A Simple Smart Shop Floor Paradigm for Industry 4.0

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Abstract. This paper illustrates the needs and challenges of the smart shop floor in intelligent manufacturing and combines with insights from the field of current MES system needs, advantages and drawbacks, and describes the cloud platform enrich production service system. In a word, recent advanced technologies has paved way for a complete and systematic implement of it. the smart shop floor is in the initial stage of development in factory. At present, there is an urgent need for a viable paradigm of smart shop floor as a guideline. By integrating all relative applications and solutions, Chongqing Guangshu Robot Co., Ltd has designed a simple enough paradigm to adopt the Industry 4.0, within which all related information is closely monitored and synchronized between the physical shop floor and the network computational space.

1. Introduction

The rising fourth industrial revolution has brought great changes for the global industrial system. The pursuit of high quality, low cost, on-time delivery, has become more difficult. Especially, individualized requirements and mass customization force manufacturers to transform the operation of existing manufacture systems. Under this trend, Germany proposes Industry 4.0 [1], the United States raises Industrial Internet of Things(IIoT)[2]. The key is to realize intelligent manufacturing [3], resulting in the smart shop floor, which is the main battlefield of intelligent manufacturing.

The smart shop floor is described as follows: It is the most important thing of smart shop floor is to improve production and make manufacturers more competitive. Through the network and software management system, automation equipment (process machine, testing equipment, transmission device, robot) can be interconnected [4], in order to sense the state information of customer needs, production conditions, raw materials, operators, equipment, production process, environmental safety, reach the goal of data analysis, self-organization production and lean management [5].

Nevertheless, the smart shop floor is in the initial stage of development in factory. Moreover, there is no clear the structure and methodology of smart shop floor as guidelines. To meet demands, Chongqing Guangshu Robot Co., Ltd has designed a simple enough paradigm to adopt the Industry 4.0.

The rest of this paper is organized as follow. Section 2 introduces the main approaches enabling smart shop floor. Section 3 presents a case study which includes the key problems, Smart shop floor architecture, Control system structure and human-machine interaction. Finally, Section 4 discusses the results and future research.

2. Approaches enabling smart shop floor

2.1. *Manufacturing execution systems*

Manufacturing execution systems (MES) are software packages used to manage factory floor material control and labor and machine capacity, and to track and trace components and orders, manage inventory, optimize production activities from order launch to finished goods, etc [6].It plays an important role in the collection of production data, equipment management and process optimization in manufacturing shop-floor systems.

Nevertheless, the existing MES system lacks the function of openness, distribution, interactivity and maintenance, following changes in different types of production and process. It is very hard to satisfy individualization services. It is very difficult to realize real-time monitoring, on-line diagnosis, early warning, remote maintenance for machine tools. It is not available to acquire products information through mobile devices. Besides, a commercial MES is always accompanied by enterprise resource planning (ERP)system. It presents a large expense to some small and medium-sized enterprises (SMEs). Thus, these factors hinder the wide adaptability of MES system.

Current research and application provide a new approach to solve the problems. The architecture of MES system having the character of openness and distribution has been proposed. The MES utilizes web services to access industrial cloud platform, which provides services including design, manufacturing, procurement, marketing covering the product life-cycle. As an application, MES is installed on Android-based mobile devices. Nowadays, the problem is how to integrate industrial cloud, smart phone apps into MES in order to realize smart shop floor.

2.2. cloud manufacturing (CMfg)

Xu definition of CMfg is: Cloud Manufacturing is a service-oriented, high efficiency,1ow cost and knowledge-based network intelligent manufacturing new model, is the existing network manufacturing and service technology extension and change. It combines existing information-based manufacturing technology and cloud computing, networking, semantic Web, high performance computing and information technology, all kinds of manufacturing resources and manufacturing capabilities, service virtualization, composed of manufacturing resources and manufacturing capacity pool, and intelligent management and centralized and unified, intelligent, and win a universal and efficient sharing and cooperation, through the network and cloud manufacturing system for the manufacturing process of the whole life cycle to provide ready access, on-demand use, safe and reliable, high-quality and cheap intelligence service[7].

CMfg is the creative application of cloud computing in the field of manufacturing. Its services are mainly composed of infrastructure as a service (IaaS),platform as a service (PaaS),software as a service (SaaS) and Manufacturing as a Service(MaaS). MaaS is CMfg's core body including design, simulation, test and production process, that greatly enrich production service system, especially for SMEs. The mass of services are published on cloud manufacturing platform, which include equipment, materials, software, knowledge, data and technology, as well as design capacity, production capacity, equipment capacity, management capacity and communication capacity[8].Users can easily select a variety of services they need though internet anytime and anywhere.

3. A case study

3.1. Key problems

Through interview, There are three problems that need illustration:

1.The flow and logic control of intelligent unit includes the transmission and acceptance of movement, switching, displacement and data.

2.Cloud system management includes monitoring, warning, maintenance, repair and product life-cycle management, user client, data analysis.

3.Production management includes BOMs, scheduling, record, download and upload, andon

monitor, real-time display results.

3.2. Smart shop floor architecture

The overall architecture of the smart shop floor is based on a four-tier model: user interface, data layer, control layer and execution layer. Fig1. illustrates the smart shop floor architecture overview. The developed architecture overcome the drawbacks of small and medium-sized enterprises (SMEs) through the cloud platform. The user interface is responsible for receiving database, querying database and displaying database. The data layer (MES) includes all the integrated database and links the user interface layer and control layer. The control layer utilizes GPC1000A, which is the main controller of the production line. The execution layer mainly realizes the transmission, processing, measurement and storage.

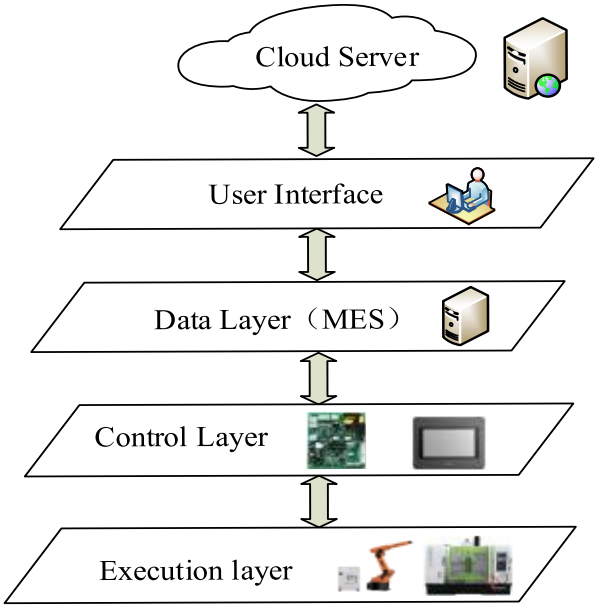


Fig1.Smart shop floor architecture

3.3. Control system structure

The basic control system structure is shown in Figure2.The GPC1000A is a general programmable controllers, which is developed and manufactured by Guangzhou CNC Equipment Co., Ltd itself. It includes Programmable Logic Computer (PLC) function, muti-channel control function and communication function. The real-time control of servo unit and I/O unit are realized by GSK-Link Industrial Ethernet control bus. The real-time data exchange is realized by GSK-Link-PA device bus. It can independently control automation equipment (CNC machines, robots) or lines. It can also be connected to factory LAN to support remote monitoring and process management to realize the seamless between automation and information.

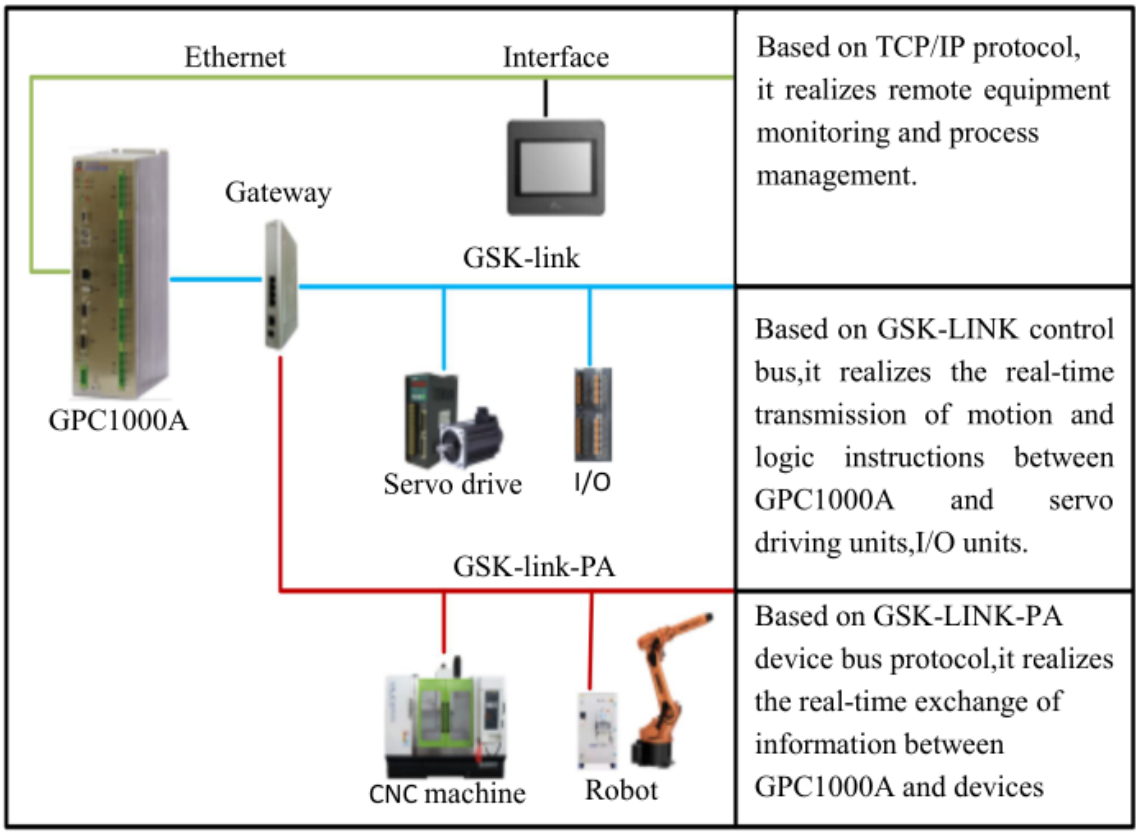


Fig2.Control system structure

3.4. Human-machine interaction

The human-machine interaction interface is shown in Figure3.It can implement real-time monitoring the status of robots, lathes, machining centers, transmission lines, warehouses, and no-conformance products and qualified products in practical production. It displays bus connection state, bus communication phase, bus configuration slave station number, gateway configuration slave station number, loop connection state, loop slave station ID and the state and change of all I/O devices information of controller. The signal of controller can be forced to output by enabling key. The operators can open and close the whole system manually or automatically. It can also be used for the individual operation for the robot.

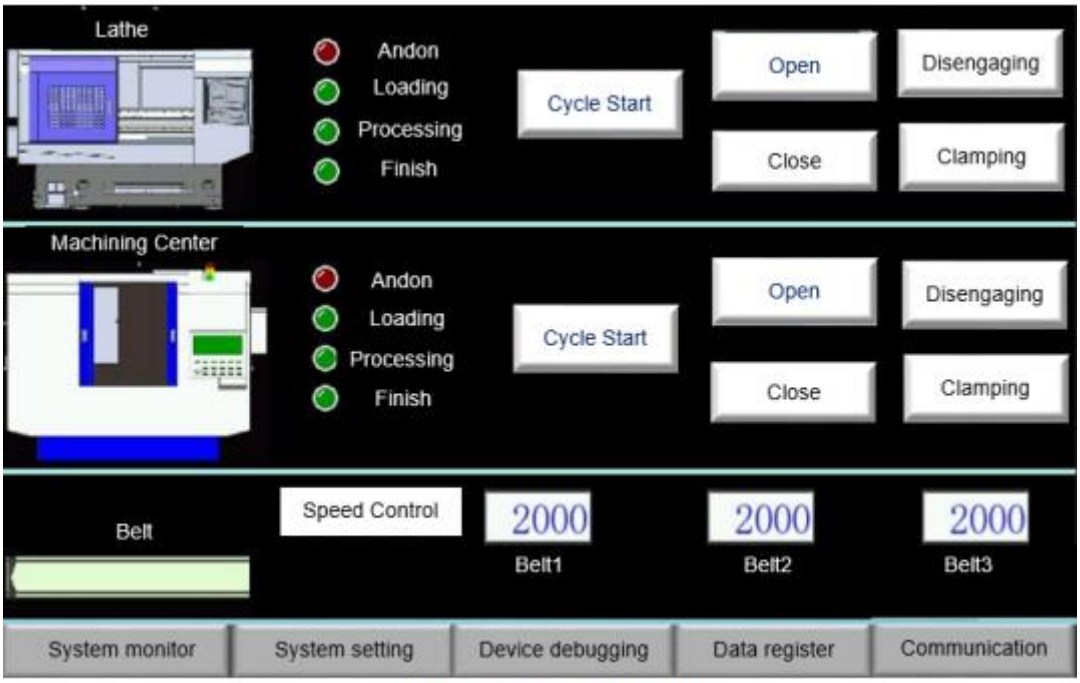
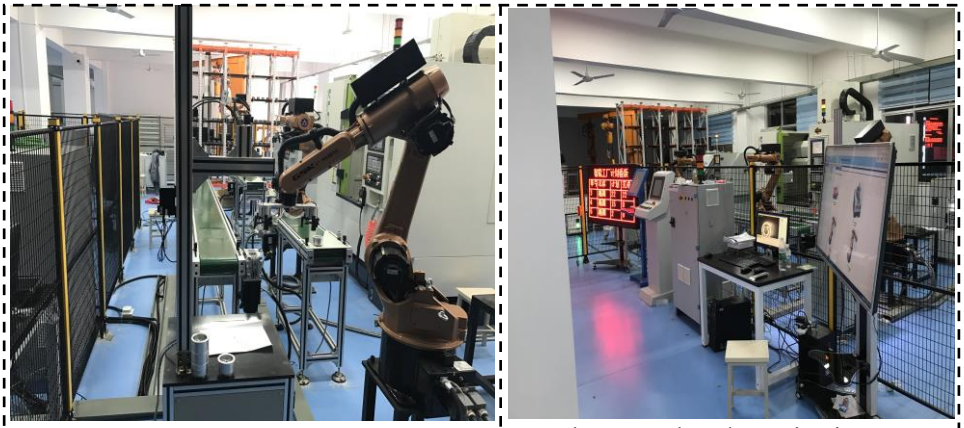


Fig3 .Human-machine interface

4.conclusion and future work

The contribution of this work is to present a enough simple paradigm of smart shop floor adopting of industry 4.0 and provides a practical guideline for SMEs. Based on Smart shop floor architecture, cloud sever, MES sever, process machines and storage systems can be connected and exchange information with each other, and be able to deliver orders and trigger actions smoothly. The control system based on GPC1000A, makes the machine tool operate orderly. Through the human-machine interaction, the whole shop floor realizes the real-time monitoring, debugging and testing for the production line. The performances are shown in Fig4.0

In future research, it is essential to define a unified and viable framework of smart shop floor as a guideline. In addition, corresponding intelligent algorithms and technologies are also proposed at every layer.



a.Production b.Control and monitoring

Fig4. Smart shop floor performance

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