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Fuzzy Controlled Resource Management Strategies Resource Planning in Fog Calculation

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Abstract

One of the critical features of fog computing is the distribution of resources. This ensures that the resources in the system are effectively managed and used. This, in turn, increases performance and efficiency in the system and improves the user experience. In addition, fog computing can be useful in areas that require maximum network performance, such as broadcasting applications in real-time, integrating with sensor networks, and the Internet of Things. However, the reliability of the Internet infrastructure is of great importance for the reliability and efficiency of these systems. Fog computing is similar to cloud computing; there are also important differences. One of these differences is that data subjects can manage and respond to users more quickly. This article introduces a resource management for fog calculation. The results show that the proposed method improves resource management, efficiency, and service quality of cloud computing. This situation supports that the adoption and use of fog computing is the right decision. Fog computing increases the performance of cloud computing systems and improves service quality by enabling resources to be managed more effectively. This, in turn, provides a better experience for users and helps businesses gain a competitive advantage. These results may encourage the increasing preference and adoption of fog computing.

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INTRODUCTION

The Internet of Things (IoT) and Cloud Computing are rapidly evolving and complementary technologies today. Cloud computing is a model that allows users to access various services over the internet and shares computing resources. This model allows users to access resources in an on-demand and scalable way. Cloud computing makes it possible to provide various services such as making these resources available to the user, storage, processing, and data analysis. IoT, on the other hand, stands for the internet of things and means that all kinds of objects connect to the internet and communicate with each other.

It is used in various fields such as IoT devices, sensors, smart home devices, industrial equipment. These devices often generate large amounts of data and require cloud computing infrastructure to store, process, and analyze this data. Cloud computing provides an ideal platform for storing, processing, and analyzing the data collected by IoT devices. In this way, IoT applications can work more efficiently and reach wider audiences. Therefore, cloud computing and IoT are increasingly being adopted as technologies that complement each other and work together (Malik & Om, 2018).
Internet of Things (IoT) technology is a technology that significantly impacts daily life and provides many benefits. However, the widespread use of this technology has brought with it a number of security risks. IoT devices are often connected to the internet, and they provide online services. This, in turn, potentially exposes them to cyberattacks and vulnerabilities. For example, it is possible for malicious people to infiltrate IoT devices and control them. In addition, the confidentiality and integrity of sensitive data collected by IoT devices is also under threat.

Therefore, it is important to develop and maintain a secure IoT ecosystem. This requires a systematic and holistic approach. This approach involves identifying potential security threats, assessing risks, and implementing appropriate security measures. Cybersecurity research provides the basis for designing and implementing security measures that can address such risks. These investigations are important for identifying new vulnerabilities and testing and improving security measures. In this way, the security of IoT devices and connected systems can be increased and the protection of users' information can be ensured (Tariq et al., 2023).

Although a significant number of domain names are used in the field of cloud computing, some new problems have arisen with the development of the Internet of Things. The diversity and latency sensitivity of IoT systems may cause cloud computing infrastructure to not fully respond to these new demands. In addition, the requirements of location-aware applications can also put a strain on cloud computing infrastructure.

In particular, in cases where data from IoT devices needs to be processed and responded instantaneously, the problem of latency may arise. Cloud computing typically processes data centrally in high-power data centers to minimize such delays. However, for some IoT applications, this centralized approach may be insufficient and may incur local processing and storage requirements. In addition, optimizing cloud computing applications for IoT can be challenging in terms of design costs. IoT devices may have constraints such as low power consumption, low cost, and limited processing power. This can increase the adaptation of cloud computing services to these devices and increase design costs.

According to IDC's predictions, IoT devices will generate an incredible amount of data in the next five years. According to this estimate, a data amount of 79.4 zettabytes is projected. Some of this IoT data has been described as "compact and abnormal". This includes, for example, relatively short updates provided by devices such as sensors or smart meters. In addition, devices such as security cameras with built-in computer vision can also generate large amounts of data (Das et al., 2022; as cited in Tariq et al., 2023:2).

According to IDC's predictions, the amount of data generated by IoT devices will increase rapidly in the coming years. The report suggests that video surveillance, which is currently in the leading position in data generation, but other industries and medical applications will soon overtake it. It is also envisaged that interconnected drones with on-board cameras will be an important data collection tool. Data from a wide range of sensors, including audio, video, and custom automotive sensor data, will be generated by autonomous vehicles in the near future, further increasing the amount of data. This could lead to a huge increase in demand for data analytics and storage systems, and may also require more measures to be taken in terms of data security and privacy (Das et al., 2022; as cited in Tariq et al., 2023:2). However, managing this amount of data traffic with traditional cloud computing approaches can be challenging. The constant and large amount of data coming from IoT devices can cause delays and bottlenecks in computer systems. This can overwhelm the capacity of data centers and negatively impact performance. With the rise of Industry 4.0, the world is currently experiencing the effects and changes of the fourth industrial revolution. Industry 4.0 refers to the integration of digitalization, automation, internet of things (IoT), artificial intelligence, big data analysis, and other advanced technologies into production processes. However, some experts and industry leaders believe that Industry 4.0 should be followed by the fifth industrial revolution, or Industry 5.0.

Industry 5.0 refers to a period in which cooperation between humans and machines is increasing. This is an era where the human touch and human skills play an important role in production processes. The focus of Industry 5.0 is to create more flexible, personalized and sustainable production models by leveraging people's emotional intelligence, creativity and collaboration capabilities. This marks an era in which robots and other automation technologies work in harmony with humans. Therefore, with the rise of Industry 5.0, businesses and industries will have opportunities and challenges to reshape their production processes and adopt human-centered approaches. This is seen as part of the future industry transformation (Raja & Muthuswamy, 2023). Industry 4.0 refers to a manufacturing approach with digital prototypes and components. This approach allows many devices such as mobile robots, chain drives to be used to start production at every stage. Fog devices, on the other hand, play an important role in this process. Each fog device uses sensors to gather information about the situation in real-time and then analyzes that information to identify false alarms and exceptions.

Each device can access sensor data to a high-performance cloud service to minimize the impact of hardware failures. This allows devices to transmit their instant data to the cloud and to analyze this data quickly. On a server, this data is examined in real-time and appropriate actions are determined. These actions can include migrating to a backup repository, checking for alerts, or identifying situations where maintenance professionals need to intervene. Fog computing can quickly predict failures. For example, the detection data sent by the automation can be examined under virtual situations and the relevant maintenance personnel can be notified immediately. This helps to avoid a potential failure during the production process and allows the systems to operate more reliably and continuously. This type of system can improve reliability in industrial production and increase the efficiency of enterprises. Through continuous monitoring, rapid response, and automated response capabilities, potential problems in the production process can be minimized and productivity can be increased. This, in turn, can improve quality and provide a competitive advantage while reducing costs.

Automation, networking, and storage resources are offered to sensors that require cloud services and can solve problems instantly. These systems are integrated through cloud computing and fog computing infrastructures. Different devices transmit sensor data to neighboring fog nodes. These fog nodes detect incoming data, analyze it, and determine appropriate actions. However, existing fog nodes often have limited data analysis, networking, and storage resources. In some cases, this may result in limitations in data processing and analysis. Therefore, it may be necessary to incorporate more components into the fog environment to improve the efficiency of the system and perform more complex analyses.

This context, FD (Fog Device) components play an important role. FD components can perform a variety of calculations, filter data, and provide labels to data. This allows fog nodes to perform more complex data analysis and gain a richer insight. For example, it can detect unsuitable objects and take warnings or measures regarding these objects.

FDs provide resources for programming interfaces as Micro Data Centers (MDCs). MDCs improve resource efficiency to optimize the deployment of compute components (CCs) into process modules. This makes more efficient use of resources in the system and improves performance. Resource scheduling in fog computing defines the resources in a given exchange into components. This ensures that the system operates in a balanced manner and ensures that resources are distributed efficiently. However, if a fog design has more than enough resource management and components, resource allocation can be a difficult issue. Therefore, it is important to allocate and manage resources correctly. Quality of Service (QoS) parameters form the basis of resource allocation. These parameters determine the utilization and performance of resources in the system. Determining the correct QoS parameters can improve the stability and efficiency of the system.

This article provides a dynamic resource management process based on the idea of a fuzzy logic controller. This research reveals the following findings, as it observes:

(1) A resource management system fog calculation.

(2) A resource requirement method plays an important role in long and continuously available resources.

(3) In the process of resource development, Fuzzy logic control methodology is introduced to determine resource scheduling. The theory classifies users' requirements and resources into various resource sets and user-friendly production technology, significantly improving QoS for cloud computing reliability.

Related Work

Bonomi et al. (2012) presented an economic model of fog informatics. In this model, fog computing provides a virtual server service between the classic cloud computing network infrastructure and terminal devices, providing compute, networking, and storage providers. This aims to provide a faster and more local service while reducing the reliance of terminal devices on the cloud. Research shows that fog computing focuses on areas such as layout, architectural design, and management of resources. Building on previous studies, Vaquero et al. (2014) described fog computing as a type of state in which interconnected and decentralized devices can communicate and possibly cooperate. This emphasizes that, unlike the centralized structures of cloud computing, fog computing has a distributed and flexible structure. This definition helps us understand the characteristics and potential of fog computing. Fog computing can enable fast and effective communication between devices, especially in areas such as IoT, increasing efficiency and opening the door to new application areas. Therefore, research on fog computing helps to better understand the developments in this field and to fully unlock the potential of this technology. Network issues based on real-time user experience scheduler focuses on solving network problems to optimize user experience. The fault-tolerant task routine includes spot VMs and other strategic planning to ensure uninterrupted operation of workloads. Genetic algorithms are structured to improve resource management and efficiency of processes. A cluster-based coalition game has been proposed to optimize network performance in fog-filled access networks. This mission approach was created based on the specifics of fog resource management. The proposed algorithm, in combination with a specific fog computing computer system, can be significantly larger than static application methods, along with some of the above data analysis resource allocation mechanisms. Masmoudi et al. (2013) analyzed the fuzzy modeling studies of the challenge control triggered by the fuzzy business model and proposed a technique that would provide uncertainty at all stages of the modeling techniques development and solution finding protocol. The process is used for the maintenance of civil-military aircraft and has been successful.

Factors such as cost, bandwidth, and completion times, which are standard QoS (Quality of Service) requirements, are important, but some extended QoS features, such as system friendliness and user interface, cannot be ignored. These advanced QoS requirements are an important part of implementing cloud computing correctly, as they play a role in maintaining the challenging behavior of several participants for a customer. Depending on the complexity of the work, erroneous claims may be developed. Meeting such fluid requirements is a prime example of cloud computing. This highlights the flexibility and efficiency of cloud computing, as well as its ability to adapt to variable and complex workloads. It also shows that extended QoS capabilities are critical to improving the customer experience and improving the quality of service. Therefore, it is important to consider such features in the design and implementation of cloud computing services.

System Model

The received data is processed in Figure 1 or sent to the cloud. Fog devices and unique products demonstrate this. An MDC that detects, sences, and stores data received from sensors is a fog device.

The fog device features encompass a million instructions per second (MIPS), RAM, throughput, frequency band down, route level number, MIPS level, authority in the busy scenario, and stagnant energy. Including anchors as {$Anchor_1$, $Anchor_2$,…,$Anchor_n$}, each fog device. The features of an anchor include RAM, Bandwidth, storage, and Computer Components (CC).

$$FB_{Low} \leq \sum_{i=1}^{N} AB_i \leq FB_{High}$$

where,

FB - Bandwidth of Fog Computing

AB - Bandwidth of Anchors

FB_{Low} – Lower Bound of Bandwidth

FB_{High}- Upper bound of Bandwidth

AB_i - i^{th} Anchor Bandwidth

N - Sum of Anchors

The overall Bandwidth of all anchors in individually fog device is between FB_{Low} and FB_{High}. CC of anchors is assigned and performed with fog nodes to software modules. MIPS is the primary component in a CC. The significance sets for all fog node at the beginning of the procedure. The combined granted MIPS of all CCs is verified after a CC is assigned to a control system application.

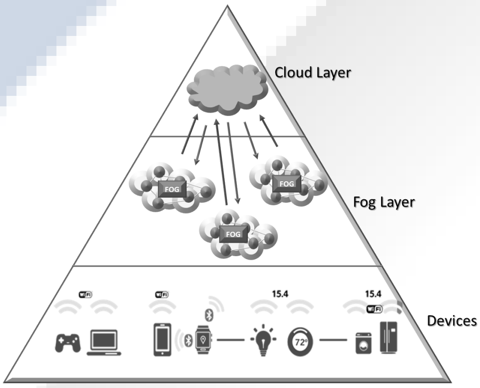
Thus, we have $CGM = \sum_{i=1}^{N} \sum_{j=1}^{M} CEM_{i,j}$, where CGM is the combined granted MIPS of a fog device that is <= to MIPS of that fog device ($CGM \leq FDMIPS$), and CEM is the CC's MIPS.

N - *Number* of Anchors

M - Number of CCs in an Anchor

$CEM_{i,j}$ - MIPS of j^{th} CC in i^{th} Anchor

The application module is a type of VM. The MIPS Properties of the configuration also provide MIPS, size, Bandwidth, and percentage of the CCs properties to cooperate. In each fog device, the simulation time is significantly higher than the CCs. In fact, $\sum_{i=1}^{C} Module_i > \sum_{j=1}^{K} FD_j$, where C is the overall number of elements, and K is full of fog devices.



Model of User Entity

The client is the entity that rents cloud storage by threshold and problem to solve confirmation. The user settings can be shown as $Users = \{U_1, U_2 \ldots U_m\}, U_i$ The following six tuples can be highlighted as a service attribute that owned the cloud

$$U_i =< U_{ID}, U_{Name}, USL, U_{Jobs}, U_{Pos}, U_{Sec} >$$

U_{ID} - Cloud Services User Entity Tag for CSP

U_{Name} - Friendly classification of the User Entity

USL - Level of User Service

SL - Service Level

$SL = \{Tier\ I, Tier\ II, Tier\ III\}$ Criteria for the user's billing tasks.

U_{Jobs} - Collection of the task request and a collection of the job. Identify the user's location

U_{Sec} - Level of security of user data has been mentioned

Model of Task

In addition, goals are set to characterize the task model: Parallel function with several jobs to interact with on a regular basis. Each activity controls the virtualization resources. To verify that all activities in the program have been carried out, to avoid the work component and to reduce the cost of energy. The tasks introduced are being exposed $Tasks = \{Task_1, Task_2 \dots Task_n\}$, $task_t$ can be exposed by the subsequent tuple:

$$< T_{ID}, T_{Type}, T_{Len}, T_{Res}, T_{ART}, T_{AWT}, T_{Tasks} >$$

T_{ID} - Unique Value of $Task_t$

T_{Type} – Classification of j#obs

$$T_{Type} = \{Small \mid T_{Len} \in [0, Max - 1]\}, T_{Type} = \{Large \mid t \in [Max]\}$$

$T_{Len} = |t_{tasks}|$ Job Length

T_{Tasks} – Set of Tasks in lively, $T_{jobs} = \{Job_1, Job_2, \dots Job_k\}$

T_{Res} - Minimum Set of Resources

To study process cost and delivery, we can use the term "t-art" to symbolize limitations and business process. It refers to the Average Response Time of the job, that is, the time from the job planning line to the exit line. The job's Average Wait Time, on the other hand, represents the time it has taken since the job arrived on the planning line to activate the line. Calculating these times is important for assessing the efficiency and effectiveness of the workflow.

Model of Resource Management

Computational and storage managements are managed and configurable (e.g., networks, servers, storage, etc.).

Model of Resource Management demonstrations $Resource = \{R_1, R_2, \dots rR_p\}$, resource total number $P = |Resource|$, $_k$ is the following tuples:

$$R_k = < R_{ID}, R_{Supply}, R_{Type}, R_{Comp}, R_{Mem}, R_{Stor}, R_{IO}, R_{Net}, R_{Pos} >$$

R_{ID} —Unique Resource ID

R_{Supply} - Resource's Provider

R_{Type} – Type of Resource

R_{Comp}-The processing Volume of Resources

R_{Mem} - Availability of Memory Management

R_{Stor} - Storage Size of resources

R_{IO} - IO Size

R_{Net} - Bandwidth

R_{Pos} – Information Geographical Position

Resource Scheduling Algorithm Design

The resource index in the development process is significantly reduced after a logical division of fog resource management. The characteristics of user groups can be divided into the following classifications. Primary users are linked to resource management in the class after searching for the appropriate resource classification. This plays an important role in the process of accessing and using the system's resources.

To complete the resource schedule, this article utilizes minimal weight interaction to reach it.

$$Rank = Total\ (Result\ (Req_i - Rset_i\ ) * \text{Weight}_i\ )/\text{Total}\ (\text{Weight}_i\ )$$

Where,

Req_i represents the attribute of the user's needs,

Res_i represents the attributes of the resources, and

Weight_i represents the weights of the attributes

Figure 2 shows the speed at which the CPU is executed on many edge machines. Represents the FRSFC schedule to host available resources to associate connected devices based on the length of the activities. If the task length is longer, the application speed of the virtual machine increases.

The resource sequence-dependent setup pseudo-code for Fuzzy Control (FRSFC) Method Fog resource management resource allocation is as shown in:

Algorithm 1: FRSFC

Input: Resource Set $\{Rset1, Rset2, \ldots, Rsetm\}$, Job Set $\{Job1, Job2, \ldots, Jobn\}$, n,φ, M

Output: Ranking, Similarity Result

1: Process the Original Data

2: Perform the Resource Clustering on Resource Set

3: RConRS $(M, L) \rightarrow$ *User* and Resource Clusters

4: *Res (s)*=size(R)

5: U = RConRS(m)

6: **Do Until Test < 1**

7: $Test \leftarrow Test + 1$

8: $x^J \leftarrow x$

9: Process xn

10: **For** $l = 1 \rightarrow l$ **Do**

11: **For** $j= 1 \rightarrow m$ **Do**

12: Space (k, i) = Sp (Info $(j, :)$

13: **End**

14: **End**

15: Measure x^J

16: **If** Result $(x^J - x, \text{data}) < \varphi$ **Then**

17: Break

18: **End If**

19: $x \leftarrow x^J$

20: **End While**

21: Obtain Resource Categories

22: Measure Rank $(Req_i, Rset_i, \omega_i)$

23: $Rank = Total\ (Result(req_i - Rset_i) * \text{Weight}_i) / \text{Total}\ (\text{Weight}_i)$

24: **Return** Similarity Measure S

5.Experimental results from Fog Resource Scheduling using Fuzzy Control (FRSFC)

Figure 2 shows the speed at which the CPU is executed on many edge machines. Represents the FRSFC schedule to host available resources to associate connected devices based on the length of the activities. If the task length is longer, the application speed of the virtual machine increases.

This phenomenon differs from other methodologies because ALGM 3 and ALGM 2 can adapt more quickly to the duration of tasks as FRSFC. To have access, ALGM 1 can perhaps react to certain features. When five virtual machines are present, the following Figure 3 shows the runtime using the new targets. The time to perform the work is the maximum time when ALGM 1 is accepted. The possible explanation for this is that activities are distributed to virtual servers in an orderly manner, triggering a lack of supply and completely inadequate use of resources. ALGM 2 improves the efficiency of the task and reduces the execution time compared to ALGM 1. However, processes are not defined, resulting in misuse of simple activities and resources following best-practice virtual machines.

When the decision is made to adopt ALGM 3, the resources of the processing system are gradually included in the length, and the problem of total processing time between virtual machines is significantly reduced. When it is decided to accept the FRSFC, the execution time will be reduced. This is because FRSFC automatically manages resource availability between virtual machines; However, according to the demand, it significantly reduces the cost of computation and significantly reduces the time interval between computers.

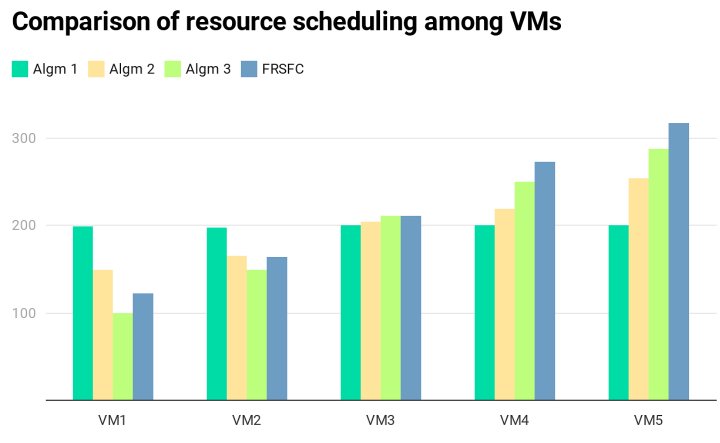


Figure 2. Running CPU speed on respective virtual servers

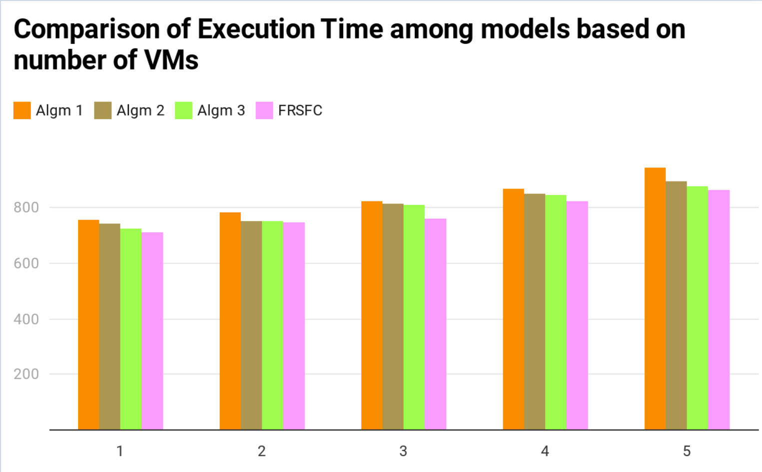


Figure 3. Task time using practical scenarios if five VMs are configured

Conclusion

This article describes the performance of resource management in fog computing. The researchers initially clustered the fog sources, which mostly reduced the sequence of the analysis phase. The FRSFC technique is also proposed to find out the timing of resource management. As a result, based on data from experimental research, a higher accuracy rate has been observed in this paper than other algorithms. In addition, the FRSFC's proposed technique can match user requests more quickly and significantly improve data quality with advanced management classifications. In future studies, the authors aim to understand dynamic resource transformation and provide an appropriate timeline strategy to improve resource utilization and solve user problems.

Conflicts of Interest: The authors declare no conflict of interest.

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