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Mass Customization-Oriented Customer Demand Response Service Platform Based on Cloud Computing and Internet of Things

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ABSTRACT The purpose is to establish Mass Customization (MC)-oriented Customer Demand Response (CDR) service platform based on Cloud Computing (CC) and the Internet of Things (IoT). Firstly, the MC-oriented Demand Response (DR) process and the characteristics of CC are analyzed. Secondly, an MC-oriented CDR service platform system based on CC and IoT is proposed. Finally, the edge-cloud collaborative computing method is used to maintain the efficiency and stability of the CC platform, and the proposed method is compared with other state-of-art algorithms to further prove its effectiveness. The results show that the parameters φ and V have a significant impact on the queue size and operation cost. Compared with other methods, the operation cost of the proposed edge-cloud collaborative computing method is relatively low. Thus, the proposed edge-cloud collaborative computing method is more applicable in high-speed and low-speed data; it can also improve the resource utilization of the Data Center (DC) and reduce the operation cost. The research results provide a basis for the establishment of the MC-oriented CDR service platform.

INDEX TERMS Cloud computing, mass customization, Internet of Things, customer demand response.

I. INTRODUCTION

Under the background of economic globalization and informatization, to better adapt to socio-economic development and the transient market environment, enterprises nowadays are upholding the customer-oriented corporate cultures, and many enterprises have adopted informalized management mode [1]–[4]. The progress of the Internet of Things (IoT), Data Mining (DM), Cloud Computing (CC), and Artificial Intelligence (AI) technology have offered a better means for enterprise intelligent management [5]–[8]. As mass-production mode popularizes, more enterprises are striving to provide customized products and services at the cost and efficiency of mass production. That is, for contemporary enterprises to realize Mass Customization (MC), they must provide customers with products and services that meet customers' personalized needs at low cost and high efficiency [9], [10].

The existing MC platforms provided by enterprises are mostly customer demand acquisition platforms, on which customers can freely choose product configuration functions [11], [12]. Yet, these platforms lack genuine customized products or services, which can be well depicted in such situations as customers who are unclear about the provided options or having difficulty making decisions; this is somehow against the initial purpose of MC to meet customers' personalized needs and improve customer satisfaction. The research on MC has been flourishing in both academic and business fields. For example, Dou *et al.* (2021) [13] elaborated on the main technical applications of MC and social IoT systems and listed the key problems for MC-oriented social IoT systems. Turner *et al.* (2020) [14] investigated the influence of consumers' perceived value of collaborative design experience on consumer satisfaction with the experience and loyalty to online MC plans, as well as the influence of consumers' way of thinking in collaborative design experience on their perceived value. Jost *et al.* (2020) [15] studied how the trade-off between uneconomic scale and higher profit margin of manufacturers was affected by the trade-off between customized products and interaction costs of each consumer according to their needs and provided several key insights: firstly, it showed that the interaction of

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marketing and production factors would affect the optimal degree of customization. Secondly, it was found that the degree of customization selected by manufacturers would also maximize consumer surplus. Given the high customization cost, manufacturers were motivated to provide additional standard products at lower prices. In the IoT architecture, Edge Computing (EC) and CC could provide resources and services for IoT applications. Edge cloud computing could be used as a data acquisition module. Through big data analysis, CC output optimized and published working rules (or feedback) to improve the performance of EC. The edge-cloud collaborative computing platform could realize life cycle management and value mining according to the load and Cloud Data Center (DC) nodes [16]–[18].

The above literature analysis indicates that the research on MC mainly focuses on the improvement of enterprise customization ability or Customer Demand Response (CDR) ability and the optimization of product or service customization degree, but there is little research on support tools, such as MC-oriented CDR. Meanwhile, although there are some works of literature on enterprise CDR Decision-Making (DM) systems, the particularity of MC-oriented CDR DM is not considered. The main reason is that the particularity of MC-oriented CDR DM and the required service support are difficult to realize in the general computing environment.

Aiming at the above problems and corresponding demands, this paper designs an MC-oriented CDR service platform based on CC and IoT and proposes an edge-cloud collaborative computing platform to improve the resource utilization of the DC and reduce the operation cost. The research results can provide practical value for the construction of a mass CC-oriented CDR service platform. MC-oriented CDR service platform adopts the structure of Enterprise Service Bus (ESB) to realize Service-Oriented Architecture (SOA). The proposed MC-oriented CDR service platform based on CC and IoT encompasses the business logic layer, presentation layer, service layer, infrastructure layer, and data layer.

Section 1 is the introduction, which describes the research background, research status, and research significance. Section 2 mainly describes the MC mode, analyzes the MC-oriented CDR services, designs the MC-oriented CDR service platform, and introduces the edge-cloud collaborative computing. Section 3 uses the edge-cloud collaborative computing method to maintain the efficiency and stability of CC and compares it with other system algorithms to further prove its effectiveness. Section 4 is the conclusion.

II. MATERIALS AND METHODS

A. OVERVIEW OF MC

Definition of MC differs greatly among scholars, but the core idea is the same. MC is a new advanced mass production mode integrated with the idea of custom-made production. Its goal is to produce and provide customers with personalized products and services at a low unit cost through efficient mass production, and finally, achieve the mutual benefit between enterprises and customers [19], [20]. MC enterprises adopt the postponement strategy. That is, after receiving orders, they will postpone customization activities to realize the seamless connection between products or services and customer needs. Customers are the core of the MC process. They can put forward personalized product demands according to their will and can participate in product design and manufacturing [21], [22].

MC must be realized by the Internet, and the operation modes of Internet-based MC are as follows [23]–[25]:

(1) Customization enterprise-centered MC mode. In this model, the customer communicates directly with the enterprise through the network. When the customer's order is valid, the production instructions of relevant product modules are distributed to various suppliers through the Internet, in which the third-party logistics enterprise is instrumental. Enterprise internal resource allocation is the organic combination of internal departments and internal networks. Enterprise internal resource allocation plays an important role in the whole Supply Chain (SC). The customization enterprise-centered MC mode is shown in Figure 1:

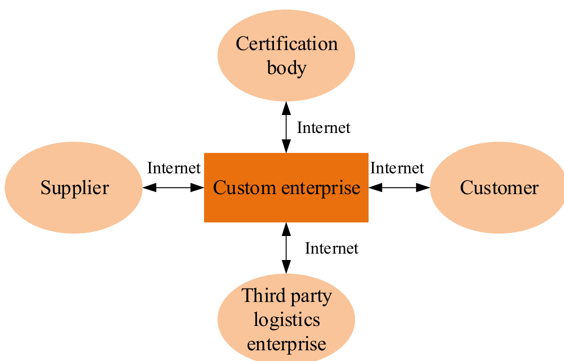

FIGURE 1. Customization enterprise-centered MC mode.

(2) SC alliance-centered MC mode. In this model, specific product type-based enterprises form an SC alliance. Customers can log in to the information processing center managed by the enterprise alliance or a third party. The SC alliance provides a customized network to the information center, on which customers can put forward their personalized demands online, according to which orders can be generated. After the effectiveness of customer orders is confirmed, the information center allocates the bill of materials of products and then sends the production instructions of each product unit to each manufacturing alliance project. Its mode is shown in Figure 2:

(3) Customization agent-centered MC mode. The customization agent is the intermediary between customers and enterprises. Customers can log in to the customization agent website for online product customization; on the other hand, various products can be launched on the customization agent websites according to customer demands; meanwhile, customization information is transmitted to enterprises or SC alliances through customization agents. Customers can

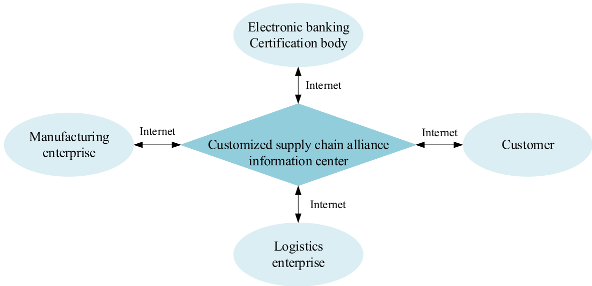

FIGURE 2. SC alliance-centered MC mode.

customize multiple products. Because of customers' strong market influence, customer customization can improve customers' confidence in the quality of customized products but also encourage more new customization manufacturers to enter the customization market. Customization enterprises can focus their resources on the cultivation of core competitiveness. Its mode is shown in Figure 3:

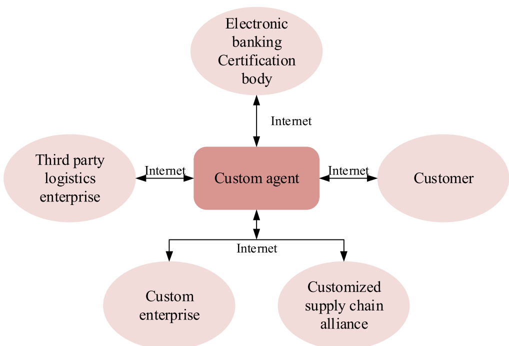

FIGURE 3. Customization agent-centered MC mode.

B. DEMANDS FOR MC-ORIENTED CDR SERVICE

1) MC CUSTOMER DEMAND ACQUISITION METHODS

Generally, there are three ways to obtain customer demands:

(1) Market Survey (MS) [26], [27]: this method is the most basic, which can be either an interview survey or an observation survey. The interview survey method designs a Questionnaire Survey (QS) according to 5W1H and "internal/external" to intuitively express the demand for information, thereby fully mining customers' potential demands to improve customers' personalization and customer satisfaction. An observation (investigation) survey is to observe the situation of the subject and obtain necessary information. The observation investigation method can be subdivided into the observation behavior investigation method and the observation objective thing investigation method. The advantages of the observation method are: the investigation is more objective and effective, without being affected by the subjective bias of investigators; the disadvantage is that the information obtained by the investigators is not very comprehensive, and the real demands of customers might be hard to get.

(2) Enterprise internal database information analysis [28], [29]: this method is to query the internal information of the enterprise through the analysis of basic customer information, such as order records, after-sales service, customer complaint records, and other information.

(3) Web-based customer demand acquisition [30], [31]: this method transmits, exchanges, and interacts with information over the Internet. It breaks through the traditional geographical and spatial constraints and has become the most effective way of communication and understanding between enterprises and customers. Enterprises can obtain customer demand information through the Internet. The Web-based customer demand information acquisition model is shown in Figure 4:

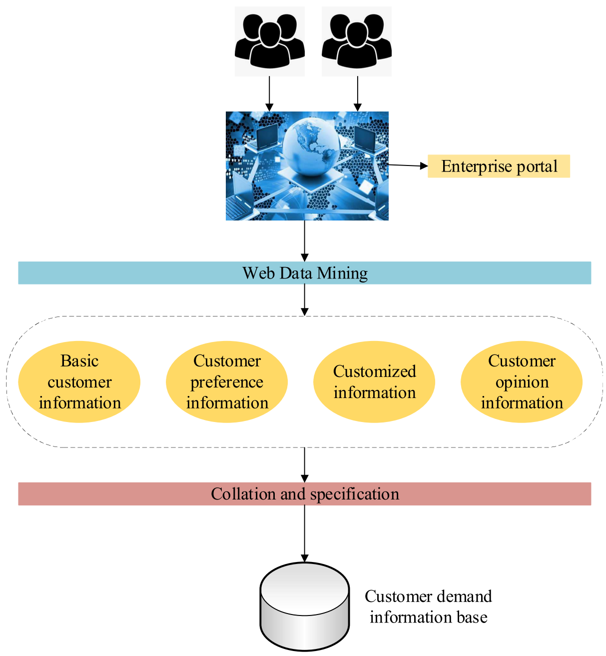

FIGURE 4. Web-based customer demand acquisition model.

2) DEMANDS CLASSIFICATION OF THE MC-ORIENTED CDR SERVICE PLATFORM

a: CUSTOMER DM ORIENTED DEMANDS

Customer DM refers to the customers' expression of their personalized needs through a special DM platform and sending them to enterprises on-demand in the form of orders. The customer has the following demands in the DM process:

In the actual product customization process, without correct guidance, customers can hardly express their personalized needs, that is, the expression forms of product configuration might vary greatly, which will increase the difficulty of customization enterprises in dealing with product configuration demands and, sometimes, causes configuration failure. On the one hand, most customization enterprises require customers to express their needs from the perspective of designers rather than from the customers' standpoint; on the other hand, customers are requested to express their needs by establishing a personalized platform.

Customization Decision Support (DS) encourages customers to express their personalized demands through a customization platform. In the process, the platform might provide some unclear configuration options, from which customers might have no idea how to choose. Thus, there is a need to provide a platform for customer customization DM with good suggestions, which is of great significance to improve customer experience and satisfaction.

Customer needs interaction with the enterprise in the customization process. For example, when some configuration options are unclear, the customer can communicate with the enterprise of the customized project to understand the customer's needs. Through the detailed configuration options and function parameters, the user's personalized demands can be more accurately met. Moreover, customers need to communicate according to their own demands, as well as the needs of the enterprise, which is essentially the problem of whether the product configuration portfolio enterprise can produce on demand; if they cannot, there is a need to change the customization demands of the enterprise in time. MC-oriented CDR service platforms should not only meet the customer demands but also meet the customization enterprise demands. The functions of the MC-oriented CDR service platform for customer DM are shown in Table 1:

TABLE 1. Functions of MC-oriented CDR service platform for customer DM.

Names	Descriptions
Customized guidance	Help customers efficiently express personalized demands that can be recognized by customization enterprises.
Customer customization-aided decision making	Provide auxiliary DS for customer customization
Interaction between customers and customization enterprises	Adjust unreasonable initial demand to make customer demand more accurate and reasonable

b: DEMAND FOR ENTERPRISE DECISION

Enterprise DM refers to the process in which an enterprise verifies the system after receiving design, purchase, production, and delivery demands. Customization enterprises have the following demands in the enterprise DM process:

The platform can review the rationality and feasibility of orders. Customization enterprises provide the platform with product configuration rules and constraint rules between system components, and there is a need for the platform to verify the correctness and feasibility of the system according to relevant regulations to interact with customers. The participation of customers can ensure the final production of products to meet the customer demands.

DM for supplier selection. In general, there are many alternative suppliers. The selection of the appropriate supplier is critical. Customization enterprises need a platform to help them better select suppliers and facilitate spare parts procurement.

Additionally, customers can also participate in the DM process of the enterprise and track the order implementation, during which enterprises can timely control the production according to the customer demands. The enterprise system can also act as a supervision mechanism on the production to ensure the quality of customized products. Therefore, the participation of customers will also help to control the quality of products.

c: COLLABORATIVE SUPPORT DEMANDS

The main beneficiaries of MC-oriented CDR service include customers, customization enterprises, suppliers, and logistics providers. Through the interaction between customers and customization enterprises, various demands can be combined and optimized. In the enterprise DM stage, customers participate in the product design and manufacturing process, and the interaction and cooperation between customers and customization enterprises provide a strong guarantee for the production of customized products. Customization enterprises send purchase orders to suppliers, and suppliers send parts to customization enterprises through logistics. The cooperation between these entities constitutes information sharing, which helps to improve the efficiency of the SC. The relationship between the four entities is shown in Figure 5:

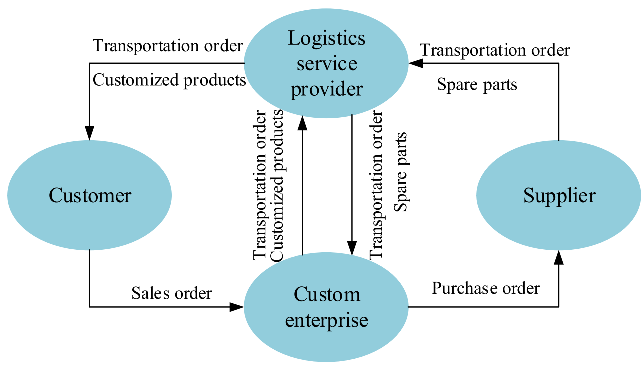

FIGURE 5. Order collaboration among customization enterprises, customers, suppliers, and logistics service providers.

d: PROCESS CONTROL-ORIENTED DEMANDS

Process control is the management and control of the whole process of MC-oriented CDR. Its functions are shown in Figure 6:

C. DEMANDS FOR MC-ORIENTED CDR SERVICE BASED ON CC

The MC-oriented CDR service platform involves huge amounts of calculation. On the one hand, it needs to mine historical data from suppliers to obtain negotiation strategies with suppliers. To obtain better prices, it also needs to carry out several rounds of long-time computer simulation and

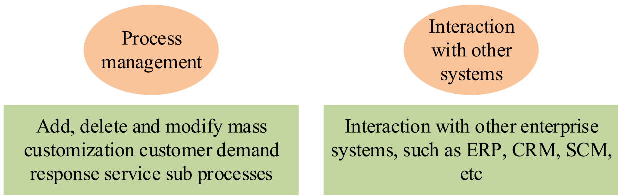

FIGURE 6. Functions of MC-oriented CDR service platform for process control.

cooperate with Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), and Supply Chain Management (SCM), and other systems. Thus, there is a need to establish a hardware platform with strong computing power to support MC-oriented CDR. On the other hand, the main purpose of MC from the perspective of enterprises is to improve customer satisfaction and make more profits, which, however, will increase inevitably costs and investment in information technology infrastructure; these funds might bring more benefits than MC itself. Hence, it is required to meet the functional requirements of enterprises at a low cost. CC technology can effectively solve the above two problems.

(1) The computing power demands. Through the distributed computing technology connecting tens of thousands of high-performance computers and servers, as well as parallel processing, CC can provide "infinite capabilities" in terms of computing and processing.

(2) Costs saving demands include infrastructure construction cost and maintenance cost savings. To respond to the demands of strong computing power and information technology infrastructure, the platform usually has to take into account such devices as high-performance servers, routers, network equipment, which requires extensive human and material costs. By contrast, by applying the CC technology, only a low "rent" has to be paid to meet these demands.

D. DESIGN OF MC-ORIENTED CDR SERVICE PLATFORM

MC-oriented CDR service platform adopts ESB to realize Service-Oriented Architecture (SOA). It is a group of application modules that provide services to the caller through external interfaces, transmit, control, and manage data through internal modules, and contribute to the loose coupling and integration between different applications. The proposed MC-oriented CDR service platform based on CC and IoT includes the business logic layer, presentation layer, service layer, infrastructure layer, and data layer. The specific architecture is shown in Figure 7.

(1) Presentation layer. Its main function is to guide customer customization and assist customer DM. Moreover, it also involves systematic and effective management of commodity orders and customer information, as shown in Figure 8.

(2) Service layer: it uses the ESB architecture to improve the system flexibility and reduce system integration

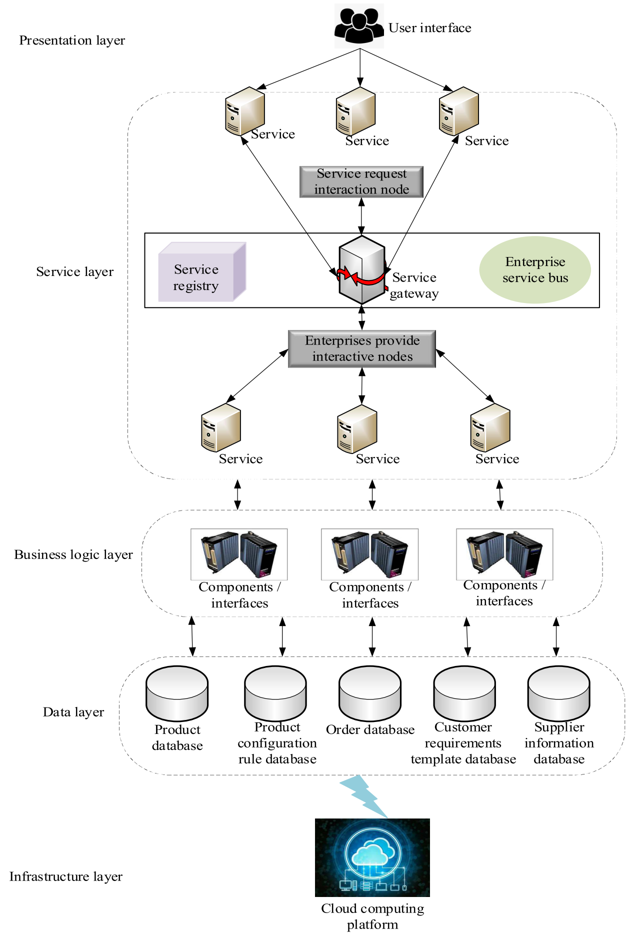

FIGURE 7. Architecture diagram of MC-oriented CDR service platform based on CC and IoT.

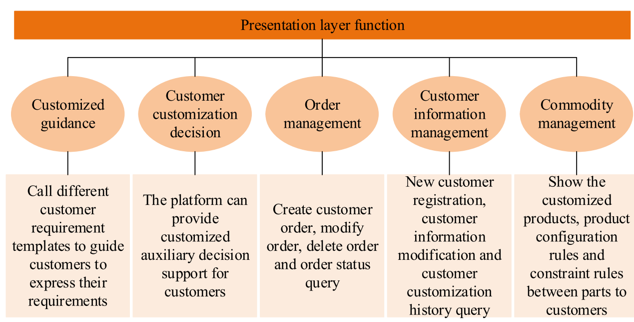

FIGURE 8. Main functions of the presentation layer.

complexity. It is the most critical layer in the whole system. It uses the service adapter to realize the conversion between protocols. When there are new business demands to integrate with other systems, the business requirements of the integrated system are encapsulated into services and sent to the ESB in the form of business requests using the standard SOAP protocol. Therefore, the service layer plays a key role in the CC and IoT-based MC framework and is the key to the realization of MC.

(3) Business logic layer: it is the middle layer to realize the interactive integration of CC and MC. The five subsystems of MC can interact with existing systems.

(4) Data layer. Its main function is to store and manage data, usually, through a relational database. The specific content of the relational database is shown in Figure 9.

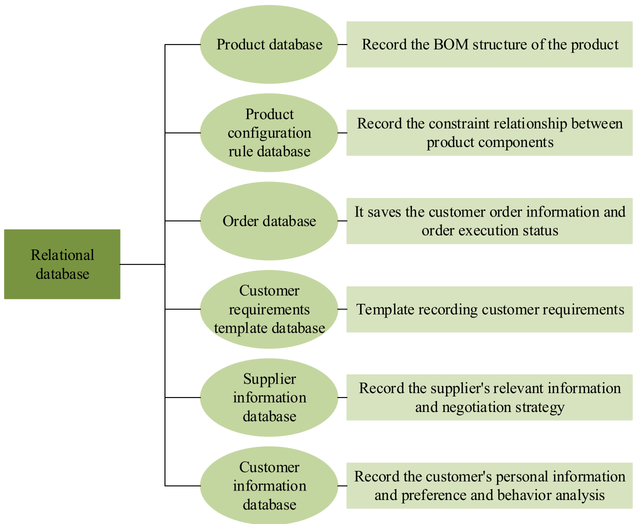

FIGURE 9. Main functions of the data layer.

(5) Infrastructure layer: it is designed to meet the operation demands of the MC service platform. At present, the CC platform mainly includes the public cloud and private cloud. Public cloud is similar to Ajax and SaaS. Some large enterprises can establish their own cloud that is exclusively controlled by themselves.

E. EDGE-CLOUD COLLABORATIVE COMPUTING

The algorithm is optimized to reduce the energy consumption and operating costs of service providers and maintain the efficiency and stability of the CC platform. Edge-cloud collaborative computing is introduced: edge nodes collect data and dynamically allocate them to the cloud center that analyzes and processes the received data.

$P_j(t)$ represents the energy consumption of DC j in time slot t, and the modeling can be expressed as Eq. (1):

$$P_j(t) = n_j(t)\left[\rho\left(\upsilon_j(t) - \upsilon_j^{\min}()^{\theta}_{\min}\right)\right] \tag{1}$$

In (1), $n_j(t)$ is the number of active servers in the DC j; ρ represents the slope that the power consumption increases with the increase of CPU frequency; $\upsilon_j(t)$ denotes the actual frequency of CPU; $\upsilon_j^{\min}$ refers to the minimum frequency of CPU; $P_{\min}$ stands for the power consumption in idle condition; θ means the experimentally measured constant, and, generally, $\theta = 2$.

The energy consumption cost $E(t)$ of the cloud DC can be expressed as Eq. (2):

$$E(t) = \sum_{j\in D} E_j(t) = \sum_{j\in D} \varphi_j(t) P_j(t)\,\tau \tag{2}$$

In (2), $E_j(t)$ is the energy consumption cost of DC j in t slot; $\varphi_j(t)$ represents the price of unit energy consumption of DC j in t slot; $P_j(t)\tau$ indicates the total energy consumption of DC j in t slot.

$Q_j(t)$ is a backlog queue, the amount of data backlog in this queue will change with time, as shown in Eq. (3):

$$Q_j(t+1) = \max\left[Q_j(t) - \lambda_j^d(t) X_j(t), 0\right] + \sum_{i\in\Re} \mu_{ij}(t) \tag{3}$$

$X_j(t)$ is data processing capacity; $\lambda_j^d(t)$ represents the proportion of time that the CPU processes the original data in time slot t.

The DC j updates a backlog queue $R_j(t)$, which can be expressed as in Eq. (4):

$$\begin{aligned} R_j(t+1) &= \max\left[R_j(t) - \beta\cdot\lambda_j^{\Gamma}(t) X_j(t) - \sum_{k\in D\backslash j} r_{jk}(t), 0\right] \\ &\quad + \sum_{k\in D\backslash j} r_{kj}(t) \end{aligned} \tag{4}$$

$\lambda_j^{\Gamma}(t)$ is the time proportion of CPU aggregation to processing of temporary results; $r_{kj}(t)$ means the opposite migration direction; $r_{jk}(t)$ denotes the amount of data migrated in the time slot t from DC j to k; $\beta\cdot\lambda_j^{\Gamma}(t)$ stands for the resultant synthesis rate.

The link price of 1GB data routed from DC k to DC j is represented by $\eta_{kj}(t)$ where $k, j \in D$, and $k \neq j$, then the cost required for DCs to migrate to each other can be expressed as in Eq. (5):

$$M(t) = \sum_{j\in D}\sum_{k\in D\backslash j} \eta_{kj}(t)\, r_{kj}(t) \tag{5}$$

Then, in the time slot t, the cost $F(t)$ generated by the edge layer can be expressed as in Eq. (6):

$$F(t) = \sum_{i\in R}\sum_{j\in D} k_{ij}(t)\,\mu_{ij}(t) \tag{6}$$

If a queue $G_i(t)$ is maintained by fog node i, the amount of data accumulated in this queue will change with time, as shown in Eq. (7):

$$G_i(t+1) = \max\left[G_{i(t)} - \sum_{j\in D} \mu_{ij}(t), 0\right] + A_i(t) \tag{7}$$

The edge-cloud collaborative computing platform must be stable. Therefore, it is necessary to set a boundary on the sum of the time average queue size on the DC and the edge gateway, which is specifically expressed as in Eq. (8):

$$\bar{Q} \triangleq \lim_{T\to\infty} \frac{1}{T} \sum_{t=0}^{T-1} \left\{ E\left[\sum_{i\in R} G_i(t)\right]\right.$$

$$+E\left[\sum_{j\in D}\left(Q_j(t)+R_j(t)\right)\right]\Bigg\} < \infty \quad (8)$$

$C(t)$ represents the total cost for data processing at time slot t of edge-cloud collaborative computing platform, and it is expressed as in Eq. (9):

$$C(t) = F(t) + M(t) + E(t) \quad (9)$$

$x(t)$ is used to collect all variables to be optimized at time slot t, which can be expressed as in Eq. (1):

$$x(t) = \left\{\mu_{ij}(t), r_{kj}(t), \lambda_j^r(t), n_j(t), \upsilon_j(t), \forall i,j\right\} \quad (10)$$

If X is used to collect the variables to be optimized in all time slots, the calculation of the cost minimization problem of the edge-cloud collaborative computing platform reads:

$$P1: \min_X \overline{C(x(t))} \quad (11)$$

$$C1: 0 \le \mu_{ij}(t) \le U_{ij}(t), \quad \forall i,j,t \quad (12)$$

$$C2: \lambda_j^d(t) + \lambda_j^\Gamma(t) \le 1, \lambda_j^d(t) \ge 0, \quad \lambda_j^\Gamma \ge 0, \ \forall j,t \quad (13)$$

$$C3: X_j^{\min} \le X_j(t) \le X_j^{\max}, \quad \forall j,t \quad (14)$$

$$C4: \overline{Q} < \infty \quad (15)$$

In Eqs. (11)-(15), constraint C1 ensures that the amount of data transmitted from the edge gateway i to the DC j is within the range of link capacity requirements; Constraint C2 ensures that each DC can be safely and effectively allocated with the CPU time; Constraint C3 ensures the real-time processing rate within the allowable range; Constraint C4 ensures the stability of all queues. The proposed algorithm can be extended and run on two different time scales, that is, based on multi-time scale technology, the DC uses the slow time scale to change CPU frequency and uses the fast timescale to accept, process tasks, and deliver processing results.

III. RESULTS AND DISCUSSION

A. PARAMETER INFLUENCE ON ALGORITHM PERFORMANCE

The impact of parameter V on queue size and operation expenses is shown in Figure 10.

Figure 10 illustrates that the influence of parameter V on queue size and operation cost is significant. With the increase of parameter V, the average queue size will also increase significantly, while the average operation cost will gradually decrease. Therefore, specific demands can be achieved by selecting the appropriate parameter V.

Figure 11 demonstrates the influence of parameter φ on queue size and operation cost.

As shown in Figure 11, the influence of parameters on queue size and operation cost is significant. With the increase of parameters φ, the average queue size and average operating cost will increase significantly because the working frequency of the CPU drops with the increase of partner φ.

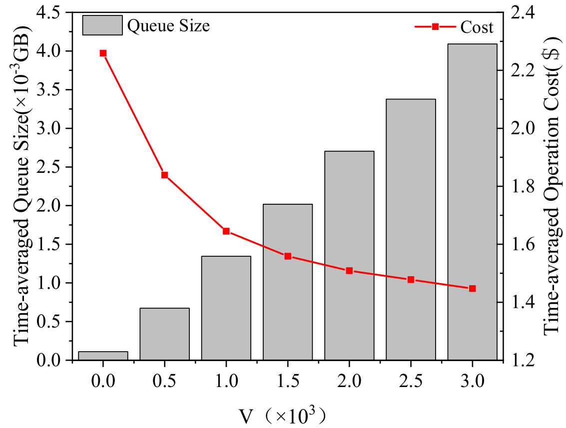

FIGURE 10. Influence of parameter V on queue size and operation cost.

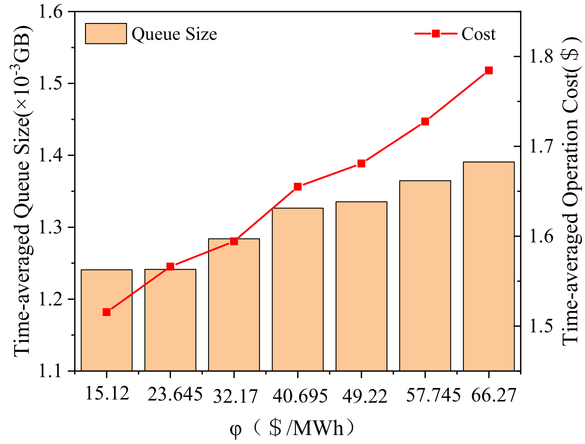

FIGURE 11. Influence of parameter φ on queue size and operation cost.

B. PERFORMANCE COMPARISON OF DIFFERENT METHODS

Subsequently, the proposed edge-cloud collaborative computing method is verified through the comparative analysis with the combined algorithm from the Random Date Dispatch (RDD), Minimum Link Cost (MLC), Queue Date Dispatch (JSQDD), Minimum Migration Cost (MMC), Join-the-Shortest-Queue Aggregation Selection (JSQAS), and Stable Resource Provision (SRP); the performance of different methods with the data arrival rate μ is shown in Figures 12-15.

Figure 12 reveals that the proposed edge-cloud collaborative computing method has high-cost performance compared with other methods because the parameter V has been adjusted in the early stage; thus, given a constant overhead, a more flexible throughput can be obtained.

As presented in Figure 13, when μ increases, the throughput of the edge-cloud collaborative computing method also increases and then slowly stabilizes. By comparison, when μ passes over 2, the throughput of other calculation methods begins to stabilize and stops changing with time μ due to limited bandwidth; that is, the DC cannot process the data of the

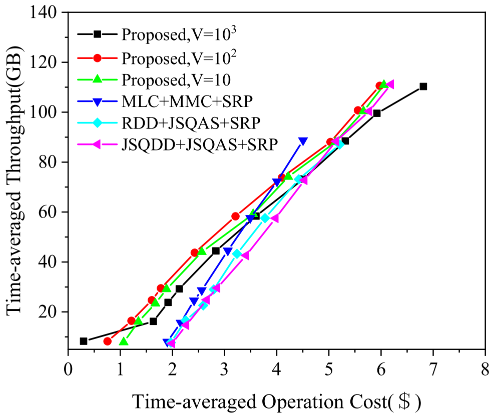

FIGURE 12. Cost performance (ratio of throughput to cost) comparison.

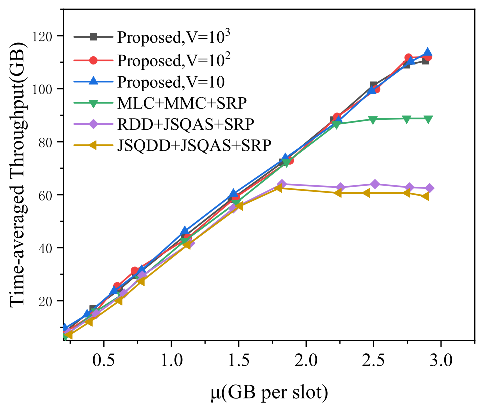

FIGURE 13. Influence of parameter μ on time-averaged throughput.

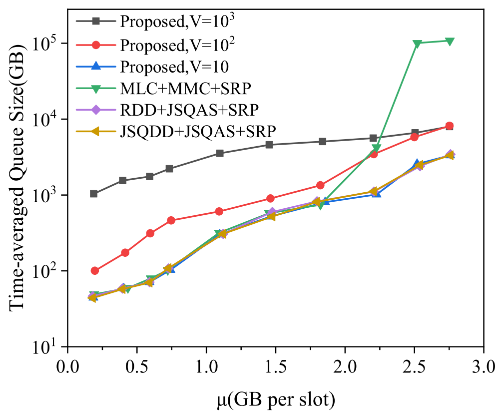

FIGURE 14. Influence of parameter μ on the time-averaged queue size.

edge gateway timely and effectively under other calculation methods.

As depicted in Figure 14, as μ increase, the average queue size of all the methods gradually increases. Yet, compared with other methods, the average queue size of the proposed edge-cloud collaborative computing method is relatively long.

As signified in Figure 15, compared with other methods, the operation cost of the proposed edge-cloud collaborative

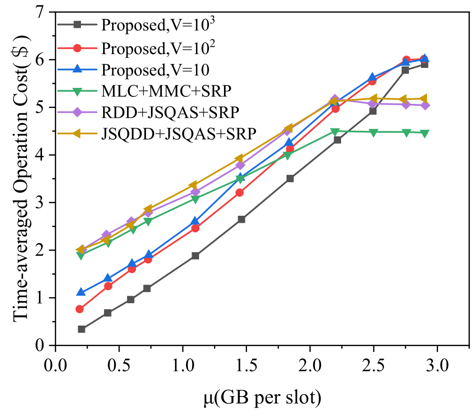

FIGURE 15. Influence of parameter μ on the time-averaged operation cost.

computing method is relatively low. When $\mu < 2.26$, the operating cost of JSQDD + JSQAS + SRP method is the highest. This is mainly because the edge gateway will directly transmit the collected data to the DC with the smallest load timely without considering other factors, such as link cost.

Therefore, the proposed edge-cloud collaborative computing method applies to both high-speed and low-speed data, can improve the resource utilization of the DC, and reduce the operation cost. This is probably because the edge-cloud collaborative computing method can improve the data distribution and scheduling, and it considers the configure ability of DC resources.

IV. CONCLUSION

CC and the IoT can provide excellent technical support for MC applications. Based on the demands of MC customers, this paper analyzes the MC Demand Response (DR) process and the characteristics of CC; then, an MC-oriented CDR service platform is proposed based on CC and the IoT, and the edge-cloud collaborative computing method is adopted to reduce the energy consumption and operation cost of service providers and maintain the efficiency and stability of CC platform. The results show that the parameters φ and V will have a significant impact on the queue size and operation cost. The proposed edge-cloud collaborative computing method is more applicable to both high-speed and low-speed data. The proposed method can also improve the resource utilization of the DC and reduce operating expenses. The results provide a basis for the establishment of the MC-oriented CDR service platform. The deficiencies of this research are summarized as follows: the proposed algorithm is only optimized at the same scale, while in practical application, the IoT devices have many random and dynamic factors. In the follow-up study, more in-depth research will be conducted on the proposed algorithm to run on different time scales, and AI will also be used to improve data processing efficiency. Meanwhile, the proposed MC-oriented CDR service platform based on CC and IoT does not interact with Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), or other enterprise systems, which needs to be further studied; lastly, CC is the current research hotspot, but cloud security is not considered enough in the current research.

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