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   HYPOTHESES

   RESEARCH METHODOLOGY

   RESULTS & DISCUSSION

   FINDINGS

   RECOMMENDATIONS/SUGGESTIONS

   CONCLUSIONS

   SCOPE FOR FURTHER RESEARCH

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   APPENDIX/ANNEXURE

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AN ADAPTIVE DECISION SUPPORT SYSTEM FOR PRODUCTION PLANNING: A CASE OF CD REPLICATOR

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ABSTRACT
Latest advances in information and computer technology and production planning methods as well as improvements in development of user-friendly interfaces have led to considerable growth in the development and application of Decision Support Systems (DSS) for production planning. This study provides an example of the development and implementation of an adaptive DSS for management of production planning for a manufacturing company -ShimaFilm. The system provides an optimized real-time production plan based on new and existing orders, priorities, availability of production lines and available raw material. The system includes Customer Prioritizing (CP), Human Resource Management (HRM), Inventory Replenishment (IR), and Preventive Maintenance (PM) subsystems.

KEYWORDS
Adaptive decision support system, Information systems, Procurement planning, Production planning.

INTRODUCTION
Nowadays, organizations are facing globalization of markets, the ever-changing vigorous customer preferences and dynamic spirit of markets; which forces Top Management Team (TMT) of organizations make decisions besides managing the resources, (Clark et al., 1991, Davila et al., 2006). One of the most critical decisions that an industrial unit manager should make relates to production planning. However, always there are some uncertainties beyond the production process, in particular, uncertainties in demand and supply. Many researches strive for formalizing the uncertainty in production systems (Yano and Lee, 1995, Sethi et al., 2002).

Production planning in manufacturing firms includes several aspects, at different organizational levels, for example decisions on production and inventory quantities, resource acquisition, and sequencing the products. As a result, different and often contrasting objectives can be pursued; also, several limitations may need to be considered. In this complex context, TMT should make not only accurate but also swift decisions; which is not a straightforward task. In order to address this looming problem, a decision maker needs a system that can support him in different problem situations (Chuang and Yadav, 1998). Massive development in information and communication technology intensifies the approach to using computer systems to support decision-making.

Decision Support Systems (DSS) are computer-based systems designed to enhance the effectiveness of decision makers in performing semi-structured problems; tasks that the decision maker is uncertain about the nature of the problem or opportunity, the alternative solutions and the criteria or value for making a choice. Hence, the primary role of a DSS is to aid the judgment processes as the decision maker challenges inadequately defined problems (Alavi and Napier, 1984).

The nature of the production planning process is closely related to the type of manufacturing (Gelders and Van Wassenhove, 1981). In this research, we addressed tactical production planning and scheduling issues in a manufacturing company, which produces, replicated CDs and DVDs as well as developed DSS specifically for their use.

Section 2 summarizes the related literature and section 3 synthetically describes the addressed problem including product type and demand structure, production facility and planning the production lines. Section 4 describes the proposed approach. Section 5 is about developed ADSS. Final remarks and possible future developments are mentioned in Section 6.

BACKGROUND
This section reviews related literature to the subject of design and development decision support systems based on previous researches.

Gorry and Morton coined the phrase 'DSS' in 1971(Gorry and Morton, 1971). As a general definition, DSS is a system providing both problem-solving and communications capabilities for semi-structured problems (McLeod Jr and Schell, 2001). But while speaking in a precise and professional world, DSS is a system that supports a single manager or a relatively small group of managers working as a problem-solving team in the solution of a semi-structured problem by providing information or making suggestions concerning specific decisions (McLeod Jr and Schell, 2001). Based on studies of Keen and Morton (1978) a DSS may have three different objectives: (1) assist in solving semi-structured problems, (2) support, not replace, the manager, and (3) contribute to decision effectiveness, rather than efficiency. Power (2008) defined DSS as an interactive computer-based system intended to help managers make decisions; a DSS helps a manager to retrieve, summarize and analyze decisions relevant data.

DSS is a software package based on mathematical programming models defined and solved within a user customizable decision framework (Caricato and Grieco, 2009). According to Finlay (1994), a DSS is simply a computer-based system that aids the process of decision making. Turban presented another definition; an interactive, flexible and adaptable computer-based information system, especially developed for supporting the solution of a non-structured management problem for improved decision-making. It utilizes data, provides an easy-to-use interface and allows for the decision-makers' own insights (Turban, 1993).

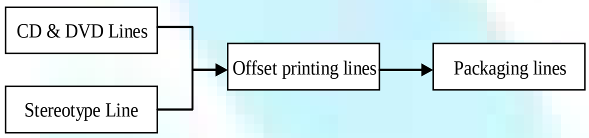
A general notion about a DSS is that it is an interactive computerized system consisting of three major components: a dialog subsystem, a database subsystem, and a model base subsystem (Watson and Sprague Jr, 1993); or, an interface subsystem, a knowledge subsystem, and a problem processing subsystem (Bonczek et al., 1981, Holsapple et al., 1996). With the knowledge and other capabilities embodied in these components, a DSS is intended to help a decision maker interactively solve managerial decision problems (Chuang and Yadav, 1998). The three-component architecture is capable of managing data; fitting data into models; and providing methods to reach decisions (Angehrn and Jelassi, 1994). By manipulating models and data, the decision maker is able to examine various scenarios and their consequences. The user interface component, which may be individually tailored to the user's preferences and expertise, lends itself to being

a friendly and effective communication facility. The three components, as a whole, contribute to the quality of decisions that are taken by a decision maker (Chuang and Yadav, 1998).
With the advent of Artificial Intelligence (AI) and expert system (ES) techniques, it has been broadly recognized that it is possible to empower a DSS by incorporating these techniques into the system (Angehrn and Jelassi, 1994, Chuang and Yadav, 1998, Finlay and Martin, 1989, Henderson, 1987, Holsapple and Whinston, 1985, Holsapple et al., 1996, Keen, 1987, Liang, 1993, Radermacher, 1994, Turban and Watkins, 1986). Such techniques can be incorporated into each component of the DSS (Holsapple et al., 1993, Turban and Watkins, 1986), and, accordingly, the performance of that strengthened component can be improved (Chuang and Yadav, 1998).
To deal with the ever-growing need of ventures for managing worldwide spread activities, various decision support techniques have been developed over last decade (Caricato and Grieco, 2009). Mathematical programming techniques in general and linear programming in particular have been widely used for production planning issues since the 1960s (e.g. van de Panne, 1965). However, since those early years, researchers suggest that managing the whole production as a huge single problem is not an efficient solution to realize effective decision support systems; and some more complex models such as the ones described in (Pochet and Wolsey, 2006) created. For instance, in (Anthony and Administration, 1965), the problem was already divided into three different levels: strategic planning, management control and operations control. A thorough analysis of planning and scheduling applications as applied in both manufacturing and services industries can be found in (Pinedo, 2009).
The term Adaptive Decision Support System (ADSS) was coined by Holsapple et al. (1993) to represent a category of decision support systems capable of self-teaching, which is accomplished by equipping systems with unsupervised inductive learning methods. One distinguishing feature of the systems in this category is that they are able to generate a better solution to a problem by gradually refining an initial solution (Holsapple et al., 1993). One distinguishing feature of the systems in this category is that they are able to generate a better explanation to a problem by gradually refining an initial solution (Holsapple et al., 1993). Also adaptiveness must be understood from the user's point of view: an adaptive DSS enables the user to build an information environment based on his needs (Deutsch and Metelka, 2008).

THE PROBLEM

ShimaFilm Company was established in 1994 in Iran, which is known as the first Iranian VHS cassette producer. Then the company was expanded and started to produce replicated Compact Discs (CD) by the end of 1999 and Digital Video Discs (DVD) in 2003. Today, by initiating an audio and video recording studio, photography and designing atelier, and distribution channel, the company is one of the largest digital media producers in the region.
The production of CD and DVD takes place in four different stages with dissimilar production speeds (Figure 1). Orders differ by number and some orders should deliver at precise time (for example at least one day before first day of an exhibition). When a potential order comes, the marketing manager does not know exactly what time it can be delivered. In addition, the production manager does not know which production line should product, which order to do not delay the customer order. We present a decision support system (DSS) being developed to provide managers with an effective tool for this task.

FIGURE 1: SHIMAFILM COMPANY PRODUCTION SYSTEM



Product type and demand structure

The company offers two main kinds of productions, CDs and DVDs. Demand is specified in terms of kind (CD or DVD), quantity, printing (four or 5-color printing) and packaging (bulk, wallet and frame). In addition, the company has a costumer ranking system, so the priorities of orders differ. The customers are classified according to four criteria, which include loyalty, agreed price they can pay, their order size and their limitation in time. This classification leads to different priorities in production orders (normal, high and top priority), so the system changes its parameters and adapts itself related to background of each costumer.
The nature of products of this company is that it cannot be produced before finalizing the order and it cannot be stored. Because of the considerable variation in demand, the company management faces different decision-making problems.

Production facility

The production facility consists of six CD lines, seven DVD lines, one stereotype line, four offset printing and three packaging lines, each with its own capacity and production rate. Each line can be run on 1, 2 or 3 shifts operating mode depending on demand and raw material availability levels. The production rate will vary based on the operating mode.
The production is made of one primary type of raw material supplied by three major vendors. As it happens to raw material, the more expensive the quicker it can be supplied.

Planning the production lines

In producing these products, the company faces several decisions in order to take the advantage of the various planning trade-offs. Such decision involves: (1) prioritizing the orders, (2) timing and amount of production of each line in every stage, (3) raw material availability versus cost and (4) the best time for preventive maintenance.
On the other hand, the most important question each customer needs to know is that "what time, exactly, the order is ready?" The delay in delivery of orders leads to customer dissatisfaction so delivering the orders on time is the critical success factor and their core competency of ShimaFilm Company.

THE PROPOSED APPROACH

The proposed approach in this research consists of two main streams. First, one is designing the conceptual model and the second is developing the system.

Conceptual model

The basic problem from a user perspective is the production order. Actually, each production order can usually be decomposed into the production phases that can be individually assigned to different departments inside the firm.
Without considering any other aspect, orders could be in any array. If we denote the production order with *i*, the production line with *j*, the production phase with *k*, the production type with *l* and the priority of order with *m*. So the decision variable x_{ijklm} can be introduced. Being M the number of orders to be assigned, N the number of lines, O the number phases, P the type of product and Q the different priorities the solution space before considering any constraints has the cardinality of M*N* O*P*Q.
Possible choices for *j*, *k*, *l* and *m* are summarized in table 1, table 2, table 3 and table 4 respectively.

TABLE 1: PRODUCT LINE

j	1	2	…	20	21
meaning	1st CD line	2nd CD line	…	2nd packaging	3rd packaging

TABLE 2: PRODUCT PHASE

k	1	2	3	4
meaning	Production	Sterotyping	Printing	Packaging

TABLE 3: PRODUCT TYPE

l	1	2
meaning	CD	DVD

TABLE 4: ORDER PRIORITY

m	1	2	3
meaning	Normal priority	High priority	Top priority

Without considering any priority, orders arrange chronologically. Suppose there is a new order. Depending on previous orders and the priority of the new order, the system should plan the lines so the orders serve in optimum time. Depending on priorities previous production planning may change.

The orders, depending on their types and the stage, should go to correct empty lines. If there is not any empty line, the order should wait in queue. The program should check every order in the queue and find first order with lower priority. Then it should change the sequence of orders according to do the higher priority before lower priority orders. Start and finish time of all the orders should be calculated and renewed. If the new finish day shows a delay more than 10 days of agreed deliver day, then the priority of that order should change to a higher priority. Also by adding new data of each customer to database, the system should adapt itself and learn of current operations. According to production, planning the system should recommend an optimum time for raw material inventory replenishment. In addition, it should plan the preventive maintenance program.

DEVELOPING THE SYSTEM

The way of designing a DSS is different from that of a transaction processing system. A fundamental assumption in the traditional "life cycle" approach is that the requirements can be determined prior to the start of the design and development process (Alavi and Napier, 1984). However, Sprague (Sprague Jr, 1980) stated that DSS designers literally "cannot get to first base" because the decision maker or user cannot define the functional requirements of the DSS in advance. The proposed approach in this article is adaptive design process based on previous researches e.g. (Alavi and Napier, 1984, Keen, 1980) but it has been revised. In an adaptive design approach, the four traditional system development activities (requirements analysis, design, development, and implementation) are combined into a single phase, which is iteratively repeated in a relatively short time (Sprague Jr, 1980). We used a five phase system life cycle based on (McLeod Jr and Schell, 2001) which includes planning, analyzing, designing, implementing and use for each subsystem. In the planning phase, a general description of potential system described. In the next phase, analyzing, a detailed analysis of subsystem defined. Design phase included defining data needs of proposed subsystem. In implementation phase, the proposed subsystem based on data needs gathered in previous phase developed and link between the subsystem and total system made. The last phase was auditing, using and improving each subsystem.

The ADSS

The developed ADSS includes several modules and procedures, each of them allocated to a specific task. Each module is written so that its behavior is entirely specified through its interface. The main modules and subsystems are introduced below:

The graphical user interface module, which is the connection between system and users.

The database module that updates the database and knowledgebase.

Queuing module, which is a simulation module that calculate the start and finish time of each order (This module is the decision module).

Customer Prioritizing (CP) subsystem, which prioritize the customers (and subsequently the orders).

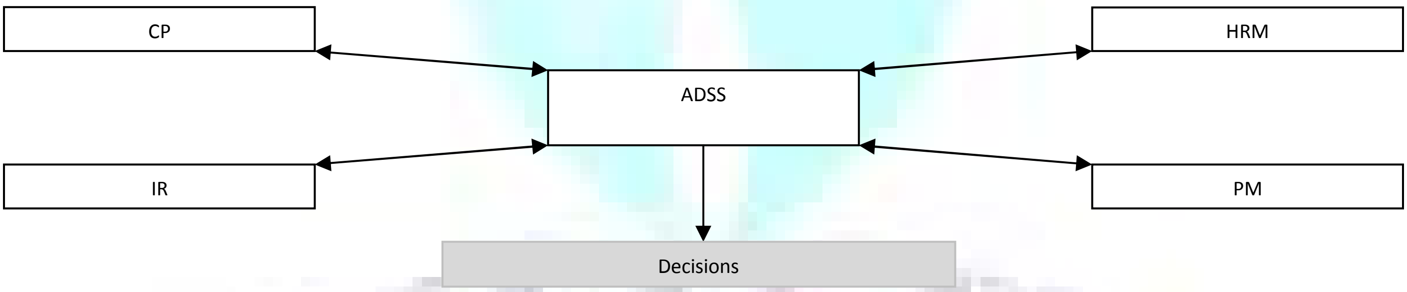
Human Resource Management (HRM) subsystem that plans the overtime work of operators.

Inventory Replenishment (IR) subsystem, which suggests optimum time for ordering raw material.

Preventive Maintenance (PM) subsystem that seeks for potential idle time of production lines.

The connection of subsystems is shown conceptually in figure 2, in which arrows show that the flow of data and information.

FIGURE 2: CONCEPTUAL SUBSYSTEMS



In the industry of producing CDs and DVDS, each customer should know the time that company can deliver his or her order. Many costumers tolerate an extra pay for taking their order sooner. On the other hand, some of them leave the company and go to competitor firms as the company cannot deliver the order on-time or he may claim against the company for delay.

While a potential customer negotiate with marketing manager, gives some data about the order and its properties. This is the time that marketing manager loads this data to the system, and system can provide different scenarios. The most generic scenario is that the order waits in the queue for its turn. Another one is the cheapest and often the slowest choice. If the customer be in a hurry he can select a top priority order but should pay an extra charge for human resource overtime work and sometimes the delay in other orders. The customer can select between scenarios. After the agreement about the conditions, this is the time for recording the order.

Now the DSS checks for inventory and if needed it can alert the inventory replenishment staffs. In addition, if the orders cannot be done in agreed time, the system plans the overtime of operators.

Before and after implementing this ADSS the satisfaction of two main interest groups, the marketing staffs and costumers, were measured. Statistics showed an 18 percent increase in staff satisfaction but about 40 percent in customer satisfaction.

CONCLUSION

This paper proposed and implemented adaptive design process in combination with traditional system life cycle to develop an ADSS to solve the problem of production planning in a manufacturing firm. It is assumed that under the condition of diversity in the orders, marketing manager does not know when the customer order can be delivered, inventory replenishment staffs do not know when, and how much they should order raw materials. In this occasion an ADSS, which mainly can plan the product lines, was developed.

One extension of the present study is implementing fuzzy logic in prioritizing the orders. Also by global use of internet, it is recommended that such systems designed for using in different production areas worldwide.

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