Cloud-based Approach for Prevention Maintenance Management Platform of Printing Press equipment

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Abstract. It is easy to understand that presentation maintenance can prolong the lifecycle of the equipment. Due to the lack of an efficient maintenance management platform for Printing Press equipment, we develop a cloud-based platform to record routine inspections, to notify management information, and to remind replacement with a monitoring analysis model. In that case, the producer of the printing press could master the data of prevention maintenance and provide better after-sales service. The platform consists of equipment data sensing analysis workflow, routine inspection, and equipment warning/failure detection. This enables effectively extending the service life of the equipment, reducing the maintenance costs of equipment, and providing on-demand access to computing resources. In the future, new artificial intelligence models could be added to provide smarter manufacturing solutions.

1. Introduction

Industrial Internet of things (IoT) and machine-to-machine (M2M) communications technologies have been widely used in recent years. Industry 4.0 technology strategies aims to connect machinery and cloud computing to achieve benefits such as improving productivity and reduce total energy consumption in factories [1,2]. In the domestic printing press manufacturing industry, it has gradually entered the Industry 4.0 era, but there is no complete solution.

At present, the total output value of China’s printing, packaging, and publishing industry is about 3 trillion Yuan, of which the total output value of the printing industry in 2019 exceeded 1.3 trillion Yuan. Due to the low service quality of maintenance management in that area, high maintenance cost becomes a common issue in the printing Press industry of China. To solve this problem, a cloud-based Prevention Maintenance Management (PMM) platform is implemented merging an equipment monitoring system.

Currently, many researchers have done remote monitoring and maintenance systems based on cloud computing in other industry areas. Mori used email with XML file to process equipment status in early times [4]. Hitachi proposed Cloud-based Equipment Maintenance and Facility Management service which could provide cloud and operational data analysis services to industrial equipment manufactures [3]. In [7], authors devised a control loop performance monitoring system operating in cloud fully remote monitoring data coming from various industrial plants in different locations. In [8], Terrazas presents a novel framework of the big data approach, and analytics machine-generated data in the cloud can be adapted to and deployed on different cloud computing platforms.

We provided a cloud-based PPM platform into existed equipment monitoring. There have the following three main contributions
2. Architecture and design of the PMM

This paper proposes a PMM approach integrated into equipment monitoring. As shown in Figure 1, the system collects data from two data sources, running parameter data derived from PLC or sensors (blue line) and operational data (green line). Two different modules are used to process separately for running parameter data and operational data. The running parameter data is provided by Root cloud [5] using specific hardware and software. Operators can view information through PPM system through mobile phones or web pages, and submit task results through the system after completing the corresponding work.

![Diagram of PMM system]

The system has a notification module to send reminder information by email. Specifically, notification types are reminders of routine inspections ahead of time, reminders after tasks are completed, reminders of warning messages, and reminders of fault messages.

Yellow modules indicate management functions. Warning handling is used to process warning information, such as the exception of certain parameters. Failure analysis is used to control error information and evaluate the probability of failure during operation. Routine inspection is used to manage the daily, weekly, and monthly inspection plans of the equipment. Different equipment uses different routine templates, which are usually made by the manufacturer's technical experts.

Decision-making support is the most challenging part. At present, data analysis and result judgment mainly rely on data analysts and engineers. With the advancement of artificial intelligence technology, we rely on Tensor Flow’s deep learning model framework to train several fault classification models for bearings.

Both PMM and Decision-making support are deployed on cloud services. It can be more scalable and flexible provide various types of technical services.

3. Software Implementation

The platform is implemented as a Web application, deployed on top of a Cloud Service. This application conforms to the Representational State Transfer (REST) web standards-based architecture and uses HTTP Protocol. It revolves around a resource where every component is a resource and a resource is accessed by a common interface using HTTP standard methods. REST uses various representations to represent a resource like text, JSON, XML. JSON is the most popular one which is used in this system for data exchange.
The PPM is deployed on infrastructure in Ali Cloud[6], running a Linux-based operating system, and includes an Apache HTTP server, Nginx server, SQL database, and other plug-ins. Furthermore, graphic user interfaces (GUI) are developed for visualization. The key technologies are divided into three parts as in fig.2.

3.1. Front end
The front end is mainly responsible for sending a request to the server and receiving the data returned by the server for rendering when the user opens a page and presents it to the user in the form of an operator interface.

Vue is a progressive framework for building user interfaces. It cooperates with the element component library to complete the construction of the operation interface. Then send a request to the server through Axios to get dynamic data. The HTTP protocol is widely used for front-end and back-end transmission. To meet the real-time nature of messages, this project uses Web Socket real-time communication in message push, and the back-end can also push data to the front-end.

The front-end service of this project is deployed on Nginx, which is a lightweight web server, which is characterized by low memory usage and strong concurrency. The back-end project is deployed on tomcat. It is a lightweight application server. It is commonly used in small and medium-sized systems and occasions where there are not many concurrent users. It is used to respond to front-end page access requests.

3.2. Back end
The backend mainly completes the logic part, such as data storage and retrieval, business logic and rules that need to be followed, and prediction of the results, all of which are completed by the back-end. For security, the identification of clients through Secure Sockets Layer/Transport Layer Security (SSL/TLS) protocol is used. Shiro is a security framework that implements serious identity, authorization, password, and session management to ensure system security. The other three parts complete the operation and logical processing of the database and return to the front end.

Spring Data JPA is a sub module of Spring Data. Using Spring Data makes the implementation of JPA based on the concept of "repositories" easier. Spring Data JPA greatly simplifies the coding of data access layer code. As users, we only need to write our repository interface, which contains some personalized query methods, and Spring Data JPA will automatically implement the query
methods. JPA uses hibernate as the ORM implementation by default, so generally, Spring Data JPA will use hibernate. This project also uses MyBatis, which supports customized SQL, stored procedures, and advanced mapping. MyBatis avoids almost all JDBC code and manual setting of parameters and obtaining result sets.

Spring Data Redis provides Spring Data access abstraction to the current hot data structure storage engine Redis database.

### 3.3. Database

For the database part, Mysql is a relational database management system, which is widely used in web applications. Redis is an in-memory data structure storage system, which is used as a database and message middleware in projects.

When logging in Redis stores the token and each subsequent request carries the token to determine whether the user is logged in. It is used as a data cache and is requested again without querying the database. It is directly obtained from Redis. As the framework of the entire project, Springboot integrates other components, such as Redis, MySQL, and mybatis Plus. mybatiesPlus is a data persistence layer framework, connecting business and database data addition, deletion, modification, and data processing.

Redis is mainly used as a MySQL cache to solve the problem of high database concurrency. Redis cache realizes the separation of data read and write. For a data request in SQL statement format, first, calculate the MD5 of the statement and obtain the result set identifier based on this, and use the identifier to find the result set in Redis. Each row in the result set has a corresponding key, and these keys are stored in the Redis collection structure. If such a set does not exist in Redis, query the corresponding result set in MySQL and store it in it.

### 3.4. Decision making support

In this work, the deep learning model is implemented in python. For the problem of calling the python deep learning training model for java web applications, we have made many attempts, such as packaging the python code into a jar package, and then letting java call; saving the python training model parameters into the text, and reproduce the model with java code Forecasting algorithm. The problem with the former is that many third-party libraries of python cannot be packaged into jar packages. The problem with the latter is that the workload is huge, and the probability of bugs is also greatly increased. In the end, we chose to use the python process to run the deep learning model, call the services provided by the python process in the java application, and communicate between the processes through sockets.

![Fig.3: Screenshot from overview page](image-url)
Fig. 4: Screenshot from device lists

Fig. 5: Screenshot from equipment running status

Fig. 6: Screenshot from the email report
4. Case study and Results
The proposed system has completed the test work. There are more than 200 pieces of equipment
connected to the system. In this case, several operation interfaces and functions will be explained in
this part.

When accessing the PMM, the overview of the managed equipment is displayed in Fig.3. Three pie
charts respectively show the statistics of routine inspection tasks. The following equipment list lists
the managed equipment list and gives the summary information of the equipment. The upper right part
shows the basic information of the login personnel.

Fig.4 displays the devices that are visible to the user under a single type. On this page, it is showed
detailed history information about the operation of the device and configuration task of the device.
Following the green button, it will pop up the configuration information window to set the equipment
check information. Besides, click the orange button to display the details of the device, as shown in
Fig. 5.

Fig.5 is the details of the operation of the equipment. The equipment B624-4-37 is currently in
operation. The device parameters and values are showed in the latest state.

Fig.6 shows the received daily inspection reminder email, through which you can know the
inspection type, inspection equipment information, inspection completion time, inspection items, and
other details.

5. Discussion

5.1. Design standards
To implement a prevention maintenance platform, certain specific design rules need to be followed:

- It is necessary to able to send notifications of daily, monthly, and quarterly inspections in time
  and correctly. The notification content includes the checkpoint content, deadline, precautions, and
  other information.
- Regardless of any unexpected conditions, the data of the operation must be recorded correctly.
  Automatically generate operation logs, and can automatically generate operational statistical
  reports. The statistical report is automatically sent to the supervisor through the preset.
- Data acquisition and transmission need to be encrypted. Adopt security measures to prevent
  malicious third parties from illegally using data through the network.
- Maximize the value of data as much as possible. Operation history records and equipment status
  parameters should be an important hint for the operator to follow the proper procedure.
- When the number of equipment, equipment parameter data, and manual operation data is
  increasing, it is recommended to adopt distributed data processing technologies. Using cloud
  technology can provide a flexible database size and improve the response efficiency of the system.
- The system has the ability of resistant to system risks. Like some potential risks such as network
  unstable connections, the corresponding data should be automatically recovered after the network
  is restored.
- It must be scalable to provide the corresponding data interfaces not limited to the current data
  access methods. Some control interfaces should be considered automatic control of feedback in
  the future.

5.2. Pros and cons
The advantage of the PMM system is to avoid the possibility of irregularities in the inspection records
of workers. Remind the operator of the content of the inspections and record it correctly, and then
automatically generate a statistical report to the manager. Therefore, the factory is urged to conduct
more standardized operations to effectively increase the service life of the equipment.

Secondly, by remotely monitoring the equipment, real-time relevant status data and operating data
are recorded. It could support tuning equipment parameters and analyzing equipment operating
conditions in the future.
Thirdly, through timely acquiring of warning and failed data, the equipment can be restored and maintained in time as soon as possible to prolong the life cycle.

However, there are still many areas for improvement. The current system implementation is still very rudimentary, and there is still a big gap between true intelligence. Now each device can export hundreds of types of operating parameters in real-time, due to the limitations of the environment and device locations, sensors cannot be installed in all key locations.

Based on Beiren’s decade's experience in equipment manufacturing and maintenance, many failure models and repair plans have been built and determined. Now it can realize the fault self-diagnosis of the equipment. But how to realize the automatic recovery of equipment is still very difficult.

There is another very important thing. It is incorrect to over-dependent on artificial intelligence or too much reliance on data analysts or experts. There needs to find a criterion to balance the usage of the two aspects.

6. Conclusions
This paper proposes a cloud-based PMM platform into existed equipment monitoring. The main function of the system help operators can view information through PPM system through mobile phones or web pages, and submit task results through the system after completing the corresponding work. At the same time, Beiren can obtain the operation and usage of all equipment from the management console. This will solve the problem of incorrectly routine inspection in many printing plants. To summarize, it will extend the service life of the equipment and reduce the cost of service overhead.

The system provides a safer notification module by using buffer management queues. The implementation of the system adopts the advanced SSM architecture and provides highly reusable extended functions. Another benefit is the system is deployed on the cloud and uses the advantages of cloud computing to perform elastic expansion of data.

In a future study, further validation of the proposed system focusing on the extensions of the remaining life. Besides, this study will be enhanced with maintenance planning according to the conditioned artificial intelligent modes.

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