Intelligent Library Architecture Based on Edge Computing

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Abstract. The development of the Internet of Things promotes the integration of physical space and information space. In addition, more and more people, machines and things are connected to the information space. The centralized cloud computing model has been gradually hard to accommodate the resulting massive data treating requirements. However, the emerging edge computing provides a new technical means to solve this problem. By comparing and analyzing the basic framework and features of edge computing and cloud computing, taking the typical case of Intelligent Library as an example, this paper constructs an Intelligent library system architecture based on edge computing. It analyzes the functions of each level of the architecture. The architecture can reduce the minimum delay and network bandwidth pressure of Library intelligent service, thus saving the data processing cost of Intelligent Library.

Keywords: Edge of computing, Cloud computing, Intelligent library, The architecture.

1. Introduction

As a highly integrated and comprehensive application of new-generation information technology, IoT is widely used in Intelligent City, Intelligent Medical, Intelligent Grid, Intelligent Home and other fields. The rapidly growing number of IoT devices and the amount of data generated have given rise to explosive data growth and new data demands. As a result, the centralized processing model represented by cloud computing cannot efficiently and in real-time process the data generated by IoT devices, and the problem of high latency is serious, which makes it difficult to meet people's demand for quality of service. Therefore, in order to relieve the load pressure on data storage, computation and transmission of IoT, a new computing model, edge computing, comes into being in time.

As an intensive place for major universities and metropolitan areas, libraries have the dual task of serving the public and scientific research. With the development of the times, Intelligent libraries using new technologies such as big data and artificial intelligence have begun to enter people's view. However, with the increasing number of library users and their needs, and the increasing resources such as e-books and books in the collection, the total amount of information resources of Intelligent Libraries is accumulating rapidly, which makes it difficult to process information and provide services. As an emerging technology, edge computing can not only promote the improvement of library services, but also have positive significance in promoting the transformation and upgrading of Intelligent Libraries in the digital information environment.
2. Edge Computing and Cloud Computing

2.1. Cloud Computing

Cloud computing is a kind of distributed computing, which does not need the direct active management of users. The birth of cloud computing means that enterprises can purchase the required computing, storage and other services directly from cloud service providers. Thus, cloud computing provides enterprises with high reliability, security, and usability, saves social resources.

![Cloud computing infrastructure.](image)

With the emergence of many new devices that are sensitive to latency, network bandwidth, privacy security, and other factors, it is becoming increasingly difficult to meet the demand for the services provided by cloud computing with a centralized management approach. Cloud computing's processing model brings some problems that are difficult to solve, including insufficient network bandwidth, difficulty in meeting real-time requirements and ensuring the security of users' private data.

2.2. Edge Computing

2.2.1. Edge Computing Overview. The convergence and development of IoT and big data have prompted the emergence of edge computing[3]. By adding task computing and analysis capabilities on edge devices, computing tasks are selectively offloaded from traditional cloud service centers to edge devices for execution, thus greatly reducing the processing load of cloud service centers and alleviating network congestion and high latency.

2.2.2. Development status of edge computing at home and abroad. Currently, edge computing technologies and applications are still in the early stages of development. The Korvo research group at the Georgia Institute of Technology has introduced the PCloud platform, which integrates computing and storage resources. That is, after the integration of edge data and "cloud" data, the latter will provide a large amount of resources while allowing the former to provide low-latency computing[4]. Lee and others provide a platform-level solution CollaboRoid proposed that mobile edge computing services could be provided for mobile users by combining the hardware resources, software resources and multimedia resources of multiple mobile devices[5]. In terms of standards research, the standard system of edge computing is gradually being established.
The industrial edge computing platform jointly built by Intel and AliCloud, which runs locally at industrial edge computing nodes, can aggregate and store the results on the edge servers and realize data on the cloud through AliCloud's LinkEdge. In 0.695 seconds, the platform uses a machine vision solution that enables almost real-time identification of manufacturing defects with a detection accuracy of approximately 100%. In general, China's edge computing is mainly in the initial stage of pre-commercialization of relative scenarios, as well as the primary and laboratory testing stage. What is more, less research on architecture for different application scenarios, and edge computing has not yet been fully applied in various fields.

2.2.3. Edge computing advantages.
(1) Low latency. Network response speed and data processing location are interrelated. Shortening the physical distance between the data center and users can minimize latency. In edge computing, as the processing of data is moved to the user side of the "edge" of the network[6], the network traffic response is reduced. Thus edge computing can minimize latency and maintain high connection speeds.
(2) Security. Compared with cloud computing, edge computing improves security. The data collected by edge computing models at IoT devices can be processed at the source. As a result, the risk of widespread dissemination of sensitive data over the network is reduced, and the misuse and theft of users' private information over excessively long transmission links could be avoided.
(3) Data processing location optimization. Enterprises can determine where different types of data should be processed. For example, critical type data can be processed at the edge data center, while non-critical data that is not sensitive to latency can be taken up by other facilities or cloud computing services, thus improving data processing efficiency while saving network bandwidth and ensuring efficient service.

Table 1. Comparison of the main attributes of cloud computing and edge computing.

| Properties                | Edge Computing | Cloud Computing |
|---------------------------|----------------|-----------------|
| Time delay                | Low            | High            |
| Transmission path         | Short          | Long            |
| Security                  | High           | General         |
| Number of service nodes   | Very much      | lesser          |
| Terminal Mobile Support   | Support        | Partial Support |
| Real-time interaction     | Support        | Partial Support |

3. Intelligent Library System Framework Design Based on Edge Computing
Given the characteristics of the total amount of information resources in the Intelligent Library and the need for fast response to user requests, this paper constructs a framework of Intelligent Library system based on edge computing, as shown in Figure 2[7]. The framework mainly consists of three modules, namely, data terminal layer, edge node layer and cloud data center. And the processing process of Intelligent Library data is divided into three stages. That is, first, data is collected through various sensors. Secondly, upload the collected data to the edge gateway or server for processing. Finally, the processed results will be fed back to the terminal to realize the agile operation of the whole terminal.
3.1. Data Terminal Layer

In the Intelligent Library service system of edge computing, the devices in the data terminal layer are divided into two major categories. One is with various types of sensors such as temperature sensors, security monitoring systems, lighting systems etc., and the other is with Intelligent devices of Internet of Things. These two types of terminals are responsible for the full collection of data in the library\(^9\), including the basic behaviors of users such as borrowing book situation, the library seat usage, query all-in-one collection download and other behaviors, and basic attributes like gender age, job and other attributes, as well as data related to library items like collecting data and spatial data.

Various Intelligent terminal devices collect real-time data generated by sensors in the pavilion nearby to achieve comprehensive monitoring and control of resources, personnel and environment in the pavilion. For example, temperature and humidity sensors, security monitoring systems, lighting systems are used to collect and monitor environmental status data in the pavilion in real-time. Through the wireless communication link, such as using Lora, WiFi, BLE, ZigBee and other wireless communication protocols, the data exchange between the edge devices and the upper layer is realized.

The data terminal layer is close to the data source when collecting the environmental status and resources in the library, and can quickly and intuitively collect relevant data. Therefore, the data terminal layer has high efficiency and accuracy, which makes it easier and more comprehensive to monitor and control the situation in the pavilion.

3.2. Edge Node Layer

The collaborative architecture of the edge layer in performing computing tasks is shown in Figure 3. The computing tasks are performed in collaboration with related resource frameworks using edge devices to form an edge computing network. The core node communicates with the cloud data center upwards and interacts with edge devices downwards. The edge device module accepts tasks distributed by the core node and monitors the running status of the node. The core nodes in the entire edge network allocate computing engines to control specific computing tasks according to task scheduling, and collaborate to complete real-time data processing. The edge group acts as a processing and storage center for edge data, and realizes data exchange with intelligent edge devices and cloud centers\(^9\).
3.3. Cloud Data Center
The cloud data center consists of cloud servers, which are responsible for the device management of various types of sensors, the configuration of device driver functions and linkage functions in the library. The data processed at the edge node layer is deeply integrated through multidimensional multi-source data fusion, data forwarding, model training based on lightweight deep learning, image recognition, and video recognition. Besides, the cloud server deploys the trained and inferred models to local inference calculation, thus increasing the speed of calculations in the library, reducing the response delay of terminal equipment, and further improving the effective utilization of library digital resources[10].

4. Analysis of the Advantages of Edge Computing in Intelligent Libraries
The framework of Intelligent Library service system integrated with edge computing optimizes and improves some functions in terms of real-time responsiveness, data processing volume, and processing capacity, etc. This paper will focus on three aspects, Namely, real-time prevention of disease, real-time update of seat status, and implementation of forecasts.

4.1. Real-time Prevention of Disease
The outbreak of COVID-19 has made epidemic prevention necessary for entering and leaving intensive places. In addition to traditional protection such as masks, disinfection and cell phone washing, infrared body temperature thermometers and security systems are also effective means. Intelligent Libraries can be effectively protected against epidemics by accessing intelligent devices and sensors of the Internet of Things in the library. After adopting edge computing, data processing can be moved to a location closer to the data source to improve the real-time decision-making, thus ensuring the safety, convenience and comfort of the library environment. For example, the infrared thermometer in the library can be used to measure and control the body temperature of incoming and outgoing staff in real-time. In addition to taking effective measures, such as isolation and disinfection of articles, for the library entry personnel with abnormal temperature, the action track of the library exit personnel can be determined through the security system, and the disinfection machine and other sensors can be used to disinfect the library, so as to reduce the communication between personnel contact.

4.2. Real-time Update of Seat Status
In recent years, more and more people are studying for exams in the library, making library seats more and more tight. Users of library seats can inquire about seat update through online interactive channels that are in direct contact with users such as Pocket Library APP and Library WeChat official account, and make balance inquiries about seats and common seat usage, and advance reservation etc. The library back-end operation system takes advantage of edge computing to process user information and behavior data with low latency and highly sensitive to user needs to quickly respond to library users’ requests.

4.3. Real-time Forecasting
Forecasting with a large amount of processed in-library business operation data. For example, combined with the processed data, the preferences of library users are judged. Data is processed in real-time.
through nodes close to the data source, reducing the pressure on the cloud and time delay, and quickly predicting and responding to the needs of library users. When the number of students preparing for exams increases, the cloud data center uses sensors to control the temperature and lights to lower the pressure for students, and prepares relevant electronic books in time to help students prepare for exams.

5. Conclusion
This paper integrates emerging edge computing technology into the framework of Intelligent Library, and builds an Intelligent Library system framework based on edge computing. By shortening the distance between data acquisition and processing, it can not only reduce the delay to the greatest extent, but improve the reliability, reduce the cost of data processing and the pressure of network bandwidth. It provides technical support for building a new Intelligent Library that can provide customized services, and also provides innovative ideas for the application of edge computing in more fields.

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