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A generic bill-of-material processor using indirect identification of products

H. M. H. HEGGE

Abstract. The industrial product market has become more demanding over the last decade. In particular, the number of product variants within a product family has increased very quickly. Therefore, the description of product variants in terms of product data and product structure has become a problem for existing production/inventory control information systems. In the first part of this paper we develop a classification for the existing solutions in the literature. In the second part we describe another solution, the generic bill-of-material, using indirect identification of products. The generic bill-of-material provides the user with a means of describing a large number of variants with a limited amount of data, while leaving the product structure intact.

1. Introduction

The industrial product market has become more demanding over the last decade. The demand for industrial products has become more diverse. In other words, the products supplied are more customer specific, which means that more variants of one basic product are being developed.

This diversity in end products has enormous implications for the different functions within a company. For example:

- the product development department has to design more product families rather than end products;
- the production department will be assembling more to customer order;
- the sales department will be able to offer more alternatives to meet a customer's wishes, each alternative having its own specific price and delivery time;
- the service department will have to manage more, different configurations with their service/installation instructions and service parts.

The *product family* will be a key concept in this paper. Roughly speaking it refers to a set of similar product types which can be described by different means. The simplest means is by giving a set of code-numbers of the product types involved. Another method is by using parameters. Further methods will be investigated in this paper.

The variety of end products will usually also mean a greater variety of components, so not only do we have product families at end product level, but also at component level. This is argued in depth in Veen (1992).

Of course all this has repercussions on the information systems that support the functions within the company. The core of these systems is formed by the product and process knowledge recording systems. In this article we shall be confining ourselves to product knowledge.

Product knowledge, or the description of a product with all its variants, is also known as the *product model*. The product model does not only describe the characteristics of the product in terms of drawings, tolerances,

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etc., but also describes the structure of the product. This includes a description of the components from which the product is made In this paper we are mainly interested in the product structure

In a company with few products and few variants the product structure will usually be a parts list (bill-of-material) With a sharp increase in the number of variants, and as a result a sharp fall in the number of customer orders per possible end product, this recording method ceases to suffice

In the first part of this article we shall be developing a classification system for the product models for recording the structure of product families We shall be using this classification system to classify a number of product models known in the literature (Veen 1991, Wedekind and Muller 1981, Schönsleben 1985, Carruthers 1976, Daniels). In the second part of the article we shall go on to describe a new product model, the generic bill-of-material, using indirect identification of products.

2. Product family and variant identification

A product family can be defined as a group of more or less similar products A product belonging to such a family is a variant of this product family A product family is usually developed from a basic product. This is why the variants differ only slightly in terms of product structure. A model of a product family is a *product family bill-of-material* (PFBOM), from which the bill-of-material of a variant can be derived by means of a variant identification

2 1 *Identification of a variant*

There are different ways of identifying a variant within a product family We can illustrate them with the example of an office chair product family This product family has initially two variants, one in red and one in blue The product structure of the red variant is graphically represented in Figure 1. The blue variant differs from the red one in colour of the material used for the upholstery of the seat and the back of the chair

The simplest way of identifying a variant is by means of giving each variant a code-number This kind of identification treats the variant as an independent entity We will call this way of identification *direct* For the direct identifying of the red chair variant we can use the code-number 5612R and for the blue one 5612B

The second way of identifying a variant is by means of enumerating all the components of the variant involved Hence we call this identification *indirect*. This kind of identification treats only the component of a variant as an independent entity. For the indirect identifying of a variant we use the parts list The indirect identification of the red chair variant is the parts list given in Figure 2.

This type of identification is used in several MRP II packages for end product variants (Veen 1991) All that is necessary for identification purposes is to include those components in the parts list that cause the variation in the product family What this means for the example in Figure 2 is that the red seat and the red back alone are sufficient to identify the red chair We can use this form of identification in the recording of a customer order, for example We can generate a complete parts list for this specific customer order using this form of identification

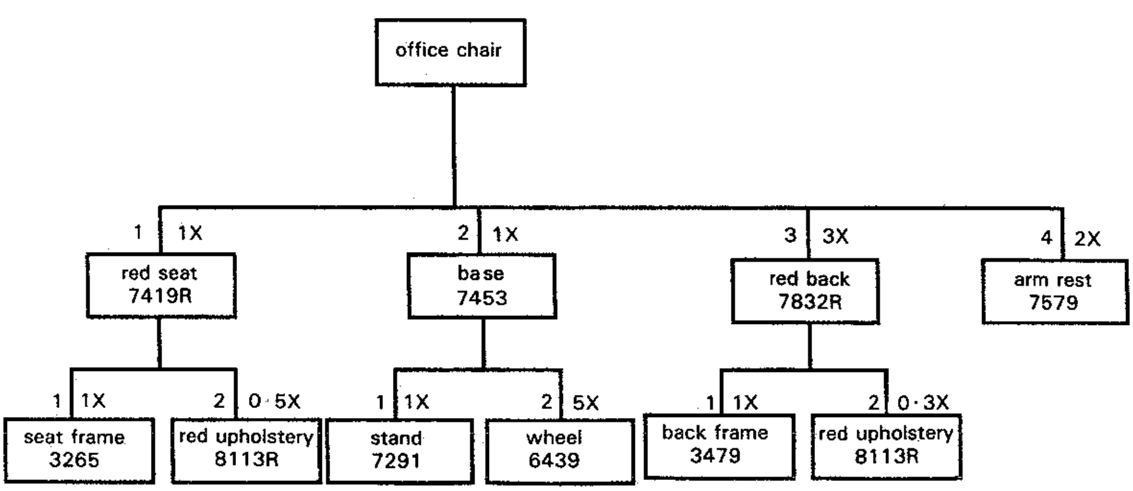

Figure 1 Product structure of a red chair

Product family : office chair Red variant			
Serial number	Component number	Description	Quantity
1	7419R	red seat	1
2	7453	base	1
3	7832R	red back	1
4	7579	armrest	2

Figure 2 The indirect identification of a red chair

and the parts list system And then we will be able to produce this customer order.

Wedekind and Müller (1981) use indirect identification to describe a variant within a product family.

A third way of identifying a variant occurs if a product family is treated as an entity. To identify a variant within such a product family we use *parameters* Each of these parameters has a list of possible parameter values The identification of a variant consists of two parts The first part is the identification of the product family involved The second part consists of a set of parameter values For each parameter of the product family one parameter value must be present in this second part

In our example the product family has just one parameter, i e. colour The associated parameter value list contains the colours red and blue. The identification of the product family 'office chair' is 5612G The identification of a red chair could be shown as follows· 5612G [red].

Schönsleben (1985), van Veen (1991), Carruthers (1976) and the SCOUT package (Daniels) make use of this parameter description for identifying a variant

A fourth way of identifying a variant is a combination of the indirect identification and the identification using parameters This fourth identification consists of an enumeration of all the components These components belong to component families. Each component variant is identified by the parameter identification in terms of the parameter values of the component family involved Here the component families are treated as the independent entities A component family may contain just one variant, of course In this case, a parameter is then unnecessary for identifying the component variant

By using this kind of identification in our example there are four component families, seat, base, back and armrest The component families are coded with four-digit numbers followed by the letter G The families seat and back contain each two variants and use the parameter COLOUR for describing the variants The other two families contain each only one variant As mentioned above, there is here no need for parameters

Summarizing the above-mentioned identifications we set up a scheme shown in Figure 3 The first dimension of this scheme distinguishes between direct and indirect identification The second dimension of this scheme distinguishes between identification with and without parameters In this scheme we show the four different identifications for a red chair The two dimensions of this scheme can also be interpreted as two characterizations of PFBOM systems.

Identification	Without parameters	With parameters
Direct	5612R	5612 [red]
Indirect	7419R 7453 7832R 7579	7419G [red] 7453G 7832G [red] 7579G

Figure 3 Four different identifications for a red chair

In addition to the above two characterizations of variant identification, there is a third characterization that is important for proper view of the supply of product family bill-of-material systems. This third characterization divides the PRBOM systems into systems with the option of product families at component level and systems without this option In the first case, it must be possible to use the same identification technique for both the end product and the component product families The identification technique is used *recursively* in this case At the same time an end product variant must be able to use components that have been defined as variants within a component product family. For example, if we take the case of the direct identification with parameters, Figure 3 shows the way the red variant of the chair is identified The red seat is a component of the red chair As shown in Figure 1, the red seat is assembled from the seat frame and the red upholstery If the identification is here recursive, the same kind of identification may be used for the red seat as for the red chair The direct identification with parameters of the red seat is 7419 [red]. An example of such a system is that developed by van Veen (1991)

3. A new product model for describing product structures

3 1 *Introduction*

In this section a new product model, the generic bill-of-material, will be described Three kinds of identification, which have been discussed above, are applied in the generic bill-of-material concept

A *generic product* (GP) is a set of products with more or less the same structure A generic product can be a set of end products, a set of primary products or a set of subassemblies A generic product can contain one or more products.

Since from our point of view the structure of a product is expressed in the bill-of-material, the products belonging to a generic product will have to have more or less identical bill-of-materials. We call the generalization of such more or less identical bills-of-material the *generic bill-of-material* The representation of such a generic bill-of-material consists of two entity types, i.e generic product and generic bill-of-material link

The entity type 'generic product' represents the sets of similar products We shall elaborate on this below

The entity type 'generic bill-of-material link' records the link between a generic parent and a generic component The meaning of this link is that there is ***at least one*** bill-of-material link between some parent belonging to the generic parent of the generic bill-of-material link and some component belonging to the generic component of the same generic bill-of-material link This is in contrast to the way in which van Veen (1991, p 108) defines the generic bill-of-material link Van Veen assumes that there must always be a link between each parent of the generic parent and a component of the generic component belonging to the same generic bill-of-material link

3 2 *Basic idea*

Each variant of a generic product has a more or less identical structure The differences between the generic product variants manifest themselves in the choice of the variants of their generic components These differences in turn manifest themselves by their component variants Ultimately, we can reduce the variant differences to the variants of the generic products at the lowest level of the generic bill-of-material, the generic primary products

The basic idea behind the generic bill-of-material can therefore be formulated as follows·

> The variation within a generic product G is only caused by the variation in the generic primary products at the beginning of the paths running from the generic primary products to the generic product G in the generic bill-of-material

The significance of this idea will become apparent as this article proceeds

3 3 *Generic primary product*

Generic primary products are found at the lowest level of a generic bill-of-material set A generic primary product consists of a number of variants of a primary product, such as upholstery in the example A *generic primary product* (GPP) is therefore a set of all the variants of a primary product So the GPP 'upholstery' is the set (red upholstery, blue upholstery)

Direct identification of the variants within a GPP makes use of code numbers only Another way of describing a variant within a GPP is to use parameters in addition to a code number for the GPP In other words, a list of parameters is assigned to each GPP And each parameter has a number of parameter values going with it A GPP variant can be identified by any permitted combination of parameter values. For example, the GPP 'upholstery' can be described by the code number 8113G and by the parameter 'COLOUR' with permitted values (RED, BLUE) A particular variant is obtained by choosing one permitted value for 'COLOUR'

A GPP may also contain just one variant A parameter description is then unnecessary The code number of the primary product can serve equally as the code number of the GPP. Take, for instance, the primary product seat frame The seat frame has no variants Which is why the GPP 'seat frame' 3265G only has one element, i e. 3265

The only requirement made of the parameter description of a GPP is that it produces only one and not more than one variant, if each parameter has received a value in a permitted combination This requirement applies only if we want a fully specified product It does not apply to non primary generic products

3 4 *Generic assemblies*

A *generic assembly* (GA) contains assemblies put together according to a more or less identical bill-of-material In order to identify variants within a generic assembly we can, for example, assign to each variant a code number

Since the bill-of-materials of the variants are approximately the same with a GA, the variation within a GA comprises the variation within its GPPs Another form of identification is therefore of interest here, that is, indirect identification We shall illustrate this with the example of the red seat

A fundamental question for identification of a variant within a GA appears in this example· how does the red seat differ from the blue seat? The answer is that one primary product differs in the two assembly variants, i e upholstery The red seat has red upholstery and the blue seat has blue upholstery For identification of the red seat therefore it is sufficient to say that a variant of the GA 'seat' contains the red variant of the GPP 'upholstery' In other words, indirect identification and parameter identification are combined. This combination is used for the identification of a GA variant This form of

Serial number	Generic product number	Description	Parameters	Parameter value
1	7419G	seat		
1	3265G	seat frame		
2	8113G	upholstery	COLOUR	RED

Figure 4(a) Identification of a red seat

Serial number	Generic product number	Description	Parameters	Parameter value
1	7419G	seat		
.2	8113G	upholstery	COLOUR	RED

Figure 4(b) Identification of a red seat (without common generic components)

identification is shown in Figure 4(a) for the red seat The generic products are coded with four-digit numbers with the letter G for generic Indirect identification requires the indication of the path between the GPP and the GA This is what happens in Figure 4(a) under the heading serial number The seat frame is not necessary for identification of a seat because there is a seat frame in all the seats (Figure 4(b)) We call generic components such as these common These common generic components will not appear in the identifications from now on

3 5 *Paths*

Using the example below, we will show that the identification of a variant requires the use of paths

This example is the identification of a chair with a red seat and a blue back. The generic bill-of-material for this chair can be shown in the multilevel explosion in Figure 5 Provided we make the code numbers generic or add a letter G to them Since the GPP 'upholstery' appears twice in this bill-of-material, two choices have to be made

Serial number	Generic product number	Description	Parameters	Parameter value
1	5612G	chair		
1	7419G	seat		
.2	8113G	upholstery	COLOUR	RED
2	7832G	back		
2	8113G	upholstery	COLOUR	BLUE

Figure 5 Identification of a red chair with a red seat and blue back

as well, i e. one of upholstery for the seat and one of upholstery for the back In this example we must choose both the red upholstery for the seat and the blue upholstery for the back. This is why two paths have been included in the identification of the chair with the red seat and the blue back in Figure 5

A specification of a GA variant is complete once all the GPPs at the beginning of the associated paths have been specified

3 6 *Generic primary product co-ordination*

It often happens that several GPPs of a GA have the same parameters It is sometimes necessary that the parameter values chosen for identical parameters of these GPPs be the same for a particular GA variant To make this possible, we place the co-ordination for these parameters at the lowest common generic parent of the GPPs in question We call this form of co-ordination *GPP co-ordination*

With our chair, we might find it necessary for the colours of seat and back to be the same In that case, the colour will not have to be chosen twice, just once The choice of colour must be done at the first common parent of the seat upholstery and the back upholstery. This means that the choice must be made at the GA 'chair' itself The parameter COLOUR will therefore have to be linked to the GA 'chair' Consequently, the parameter COLOUR is not just a parameter for the upholstery, but also a parameter for the chair

3.7 *Inheriting*

Where a parameter is defined at a common parent for the co-ordination of several GPPs, those GPPs will then have to have the choice of parameter value passed on to them We call this process *inheriting*. The parameter to be co-ordinated will therefore have to be present for all the GAs on the path between a GPP to be co-ordinated and the relevant common parent All these GAs will inherit the chosen parameter value

Applied to the example above, the GAs 'seat' and 'back' will have the parameter COLOUR, as they are on the paths upholstery – seat – chair and upholstery – back – chair respectively Identification of a chair with red upholstery consequently becomes a very simple one, see Figure 6

With the introduction of GPP co-ordination·

- the number of possible variants will diminish;
- identification will move to a higher level in the generic bill-of-material

Serial number	Generic product number	Description	Parameters	Parameter value
1	5612G	chair	COLOUR	RED

Figure 6 Identification of a red chair

- the number of parameter values to be chosen will diminish

3 8 *Specialties of a generic product*

A generic product is a set of products If one or more parameters have been assigned to a generic product, then we can easily distinguish subsets These subsets, the *specialties* are described by specifying the values of these parameters A specialty may be empty or contain one (a singleton) or more variants If all the parameters of a generic assembly have a value, this does not necessarily mean that a variant has been specified. The subset thus arising will usually contain several variants This is due to the fact that it is highly likely that there are other parameters to be specified at lower levels of the generic bill-of-material

If all parameters of a generic primary product have received a value, the resulting specialty will be empty or singleton Consequently, if a generic primary product has specialties, then one or more of these specialties will be an empty one or a singleton If a generic primary product has no specialties, the GPP has only one variant For example, the seat frame is such a GPP

To demonstrate this, we shall have to expand the example of the chair somewhat The chair can be supplied in a movable and a non-movable variant Swivel and non-swivel variants can also be supplied This is made possible by introducing a number of variants of the stand and of the wheel

The wheel is a generic primary product with the parameter MOVABLE with the values YES and NO With this parameter there are two subsets, i e singleton (the movable wheels) and an empty set (the non-movable wheels). The stand has two parameters· MOVABLE and SWIVEL The associated values for the two parameters are YES and NO

The co-ordination of the parameter MOVABLE must take place at the lowest common parent of the wheel and the stand· the base. This is why the base acquires the parameter MOVABLE As a result we can distinguish two specialties· the movable and the non-movable bases. Each of these specialties has two variants: the swivel and the non-swivel variant. The parameter SWIVEL is not defined at the level of the base, since this parameter only occurs with the stand The value of the parameter MOVABLE will be passed on from the base to the wheel and to the stand

The specialties of the GPPs appearing in an identification of a variant are empty sets or singletons. If this is not the case, then the identification is *incomplete*. An incomplete identification can sometimes be useful during the design phase of a product

As an illustration of the above example, see Figure 7, which gives an identification of a blue, movable and swivel chair Note that a specialty is recorded on each identification line and is characterized by the parameters and parameter values on the end of the identification line If we pass along an identification path from a GA to a GPP, then the number of GPP variants within the specialties on that path will diminish or remain the same If we look, for example, at the number of variants of the stand on the path shown in Figure 7, then we can see the following The first specialty on the path is the blue chair This blue chair specialty contains all four variants of the

Serial number	Generic product number	Description	Parameters	Parameter value
1	5612G	chair	COLOUR	BLUE
1	7453G	base	MOVABLE	YES
2	7291G	stand	MOVABLE	YES
			SWIVEL	YES

Figure 7 Identification of a blue, movable and swivel chair

Identification	Without parameters	With parameters
Direct	Seat frame 3265G	Red upholstery 8113G[colour = red]
Indirect		Movable and swivel base 1 7453G[movable = yes] 1 7291G[movable = yes, swivel = yes]

Figure 8 Three different identification types used in the generic bill-of-material

stand The second specialty, the movable base, contains two stand variants, i.e. the movable, swivel and the movable, non-swivel variants Finally, the third specialty, the movable and swivel stand, contains just one variant

3.9 *Three possible identification types in the GBOM*

In section 1 of this paper we give four different types for identification of variants within a product family In the generic bill-of-material concept we use three of these types.

Some components of the chair are characterized in Figure 8

4. Concluding remarks

The generic bill-of-material provides the user with a means of describing a large number of variants with a limited amount of data, while leaving the product structure intact. For this reason the generic bill-of-material is especially suitable for describing the variants of a product family

The generic bill-of-material can be used for describing both end products and components Generic components already recorded can be used again at once for describing new product families

Owing to lack of space a number of aspects of the generic bill-of-material have not been dealt with here, including·

- description of interfaces between parent variants and component variants;
- recording non-permitted parameter value combinations;
- inheritance mechanism between parent and component;
- use of numerical parameters;
- use of algorithms for deriving parameters from other parameters

A prototype for a GBOM database has been assembled using a 4GL tool Some applications have been implemented, such as a configurator and a bill-of-material generator A number of practical examples of product families have been successfully implemented A major test example of a generic product, an office island with 300,000 possible variants, has been set up

In our present research we are working on a material requirement planning system using the generic bill-of-material

References

CARRUTHERS, J M., 1976, Product structure charts· key to designing and controlling modular bills-of- material *APICS Conference Proceedings*.

DANIELS, G , undated, *An Integrated Industrial Production Planning and Control System with a 'Generic' Product Structure* (in Dutch) (Datanorm Software GmbH, Freiburg).

ORLICKY, J A., PLOSSL, G W , and WIGHT, O W., 1972, Structuring the bill-of-material for MRP *Production and Inventory Management*, 13 (4), 22–27

SCHÖNSLEBEN, P , 1985, *Flexible Production Planning and Control With the Computer* (in German) (CW-Publikationen, Munich)

VEEN, E A. VAN, 1991, Modelling product structures by generic bills-of-materials Thesis, Eindhoven University of Technology.

VEEN, E A VAN, and WORTMANN, J C , 1992, Generative bill of material processing systems *Production Planning and Control*, 3, 314–326.

WEDEKIND, H , and MÜLLER, T., Parts list organization with large numbers of variants (in Germany) Angewandte Informatik, 9/1981, pp 377–383