DECISION SUPPORT SYSTEMS IN LITHUANIA

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1. DECISION SUPPORT SYSTEMS

1.1. Decision support systems and multiple criteria analysis

Quite a number of people when purchasing a house pay attention to its price. Others concentrate on operating and maintenance costs comprising of the house's heating and maintenance costs, the repair work, insurance, taxes and other related expenses. A third group of customers are concerned with the development rates of the surrounding area's infrastructure (i.e. schools, hospitals, theatres, concert halls, stores and communication lines, etc.), the environment's level of contamination and neighbours, etc. A fourth group of purchasers' puts emphasis on the issues of comfort and convenience.

Most customers identify comfort and convenience with the number of rooms, their size and height, layout and planning, functional efficiency, proportional distribution of rooms, size of the kitchen, total area of the apartment, absence of hazardous substances, thermal and acoustic insulation of walls and level of the engineering equipment, etc.

However, most often purchasers try to carry out a complex evaluation of both positive and negative characteristics of the house. It should be also noted that different people when choosing between alternatives and depending on their needs and possibilities, usually use different systems of criteria and attach different values and weights to the similar criteria.

With the aim of providing customers with substantial assistance in choosing the most effective house, the decision support system (DSS) should have comprehensive historical information covering analogous buildings life cycle. This data can be both objective and subjective.

Objective data is the price of a building, its dimensions, year of construction, interest rate of the loan taken for purchasing or construction the building, the thermal and acoustic insulation of external walls, levels of contamination with hazardous substances and fluctuations of this level. Subjective data is related to the aesthetic issues of the building's exterior, the surrounding area, comfort and convenience and neighbours, etc. As a rule, people have quite different opinions on these rather subjective issues. Such opinions may change in time, which is not bad because such opinions represent people's goals and their possibilities to changes.

When analysing possible alternatives, the customer should have the possibility to quickly receive comprehensive information (i.e. quantitative and qualitative criteria, their values and weights with the necessary explanations) that describes the project under consideration. For example, the customer should receive updated and detailed information on the substances hazardous to human health, changes on their impact in terms of time; a building's exterior finishing materials, their prices, quality, heavy-duty specification; and possible building insurance alternatives under different conditions, etc. Besides, depending on their experiences, needs and available resources, customers should be provided with the possibility to update and upgrade the criteria, their values and weights that describe the possible alternatives.

As we can see, the customer, on the basis of digital, textual, graphic, audio and video information provided by the database management system as well as the model-base management system, can generate and comprehensively analyse the possible alternatives, i.e. carry out a complex evaluation of the system of criteria, their values and weights that describe specific alternatives and help to make the necessary decisions.

The decision support system should comprise of the following four major constituent parts. These parts are: a data (database and its management system), models (model base and its management system), a user interface and a message management system.

There are several interpretations of databases (DB). The first DB is an aggregate of the interrelated and jointly stored data, i.e. information objects intended for computer processing. The concept of the second DB is wider and identifies DB with the data and a set of programs that process the same data.

Database Management Systems (DBMS) are developed for defining, creating, maintaining, controlling, managing and using databases. Special software is required for enabling the user to operate and communicate with databases. The database management system provides access to data as well as to all the control programs necessary to receive data in the form that is appropriate for an object under consideration to be analysed without too much effort from the user who is programming.

The major functions of the Database Management System are as follows: designing of the database's structure; enlargement, collection and editing of the database; maintenance, search, sorting and other handling of data.

Some people view databases as being more or less independent systems and databanks, i.e. treating databanks as a system of information, mathematics, linguistics, organizational, software and hardware facilities.

The model-base management system performs a similar task for models in the DSS. It keeps track of all the possible models that might be run during the analysis, as well as controls for running the models. The model-base management system also links between models so that the output of one model can be input into another model.

The user interface represents all the mechanisms whereby information is input into the system and is output from the system. The system includes all the input and screens by which users can request data, models and output screens and through which users can obtain their results.

The message management system allows for the use of electronic mail as another source of providing data.

DSS provides a framework through which decision-makers can obtain the necessary assistance for a decision through an easy-to-use menu or command system. Generally, a DSS will provide help in formulating alternatives, accessing data, developing models and interpreting their results, selecting options, or analysing the impacts of a selection.

1.2. Model Dimensions

The decision support system can include many models. These models can exist both inside and outside the DSS. The following three dimensions define the models: representation, time dimension and methodology.

Accordingly, the representation models can be divided further into quantitative and qualitative ones. The qualitative (i.e. expert and multiple criteria) models are based on judgments, subjective estimates, opinions and the expert's evaluations. When different experts evaluate the same qualitative characteristics of the same option, they often get different results. This can be explained by the different experiences, educational background, goals and available tools, etc. that may be used. The achieved results can be made more objective by applying expert evaluation methods.

The quantitative models (i.e. statistics and accounting) represent objective features of the options, irrespective of the expert's subjective evaluations and judgments. Objective features are represented directly by physical measurement units such as monetary units, kilograms, meters, degrees, percents and ratios, etc.

Both quantitative and qualitative models have their advantages and drawbacks. The quantitative models represent their options in an objective way, but usually not thoroughly and comprehensively enough. On the contrary, the qualitative models represent reality subjectively, and more thoroughly and comprehensively. Therefore, the application of quantitative or qualitative methods usually depends on the concrete decision-making situation. Very often a complex method of application of both quantitative and qualitative methods should be applied when making a decision. For example, when analysing the general level of a building's comfort, the best way would be to apply qualitative research methods. However, when making an assessment of the funds that will be spent during the period of the existence of a particular building (e.g. building's purchase, construction, maintenance, repair work and insurance expenses, etc.), it would be best to apply the quantitative methods.

Time dimension models are divided into static and dynamic ones. The static models support the position that feature the options, in the course of time that do not change, whereas the dynamic models take into consideration the changing nature of the options also in the course of time.

The methodology addresses how the data will be collected and processed. According Sauter [Sauter], there are five general methodologies: complete numeration, algorithmic, heuristic, simulations and analytical ones.

When applying the complete numeration method we collect and evaluate information about all the feasible options. This method is highly time-consuming, costly, and often impractical and is used for example when conducting a general census.

The algorithmic models are best represented by operations research methods and are applied when counting from the beginning till the end (i.e. from the moment of the initial data's entering until the gaining of the wanted results or goals).

The heuristic models are applied for settling problems that cannot be solved algorithmically. All heuristic models involve searching, evaluating and finding a good solution. The heuristic models help to diminish the number of search options and aim at providing a solution and other findings. Heuristics is the most important part of the artificial intelligence and expert systems.

Simulation settles problems that cannot be accurately and precisely examined on the basis of a mathematical analysis. When applying these models we can create an adequate and typical situation of the options. Simulation models simplify the relationships and interdependencies of the alternatives being considered and provide information about conditions from which can be find a rational solution. Repeating the possible states of the option provides the possibility to experiment and reveals ways of improving the system's functioning. Such a method of simulation is often used when examining problems related to storage and the servicing of reserves, the demand for products, raw materials arrivals.

At the beginning of the analytical modelling, a general analysis of the option is carried out. Thereafter, the option is divided into separate parts for their examination. Later we have to determine the relations and dependencies of the elements that comprise of the option. A statistical analysis serves as a perfect example of analytical modelling.

2. DECISION SUPPORT SYSTEMS AS CREATED BY VILNIUS GEDIMINAS TECHNICAL UNIVERSITY

Many Internet based systems are processing and submitting only economic information for decisions. Alternatives under consideration have to be evaluated not only from the economic position, but take into consideration qualitative, technical and other characteristics. Therefore, applying multiple criteria decision support systems may increase the efficiency of e-business and Web-based systems.

Web-based decision support systems created by authors in cooperation with their associates are described in various publications:

- Multiple Criteria On-Line Export Decision Support System (A.Kaklauskas, 2002 a, 2002 b).
- Multiple Criteria Decision Support Web-Based System for Facilities Management (E.Zavadskas, 2002 a, 2002 b).
- Ethical Multiple Criteria Decision Support Web-Based System (A.Kaklauskas, 2002 c).
- Internet Based DSS for Real Estate (A.Kaklauskas, 2002 d, E.Zavadskas 2001).
- Multiple Criteria Decision Support On-Line System for Construction Products (A.Kaklauskas, 2002 e, E.Zavadskas 2002 c).

The above decision support systems comprise of the following constituent parts: a data (database and its management system), models (model base and its management system) and a user interface.

When creating the Web-based decision support systems the authors based their work on the following major principles and methods:

- Method of complex analysis. The use of a complex analysis makes it possible to carry out economic, technical, qualitative, technological, environmental, managerial and other kinds of optimisation throughout the life cycle of a project.
- Method of functional analysis. The expenditures associated with project functions are usually determined by taking into account the benefits of a function and the cost of its realization.

- Principle of cost-benefit ratio optimisation. Efforts are made to get maximum benefit (economic, qualitative, environmental and social, legal, etc.) at minimum project's life cycle expenses, i.e. to optimise the cost-benefit ratio.
- Principle of interrelation of various sciences. The problem of cost-benefit ratio may be successfully solved only when the achievements of various sciences, such as management, economics, law, engineering; technology, ethics, aesthetics and psychology, etc. are used.
- Methods of multi-variant design and multiple criteria analysis. These methods allow us to take into consideration the quantitative and qualitative factors, as well as cutting the price of the project and better satisfying the needs of all interested parties.
- Principle of close interrelation between project's efficiency and interested parties and their aims.

Presentation of information in databases may be in conceptual (digital, textual, graphical, photographic, video) and quantitative forms.

Conceptual information means a conceptual description of alternatives, the criteria and ways of determining their values and weight. Conceptual information is needed to make more complete and accurate analysis of the alternatives considered. In this way, the above DSS enable the decision maker to receive conceptual and quantitative information on alternatives from a database and a model-base allowing him/her to analyse the above factors and form an efficient solution.

Quantitative information presented involves criteria systems and subsystems, units of measurement, values and initial weight fully defining the variants provided. Quantitative information of alternatives is submitted in the form of grouped decision-making matrix, where the columns mean n alternatives under analysis, and rows include quantitative information.

The databases were developed providing a multiple criteria analysis of alternatives from economical, legislative, infrastructure, social, qualitative, technical, technological and other perspectives. This information is provided in a user-oriented way. To design the structure of a database and perform its completion, storage, editing, navigation, searching, and browsing, a database management system was used in this research.

Then the brief study of authors above developed (construction and facilities management) Web-based DSS follows.

2.1. Multiple Criteria Decision Support On-line System for Construction Products

Today there are a great number of directories and electronic commerce systems, in the world related to construction products. Some of the well known Web-sites are: www.needproducts.com, www.4specs.com, www.buildscape.com, www.commerce.net and www.sri.com.

This section deals with Multiple Criteria Decision Support On-Line System for Construction (OLSC) developed by authors with V.Trinkunas. At the present moment the developed OLSC allows the performance of the following functions:

1. Search of construction products. A consumer may perform a search of alternatives from catalogues of different suppliers and producers. This is possible since the forms of data submitted are standardized into specific levels. Such standardization creates conditions to use special intelligent agents who perform a search of the required construction products from various catalogues, and gather information about the products. One or several regions may limit such search.
2. Finding out alternatives and making comparative tables. Consumers specify requirements and constraints and the System queries the information of specific construction products from a number of online vendors and returns a price-list and other characteristics that best meets the consumer's desire. The System performs the tedious, time-consuming, and repetitive tasks of searching databases, retrieving and filtering information and delivering the information back to the user. Results of a search of specific construction products are submitted in tables, which may include direct links to a Web page of a supplier or producer. By submission such a display, of the multiple criteria comparisons can become more effectively supported. The results of the search of a concrete construction product are often provided in one table where one can sometimes find direct links to the Web page of the supplier or manufacturer.
3. Evaluation stages of alternatives (i.e. multiple criteria analysis of alternatives and selection of most efficient ones). While going through the purchasing decision process a customer must examine a

large number of alternatives, each of which is surrounded by a considerable amount of information (price, discounts given, thermal insulation, sound insulation, rate of harm to human health of the products, aesthetic, weight, technical specifications, physical and moral longevity). Following on from the gathered information the priority and utility degree of alternatives is then calculated. The utility degree is directly proportional to the relative effect of the values and weights of the criteria considered on the efficiency of the alternative. It helps consumers to decide what product best fits their requirements.

4. Analysis of interested parties (competitors, suppliers, contractors, etc.).
5. The after-purchase evaluation stage. A consumer evaluates the usefulness of the product in the after-purchase evaluation stage, etc.

2.2. Multiple Criteria Decision Support System for Facilities Management

An analysis of multiple criteria decision support systems (see first section) and facilities management Web-based automation applications (calculators [1-5], analysers [6-8, software [9-13], expert [14] and decision support [15-17] systems, etc.) that were developed by researchers from various countries assisted the authors to create one of their own Multiple Criteria Decision Support Web-Based System for Facilities Management (DSS-FM). The DSS-FM developed by authors with M.Gikys and A.Gulbinas is presented in this section. The following tables form the DSS-FM's database:

- Initial data tables. These contain information about the facilities (i.e. building, complexes, alternative facilities management organisations).
- Tables assessing facilities management solutions. These contain quantitative and conceptual information about alternative facilities management solutions: space management, administrative management, technical management and management of other services, complex facilities management, market, competitors, suppliers, contractors, renovation of walls, windows, roof, etc.

The tables assessing facilities management solutions are used as a basis for working out the matrices of decision-making. These matrices, along with the use of a model-base and models, make it possible to perform a multiple criteria analysis of alternative facilities management projects, resulting in the selection of the most beneficial variants. The efficiency of a facilities management variant is often determined by taking into account many factors. These factors include an account of the economic, aesthetic, technical, technological, management, space, comfort, legal, social and other factors. The model-base of a decision support system includes models that enable a decision-maker to do a comprehensive analysis of the available variants and to make a proper choice.

Below is a list of typical facilities management problems that were solved by users: multiple criteria analysis of space management, administrative management, technical management and management of other services alternatives; analysis of complex facilities management alternatives; analysis of interested parties (competitors, suppliers, contractors, etc.); determination of efficient loans; analysis and selection of rational refurbishment versions (e.g. roof, walls, windows, etc.); multiple criteria analysis and determination of the market value of a real estate (e.g. residential houses, commercial, office, warehousing, manufacturing and agricultural buildings, etc.), analysis and selection of a rational market, determination of efficient investment versions, etc.

3. CONCLUSIONS

The analysis of information systems used in construction, real estate and facility management that were developed by researchers from various countries assisted the authors to create of their own Web-based decision support systems. These systems differ from others in the use of new multiple criteria analysis methods as were developed by the authors. The databases were developed providing a comprehensive assessment of alternative versions from the economic, technical, technological, infrastructure, qualitative, technological, and legislative and other perspectives. Based on the above complex databases, the developed systems enable the users to analyse alternatives quantitatively (i.e. a system and subsystems of criteria, units of measure, values and weights) and conceptually (i.e. the text, formula, schemes, graphs, diagrams and videotapes). Applying above Web-based decision support systems may increase the efficiency of information systems.

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