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Retraction

Retracted: 5G Edge Computing Access Node Selection Algorithm Based on Energy Efficiency and Delay

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] W. Hu, S. Guo, L. He, L. Wang, and Y. Yuan, "5G Edge Computing Access Node Selection Algorithm Based on Energy Efficiency and Delay," *Wireless Communications and Mobile Computing*, vol. 2022, Article ID 4491961, 7 pages, 2022.

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Research Article

5G Edge Computing Access Node Selection Algorithm Based on Energy Efficiency and Delay

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In order to address the dissipation of energy efficiency in 5G edge computing, and the problem of network delay, better improve the quality of user service, considering the data aggregation delay while improving the network energy efficiency. The author proposes a 5G edge computing access node selection algorithm based on energy efficiency and delay; through the energy efficiency and delay balanced data collection mechanism (EEDBDG), a new dynamic tree is used to organize the network topology, eliminating the hot zone problem; nodes dynamically choose routes and take turns acting as the root of the tree, which collects data and communicates directly with the base station. At the same time, three data collection strategies are proposed for different latency and energy efficiency requirements: delay optimal algorithm (EEDBDG-D), energy efficiency optimal algorithm (EEDBDG-E), and energy efficiency delay balance algorithm (EEDBDG-M). Experimental results show that, when the communication radius of nodes is limited, EEDBDG balances the energy consumption of nodes, prolongs the network life time, and shows outstanding performance in energy saving and time saving. Compared with GSEN, in the best case, the network lifetime of EEDBDG-E is increased by 72%, and the convergence delay of EEDBDG-D is reduced by 74%. *Conclusion*. The algorithm can effectively reduce the energy dissipation and delay of edge computing.

1. Introduction

In recent years, with the wide application and popularization of IoT access devices, as well as the rapid development of mobile data networks, the 5G (The 5th Generation Mobile Communication) era of Internet of Everything has provided a good environmental foundation [1]. At the same time, in order to cater to the rapidly developing mobile Internet of Things information technology, the 5G communication era needs to carry larger data services, making the information transmission between "people" and "things," "things," and "things" more smooth and convenient [2]. The wireless communication technology has undergone a complex and huge evolution process from the initial 2G, to the mature 4G, and now the hot 5G. There are more and more emerging applications such as deep learning, face recognition, and natural language processing. Obviously, smart terminals have gradually become an indispensable part of people's daily life [3]. It is predicted that there will be up to 4 billion Internet users in the future, with as many as 10 million users. By then, 8 billion terminal devices will be connected to the Internet, the number of IoT connections will be 100 billion, and the number of virtual connections will even reach trillions. The study found that the innovation of enterprises is closely related to 5G, artificial intelligence, and the Internet of Things and also generates a large amount of application data [4]. The large-scale access of heterogeneous devices makes the applications of terminal devices more and more complex, not only demanding more and more wireless and computing resources, but also causing excessive delay and high energy consumption during data transmission or execution, moreover, the limited resources, low battery capacity, and task execution capability of intelligent terminals are difficult to match with intensive task execution requirements. For end users, the low computing power will seriously affect the response speed of the application, and the poor battery life will cause the interruption of the computing-intensive task program and affect the task execution process. Therefore, how to improve user service quality while meeting application processing requirements has become the focus and research focus of many scholars [5].

Therefore, the author proposes a food packaging design based on green ecology, through the discussion of the theoretical framework of ecological design and the research on ecological materials of food packaging; the author summarizes the ecological design principles of green ecological food packaging, so as to better guide packaging design.

2. Literature Review

Regarding the research on 5G edge computing (Figure 1) optimization, Li et al. proposed to design a spatiotemporal offloading decision algorithm for heterogeneous networks in edge cloud scenarios. According to the energy consumption and wireless channel model, a threshold-based task scheduling strategy is derived. Each timeslot user offloads some data tasks to the MEC server for execution based on the channel quality, local energy consumption and fairness among users, and an optimal resource allocation scheme is given [6]. Wang et al. proposed a computational offloading scheme in multiuser and multismall cell scenarios and proposed an energy-efficiency optimized offloading scheme based on artificial fish swarm algorithm [7]. Iwagami et al. proposed the optimal task offloading strategy and resource allocation problem under user MEC network; aiming at minimizing the weighted sum of wireless device energy consumption and task execution time, a reduced-complexity Gibbs sampling algorithm is proposed to obtain optimal offloading decisions, and the research is extended to multiuser scenarios [8]. Wang et al. proposed to transform the objective function into convex optimization; a computational offloading and resource scheduling scheme based on the multiplier method is presented. In order to minimize the network system delay, the problem of computational offloading in ultra-dense networks is studied; according to the NP-hard property of the objective function, it is transformed into two subproblems of task allocation and resource allocation, and an efficient offloading strategy is proposed. In the case that the execution completion time is constrained by a strict deadline and the task offloading occurs in the Markov wireless channel, considering the multidecision problem, an online energy optimization calculation offloading algorithm is proposed [9]. Moore et al. proposed the use of computational unloading technology to optimize the objective function. By formulating an appropriate unloading strategy and designing a reasonable unloading algorithm, the solution problem of the function to be optimized is completed [10]. For the calculation offloading decision-making strategy in the MEC system network, it is generally under the condition that the acceptable execution delay limit of the terminal is satisfied, aims to minimize energy consumption for smart end users, or seeks and analyzes a compromise between the two.

Based on the current research, the author proposes a 5G edge computing access node selection algorithm based on energy efficiency and delay. Through the data collection mechanism of energy efficiency and delay balance (EEDBDG), it is compared with the traditional algorithm GSEN, so as to demonstrate the superiority of the algorithm in reducing energy efficiency dissipation and delay reduction.

3. Research Methods

3.1. 5G Edge Computing Network Architecture. 5G edge computing is mainly composed of 5GUPF (userplane function) and edge computing platform system; the network architecture is shown in Figure 2.

3.1.1. 5GUPF. The 5G core network adopts an architecture in which the control plane and user plane are separated; UPF is the user plane network element in the 5G core network; it mainly implements functions such as service data routing and forwarding, data and service identification, and policy execution and is directly controlled by the control plane network element, control, and management of SMF (session management function) and executes business flow processing according to the policies issued by SMF [11]. UPF can be flexibly deployed to the edge of the network, while control plane network elements such as SMF are usually deployed centrally in the network cloud. In the edge computing business scenario, SMF selects the UPF close to the user to provide services to achieve local route establishment and data offloading [12].

3.1.2. Edge Computing Platform System. The edge computing platform system consists of the MEC host and the edge computing management system.

MEC host includes edge computing platform (MEP) (providing the app running environment and calling edge computing services: load balancing, security functions, traffic management, user metering, etc.), virtualized infrastructure (providing the computing required for running edge computing applications, storage, and network resources), and various edge computing applications and services (edge computing App) running on it [13].

Edge computing management system includes host-level management and system-level management. Host-level management mainly includes edge computing platform management (MEPM) and virtualized infrastructure management (VIM). System-level management mainly includes edge computing operation management platform, edge orchestrator (MEO), operation management subsystem (BSS) and operation management system, and dimension management subsystem (OSS) [14].

3.2. 5G Edge Computing Deployment Architecture. The overall deployment of edge computing mainly includes computer room infrastructure, IaaS facilities, PaaS platforms, and SaaS applications from the bottom to the top.

The equipment room infrastructure mainly includes the equipment room, cabinet, power supply, transmission, environmental monitoring, and other supporting resources

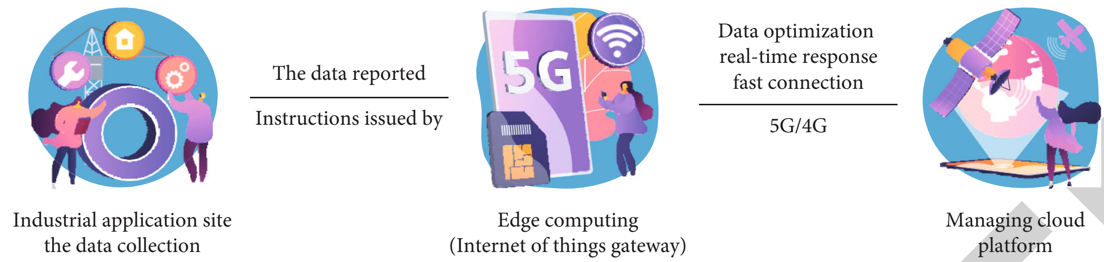

Figure 1: 5G edge computing.

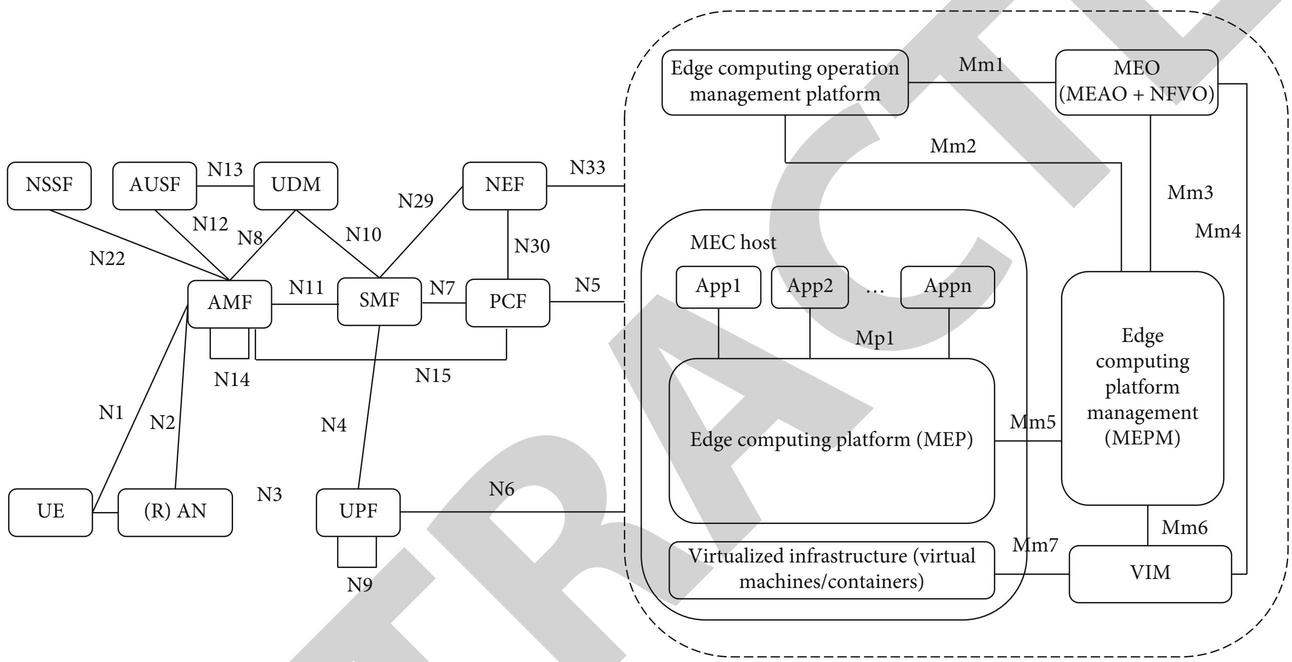

Figure 2: 5G edge computing network architecture.

required for the installation of edge computing equipment; IaaS facilities include hardware physical resources and virtual resources including servers, network equipment, and accelerators, which are used to deploy and Cloud infrastructure for running edge computing services and related network element functions [15]. The PaaS platform is a key enabling module in the full stack of edge computing, providing platform capabilities and network capabilities for upper-layer SaaS applications, including operators' basic PaaS platforms and third-party PaaS platforms. The SaaS application layer includes various applications developed and run for all walks of life based on the PaaS layer.

3.3. Energy Consumption Model. The energy consumption model and its parameters affect the energy efficiency of the protocol and the network lifetime [16]. The author adopts the first or der radio model to calculate the node energy consumption and use it for performance evaluation; the energy consumption of transmitting k bits data to the distance d is

$$E_{Tx}(k, d) = kE_{\text{Elec}} + k\xi_{fs}d^2. \tag{1}$$

The receiving energy consumption is

$$E_{Rx}(k) = kE_{\text{Elec}}. \tag{2}$$

In the formula, $E_{\text{Elec}} = 50nj/bit$ is the power consumption of the module circuit, and $\xi_{fs} = 100pj/(bit * m^2)$ is the power consumption of the transmission amplifier. In addition, data fusion also consumes energy $E_{\text{da}} = 5nj(bit * signal)$.

3.3.1. Delay Optimal Algorithm (EEDBDG-D). After the nodes are placed, the initial establishment phase begins, and the EEDBDG-D initial establishment phase consists of four steps [17]:

(1) Neighbor discovery: All nodes broadcast information to their neighbors with a default size of power (communication radius dcr) so that the neighbor node obtains the ID of the node and the distance to the node and stores it in the neighbor table

(2) Base station discovery: The base station sends hello information with a known power that can cover the entire network so that the node can estimate

the distance to the base station so that it can directly communicate with the base station when it is the root node [18]

(3) Initial tree establishment: A similar controlled flooding is initiated from the node whose ID is 1 to surrounding nodes. Each node has a height value H, which is initially a large integer. Set the H value of node 1 to 0, and the initial tree establishment message broadcast by node 1 contains its H value of 0. After receiving it, the neighbor node sets its own H value to 1 and modifies the H value of the establishment message to 1 and broadcasts it to its neighbors, and so on. Each node only sends a setup message once when it receives it for the first time, but it will monitor the change of the H value of the neighbor node and adjust its neighbor table accordingly. Since the channel is bidirectional, a tree with node 1 as the root is established according to the order of sending and receiving messages and the level of H value

(4) Tree topology adjustment: The tree topology in Step (3) is already the best in terms of delay, but the energy consumption still needs to be optimized to save energy. The algorithm is as follows: The node selects the nearest neighbor from the neighbor node with the lowest H value as the parent node

The data collection phase occupies most of the network lifetime. Data is periodically sent to the root node; then to the base station, the tree topology is being adjusted every round. Data aggregation starts from the leaf nodes; the leaf node selects the nearest neighbor among the neighbor nodes with the lowest H value as the parent node and packages the collected data and sends it to its parent node. After the parent node receives the data of all child nodes, perform data fusion compression, then select its own parent node and send it, and so on, until the root node receives the data of all child nodes; after the same fusion, it is sent to the base station. After the root node has sent the data, it selects the tree root with the largest energy among the neighbors as the root of the next round and notifies the node; the new root node changes its own H value to the H value of the original root node minus 1. In this way, the height value of the root node is always the lowest in the entire network, which ensures the effectiveness of routing and avoids loops.

3.3.2. Energy Efficiency Optimal Algorithm (EEDBDG-E). EEDBDG-E tree topology adjustment steps are completely different from EEDBDG-D; it needs to be adjusted to the minimum distance spanning tree to save energy. In order to reduce the complexity, the author proposes an approximate minimum spanning tree algorithm (PMSTA), which only uses the information in the neighbor table, and the packet complexity is very low. PMSTA algorithm is a search mark algorithm, there are two ways [19]:

(1) Passive marking: initiated by node 1 of the initial tree root. Node 1 finds its nearest neighbor k and sends the marking information; after k receives it, it changes its own H value to the value of node 1 plus 1 and establishes that after the link k node is marked, it can send the marking information to its nearest child node, and so on

(2) Active marking: When a node receives or overhears the change of the H value of the neighbor node, it re-compares the neighbor distance and H value, selects the neighbor with a low H value, and is closest to itself as the parent node, and changes its own H value [20]. After a certain period of time, the marking process is completed. Except for individual links, each node selects the nearest sending link so that an approximate minimum spanning tree is established

Since the minimum distance spanning tree is unique (assuming that all links are of unequal length), the dynamic topology adjustment based on the minimum spanning tree is relatively easy. And since the energy consumption is mainly related to the transmission distance, see Equation (1); therefore, the minimum distance spanning tree topology is the most energy efficient; similar to EEDBDG-D, the data is aggregated from the leaf node to the root node, and the root node is rotated, but the selection of the parent node of EEDBDG-E is based on the following formula:

$$w_{ij}(\mathrm{T}) = \frac{\left(2k_{ij}E_{\mathrm{Elec}} + k_{ij}\xi_{fs}d_{ij}^{2}\right)}{E_{j}(\mathrm{T})}. \quad (3)$$

$w_{ij}(\mathrm{T})$ is the link weight from node i to node j, which is related to the sending and receiving distance d_{ij}^{1} and the remaining energy Ej(S) of the receiving node at the current moment S. On the basis of the closest link distance, considering the remaining energy of the node, prevent some nodes from dying prematurely due to heavy traffic [21]. When the node receives the data of all sub-nodes, it performs data fusion and compresses it into fixed-length data packets and then, using the neighbor Table information, calculates the link weight corresponding to the neighbor whose H value is lower than its own and selects the neighbor of the link with the smallest weight as parent node and send data and, at the same time, changes its own H value according to the H value of the parent node (guaranteed to be 1 lower than the H value of the parent node).

3.3.3. Energy Efficiency Delay Balance Algorithm (EEDBDG-M). EEDBDG-M is an energy-efficiency-delay tradeoff algorithm, and its topology control is the same as EEDBDG-E. The data establishment phase is the same as EEDBDG-E, creating a minimum distance spanning tree. In EEDBDG-E, the data aggregation path is consistent with topology control, but the data aggregation path in EEDBDG-M adopts/false path 0, that is, the data is not sent to its own parent node; it may be a grandfather node or other A node with a low H value. The routing strategy of EEDBDG-M is as follows: The node first sorts the neighbor nodes lower than its own height by height value. Then, it selects the neighbor

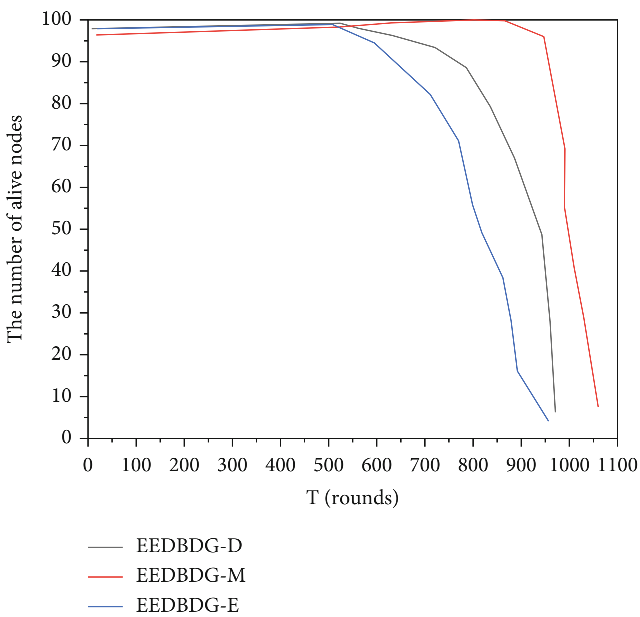

Figure 3: Network life cycle under different protocols.

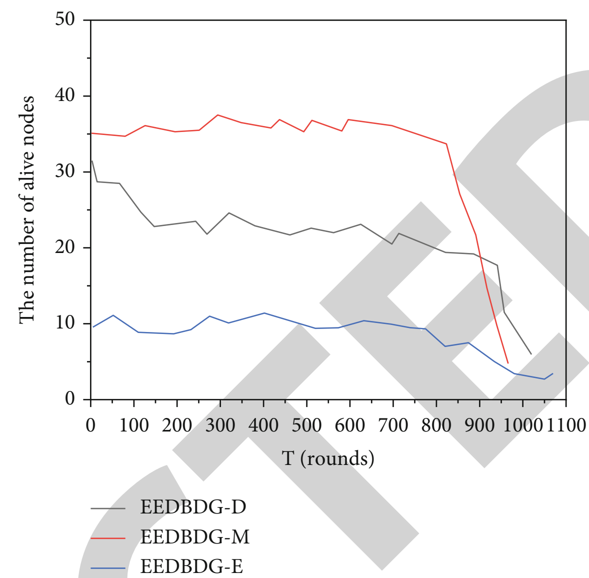

Figure 4: Data aggregation delay under different protocols.

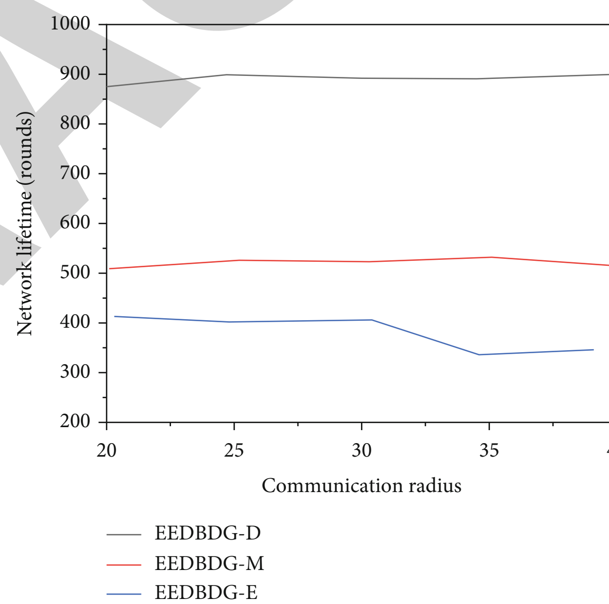

Figure 5: Communication radius and protocol performance.

node corresponding to the median of the height value sequence as the data receiving node. In addition, nodes also need to perform topology adjustment on the basis of information update, including the rotation process of the root node and the selection process of the parent node based on H value and routing weight.

At the end of the network's life, the EEDBDG adopts the following measures to maintain the network. When a node dies, its neighbor nodes will learn after a certain period of time (without periodic broadcast) and then delete it from the neighbor Table. When all the neighbor nodes of the node are dead, the node will increase the transmit power to find neighbors or communicate directly with the base station. Since the communication between nodes is local, EEDBDG can effectively deal with the joining and failure of nodes, the joining node can run the EEDBDG algorithm as long as it builds its own neighbor table, and the failed node will be deleted from its neighbor table by its neighbors after a certain period of time.

4. Analysis of Results

Write a simulation program in C++ to analyze and evaluate the performance of the EEDBDG protocol. The EEDBDG protocol belongs to the network layer protocol; for simplicity, the MAC layer protocol is assumed to be ideal, and channel errors are ignored. In order to demonstrate the advantages of the protocol proposed in this paper, we compare EEDBDG with the latest data collection protocol GSEN, which is an energy-efficient and low-latency algorithm that uses a two-layer chain structure for data aggregation, thereby improving the latency of PEGASIS performance. It has been verified that the energy efficiency of the GSEN algorithm is better than that of PEGASIS and LEACH and the average data aggregation delay of GSEN is only 40% of that of PEGASIS. The simulation program obtains the average sampling results by performing 200 experiments on random node distribution scenarios. Each node in the simulation program has parameter attributes such as position, energy, and neighbor table. At the beginning of each round, the queue is first updated according to the information recorded in the previous round, and the parameters of each node are updated, and then each node performs algorithm calculation according to its own parameters and generates a new information update queue. The simulation program counts the energy consumption of nodes in each round, calculates the data aggregation delay, and finally records the network lifetime.

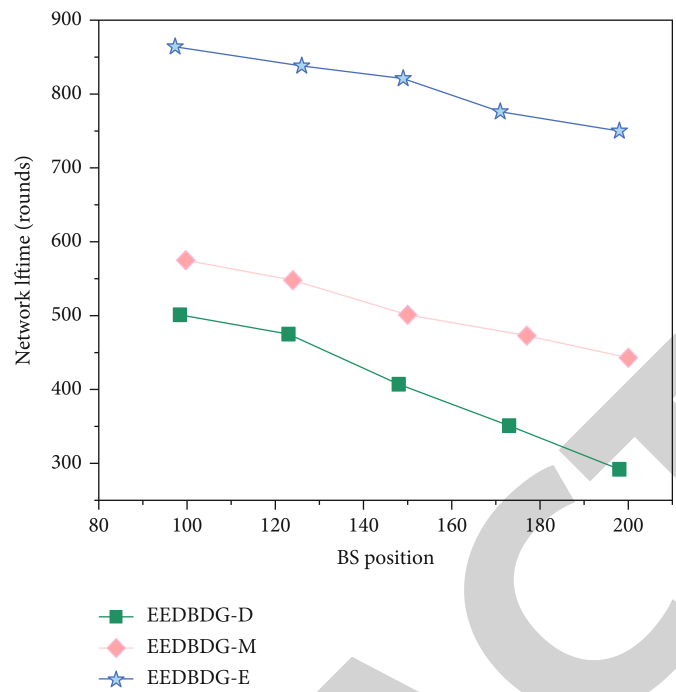

Figure 6: Base station location and protocol performance.

The author analyzes the scenarios where the base station is located at (50, 150), and 100 nodes are randomly distributed in the (100 m@100 m) area, perform multiple simulations (set the communication radius of the EEDBDG protocol to 20 m), and obtain the average network lifetime and convergence delay by statistics, as shown in Figures 3 and 4.

Figure 3 describes the relationship between the number of surviving nodes and time for the four protocols. As can be seen from the Figure 4, EEDBDG-D nodes die first, followed by GSEN, while EEDBDG-M and EEDBDG-E nodes start to die very late. Their network lifetimes are sequentially: 409 rounds, 513 rounds, 831 rounds, and 883 rounds. The average network lifetimes of EDBDG-M and EEDBDG-E are 62% and 72% higher than GSEN, respectively. In addition, the node death time of these two algorithms is concentrated in the last 200 rounds, and the GSEN node death lasts for 500 rounds. This is because the greedy algorithm adopted by the chain protocol has defects. This shows that EEDBDG better balances the energy consumption of all nodes and describes the variation of data aggregation delay under the four protocols. The GSEN algorithm is regrouped every 25 rounds, and the delay in the 25 rounds is unchanged, which is convenient for comparison; the author averages the corresponding delay sampling of EEDBDG every 25 rounds; it is easy to see that the delay of EEDBDG-D is the lowest, which is only 74% of GSEN; the average delay values of are as follows: 9, 15, 23, and 35; the average delay of EEDBDG-E with the worst delay in the EEDBDG protocol is only 66% of that of GSEN. The performance relationship of the three algorithms of EEDBDG is that the energy consumption is related to the square of the communication distance; EEDBDG-E has the shortest average communication distance and is the most energy-efficient, while the long communication distance reduces the number of hops to the root, so the EEDBDG-D algorithm has the smallest delay. The advantage of the EEDBDG protocol in delay is mainly because it is more suitable for the random distribution of nodes, that is, the distance between nodes is quite different, and the delay of the dynamic tree algorithm only depends on the depth of the tree. The chain algorithm GSEN is more suitable for the case where the nodes are evenly distributed; otherwise, it cannot reduce the number of members of the maximum group, resulting in high latency.

In the experiment, the influence of the parameters on the performance of the protocol is also studied by changing the simulation parameters for simulation, as shown in Figures 5 and 6.

Summarizing the experimental results, whether the communication radius, base station location, node density, or area size changes, the performance of EEDBDG algorithm is better than GSEN in both energy saving and time saving, which can reduce energy consumption and time delay more effectively.

5. Conclusion

The author proposes a 5G edge computing intervention point selection algorithm based on energy efficiency and delay, through the data collection protocol algorithm EEDBDG; it consists of three sub-strategies, which, respectively, achieve optimal delay (EEDBDG-D) and optimal energy efficiency (EEDBDG-E) and energy efficiency delay balance (EEDBDG-M). Experiments show that under different parameters and scenarios, the EEDBDG-D algorithm maintains the lowest delay, the average delay is reduced by 70% compared with GSEN, the average network life is only reduced by 20%, the EEDBDG-M and EEDBDG-E protocols are significantly better than GSEN in terms of performance, and the delay performance and energy efficiency performance are improved by more than 60%.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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