APPLICATION OF RULES ENGINES IN TECHNOLOGY MANAGEMENT

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Abstract: In the paper we present the initial results of our research aimed at development of the tool which will benefit from virtues of BRMS and will enable support of technological decisions. Our task was focused on preparation of use cases set along with precise description of rules used for solving specific decision problems. For this purpose two decision problems were analysed which covered such issues as selection of feedstock or executive production planning. These problems were analyzed in view of a company producing cold-rolled strips in a wide dimension range and diversified grades of steel. The general conclusion which is the answer to the question of the possibility to create a tool similar to BRE but capable of technological decision supporting is a statement that it is necessary to combine two forms of knowledge presentation: declarative and procedural. It is also necessary to ensure the possibility of communication between this type of instrument and external data sources as well as various types of IT tools supporting specific technological decisions.

1 INTRODUCTION

Nowadays an integrated information system supports almost every corporation in all fields of management. Nonetheless, such support is limited to realization of administrative tasks and does not influence significantly the decision making processes. On the other hand, engineering solutions are applied in the specific fields of management (such as logistics, technology management, transportation etc.), however they are not well integrated with corporate IT systems. In the recent years there were many attempts aimed at broadening the functionalities of IT systems as well as their integration with specialized tools. These work were conducted in parallel in two fields. On one hand, sophisticated expert systems for support of technological decisions were developed, and on the other the results of operational research were used for the development of systems which support specific decisions (e.g. advanced planning and scheduling systems). Regrettably, no widely accepted results were obtained in either of these fields. A similar issue arose in case of management problems that are not characterized by standard, repetitive decisions. It was grounded on the fact that development of individual IT solutions required participation of specialists from a given domain, the development process of application was excessively long and ultimate solutions were hardly flexible. In the first decade of the century in the domain of business rules a new opportunity came to existence, i.e. BRM systems. They allow for considerable simplification of application development process and enable to formulate characteristic repositories of organizational knowledge. Nonetheless, up to now such solutions were not successfully applied for support of technological decisions or more complex decisions related to management of manufacturing processes.

Support of technological decisions may be realized through expert systems. Presented in literature automatic support systems of production process design, despite different scope as well as the manner of presenting technological knowledge, are characterized by a stiff, *a priori* formulated structure. In consequence, user has possibility neither to develop knowledge nor introduce results of his own research without reformulating knowledge base – doubtlessly with cooperation of system designer.

The research, co-funded with the European resources, is aimed at development of the tool which will benefit from virtues of BRMS and will enable

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support of technological decisions. In this paper we present results of our research on capabilities of BRMS and characteristics of technological decisions.

In particular our task was focused on preparation of use cases set along with precise description of rules used for solving specific decision problems. For this purpose two decision problems were analysed which covered such issues as selection of feedstock or executive production planning. These problems were analyzed in view of a company producing cold-rolled strips in a wide dimension range and diversified grades of steel.

2 RULE BASED TOOL FOR TECHNOLOGY MANAGEMENT

As part of our project we developed assumptions of a new tool for decision support, including technological decisions.

Main stream of research activities in the area of knowledge modelling for BRE is connected with application of description logics for ontology formulation. Our experiences indicate that the most effective solution, capable of direct cooperation with majority of industrial information systems which simultaneously provides decidability, is a combination of relational model with inference system that utilizes attributive logics. Our solution, named Inference with Queries (IwQ) (Maciol, 2008), has been developed as a knowledge model and an inference engine for formulation of Business Rules Management Systems. Knowledge storage is realized in accordance with principles of Variable Set Attribute Logic (VSAL) (Ligeza, 2006). An assumption was made, that in rule-based decisive system, attributes as well as variables will be stored in form of relations. Owing to the utilization of extended selection formula, knowledge definition process becomes simplified. SQL queries realize a significant part of inference.

The essential functional requirements (solution features) are as below:

1. User will be able to easily create, delete and modify knowledge bases.
2. The way of inference (forward and backward) and process parameters (the start-up fact, the way of passing messages, the ending conditions) can be set automatically by the system, the knowledge architect at the stage of its creation or at the stage of inference.
3. The system provides a set of tools for acquiring knowledge of facts from external sources (databases, procedures, programs, global network).

The inference process in our solution is controled by variable values of attributes that indicates which rules will be fired on current step of the reasoning.

3 EXEMPLARY DECISION PROBLEMS ANALYSIS

In the initial phase of our research we found that the system must combine the possibilities given by declarative as well as procedural notation of knowledge. Our solution gives such possibilities.

Research were carried out in a company producing cold-rolled strip in a wide dimensional range and variety of steel grades.

3.1 Feedstock Selection for Actual Order

Parameters of feedstock selection may be characterized as follows:

1. Steel grade of feedstock strip and rolled strip should be identical. There are possible some departures from this ‘literal’ conformity, especially in case of low-carbon grades of steel. In many cases chemical composition of grades of steel resemble one another. Rules that define changing process of steel grades may be visualised in the form of decision grid.
2. The width of the feedstock strip must be greater than the width of the rolled strip. In order to minimize ‘unjustified’ loss, different orders are combined together to prepare a milling from a single feedstock coil.
3. The width of the feedstock strip should make allowance for the width of the rolled strip in view of eventual cutting of the strip into strands.
4. A specific processing rate of feedstock into given thickness is required.
5. The weight of the feedstock coil should be in a proper relation to the weight of the order. The realization of order from the minimum possible number of different feedstock charges is the most favourable option in terms of uniformity of produced strip.

Hereunder we present the exemplary rules stored in a knowledge base:

```
rule 1
if
    input_material = 'hot-rolled'
and
    rolling_ratio >= 25%
and
    reduction_of_thickness >= 0.5 mm
then
    treatment_ratio := 'sufficient'
rule 2
if
    ordered_steel_grade =
           current_coil_steel_grade
and
    feedstock_coil_width >=
                 min_adequate_width
and
    treatment_ratio := 'sufficient'
then
    feedstock_coil := 'admissible'
```

The main task of the rule-based system is to verify which of the feedstock coils are 'suitable', i.e. whether they can be used as a charge for the realization of a particular order. Along the inference process, a given charge is marked as 'acceptable' if it is characterized by the proper grade, width and 'sufficient' degree of material reduction. The charge is 'suitable' if some additional conditions are satisfied, i.e. those related to the mass of the charge, the size of the crop and the number of strands being cut. If any of these conditions is not satisfied ('acceptable' charge is not 'suitable'), possibilities to combine orders are searched for or the coil is split.

The order which is supposed to be combined with the one analysed must satisfy the following conditions:

- grades of materials used in the realized order and the combined order must agree,
- the width of strip in the combined order must be greater than the width in the analysed order,
- the thickness of strip in the combined order can be smaller or equal to the thickness in the analysed order,
- the difference in weight between the coil and the analysed order/output must be at least greater or equal to the half of the combined order.

If there is no possibility to combine orders, the feedstock coil is divided into two strands of equal width.

If in this very case the conditions dictated by the rules of knowledge base are satisfied, the coils is designated for the realization of order.

If the mass of the coil is too big for the realization of the analysed order, the coil should be split into two smaller coils. The first coil is then used for the realization of the order, and the other is sent back to the store.

3.2 Production Scheduling

The input data for production schedule is:

1. planned sails quantity in tons,
2. production plan in tons,
3. production cards elaborated by Technology Division containing:
   - parameters of actual input strip coils,
   - parameters of final strip;
4. working time,
5. currently active machines,
6. machines productivity and capacity,
7. currently active workers staff,
8. rolling and cutting rates,
9. time priorities of particular order.

Time priorities of order realization arise mainly from:

- confirmation date of order realization,
- importance of the client for the company,
- declaration of fast realization time,
- acquisition of new recipients;

The executive production plan is prepared for a given monthly production rate on the basis of annual production plans as well as the set of orders confirmed for the current month.

An algorithm for preparation of the executive production plan with the use of knowledge base must be executed in multiple phases and use both declarative and procedural knowledge.

In the first stage the rolling mills are assigned to realization of particular orders.

In the next phase, the individual tasks are arranged. Formulas that are stored in the knowledge base allow to determine whether two consecutive orders are optimally arranged from the point of view of criteria that define urgency of orders. Those formulas classify current arrangement of two orders (i and j) as 'wrong' or 'correct'. If the arrangement is 'wrong', a swap in their order should be conducted. Exemplary arrangement rules are presented below:

```
rule 1
if
    distance_i_j = 'long'
and
    customer_i = 'important'
and
    customer_j = 'important'
then
```

```
    sequence := 'correct'
rule 2
if
    distance_i_j = 'long'
and
    customer_i = 'important'
and
    customer_j = 'new'
then
    sequence := 'wrong'
```

where `distance_i_j` is the distance between time of *i* order confirmation and *j* order confirmation.

The rules listed above are used for verification of arrangement of two orders in a milling process. They are applied in the algorithm presented below, which sorts the orders from the point of view of their urgency.

```
For i = 1 to OrdersCount - 1
  For j = i + 1 to OrdersCount
    If not Sequence(Queue(i),_
              Queue(j)) then
      X = Queue(i)
      Queue(i) = Queue(j)
      Queue(j) = X
    End If
  Next j
Next i
```

The **`sequence`** statement is the call to inference engine that verifies if the order ***i*** should by processed before the order ***j***.

The successive formulas and procedures assign the cutting operations to a specific cutting unit, determine the number of work mode rotations for individual rolling mills, delegate the tasks prescribed to a given rolling mill for execution in individual weeks, and compute a working time of the cutting units for each week of the month. In every case mentioned above we deal with a smooth combination of typical procedures utilizing numerical formulas with complex logical blocks that can be effectively implemented by means of declarative knowledge.

4 CONCLUSIONS

The two problems presented above are very complex problems of decision-making. This statement concerns especially the development of a monthly action plan. Due to the high complexity of this decision problems the test data will be perfectly suitable for the verification of the inference engine model which has been created.

The devised database compatible with the concept of a knowledge base with various attribute values will be used to verify the assumed conceptions at the further stages of the project. The works confirmed that it is necessary for the solution of complex decision problems in the area of production technology to apply hybrid systems – the combination of a rule system and procedural calculations. It appeared practically in each of the analyzed problems. The rule systems check the fulfillment of certain technological requirements (whether the condition of an adequate degree of processing of feedstock is fulfilled, whether reduction of strip is sufficient, whether the parameters of cutting unit allow to cut a strip of defined parameters in a set number of strips etc.).

The checking of these conditions is a part of the algorithms which support analyzed decision-making processes.

Ultimately, the verification of the proposed solutions will therefore need to develop programs realizing procedural calculations and using devised inference engine.

The general conclusion which is the answer to the question of the possibility to create a tool similar to BRE but capable of technological decision supporting is a statement that it is necessary to combine two forms of knowledge presentation: declarative and procedural. It is also necessary to ensure the possibility of communication between this type of instrument and external data sources as well as various types of IT tools supporting specific technological decisions.

None of the currently available BRE does not meet the requirements arising from the need to combine declarative and procedural knowledge while maintaining the logical consistency of the knowledge model.

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