An Object-Oriented Model for Strategic Analysis

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Abstract

Strategic analysis is a domain in which human expertise and experience are key factors. This is the reason that attempts have been made to automate the strategic analysis by expert systems. This article means to capture the expert knowledge to be used in an expert system with the focus on an object-oriented model of the domain. Based on this OO model an expert system can be developed that is able to analyze a corporate enterprise with several Strategic Business Units each of which carrying more than one product at a time. Such an expert system would be able to analyze the various synergetic aspects.

1. Introduction

The aim of this research has been to design and develop an object-oriented model in the domain of strategic analysis. This has been achieved in two steps. First an OO model has been designed and developed that serves as a backbone for the expert system to be developed. This model is not only crucial to the technical development of the expert system. It also forces the domain expert to carefully design the domain in terms of classes, instances, procedures and mutual relations, which will enhance the quality of the final model considerably. Next, based on this model a prototype expert system has been developed employing expert rules more or less modeled after the assertions as being used in an existing computer program, Business Insight [Business Insight, 1993]. This commercially available product is described as an *'expert system for strategic analysis'*. There are two fundamental differences between Business Insight and the expert system that is discussed at the end of this article. Firstly, unlike Business Insight, this prototype expert system is based on an object-oriented model. A second difference concerns a modification of the reasoning process. Since the prototype expert system does not support inexact reasoning, the rule base easily tends to get unmanageable. The number of combinations in the premise could lead to an unacceptable large number of expert rules, but these can be cut back dramatically by applying a kind of pattern recognition when considering the premise of an expert rule. The latter technique is also applicable in other applications with the same characteristics.

In the next section a brief overview is presented of expert systems in the field of strategic analysis. Since the expert system discussed in this article is merely modeled after the knowledge present in Business Insight, it is essential to consider several aspects of this commercial expert system in more depth. This is the main subject of section 3. The design and develop-

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ment of the object-oriented model that serves as the backbone of the prototype expert system are discussed in section 4. In section 5 the various components of the prototype expert system are considered. The emphasis is put on the way the expert rules are represented and the inference methods are employed. It is also explained that the proposed method is generally applicable in other domains with similar characteristics. Finally, in section 6 the results are summarized and conclusions are drawn with respect to further research.

2. Strategic analysis and expert systems

Strategic analysis is a field of marketing that is very well suited to be modeled by expert systems. It is a field that is characterized by uncertain or incomplete knowledge and an analysis of an enterprise's strategy is considered a genuine human task. The analyst's experience and expertise are generally considered indispensable to judge the many facts and circumstances that enter into an enterprise's position, for now and in the future. For example, Porter's SWOT analysis (Strengths, Weaknesses, Opportunities and Threats) [Porter, 1985], being a part of the strategic analysis, offers a handle to analyze the position of an enterprise, but it is still the analyst's task to find and weigh all relevant, contributing factors. Expert systems claim to be able to model an expert's knowledge and expertise and to act like an expert and consequently should also be able to generate helpful advice in this field.

Yet, in literature relatively little attention has been paid thus far to the applicability of expert systems in this specific field. Since the introduction of knowledge-based systems in marketing in the late eighties, a growing interest emerged in expert systems, mostly as a part of decision support systems. In [Walden, 1992] expert systems are introduced in Strategic Market Management and the report *Knowledge-Based Systems in Marketing* [Wierenga, 1992] presents a thorough study of the (potential) role of expert systems in this field of applications. Wierenga states that *"… Marketing is much too broad to develop 'General Purpose Knowledge Based Marketing Systems' …"*, and enumerates a number of domains in which special purpose expert systems could be successfully applied such as sales promotion, advertising, personal selling, analysis of scanning data, brand management, new product introductions and, last but not least, competitive strategies. He found 27 expert systems in marketing: sales promotion (25%), monitoring markets & report writing (19%), advertising (15%), media planning (11%), new products (11%), automated data analysis (7%), negotiations (4%), strategy (4%) and prediction (4%). Unfortunately, only a few of these systems reached the operational stage. Most of these have not passed (yet) the phase of prototype system.

A few more remarks can be made. By far the majority of the expert systems (more than 90%) acquired the knowledge either from general scientific knowledge or published literature, by informal interviews with professionals or by expertise of the authors themselves. Also, a considerable number of systems was not or only to some extent validated. Most of the expert systems were based on expert rules, but only 15% were based on an OO model.

Also more recent publications indicate that an increasing amount of expert system research is being conducted for a diverse range of business activities [Wong & Monaco, 1995]. For example, a hybrid system for strategic marketing planning [Duan & Burrell, 1995] that aims to provide a structured marketing planning process, guide a user through this process, offer expert advice at key stated and finally make recommendations for users in setting objectives and strategies. It combines the advantages of the expert system and decision support system technology in order to enhance its effectiveness. Another expert system is one in strategic marketing with the objective of helping marketing managers to analyze the position of their company relative to their competitors, in a particular business or product area, and then suggesting ways in which this position might be improved [Moutinho, Curry & Davies, 1993]. It is interesting to notice that this subject has a lot in common with the commercially available product Quick Insight [Quick Insight, 1995], developed by the same company that developed Business Insight.

Concluding remarks are that hardly any expert systems concern strategic analysis and that in general an OO approach is not common, and that most expert systems in the field of marketing found in literature have been developed by using some (advanced) expert system shell.

3. Main aspects of Business Insight

One expert system in strategic analysis is Business Insight that is - according to its developers - *'A business factors analysis tool that is used to gather knowledge and formulate strategies for business planning'*. In figure 1 an overview of a number of functions of Business Insight is given. Data concerning all kinds of aspects is input (Data Input); altogether about 400 questions have to be answered subdivided in 8 categories: Enterprise Information, Product or Product Line, Market Definition, Marketing and Sales, Competition, Production, Suppliers and Financials. As an example, figure 2 shows how to input the value for the attribute *CommitmentToIndustry*.

After this tedious and time-consuming task has been completed there are several options possible. One is the function *Summary provides critique* that provides an analysis of the company with its pros and cons based on the input data and a large number of assertions (expert rules). Hypertext links guide the user back to the data through these assumptions. There are several other helpful functions, for example to perform what-if analyses, to provide a summary of highlight and lowlights, inconsistency-checking, etc. These features are quite often illustrated with helpful presentations in the form of tables, charts or graphs. Business Insight's functionality is based on several strategic models, in particular on the one of Porter [Porter, 1985]. This model basically distinguishes three strategies: Differentiation Strategy (e.g. the strategy is directed to carrying a unique product), Cost Leadership Strategy (e.g. the emphasis is put on low costs and cost control) and Focus Strategy (a particular part of the market).

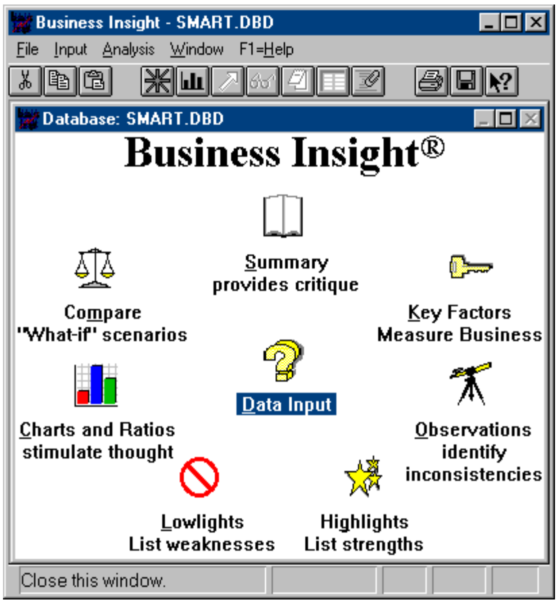

Figure 1. *Overview of the functionality of Business Insight*

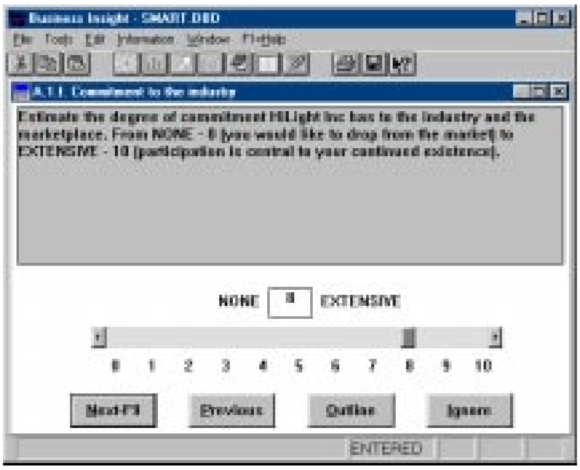

Figure 2. *Data input for the variable Commitment to Industry*

Business Insight's expert tasks involve a reasoning model that combines input data and a number of assertions based on these models, ultimately leading to a strategic analysis and advice. Although the assertions (contained in what may be compared to a rule base) are not explicitly provided to the user, with some effort a few hundred of these assertions can be extracted. One example of such an assertion is given in section 3.1.

It is beyond the scope of this article to discuss Business Insight in depth. However, it has some restrictions. The analysis is restricted:

1. to only one enterprise at a time;
2. to only one product at a time.

The first restriction means that for a corporation with several Strategic Business Units (SBUs) each of these units can be analyzed separately by Business Insight, but possible synergetic aspects cannot be taken into account. Secondly, if one single enterprise is considered, its strength in relation to only one product at a time can be considered and possible effects of carrying more than one product at a time cannot be analyzed. Another minor restriction is that Business insight does not regard the branch of industry of the enterprise and, consequently, its characteristics and developments cannot be taken into account while analyzing a specific enterprise belonging to this branch of industry.

It is our view that the quality of the analysis will enhance if an expert system can deal with an enterprise carrying more than one product at a time, can consider the synergetic effects of several Strategic Business Units and can take the effects due to its environment into account. For this reason it was decided to develop and design a prototype expert system that could also cope with these aspects.

The model of an enterprise in an economical environment has many hierarchical relations (e.g. the class of managers is a subclass of the class of employees which on its turn is a subclass of the class of persons; similarly, the class of SBUs is a subclass of the class of enterprises as are the classes of suppliers and competitors) and deals with many instances (e.g. two or more actual enterprises as elements of the same object class, two or more managers as elements of the same manager's class). For this reasons it was considered to be the best choice to develop an OO model that will serve as a backbone for this new expert system. The advantages are the same as for OO modeling in general: it facilitates the description of the domain resulting in a better model, and better reusability and maintainability of (parts of) the final product.

Most of the variables used in Business Insight have been incorporated as attributes (also called slots) in the OO model, be it that their place in the OO model quite often differs from their place in Business Insight.

3.1 Domain knowledge and assertions

The domain knowledge of Business Insight is said to be based on many strategic models of which the one of Porter is prevailing. Since the domain knowledge itself is no subject of research in this article, it is not further discussed here. Relevant to mention is that the assertions (a type of expert statements that may be compared with expert rules in conventional expert systems) in Business Insight are the main (and only) knowledge structure and actually represent the knowledge base. Although the data input process is organized in eight blocks with several sub-blocks, the assertions are not based on some object- or frame-based knowledge structure. We can illustrate this with the following example assertion:

Enterprise Strength
1. Enterprise has limited capacity to be leader in low-cost (30,10)
2. Enterprise cannot construct entry barriers to competition (35,10)
3. Enterprise is not prominent (47,10)
4. Enterprise has poor ability to sustain position (48,10)
5. Enterprise has a capable management team (57,10)
6. Enterprise has sufficient infrastructure to support activities (62,6)
7. Enterprise has significant freedom of action (64,6)
8. Enterprise has significant capacity to differentiate (69,10)
9. Enterprise has no outstanding legal problems (75,3)

This assertion concludes about the strength of an enterprise based on nine clauses that on their turn are conclusions of other similar assertions. The first of the two numbers associated to a clause indicates how true it is considered in the enterprise under consideration (on a scale ranging from 0 to 100), the second number how relevant this clause is to the conclusion to be drawn (on a scale ranging from 0 to 10). For example, clause 6 states that the actual enterprise has sufficient, i.e. more than average (64), infrastructure to support activities and this aspect is considered of more than average (6) importance to the strength of the enterprise. In this case the strength of the actual enterprise is considered to be less than average, namely 43 (also on a scale ranging from 0 to 100), calculated according to the principle of weighted means: (30*10 + 35*10 + … + 75*3)/900 = 43.

The inference is of type forward chaining, meaning that based on the input data the assertions are executed. After an assertion is dealt with the conclusion is drawn in the way that is explained above.

3.2 Some observations of Business Insight

The first and most important observation has already memorized. Business Insight is not able to analyze an enterprise carrying more than one product at a time, nor can it analyze more than one enterprise at a time. These restrictions can be easily removed by employing an object-oriented domain model of the enterprise with all its necessary aspects such as products, employees, management etc. and its environment concerning competitors, suppliers, customers, market and branch of industry, etc.

A second observation concerns the fact that the assertions (of which the one in section 3.1 is an example) in Business Insight differ from a conventional expert rule. Such a rule is a knowledge structure with a premise part and an action part. The premise is a (fuzzy) Boolean expression that can found to be true in which case the action(s) will be executed. Both the clauses of the premise and the various actions are generally based on a data model, sometimes of the type object-attribute-value or in more advanced systems object-oriented. Although a Business Insight assertion undeniable aims to do the same, in effect it is processed differently (as described in the previous section).

Thirdly, it is important to notice that the input data and the assertions in Business Insight are considered as facts. A specific aspect is given certain relevance (the second number) and its actual value (the first number). Although strategic analysis is a domain in which the expert's experience is considered to be crucial, Business Insight does not have a certainty model incorporated. So, assertions cannot be given a degree of uncertainty, nor is the case with input data. Despite this lack of uncertainty, Business Insight can deal with incomplete knowledge. For example, some aspects of the enterprise may have been ignored (either not known or not relevant) but Business Insight nevertheless succeeds to come to a number of conclusions.

A final observation concerns the fact that Business Insight does not seem to be developed by a dedicated tool for knowledge processing (e.g. an expert system shell); it is a special purpose software package. On the one hand this has the obvious advantage that the system can be designed and developed tailor-made. On the other hand, modern knowledge tools provide a great degree of freedom in designing and developing expert systems while offering many predefined knowledge structures and procedures such as object classes (with their attributes and methods), instances (elements of the object classes), expert rules, inference techniques (backward/forward chaining), agendas, interfaces to databases and other programs, etc. Using these knowledge tools reduce the costs of development considerably.

3.3 Conclusion

The four observations discussed in the previous section gave rise to the present research. Based on the expert knowledge contained in Business Insight an OO-model has been designed and implemented that structures the domain knowledge in terms of (hierarchies of) classes, attributes (or slots), instances and procedures or functions. This model serves as a backbone of the prototype expert system that incorporates expert rules.

4. An OO model of the enterprise and its environment

This section will discuss the object-oriented model on which the OO expert system is based. More details of this model can be found in [Jellema, 1997]. First, in section 4.1 some introductory remarks are made about OO modeling and design techniques for object models, and the Object Modeling Technique (OMT) is discussed. In section 4.2 the model itself is presented.

4.1 OO modeling and OMT

In the context of this paper we confine ourselves to discuss those aspects of OO modeling and OMT that are relevant to understanding the subject. Important notions of OO are - of course - the objects, which can loosely be defined as a representation of some coherent set of data and processes in some problem domain. Such an object mostly is a member of a class of objects and is often referred to as an instance. An object is described by a number of attributes (also called slots). Crucial to OO modeling is its capability to represent the various relations between objects, such as aggregation and inheritance. An example can be found in a sub-model of the enterprise, see figure 3.

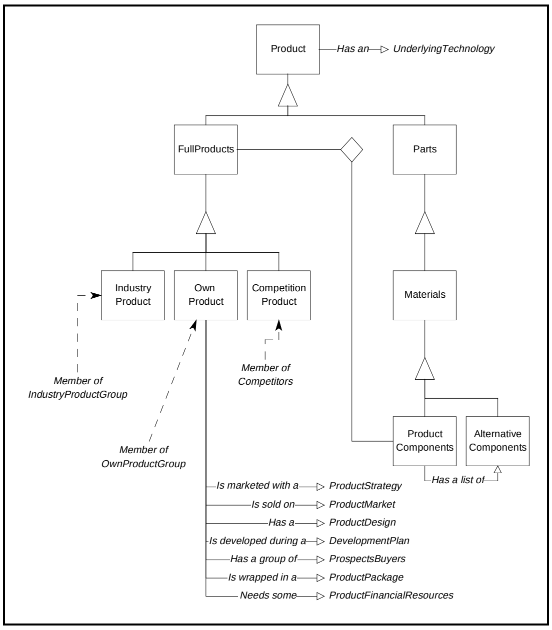

Figure 3. *The class structure for Product*

The class of objects *Product* has two subclasses, *FullProduct* and *Parts*, inheriting all attributes, methods and messages from *Product*. The subclass *FullProduct* itself has again three subclasses, *IndustryProduct*, *OwnProduct* and *CompetitionProduct*. It can also be noticed that *FullProduct* consists of a number of *ProductComponents*, which is a subclass of *Materials*, etc. In the figure there are links to other object classes: Product has a link to *UnderlyingTechnology*, and, for example, *IndustryProduct* is a member of the *IndustryProductGroup*. When a domain has to be modeled in an object-oriented way, it is not only important to be able to identify the relevant objects with their attributes and relations. It is equally crucial to have a consistent notation technique available. In [Rumbaugh, 1991] extensive attention has been paid to object modeling and design and OMT (Object Modeling Technique) and to the concepts on which this notation is based (OMT distinguishes between static and dynamic models, but in this context the static will be adequate). A few of the most relevant OMT notations are given in figure 4. Now, the diagram given in figure 3 can be better understood.

4.2 The OO model

The model is too big to be discussed in full detail. It consists of more than 110 classes, almost 100 instances and more than 700 slots. Globally, it consists of 17 separate groups of object classes; i.e. a group contains a number of object classes that are closely related to each other. Important kinds of relations are inheritance and aggregation. Other types of relations (links) are defined between the various groups. One such group is depicted in figure 3, which describes the relevant relations concerning the object class *Product*. The object classes used are given in the table 1.

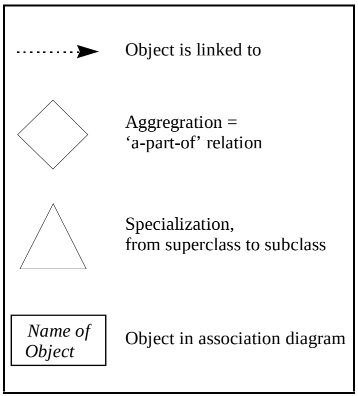

Figure 4. *Some relevant notations in OMT*

1.	*Analysis*	7.	*Group*	13.	*Program*
2.	*Design*	8.	*Market*	14.	*Resources*
3.	*Enterprise*	9.	*Package*	15.	*Strategy*
4.	*Enterprise Process*	10.	*Plan*	16.	*Technology*
5.	*Equipment*	11.	*Person*	17.	*Industry and Product Market Combination*
6.	*Facilities*	12.	*Product*		

Table 1. *Groups of object classes*

Analysis has two subclasses, *BusinessFactorAnalysis* and *AnnualAnalysis*, and concerns the financial analysis of the enterprise. The group *Design* concerns the product design; the group *Enterprise* contains the information of the enterprise itself (*OwnEnterprise*), of *Competitor, Supplier*, *Distributor*, i.e. all kinds of *Enterprise*. The group *EnterpriseProcess* describes the manufacturing process, the group *Equipment* the various types of equipment, with *ManufacturingEquipment* and *DevelopmentEquipment* as subclasses of *Equipment*; the group *Facilities* contains the object class *Facilities* with *ServiceFacilities*, *SalesFacilities* and *ManufacturingFacilities* as subclasses; the group *Group* exists of all kinds of groups such as *ManagementTeam*, *SalesPersonnel*, *ProductBuyers*, *Employees*, etc. Some of these are a list of objects, such as *Employees*, being a list of *Employee*, others are only used as group such as *ProductBuyers*. The group *Market* is also quite extensive, with classes such as *Market* with subclasses *ConsumerGoodsMarket* and *ProducerGoodsMarket*, each of which with their own subclasses (e.g. *ConvenienceGoodsMarket*, *SuppliesMarket*, etc.). The group *Package* deals with the packaging of the product, *Plan* with the development plan of the product. The group *Person* describes the object class *Person*, its subclasses *Employee* and *Founder*, the first of which has a subclass *Manager* that on its turn has subclasses such as *ChiefOperatingOfficer*, *ChiefFinancialOfficer*, etc. The group *Program* defines all kinds of programs such as its subclasses *EmployeesBenefitProgram*, *DevelopmentProgram*, *ProductSalesProgram*, etc. The group *Resources* concerns *FinancialResources* with subclasses *ProductStartupCapital* and *ProductFinancialResources*. The latter is a part of *ProductStartupCapital*. The group *Strategy* differs between *LongTermStrategy* and *ProductStrategy*. As could be expected from Porter's model *LongTermStrategy* is subdivided in the subclasses *CostLeadership*, *Differentiation* and *Focus*. Finally, the group *Technology* concerns *ProductTechnology* and *IndustryTechnology*; *Industry&ProductMarketCombination* deals with the environment of the enterprise.

5. A prototype OO expert system

The OO model will serve as a backbone for the development of a prototype OO expert system. The expert rules will be based as much as possible on the assertions extracted from Business Insight. Other expert rules can be designed and developed bases on the same OO model, see e.g. [Flaes, 1998].

5.1 More SBUs with one product or more each

In this prototype OO expert system the two most restricting characteristics of Business Insight have removed. The OO structure allows the expert system to represent a corporate enterprise with a number of SBUs, each of which carrying one or more products. On SBU level the strength and strategy of each individual SBU is analyzed, on corporate level synergetic aspects can be taken into account. For a detailed discussion of this subject, see [Jellema, 1997].

In this stage there has been no intention to fill in the knowledge base dealing with expert knowledge on corporate level. Although there is no doubt of the existence of synergetic aspects in relation to SBUs, there is in fact little or no formalized knowledge available that provides a reliable understanding of the synergetic aspects of SBUs. One of the sources in this field is [Daems & Douma, 1984]. In the present article only a few provisional expert rules are implemented to demonstrate the potentials of such an expert system. The same reasoning holds for a SBU carrying more than one product.

In the following section the design of the prototype expert system is discussed. In this discussion several aspects are dealt with: the changes in input of most of the data, how most of the original assertions are replaced by expert rules that can be processed by a conventional knowledge development tool such as Aion DS and, consequently, the necessary changes in inferencing. In particular, this last aspect is worth mentioning because the proposed method is also applicable in many similar applications. In section 5.3 more detailed attention is spent to some example expert rules dealing with more than one product within one SBU and at corporate level.

5.2 A pattern recognition approach of dealing with expert rules

In contrast to Business Insight, where most of the input data has a value ranging from 0 to 100, the data in the prototype expert system may have only three values: *good*, *average* and *poor*. Even with only three choices the number of possible combinations can be enormous. For example, the assertion in section 3.1 has 9 clauses. If this assertion is converted into a similar expert rule and each of the clauses contains a slot that can take 3 possible values (e.g. clause 3 deals with the slot prominent that may be either good, average or poor), the number of possible combinations is 3^9, a number that needs to be cut back dramatically.

In this section an approach is discussed that is suited to reason with expert rules with many clauses of more or less similar importance. A more detailed discussion can be found in [Jellema, 1997].

5.2.1 Modifications to data input

The numerical input to Business Insight suggests a hardly-existing accuracy. The relevance of the input data has to be specified on a scale from 1 to 100, whereas most experts are not able to be more specific than good, average or poor. For this reason most of the input data take a value from the set (good, average, poor) or something of the kind. However, this has consequences for the way the expert rules are inferenced and, in a sense it reduces the degree of detail of the conclusions of the rules. Both aspects are considered in the following sections.

5.2.2 The inference method

A crucial condition for the new approach is that the clauses of an expert rule are of more or less similar importance to the conclusion. If this condition is not satisfied, the rule has to be reformulated in such a way that the condition is met.

The reduction of the set of values for most of the (input) data and its consequences for the inference process may be considered as a major modification. An important consequence of this is the exponential growth of the number of expert rules. It was already explained that this would lead to an unacceptable number of expert rules.

The rules that are used in the expert system come down to an intuitive assessment of a number of more or less equally important data with the same type of values. In the domain of strategic analysis most data are assessments of enterprise factors and consequently a choice has been made for the values good, average and poor. In the example rule also the conclusion will get a value taken from this set. In the example rule also the conclusion will get a value take from this set.

In one extreme case, when each of the nine clauses has been given the value good, it is not surprising that also the conclusion will be good as well. In the other extreme case, nine times poor, also the conclusion will have the value poor. Similarly, nine averages will lead to average. However, what about all the other combinations, such as five times good, one average and three poor? The idea behind the suggested solution can be illustrated best on the basis of two examples.

1. In the first example, suppose that there are five goods, implying four values being either average or poor. If there two averages and two poors the final answer will be just good (5* good + 2* average + 2* poor ⇒ good). When there is one average and three poors then the conclusion will be average (5* good + 1* average + 3* poor ⇒ average). After all, there are only five good versus three poors. This will be justified later on.
2. The second example shows the breakpoint of the conclusions and is depicted in figure 5: an expert rule from the actual implementation. In this figure *NumOfGoods* and *NumOfPoors* represent the number of goods and poors, respectively; *Maxvalue* indicates the number of occurrences of the value that has appeared most. Then the approach is as follows: if good occurs most (*NumOfGoods = Maxvalue*), the number of times that good is in some given interval (*InBetween LowCutOfValue*, *NumOfGoods*, *HighCutOfValue*) and the number of occurrences of good is less than twice the number of poors then the conclusion will be average. If the number of goods is twice as much or more than the number of poors, then the result will be good.

There are a few aspects that need some more explanation: the meaning of the constants LowCutOfValue and HighCutOfValue and why the number of goods need to be twice as much or more as the number of poors.

The two constants are introduced because of an arbitrary choice of the number of times the same value must be present in order to come to a conclusion, irrespective the pattern of the values. In the OO model these two constants have been chosen as follows:

1. The maximum of the numbers of equal values ≥ 2/3 (= HighCutOfValue) of the total number of clauses ⇒ The conclusion equals the value occurring most.
2. The maximum of the numbers of equal values ≤ 1/2 (= LowCutOfValue) of the total number of clauses ⇒ The conclusion will be average.

If a potential value does not match condition 1 then the various frequencies are looked at. If the potential value occurs twice as much as its opposite then the result will equal this potential value, otherwise it will be average.

In figure 5 this approach is depicted schematically for a rule with nine clauses as is the case with the rule on the strength of the enterprise in section 3.1. The two constants (HighCutOfValue = 2/3 and LowCutOfValue = 1/2 can be distinguished as the boundary values that separate the various areas. In the two white areas the conclusions are good and poor, respectively, without the need to inspect the exact composition of the various values. If the number of goods and poors are in the dark gray area then the conclusion will be average, regardless of the composition of the values. Conclusions in the light gray area may be either good or average, or poor or average.

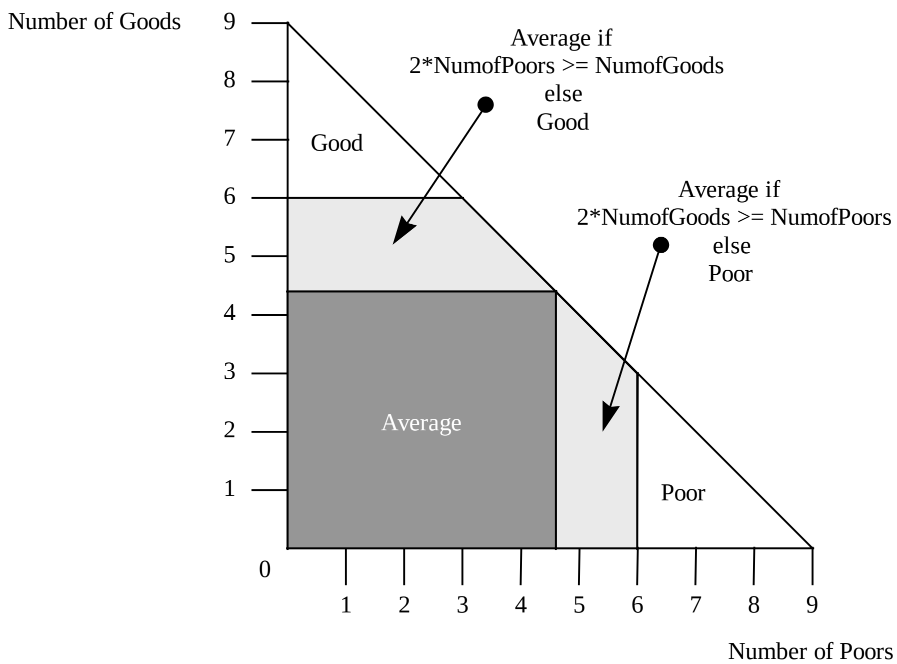

Figure 5. *Graphical representation of the pattern recognition model*

Now the inference procedure can be summarized as follows. After the necessary data have been input per expert rule an answer list is generated containing the input data. For example, an expert rule with 5 clauses will have a corresponding answer list of 5 values, each of them being either good, average or poor. When during the reasoning process such an expert rule needs to be processed, the answer list is analyzed according to the method described above. If this expert rule has a complete answer list the conclusion will get one of the values good, average or poor accordingly. If the answer list is not yet complete, the expert rule is skipped and may be fired later, according to the characteristics of the forward chaining process. When this conclusion appears as one of the clauses in the premise of another expert rule the answer list of this rule will be updated. The corresponding expert rule, and thus the answer list, will be examined later on by the forward chaining process.

5.2.3 General applicability

The inference method outlined in the previous sections is not only suited to this kind of application. Any problem that can be described by a set of rules each of which having clauses of more or less equal importance and values from the same answer list can be handled in a similar way. In fact, the proposed approach is a kind of pattern recognition: given a list of values taken from a set of values, what overall assessment has to be made.

In this specific case only three values (good, average and poor) are involved but the method is not restricted to this number of values. A similar approach can be applied when any odd number of values is involved. In [Jellema, 1997] an example has been worked out where the values are *good*, *above average*, *average*, *below average* and *poor*.

5.3 Expert knowledge at corporate level

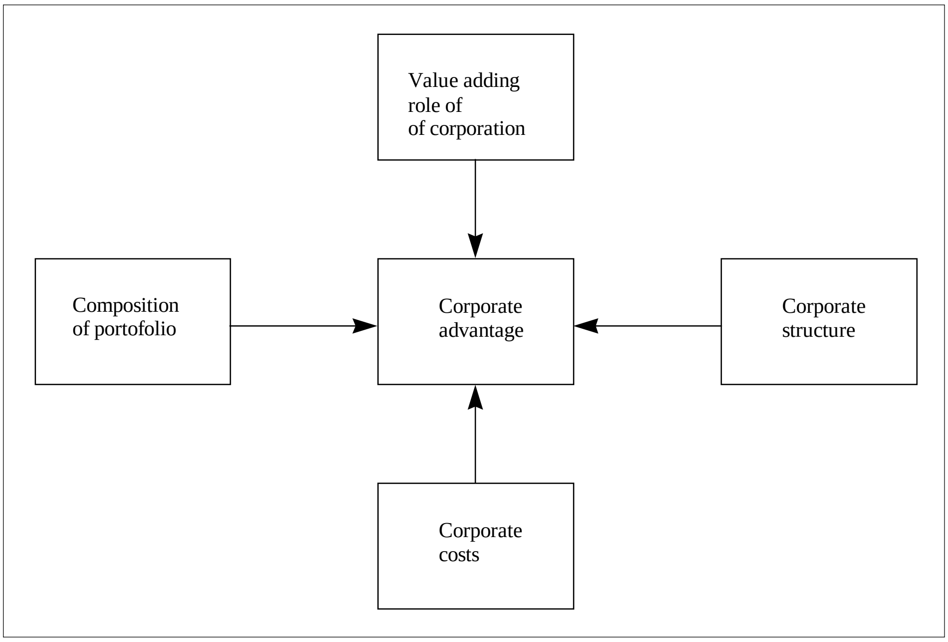

Figure 6. *Four determinative factors of the corporate advantage [Daems & Douma, 1984]*

An important part of the expert system affects the analysis of a corporation with several SBUs each of which carrying several products. On this point Business Insight does not provide any domain knowledge. In order to deal with this part of the expert system a theory has been used originating from a publication of Daems and Douma [Daems & Douma, 1984]. In this publication it is argued what can be understood by what is called a corporate strategy and the additional benefits are discussed compared to the competition of a corporation being built up by a number of SBUs.

Apart from the description of a corporate strategy, Daems and Douma also provide an insight in the effect that the branch of industry can have on the strategy of a corporation. Again, Business Insight pays only no or minor attention to these aspects.

Both the model of a branch of industry and the number of rules with regard to a corporate strategy have been incorporated in the new expert system. In addition, the expert system can deal with an enterprise carrying more than one product. The way in which these two aspects have been realized can be clearly demonstrated with the object class Enterprise. Objects of this class have a list with 'own' products and a list of SBUs that are part of the enterprise. The branch of industry and the so-called product/market combinations have also been added.

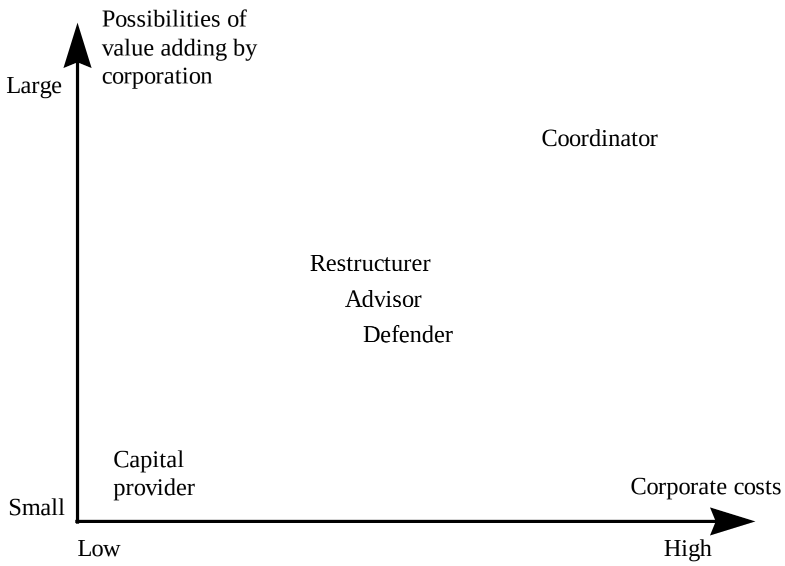

Figure 7. *Role of corporation vs. corporate costs [Daems & Douma, 1984]*

Based on figure 6 two expert rules have been added to the domain model concerning the following aspects:

1. The corporate advantage that can be achieved by the corporation to be analyzed;
2. The so-called *economies of scope* that is brought on by the corporation that is analyzed.

Now, the corporate advantage is determined by four factors deduced from figure 7.

1. The role of the headquarters has to be provided by the user. Possible values are: Capital provider, Restructurer, Advisor, Defender or Coordinator.
2. Based on the role of the headquarters the corporate costs are determined. In practice, this is not the only factor that plays a role. For example, Daems and Douma also mention the diversity of the SBUs, the degree of centralization, etc. Since the model must be solidly designed, for the sake of simplicity only the role of the headquarters has been taken into account.
3. The composition of the portfolio is determined based on the attractiveness of the branches of industry in which the SBUs are active, the diversity of the portfolio and the number of mutations in the portfolio. On the other hand, the diversity of the portfolio is determined on the basis of the possible vertical integration per product. The number of mutations depends on the role of the headquarters. If this role is of the type of capital provider or restructurer, the number of mutations is expected to be high. A headquarters that serves as an advisor, coordinator or defender generally has a low number of mutations.
4. A corporate structure with much centralization will have an adverse influence on the potential corporate advantage. A decentral structure has adverse consequences with a headquarters with one of the other roles.

The economies of scope are determined on the basis of the vertical integration potential of the various products. The factors that play a part in this are also present in Business Insight, but are not used to determine the economies of scope.

It was stated before that this part of the expert system was only meant to demonstrate the potential of the new expert system on this point and, consequently, it has only a relative meaning. A more definite completion needs to be done later on.

6. Results and conclusions

It must be stated that Business Insight has proven (and still continues to prove) to be a useful tool for strategic analysis, although according to [McNeilly & Gessner, 1993] in their research, in a few instances, the program gave recommendations that were not felt to be applicable. Business Insight has many excellent features, both at the input and the output side. Therefore, in many aspects the prototype expert system can not be patched on Business Insight. One aim of the present research however has been to improve some fundamental aspects concerning the enterprise and its products.

Another major aim has been the development of an OO domain model on which an expert system can be founded. The model presented in this paper is very well suited for this task.

It appeared possible to convert Business Insight to a conventional proportional expert system (extracting the knowledge from Business Insight took some time) that is based on this OO model. Because it was only meant to serve as a prototype system, just a part of the input data of Business Insight have been used and the values of higher level slots have been provided by the user, rather than concluded by the inference process.

After the input phase all relevant data are stored in database files that can easily be read and used by most current relational database management systems, such as Paradox or MS Access. Consequently, existing databases can easily be used, be it after some minor modifications.

The set of assertions being used by Business Insight has been replaced by an Aion DS rule base, be it with some modifications. One of the difficulties that arose, has been the exponential nature of the number expert rules if uncertainty nor incompleteness are modeled. In the prototype expert system a model has been developed that can deal with this kind of situation. The only assumption for a successful conversion from a Business Insight assertion to an acceptably small number of expert rules has been that the clauses of the expert rule be of equal importance. In most cases this requirement can easily be met.

The prototype expert system has been set up such that the existing rule base can be replaced by some other rule base. Based on the same OO model and with only minor modifications a completely new set of expert rules can be developed, inserted and used. This approach has been of great importance. It was already mentioned that expert knowledge is generally based on experience and expertise and contains a lot of uncertainty. Consequently, the expert system must be able to reason with uncertain or incomplete knowledge. From the very beginning it was our intention to develop such an expert system, based on the same OO model. Therefore, following to the present research a start has been made to develop an expert system that can deal with uncertain or incomplete knowledge.

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