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Grain Order Sorting Based on the Polling Control Mechanism of Exhaustive Parallel Limited-1

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Abstract: China is a large country of grain production and population so that the grain problem has a significant impact on China's economic and social development. However, the existing grain supply chain "wholesale layer-by-layer" circulation system can not meet consumers individual requirements. Therefore, this paper applies of polling system to study the automatic control mechanism of order sorting of grain, such as the flour, rice and other grain. Based on the sorting characteristics of the grainl and the actual business needs, this paper distinguishes common order from priority order. Besides, establishing two level priority polling order sorting system model of exhaustive parallel limited-1. The proposed model takes exhaustive control strategy to sort the priority order and takes limited-1 control strategy to sort the common order, which can ensure priority order customers receive better service and the fairness of order sorting systems. Using the embedded Markov chain and Laplace transform to solve theoretical model. Then through numerical calculation and analysis to get system's first order characteristics and second order characteristics and other key performance parameters for intensive study of the control mechanism of order sorting.

1. Introduction

The population of China ranks the first in the world, accounting for 1/5 of the world's total population. Therefore, making the high-efficiency grain security policy is the foundation of social stability. The traditional grain supply chain belongs to functional product supply chain. Its aim is to forecast production mainly through the stockpile and reduce cost by smooth operation of procurement, production and distribution. There has been a lot of problems in the grain supply chain of China, for example, ignoring market forecast or incorrect prediction, planning and production either surplus or deficiency, aging of grain batch, slow response to customer demand, low rate of channel penetration, safety responsibility is difficult to be divided, and so on [1]. These problems all belong to the supply chain operation and are closely related to the choice of supply chain model. Vertical integration of the grain industry will make it face with a personalized era of mass customization. In the future, applying personalized and customized new circulation mode, namely, on-demand customization, to achieve the supply side reform of grain industry is promising [2].

In order to meet consumer's individual demand, accurate and efficient sorting and packaging of grainl will promote the new circulation mode. With grain and other grainl as an example, the new circulation business model (see Figure 1) can be described as: establishing online and offline sell and distribution integrated logistics center—grain and oil station, which is a node in the grain lean supply chain. It's important that products in the station are directly transported from the factory warehouse or area logistics center of factory. Automatic grainl sorting machines are located in the station so that consumers can make an order either online or offline to purchase the goods by material quantity or amount of money according to their actual needs. This business model of lean supply chain can ensure grain safety from the source of the grain industry, and greatly facilitate the people's lives, and truly realize the reform of the supply side of the grain industry.

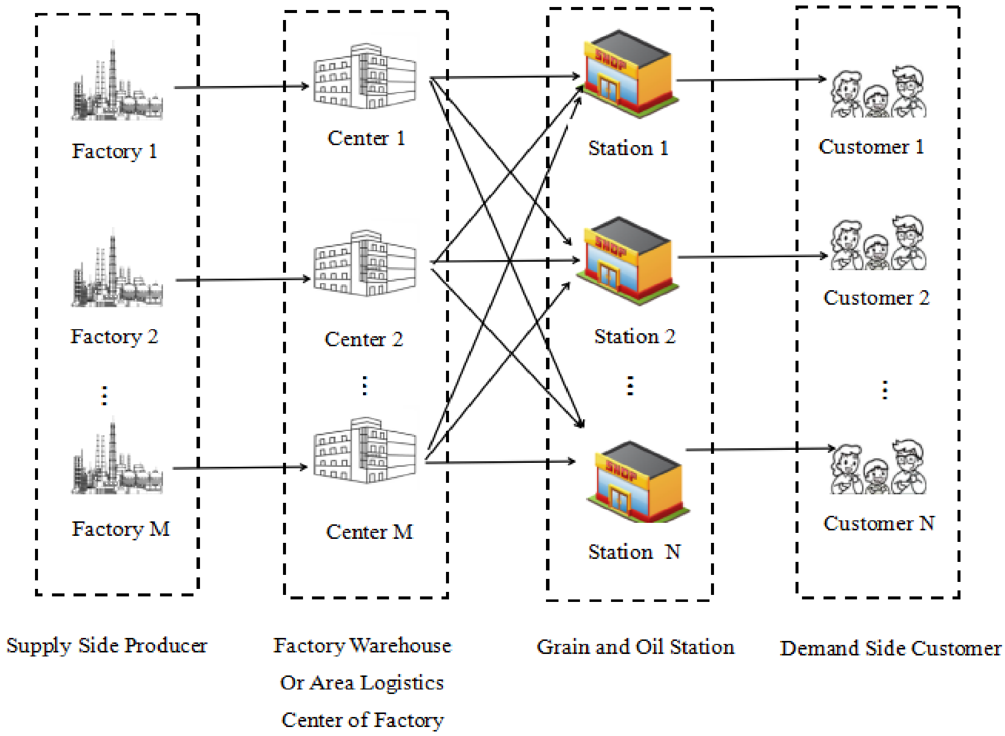


Figure 1: "New circulation" model of the streamlining grain supply chain

With the passive consumption mode of the seller's market turned into the active consumption of the buyer's market and improving of people's living standard, customer needs are increasingly tended to multiple batches, small amount and individuation. What's more, customer requires to receive more efficient and better service as soon as possible after submitting the order. Therefore, how to improve the order sorting efficiency of distribution center has become more and more important. In addition, the order sorting as one of the core businesses of the warehouse operations, is the most labor-intensive and cost-consuming part in the warehouse operations. Rubricoa, etc. found that the cost of order sorting accounted for more than 55% of the total cost of warehousing operations [3].

In order to further improve order sorting efficiency of distribution center, the polling theory is applied to order sorting system. Polling is a kind of periodic resource dynamic scheduling and distribution system, and has the characteristics of high efficiency, fairness, flexibility and practicality. Because the polling system can get better sharing resource utilization in high load condition, and avoid the competition conflict between service objects. In recent years, domestic and foreign scholars have made a thorough theoretical study, such as the analysis and evaluation of the system performance, polling system optimization, polling system architecture development, and the system efficiency of polling system application, on the polling system and has achieved fruitful results [4]-[5].

Although scholars have done more thorough research on polling theory and how to improve the order picking efficiency, the research application of polling theory to the sorting system is still limited. Gong and De Koster has done pioneering research on the application of polling theory. They describe and analyze the semi-automated dynamic order picking system under the electronic commerce environment by using polling theory and the results show that compared with the traditional method (e.g., order batch sorting etc.) of sorting system, dynamic sorting system based on polling theory saves more time [6]. Then, Gong etc. extends the above research, and introduces random variables into the dynamic sorting system, which can effectively improve the efficiency of sorting system. However, their research is mainly applied to the semi-automated dynamic sorting system, and for the electronic commerce environment, the gradual implementation of automated distribution center warehousing operations guidance is limited. Wenxue Ran applies the polling theory to the unit material order-sorting, and extends the classic control mechanism of polling to the two-level parallel control and compares the application of multiple polling system models in order picking [7]. But the polling and sorting mechanism of Wenxue Ran's research is the category of unit material. This paper studies the polling and sorting of grainls.

China's grain demand is large, so this paper studies the grainl order sorting based on the polling control mechanism with the consumer as the core to promote the reform of the supply side of the grain industry. This paper establishes two level priority polling order sorting system model[8] of exhaustive parallel limited-1, and the mathematical method is used to solve the theoretical model. Then through numerical analysis, the system's first and second order characteristics of the polling control system are solved to verify the reliability of the model.

2. Environment variables and working conditions of polling control model for grain order sorting

2.1. Definition of environmental variables

The embedded Markov chain, probability generating function and Laplace transform method are used to study polling system control model for order sorting[9]-[10]. So, define the following environment variables:

$\xi_i(n)$: the amount of material of the common queue i $(i=1,2,\cdots,N)$ at time t_n .

$\xi_h(n)$: the amount of material of the priority queue at time t_n .

$\xi_h(n^*)$: the amount of material of priority queue at time t_{n^*} when sorting machine switches to priority queue from queue i .

v_i : sorting time of material in common queue i .

v_h : sorting time of material in priority queue.

u_i : transition time from queue i to priority queue.

$\eta_j(v_i)$: the material quantity of common queue that enters the queue j $(j=1,2,\cdots,N,h)$ during time v_i needs to be sorted.

$\eta_j(v_h)$: the material quantity of priority queue that enters the queue j $(j=1,2,\cdots,N,h)$ during time v_h needs to be sorted.

$\mu_j(u_i)$: the material quantity that enters the queue j $(j=1,2,\cdots,N,h)$ during time u_i needs to be sorted.

The state variable of the sorting machine at time t_{n+1} is related to the system status of the last sorting service at time t_{n^*} which is a Markov process with no aftereffect. Under the steady state condition, the Markov process is homogeneous, non-periodic, irreducible and ergodic.

2.2. Description of working conditions

(1) The grainl order sorting process is defined as the continuous time control of the service.

(2) Order queue waits for service according to the rule of FCFS (First Come First Service) .

(3) The arrival process of the material entering the system waiting for sorting is independent and obeys the Poisson distribution. Arrival rate is $\lambda = \tilde{A}'(1)$. Probability generating function is $\tilde{A}(z)$, $\tilde{A}''(1) = |\lambda^2 - \lambda|$.

(4) The random variables of service time required for sorting of the regular orders are independent of each other, and are subject to the same probability distribution. The Laplace transform is $\tilde{B}_i(s_i)$. Mean value is $-\tilde{B}_i'(0) = |\beta|$. Second geometric moment is $\tilde{B}_i''(0) = \tilde{B}''(0) = |\beta^2 - \beta|$.

(5) The random variables of the service time required for sorting of the priority orders are independent of each other, and are subject to the same probability distribution. The Laplace transform is $\tilde{B}_h(s_h)$. Mean value is $-\tilde{B}_h'(0) = |\beta_h|$. Second geometric moment is $\tilde{B}_h''(0) = |\beta_h{}^2 - \beta_h|$.

(6) The random variables of the service transition time between any two adjacent order queues are independent of each other and are subject to the same probability distribution. The Laplace transform is $\tilde{R}_i(s_i)$ .Mean value is $-\tilde{R}_i'(0) = |\gamma|$. Second geometric moment is $\tilde{R}_i''(0) = \tilde{R}''(0) = |\gamma^2 - \gamma|$.

(7) The material order queue in the polling model obeys the control strategy that has been set and waits for service.

3. Polling service system of exhaustive parallel limited-1 for grain order sorting

The two-level priority polling order sorting system model of exhaustive parallel limited-1 can be described as: the basic model of the system consists of a sorter and N+1 order queues which contains priority order and common order. The sorter adopts parallel operation for both one priority order queue and the amount of N common order queues. In addition, the priority order queue is adopted by the exhaustive service control strategy, and the common order queues are adopted by limited-1 service control strategy. When the sorter starts working, if there are any common order queues need to be sorted, parallel limited-1 sorting service is performed for common order queues, and after sorting an order queue, it turns to the priority order queues immediately. The process of order sorting polling control system in the model includes the arrival process of the orders, the sorting service process of a sorter for each order and polling conversion process between orders.

Under the condition of the arrival process of orders is Poisson distribution, the sorter services the common queue i $(i = 1, 2, \cdots, N)$ at time t_n when the material quantity is $\xi_i(n)$ in the queue i and system state variable is $\{\xi_1(n), \xi_2(n), \cdots, \xi_N(n), \xi_h(n)\}$. By this time, the sorter provides service to the common order queue i by the limited-1 sorting strategy. After the sorter finishing its service for the queue i , it passes through a transfer time $u_i(n)$ then starts to service priority order queue. The material quantity that enters the queue j $(j=1,2,\cdots,N,h)$ during time $u_i(n)$ needs to be sorted is $\mu_j(u_i)$. While at the time t_n^*, the sorter inquiry the amount of material which waiting for sorting in the priority queues is $\xi_h(n^*)$,and the system state variable is $\{\xi_1(n^*),\xi_2(n^*),\cdots,\xi_N(n^*),\xi_h(n^*)\}$. If the priority queues are not empty, the service is completed according to the exhaustive sorting strategy for priority queue. If the priority queues are empty, then the sorter begins to service common order queue $i+1$ at time t_{n+1} and the system state variable is $\{\xi_1(n+1),\xi_2(n+1),\cdots,\xi_N(n+1),\xi_h(n+1)\}$.

3.1. Probability generating function of polling service system for grain order sorting

Assumption that the steady state condition of the polling system is $\sum_{i=1}^{N}(\lambda_i\beta_i+\lambda_i\gamma_i)+\lambda_h\beta_h<1$ $,i=1,2,\cdots,N$. If the queue i is served by the sorter of the polling control system at time t_n, then at the time t_{n+1} the sorter services queue $i+1$. When the queue $i+1$ is served by the sorter at the moment t_{n+1}, the relation equations for system state variable are as follows:

$$
\begin{aligned}
&\xi_j(n^*)=\xi_j(n)+\mu_j(u_i)+\eta_j(v_i)\cdots\cdots\quad j=1,2,\cdots N,i\neq j\\
&\xi_i(n^*)=\xi_i(n)+\mu_i(u_i)+\eta_i(v_i)\cdots\cdots\quad \xi_i(n)=0\\
&\xi_i(n^*)=\xi_i(n)+\mu_i(u_i)+\eta_i(v_i)-1\cdots\cdots\quad \xi_i(n)\geq 1\\
&\xi_j(n+1)=\xi_j(n^*)+\eta_j(v_h)\cdots\cdots\quad j=1,2,\cdots N\\
&\xi_h(n^*)=\xi_h(n)+\mu_h(u_i)+\eta_h(v_i)\\
&\xi_h(n+1)=0
\end{aligned}
\tag{1}
$$

Meanwhile, if the sorter sorting the priority orders according to the exhaustive service strategy at the moment t_n^* , the probability generating function of the system state variable is given by:

$$
\begin{aligned}
&\tilde{G}_{ih}(z_1,z_2,\cdots,z_N,z_h)=\lim_{n\to\infty}E\left[\prod_{j=1}^{N}z_j^{\xi_j(n^*)}z_h^{\xi_h(n^*)}\right]\\
&=\tilde{R}_i\Big(\sum_{c=1}^{N}\lambda_c(1-z_c)+\lambda_h(1-z_h)\Big)\Big\{\frac{1}{z_i}\tilde{B}_i\Big(\sum_{j=1}^{N}\lambda_j(1-z_j)+\lambda_h(1-z_h)\Big)[\tilde{G}_i(z_1,z_2,\cdots,z_N,z_h)\\
&-\tilde{G}_i(z_1,z_2,\cdots,z_N,z_h)\big|_{z_i=0}]+\tilde{G}_i(z_1,z_2,\cdots,z_N,z_h)\big|_{z_i=0}\Big\}
\end{aligned}
\tag{2}
$$

If the sorter services the queue $i+1$ at time t_{n+1}, the probability generating function of the system state variable is given by:

$$
\begin{aligned}
&\tilde{G}_{i+1}(z_1,z_2,\cdots,z_N,z_h)=\lim_{n\to\infty}E\left[\prod_{j=1}^{N}z_j^{\xi_j(n+1)}z_h^{\xi_h(n+1)}\right]\\
&=\tilde{G}_{ih}\Big(z_1,\cdots,z_N,\tilde{H}_h\Big(\sum_{c=1}^{N}\lambda_c(1-z_c)\Big)\Big)
\end{aligned}
\tag{3}
$$

In the formula (3), $\tilde{H}_h(s)=\tilde{B}(s+\lambda_h(1-\tilde{H}_h(s)))$.

The first derivative of $\tilde{H}_h(s)$ is given by:

$$\tilde{H}_h'(0)=-\frac{\beta_h}{1-\lambda_h\beta_h},\beta_h=-\tilde{B}_h'(0) \tag{4}$$

The second derivative of $\tilde{H}_h(s)$ is given by:

$$\tilde{H}_h''(0)=\frac{\tilde{B}_h''(0)}{(1-\lambda_h\beta_h)^3},l_h=-\tilde{H}_h'(0) \tag{5}$$

3.2. First order characteristics of polling service system for grain order sorting

(1) Mean cyclic period

We defined the mean cyclic period as the statistical mean time of the sorter that complete a service for each queue in the system by the corresponding service rule, which is made up of sorting time and ordering conversion time. According to the probability generating function relation, the following equality can be calculated:

$$\tilde{G}_{i0}=\tilde{G}_i(1,1,\cdots,z_i,1,\cdots 1)\big|_{z_i=0} \tag{6}$$

$$1-\tilde{G}_{i0}=\lambda_i\tilde{\theta} \tag{7}$$

By further simplifying and sorting the equation (6) and (7), the mean cyclic period can be given by:

$$\tilde{\theta}=\frac{\sum\gamma_c}{1-\lambda_h\beta_h-\sum\left(\lambda_c\beta_c+\lambda_c\gamma_c\right)} \tag{8}$$

(2) Mean queue length of priority order queues

If the queue i is served by the sorter at time t_n, when the mean queue length of queue j is $\tilde{g}_i(j)$. If the priority order queues receive service at time t_{n^*}, when the mean queue length of the queue j is $\tilde{g}_{ih}(j)$. Thus, according to the characteristics of the probability generating function, we are going to show $\tilde{g}_i(j)$ and $\tilde{g}_{ih}(j)$ respectively:

$$\tilde{g}_i(j)=\lim_{z_1,z_2,\cdots,z_N,z_h\to 1}\frac{\partial\tilde{G}_i(z_1,z_2,\cdots,z_N,z_h)}{\partial z_j}$$

$$i=1,2,\cdots,N,h;\ j=1,2,\cdots,N,h \tag{9}$$

$$\tilde{g}_{ih}(j)=\lim_{z_1,z_2,\cdots,z_N,z_h\to 1}\frac{\partial\tilde{G}_{ih}(z_1,z_2,\cdots,z_N,z_h)}{\partial z_j}$$

$$i=1,2,\cdots,N,h;\ j=1,2,\cdots,N,h \tag{10}$$

Then, substituting equality (2) and (3) into equality (9) and (10) respectively and searching for the derivative and simplify, so we can obtain the mean queue length $\tilde{g}_{ih}(h)$ of the polling control system about the priority orders:

$$\tilde{g}_{ih}(h) = \lambda_h(\gamma_i + \lambda_i \beta_i \tilde{\theta}) \tag{11}$$

3.3. Second order characteristics of polling service system for grain order sorting

(1) Mean queue length of common queues

For the polling control system of exhaustive parallel limited-1 order sorting, the mean queue length of the common order queues waiting in its buffer is $\tilde{g}_i(i)$, which only can be obtained through the second-order partial derivative.

Defining the joint moment of the random variables (x_j, x_c) about priority order queues as $\tilde{g}_{ih}(j,c)$, while the joint moment of the random variables (x_j, x_c) about common order queues are defined as $\tilde{g}_i(j,c)$. According to the characteristics of probability generating function, the following equations can be obtained:

$$\tilde{g}_{ih}(j,c) = \lim_{z_1, z_2, \cdots, z_N, z_h \to 1} \frac{\partial^2 \tilde{G}_{ih}(z_1, z_2, \cdots, z_j, \cdots, z_c, \cdots, z_N, z_h)}{\partial z_j \partial z_c}$$

$$i = 1,2,\cdots,N;\ j = 1,2,\cdots,N,h;\ c = 1,2,\cdots,N,h \tag{12}$$

$$\tilde{g}_i(j,c) = \lim_{z_1, z_2, \cdots, z_N, z_h \to 1} \frac{\partial^2 \tilde{G}_i(z_1, z_2, \cdots, z_j, \cdots, z_c, \cdots, z_N, z_h)}{\partial z_j \partial z_c}$$

$$i = 1,2,\cdots,N;\ j = 1,2,\cdots,N,h;\ c = 1,2,\cdots,N,h \tag{13}$$

Thus, substituting equation (2) and (3) into equation (12) and equation (13) respectively to search for the second partial derivative and iterative simplification. Then the mean queue length of the common order queues $\tilde{g}_i(i)$ and the second order origin moment of the central station $\tilde{g}_{ih}(h,h)$ can be calculated:

$$\tilde{g}_i(i) = \frac{N\gamma\lambda^2}{2(1-\lambda_h\beta_h)(1-\lambda_h\beta_h - N\lambda\beta)[(1-\lambda_h\beta_h - N\lambda(\gamma+\beta)]}\{(1-\lambda_h\beta_h - N\lambda\beta)\frac{\tilde{R}''(0)}{\gamma} + \lambda_h\tilde{B}''(0) + N\lambda\tilde{B}''(0) + 2N\gamma\lambda\beta - (N-3)\gamma\lambda_h\beta_h - (N+1)\gamma + 2(1-\lambda_h\beta_h)(1-\lambda_h\beta_h - N\lambda\beta)/\lambda\} \tag{14}$$

$$\tilde{g}_{ih}(h,h) = \tilde{R}_i''(0)\lambda_h^2 + \tilde{R}_i'(0)\tilde{B}_i'(0)\lambda_h^2(1-\tilde{G}_{i0}) + \tilde{B}_i''(0)\lambda_h^2(1-\tilde{G}_{i0}) \tag{15}$$

(2) Mean waiting time

The time from the order entry the queue $j(j = 1,2,\cdots,N,h)$ to the time the order is dispatched which is called the waiting time w_j of the order sorting job. Using the notations $E(w_h)$ and $E(w_i)$ to denote the mean waiting time of the priority queues and the common queues respectively.

Thus, the mean waiting time of the exhaustive service system for information grouping can be defined as following:

$$E(w_E)=\frac{1}{2}\left\{\frac{\tilde{R}''(1)}{\gamma}+\frac{1}{1-N\lambda\beta}\left[(N-1)\gamma+(N-1)\lambda\beta+N\lambda\tilde{B}''(1)\right]+\frac{\lambda\beta\tilde{A}''(1)}{\lambda^2(1-N\lambda\beta)}\right\} \tag{16}$$

Meanwhile, the mean waiting time of the limited-1 service system for information grouping can be defined as following:

$$E(w_{L-1})=\tilde{R}''(1)/(2\gamma)+1/\left\{2\left[1-N\lambda(\gamma+\beta)\right]\right\}$$
$$*\left[(N\text{-}1)\gamma+(N\text{-}1)\lambda\beta+2N\gamma\lambda\beta+(N\lambda\gamma+\lambda\beta)\tilde{A}''(1)/\lambda^2+N\lambda\tilde{B}''(1)+N\lambda\tilde{R}''(1)\right] \tag{17}$$

By using the above calculating methods, the mean waiting time of the priority order queues and common order queues in the system model can be obtained.

The mean waiting time of the common order is as follows:

$$E(w_i)=\frac{\tilde{g}_i(i)}{\lambda_i^2\tilde{\theta}}-\frac{1}{\lambda_i} \tag{18}$$

The mean waiting time of the priority order is as follows:

$$E(w_h)=\frac{\tilde{g}_{ih}(h,h)}{2\lambda_h\tilde{g}_{ih}(h)}+\frac{\lambda_h\tilde{B}_h(0)}{2(1-\lambda_h\beta_h)}-\frac{\tilde{A}_h''(1)}{2\lambda_h{}^2(1+\lambda_h\beta_h)} \tag{19}$$

4. Numerical analysis and verification

On the basis of the above solution and analysis, in order to verify the reliability of the model, the numerical analysis of the system model is carried out by MATLAB programming. The arrival process of each queue is subject to Poisson distribution, and the same normalization parameter is used in theoretical calculation and simulation experiment. Taking $\beta_h=\beta_i=25$, $\lambda_h=\lambda_i=\lambda$, $\gamma=5$, the system meets stability condition $\sum_{i=1}^{N}(\lambda_i\beta_i+\lambda_i\gamma_i)+\lambda_h\beta_h<1$, $i=1,2,\cdots,N$.

Theoretical calculations and experimental results are shown in Figure 2 to Figure 10.

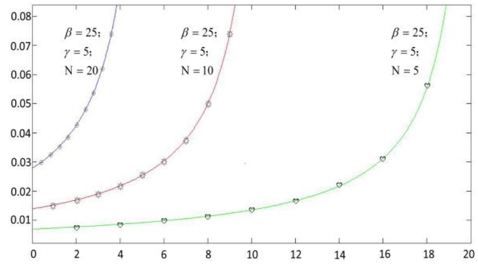


Figure 2: Change trend of mean order sorting time with customer arrival rate under different queue numbers

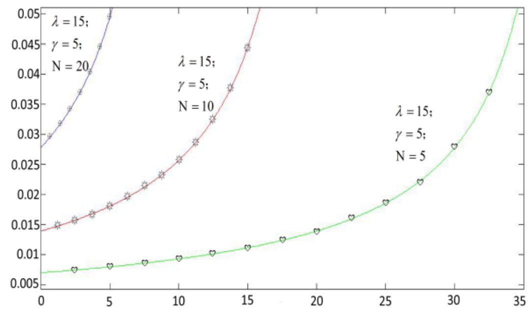


Figure 3: Change trend of mean order sorting time with sorting service time under different queue numbers

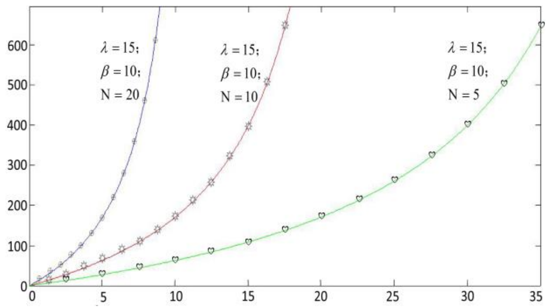
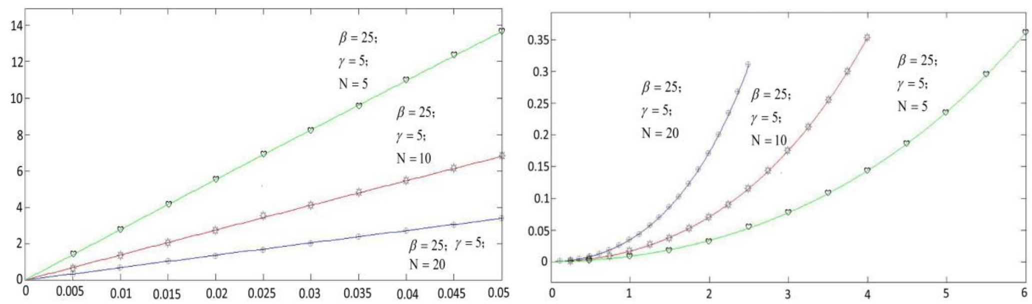
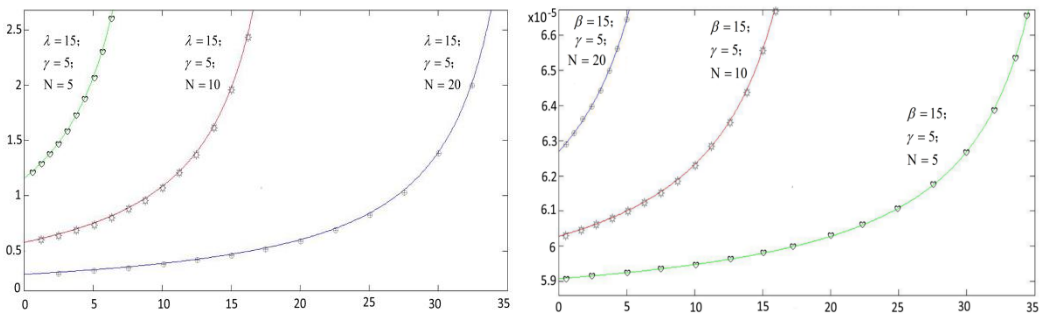


Figure 4: Change trend of mean order sorting time with order switching time under different queue numbers



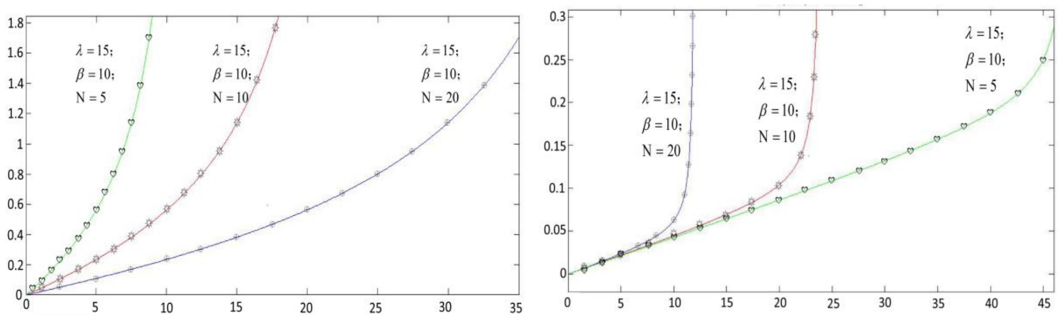
(a) common order queue (b) priority order queue

Figure 5: Change trend of mean queue length with customer arrival rate under different queue numbers



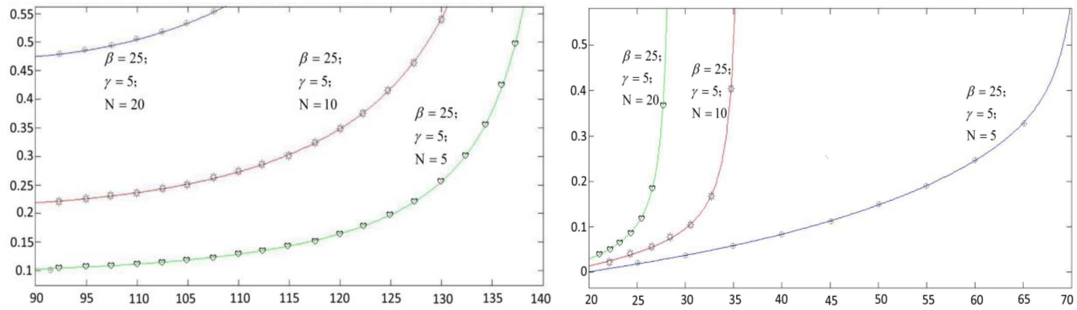
(a) common order queue (b) priority order queue

Figure 6: Change trend of mean queue length with sorting service time under different queue numbers



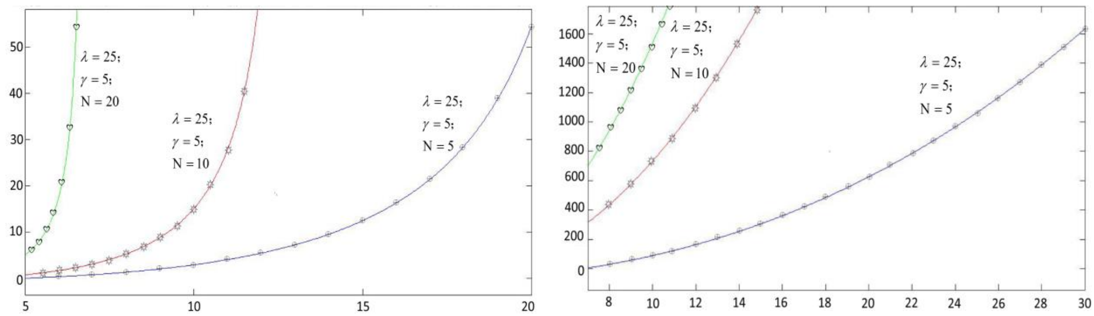
(a) common order queue (b) priority order queue

Figure 7: Change trend of mean queue length with order switching time under different queue numbers



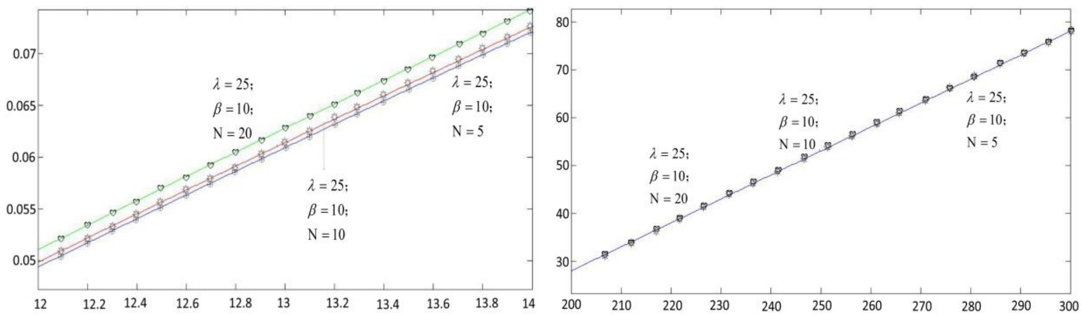
(a) common order queue (b) priority order queue

Figure 8: Change trend of mean waiting time with order arrival rate under different queue numbers



(a) common order queue (b) priority order queue

Figure 9: Change trend of mean waiting time with service time under different queue numbers



(a) common order queue (b) priority order queue

Figure 10: Change trend of mean waiting time with order switching time under different queue numbers

As shown in figure 2 to figure 10, the theoretical results are in good agreement with the results of

MATLAB simulation experiments. Further analysis of the polling system model has the following characteristics:

(1) Figure 2 to figure 4 shows the changing trend of the mean order sorting time with the change of the customer arrival rate, sorting time and order switching time. With the increase of the customer arrival rate, the mean order sorting service time of different queue numbers present a nonlinear increase. When the number of queues is small, the system polling cycle is short, and it has good stability and fast response characteristics. At the same time, from the distribution of the three curves of the graph, we can see that the three curves in the case of increasing customers do not appear to crossing and the average order sorting service time of the system is based on the vertical distribution of the number of queues. Besides, with the extension of sorting time, the mean order sorting time of different queue numbers also present a nonlinear increase. When the number of queues is small, the system polling cycle is short and it has good stability and fast response characteristics. What's more, with the extension of the order switching time, the mean order sorting time of different queue numbers also present a nonlinear increase, but relative ease. When the number of queues is small, the system polling cycle is short and the system is more stable and responsive.

(2) From figure 5 to figure 7, we show the changing trend of the mean queue length about the priority queue and common queue with the changing of the customer arrival rate, the sorting time and the order switching time. The curve in the figure can be seen clearly that the common queue order is smaller, the steepness of the curve is greater. While, the priority queue order is bigger, the steepness of the curve is greater.

Besides, with the extension of sorting time, the mean queue length of the queue with different queue numbers presents a nonlinear increase. What's more, with the change of the order switching time, the priority order queue is changing more obvious than the common order queue.

(3) From figure 8 to figure 10, we show the changing trend of the mean waiting time of the customers with high and low priority along with the changing of arrival rate of customers, the sorting time and the order switching time. Similar to the mean queue length, the mean waiting time of the priority queue and common queue is also distinguished. With the increase of the number N of queue and arrival rate λ, the mean waiting time of the priority queue and common queue is increasing. However, compared with common queue, the mean waiting time of the high priority queue has been changed smoothly with a small value, and maintains a good stability. Besides, with the change of order switching time, mean waiting time of priority queue and common queue present a linear growth so that the stability of the system is proved relatively strong. At the same time, three lines of priority order queue almost coincide, whose change is not obvious which prove that the stability of priority queue is more stable than common queue.

5. Conclusions

This paper study the mechanism of automatic order sorting for grainl based on exhaustive parallel limited-1 and in the polling system, the priority order and the ordinary order are distinguished to ensure that the priority order customers get better service and the fairness of the order picking system. The aim is to expand the depth of theory and expand the application polling order sorting breadth of theoretical research, improve the sorting efficiency and service quality, to explore the logistics sorting mode of cost minimization and high efficiency, promote the structural transformation of China's economic development. The proposed streamlined supply chain mode of "new circulation" business model, fully meet the individual needs of consumers and improve people's quality of life.

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