IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

Minimization of overall power transmission in a 5G HetNets Using Glowworm Swarm Optimization Algorithm

[1]ISA M. SANI, [2] DAHIRU SANI SHUAIBU, [3]S.H LAWAN [4] Y.M SAGAGI and [5] Huzaifa Isah
[1]Lecturer II, [2]Professor [3]Doctor, [4]lecturer II and [5] Lecturer II

[1] Department of Electrical and Electronics Engineering, Faculty of Engineering University of Maiduguri,
[2]Department of Electrical Engineering Bayero University Kano, [3] Department of Electrical Engineering Bayero University Kano
[4]Federal University Birnin kebbi and [5] Federal University Birnin Kebbi
[1]University of Maiduguri, Maiduguri, Nigeria

Abstract
The major challenges associated with 5G network is the minimization of power consumption particular at the base station (BS) which uses more than 70% of the total access power of the network , and is usually characterize by dense deployment of small base station , In this research small base station (s-Bs) are inter-connected through the mm-Wave backhaul link to transfer traffic to the macro base station (M-Bs) and onto the core network (CN), in this set-up the network power consumption is affected by the way the user equipment (UE) are connected to the based station and the traffic routes through the BH links. Objective of this research is to minimized the power consumption of the heterogeneous network (HetNets) with use of Glowworms swarm optimization algorithm backhauling and s-BS/BH link I/O framework (GSOBSBS) is proposed to solve the power consumption problem in the HetNets. The proposed framework uses GSO algorithm for UEs association and BH, and a load sharing based s-BS I/O (LSBI/O) algorithm for the switching (on/off) of the s-BSs respectively , According to traffic load, the LSB (I/O) algorithm dynamically modifies the state of the s-BS from on to off. The load of that s-BS is then shared proportionately with other s-BS based on their respective loads demands. The GSO method uses a lowest cost flow heuristic technique to establish optimum network power consumption. It does this by utilizing a heuristic function that estimates the minimum power consumption towards the destination while taking the Access Network power (AN) and Backhaul power (BH) limitations into account. The suggested framework offers a way to reduce network power usage. When it comes to energy efficiency, the number of active small base stations, BH linkages, and network power consumption, the evaluation findings of the suggested framework beat those of the most advanced state of art algorithms.

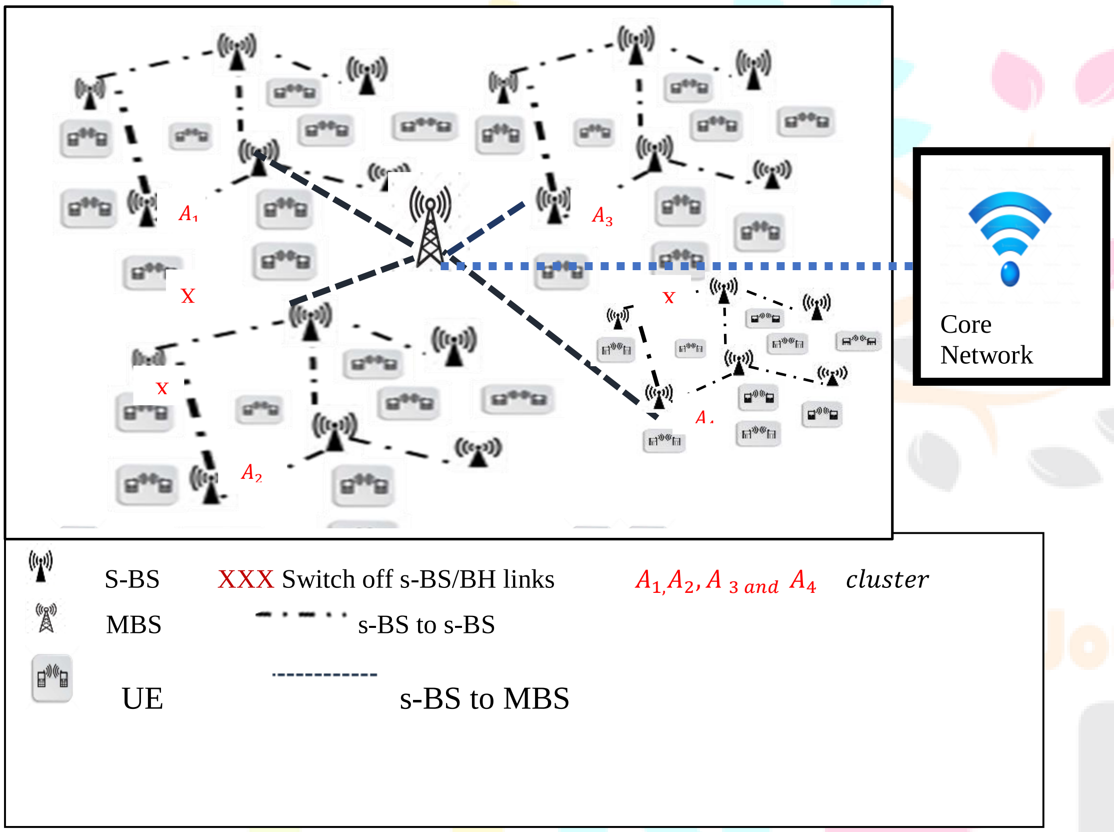
key words: Glowworm Swarm Optimization (GSO), User Equipment (UE)**;** Base Station (BS); Backhaul (BH); 5G HetNets; Quality of Service (QoS)

1.0 Introduction

The current generation of wireless smart devices and application systems is driving up demand for the existing mobile communication network(1). To meet current traffic demands and provide customers with a sufficient Quality of Service (QoS), it is imperative to deploy new technologies of the fifth-generation (5G) communication systems to expand network capabilities and coverage(2,3). These technologies include next-generation radio access network (NG-RAN), densification of base stations (BS), millimeter-wave communication, and software-defined networking (SDN). Throughout the macro base station (MBS) coverage area, low-power radio access nodes, or small base stations (s-BSs), are densely deployed to build a heterogeneous network (HetNets) that boosts network capacity and coverage.

5G HetNets architecture links s-BSs either directly or indirectly through the MBS to the core network (CN) based on the BH, or HetNets backhauling. The deployment of BH links in HetNets is essentially limited due to high running expenses(4). Wireless BH in the HetNets is a practical and cost-effective solution to this issue. In this study, we suggest a setup in which the s-BSs are connected to the Core Network (CN) via MBS using millimeter wave (mm Wave) wireless BH connections operating at 60 GHz and 70–80 GHz respectively(5). Due to propagation conditions and dense s-BS placement, many of them are not able to be efficiently connected directly to the MBS; instead, these s-BSs are connected to the MBS through the s-BSs that surround them. Therefore, multi-hop mm Wave BH links are required to connect s-BS communication to the MBS and their associated user equipment (UE). The s-BSs' access network (AN) and backhaul (BH) features are similar to those of MBSs. However, because of their lower transmission power, the s-BSs are only able to support a small number of UEs and have a limited coverage area (tens of meters). The 5G network places a high value on energy efficiency (EE). THE Energy efficiency is determine by the power used by power used by AN and BH(6). This article aims to improve the EE of the AN while maintaining the UEs' level of service quality by employing effective UE association methods. Analogously, the EE of the BH system may also be enhanced by optimizing the path for traffic flow towards the core network without violating BH power and capacity constraints on the accessible BH links. This study employs Glowworm swarm optimization algorithm backhauling and s-BS/BH link off/on framework (GSOBSBS) to address the joint UE association and backhaul problem with a single solution, while staying within the QoS constraints of UEs and power limits of the BH system.

2.0 System Model



In this work a 5G network is considered with a single Macro Base Station (MBS), some set of Small Base station s-BS (β) and a set of user equipment UEs (U) as shown in the network model in fig 1. Below. the small base station s-BS are group into cluster (A_N= 1, 2, …, N) Which are based on the placement of the s-BS Line of sight (LOS) mm-Wave BH links are used by each cluster to connect to the MBS through a single aggregate s-BS (a-BS). The s-BS are connected to the MBS directly or indirectly through a neighboring s-BS by using a loss mm-wave BH links and forming a mesh BH network. The BH links uses optical fiber links and connect to the network. different frequency band are used to avoid cross tier interference between the MBS and s-BS. it was assumed that neighboring MBS uses the orthogonal channels and are located far away, which prevent inter-cell interference. each UE is associated with only one s-BS at a time when it satisfied the strict guaranteed bit rate (GBR)α_u.

The set of BSs (MBS and s-BS) is denoted by B. the microwave links between the UEs and s-BS are denoted as L_{AN}, and the micro wave based links between BSs are denoted as Backhaul links (BH), i.e.,L_{BH}. The flat slow fading channel mode is adopted where the power allocation to the BS is constant , i.e,. maximum transmission power (T_{max}^{AN}) $.the\ T_{max}^{AN}$ Is divided into physical resource block (PRBs). the presence of UE traffic which is passed through the AN link is denoted as X^{AN} , and through the BH links is denoted as X^{BH} the Binary variable X^{AN} $and\ X^{BH}$ is one , when the user traffic UEs traffic is transmitted over the AN links or BH link , and zero otherwise the state of the base station (S^{AN}) and BH links , (S^{AN}) $and\ BH\ link$ ((S^{BH}) are either on or off (I/O) when the BS or BH links is ON, the binary variable S^{AN} $and\ S^{BH}$ are 1; $otherwise$ 0.

For meeting the traffic demand rate α_u of a UE a specific number of PRBs is required to connect to the ith BS, denoted as $\Gamma_{i,u}$ as given in eqn. (1)

$$\Gamma_{i,u} = \frac{\alpha_u}{\eta\, log_2(1+SINR_{i,u})} \quad (1)$$

Where η represents the bandwidth of the PRB and $SINR_{i,u}$is the effective SINR between the base station and the user equipment. Moreover, the number of utilized PRBs at each based station BS is less than or equal to its maximum capacity, i.e.

$$\sum_{u\in U}\sum_{i\in B} X_{i,u}^{AN}\,\Gamma_{i,u} \leq \Gamma_{max} \quad (2)$$

The total power consumption of the network (P^{Net}) is a combination of power consumed in AN (P^{AN}) and BH (P^{BH}) which is given in eqn. (3)

$$P^{Net} = P^{AN} + P^{BH} \quad (3)$$

The total network energy efficiency (EE) of the HetNets formulated as the fraction of the network throughput and power consumption which includes the AN and BH power consumption. Thus, the total network Energy efficiency (EE) of the network is given as

$$Net_{EE} = \frac{\sum_{u\in U}\sum_{i\in B} X_{i,u}^{AN}\,\Gamma_{i,u}}{P^{Net}} \quad (4)$$

The power consumption models are discus below as

2.1 Power Consumption Model in AN

The total power of the P^{AN} consist of two parts the dynamic power consumption of the BS that depends on the transmission power consumed at microwave links and the static power consumption of the active BS , the P^{AN} is calculated using the linear approximation power consumption model journal (26) which is given in eqn. (5)

$$P^{AN} = \sum_{i\in B} T_{X_i}^{AN}\left(S_i^{AN} P_{O_i}^{AN} + \Delta_{P_i}^{AN} P_{d_i}^{AN}\right) \quad (5)$$

$$P_{d_i}^{AN} = \frac{T_{max_i}^{AN}}{\Gamma_{max_i}} \sum_{u\in U} X_{i,u}^{AN}\,\Gamma_{i,u} \quad (6)$$

Where $T_{X_i}^{AN}, S_i^{AN}, P_{O_i}^{AN}$ represents the number of transceivers chains, state and non-zero output power consumption of the ith BS, respectively. $\Delta_{P_i}^{AN}$ denotes the slope dependent power utilization of the ith BS. Total transmission power consumption of the ith BS denoted as $P_{d_i}^{AN}$ which is calculated using eqn (6). $T_{max_i}^{AN}$ represents the maximum transmission power of the ith BS. $X_{i,u}^{AN}$ represents the traffic of the uth UE passed through the ith BS AN link.

2.2 Power Consumption Model in BackHaul

The power consumption model in Backhaul link (BH) consist of power utilized on the BH links that are interconnected to the BS. in this research work two frequency band was used for the BH links (24) 60GHz band (V-Band) for interconnection between the s-BS each cluster and 73GHz Band (E-Band) between the s-BS and the MBS. The P^{BH}consist of static power consumption which are associates to the BS for providing service to the UEs.

When a BH link is active, and the dynamic power consumption when traffic is routed through a link. The linear approximation power consumption model is used for estimation of BH power consumption which is given in eqn. (7).

$$P^{BH} = \sum_{l\in L_{BH}} T_{X_l}^{BH}\left(S_l^{BH} P_{O_l}^{BH} + \Delta_{P_l}^{BH} P_{d_l}^{BH}\right) \quad (7)$$

Where $T_{X_l}^{BH}, S_l^{BH}, P_{O_l}^{BH}$ represents number of transceivers chains , Non-Zero output power and state (on or off) of the lth BH links respectively. $\Delta_{P_l}^{BH}$ is the slope dependent power utilization of the lth BH links, respectively. $P_{d_l}^{BH}$ represents the dynamic power consumption of the lth BH links, which is calculated with using eqn. 8

$$P_{d_l}^{BH} = SINR_l^{min} - G_{rx_l} + L_{rx_l} + PL_l + LM_l + T_{n_l} + N_{f_l} \quad (8)$$

Where G_{rx_l}, L_{rx_l} represents the receiver, antenna gain and losses of the lth BH links, respectively PL_l is the path loss (PL) of the lth BH links (total of free space PL, rain and gas attenuation (25). LM_l Represents the link margin, T_{n_l} is the thermal noise, N_{f_l} is the receiver noise of the lth BH link. Where $SINR_l^{min}$is the minimum achievable target SINR for successfully transferring aggregate traffic of BS routed through the lth BH link? Adaptive modulation and coding technique (AMC) (26) are used to defined $SINR_l^{min}$ of the BH link as given in eqn.9.

$$SINR_l^{min} = 10log_{10}\left(2^{\frac{R_l^{BS}}{\eta_l}} - 1\right) \quad (9)$$

$$R_l^{BS} = \sum_{i\in B, u\in U} X_{i,u}^{AN}\, \alpha_u \quad (10)$$

Where η_l represents the allocated bandwidth of the *l*th BH link which is estimated by using eqn.10

Due to high PL at mm-Wave Bands, the generated inter link interference is negligible, i.e., SINR=SNR. The maximum transmission power allowed on a BH link ($T_{\max}^{BH}$) limits to the total transmission power of the BH link $P_{d_l}^{BH}$, i.e.,

$$0 \leq P_{d_l}^{BH} \leq T_{max}^{BH} \quad (11)$$

The minimum transmission power of the BH link is calculated as

$$T_{\max}^{BH} = EIPR_{max} + L_{tx} - G_{tx} \quad (12)$$

Where L_{tx}, G_{tx} denotes transmitter loss and gain respectively, the $EIPR_{max}$is the maximum equivalent isotopically radiated power which is calculated as (27).

$$EIPR_{max} = 85_{(dbm)}\text{-}2.x_{db} \quad (13)$$

Where x, is less than 50 dBi if its E-Band (73GHz) and less than 51 dBi in V band (60GHz).

2.3 Problem Formulation

The objective of this research is to minimized the power consumption of the 5G HetNets backhaul (BH) network without violating the quality of service (QoS) of the user equipment (UE). The total HetNets power consumption is the power utilized by a set of active based station and BH links that are used to transfer the traffic to the MBS. The estimated BH load is routed by finding the path which consumes minimum power. therefore, the problem can be considered as a minimum cost flow problem where the source node chooses the minimum cost path to reach the destination.

The cost flow problem can be translated as a directed graph $G = (B, E)$ where B represents set of nodes i.e., s-Bs, and E represents the BH links between the two nodes. each BH link *l* is associated with values of P_l^{BH} (power consumption), dynamic power consumption P_{dl}^{BH} and flow constraints X_l^{BH}. For transferring aggregate traffic of nodes (R^{BS}) to the MBS (destination) the proposed model estimates the optimal cost from sources to destination, including all en-route BS and BH links. The following assumption are considered;

-All BH links cost such as P_l^{BH}, P_{dl}^{BH}, and X_l^{BH} are integral

- All BH links cost are non-negative;
- All BH links are Los mm wave links;

The problem is expressed to be an optimization problem where the BH power consumption of the HetNets is optimized by using equation 14 below

Min P^{Net}

s.t

$A_1: X_{i,j}^{BH}, X_{iu}^{AN} \in \{0,1\}, \forall(i,j) \in L_{BH}, \forall(i,u) \in L_{AN}, \forall u \in U$

$A_2: S_i^{AN}\ S_{i,j}^{BH} \in (0,1), \ \forall i \in B\ \ \forall(i,j) \in L_{BH}$

$A_3: X_{i,j}^{BH} + X_{j,i}^{BH} \leq 1, \forall(i,j \in L_{BH})$

$A_4: S_i^{AN} \geq X_{i,j}^{BH} + X_{j,i}^{BH}, \forall(i,j) \in L_{BH}, \forall i \in B$

$$A_5: \sum_{i\in B}\sum_{u\in U} X_{i,u}^{AN} \leq \Gamma_{max_i}, \forall i \in B \quad (14)$$

$A_6: P_{i,j}^{BH} \leq T_{max_{ij}}^{BH}, \forall(i,j) \in L_{BH}$

$$A_7: \sum_{i\in B} X_{i,j}^{BH} - \sum_{i\in B} X_{j,i}^{BH} = \begin{cases} 1, \text{ if I= source} \\ -1 \text{ if I= BS (Sink)} \\ 0, \text{ otherwise} \end{cases}$$

$\forall i \in B, \forall(i,j) \in L_{BH}$

Where A_1 represents the binary variables for user equipment (UE) traffic routed through the BH link and AN of the Network. the traffic routed through the AN and BH when it's in active stage which is represented in A_2. The constant A_3 shows that two-way transmission between two nodes is not acceptable. A_4 represents that the based station is active when the traffic is transmitted through the BS. The constraint A_5 shows that the utilization of physical resources blocks at each based station which cannot exceed the maximum limits. A_6 represents the maximum transmission power of the BH link which limits to the resultant transmission power of the BH link. A_7 denotes the path constraint for transferring the traffic rate of ith BS to the destination node. A_7 indicates that for the intermediates BS (Excluding the source and destination nodes) the total outgoing and incoming traffic must be equal.

2.4 Proposed Solution

A glowworms swarm optimization algorithm and s-BS/BH link on/off frame work (GSOSBOF) is proposed to solve the minimum power consumption problem in HetNets. In the GSOSBOF framework, the network is first established by using a Glowworms swarm optimization algorithm (GSO) then the underutilized active s-BSs in the HetNets are put to off by using a load sharing based s-BS off (LSBO) algorithm , finally the ideal BH links in the network are put to off the proposed GSO and the LSBO algorithm will be discuss below.

2.5 Glowworms Swarm Optimization Algorithm

Glowworms swarm optimization technique (GSO) is a derivative free, Meta heuristic in nature looking at glow behaviour of glowworms which can efficiently capture all the maximum multimodal function, a glowworms has the ability to spread randomly in a search space. It's attracted to the glowworms with the highest glow intensity in its neighbourhood. Each glowworms broadcast its glow intensity and it's attracted to its neighbours on the basis of a fitness function. The glowworms moves towards the neighbouring glowworms having the most glow intensity. The fitness is proportional to the function being optimized.

Steps of the glowworms are depicted in the flow chart below on initialization all glowworms contain the same amount of luciferin l_o . Every cycle of the algorithm passes through three stages. Luciferin modify stage, association stage and community array update stage. The luciferin modify stage denotes the function assessment at the glowworms position, while every glowworms updates its level from its prior luciferin level.

$$\boldsymbol{l}_{i(t+1)} = (1-\rho)l_i(t) + \gamma J(x_i(t+1)) \qquad (15)$$

Where $l_i(t)$ denotes the luciferin level of the i^{th}glowworm at time t, ρ represents luciferin degeneration variable (0< ρ <1), γ is the luciferin enhancement variable, J $(x_i(t)$ denotes cost of the objective function or the prior level of the luciferin of the $l_i(t)$ glowworm at time t.In the movement period each glowworm determines the probability to move in the direction where an adjacent glowworm has luciferin quantity greater than its own , so the glowworm would move towards where the intensity of the radiance is the highest the probability of moving towards a glowworm at the adjacent j^{th} position is given by,

$$\boldsymbol{\rho ij(t)} = \frac{lj(t)-li(t)}{\sum k\in Ni(t)\ \ lk(t)-li(t)} \qquad (16)$$

$J£\ \boldsymbol{Ni(t)},\ \boldsymbol{Ni(t)} = [\{\boldsymbol{j}: \boldsymbol{d_{ij}}(t) < \boldsymbol{r^i d}(t); \boldsymbol{li(t)} < \boldsymbol{lj(t)(t)}\}]$ at neighborhood of glowworm i in time span t, $d_{ij}(t)$ the Euclidean distance between glowworms i and j in time span *t* and $r^i d(t)$ indicates the adjacent array related to glowworm i in time span t. so the glowworm i select a glowworms j £ $Ni(t)$ with $P_{ij}\ (t)$. The prototype for the glowworm arrangement is specified as;

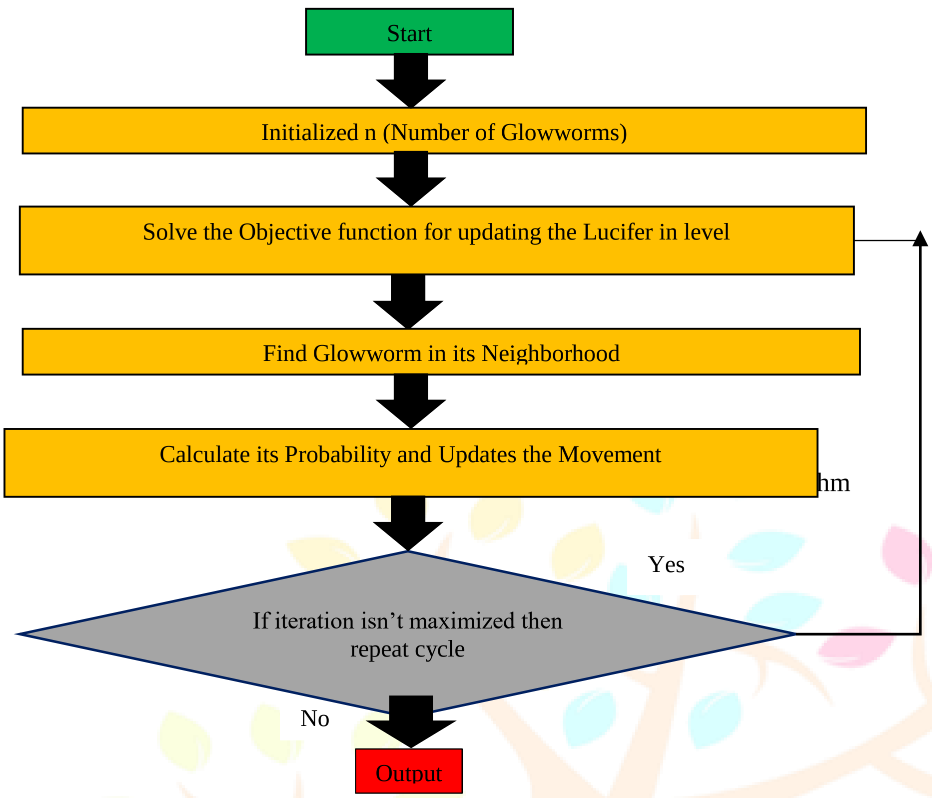
$$\boldsymbol{yi(t+1)} = \boldsymbol{yi/(t)} + \left(\frac{yi(t)-yj(t)}{||yi(t)-yj(t)||}\right) \qquad (17)$$

Where yi (t) £ R^m is the position of glowworm i, in time span t, in the m, dimensional real spaceR^m , ||. || represents the Euclidean norm operator and S > 0) is the step size. In the neighborhood range update stage, each glowworm i has a neighborhood in its radial range $\boldsymbol{r^i d(0 < r^i d <= r_s}$

Where r_s is the glowworm sensor range? Each glowworms neighbourhood range is updated as

$$\boldsymbol{r^i d(t)(t+1)} = \mathbf{min}\{\boldsymbol{rs}, \boldsymbol{max}\{0, \boldsymbol{r^i d(t)} + \boldsymbol{\beta}(\boldsymbol{n_{t-|N_i(t)|}})\} \qquad (18)$$

Where β is a constant and n_t is the number of neighbors?



Algorithm 1 Glowworms Swarm Optimization Algorithm

Input: set of BSs B, Set of UEs U.
Output: Minimize power consumption of network.
for each UE u in U **do**
  for each BS i in B **do**
$\Gamma_{i,u}$ = Calculate the PRBs of UE using $\Gamma_{i,u} = \frac{\alpha_u}{\eta \log_2(1+SINR_{i,u})}$
if $(\Gamma_{i,u} \leq \Gamma_{max})$**then**
$conn\_BS_{list} = conn\_BS_{list} \cup BS$
  for each BS of $conn\_BS_{list}$ **do**
$M_{in\_}Powcon_{list}$ = Calculate the minimum power consumption path using $\sum_{u \in U} \sum_{i \in B} X_{i,u}^{AN} \Gamma_{i,u} \leq \Gamma_{max}$
  end for
    end if
  end for
  $M_{in\_}Powcon_{bs}$ =Find BS have minimum path from $M_{in\_}Powcon_{list}$ connect the UE u with the $M_{in\_}Powcon_{bs}$
  $Con\_Net = Con\_Net \cup u$
  Update the PRBs of the BS
  output: minimized power consumption of the network
  end for

2.6: Load Sharing Based S-BS Off (LSBO) Approach_Base on Minimum Cost Flow Heuristic Approach

The minimum cost flow heuristic approach is a method used in network flow optimization problems, particularly in the field of operations research and optimization. It involves finding the minimum cost flow through a network, where the objective is to minimize the total cost of sending flow through the network. This approach is often used in transportation, logistics, and supply chain management to optimize the flow of goods and resources through a network of interconnected nodes and edges while minimizing costs. The heuristic approach involves using heuristics, or rules of thumb, to guide the search for an optimal solution, especially in cases where finding the exact optimal solution is computationally expensive or infeasible

The outcome of the Glowworms swarm optimization algorithm in equation One provides an initial association of UEs to s-BS, resulting in the formation of a connected network (con_Net). The load sharing based s-BS off (LSBO) algorithm 3 takes the con_Net, set of s-BS (β) $and\ UEs(U)$ as inputs and output optimizes the number of active s-BS (Act_BSs). The number of active s-BS are optimized by changing the states of the s-BS in the HetNets. The detail LSBO Algorithm is shown in algorithm 3 and detail description is given below.

Algorithm 2: Minimum Cost Flow Heuristic Approach

Input: $G(B,E)$, Source node ($Source_{node}$), Goal node ($Goal_{node}$), heuristic cost function $h(n)$
Output**:** Minimum BH power usage between $Source_{node}$ to $Goal_{node}$**.**
Initialization: $L_{open} = Source_{node}$, $L_{closed} = \emptyset$.
while $L_{open} \equiv \emptyset$ do
$Curt_{node}$= Find min (f) from $Lopen$
If ($Curt_{node} \equiv Goal_{node}$) **then**
return $Curtnode$;
end if
Generate successor nodes of the $Curt_{node}$
for each $Sucr_{node}$ of $Curt_{node}$ **do**
if (($Sucr_{node} \notin L_{open}$) & ($Sucr_{node} \notin C_{open}$)) **then**
Add $Sucr_{node}$ to L_{open}
$Sucr_{curcost}$=g($Curt_{node}$)+ w ($Curt_{node}$, $Sucr_{node}$)
else if (g($Sucr_{node}$) $\geq Sucr_{curcost}$ **then**
g($Sucr_{node}$) = $Sucr_{curcost}$
else
if ($Sucr_{node} \in L_{closed}$) **then**
Remove $Sucr_{node}$ form the L_{closed}
Add $Sucr_{node}$ to the L_{open}
end if
end if
end for
Remove $Curt_{node}$ from L_{open}
Add $Curt_{node}$ to the L_{closed}
end while

- Initially, the state (on/off) of the s-BSs (s^{AN}) are identified. The load of the s-BSi BS^{loads}) is calculated by using equation (19) below when it's in on active mode (on) ($S_i^{AN} = 1$).Then, the active s-BS_i is added to the s-BS active set (Act_BS_s). the load of the s-BSs is sorted in ascending order and sorted in a list, i.e., BS^{loads}**.** Then the least loaded s-BS from the sorted list (BS^{Loads}) is found and sorted in the variable BS^{least}. Local search is performed within the coverage area of BS^{least}. Thereafter, the identified s-BS are added to the list of the neighboring s-BS i.e. NB^{list}.
- The NB^{list} list is sorted in increasing order with respect to the traffic load and respective identity stored in the SN^{list}. Similarly, the loads of the s-BS are stored in descending order in the SL^{list} . then, the traffic load of the BS^{least} is shared with the SN^{list} using eqn. 20.
- If the traffic load of the BS^{least} is successfully shared with SN^{list} then the state of the BS^{least} is change to off state and the Act_BS_s list is updated. Else, this process is aborted and the network is restored to its original state. This process is continued until the traffic load of theBS^{least} is shared with its neighboring s-BS.

$$BS^{loads} = \sum_{u=1}^{U}\left(\left(\sum_{i=1}^{\beta} X_{i,u}^{AN}\,\Gamma_{i,u}\right)/\Gamma_{max}\right) \quad (19)$$

$$SN^{loads} = \sum_{i=1}^{SN^{list}}\left[\frac{SL_i^{list}}{\sum_{j=1}^{SL^{list}} SL_j^{list}} BS^{least}\right] \quad (20)$$

Where SN^{loads} is the shared percentage of traffic to the SN^{list}

Algorithm: 3 Load sharing based s-BS on/off algorithm

Input set UEs, set of s-BSs, β $Conn\_Net$
Output Act_BSs
initialization $BS^{load} = \emptyset$ $SN^{loads} = \emptyset$ $Dep\_BSs = \emptyset, BS^{least} = \emptyset$ $NB^{list} = \emptyset$
    while Act_BSs=∅ do
for each s-BS i∈ Mdo
if ($S_i^{AN} \equiv 1$ $then$
for each UE j∈∪ do
$BS^{loads} = compute\ the\ traffic\ loads\ of\ the\ s - BS_i\ using\ eqn\ 17$
$Act\_BSs = Act\_BSs\ \cup_s - BS_i$
        end for
    end if
end for
    sort BS^{loads}
    $BS^{least} = identify\ the\ least\ loaded\ s - BS\ from\ the\ BS^{loads}$
    for each s-BS i∈ β do
    perform local search within the coverage area BS^{least}
    if ($S_i^{AN} = 1$) $then$
    $NB^{list} = s - BS_i$
    end if
        end for
    $SN^{list} = sort\ asc\ NB^{list}$
        $SL^{list} = sort\ desc\ NB^{list}$
    $SN^{loads} = share\ the\ traffic\ load\ (BS^{least})to\ the\ SN^{list}$ using equation 18
    if (loads (BS^{least}) $shared\ successfully$) $then$
        State (BS^{least}) $= off$
    update Act_BSs
    Else
    Abort process and recover original $Conn\_Net$
        End if
    End whiles

Simulation Parameter and value;
Table :2

Parameter	Values	
T_X^{BH}	8	
ΔP_p^{BH}	10^5	
ΔP_p^{BH}	0.0631W	
P_o^{BH}	3.9W	
	MBS	**s-BS**
T_X^{AN}	8	8
T_{max}^{AN}	130W	1W
ΔP_p^{AN}	4.7	4
P_o^{AN}	130W	6.8W

3.0 Results

Below is graph of the total annual (AN) power consumption, backhaul power consumption (BH), combine (AN + BH) power consumption of the user equipment and efficiency of the network.

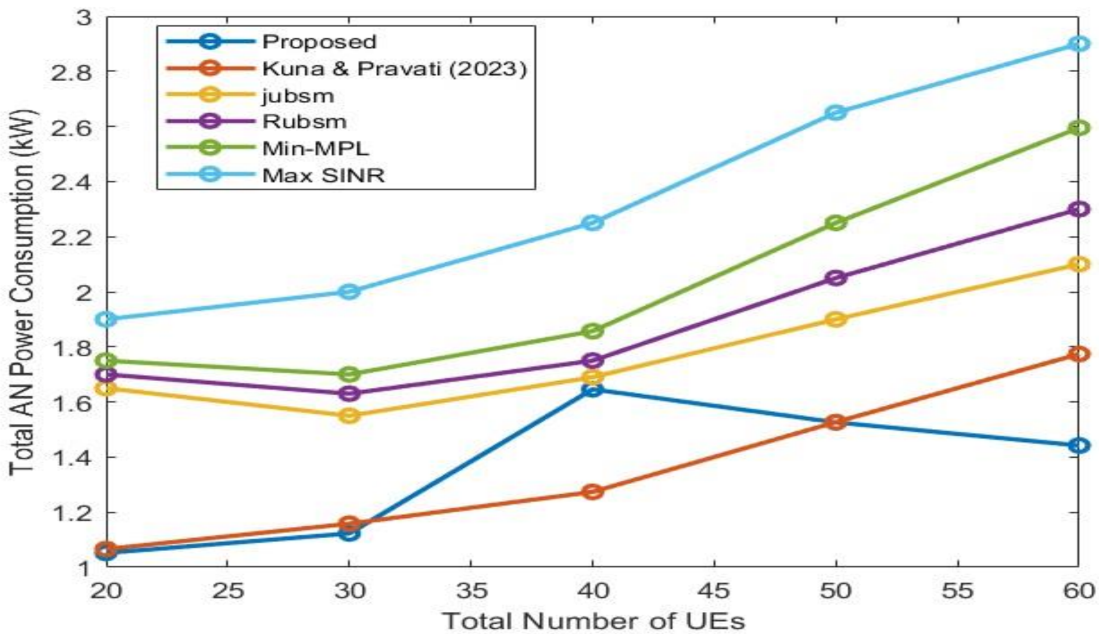


Fig: 2 Total AN power consumption against the number of user equipment

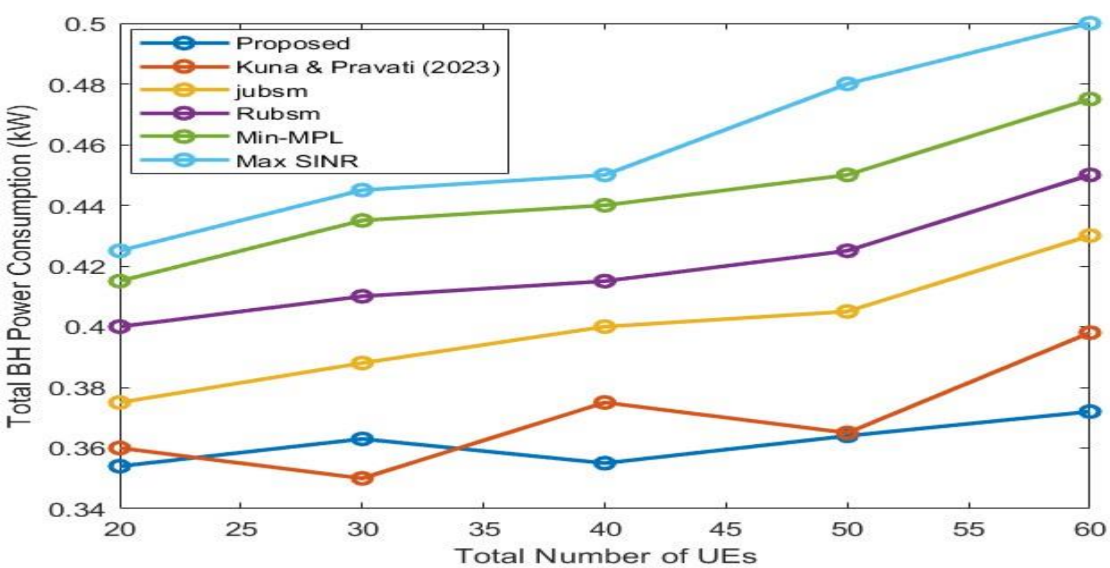


Fig 3. Total Backhaul power consumption vs total number of user equipment

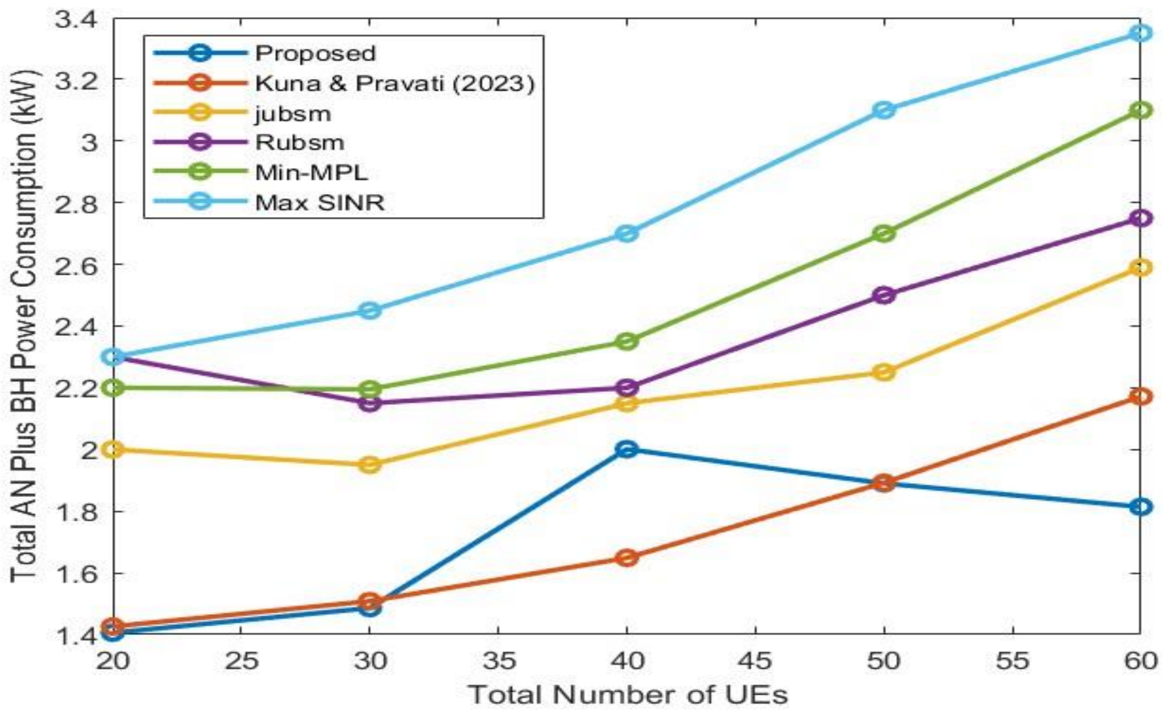


Fig .4

Total access network +Backhaul user power consumption vs number of UEs

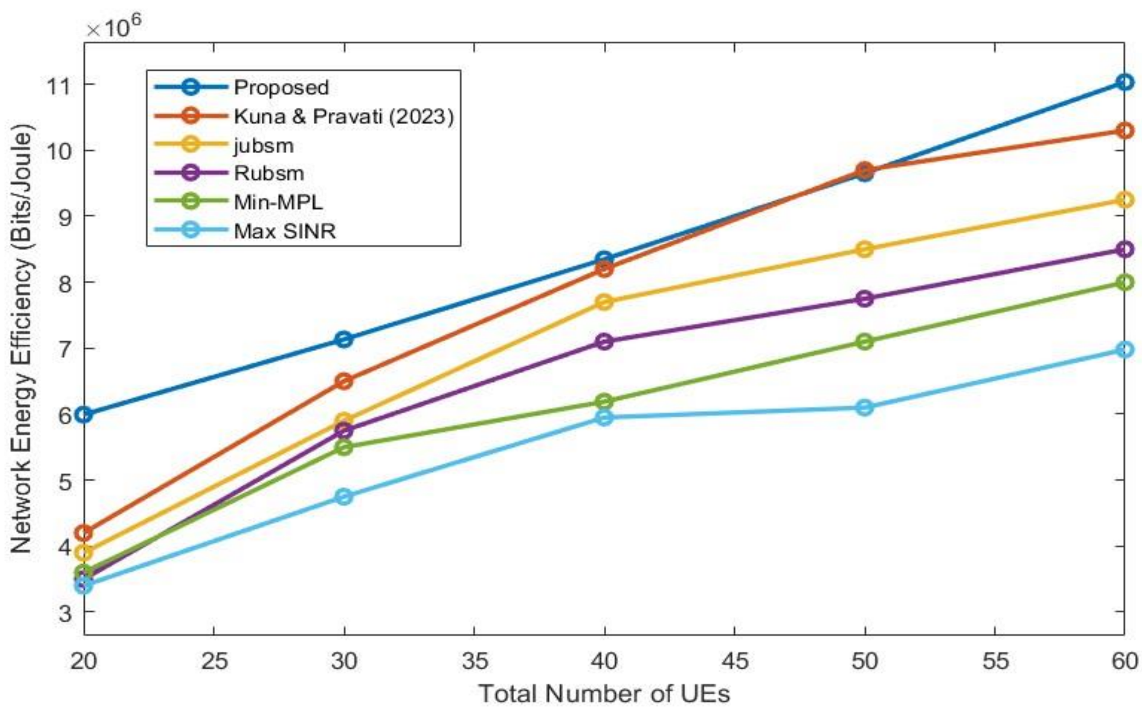


Fig 5 Energy Efficiency vs number of user equipment.

3.1 Results Analysis

The proposed work is simulated for different number of user equipment with the same instant of network scenario and the network performance is evaluated. the total AN power consumption of the network for different number of user equipment is depicted in fig 2. As can be notice the proposed framework uses the least amount of power as compared to Max-SINR Algorithm, the Min-PL Algorithm, the JUBSM algorithm, the RBSM algorithm and the intelligent algorithm even when the number of user equipment UE is increasing.

THE Max SINR Algorithm increases the power consumption by 45% to 51% as compared to the proposed algorithm , while the Min PL Algorithm increases the power consumption from 40% to 44% , RUBSM algorithm increases the power consumption from 36% to 32% and intelligent Algorithm increases the power consumption from 4.5% to 19% as compared to the proposed algorithm , intelligent algorithm the UE is connected to the nearest s-BS towards the MBS by using the heuristic function , the Max-SINR algorithm is the highest power consumption because most of the User equipment are connected to the MBS, while the Min PL algorithm more user equipment are connected to the small base station irrespective of the SINR from the Base station BS, in JUBSM algorithm the user equipment are connected based on required PRBs.

Fig:3 Shows the total Backhaul power consumption of the network for different UEs. For Max SINR algorithm, Min PL algorithm, RUBSM Algorithm, JUBSM Algorithm, intelligent algorithm and the proposed algorithm. The highest BH power consumption is when using the Max SINR due to the fact that more UEs are connected to the MBS and the Min PL algorithm is the second highest because most of the UEs are connected to the s-BS which eventually raises the BH Load on the Network. finally the RUBSM Algorithm , JUBSM Algorithm and the intelligent Algorithm power consumption is higher than the proposed method because more UEs are connected to the nearest Base station (BS) which raises the BH load of the network , the Max SINR Algorithm increases the power consumption at the BH from 16.5% to 25% as compared to the proposed algorithm , Min PL Algorithm increase the power consumption from 15% to 21% as compared to the proposed algorithm , RUBSM Algorithm increase the power consumption of the BH loads from 11% to 17% as compared to the proposed algorithm , JUBSM Algorithm increases the power consumption of the BH link from 5% to 12% as compared to the proposed algorithm intelligent Algorithm increases the power consumption of the backhaul network from 1.4% to 6%. The User association s-BS and the Backhaul route for power utilization of the network, the proposed method BH power consumption is significantly lower as compared with the state-of-the-art algorithm.

While taking into consideration of the total power consumption of the heterogeneous network (HetNets) i.e AN plus BH , as shown in fig 4 , the proposed method has the least power consumption of them all , when the proposed method was compared to Max SINR algorithm the total power consumption was reduced from 39% to 47% , with Min-PL algorithm when compared was reduced from 36% to 45% , while when compared to RUBSM , JUBSM and intelligent Algorithm we have 39% to 43%, 30% to 33% and 3% to 10% respectively.

Fig:5 shows the results for the Energy Efficiency (EE) of the proposed method and the rest of the state of art algorithm. as compared to Max SINR we have 36% to 43%, Min-PL algorithm we have 27% to 40%, RUBSM we have 23% to 43%, JUBSM 15% to 33% and using intelligent algorithm when compared we have 5.5% to 27% respectively.

4.0 Conclusion

From the results obtain shows that the proposed algorithm has the least power consumption of all the state-of-the-art algorithm, and also has a better energy efficiency compared to them.

Reference:

1. Li Y, Gao Z, Huang L, Du X, Guizani M. Resource management for future mobile networks : Architecture and technologies. Comput Networks [Internet]. 2017;129:392–8. Available from: https://doi.org/10.1016/j.comnet.2017.04.007
2. Fourati H, Maaloul R, Chaari L, Jmaiel M. Comprehensive survey on self-organizing cellular network approaches applied to 5G networks. 2021;199(August).
3. Titouna C, Naït-Abdesselam F, Khokhar A. DODS: A Distributed Outlier Detection Scheme for Wireless Sensor Networks. Comput Networks. 2019;161:93–101.
4. Next Generation Mobile Networks Alliance. 5G White Paper. A Deliv by NGMN Alliance [Internet]. 2015;124. Available from: https://www.ngmn.org/fileadmin/ngmn/content/downloads/Technical/2015/NGMN_5G_White_Paper_V1_0.pdf
5. Venkateswararao K, Swain P, Christophorou C, Pitsillides A. Using UE-VBS for dynamic virtual small cells ss and backhauling in 5G Ultra-Dense networks. Comput Networks [Internet]. 2021;189(January):107926. Available from: https://doi.org/10.1016/j.comnet.2021.107926
6. Gulia S, Ahmad A, Singh S, Deep M. Interference management in backhaul constrained 5G HetNets through coordinated multipoint. Comput Electr Eng [Internet]. 2022;100(August 2021):107982. Available from: https://doi.org/10.1016/j.compeleceng.2022.107982
7. Xu J, Dziong Z, Luxin Y, Huang Z, Xu P, Cabani A. Intelligent multi-agent based C-RAN architecture for 5G radio resource management. 2020;180(November 2019).
8. Sigwele T, Fun Y, Susanto M. Energy-efficient 5G cloud RAN with virtual BBU server consolidation and base station sleeping. Comput Networks [Internet]. 2020;177(May):107302. Available from: https://doi.org/10.1016/j.comnet.2020.107302
9. Liu D, Member S, Wang L, Chen Y, Member S, Elkashlan M, et al. User Association in 5G Networks : A Survey and an Outlook. IEEE Commun Surv Tutorials. 2016;18(2):1018–44.
10. Chiu C sheng. An Interference Coordination Scheme for Picocell Range Expansion in Heterogeneous Networks. 2012 IEEE 75th Veh Technol Conf (VTC Spring). 2012;1–6.
11. Chien T Van, Member S, Björnson E, Larsson EG. Joint Power Allocation and User Association Optimization for Massive MIMO Systems. IEEE Trans Wirel Commun. 2020;15(9):6384–99.
12. Ari AAA, Gueroui A, Titouna C, Thiare O, Aliouat Z. Resource allocation scheme for 5G C-RAN: a Swarm Intelligence based approach. Comput Networks [Internet]. 2019;165:106957. Available from: https://doi.org/10.1016/j.comnet.2019.106957

13. Huynh T, Kuroda K, Hasegawa M. User Association for Massive MIMO Cellular Networks with Small Cell Wireless Backhaul. 2016 19th Int Symp Wirel Pers Multimed Commun. 2016;(c):8–13.
14. Xu Y, Member S, Mao S, Member S. User Association in Massive MIMO HetNets. 2015;
15. Gan C hien, Lin Y chun, Yang S neng, Lin Y bing. 2013 Seventh International Conference on Innovative Mobile and Internet Services in Ubiquitous Computing A Seamless Multi-Link Switch Solution for LTE and Wi-Fi Integrated Networks. 2013 Seventh Int Conf Innov Mob Internet Serv Ubiquitous Comput. 2013;19–23.
16. Mao Y, Member S, You C, Member S, Zhang J, Member S, et al. A Survey on Mobile Edge Computing : The. 2017;(c):1–38.
17. Huynh LNT, Pham QV, Pham XQ, Nguyen TDT, Hossain MD, Huh EN. Efficient computation offloading in multi-tier multi-access edge computing systems: A particle swarm optimization approach. Appl Sci. 2020;10(1):1–17.
18. Liu Y, Lu L, Li GY, Cui Q, Member S, Han W. Joint User Association and Spectrum Allocation for Small Cell Networks With Wireless Backhauls. 2016;5(5):496–9.
19. Hao W, Member S, Muta O. Dynamic Small Cell Clustering and Design for Two-Tier Heterogeneous Networks With Massive MIMO. 2018;66(2):675–87.
20. Vu TK, Member S, Bennis M, Member S, Mar NI. Joint Path Selection and Rate Allocation Framework for 5G Self-Backhauled mmWave Networks. :1–16.
21. Mesodiakaki A, Zola E, Santos R, Kassler A. Ad Hoc Networks Optimal user association , backhaul routing and switching off in 5G heterogeneous networks with mesh millimeter wave backhaul links. Ad Hoc Networks [Internet]. 2018;78:99–114. Available from: https://doi.org/10.1016/j.adhoc.2018.05.008
22. Martin-escalona I. A Robust User Association , Backhaul Routing , and Switching Off Model for a 5G Network With Variable Traffic Demands. 2022;8.
23. Venkateswararao K, Swain P, Shekhar S, Ioannou I. A novel power consumption optimization framework in 5G heterogeneous networks. Comput Networks [Internet]. 2023;220(July 2022):109487. Available from: https://doi.org/10.1016/j.comnet.2022.109487
24. Jaber M, Member S, Ali M, Senior I, Tafazolli R, Member S, et al. 5G Backhaul Challenges and Emerging Research Directions : A Survey. IEEE Access. 2016;4:1743–66.
25. Pattan B. Michael Marcus and Bruno Pattan. 2005;(70).
26. Xiong C, Li GY, Zhang S, Chen Y, Xu S, Member S. Energy-Efficient Resource Allocation in OFDMA Networks. 2012;60(12):3767–78.
27. Chen DC, Member S, Quek TQS, Member S. Backhauling in Heterogeneous Cellular Networks : Modeling and Tradeoffs. 2015;14(6):3194–206.