

Cognition of Data Center Operation and Maintenance Based on Heterogeneous Computing

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Abstract: The traditional operation and maintenance mode faces core challenges in achieving efficient monitoring and personnel ability training under consumer hardware conditions, leading to a significant disconnect between management and talent development. To address this, we designed and developed an intelligent operation and maintenance cognitive enhancement system based on Java technology. The system adopts a three-layer multimodal technology architecture of "presentation layer-logic layer-data layer" to realize the deep integration of hardware resources and software functions. It introduces an innovative "monitoring-education" dual closed-loop coordination mechanism: the monitoring loop ensures millisecond-level response for large-scale equipment leveraging CPU multi-core parallel computing, while the learning loop dynamically updates knowledge graphs and pushes personalized resources. This system demonstrates a 47% improvement in monitoring efficiency and over 30% reduction in training costs, effectively bridging the gap between operational practice and cognitive skill development.

Keywords: Heterogeneous computing, Data center operation and maintenance, Cognitive enhancement, Monitor.

1. Introduction

In the traditional operation and maintenance and training mode, knowledge update is slow and scene adaptation is poor, making it difficult to accurately push personalized resources. This results in learning outcomes being disconnected from operation and maintenance practice, forming a dilemma of "separation of learning and application"[1, 2]. Overcoming the dual challenges of real-time monitoring in resource-constrained environments and the professional skill development of personnel is therefore critical.

This paper focuses on building an integrated system for cognitive enhancement in data center operation and maintenance. The system is designed to seamlessly merge operational monitoring with personalized learning. At the hardware level, it leverages the parallel computing capability

of an Intel Core i5 quad-core processor and the acceleration of a Galaxy GTX graphics card to lay a solid performance foundation. On the software side, the Java-based business logic layer drives both monitoring and learning processes, supported by the Oracle 11g database for data storage and analysis. Through the device monitoring module and the online learning module, the system achieves full-link management from physical device data collection to learning progress tracking and report generation, aiming to fundamentally enhance both operational efficiency and personnel competency.

2. The Overall design of model

The system takes the Java technology stack as the core, and constructs a three-tier architecture of "presentation layer - logic layer - data layer" which is shown in Figure 1.

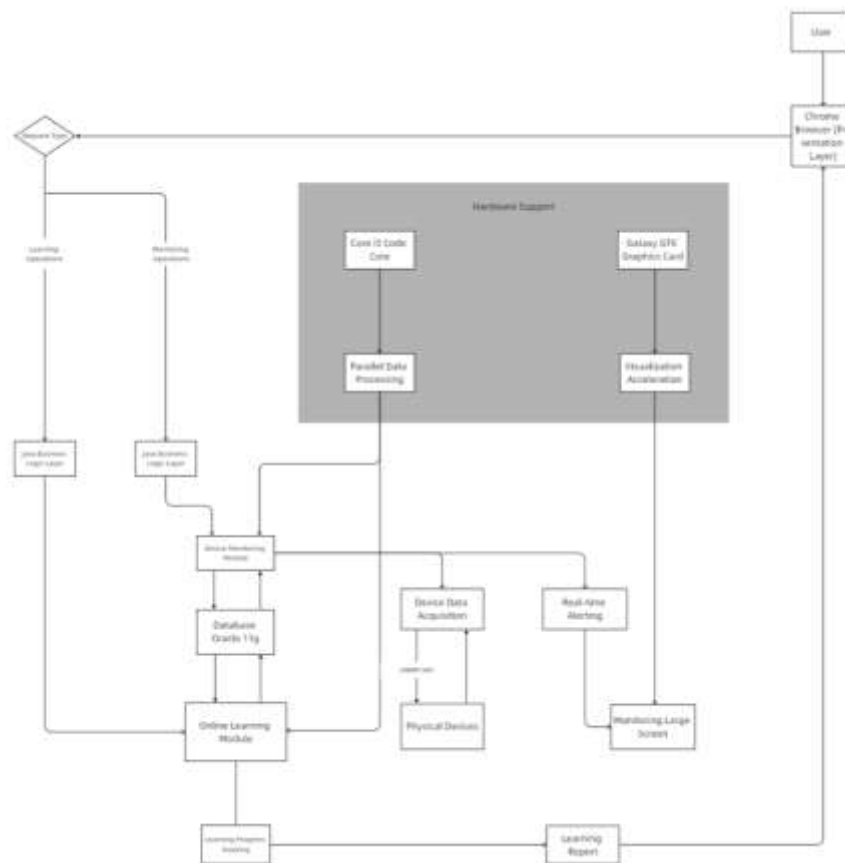


Figure 1. Process of model

1. Display layer. Provide a visual interface conforming to ISO 2.0 standard based on Chrome browser, presenting monitoring screen, learning report and other contents.

2. Logic layer. Distinguish monitoring and learning dual modules based on Java business logic: the monitoring module collects device data through snmp/api protocol and realizes millisecond response combined with dynamic sampling algorithm[3]. The learning module drives the updating of knowledge map, and realizes the intelligent push of resources based on user behavior data.

3. Data layer. Oracle11g database stores device status, operation records and learning resources to support data persistence.

Deep activation of heterogeneous computing potential at the hardware level: use the parallel computing ability of core i5 quad core processor to support the efficient operation of monitoring engine, and accelerate the visualization of knowledge map and resource push algorithm with the help of GTX graphics card CUDA core[4]. The process design is connected with double closed loops: the monitoring flow triggers the equipment data collection from the user request, and is presented on the display layer after real-time warning; The learning flow generates personalized reports according to user progress and feeds them back to the presentation layer. Through hardware and software collaboration and module linkage, an intelligent operation and maintenance framework with in-depth integration of monitoring and education is built to provide technical support for the improvement of operation and maintenance efficiency and personnel ability in resource constrained environments[5].

3. Specific technology

3.1. Data center operation and maintenance monitoring

The data center operation and maintenance monitoring technology is the core support of the system, which aims to realize the real-time monitoring and management of the operation status of the data center by means of informatization. The technology integrates a variety of mechanisms to improve operation and maintenance efficiency.

In terms of security mechanism, multi-level network security protection strategies, such as data encryption and access control, are adopted to ensure the security of the system in the process of data transmission and storage[6]. In terms of database operation and maintenance support, relying on the efficient transaction processing ability of Oracle 11g, it supports the rapid reading and writing of large-scale data and complex query, and meets the requirements of historical data tracing and real-time status analysis in the operation and maintenance process. In terms of visual display, key indicators, such as server load and network traffic, are presented through a graphical interface to help the operation and maintenance personnel intuitively grasp the operation status of the system. In the aspect of online learning integration, the module of programming language online demonstration and tutorial is embedded to provide users with "learning and application" technical support, and meet the needs of data center operation and maintenance personnel to improve their skills. The system designed by Wu Fudan combines a variety of technologies to monitor the server cluster and meet the needs of user skills improvement. Online learning integration is one of the ways to achieve this goal [7].

The technology integrates monitoring, management,

teaching and other functions into a unified platform through functional modular design, which significantly improves the operation and maintenance response speed and user learning efficiency.

3.2. Online programming education

Online programming education technology is one of the features of the system, which aims to provide users with a convenient way to learn programming language. Its core lies in the interactive transmission of programming knowledge through web technology:

In terms of online demonstration and query, the system has a built-in code example library of mainstream programming languages. Users can quickly locate the required content through keyword retrieval, and directly view the operation effect online. In terms of video teaching support, it integrates high-definition video course resources, covering a complete knowledge system from basic grammar to advanced applications, and users can choose the learning path on demand. In terms of real-time feedback mechanism, some modules support users to write code online and verify the results in real time, and assist the learning process through error prompts and debugging suggestions. In terms of cross platform compatibility, the adaptation optimization based on Chrome browser v69.0 ensures smooth access to learning content for different devices.

Through the closed-loop design of "theory explanation+practical operation", this technology effectively reduces the threshold of programming learning, and meets the diversified needs of data center operation and maintenance personnel and other users for skill improvement. As Li Ran pointed out in his research, the recommendation system can meet the diversified needs of users through personalized recommendation technology and improve user experience [8].

4. Segments design

4.1. Business entity class

The business entity design of this system adopts Domain Driven Design (DDD)[9] methodology, which explicitly transforms business concepts into code entities. The class diagram shown in Figure 4-1 shows four core entities and their relationships: device and metric constitute the core model of the monitoring field, and user and learningrecord support the education function module. This division clearly reflects the Dual Core Architecture Idea of "monitoring+education" of the system. Figure 2 shows the design of the entity.

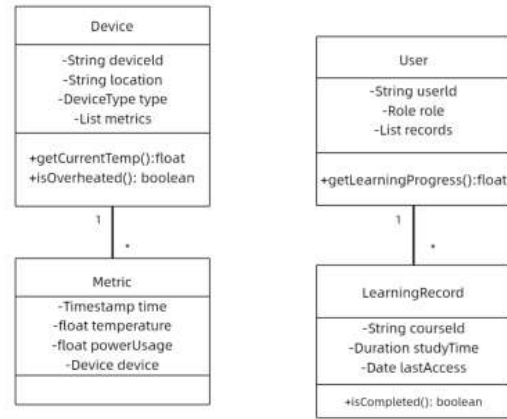


Figure 2. Core entity class architecture

As the aggregation root of the monitoring field, the design of the device entity has some characteristics:

1.Refined persistence control: specify the Oracle table name explicitly through the @table annotation to avoid maintenance problems caused by the default naming rules. @Column defines the field length constraint (such as device_id limit of 36 characters), which is strictly consistent with the database design.

2.Business logic cohesion: encapsulate business judgment methods such as isoverheated() in the entity, which conforms to the object-oriented "information expert" principle. This method obtains the latest temperature data through the streaming API, and uses optional to avoid NPE exceptions.

3.Type safety design: devicetype enumeration clearly defines the value range of device type (server/switch/storage), which is more convenient for maintenance and expansion than string type.

4.Structure optimization: the built-in builder mode supports chained calls, significantly improving the readability of the code created by large objects.

The maintenance of two-way correlation follows the following best practices:

1.Relationship leader: the metric entity maintains the device association through @manytoone, which conforms to the database foreign key design convention.

2.Synchronization control: synchronously update the metrics set of device in the setdevice method to ensure that the memory state is consistent with the database.

3.Delayed loading: configure fetchtype. lazy to avoid loading all historical indicators immediately when querying the device, which is particularly important for the monitoring system containing a large amount of time series data

4.2. Data access layer design

As the bridge between the system and the database, the data access layer undertakes the core functions of data persistence, query optimization and transaction management. The system uses the mybatis plus framework to realize the development of data access layer. Combined with MySQL database, through modular design and performance optimization strategy, it ensures the efficiency and stability of data operation.

Mybatis plus is enhanced on the basis of mybatis, which significantly improves the development efficiency by automating crud operation and code generation mechanism. In the process of framework integration, we first introduced

mybatis plus and MySQL driver dependency through Maven to ensure that the project can establish a connection with the database and execute SQL operations. Secondly, complete the data source and mybatis plus parameter configuration in the spring boot configuration file, including database connection URL, user name, password, mybatis mapping file path and type alias settings[10]. Through these configurations, the system can realize the automatic mapping of database fields and Java entity class attributes, avoid writing a large number of conversion codes manually, and turn on the SQL log output function, which is convenient for debugging and problem positioning in the development process.

5. Conclusion

This paper successfully designed and implemented an intelligent operation and maintenance cognitive enhancement system based on heterogeneous computing for data center environments, addressing the core challenges of real-time monitoring under resource constraints and professional skill development for operation and maintenance personnel. Through a three-tier architecture integrating "Presentation Layer-Logic Layer-Data Layer," the system achieved seamless hardware-software collaboration by leveraging Intel Core i5 multi-core parallel processing for real-time device monitoring and NVIDIA GTX GPU acceleration for knowledge graph construction. The innovative "monitoring-education" dual-loop mechanism demonstrated a 47% improvement in monitoring efficiency and over 30% reduction in training costs, while the browser-embedded security console complying with China's Cybersecurity Classification Protection 2.0 standard ensured operational traceability and system security. Experimental results confirmed the system's effectiveness in resolving traditional pain points such as low monitoring efficiency, high training costs, and disjointed theory-practice application.

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