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Rule-based Approach For Supplier Evaluation

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***Abstract*—This paper presents a concept of use of the rule-based reasoning systems for evaluation and classification of the suppliers. The problem of suppliers selection is widely discussed in literature. Majority of the authors apply the method of multi-criteria evaluation for selection of suppliers, mainly the Analytic Hierarchy Process (AHP) algorithm and related ones, to find its solution. In this paper it has been proved that a suitably expressive system of rules management can be used as an effective tool for suppliers evaluation. In the presented work we have applied the Rebit system which was elaborated by the AGH University of Science and Technology. An example of evaluation of a supplier of primary charging materials for metal processing enterprise has been presented. It has been shown how individual evaluation criteria are grouped into sets of independent rules and how one may use tools to enhance the knowledge acquisition.**

I. Introduction

THE PROBLEM of supplier selection plays a prominent role in the modern economy. Supplier selection and evaluation is one of the most vital actions of enterprises in a supply chain. Undertaking faulty decisions in this area may be a cause of critical disturbances in execution of the fundamental tasks of the manufacturing enterprises.

Over the past several years, with the recent trend on just-in-time (JIT) manufacturing systems, there is an emphasis on strategic sourcing that establishes long-term mutually beneficial relationship with fewer but better suppliers [1].

Strategic decisions concerning supplies with raw materials are tied up with evaluation and selection of potential strategic suppliers. Selection of suppliers presents itself a complex decision-making problem which is featured with multi-criteria, of different nature of the criteria (quantitative, qualitative) and with multi-stages of the decision. In today's global and open innovation economy strategic supplier selection and evaluation decisions must not be solely based on traditional selection criteria, such as cost, quality and delivery. In strategic sourcing, many other criteria should be considered with the aim of developing a long-term supplier relationship such as quality management practices, long-term management practices, financial strength, technology and innovativeness level, suppliers' cooperative attitude, supplier's co-design capabilities, and cost reduction capabilities [1].

Both the procedure and algorithms for supplier selection cannot rely exclusively on the "historic" experience of a manager. It must reflect some strategy of the enterprise as defined by the management of the enterprise in scope of execution of its fundamental activity. This strategy determines then the purchase strategy including such factors as acceptable standard of prices, required quality, desirable conditions of the long-term cooperation etc. Thereby the selection of suppliers can be treated as an integral element of definition of the processes and business rules. Therefore, the rule-based approach which is characteristic for Business Rules Management Systems can be useful while solving the problem of selection and ranking of the suppliers. Nevertheless, there is a pre-condition that one must have at one's disposal a suitably expressive and reliable tool. And there is such a tool: The Business and Technological Rules Management - The Rebit System elaborated by the AGH University of Science and Technology.

The aim of the paper is to present the possibility of use of tools purposed for business management rules to solve the problem of supplier selection. We have presented the results of our research directed on proposing a solution which would enable one to get flexible formation of purchase strategy and current adaptation of the selection criteria for the choice of suppliers to changing market conditions.

This paper concerns problems of selection and grouping of suppliers of charging materials in respect to the quality of the services provided by them, as well as the quality and parameters of the delivered materials. Furthermore, we have analyzed the influence of factors resulting from the purchase strategy and such external factors as the destination of the acquired materials on the issue of supplier selection.

In the first part of the paper there will be formulated a problem of evaluation and classification of the suppliers and we will present a review of the relevant literature. Then we will present the Business and Technological Rules Management - the Rebit System and its specific features used to solve the problem of suppliers evaluation. An example of evaluation of a supplier of charging materials accomplished with use of the Rebit system will be also presented. The paper will be finished with a critical comparison of the proposed solution with some concepts known from the literature; some suggestions concerning further works will be also presented.

II. Supplier evaluation and selection

The problem of supplier selection can be considered from different points of view. Firstly, this is a task relying on a

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single selection, from the list of the suppliers, such supplier who in the best way fulfills the requirements resulting from execution of the specific production order. In such case we have to do with a simple issue of multi-criteria evaluation. The set of the criteria, their inter-relation, as well as the method of their evaluation may be different in each individual case.

In business management practice much more important meaning has a task of creation and periodic updating of the list of suppliers for different groups of charging materials permanently tied up with the recipient. Depending on the nature of the realized manufacturing processes we can have to do with complex deliveries covering different kind of materials (and in some cases also services) or with special-purpose deliveries including deliveries of strictly defined sort of products. The way of solving the problem of supplier selection depends also on kind of the material needs. One shall consider the selection issue in case of materials directly consumed in the production process and otherwise in case of accessory materials. The very procedure of evaluation of the potential suppliers will be in case of any of the above mentioned situations similar and will resolve itself into establishing a ranking list of the evaluated subjects or classifying them into the previously established categories (e.g. permanent main supplier, permanent auxiliary supplier, occasional supplier). However, the evaluation criteria will differ. Due to the number of criteria and their interrelation, the procedure can be executed in one stage or in multi-stages. A special group of decision issues are decisions of strategic nature that bind the recipient with the supplier for a long time.

Supplier evaluation and problem selection have been presented in the literature as the goal of the development research or as the task related with creation of the software applications. In most cases we have to do with proposals of creation of the Decision Support Systems (DSS) which could be applied in business practice. Thus, an issue of essential significance is not only the way of solving the problem of multi-criteria evaluation but also assumptions and methods of execution of an application meeting user's requirements. These both decisions must be considered together, because the characteristics of the evaluation algorithms exerts an essential influence on the way of realization of the application and particularly on creation of conditions for current updating of the assumptions without the necessity of modification of the very structure of the programming modules. Therefore, the way of proper knowledge modeling and management is very important.

The object of our research is the problem of classification of potential suppliers of the primary charging materials. Taking the above into consideration and assuming that the adopted methodological solutions should permit one to achieve easy creation of flexible application serving, inter alia, in practical realization of the current purchase strategy, we have made the following assumptions specifying the research problem:

- any potential supplier will be evaluated individually and not with use of the method of pairwise comparisons, as it happens in the Analytic Hierarchy Process (AHP) and similar methods;
- criteria related with complexity of the deliveries are not taken into consideration;
- while evaluating the deliveries one takes into account the destination of the materials earmarked to produce different groups of product;
- the way of presentation of the criteria in the model and criteria evaluation must be readable for the managers and allow them to present the purchase strategy;
- the application based on the proposed solution must allow one to perform simple updating of the evaluation criteria with no interference in the code.

The fulfillment of every of the above presumptions places specific requirements to the method used in knowledge representation and consequently - also to the inference mechanisms. We have acknowledged that the most profitable solution would be use of the rule based knowledge representation. A symbolic (linguistic) mapping of the assessment criteria and declarative nature of the knowledge optimally corresponds with the requirements and needs of the managers responsible for execution of the business operations.

III. Literature review

In the face of acute global competition, supplier management is rapidly emerging as a crucial issue to any enterprises striving for business success and sustainable development. As it was mentioned above, supplier evaluation and order allocation are complex, multi-criteria decisions.

Incorporating multi-dimensional information into vendor evaluation is important and well established in both academic and practitioner's literature [3], [4]. Over the years, several multi-criteria techniques have been proposed for the effective evaluation and selection of vendors. According to the literature, some supplier selection criteria are found to vary in different situations, and experts agree that there is no one best way to evaluate, select suppliers and that organizations use a variety of different approaches in their evaluating processes.

As it has been previously mentioned, the evaluation of a supplier is realized in different phases of the process of supply management and may concern different special cases. Depending on the purpose of the evaluation and the adopted assumptions, different criteria are taken into consideration.

Ha and Krishnan [3] summarizes some of these criteria which have appeared in literature since 1966. Among them one can mention (ordered according to the frequency of quoting in the literature): price, quality, delivery warranties and claims, after sales service, technical support, training aids, attitude performance history, financial position, geographical location, management and organization, labor relations, communication system, response to customer request, e-commerce capability, JiT capability, technical capability, production facilities and capacity, packaging ability, operational controls, ease-of-use maintainability, amount of past business, reputation and position in industry, reciprocal arrangements, impression, environmentally friendly products, product appearance, catalog technology.

In an overall analysis of 181 articles referenced within the studies made by Erdem and Göçen [2], AHP related methodologies seem to be the most popular techniques which are applied in over 36% of the studies. This is mostly due to the fact that AHP incorporates both qualitative and quantitative evaluation of the decision maker by use of tangible and intangible factors designed in a hierarchical manner. It is suitable, flexible and easy-to-use for multi-criteria decision making and can be applied in group decision making environments as well.

Along with usage of the AHP method one can find in the literature other solutions [1], [5], [6], [7]: multicriteria classification and sorting methods (among other sorting method based on the PROMETHEE methodology), Game Theory, Decision Trees, Factor Analysis, Structural Equations, Loss Functions, Process Capability Index, Expert Systems, Case Based Reasoning (CBR), data envelopment analysis (DEA), and neural network (NN).

Although several techniques and models have been utilized for the selecting and evaluating of vendors, efficient partner selection, combining multiple techniques (AHP, DEA, and NN), has not been suggested previously with regard to the purchasing evaluation process [3]. The hybrid method uses an AHP to assign weight to the qualitative selection criteria, and it uses a DEA, NN or other methods in order to choose efficient vendors in the final selection process. Exemplary, the study [1] aims to develop models and generate a decision support system (DSS) for the improvement of supplier evaluation and order allocation decisions in a supply chain. Initially, an analytic hierarchy process (AHP) model is developed for qualitative and quantitative evaluation of suppliers. Based on these evaluations, a goal programming (GP) model is developed for order allocation among suppliers.

As it has already been stated decisions concerning organization of the supply of strategic nature are of specific character. An example of such situation one can find in work [8] where the problem of warehouse selection for a company was presented. This is a valuable and realistic decision problem in logistic and supply chain management (LSCM). The authors provided a solution for solving the raised problem via knowledge discovery and utilization. The decision knowledge in the form of ”if. . . then . . .” rules are generated based on known information of owned warehouses and then utilized for predicting the preference order of alternatives according to their profitability. The process of solving of the problem is realized in four stages. In the two first stages the expert knowledge and the knowledge derived from previous experiences is gathered. The third stage relies on elaboration of rules purposed for evaluation of the decision variants, whereas the fourth stage relies on their implementation in the specific case. Because both certain and uncertain information are taken into account, the authors introduce interval-valued intuitionistic fuzzy set (IVIFS), which consists of a membership function and a non-membership function, whose values are intervals rather than exact numbers. The presented procedures are sophisticated, time- and cost-consuming (due to engagement of external experts) and serve to solving individual problems.

One can also find some works which discuss the use of the rule-based approach in less complex problems related with undertaking multi-criteria decisions. Vokurka, Choobineh, and Vadi [9] develop a prototype expert system to evaluate the potential suppliers. Interesting approach to the preference modeling in the form of a set of "if..., then..." decision rules discovered from the data by inductive learning is presented in [10]. To structure the data prior to induction of rules, the authors use the Dominance-based Rough Set Approach (DRSA).

Summarizing the review of the literature one may find that the dominant method applied in the multi-criteria evaluation of the suppliers is the AHP method. Its imperfection one tries to level with use of supplementing method that permit objectification of the inherently subjective evaluations of experts. Nevertheless, there is lack of reports on the problem of the suppliers selection which would permit to treat them as activities aiming at business processes standardization. There are also no reports regarding usage of the concept of management with business rules in the matter under discussion.

IV. Business and Technological Rules Management System

Rebit System belongs to the category of Business Rule Management System (BRMS). It consists of rule and workflow engines, knowledge base editor, generic client, testing, validation and simulation tools, knowledge base repositories and resource management module. All these components may be configured and integrated into a standalone application. However, the main advantage is that they are also a set of loosely coupled components working in Service Oriented Architecture (SOA).

Rebit System supports all stages of knowledge base development process. Knowledge base editor is generally the first tool used in this process. It allows knowledge base creating and editing in a graphical or textual way with the help of intelligent prompts. All classic elements used in knowledge representation are available in Rebit editor. The main building blocks are rules, variables and functions. Rebit rules belong to the category of productions rules. Rule premises are logical conditions based on variables and functions. Rule conclusions are simple assignments. Rules are organized in so called rule sets, i.e. a group of logically connected rules. Rebit language provides more sophisticated elements, such as grids and decision tables. They allow for more concise and user friendly knowledge representation. The knowledge contained in decision tables and grids may be converted into ordinary rules. Rebit System is equipped with algorithms of learning by examples which allow for rational translation of decision tables into an effective rule set. The translation process usually takes place just before deployment.

The next steps in the process of knowledge base development are validation and testing. Rebit System provides an efficient validation and testing tools. Testing and validation algorithms allows for finding most inconsistencies and incompleteness. In order to perform validation and testing the knowledge base must be translated to Prolog language. The translation process is automatic and transparent to the user. The user sees only the results and some additional statistics. The standard verification procedure include testing for knowledge base integrity, consistency and completeness. This procedure may be optionally extended by looking for hidden cycles and other unsafe phenomena.

Rebit inference engine handles three modes of inference: forward, backward and mixed, i.e., inference with predefined target variable. In the first inference mode the engine tries to infer all possible facts (variable values) from input data. The inference session may be continued after entering new input data. Backward reasoning is the verification of the hypothesis (concerning the value of some variable) on the base of information entered by the user at the request of the engine. The third inference mode, co-called mixed, combines forward and backward reasoning. The user specifies the final variable, i.e. the variable which must have the value. The inference engine finds the most efficient path and the set of variables that must have values. After that the mixed process of forward and backward chaining is accomplished. The process is stopped when the goal is reached or there is an evidence that the goal cannot be reached. The unique feature of Rebit engine is the possibility of controlling the reasoning process. It allow to reduce the total number of questions asked to the user.

Generic client is integrated with simulation module which enables automatic or semi-automatic simulation. The simulation allows finding groups of "not optimal rules", unused variables or rules, repeating or overlapping rules and other harmful elements. The first step in simulation procedure is the setup of statistical properties of all input variables. In the next step constraints and typical simulation properties like exit conditions are defined. The result of simulation procedure is a detailed report containing many useful statistics relating to variables and rules.

The knowledge base development process has not been as extensively explored as the software development process. However, general guidelines on how to proceed are the same in both processes. The iterative and incremental approach known from software development seems to be the most appropriate also in knowledge base development. The general idea is as follow: each iteration consists of identification, conceptualization and formalization of a selected portion of the domain. Next iteration starts after successful testing. It usually extends the previous portion of the domain. The iteration process ends when the entire domain is covered in knowledge base.

A special role in Rebit model of knowledge representation play elements called resources. They are introduced to enable access to data stored in SQL databases and other data sources. The current version of Rebit System includes connection strings, queries, variables and bindings. Query combined with variable - which represents the result of this query - form a new element called binding.

V. Rule-based approach implementation

A. Exemplary problem description

Our proposal has been verified on an example of selection and grouping of suppliers in enterprises producing metal products. All the enterprises for which the supplier selection problems play key role and are operating currently on the market have their own, substantially formalized procedures of suppliers selection. Standards in this domain are formally specified by ISO 9001:2000 norms (Clouse 7.4 Purchasing). Below there are shortly discussed: a process of evaluation and qualification of a supplier applied by a chosen producer of structural closed cold formed steel profiles.

A new supplier is evaluated from the point of view of the foreseen quality of cooperation with the enterprise and from the point of view of possibility of purchasing from him the commodity from given assortment group.

The supplier, in view of the quality of cooperation, is classified to the one of three groups: permanent main supplier, permanent auxiliary supplier, and occasional supplier. The classification based on the possibility of delivery of different assortments of the charging materials distinguishes three group of product providers: low cost, standard and HQ (high quality).

The assessment of the supplier takes into consideration the following aspects of cooperation:

- the experience in the cooperation,
- the contractual cooperation,
- the effectiveness of the complaints,
- servicing procedures,
- the reputation of the supplier,
- the balance of liabilities and receivables.

The supplier evaluation model in exemplary case is as shown in Fig. 1.

B. Knowledge base formulation

The considerable number of the criteria brings about need of grouping them in accordance with partition presented in Fig. 1. Simultaneously it is necessary to provide independent updating, testing and verification of groups of rules evaluating individual criteria. The Rebit system allows one to group rules into relatively independent rule sets.

Individual partial criteria can be both of quantitative or qualitative. Taking into consideration the necessity of adaptation of the knowledge model to symbolic reasoning which is specific for human being, it was assumed that the "rough" model would operate exclusively on qualitative variables. An additional justification of such solution is the fact that quantities which could be recorded as a constant or numerical variables can undergo dynamic changes. The updating of the knowledge model would require then frequent verification of many rules, what in turn is time-consuming and can be a source of errors. On the other hand, one shall assume that to some extend the values necessary to rules evaluation will be collected from external sources of data and perforce will be of quantitative type. This apparent contradiction can be solved with use of the mechanisms and tools of the Rebit system.

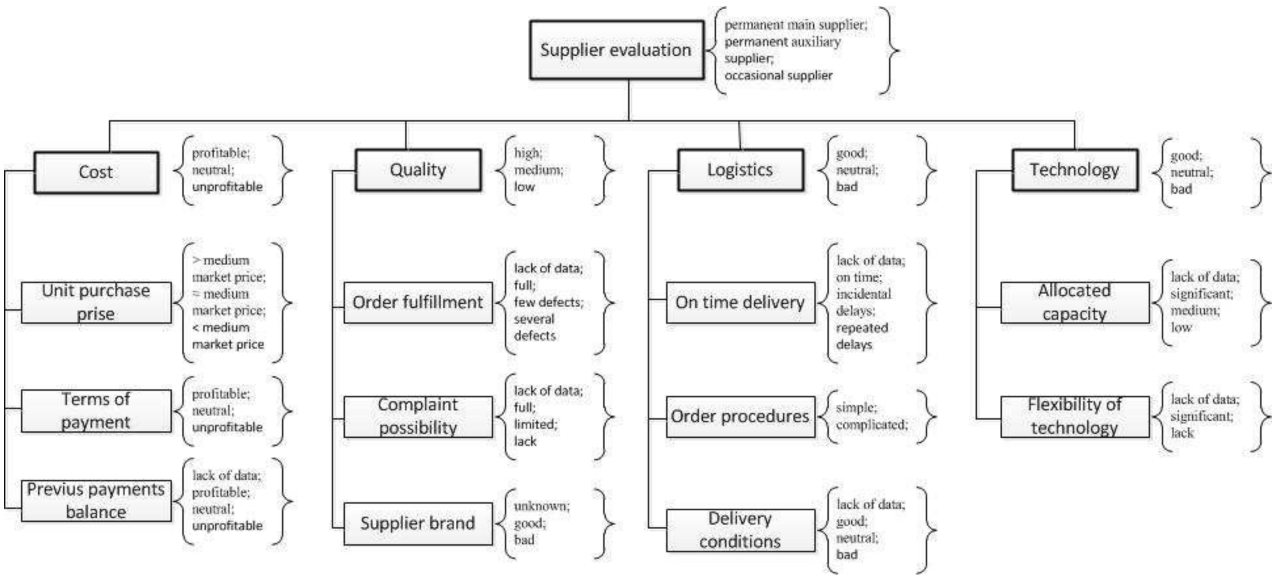


Fig. 1. The supplier evaluation

The adopted concepts can be illustrated on an example of knowledge acquisition for needs of evaluation of the criterion "Cost".

In case of the linguistic variables the most convenient form of knowledge representation is the decision table. In the Rebit system there is a possibility of generating such table after having previously declared appropriate enumerated types. Figure 2 presents a fragment of such table. The algorithm of learning by examples based on ID3, which is incorporated into the Rebit system, allows one to generate the "minimal" set of rules for the examples recorded in the decision table.

UnitPurchasePrice	= greater then m	= greater then m	= greater then m
TermsOfPayment	= profitable	= profitable	= profitable
PreviuosPaymentBalanc	= lack of data	= profitable	= neutral
Cost	= unprofitable	= neutral	= unprofitable

Fig. 2. Decision table for criterion Cost

Below one can find some exemplary rules:

```
RULE Cost_21
IF UnitePurchasePrice =
"greater then medium market price" AND
PreviousPaymentsBalance = "lack of data"
THEN Cost = "unprofitable"

RULE Cost_22
IF UnitePurchasePrice =
"greater then medium market price" AND
PreviousPaymentsBalance = "neutral"
THEN Cost = "unprofitable"

RULE Cost_23
IF UnitePurchasePrice =
"greater then medium market price" AND
PreviousPaymentsBalance = "unprofitable"
THEN Cost = "unprofitable"

RULE Cost_24
IF UnitePurchasePrice =
"greater then "medium market price" AND
PreviousPaymentsBalance = "profitable" AND
TermsOfPayment = "profitable"
THEN Cost = "neutral"
```

For the needs of symbolic representation of knowledge it was convenient to present the variable `UnitePurchasePrice` as a linguistic variable. In practice it is however compared with numerical quantities. This problem can be solved by introducing additional numerical variables `AskPrice`, `LowerPriceBound` and `UpperPriceBound`, as well as rules allowing for mapping a numerical to linguistic variable.

The pertinent rules have been presented below:

```
RULE CostPar_0
IF AskPrice <= LowerPriceBound
THEN UnitePurchasePrice =
"less then medium market price"

RULE CostPar_1
IF AskPrice >= LowerPriceBound AND
Ask_price <= UpperPriceBound
THEN UnitePurchasePrice =
"equal to medium market price"

RULE CostPar_2
IF AskPrice > UpperPriceBound
THEN UnitePurchasePrice =
```

```
"greater then medium market price"
```

As a result one obtains a model of knowledge which on the one hand is readable and easy to updating from the point of view of the manager but on the other hand, it permits one to data acquisition without the participation of the user (quantitative values can be downloaded directly from databases by means of the module of resources management). It is also worth pointing out that updating of the knowledge (e.g. in case of change of the purchase strategy) takes place on level of decision tables and does not require any interference into rules which are updated "automatically".

As it has been previously mentioned, one of the main criteria of evaluation of the supplier is the destination of the materials acquired from him. Depending on the requirements placed against the final goods which will be produced from the purchased materials, the way of the evaluation of the supplier's offer will also be different. The simplest solution would be to construct three separate models of the knowledge for: low cost, standard and high quality products. However, it is not justified whereas in case of a suitably expressive model of knowledge - which can be recorded in the Rebit system - not necessary. Some of the criteria are independent from the destination of the purchased materials (e.g. economic parameters). However, in case of some materials one can, thanks to parametrization, construct a model of knowledge that is common for different cases.

One can illustrate this on an example of quality evaluation of the delivered materials. Like in the former case the "rough" - linguistic knowledge base is created with the aid of a decision table transformed into the form of rules:

```
RULE Quality_12
IF OrderFulfillment = "full" AND
ComplaintPossibility = "full"
THEN Quality = "high"

RULE Quality_13
IF OrderFulfillment = "full" AND
ComplaintPossibility = "lack"
THEN Quality = "medium"

RULE Quality_14
IF OrderFulfillment = "full" AND
ComplaintPossibility = "limited" AND
SuplierBrand = "unknow"
THEN Quality = "medium"

RULE Quality_15
IF OrderFulfillment = "full" AND
ComplaintPossibility = "limited" AND
SuplierBrand = "good"
THEN Quality = "high"
```

In this case, parameterization of rules will consist of introduction of numerical variables and appropriate rules:

```
QualityPar_0
IF DefectsRatio <= FirstDefectsBound
THEN OrderFulfillment = "full"

RULE QualityPar_1
IF DefectsRatio >= FirstDefectsBound AND
Defects_ratio <= SecondDefectsBound
THEN OrderFulfillment = "few defects"

RULE QualityPar_2
IF DefectsRatio > SecondDefectsBound
THEN OrderFulfillment = "several defects"

RULE QualityPar_3
IF ProductRange = "low cost"
THEN FirstDefectsBound = 10

RULE QualityPar_4
IF ProductRange = "low cost"
THEN SecondDefectsBound = 15

RULE QualityPar_5
IF ProductRange = "standard"
THEN FirstDefectsBound = 8

RULE QualityPar_6
IF ProductRange = "standard"
THEN SecondDefectsBound = 10

RULE QualityPar_7
IF ProductRange = "high quality"
THEN FirstDefectsBound = 4

RULE QualityPar_8
IF ProductRange = "high quality"
THEN SecondDefectsBound = 7
```

Let us notice that quality of the materials from the supplier with a nine percent level of discard will be evaluated as meeting the requirements in case their destination is a low-cost product, as "few defects" in case of "standard" products and as "several defects" for "high quality" products.

In this case, the restrictions concerning the level of the expected discards have been entered as constants in the rules. This is justified by relative permanence of these values, as well as by the fact that each of them appeared in one rule only.

The problem of modification of the way of inference, depending on certain parameters, can be more complex. Let us assume that the criteria grouped to the class "Technology" are not evaluated in case of destination of the materials on "low cost" products. In order to not complicate the universal set of rules designed for final classification of the supplier one may assume that in case of "low cost" products the parameter `Technology` is set to "good" whereas parameters `AllocatedCapacity` and `FlexibilityOfTtechnology` are not verified. Some properties of the inference engine of the Rebit system allow one to carry out this task in a very simple way. It is enough that to the set of rules defining the value of the variable Technology and generated on the basis of appropriate decision table:

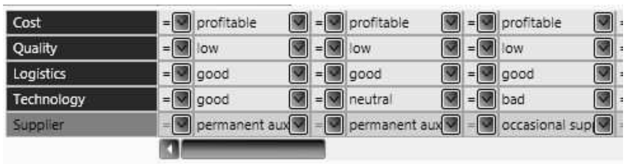
```
RULE Technology_9
IF AllocatedCapacity = "lack of data" AND
FlexibilityOfTechnology = "lack of data"
THEN Technology = "bad"

RULE Technology_10
IF AllocatedCapacity = "lack of data" AND
FlexibilityOfTechnology = "significant"
THEN Technology = "neutral"

RULE Technology_11
IF AllocatedCapacity = "lack of data" AND
FlexibilityOfTechnology = "low"
THEN Technology = "bad"
```

one adds the following rule:

```
RULE TechnologyPar_01
IF Product_range = "low cost"
THEN Technology = "good"
```

The inference engine of the Rebit system, at each stage of evaluation of the rules, searches for the least expensive (i.e. requiring the least number of "questions" for variables) path of premises confirmation. In case of rules defining the value of the variable `Technology` "the cheapest" rule will be the rule `TechnologyPar_01`. This allows the engine will always have to do with "low cost" products, it will set up the value of the variable "Technology" on "good" and will not verify the consecutive rules defining this variable.

According to the principles identical with the above presented there are constructed all rule sets which describe four partial criteria. Then one constructs superior rule set which connects partial evaluations so as the final classification of the recipient is possible. In this case, one can also take advantage of the decision table (Fig. 3).



Cost	profitable	profitable	profitable
Quality	low	low	low
Logistics	good	good	good
Technology	good	neutral	bad
Supplier	permanent aux	permanent aux	occasional sup

Fig. 3. Decision table for final evaluation criterion

As a result of all these actions one gets the model of knowledge composed of 146 rules.

Rebit inference engine, working in mixed mode and using this knowledgebase, allows for evaluation of each case of suppliers description in much effective way.

C. Business Application Recommendation

The interactive Rebit environment allows for creating, validation, testing and simulation of knowledge bases in a user friendly way. Although there is a possibility to use Rebit System as a standalone solution, it seems that the tighter integration of Rebit components with target environment would be more useful in cases when reasoning and knowledge base are a part of more complex business activity.

It is worth to consider two scenarios of such integration. They differ in scope and depth. The first one is based on SOA architecture of Rebit components. In this scenario rule engine acts as an external, independent component providing services for inference for a selected knowledge base. Knowledge bases may be stored in Rebit or in local repository. This scenario requires an implementation of SOA client and its integration with the target application. The main advantage of this form of integration is that the resulting system consists of loosely-coupled components which are easy to manage and update. Rebit package supports this form of integration by providing library for building a dedicated SOA client.

In the second integration scenario rule engine work as an integral part of the target application. There are two ways to communicate with the rule engine: directly or by means of inter-process communication based on pipes. Since this scenario is moving towards tight integration with the target application, it is recommended to store knowledge bases in local repository. The main limitation of this scenario is that it can only be realized on the .NET platform. As in the previous case, it is necessary to implement the client code. Rebit package provides library supporting integration based on direct access as well as the one based on pipe communication.

VI. CONCLUSION AND FURTHER WORKS

The problem of evaluation, selection and classification of suppliers is generally considered as one of the more essential issues in practice of enterprises management. Such statement is confirmed by numerous publications. On the other hand, in the organizational documentation (procedures) of all significant enterprises much attention is paid to procedures of supplier selection. Most often one can find in the literature examples of application of the AHP method and related ones, as the most effective ways of solving the problem of multi-criteria evaluation. Therefore, effective methodologies that have the capability of evaluating and continually monitoring suppliers' performance are still needed.

The above mentioned AHP method is the subject of many scientific research studies which confirm its usability and correctness. Nevertheless, there are also critical opinions. Among them the following issues are worth mentioning:

- the existence of large number of pairwise comparisons characteristic for this method brings some limitations on the number of criteria used [2],
- high degree of subjectivity of the evaluations and scale conventionality,
- lack of possibility of verification and reasoning of the evaluations resulting from numerical nature of the aggregation procedures,
- problems related to the phenomenon called rank reversal.

In majority of publications with critical approach to the AHP method a special attention is paid on the problem of objectivation of the evaluation criteria or their more flexible expression, particularly in case when the information on criteria may be deficient, uncertain and incomplete. There are proposed, inter alia, solutions basing on Fuzzy Sets Theory or Rough Sets Theory.

In our opinion an issue of much greater importance, from the point of view of the needs of the users responsible for the management processes, are these restrictions of the AHP method and similar ones which hinder expressing conscious and desirable preferences in the decision making model. While designing the management system of an enterprise as a set of rules, the manager realizes his own preferences and sees no need for their examination. Such situation is diametrically different when compared with research basing on the evaluation of external experts. Experts foresee that e.g. prices can exert influence on the efficiency of the supply greater than quality of the materials. The purchasing officer determines the weight of these criteria.

Therefore, in our opinion, the methods used in Business Rules Management Systems may be successfully applied in case of solving the problem of supplier evaluation and selection. They can be used provided that the tools are expressive enough and there is a possibility of an easy generation of useful business application. The Rebit system presented in the this paper has got these properties.

Rule based approach to the multi-criteria evaluation creates however some problems. They are related with exponentially growing number of examples which should be analyzed in case of formulating the knowledge. Solving this problem through segmentation of the evaluation on increasingly detailed partial criteria creates similar problems as in the AHP method. It is true that explicit presentation of principles of aggregation allows one to avoid most of the problems specific to the methods which, in this case, use computational procedures. Nevertheless, it is a source of flattering of the results of successive aggregation. Therefore, the target of the successive works will be examining, based on the data describing real examples of selection and their results, how big is the scale of this phenomenon and its influence on the correctness and repeatability of decision- making.

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