditions. The working of the data placement under block enabled cache process is explained as follows:

a) Blocks for new content: It takes the responsibility of locating the new information i's from the node eNBs. Whenever any new content enters, a node will be created and linked with its successor nodes.
b) Blocks for large size caches: It is generally assumed that the nodes can store a larger content. In the case of memory constraints, the nodes are shared under different services and applications and thus, the caching decision takes place for the requested services. It minimizes the network complexity without decreasing the performance of the information retrieval process.
c) Blocks for small size caches: Here, the nodes are dedicated in which the contents are stored in the smaller sizes. Here, it just translates into a cache replacement strategy that

selects the information items to be dropped among the information items just received and the information items that already fill up the dedicated.

Then, the followings are the formulation of different parameters which are explained as follows:

i) Modelling of the energy

It is one of the important parameters which has to be seriously focused, so as to prevent interference. Let the initial energy (i_e); receiving power (R_p); transmission power (T_p); Idle power (I_p) and the sleep power (s_p). The energy model (η) is computed as:

$$\eta = p * t \tag{1}$$

where p is the ratio between the initial energy and the receiving power, t is the time period.

ii) Modelling of the throughput

Throughput is defined as the success rate of data reached the intended nodes from the source nodes. It is estimated as:

$$T_p = \frac{N_{Rp} * P_l * 8}{c_t * 1000} \tag{2}$$

where T_p is the throughput, N_{Rp} is the aggregate value of the received packets, P_l is the length of the packets, c_t is the time taken for communication

iii) Modelling of the packet drop

Packet drop is defined as the rate of the failed packets i.e. which didn't reach the intended region within a stipulated period of time. It is given as:

$$P_{LR} = 1 - \left\{ \frac{N_{RP}/RS}{N_{PS}/SS} \right\} \tag{3}$$

where P_{LR} is the representation of the rate of the packet loss, N_{RP}/RS is the representation of the number of packets received from the receiver end, N_{PS}/SS is the representation of the number of packets sent from the sender end.

iv) Modelling of the end-to-end delay

End-to-end delay is defined as the successful transmission of the packet reaching the head of the queue to the sender time without any delay. It represents the average time taken to send/receive the packets. It is computed as follows:

$$E_{2T} = T_D + P_D + Q_D + R_D \tag{4}$$

$$E_{2T} = N * \left(T_D + P_D\right) + (M - 1) * \left(R_D + Q_D\right) + (N - 1) * \left(T_D\right) \tag{5}$$

where E_{2T} is representing the end-to-end delay, T_D is representing the delay of transmission, P_D is representing the delay of propagation, R_D is representing the delay of processing, Q_D is representing the delay of queuing, N is the number of the links, M is the number of mm-wave link.

v) Backhaul routing

Backhaul routing is defined as the integration of the power consumed and the power gained by all the prior backhaul links. It is computed as follows:

$$Q_i = q_i^{AL} + q_i^{BH} \tag{6}$$

here the power consumed near the cell i is linear with its output power RF is calculated as:

$$Q_P^{AL} = k_{TRP}^{AL}\left(Q_{OP}^{AL} + \Delta_{Qi}^{AL} Q_{outi}^{AL}\right) \tag{7}$$

where Q_i^{AL} is the representation of the power consumed in ALS (Alternative Links), q_i^{BH} is the representation of the power consumed by BH(Backhaul) links, Δ_{Qi}^{AL} is the representation of the slope of the load dependent on the AL power cell, Q_i is the representation of the power cell, $k_{TRP}^{AL}$is the representation of the transceiver AL, Q_{outi}^{AL} is the representation of the RF output power for AL near cell i.

Henceforth, the power consumed near transceiver AL and its associated u ∈ S is given as:

$$Q_{outi}^{AL} = \frac{Q_{maxi}^{AL}}{RF_{max}} \sum_{u \in U} (a(i,u)Q(i,u)) \tag{8}$$

where Q_{maxP}^{AL} is the maximum of the power transmitted to the ALS near cell i.

However, in case of mm wave link ($\beta(m,n)$ is calculated as:

$$\beta_{(m,n)(d_{Bm})} = \left(R_{Tx_{(m,n)}} + R_{RX_{(m,n)}} + PL_{(m,n)} + RM + NF_{db} + N_{TH(dBM)} - G_{TX_{(m,n)}} - G_{RX_{(m,n)(dbi)}}\right) \tag{9}$$

here $R_{Tx_{(m,n)}}$, $R_{RX_{(m,n)}}$, $G_{TX_{(m,n)}}$, $G_{RX_{(m,n)(dbi)}}$ are the classes and the antenna gains of the backhaul links, $PL_{(m,n)}$ is the path of the loss in the backhaul links, $N_{TH(dBM)}$ is the representation of the thermal noises.

vi) Selection of the cluster head

Here, a distance based clustering process is followed to elect the cluster head. The parameters considered are the cache size, distances, mobility, battery power and the popularity of the nodes. The followings are the steps for the d-clustered election model:

Step 1: Computing the local cache capacity CSn for all nodes n.

Step 2: Sum of the distances D_n on all nodes n is calculated by below eqn.

$$D_n = \sum_{n \in N(n)} \{dist(\mathrm{n}, \mathrm{n}')\} \tag{10}$$

Step 3: Estimating the average speed of the node for a current time T. It is helpful for deriving the measures of the mobility m_n.It is calculated as follows:

$$M_n = \frac{1}{t} \sum_{t=1}^{T} \sqrt{x} \tag{11}$$

where X= $(c_t - c_{t-1})^2 + (D_t - D_{t-1})^2$, (c_t, D_t) and (c_{t-1}, D_{t-1}) are the coordinates of the nodes n at time t and t − 1

Table 1 Simulation parameters

Simulation parameters	No. of deployed nodes and its parameter values
No. of mobile nodes	42
Small cell base station nodes	8
5G heterogeneous-base station and Cluster head	8
X- Dimension	1600 m
Y- Dimension	900 m

Step 4: As we stated, cluster heads consume more battery power than the normal nodes in the networks.

Step 5: Estimating the combined weight W_n of each node n which is given as:

$$W_n = \frac{I}{H1} RS_n + H_2 D_n + H_3 M_n + H_4 BP_n + \frac{1}{H5} P_n \tag{12}$$

where H1, H2, H3, H4 & H5 are the weighting factors of the system's parameters.

Finally, with the help of the mesh mm-wave network configuration under the active components of small cells has influenced the decision, along with the multiple factors. Different new configurations can increase the traffic in UEs which leads to connectivity problems with the mmwave links. Line of Sight (LoS) configuration has reduced the computational load and also some efficiency measurements.

4 Experimental results and discussion

This section presents the experimental analysis of the proposed methodology. Here, Network Simulator (NS-2) is employed to implement the proposed workflow. It is one of the best simulation tools that supports a variety of network modelling and interfaces. Since the packets contain the information about header and the payload, it helps to easily track the scenario of current transmission systems which can't be ensured by other programming languages. The simulation parameters of the study are given in Table 1.

The Fig. 1 presents the initialization of the mobile nodes under the wireless mesh networks. Here, 42 mobile nodes are taken for the study. These nodes are communicated with 8 small-cell base station nodes with 1 cluster head node.

The Fig. 2 presents the nodes are broadcasting in search of getting the details of its neighboring nodes. Here, Dynamic Source Routing protocols (DSRP) is initiated in order to achieve an efficient packet transmission process.

It is inferred from the Fig. 3 that the nodes are randomly communicated. Thus, a formal communication process is done by discovery of the topology. Here, base station node 9 discovers the neighboring node 1 at a period of 2.04 s.

The Fig. 4 presents the RTS process. Once the source node is determined, the destination nodes will be determined by its communication route path. Thus, RTS is being forwarded by each node in the network, so as to form the communication route. By doing so, we are able to find the mobility of the nodes. In general, RTS composes of five fields, namely, Frame Control, Duration, Receiver Address, Transmitter Address and the FCS.

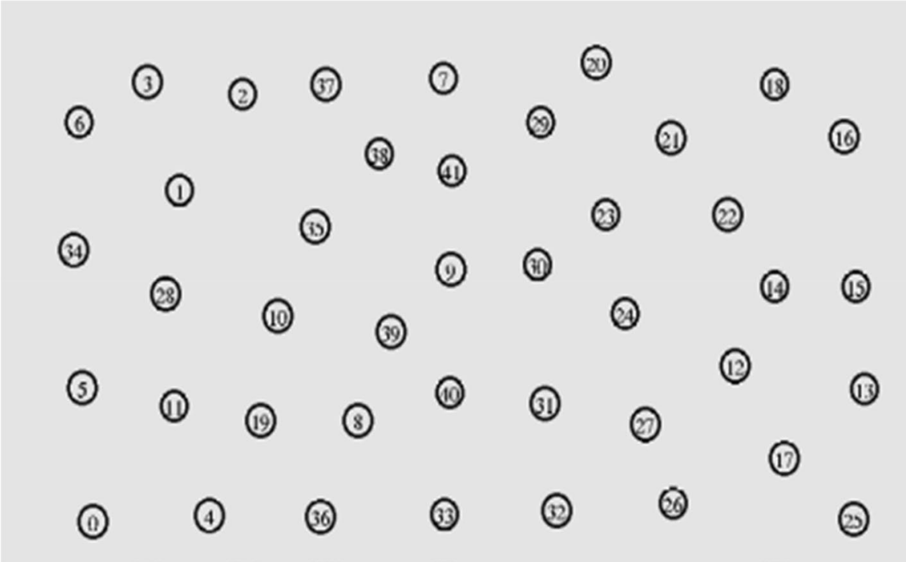

Fig. 1 Initialization of the nodes

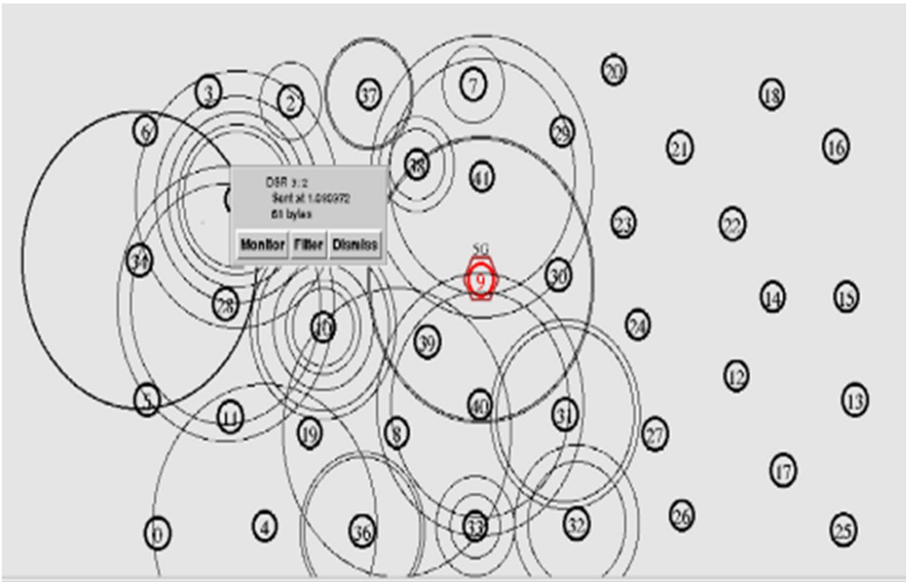

Fig. 2 Nodes broadcasting searching for neighboring nodes

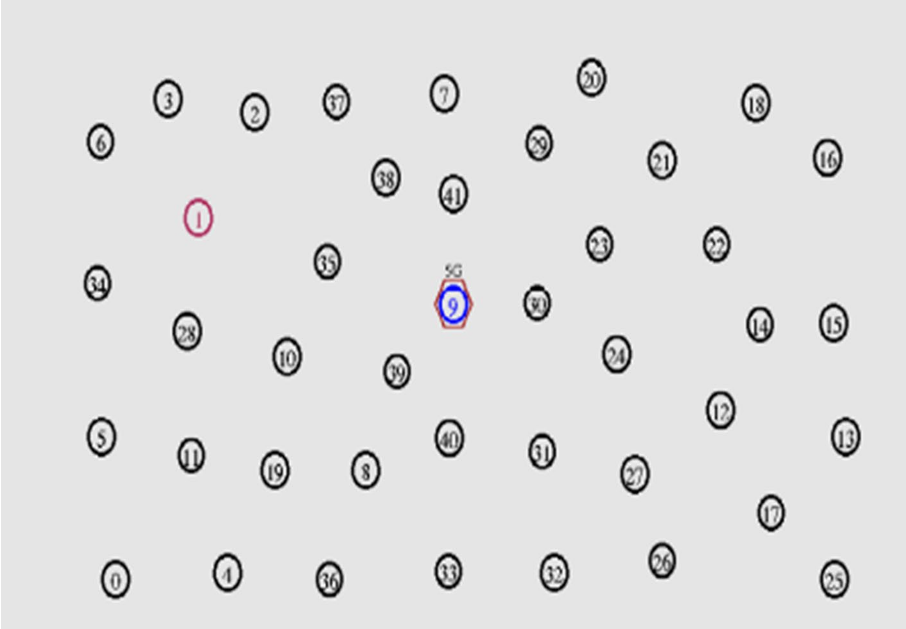

Fig. 3 Discovery of the topology

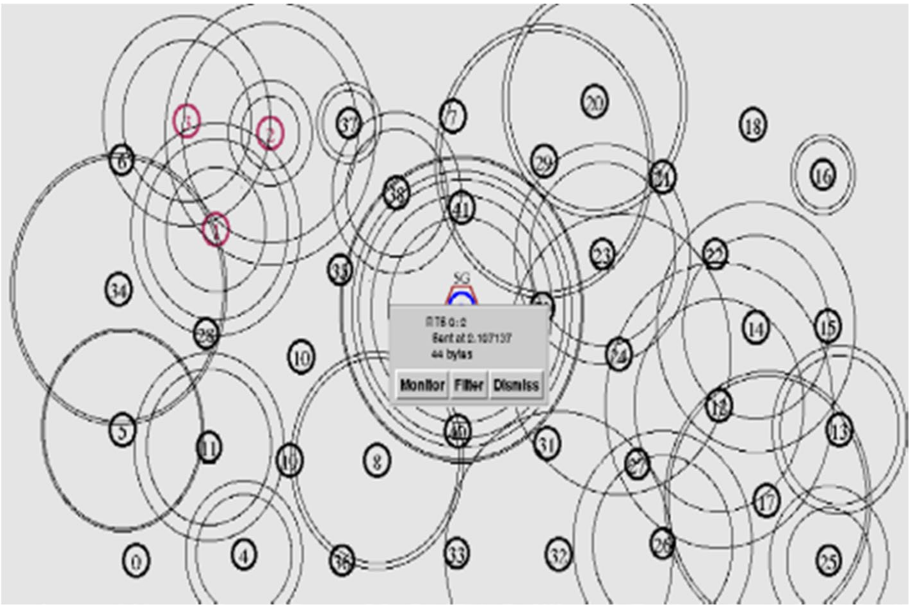

Fig. 4 Request to Send (RTS)

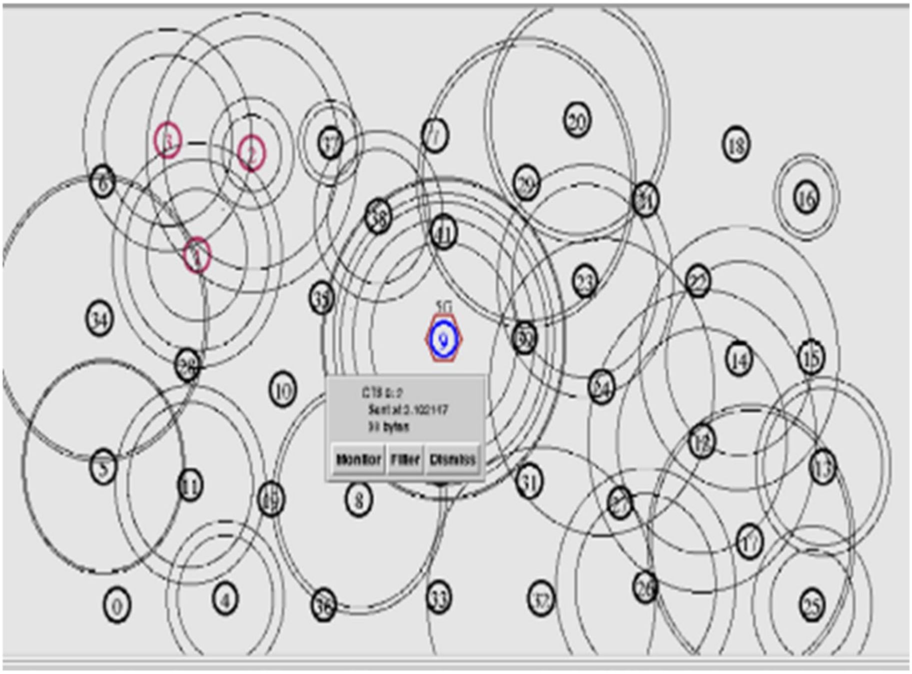

Fig. 5 Clear to Send (CTS)

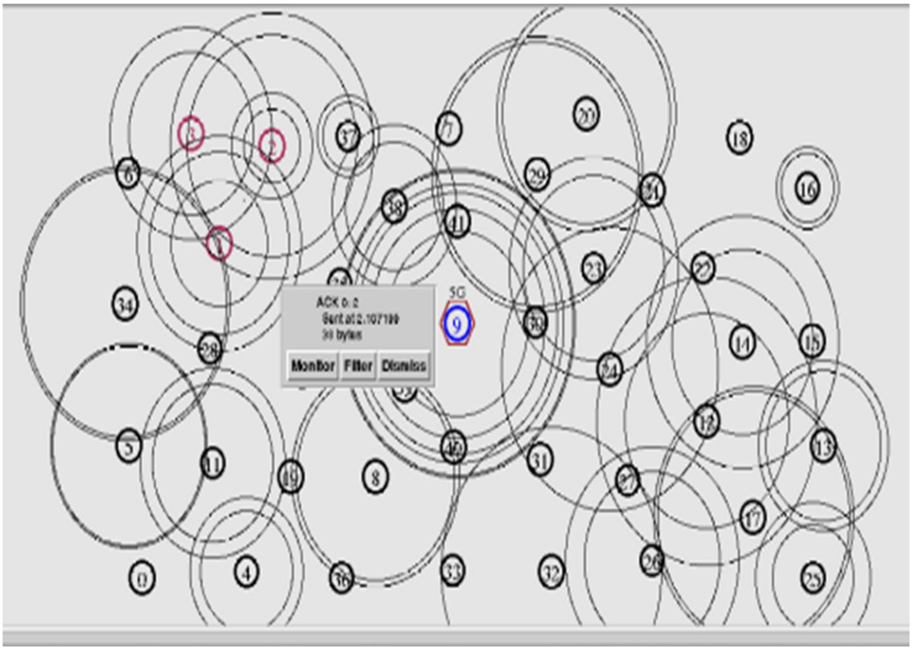

Fig. 6 Packet acknowledgement

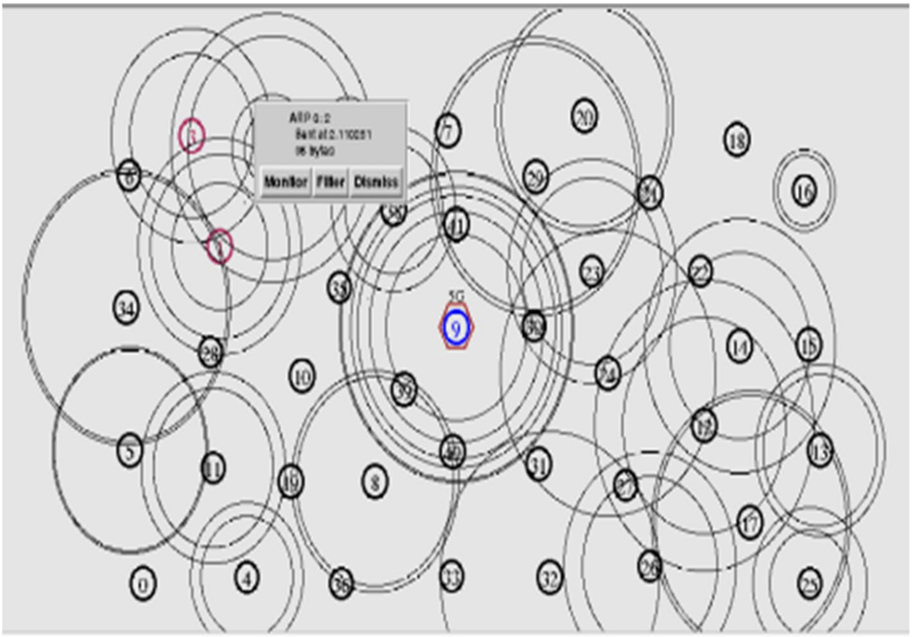

Fig. 7 Address resolution protocols

The Fig. 5 presents the clear to send (CTS) process which takes the responsibility of sharing the availability of the nodes in the networks. Like RTS, CTS comprises four fields, namely, Frame Control, Duration, Receiver Address and the FCS.

Figure 6 presents the acknowledgement packets, which helps to verify whether the appropriate destination node gets the packets. The acknowledgment of the packets comprises four fields, namely, frame control, duration, receiver address and the frame control sequence.

In Fig. 7 address resolution protocols (ARP) is executed at the data link layer. It will help us to develop the backhaul links among the mobile nodes.

The Fig. 8 presents the packet dropping analysis. It is inferred that the communicated packets need to be supervised under Transmission Control Protocol (TCP). Henceforth, packet dropping is minimized, so as to improve the throughput rate.

Figure 9 presents the selection of the cluster heads using distance based clustering models. The nodes with the minimal hop count, is considered to form the communication path.

Creating the link between nodes is given in Fig. 10 which shows that the data link layer and the physical layers are communication by following a set of telecommunication protocols.

Once the link is created by the cluster heads, the position of the neighboring nodes are updated and preserved in the routing tables (Fig. 11).

The Fig. 12 presents the collected data being forwarded to the base station. Irrespective of the improving spectral efficiency and the data rate, the density of the base station, cell size and so on reduced based on the set of BSs and the SCs, even under switching off mechanisms. Along with that, Table 2 presents the simulated values while performing analyses which helps to understand the efficiency of the proposed frameworks.

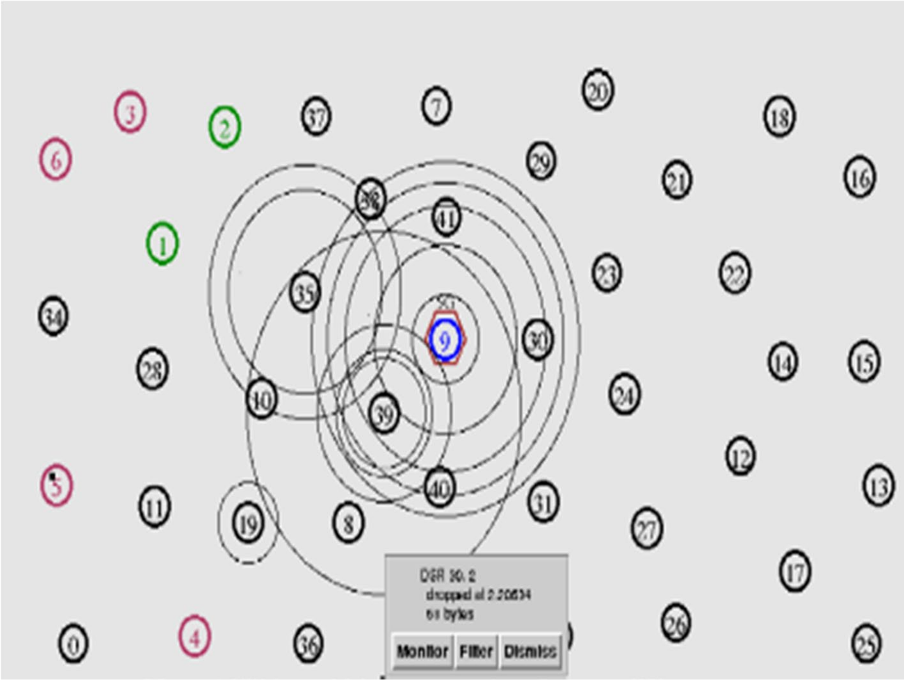

Fig. 8 Packet dropping

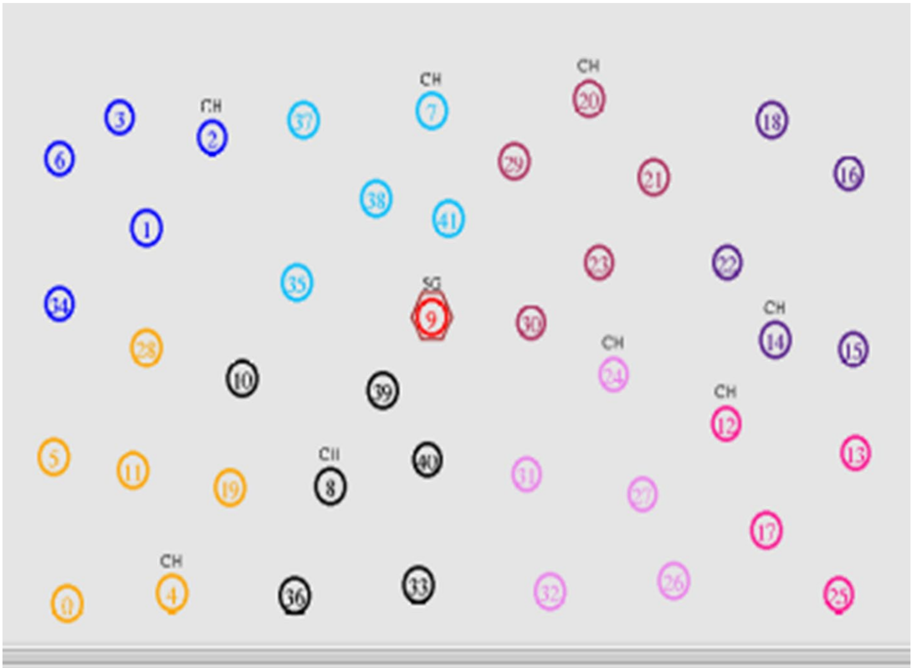

Fig. 9 Selection of the cluster heads

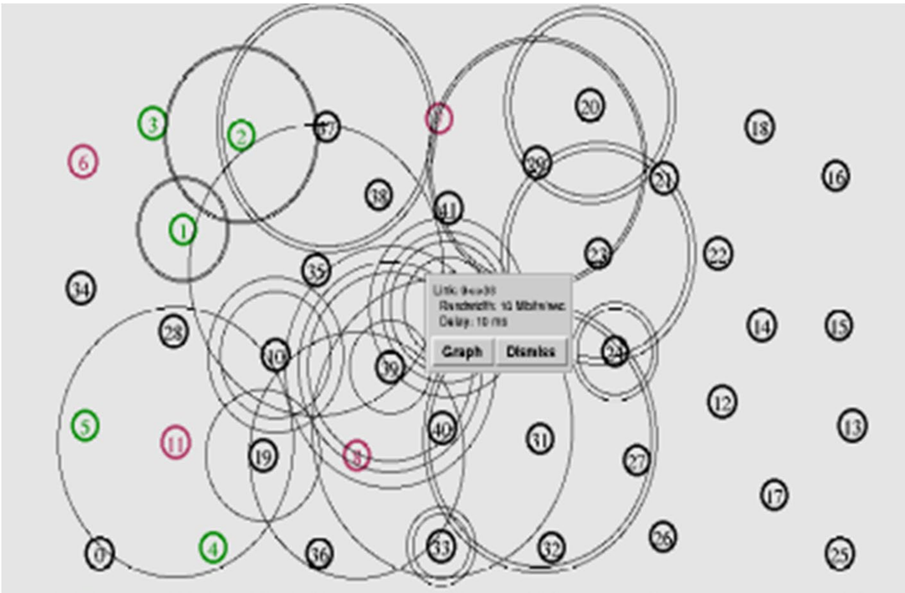

Fig. 10 Creating the link between nodes

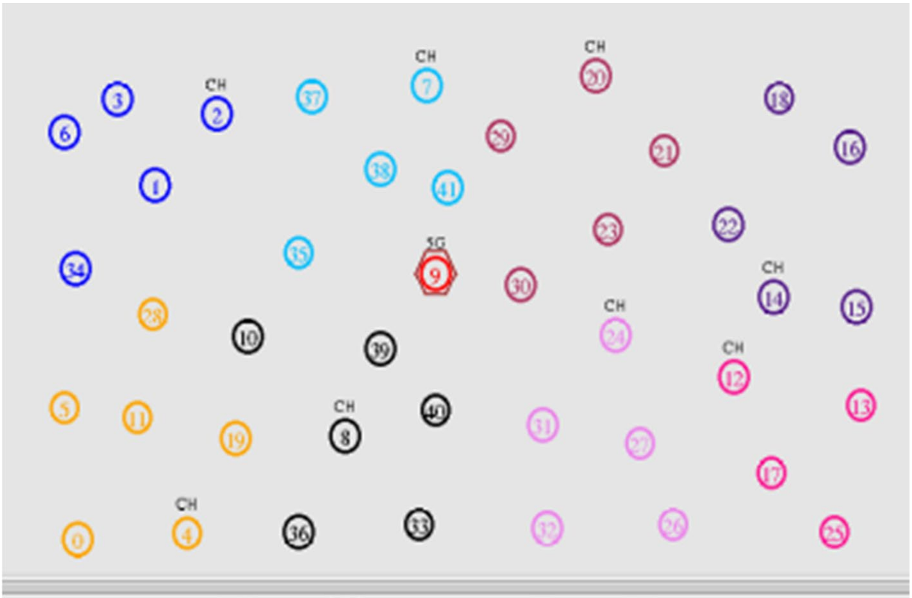

Fig. 11 Updating the routing tables

The Fig. 13. explains the analysis of the packet delivery ratio. Here, X- axis represents the time taken by the packets and the y-axis represents the no. of packets. The obtained

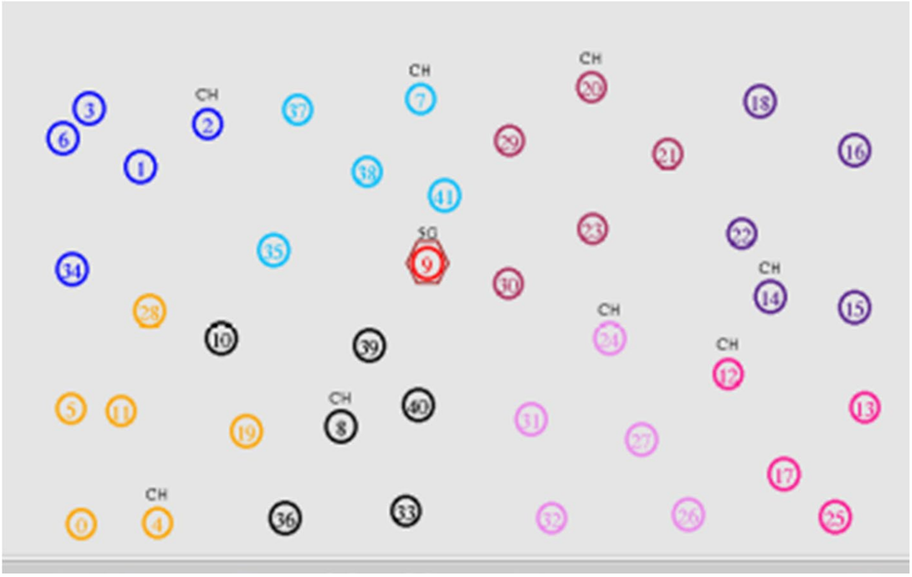

Fig. 12 Forwards to the base station

proposed values are significantly greater than the existing values. As the time scale increases, the delivery packets are not compromised by the cache enabled packets.

This Fig. 14 presents the packet delay analysis. Here, X-axis represents the time taken by the packets and the y-axis represents the no. of packets. Due to the available energy, the nodes are adjusted dynamically. The sensor nodes make use of available energy that affords the transmission power usage. In our study, along with the energy constraints, the delay computation is also encountered. Generally, many routing paths are encountered from different source nodes to receiver nodes in a backhaul network. The chance of intersecting paths may delay the communication environment. Henceforth, different nodes with the chance of highest packet delivery will be forwarded to the network environment. This bounding procedure minimizes the effects of E2E delay. It is inferred from the results that the proposed algorithm has reduced the network delay gradually, when the time scale increases.

This Fig. 15 portrays the analysis of the throughput rate. Here, the X-axis represents the time taken by the packets and the y-axis represents the no. of packets. The proposed model explores a drastic throughput rate than the existing model. Since the interferences are somehow managed in small cells, the results are greater. The sensor nodes transmit the data by initiating the route discovery process. The message is broadcasted until it reaches the relevant destination point. This communication mode removes the additional overheads within the network.

The Fig. 16 represents the comparative analysis of the energy consumption rate. Here, the x-axis represents the time period and the y-axis represents the energy consumption rate. The role of the 5G enabled packets is to minimize the energy consumption rate by means of cooperative communication systems. The user terminals are linked with each other which is the main reason for minimized energy consumption.

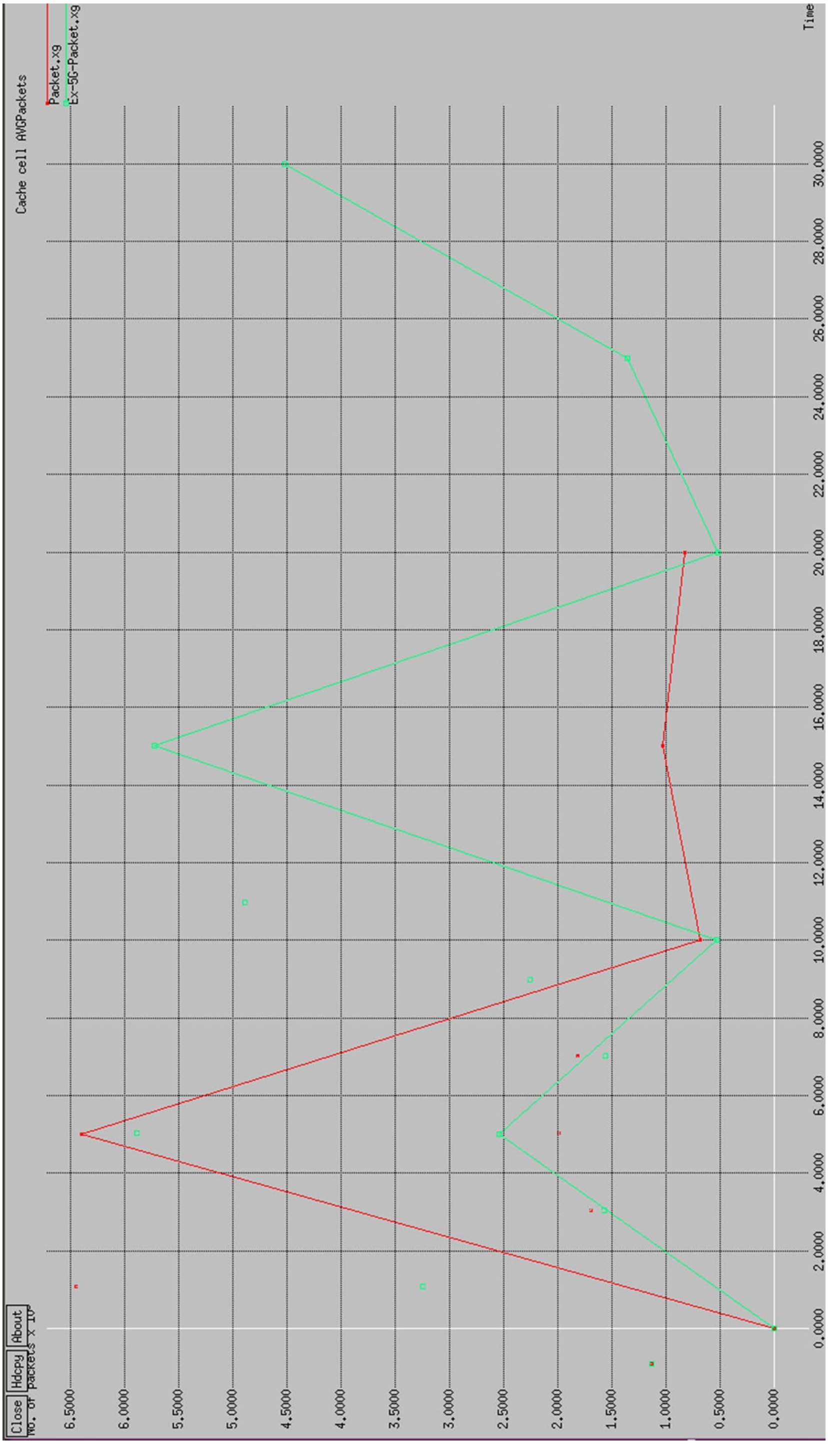

Fig. 13 Analysis of the packet delivery ratio

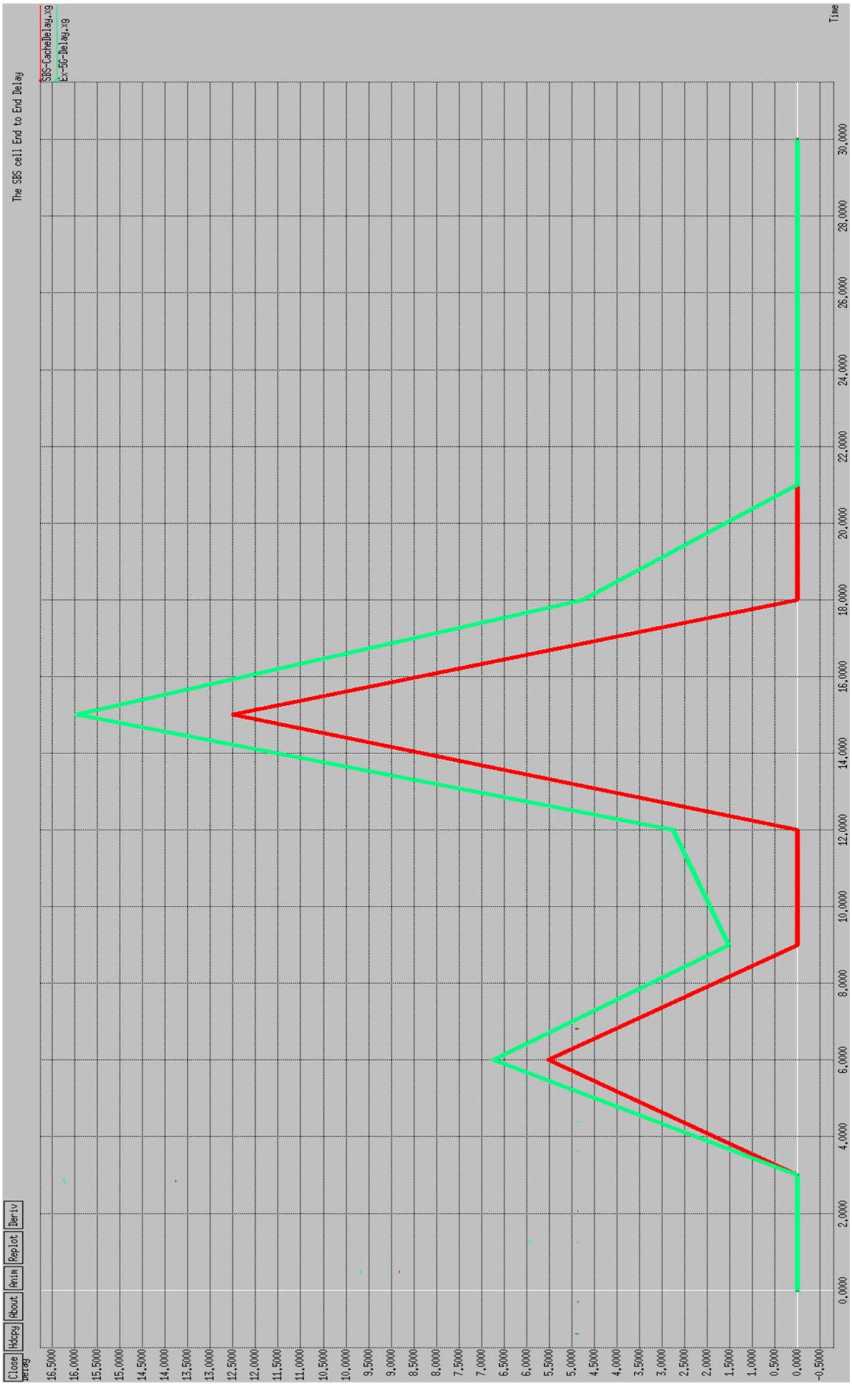

Fig. 14 Analysis of packet delay

Fig. 15 Analysis of the throughput rate

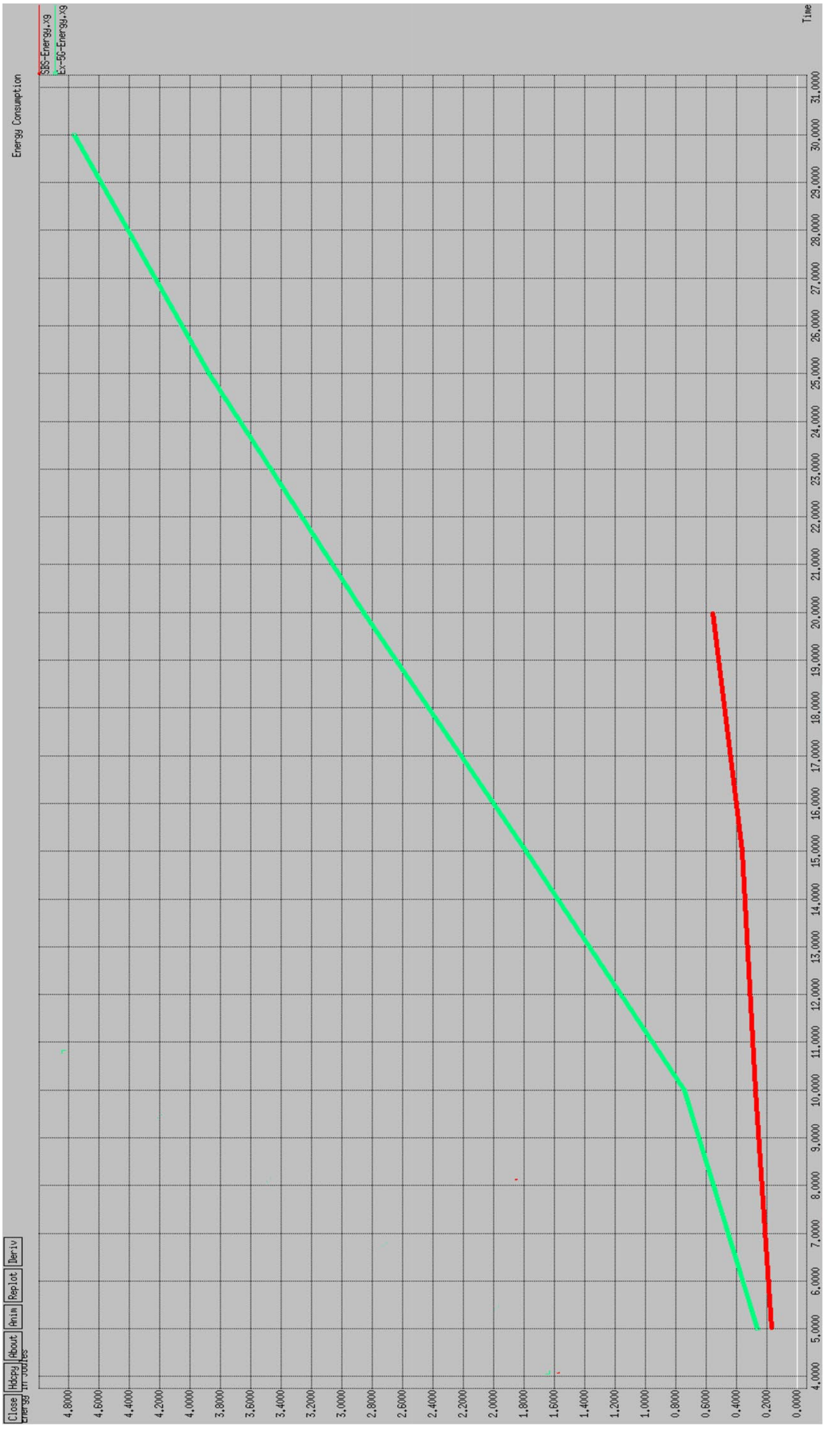

Fig. 16 Analysis of the energy consumption rate

Table 2 Simulated values from the simulation analysis

Time (s)	5G- Enabled packets				Cache enabled packets			
	Packet delivery (kb/sec)	Packet delay (packets/ sec)	Throughput (kbps)	Energy consumption (joules in %)	Packet delivery	Packet delay	Throughput (kbps)	Energy consumption (joules in %)
2	1000	2100	400	35%	2500	2000	900	2%
6	2200	3000	450	59%	5300	1900	1000	22%
16	1100	12,000	700	2%	4700	8000	9000	4%
18	900	4900	800	28%	2600	0	9100	6%

5 Conclusion

This paper is the development of hybrid models to optimize the inference, switching and the backhaul routing process under 5G HetNets with mm-Wave backhaul links. Here, we have proposed a novel cache placement strategy which developed as a fast and heuristic solution for the interference and backhaul routing problems. The data caching paradigm supports an effective data access model for the wireless environments. It has reduced the memory capacity of the mobile nodes. System has reduced the overall access cost by improving the energy consumption rate, mobility rate and throughput rate. Simulation analysis has been processed in NS2 by testing 42 mobile nodes with 8 base stations and 1 cluster heads. The results have stated that the backhaul link developments in 5G pose interference issues which are legally resolved by the cache enabled technologies. In future work, the proposed methodology will be extended to analyze the minimization of Maximum Expected Delivery Time issue under joint relay and the link selection optimization models. Non- Polynomial (NP)- Hard is a concept that deals to find the optimal solutions from a polynomial set (network coverage) of regions (heterogeneous wireless networks). Generally, the above two models will be formulated under NP-Hard problems, yet the global optimal solutions on network capacity and the network fairness will be the aim of the future study. We also look forward to address the challenge in designing mmWave link considering atmospheric induced turbulence and also employ mesh topology to minimize the effect of dust particles which are present in the proposed link which is 3–6 m high from the street level.

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Data Availability All the data generated or analysed during this study are included in this published article.

Code Availability The code will be made available on prior request from the Authors.

Declarations

Conflict of interest The authors have declared that no conflict of interests exist.

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