# The Algorithm of Laundry Lining Procedure Scheduling Based on RFID

**Quanming Cheng, Sen Wu and Yang Zhao**

**Abstract** With the using of mobile devices with location sensing and positioning functions, people now are able to acquire the information of objects' present locations and collect them. Combining the Radio Frequency Identification (RFID) with the intelligent analysis of information and decision-making technology, this paper firstly presents the background of the RFID applications. Based on the foundation conceptions of washing line, this paper proposes the algorithm of laundry lining procedure scheduling based on RFID. At last, the experimental results demonstrate that our techniques are available and feasible.

**Keywords** RFID · Laundry · Lining procedure scheduling

## 1 Introduction

Laundry is the business which specially supplies the cleaning service. The facilitators convert the product system, service system, technology system and brand system into the cleaning clothes and keep the clothes nattiness.

The using of bar code saves a lot of human resources and time. But it cannot actualize the effect of batches, distant range and automatic recognition. RFID can solve the problem of bar code. RFID can read information without contact, have high memory capacity and identify the goods automatically. That the RFID leads into the washing procedure as the information manage is the common view in the industry (Li and Hao 2008; Moon and Ngai 2008). When the goods with the tag

Q. Cheng (✉) · S. Wu
Dongling School of Economics and Management, University of Science Technology Beijing, 100083 Beijing, China
e-mail: cqm@fornent.com.cn

S. Wu
e-mail: wusen@manage.ustb.edu.cn

Y. Zhao
Beijing Enginest Optimization Technology Co. Ltd, 100085 Beijing, China
e-mail: zhaoyangprc@163.com

 
Z. Zhang et al. (eds.), *LISS 2014,* DOI 10.1007/978-3-662-43871-8_242

come into the reader magnetic field, the reader receives the information and decode. The data will be sent to the application system to analyze (Lee et al. 2004).

Currently, RFID is widely used in the clothing inventory control management system. When the clothing chest comes into the RFID reader magnetic field, the RFID reader reads multi-tag information and transfers this information into the Warehouse Management System (WMS). The system arranges the storage location according to the information of storehouse. When the goods are ex-warehouse, the goods' RFID signal are read and compared with the invoice. Then, WMS updates the information of goods in storehouse (Gaukler et al. 2007; Hou and Huang 2006. In addition, RFID system can count the inventory status automatically and all kinds of clothing (style, color, size) residence time (Chowa et al. 2006).

## 2 Basic Principle

Based on RFID technology, process for laundry is designed as follows. Firstly, collect clothes which need to be washed on workstation and load the clothes into clothing laundry bucket. As a result of the wide range of customers of the workstation, the number and type of clothing for each bucket have great randomness. Within a certain period of time, ship a certain amount of laundry from the workstation to the laundry tub. For different clothes, there are three main ways for washing laundry: dry cleaning, washing and wet cleaning. Use RFID to classify clothing delivered from the workstation and then sent to the three washing lines. By reading RFID tag on each clothes, clothes are classified by the classification system. Clothes will be transported to the corresponding cleaning line automatically throughdevice. The record of the clothing to be washed which come through the RFID readers is showed as Fig. 3. The time and the related information of every clothes in the wash bucket which is in the buffer queue will be record as show in Fig. 1. *Tag* is the ID number, *C_workstation* is the name of the workstation where the clothes comes from. *C_type i*s the type of clothes. *C_size* is the size of clothes. *C_washtype* is the Cleaning type of clothes.

The type and quantity of the clothes in the wash bucket which is in the buffer queue is stochastic. Three cleaning lines are working at the same time. If the clothes in the wash bucket which is in the buffer queue are sent to the cleaning line in order, this sequence cannot ensure all clothes in the buffer queue symmetrical distribute in three cleaning line. This condition probably leaves some cleaning devices unused and some cleaning devices very busy. This situation causes the imbalance of devices.

| | | | | | | |
|---|---|---|---|---|---|---|
| *Tag* | *Timestamp* | *Location* | *C_workstation* | *C_type* | *C_size* | *C_washtype* |

**Fig. 1** The record of object based on RFID

Because the requirements of every customer are different, the expected finished time of task is also different.

*Definition 1* (*The expected finished time of task*) For a clothes object $C_i$, the mapping based on the tag information property is set up: (*C_location, C_type, C_size*) $\mapsto TF$. Where $TF$ is the nominal expected finished time of task for clothes object $C_i$. $\Delta T$ is the waiting time in the buffer line. The actual expected finished time of task is $TFP = TF - \Delta T$.

In the buffer line, the clothes are partitioned by the wash bucket. The whole expected finished time of task for every wash bucket is defined by definition 2.

*Definition 2* (*The average expected finished time*) For all clothes object $C_i$ in a wash bucket $B_i$, the average expected finished time of task is $\overline{TFP_i} = \sum_{j=1}^{|B_i|} TFP_j \Big/ |C_i|$

The quantity of clothes in every wash bucket is stochastic. The difference between the number of clothes in a wash bucket and the average quantity of the whole buffer line is measured by definition 3.

*Definition 3* (*The ratio of quantity*) At time $t$, for a wash bucket $B_i$, the number of clothes objects $C$ in $B_i$ is $Num\_B_i$. All wash buckets in buffer queue compose the buffer queue vector $\overline{B}$, where $\overline{B} = (B_1, B_2, \ldots, B_n)$. $n$ is the number of the wash bucket in the buffer line. Let $Mean(\overline{B})$ be the average value of all $Num\_B_i$ in the buffer line, where $Mean(\overline{B}) = \sum_{i=1}^{n} Num\_B_i \Big/ n \cdot Mean(\overline{B}) - Num\_B_i / Mean(\overline{B})$ is the ratio of quantity of $B_i$ in buffer line $\overline{B}$, denoted by $S(B_i)$.

The extent of demand for corresponding clothes style is indicated by the ratio of the idle line to the whole cleaning line.

In Fig. 2, at time $t$, let $L$ be the length of the cleaning line. The length of idle line is $\Delta L$. For three cleaning lines, the ratio of the idle line to the whole idle line is $W_i = \Delta L_i / (\Delta L_1 + \Delta L_2 + \Delta L_3)$, where $i = 1, 2, 3$.

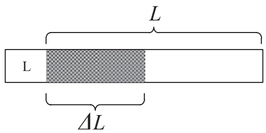
If the number of three type of clothes is $A_{j1}, A_{j2}$ and $A_{j3}$ in wash bucket $B_j$, the proportion of the *ith* clothes is $B_{ji} = A_{ji} / Num\_B_j$.

*Definition 4 (The diversity degree of working condition)* At time $t$ the diversity between the proportion of clothes in $B_j$ and the proportion of idle woke space is:

$$d(B_j, L) = 1 \Big/ 3 * \sum_{k=1}^{3} d_{jL}^{(k)}, \text{ where } d_{jL}^{(k)} = \frac{|B_{jk} - L_k|}{Max\{B_{j1}, B_{j2}, B_{j3}\} - Min\{L_1, L_2, L_3\}}.$$

Synthesizing the concepts above, we introduce the prior schedule function.

**Fig. 2** Cleaning line



*Definition 5 (Prior schedule function)* At time $t$, the prior schedule function of buffer line $\overline{B}$ is $F(\omega_i)=Min\left\{\overline{TFP}_i*\omega_1+\frac{1}{S(B_i)}*\omega_2+d(B_j,L)*\omega_3\right\}$, where $S(B_i)>0,\omega_i$, is weight $i=1,2,3$.

## 3 The Algorithm of Laundry Lining Procedure Scheduling Based on RFID

The purpose of the algorithm is to make the prior selection sequence for the wash bucket in buffer line. This paper mainly considers these factors:

(1) The expected finished time of task. One considering factor for which bucket will be carried on the cleaning line prior is decided by the expected finished time of clothes in a bucket. (2) The quantity of clothes in a bucket. The quantity of clothes in some bucket is very few. On this occasion, if other conditions are identical, we consider take this bucket to the clean line prior. (3) The similarity degree of the clothes proportion with the idle ratio in cleaning line. In order to avoid the idle state of the cleaning device, we need to distribute symmetrically the clothes to the cleaning lines. The algorithm of laundry lining procedure scheduling based on RFID is show below (Table 1).vww

## 4 Experiment

This paper generates randomly 500 data of wash bucket. There are at most 50 clothes and three styles in every wash bucket. Every clothes has the nominal expected finished time. In our experiment, the parameters are set as below: The length

**Table 1** The algorithm of laundry lining procedure scheduling based on RFID

| The algorithm of laundry lining procedure scheduling based on RFID |
|---|
| *Input*: Clothing set $C$; $\overline{B}$ ; $m$; scheduling weight $\omega_1$, $\omega_2$, $\omega_3$ |
| *Output*: line sequence $L\_Seq$ |
| *If* $\lvert\overline{B}\rvert < m$ , *when* $(\lvert\overline{B}\rvert \neq m)$ Add $Ci$ into $\overline{B}$ . Where $m$ is the length of $\overline{B}$ and $Ci \in C$ |
| *Else* |
| *For* each $Bi \in \overline{B}$ , compute $\overline{TFPi}$ ; compute $S(Bi)$; compute $d(B_j,L)$ |
| *End for* |
| Compute $F(\omega_i)$, find out $Bi$ which have the smallest scheduling function value |
| Add $Bi$ into $L\_Seq$ and delete $Bi$ from $\overline{B}$ |
| *While* $(C!=0)$ |

**Fig. 3** The ratio of service time for three devices under different buffer line length

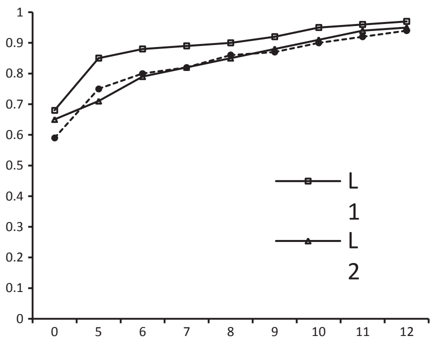
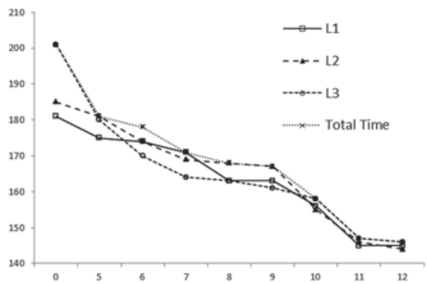



**Fig. 4** The total finfish time for three under different buffer line length




of every cleaning line is 30. Every device can clean 50 clothes at a time. When the quantity of clothes in cleaning line is up to 50, the device begins work. The work time of device is 0.25 h at a time. The weights of prior schedule function are set as $\omega_1 = 0.4, \omega_2 = 0.2, \omega_3 = 0.4$. The work time of RFID management system for a bucket is 0.2 h.

The ratio of service time for a device is the ratio of the service time to the entire time for a cleaning project. According to the experiment (Fig. 3), the condition that there is no buffer line have lower ratio of service time than the condition that the length of buffer line is 5. The compare result that the length is 5, 6, 7, 8, 9, 10, 11, 12 show that the ratio of service time raise with the increase of the length of buffer line. When the length of buffer line is greater than 10, the enhance extent of the ratio of service time is slow. This illustrate that increasing the length of the buffer line can enhance the ratio of service time. But this effect is not remarkable after the quantity is up to a certain extent. The total finfish time for a task is the longest time in three cleaning lines when the task is done. According to the experiment (Fig. 4), with the increasing of length of the buffer line, the total finfish time of this cleaning project decrease. This experiment illustrate the algorithm proposed in this paper is effective.

## 5 Conclusion

In this paper, we study the method of laundry lining procedure scheduling based on RFID. First, we discuss the background of the RFID applications for the laundry. Second, based on fundamental conceptions, we develop the algorithm of laundry lining procedure scheduling based on RFID Experimental results show that this method is available and feasible than the condition without using it.

## References

Chowa HK, Choya KL, Leea WB, et al (2006) Design of a RFID case-based resource management system for warehouse operations. Expert Syst Appl 1(30):561–576

Gaukler GM, Seifert RW, Hausman WH (2007) Item-level RFID in the retail supply chain. Prod Oper Manage 16(1):65–76

Hou JL, Huang CH (2006) Quantitative performance evaluation of rfid applications in the supply chain of the printing industry. Ind Manage Data Syst 1(1):96–120

Lee YM, Feng C, Ying TL (2004) Exploring the impact of RFID on supply chain dynamics. In: Proceedings of the 2004 Winter Simulation Conference, Association for Computing Machinery, 2004

Li Y, Hao L (2008) Application of RFID technology in apparel supply chain. Electron Technol 45(11):10–13

Moon KL, Ngai EW (2008) The adoption of RFID in fashion retailing: a business value-added framework. Ind Manage Data Syst 1(5):596–612