Multidisciplinary Journal of Engineering and Technology
ISSN: 3007-6900
DOI: https://doi.org/10.61784/mjet3020

RESOURCE SCHEDULING STRATEGY FOR INTERNET OF THINGS EDGE COMPUTING BASED ON ARTIFICIAL POTENTIAL FIELD ALGORITHM

ZongYang Du
Kwangwoon University, Seoul, South Korea.
Corresponding Email: duzy@kw.ac.kr

Abstract: With the rapid development of the mobile Internet, smart devices are playing an increasingly important role in people's lives. Edge computing is a key technology for solving resource scheduling problems and is of great significance for meeting high-performance user requirements. This paper deeply studies the resource scheduling strategy for Internet of Things edge computing based on artificial potential field algorithm. It analyzes the architecture of edge computing, resource scheduling methods, research problems, and technical methods, and discusses its application scenarios and challenges. Through the introduction of artificial potential field algorithm, the edge computing resource scheduling is optimized to improve system performance and user experience.
Keywords: User experience; System performance; Internet of things; Key technology

1 INTRODUCTION

With the rapid development of the Internet of Things, the data generated by smart devices is massive, which puts forward higher requirements for resource capacity and processing capabilities. The centralized processing mode of cloud computing has limitations in terms of bandwidth, latency, and energy consumption, making it difficult to meet users' high-performance requirements. Edge computing moves services and functions to the user's side, providing users with communication, storage, and computing capabilities. Resource scheduling is the core issue of edge computing and the key to optimizing resource allocation and improving system performance.

2 EDGE COMPUTING ARCHITECTURE

2.1 User Layer

The user layer mainly consists of IoT devices, including drones, networked autonomous vehicles, AR devices, public security surveillance cameras, medical sensors, IoT devices in intelligent manufacturing, smart anti-theft detectors, etc. These devices have sensing capabilities and also possess certain storage and computing capabilities [1]. They can collect various data, process it, and upload it as input for application services (Figure 1).

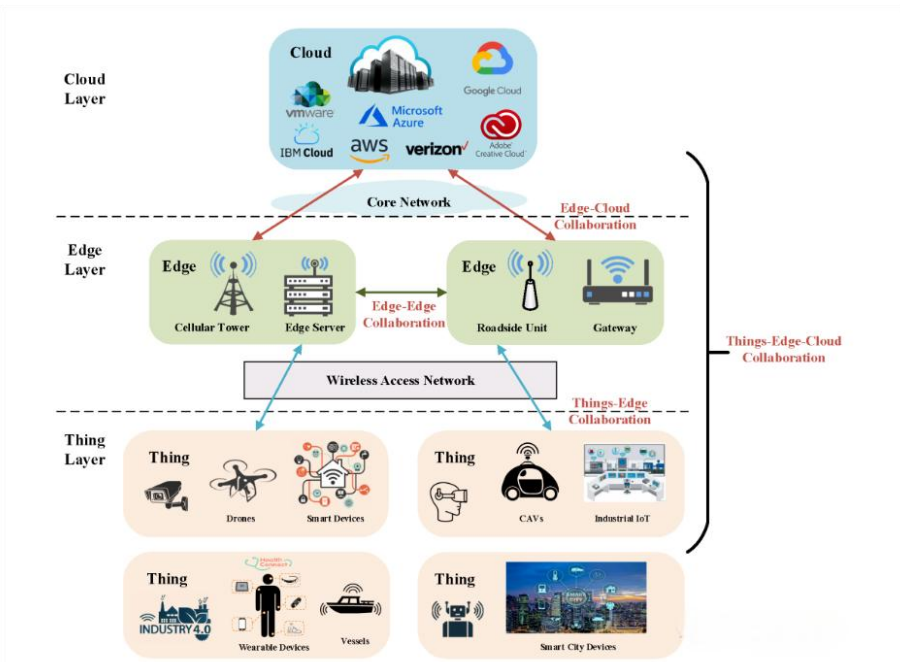

Figure 1 Edge Computing Resource Scheduling Framework

2.2 Edge Layer

The edge layer is widely distributed between the end devices and the cloud computing center and is deployed together with the access points, such as gateway routers, RSU(Road Side Unit) [2], base stations, etc. Edge nodes have strong storage and computing capabilities. They receive, process, and forward the data streams from the user layer, providing services such as intelligent perception, security and privacy protection, data analysis, intelligent computing, process optimization, and real-time control. The edge layer also includes edge manager software, which can perform operations on edge computing nodes through business orchestration or direct invocation to complete tasks.

2.3 Cloud Computing Layer

The cloud computing layer consists of powerful computing centers and storage units. Tasks that cannot be processed by the edge layer and tasks involving comprehensive global information still need to be completed in the cloud computing center. The cloud computing layer provides decision support systems and application service programs in specific fields such as intelligent production [3], networked collaboration, service extension, and personalized customization. The cloud computing layer receives data streams from the edge layer and sends control information to the edge layer and through the edge layer to the user layer, optimizing resource scheduling and on-site production processes from a global perspective (Figure 2).

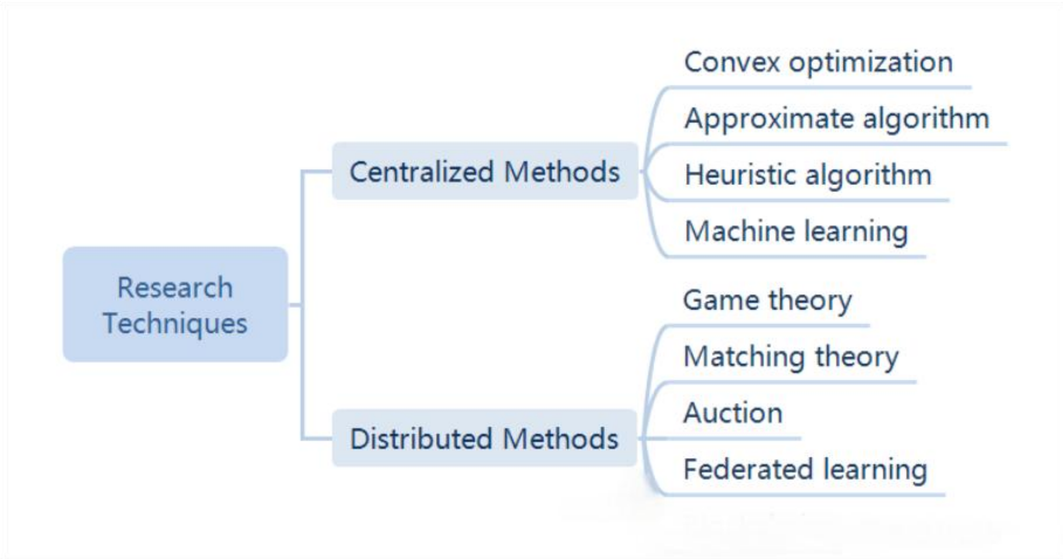

Figure 2 Edge Computing Resource Scheduling Method

3 RESOURCE SCHEDULING COLLABORATION MODES

3.1 "User-Edge" Collaboration

Under this collaboration mode, a close connection is established between users and the edge. Based on their own needs, users offload tasks to edge nodes. Relying on their powerful computing capabilities and abundant resources, edge nodes provide users with efficient processing services [4]. For example, in the smart home scenario, users' smart devices transmit various collected data to edge nodes, and the edge nodes analyze and process the data, such as intelligent control of the indoor environment and equipment status monitoring. In this process, in addition to completing data calculations, edge nodes can also provide real-time feedback to users to ensure that they can have a good experience.

3.2 "User-Edge-Cloud" Collaboration

When users offload tasks to edge nodes, the edge nodes will conduct preliminary processing on the tasks. When encountering complex tasks or when further resource support is needed, the edge nodes will send part of the tasks or data to the cloud center. Relying on its powerful computing capabilities and vast storage resources, the cloud center will conduct in-depth analysis and processing on these tasks. For example, in the field of intelligent healthcare, edge nodes collect patients' health data, which is then transferred to the cloud center after preliminary processing. The cloud center conducts a more comprehensive analysis and diagnosis and then returns the results to the edge nodes [5]. Finally, the edge nodes feed back the results to the users. This collaboration mode realizes the complementary advantages of the edge and the cloud center, providing users with more comprehensive and high-quality services.

3.3 "Edge-Edge" Collaboration

Edge nodes collaborate with each other, share resources, and jointly handle tasks. In this process, each edge node gives play to its respective advantages to achieve optimized resource allocation. For example, in the intelligent transportation system, different edge nodes collect and process traffic data for different road sections. When a node encounters congestion, other nodes can share resources and jointly handle the situation to help this node relieve the congestion. This collaboration mode improves the overall performance and resource utilization rate of edge nodes and ensures the stable operation of the entire system [6].

3.4 "Edge-Cloud" Collaboration

Edge nodes and the cloud center conduct resource scheduling. Edge nodes send tasks to the cloud center, and the cloud center will process the tasks and return the results. In this process, the cloud center provides powerful computing support and resource guarantee for edge nodes [7]. For example, in industrial production, edge nodes send production data to the cloud center for analysis and processing. Based on the analysis results, the cloud center provides optimization suggestions and decision-making support for edge nodes. This collaboration mode enables edge nodes to play their roles better and improves the efficiency and quality of the entire system (Figure 3).

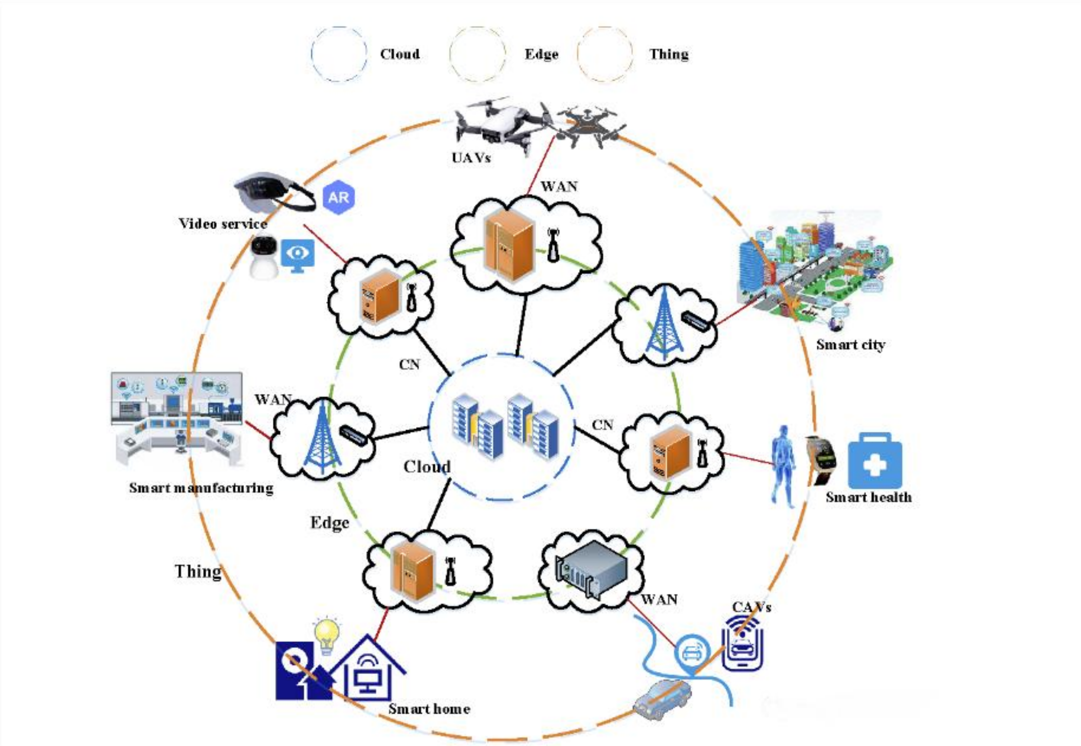

Figure 3 Main Application Scenarios in Edge Computing Resource Scheduling

4 RESEARCH PROBLEMS IN RESOURCE SCHEDULING

4.1 Computational Offloading

Computational offloading is an important part of edge computing resource scheduling, which refers to achieving specific goals through the transfer of computational tasks among different layers. In practical applications, there are multiple levels of interaction in this process. In terms of offloading directions, user-to-edge offloading is the most common way. Users offload their computational tasks to edge nodes and use the computing resources and processing capabilities of edge nodes to complete them [8]. For example, various applications run on mobile devices. When users need to process a large amount of data or perform complex calculations, offloading tasks to edge nodes can greatly reduce latency. Edge-to-edge offloading refers to the transfer of tasks between edge nodes. When an edge node has a heavy load or encounters specific tasks, it can transfer some tasks to other edge nodes to balance the load and improve resource utilization. Cloud-to-edge offloading means that the cloud center offloads tasks to edge nodes. The cloud center has powerful computing capabilities and resources [9]. By offloading tasks to edge nodes, the cloud center can make better use of edge resources and achieve more efficient computing and services. In terms of offloading granularity, full offloading means completely transferring the entire task from one layer to another. This method is suitable for some scenarios that require high computing resources and where tasks are relatively independent. For example, for large data processing tasks, the entire task can be offloaded to edge nodes for processing. While partial offloading is to transfer a part of the task, which is more common in some complex tasks. For example, in a video processing task, the processing tasks of some video frames can be offloaded to edge nodes, and the other parts are processed by the cloud center.

4.2 Resource Allocation

Resource allocation is a key link to ensure the effective utilization of resources in the edge computing system. In the edge computing environment, the rational allocation of resources directly affects the processing efficiency of tasks and system performance. Computing resources are a key part of it. It includes devices such as processors and memory. Computing resources need to be allocated according to the requirements of tasks and the capabilities of edge nodes. For example, for some tasks that consume a large amount of computing resources, such as artificial intelligence model training, sufficient computing resources need to be allocated to edge nodes to ensure the smooth execution of tasks. Communication resources are also an important part of resource allocation [10]. It includes network bandwidth, signal transmission, etc. In the edge computing system, the allocation of communication resources determines the transmission speed and quality of data. For example, in the communication between Internet of Things devices, sufficient network bandwidth is needed to ensure the timely transmission of data. Storage resources are for the storage and management of data. Edge nodes need to store a large amount of task data and intermediate results. The rational allocation of storage resources can ensure the security and effective management of data.

4.3 Resource Configuration

At the service provider level, resource configuration is an active and strategic process. The decentralization of cloud services to the edge means that some services and functions of the cloud center are migrated to edge nodes for the optimization of resource configuration. These are beneficial to the improvement of the service capabilities and response speeds of edge nodes. The optimal deployment of edge servers involves reasonably arranging the locations and performances of servers according to the actual needs and environmental characteristics of edge nodes. For example, the optimized deployment of edge servers in some remote areas or places with poor network conditions can improve the service quality of edge nodes [11]. The allocation of the number of edge resources is also an important link. Resources should be reasonably allocated according to the requirements of tasks and the carrying capacities of edge nodes. Virtual edge resource configuration refers to creating virtual resources according to the needs of different tasks. From the user's perspective, resource configuration is a passive process. It is about the optimal allocation and matching scheme between user tasks and edge resources. For example, when users use edge computing services, they hope to obtain the best resource configuration to meet their own needs. This requires reasonable matching according to the characteristics of user tasks and the status of edge resources. When the task requirements of users change, the resource configuration should also change accordingly [12]. This passive resource configuration method ensures that users can obtain the most suitable resources and services in the edge computing environment.

5 RESOURCE SCHEDULING STRATEGIES BASED ON ARTIFICIAL POTENTIAL FIELD ALGORITHM

5. 1 Principle of Artificial Potential Field Algorithm

The artificial potential field algorithm is simulated from the interaction of objects in a physical field. Its core idea is to describe the state and behavior of objects based on the construction of potential field functions. The construction of potential field functions is particularly important in the context of edge computing resource scheduling. It takes the state of resources and the needs of users as important bases and incorporates factors such as the load situation of resources and the distance from users. For example, for the resources of edge nodes, when the resource load is relatively large, in order to avoid excessive concentration of resources, a potential field function can be established to generate a repulsive force among resources, thus dispersing the load [13]. Meanwhile, if an edge node is relatively close to the user, considering the user's need for a quick response, we can construct a potential field function to generate an attractive force between the resources and the user. This potential field function, which is constructed based on the resource state and user needs, can provide an effective mathematical model for resource scheduling [14].

5.2 Algorithm Implementation Steps

In the process of edge computing resource scheduling, first, determine the parameters of the potential field function according to the initial state of edge computing resources [15]. The parameters of the potential field function directly affect its characteristics. For example, the initial load situation of resources, the distance between resources and users, etc. Then calculate the potential field force of each resource according to the potential field function. This potential field force can be manifested as the attractive or repulsive force between resources.

For example, when there is a load difference between resources, the potential field force will make resources move from high-load areas to low-load areas, so that resources can be evenly allocated. Then, adjust the state of resources according to the magnitude and direction of the potential field force [16]. This includes aspects such as resource allocation and scheduling. For example, when resources have an attractive force, they are scheduled to users, and when resources have a repulsive force, they are also scheduled to users. Finally, repeat the above steps until the purpose of resource scheduling is achieved. This is a dynamic and continuous process, and the potential field function as well as the resource state will be continuously adjusted with the changes in the resource state and user needs.

5.3 Advantages and Application Scenarios

The artificial potential field algorithm has great advantages in edge computing resource scheduling. Firstly, it can quickly respond to user needs [17]. The potential field function can be quickly adjusted when user needs change to achieve efficient resource allocation. For example, during the driving process of intelligent networked vehicles, when the user's needs change, the potential field algorithm can timely adjust resource allocation to ensure the safe driving of vehicles. Secondly, this algorithm can be adjusted in real time according to the dynamic changes of resources. The state of edge computing resources is constantly changing, and the potential field algorithm can monitor these changes in real time and adjust resource allocation accordingly. For example, in video services, as the video content changes and the number of user needs increases, the potential field algorithm can adjust resource configuration in real time to ensure the smooth playback of videos. In addition, the artificial potential field algorithm has good adaptability to complex environments. Whether in the complex urban environment or in the complex scenarios of industrial manufacturing, the algorithm can effectively play its role. For example, in the construction of a smart city, the potential field algorithm can optimize resource scheduling according to the city's resource distribution and user needs [18-19]. It has a wide range of application scenarios, involving drones, intelligent networked vehicles, video services, smart cities, smart health, intelligent industrial manufacturing, smart homes, etc. The potential field algorithm can optimize resource scheduling according to the flight state and mission requirements of drones during their flight process [20]. The potential field algorithm can also reasonably allocate resources according to the user needs and resource status in the smart home scenario.

6 CONCLUSION

This paper has deeply studied the resource scheduling strategy for Internet of Things edge computing based on artificial potential field algorithm. Through the edge computing architecture, resource scheduling collaboration methods, research problems, and technical methods, the application of artificial potential field algorithm in resource scheduling has been analyzed. The artificial potential field algorithm can effectively optimize resource scheduling and improve system performance and user experience. However, in practical applications, there are still many problems that need to be studied and solved. The future development of edge computing technology will provide more opportunities and challenges for resource scheduling in Internet of Things edge computing. We hope that more scholars will engage in the research of edge computing resource scheduling to promote the development and application of related technologies.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

REFERENCE

[1] Hari Prasad Acharja, Sonam Choki, Dorji Wangmo, et al. Development of fog visibility enhancement and alert system using IoT. Cogent Engineering, 2024, 11(1).
[2] Amenu Leta Duguma, Xiuguang Bai. How the internet of things technology improves agricultural efficiency. Artificial Intelligence Review, 2024, 58(2): 63-63.
[3] Basil C E Oguguo, Barnabas C Madu, Anayo David Nnaji, et al. The Predictive Potency of Internet of Things Cybersecurity Technology on Classroom Assessment Practices in Higher Institutions of Learning in Nigeria. SN Computer Science, 2024, 5(8): 1174-1174.
[4] Lingya Zhang. Internet of things vs. factory of things:an evaluation of evolving technologies for corporate sustainable development. International Journal of Electronic Business, 2025, 20(1): 17-33.
[5] Mst Nargis Aktar, Nilanjana Basak, Shuvo Biswas, et al. SPR-Based Fiber Optic Sensor for the Development of Internet of Things (IoT) Technologies. Plasmonics, 2024, (prepublish): 1-11.
[6] Apinan Aurasopon, Thawatchai Thongleam, Sanya Kuankid. Integration of IoT Technology in Hydroponic Systems for Enhanced Efficiency and Productivity in Small-Scale Farming. Acta Technologica Agriculturae, 2024, 27(4): 203-211.
[7] Neerav Sharma, Shubham Bhattacharjee, Rahul Dev Garg, et al. Sustainable management and agriculture resource technology system using remote sensing descriptors and IoT. Geomatica, 2024, 76(2): 100040-100040.
[8] Rehman Shafique Ur, Usman Muhammad, Fernando Yudi, et al. Improving manufacturing supply chain performance:nexus of industrial Internet of Things, blockchain technology and innovativeness. Journal of Science and Technology Policy Management, 2024, 15(6): 1641-1664.
[9] Boyuan Wang, Xiali Shi, Xihao Han, et al. The digital transformation of nursing practice:an analysis of advanced IoT technologies and smart nursing systems. Frontiers in Medicine, 2024, 11: 1471527-1471527.
[10] Ding Dawei, Shankar Achyut. Industrial mechanical equipment fault detection and high-performance data analysis technology based on the Internet of Things. Intelligent Decision Technologies, 2024, 18(4): 3171-3184.

[11] Zhang Zongju, Shankar Achyut. Design and simulation of electronic communication positioning system based on Internet of Things technology. Intelligent Decision Technologies, 2024, 18(4): 3347-3363.

[12] El Jaouhari Asmae, Arif Jabir, Samadhiya Ashutosh, et al. An environmental-based perspective framework:integrating IoT technology into a sustainable automotive supply chain. Benchmarking: An International Journal, 2024, 31(10): 3655-3689.

[13] Valentin Iordache, Marius Minea, Răzvan Andrei Gheorghiu, et al. Integrating Connected Vehicles into IoT Ecosystems:A Comparative Study of Low-Power, Long-Range Communication Technologies. Sensors, 2024, 24(23): 7607-7607.

[14] IoT MVNO Market Growing Trends, Future Outlook, Advance Technology, Global Size, Share And Forecast-2028. M2 Presswire, 2024,

[15] Liying Zhao, Lina Ding. Wireless sensor network based on IoT automation technology application in green supply chain management of automobile manufacturing industry. The International Journal of Advanced Manufacturing Technology, 2024, (prepublish):1-12.

[16] Seetah Almarri, Ahmed Aljughaiman. Blockchain Technology for IoT Security and Trust: A Comprehensive SLR. Sustainability, 2024, 16(23): 10177-10177.

[17] Xueting Yang, Bing Sun, Shilong Liu. Study of technology communities and dominant technology lock-in in the Internet of Things domain-Based on social network analysis of patent network. Information Processing and Management, 2025, 62(1): 103959-103959.

[18] Yasir Ali, Habib Ullah Khan, Faheem Khan, et al. Building integrated assessment model for IoT technology deployment in the Industry 4. 0. Journal of Cloud Computing, 2024, 13(1): 155-155.

[19] Agostino Marengo, Alessandro Pagano, Vito Santamato. An efficient cardiovascular disease prediction model through AI-driven IoT technology. Computers in Biology and Medicine, 2024, 183: 109330-109330.

[20] Ruoqian Yang, Xingfang Peng. Blockchain Technology Marketing Sustainable and Accurate Push System Based on Big Data and Internet of Things. Advances in Computer, Signals and Systems, 2024, 8(7).