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A Study on Auto-Processing Flexible Production Line for Mass Customized BPO Data Based on Multi-Agents

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Abstract

Traditional Data Business Process Outsourcing (Data-BPO) centers are facing the challenge of a static workflow based on manual operation. They cannot adapt to fast-changing demands from customers, which is proving to be a bottleneck in the Data-BPO service. This problem can be resolved through a Data-BPO automated production line, based on the usage of multi-agent (MA) and ontology. Through the cooperation of MA and categorization of ontology, the flexible production line can meet various requirementsofmass-customized data orders from different industries, professions, transactions and classes with instantaneous response. A Data-BPO flexible workflow will beimplemented dynamically, securely, quickly and smoothly. Therefore, developing an auto-processing flexible production line can greatly promote the efficiency and competitiveness of BPO enterprises currently based mostly on manual data-processing stations or manual-input equipment.

Key Words: *Data service; Business Process Outsourcing (BPO); Productionline; Multi-Agent systems; Flexiblesystems*

1. Introduction

While the profits of the manufacturing industry are decreasing, the service industry is entering a prosperous epoch. Banks and insurance companies have massive quantities of manual deposit slips, withdrawal tickets *etc.*, whose information needs inputting into their database systems on a daily basis (we sometimes call this computerization). As we know, management guru Peter Drucker advises the industry, "Do what you do best, and outsource the rest." [1] On this basis, banks, insurance companies and other financial enterprises are going to outsource their data input business to data Business Process Outsourcing (data-BPO) providers. It is clear why the Data-BPO industry has been destined to become one of the strongest trends in today's digital service industry. A typical demand of Data-BPO service—a situation of traditional bankwork flow without Data-BPO service is described as follow:

In traditional bank work flow: after people fill out their deposit slips, withdrawal slips or accounting transfer tickets, they submit these documents to bank clerks. Then, the bank tellers will have to manually input them into the bank's database system as important transaction information. Figure 1 describes the situation of traditional bankwork flow without Data-BPO service:

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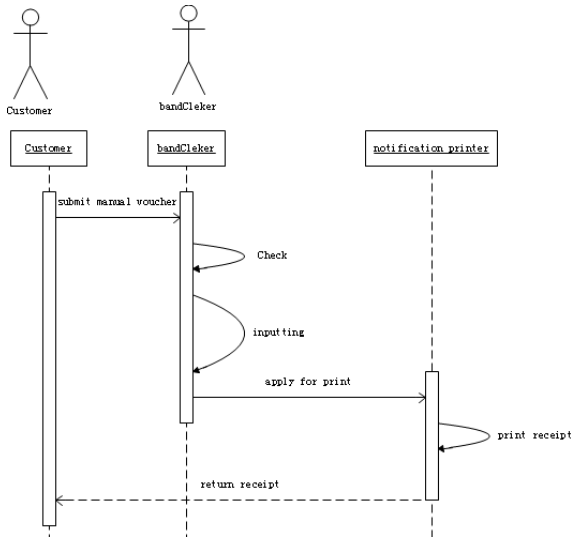

Figure 1. Traditional Bank-work-flow

However, in my study project of production line for data BPO , after accepting customer's manual accounting vouchers, the bank clerks can skip the input step because the inputting business can be outsourced to Data-BPO providers. In this case, the bank clerks need not spend time typing trivial contents anymore, leaving the inputting work to the data-center of BPO. Outsourcing of this data entry can help bank clerks save more time to concentrate on service quality. This means production can be fine-tuned to what the customer wants and staff can spend more time talking in depth with the customer so that they know which production he/she wants in future. Meanwhile, the data-BPO provider will complete the input works professionally and immediately in the background. Finally, after pleasant small talk, the customers will receive their successful transaction notification or receipt from the bank tellers. This means less wait time, quicker transaction speed, better service quality, more smooth work flow and friendly customer relationships. Comparing with the time cost of 9 minutes in traditional bank-work-flow, the whole process (the new workflow) takes only about 5.5 minutes and is described as Figure 1.2.

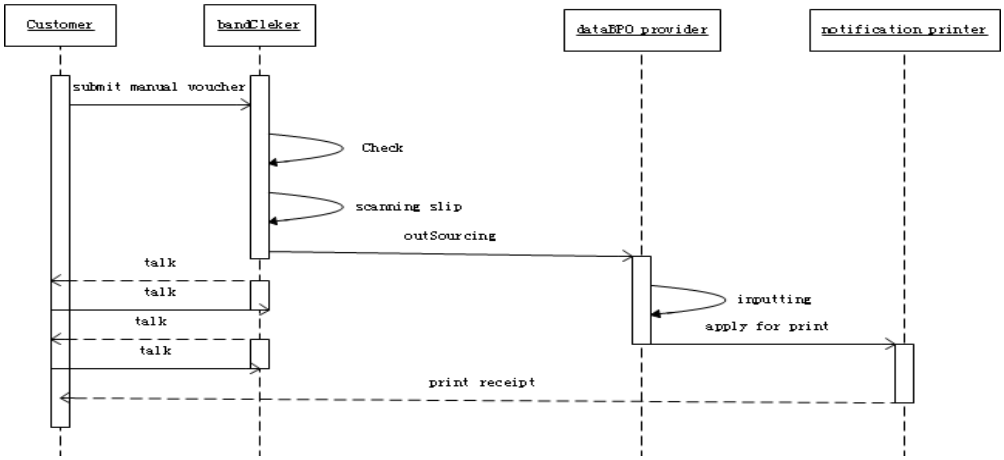

Figure 1.2. The New Bank-work-flow with Production Line of Data BPO Service

However, in some developing countries, unmatched with the speed of this business development, Data-BPO often stays at a low or even full manual production level because of bottle-necks in scalability and a lack of advanced organization in workflow. In contrast, the traditional manufacturing industry has developed production lines with notably high efficiency, there are many advanced technologies that could be simulated, inherited or reused

for the Data-BPO industry by ontology and Multi-Agent. Therefore, a production line based on ontology and Multi-Agent technology is designed to solve main problems occurring in the data outsourcing business.

2. Problems in Current Data-BPO Production

There are two main problems need to be resolved:

(1) The static system model unable to adapt to the changes that occur in BPO customer demands in time, and that will become the bottleneck in development of BPO industry.

(2) A manual template design operation can also jam and slow data processing work flow.

This paper focuses on these two points to try to find a solution to production of mass customized BPO data [4]. The description of the problems in production is as follows (Figure 2.):

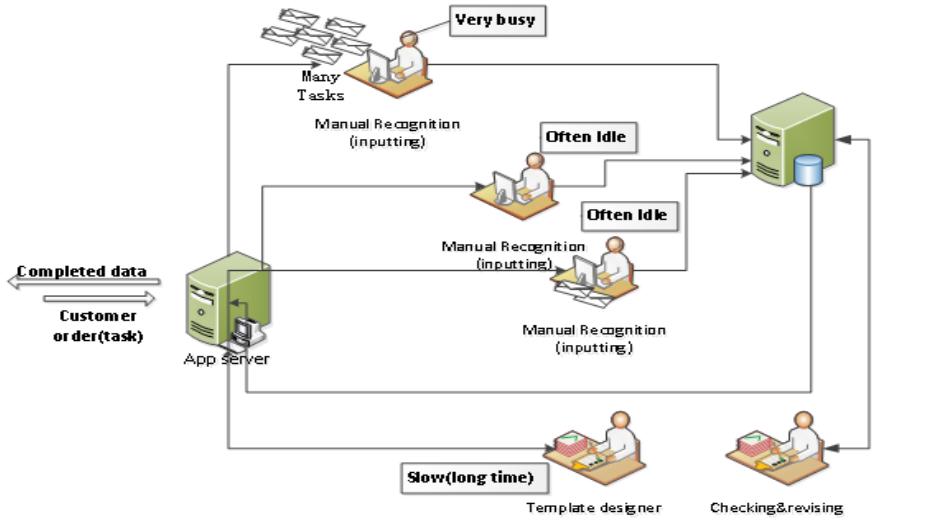

Figure 2. Current Unoptimized Production Static Workflow

a) Figure 2 depicts a scenario in Data-BPO firms (specifically their data center). From the figure, we can see there are different kinds of operators in BPO provider data centers: inputting operators, checking /revising operators, and template designers. They can work well in a static mode but when task volumes increase suddenly, task content changes, the idle stations fail to convert their status into busy immediately. So, the busy station becomes busier, while idle ones are still idle. Then, there is a long waiting queue in front of busy stations - a jam. This leads the work flow to become slower and slower, and finally fails. That is because the tasks increase but the workers' pace does not increase. When a jam occurs, work flow is interrupted. The busy operators often become a bottleneck station delaying the customer order while some other stations still stay idle if there is no mechanism to adapt to varied customization. This kind of unclear and inefficient workflow is common in the current Data-BPO industry.

b) Figure 2 also presents us a job named "template designer" whose task is to design a template for a segment of BPO data manually when customer orders arrive. It is a relatively difficult job requiring specific professional skills, and always takes a long time. Generally, a Data-BPO provider has many customers. For example, an order comes from a bank customer one of their own bank vouchers, such as deposit slips, withdrawal slips, various transfer tickets, *etc*. So after a bank offers a new order, the template designer station will become the next bottleneck because it takes a long time to develop a new style template for the bank voucher. In additional, many different customers' requirements in the BPO data service industry need to be met, such as

different industries, different professions, different transactions and different classes of instantaneous response. It is greatly beyond what a manual system or even a fix automated production system can do quickly [3].

Concluding the above description, The purpose of this paper is to study how our Auto-Processing flexible production line works. The rest of this paper is organized as follows: a brief overview of related literature is presented in Section 3.The two key technologies and research approaches are formulated in Section 4.The proposed model is illustrated in Section 5, and finally, section 6 covers the conclusion and our work in the future.

3. Literature Review

Mass customization (MC) is a kind of new produce pattern which has superiorities both on mass manufacture and customized production [5].Nowadays, the hot points in the native field locate on the principle of engineering and given some methods on MC project modeling.R.W.Li and G.N.Qi *et al.*, proposed a series of modeling ways to MC-oriented,and create a MC model in extenics,and proposed that it should be optimizing from the aspects of temporal dimension and special dimension. In recent years, there are few of researches on applying Multi-Agent to MC. BleckerThorsten proposed mass customized products which are assumed to be based on a modular architecture and each module variant is associated with an autonomous rational agent for complexity problems [18-20]. The flexible manufacture management can be realized through some key technologies such as the management of product cluster, order-oriented assembly and sophisticated production [6]. Felfernig, 2000, proposed [21] that the setting method currently cannot support the integration of Heterogeneous systems though it is proved to be effective in the local configuration setting. He also proposed that in supply chain integration for customized product under the cooperative mechanism.The configuration agent can get customized requirement from the communication interface, then pass it to the provider. Redline(1999) proposed that it is necessary for the manufacture system to have the ability of adaptive and flexible for small production in order to solve the problem in cost and variability in speed of production, because it can reduce the temporal and setup costs if we use a flexible system.

X.F.Shaoand P.Q.Huang in Shanghai Jiao Tong University study the model of supply chain oriented MC and they propose an agile supply chain which combined push and pull technologies based on Internet. They also driver model for the supply chain which has some branches points and analysis the compact of the relay strategy to inventory in supply chain and modeling MC in concentrated or distributed pattern which includes some product ID[7].With this approach, the unreliability in supply chain and inventory costs will decrease.Research and development of flexibility emerge in flexible manufacturing. DE Groote (1994) defined that flexibility is the ability which can avoid the difference in environment while it also can provide a framework of flexibility analysis. A flexible manufacturing system (FMS) is a manufacturing system in which there is some amount of flexibility that allows the system to react in the case of changes, whether predicted or unpredicted[8]. This flexibility is generally considered to fall into two categories, which both contain numerous subcategories.

Currently,there are many academic researches on MFS,but it is seldom to see the technology of MC modeling and flexible product line utilize in data BOP service.So,if it can be utilized in BPO service, the service provider will get stronger competence and better profits. The flexible product line will have good effect on economy, higher application value and popularization value.

4. The Two Key Technologies in the Solution

4.1. Multi-Agent

Agents are high-level autonomous software abstractions. They are characterized by behavior and ontology which is a powerful tool to enable knowledge sharing and help categorize. In Multi-Agent system (MAS), agents are distributed and coupled together in a network of intelligent software agents for a global goal. The several types of agents [9]are broadly classified as follows.

a) Software Agents: Software programs that can work without human intervention and perform intelligently.
b) Mobile Agents: Mobile agents are software agents that can migrate between multiple machines.
c) Reactive Agents: The Agents only act by stimulus. A new behavior emerges from their interaction.
d) Interface Agents: These agents assist in communicating the user's task to the computer.
e) Middle Agents or Intermediate Agents: They are a mediator of agent communication.

It is worth noting that not all agents mentioned above should be designed in MAS. Division of labor is not only the one of principles which modern production line based on but also one of foundations for Data-BPO production line. According to the principle, we are going to design a series of agents for these work stations on production lines(refer to Figure 3).They are named after their corresponding jobs: scanning agent, segment agent, recognition agent, checking agent, correction agent and assembly agent.

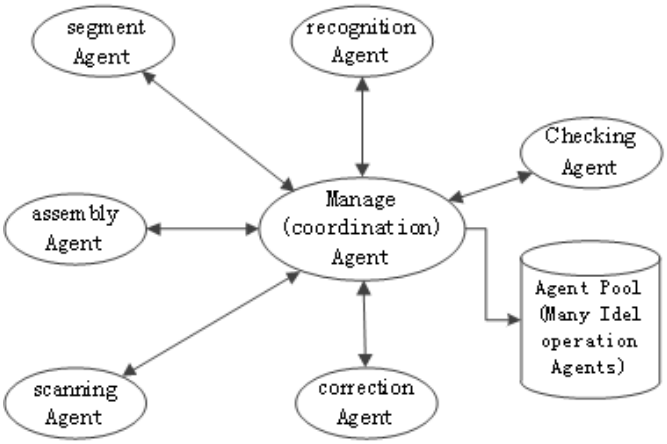

Figure 3. Technical Architecture of MAS in BPO Production Line

Additionally, a system manager or dispatching agentwho coordinate the variety roles is necessary for system administration.

A MAS is a community of agents. In other words, each agent belongs to a society of agents and abides by a set of social norms, and each of them is a software program thatperforms specific tasks or activities on behalf of its user. Agents work together and communicate through messagesto accomplish individual and/orcommon goal. The agents match to objects in the knowledge domains such as benchmarking, financial costing, security issues, whichare explicitly defined by ontologies. These ontologies are implemented withasoftware (Protégé) which incorporates the Open Knowledge Base Connectivity (OKBC) knowledge model[10]. Ontology is a powerful tool to enable knowledge sharing, and has become the foundation for many MAS applications as means to achieve semantic interoperability among heterogeneous agents systems.

Generally, the whole BPO data process has the following basic steps: image capture, pro-processing, whole page analysis, character segmentation, character recognition, the restore the page, post-processing, and verification.

As the first role, Character segmentation is a necessary preprocessing step for character recognition. An example of bank ticket recognizing task in Data-BPO automated production line is shown as Figure 4. There are four key information fields needed to be recognized in a withdrawal ticket.

Figure 4. A Withdrawal Ticket in BPO Production Line

So the withdrawal ticket on BPO Production Line will be divided into four parts (called as segments, refer to Figure 5)by segment agents for the next step---recognition.

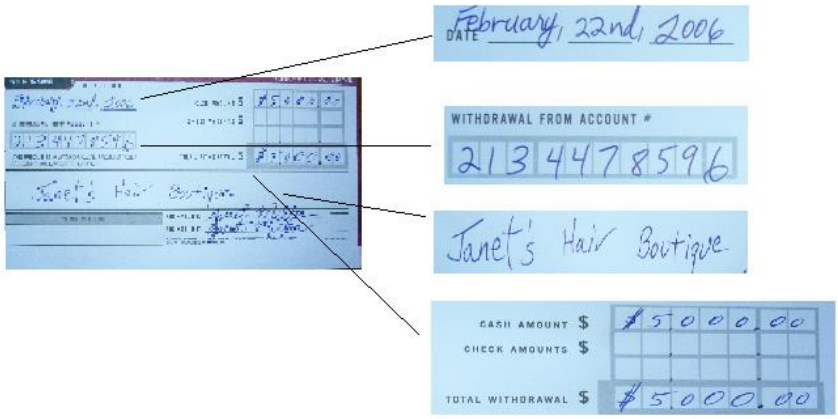

Figure 5. Four parts of A Withdrawal Ticket after the Segment

Recognition agent is core of Data-BPO production line. It should only keep up doing two tasks: recognition and interaction with other agents. In the field of pattern recognition, selecting a more appropriate modeling algorithm is the key. There are also several pattern recognition algorithms for choice: LDA method means linear discriminant analysis, which has become one of the most effective waysto complete feature extraction [11]. The character object extraction methods include: Otsu Method, maximum entropy methods, improved by Barnes, logical layer method (LLT), Fihformity method, in which the first two methods belong to the global threshold method, improved Barnes method is a local threshold.The latter two segmentation methodsare based on the character stroke model. Adhesion based on contour analysis in the character segmentation method, drip algorithm is widely used because of its fast and efficiency.

The key technology in the recognition areas consists of the OCR and OMR.OCR, the abbreviation of Optical Character Recognition, isthe conversiontechnologyof scanned images of typewritten or printed text into computer-readable text; OMR is the acronym which stands for Optical mark recognition that is the process of capturing human-marked data from

document forms, massively applied in surveys and tests.The research should focus on OCR and OMR technologies to automatically identify the fields' collection, and then to check and revise at the workstation. Once the full-automated processing is realized in this kind of agent, efficiency will be enhanced, and the labor cost will be reduced greatly.

There are other methods to support the agents'recognition to the contents of bank tickets:Multiple-value and continuous sequences are widely used in the area of pattern recognition and signature comparison,where the values describe certain features like curvatures,angles,velocity,etc.

Then, how do the agents get the tasks from Data-BPO production line. In fact, the agents are working in a mode which is quite different from traditional distributed system.Because when the tasks are going to be dispatched by manager agent, the operator agents, e.g. recognition agents are ready to auction. The operator agents will get their tasks by using proper auction strategy. For instance, the negotiationprocess among the agents is based on a market mechanism supported by the target costing concept and a Dutch auction. In this case, agent is not passively dispatched a task but is active to win a task. Consequently, the efficiency is quit improved. In practice, the workstations also can periodically request administrator agent for tasks and download them autonomously. However, it is possible more efficient to subscribe to some BPO-data-processing tasks which are later pushed to the inputting workstations based on required events[12].

Theoretically, every role in production line can be converted into an agent. But for inspection agents and partial correction agents, manual labor is preferred over automation in parts of our production line. The reasons are:

(1) Adjustments required in the inspection (judge to assert quality, correct something difficult to recognize).
(2) Manual dexterity requirements.
(3) Demands on hand-eye coordination.

Notwithstanding the attractiveness of full-automation, it is better that a semi-automatic inspection subsystem is designed (production line remains some manual operators) for quality control, and the simulation test shows the correction rate reach 99.99%.

There are three kinds of systems in manufacturing: fix automation system, flexible manufacturing system (FMS), programmable automation system. Then our production line is between the programmable automation and FMS with more variety and quantity.

4.2. Flexibility

Why Data-BPO production line choice flexibility technology is that flexible automation is an extension of programmable automation. Programmability is an undoubted most flexible solution to different production. A flexible automated system is capable of producing a variety of parts with virtually no time lost for changeovers from one parts style re-programming the system and altering the physical setup.

The features of flexible automation include:

a) Custom-engineered system.
b) Continuous production of variable mixtures.
c) Improve the production rate to high.
d) Flexibility to deal with product design variations.

Flexibility of production line also bases on pro-group by the types of customer order. Here the ontology technology is applied once more. It is a powerful mechanism for describing the concepts, instances, events, relations, constraints and goals pertinent to the outsourcing domain knowledge, including bank tickets, financial certifications, etc. Here the reasons why we develop ontology are mainly about:

1) To analyze domain knowledge.
2) To achieve common knowledge among agents
3) To build the protocol for the communication of agents.

4) To enable reuse of bank ticketdomain knowledge.
5) To make domain assumptions explicit.
6) To separate domain knowledge from the operational knowledge.

If these vouchers share the same underlying ontology in the terms, then computer agents can extract and aggregate information from these different vouchers. The agents can use theseinformation and structure to segment the images of voucher. Many database fields come from these recognizable (discernible) image data of rawvouchers and certifications(refer to Figure 5, *e.g.* In deposit and withdrawal slips,there are many account factors such as account ID, account name, credit account item, debit account item, and the similar things in financial or insurance domain.).

Then, we deduce voucher component ontology from the image data. This ontology can be used as a basic template for segmentation of the financial voucher. The reason why the template designer is slow in working is due to the designer being lack of knowledge about finance, accounting and banking transactions. If we build a voucher template-base, the segmentation will be easily navigated, located and completed quickly.

The ontology structure of the Data-BPO domain should be built in a modular way using a mixture of generic domain, generic task, and application ontology. For example, there are so many styles of voucher and still new ones will merge now and again. A voucher database should be included in the production line. The foundation of the database is the attributions, relationships, functions and steps of transactions about vouchers of different banks. An example ontology description for a voucher and its XML schema are listed as follows:

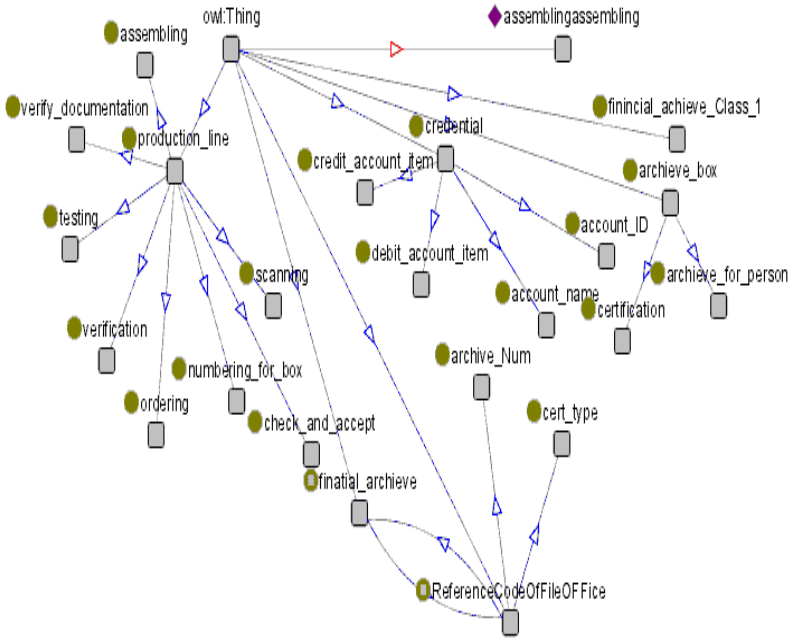

Figure 6. Description of XML's Class in data-BPO Production Line

Table1. Example XML schema of a voucher

```
<?xml version=”1.0”          encoding=”gb2312”>
<root>
<archive>// all field
<field fieldName=” ReferenceCodeOfFileOFFice”attrName=”archive
Num”fieldType=”string”fieldLength=”20”>0000110700G000001</field>
<field fieldName=” ClassificationNumber”attrName=” Class
Num”fieldType=”string”fieldLength=”2”>23</field>
……
</ archive >
<CusInfo>
<field fieldName=”account ID”attrName=” account
Num”fieldType=”string”fieldLength=”12”>0000110700G000001</field>
……
<field fieldName=”cert type”attrName=” cert type”fieldType=”string”fieldLength=”
120”>0000110700G000001</field>
</CusInfo>
……
</root>
```

According to the XLM’s class, all agents can get coherent understanding in processing the BPO data.Moreover, the loose coupling is able to realize in the production line.

In order to realize Flexible production in Data-BPO, we should ensure that the system for different business needs to generate different formation of production lines. In other words, a dynamic combinatorial optimization should occur among the workstationsin the production line. Meanwhile, we should enhancing the image segmentation techniques, achieve fast image scanning unit and a precise automatic identification which will substitute a lot of human inputting. Generally, inputting error rate is much higher than the error rate fromchecker (cognizing a character is far easier and quicker than typing a character). Therefore, a single element of pattern recognition on voucherwill have a lower error rate. As long as achievement of a precise segmentation fromthe image in fine-grain, along with multi-dimensional pattern recognition algorithms and scanned image error recoverytechnology based on primitive unit, error rate of recognitioncan reduce to zero.

In order to design a production line with better transaction processing performance, the system is based onSOA which is an acronym for “Service-oriented Architecture”.SOA makes it easy for workstations connected over a network to cooperate. A service is a self-contained unit of functionality, for example, includes some steps in the digitalization of a bank statement.The production line can ensure the interoperability between systems. That means cross-process, cross-machine and even cross-platformcommunication, as long as the client supports standard Web Service. Through ASMX (a kind of WEB service of .NET Framework) and Dot-Net-Remote (another kind of WEB service, an enhance version), italso makes directly communicate with the control part of the production line, some good compatibility to customers--- clients no longer need to be invested for updating.

In the production line, through workstations’reorganization, the work flow can actually take several forms in order to suit the production requirement. We classify them as follows :(1) normal. (2) Asymmetric.(3) Multi-layer Checking. (4) Pre-grouping. Petri-net modeling tool is used to describe the flexible changovers for different production processes [13]. It is worth noting that the changeover time of operating configuration and program is very short. The organization the new form of work flow is also dynamically taken with no time lost between one segment and the next.

(1) The workflow named "Normal model" is show as Figure 7:

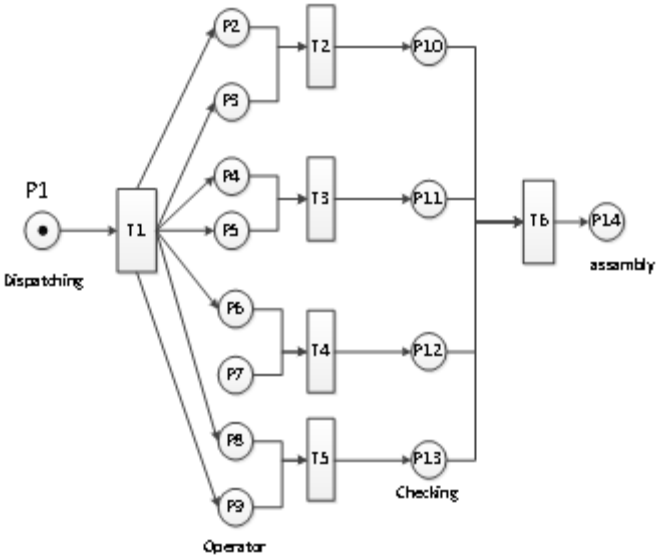

Figure 7. Normal Model

P2~P9 are operators (workstation); P10~P13 belong to Checking.

(2) Sometimes, however, some relatively easy typingvoucher (inputted slip or ticket elementsare only numbers, letters), the recognition error rate is very low, checking station's pressure is not great, in order to reduce labor costs, we change the normal model into "Asymmetric" shape is shown as Figure 8:

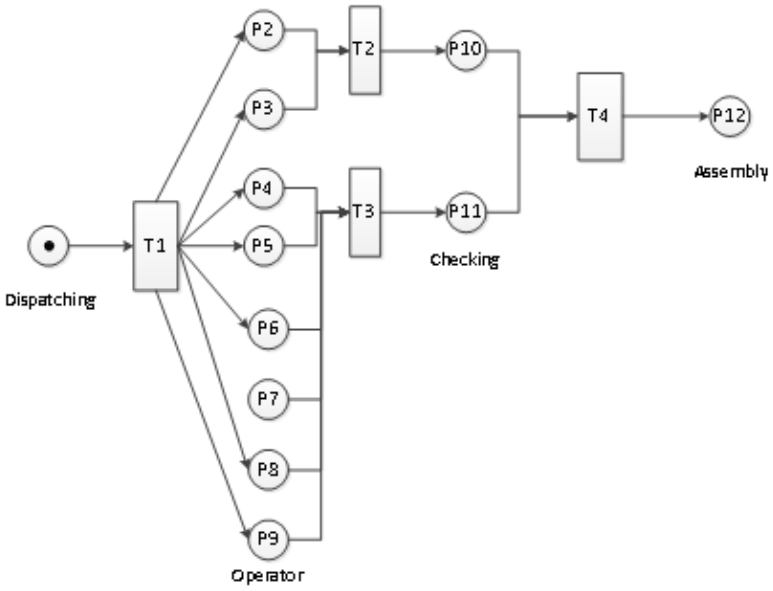

Figure 8. Asymmetric MAS ProductionLine Model

P2~P9 are operators (workstations);only P10~P11 belong to Checking work-stations. In this situation, P11 can sufficiently meet the requirements from P4-P9.P13 can also be allocated to strength the recognition power.

(3) When the inputting rate isthe mostimportantfactor (for one error, the entire voucher will be refused), "re-checking-type" line is formed by increasing the checking station, with configuration as "triple-recognition with double checking ". Figure 9 shows the "re-check-type line" in whichP10 ~ P13 are the first-checking stations, P14

~ P15 are the second-checking stations - through the double checking to ensure the accuracy.

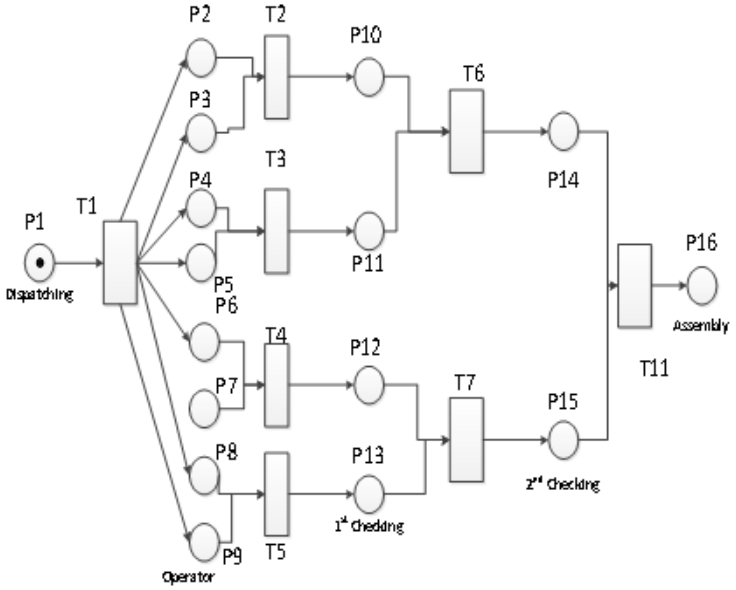

Fig.9. Multi-layer Checking Model

In the case of a wide variety of vouchers' elements, *e.g.*, account and insurance transactions start up simultaneously. The production line arranges some stations togroup the contents of voucher in advance – by inserting a station into a workflow to group the voucher by types and styles. These stations are called as grouping stations (places: P2, P3, P4), contributing on classification, reducing the difficulty of recognition, improve the correct rate. P10, as the only checking station, is enough to meet the needs of correction. This model is shown as Figure 10.

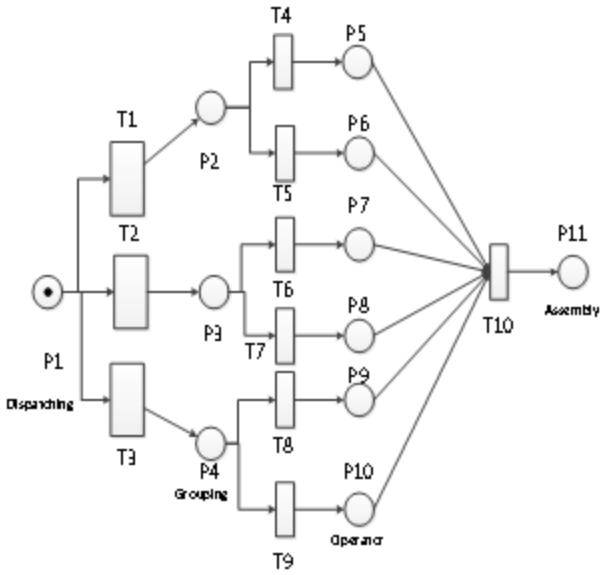

Figure 10. Pre-grouping Model

5. Model of Production Line

After optimization, our produce line is made up by many workflows. Every workflow bases on six kinds of agents: manager agent, scanning agent, segment agent, inputting agent, inspection agent, correction agent and assembly agent. We define these agents in workstations, shown as Figure 11.

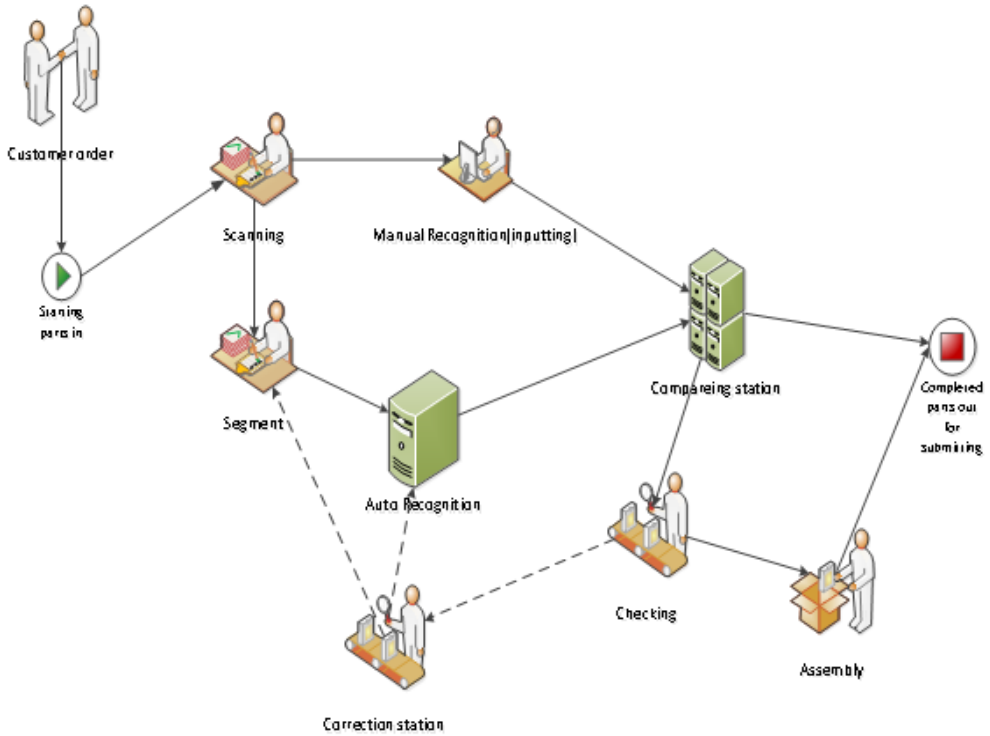

Fig.11. Optimized Workflow in Production Line

Now, from the perspective of production line, we redraw the model illustrated in Figure 11 as follows (Figure 12).

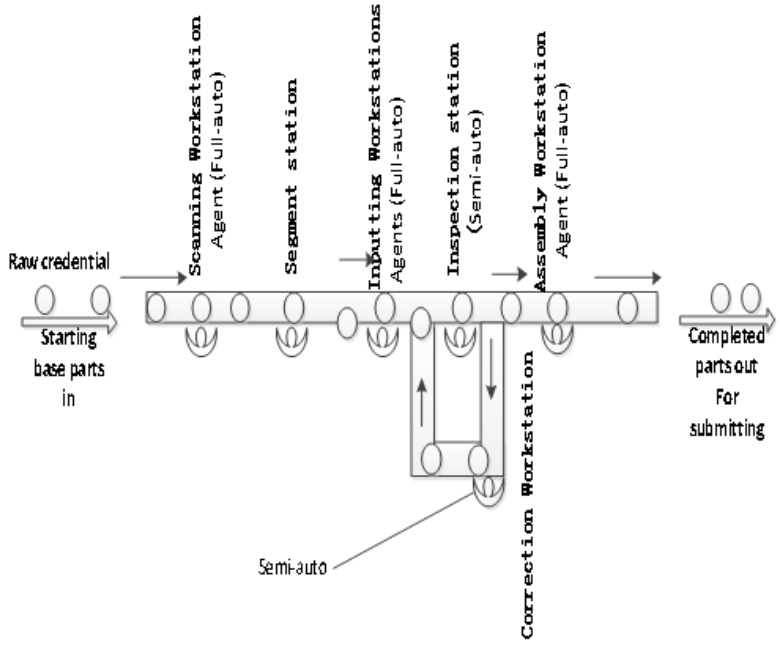

Figure 12. Model of Data-BPO Production Line

1) Manager(ruler) agent. Theagent is responsible for workflow designing, scheduling, management, definition, preparation game rules and dispatches the tasks to other operator agents when a customer order reaches [14]. A part of its function includes the template designer. The template designer, as mentioned in section 2, is very important role in production line because its speed directly decides the production speed and capacity. An equation about T_b, the total processing time in production line, can be obtained:

$$T_b=T_{su} + Q_{Tc}(3)$$

where T_{su}= setup time to prepare for the batch, Q_{Tc} = batch quantity and T_c= cycle time per work unit [15]. It indicates that T_{su} possesses a majority of processing time. After using ontology, the design procedure will speed up greatly because T_b drops greatly. Additionally, we will enhance thesystem's learning ability to establish a rule base to adapt to multi-service rules, including rules of the parsing and execution. It is a kind of ability to "Soft" extension.

2) Scanningagent. It accepts the task of scanning the raw accounting documents such as accounting ticket, proofs, certification, etc. Then transfer the tiff files to the segment agent located at next station.

3) Segment agent. The agent's task includes important technical process. Because the more fine-grain segment the agent works out, the better and faster results of recognition will get. So sometimes in order to get better affect, the production line will arrange two or more layers of segment agents to enhance the ability of segment, so called "re-segment" layer.After the process of "re-segment", the segment of vouchers often consist of few or single type of data which is very convenient for recognition. At last, segment agents transfer the unit parts to the next stations where recognition agents are.

4) Inputting (recognition) agent. This type of agent is the most in quantity because they are the basic labor force in the production line. Generally, every two inputting agents comprise a group. They input or recognize the same segment for correctness. In the automation system, each agent is a software component which can recognize the elements, such as letter, character from segment. Their efficiency effect the whole performance of production line.

5) Inspection agent. This type of agent is responsible for comparing the workout of recognition (inspection of consistency) and delivering the different results to correction agent while transferring the same information to assembly agent [16].

6) Correction agent. This type of agent plays the feedback role in the production line after receives wrong recognition result then revise them. The correction task sometimes is too difficult to complete for software (cannot ensure the correction), so major correction station depend on manual force.

7) Assembly agent. They are responsible for assembling these segment data into integrated information. In fact, after recognition, the assembly-agents comprise an assembly line, and the data in assembly line are in the XML form [17]. The assembly line needs a template for assembly shown as Figure 13. These XML segments have their array number indicating as XML_i, assembly number I stands for coming from $workstation_i$. When XML_i information reaches assembly station, it will go into the unit according to its assembly number. This approach costs great but it gains a fast speed in parallel computing.

Figure 13. XML Assembly Segments in Template

There is a model of template which is depicted by Petri-net which is shown as follows (refer to Figure 14).The token stands for XML information.

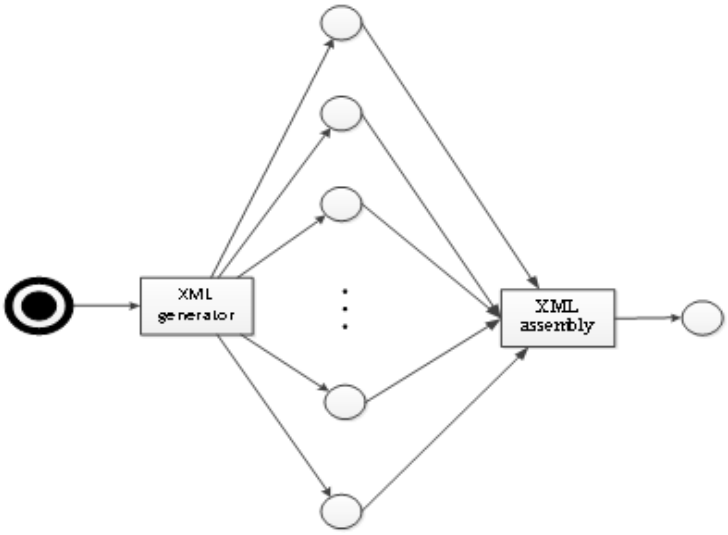

Figure 14. XML Assembly Model on Petri-net

The main part of the production line consists of all workstations. Although some workstations are operated by manual force, every workstation can also be called operator. In order to ensure a higher efficiency, these manual operators are grouped into beginner, middle level and high level. BPO providers can dispatch different level of tasks to them according to the operator's group. In this case, a completed bank transaction can be satisfactorily returned to bank printer in two minutes.

6. Conclusions and Future Work

In Data-BPO industry, facing thetwo challenges:

(1) Astatic system model that can't adapt to afast changeablecustomer's demandsany long and will become the bottleneck in development of BPO industry. So a flexible BPO data production line works instead.The dynamic and flexible systemcan quickly meet the requirement of customer for various specificationsof BPO data.

(2) A manual template design operation will jam and slow BPO data work flow. An automatic smart template based on domain ontology can overcome it.

Although BPO is not a new phenomenon, there are always some interesting challenges coming in Data-BPO. Mass customization (MC), a new efficient produce pattern, which combines mass produce with customized produce, has the superiority in modern manufacturing industry and is great favorite of BPO providers currently. Ontology can optimize the domain knowledge further, while MA is a very efficient tool in the distributed system. The solution of combining the two technologies will make the production service industry promote to more advanced level with high flexibility and automation mostly. Additionally, the solution also provide an approach to facing the problem that BPO providers have to overlapping invest on development of mass-customized-data BPO production systems in order to meet variable requirements from different industries and domains.

After the model of Mass Customization production line is built, there will be an exciting platform for us to explore in the parallel computing field. At the next research stage, we are going to find a practical method to implement high speed parallel computing in the production line under a distributed corporative computing environment.

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