

Optimization Analysis of Hospital Business Process Based on Colored Time Petri Net

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Abstract — The optimization of hospital business process is a powerful method and way to improve the quality of medical management and management, minimize resource costs, improve the time efficiency and benefit. In this paper, based on the current business process of a hospital, the business process of the hospital is modeled by using colored time Petri net, and the simulation analysis of Petri net model is carried out by using CPN-Tools software, then, the average time of see-doctor time, consuming time of each module and other important data indicators are obtained, On this basis, the existing business process is improved and optimized, the important data indicators are analyzed and compared by using the process simulation, the effect of business process optimization is verified.

Keywords - colored time Petri net; model; simulation analysis; comparison analysis; optimize

I. INTRODUCTION

The limited medical resources and the urgency of life rescue, requires the hospital to provide more economic and efficient medical services. The medical procedure and medical quality is closely related to safety. The optimization and reengineering of hospital business process is a powerful method and way to improve the medical and management quality, realize the minimization of resource cost, improve the prescription and benefits.

In recent years, with the successful implementation of BPR (Business Process Reengineering) method in the enterprise, national experts and scholars began to put forward through the transformation and optimization of medical service process to improve the operating efficiency and save operating costs of the hospital^[3-4]. However, these studies only stay in the concept level, but lack of specific methods to model and analyze the actual medical service process. At present, K. Barkaoui et al have applied the ordinary Petri net to the research on the

optimization of the resources in the hospital operating room^[5], But they only have proposed the optimization scheme of the operation room process from the perspective of improving the resource elasticity^[6] and neglected the inherent defects of the process, moreover, the ordinary Petri net model of the operation room process is extremely complex, which is not conducive to understanding the specific meaning of the model; Pedram Sendi and other scholars have applied TCP - net to the analysis of the optimal allocation of initial resources for the clinic doctor^[7], but, the consideration of outpatient procedure is too simplified, and the analysis of the model is only stay in the modeling stage.

On this basis, this paper presents the application of colored time Petri net to the medical service process model for a university hospital, we through the process reengineering, the rational allocation of hospital resources, and integration of the same resource type skills, the improvement of hospital resources flexibility to optimize process, and through the Petri nets simulation, the analysis

and comparison of process before and after optimization, to verify the optimized effect.

II. BUSINESS PROCESS MODELING

Taking a university hospital as the study object, its current business process is investigated and the data is collected. For the first time the persons who go to the hospital need to experience the “filing-registration-waitingfortreatment-charge-getting medicine” five steps, and persons who come back to hospital need to experience “registration-waiting for treatment –charge-geting medicine” four steps, during this period,

they need to wait for registration, charging and getting medicine in long lines. After analysis, during peak hours, it is found that patients need to wait patiently for registration, triage, pricing, payment, and getting medicine in line, and patients really enjoy medical service time only in a few links, such as diagnosis, testing and treatment. Because there is a lot of waiting time, patients stay in hospital for a long time, the limited area of the hospital can not accommodate more patients. Based on the survey of current business process, the Petri net model of current process is established by using modeling technology of the colored time Petri net(Fig. 1).

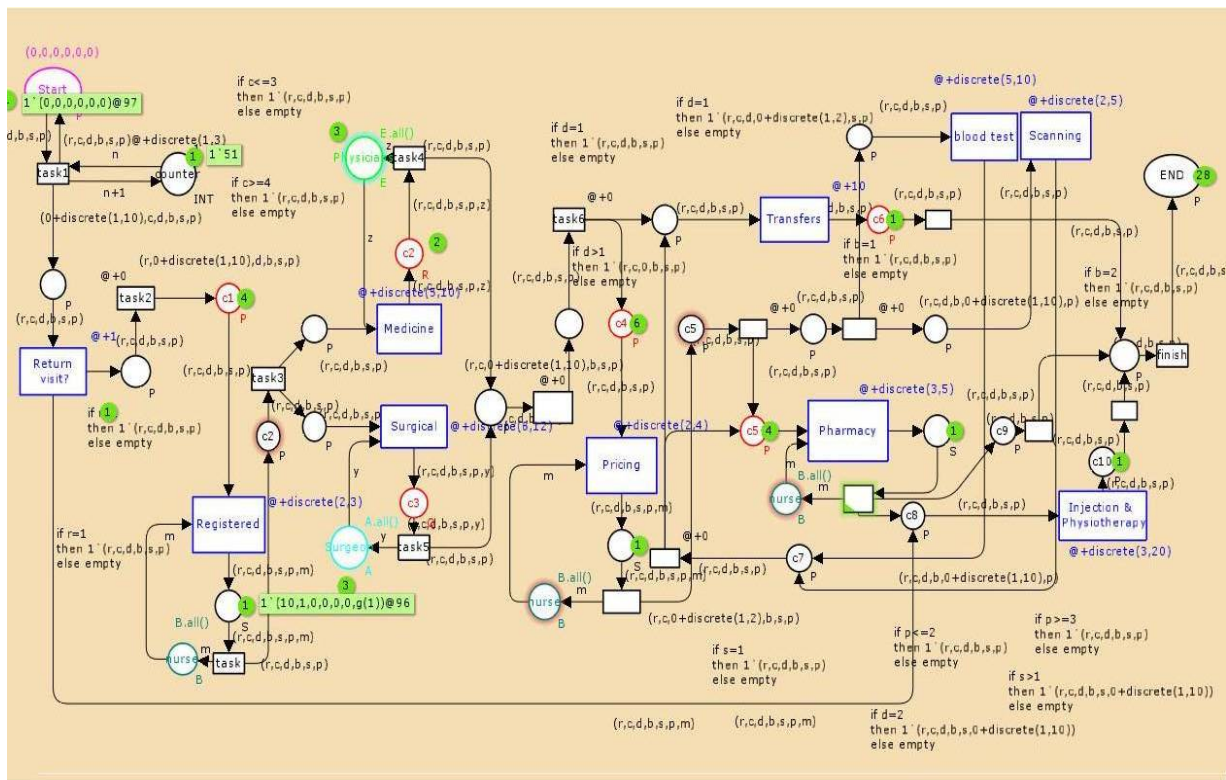


Fig.1 The Model of Original Business Process

A part of this class library and the function of

changes are given in table 1.

TABLE 1. THE INSTRUCTIONS OF IMPORTANT PLACE AND TRANSITION OF THE PETRI NET OF ORIGINAL PROCESS

designation	function
Start place	The patient obeys the random arrival of the (1, 3)per unit of time
Counter place	Recording the number of patients who entered the hospital
Return Visit change	determine whether to visit
C1 place	Waiting sequence for registration
Registered change	registration
Nurse place	resource place for registration
Medicine change	Medical clinic
Physical place	Resource place for Medical clinic
Surgical change	Surgical clinic
Surgeon place	Resource place for Surgical clinic
C4 place	Waiting sequence for Pricing
C5 place	Waiting sequence to pharmacy for medicine
Pricing change	Prescription pricing
Transfers change	Transfers
Pharmacy change	Going to pharmacy for medicine
Blood test change	Blood test
Scanning change	Scan check
Injection & Physiotherapy change	Injection and physiotherapy
End place	discharging from the hospital

In order to improve the efficiency of service system, the hospital intends to introduce intelligent medical card for process optimization. After using medical card, the process is:

(1)Patients go to register, and fee for IC card; (2) Patients go to the triage area; (3) Patients go to the appropriate department. During the treatment, if patients need to test, they go directly to the laboratory test, the fees for testing are deducted directly from the payment IC card, patients continue to see the doctor, as the test results come out. According to the doctor's advice, patients come to the

pharmacy to get the medicine, and they receive treatment. Patients use IC card for payment. (4) After the visit,, when patients are finally away from the hospital, the fees of medical treatment are settled.

In the optimized process, the first visit can be reduced to "filing -waiting for treatment-getting the medicine-printing invoices" four major steps, the next visit can be reduced to "waiting for treatment-getting the medicine-printing invoices" three major steps. Based on the improved treatment process, we can rebuild a Petri net model for the hospital business process (Fig. 2).

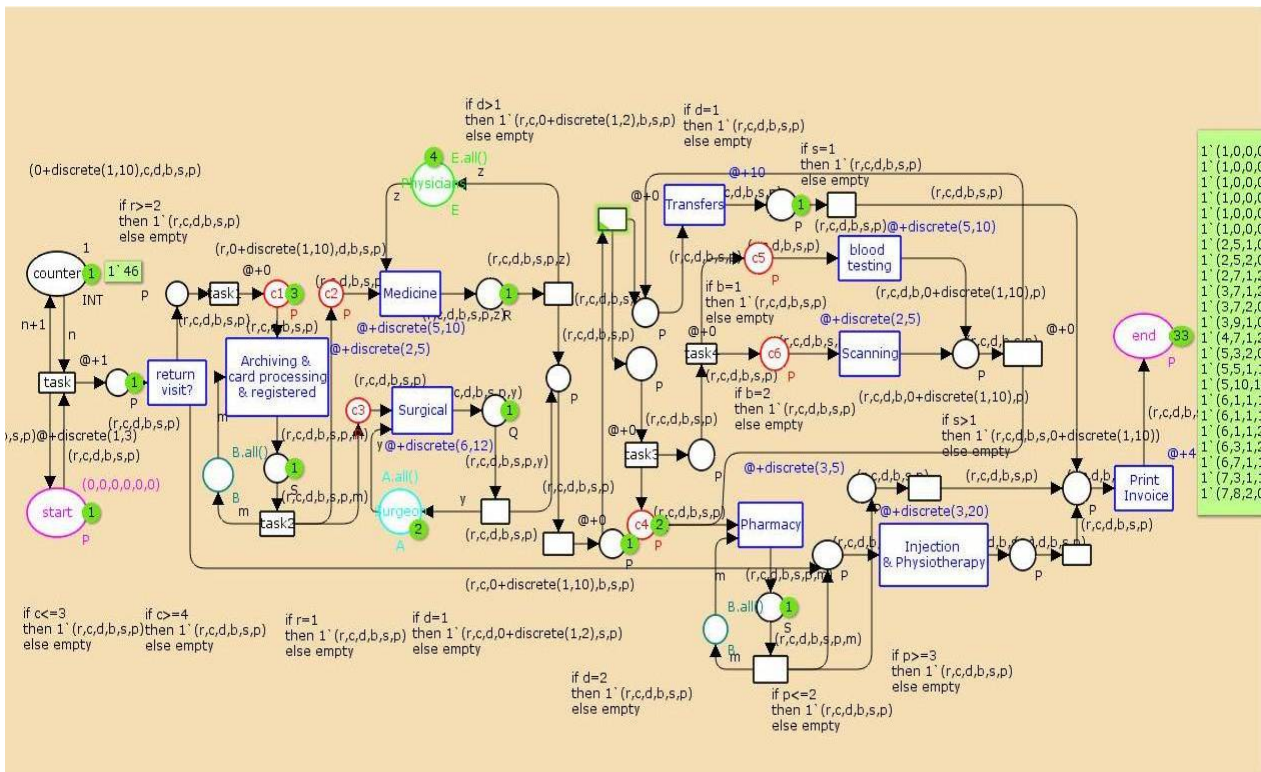


Fig.2 The Model of Improved Business Process

III. SIMULATION EXPERIMENTS ANALYSIS

Using CPN-TOOLS software to simulate the model, we can get the change of the token number (that is the number of customers) in each place (Fig. 1):

- (1)The number of a token is 51 in the Counter place, which indicates that 51 patients have entered the process.
- (2)There are 4 green tokens in the C4 place, which means 4 patients are waiting in line. Similarly, there are 6 green tokens in the C6 place, which means 6 patients are waiting for pricing, there are 4 green tokens in the C5 place, which means 4 patients are waiting for getting medicine.
- (3)There are 2 green tokens in the C2 place, which means 2 patients are treated by physicians, in the corresponding Physical place, originally, there are 5 tokens, and now there are 3 tokens, which means that two doctors are with 2 patients, three doctors are at leisure. If the doctors are busy, patients to see the doctors need to wait.

(4)There are 28 tokens in the END place, which shows that 28 patients have been discharged from hospital.

(5)Changing the above @+, which indicated the change of business processing time, tokens need to wait in the place.

Based on the statistics of the important parameters such as token numbers and changing time in the process of Petri net simulation, two important indicator data of the process are obtained, which includes the total average time in hospital, average time of registration, average time of pricing and effective treatment time. The simulation data of Petri net before and after optimization are compared, and the effect of the optimization process is analyzed quantitatively.

(1)The Contrast of The Total Residence Time of 50 Patients Before And After The Ptimization Process

It can be seen from the figure(Fig. 3), the period when the first 10 patients went to the hospital in succession, due

to less people, and adequate resources, there is no queuing phenomenon, and so the total residence time of the two processes is similar. But, with the increasing number of patients, the average time of the original process is increasing, and the improved process tends to be stable, or

even it is reduced, formed the scissors with the original process, the improved effect is very significant. The total average residence time was 52.58 and 31.98 units respectively. By the test analysis, the difference was significant.

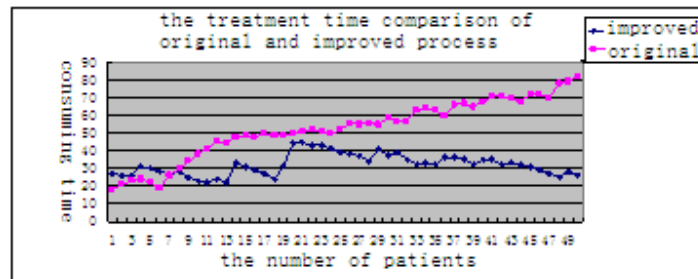


Fig.3 Contrasting Chart of Total Time

(2) Comparison Analysis of Process ModuleTime.

Process module time comprises of the registered waiting time, pricing waiting time and effective medical treatment time (except for registration and pricing). The consuming time in each module before the optimization is shown (Fig. 4). The ratio relationship of the average time of the three modules is listed respectively (Fig. 5). From the figure, the time of registration and pricing accounts for a very large proportion of the total residence in the un-optimized

process, the phenomenon of waiting in a queue is obvious, especially the queue of pricing and charge is the longest. The time of effective diagnosis, detection, treatment is a small proportion of the total time, it only takes 29% of the total time, and this phenomenon leads to a lower service quality. This result is quite coincident with the actual situation of the hospital, during the surveys, process bottlenecks of the hospital occurs in the pricing and charge.

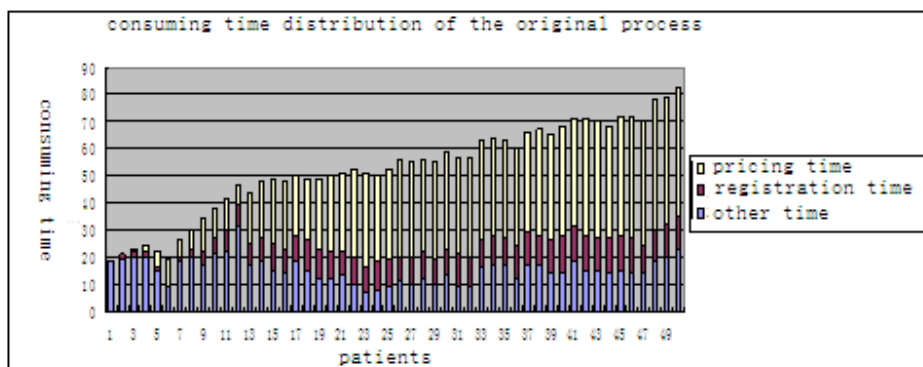


Fig.4 The Distribution of Each Module Time of The Original Process

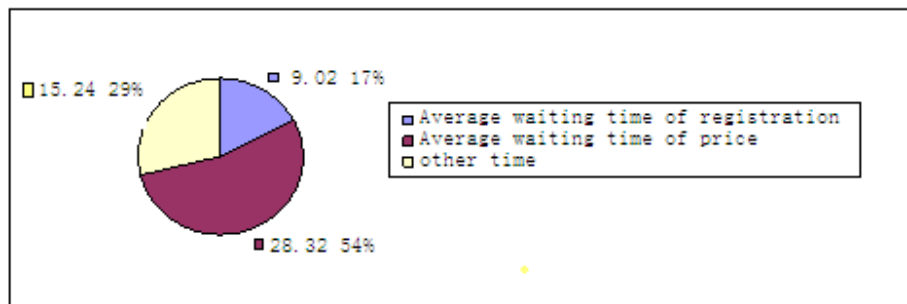


Fig.5 The Proportion of Average Time in Each Module of The Original Process

The module time of improved process can be divided into four parts of handling IC card, filing and registration, waiting to get the medicine and effective medical treatment.

The consuming time of per patient in each module is shown (Fig. 6). The proportional analysis of the average consumption time in each module is shown (Fig. 7).

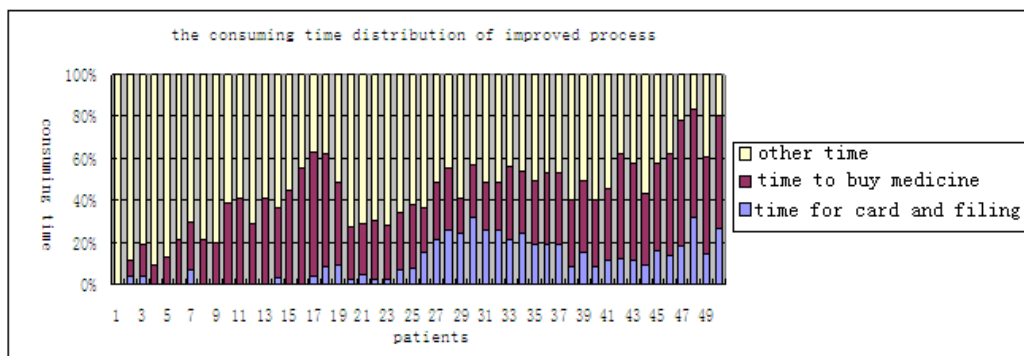


Fig.6 The Distribution of Average Consuming Time of The Improved Process

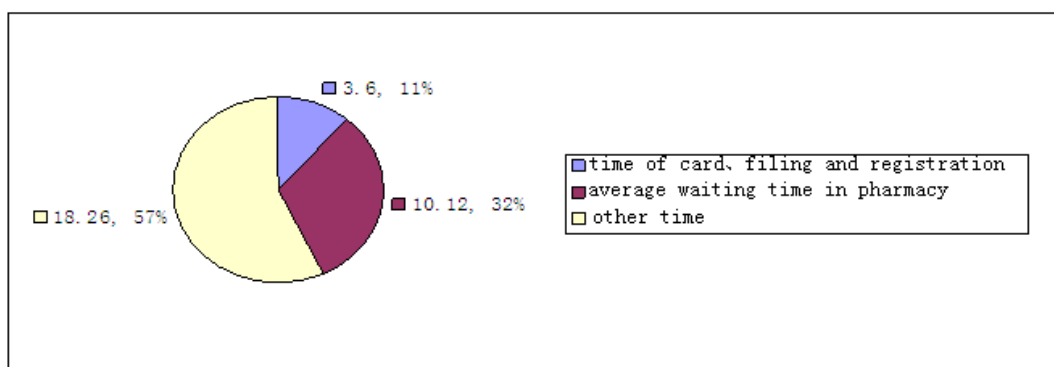


Fig.7 The Proportion of Average Consuming Time of The Improved Process

From the above two figures, we can see the proportion of average effective medical treatment time was significantly increased in the total time, and the main reason is that the waiting time of pricing is reduced. But it should be noted that the time to get the medicine will rise significantly,

along with the increase of patients, so it is necessary to further optimize the process, such as increasing pharmacy windows or increasing medical resources of diagnosis, inspection, treatment and other links, etc.

IV. CONCLUSIONS

Process simulation can effectively simulate the realistic workflow. Before the enterprise really prepares to reform process, the feasibility, advantages and disadvantages of the reform should be determined by simulation, assisting management decisions, so that it can save a lot of cost. In this paper, with the aid of Petri net modeling and simulation tools, the business process of the hospital is modeled, simulated and optimized, average time of medical treatment, consuming time of each module and other important indicator datum are obtained, the effect of business process optimization is verified.

From the optimization results, the optimization effect of the process by introducing intelligent medical card is very significant, especially, the time of registration and payment can be significantly reduced. But the simulation results showed that the hospital service system still has the space for optimizing, that is, it should further adjust the resource allocation, which will be the next research direction.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflicts of interest.

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