AN ICT SYSTEM FOR DECISIONAL SUPPORT IN UNIVERSITY MANAGEMENT

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Abstract: Informational systems are becoming essential for the success of the organization. A successful information system must utilize both global and local knowledge of both products and customers. This paper presents a Decision Support System that aims to be a grey-box system that combines specific knowledge in a certain domain, with the preferences of the user. It is addressed especially to university managers who wish to base their decisions on rigorous solid scientific methods. The Grey Decision Support System (GDSS) is a tool that helps decision makers choose from more possible decision alternatives the one that suits best their needs, based on a set of decision criteria of their choice and a set of recommendations given by the system. Thus the proposed system is a Business Intelligence system as it is a specialized tool for data analysis, query, and reporting, that supports organizational decision-making that potentially enhances the performance of a range of business and academic processes.

Keywords: organizational decision-making, business intelligence system, knowledge management, university management.

1. Introduction

Knowledge management is a relatively new concept that first emerged during the 1990s. Its main objective is to improve the way in which organizations manage one of their most important and intangible assets, Knowledge. One of the first definitions of knowledge management can be traced back to Davenport[1] who defines the concept: “Knowledge management is the process of capturing, distributing, and effectively using knowledge”.

Another more elaborate definition is given by King[2] “Knowledge management is the planning, organizing, motivating, and controlling of people, processes and systems in the organization to ensure that its knowledge-related assets are improved and effectively employed”.

By conducting an analysis of the various definitions existent in the field[3], [4], [5], [6] and those presented above we can state that the knowledge management process postulates the existent connection between knowledge and organizational performance. It is concerned with managing the steps required to effectively and efficiently utilize knowledge and also with the processes that support these steps.

Knowledge management has to contend with three types of knowledge:
• **Tacit knowledge** which is located within the mind of a human being and can be very difficult or even impossible to explicate and extract.

• **Implicit knowledge** which is held within the mind of a person and can be synthesized into various forms (e.g. documents), but has not been thus far.

• **Explicit knowledge** has been codified and stored in a certain media and can be easily transmitted to others.

Lew Platt, ex CEO of Hewlett Packard emphasizes the importance of knowledge management in business thru the following statement: "If only HP knew what it knows it would make three times more profit tomorrow". O'Dell and Grayson[7] suggest that an ineffective knowledge management approach can lead to opacity within organizations and to a state in which “the organization does not know what it knows”.

Knowledge management is important, in today's highly flexible and increasingly demanding marketplace in which the only constant is uncertainty, because it provides the only sustainable competitive advantage[8], [9].

### 2. Types of decisional support programs

Knowledge management (KM) can have great efficiency, on an individual and organizational level, when it is implemented correctly thru decision support systems. This is because KM is closely integrated with information and communication technologies[10], [11], which play a key role in enabling and supporting its practice[12] and because of its capability of reducing bias in the strategies formulated by a decision maker. In this respect decision support systems are a key tool in KM, because they act like an expertise locator for the individual or organization, which is trying to ascertain a correct path of action.

Decision support systems come in a varied array of shapes and sizes. They vary based on the way organizational and individual knowledge is located, extracted, organized and ultimately presented to the decision maker. We identify two types of support system: the “Black Box” and “White Box” systems and propose a third type the “Grey Box”.

The “Black Box” DSS (BBDSS) is centered on automating knowledge by applying systems that tend to solve problems in the place of individuals[13]. These have the propriety of reasoning in a limited and narrow field[14]. They are useful when applied to routine activities and in the case of rule based or case based reasoning. There are some drawbacks in the utilization of BBDSS. They tend to become cumbersome, unwieldy and error prone when the number of rules applied in a system increases, or when these cannot be specified precisely. The rigidity and frailty of such systems was eloquently displayed a few weeks ago when Wall Street’s BBDSS triggered an automatic response to the fake news that the president of the U.S. was shot, causing billions of dollars in losses to stock market investors.

The “White Box” DSS (WBDSS) takes the diametrically opposite approach. It is focused on guiding the decision maker by presenting relevant knowledge, thus enhancing their interpretation
of it and facilitating problem solving[15]. Sometimes though this system can overload the individual with information and create confusion and unnecessary time depletion in the process.

This paper presents a “Grey Box” Decisional Support System (GBDSS) as a tool in the KM arsenal that combines characteristics of the “Black Box” and “White Box” systems. It facilitates and explicates an individual’s decisions based on a set of personal, programmable criteria (BBDSS) and it presents recommendation and guidance (WBDSS) solely based on them. As a result the vast amount of information available is synthesized into knowledge based on which the decision maker can ascertain the best course of action in a shortened time span. The presented GBDSS can be used in various situations both by business administrators, but also by academics who have managing positions and are faced with daily challenges.

3. A Grey Decision Support System for knowledge management

Informational systems are becoming essential for the success of the organization, be it profit oriented or non-profit. A successful information system must utilize both global and local knowledge of both products and customers. By global customer knowledge we mean knowledge that is independent of the particular product domain, such as knowing how people make purchase decisions or how best to “converse” with them online. Global product knowledge includes the product’s attributes, their functionalities, and anything else that is independent of the particular seller’s offerings.[16] A domain expert in personal computers, for instance, knows video cards, their performance capabilities (e.g., which type of card is needed for displaying photographs, playing video games, or showing movies), their approximate prices, and even how rapidly their technology is changing. Local customer knowledge refers to the ability to link a customer’s personal needs, uses, and preferences to the focal product. Thus, a consumer may have a high need for status among coworkers that might influence many purchases. However, local consumer knowledge enables a DSS to direct the consumer toward a particular product, such as a personal computer with the image of the latest and greatest technology or an automobile that signals status (at least to the target audience of coworkers). Local product knowledge focuses on the vendor’s offerings. Such knowledge not only includes models, styles, components, add-ons, etc., but also which components can be configured with others and the moment-to-moment availability of any recommended product or special offers.

We propose a Decision Support System that aims to be a grey-box system that combines specific knowledge in a certain domain with the preferences of the user. The Grey Box Decision Support System (GBDSS) is a tool that helps decision makers choose from more possible decision alternatives the one that suits best their needs, based on a set of decision criteria of their choice and a set of recommendations given by the system.

The GBDSS is based on an algorithm that combines two well-known methods: the hierarchic-analytic process and the advanced multi-criteria analysis based on FRISCO formula.[17] The GBDSS is applicable for an unlimited number of decision alternatives and selection criteria. For
exemplification, we have chosen to present the situation with 5 selection criteria and 5 decision alternatives. The GBDSS has a vast applicability and the set of recommendations that the user should consider when making a decision is different for each specific domain.

Following we present an example of a hypothetical situation that can be encountered in a university. Let’s assume that the computer infrastructure needs to be renewed and thus the administrator is faced with the challenge to purchase a certain number of computers for a computer lab. The system allows him/her to choose from a drop-down list the purpose of the computers. Such a list can contain the following options: buy the computer for gaming, video editing, 3D product design or text editing. If the decision maker chooses that he/she wants to buy the computer for video processing, for example, the system returns a list of recommendations regarding the configuration of such a computer. Thus the decision maker can make informed decisions. He knows now that he should consider buying a computer that has a good video card and that it’s also important to have a high speed processor and RAM memory.

The system allows the decision maker to define his/her own selection criteria and decision alternatives. In table 1 there are presented the ones used for exemplification.

<table>
<thead>
<tr>
<th>Selection Criteria</th>
<th>Code</th>
<th>Selection Alternatives</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costs</td>
<td>C1</td>
<td>HP</td>
<td>A1</td>
</tr>
<tr>
<td>Processor</td>
<td>C2</td>
<td>Dell</td>
<td>A2</td>
</tr>
<tr>
<td>RAM Memory</td>
<td>C3</td>
<td>Acer</td>
<td>A3</td>
</tr>
<tr>
<td>Video Card</td>
<td>C4</td>
<td>Lenovo</td>
<td>A4</td>
</tr>
<tr>
<td>HDD</td>
<td>C5</td>
<td>MSI</td>
<td>A5</td>
</tr>
</tbody>
</table>

After naming the criteria, the decider has to define the relationships between every pair of two criteria. In other words, every criterion is compared against the others and a quadratic matrix that presents how these criteria relate to each other is filled in by the decider. When comparing two criteria the decision maker faces three possible situations:

- Criterion 1 is more important than criterion 2 – in this situation the score for criterion 1 is “1” and the score for criterion 2 is “0”
- Criterion 1 is equally important as criterion 2 – in this situation the score for both criteria is “0.5”
- Criterion 1 is less important than criterion 2 – in this situation the score for criterion 1 is “0” and the score for criterion 2 is “1”

In order to simplify the completion of the relationship matrix, a formula has been added to the cells below the main diagonal of the matrix, so if the decider believes that criterion 1 is more important than criterion 2, the formula automatically shows that criterion 2 is less important than
criterion 1. Also the main diagonal has been automatically filled in with “0.5”, showing that each
criterion is equally important with itself. This eliminates the risk of inconsistency of the
relationship matrix. Table 2 shows how the matrix is filled in, highlighting with different colors
the fields that can be filled in by the user and the ones that will be automatically filled in.

<table>
<thead>
<tr>
<th>Selection Criteria</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
<th>C5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costs</td>
<td></td>
<td>0.5</td>
<td>0.5</td>
<td>0.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Processor</td>
<td></td>
<td>0.5</td>
<td>0.5</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>RAM Memory</td>
<td></td>
<td>1.0</td>
<td>1.0</td>
<td>0.5</td>
<td>1.0</td>
</tr>
<tr>
<td>Video Card</td>
<td></td>
<td>0.0</td>
<td>1.0</td>
<td>0.0</td>
<td>0.5</td>
</tr>
<tr>
<td>HDD</td>
<td></td>
<td>0.0</td>
<td>1.0</td>
<td>0.0</td>
<td>0.5</td>
</tr>
</tbody>
</table>

It is important to remember that the scores presented above are the choice of the decision maker.
This choice can be based on recommendations from the literature, vision, mission and strategy of
the university, market research, specific particularities of the university etc.

After the relationship matrix is complete, the SDSS will apply FRISCO formula (1) to rank the
criteria and allocate an importance coefficient or weight factor ($\gamma_i$) for each of them. The
FRISCO formula (an empiric formula given by a well-known creation group in San Francisco -
USA) was chosen as it is recognized worldwide as being the best and most used formula for this
type of analysis [3, p.1933].

$$\gamma_i = \frac{p + \Delta_p + m + 0.5}{-\Delta_p + \frac{N_{crit}}{2}}$$

where:

- $p$ – is the sum of the points (on a row) scored by the analyzed element;
- $\Delta_p$ – the difference between the score of the analyzed element and the score of the
element on the last level; if the regarded element is the element on the last level, $\Delta_p$ will
have the value 0;
- $m$ – number of criteria outranked (standpoint of the score) by the regarded criterion;
- $N_{crit}$ – number of regarded criteria;
- $\Delta p'$ – difference between the score of the regarded criteria and the score of the first criteria (resulting in a negative value); if the regarded criteria is the one place on the first level, the result will be 0.

For the example given above, the weights for each criterion, calculated using the FRISCO formula are given in table 3

<table>
<thead>
<tr>
<th></th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
<th>C5</th>
<th>SCORE</th>
<th>RANK</th>
<th>Dp</th>
<th>Dp'</th>
<th>m</th>
<th>FRISCO</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>0.50</td>
<td>0.50</td>
<td>0.00</td>
<td>1.00</td>
<td>1.00</td>
<td>3.00</td>
<td>2</td>
<td>2.00</td>
<td>-1.50</td>
<td>3</td>
<td>2.125</td>
</tr>
<tr>
<td>C2</td>
<td>0.50</td>
<td>0.50</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>1.00</td>
<td>5</td>
<td>0.00</td>
<td>-3.50</td>
<td>0</td>
<td>0.250</td>
</tr>
<tr>
<td>C3</td>
<td>1.00</td>
<td>1.00</td>
<td>0.50</td>
<td>1.00</td>
<td>1.00</td>
<td>4.50</td>
<td>1</td>
<td>3.50</td>
<td>0.00</td>
<td>4</td>
<td>5.000</td>
</tr>
<tr>
<td>C4</td>
<td>0.00</td>
<td>1.00</td>
<td>0.00</td>
<td>0.50</td>
<td>1.00</td>
<td>2.50</td>
<td>3</td>
<td>1.50</td>
<td>-2.00</td>
<td>2</td>
<td>1.444</td>
</tr>
<tr>
<td>C5</td>
<td>0.00</td>
<td>1.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.50</td>
<td>1.50</td>
<td>4</td>
<td>0.50</td>
<td>-3.00</td>
<td>1</td>
<td>0.636</td>
</tr>
</tbody>
</table>

Then, the decision alternatives are compared against each other, based on the extent to which they satisfy each criterion. Thus, in the example given, the alternatives have been compared to each other five times – once for each criterion. The same algorithm was applied when the quadratic matrix was generated and the scores 0, 0.5 and 1 were allocated as shown above.

In addition to the calculation of the weights based on FRISCO formula, which show how each alternative satisfies the criterion, there has been calculated the “array of importance”. The array of importance is calculated with the algorithm specific for the hierarchic-analytic process:[19]

After the quadratic matrix has been generated, it is “normalized”, generating a new matrix, noted with $A$. Each value of each column is divided to the sum of the values of that column, using the formula (2):

$$b_{ij} = \frac{a_{ij}}{\sum_{k=1}^{n} a_{kj}}$$

(2)

The array of importance, $w$, is calculated as the average of each line from the normalized matrix, using formula (3):

$$c_{ij} = \frac{\sum_{k=1}^{n} b_{ik}}{n}$$

(3)
Given the fact that the quadratic matrix is filled in based on the algorithm presented above, it is consistent and thus the calculation of consistency is no longer required.

The final score for each decision alternative is calculated by adding the products generated by multiplying its score of the alternative for each criterion with the weight of the respective criterion. This is done both for the weights generated with FRISCO and the array of importance. Then the arithmetic average is calculated between these values, for each alternative and the one with the highest score is the optimal solution (see table 4).

<table>
<thead>
<tr>
<th>Decision Alternatives</th>
<th>Score W</th>
<th>Score FRS</th>
<th>Average</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP A1</td>
<td>0.59</td>
<td>11.22</td>
<td>5.91</td>
<td>5</td>
</tr>
<tr>
<td>Dell A2</td>
<td>1.43</td>
<td>16.49</td>
<td>8.96</td>
<td>4</td>
</tr>
<tr>
<td>Acer A3</td>
<td>1.17</td>
<td>18.19</td>
<td>9.68</td>
<td>2</td>
</tr>
<tr>
<td>Lenovo A4</td>
<td>3.64</td>
<td>36.63</td>
<td>20.1</td>
<td>1</td>
</tr>
<tr>
<td>MSI A5</td>
<td>1.14</td>
<td>17.64</td>
<td>9.39</td>
<td>3</td>
</tr>
</tbody>
</table>

4. The on-line grey Decision Support System

The usefulness of the Grey Decision Support System is highlighted by the need to make decisions based on real facts and needs specific to each domain. However, the algorithm presented requires good mathematical abilities for the decision maker, and this can therefore limit the usage of the proposed decision support system.

In order to ease the use of the GDSS and increase the number of potential users, the system was put online. The GDSS allows an indefinite number of criteria and decision alternatives in a user friendly interface. For this purpose an extension for the Content Management System Joomla! 1.5 has been developed. It can be easily integrated into any website created with Joomla! 1.5.

First, the user is requested to enter the number of criteria and the name (or label) for each criterion (figure 1). Then the quadratic matrix is generated and the user has to compare each criterion against the others, having the option to choose whether it is more important, equally important or less important than other criteria (see figure 2).
Then, the user is asked to enter the alternatives and then to compare each alternative based on each criterion (see figure 3).

Figure 1. Entering the criteria

Figure 2. Generating the quadratic matrix

Figure 3. Comparing each alternative from the point of view of criterion “Costs”
The software then uses the algorithm described in the previous paragraph and returns the optimal solution, as shown in figure 4.

![Congratulations for completing all steps! Press the button below to view the results.](image)

Figure 4. The optimal solution

5. Conclusions

The proposed decision support system allows university managers to choose the best alternative out of a set of possible ones, based on a group of custom-defined criteria. The system allows the use of an indefinite number of alternatives and criteria. However, in this paper there was presented a scenario with five possible decision alternatives and five selection criteria.

Universities have different approaches of the management process. There are of course different challenges, budgets and opportunities and the decisions that a university manager has to deal with may vary substantially from one day to another. The grey box decision support system (GBDSS) speeds up the decision making process and increases the quality of the management process. It can be used both by university managers and by business administrators and is easily adaptable to any situation.

Underlying the GBDSS is an innovative approach that combines two well-known algorithms: the hierarchic-analytic process, used mainly in operations management, and the advanced multi-criteria analysis based on the FRISCO formula. The developed algorithm requires good mathematical abilities from the user, and this can therefore limit the real-life applicability of the proposed decision support system. In order to make it easier to use the GBDSS and increase the number of potential users, the GBDSS was implemented online with a user-friendly interface.

The aim of this paper was to assist decision makers and providing them a scientific instrument for an objective approach. The presented Grey-Box Decision Support System can be improved and adapted to various situations, according to the needs of the decision maker. The example that was used to exemplify the usability and utility of the system can be substituted with any other potential dilemma. Further research may mean creating a series of databases with recommendations based on knowledge, in order to guide the user when choosing the decision criteria and their importance for the project.
References


