CLOUD COMPUTING BASED INTELLIGENT MANUFACTURING SCHEDULING SYSTEM USING THE QUALITY PREDICTION METHOD

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ABSTRACT
This paper proposes the development of a cloud computing based intelligent manufacturing scheduling system (CBIMS) using the quality prediction method. A CBIMS continuously builds up many different production line layout modes. We use the cloud database for scattering and storing data, and the scheduling engine contains a sequence score system of products, an optimized layout system, and a monitoring system for all available resources. The results show the advantages, including low cost, good quality, production fluency, and flexible management.

Keywords: cloud computing; intelligent scheduling system; manufacturing quality; optimized layout.

SYSTÈME INTELLIGENT DE GESTION D'HORAIRE BASÉ SUR L'INFORMATIQUE EN NUAGE "CLOUD COMPUTING" UTILISANT LA MÉTHODE PRÉVISION DE QUALITÉ

RÉSUMÉ
Le développement d'un système intelligent de gestion d'horaire basé sur l'informatique en nuage (CBIMS) utilisant la méthode prévision de qualité est proposé dans cet article. Un CBIMS réalise continuellement différents plans de production. Nous utilisons les données de "Cloud Base" pour diffuser et entreposer les données, et le moteur de gestion d'horaire contient un système de fiches de produits, un système optimisé du plan, et un système de suivi pour toutes les ressources disponibles. Les résultats montrent les avantages, incluant la réduction du coût, la bonne qualité, la fluidité de la production et la gestion flexible.

Mots-clés : informatique en nuage "cloud computing" ; système intelligent de gestion d'horaire ; qualité de production ; plan optimisé.

NOMENCLATURE

A	Available
D	Desire
E	Equipment
F	Final
H	Human Resources
L	Layout
M	Materials
O	Original
P	Products
Q	Quality
S	Score

1. INTRODUCTION

Advanced manufacturing systems are intended primarily to focus on manufacturing quality and scheduling automation to improve efficiency and reduce various costs associated with production. Therefore, many scheduling systems have been developed using the optimized approach of manufacturing systems. In this study, the main purpose of using Cloud Computing for the optimization of manufacturing resources in real time is to achieve optimal scheduling and expected quality. Most optimal algorithms, including artificial neural networks, genetic algorithms, and multi-agent systems, commonly used to improve the efficiency of the scheduling systems.

In 1991, Tsukiyama et al. [1] developed an advanced scheduling method based on a constraint based scheduling editor and Petri-net simulator. The advantage of this method was that the human scheduler can debug the schedule through a comprehensive Gantt chart and process chart as desired. In 2001, Kim et al. [2] presented the new concept of a real-time scheduler based on system states, which was classified autonomously using a neural network. For the development of the scheduler, a general methodology for the simulator and the clustering method for the system states was proposed. The proposed method may be applied to any existing manufacturing system with minimum installation effort, and can generate efficient schedules using only a control computer equipped with a state reporting system. In 2010, Guo et al. [3] proposed a new manufacturing scheduling system using an organization model based on a virtual manufacturing cell (MROM-VMC). The results showed that the VMC generation algorithm needed to be further optimized and that the manufacturing resources of the organization model should include labor grouping considerations. In 2004, Lin et al. [4] proposed the Combination of Project Management theory and the limitations of automated production scheduling. If the project management method uses Cloud Computing, the schedule of the plant can be flexible and can be monitored at any time. In 2005, Zhao et al. [5] proposed a new hybrid approach combining neural networks and genetic algorithms for job-shop scheduling. The computational ability of the hybrid approach was strong enough to deal with complex scheduling problems, and the results indicated that the proposed algorithm can obtain a satisfactory solution for the job-shop scheduling problem. In 2006, Wang et al. [6] proposed a distributed scheduling method, which is composed of an iterative coordination mechanism and a modified genetic algorithm. For simplicity, the complicated scheduling problem was divided into several sub-problems. The scheduling objective was to achieve a multiple performance index, i.e. to minimize the manufacturing costs and meet due dates. The capability of the proposed method has been tested with satisfactory results by several numerical experiments. In 2011, Cao et al. [7] proposed a scheduling model for complex manufacturing processes based on a multi-agent system. The results achieved so far in the research community provide excellent motivation for further development of solutions in the area; however, because most scheduling problems have been proven to be NP-problems and subject to multi-constraint, multi-objective, and high uncertainty features, solutions are difficult to find.

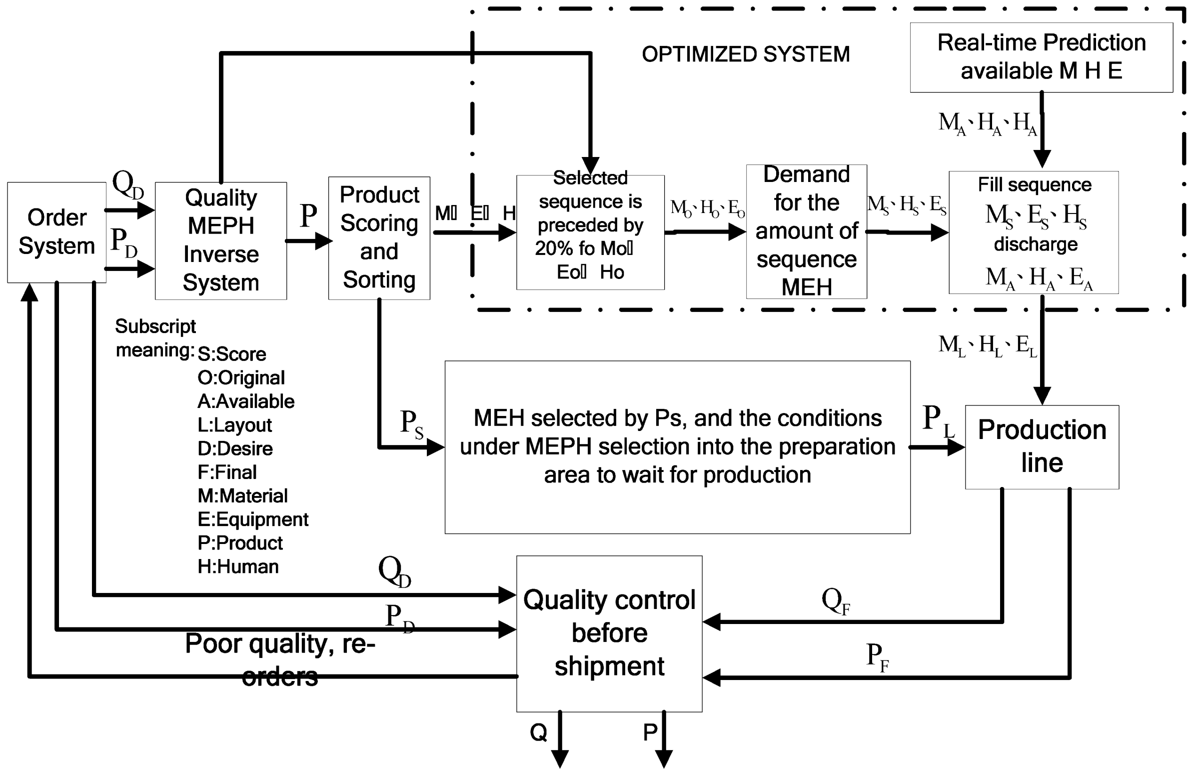


Fig. 1. Model of scheduling system using optimized layout method for manufacturing quality.

In 2012, Ramesh et al. [8] proposed the prediction and optimization of cutting process parameters using ANN and RSM methods for phosphor bronze damping material attached to the boring tool. Tool wear was measured using profilometer, while the temperature and tool wear were accurately predicted using the developed ANN model.

But most above optimal algorithms in computing, including artificial neural networks, genetic algorithms, etc., are too complicated to be suitable for dynamical real-time scheduling systems. So we propose an innovative algorithm of optimized layout for production. It is easier than other exiting methods in computing and controls the scheduling time well. In summary, it is necessary to develop Cloud Computing technology for dynamical optimization of the scheduling system by using information and communication technology. Therefore, in this study we develop a cloud computing based scheduling system using the optimized layout method for manufacturing quality.

2. INTELLIGENT SCHEDULING SYSTEM

In this study, an automated scheduling system can be linked to a Cloud Computing based intelligent manufacturing quality prediction engine [9], and the manufacturing quality can be calculated by neural networks in the system [10]. In this way, we can perform forward computing of MEPH (Material/Equipment/Product/Human) factors to predict the quality indicator, or perform inverse computing of the quality indicator to predict the MEPH factors [11]. The model of the scheduling system is shown in Fig. 1.

The Quality MEPH Inverse System received requirements of quality (Q_D) and requirements of product (P_D) from Order System and then sent Original $M_O H_O E_O$ to Optimized System. Product Scoring and Sorting System got all product No. (P) from Quality MEPH Inverse System and then sent MHE with scores to

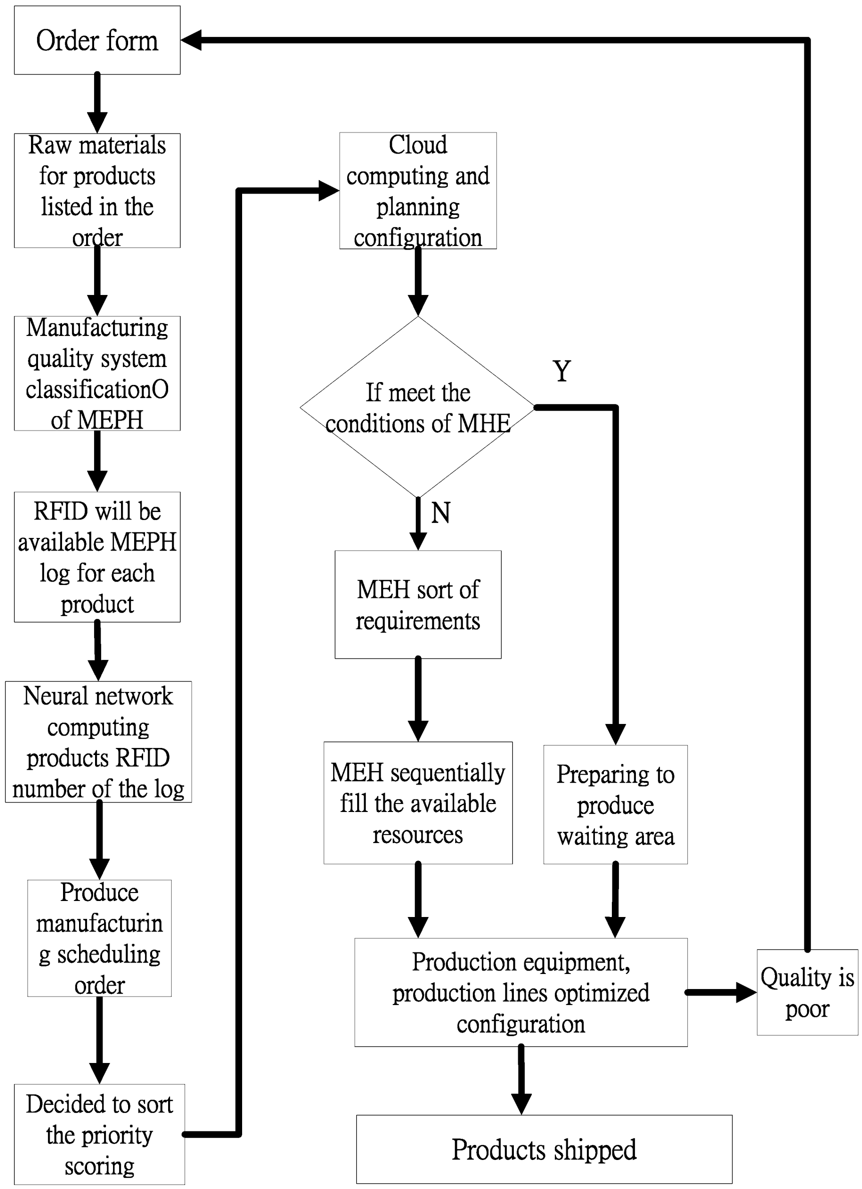


Fig. 2. Sequence score mode for products.

Optimized System and sorted Product No. (P_S, P_L) to Production Line with Optimized Layout ($M_L H_L E_L$). The comparisons of desired quality (Q_D) with final quality (Q_F) and desired of product (P_D) with final product (P_F) decide if it makes Re-orders.

3. SEQUENCE SCORE SYSTEM OF PRODUCT

The process priority of the products depends on the value of the sequence score in the system. The flow chart of the sequence score mode for the products is shown in Fig. 2. Time factors, such as lead time, delivery time, and material inventory, are incorporated accordingly by the implementation of the rules of the sequence score system. The rules result in product process priorities which are fair and reasonable even if any urgent orders or other new orders are inserted.

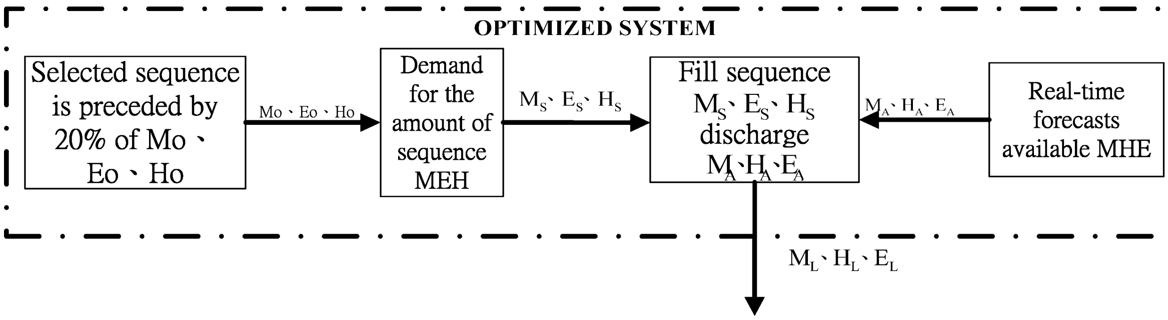


Fig. 3. The flow chart for generating the optimized layout for the automated scheduling system.

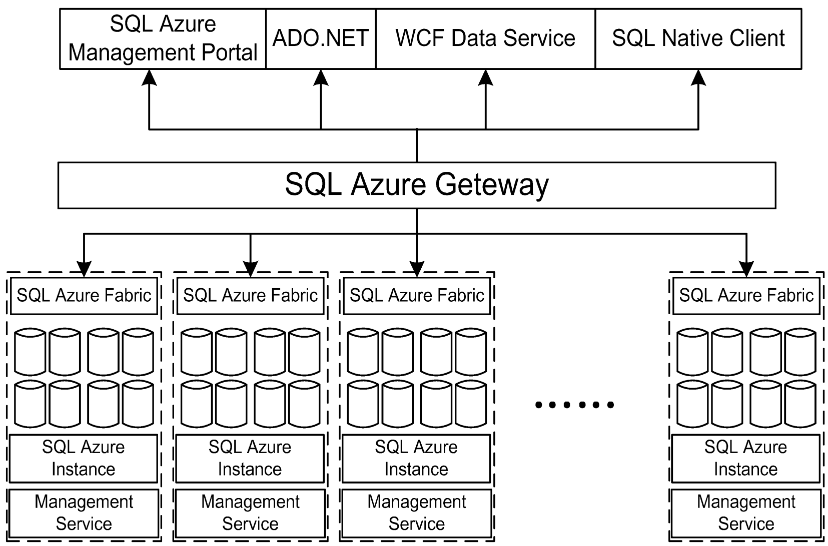


Fig. 4. SQL Azure database structure.

4. OPTIMIZED LAYOUT METHOD

The flow chart of generating the optimized layout for the automated scheduling system is shown in Fig. 3. The algorithm of optimized layout for production used in this study includes the following steps:

1. Start the inverse computing of the intelligent quality prediction engine.
2. Select the MHE of the first 20% of the sequence score for the products.
3. Sort out the demand for the original $M_O H_O E_O$.
4. Predict available $M_A H_A E_A$ in real time.
5. Fill the demand for the original $M_O H_O E_O$ by the available $M_A H_A E_A$ according to the designated order. This results in $M_L H_L E_L$, an optimized layout for the automated scheduling system.

5. DESIGN OF THE CLOUD COMPUTING BASED INTELLIGENT SCHEDULING SYSTEM

5.1. Cloud Database Structure

The SQL Azure database structure, used as the cloud database server, is shown in Fig. 4. The SQL Azure Gateway Services are the front end for all client applications trying to access the SQL Azure services. In

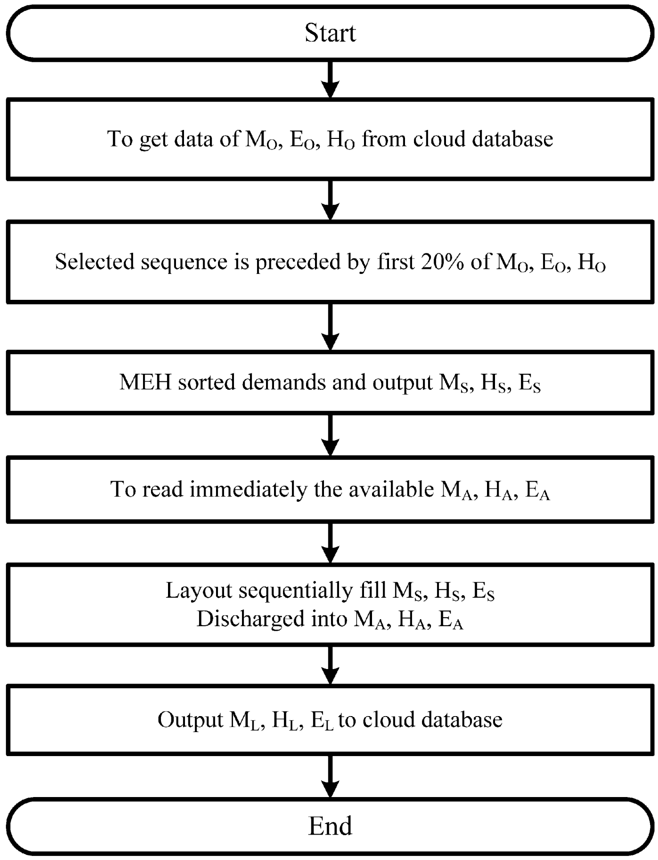


Fig. 5. Flow chart of the intelligent scheduling engine.

addition to providing gateway services like user authentication, basic request parsing, firewall verification, etc.

The functions of Azure Fabric Controller are as the kernel of the Azure operating system. The Azure Fabric Controller provisions, stores, delivers, monitors and commands the virtual machines and physical servers which make up Azure. Distributed computing of SQL Azure is achieved using multiple SQL Azure execution units, with the use of SQL Azure Fabric for control. Distributed data is stored in multiple SQL Azure nodes, where both sets of data access the SQL server and can access the correct information.

5.2. Intelligent Scheduling Engine

The intelligent scheduling engine contains the sequence score system of the products, the optimized layout system, and the monitoring system of the available resources. Even if materials, equipment, and human resources are changed with customized orders, Cloud Computing is still capable of real-time analysis and planning. The flowchart of the intelligent scheduling engine design is shown in Fig. 5.

5.3. Real-Time Human-Machine Interface

When web pages of real-time human-machine interface load charts, the SQL data source controller connects to the database for the chart controller. Web pages are refreshed from time to time to keep current the SQL data source controller data. The executing process is shown in Fig. 6. The scheduler can decide new scheduling from the information of the human-machine interface. The workflow of real-time human-machine interface is as the following steps:

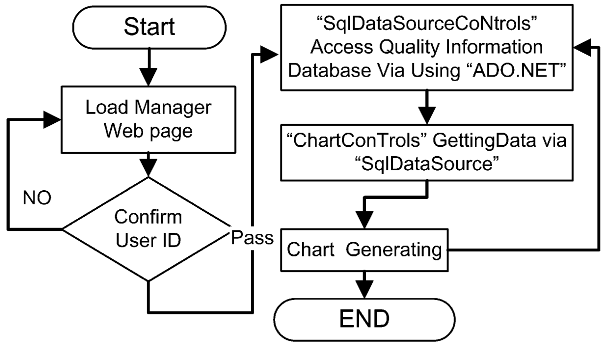


Fig. 6. Flow chart of real-time human-machine interface.

USER-PC.Scheduling - dbo.MEPH

Pa	Pd	Ps	Pf	Pl	Po	Ms	Mo	Ma	Ml	Md	Mf
P0001	2	3	4	5	4	4	5	5	2	2	2
P0002	4	5	5	4	5	5	4	4	3	4	3
P0003	5	5	5	5	4	4	5	5	4	5	5
P0004	4	5	4	5	4	5	4	4	4	2	2
P0005	2	3	5	5	5	5	5	5	3	5	3
P0006	4	5	4	5	4	4	4	4	3	4	5
P0007	5	5	5	4	5	4	4	4	3	2	5
P0008	2	3	5	5	5	4	5	4	4	4	5
P0009	5	5	4	5	5	5	5	4	4	4	3
P0010	2	3	3	5	4	5	5	5	3	2	5

Fig. 7. Cloud database structure of the intelligent scheduling system.

1. Start to load Manager Web Page.
2. Identify Users for Security Policy.
3. "SqlDataSourceControls" accesses the data of Quality Information via using ADO.NET. "SqlDataSourceControl" enables you to use a Web server control to access data located in a relational database.
4. "ChartControls" generates charts by using data from "SqlDataSource".
5. And then users can real-time get the information by the human-machine interface.

6. RESULTS AND DISCUSSIONS

In this study, all experiments and testing are for TPU lamination production lines. The cloud database structure of the intelligent scheduling system is shown in Fig. 7. It contains the fields M_L, H_L, E_L, M_O, H_O, E_O, M_A, H_A, E_A, M_L, H_L, E_L, etc. The real-time human-machine interface for the scheduling system is shown in Fig. 8. The figure shows the results of the sequence score system of the products, the optimized layout system, and the monitoring system of the available resources in real-time HMI. By the experiments, we also find the algorithm of optimized layout for production is easy and controls the scheduling time well.

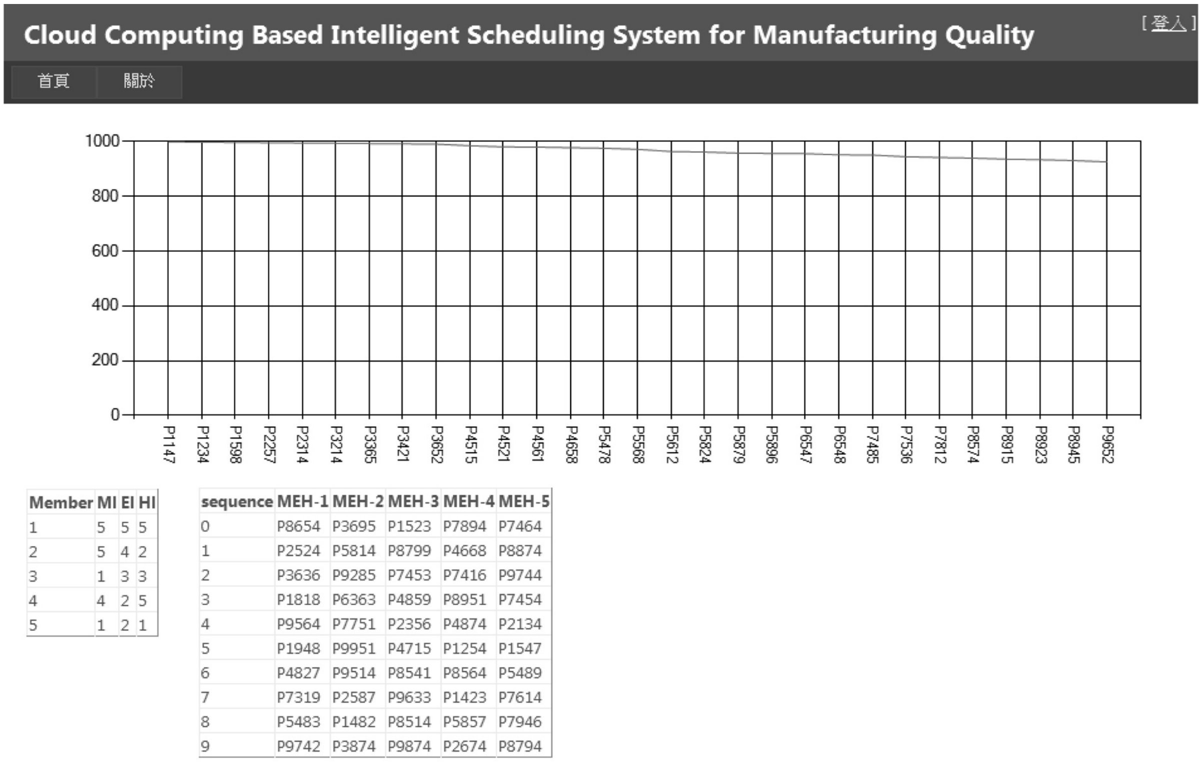
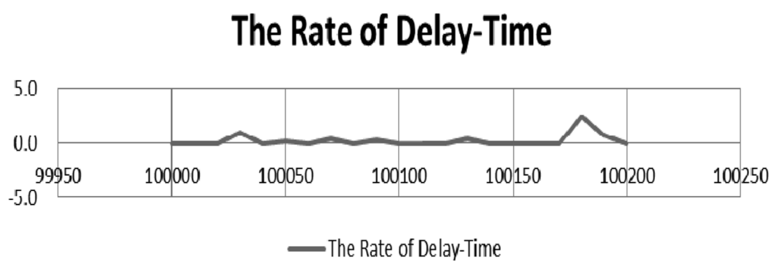
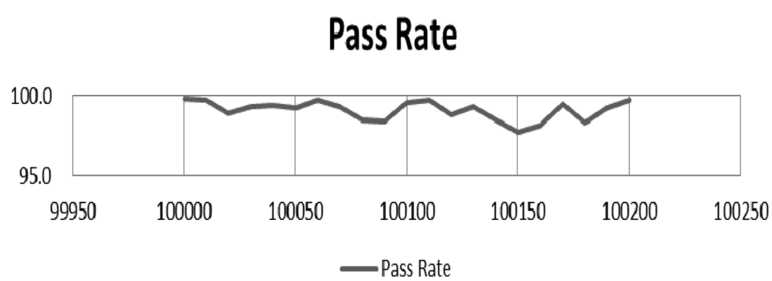


Fig. 8. The real-time human-machine-interface for the scheduling system.



(a) Timeliness of production



(b) Pass rate of production quality

Fig. 9. Results achieved by the scheduling system.

The results of the scheduling system are shown in Fig. 9. It can be seen that production delays are controlled within 2% and the pass rates of product quality are all over 97%. This suggests that the timeliness and quality of the production are controlled very well by the cloud computing based intelligent scheduling system.

7. CONCLUSIONS

The greatest advantage of the proposed scheduling system is that Cloud Computing is still capable of real-time analysis and planning even if materials, equipment, and human resources are changed with the customized orders, and we have demonstrated good performance of the scheduling system regarding timeliness and quality of the production. And the algorithm of optimized layout for production is easier than other exiting methods and controls the scheduling time well. Because of the advantages of low cost, good quality, production fluency, and flexible management, it is necessary to further develop a Cloud Computing based intelligent scheduling system for manufacturing quality. In the future, we can use this system in more applications, such as bakeries, airlines, etc.

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