

Job Scheduling Management Research of Intelligent Manufacturing Based on the Internet of Things

Guangrong Li^{*a}, Yingfei Ge^a, Yunxia Wang^a, Shengping Hu^b

^a School of Mechanical Engineering, Nanjing Institute of Technology, Nanjing, Jiangsu, 211167, China,

^b Nanjing Bilin Software Company, LTD, Nanjing, Jiangsu, 210008, China.

grongli@njit.edu.cn

In-depth and detailed requirements of intelligent manufacturing are analyzed for the virtual cloud enterprise, and it is explained that the process of the main task of job scheduling about intelligent manufacturing based on Internet of things. It is concluded that the relationship and associations among parameters after the research of the physical model and object model based on Internet of things. Parameters include the process of production and basic information data. Different orders are analyzed and compared for job scheduling condition, then it is concluded that to get the specific process of qualified products. The detailed analysis and disassemble program are carried on back business of work ticket and splitting business, which makes the management more rationalization and improves the efficiency of intelligent manufacturing. Finally the scheduling of query is carried on and other business query functions have been implemented, which is the solar panels of a factory production. The system of job scheduling is more reasonable and more efficient in scheduling management, which saves time and resources for the enterprise. This research could be applied in the job scheduling of cloud virtual enterprise.

1. Introduction

Cloud enterprise build the integration electronic commerce including Internet marketing promotion, services with the cloud promoting by independent research and development of enterprises based on the analysis and view of the present status of the international enterprises and the development trend of Internet marketing. Its core and basis is Internet, combining with the mobile Internet, network, communication network, Internet of things. It provides users with Internet marketing and operational solutions of convenient human nature strictly accordance with the standards. It brings the largest e-commerce application value for customers, creating a new generation of Internet marketing operation system. Virtual cloud enterprises in intelligent manufacturing do intelligent operations scheduling of manufacturing process usually in combination with the actual demand and the arrangement of production resources in the process of production, to reduce the waste of the resources and some unreasonable arrangements in the production process, and to save times of intelligent manufacturing and due to resource scheduling and arrangements^{[1][2]}. It is very important for the enterprise, a key role in terms of cost savings.

According to the characteristics of the management mode, manufacturing system of virtual cloud enterprise can be divided into two kinds. At the same time the division of manufacturing system is in consideration of people-oriented, which is divided into workshop and workstation. Job scheduling in operation of the system is more complex. The scheduling problem is an important part of the operation control theory for manufacturing system. The ability of operation control decides the speed of the development of modern manufacturing system. Job scheduling of intelligent manufacturing not only includes the open job scheduling (Open Shop Scheduling Problem, OSP) and different job scheduling sequence (Job Shop Scheduling Problem, JSP) and mixed flow operation scheduling (Hybrid Flow Shop Scheduling Problem, HF2SP), but also includes other basic ways^{[3][4]}. For improving operation results, several kinds of traditional basic operating will be combined into a large problem, which is coexist and is analyzed in a manufacturing system. The problems of the OSP and JSP or a mixture of job scheduling problem, which is called to Mixed Shop Scheduling Problem (MSP) and is combined with OSP and flow operation scheduling problem (Flow Shop Scheduling Problem, FSP), have been studied by some scholars. It could be built to be a processing of a whole, which is combined with OSP, JSP and HFSP3 mode of operation, as the general job scheduling problem (Universal Shop Scheduling

Problem, USP). Its essence is the expansion of the MSP problem. Hybrid ant colony algorithm (Hybrid Ant Colony Optimization, HACO) has been also put forward for USP problem. Calculation results show that searching speed of the HACO algorithm and convergence of the two aspects are more advantage^{[5] [6] [7]}. In this paper, these researches are done and implemented on the basis of the general job scheduling method, which are the main business of intelligent job scheduling, splitting and back business, research and implementation of the query function. These are a foundation for job scheduling of intelligent manufacturing to achieve maximum efficiency.

2. Job scheduling management of intelligent manufacturing based on Internet of things

2.1 Object model of job scheduling

Internet of things is form the people and things, things and things, connecting together by such as new way using the local network or the Internet communication technologies such as the sensor, controller, machines, personnel and property, which is to be informationized, remote control and intelligent network management. Internet of things is the extension of the Internet. It includes all the resources on the Internet and the Internet. It is compatible with all Internet applications, but all of the elements in the Internet of things (all of the equipment, resources and communication, etc.) are personalized and privatization. Intelligent Manufacturing (IM) is a kind of intelligent man-machine integration system composed of intelligent machine and human experts. It can do intelligence activities in the manufacturing process, such as analysis, reasoning, judgment, planning and decision-making, etc.

Intelligent manufacture of virtual cloud enterprise based on Internet of things adjust real-time relevant factors in the manufacturing operations, and schedule related materials and resources according to the online machining requirements and actual requirement, combined with the processing conditions of the enterprise to the highest efficiency of the best products. Intelligent manufacturing network of cloud enterprise usually need to online monitor due to various reasons in the parts production and processing^{[8] [9]}. Intelligent manufacturing of cloud enterprise based on Internet of things usually monitor job scheduling of the machining center and the products production, and provides real-time suspending, terminating and querying job scheduling and other operations. It provides the business processing of production orders and the division of votes about unfinished work in products of job scheduling, which include splitting or being back to production orders. The business processing print tags for splitting work tickets again.

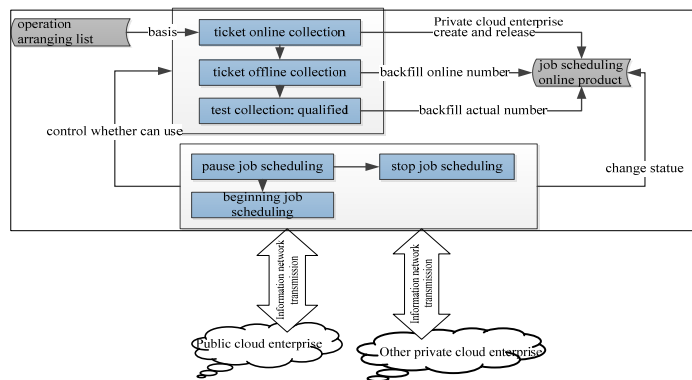


Figure 1: Main business process of job scheduling

Job scheduling work is very important and key in the process of processing and manufacturing for cloud enterprise. It is the production basis of processing center^{[10] [11]}. A work plan creates a job scheduling, and create a product being processing under a job scheduling. There are a few products under a job scheduling in the late factory after splitting in this project. Data gathering can be done including undertaking tickets online and offline. If qualified, job scheduling in products can be done in undertake specific. If not qualified, the suspension job scheduling is stopped, then ending up job scheduling and restarting job scheduling. Job scheduling in the process of management can be operated, such as be suspended, be started, be terminated. If it is paused, corresponding working ticket cannot be online and be inspected, but the number can be zero. Because only one product online can be controlled in process of some machining center at the same time. This ticket is using and other work tickets cannot be online. Termination of the operation is done under the condition that job scheduling state of the products are all finished, and the job scheduling state should be set to end. Then job scheduling will not be able to use again. Type of job scheduling inheritance the type of

operation ticket plan, which also can be divided into "normal", "rework", "transformation", "splitting", "repair" five types. If the scheduling function is weak, there must be a job scheduling control in order to the continuation of the products of the company.

A concrete object model is in Figure 2, including related parameters of the job scheduling and on products, as well as the contact between them. The specific process of job scheduling, online production status and quality status are listed in Figure 3. Job scheduling and production status in the online products are respectively planning, according to the production situation is unqualified. Then it is judged whether to stop or offline, and further completion. Quality status is judged to repair after the inspection process operation according to whether the qualified.

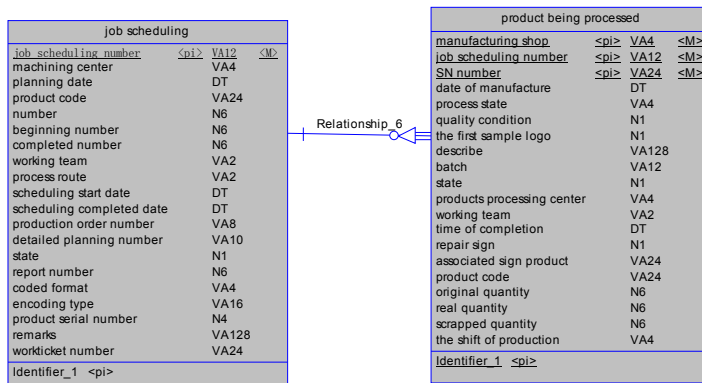


Figure 2: Object model of job scheduling

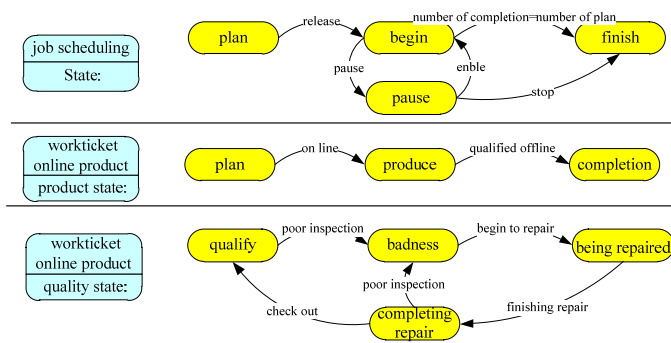


Figure 3: Part process flow of job scheduling

2.2 Job work ticket splitting and back business

Virtual cloud enterprise needs to do job work ticket splitting and back business when making parts online job scheduling and management^{[12][13]}. If one team of work ticket has been completed part of work, others will be done by the next team then. Because production statistics are done in strict accordance with the teams and groups, it needs to split into two work ticket, which is corresponding to different teams and groups. After parts of the production on a work ticket have been finished, the production can't continue because the fault of the equipment and mold. Complete part need to be gone at first. The two work ticket need to be split, and one is been gone to next process workshop, and the another one to be produced. When the number of plan working ticket is greater than the number of the physical frame storing for new products, the number which cannot be deposited will be back to the production orders to organize production again. The back action is only allowed to occur in the first process of extrusion workshop.

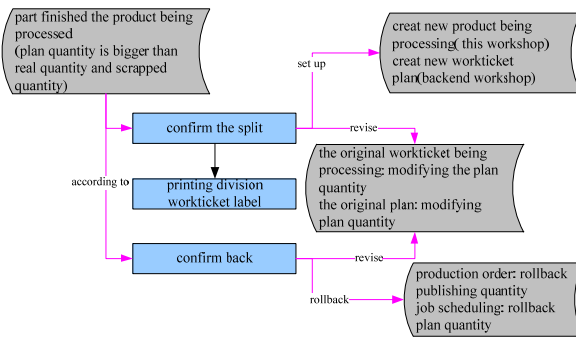


Figure 4: Specific business process of job scheduling

New work tickets for this workshop will be held under the job scheduling of the female work ticket about splitting in the system. New work ticket can directly be online produced, which is used to solve the problem of shifting groups without changing mold. The plan of job work ticket will be recreated for the next workshop. It will be produced after the reproduction scheduling. There will be a separate business function of printing work ticket label for the splitting work ticket, which will not be allowed to print again after the next workshop do the production scheduling. A fraction of the multiple work ticket under a production order is back to production orders only on the first working procedure. The new plan of work ticket will be released after a summary, and products will be scheduled and be done in group production. There are solutions if the split will lead to a lot of the work ticket of small non-standard box. But there are also differences or inadequate description: not being box business in the true sense. Box business will be actually implemented through the back for the first process of workshop. The comprehensive box business will be quite complex.

Work ticket splitting and back business are done between public clouds and private clouds enterprise or internal between various departments in the process of production due to business requirements. If work ticket splitting and back business are done in the internal of public or private cloud enterprise, a demand of work ticket is sent from related production and production scheduling department at first. Then tickets are checked and confirmed to work shop. Detailed advices are returned back to the production department. It will be decided by joint according to the separation requirements and back reason. If work ticket operations is done between the public clouds and private clouds enterprises, depending on the actual need, the specific requirements of the production and orders, work ticket demands are issued by production enterprises, then sub companies accept demand and work tickets of actual production are verified and the details of the investigation are done. The feedback suggestions are given with the actual production situation. Work ticket split or back are finally made by joint. This is also the operation of different departments and different enterprises.

3. Job scheduling query function

3.1 job scheduling query

Virtual cloud enterprise can often query the specific job execution due to various reasons in manufacturing process. In particular, the change of some parameters are queried in the process of job scheduling according to the requirements, which are such as specific staff scheduling, material production scheduling etc^[14]. As shown in figure5 for the realization of the query function, the object of query includes the followings: planned date, serial number, personnel, material code, material name, production orders, specifications, production orders, plans quantity, starting number, finish number, finish date, product condition. And the specific process query of the online products includes work procedure name, status, process diagram, online SN, online time, quality status, plan number, offline number, scrap number, finish time, the production crew, production groups, process content etc. But these must be queried and gotten by the permissions of corresponding personnel.

In the process of production query for job scheduling not only can happen between different departments of the same enterprise, but also between public and private cloud enterprise according to the requirement of manufacturing enterprises. Analysis of job scheduling and requirements query is done by enterprises or departments on the basis of production. And query request is sent to relevant enterprises or departments. The information is searched by special business sector in the case of actual production according to the database or location, which is checked and is feedback to the corporate sector to the final query result, so as to realize job scheduling query of the virtual cloud between enterprises^[15].

3.2 Job scheduling

Serialnumber	Number	Productionorder	Materialcode	Nameofmaterial	Specification	Manufactureorder	Plan
7001	0111B090017	WO-0368	02130009	ZYF090-500-63	solar panel03	11110749	91
7002	0111B090018	WO-0368	02130010	ZYF090-500-69	solar panel09	11110756	56
7003	0111B090019	WO-0369	02130543	ZYF080-520-01	solar panel01	11110780	90

Process	Processname	Productsn	Onlinetime	Qualitycondition	Plannedquantity	Numberofreferrals
110	protest	11B0900147	13:36:06	OK	20	20
110	protest	11B0900148	13:45:12	OK	15	15

Figure 5: The implement of job scheduling

Query instance of job scheduling is as shown in figure 5. It is a factory production of solar panels. For example, serial number is listed the first column, starting with 7 series, 00 *. A specific number is added in the second column with 0111 b0900 * * number. Production orders are listed in the third column, coding for settlement - 03 *. And material code is listed in the fourth column, code with 0213 * * * *. Material name is in the fifth column, beginning with a specific material abbreviated as ZYF, 090-500-500 and adding specific parameters etc. The specifications are listed in the sixth column, being the name of the specific components for solar energy. A production order is listed in the seventh column, which is 11110749. Starting number is listed in eighth column and completing number is listed in the ninth column. The 8 and 9 columns is respectively expressed in integer count. The planned date is listed in tenth column, which are date and month and year, such as the 2015-02-11. The serial number for a particular process arrangement is listed in the first column as a specific process of inquiry of working procedure. A process name is listed in the second column, which is called for practical process. The SN of products is listed in the third column, being SN Numbers of online product. Online time is listed in the fourth column, including date and month and year and minutes. Quality status is listed in the fifth column, being divided into qualified one and the unqualified one. Plan number is listed in the sixth column. A referral number is listed in the seventh column. Scrap number is listed the eighth column. And the 6, 7, 8 columns are integer count. Completion time is listed in the ninth column, which is expressed with second and minute time and date and month and year. The production class and groups is listed in the tenth column, for the process name and number. Production shifts is listed in the eleventh column for day and night. Specific description is listed in the twelfth column, writing out the specific content of the process. Other inquiry of job scheduling and process can be also performed.

4. Conclusions

With the development of the Internet of things, job scheduling process is more and more important in intelligent manufacturing of virtual cloud enterprise. Its role is becoming more and more obvious. Job scheduling can help enterprises to adjust the allocation of resources in production. And some problems can also be found in time in the process of manufacture. The mode of intelligent manufacturing can be even restructured. It makes virtual cloud enterprise efficient cooperation, which can be highly integrated manufacturing share. The object of job scheduling is built and the relation among them is expressed. The query function is implemented by the system of solar pane. It can satisfy the practical production scheduling in the intelligence process of enterprise of virtual cloud enterprise by implementing the management of job scheduling resources query, which provides the basis for more efficient data and information sharing and provides reference for the cooperation model of cloud enterprise.

Acknowledgements

This project is supported by research fund project of Nanjing institute of technology (No. CKJB201201) and the support project of science and technology of Jiangsu Province, China (No. BE2011712) and the planning project of humanities and social science research fund of the ministry of education (No. 12YJAZH151) and the college fund project of Jiangsu Province, China (No. 10KJB460003) and the youth project of humanities and social science research fund of the ministry of education, China (No. 12YJCZH209).

References

- Bawa R.K., Sharma G., 2013, Modified min-min heuristic for job scheduling based on QoS in Grid environment. Proceedings of the 2013 2nd International Conference on Information Management in the Knowledge Economy, IMKE, 166-171, October 1, 2014.
- Javad A.T., 2012, A new approach to the job scheduling problem in computational grids. *Cluster Computing*, v 15, n 3, 201-210, September, DOI: 10.1007/s10586-011-0192-5
- Liliana G., 2015, Scheduling on uniform processors with at most one downtime on each machine, *Discrete Optimization*, 17, 14–24. DOI: 10.1016/j.disopt.2014.10.001
- Mahapatra S., Dash R.R., Pradhan S.K., 2015, A heuristic job scheduling algorithm for minimizing the waiting time variance. 2015 1st International Conference on Futuristic Trends in Computational Analysis and Knowledge Management, ABLAZE 2015, 446-451, July 10, DOI: 10.1109/ABLAZE.2015.7155026
- May G., Stahl B., Taisch M., Prabhu V., 2015, Multi-objective genetic algorithm for energy-efficient job shop scheduling. *International Journal of Production Research*, January 30, DOI: 10.1080/00207543.2015.100524.
- Mehdi S., Richard M.W., Lucio G., José L.V., Francesca G., 2015, A multi-dimensional job scheduling. *Future Generation Computer Systems*, Available online 27 March, 3, 014-020. DOI: 10.1016/j.future.2015.03.014.
- Nouri H.E., Driss O.B., Ghédira K., 2015, A holonic multiagent model based on a combined genetic algorithm tabu search for the flexible job shop scheduling problem, *Communications in Computer and Information Science*, 524: 43-54, DOI: 10.1007/978-3-319-19033-4_4
- Nouiri M., Bekrar A., Jemai A., Niar S., Ammari A.C., 2015, An effective and distributed particle swarm optimization algorithm for flexible job-shop scheduling problem, *Journal of Intelligent Manufacturing*, February 5, DOI: 10.1007/s10845-015-1039-3
- Paletta G., Ruiz-Torres A.J., 2015, Partial Solutions and MultiFit Algorithm for Multiprocessor Scheduling, *Journal of Mathematical Modelling and Algorithms in Operations Research*, 14(2), 125-143.
- Piroozfard H., Wong K.Y., 2015, An imperialist competitive algorithm for the job shop scheduling problems. *IEEE International Conference on Industrial Engineering and Engineering Management*, v 2015-January, 69-73, March 11.
- Shen J.Y., Zhu Y.G., 2015, Chance-constrained model for uncertain job shop scheduling problem, *Soft Computing*, March 19, DOI: 10.1007/s00500-015-1647-z
- Tantitharanukul N., Natwichai J., Boonma P., 2014, A trail-based approach for job scheduling in distributed systems with workflows, 2014 9th International Conference on Digital Information, ICDIM 2014, 57-62, December 17, ISBN-13: 9781479954209, DOI: 10.1109/ICDIM.2014.6991414, Sponsor: DLINE, Phranakhon Rajabhat University, Publisher: Institute of Electrical and Electronics Engineers Inc.
- Tayal S., 2011, Tasks Scheduling optimization for the Cloud Computing Systems. *International Journal of Advanced Engineering Sciences and Technology*, 2(5), 111-115.
- Xiong C.C., Feng L., Chen L.X., Su J., 2012, Research of task scheduling algorithm based on genetic algorithm of cloud computing, *JOURNAL OF HUAZHONG UNIVERSITY OF SCIENCE AND TECHNOLOGY, NATURE SCIENCE*, S1, 1-4.
- Zhang Z., Li C., Tao, Y.Y., Yang R.Y., Tang, H., Xu, J., 2014, Fuxi: a fault-tolerant resource management and job scheduling system at internet scale. *Proceedings of the VLDB Endowment*, v 7, n 13, 1393-1404.