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Indoor formaldehyde monitoring system based on fog computing

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Abstract. With the enhancement of people's awareness of environmental protection, environmental monitoring technology has gradually entered into all aspects of people's life and work. However, due to the high demand of real-time monitoring for data transmission delay, the traditional cloud computing architecture cannot meet the demand, and the fog computing architecture emerges at the historic moment. In this paper, the traditional cloud computing architecture is improved by using the fog computing architecture combined with the function as a service mode of the serverless architecture, and an environment monitoring architecture based on fog computing is proposed. Taking indoor formaldehyde monitoring as an example, the delay of the system is significantly improved, and the resource utilization efficiency is higher and the energy consumption is lower. It solves the deficiency of traditional cloud computing architecture and better meets the demand of real-time environmental monitoring.

1. Introduction

Environmental Monitoring Technology is evolving as people have become more environmentally conscious. Environmental monitoring usually refers to the use of physical, chemical, remote sensing, computer and other technologies, monitoring and measuring one specific environment[1], timely and continuously access to environmental pollution data. The significance of Environmental monitoring is to improve the efficiency of environmental pollution treatment, to promote pollution prevention, and to promote the process of urban environmental planning[2].

Formaldehyde monitoring has always been a hot topic. The concentration of formaldehyde affects the air quality to a great extent. It is an important index to judge the quality of the Living Room Environment, which is closely related to people's health. In order to prevent and control the excessive concentration of formaldehyde in the environment, we need to take effective measures to carry out real-time and accurate detection of the concentration of Formaldehyde in the air. Once the monitoring data exceed the standard, we can carry out targeted control work according to the actual situation or establish a preventive mechanism[3] to reduce the level of pollution. However, the existing methods of instrument detection and chemical detection generally have the disadvantages of poor real-time performance, poor mobility or high technical requirements for users[4]. Combining the advantages of cloud platform, fog computing and server-free architecture, we effectively solve the problems of inefficient data transmission and storage in traditional monitoring technology. While realizing the indoor environment



monitoring with low delay, convenient movement and wide distribution Environmental Monitoring has also come up with new ideas for what to do.

2. Cloud computing framework

Based on the traditional cloud computing formaldehyde detection platform architecture can be divided into cloud computing layer and user layer[5]. The cloud computing layer provides computing power, storage and other resources to support a variety of services and applications, while the user layer mainly sends requests to the cloud to obtain data and realize the access between the cloud layer and the terminal. As shown in figure 1:

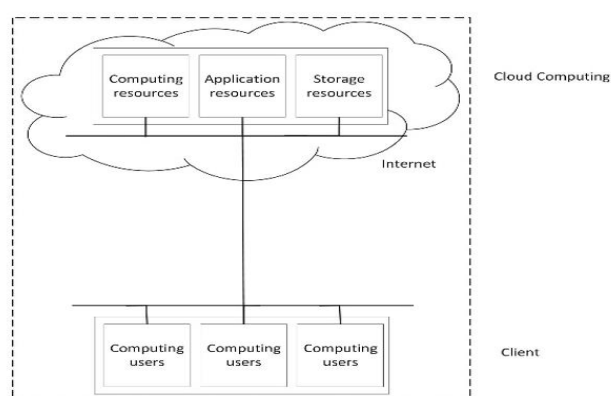


Figure 1. Platform Architecture Based on Cloud Computing

Using cloud computing technology to place a large amount of data onto the "cloud", that is, in the "Data Center" where a large number of servers and storage are assembled, has the advantages of strong security, high availability and large amount of data storage. However, in the traditional computing mode, when the amount of data produced by the device increases too much, the burden of data transmission and acquisition will be greatly increased. And it may cause I / O Bottleneck between the data center and the terminal. The transmission rate will decrease and the delay will increase. Because cloud computing centralizes the data and it is far away from the terminal, the workload of data center is always limited, and IT can't reach the distributed IT resources of general, flexible and supporting multi-ecological business. In addition, the enormous economic cost of transferring massive amounts of data onto the cloud is also a concern. Therefore, this paper proposes a fog computing architecture based on function as a service (FaaS), and taking indoor formaldehyde monitoring as an example, the time delay of the system is obviously improved, and the shortcomings of traditional cloud computing architecture are solved to better meet the demands of Real Time Environmental Monitoring.

3. Design of formaldehyde monitoring platform based on fog computing

3.1. Fog computing architecture

For the traditional cloud computing, after the generation of the data, it needs to go through the cloud process from the terminal to the remote, which causes defects of high delay and high energy consumption. However, Fog Computing extends applications of computing power and data analysis to the Edge of Network by applying intermediate deploy of computing and short-term storage between the Cloud and terminal equipment[6]. It allows local devices provide services directly to the mobile terminal users that realize the decentralization of resources. At the same time, fog computing retains the cloud data center computing and storage functions, using regular uploads mode to be collaboration with services. Therefore, fog computing significantly improved system computing, storage, application and other capabilities.

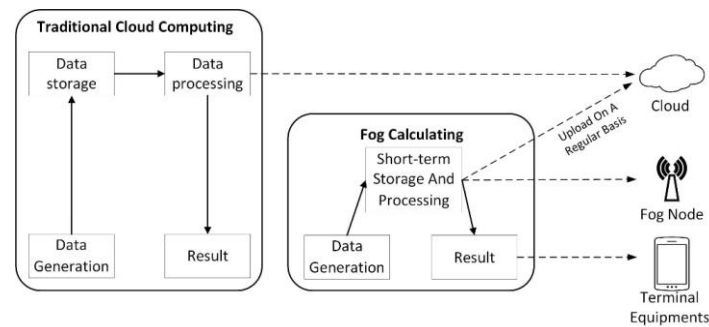


Figure 2. Data Processing of Cloud Computing and Fog Computing

Because the fog nodes are close to the end point, the transmission distance is reduced and the influence of the data center is avoided, the analysis and the response to the data are much faster than the centralized processing. The characteristic of low time delays to satisfy the requirement of real-time interaction for Formaldehyde monitoring application. On the one hand, fog computing enables mobile users and fog nodes to directly exchange information without the need to transfer to the cloud, truly achieving dynamic data analysis, so fog computing can support higher mobility. On the other hand, this method also reduces the amount of network transmission, avoids a lot of heat generated by power saving, and greatly saves energy consumption.

3.2. Functions as a service

The traditional data storage procedure is to cache or store data first, then analyze and apply it. The operation mode of FaaS is trigger operation, that is, a specific event is issued by the terminal, the corresponding function is triggered immediately after generating the event, and the corresponding running instance is immediately pulled up to process the data [7]. Therefore, the entire process avoids storing data immediately after it is generated. Instead, the results are calculated first and then saved directly, saving the space needed for storage and speeding up the calculation and processing of data as well as the subsequent retrieval and retrieval processed. The end result will be a consolidated data set, with incomplete data removed.

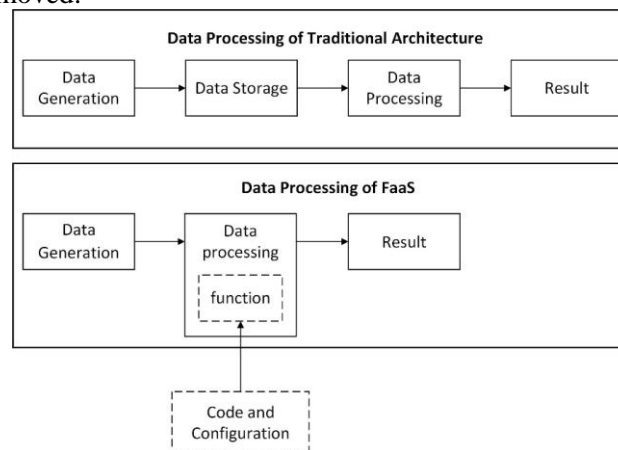


Figure 3. Data Processing Based on Traditional Architecture and FaaS

FaaS can treat a function as an online service, a remote computing service, and divide computing into smaller function levels. Developers only need to write a unified functional function, the whole function scheduling process is completed by the platform, greatly simplifying the operation and maintenance of the platform. Because the memory resources are incompressible, the platform usually only allows users to configure the memory size, while the CPU, bandwidth and other compressible resources are allocated and dynamically adjusted by the platform according to the memory size and actual needs to avoid the waste of business resources caused by excessive application of the program.

Therefore, users only need to focus on specific functions, which is consistent with the original intention of the system design

3.3. Design of formaldehyde monitoring platform based on fog computing

The formaldehyde monitoring platform constructed in this paper mainly includes three processes of data processing: pre-processing the data collected by sensor nodes; pushing the data to cloud computing layer; analyzing and mining the data to get the prediction results. Since the first two data processing processes do not require too much computing resources, this part is deployed in the fog computing layer, the resources are decentralized, and the data preprocessing process is accelerated through functions as a service.

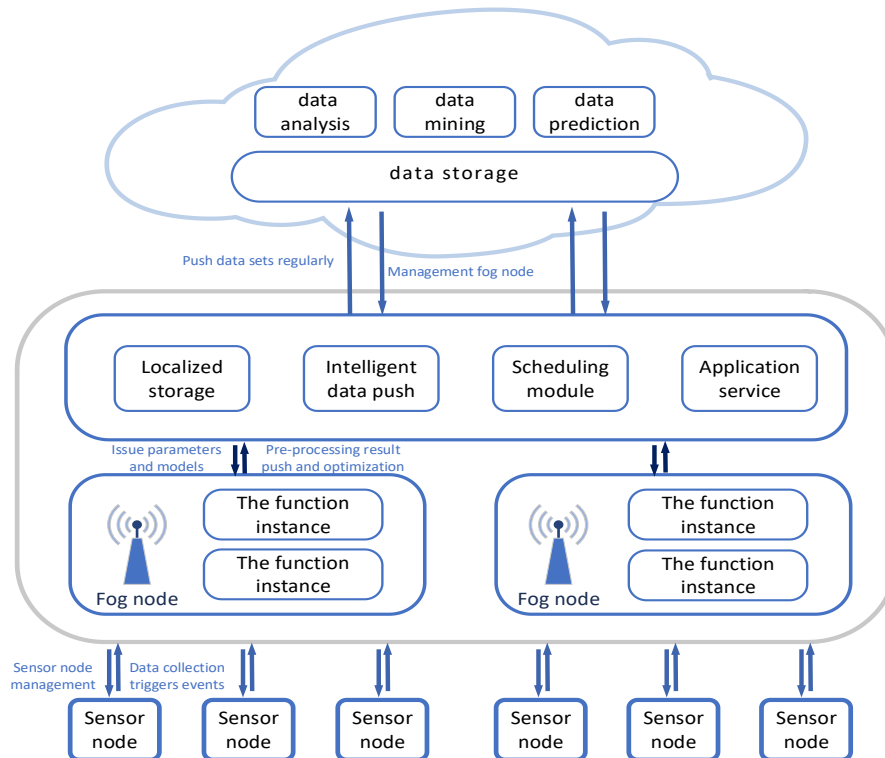


Figure 4. formaldehyde monitoring platform based on fog computing framework

As shown in the figure 4, this paper proposes a new system model based on fog computing. The first two stages of data processing of formaldehyde monitoring platform, namely data preprocessing and data set transmission, are transferred to the fog computing layer by taking advantage of the characteristics of fog computing. Through the fog of the local node for data preprocessing, and will be processed data sets, short-term storage nodes in the fog, because of the fog nodes closer to the user layer, decrease the transmission of data onto the cloud layer and transfer times, directly to the user provide part time delay demanding service support layer, so as to realize data processing and service provided by the acceleration, reduces the request delay; In addition, the function as a service technology in the serverless framework is adopted in the process of data preprocessing, so that the data preprocessing process can be triggered as needed and the computing and storage resources of data preprocessing can be saved. The serverless framework deployed in the fog computing layer can set up the fog function processing instance according to the data collection amount of sensor nodes according to the demand, and can expand and shrink the resource according to the demand, so as to make the whole platform more energy saving and improve the resource utilization rate.

4. Experimental protocol

4.1. Experimental purpose

Verifying that the formaldehyde monitoring platform based on fog computing proposed in this paper has the advantages of low time delays, high resource utilization and low energy consumption. The following experiments will be designed for verification.

4.2. Experimental design

In this experiment, two formaldehyde monitoring platforms were set up as the control group. The formaldehyde monitoring platform 1 was set up using the traditional cloud computing framework, and the platform 2 was set up using the framework based on fog computing proposed in this paper. 40 formaldehyde sensor nodes and 5 fog servers were deployed indoors, as well as 3 remote cloud computing servers.

This paper conducts comparative experiments in three aspects: (1) the real-time data of formaldehyde obtained from the cloud layer was compared with the time delay generated by the data obtained from the fog layer; (2) run the same number of tasks on the traditional cloud computing platform and the fog computing platform, and analyze the resource utilization rate; (3) The energy consumption of the two platforms under the same task amount.

4.3. Experimental results and analysis

4.3.1. Request delay comparison experiment. The figure 5 shows the results of 29 experiments that obtained data from the cloud computing platform and the fog computing platform respectively:

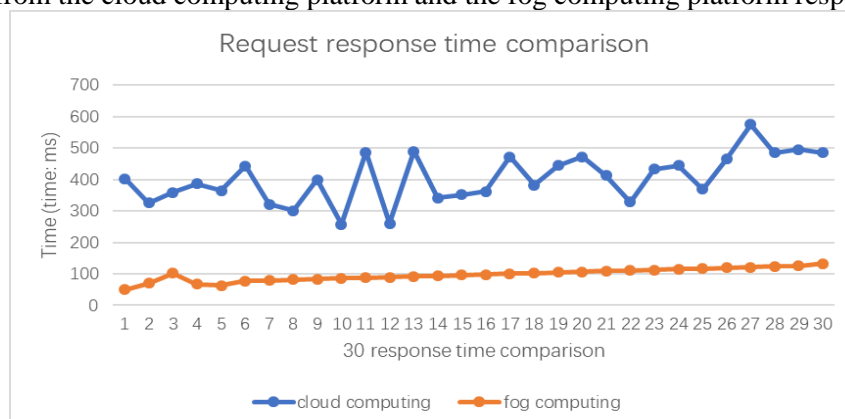


Figure 5. Comparison of fog computing and cloud computing response delay

It can be obtained in this paper, based on fog computing platform due to data preprocessing using functions as a service acceleration and local fog server directly provide services in support of the solution, the response delay is far less than the traditional framework of cloud computing platform, and in the fog calculation due to the storage of the localized its response time delay is relatively stable, and the cloud the response delay of volatility is larger.

4.3.2. Comparative experiment of resource utilization. It can be concluded from the figure 6 that in most time periods, the CPU utilization of the fog computing architecture is lower than that of the cloud computing architecture, and only exceeds the cloud computing utilization at a few time points, and the utilization peak also appears in the cloud computing architecture. Therefore, it can be concluded that the resource utilization efficiency of the fog computing layer is higher and the CPU utilization is lower.

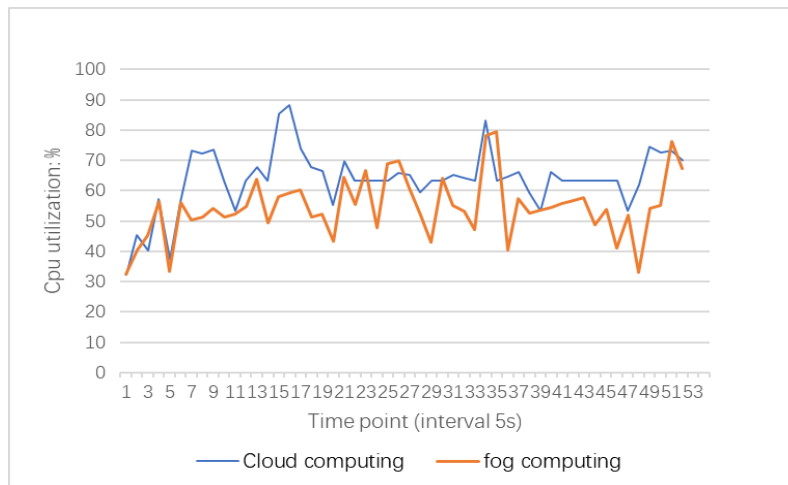


Figure 6. Comparison of fog computing and cloud computing resource utilization

Because the fog computing architecture devotes the resources of data processing to the lower level and the fog computing layer provides partial service support scheme, the data computing and data transmission amount in the cloud computing layer are significantly reduced, so the resource CPU utilization rate in the fog computing architecture is reduced and the resource utilization rate is higher.

4.3.3. Energy consumption comparison experiment. According to the energy consumption calculation formula combined with energy consumption, the expected energy consumption generated by any task from entering the cloud computing system to leaving after execution can be expressed as[8]:

$$E(\text{Energy}) = E(\text{Power}) \times E(\text{Time}) = \sum_{i=1}^m \left[\frac{\lambda_i}{\lambda} \times E(P_i) \right] \times \sum_{i=1}^m \left[\frac{\lambda_i}{\lambda} \times E(T_i) \right] \quad (1)$$

$E(\text{power})$ is the expected power of the whole cloud computing system for all M-type tasks, and $E(\text{Time})$ is the expected response time for M-type computing tasks[8]. The energy consumption of the two architectures in Figure 7 below can be calculated from the above formulas.

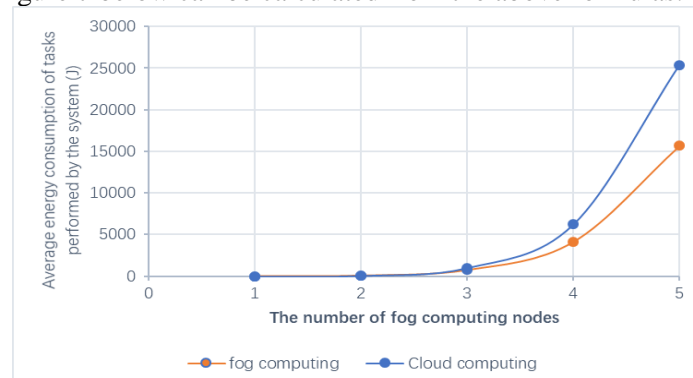


Figure 7. Comparison of fog computing and cloud computing energy consumption

As can be seen from the figure above, with the increase of fog nodes, the energy consumption of the architecture based on fog computing will decrease gradually, which is due to the fog computing architecture proposed in this paper devotes the calculation of the data preprocessing part to the fog node and adopts the method of functions as a service to shorten the processing time and simplify the process, thus reducing the calculation amount of the whole system and realizing the reduction of energy consumption.

5. Conclusion

This paper aims at the problem of insufficient application support of cloud computing in environmental

monitoring applications in the face of high data transmission delay requirements. By using this function as a service and fog computing architecture, part of the data processing process is delegated to the fog computing layer, and the data preprocessing process is accelerated by FaaS, and the fog computing layer provides partial application service support. Finally, the comparative experiment proves that the architecture has the characteristics of low service delay, high resource utilization and low energy consumption. It solves the shortcomings of the traditional cloud computing architecture and better meets the needs of real-time environmental monitoring.

Acknowledgments

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