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INTEGRATED MODELS FOR WAREHOUSE DESIGN AND PLANNING

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ABSTRACT

Market competition requires continuous improvement in the design and operation of supply chains. Warehouse management is a field of interest for both practitioners and researchers and involves material, information and financial flow management in a highly dynamic environment. Designing and planning a warehouse (distribution centre) involve different levels of decision-making, with high levels of interactions and interdependencies. So, to ensure an efficient performance of the warehouse, decisions having a significant impact on each other must be integrated. The aim of this work is to develop integrated models capable of capture the complex tradeoffs of a warehouse system.

INTRODUCTION

With many markets becoming volatile and unpredictable, warehouse management turned out to be a key aspect within agile supply chains. Although many companies have examined the possibilities of direct supply to customers, there are still many circumstances where this is not appropriate. According to Bartholdi and Hackman (2006) there are four main reasons why warehouses are useful: to consolidate products in order to reduce transportation costs and to provide customer service; to take advantage of economies of scale; to provide value-added processing and to reduce response time. Thus, warehouses will continue to be an important node of the logistic network.

In distribution logistics where market competition requires higher performances from warehouses, companies are compelled to continuously improve the design and planning of logistics operations. Furthermore, the ever-increasing variety of products, the constant changes in customer demand and the adoption of management philosophies also bring new challenges to reach flexible structures that provide quality, efficiency and effectiveness of the logistics operations. In practice, warehouses must be modular, adaptable, compact, accessible, and flexible and must be capable to respond to changing conditions, to improve space utilization and to reduce congestion and movement.

WAREHOUSE DESIGN AND PLANNING

Warehouse design and planning typically runs from a functional description, through a technical specification, to equipment selection and determination of the layout.

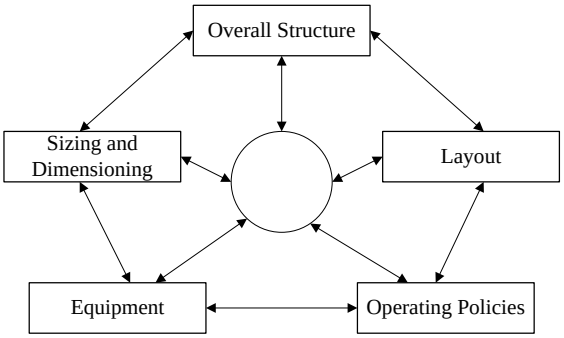

Figure 1: Warehouse Design Problems (Gu *et al*. 2007)

Figure 1 illustrates the five major decisions involved in warehouse design according to Gu *et al*. (2010). The overall structure decision determines the materials flows patterns within the warehouse, the specification of functional areas and the flows between areas. Sizing and dimensioning decisions determine the total size of the warehouse as well as the space allocation among functional areas. Layout definition is the detailed configuration within a functional area and equipment decisions define an automation level for the warehouse and identify equipment types. Finally operating policies refer to storage, picking and routing decisions.

Hassan (2002) presented a framework for the design of warehouse layout. The proposed framework accounts for several factors and operations of warehousing such as:

1. Specification of warehouse type and purpose;
2. Analysis and forecasting demand;
3. Definition of operating policies;
4. Establishment of inventory levels;
5. Class formation;
6. Definition of functional areas and general layout;
7. Storage partition;
8. Selection of equipments for handling and storage;
9. Design of aisles;
10. Determination of space requirements;
11. Location and number of I/O points;
12. Location and number of docks;
13. Arrangement of storage;
14. Zone formation.

Once warehouse decisions are strongly interrelated, warehouse design is a highly complex task where frequently conflicting objectives impose specific trade-offs.

INTEGRATED DECISION MODELS

At all decision levels warehouse managers have to tackle inventory management problems and warehouse management problems. In the former managers have do decide which products and the quantities of each product need to be stored. In the latter it must be decided where to assign the products within the warehouse.

Although interrelated, up to now, those decisions were dealt independently in a pyramidal top-down approach. Strategic policies create limits to decisions taken at the tactical and operational levels and tactical decisions limits operational decisions. Also decisions taken at each different level are handled independently and sequentially (Berg 1999b).

The majority of scientific research studies addresses isolate problems. However, most real problems are unfortunately not well-defined and often cannot be reduced to multiple isolated sub-problems. Therefore, warehouse design often requires a mixture of analytical skills and creativity. Anyhow, research aiming an integration of various decisions models and methods is badly needed in order to develop a methodology for systematic warehouse design (Rouwenhorst et al. 2000).

To accomplish our purpose we have to:

1. Identify and characterize logistic operations within a warehouse at strategic, tactical and operational level
2. Model, in an integrated way, some of the design and planning decisions in a static environment;
3. Develop suitable methodologies to solve the static models;
4. Integrate dynamical aspects such us demand and inventory levels in different periods;
5. Develop suitable methodologies to solve dynamic models;
6. Finally, validate the models.

In order to solve these models we will study and use Operational Research techniques such as Mathematical Programming, Heuristics or Simulation.

CONCLUSIONS AND FUTURE WORK

Developing a general model which includes all the elements of a warehousing system is rather difficult because of the tremendous amount of existing alternatives. More research is needed on the integration of various models and methods in order to develop a systematic warehouse design methodology. Such research is needed to fill an important gap between the scientific literature and the practice of warehouse design and management. In particular, research attention on operational decisions where the different processes are jointly considered and problems are placed in their dynamic nature is still needed.

The above considerations allow us to claim that there exist many challenging research opportunities for developing more global warehouse decision support models.

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