MANAGEMENT INFORMATION SYSTEM FOR PRINTING MACHINE ASSIGNMENT PROCESS WITH TABU SEARCH ALGORITHM

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ABSTRACT

Printing industry involved a sequence of processes involving various machines and work stations. One particular problem related to this is delays in fulfilling customer orders due to inefficient assignment of machines. Inappropriate sequence and assignment of jobs to the machines usually causes idle times in one hand and congested processes in the other hand. To overcome this problem, an assignment system in the form of an application will be developed using the tabu search method. The system will calculate the combination of optimal job completion time iteratively until the furthest value from the deadline of the job is obtained. It will generate assignment solutions for multiple jobs and machines simultaneously thus helping the management to make decision. Besides generating assignment solutions, the system will also provide with reports and feedbacks features, as well as flexible features when dealing with sudden or urgent jobs and overtimes.
Keywords*: tabu search, machine assignment, printing process*

1. INTRODUCTION

The printing process consists of various steps including folding, cutting and printing and involves various machines and work station. Customer orders, here termed as jobs, are usually varied and could have different routings and settings of the processes involved. Every day the management generates a production plan which consists of an assignment of jobs to machines. Production process involves the planning of resources such as material, capacity and human resources, scheduling resources in long term and short term time frame, and assignment of resources for the manufacturing execution process (Herjanto, 2008).

A recurring problem in this industry is the failure to meet customer deadlines. Many times jobs are finished late and this can reduces customer satisfaction and loyalty. In this case up to 20% of customer orders are late and the main cause is the inefficient assignment of jobs to machines. Some machines usually have long idle times while the other machines have congested schedules. The staff who carry out the planning have difficulties to arrange the most optimal assignment. The current system only uses personal judgment and Microsoft Excel to do the assignment. Other problems include of sudden or urgent jobs which could mess up all the other schedules.

Based on these problems an information system will be developed to help the management to do the planning which will have a feature to assign jobs to machines in the most efficient way. This system will also have other features such as flexibility in dealing with sudden or urgent jobs as well as report and feedback tools for evaluation and control.

2. THEORETICAL BACKGROUND

Tabu search is a mathematical optimization algorithm which is part of the local search classification. Tabu Search improves the performance of local search by using memory structure. Tabu search works iteratively, seeking the best solutions from temporarily selected solutions. In every iteration, tabu search selects the neighbour solutions which yield the highest quality improvement. But if all neighbour solutions could not give quality improvement, then tabu search will select the solution with the lowest quality decrease. This is where tabu search attempts to exit from local optimal

condition (Suyanto. 2010). The algorithm in figure 1 shows a tabu search algorithm with short term memory, without medium and long term memory management (Brownlee, 2014). Temporary selected solutions which has been surpassed by other more optimal solutions will be marked as "tabu" (in other words "taboo" which means something forbidden), thus the generated solutions will not be chosen repeatedly

3. RESEARCH METHOD

The study research is to assign jobs to machines in the most efficient way using tabu search and also have other features such as flexibility in dealing with sudden or urgent jobs as well as report and feedback tools for evaluation and control. The following data that used in this research is taken from a medium-sized printing shop in Bandung. Printing shops produces printed materials such as books, pamphlets, brochures, posters, and cards among others.

4. DESIGN AND IMPLEMENTATION

In this section we will describe the design and implementation of the proposed system.

4.1. Design System

The system will be designed as an information system with these features:

a. Job or customer order registry
b. Master data to maintain machines, routings, and customers
c. Machine assignment system using tabu search algorithm
d. Reporting functions

Figure 1 shows the overview of machine assignment system in an improved business process flowchart.

With some additional policies:

a. Machine assignment is prioritized based on the deadline of the jobs (customer orders)
b. Every job is unique and can have different routing sequence of the machines used, passing the sequence is not allowed
c. All machines are operated from 8 am to 8 pm, overtime allowed when necessary but not by default
d. Deadlines are negotiated before the planning

Orders accepted before midday will be scheduled for the afternoon 1 to 8 pm, orders accepted after midday will be schedule for the next day from 8 to 12 am.

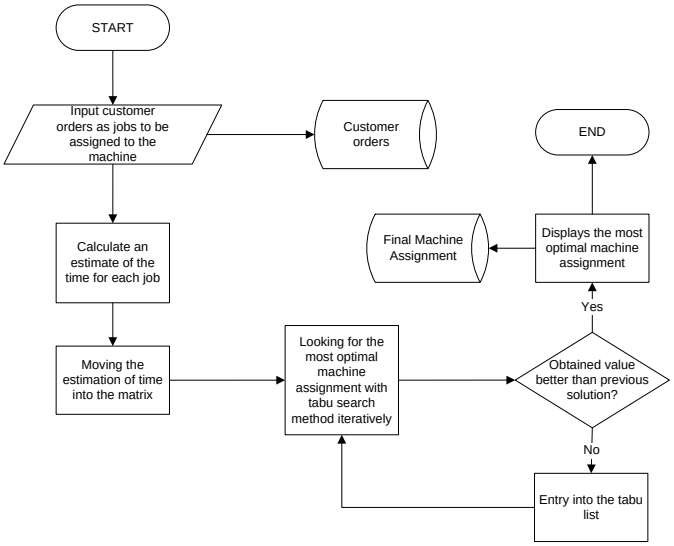


Figure1. Improved Business Process and the Assignment System

The input of the system will be:

a. Jobs or customer orders
b. Deadline of jobs
c. Required processes (routings) of each jobs
d. Required machines related to the routings
e. Processing time for each machine

The process of generating final machine assignment solution will follow these steps :

1. $Time\ Estimation = \left\{\frac{Number\ of\ Jobs}{First\ MachineCcapacity}\right\} + \left\{\frac{Number\ of\ Jobs}{Second\ Machine\ Capacity}\right\}, and\ so\ on$
2. Develop assignment matrix
   The following figure 2 shows an example of 7 jobs (with notation J) and 6 machines (with notation M). The machine notation is not the same for every job for every job can have different routing of processes. Thus J will always be unique while M depends on the routing steps of each Js. For example in J1M1 and J2M1, the M could be different machines. The matrix shows the possible combination of job processing in every machine.

0	J1M1	J2M1	J3M1	J4M1	J5M1
J6M1	0	J1M2	J2M2	J3M2	J4M2
J7M1	J6M2	0	J1M3	J2M3	J3M3
J5M2	J7M2	J6M3	0	J1M4	J2M4
J4M3	J5M3	J7M3	J6M4	0	J1M5
J3M4	J4M4	J5M4	J7M4	J6M5	0
J2M5	J3M5	J4M5	J5M5	J7M5	J6M6
J1M6	J2M6	J3M6	J4M6	J5M6	J7M6

Figure 2. Assignment Matrix Example

3. Calculation of the optimal value using tabu search algorithm :
   a. Initialize the solution
      solution←[J1M1,J2M3,J1M5,J5M2,J2M]
      best_solution ← solution
   b. Search the solution
      i ← 0
      j ← 0
      best_time ← 99
      For i to many_trials do
        For j to Solusi.length do
          solution←exchange_position_of_machine
          total_time ← solution[j] + solution[j+1]
        End for
        If total_time < best_time and best_time_not_in_tabu_list then
          best_time ← total_time
          best_solution← solution
        End If
      End For
   c. Take the most optimal solution
      Write (best _solution)

The first step is initialization of the solution which is executed randomly. The best value of the solution represents the minimal time required to complete the jobs. A temporary best value of 99 is initialized for comparison with the best solution that should be less than 99. Then another solution is generated iteratively for all possible combination of machines and jobs but still consistent with the routings of each job. When a generated solution have less time than the previous solution, the the previous solution will be replaced by the new solution and moved to the tabu list. Final best value will be taken when no other solutions give better results.
The following case will explain more of how the system works. Table 1 shows 7 jobs or customer orders in queue along with information about quantity, deadline and routing.
Table 2 shows the machines that will be used.

Table 1. List of Jobs (customer orders)

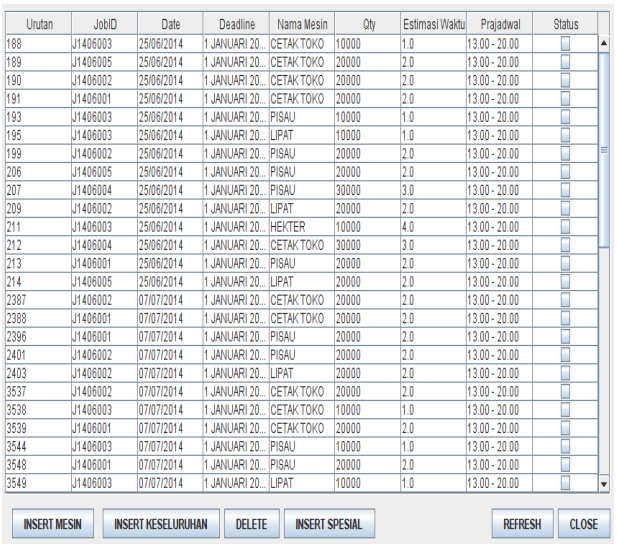
No	Job	QTY	Date In Order	Deadline	The process required
1	Brochure	20000	1-Jan-14	1-Jan-14	Print, Cut
2	Invitation	20000	1-Jan-14	1-Jan-14	Print, Cut, Folding
3	Book	100 books / @ 100	1-Jan-14	1-Jan-14	Print, Cut, Folding, Clips
4	Brochure	30000	1-Jan-14	1-Jan-14	Print, Cut
5	Invitation	20000	1-Jan-14	1-Jan-14	Print, Cut, Folding
6	Brochure	20000	1-Jan-14	2-Jan-14	Print, Cut
7	Brochure	20000	1-Jan-14	2-Jan-14	Print, Cut

Table 2. List of Required Machines

Machine	Sheets/hour	Qty
Print	10000	7
Folding	10000	1
Cut	10000	2
Pond	1000	1
Emboss	1000	1
Varnish UV	2500	2
Clips	2500	1
Laminating	1200	1
Total Machine		16

From both tables all the required information is obtained, including processing time which is calculated using the quantity and capacity data. Then the system will generate solutions as explained before using the tabu search algorithm until a final solution is generated. Table 3 shows the final assignment of machines after many iterations of tabu search has been conducted.

Table 3. Tabu Search Result



The result can be compared with the result when using the current method as can be seen in Figure 3 which has a total time of 23 hours. Figure 4 shows the result generated using tabu search with total time of 17 hours. The second result shows a difference of 6 hours.

No	Deadline	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00
1	1-Jan-14	Print	Print	Cut	Cut										
2	1-Jan-14			Print	Print	Cut	Cut	Folding	Folding						
3	1-Jan-14					Print		Cut		Folding	Clips	Clips	Clips	Clips	
4	1-Jan-14						Print	Print	Print	Cut	Cut	Cut			
5	1-Jan-14									Print	Print		Cut	Cut	Folding

No	Deadline	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00
5	1-Jan-14	Folding													
6	2-Jan-14		Print	Print	Cut	Cut									
7	2-Jan-14						Print	Print	Cut	Cut					

Figure 3. Result with Current Method

No	Deadline	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00
1	1-Jan-14						Print	Print	Cut	Cut					
2	1-Jan-14				Print	Print	Cut	Cut	Folding	Folding					
3	1-Jan-14	Print	Cut	Folding	Clips	Clips	Clips	Clips							
4	1-Jan-14								Print	Print	Print	Cut	Cut	Cut	
5	1-Jan-14		Print	Print	Cut	Cut	Folding	Folding							
6	2-Jan-14													Print	Print
7	2-Jan-14											Print	Print		Cut

No	Deadline	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00
6	2-Jan-14		Cut	Cut											
7	2-Jan-14	Cut													

Figure 4. Result with Tabu Search

Therefore using tabu search algorithm, all the combination of solutions can be compared and the best solution can be generated using the system. Based on the case studied, the average time saved by this method is about 4 hours. Figure 5 shows the Data Flow Diagram (DFD) of the proposed system.

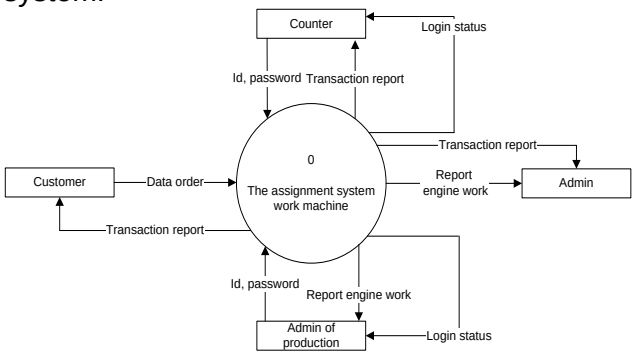


Figure 5. DFD of Proposed System

DFD is made based on the flow of data into the machine assignment system and shows the output of processed data as the information entered into the system. Based on DFD design the next step is to design the ERD (Entity Relation Diagram) as can be seen in Figure 6.

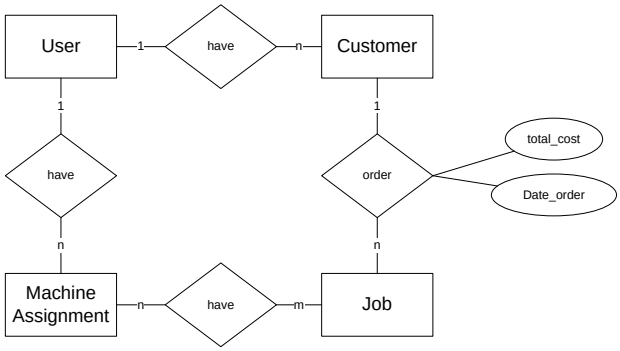


Figure 6. Entity Relationship Diagram (ERD)

Table 4. Description of ERD Entities and Attributes

ENTITY	ATRIBUTTE
User	**#userid,** password, username, info
Customer	**#customerid,** name, address, phone, mobile, transactionid
Job	**#jobID**, title, size, sheets, qty, deadline
Machine Assignment	**#no,** date, deadline, jobid, qty, j0700, j0800, j0900, j1000, j1100, j1200, j1300, j1400, j1500, j1600, j1700, j1800, j1900, j2000

ERD is based on the interaction between the entities that occur in the machine assignment system. Each entity has attributes to decrypt each character of each entity. In the interaction between customer and job entities, produce attributes that show the total cost and the date of the transaction. Based on the Entity Relationship Diagram, the database relationship scheme is designed.

4.2. Implementation

The system is developed using PHP and MySQL as a web-based application. The following system testing shows good results and calculation testings of the tabu algorithm using cases also shows consistent results. Some screenshots of the main functions of the system can be seen in Figures 7 and 8.

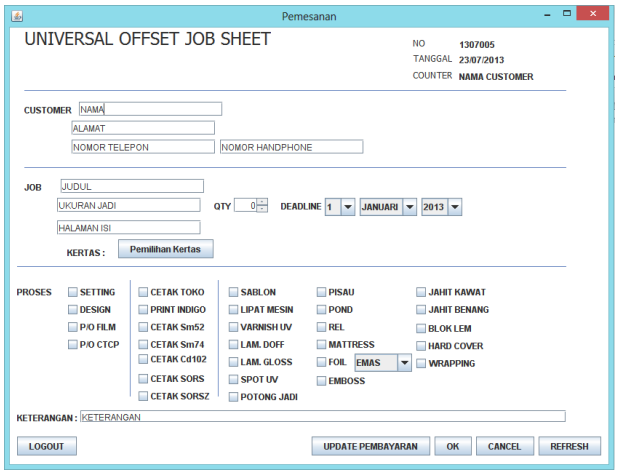


Figure 7. Customer Order Form

First the customer order form records transactions with the customer. Through this form all required inputs are obtained. Customers will get sales orders. Based on the data of customer orders received on a particular day, the planning staff can generate optimal solutions based on these jobs. In the planning phase the planner can arrange the machine assignments. The use of tabu search algorithm is by default the method for machine assignment. But the system is also flexible when a sudden or urgent job is inserted in the queue and all is in the control of the planner. Nevertheless the assignment system will generate the solution with the minimal time required and the least lateness when unavoidable.
When an optimal solution with the smallest time is generated, the planner can execute and release the schedule using the assignment solution. This can be seen in figure 8.

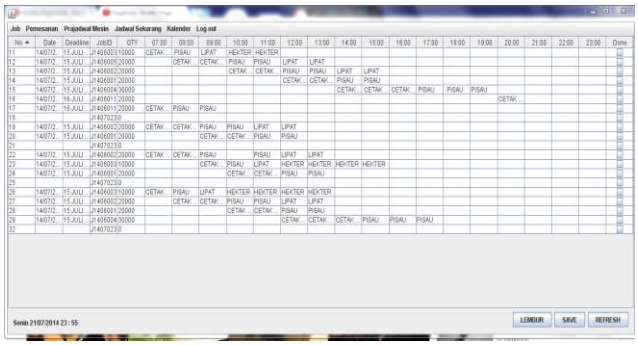


Figure 8. Machine Assignment Results

5. CONCLUSION

Based on the research that has been conducted the conclusions are as follows:

1. The tabu search algorithm in the machine assignment system can help to generate the most time-efficient schedule for job sequencing and processing thus helping the company to minimize delays and idle times of machines. This is done by calculating the optimal time for given job sequences and the use of iterative tabu list.
2. Variables required for the system are job deadlines, number of machines needed, job routing, finishing and time for every process. These variables act as constraints for the system and helps the system to fulfill all required conditions.
3. The system also helps the management with reporting and feedback tools. Information such as average lead time, most congested processes, idle time average, and delay time average among others. Customer-related Information is also presented such as customers with the most jobs, customer with the longest routings, most frequent customers, and popular products. All this information can help the management for decision making and strategic planning.

6. REFERENCES

(a) Suyanto. 2010. *Algoritma Optimasi*. Yogyakarta: Graha Ilmu.
(b) Brownlee, Jason, 2014. *Clever Algorithms: Nature-Inspired Programming Recipes*. Melbourne: Swinburne University.
(c) Herjanto, Eddy. 2008. *Manajemen Operasi*. Edisi Ketiga. Jakarta: Grasindo.
(d) Baker, Kenneth, 1984. *Sequencing Rules and Due-Date Assignments in A Job Shop*. USA: Dartmouth College.
(e) Bedworth, David and Bailey, James E., 1982. *Integrated Production and Planning Control*. Canada: John Wiley and Sons.
(f) Ladjamudin, bin Al-Bahra. 2005. *Analisis dan Desain Sistem Informasi*. Edisi Pertama. Yogyakarta: Graha Ilmu.

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