THE UTILIZATION OF AN INFORMATION SYSTEMS SIMULATOR FOR LINE BALANCING

M. W. Shiveley[1] and J. W. Simonds[2]

[1]Lehigh University

[2]Western Electric Company

ABSTRACT

A simulation technique for line-balancing has been developed to utilize an Information Systems Simulator Developed at Lehigh University. A precedence diagram is constructed from the work elements of the line and translated into a partially ordered file. The file system enables the user to determine, store, and maintain pertinent information such as the ultimate followers of each task, the total number of immediately preceding tasks, tasks larger than the desired cycle time, and other information essential for decision-making. The algorithm can process an almost unlimited number of activities and requires less than 30,000 words of core storage. Where perfect balance is impossible, the balancing algorithm can obtain the "best" balance through the use of prescribed station flexibility.

I. INTRODUCTION

This paper addresses two key concepts which appear to be useful in solving large scale production line balancing problems. A production process can be represented by a precedence-constrained network of tasks. Line balancing consists of grouping these tasks into sequential stations such that no precedence constraints are violated and at the same time a specified output rate is met with a minimum number of stations.

It has been previously illustrated that as the task network grows in size and complexity, enumeration, analytic methods, and most heuristic techniques become either infeasible or at least increasingly more inferior to a biased sampling procedure called COMSOAL (Computer Method of Sequencing Operations for Assembly Lines). The standard COMSOAL method simulates numerous feasible solutions by assigning tasks one at a time to stations based on random selection biased by various heuristic factors calculated from the task network. After a satisfactory number of feasible solutions have been simulated, the accepted solution is taken as the best of the generated solution.

II. THE NEW APPROACH

Despite the effectiveness of standard COMSOAL, applying it to very large networks is not without complication.

1. Even with COMSOAL the large networks present difficulties in managing both the original problem data and the working data for the algorithm.

2. Standard COMSOAL forces each station time to be equal to or less than the ideal cycle time. This means that COMSOAL tends to generate many solutions containing an extra station which is extremely underloaded.

The authors have employed two concepts to aid in overcoming these difficulties.

1. Use a data base with hierarchical structures to represent the network.

2. Allow specified amounts of overloading, as well as possible underloading, at any and every station.

The data base consists of three separate hierarchical files designed to provide efficient data access: an indexed key file, or location directory for the data; a directly addressable activity file containing task durations, first follower task locations, etc.; and a directly addressable ordered sequence file containing addresses of other following tasks, immediate predecessor tasks, etc. This type of data base provides quick retrieval and convenient updating capability. Also, problems with excessive core storage requirements are alleviated by the data base's efficient disk utilization.

The second concept, concerning allowed overloading and underloading, stems from the least-squares concept. Rather than always attempting to obtain perfect station times, the authors' algorithm tends to minimize the smoothness index (square root of the sum of squared station errors).

III. RESULTS

Task networks ranging from 21 to 45 tasks were taken from previous literature and balanced using this new method. Some very encouraging results were obtained.

1. None of the problems required over 12 K of core storage on the IBM 1130.

2. In some cases very good solutions were quickly obtained for problems not solvable by standard COMSOAL. These were problems requiring some station overloading to prevent use of an extra, underloaded station.

3. In general, decreasing the allowed station overload amount did not increase the total solution time.

These results, coupled with the previously established advantages of COMSOAL, offer reasonable support for the authors' suggested technique of combining data bases with a modified COMSOAL algorithm to balance large, complex networks.

BIBLIOGRAPHY

1. Buffa, Elwood S. and William H. Taubert. Production Inventory Systems: Planning and Control, Richard D. Irwin, Inc., Homewood, Ill., 1972.
2. Hoffman, T. "Assembly Line Balancing with a Precedence Matrix," Management Science, Vol. 9, No. 4, 1963.
3. Shiveley, M.W. "Computerized Storage and Analysis of Networks," a paper presented at the ORSA convention (Spring 1972).