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FACILITY DESIGN VARIATIONS USING A STRONG COMPONENT BASED METHODOLOGY

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ABSTRACT
In this presentation is shown how a strong component-based facility layout design methodology addresses the design problem when some design relevant factors are adapted. The strong-component-based methodology proposes a unique structural design, a non-dedicated facility, capable of producing a family of products that required similar operations and workstations which can be shared. Simultaneously, the methodology suggests that this structure can take advantage of both, known classical layout designs, product and process, in a single or multiple machine environments. In addition, adding or reducing a number of stations, adding feeding and storage facilities, considering qualitative and quantitative coefficients are some of the factors variations which can addressed when using this methodology. In consequence, organisational impacts of the facility layout problem are addressed and solutions that can be obtained are suggested when using the strong component-based methodology to create the interrelations diagram, an essential diagram which eases the facility design goals.
Keywords: Facility Layout, Graph Theory, Strong Components,

1. INTRODUCTION
It has been widely accepted that a good layout design can help reduce costs; for instance, it may help to reduce from 10 to 30% of the total operating expenses increasing the performance of a production and a material handling systems by supporting improvement process strategies [1, 2, 3]. In this presentation a heuristic methodology based in the theory of directed graphs is used to create a single structure which is capable of producing various products running in a batch mode. Although the methodology is not discussed in this presentation, it is used to highlight some design issues such the transfer batch size, input and output points and the single and multiple machine, explore these issues and point put some implications in the design that may support production, maintenance and material handling processes. Additionally, the structure is presented as an interrelation diagram that is the fundamental tool to create the facility layout design implementation.

2. STRONG COMPONENT BASED METHODOLOGY
This methodology considers the design of a single structure (non-dedicated facility) capable of producing various products, one at the time and in a batch mode, combining each product operation sequence of a group of products that can share the same production machines and equipment [4]. The heuristic method used creates an interrelation diagram which is based on directed graph theory using relevant product flows sequences that should be followed during production time [5]. For instance, assume that three products are to be produced, as shown in Table 1 [6]. As can be seen in this table,

the production and the number of displacements required vary with the operation sequences needed by each product and it is assumed that the transfer batch size may be of size one.

Table 1. Product Operations Sequences and Requirements

Product	Operation Sequence	Production Requirements	Displacements Required
1	A-C-D-F	500	3
2	B-A-C-D-F	1000	4
3	E-B-C-A-F	300	4

Figure 1 shows the resultant strong component based directed graph which is obtained by combining these three products into this single structure called interrelation diagram.

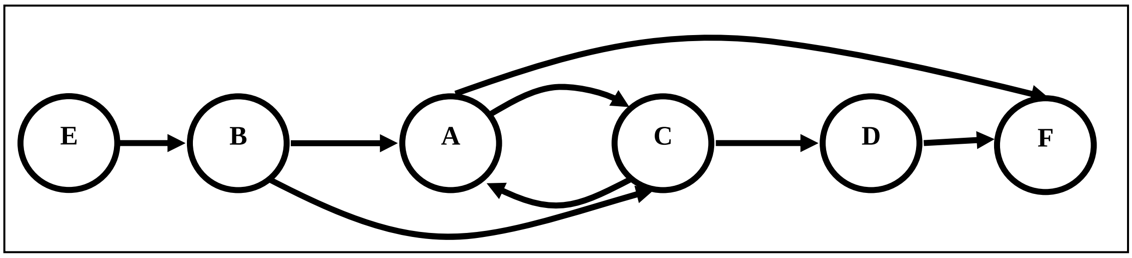

Figure 1. Interrelation Diagram

Any of the product operation sequences can be followed in the diagram. It should be noted that, although any of the three products can be elaborated; there are new issues that should be highlighted. When comparing to dedicated facilities (product layout design): a. unwanted flows have been created such as by-passing displacements, between stations B and C, and between A and F; b. backtracking displacements have been produced, between stations A and C, and c. more displacements may appear. These risks are unavoidable when combining different products into a single structure, but can be reduced by adding new machines, as shown in Figure 2. Also, it should be noted that these new and more added displacements may affect production rate and material handling distances but at the same time should be pointed out that, less resources may be used.

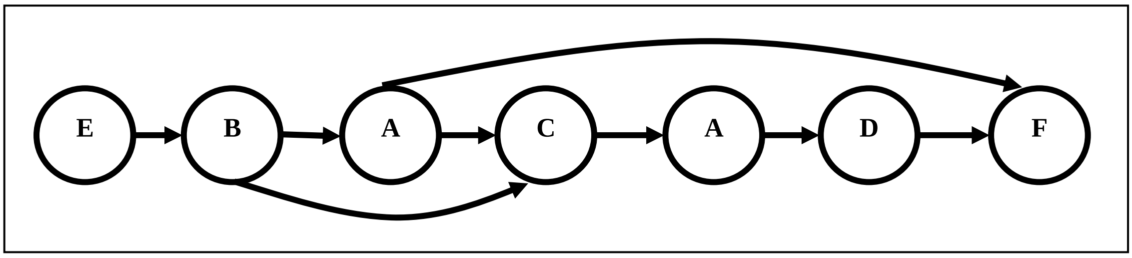

Figure 2.Forward Flow Interrelation Diagram

3. SUPPLY AND STORAGE FACILITIES

Adding supply and storage facilities will increase the number of nodes required, and in consequence, the complexity of the problem to be solve may increase. Since this is a combinatorial problem classified to be NP Complete [7], the need of more computer resources may increase during its solution procedure; therefore a heuristic procedure is suggested to obtain its solution. Following the previous example, a supply (I) and a storage node (O) are added and the modified diagram is as shown in Figure 3. It should be noted that when comparing to the original diagram, this is not affected by including these nodes at the beginning and at the end of the diagram, but more space is required to provide better access to those stations that are going to be fed and to those stations that are going to feed the storage (O).

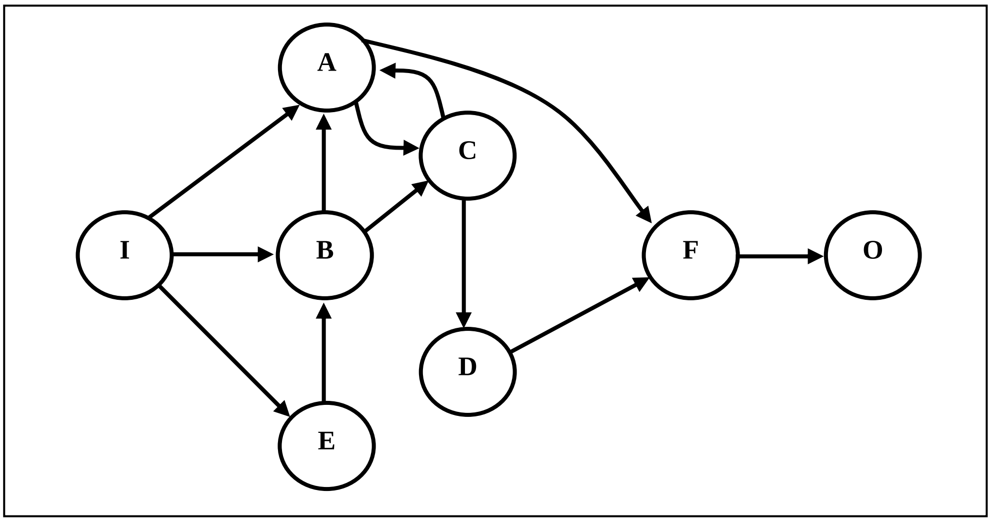

Figure 3. Interrelation Diagram with Supply and Storage Facilities

4. SINGLE AND MULTIPLE MACHINES

In the case of more machines which may be needed to satisfy the production requirements by using this strong component methodology to create the interrelation diagram, now, it should be noted that instead of a place and space situation, only a space situation has to be solved. Since the sequence has been determined by using the product operation sequences and considering that the transfer batch is of size one, it should be examine the space required by adding a second or the required number of machines and place them in the same location assigned to it (process layout design). For example, if a second machine F is needed then it should be placed besides the existing one as shown in Figure 4.

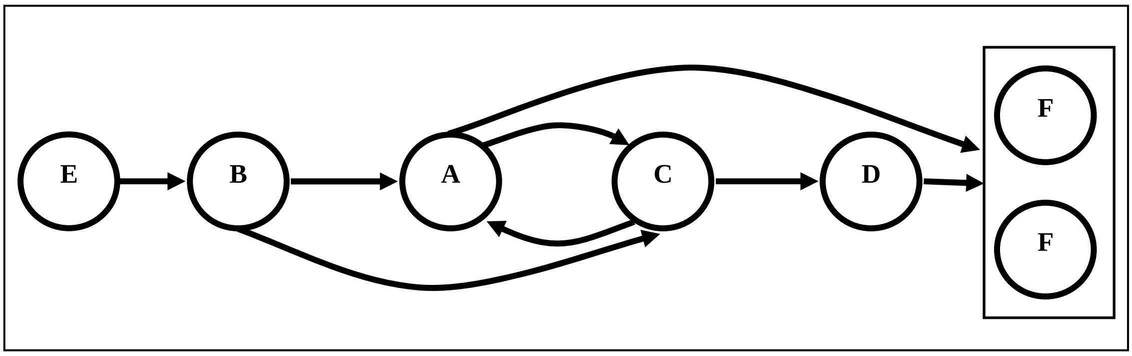

Figure 4. Multiple Machine Interrelation Diagram

5. ARC WEIGHTS

Usually, it is a common practice in Facility Layout Design to attach weights to arcs to establish the importance of the proximity among nodes of facilities. These weights can be qualitative, quantitative or adimensional and be represented using tables. In the qualitative case, the importance is reflected using the taxonomy proposed by Richard Muther using the experience and knowledge of the designer and an interrelation table is constructed [8]. Using distances, costs, times and production rates are quantitative measures to represent these weights and a from-to table is used to represent them [9, 10]. Also, the number of steps can be considered as an adimensional measure which may leads to a formulation where all the arcs are equal weight and where many mathematical programming formulations can provide trivial solutions and the strong component based methodology can provide a more comprehensive solution [3], as the ones shown in section 2 and 3; in this case, the representation is known as adjacency table.

6. CONCLUSION

Some Facility Layout Design issues have been addressed in a situation when: a. a single piece transfer batch is used, b. various products have to be produced sharing the same production resources available (non-dedicated facilities), c. a batch mode production is suggested and d. product operation sequences are the main data source. It should be stressed that the strong component based methodology can be used as a supportive tool for the Facility Layout Design when:

a. Adding supply and storage facilities in the layout design
b. Adding more machines,
c. Considering quantitative and adimensional arc weights.

The relevance of these issues and its implications to the design of production facilities, maintenance and material handling processes has been highlighted. Additionally, it has been mentioned, how the proposed methodology can be used to ease the analysis and the solution under these circumstances and pointed out its flexibility to handle them. Furthermore, the interrelation diagram obtained by this methodology have further properties that may help to identify alternative production routes and to determine the displacements required between different facilities that also can be used to improve and support production, maintenance and material handling activities.

Currently more research is being done in how these structures may affect the production performance under different scenarios and identify possible contributions and limitations of these sorts of structures.

7. REFERENCES

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