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Doctor Custos, Doctor Opponent, Ladies and Gentlemen

Decision making is a task we constantly face in our lives. Every day we make various decisions, for example, what to wear or what to eat. Often, these are made intuitively or automatically based on our earlier experiences, and we may even be unaware that we are making a decision. At the other end of the scale are the big decisions such as buying a new house that may affect our lives for years to come. These decisions require us to compare and analyze different alternatives thoroughly so that we can be sure of the right decision.

Public decisions made in our society require special consideration, as they can concern thousands of people with diverse interests and their consequences can be far-reaching. Especially, in environmental decision making, there may be several different stakeholder groups with even conflicting interests. For example, a decision on whether to regulate a lake will affect citizens around the lake, recreational users, the nature, water power companies, fishermen, and so on. In these cases, it is important that the strategy alternative to be implemented tries to take all the different viewpoints into account fairly so that all the stakeholders as well as the public will approve the decision.

Multi-criteria decision analysis is a general term for structured approaches to support decision making in complex problems involving multiple attributes and alternatives. The aim is to take all the elements of the problem into account systematically, so that the decision will be based both on the decision makers' preferences and on the data about the alternatives. Consequently, the decision making process will be transparent and justifiable. In group decision making, this makes it possible to analyze different stakeholders' preferences in a common framework.

Multi-attribute value tree theory is a decision analytical approach in which the problem is structured into a hierarchical value tree consisting of attributes and alternatives. The preferences of the decision makers can be elicited, for example, by directly weighting the attributes according to their importance, or by carrying out trade-offs between these. In fact, we often make similar trade-offs in our daily decisions. For example, when comparing two items to buy, we deal with questions such as is it worth paying some extra money to get an item with more quality? In decision analysis, these trade-offs are carried out through a formal procedure to get preference relations between all the attributes. The alternatives are measured with respect to each attribute, and as a result, the process gives the overall values of the alternatives that represent their overall preference.

The more complex the problem, the more useful it usually is to apply some decision analytical approach. Thus, it is not reasonable to use these in our daily decisions, as the problems are typically small and they can easily be solved otherwise. In addition, the use of the methods requires certain expertise, and thus they may not be generally applicable. However, in societal decision making, the problems are typically complex and, thus, decision analysis can be very useful. There are also more resources available; for example, one can employ an outside decision analyst to facilitate the process.

Decision support systems are computer software designed to support decision making. The aim is to facilitate the practical implementation of the method and the process so that the decision maker does not have to worry about the technical details, but he or she can concentrate on the problem itself.

The first systems in the early 70's were merely calculators that were used to calculate the mathematics behind the methods. Since then computer technology has developed rapidly and has provided new opportunities to develop systems. For example, since the late 80's the graphical user interfaces have made it possible to easily visualize the methods. The invention of the World Wide Web in the mid 90's has enhanced communication possibilities considerably. The computational power has increased all the time and with modern computers it is possible to apply methods that require solving extensive mathematical problems.

In recent years, more and more researchers and developers have begun to emphasize the importance of process support in the system development. My thesis focuses on this process-oriented decision support system development. The basis for the discussion is that systems can be much more than just calculators and they can also provide procedural support that may considerably enhance the process.

Usually, decision analytical methods are mathematically sound, but the practical use of them may not have been considered thoroughly. However, the practical usability of the method often originates from the way it is applied. By properly applying the method, one can affect, for example, how effectively and accurately the true preferences of the decision maker are elicited.

Another important issue is to realize that the method and system development are not distinct, but they can complement each other. That is, by considering the new opportunities provided by computer technology, one can also get new innovative ideas to further develop the methods. The experiences obtained from real life cases as well as the needs of the practice also play an important role in the development of both the systems and methods.

Traditionally, the software has been used with the help of a decision analyst, but the familiar user interfaces of today's software also make independent use of them possible. However, as mentioned above, it may not be reasonable to allow decision makers to independently carry out the process. For example, there are different kinds of biases and possible errors that can occur in preference modeling. In practice, these can be difficult to detect, as the software can give proper looking results even if the methods are applied incorrectly.

In group decision making, one applicable approach is that certain part of the process is carried out in collaboration with a decision analyst and another part interactively by the decision makers according to the given instructions. For example, the construction of the model can be technically run by a decision analyst, but in the preference elicitation the stakeholders can independently use the system. There can also be some assistants available to help the stakeholders if needed and, thus, these do not need to have decision analytical background. Finally, the preference models can then be analyzed together to get a view of the other stakeholders' preferences.

Another applicable approach is a setting in which a steering group is set up to represent various stakeholder groups. Then, decision analysis interviews are carried out to model the preferences of the steering group members one by one. The models are analyzed and discussed together within the group with an aim to get a view of the other stakeholders' interests. The public can be involved in the process by arranging public meetings in which the results of the steering group meetings are presented and discussed.

My thesis studies various issues related to the process-oriented decision support. These range from the ones on system development to the ones related to studying the best ways to use the methods. The thesis also reports practical experiences on the use of the decision analytical approaches and new tools in the two above-mentioned group decision making settings. The aim is to find out the best practice to involve decision makers interactively in the process.

The systems developed in the thesis – Web-HIPRE and Smart-Swaps – are based on the use of the latest advances of information technology. At the time of their introduction, Web-HIPRE was the first Internet-based multiattribute software in the world, and Smart-Swaps the first software to support the Even Swaps method.

Web-HIPRE allows using different methods in the same model. This makes, for example, behavioral research on the differences between the methods possible. The software also provides a group model that allows combining individual preference models to a group model through the Web. Web-HIPRE has already been applied in several real life cases, especially in environmental management. It has also been integrated as a decision support module into the European realtime online decision support system for nuclear emergency management called RODOS.

The Smart-Swaps software provides support for the elimination process of the Even Swaps method. The method is based on value trade-offs, which are called even swaps. In these, the consequence of an alternative in one attribute is changed and this change is compensated with a preferentially equal change in the consequence of some other attribute. The new virtual alternative with the revised consequences is equally preferred to the initial one and, thus, it can be used instead. The aim is to carry out swaps so that eventually one alternative dominates all the other ones so that in every attribute this alternative has a better or equal value than the other alternatives. This can be considered the most preferred alternative.

The development of the Smart-Swaps software can be seen as a typical example of true process-oriented system development. Conceptually, the Even Swaps method is easy to use, but especially in large problems, its practical use may not be straightforward. For example, already in problems with 6 or 7 alternatives and criteria, the identification of possible dominances as well as the selection of the next swap can be difficult, as there are usually several different options on how to proceed with the process. Thus, some support is needed so that the method could also be applied in large problems.

To meet these needs, my thesis presents a new process-oriented approach that helps the decision maker in these tasks. In this approach, the even swaps method is carried out as usual, but simultaneously a value tree approach is applied in the background of the process to provide suggestions to the decision maker on how to effectively carry out the process. The approach together with other technical and procedural help has been implemented in the Smart-Swaps software.

As one special area of interest, my thesis considers different ways to apply interval methods in practice. In these methods, the decision maker does not have to give precise estimates about the preferences on the attributes or about the performance of the alternatives. Instead, he or she can give a range of values within which the 'true' value is. This makes it possible to include imprecision or uncertainties in the modeling.

Technically, the interval approaches are well documented but the practical use of them has not been widely studied. My thesis discusses this practical use with an aim to find efficient and applicable ways to apply the approach in various tasks. The thesis demonstrates, for example, how intervals can be applied to study the sensitivity of the results to possible simultaneous changes in the model parameters.

The real life experiences are reported in two environmental cases of lake regulation and nuclear emergency management. These experiences strongly support the applicability of the decision analytical approach and new tools in environmental decision making. Especially, in group decision making, the support provided by the system can help the structuring and understanding of the effects of different alternatives as well as the preferences of the other stakeholders. Consequently, these can help to reach a result that satisfies all the stakeholders. The hands-on use of the software by the stakeholders in preference elicitation also appeared to be an applicable approach, assuming that the models are simple enough and the help is available, if needed.

Overall, this thesis has given new insights into the process-oriented decision support system development. The obtained experiences show that with suitable process support and proper ways to carry out the process, one can considerably enhance the process. Thus, one can expect that, in the future, the development towards more and more process-oriented decision support systems will continue.

I ask you Professor Theodor J. Stewart as the opponent appointed by the Department of Engineering Physics and Mathematics to make any observations on the thesis which you consider appropriate.