The Pattern-Oriented Decision-Making Approach

Delibašić, A., Boris; and Suknović, B., Milija

Abstract*-This paper introduces a pattern-based approach when solving decision-making problems. We believe that integrated solutions of algorithms and methods in multiattribute decision-making (MADM) and data mining (DM) do not support the decision making process as they could in the process of finding an acceptable solution, or gaining knowledge. Most methods and algorithms in MADM and DM provide the decision maker an acceptable solution. On the other side the analysts have no freedom to adapt the methods or algorithms to the subtle details of the problem; so many new problems can't be handled well. We propose a solution of building pattern solutions for algorithms and methods of MADM and DM, where these patterns have passed experience validation and could be used well as building components in modular development environments. We believe this way that analysts could be able to generate their own algorithms and methods which could better adapt to new problems and generate better solutions. In this paper we present the four big patterns of decision-making and their common realizations. We present also the developed platform for modular MADM.

Index Terms: ***Decision-making patterns, Decision-making process, Business intelligence, Modular multiattribute decision-making application***

1. INTRODUCTION

When designing solutions in different areas there are integrated and there are modular solutions. Integrated solutions provide us with simplicity, but the lack of choice. Modular solutions give us the ability to have greater influence on our solution, but ask for more knowledge and attendance of the decision maker. In reality all solutions are between full modularity and full integrality [10,s.4]. We believe that for solving problems in the decision-making area, it is more appropriate to use modular solution, than integrated one.

We think that MADM methods and DM algorithms could be used more intensive in the decision-making process. Decision-making is sometimes an innovative activity. Decision-making and the process of design are interrelated [14]. Sometimes, it is unacceptable to model a decision or to seek knowledge with a method or algorithm which is not adaptable to the new problem. For the decision-makers the formal decision-making process is a black box. We think the time is right for making a white box of the algorithms and methods in DM and MADM.

With the development of pattern theories in various areas (architecture, IS, tele-communications, organization) it seemed that the problems of adaptability and maintenance of decision-making methods and DM algorithms could be solved using patterns. That is why decision-making patterns in the area of business intelligence and business decision-making have been identified and presented.

In this paper an original software platform for modular MADM is being presented. The decision analyst is now equipped with a tool that allows him generating his own MADM method.

2. PATTERNS ARE BUILDING BLOCKS

The ideologist of the pattern movement, Cristopher Alexander defines pattern as *a three-part rule that expresses the relation between a certain context, a problem and a solution. It is at the same time a thing that happens in the world and a rule that tells us how to create that thing and when to create it. It is at the same time a process, a description of a thing that is alive and a process that generates that thing.* [3] This definition tells that for problems in certain context, there is most often a solution. The solution a pattern provides is a thing (the solution) and a process of achieving the solution. A pattern is a building block that can be used for generating solutions. What is more important is the following statement of Alexander [1]: *The human feeling is mostly the same, mostly the same from person to person, mostly the same in every person. Of course there is that part of human feeling where we are all different. Each of us has our unique individual human character. That is the part people most often concentrate on when they are talking about feelings, and comparing feelings. But that idiosyncratic part is really only about 10% of what we feel. 90% of our feelings is stuff in which we are all the same and we feel the same things. So, from the very beginning when we made the pattern language, we concentrated on that fact, and concentrated on that part of human experience and feeling where our feeling is all the same. That is what the pattern language is – a record of that stuff in us, which belongs to the 90% of our feeling, where our feelings are all the same.* This means that in the Alexandrian way [1][2][3] a pattern is something that belongs to the common value of humans, that is, a pattern is understandable for most decision-makers, if not all.

So, patterns can be used for building systems and patterns are understandable for most people. If patterns could be identified in methods and algorithms of MADM and DM, then the decision-maker could be provided with a tool of generating their own methods and algorithms, depending on the problem he/she is solving. That way, black boxes from business intelligence could transform into white boxes.

For the formal representation of patterns in this paper the J.O. Coplien pattern formalization form has been used [4] [5, s. 8]. This form consists of the following elements:

- Context,
- Problem,
- Forces,
- Solutions and
- Resulting context.

Pattern starts with a context and result with a resulting context. Patterns change the space in which they are used. A context describes the surrounding that should be able to fit the pattern. Patterns are dependant of the context in which they are used.

Problem describes what produces the uncomfortable feeling in a certain situation, and what forces the decision-maker to seek a solution. The uncomfortable feeling comes from the forces. Forces are keys for pattern understanding. They describe the problem space. They are directed in different ways (example: force 1: excellent book, force2: very expensive), so they are not harmonized and do not produce a solution.

When a problem and its forces are well understood, then a solution is easily recognized. The reason is because patterns are familiar to people. People and the nature alone are made of patterns. The solution, the pattern itself, resolves forces and provides a good solution. On the other hand, a pattern is always a compromise, while it resolves some forces, it adds to the context space new ones.

The resulting context describes what the pattern has done positive and what negative. The five steps or elements can be done many times in order to find better patterns. Patterns change because new forces can make the pattern become inapplicable, so a new pattern can replace previous used pattern. So the process of reaching pattern is continual.

Alexander says [2]:

1. Patterns contain life.
2. Patterns support each other: the life and existence of one pattern influences the life and existence of another pattern.
3. Patterns are built of patterns, this way their composition can be explained.
4. The whole (the space in which patterns are implemented to) gets its life depending on the density and intensity of the patterns inside the whole.

3. *THE FOUR GREAT DECISION-MAKING PATTERNS*

We have conducted an analysis in MADM, DM [12], case-based reasoning [16], and artificial neural networks [15] [9] and identified four patterns that fully describe and support the decision-making process. Four patterns that were identified are:

1. Divide et impera,
2. Assign a common value,
3. All as one (More information in one), and
4. Analysis (Feedback).

3.1. Divide et Impera

Divide et impera is a common pattern. People have been using this pattern since their creation, this pattern can be found everywhere in nature. Every problem is usually separated into small parts in order to be handled. All our problem solving is dependent upon this pattern. It is referred to as analysis. A symbolical representation of the pattern is shown on Figure 1. The height can not be conquered “at once”, but it is necessary to divide the height into smaller, manageable heights and the big problem can then easily be solved.

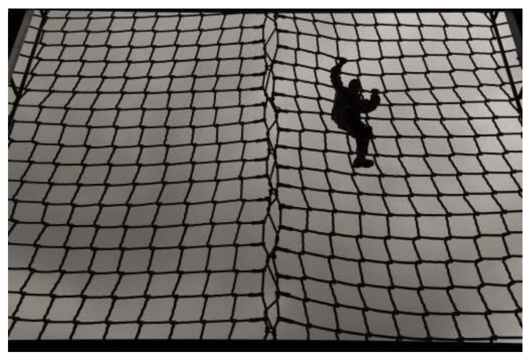

Figure 1. A height that can not be solved at once

In decision-making this pattern is used for structuring problems. It is necessary to define for a problem several attributes, their weights and relations. In the Coplien form it can be written down as follows:

Context: A decision-making problem has aroused.

Problem: There is not a criterion that can describe the problem by itself. There are a lot of attributes that have different intensity (weights), that have relations among them, and that can define the problem. How to know what attribute to choose?

Forces:

- By dividing the problem into sub problems (attributes) it is possible to handle the problem.

- It is not clear how much each attribute influences the problem, its weight is unknown.

- It is possible to choose an attribute that has no influence on the solution of the problem or to

leave out an attribute that has big influence on the solution of the problem.
Solution: The problem should be divided into attributes, so the problem model will be gained. In this model all attributes should be assigned with weights and their relation towards other attributes. It is a crucial task, so it is advisable to consult an expert.
Resulting context: Problem structure is given. One can not be sure if the problem structure will solve the problem correctly. It is known that the problem structure (model) has big influence on the solution.

3.2. Assign a Common Value

Assign a common value is a crucial pattern in team building, organization and all spheres of life where cooperation between objects is necessary. It can be found in all armies on the world and it is one of the army's basic principles. On Figure 2, it is shown what this pattern does.

Figure 2. Uniforms in armies (common values assignment)

All soldiers wear the same uniform. In order to have a good army, every soldier must accept common values on behalf of his/her own individuality. Only this way an army can be successful.

In the decision-making area, this pattern is known as normalization. Normalization provides the data with uniformity, but on the other hand makes a lot of information loss. It is the same principle like in the army. It is a compromise. The Coplien pattern form is:
Context: A problem is structured and the cases (alternatives) have been selected according to the problem structure.
Problem: Not all attributes have the same data type. How to compare and manage the data?
Forces:
- Assigning a common value to all data, the case table becomes easy to manage and analyze.
- A huge amount of information is lost in the data normalization process.
- Expert knowledge about the decision problem is needed.
Solution: Assigning a common value and taking care about minimal loss of information.
Resulting context: The case table is ready for analysis. It is possible that the wrong normalization (assignment of common value) will produce a wrong solution.

3.3 All As One

All as one is a pattern that is known as synthesis. When a team, an organization etc., has reached a common value, it produces excellent results. The team acts as one and solves problems very efficiently. On Figure 3 it is shown how a well prepared team looks like.

Figure 3. The whole team is aiming at the same direction

In decision-making it is necessary to have a summarized value upon which the decision-maker can act. If the data is not well normalized, the summarized value and the solution will not be good. The pattern can be presented as:
Context: The problem has been structured and a common value has been assigned to data.
Problem: The decision maker can not decide upon multiple attributes. How to decide upon multiple attributes? How to sort a case table according to many attributes at the same time?
Forces:
- Having many attributes provides the decision-maker with good information for decision-making.
- The decision-maker needs a summarized attribute upon which he can decide what to do.
- Summarizing attribute values is followed with information loss.
Solution: Choose an aggregate value that can summarize more information in one. One should test more summarizing functions and select the one that gives best information to the decision-maker.
Resulting context: All alternatives (cases) have been assigned with a summarized value upon which the decision-maker knows what to do. All cases can now be sorted. The problem is that the summarized value often does not reveal all aspects of the solution, because a huge amount of data has been lost in data aggregation.

3.4 Analysis

Analysis is the last, but maybe the most important pattern in decision-making. It is a feedback pattern that allows improvement and learning of every system. On Figure 4 a feedback is shown. Though all soldiers are experienced, the trainer explains them their mistakes and explains how they could get even better.

Figure 4. Analysis and preparation for new tasks

In decision-making it is important to see the accuracy of the solution and how it can be improved. It is often measured as the distance of the expected results and the results produced by the model. This pattern checks if the problem has been structured well, if the common value has been assigned properly and if the summarizing function has been well chosen. The Coplien form of the pattern is:

Context: A model has generated a solution for a problem.

Problem: The question is if the solution responds well to the problem? It is not possible to check if all of the previous performed patterns are done well separately.

Forces:

- Analysis can help improve solutions, by changing problem structuring, common value assignment, and aggregate functions.
- When the improvement of a previous mentioned pattern is done, it is assumed that the other patterns are performed well, that is, one can not see at the same time which pattern is good and which not.

Solution: Analysis should be done. A perfect solution can not be reached, because it is always assumed that some patterns are correct in order to improve the other ones. One must always have a leaning point.

Resulting context: Analysis helps in improvement of the system. On the other side, it can not guarantee reaching a perfect solution, just an acceptable one.

3.5 The Decision-making Process

Using the four great patterns of decision-making, it is now possible to define the decision-making process by forming a pattern language. The decision-making process, which is at the same time knowledge retrieval process, is shown on Figure 5.

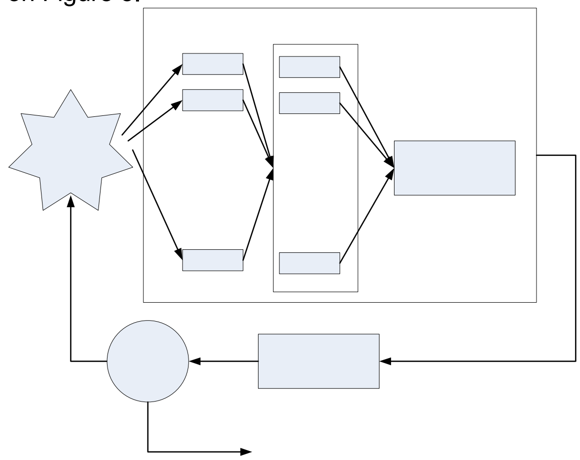

Figure 5. The pattern decision-making process

After a problem arises, it is necessary to divide the problems into sub-problems (attributes) to handle the problem. On the other side, one can not solve problems using multiple attributes. One attribute is needed in order to reach a solution. It is necessary to transform more attributes into one aggregate attribute. One can not get aggregate functions, until all data has been assigned a common value.

At last, one needs to check if the problem is solved well, and if not, to improve the system. So, the process of decision-making and problem solving is eternal and consists of analysis-normalization-synthesis-feedback-analysis etc.

4. THE MODULAR DECISION-MAKING APPLICATION (MADAM)

The ideas in the previous part where used to identify common patterns in MADM. Several MADM methods were analyzed in order to identify patterns of MADM. The analyzed methods are [6]: Simple additive method, Hierarchical additive method, AHP [6], ELECTRE [6], PROMETHEE [6], utility theory etc. In Figure 6 the identified patterns are classified depending on that to which pattern they belong.

In *Divide et impera* there are three patterns: Attribute rank, Attribute weight, Estimation matrix. In A*ssign a common value* there are six patterns: Quantification, Estimation matrix, Min to Max, Preference types, Normalization, Utility functions. In *All as one* there are three patterns: Maxmin, Maxmax and Expected utility. In *Analysis* there is one pattern: What-if analysis. These patterns have been implemented in an application we call MADAM. It is developed in Python program environment and represents a modular MADM system.

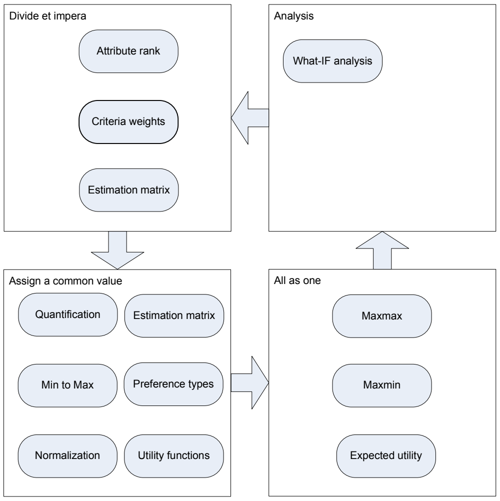

Figure 6. MADM pattern language

4.1 An example of application

We have developed a system we call modular multiattribute decision-making platform (MADAM) [7][8][9]. MADAM has user interface like depicted on Figure 7. It resembles the user interface of SPSS Clementine. The decision maker has to lead the decision-making process in order to reach an acceptable solution. He is building a stream that represents a new generated MADM method.

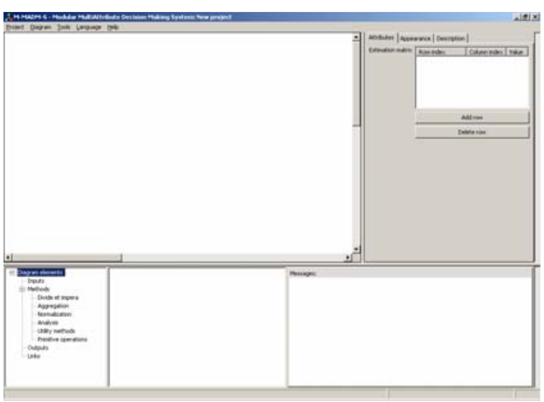

Figure 7. MADAM Interface

Suppose we solve a MADM problem. In general, there are *n* attributes and *m* alternatives. The goal is to find a most acceptable solution, to choose an alternative.

How was this done traditionally? [11] One would choose several MADM methods and see if they generate a common solution. One would, after several iterations of testing and analysis, choose the alternative which came out as the most acceptable for most MADM methods.

Our approach is different. We don't want the decision-maker to work with many MADM methods (many integrated methods) but we want him into the decision-making process. That means that we want the decision-maker, if needed, to model his own MADM method. The decision-maker has to be aware of the compromises he makes in that process. He has to be aware what he gets, and what he looses in every step in decision-making. He/she builds the solution by composing patterns. Every pattern gives something to the decision-maker, but takes something away. We think this is a more natural way of modeling the MADM problem.

Every MADM method has some good and some bad things. But, they are integrated. Often we can not "pull out" what is good from a method and leave out the inappropriate stuff. Traditionally, several MADM methods are being used and there results are being compared in order to look for some consensus between methods solutions.

As an example, suppose there are five attributes when solving a MADM problem. The attributes are k_1 to k_5. Figure 8 presents a stream in MADAM that could solve the MADM problem. After the data from the case table has been structured and read, the decision-maker does the following:

1. Transforms qualitative data to quantitative (Quantification). All data becomes numerical, but a lot of information is lost.
2. The decision maker can decide to use L1 metrics for normalizing attribute k_1, and $L\infty$ metrics to normalize attribute k_2. Every normalization type has its good sides and its bad sides. Choosing metrics depends upon the nature of data and the nature of the problem.
3. Normalizing attribute k_3 using the linear preference type from PROMETHEE (Preference type).
4. Normalizing attribute k_4 using an estimation matrix from AHP, and
5. Normalizing k_5 using utility functions.

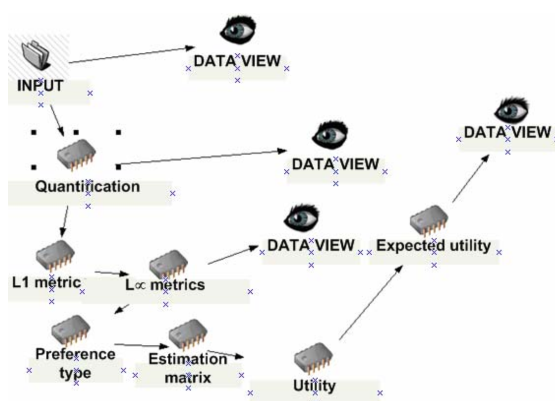

Figure 8. The stream of generating a new method for problem solving in MADAM

All values in the case table are afterwards normalized [0,1] and the decision maker can choose an aggregate function. He selects the Expected utility function and uses estimation matrixes from AHP to define attribute weights (AHP weights module). The decision maker reaches a satisfactory solution and ends the decision-making process.

A method editor is implemented inside MADAM which allows easy implementation of new patterns that could be identified in praxis. The interface of the editor is shown on Figure 9. When implementing the mentioned patterns inside MADAM, the idea was to implement the frequently used patterns in MADM.

MADAM presents a platform that supports the decision process in MADM. The decision maker influences the process and has great influence on the solution. The decision maker has now the ability to make a compromise between using integrated solutions (old streams) or to build its own solution (stream). This decision depends mainly on the problem structure. If the problem is new, it is better to form a stream, or modify an existing one.

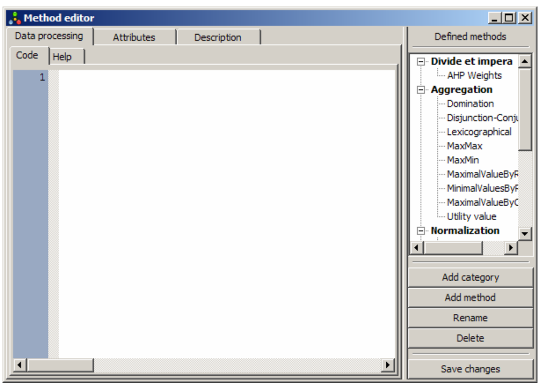

Figure 9. The method editor for modules maintenance and insertion.

5. CONCLUSION

When solving real MADM problems in the praxis, one can notice that the solutions are some kind of modification of existing MADM methods. So, the decision-maker always adapts his knowledge to new problem solving. It is like case-based reasoning [16].

What is important is that for a new problem, often a new method is created. We think that the expert decision maker does not like integrated solutions, but often uses modular approaches (combinations, mutations, etc.) which help him/her generate a solution.

It is also possible to help decision-makers explain the logic that is behind mathematical methods and algorithms. This is possible if the modules of the algorithms and methods are written down as patterns. The decision maker can then see the logic behind the methods and algorithms. He is then enabled to create his/her own method or algorithm that is better adapted to the problem.

There is not an infinite number of patterns, but a limited number. That is why it is possible to discover them in every area of human activity. *A decision maker becomes an expert in his area when he learns to use patterns from this area. A decision-maker is not an expert if he only knows integrated solutions*.

We have shown how this is possible to do in MADM. If the decision maker is looking for knowledge, it is a better approach to let him into the process, to see what he gets on every step, and what he looses. It is a more natural solution and in our opinion one direction of future data mining development.

REFERENCES

[1] Alexander, C., "The Nature of Order Book 1: The Phenomenon of Life", *The Center for Environmental Structure*, Berkeley, California, 2002.

[2] Alexander, C., „The Nature of Order Book 2: The Process of Creating Life", *The Center for Environmental Structure*, Berkeley, California, 2002.

[3] Alexander, C., "The Timeless Way of Building", *Oxford University Press*, 1979.

[4] Coplien, J.O., Zhao, L., "*Toward a General Formal Foundation of Design - Symmetry and Broken Symmetry", Brussels: VUB Press*, 2005.

[5] Coplien, J.O., "Software Patterns*", SIGS Books & Multimedia*, 1996.

[6] Čupić, M., Suknović, M., „Decision-Making: A Formal Approach", *FOS-Belgrade*, 2003.

[7] Delibašić, B., Suknović, M., "Pattern Decision Making", *Management,* No.– 39, 2005.

[8] Delibašić, B., Čupić, M., Suknović, M., Krulj, D., "A pattern based decision support system", *SIM-OP-IS*, Fruška Gora, Serbia, 2004.

[9] Delibasić, B., "Formalization of the business decision making process using patterns", doctor thesis, *FOS-Belgrade*, 2007.

[10] Eckert, C., Clarkson, J., "Design Process Improvement: a review of current practice", *Spriger Verlag London*, 2005.

[11] Holsapple, C., Whinston, W., Andrew, B., "Decision Support Systems - A Knowledge-Based Approach", *West Publishing Company*, 1996.

[12] Larose, D.,"Discovering knowledge in data, an introduction to data mining", *John Wiley & Sons Inc.*, December 2004,

[13] Lahdelma, R., Salminen, P., Hokkanen J., "Using multicriteria methods in environmental planning and management", Environmental Management 26(6),2000, 595-605.

[14] Simon, H.A, "The New Science of Management Decision", *Harper & Row*, 1960.

[15] Turban, E., "Decision Support and Expert Systems: Management Support Systems", Fourth Edition, *Prentice-Hall*, 1995.

[16] Watson, I., "Applying Knowledge Management – Techniques for Building Corporate Memories", *Morgan Kaufmann Publishers*, 2003.

Delibašić A. Boris is teaching and research assistant at the University of Belgrade, Faculty for Organizational Sciences, Center for Business Decision-Making.
Website: www.odlucivanje.fon.bg.ac.yu
Email: boris.delibasic@fon.bg.ac.yu

Suknović B. Milija is associate professor and vice-dean for curriculum at the University of Belgrade, Faculty for Organizational Sciences, Center for Business Decision-Making.
Website: www.odlucivanje.fon.bg.ac.yu
Email: milija.suknovic@fon.bg.ac.yu