A Simulation Analysis of a New Mail Processing System

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ABSTRACT The Japanese Postal Services plan to start the new mail processing system from February 1998, mechanizes most processes from dispatch sorting to delivery sorting by using a new postal code and postal barcode. We developed a model to simulate indoor operation at an urban sorting office using the new mail processing system. This helped us issues including machine installation, required manpower and how to efficiently solve potential bottleneck. This paper describes the simulation results and provides guidelines for determining the number of new sorting machines needed and whether the number of VCS personnel is suitable.

1. INTRODUCTION

The Japanese Postal Services plan to initiate the new mail processing system from February 1998, will mechanize most processes from dispatch sorting to delivery sorting by using a new postal code and postal barcode. Based on past experience, we repeated the mechanization and improved processing for the increase in mail volume. We did not use scientific analysis for such improvements. When we calculate the required machines and manpower for mail processing in a certain post office, we use Mail points which correspond to the volume of mail arriving each hour. This method, however, is not always appropriate.

On the other hand, we found some examples in which a simulation technique was used to design the mail processing system.[1] Simulation is one of the most appropriate methods for these studies as it can be used to analyze dynamic behavior during processing and the effects of yet undetermined causes on post office mail processing.

This paper describes the development of our simulation model to study machine installation, required manpower and to designate the most efficient operating methods in the post office when the new automated mail processing system is introduced. We show that simulation is one of the most appropriate methods for the design and analysis of mail processing system.

2. FLOW OF MAIL PROCESSING

2.1 Present Mail Processing System

Since 1968, when the present post code system was introduced, 167 automatic postal code reading and sorting machines and 142 automatic postal address-reading and sorting machines were installed. The present mechanized mail processing flow is described below.

In the acceptance office, the mail, which is accepted at the counter or collected from the mail boxes or small post offices, is placed in the automatic facing and canceling machine. Mail is sorted by the automatic postal code reading and sorting machine and placed in trays and basket type pallets, then sent to the next mail office. This is called our dispatch process. The principle behind our sorting method for postal items is its detailed sorting where items are sorted into either 3-digit or 5-digit or delivery area code for those addressed within the same area, and 2-digit code sorting for those addressed to other area shall be carried out. The mail addressed to the collecting office itself is put into trays and sorted for delivery. Rejected or flat mail is sorted manually. Mail sent to other regions is transmitted to the regional post office.

In the delivery office, the mail, which is sent from regional post office, with collected mail from letter boxes, is sorted by delivery sorting, rough sequence sorting and final sequencing in this order. In this process, rough sequence sorting and final sequencing are done manually. An automatic postal address-reading and sorting machine is used for delivery sorting by reading a town name and a geographical area number. This machine is also used for dispatch sorting in the different hours.

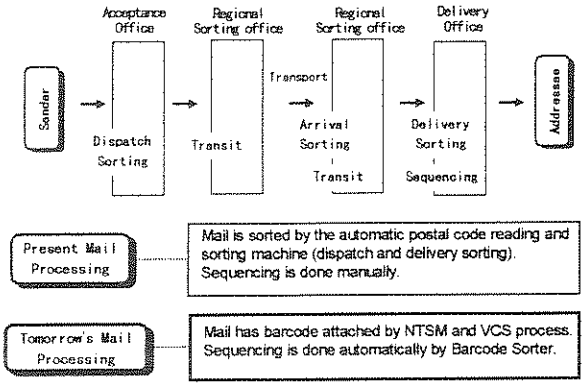

Figure 1 Outline of mail process flow

2.2 Tomorrow's Mail Processing System

The Ministry of Post and Telecommunications has decide to employ a new 7-digit postal code and postal barcode system for efficient postal handling operations, especially for delivery mechanization including "rough sequence sorting" and "final sequencing" after February 1998. The mail processing system will be configured as outlined below. Accepted mail will be fed to a New Type Sorting Machine (NTSM). The NTSM will capture an image of the mail piece which will then be processed by OCR in order for the post code and the numbers in the address to be identified. The result of this OCR reading will then be printed on the mail piece as a bar code. This is called mixed mode sorting. If the OCR system is unable to identify the post code and address details, an ID tag will be printed on the mail piece itself and it will be stored temporarily in a tray. The image of the mail and the ID tag information will be sent to video coding terminals and coded manually. This is called the Video Coding System (VCS). When this coding is completed, the stored mail is fed to the machine again and the bar code is printed on the mail. Ultimately, all mail processing will be performed through bar code reading. In the case of customer bar coded mail, the processing will be carried out by customer bar code reading operations. This is called the barcode mode sorting.

Sequencing is to sort mail in order of delivery at delivery post office. Currently this work is done manually and occupies a considerable portion of the entire work load. The most improved point in the mail processing system is that mail having reached a delivery post office will be autimatically sorted in order of delivery sequence by reading a postal bar code at a NTSM and/or a barcode sorter.

2.3 VCS and Its Problems

VCS process is the additional operation in this new mail processing system. There are two kinds of system, on-line and off-line, which are shown in Figure 2 and Figure 3. The on-line system is the real time processing and does not need re-feeding. In the off-line system, as mail is stored once, the process can be done when mail gathers to a certain volume or when convenient for an operator.

As re-feeding is required for VCS operation, we are afraid the mail processing may not complete within the transfer connection time. For this reason, the following subjects should be considered.

1) In which site is VCS more effective, at dispatch or delivery.
2) In case of off-line VCS at dispatch site, how much manpower or machine support is needed to keep the connection time?
3) If VCS operation is introduced at delivery site, will it produce bottlenecks or not? Countermeasures against overload?

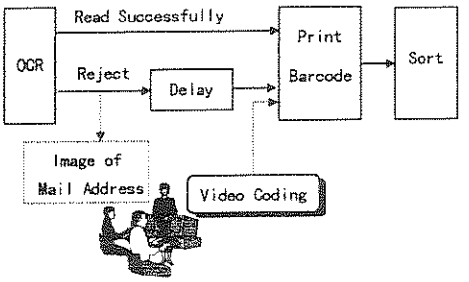

Figure 2 On-line VCS

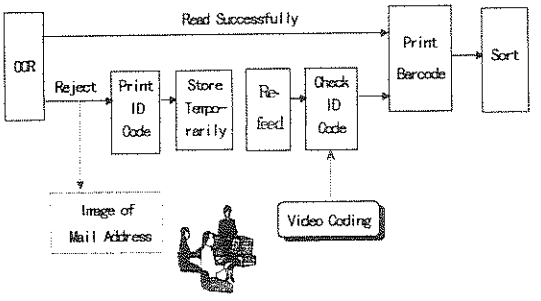

Figure 3 Off-line VCS

4) How is efficiency improved by changing the rate of barcode written by bulk users.

We consider 1) and 4) above by spread sheet application software and 2) and 3) by a simulation tool.

3. DEVELOPMENT OF SIMULATION MODEL

Based on the subjects described in the previous chapter, we have developed the simulation model for the new mail processing system which uses barcode technology to perform the indoor operation of a regional sorting office and a general sorting office. We used small size letter-post items in the simulation. The analysis utilizes the ARENA simulation model which has easy user-interface and provides animated color graphics to help in visualizing the solution.

This simulation model has the following characteristics:
- The entities occur just as the mail arrives at the post office for simulation.
- The status at connection can be confirmed.
- The operation of the sorter and VCS (Video Cording System) can be checked.
- The parameter can be changed during simulation.
- The priority of process can be determined according to the results of the simulation.

3.1 Modeling

The indoor mail process flow in the post office consists of the four processes shown in Figure 4. The process flow in the developed model is shown in Figure 5. This figure indicates the new flow in the regional sorting office. In this flow, the mail without a barcode is fed to a New Type Sorting Machine (NTSM) at first with mixed mode. The mail with an attached barcode is estimated to be about 65% of the mail which

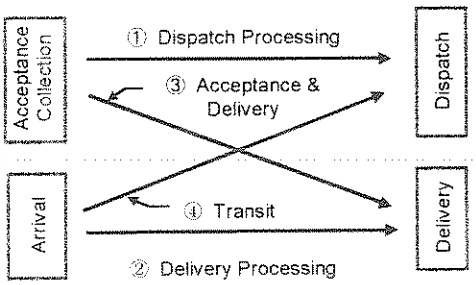

Figure 4 Indoor mail process flow

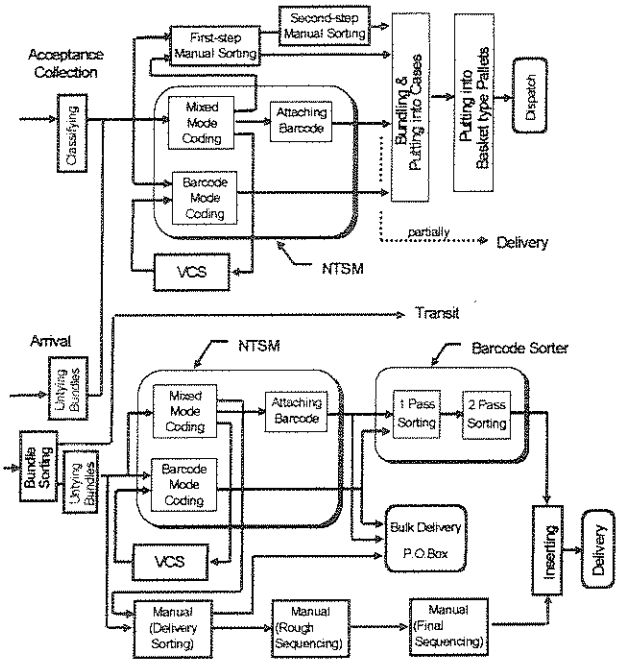

Figure 5 New process flow in regional sorting office

enables OCR reading. The other mail is attached by on-line or off-line VCS operation.

In delivery sorting, 2-pass type sequencing is achieved by feeding mail to the NTSM two times. We assume that the number of NTSM stackers is two hundred. The 2-pass unit pre-sorting and 1-pass sorting at partial delivery are fed first to NTSM in the very early morning. 2-pass sorting of the mail delivered on that day usually starts in the early morning. The mail, which has completed 1-pass sorting in the afternoon on that day, is stored till starting time of 2-pass sorting on the next day keeping in order.

Each mail item contains data concerning conditions of acceptance, such as collected, accepted at the counter of the office, arrived from other regions and arrived from the self-controlled-region. Furthermore, there is classified mail from general customers and that from bulk users. Mail volume per hour is input into the simulation. Each mail has data concerning connection time, that is the time when process has to finish. The decision is based on whether mail is processed in the connection time.

3.2 Consideration by Simulation

At first, we chose a typical condition of manpower, machine and a schedule, suitable to mail arrival. We call this the baseline. Next, we change certain variables and parameters and evaluate simulation results. Restricted conditions are the sorter's process time, schedule and the time of transfer connection.

We choose a minimized variables of manpower and the number of machines or a maximized rate of operation which satisfies these restricted conditions.

The parameters to be considered are shown in Table 1. Input data on the amount of mail arriving per hour is shown in Figure 6. The dispatch mail volume is about two hundred and fifty thousand pieces per day not including bulk and transit mail. Delivery mail is one hundred and eighty thousand items per day. The processes and its process times are shown in Table 2.

4. SIMULATION RESULTS

The mail flow, operation condition, time, delayed mail and sorted mail are displayed as animation during simulation. The bottleneck in the process becomes clear immediately. Furthermore, the following summary results are outputted as criterion of evaluation after the simulation is finished.

- Rate of the operation of primary process, stagnated mail volume
- Total process time of mail
- Volume of delayed mail
- Rate of mail volume attached barcode
- Time when sequencing is completed

Table 1 Parameters and items to be considered

Parameters	Items to be considered	Parameters for evaluation
Variance of arriving mail	Condition of system when arriving mail volume increases by 5, 10 or 20%	Time in system, Delayed mail, Connection time
Rate of mail volume barcode-attached	Effect when rate of mail volume barcode-attached becomes to 5 or 10%	Time in system, Operation rates of machines and workers
VCS mode	On-line or off-line	Connection time
Handling time	Effect when handling time increases to 5 or 10 minutes	Thoughput, Time in system

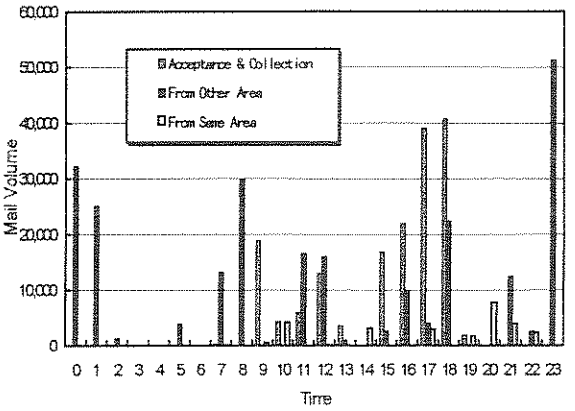

Figure 6 Input data on amount of mail arriving

Table 2 Processes and its process times

No	Machine / Process	Process Time	Manpower
1	Facing & Canceling	25,000 Items/Hour	3
2	NTSM Barcode mode Mixed mode	 32,000 Items/Hour 24,000 Items/Hour	 2.5 2.5
3	VCS Processing	1,500 Items/Hour	
4	Manual sorting (Dispatch)	2,800 Items/Hour	
5	Bundling and Putting into cases	300 Bundles/Hour	
6	Transit Processing	1,500 Bundles/Hour	
7	Untying bundles and Classifying	1,500 Bundles/Hour	
8	Barcode sorter	32,000 Items/Hour	2.5
9	Manual sorting (Delivery sorting)	1,500 Items/Hour	
10	Manual sorting (Rough sequence sorting)	2,350 Items/Hour	
11	Manual sorting (Final sequencing)	900 Items/Hour	
12	Inserting	2,200 Items/Hour	

4.1 Simulation Results Based on Baseline

Table 3 shows the simulation results based on the baseline considered in the previous chapter. It is the most preferential restricted condition to finish all processes of mail within transfer connection time limits. It became clear that the number of delayed mail occurred because of a slight increase in the arrived mail cases of only one sorter in the dispatch processing. Therefore it is clearly recognized by the simulation results that the suitable number of sorters is two.

Table 3 Simulation results based on the baseline

No	Matters	Baseline	Simulation Results
	<Dispatch site>		
1	Automatic facing and canceling machine	1	1
2	NTSM[1]	1	2 is suitable (Ref. Table 4)
3	Manpower for manual sorting	3	3
4	VCS manpower	5	6 (on-line)
5	VCS mode	on-line	off-line mode can't keep connection time
6	Hundling time	5-10 minutes	5-10 minutes
	<Delivery site>		
7	NTSM	2	2
8	Manpower for delivery sorting	3	2
9	VCS manpower	5	4 (off-line)
10	VCS mode	off-line	off-line is more effective

1) One of NTSM is Barcode sorter

Table 4 Margin of increase of mail

	Time in system	Operation Rate	Margin of increase of mail
<Dispatch site>			
One sorter	85 minutes	48.7%	Avarable to1.05 times
Two sorters	67 minutes	26.2%	Avarable to1.65 times

In case of input data of Figure 6

4.2 Margin of Increase of Mail

Table 4 shows the margins in cases where sorter numbers are one and two. When the number of sorters is two, the rate of operation of the sorter decreases while total process time shortens and transfer connection is ensured.

If the arrived mail should increase by over 5%, the delayed mail increases when the sorter number in the dispatch process is one. If the number of the sorters is two, mail increased by 65% can be processed in time. It is an important subject to decide sorter numbers based on estimates of volume increase. We can say that about two hundred and several tens of thousands of dispatch mail besides bulk will be the determining factor between one and two sorters in the model of the objective post office in this simulation.

4.3 VCS and Its Required Manpower

The manpower required for the VCS process of dispatch sorting is 1.6 persons and the manpower required for the VCS process of delivery sorting is 0.7 persons on average. Six person is required at peak times. This shows that the off-line VCS process for several post offices is better than the on-line VCS for one post office, because the work is leveled, the peak of the required manpower becomes low and the rate of operation is improved. However difficulty in keeping the transfer connections may occur in the case of off-line VCS, because the off-line VCS needs more process time than the on-line VCS. If we can't keep the transfer connection, we have to change the connection time.

5. CONCLUSION

We developed the simulation model of the new mail processing system and considered the required machines and manpower, the operation rate, the rate of delayed mail and the end time of processing. Simulation outputs information that provides guidelines for determining the number of new sorting machines needed and whether the number of VCS personnel is suitable or not. This indicates that simulations can be used as an effective support tool in determining the number of machines and personnel required when installing a new mail processing system, provided that certain conditions are given.

In order to utilize simulation successfully, it is necessary to define problematic points clearly and simplify the model and collect related data. It is also essential to have constant communication between simulation engineers and mail processing office personnel.

In the future we will proceed with the study concentrating of each postal office's processing by extending the simulation model. We will consider how large scale operation is most efficient from the viewpoint of number of machines and manpower and compared with the dispersion type network currently in use.

ACKNOWLEDGMENT

The authors wish to thank Dr. S. Morito of Waseda University and Mr. S. Watanabe of NEC Corporation for their helpful comments during the preparation of this paper.

REFERENCE

(1) S.D.Wert, J.F.Bard, Anura de Silva and T.A.Feo, "A Simulation Analysis of Advanced Concepts for Semi-automated Mail Processing", J.Opl Res. Soc., vol.42, No.12, 1071-1086(1991)