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RESEARCH ARTICLE

Throughput Optimization - Based Gateways Placement Methods in Wireless Networks

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Abstract – The Internet of Things (IoT) allows interconnected devices for sharing and controlling data among each other as things are connected through the Internet. Communication among these devices that are part of Wireless Sensor Networks (WSNs) and the Internet is eased with the help of Internet Gateway, which is termed IoT gateway. The performance of IoT networks is affected by various network parameters such as the position in the network gateways, heterogenous coordinating devices, link selection and link assignment, link scheduling, and transmission scheduling. To increase the performance of the network, the placement of the gateways should be optimal, which reduces the deployment cost and increases throughput. Furthermore, more than one gateway is placed to reduce congestion within the IoT network, resulting in noise and increasing the cost. Most researchers focused on the placement of internet gateway or mesh routers in the Wireless Mesh Network (WMN). The gateway placement problem needs to focus on IoT networks where heterogeneous wireless technologies are involved for machine-to-machine communication (M2M). It is challenging to deal with different wireless technologies along with gateway placement for the network throughput maximization. In this article, we propose the "Novel Gateway Select Algorithm," which selects the best candidate gateways to achieve throughput maximization during heavy traffic load on coordinating devices or intermediate gateways. The evaluation of the performance of the Novel Gateway Select algorithm is demonstrated by using simulation. The result proved that the proposed system selects the appropriate candidate gateway with high throughput and minimum average load considering the dynamic variance of heavy traffic at each coordinating device or intermediate gateway in the IoT network.

Index Terms – Internet of Things, Multiple Gateways, IoT Network, Gateway Placement Problem.

1. INTRODUCTION

In the world of IoT technology, the number of devices connected by different wireless technologies is predicted to jump to 55 billion by 2025. Devices can interface within a network with the help of various network interfaces such as Wi-Fi (802.11 a/b/n/g), ZigBee (802.16), or Bluetooth (802.15) and is embedded with suitable sensors and actuators. The IoT is thought of as one of the third famous waves of the latest evolving information technology after mobile communication networks and the Internet, which have added clear sense and data measure characteristics, network interoperability, and smart intelligence [1]. The authors [2] stated that the IoT is a complex, self-configuring, and adaptable network that uses standardized communication protocols to link things to the Internet. The interconnected things have physical or virtual representation in the digital world, sensing/actuation capability, a programmability feature, and are uniquely identifiable. These emerging technologies of smart IoT can efficiently ease integrating smart products, services and controlling these services. The physical world is also merged into the digital world. IoT application areas constitute disaster management, smart city areas, infrastructure construction, smart agriculture, public security, intelligent environment protection, smart industry, modern urbanization, and smart business service. IoT is a Universal global neural network in the cloud [3].

As per the perspective of information technology in wireless networks, the IoT is termed an extensive global information intelligence system comprised of hundreds of millions of embedded objects. Those are meant for identification, sensing the various parameters, and processing of collected data based on communication protocols in standardized and interoperable formats. The IoT system can process the state of an object, managed and controlled to achieve decision-making and cooperation among all these objects automatically without any human intervention with the support of machine-to-machine (M2M) communication, broadband mobile communication, advanced networking, and the latest cloud computing technologies. In M2M communication [4], data is transmitted using different forms of communication such as a

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coordinating device to coordinating device, a coordinating device to a gateway, and gateway to gateway. In stated architecture, the gateway should have the capability to autonomously interact with the surrounding environment and adapt to changes in the network traffic [5].

IoT comprises embedded systems, wireless networks, wireless sensor networks, various control systems, automation, and many other fields. In a wireless network, the data is transmitted from source to the destination through different intermediate heterogeneous nodes (coordinating devices and intermediate gateways) is a multi-hop communication heterogeneous network. Multi-hop wireless networks consist of nodes such as routers, coordinating devices, gateways, and sensor networks. These intermediate nodes are mobile or stationary and can access the Internet through an internet gateway. Thus, all traffic is flowing towards the internet gateway. As the number of internet gateways is less in number, it warrants an appropriate selection of gateway to increase network throughput. The main contribution of the work is at the network layer, as shown in Figure 1.

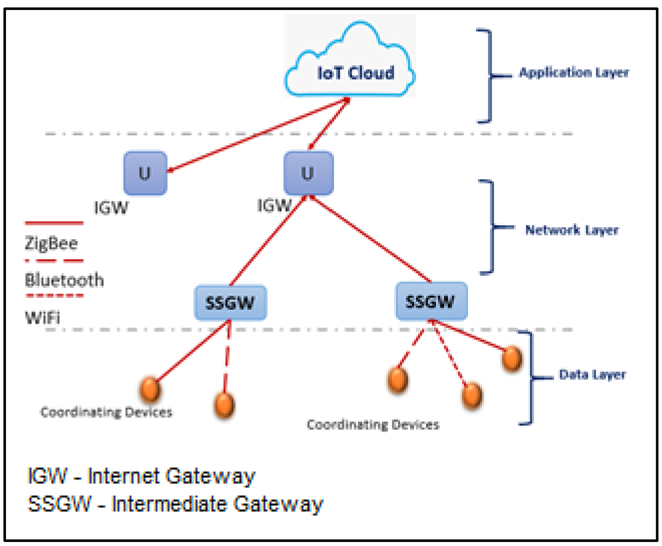

Figure 1 Layered Architecture of IoT Network

Furthermore, the location of these gateways is also essential to maintain network performance. In this paper, this gateway placement problem is tackled to increase the throughput of the network. The solution to this problem is proper gateway placement and optimal gateway selection within the network. In the IoT scenario, wireless networks gateways are termed Internet Gateway. Placement of these gateways in an optimal way is challenging in the IoT network as IoT network supports different wireless technologies. Most of the research [6,7,8] focused on the placement of internet gateway with considering different parameters such as heterogeneity, traffic delay, load balancing, and fault tolerance. Many research articles [9, 10,11,12,13] have investigated the gateway within the WMN, but more research needs to be done in gateway placement for IoT networks. With load balancing, interference with multiple routers, and multiple clients in Wireless Mesh Network, Gateway placement are research topics in recent studies. Most of the research work considered these issues together. Few authors [14,15,16,17] have presented solutions for clustering and selecting internet gateways to achieve throughput in the wireless mesh network.

Considering all previous issues, major concerns for this research gateway placement in IoT network with more than one internet gateway which leads to high deployment cost and a multi-hop count which causes the network delay, interference due to simultaneous transmission, static and dynamic load balancing, and dropping of the packet to increase the overall throughput of the system.

As mentioned in the above scenario, after gateway placement in the network, there is a need to select one gateway as an internet gateway directly connected to the internet for communication within the IoT network. For direct connection with the cloud, clients or users need to be directly or indirectly linked to the internet gateway through intermediate gateways. Therefore, an appropriate internet gateway among placed intermediate gateways.

The selection of an internet gateway is based on two parameters as proper network coverage and communication capability. This problem of gateway selection which guarantees maximum throughput is also proposed in our system. Hence, the proper and optimal location of the internet gateway solves the problem of achieving maximum throughput.

The contribution of the research is as follows,

1. The formulation of the gateway placement problem aims to minimize the number of intermediate and internet gateways in IoT networks.

2. Select the optimal location of intermediate and internet gateways from existing gateways to avoid further reducing network deployment costs.

This article is arranged in different sections. Section 2 focuses on an investigational review of existing gateway placement methods. Section 3 discusses the multiple gateway placement problem for the wireless networks and comparative analysis of research gaps of existing gateway placement methods. More investigation is carried out to understand better services for the users and studied parameters that satisfy throughput to achieve more network performance. Section 4 highlighted the optimal gateway selection and gateway placement method to achieve maximum throughput. Finally, section 5 covers the proposed system evaluation. Sections 6 provides the discussion on the obtained results and Section 7 concludes the research work.

2. RELATED WORK

Presently, the most challenging job in the wireless network is the selection of the location of gateways and proper placement of the gateways. In this section, the Gateway Placement problem is reviewed considering various network parameters: (1) Resource constraints, (2) Heterogeneity, (3) Energy consumption, (4) Packet delay, (5) Throughput, (6) Overall network cost, and (7) Load balancing. Most studies [18,19,20] have focused on homogeneous wireless mesh networks for machine-to-machine communication but not for IoT networks that use heterogeneous wireless technologies. Therefore, focus on the problem of IoT network gateway placement is the main aim of the research.

Authors [21] proposed an algorithm to unfold the gateway placement problem with the help of clustering technique using four steps: choose cluster heads, assignment of every node to existing cluster such that the delay constraint to be satisfied, drop the clusters that fail to satisfy constraints the gateway capability or the relay node.

However, the difficulty with these schemes is that they do not update step-by-step; instead, gateway locations are created consecutively. Particle Swarm Optimization (PSO) based method is proposed in [22, 23], which studied gateway placement optimization, which focused the throughput optimization in WMNs. They are updated step by step with the random and independent methodology. Stated methodology realized the best scheme and achieved a higher result as compared to previous methods. Apart from considering throughput and quality of service, constructing the model to measure the turnout of WMNs is equally important. Authors in [24] focused on the gateway placement problem with load balancing and PSO algorithm, which invented techniques to partition the given WMN into load-balanced and independent clusters which are not connected sequentially.

In this approach, every cluster in a network satisfied QoS requirements as stated in the proposed formula. A hybrid technique is suggested, which outperforms other existing algorithms. The main objective was suggested in [25] to place a minimum number of mesh routers and gateways to ensure Quality of Service (QoS). In this research, the focus is given on three network parameters like throughput, connectivity, and coverage of a network. The authors discussed existing approaches for effective mesh router placement to provide internet services to many consumers. After that, the system chooses the best gateways to reduce the load on the relay was studied [26]. Clustering-based gateway Placement algorithm (CBGPA) studied in [27] guaranteed end-to-end communication with a bounded delay that handled network measurability. This approach split the network into clusters with network constraints and is also disjoint. Among all these clusters, the gateway for every cluster is selected. The main task of this gateway is to provide service to all the nodes in the cluster.

The authors presented a gateway problem strategy to evaluate the complex challenge in the wireless mesh network at each gateway, which successfully achieved the goal of enhancing network performance [28]. The authors also proved that mesh routers in a network should be appropriately distributed to function as nodes. Among these, the node with the highest throughput and the best connectivity were deployed as gateways. The author applied the tree-set partition (TSP) approach to select a gateway from all these nodes. The authors of [29] adopted a grid-based strategy to deploy the gateway approach and throughput optimization for the cross-layer approach.

The proposed approach used the available resources effectively in proposed methods for efficient data transmission. Because this strategy uses many gateways, it achieved improved optimal throughput, coverage, and connectivity. However, this strategy has resulted in a higher overall network cost. As part of future study, this strategy does not consider that a specific gateway should limit the number of users of routers in the wireless mesh network. The authors [30] proposed a delay-optimal routing forest, which used the concept of selecting a root of a tree at every entree. The cost calculated was not load-dependent, failing to achieve considerable gains than shortest path routing in minimum balanced topologies

In [31], the authors developed a model for a WMN that achieved throughput optimization. Wireless nodes which are located at a fixed position and data flow distribution were used to achieve throughput. Also, it emphasized network configuration for maximum network throughput. The optimization framework which is utilized to achieve throughput optimization and network setup is investigated in this research. The authors study enumerative approaches to obtain expected numerical results in different situations with different gateways and understand the network topology with different schedules, optimal routes, and physical layer parameters. Optimal throughput is also achieved in this scenario.

In [32], the authors proposed the load balancing issues in the mesh network. In this approach, the interference-free graph model is used to achieve load balancing as a central point outside the mesh network. An algorithm was implemented to calculate a load-balanced tree with the balanced distributed approach using an interference-free model. In [33, 34], the authors have used clustering-based techniques to achieve QoS requirements of wireless networks and obtain the optimal and efficient solutions for gateway placement. The authors proposed a heuristics algorithm for the placement of gateway to achieving optimization. The proposed algorithm is compared its performance with previously investigated

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suboptimal solutions. In [35], proper gateway placement is addressed to achieve throughput by placing the optimal number of gateways. QoS is achieved termed as polynomial-time near-optimal algorithm in the proposed algorithm. This proposed algorithm computed minimum weighted Dominating sets (DS). It is compared with similar existing schemes using important parameters such as the number of gateways to be placed within the network and QoS. This approach concluded that it outperforms other alternatives algorithms.

The capacitated facility location issue (CFLP) was solved by utilizing a clustering strategy for the gateway placement problem [36]. Each gateway provides service to the cluster of its connected MRs in this technique. At the rooted gateway or cluster head, a spanning tree was applied to deliver messages. In this approach, algorithms involved two steps algorithms. The first step was to search various disjoint clusters with a minimal variation which included nodes subjected to clusters' radius as an upper bound. In the last step of this approach spanning tree is determined in each cluster. This cluster is divided into sub-clusters. These clusters are not considered relay nodes and are constraints on cluster size. A problem based on throughput was also investigated in [37, 38].

Hence, the gateways' proper and optimal location needs to focus on solving the problem of achieving maximum throughput in the IoT network and gateway selection to connect to the cloud for storage and processing directly.

3. MULTIPLE GATEWAYS PLACEMENT PROBLEM IN WIRELESS NETWORK

Because of the IoT network's complex structure and heterogeneity, effective network implementation is the highest priority. Therefore, many competing research parameters or limitations such as network connectivity, heterogeneity, resource limits, bandwidth allocation, coverage, and gateway position must be analysed to design an IoT network. As a result, the minimum and the most desirable number of gateways inside the network is prioritized to improve network performance. While investigating the gateway placement algorithm, various research parameters are detected. The following is a detailed comparison of alternative gateway placement approaches for wireless networks:

Most of the research focused on increasing the throughput of WMN, not heterogeneous networks using diverse wired technologies. Therefore, the main objective of this article is the proper placement of gateway followed by internet gateway selection to achieve maximum throughput. Table 1 shows that existing gateway placement solutions for WMNs and IoT network.

Solution	Remarks	Algorithms Used	Research Gap
40	The authors created an approximate technique for efficiently planning large-scale LoRa networks. In all iterations, the Hybrid strategy outperforms the Adaptive Data Rate (ADR) strategy, and in most iterations, the Hybrid strategy outperforms the Spreading Factor (SF) assignment strategy.	Greedy Gateway Placement hybrid algorithm	Used only for small networks and load balancing is not considered
41	The effectiveness of a multicriteria-based load-balancing strategy among fog-assisted IoT gateways was investigated. Latency and load fairness are calculated.	Analytical Hierarchy Process (AHP) Load association Algorithm	Plan to deal with the situation where the network has distinct traffic classes of task requests assigned to gateways based on their QoS requirements.
42	The study's main contribution is to find a near-ideal gateway deployment in a short amount of time. WSNs' cost-effectiveness is also improved.	Cost Minimizing Gateway Deployment algorithm	Because the suggested approach does not produce ideal linear results, it should be considered for linear networks.
43	Due to space constraints, it is necessary to regulate the energy consumption of	Power-efficient K-means	The load balancing factor is to be considered in future work to

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	WS nodes and improve the WSN's running time. Effectively balance the energy usage in the proposed method	clustering algorithm	achieve fairness
44	The most recent structure and a successful clustering approach, and an Intra Cluster Gateway are presented in this study (IC-GW). IC-GW uses Particle Swarm Optimization with a Genetic Algorithm (PSO-GA), also known as ICGW-PSOGA, for long-distance communication and optimal SINK placement in WSNs.	Particle Swarm Optimization with Genetic Algorithm (CGW-PSOGA)	In the future, inter-cluster to be considered for placement of gateway in wireless networks.
45	The authors contributed to this paper by establishing a Mixed-Integer Linear Programming formulation that satisfied data flow demands while reducing overall network energy consumption. To tackle multiple cases of the problems efficiently, a heuristic-based greedy method was proposed.	Energy-Aware Gateway Placement (EAGP)	Fairness is not considered for better network performance
46	Mesh router load balancing is offered in the proposed system. Then, using PSO and distributed GA, a hybrid intelligent simulation system (DGA) is proposed	PSO and distributed GA (WMN-PSOD-GA)	Fairness while resource allocation be the part of future work
47	The authors achieved a near-optimal solution to the Gateway Placement Problem (GPP) using the Genetic Algorithm (GA). The number of Internet gateways and multiple hops to traverse the packet from the IG to the source/destination MR or MR gateway is considered to achieve this goal.	GPP using Genetic Algorithm	Considered only population size, tournament size, and crossover-type in GA.
48	The problem of joint gateway placement, routing, and transmission slot allocation in a wireless mesh network was investigated. The k-opt local search heuristic was utilised to obtain more resilient gateway sets. Proposed a collection of relevant inequalities for the IGP problem, as well as two alternate formulations.	Robust Gateway Placement	An alternate approach for delivering predicted traffic to the Internet in the shortest time is to choose among various gateway sets.
49	Assumed nodes with no mobility. No security aspects and load balancing are considered. Assuming that every end device may	Integrated Linear Programming Problem (ILP) Problem and low-end transmission device allocation problem	Load balancing is not considered on the network since optimal installation cost is considered.

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	have a minimum of one neighbour, it can communicate directly.		
50	In the wireless network design, the authors built an RGA to solve the gateway placement problem. This method is used to determine how many gateways are required in a network to maximize efficiency.	Repairing genetic algorithm (RGA)	Used only for the linear network should be focused on remaining data
51	Load balancing algorithm increases the network performance in networks with a relatively rare number of flows. The improvement depends on network resources, like queue size. When the resources are limited, the network benefited a lot from the Load Balancing Algorithm	Load Balancing Algorithm	Investigation of the new algorithms for improving the QoS for WSN by load balancing algorithm.
52	Clustering is done using the Soft k-means approach, which considers node distance, position, and speed to produce the optimum cluster. Methods are used to pick the Cluster Head (CH) from the nodes to optimize the MANET network energy efficiency and lifetime.	Hybrid Particle Swarm Optimization-Genetic Algorithm	The CH selection technique is to be used in the future, together with energy-efficient routing, to assess total network performance and lifetime.
53	More gateways can be added to improve throughput, and selecting appropriate locations of these gateways helped optimize network topology and traffic distribution. But more gateways increased the cost due to costly wired links used to connect gateways. Gateway placement is an important aspect of WMN. Placement of a large number of gateways improved the throughput and reduced congestion resulting in increased interference and cost.	Load balanced Gateway placement algorithm	Fault-tolerant is not considered, and a proper simulation model proved that the proposed algorithm is better than others.
54	It is based on an evolutionary algorithm to solve the optimization problem for placing gateways for maximum throughput in WMN. Random selection of the location of the gateway. Calculate fitness value	MTW (Multi-hop Traffic-flow weight) -BASED GATEWAY PLACEMENT with Evolutionary Algorithm	Throughput maximization along with optimizing gateway placement is not achieved.

Table 1 Comparative Analysis of Gateway Placement Algorithm

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4. OPTIMAL GATEWAYS SELECTION AND GATEWAY PLACEMENT METHOD

In this section, an innovative approach for selecting the intermediate or internet gateways within an IoT network is proposed to achieve maximum network throughput. For example, when an effective data communications IoT network is to be deployed in the disaster area, some coordinating devices and intermediate gateways might have to handle heavy traffic loads, and others might have less load. Therefore, to distribute the load equally in the existing deployed network number of gateways should be increased, but it may increase cost and overhead within the network. Moreover, different gateways exhibit different throughput in the deployed network depending on dynamic traffic conditions. Hence, the solution to this problem is to provide an optimal candidate selection followed by proper gateway placement in the given deployed network.

In the given scenario, the number of Coordinating Devices (CDs) is distributed uniformly at random, supporting different technologies such as Zigbee, Bluetooth, and 802.11. Each CD has a different transmission range (radius) depending on the technology it supports. As CDs can communicate through only one specific technology, they are connected to any specific gateway and IoT gateway that supports that specific technology. Two intermediate gateways are connected if they are within range and support at least one common technology. Intermediate gateway route the data received from CDs associated with them to IoT gateway. Each IGW sends the data received directly to the application servers. In the proposed system, the main IoT gateway problem is to determine optimal locations for placing gateways such that it covers all CDs while data transmission by considering dynamic traffic conditions using the following steps,

Step 1:

In the proposed method, the problem of finding the optimal location of the gateway is addressed by considering intersection-based gateway location selection for the candidate in the network. In this method, coordinating devices with a maximum number of intersection points having minimum routing paths are selected as an intermediate gateway.

Step 2:

Before selecting the optimal location of intermediate gateways, the total number of CDs is assigned as network count. In each iteration, CD with maximum network count is chosen and assigned to all remaining candidate locations. The same procedure is repeated until all continue all CDs within the network are covered. After all iterations, an optimal set of intermediate gateways locations is finalized by considering network coverage constraints.

Step 3:

Intermediate or Internet Gateway Selection Gateways selection is to be completed as the next step in the gateway selection problem. Instead of placing a new intermediate gateway or Internet gateway in each cluster, an intermediate gateway with maximum throughput with maximum load factor is considered. An intermediate gateway with the maximum value of effective throughput Ʈg is replaced by an Internet gateway to ensure maximum data to be transmitted to the Internet in every cluster.

5. PERFORMANCE EVALUATION PARAMETERS

Evaluation of the proposed algorithm is to be completed based on essential research parameters as the number of gateways within the network, throughput, latency, average load, and transmission rate. Based on these performance metrics, the existing algorithm for finding the optimal location of gateway such as K-means, PSO based, agglomerative, and mean shift is compared with the novel proposed algorithm. To evaluate the overall performance of the proposed algorithm, all these performance metrics considered are compared against existing algorithms. These parameters are discussed as given below,

5.1. Average Delay or Latency

It is the time taken for a packet transmission within a network from source to destination. The best solution to reduce average packet delay is to reduce intermediate hops among cluster heads and nearest gateways. The gateways within the wireless network are to be placed at the optimal position to achieve successful transmission with maximum throughput and minimum delay considering coverage of cluster heads in the network. In our proposed approach, gateways are placed using a position-based approach considering both Euclidean and Manhattan distance.

Consider D (CH_i, $G_{i,k}$) as the distance between the cluster head CHi and its corresponding gateway $G_{i,k}$. In our approach criteria used for clustering is to minimize the sum of all the distances as shown in Eqn. 1 between cluster head and its corresponding gateway, i.e., to minimize

$$\sum_{i=1}^{N}(D(CH_i, G_{i,k})) \quad (1)$$

In this approach, it does not involve additional overhead for generating intra-cluster routing for optimization.

5.2. Throughput

The rate of successful transmission from source to destination within a network through a communication channel is measured by this performance metric. Bytes per second or bits per second are the units of measurement. To evaluate the overall performance of the gateway placement method, the worst-case per-client throughput and aggregate throughput

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metrics are measured in the proposed model. The aggregate throughput is given in Eqn. 2 as follows,

$$\sum_{i=1}^{N_{CH}} Tr(m, N_g) \quad (2)$$

Which is to be is maximized. In the above equation, Tr denotes the node throughput of the mth node for N_g gateways

The number of access points or cluster heads, the number of intermediate and Internet gateways, traffic from sensors networks, interference from existing intermediate gateways, the location of existing intermediate or Internet gateways in the network, and are all that influence throughput.

5.3. Average Load

Load is termed as traffic flowing towards each access point or cluster heads and at each gateway. More traffic at each cluster head or gateway leads to saturation resulting in packet drop because of buffer overflow as packet dropping at each cluster head or gateway may reduce network performance. Load at each cluster head and gateway is to be balanced. In our proposed algorithm, to reduce workload at each gateway, the clustering technique is used by balancing the number of cluster heads connected to each gateway. G-value as shown in Eqn. 3 is calculated for each gateway within every cluster. The cluster head with the highest G-value is selected. G-value is given as follows,

$$\text{G-Value} = \frac{P_{suppy} * P_{CPU} * D_{from-centre} * C * T_{QL}}{V + |QL_{Avg} - QL_{value}|} \quad (3)$$

Within the cluster, as all the nodes are in close vicinity, resulting in power-efficient network and simple routing within the network., also minimizes the cost of the route. The proposed algorithm thus ensures the balanced and efficient utilization of both specific and Internet gateways within the IoT network.

5.4. Packet Delivery Rate (PDR)/Transmission Rate

Packet delivery rate is an important network performance metric that measures the successful transmission of a certain number of packets from a specific source to the destination packets at the initiation of transmission by the source is calculated as shown in Eqn. 4,

$$P_d = \frac{P_{rec} * 100}{\sum_{k=1}^{n} P_{gen_k}} \quad (4)$$

P_{gen} is packets transmitted from the source node, and P_{rec} is the total number of packets received by the destination node, and n represents the number of cluster heads. Thus, the packet delivery ratio decreases with every increment in traffic load.

6. RESULTS AND DISCUSSION

To evaluate the existing algorithm, a Smart City scenario is incorporated with heterogonous protocols and standards. We have used 802.11 (Wi-Fi), ZigBee, Bluetooth, and RFID for simulations in IoT networks. As mentioned earlier, these five technologies are uniformly distributed in the existing network among CDs randomly. Internet gateways are connected using Internet Protocol directly to the Internet.

The performance of the Novel gateway selects placement algorithm compared with existing algorithms in terms of the evaluation criteria as average delay, throughput, average load, transmission rate (packet delivery rate), and deployment of the number of gateways depending on the number of clusters in the IoT network. The evaluation was performed using a Java simulator. In addition, existing algorithms such as k-means, agglomerative, PSO, and mean-shift clustering strategies are evaluated to compare the performance of the proposed system. We have selected two distance approaches for optimal gateway selection as Euclidean and Manhattan distance in the proposed method.

A large delay occurs at each stage in a multi-hop network due to contention for the wireless channel, packet processing, and queuing delay. The delay is also affected by the number of communication hops between the source and the gateway. To improve the throughput of the system, an ideal location subject to latency limitations is required. In the proposed system, latency is minimized by considering Euclidean and Manhattan distance while calculating the next-hop intermediate gateway to find the shortest path. As shown in figure 2, it can be concluded that the novel gateway select method outperforms for Euclidean and Manhattan distance.

In clustering schemes, the average load on internet gateways should be analyzed. The increase in the number of small networks in wireless communication may cause overhead on cluster head or intermediate gateway to transmit information over the network. If more clusters are formed within the network, then the load increased because the number of coordinating devices connected to the internet gateway increases. In the Novel gateway select algorithm, it is observed that average load is reduced at a significant level as more number intermediate gateways are deployed as per the requirement of dynamic traffic conditions. It depends on the distance between coordinating devices and the Internet gateway, and in addition, transmission tasks can be handled by the intermediate gateways by distributing transmission tasks than that of the K-means and agglomerative algorithm.

The simulation results reveal that the average load in the Manhattan distance approach for the proposed system is significantly reduced than the other existing clustering mechanisms used for gateways placement, as shown in Figure 2. For k-mean and agglomerative approaches, a significant amount of change is not observed compared to the Novel gateway select algorithm shown in Figure 2.

The coordinating devices and intermediate gateways with maximum load are identified at the initial level because different traffic load is generated dynamically in IoT network at different situations due to the increase in the number of clusters as shown in Figure 3. Then coordinating devices with a heavy load must be assigned as the intermediate gateway and intermediate gateway with heavy load as the IoT gateway. The selected coordinating device may contribute a larger portion of total traffic if intermediate gateways or IoT gateways are not within scope. This affects data transmission through the common link, which increasing network congestion and reducing throughput. As in the proposed method, the number of coordinating devices load is decreased by increasing the number of intermediate gateways or internet gateways.

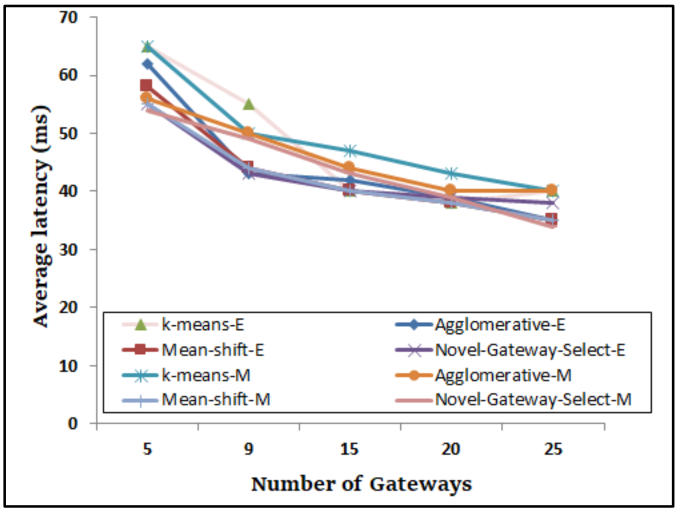

Figure 2 Performance of Novel Gateway Select Algorithm for Average Latency Varying Number of Ggateways

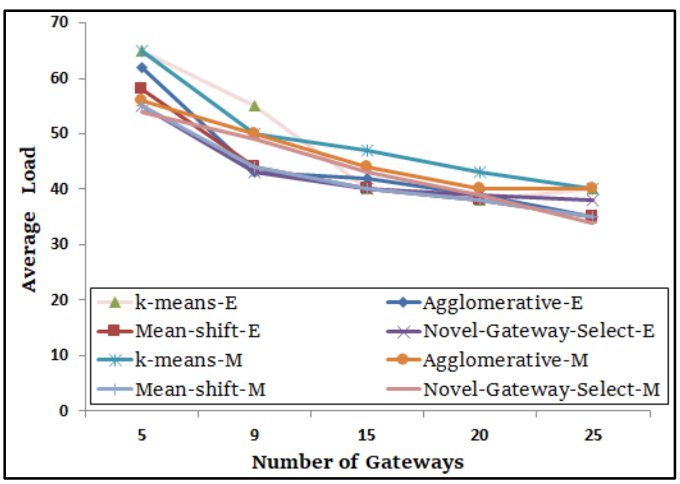

Figure 3 Performance of Novel Gateway Select Algorithm for Average Load Varying Number of Gateways

It is observed that in Figure 4, throughput is increased as the number of gateways is increased. In this experiment, we directly compute the gateway's capacity for various PDRs using different wireless technologies with variable data rates. Then, we adjust the traffic load and compute the gateway capacity by gradually increasing the number of end devices until the target PDR cannot be met. As a result, the capacity of the gateway refers to the number of devices connected at the time. The results are shown in Figure 5.

It is observed that the Novel Gateway Select algorithm reduces the number of gateways when compared with existing algorithms even number of clusters is increased within the IoT network.

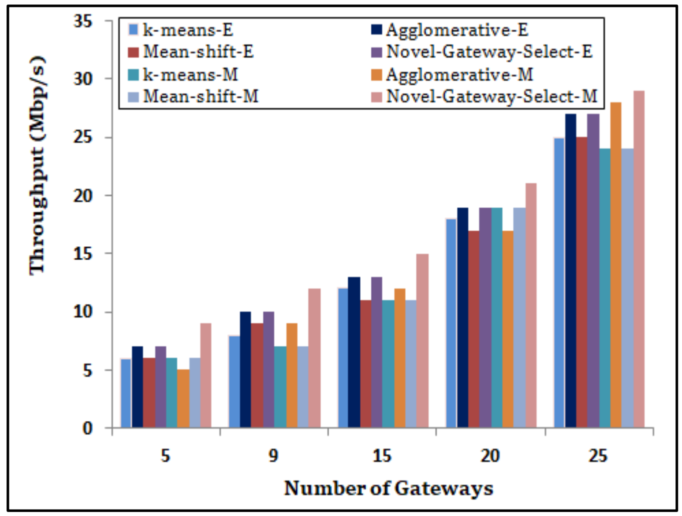

Figure 4 Performance of Novel Gateway Select Algorithm for Throughput Varying Number of Gateways

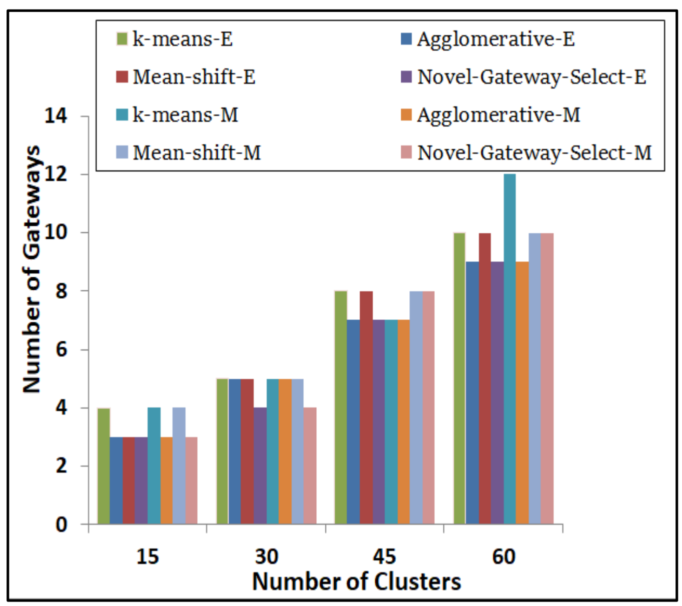

Figure 5 Performance of Novel Gateway Select Algorithm Varying Number of Cluster Heads (CHs)

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7. CONCLUSION

Several approaches are studied to achieve optimization to select the minimum gateways by considering network research parameters as heterogeneity, link failure, dynamic traffic demand, gateway failure, network throughput, link bandwidth, delay, traffic congestion to achieve better network performance. In the IoT scenario, it has become crucial to optimize internet gateways, but the network throughput and overall network cost should not be avoided. In this paper, we have analysed several approaches by various researchers to evaluate various parameters needed for gateway placement and articulated research gaps in gateway placement methods. Most of the approaches focused on Wireless Mesh Networks. However, only a few of them considered gateway placement in IoT networks. In this article, the major issue is to assign coordinating devices or intermediate gateways as IoT gateway within the wireless network to achieve maximum system throughput. The novel method is proposed gateway selection with maximum system throughput and having shortest path. The network performance of the proposed method is analysed with existing algorithms using both approaches Euclidean and Manhattan distance. It is proved from the extensive result that the proposed method is efficient and effective for optimal gateway selection with considering a considerable degree of variation in the amount of traffic generated at coordinating devices with the heavy load. Furthermore, it is stated that average load is reduced with an increase in number of gateways, and maximum throughput is achieved by selecting the optimal number of gateways according to the dynamic condition of traffic within the network.

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