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Web-enabled Decision Support System for Warehouse Layout Problem

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Abstract: The warehouse layout problem includes assigning several different product types to confident areas of warehouse so that the cost of material handling from docks of the warehouse can be minimized. The layout of a warehouse may need to be modified to accommodate new product lines or to add more flexibility to the warehouse operations. In order to guarantee the success of a project, a detailed planning process should be followed. Concerning above, Decision Support Systems (DSS) are developed to assist company's personnel (e.g., engineers and decision makers) to modify the arrangement of warehouse layout. Lately, DSS have been affected by new information technologies in design, deployment and implementation. Developing Web-Enabled decision support systems is a comprehensive area under discussion that describes how to build data-driven Web-enabled decision support systems using web programming framework. Availability and easiness of interactions in such a DSS frame inspired us to focus on developing an online warehouse location problem to simply deciding about productions which are always traffic. So that user specifies the area of the warehouse in number of bays, places for docks around the warehouse, gives the frequency of their usage, along providing demands and required area for each product type. Then the problem will be solved quickly to find the proper location of each product type for minimum material handling cost and information would be deposited. We follow these processes through an example in web pages.

Key words: Integer programming, material handling, user interface, web programming, layout design

INTRODUCTION

Warehouses usually have three main parts including docks for loading/unloading products, areas for storing and the trucks that deliver/pick up goods which may arrive at one of the loading/unloading docks. Warehousing is considered as three main activities: (1) receiving products, (2) storing products until they are ordered by a customer and (3) retrieving the products. In warehouse managing, the operating staff should decide where to store the goods (Francis *et al*., 1992).

To find the best locations for assigning goods and products in warehouse area, minimizing transportation from loading and unloading bay to docks would be important in order to minimize either the cost of accessing products and transporting them to the dock or loading and conveying them from the dock to the storage area. As a result, goods and products compete for storage areas that are closest to the docks. However minimizing the goods and products traveling distance is not the only objective which should be put under consideration. A successful warehouse layout must achieve the following objectives, in spite of material being stored: maximize the use of space, maximize the use of equipment, maximize the use of labour, maximize accessibility to items and maximize goods protection (Francis *et al*., 1992).

Considering many difficulties in warehouse layout planning; like uncertainties and fluctuation in production demand, makes warehouse management crucial to provide flexible decision making system to support varying warehouse inventory. Necessity of decision support system in plant layout problems demonstrated by

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different researchers like Arinze *et al*. (1989), Francis *et al*. (1992), Deb and Bhattacharyya (2005). A DSS is not meant to replace a decision maker, but to extend his/her decision making capabilities. The decision maker had to choose a proper model for a given situation and formulating the final layout plans. The selection of an appropriate procedure is often difficult due to the fact that the solution procedures currently in use do not include many of the planning aspects of the layout problem (Arinze *et al*., 1989).

A DSS can be viewed as a more sophisticated Management Information System (MIS) that uses the data residing in spreadsheets and/or databases, models it, processes or analyzes it using problem specific methodologies and assists the user in decision-making process through a graphical user interface, since it requires the availability of platforms that allow the integration of various technologies (i.e., data, models and programming).

A DSS gives its users access to a variety of data sources, modeling techniques and stored domain knowledge via an easy to use Graphical User Interface (GUI) (Cohen *et al*., 2001). Engineers are frequently being employed in positions that require developing DSS, which are gaining widespread popularity. Nowadays more and more companies install Enterprise Resource Planning (ERP) packages and invest in building data warehouses. In this invest those who are able to create decision technology-driven applications that interface with these systems and analyze the data, they provide will become increasingly valuable (Dong *et al*., 2004). Indeed, imparting DSS development skills, which combine Operation Research (OR)/business abilities with Information Technology (IT) expertise will make engineers highly sought after in the modern workplace.

Building decision support systems is a challenging task that requires the availability of platforms that allow the integration of various technologies such as data, models, codes and etc. However, in the past few years, several platforms have become available that allow such integration. One such platform is Microsoft's. NET frame work. The Visual Basic. NET (VB. NET) package of the NET platform can be used in conjunction with Microsoft Access databases to build Windows based single-user database applications.

The Microsoft Access database allows data storage and VB. NET, an easy to learn and yet powerful Object Oriented Programming (OOP) language, allows us to design and build object models and develop professional quality GUI for applications. Further, Web programming has also become easier with the introduction of Active Server Pages. NET (ASP.NET). This NET package makes use of standard Hyper Text Markup Language or HTML (the front end) and VB. NET (the back-end) to deploy elegant and easy-to-build database connected web-enabled applications. Another powerful. NET package is Crystal Report. NET. Crystal Report package provides an ideal environment for creating reports and charts that can effectively summarize data. Thus, Microsoft. NET and Microsoft Access provides a platform in which fairly sophisticated DSS applications can be built (Dong *et al*., 2004).

This study intend to build a web-enabled decision support system that will allow warehouse managers to decide about allocating the storage space available to goods in such a way that the material handling costs are minimized.

DEFINITION AND CAPABILITIES OF DSS

It could be defined a DSS as a model-based or knowledge-based system integrated with a GUI and a data base, intended to support managerial decision making in semi-structured or unstructured situations (Turban and Aronson, 2001). A DSS is not meant to replace a decision maker, but to extend his/her decision making capabilities. It uses data, provides a clear user interface and can incorporate the decision maker's own insights.

Holsapple and Whinston (1996) identified four characteristics one should expect to observe in a DSS. Their list is very general and provides an even broader perspective on the DSS concept. They specify that a DSS must have a body of knowledge, a record-keeping capability that can present knowledge on an ad hoc basis in various customized ways as well as in standardized reports, a capability for selecting a desired subset of stored knowledge for either presentation or for deriving new knowledge. Moreover a DSS must be designed to interact directly with a decision maker in such a way that the user has a flexible choice and sequence of knowledge-management activities. There are several ways to classify DSS applications. The design process as well as the operation and implementation of DSS, depends in many cases on the type of DSS involved (Raja and Srivatsa, 2006).

Some key definitions for a DSS are supported as follow:

- A DSS brings together human judgment and computerized information for semi structured decision situations. Such problems cannot be conveniently solved by standard quantitative techniques or computerized

- A DSS is designed to be easy to use. Graphical capabilities, user friendliness and mutually communication between human-machine greatly increase the effectiveness of a DSS
- A DSS usually uses models for analysing decision-making processes and may also include components of knowledge
- A DSS attempts to improve the effectiveness of decision making rather than its efficiency
- A DSS provides support for various managerial levels from line mangers to top executives. It provides support to individuals as well as groups. It can be PC-based or web-based

WEB-ENABLED DECISION SUPPORT SYSTEM

Traditionally, MIS have been used for relatively simple data processing and data presentation. However, as these systems have become more popular and organizations have become larger and more complex, an enormous amount of data is generated routinely. That is when a need for well developed DSS is felt that can assimilate this data and derive meaningful decisions of managerial and economic significance. Today, the era of the Internet has taken information sharing to new heights, allowing billions of users to share information on the World Wide Web (www) simultaneously (Gregg *et al*., 2002).

DSS, which are now critical to the efficient functioning of any organization, need to be upgraded and must be web-enabled (Delen *et al*., 2007). Here, we will discuss the development of such Web enabled decision support systems.

A web-enabled decision support system is a DSS that can be accessed on the World Wide Web via Internet. A typical web-enabled decision support system requires data, a Data Base Management System (DBMS), a programming language and a mechanism for web-enabling (Power, 1998). A DBMS is used to store, manage and process the data, while a programming language is used to build GUI to do complex data processing and presentation and to incorporate external optimization engines. Several different software packages can be used to build such a DSS. While the combination of Microsoft Access (a DBMS), VB.NET (a programming language) and ASP.NET (a scripting language for Web-enabling) provides the suitable way for decision making, some conventional web-scripting environments like application service provider (ASP) and hypertext processor (PHP) are widely used yet by industrial engineers in crucial decision making in their careers. The web enabled soft wares are dynamic and rapidly evolving. This complex and dynamic computing environment, complex user requirements, new features noted by Mustafa *et al*. (2007).

Here, we want to call a developed mathematical model by using a web-enabled DSS which simply solves a layout problem in a warehouse to house goods and bays and as result would bring simplicity for user of supported organization. Regarding to expanded applications of this layout and location problem that is applied in web structure, this process would be applicable and efficient for other area and industries.

FRANCIS MODEL FOR WAREHOUSE LAYOUT

Assume that there are p items to be stored and the warehouse has r loading /unloading docks. Let w_{ik} be the total cost per foot incurred when item i is moved from its storage area to dock k. Typically, warehouses store items on pallets and w_{ik} is proportional to the number of pallet loads of item i moving between dock k and the storage area of i.

This problem is discretized by subdividing the floor area into q square grids of equal size, numbered in any convenient manner from 1 to q. Let F_i be the total number of grids required to store item i. Assume that:

$$\sum_{i=1}^{p} F_i = q$$

Let d_{kj} denote the distance between dock k and the center of grid j. The decision variables are as follows:

$$x_{ij} = \begin{cases} 1 & \text{if we store item i in grid square j,} \\ 0 & \text{if we do not store item i in grid square j,} \end{cases} \quad i = 1,\ldots,p; j = 1,\ldots,q.$$

As mentioned by Francis *et al*. (1992), the integer programming formulation of this problem is as follows:

$$\min : \sum_{i=1}^{p}\sum_{j=1}^{q} c_{ij}x_{ij} \tag{1}$$

Subject to:

$$\sum_{j=1}^{q} x_{ij} = F_i \qquad \text{for } i = 1,\ldots,p \tag{2}$$

$$\sum_{i=1}^{p} x_{ij} = 1 \qquad \text{for } j = 1,\ldots,q \tag{3}$$

$$x_{ij} \in \{0,1\} \qquad \text{for } i = 1,...,p; j = 1,...,q \qquad (4)$$

where:

$$c_{ij} = \frac{1}{F_i}\sum_{k=1}^{r} w_{ik} d_{kj}$$

is the average cost for locating item i in grid j, assuming that each item is equally likely to be loaded or unloaded from each dock. The objective is to minimize the average material handling costs at the warehouse. The first set of constraints shows that the space occupied by an item should be equal to the space required for storing the item. The second set of constraints shows that in a particular storage area we can store only one item. The last set of constraints is the binary constraints.

This problem is an instance of the transportation problem. Many heuristic procedures have been developed to solve this problem. We use a heuristic method which is explained in the below:

The problem assumes that:

$$\sum_{i=1}^{p} F_i = q$$

therefore, we know that all the space available will be used. Sort the coefficients c_{ij}-s in ascending order. Start with the minimum c_{ij} and assign item i in grid j. Continue assigning the items to grids. Note that if grid j* is already assigned to an item, grid j* will not be available for the next assignments. Also, after each assignment of item i* the amount of that item available for the next assignments is reduced.

WEB-ENABLED DECISION SUPPORT SYSTEM DEVELOPMENT

Decision support systems that are built using web programming can be called web-enabled DSS. Web pages are appropriate for building a DSS with small or even models, for building a DSS prototype or for testing the DSS models, etc.

Here, Francis model for warehouse layout adapted to graphical user interface using PHP in local network designed for Mazandaran Wood and Paper Industry (MWPI®). The project conducted in a period of two months. Developed web-enabled decision support system will allow authorized users to make proper decision on warehouse layout (Fig. 1).

In this program, which developed to ease decision making for warehouse managers and staff, to cope with variation in inventory level; the user specifies the area of the warehouse in number of bays, places the docks around the warehouse and gives the frequency of their usage, along with the demand and area required per product type. Then the problem will be solved to find the best locations (Fig. 5) of each product type for minimum material handling cost.

Warehouse layout: initial data: In initial data web page, user will be ask for specifying warehouse characteristics in dimensions, number of docks and number of products. By submitting these data to system, user could be able to see the area of warehouse (Fig. 2).

Warehouse layout: bays and docks: User will need to place each of docks around the perimeter of the warehouse area (Fig. 3). The entire area of the warehouse is shown in this window to ease user in indicating the exact location of docks. Notably each numbered unit is a bay.

Complete the dock table by specifying which bay the dock is adjacent to and the frequency with which this dock is used. Absolutely these frequencies should sum to 100%. After accomplishing this process, user will navigate to next web page.

Warehouse layout: product information: For each product type, the required area (number of bays) and the daily demand should be entered (Fig. 4). This daily demand signifies the priority of this product type; it is a key value in determining the location of product types to reduce material handling cost.

Final warehouse layout: As it could be seen in Fig. 5, this is the final warehouse layout. Each product type which represented by a different color (P1, P2 and P3) is assigned to an area of bays. Note that product types with highest demand are closest to docks of highest frequency.

Proposed system is applicable in unstable situation in aid of system efficiency. Whenever one of warehouse/products characteristics changed (demand variation for products, duck's frequency of usage or even number of products user can Resolve the problem. If it is needed, user can force some product type assignments before resolving, It is possible for user to click on a product type from the legend and then click the bay in the Resolve Layout grid.

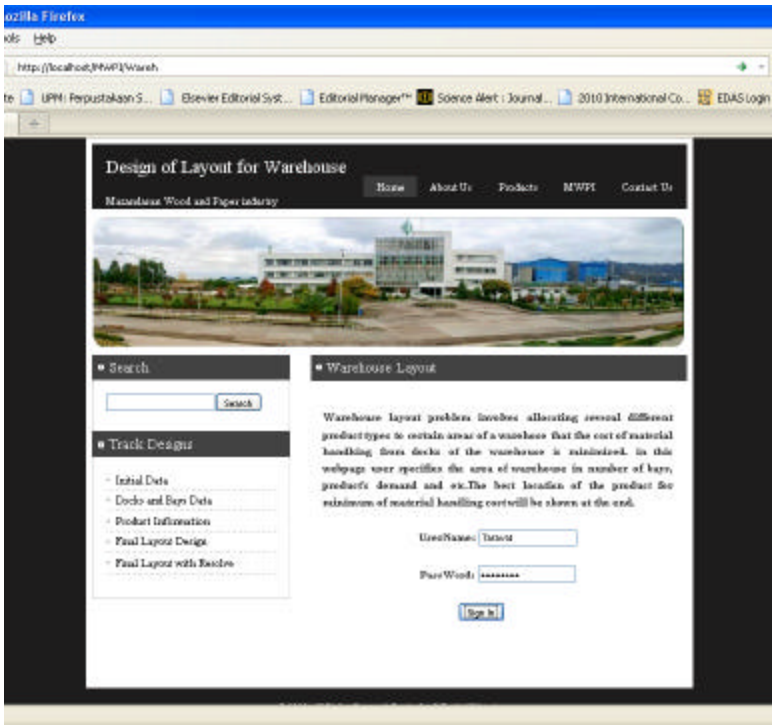

Fig. 1: Welcome page

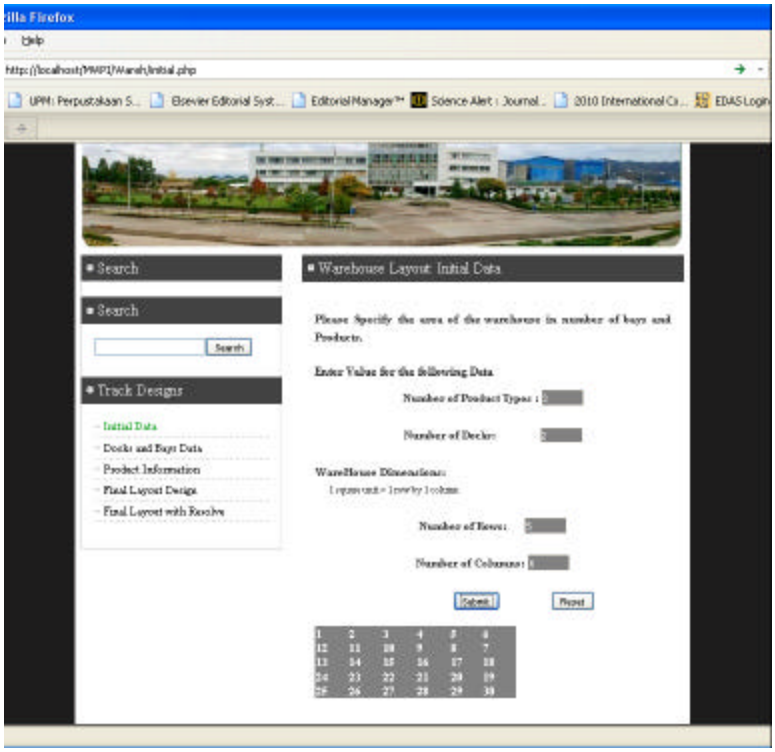

Fig. 2: Input initial data web page

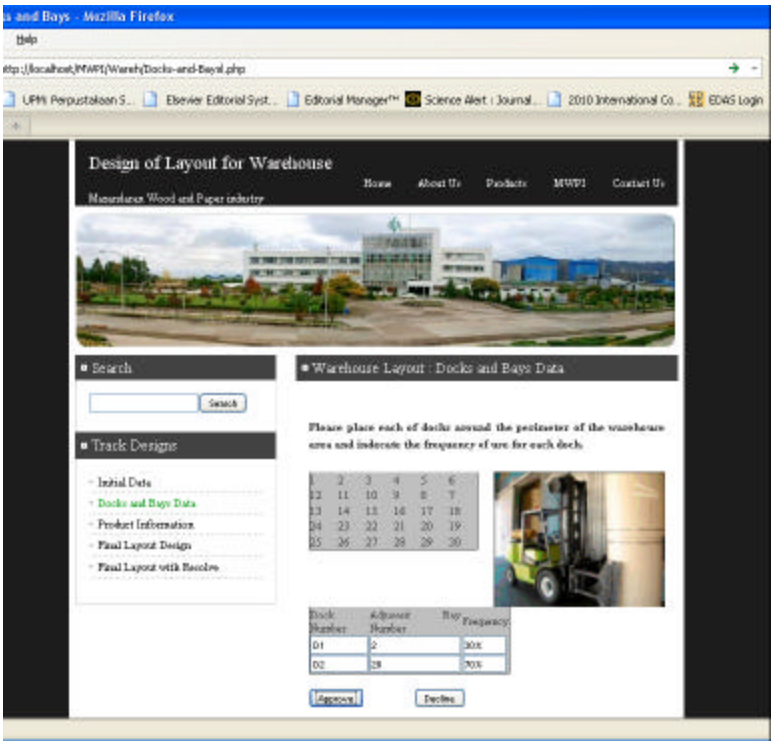

Fig. 3: Docks and bays information web page

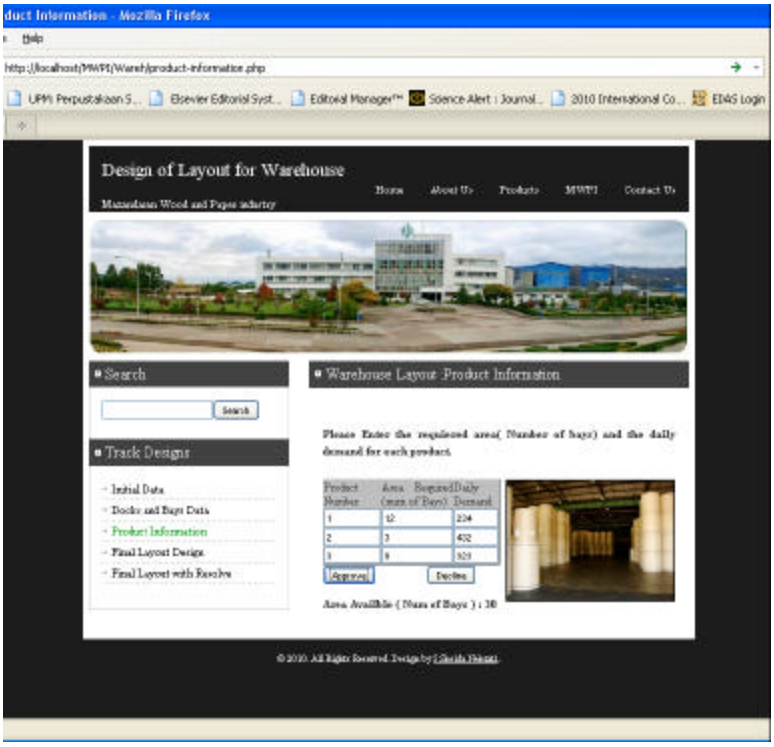

Fig. 4: Product information webpage

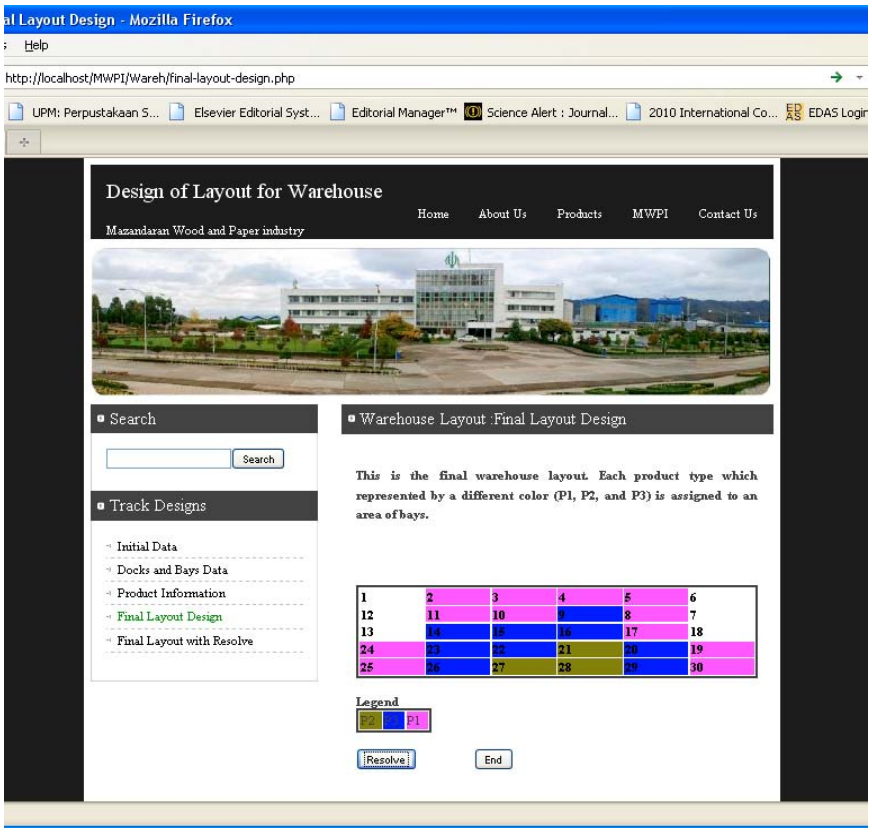

Fig. 5: Final layout webpage

CONCLUSION

The main purpose of DSS is to support managers in decision making process, to improve the quality of their decisions and to reduce the necessary time to make a decision. DSS improve managers' activities and the way the problems are solved, especially in unstable situations such as fluctuations in demand which leads to uncertainties in warehouse layout decision making process. The practice of building Decision Support Systems can benefit in many ways from the increased availability and growing sophistication of Web technologies (Sundarraj, 2004; Zhang and Goddard, 2007). These technologies provide independent platform, allocated and remote computation and the multimedia information transformations. System maintenance is simplified and centralized, letting end users focus on problem analysis and decision making. Current study tried to apply a web-based decision support system for a practical problem which usually occurred in manufacturing systems. The designed DSS helps to save time in overcoming the complexity of the location problem regularly.

While there is significant promise in the idea of Web-based Decision Support Systems, there are also some important challenges that must be overcome. We need to resolve technological, economic and social and behavioral challenges to realize the benefits the web can provide as a platform for building Decision.

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