Hybrid Decision Model for Operational Flow Scheduling

Mihaela Costin, Ştefan Dumbravă, Adrian Brezulianu

Abstract: *The global competition imposes minimizing the time-to-market and cost parameters, simultaneously increasing products quality and response to the customer demands. Information sharing, concurrent engineering and virtual enterprising prove to be stringent necessities in order to optimally achieve a better product design in an appropriate time. Automatically choosing the best products (accepting the most profitable commands), using genetic algorithms in order to minimize the idle time in optimizing production flow are useful to be employed in the struggle to be amongst the first, in delivering a competitive product on the market. Hybrid multi-criteria inference in scheduling operations priorities is a necessary tool in decision support systems.*

Key words: *genetic algorithms, decision support systems, fuzzy aggregation system.*

INTRODUCTION

Corporate success in new products design and the suitable management of the development cycle time imposes replacing the old practice of "providing the most value at the lowest cost" with the new paradigm of "providing the most value at the lowest cost in the least amount of time". A well-structured knowledge base (KB) is a first step meant to decrease the possible data-managing inconvenient. Weighting the different aspects of decisions and comparing different modalities of making the final decision, might also give more clues in product design. A previous simulation of the market environment in order to predict the problems that could arise in the moment when the product will be accomplished could prevent losing important aspects in the financial estimation. Decision support systems (DSS) may benefit of complex hierarchical strategies of inference and sophisticated scheduling programs implemented by the help of genetic algorithms.

THE KNOWLEDGE BASE STRUCTURE

Our experience in this domain [1] ÷ [6], [11] ÷ [13] revealed that the rules in the KB have different degrees of importance. Thus, they have to be structured depending on the various influences of the secondary factors that might reinforce our belief in the truth value of the stated rule [7], [8]. The way they are acting on the principal core of the rule depends on the strength of the secondary influence factors. The above-formulated problem was solved creating a structured rule-base in the context of possibility theory [10]. We usually identified four types of different rules, depending on the strength of the secondary influence factors. Vice versa, when we ignored the hierarchical knowledge structure, the obtained results were distorted [14].

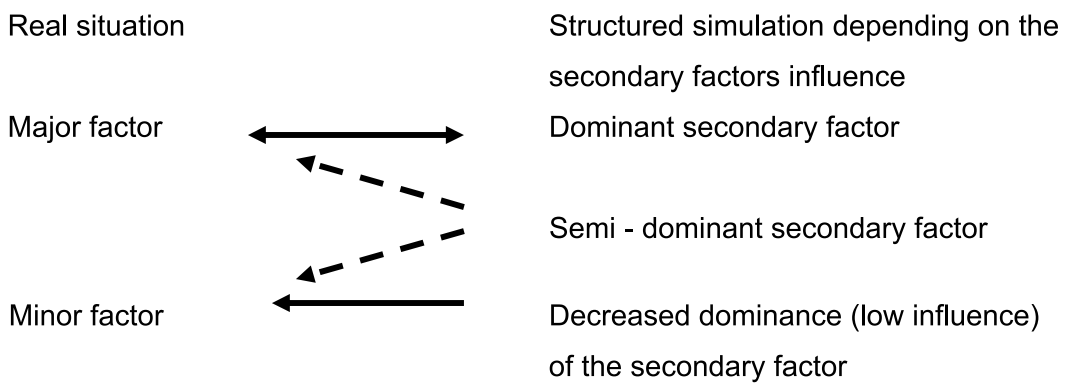

Fig.1. Secondary factors influence on the structured KB

Well-structured evaluation of the possible situations (fig.1), in a hierarchical rule-base, gave improved results in virtual estimation of the real evolutions, both in economical and in medical DSS [6].

PRODUCT DESIGN DECISION USING A MULTI-ATRIBUTE STRUCTURE

Deciding amongst the various items, candidates for the design and execution process, is a delicate problem supporting different aspects. The manager deals with a weighted reasoning as he has to choose between more or less difficult products, new technologies, high or low costs, experienced specialists or not (facing new products) and overall, the desire of maintaining good relations with traditional beneficiary costumers. In the multitude of these facets, we were capable to automatically select the characteristic rules using a particular decision structure, derived from Quinlan C5, on a priory evaluated diagram, by giving notes to the multi-attribute situations (example given in Table 1). In the decision tree structure, the inner nodes received probability computed values, in order to be able to estimate new situations even when, incomplete data were furnished (fig.2).

ORDER TYPE (COMMAND)	INOVATION DEGREE	EXECUTION COST	DIFICULTY	DECISION ON PRODUCTION
special	86	84	false	┐executing
special	81	89	false	┐executing
usual	84	77	false	executing
exception	70	97	false	executing
exception	67	79	false	executing
exception	66	69	true	┐executing
usual	63	65	true	executing
special	72	96	false	┐executing
special	70	71	false	executing
exception	76	81	false	executing
special	74	72	true	executing
usual	73	89	true	executing
usual	80	74	false	executing
exception	70	81	true	┐executing

Table 1.

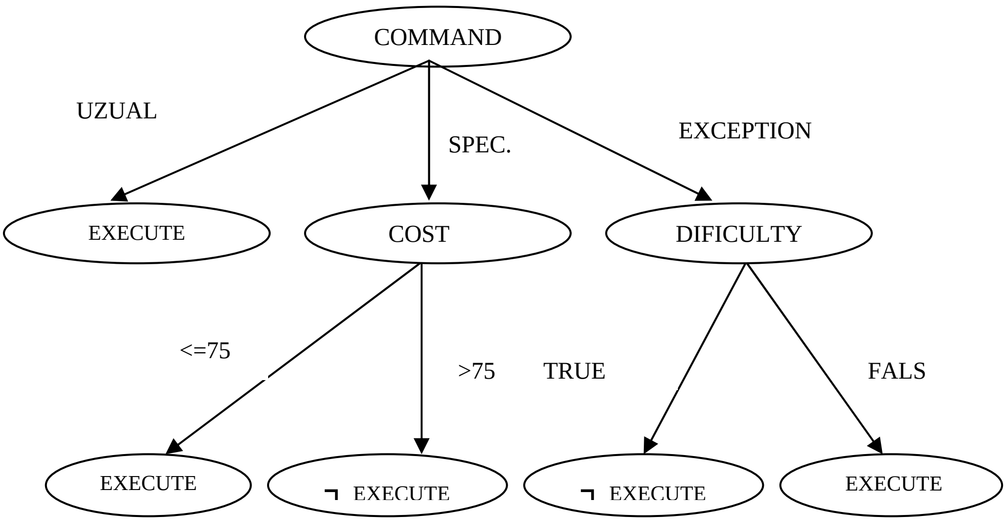

Fig. 2. Decision tree structures permit automatic selection of the rules to be implemented

MULTIPLE KNOWLEDGE SELECTION

Knowledge selection in a multi-expert type DSS has to explore information from both internal and external areas. Each of the multiple aspects to be taken in consideration for a final decision (marketing, financial, personal, production, etc.) is treated in a specialized expert module (fig.3). Interactive interrogation facilities and a special data and knowledge management are also key elements in having a flexible decision structure.

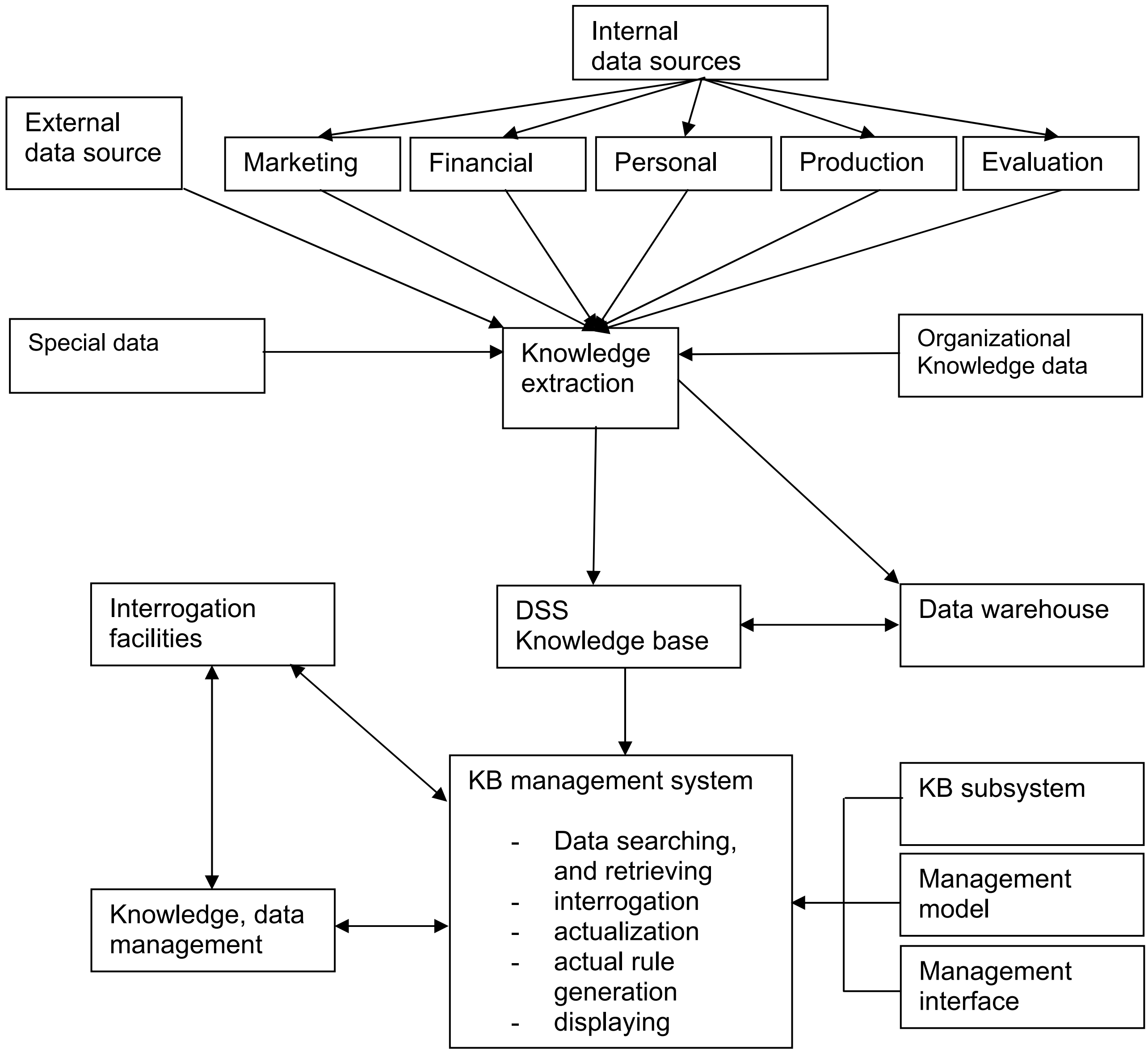

Fig. 3. The process of knowledge base structuring

GENETIC ALGORITHMS FOR OPTIMAL PROCESS SCHEDULING

In order to reduce costs and the system idle time, maximizing the production benefits, special software based on genetic algorithms was implemented – diagrams presented in fig. 4-5. The chromosome is meant to be a vector whose length is the number of tasks to be carried on (we supposed serial tasks to be accomplished in an order which is fixed upon the compulsory delivery term). Each "gene" depends on the machine index necessary for each task execution. A special case is when more stages from different streams of mechanical tasks may be superposed. A tree structure of commands is achieved beginning with the final task to be executed, passing by all the execution stages, to end with the primary operations (leaves) and a particular function is designed in order to compute each individual's fitness in the original population. Non-uniform mutation, weighted crossover and schemata [2], [3] are used in order to transform the new selected population: The production devices represent the support for the operations to be executed and they are characterised by more time parameters, describing their features for production, their quality in tolerance preferences, daily capacity and the existence of special priorities and constraints. The operations to be executed are in fact the connection between the devices, the bench marks to be produced for the commands. Each operation has: unique name, unique output, quantity of output sets, the necessary input list for production, a list of possible machines to be used for the operation to be executed (with the corresponding time) and grouping possibilities. The commands constitute the basis for the activity schedule with the priority accorded to the most approached delivery term. Each command is obviously formed of a unique name, the launching time, delivery time and the list of components and quantities composing the command. The stocks have the role to inform us about the bench marks dynamics.

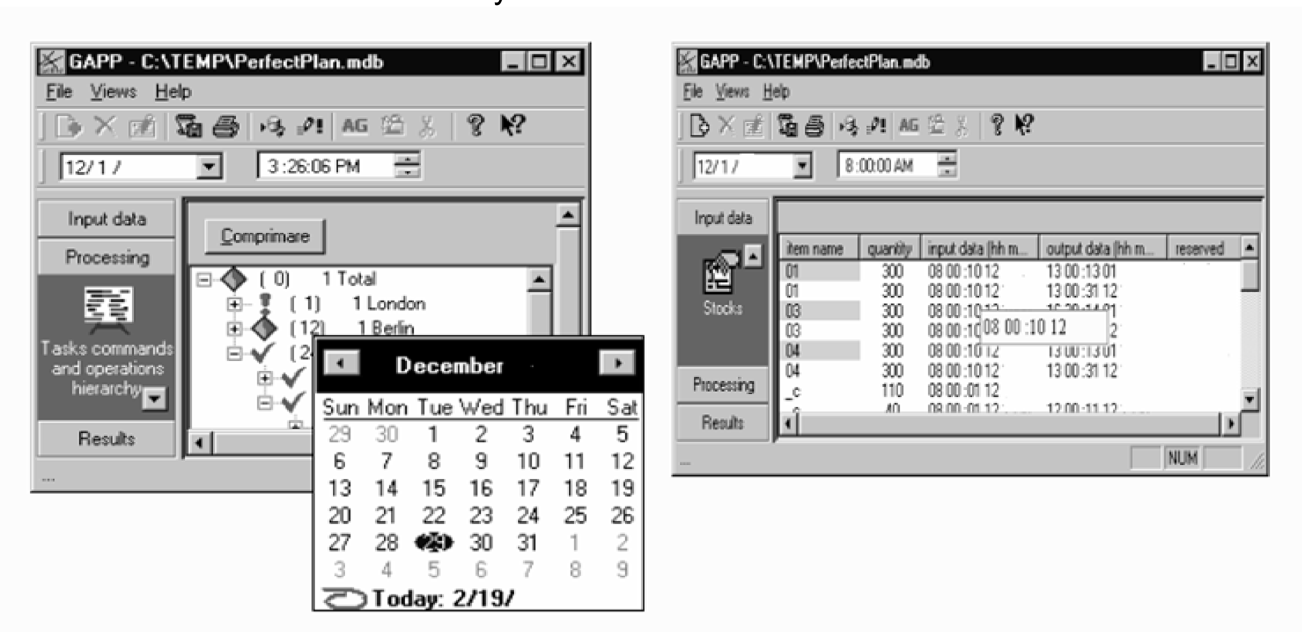

Fig. 4. Frames obtained in the optimization process: preparing/launching, stocks/tasks state

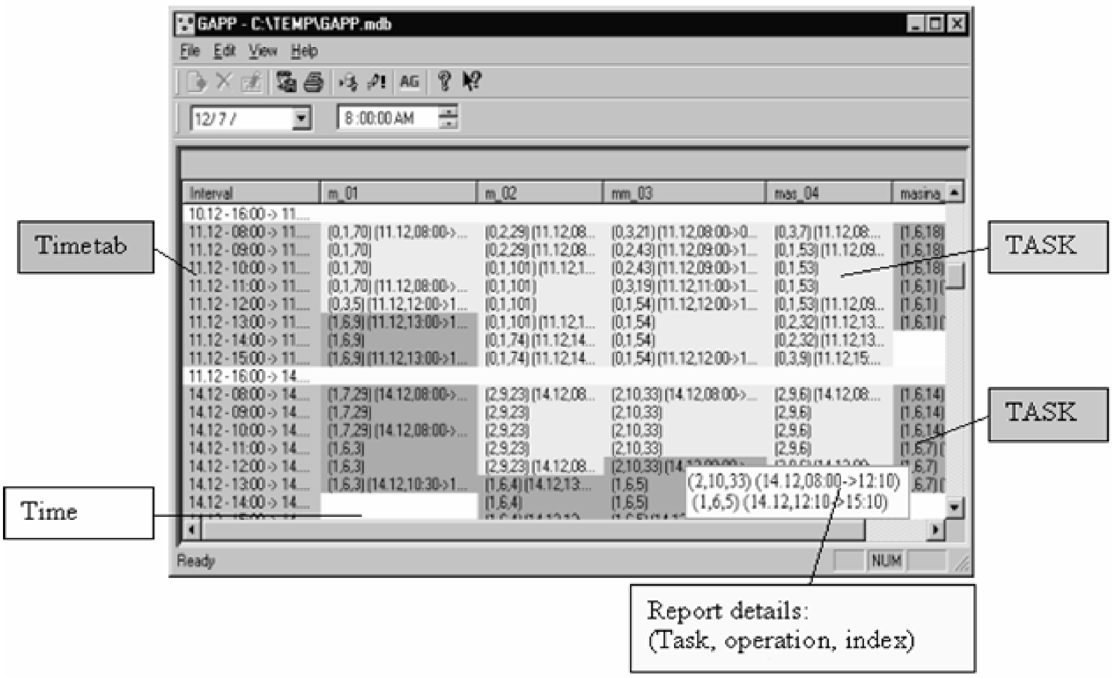

Fig. 5. GA process scheduler – a solution in the optimization process

WEIGHTED DECISION SYSTEM

Each DSS expert module gives a specialized partial decision (fig.6) and we have to deal with different degrees of influence on the final result. For example: being the first one on the market to launch a certain product (that imposes acquiring technological advantage) might have more importance for a certain decision group, than the significant amount of training expenses in order to have skilled specialists. Going, for example, 50% over budget during development stage to get a product out on time might reduce its total profits by only 4%, while staying on budget and getting it to market six months later cause a profits reduction by a third [15], that is, let's say, vast investment and production acceleration, instead of a new prospecting process. Thus, time might be an important criterion, with a special weighting w_i coefficient, reported to (somehow) less significant financial aspects. Overall, there are reinforcing aspects (support of personal demands in spite of the managerial expectations). Reinforcement detected factors influence the final belief in the final decision.

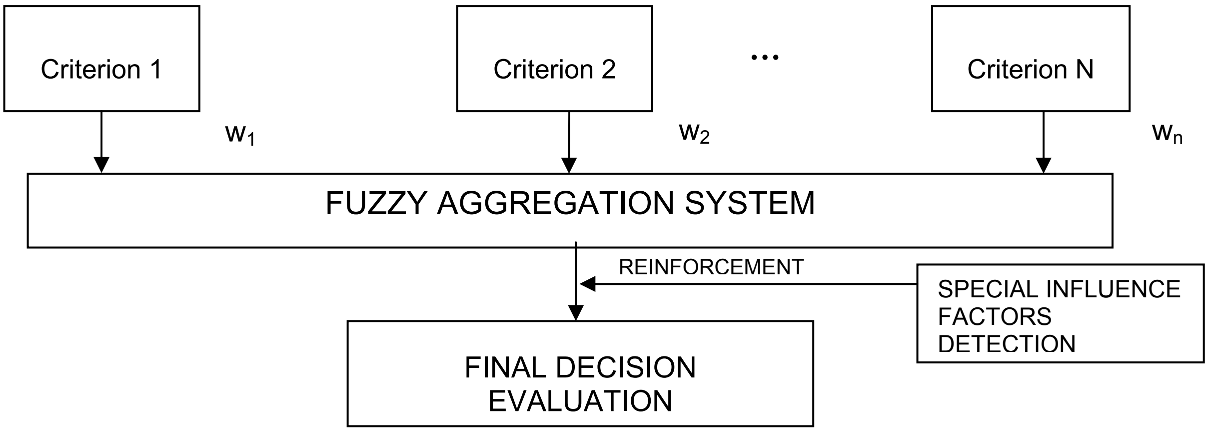

Fig. 6. Weighted decision system with a belief reinforcement module

The aggregation of different criteria is realized in a fuzzy system [1] that takes into account the range of variation and membership functions of the accorded weights. Accurately calculated statistics establish the appropriated fuzzy rules. Fuzzy CLIPS (high level rule-based programming language) constitutes an appropriate environment to deal with these particular detected rules.

CONCLUSIONS AND FUTURE WORK

As practical applications of the developed structures we presented improvements in process selection and operational flow scheduling, bringing substantial possible benefits. Some interesting conclusions deserve to be highlighted:

- hierarchical knowledge base structures give systematic better results in decision options and survey than equal importance rules systems;
- automatic rule extraction for products selection save a very important time in obtaining competing results;
- genetic algorithms minimize time in optimizing the design expenses, and realize a good scheduling of the production flow;
- weighted decision obtained in a special fuzzy aggregation system, designed according to different importance of the considered factors, is a more realistic way of treating real situations; reinforcement values may increase the confidence for the evaluated decision.

Virtual enterprising in order to eliminate unpredicted events is a must, in the actual information and continuing growing consume society.

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