Digital Workspace for Optimal E-Business Strategies

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Abstract: - The foundation of a successful enterprise is the design of strategies that work consistently and at an optimal level to support the business goals. In this paper we present the architecture of a Digital Workspace for finding the optimal production strategies in a certain period of time. We determine, using parametric programming, an optimal investment plan (strategy) with an optimal loading on all machines.

Key-Words: - Parametric programming, Digital workspace, E-business, Optimal strategy, Planning.

1 Introduction
Computers and internet have undergone an important growth in the last years. They represent a major component in several fields of activity, such as health care, education, public services, etc. Business environments also have a high potential of benefiting from computers and internet. This paper addresses the following aspect in business enterprises: designing a company’s investment plan with a digital algorithmic approach. The motivation is that optimal planning of resources and costs is the basis for successful business strategies [9, 10, 11].

Production planning is usually a time consuming and error prone process. Moreover, designing an optimal production plan requires a thorough theoretical support to attest optimality of a strategy. In order to overcome these difficulties, we construct a digital workspace for finding optimal production and investment strategies.

We concentrate our study on real-world cases. The digital workspaces shown in this paper are made for the annual, bi-annual or quarterly optimizations of the production programs for enterprises that build machines, such as Electroputere Company [3]. The model allows finding the classes of machines that stall the production program.

We use linear and parametrical models [1, 2, 4, 8] to simulate investments’ growing relative to these classes on which the optimal investment strategy or collaboration with other enterprises are determined. More specifically, our technique uses parametric programming with integers - an active field, with high potential for research [5, 6, 7]. Investments or collaboration simulations are made independently for the used classes or for the deterministic jobs and globally for all the classes that represent restrictions. The problem is preceded by a basic calculation for all stable orders and for all classes of machines and jobs specified by the technological input.

The general architecture of a digital workspace is fully dependent on the data mining models which are used when taking decisions. Furthermore, the data mining models depend on the domains they are applied on.

The rest of the paper is structured as follows: Section 2 introduces the problem that we address, and describes the basic concepts that appear in the model. Section 3 presents the architecture of the digital workspace. Section 4 gives a detailed description of the algorithm used to model the optimal investment strategies. Section 5 concludes the paper.

2 Problem Formulation
The digital workspace for optimizing the production and investment plans includes two types of data. One of them is relatively stable and is made from the technological matrix of consumption. The matrix of consumption is given by the technological input of the machines and classes of jobs on each product. The problem is preceded by a basic calculation for all stable orders and for all classes of machines and jobs specified by the technological input.

This is an m*n matrix where:

- m is the number of machines and job classes (homogeneous).
- n is the number of products (product classes) for which the sales limit established by the marketing department is estimate.
The second data type is the statistic type given on a period of 10 years. Based on this data type, the marketing programs find a permissible fabrication interval \([d^i, d^j]\), with \(i=1\ldots n\) for each product. Based on disturbances on a ten years period and on the repairing plan, we estimate the average available time which determines the technological fabrication restrictions for each class of products.

3 Architecture of Digital Workspace

We present the general architecture of the digital workspace for optimizations in Figure 1 with the detailed components.

As shown in the figure, the system used data to extract information and take decisions accordingly. There are two control units: the Loading Manager and the Interrogation Manager. The Loading Manager has the following functions:

- It extracts the data from the source database.
- It loads the extracted data fast, into variables used in modeling.
- It realizes simple transformations.

Each of these functions operates automatically without human intervention with complete recovery in case of error. The molding data are extracted for all the products having up-to-date elaborated technology. The Loading Manager is a system component which realizes all the necessary operations for extracting and loading processes. It has four components for generating the technological synthesis matrix (Figure 2):

- DW1 Component – extracts and loads a part of the technological matrix for all products that have the technology structured by utilization classes and jobs.
- DW2 Component – determines the available amount of time. It takes into account the age of every machine, the necessary plan (strategy) and the number of work changes in the described plan.
- DW3 Component – determines the profit and the costs for each product.
- DW4 Component – a marketing component for estimating the solid orders and the sales’ limits for each product class based on statistics from the previous period of time.
The Interrogation Manager acts as a linking component between the Information Modeling unit and the Decision unit. It transfers comprehensive information that is used by the Decision unit to decide the optimal investment strategy.

The Decision unit establishes the business strategy to follow, based on the data and model. Decision Support Systems (DSS) [13] appear in several organizational decision-making activities. Some examples of DSS used in business and management are the executive dashboards [15] that facilitate better allocation of resources, tracing of negative trends and fast decision taking. A DSS is usually very interactive, to assist the user in taking the best decisions regarding the analyzed situation or solved problem.

While the front end of a DSS is an interface to the user, in the back end there is a processing component that compiles raw data, background information and business models to identify and solve problems, and eventually take decisions. There are several types of DSS systems, including text-oriented, database-oriented, spreadsheet-oriented, solver-oriented, rule-oriented, and compound [14]. In our Digital Workspace architecture we use a database-oriented DSS.

We propose the use of OLAP (Online Analytical Processing) [12] Systems for Decision Support. OLAP is quite an intuitive tool, currently used in several organizations.

With OLAP, the user can develop complex decision analysis and handle large amounts of data during the decision process. The main architectures of OLAP are the multidimensional (MOLAP) and relational (ROLAP) versions, respectively. The basic difference between the two lies in the way the data is accessed. Depending on how the storage system is configured, the Digital Workspace may rely on a particular version of the decision system. With MOLAP, the data is stored in a multi-dimensional database. In contrast, ROLAP accesses the relational database (data warehouse) directly.

In general, ROLAP scales well to large databases and various business analysis scenarios. On the other hand, MOLAP might require data preprocessing and runs the risk of low performance on databases with a high number of dimensions (above ten dimensions).

4 Optimization Model

The DW1 component determines the \( a_{ij} \) elements, which represent the amount of time consumed from the \( i \) (\( i=1,2,...m \)) utilization class and a unit from the \( j \) (\( j=1,2,...n \)) product.

Therefore, the rows in the technological matrix are given by utilization classes, and the columns are given by products (\( j \) being the product identification numbers).

The DW2 component determines the total amount of available time for each utilization class and for each job at a certain given time.

The DW3 component determines the main vectors of profits and costs for each product, denoted by \( C = (c^1, \ldots, c^n) \). Finding the fabrication year is a problem of linear programming using integers:

\[
\begin{align*}
Ax & \leq b \\
x & \geq d^o \\
x & \leq d^i \\
x & \text{integer} \\
\max(\min) & \ c'x
\end{align*}
\]

The DW2 component determines the total amount of available time for each utilization class and for each job at a certain given time.
The \( \mathbf{d}^0 = (d_1^0, \ldots, d_n^0) \) vector shows the solid orders which have to be sent to fabrication given by the DW4 marketing component. The \( \mathbf{d}^1 \) shows the maximum values that can be manufactured by each product and also estimated by the DW4 component.

We name \( \mathbf{a} \) a linear vector of the \( \mathbf{A} \) matrix, \( \delta \) - the amount of available time for buying or renting a new machine, \( u_1 \) - \( u_m \) – the number of machines from the \( i = 1, 2, \ldots, m \) class.

First, we determine whether \( x = \mathbf{d}^0 \) is an admissible solution (it satisfies the restrictions), and if so, we proceed to the determination of the optimal plan (strategy). If \( x = \mathbf{d}^0 \) is not an admissible solution, meaning:

\[
\mathbf{A} \mathbf{d}^0 \not\leq \mathbf{b},
\]

then we have to determine the investment plan for the classes of machines that satisfy the conditions:

\[
\mathbf{a} \mathbf{d}^0 > \mathbf{b}_j.
\]

We apply the DINVOPT algorithm to determine how many machines are necessary for each class \( \mathbf{a} \). The DW1 component determines the \( \mathbf{a}_i \) elements (the amount of time consumed for the \( \delta \) (\( \delta = 1 \ldots j \)) class on a product unit of type \( i \)).

The DW2 component determines the available amount of time for each class of machine or job. From practical experiments, it results that for the determination of some proposals of annual strategies at Electroputere Company, there are a lot of machine classes having critical impact in establishing the optimal annual production strategy. This is given by the set of index:

\[
\mathbf{I}' = \{ i : \mathbf{a}_i \mathbf{x}^0 = \mathbf{b}_i \}.
\]
Moreover, in case the solid orders given by \( d^o = (d^o_1, \ldots, d^o_n) \) are sent to fabrication, the following situation also becomes possible:

\[ I^2 = \{ i : \alpha_i x^o > b_i \} \]

For \( I^2 \) above, a decision has to be made regarding the following: Do we increase the number of machines \( b_i \) with a number that transforms \( I^2 \) into \( I^1 \) (an investment problem), or modify the analyzing procedure relative to that machine class.

The algorithm proposed in Figure 3 represents a solution for solving the linear programming problem described above and for optimal estimation of the investment strategy.

The DINVOPT algorithm for determining the optimal investments plan allows finding the number of machines from each class that should be purchased and the classes that are determined during the realization of an optimal production strategy.

The OPTIM procedure assumes that initially \( x= d^o \) is an admissible solution for which the vector \( b \) is determined. The \( b \) vector is determined first in steps 2-5. There is the possibility that this vector will not be changed by the algorithm if \( I^1 \) is null.

In step 7 is called the procedure ANALYZE which uses linear an optimization algorithm with integers. ANALYZE determines the critical (decisive) machines or jobs - \( (a^i x^0 = b^i) \) that lead to an optimal strategy. The algorithm can be restarted from step 2 for some classes (groups) of machines. For that to work, the inequality condition is replaced equality (congruence) conditions.

5 Conclusion

This paper presents an algorithm for determining production plans and investment strategies in e-business environments. Decision making is a complex process that builds upon both data and business model. An optimized business model can lead to reduced upfront investment and increase or accelerate the profit inflow. That ultimately determines a higher probability of having a success enterprise.

We envision important applications of the proposed model in real-world scenarios. Our future work will focus on a case study: modeling the production strategy in the engine factory of Electroputere Company from Craiova, Romania.

References: