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Concept of Bills of Material for Supply Chain Planning and Its Prototyping with ERP

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Abstract

By applying the concept of distribution BOM (D-BOM, for short) , we show that whole supply chain planning with MRP can be implemented in a commercially available enterprise resource planning package, SAP R/3. We will investigate the applicability of D-BOM to R/3 by actually implementing D-BOM and related routings with work centers to model supply chain process. It will be turned out that D-BOM with routings is a suitable basis for integrated planning mechanism of supply chain as a whole, and that what function is necessary to enhance MRP to supply chain planning.

Keywords Supply chain planning, MRP, ERP

1. Introduction

A supply chain has a whole logistics process that consists of many firms. Firms in supply chain of our time have respective information systems. Thus, the implementation of coordination mechanism for SCM needs to consider such information systems.

In the history of production logistics, so-called traditional methods of inventory control have been developed. They are reorder point, base stock, economic order quantity (EOQ) and other methods[1, 2, 3]. They are effective in the economic environment that demand is stationary and random around its mean value. As computers came out into business, material requirements planning (MRP) had been invented. The reason to use MRP is that required numbers of parts of a finished product are dependent on the finished product. In other words, they are not independent, while they are considered as independent in traditional inventory methods. Adoption of MRP has something to do with the industrialization of the society in the sense that finished product such as washing machines have complex structure and then they and their part are relatively expensive, so that redundant inventories cannot be acceptable.

As is well-known (e.g., [1, 2, 4]), in order to use MRP of a typical manufacturing planning software, we need BOMs (bills of material) of products, routings of operations with work centers, inventory, and planned receipt. The MRP had been developed into ERP (enterprise resource planning software), or MRP II.

The development of SCM research had not been synchronous to that of inventory management and MRP in production logistics. Under the condition of relatively stable demand with randomness, control policies of inventory management for the whole supply chain were investigated by many researchers. For instance, Simchi-Levi et al.[5] presented the bullwhip effect in a supply chain and Hopp and Spearman[3] showed optimal order quantities of multiple products in two-stage supply chain. The planning information systems for SCM are not well investigated yet, though the practical importance has been identified by academic and business people. This gap, in part, comes from the fact that the firms in a supply chain are economically independent. They usually make independent decisions on their purchase order. So, the whole supply chain cannot be forced to use a single supply plan. But this situation can bring much unnecessary inventories of items in a supply chain. Therefore, we need to investigate what and how we can achieve the balance between satisfactory service level and less inventory in a supply chain, by introducing information systems. A planning information system is especially promising, because the experience of MRP and ERP in inventory control of production logistics has been cultivated.

Optimization of inventory level and order quantity in supply chain usually contains combinatorial complexity, because both values are not continuous but discrete. An advanced planning and optimization (APO, for short) can be used for that complexity by using genetic algorithm. Wood[6] considers optimization of the distribution process of a firm, not of a supply chain, with APO of SAP. Kawai and Sato [7] investigated more complicated phenomena of supply chain planning. They showed that if the whole supply process of an simple chain (consisting of a supplier and a manufacturer) is not fine-tuned in capacity and inventory level, then using MRP-based planning systems in both firms does not allow us to see stable behavior in purchase and production orders and inventories of both firms.

Thus, planning systems in a supply chain should be coordinated and integrated to attain certain optimality. In this research, we try to clarify the structure of the planning system for a whole supply chain to make this kind of coordination possible.

More concretely, we propose a structure of basic supply chain, and then show how the structure is effectively implemented in commercially available ERP. The structure is called distribution BOM (D-BOM, for short) with related routings, work centers, and operations in a supply chain. After Tanaka [8] had proposed D-BOM, it had not been implemented, at least, in an ERP. This research for the first time shows how it can be implemented. At the same

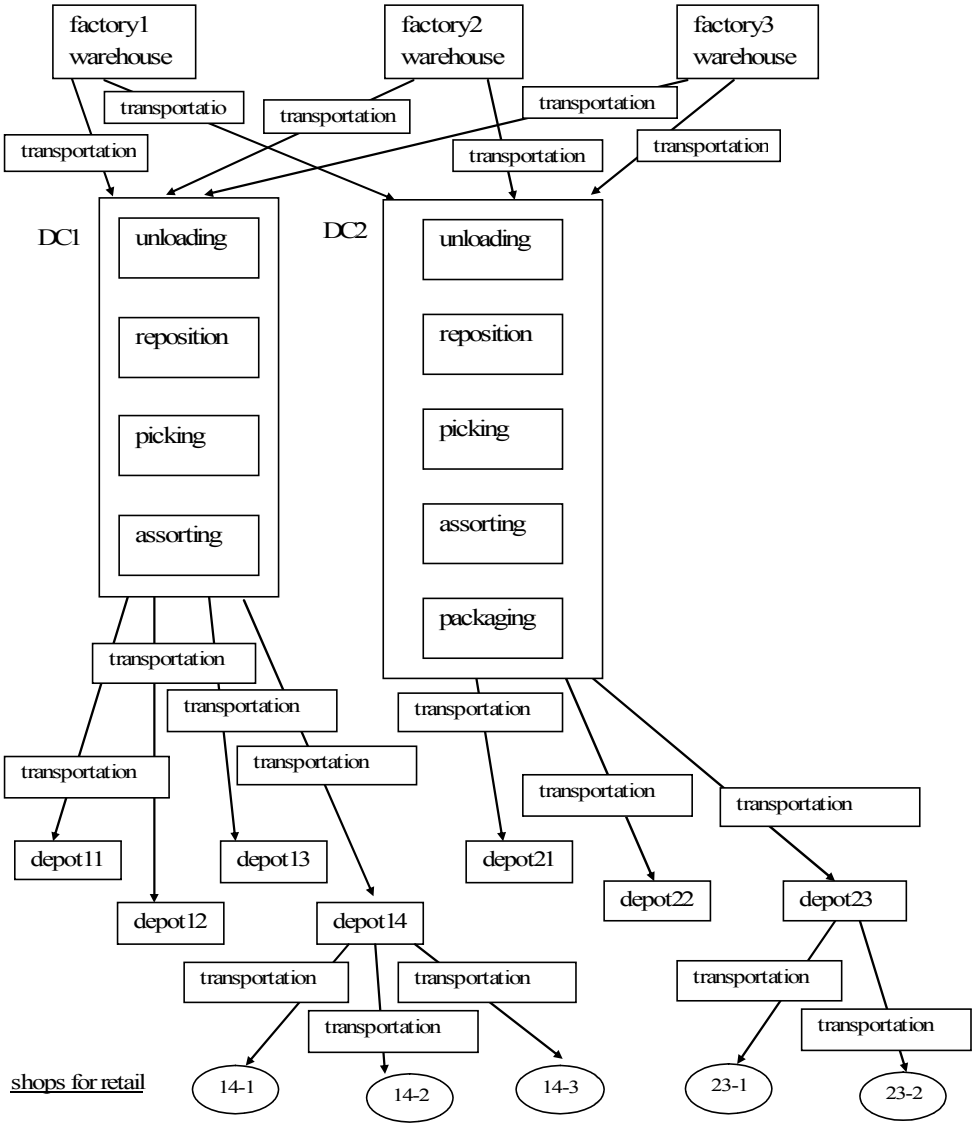


Figure 1. Factory warehouse and distribution: DC(distribution center), depots and shops

time, it will be turned out that what additional function is necessary for standard function of ERP to coordinate plannings of both supply chain and production process. Since this research will provide a concrete way of supply chain planning with ERP, it is expected to be a first step to attain the optimal supply chain planning as a whole.

2. Structure of Integrated Planning System for Supply Chain Process

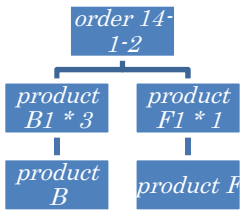
2.1 Organizations and Distribution Flows in Distribution Process

Figure 1 shows a typical example of distribution process. It is an adaptation of Tanaka [8]. The followings are the characteristics of the example, while many of them are general in distribution processes.
Three factories are manufacturing the products. The factories are numbered as 1, 2, and 3, respectively. Each factory has in-house warehouse for finished products.
Flow of products in the process are:
Suppliers --> Factories --> Plant Warehouse --> Distribution Centers (DC) --> Depots --> retail shops
All plants (i.e., factories) deliver their products to all distribution centers. A distribution center has its corresponding depots. The correspondence had been decided by geographical location.
A depot has its corresponding retailer shops as customers. Again, the corresponding had been decided geographically.

2.2 BOM Representation of a "Distribution Product": D-BOM

In our integrated planning system, a retailer's order is considered as a distribution product. A distribution product will be completed when a required number of products are delivered in the specified place at specified time. In other words, a distribution product is a combination of products, place, and time.

An order from a retail shop is a distribution product that can be modeled as a BOM. It is called distribution-BOM (i.e., D-BOM). We think that each D-BOM has three levels. Fig.2 represents that the shop 14-1 issues an order which requires 3 pieces of product B and 1 piece of F. (The rightmost digit "2" of order 14-1-2 indicate that is the second order of 14-1.) Since DC and depots are logically connected, based on physical location, this three level structure of D-BOM is used. Figure 0 is considered as the common basis for respective routings for D-BOMs. Although a different firm has different distribution network, any distribution BOM can be modeled as BOM with three levels like Figure 2, where the low level concept of usual MRP is used.



low level 0: Customer Order

low level 1: Distribution Center

low level 2: Factory Warehouse

Figure 2. D-BOM: Order 14-1-2

2.3 Structure and Naming Rule for Low Level Code of D-BOM

Low Level 0: "order 14-1-2"

A D-BOM consists of three level. The top level is 0. A customer order at level 0 is denoted as like "order 14-1-2", which shows the shop 14-1's, 2nd order for Dept 14. The shop 14-1 is always delivered from the depot, 14.

Low Level 1: "product B1 * 2" and "product F1 * 1"

At level 1, the corresponding DC and its depot is considered and represented. The order 14-1-2 has "product B1 * 2" and "product F1 * 1". Here, "B1 *2 " represents that 2 pieces of the product B in DC 1 are required for "order 14-1-2". It is assumed that DC1 is responsible for Depot 14. As like "B1*2", "F1*1" shows a piece of the product F in DC 1 is required for order 14-1-2. Notice that this low level can be split to two levels for DC and depot. For example, DC1 and depot 14 are recognized.

Low Level 2: "product B"

At level 2, "product B" represents that the product B in the warehouse of a factory. If the product B is manufactured only in the factory 1, then the warehouse is of the factory. If B is manufactured in both factories 1 and 3, then it should be decided which factory will respond to the order.

2.4 Other Examples of D-BOM

Figure 3 is an order from 14-1-1 that consists of product A, E, and F, while order 22-1-1 is an order for 22-1 for one piece of F.

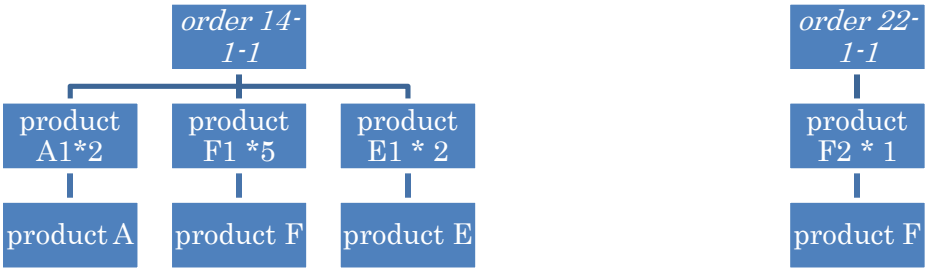


Figure 3 Order 14-1-1 and Order 22-1-1

3. Prototyping of D-BOM with ERP

In this section, implementation issues for D-BOM and integrated planning of distribution and manufacturing is considered. Screenshots of prototyping with SAP R/3 will be shown in the presentation.

In order to use a usual MRP calculation for the integrated planning and following management, distribution process should be modeled as a virtual manufacturing process. It means that a customer order in the form of D-BOM should come up with routings of the D-BOM components, and that each of the routings consists of logistics operations on logistics work centers. Those operations and work centers are of distribution centers and of depot, say, in Figure 1. This situation is modeled in Figure 4, whose data structure is the same as usual MRP-related components in SAP R/3. Thus, this model of distribution requirements can be dealt with manufacturing.

From the database point of view, D-BOM and the routings are added in R/3. Since production data for the manufactured products already exist with their primary keys that are called material numbers in R/3, components in D-BOM are newly created and yet should have some relation to the original product. This relation is not maintained in the prototype right now. If a material number were, say, P-500, then the corresponding components in D-BOM is DP-500 so that we can see the relation. In this sense the current prototype is incomplete.

When we use the proposed method for integrated planning of distribution and manufacturing, MRP calculation is two fold. Calculation with D-BOM and its routings is first. And then, based on the schedule, MRP calculation for manufacturing with production (manufacturing) BOM and its routings will follow. Figure 5 depicts the situation. Key mechanism for integration is the usual function, "stock/requirements list" function of R/3. It shows for each of material the schedule of input and output, requirements, and completion of production, as well as inventory at hand.

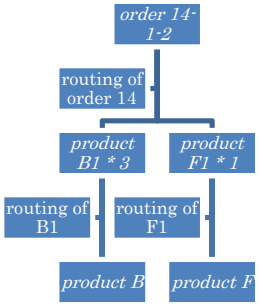


Figure 4. Routings of D-BOM components

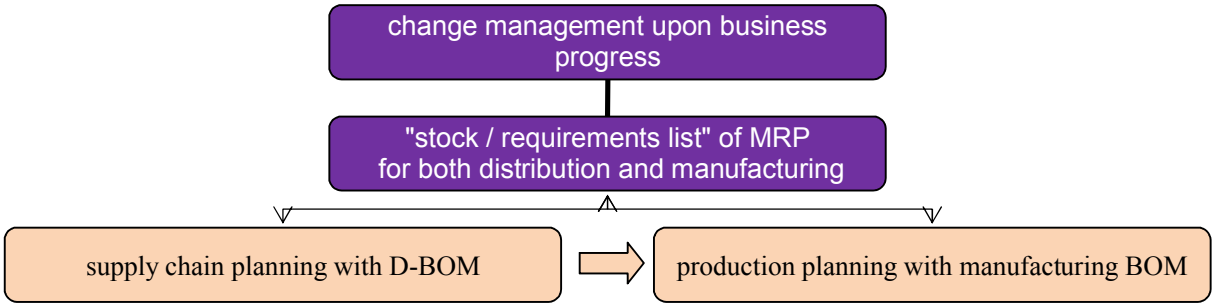


Figure 5. Integration with D-BOM and manufacturing BOM

4. Conclusion

The concept of D-BOM, that is originated by Tanaka [8], has been developed in this paper so that a planning information system for the whole supply chain can be practically implemented. The MRP mechanism [1, 2, 3] is used to coordinate manufactures, warehouses, and retailers of the supply chain. In order to use MRP for a whole supply process, distribution processes needed to be formulated with those MRP's components. By adapting and developing the concept of distribution BOM (D-BOM, for short) that is originated by Tanaka [8], we first showed the formulation, and then its implementation in the most-used enterprise resource planning package, SAP R/3 [9]. We have investigated the applicability of D-BOM to R/3 by actually implementing D-BOM and related routings with work centers to model supply chain process. It has been turned out that MRP is a suitable basis for integrated planning mechanism of supply chain as a whole. We can see planning information of both distribution and production in the system's "stock/requirements list" function.

We have proposed that any D-BOM has just three low levels, because geographical connection between central warehouses (i.e., distribution centers) and depots are fixed. It implies that material handling and transportation from a distribution center to a fixed depot can be thought of fixed time. This idea is based on Tanaka. In other words, the concept of distribution BOM has something common with that of module where variant BOM is effectively used.

By using the prototyping of D-BOM with ERP, the integration of D-BOM and manufacturing BOM in SAP ERP is effective by using the MRP function of the ERP. The procedure is shown in Figure 5. First, supply chain planning with D-BOM is executed. Based on the result, usual production planning with BOM and MRP follows. Since the components of D-BOM and corresponding routings have the same structure as that of usual MRP, and since ERP has many advantageous features of MRP calculation, we can implement D-BOM in a usual ERP.

MRP is a nice mechanism for planning production. Some say that many manufacturers do not directly use MRP result in daily operation. Even in those cases, and according to Monden [10], MRP-related data can be used to calculate and/or check the required capacity for a planned quantity for a half a year, or a month. This is also true for integrated planning for supply chains.

As future topics, more convenient planning operations with ERP is needed. It may requires programming of ERP so that more smooth planning operation of supply chain and production logistics. The other topic is application of throughput control to supply chain dynamics. The key concept, in that case, will be the critical cycle of business processes[11]. Such consideration is inevitable in designing the supply chain to attain target throughput as well as minimum-necessary inventory.

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