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Mobile Services for Customization Manufacturing Systems: An Example of Industry 4.0

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ABSTRACT In the context of Industry 4.0, it is necessary to meet customization manufacturing demands on a timely basis. Based on the related concepts of Industry 4.0, this paper intends to introduce mobile services and cloud computing technology into the intelligent manufacturing environment. A customization manufacturing system is designed to meet the demands of personalization requests and flexible production mechanisms. This system consists of three layers, namely, a manufacturing device layer, cloud service system layer, and mobile service layer. The manufacturing device layer forms the production platform. This platform is composed of a number of physical devices, such as a flexible conveyor belt, industrial robots, and corresponding sensors. The physical devices are connected to the cloud via the support of a wireless module. In the cloud, the manufacturing big data are processed, and the optimization decision-making mechanism pertaining to customization manufacturing is formed. Then, mobile services running in a mobile terminal are used to receive orders from customers and to inquire the necessary production information. To verify the feasibility of the proposed customization manufacturing system, we also established a customizable candy production system.

INDEX TERMS Mobile services, Industry 4.0, cloud computing, intelligent manufacturing, Internet of Things.

I. INTRODUCTION

Given the new competition environment and technical background, modern-day global manufacturing industries and information technologies are deepening their degrees of integration with the support of Internet of Things (IoT) [1], [2], industrial wireless networks [3], [4], big data [5]–[8], cloud computing [9]–[12], mobile computing [13], [14] and embedded technology [15]. This progress also brings increased hope for new applications, such as production customization and product life cycle management. Specifically, Industry 4.0 [16] was proposed and launched in 2013. The integration of manufacturing technology, digital technology and network technology can now be applied to the design-production- management-service. In addition, the manufacturing process now possesses the features (e.g., perception, analysis, decision and control) needed to meet the product requirements of dynamic response, as well as the rapid development of new products.

In addition, with the continuous improvements in the level of products' lifespans, the personalized demands related to products are becoming more and more obvious. Customers are no longer the passive buyers of manufacturing process. Instead, consumers have become the possible designers, who wish to participate in the customization of their goods prior to purchase. As such, there is a need to meet the social element of consumer demands by developing flexible production methods which will meet the individual needs of multiple customers. However, at this present time, the traditional industry production methods (which follow the prescribed order and passive mode in the supply chain) can no longer meet the social aspect of manufacturing development requirements. In addition, an information barrier always exists between manufacturing enterprises and market supply chains. In this context, the proposed Industry 4.0 includes two major themes [17]: 1) a smart factory and 2) intelligent production. Concretely, the machine groups will self-organize, and the supply chain will automatically coordinate.

To address the problems listed above and based on the theory and application of cloud computing and mobile computing, combined with the existing industrial control technology, this paper designs a Personalized Customization Manufacturing System (PCMS) with the ability of mobile services. Our PCMS adopts a cloud platform as an information processing means to form a flexible production mechanism. Today's smart mobile phones are adopted as a mobile terminal through which consumers can connect to the cloud platform. A PCMS exemplified by a customizable candy production system will be implemented. In our view, our proposed manufacturing production model conforms to the Industry 4.0 concepts, and this system is a representative example of Industry 4.0.

The remainder of this article is structured as follows. In Section II, the related work for PCMS is reviewed. The overall architecture and key technologies of the PCMS are introduced in Section III. In Section IV, the implementation mechanism of the proposed PCMS is described. In Section V, a PCMS exemplified by a customizable candy production system is established, in order to verify the feasibility of our system. Finally, Section VI gives the conclusions.

II. RELATED WORK

A PCMS in a production workshop or manufacturing sector is no longer just an information island. A PCMS can now be seen as an organic whole that has the ability to be market-oriented. A PCMS can meet the demand of personalized customization, with high degrees of flexibility and the ability to self-organize production. Ref. [18] points out that the current industrial networked manufacturing model emphasizes just how to aggregate the distributed manufacturing resources, allowing the network to accomplish a manufacturing task, while at the same time neglecting problems relating to service efficiency, resource savings, information sharing, and security. Reference [19] forecasts that future intelligent manufacturing systems will be supported by Cyber-Physical Systems [20], [21], and become highly intelligent and flexible manufacturing models. Therefore, the research and design of a PCMS should focus on the intelligence and flexibility of the manufacturing system, as well as the system's overall ability to implement a personalized service.

As to the intelligence aspects of the system, [22] proposes a framework for a smart factory, which integrates industrial wireless networks, a cloud platform, and physical devices (e.g., smart machines and conveyers). The framework provides a cloud agent for coordinating different types of smart objects, and effectively improves the flexibility of the distributed device cooperation through this cloud coordination mechanism. Reference [23] points out that cloud computing is at the core of IoT. Therefore, internet functionality is present. In industrial IoT, based on the cloud computing mode, a large number of various types of objects' real-time dynamic analysis can be achieved. Reference [24] applies cloud computing to an industrial manufacturing system and designs a mode of business operation which is centered around production. Meeting customer demand is the goal for the optimization of the product management mode, and as such, [25] proposes a service mode and scheduling method of system construction. In summary, when enterprises apply and integrate cloud computing technology into their dynamic resource management and sharing activities, each link of the production process (production – sales – management) will be effectively associated. The amount of delays and loss of information in the message transmission process will be reduced, and the phenomenon of an information-isolated island will be eliminated. Therefore, the various departments of the enterprise will be able to associate with each other and form an intelligent whole.

In terms of flexibility, [26] points out that the reconfigurability of a manufacturing system can help optimize the utilization of system resources and reduce production costs, simply on the premise of finishing processing tasks on schedule. Reference [27] emphasizes that distributed reconfigurable systems have inherent heterogeneous characteristics. Reference [28] describes how semantic web technology can be used to locate the system resources and by doing so, to solve the problem of resource heterogeneity in the system. Reference [29] proposes a reconfigurable intelligent manufacturing production line. This production line can adopt and implement the multi-part family processing scheduling method and flexibly adjust the operation mode of every intelligent manufacturing unit, according to the different production instructions. In this manner, the same production line can meet multiple and diverse production needs. Therefore, reconfigurable technology and multi-part family processing modes can and should be introduced to manufacturing systems. This technology, coupled with the cloud service system auxiliary switching function, will enable the production line to achieve diversification of production and flexible switching between devices.

The purpose of making the manufacturing system more ''intelligent'' and ''flexible'' is to enable that system to meet the demands of a more flexible market, which has increasingly personalized needs. Reference [30] emphasizes that the social element of manufacturing needs to be able to operate in a ''personalized mode,'' while at the same time, the manufacturing system must also ensure real-time performance and economization. With the rapid development of mobile internet, a network society is gradually forming. Reference [31] points out that the scope and range of mobile internet business covers many aspects of user information consumption. Therefore, users can conduct their business and meet their needs through mobile services. Reference [32] comments that the intelligent mobile terminal is changing from a simple communication tool to a comprehensive information processing platform. Accordingly, mobile services are being integrated into intelligent manufacturing systems. Here, the mobile systems will provide a portable intelligent interaction platform for customers, thus allowing the intelligent manufacturing system to obtain the abilities and features of a customer-oriented personalized service.

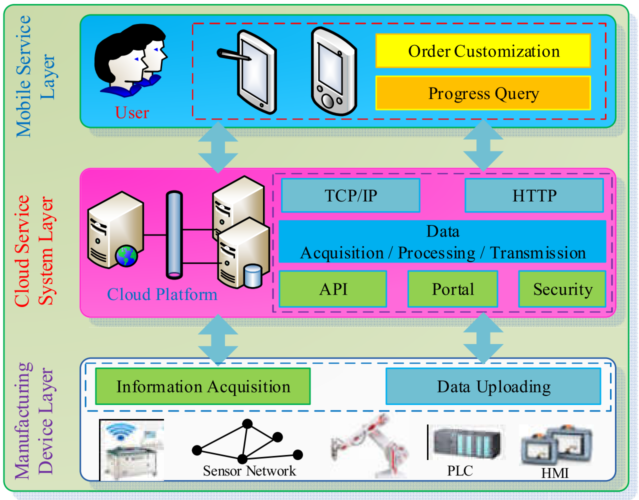


FIGURE 1. **PCMS system architecture.**

III. SYSTEM ARCHITECTURE

In this paper, the system architecture design is shown in Fig. 1. The structure of the system is divided into three layers: the manufacturing device layer, cloud service system layer, and mobile service layer. Each layer of the system depends on corresponding communication technologies and protocols to communicate with the other layers and coordinate production activities. According to the definition of Manufacturing Execution Systems (EMS) based on ISA95 standard, and the intelligent production pattern of Industry 4.0, in this paper, the PCMS (depending on the information system) is capable of convenient order customization, as well as the optimization management of the whole production process. The PCMS can collect the relevant current data for the corresponding production instructions and processing, thus enabling the plant to achieve coordinated management of intelligent production.

A. ARCHITECTURE ANALYSIS

According to the PCMS system architecture, the function definition of the three system layers is as follows.

1) MANUFACTURING DEVICE LAYER

In this layer, a software-defined sensor network [33], [34] is used to collect resource information. The embedded module has assistant nodes for information conversion, and thus, the many devices of this layer can be associated with the cloud platform through this module. The intelligent robot can ensure the working process' characteristics of real-time and accuracy. Therefore, by using the above devices, an intelligent robot can automatically receive the cloud's decision to implement multi-aspect production activities, simultaneously improving the flexibility and efficiency of workshop production.

2) CLOUD SERVICE SYSTEM LAYER

This layer must qualify the Cyber Physical Systems' (CPS) key characteristics. The cloud service system using cloud computing technology provides the APIs of data exchange, data storage and data analysis to the heterogeneous resources of industrial IoT. In addition, the system provides web services as a means to receive personalized order information and send production management information. The cloud service system can fulfill information integration and resource sharing requirements. Therefore, the cloud service system can serve as the information hub center for the PCMS.

3) MOBILE SERVICE LAYER

This layer is utilized to provide a personalized customization service and dynamic production process monitoring capabilities to consumers. To operate effectively, the mobile service layer needs a smart mobile terminal, which is used to access the cloud via the mobile internet. The mobile services carry out remote operation so as to meet the intelligent matching of the factory's production resources. In order to achieve an effective personalized-oriented service for the client, this layer must provide portable user-friendly and reliable interaction methods.

B. KEY TECHNOLOGIES

The key technologies involved in the PCMS can be broadly divided into: 1) collaborative technology of manufacturing unit, 2) network resources information processing technology, 3) cloud data processing technology, and 4) client terminal application development. By effectively combining the above technologies, a PCMS can break through the traditional manufacturing system's production mode limitations of information occlusion and single-line production style. Rather, a PCMS embodies the characteristics of intelligence, flexibility and personalized-oriented service.

1) COLLABORATIVE TECHNOLOGY OF MANUFACTURING UNIT

This technology is mainly used to solve two aspects of the manufacturing device layer, namely, the object connection and the system reconstruction.

With regard to object connection, sensor network and RFID technology are used to realize the calibration and tracking of the processing object's position information. Industrial communication technology is used to provide real-time interaction of the processing object data information being supplied to the intelligent manufacturing units in the workshop. Together, the technology and information combine to achieve mutual coordination in the production process. By this means, the interoperability problem caused by resource heterogeneity in the workshop can be solved.

With regard to system reconstruction, a modular package is carried out, according to the functionality of the intelligent manufacturing cell. The cloud service system is used to make production planning decisions. By means of the above method, the intelligent manufacturing unit of the manufacturing system can automatically adjust the working mode and therefore quickly respond to customer's individual demands for products of various styles and types.

2) NETWORK RESOURCES INFORMATION PROCESSING TECHNOLOGY

A PCMS consists of different working properties and various types of equipment (such as smart mobile phones, industrial robots, etc.) and networks (such as industrial networks, mobile networks, etc.) and so on. Thus, the network resource information processing technology must be able to facilitate the network resources' accessing and the format of data exchange.

From the aspect of accessing network resources, in the process of the information exchange between the customer terminal and the production workshop, the data exchange problem caused by the information heterogeneity of different equipment and the network is considered. Therefore, the web service technology is introduced to achieve the necessary cross network integrated application. A Uniform Resource Locator (URL) is used to locate different data resource processing centers in the cloud service systems. Therefore, different devices in the network can use the cloud service system's URL to access the corresponding data center and interact based on that data through the HTTP protocol.

With regard to the data exchange format, resource information interaction is mainly conducted through web services, in order to achieve the JSON data format description and output. We do this because this format is compressed, has low bandwidth occupancy, and is easily parsed. Therefore, every device in the PCMS depends on the JSON data parsing to obtain other devices' production information, and/or to obtain the production planning decisions from the cloud service system.

3) CLOUD DATA PROCESSING TECHNOLOGY

A PCMS needs to solve the problem of information occlusion inherent in traditional industrial manufacturing systems. Therefore, in this paper, the cloud service system adopts the Platform as a Service (PaaS) form as the PCMS's network information exchange hub. The database technology and data mining technology are used for data storage and analysis. The API key is used to provide access permissions for data reading or writing operations between the cloud platform and the mobile terminal device. The cloud service system provides data channels for information communication between terminal objects. By this means, we may collect the data generated by equipment and send the relevant messages to the mobile terminal.

4) CLIENT TERMINAL APPLICATION DEVELOPMENT

Due to the fact that customer demand for information is becoming more and more diverse and detailed, a PCMS needs to be able to break through the traditional single-batch customer order interaction pattern. Namely, the client base now not only has wholesalers, but also ordinary end-user customers. Therefore, a convenient means of interaction and an appropriate communication platform must be considered. However, the PCMS makes a good choice in this regard by relying on the interactive mode of the mobile internet and the portable mobile platform to provide the most direct personalized consumer demand information and interaction, whenever and wherever possible.

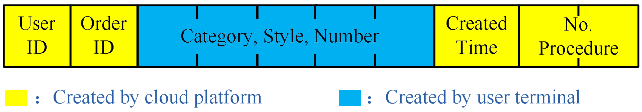
In order to achieve the requisite PCMS mobile services, we must carry out the development of mobile application software. Currently, the mobile application software development system can be used for mobile terminal APP development, such as Android and IOS. With relation to the demand of the enterprise's product supply and application environment, those same mobile application software development systems can be flexibly selected and adapted to develop a terminal APP.

IV. IMPLEMENTATION MECHANISM

A PCMS is a multi-closed-loop information system. As shown in Fig. 1, the implementation mechanism of the system (according to message response objects) is divided into the cloud platform service mechanism, client access mechanism and manufacturing system operation mechanism.

A. CLOUD PLATFORM SERVICE MECHANISM

Duo to the absolute need to ensure the safety and flexibility of data in any industry, every terminal in the system network uses information flow with built-in access rights to interact with the cloud service system. The cloud platform service mechanism mainly includes: (1) client-oriented service mechanisms and (2) service mechanisms for the manufacturing system.



User ID	Order ID	Category, Style, Number	Created Time	No. Procedure

🟨 : Created by cloud platform 🟦 : Created by user terminal

FIGURE 2. Data storage format.

1) CLIENT-ORIENTED SERVICE MECHANISM

The cloud service system will automatically allocate data channels and related API keys to registered customers to ensure the safety of those customers' data operations. The information loop is composed of the cloud service system layer and the client service layer, as shown in Fig. 1. As such, and to deal with the different information content of different customers' orders, the cloud service system will be based on a unified data storage format (as shown in Figure 2). The cloud service system will also process consumers' Write API

Key related information, to-do aggregation, classification, modification and other pre-processing tasks. With regard to customer information inquiries, the cloud service system will be based on consumers' Read API Key related information. Then, the related product processing information will be sent to the customer terminal in a JSON data format.

2) MANUFACTURING SYSTEM ORIENTED SERVICE MECHANISM

The cloud service system provides a production decision mechanism and production information access mechanism for the manufacturing system. The information loop is composed of the cloud service system layer and the manufacturing device layer, as shown in Fig. 1. According to the consumers' order sequence and product style, the cloud service system will assign the appropriate production tasks and production modes to the manufacturing system. The manufacturing system uses information conversion assistant nodes to parse JSON data and obtain the production instructions. The manufacturing system then executes the production task. In the manufacturing system, distributed sensor nodes are used to perceive the location node information relating to the products in the manufacturing process. At the same time, the information conversion assistant node encapsulates the data and uploads that data to the cloud platform.

B. CLIENT ACCESS MECHANISM

Enterprises (based on their own scope of business) provide customers with a dedicated APP. The customer can use this APP to register their related information, so as to obtain an API key to the cloud service system for their APP.

Customer terminals submit personalized demands via the selected mobile services. In this process, a terminal device must use Wi-Fi or a 3G/4G signal to connect to the network and access the corresponding internet cloud service system through the HTTP protocol. Accordingly, this type of application APP should have the corresponding order customization mechanisms and inquiry mechanisms to ensure operational safety.

The PCMS order customization function not only needs to provide users with an easily accessed and operated terminal interface, but the PCMS also needs to provide the relevant information from the submitting mechanism to ensure the reliability of order delivery. The order customization information is shown in Figure 3. The APP excludes the consumer mis-operation problem by judging whether or not the sent message is empty. In the process of message transmission, the APP needs to judge whether or not any abnormal network phenomenon exists or occurs. In addition, the APP also needs to provide users with intuitive information of user submission results, in order to ensure that successful orders have been submitted.

In order to make plans to sell products to customers easier, the mobile terminal APP needs to have a mechanism allowing the APP to exchange production information with the cloud platform, as shown in Fig. 4. The APP also needs to provide a mechanism for detecting network anomalies, as well as being able to achieve data conversion and calculation mechanism performance, so that customers intuitively know the relevant information pertaining to the production progress.

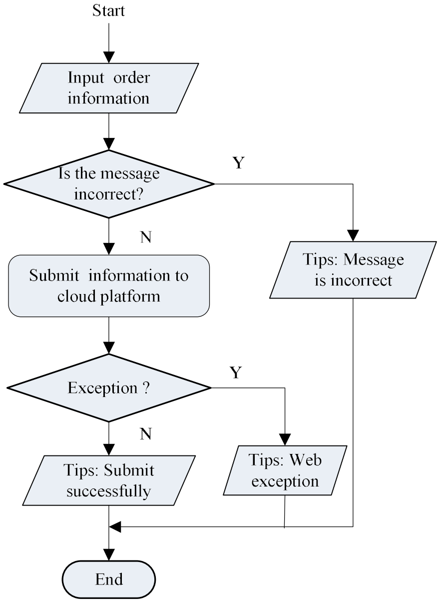


FIGURE 3. Order customization information.

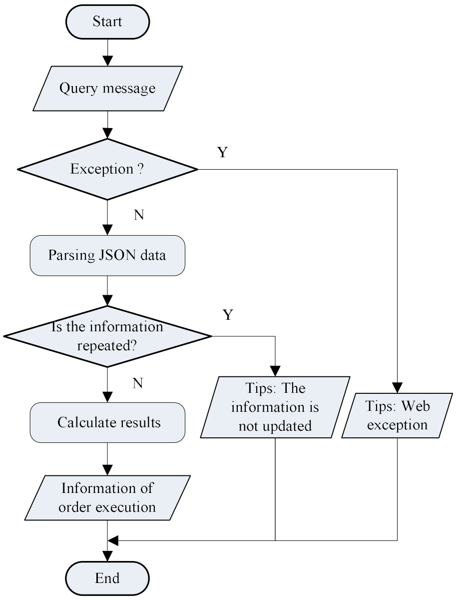


FIGURE 4. Procedure of status inquiry.

C. MANUFACTURING SYSTEM OPERATION MECHANISM

In this paper, the workshop execution structure model of an intelligent manufacturing system is shown in Fig. 5. This model is composed of a circular production line with several processing branches, a robot and a corresponding sensor.

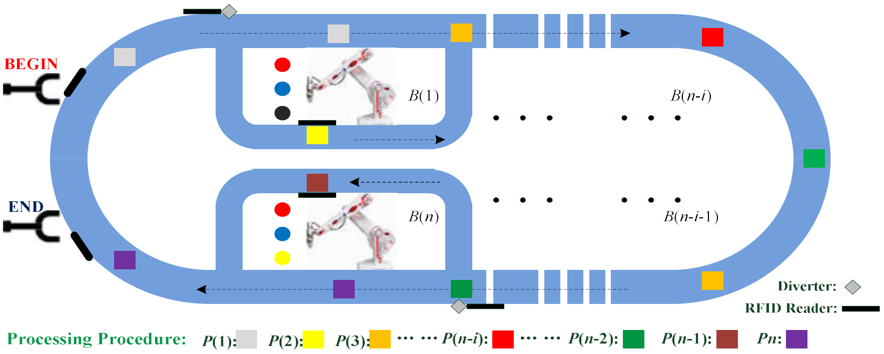


FIGURE 5. Production workshop sketch.

In order to create an intelligent and flexible manufacturing system, the design information of this model is as follows: 1) We assume that the production line has a total of $n(n \in N$, $n > 0)$ processing branches. This $B(i)$ $(i \in [1, n])$ stands for the ith processing branch. 2) The different colored blocks represent the different processing degrees of semi-finished products. Specifically, the $P(k)$ color block indicates that a semi-finished product has been completed to the kth procedure. 3) When a semi-finished product is placed at BEGIN, this indicates that the semi-finished product is about to join this production process. Removing a semi-finished product from the END means that the process tasks of the semi-finished product have been completed. If a semi-finished product fails to finish a processing task, the product will continue on to the next cycle process in the production line.

In the production process, RFID tags are used to record the procedure information of semi-finished products on the processing branch. An RFID reader and a diverter are set at every intersection entrance of the circular production line and processing branch. The RFID reader will record the semi-finished products' procedure information and send this information to the manufacturing unit system of the processing branch. This information is then used to judge whether or not to adapt this processing branch to process. If the judgment result is yes, the semi-finished product will be pushed into this branch. Otherwise, the product will go to the next branch. Once the processing procedure of a semi-finished product is accomplished, the corresponding information will be sent to the cloud platform and written into each semi-finished product's RFID tag.

The processing branch adopts a processing style redundancy design method. This method means every processing branch can bear multiple types of parts. In addition, all of the processing styles in a processing branch can be replaced with a processing style, or combination of styles, used by other processing branches. This way, the processing branch can reduce the task amount of processing branches during other branches' idle time. The processing branch can also solve the substitution problem after the faults of other processing branches appear.

Assuming that every processing branch that can bear the quantity of the part style is three, the production line allows that the quantity of parts which can be used for processing is $m(m > 0)$. Here, $Pa(z)$ stands for the style of the zth part , and the ***Part*** can be used to represent the set of parts on the production line, as follows:

$$Part = \{Pa(1), \ldots, Pa(m-i), \ldots, Pa(m)\}.$$

The $Pb(i)$ stands for the set of a part's style where it is on the processing branch of $B(i)$,

$$Pb(i) = \{Pa(\alpha), Pa(\beta), Pa(\gamma)\}, (z, \alpha, \beta, \gamma \in [1, m]);$$
$$Pb(i) \subseteq Part, i \in [1, n].$$

According to the design of the processing style redundancy, the ***Part*** $= Pb(1) \cup Pb(2) \cup \ldots \cup Pb(n)$ is proved.

The production line can produce v kinds of products, and the part's style set of the jth kind of product is $C(j)$,

$$C(j) = \{Pa(\alpha), \ldots, Pa(\beta), \ldots\}, \text{ and}$$
$$C(j) \subseteq Part, \text{ and } C(j) \cap Part \neq \emptyset, j \in [1, v].$$

In accordance with the knowledge that the manufacturing system can produce and meet many kinds of product requirements, the $Part = C(1) \cup C(2) \cup \cdots \cup C(v)$ is proved.

Assume the production line is allowed to carry $N(N > n)$ semi-finished products. In the customer's order, the jth kind of product is booked, and the number is $M(M > 0)$. The function $Num(X)$ $(X \subseteq Part)$ is used to count the number of elements which are present in the $C(j)$ set, and the total number of the required processing steps is replaced with the $Total(j)$ in this order:

$$Total(j) = Num(C(j)) * M.$$

The function $P(x)$ $(x \in [1, v])$ is used to record the number where the xth semi-finished product has finished the product's processing steps. The function $SP(x)$ stands for the xth semi-finished product.

Algorithm 1 Processing Branch $B(i)$ Execution Algorithm

```
Input: Semi-finished product $SP(x)$
Output: The information of $P(x)$ and $C_x(j)'$
begin
    switch ($B(i)$) do
        case -1
            Processing event is not allowed.
            $SP(x) \rightarrow B(i+1)$
        end
        case 0
            $B(i)$ in standby state and $C_x(j)\,'\neq \emptyset$,
            if ($Pb(i) \cap C_x(j)' \neq \emptyset$) then
                $\boldsymbol{Pr}(SP(x))|B(i)$
                $C_x(j)' = C_x(j)' \backslash (Pb(i) \cap C_x(j)')$
                $P(x) = P(x) + Num(Pb(i) \cap C_x(j)')$
            end
            else
                Processing event is not happened
                $C_x(j)' = C_x(j)'$
                $P(x) = P(x)$
                $SP(x) \rightarrow B(i+1)$
            end
        end
        case 1
            $B(i)$ is performing $\boldsymbol{Pr}(SP(y))|B(i)$, $y \in [1, v]$
            $SP(x) \rightarrow B(i+1)$
        end
    endsw
end
```

The remaining parts set of the xth semi-finished product stands for the $Cx(j)'$, and therefore, $Cx(j)' \subseteq C(j)$ is proved.

Assume every processing branch may have three working states, namely:

$$B(i) = \begin{cases} -1, & \text{fault;} \\ 0, & \text{idle;} \\ 1, & \text{busy.} \end{cases}, \quad i \in [1, n].$$

The function $Pr(SP(x))|B(i)$ stands for the ith processing branch dealing with the xth semi-finished product. When the xth semi-finished product accesses the intersection of the circular production line and the ith processing branch, the processing flow algorithm of the processing branch $B(i)$ is shown in Algorithm 1.

When a customer submits order information using mobile terminal, the cloud service system will receive and process the information. Meanwhile, the production command will be delivered to the manufacturing system. The manufacturing system will select the necessary production parts and adjust the production mode based on the production command. The production activities will also rely on the above processing algorithm to complete the corresponding task.

When a customer makes an inquiry regarding production information (using a mobile terminal), the cloud service system will sum up the uploaded data of the manufacturing system and push the data results to the consumer's mobile terminal. In the APP of the mobile terminal, that results information will be converted to the *Comp* and displayed to the consumer in an intuitive way.

$$Comp = \frac{\sum_{x=1}^{v} P(x)}{Total(j)} \times 100\%, \quad x \in [1, v].$$

V. APPLICATION CASE

In order to verify the feasibility of the PCMS design, in this paper, a candy customization and package-processing (as a simplified case model) was studied. This case was used to simulate candy production. In order to complete the simulation, this case experiment provided six different types of candies and three different types of packaging boxes, as individual parts of the finished product. According to the style of the candy box, we assumed that the application case could provide three types of products. In addition, every type of product can provide customers with a variety of candy style choices. In this paper, the experiment will be combined with the above key technologies and implementation mechanism, and the experiment will be carried out in the actual experimental platform.

A. EXPERIMENTAL PLATFORM

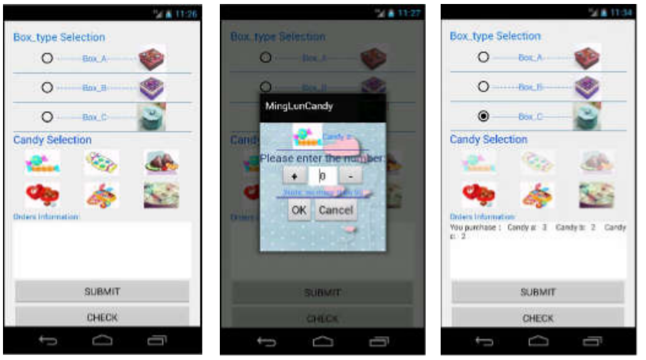
In this paper, the experimental scene and cloud platforms of the application case are shown in Fig. 6. The flexible production platform consists of several processing branches, as shown in Fig. 6(a). Every processing branch, as a production unit, can perform multi-processing tasks. The execution of the production unit needs to rely on a flexible transmission belt, industrial robots, sensors and corresponding communication technology (such as Wi-Fi, Ethernet, etc.) with each element of the unit coordinated with the others. The cloud platform consists of five servers, which constitutes a distributed cluster, as shown in Fig. 6(b). The Hadoop distributed system architecture is used to manage documents and data. In addition, this platform also provides web services for data reception and an inquiry service.

In order to meet the demand of customer orders with personalized customization and simulated information inquiries, this case provides a mobile terminal APP. This APP is suitable for the order processing operation of this manufacturing system. In order to simplify the description, the design of this APP omits the user registration interface and the operation of the number of products. The API and API key of the cloud platform also is directly set in this app. Moreover, this application case adopts single product customization to demonstrate the entire implementation process.

The mobile terminal APP's function interface is shown in Fig. 7. The order setting mainly relies on the button options of the main interface, as shown in Fig. 7(a). The candy

(a) Flexible production platform (b) Cloud platform

FIGURE 6. Experimental platform. (a) Flexible production platform. (b) Cloud platform.

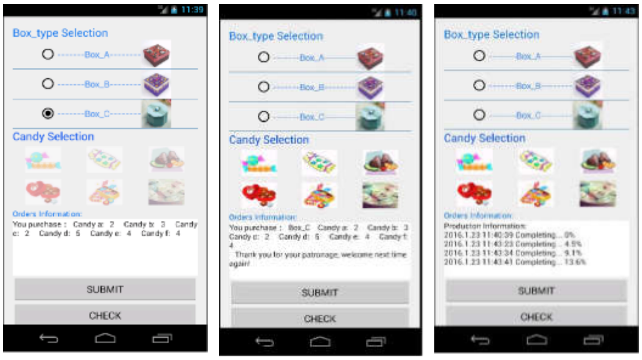


Please enter the number:

You purchase : Candy a: 3 Candy b: 2 Candy c: 2

(a) (b) (c)

FIGURE 7. Mobile terminal APP.(a) Main interface; (b) Button dialog; (c) Selected button' schematic.



You purchase : Candy a: 2 Candy b: 3 Candy c: 2 Candy d: 5 Candy e: 4 Candy f: 4

You purchase : Box_C Candy a: 2 Candy b: 3 Candy c: 2 Candy d: 5 Candy e: 4 Candy f: 4
Thank you for your patronage, welcome next time again!

Production Information:
2016.1.23 11:40:39 Completing... 0%
2016.1.23 11:43:23 Completing... 4.5%
2016.1.23 11:43:34 Completing... 9.1%
2016.1.23 11:43:41 Completing... 13.6%

(a) (b) (c)

FIGURE 8. Mobile services for customized manufacturing. (a) Customization settings. (b) Order submission. (c) Information inquiry.

box type option is a radio button group, which in turn has three options. The option of candy type is shown by six candy buttons. When a candy button is pressed, the dialog corresponding with that candy will immediately pop up, as shown in Fig. 7(b). All selected options will then appear in the text view of the main interface, as shown in Fig. 7(c). Therefore, as mentioned in the experimental platform related settings, the application case can provide consumers with a flexible candy customization method and handle the implementation of production activities.

B. EXPERIMENTAL ANALYSIS

Take the array of {2, 3, 2, 5, 4, 4} as an example. This array is used to represent the selected quantity from candy a to candy f. The customers' personalized needs are shown in Fig. 8. The order information in the mobile phone APP is shown in Fig. 8(a). The results of the submitted information are presented in Fig. 8(b). After the consumer executes an inquiry operation, the mobile phone will obtain data from the cloud service system and translate that data into intuitive information, as shown in Fig. 8(c).

The experimental scene of the flexible production platform is shown in Fig. 9. The candy is replaced with the marked yellow planchet, in order to simulate a processing experiment. Every processing branch can carry on the processing task of multiple parts. The RFID reader is used to calibrate and track the candy and the information pertaining to the candy boxes.

In this paper, the PCMS can provide consumers with a mobile terminal APP, which in turn enables order customization and information inquiries. In the manufacturing system, the cloud platform is used for data processing, and the communication technology is used for purposes of information exchange and production coordination. The PCMS system can adopt big data technology as a means to process massive data for information extraction and application modeling. By analogy, the function of this PCMS system can be extended further. Big data technology can used for massive data analysis of IoT, and the results obtained during information extraction can be applied in industrial production and management. A mobile terminal APP which responds to consumer demands can be designed. A cloud platform service mode can read an industrial production model for reference, thus enabling the production model to be flexibly customized. The manufacturing device layer (according to the function feature of the manufacturing unit) can be modularized. The information flow can be uploaded to the cloud via network technology. By combining the cloud service model and the adjustment measures of enterprise managers, the

(a) (b)

FIGURE 9. **Processing scenes. (a) Scene 1. (b) Scene 2.**

processed information will be automatically delivered to the factory, so as to achieve the goal of intelligent production.

VI. CONCLUSIONS

Based on the cloud platform, industrial IoT and mobile services, a customization-oriented of intelligent manufacturing system is initially achieved in this paper. Our system can manage personalized customer order information processing, as well as unmanned workshop and intelligent production. However, in order to realize complete automation and the intelligentizing of the manufacturing system, we find that further research on the relevant theory is necessary. We will seek the common characteristics of various IoT applications, and we will refine the scope of cloud computing applications. By this means, an intelligent manufacturing system will be able to provide an intensive application platform for enterprise management, industrial production and product sales in the future.

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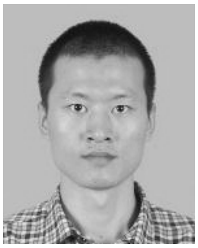

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