International Journal of Computer Networks and Applications (IJCNA)
DOI: 10.22247/ijcna/2023/218515 Volume 10, Issue 1, January – February (2023)

RESEARCH ARTICLE

Scheduling Framework for Resource Management in IoT Ecosystem Over 5G Network

Gauri S. Rapate
Department of Computer Science and Engineering, P.E.S. University, Bangalore, India.
gauri.rapate@gmail.com

N C Naveen
Department of Computer Science and Engineering, J.S.S. Academy of Technical Education, Bangalore, India.
ncnaveen@gmail.com

Received: 25 December 2022 / Revised: 23 January 2023 / Accepted: 26 January 2023 / Published: 26 February 2023

Abstract – Resource management in the 5G network is one of the critical concerns which is increasingly seeking attention from the research community; however, a review of existing literature showcases very less usage of scheduling and more inclination towards sophisticated approaches of resource management which are practically infeasible to be executed over resource-constrained devices over Internet-of-Things (IoT). Therefore, the proposed scheme presents a unique framework for effective resource management in a 5G network using a unique scheduling approach. The system executes a novel routine management of time slots considering operational time and transition states of IoT nodes to balance the state of active and passive radio mode operation. The simulated outcome of the study shows that the proposed scheme offers approximately 35% of more residual energy, 47% of reduced energy dissipation, 25% of reduced delay, and 43% of faster processing speed in contrast to existing scheduling schemes in the IoT environment.

Index Terms – 5G, Resource Management, Scheduling, Radio Mode, Network, IoT.

1. INTRODUCTION

Resource management is related to the radio and is associated with managing various radio resources along with controlling of co-channel interference as well as characteristic of radio transmission over any form of a wireless communication system [1]. A network communication channel usually depends on various resources catering to computational or communication demands [1]. However, owing to the dynamic forms of services of networks, such resource management task is becoming quite challenging with every evolving form of network applications and services. With the evolution of next-generation networks like 5G, there are certain levels of sophistication associated with resource management [2]. The importance of the allocation of radio resources is quite high with the progressive development of Multiple-Input Multiple-Output (M.I.M.O.) is 5G [3]. It has been noted that Cognitive Radio Network (C.R.N.) assists the user equipment in enhancing its spectrum quality by dynamically accessing the licensed channel [4]. However, there still exists a level of interference for both primary and secondary users. Apart from this, the spectrum-sharing concept in 5G is also associated with the fairness problem.

At present, 5G claims standard architectures of F-RAN and C-RAN for facilitating better resource management [5]. Studies show that C-RAN and its related bandwidth in fronthaul are still characterized by bottlenecks during data forwarding in 5G [6]. Hence, allocating precise resources toward remote radio heads and baseband unit is still an impending challenge in C-RAN in 5G [7]. Currently, the mechanism for managing radio resources is categorized in two forms, i.e., application and infrastructure. Various energy resources, storage, networking, and computational aspects form resource management of infrastructure based in 5G specifically designed to support the Internet-of-Things (IoT) environment [8]. It is to be noted that all these resources are quite sparse and drain faster with increasing demands of data transmission or service processing. With increased network size, e.g., IoT, ensuring consistency in the resource management operation is challenging.

Different nodes in IoT have different demands of resources, and when they are further exposed to utilized 5G networks, the draining of energy increases at a higher rate [8]. It will eventually mean that the successful implementation of an IoT greatly depends upon dedicated connection, among various things. Currently, there are no standards associated with the protocols or devices towards stating the core issues of compatibility while attempting to implement IoT. Scheduling is one of the unique approaches toward effective resource management. This is only feasible when all the services offered and the dynamic demands of users/applications are known in advance. However, this is not practically feasible to ascertain the demands of clients to schedule the resources effectively—the resource scheduling targets controlling the cost of network operation with an assigned restricted resource.

RESEARCH ARTICLE

From the perspective of an IoT, the prime aim of scheduling is to increase the throughput and utilization of the computational resources along with the reduction of consumption of power and latency [9]. Usually, highly iterative tasks are executed within an IoT device, leading to a declination in network lifespan and increasing management costs of IoT nodes. Irrespective of various scheduling approaches in the existing system, studies have been less associated with 5G network standards [10].

Therefore, the proposed scheme introduces analytical modeling that can optimize the routing performance in IoT, considering an active transmission model in IoT.

The prime objectives/contributions of the proposed system are:

i) Introduces a computational framework executed over a gateway node to perform scheduling resources in IoT.

ii) We constructed a novel carrier message with specific fields to support proper routine management of time slot-based scheduling.

iii) Introduces a simplified routing mechanism that can offer an equal emphasis towards both prioritized and normal data delivery services in IoT.

iv) It has developed simplified energy expressions that can compute the energy and fine-tune the transmitted energy based on ongoing transmissions in IoT.

The paper's organization is as follows: Section 2 discusses existing research work, while section 3 outlines the research problem. A discussion of the research methodology is carried out in Section 4. In contrast, algorithm discussion is carried out in Section 5. Section 6 discusses result outcomes, while the conclusion is discussed in Section 7.

2. RELATED STUDIES

Various studies are being carried out to improve communication performance in IoT environments. As the proposed study has introduced a scheduling mechanism as a media to improve the routing performance, this part of the study will explore the degree of contribution in research work towards improving routing and contribution of scheduling.

The work carried out by Jiang et al. [11] has developed a mechanism where routing and scheduling have been implemented together to retain the highest degree of harvested energy in IoT. According to the implementation, the scheduling of links and routes is carried out over a backhaul network. In the primary tier of the network, the study model uses communication via routers, while the second tier performs energy harvesting of radio frequencies. The scheduling uses Time Division Multiple Access (T.D.M.A.) with the shortest value, while linear programming is utilized to extract the solution. The work carried out by Han et al. [12] has designed a unique routing scheme considering the use case of the underwater acoustic network. A layering-based routing technique is implemented to leverage energy efficiency and connectivity of the network for effective routing. The work carried out by Selem et al. [13] has constructed a framework for energy efficiency for healthcare-related applications in IoT. The core idea of this protocol is to mitigate the seamless communication for wireless body sensors. The study model implements a unique handover approach to retain seamless connectivity among the coordinator nodes. The processes reduce packet redundancy, leading to a minimal packet drop rate. A mechanism for incorporating intelligence within the routing process of IoT is discussed by Kaur et al. [14]. The presented mechanism utilizes a reinforcement learning scheme incorporated within the routing strategy to enhance sensor node energy life span and reduce delay. Another uniqueness of this study is the formulation of an unequal number of clusters based on traffic load. Zhu et al. [15] have presented a collaborative node to facilitate better interconnectivity among the nodes in industrial IoT. The Author has investigated the possible effect of conventional Media Access Control (M.A.C.) scheme over a single-hop network followed by performing forwarding strategy formulation. Yang et al. [16] have presented a routing scheme that is energy efficient which is designed based on conventional R.P.L. protocol in IoT. The presented model supports large-scale network transmission based on a peer-to-peer network to optimize network performance.

Ghosh et al. [17] have implemented a unique framework for performing cognitive routing in adherence to the automation standard of Industry 5.0. The unique part of this implementation is that it supports routing performance associated with 6G networks using its capability of self-learning feature. The outcome is witnessed with reliable path generation with reduced delay. Khan et al. [18] have formulated a unique mechanism using a nature-inspired routing algorithm. Considering the use-case of flying ad-hoc network, the scheme uses AntHocNet, based on the Ant Colony Optimization scheme. The scheme facilitates energy-efficient routing with better network performance. The existing system has also developed routing schemes toward addressing the congestion problem in W.S.N., as noted in the work of Chanak and Banerjee [19]. The working model presents a scheduling approach based on a priority queue to offer reliable data transmission over healthcare applications in IoT. Narayanan and Murthy [20] have addressed the overhead problem while performing protocol conversion in the routing process. The study further contributes to formulating a graph model for developing a data transmission scheme with the least overhead.

Patel et al. [21] have conducted a study where a routing protocol is designed to ensure collision and energy-efficient

RESEARCH ARTICLE

operation reduction. The work has revised the conventional on-demand routing scheme by adding a cross-layer approach where the hop count metric substitutes link quality. M.A.C. layer and physical layer were used to extract information about the collision and link quality to make the system work with new intelligence for better routing operation. Li et al. [22] have used a blockchain-based approach to carry out routing operations in IoT. The scheme uses a reinforcement learning algorithm for learning the routing policy while optimization of the proximal policy is carried out to solve the dynamic routing problem. The unnecessary network parameters are further pruned adaptively to optimize the solution. Mahyoub et al. [23] have implemented a scheme to improve the performance of conventional R.P.L. protocol in IoT. The presented study model is implemented over Contiki and studied over simulation in Cooja. According to the study outcome, the approach offers backward compatibility. Vaezian and Darmani [24] study a similar work structure toward enhancing the R.P.L. protocol. Tsai et al. adopt R.P.L. protocols to assist data transmission for emergency applications [25]. Mohammadsalehi et al. [26] have also used the R.P.L. protocol to develop a distinct routing scheme with an awareness of mobility and reliability. Chithaluru et al. [27] have implemented a scheduling-based scheme using fuzzy logic to develop a routing protocol in IoT. According to this scheme, ranking order is incorporated using threshold energy towards evolving out of a better routing strategy. Ekler et al. [28] have presented a multi-hop routing scheme to accomplish a better IoT node lifespan. Xu et al. [29] have used an S.D.N.-based framework to optimize the routing performance in IoT. The study model has also considered constraints related to capacity while mixed integer linear programming is used to formulate the problem. Adoption of S.D.N. is also witnessed in Ding et al. [30], where a dynamic routing scheme has been discussed to select Further, the Markov chain is used for computing the probability of state transition that facilitates the investigation of temporal features of W.S.N. with S.D.N.

Hence, there are various schemes in existing approaches where the idea of improving the routing performance has been stated from the perspective of W.S.N. The next section highlights the identified research problem associated with existing methodologies toward routing improvement.

3. RESEARCH PROBLEM

After reviewing the existing approaches from the prior section, it is seen that certain significant achievements and limitations characterize existing approaches. The identified limitation is briefed in this section in the form of a research problem as follows:

- Fewer inclinations towards optimization formulation:

To carry out modeling, it is essential to look at the practicality of the complete methodology apart from the improved outcomes. Studies carried out by [25][26][27] have presented an enhanced version of existing schemes; however, such implementation cost is quite higher irrespective of the betterment in its outcome. A routing performance, to be optimized, need dual parallel focus viz. improving routing performance and inclusion of less sophisticated operations to be carried out by resource-restricted IoT devices. None of the existing schemes are found reported to deal with this problem.

- Impractical Scheduling approach:

A practical scheduling approach will lead to some segments of IoT nodes going into passive mode while some nodes will continue to be in radioactive mode. Existing scheduling practices noted in [11][19] are more prone to specific resources or specific problems which are not viable for large-scale network operations in IoT. Apart from that, none of the existing schemes have reported the allocation of resources in case of emergencies for rendering the transition of states of scheduled IoT nodes. Scheduling IoT nodes in existing systems can support some non-emergency-based applications with static behavior. They are not meant for handling emergency applications over large and dynamic networks in IoT.

- Less Emphasis on Cost-effective Computing:

There is no denying the fact that existing approaches have used some of the contributory technology, e.g., learning algorithm [14], usage of S.D.N. [29][30], usage of conventional R.P.L. protocols [25][26][27], nature-inspired algorithm [18], etc. However, these approaches have not been assessed concerning cost-effective computational models irrespective of the accomplished target outcome of routing performance. To ensure the practicality of the stated model, it is necessary to showcase cost-effective computational performance too, which is not much reported in existing cases.

- Lesser Applicability towards IoT:

W.S.N. is an integral part of IoT but doesn't formulate the entire IoT system. A closer look into existing approaches [13][14][23] has carried out the development considering sensor nodes but doesn't consider gateway nodes, edge servers, and various other essential components which play a crucial role in IoT systems. Apart from this, there is not much evidence for formulating a mechanism that could formalize the effectiveness of the existing scheme toward a complete IoT environment. This limitation is required to be addressed in order and assess routing performance in the IoT ecosystem.

4. PROPOSED CONTRIBUTION

The prime motive of the proposed scheme is to design and develop a computational framework that can optimize the routing performance in IoT—adopting an analytical research

RESEARCH ARTICLE

methodology, the proposed scheme targets optimizing the energy efficiency among the IoT devices. Before understanding the proposed architecture deployed, it is essential to understand the actual deployment scenario from the perspective of an IoT environment. The proposed methodology's core contribution is offering a layered-based operation toward performing distinct radio scheduling in IoT.

Another significant contribution is deploying a unique message field to facilitate properly syncing the control message toward performing energy-efficient scheduling. Apart from this, cost-effectiveness is another contribution of the study model. The deployment scenario exhibited in Figure 1 shows a sample of 4 different groups of communication in Layer-1 that is meant for data acquisition in IoT. The IoT devices collect the data and can communicate among themselves; however, they will need to explore the routes using access points for cross-group communication. Each access point is further connected with the gateway node, which performs translational services toward routing. The execution of the proposed algorithm is carried out within this gateway.

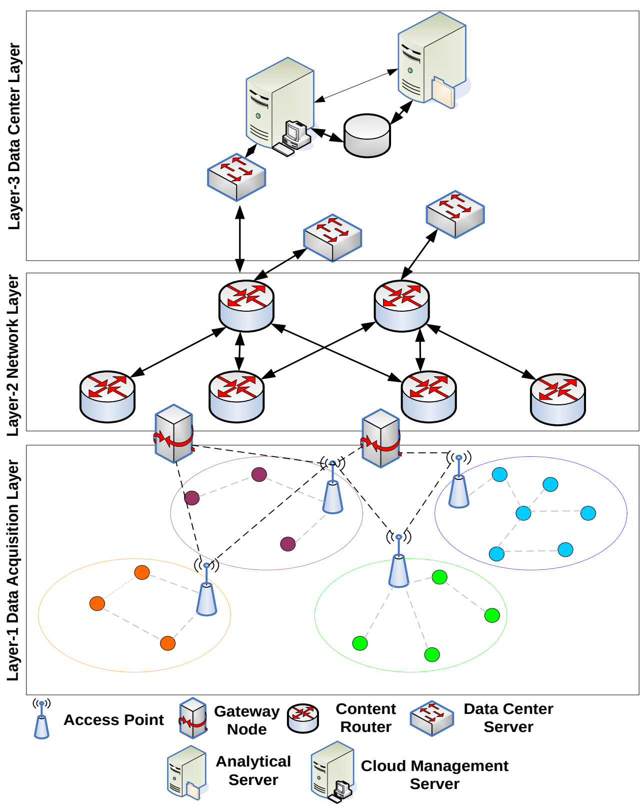

Figure 1 Deployment Scenario of IoT in the Proposed Scheme

The gateway nodes are further connected to the content server in the second layer associated with a network layer that is finally connected to the data center server in the above layer. The data center server is further connected to the cloud management and analytical servers. The proposed scheme's prime concept is to consider a unique time slot to retain a proper equilibrium between the usual data transmission in IoT and prioritized message communication evaluated over peak traffic conditions. The architecture of the proposed scheme is exhibited as follows in Figure 2.

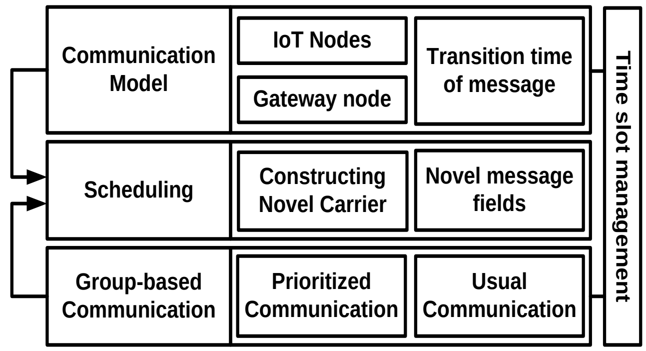

Figure 2 Architecture for Scheduling

According to the proposed architecture, the operation is classified into three prime stages, and all these stages perform a sequential and integrated operation. Following is the briefing of the operations associated with individual blocks:

- Communication Model Block: This is the first block of operation executed in Layer-1 for data acquisition. This layer consists of various IoT nodes spread wide across the transmission region. The study assumes that each node can communicate with others, provided they have similar physical and network characteristics. The prime task of these IoT nodes is to acquire data and forward it to either the next IoT node (in case of multi-hop) or forward it directly to the access point (in case of single-hop). The gateway node also characterizes this layer, essentially meant to perform translation services.

- Further, this block also performs all the assessments based on the transition time of the message (or beacon) owing to the proposed scheduling approach. The transition time refers to the duration at which a node in one state transit to another. Usually, normal communication occurs in an active state of radio of an IoT device. However, the passive state also undergoes an idle listening mode without transmitting any data or content. The study considers transition time as an emergency communication in a dynamic system that could be triggered during the state change of the node. It is essential to conduct an analysis to explore the possible impact on data transmission performance and resource management.

- Scheduling Block: The proposed scheme performs the communication where IoT device is configured to use a specific carrier message with unique fields. Including this

RESEARCH ARTICLE

carrier, fields are the prime novelty of the proposed scheme, which controls the mechanism for scheduling data transmission. Based on this transfer, the proposed scheme also facilitates a simplified mathematical computation that can adjust energy consumption. The blocks for the field are designed based on assigned time slots for the active and passive duration.

- Group-based Communication Block: This block operation also introduces a novel feature in a proposed scheme where the IoT devices are equipped with making data transmission based on the normal and prioritized communication channel. The user application controls the level of priority. The proposed scheme also uses a threshold for holding up the queue for incoming traffic flow. When the incoming traffic flow to the IoT node and its waiting/travel time exceeds the threshold, it is assigned a priority level by the system. The priority level is set as urgent, moderate, and normal. For the user-defined message, the message set with urgent priority is always given the highest priority towards reaching the destination in the shortest time. However, without the user set priority level, if the waiting time is more than 50%, the message is set to higher priority; if the waiting time is between 40-50%, it is set to be a moderate priority. Otherwise, it is a usual message for less than 40% waiting time. It should be noted that these values are assigned based on the test being carried out over dense and large IoT networks with 600-1000 IoT nodes being deployed. This value may differ based on the size and density of IoT nodes present in the network.

Before discussing the carrier message, it is to be noted that the proposed scheme considers sensory application to represent the IoT device characterized by minimal computational capabilities and restricted resources. Hence, the novel beacon is constructed to address scheduling and resource management demands while performing routing. The proposed scheme offers a specific representation of the carrier, as depicted in Figure 2.

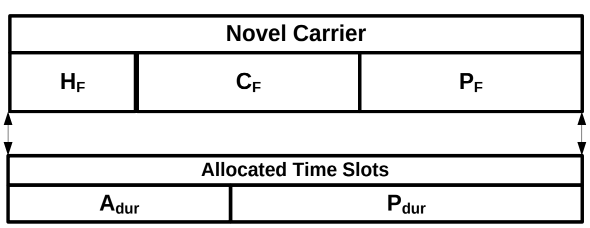

Figure 3 Construction of Novel Carrier

Figure 3 represents the novel carrier's design and allocated time slots. The core fields of the novel carrier are header field $H_{.F.}$, content field $C_{.F.}$, and priority field $P_{.F}$. The complete carrier is further classified concerning allocated time slots of active duration A_{dur} and passive duration P_{dur}. The active duration A_{dur} and passive duration P_{dur} are allocated with arbitrary and scheduled access, respectively.

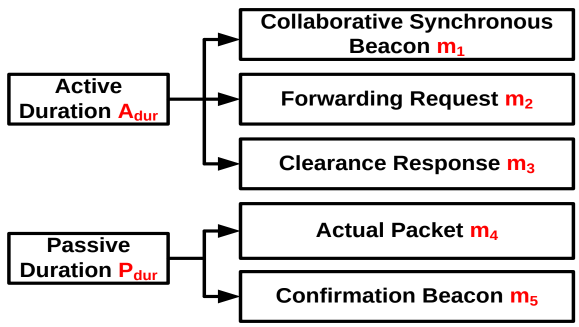

Figure 4 Allocation of Sub-Fields in a Carrier

Figure 4 highlights five different allocation forms in respective time slot fields. While performing arbitrary access in A_{dur}, there are three types of allocations, i.e., i) collaborative synchronous beacon m_1, which performs syncing operation with the different devices in IoT before and after performing routing, thereby assisting in updated routing information, ii) forwarding request m_2 that is responsible for forwarding a request message from transmitting IoT node for participating in data forwarding process, and iii) clearance response m_3 is the response message for m_2. On the other hand, while performing scheduled access in P_{dur}, there are two types of allocation, i.e., i) actual content m_4, which is the actual data to be forwarded, and ii) confirmation beacon m_5 that is responsible for forwarding a confirmation message from the recipient IoT device to the transmitting IoT device.

All the IoT nodes with similar schedules formulate a group while a hierarchy of IoT nodes with single hop connection. A similar configuration is used for formulating multi-hop connections too. The system also allocated a discreet index number to all the IoT nodes so that nodes with multi-hop connections will bear a unique index number. The scheme also introduces an operational time for an IoT node which represents the exact duration when the IoT node is busy processing data/messages. The selection of operational time is carried out so that the time slot with Pdur should be higher to forward an actual content m4 and confirmation beacon m4 sufficiently.

It should be noted that the proposed scheme renders all IoT nodes to consider any time slot to carry out transmission; however, the field $P_{.F.}$ is used only for the prioritized transmission. The IoT nodes configure Adur and Pdur time based on operational time. Apart from this, the proposed scheme also performs an exchange of state information among the communicating IoT nodes.

According to the proposed scheme, the IoT nodes will undergo a state of P_{dur} and save their energy, and then based on operational time; they will transit to a state of A_{dur}. The

RESEARCH ARTICLE

IoT nodes follow a similar schedule and belong to the same communication group in the proposed scheme. The moment the IoT node transit towards the state of P_{dur}, it will assess if it still has any actual content m4 to be forwarded or if there is a priority set to m_4. In the case of prioritized data indexed by $P_{.F.}$, the IoT device extends its schedule to forward the priority message. Otherwise, it confirms its transition towards the state of P_{dur}. Another interesting contribution of the proposed scheme is that it can perform concurrent transmission of data to each other as there is a separate hop table maintained for the adjacent nodes, which makes the routing task easier. Hence, higher throughput is expected. It is to be noted that forwarding request m_2 bears the information about the link of both transmitting and receiving IoT nodes. It reduces the quantity of the candidate IoT nodes for expecting the access towards the communication system will be of reduced dependency so that it can cater to the concurrent transmission. For this purpose, it is necessary to alter the allocation vector of a communication network in the IoT use case, which is meant to resist collision. The proposed system also offers a novelty where the IoT node will not be blocked by the time for the vector of communication channel when it receives the overheard information from other IoT nodes. Rather, the proposed scheme will analyze all the feasibility of performing concurrent transmission before blocking IoT nodes; however, if there is the presence of certain IoT nodes which have been queued for a longer duration exceeding the threshold time limit (the user can set that) than these slots will be automatically set to priority slot. To let other nodes know about the priority slot, the IoT nodes forward separately an advertisement message bearing information on the total number of such slots. When sensed by neighboring IoT devices, this information checks their buffer and synchronization of slots with other nodes and fine-tunes the individual slots automatically. Hence, over a long number of links, this process progressively updates link information, which assists in faster routing performance.

Another significant contribution of the proposed scheme is that it can fine-tune the power required during the operation of IoT nodes with an agenda to offer significant control over energy consumption. Hence, a simplified mathematical expression is formed for this purpose as follows:

$$E_{anti} = \Delta E . A_1 \tag{1}$$

In the above mathematical expression (1), the variable E_{anti} will represent the anticipated energy required to be computed while performing the transmission among IoT devices. The existing scheme doesn't allocate a static energy value that could be either over-utilized or under-utilized, owing to the fluctuating data transmission over a dynamic IoT network. Further, the second variable ΔEwill represent the ratio of maximum energy to the obtained level of energy. The third variable, $A_{1,}$ will represent the product of the signal's minimally required strength and network coefficient. It should be noted that the proposed scheme transmits forward request message m2 and clearance response message m3 with the highest possible energy E_{max}. Upon receiving m_2, the receiving IoT nodes provide an m_3 message at the same E_{max}. Upon receiving an m_3 message, the transmitting IoT nodes compute E_{anti} on obtained energy level, i.e., E_{rec}. Therefore,

$$\Delta E = \frac{E_{max}}{E_{rec}} \tag{2}$$

Hence, based on mathematical expressions (1) and (2), it can be stated that E_{anti} energy is utilized by the transmitting IoT node to perform data propagation. On the other hand, the signal energy is utilized by the receiving IoT node to obtain the m2 message, which is further utilized for computing the energy level to be adopted for computing E_{anti}. The study model also considers that the level of any artifacts (scattering, fading, interference, noise, etc.) are retained below a specific cut-off score. The algorithmic implementation in the next section further illustrates the energy computation discussion.

The consecutive section discusses the algorithms implemented to implicate the research mentioned above methodology.

5. ALGORITHM DESCRIPTION

The prior section has discussed the methodology for developing the proposed scheme where scheduling has been used to optimize the routing performance in IoT. In this regard, the proposed scheme contributes towards two essential algorithms associated with routing and optimization of the scheduled routing. An elaborated discussion of these algorithms are as discussed with respect to their operational steps and the consequences that they introduce towards meeting the study objectives of proposed scheme.

5.1. Algorithm for Routing

In the IoT environment, all the IoT nodes are dispersed in the communication zone while connected via the gateway node. Considering the presence of a heterogeneous form of IoT devices forming a discrete group of communication in a smart city, all the IoT devices of one group communicate with the IoT device of another group using a specific form of routing. This routing scheme is executed via a gateway node. The algorithmic steps are as follows:

Input: N, G.N.

Output: c

Start

1. For i=1: N

2. d=f_1[(x, y) (GN_x, GN_y)]

3. If d<R

4. c_m(i, N+1)=1

5. c_m(N+1, i)=1

6. End

7. (c, p)=f_2(c_m, xy, *i*, N+1)

8. End

End

Algorithm 1 Algorithm for Routing

The discussion of lines of algorithm-1 are as follows: The algorithm-1 takes the input of *N* (no. of IoT device) and *G.N.* (gateway node), which after execution yields an outcome of *c* (cost of the path). The execution of algorithm-1 begins by considering all the IoT nodes *N* (Line-1) followed by computing the distance between the target node position (x, y) and the gateway node position (GN_x, GN_y). A discrete function f_1(x) is used to compute Euclidean distance *d* between these two positions (Line-2). The outcome of this distance *d* is then compared with transmission radius R within each micro-cell of the IoT device (Line-3). Suppose the distance d is less than R. It will mean that the IoT device is within the communication range and can transmit data with its nearest IoT device on the same communication radius, *R*.

The next assessment line calls for analyzing a connectivity matrix c_m (Line-4). The formulation of c_m is as follows: i) the pairwise distance between two IoT devices (or one IoT device and gateway node) is computed, ii) construct a distance matrix in squared form, iii) in the final step, only the distance matrix whose value is found lesser or equal to *R* is considered as connectivity matrix c_m. Algorithm-1 checks for the first IoT device *i* and counts until the last IoT device (N+1) and allocates the connectivity matrix as 1 in both directions (Line-4/5). However, if the distance is not found within a range, the allocation of this connectivity matrix is done by 0. Algorithm-1 further applies Dijkstra's algorithm in function f_2(x) considering input arguments of connectivity matrix c_m, matrix *xy* storing all possible distances among all IoT devices to gateway nodes and all IoT devices. The outcome of this function yields the cost of path *c* and routes *p* (Line-7). The outcome of c is important as it directly indicates reduced cost values associated with the reduced number of routes *p*. This accomplishes the primary task of routing among all the IoT devices with the gateway node.

5.2. Algorithm for Scheduled Optimized Routing

This algorithm-2 continues the prior algorithm after the routing is facilitated. Once the IoT device is positioned to capture the data and forward it to the next IoT device or gateway node, the next line of operation is towards carrying out scheduled optimized routing. The algorithmic steps are as follows:

Input: N (No. of IoT Device), pL (packet length)

Output: E (Computed Energy)

Start

1. For i=1:N

2. E_{tx}(i)=f_3(d_1, pL)

3. End

4. For N_i=1: N_s

5. T_i=T_f(:, N_i)

6. For j=1: N_g

7. $Data_{id}$=Ti(C_{idx})

8. For *k*=1: length(b_p)

9. B(C_{id}(b_p))=B(c_{id}(b_p(k)))+MS

10. End

11. E=f_4(E)

12. End

13. End

End

Algorithm 2 Algorithm for Scheduled Optimized Routing

The discussion of the algorithmic steps are as follows: The algorithm-2 considers all the IoT devices *N* (Line-1) followed by computation of fine-tuned transmit power E_{tx} using a unique function f_3(x) which takes two input arguments, i.e., i) distance d1 which is Euclidean distance between target node position and next hop distance, ii) packet length. The next part of this algorithm-2 implementation evaluates all the assigned slots of time, i.e., N_s (Line-4). The algorithm-2 obtains the transition index T_i from the transition flag matric T_f for all the considered number of IoT devices N_i (Line-5). The mechanism to obtain T_f is as follows: i) initially, a matrix for the transition state is constructed with the size equivalent to a specific number of rows (equivalent to N) and a specific number of columns (equivalent to N_s), ii) for all the N IoT nodes, an arbitrary index is assigned to provide the beacon of the transition state for all IoT nodes, iii) transition flag T_f is obtained by construction a two-dimensional matrix with several slots N_s assigned to arbitrary generated index in prior step (ii). The next part of algorithm-2 considers a group of IoT devices N_g (Line-6), followed by a check for the new arrival of data by assessing the index of group C_{idx} over the respective transition index T_i (Line-7). This operation generates a new identity of a data $Data_{id}$ (Line-7). The next round of operation of proposed algorithm-2 is related to processing data based on its priority. For this purpose, the field of beacon priority b_p is assessed for all the arrived data

RESEARCH ARTICLE

counter k (Line-8). A matrix of buffer B is constructed concerning group identity C_{idx} and size of beacon *M.S.* (Line-9). The contributory step of this part of algorithm 2 is that the proposed scheme facilitates the adjustment of buffer size to stream traffic flow based on priority. The next part of the implementation is associated with fine-tuning the energy E using a discrete function f_4(x), as shown in Line 11. The formulation of the function f_4(x) is as follows:

$$E=Q_1+Q_2+Q_3+Q_4 \quad (3)$$

In the above expression (3), the variable Q_1 represents the $Q_1=w_1+w_2$, where w_1 is a product of the cardinality of scheduled transmission for broadcasting and the mean of receiving energy concerning conformity message m_5. In contrast, w_2 represents the product of the cardinality of the scheduled link and the mean of receiving energy concerning conformity message m_5. The variable Q_2 represents $Q_2=w_3+w_4$, where w_3 represents the product of cardinality of received scheduled broadcasting and associated energy concerning allocated data and conformity message m5. In contrast, variable w_4 represents the product of the cardinality of the received scheduled link and associated receiving energy. The variable Q_3 represents $Q_3=w_5+w_6$, where w_5 represents the product of the overhead of the beacon and its associated energy consumed (this is assigned during simulation).

In contrast, w_6 represents the product of time for idle listening with associated assigned energy. The final variable, Q_4, represents $Q_4=w_7+w_8$, where w_7 represents the product of time for the IoT node to become passive and consume energy during that passive mode. In contrast, w_8 represents the product of time for the transition of state and associated energy consumed during that transition process. Finally, the fine-tuned energy is obtained by this algorithm-2 which, unlike any existing approach in IoT, adjusts the energy parameters to ensure enough resource efficiency is maintained. This completes the algorithmic operational steps. The next section discusses the outcome accomplished.

6. RESULT ANALYSIS

The logic presented in the proposed system is implemented using M.A.T.L.A.B. over normal windows machine 64-bit. To assess the proposed scheme, an environment of an IoT is constructed with IoT nodes, edge servers, gateway nodes, access point, and storage servers. A specific time slot of 100s is given for the novel subcarrier that is further split for the active and passive duration. The target is to balance the state of active and passive duration so that communication performance doesn't get affected. One of the essential parts of assessing the proposed scheme is benchmarking by comparing it with some existing standard systems. In this direction, the nearest routing scheme is the R.P.L. protocol in IoT, which offers higher throughput and low-power data transmission. However, there is evidence to showcase that the R.P.L. protocol also features various shortcomings, e.g., load balancing, path selection, energy, ranking, mobility, and network traffic [31]. The simulation parameters are exhibited in Table 1.

Table 1 Simulation Parameters

Parameter	Values
No. of IoT device	600-1000
Transmission radius	10m
Simulation area	1000x1000m2
Operational Time	0.15s
Channel Capacity	15 kbps
Data size	15 bytes
Transmit Power	36x106 joules per second
Receive Power	15x106 joules per second
Iteration	1000

Apart from this, the R.P.L. protocol doesn't have the inherent scheduling characteristic, rendering it inapplicable for comparative analysis with the proposed scheduling approach. A closer look into the scheduling operation carried out in the proposed scheme shows a slight similarity with the M.A.C.-based scheduling approach. Search in this direction has led to exploring a significant contributory work carried out by Khalifa [32] and Zeb et al. [33]. The prime reason for selecting these two works are as follows:

- Exist1 [32]: The work carried out by Khalifa et al. [32] have further introduced a dynamic M.A.C. system specially built for IoT system. The model uses machine learning to construct better network condition while the study outcome proved to offer better energy conservation and scalability. Hence, a smart scheduling approach is presented in this work, making it ideal for carrying out comparative analysis.
- Exist2 [33]: The work of Zeb et al. [33] has presented an enhanced M.A.C. scheme that emphasizes successful message transmission using the handover approaches. The study outcome of this scheduling scheme has proven to offer better response time and enhanced delivery performance. The authors have handled a similar problem in the proposed scheme and solved it using a scheduling approach.

The implementation of both above schemes has been carried out in two different test scenarios, and it is required to ensure that both proposed and existing schemes should be assessed over similar test-bed. For this purpose, a slight refinement is carried out in existing schemes concerning simulation

RESEARCH ARTICLE

parameters to ensure that reliable benchmarking can be stated.

6.1. Analysis of Energy

Energy is the primary performance parameter for assessing the scheduling approach presented by the proposed and existing scheme. The proposed scheme Prop offers a discrete process to compute total energy followed by fine-tuning it. However, this parameter doesn't exist in both the existing scheme. Hence, to retain uniformity, the analysis is carried out standard energy model for IoT devices [34] in both the proposed and existing system. The analysis is carried out considering the test parameter for the transition time of the message in the x-axis. In each transition time over the simulation area of IoT, randomized data is allocated for transmission with arbitrarily selected prioritized data to be forwarded. The outcome is exhibited in Figure 5.

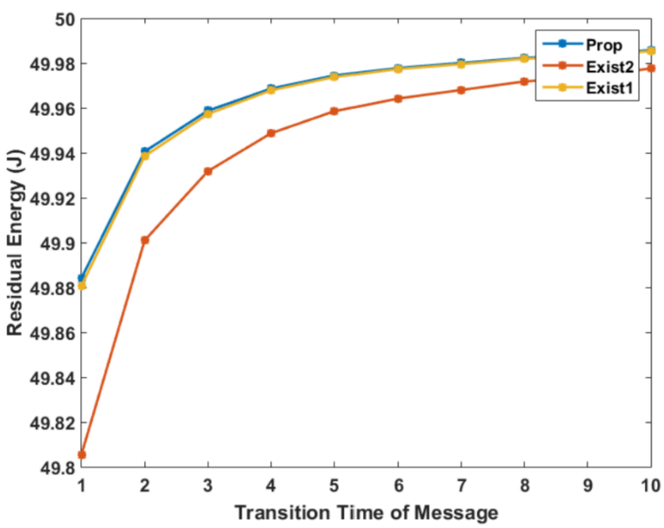

Figure 5 Comparative Analysis for Residual Energy

The outcome in Figure 5 showcases that the proposed scheme Prop exhibits better conservation of residual energy than Exist2[33]; however, the residual energy score is nearly equivalent to Exist1[32]. A similar trend can also be observed in Figure 5 associated with dissipated energy.

The prime reason behind the unique outcome pattern exhibited in Figure 5 and Figure 6 are as follows: The approach of Exist1[32] uses historical data to formulate a better network condition using a machine learning approach. However, this approach may be suitable for a static network whose network history may be quite predictable. Still, they do not apply to a dynamic network with unknown or error-prone network history.

Hence, the outcome for Exist1[32], although it offers better energy conservation in residual and dissipated energy, cannot be wholly considered a reliable outcome. On the other hand, the outcome exhibited by Exist2[33] is completely based on clustering operation-based scheduling in IoT. The role played by the IoT nodes in this method are cluster head node, border node, and cluster member node. These three nodes have different energy requirements to carry out their individual task. A closer look into the implementation technique of Exist2[33] showcase that their exchange of SYNC packets is highly iterative, with no connectivity with the adjacent nodes. It is just based on the time window. Hence, when the traffic starts fluctuating in increasing transition time of the message, Exist2[33] starts exhibiting higher energy depletion. Still, it can be considered reliable compared to Exist1[32]. The proposed scheme offers a dynamic scheduling practice where the energy can be fine-tuned considering multiple network parameters (as discussed in the second algorithm). This results in significant control over energy consumption and offers highly on-demand energy-efficient scheduling practices. The passiveness duration of the nodes is balanced well with active duration in this process resulting in better energy efficiency for resource-constrained IoT nodes.

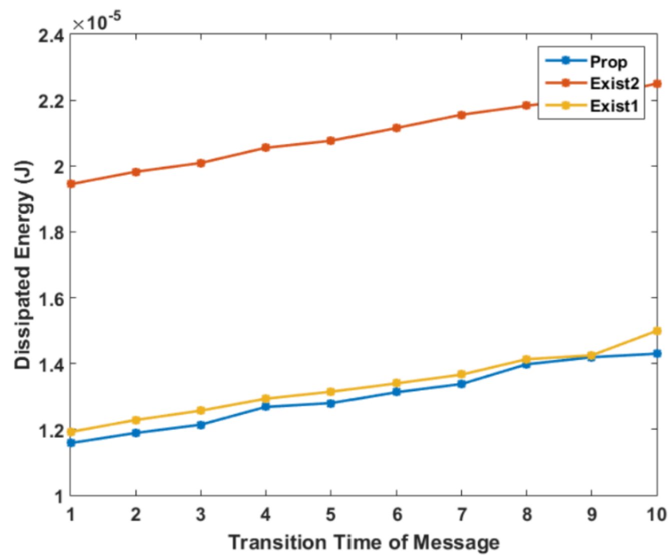

Figure 6 Comparative Analysis of Dissipated Energy

6.2. Analysis of Delay

The delay is another essential parameter to analyze the effectiveness of the scheduling scheme.

The computation of delay (Figure 7) evaluates the total time required to forward data from the transmitting IoT node to the destination IoT node. It is essential to control the scheduling operation so that it doesn't affect the cumulative data transmission, so lower delay is the best indicator. This is because any alteration in the topology in the Exist2[33] method is identified using the link quality indicator and received signal strength, which is quite a faster process. Hence, the updating process is a bit faster. However, it should be noted that the estimation of the link quality indicator is

RESEARCH ARTICLE

highly supportive of virtual clusters with higher memory dependency. Hence, an additional number of resources are required to process it. This phenomenon will cause a bigger imbalance between resource consumption and delay. This will eventually mean that Exist2[33] offers good delay performance at the cost of high energy.

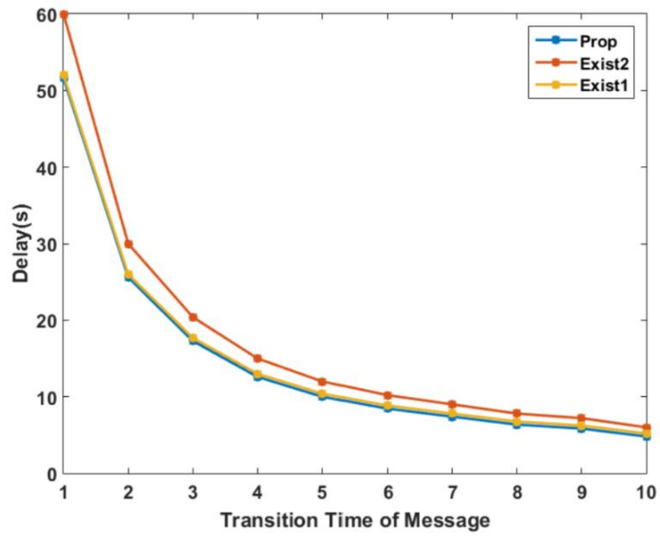

Figure 7 Comparative Analysis of Delay

6.3. Analysis of Execution Time

Execution time is a critical performance metric that can be used to offer evidence for the practical imposition of the algorithm in an actual deployment scenario. As IoT nodes are characterized by restricted resource availability, the prolonged operation will lead to much drainage of resources. It may not be suitable to cater to up original demands of the application. The implication of schedule in the proposed scheme has introduced a novel carrier message design for dynamic routine management of slots foto optimization. Therefore, it is necessary to assess the possible complexity associated with execution time.

The outcome exhibited in Figure 8 showcases that the proposed scheme offers significantly faster execution in contrast to existing schemes of scheduling. A closer look into the algorithmic expression of the proposed scheme will show that a simplified and non-iterative method of constructing the logic of scheduling has been presented. At the same time, the logic present in both existing schemes demands frequent updating operations or iterative computation. This demands more algorithmic processing time for the existing scheme. Another justification is that the proposed scheme performs the routing in two layers. The shortest path carries out the first form of routing.

In contrast, the second layer of routing is carried out as a sequence to the prior one using a window of operational time and almost all the essential field information of the carrier message. Hence, a balance is well maintained for regular and prioritized traffic to maintain better data transmission performance. Therefore, the proposed system offers faster execution time while including the sophisticated and iterative operation that has manifold dependencies is the sole reason for the increased processing time. Hence, an efficient scheduling scheme can be found.

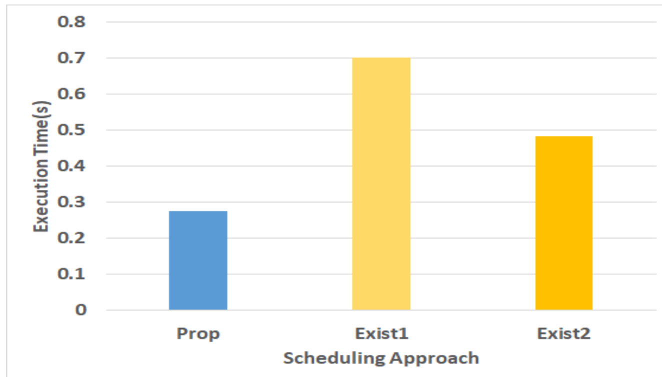

Figure 8 Analysis of Execution Time

7. CONCLUSION

It is now noted that the 5G network system and its associated characteristic are highly suitable for high-rate data transmission. It is meant specifically to support applications running on IoT environments. The resource management of such a large IoT environment is quite a challenging task whose solutions are not yet presented by the scientific community and standards defining IoT. Hence, the proposed study addresses this gap in this paper. The contributions that the proposed study offers in the form of a novel solution are as follows: i) the proposed study presents analytical modeling where the scheduling algorithm is executed in a gateway node which significantly stores processing resources of individual IoT devices, ii) the study also introduces a novel carrier framing strategy considering multiple fields of a message that facilitates the exchange of information associated to routines of time slots among the IoT nodes, iii) the proposed study also introduces a routing mechanism that essentially formulates prioritization (both using user-defined or self-automated assigning of priority based on extended wait time in queue) without affecting the normal traffic, iv) the proposed scheme also presents a unique energy scheme which can reduce the transmit power and allocate the power exactly to meet the demand of transmission. Future work will be carried out further to optimize the scheduling performance in presented IoT environments with more complexity.

REFERENCES

[1] K. Zhang, X. Lin, X. Shen, Encyclopedia of Wireless Networks, Springer International Publishing, ISBN: 9783319782614, 3319782614, 2020

RESEARCH ARTICLE

[2] A. Soong, R. Vannithamby, 5G Verticals-Customizing Applications, Technologies and Deployment Techniques, Wiley, ISBN: 9781119514831, 1119514835, 2020
[3] S.K. Koul, Z. Wani, Novel Millimetre Wave Antennas for M.I.M.O. and 5G Applications, Springer Nature Singapore, ISBN: 9789811672781, 9811672784, 2021
[4] R. Prasad, 5G: 2020 and Beyond, River Publishers, ISBN: 9781000793314, 1000793311, 2022
[5] M. Peng, Z. Zhao, Y. Sun, Fog Radio Access Networks (F-RAN)-Architectures, Technologies, and Applications, Springer International Publishing, ISBN: 9783030507350, 3030507351, 2020
[6] N. Kumar, A. Ahmad, "Cooperative evolution of support vector machine empowered knowledge-based radio resource management for 5G C-RAN", Elsevieer-Ad Hoc Networks, Vol.136, 2022. DOI: https://doi.org/10.1016/j.adhoc.2022.102960
[7] J. Tanveer, A. Haider, R. Ali, and A. Kim, "Machine Learning for Physical Layer in 5G and beyond Wireless Networks: A Survey," Electronics, vol. 11, no. 1, p. 121, Dec. 2021, doi: 10.3390/electronics11010121.
[8] A.K. Bhoi, P. Barsocchi, S.N. Sur, V.H. C. de Albuquerque, 5G IoT and Edge Computing for Smart Healthcare, Elsevier Science, ISBN: 9780323906647, 0323906648, 2022
[9] A. Mamane, M. Fattah, M. E. Ghazi, M. E. Bekkali, Y. Balboul, and S. Mazer, "Scheduling Algorithms for 5G Networks and Beyond: Classification and Survey," in IEEE Access, vol. 10, pp. 51643-51661, 2022, doi: 10.1109/ACCESS.2022.3174579.
[10] H. Zhong, R. Sun, F. Mei, Y. Chen, F. Jin, and L. Ning, "Deep Grid Scheduler for 5G NB-IoT Uplink Transmission", Hindawi-Security and Communication Networks, Article ID 5263726, 2021. DOI: https://doi.org/10.1155/2021/5263726
[11] M. Jiang, K. -W. Chin, T. He, S. Soh and L. Wang, "Joint Link Scheduling and Routing in Two-Tier RF-Energy-Harvesting IoT Networks," in IEEE Internet of Things Journal, vol. 9, no. 1, pp. 800-812, 1 January 1, 2022, doi: 10.1109/JIOT.2021.3085862.
[12] D. Han, X. Du, and X. Liu, "C.E.L.R.: Connectivity and Energy Aware Layering Routing Protocol for U.A.N.s," in IEEE Sensors Journal, vol. 21, no. 5, pp. 7046-7057, 1 March 1, 2021, doi: 10.1109/JSEN.2020.3039808.
[13] E. Selem, M. Fatehy and S. M. A. El-Kader, "mobTHE (Mobile Temperature Heterogeneity Energy) Aware Routing Protocol for WBAN IoT Health Application," in IEEE Access, vol. 9, pp. 18692-18705, 2021, doi: 10.1109/ACCESS.2021.3054367.
[14] G. Kaur, P. Chanak and M. Bhattacharya, "Energy-Efficient Intelligent Routing Scheme for IoT-Enabled W.S.N.s," in IEEE Internet of Things Journal, vol. 8, no. 14, pp. 11440-11449, 15 July 15, 2021, doi: 10.1109/JIOT.2021.3051768.
[15] M. Zhu, L. Chang, N. Wang, and I. You, "A Smart Collaborative Routing Protocol for Delay Sensitive Applications in Industrial IoT," in IEEE Access, vol. 8, pp. 20413-20427, 2020, doi: 10.1109/ACCESS.2019.2963723.
[16] Z. Yang, H. Liu, Y. Chen, X. Zhu, Y. Ning, and W. Zhu, "UEE-RPL: A UAV-Based Energy Efficient Routing for Internet of Things," in IEEE Transactions on Green Communications and Networking, vol. 5, no. 3, pp. 1333-1344, Sept. 2021, doi: 10.1109/TGCN.2021.3085897.
[17] S. Ghosh, T. Dagiuklas, M. Iqbal and X. Wang, "A Cognitive Routing Framework for Reliable Communication in IoT for Industry 5.0," in IEEE Transactions on Industrial Informatics, vol. 18, no. 8, pp. 5446-5457, Aug. 2022, doi: 10.1109/TII.2022.3141403.
[18] I. U. Khan, I. M. Qureshi, M. A. Aziz, T. A. Cheema, and S. B. H. Shah, "Smart IoT Control-Based Nature Inspired Energy Efficient Routing Protocol for Flying Ad Hoc Network (F.A.N.E.T.)," in IEEE Access, vol. 8, pp. 56371-56378, 2020, doi: 10.1109/ACCESS.2020.2981531.
[19] P. Chanak and I. Banerjee, "Congestion Free Routing Mechanism for IoT-Enabled Wireless Sensor Networks for Smart Healthcare Applications," in IEEE Transactions on Consumer Electronics, vol. 66, no. 3, pp. 223-232, Aug. 2020, doi: 10.1109/TCE.2020.2987433.
[20] R. Narayanan and C. S. R. Murthy, "A Routing Framework With Protocol Conversions Across Multiradio IoT Platforms," in IEEE Internet of Things Journal, vol. 8, no. 6, pp. 4417-4432, 15 March 15, 2021, doi: 10.1109/JIOT.2020.3028239.
[21] N. R. Patel, S. Kumar, and S. K. Singh, "Energy and Collision Aware W.S.N. Routing Protocol for Sustainable and Intelligent IoT Applications," in IEEE Sensors Journal, vol. 21, no. 22, pp. 25282-25292, 15 Nov.15, 2021, doi: 10.1109/JSEN.2021.3076192.
[22] Z. Li, W. Su, M. Xu, R. Yu, D. Niyato and S. Xie, "Compact Learning Model for Dynamic Off-Chain Routing in Blockchain-Based IoT," in IEEE Journal on Selected Areas in Communications, vol. 40, no. 12, pp. 3615-3630, Dec. 2022, doi: 10.1109/JSAC.2022.3213283.
[23] M. Mahyoub, A. S. Hasan Mahmoud, M. Abu-Amara and T. R. Sheltami, "An Efficient RPL-Based Mechanism for Node-to-Node Communications in IoT," in IEEE Internet of Things Journal, vol. 8, no. 9, pp. 7152-7169, 1 May 1, 2021, doi: 10.1109/JIOT.2020.3038696.
[24] A. Vaezian and Y. Darmani, "MSE-RPL: Mobility Support Enhancement in R.P.L. for IoT Mobile Applications," in IEEE Access, vol. 10, pp. 80816-80832, 2022, doi: 10.1109/ACCESS.2022.3194273.
[25] R. -G. Tsai, P. -H. Tsai, G. -R. Shih and J. Tu, "R.P.L. Based Emergency Routing Protocol for Smart Buildings," in IEEE Access, vol. 10, pp. 18445-18455, 2022, doi: 10.1109/ACCESS.2022.3150928.
[26] A. Mohammadsalehi, B. Safaei, A. M. H. Monazzah, L. Bauer, J. Henkel, and A. Ejlali, "ARMOR: A Reliable and Mobility-Aware R.P.L. for Mobile Internet of Things Infrastructures," in IEEE Internet of Things Journal, vol. 9, no. 2, pp. 1503-1516, 15 January 15, 2022, doi: 10.1109/JIOT.2021.3088346.
[27] P. Chithaluru, S. Kumar, A. Singh, A. Benslimane and S. K. Jangir, "An Energy-Efficient Routing Scheduling Based on Fuzzy Ranking Scheme for Internet of Things," in IEEE Internet of Things Journal, vol. 9, no. 10, pp. 7251-7260, 15 May 15, 2022, doi: 10.1109/JIOT.2021.3098430.
[28] P. Ekler, J. Levendovszky and D. Pasztor, "Energy Aware IoT Routing Algorithms in Smart City Environment," in IEEE Access, vol. 10, pp. 87733-87744, 2022, doi: 10.1109/ACCESS.2022.3199757.
[29] S. Xu, X. Wang, G. Yang, J. Ren, and S. Wang, "Routing optimization for cloud services in SDN-based Internet of Things with T.C.A.M. capacity constraint," in Journal of Communications and Networks, vol. 22, no. 2, pp. 145-158, April 2020, doi: 10.1109/JCN.2020.000006.
[30] Z. Ding, L. Shen, H. Chen, F. Yan, and N. Ansari, "Energy-Efficient Relay-Selection-Based Dynamic Routing Algorithm for IoT-Oriented Software-Defined W.S.N.s," in IEEE Internet of Things Journal, vol. 7, no. 9, pp. 9050-9065, Sept. 2020, doi: 10.1109/JIOT.2020.3002233.
[31] K. Subhas, L. Arockian, "A Survey on Issues and Challenges in R.P.L. Based Routing for IoT," Annals of R.S.C.B, Vol. 25, Issue 5, pp.501-510, 2021
[32] A. B. Khalifa, "Medium Access Control Layer for Dedicated IoT Networks," Doctoral Thesis, NSALyon,2020
[33] A. Zeb, S. Wakeel, T. Rahman, I. Khan, M.I. Uddin, and B. Niazi, "Energy-Efficient Cluster Formation in IoT-Enabled Wireless Body Area Network," Hindawi-Computational Intelligence and Neuroscience, Volume 2022, Article ID 2558590, 11 pages, https://doi.org/10.1155/2022/2558590
[34] X. Dua, Z. Zhoua, Y. Zhang, "Energy-Efficient Data Aggregation Through the Collaboration of Cloud and Edge Computing in the Internet of Thing's Networks," Elsevier-ScienceDirect, vol.174, pp.269-275, 2020.

Authors

Gauri Sameer Rapate is a Research Scholar in the Department of Computer Science and Engineering at Visvesvaraya Technological University. She has done her masters in engineering from Anna University. She is currently working as Assistant Professor in PES University. Her research is concerned with Routing optimization in Internet of Things. ORCID: 0000-0002-3746-6977.

RESEARCH ARTICLE

Dr. N C Naveen has done his doctorate from SRM University in 2013. Currently he is woking in Department of Computer Science and Engineering as HoD and Professor, at JSS Academy of Technical Education. He has more than 20 years of teaching experience. His area of interest are Big Data Analytics, Data Mining, Machine learning Techniques, Network Security and IDS. He has published more than 45 multidisciplinary research articles in various journals. ORCID: 0000-0001-9032-8445.

How to cite this article:

Gauri S. Rapate, N C Naveen, "Scheduling Framework for Resource Management in IoT Ecosystem Over 5G Network", International Journal of Computer Networks and Applications (IJCNA), 10(1), PP: 107-118, 2023, DOI: 10.22247/ijcna/2023/218515.