Management Adviser

Volume 10 | Number 4 Article 6

7-1973

Aiding the Flow of Sales Order Documents Through Machine-Scheduling

Lane K. Anderson

Many paper work routines as they flow through the necessary steps of their processing are analogous to a product flowing through a production line. Why not apply machine scheduling techniques to such work?

AIDING THE FLOW OF SALES ORDER DOCUMENTS THROUGH MACHINE-SCHEDULING

by Lane K. Anderson
Brigham Young University

SOME of the techniques for solving the machine scheduling problem (ranging from rules of thumb to scientific procedures) have applications in other similar areas. This article concerns batch work priority for the flow of documents through different departments. The technique used is a branch-and-bound algorithm developed by Lomnicki[1] and extended later by Brown and Lomnicki.[2]

The machine scheduling problem is characterized by the ordering of n jobs $(J_1, J_2, \ldots, J_n)$ on each of m machines $(M_1, M_2, \ldots, M_m)$ to minimize job completion time. The model formulated to accomplish this objective assumes: (1) a job cannot proceed to machine M_j before it is finished on machine M_{j-1}; (2) the time involved in transferring any job from one machine to the next is negligible; (3) a machine cannot process more than one job at a time.

The sales order problem

A specific case is where all jobs are to be processed on the m machine in a common order. If job 2 is the first one started on machine 1, it will be the first job started on all succeeding machines. The same is true of the second job started on machine 1, etc.

The sales order originates with

[1] Lomnicki, Z. A., "A 'Branch-and-Bound' Algorithm for the Exact Solution of the Three-Machine Scheduling Problem," *Operational Research Quarterly*, March, 1965.

[2] Brown, A. P. G., and Z. A. Lomnicki, "Some Applications of the 'Branch-and-Bound' Algorithm to the Machine Scheduling Problem," *Operational Research Quarterly*, June, 1966.

an order department set up to standardize incoming orders. Exhibit 1, below, shows the documentation flow between order and billing. All orders are approved by the credit function which, in turn, authorizes stores to release the goods from inventory. Once the release of merchandise is approved by stores, the traffic function authorizes and arranges for shipment. Finally, the billing function invoices the shipment and bills the customer.

Whether these basic functions span several departments or are concentrated in only a few depends upon the firm's size and complexity. For control purposes, it is necessary to move the orders through the various departments in some pattern.

This may involve placing the orders in batches either arbitrarily or in terms of a common denominator, such as, salesman, geographical region, customer classification, etc. There should be a relationship between the method and the ease of processing batches using it.

Processing for seven regions

Consider the following example. A manufacturer of interior decorating products has seven sales regions in the United States. The home office is responsible for one of these regions as well as for maintaining the general offices and the manufacturing facilities. A distribution center, supplied periodically by the manufacturing division, is located in each of the seven regions. Although regions maintain their own stock of inventory, all orders are processed through the home office. The records for sales and accounts receivable, and credits and collections, are arranged into regions. Each regional record volume is further subdivided into six customer classifications. Inventory records are maintained for the individual distribution centers.

Sequence in home office

The flow of customer and salesmen orders after being received by the home office is shown in Exhibit 2, on page 46. First, the orders are separated into groups, depending on whether they are for new or continuing customers. New customers require special attention in the sales and credit departments. Second, the orders are sorted into groups by region. Third, each of the regional groups is further divided into customer classification. The result, at most, is 42 batches of continuing customers and 42 batches of new customers. However, for any one day, the number of batches is significantly lower. Once the batches are determined, the documentation for each order is processed through the seven departments.

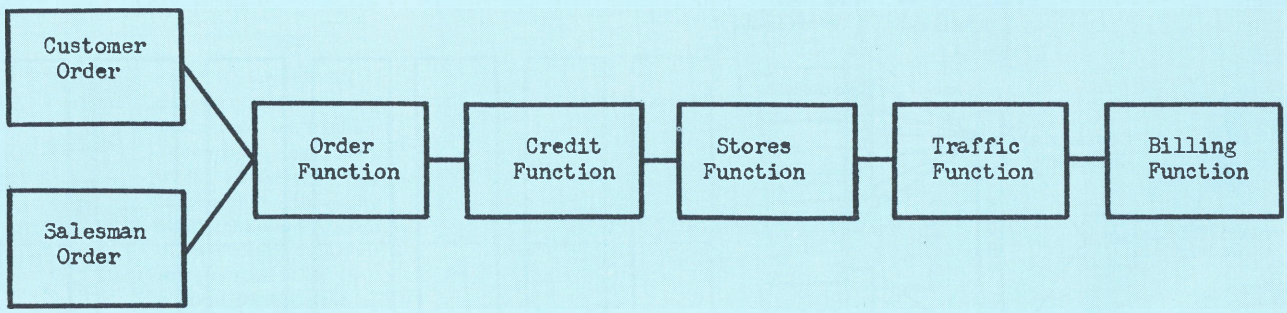
The similarity of the sales order problem and the machine scheduling problem is beginning to take form. There are n batches (B_1, B_2, . . ., B_n) which must traverse m departments (D_1, D_2, . . ., D_m) in such a way that total processing time is minimized. However, there is one unique feature of the sales order problem in practical situations which is not characteristic of the machine scheduling problem. This is, once an optimal processing order has been found, that sequence is followed day after day. Monday's orders will be processed in the optimal sequence, then Tuesday's orders, etc. Only if processing times change will a new optimal sequence be found.

Find average batch size

This feature is justified by the fact that finding a new optimal sequence for orders received each day costs more than the benefits derived. An efficient solution is to find the average batch size for each classification per day and the average time of processing such batches. This way only one sequence determination need be made unless the average processing time changes.

For the illustration given in Exhibit 2, there is a restriction on the comparability of machine scheduling and the sales order flow. The sequencing of batches has an effect on processing time only in the first

EXHIBIT I



four departments. In the last three departments, batching is of little value for ease in processing orders.

The Moveslow Corporation is a manufacturer of doodads of all shapes and sizes. The company maintains only 12 per cent of the doodad market but is the fourth largest manufacturer in the field. The home office and production facilities are located in a small town near Pittsburgh. Warehousing and distribution centers exist at the home office and in Los Angeles. These two centers are located to facilitate selling and distribution to the eastern and western halves of the United States. Occasionally, the home office will supply customers in both areas, especially when the Los Angeles center is unable to fill the order. Customers are grouped into three classifications: (1) retail and discount houses, (2) distributors, and (3) custom jobbers.

For planning and control purposes all records regarding the sales, shipping, and credit and collection functions are grouped by region. Within each region the records are further broken down by customer classification. For example, if one were looking to see if custom jobber customer X in Seattle had exceeded a credit limit, the accounts receivable file for the Los Angeles region would be selected and the record under custom jobbers reviewed.

Once an order is received, the processing cycle covers four general areas: (1) sales or sales ordering, (2) locating inventory, (3) shipping document preparation, and (4) order distribution. The departments in Moveslow are based on these general functions.

The sales department is the receiving point of all orders whether from new or continuing customers. A multicopy sales order is prepared for each customer order. The authorized prices are entered on the sales order or at least are compared with the prices the customer has indicated. If special price arrangements have been made, they must be verified. Appropriate quantity, trade and cash discounts are entered on the order, depending upon the customer classification. Better discounts are available to retail and discount houses and distributors because costs are less when servicing these volume buyers. For continuing customers, the credit check involves a review of a biweekly accounts receivable listing. This listing is in two volumes, one for each region. The credit department completes a credit investigation for new customers. After the credit check, copies of the sales order go to inventory control.

The inventory control department determines the shipping point according to which center has sufficient inventory to cover the order. The shipping documents are then prepared by a shipping expediter department and sent to the appropriate distribution center.

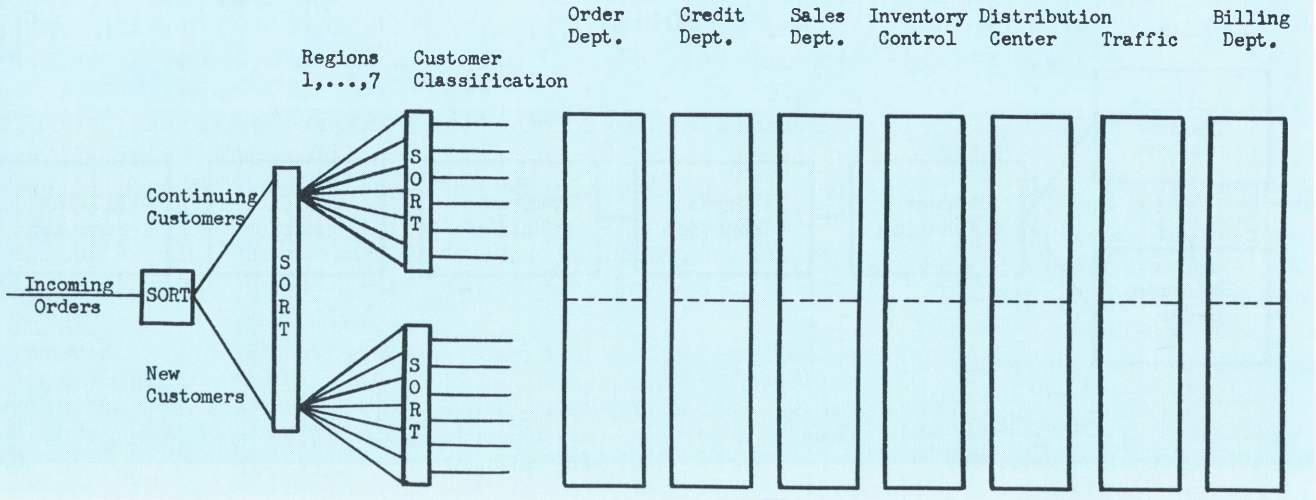
These documents are hand delivered when distribution is from the home office or mailed to the Los Angeles center. The distribution center is then responsible for timely delivery.

The problem

Customer complaints about time delays between order placement and delivery lead to an investigation of the "sales order to distribution" cycle. This reveals inefficient processing between order receipt and delivery to a distribution center.

The basic problem is not a lack of manpower, but a lack of a structured procedure for working on each order. The mailroom delivers orders to the sales department where they are processed by the clerical help in the order received. This usually means a loss of time in at least two areas: (1) in credit checking, and (2) in locating inventory. The time loss is obvious when one remembers that the accounts receivable and inventory location records are maintained separately for each region. Under the present system a clerk may continually be skipping from one set of books to another only to return

EXHIBIT 2



to the set which had been used earlier. In addition to this, the credit checking phase involves customer classifications within regions. It is possible, therefore, to be skipping back and forth among the various classifications within a region.

The solution

Each day the customer orders received are to be segregated: first, as to whether they are new or continuing customers; second, as to region; and third, as to customer classification. Since new customers (making up approximately 10 per cent of all orders processed) require special treatment and longer processing time, for ease in handling they are not included in the following suggested solution.

With 90 per cent of the orders processed being continuing customers and following the same processing path, a question arises as to whether each day's batches can be sequenced in some way so that the total processing time through the three functions will be minimized — the machine scheduling problem.

In order to set up a scheduling problem, it is necessary to find the average time to process each batch through the three functions. The batching system is allowed to run for several weeks before time studies are made. The following is a time matrix in man-hours for this example:

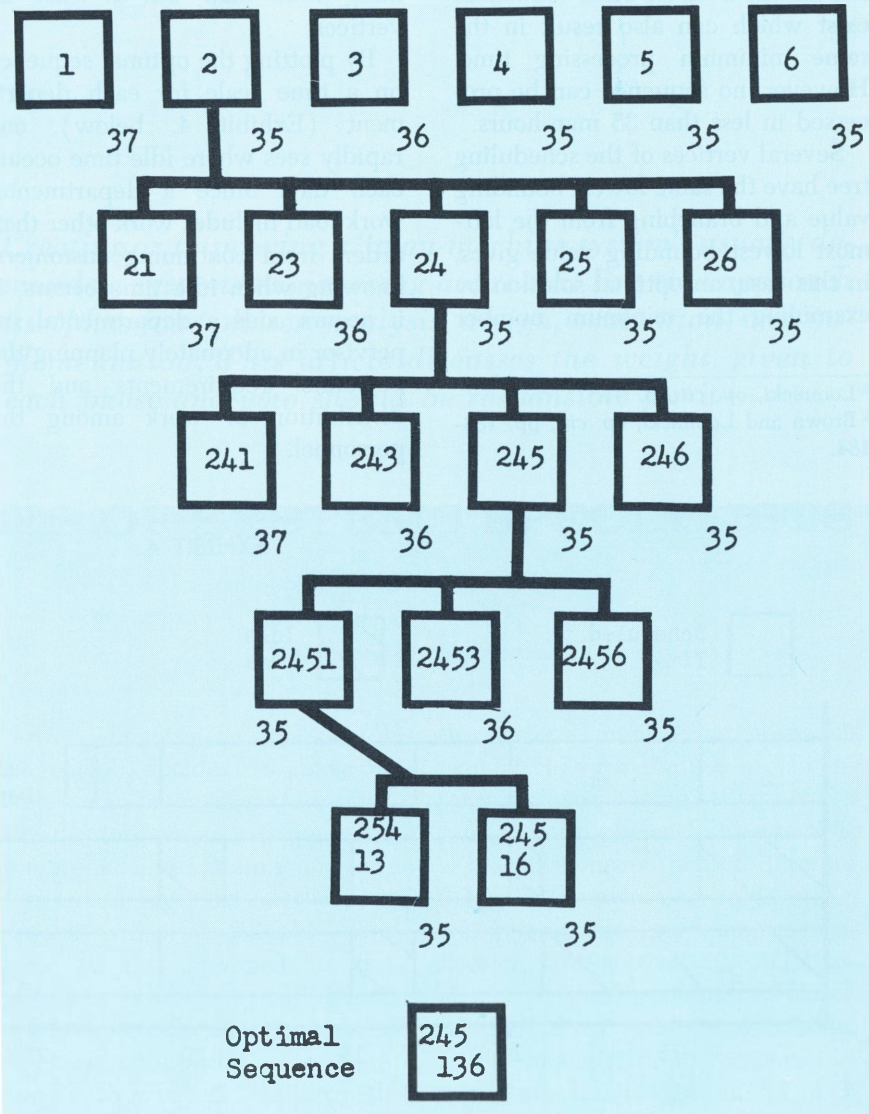
		Batch No.	Sales	Inventory Control	Shipping Expeditor
Pitts. Region	Retail and Discount	1	8	6	6
	Distributors Custom Jobbers	2	4	5	4
		3	2	1	1
L. A. Region	Retail and Discount	4	6	5	6
	Distributors Custom Jobbers	5	3	4	5
		6	1	1	1
			24	22	23

Since retail and discount houses are expected to place large orders, more time is required to process them.

Custom jobbers require the least amount of time for processing because their orders are generally small.

The branch-and-bound technique involves computing several lower bounds for the total time to process the six batches through the three

EXHIBIT 3



LANE K. ANDERSON is assistant professor of accounting at Brigham Young University, Provo, Utah. Previously he taught at the University of Wisconsin and was on the audit staff of Arthur Andersen & Co., Milwaukee. Dr. Anderson received his B.S. and M.Acc. from Brigham Young University and his M.B.A. and Ph.D. from the University of Wisconsin. He is a member of the American Accounting Association.

departments. In applying the algorithm, five lower bounds are used for each batch. Three of these bounds are computed as suggested by Lomnicki[3] and the other two as suggested by Brown and Lomnicki.[4]

The result of the straightforward application of the algorithm is shown as a scheduling tree in Exhibit 3, on page 47. (The figures inside the boxes represent job numbers while the figures outside represent the bounding value of the processing time for that box.) An optimal sequence of batches, 245-136, can be processed in a minimum of 35 man-hours. This solution is not unique because other sequences exist which can also result in the same minimum processing time. However, no sequence can be processed in less than 35 man-hours.

Several vertices of the scheduling tree have the same lowest bounding value and branching from the left-most lowest bounding value gives, in this case, an optimal solution by examining the minimum number of vertices possible—20. That is, at least 20 vertices must be examined in any problem involving six batches and three departments to arrive at an optimal solution. There is nothing magic about always branching from the left-most lowest bounding value, but this procedure is used for the sake of consistency. For example, if branching from the right-most lowest bounding value is used, an optimal sequence of 654213 with 35 man-hours of processing time is found by examining only 20 vertices. If the figures in this example had been different, either procedure may have resulted in examining more than, but at least, 20 vertices.

By plotting the optimal sequence on a time scale for each department (Exhibit 4, below), one rapidly sees where idle time occurs each day. Since a departmental work load includes work other than orders from continuing customers, knowing when idle time occurs, if it occurs, aids a departmental supervisor in adequately planning the personnel requirements and the distribution of work among the personnel.

Intuitively, there are other procedures for processing batches. Two which immediately come to mind are: (1) process batches in the original sequence of 123456, and (2) process by region regardless of customer classification. The minimum processing time using the original sequence is 37 man-hours—two more than the optimal level. Processing only by region requires at least 47 man-hours. As can be seen, considerable time is saved by subdividing a large batch of orders into smaller batches of some common denominator. However, one must remember that there is a trade-off between time saved in processing and time expended in segregating orders into smaller batches.

Conclusion

This example shows that one of the techniques for solving machine scheduling problems can be used in systematizing the flow of documents through several departments. There are probably many other applications if one is observant enough to recognize opportune situations.

[3] Lomnicki, *op. cit.*, p. 94.

[4] Brown and Lomnicki, *op. cit.*, pp. 183-184.

EXHIBIT 4