Institute of Internet and Intelligent Technologies
Vilnius Gediminas Technical University
Saulėtekio al. 11, 10223 Vilnius, Lithuania
http://www.isarc2008.vgtu.lt/

The 25th International Symposium on Automation and Robotics in Construction

June 26–29, 2008

ISARC-2008

MULTI-CRITERIA DECISION SUPPORT SYSTEM OF INTELLIGENT AMBIENT ASSISTED LIVING ENVIRONMENT

Edmundas Kazimieras Zavadskas
Vilnius Gediminas Technical University
Civil Engineering Faculty
Saulėtekio al. 11, LT-10223 Vilnius, Lithuania
Edmundas.Zavadskas@adm.vgtu.lt

Jurga Naimavičienė
Vilnius Gediminas Technical University
Civil Engineering Faculty
Saulėtekio al. 11, LT-10223 Vilnius, Lithuania
Jurga.Naimaviciene@st.vgtu.lt

Artūras Kaklauskas
Vilnius Gediminas Technical University
Civil Engineering Faculty
Saulėtekio al. 11, LT-10223 Vilnius, Lithuania
Arturas.Kaklauskas@st.vgtu.lt

Mindaugas Krutinis
Vilnius Gediminas Technical University
Civil Engineering Faculty
Saulėtekio al. 11, LT-10223 Vilnius, Lithuania
Mindaugas.Krutinis@st.vgtu.lt

Povilas Vainiūnas
Vilnius Gediminas Technical University
Civil engineering faculty
Saulėtekio al. 11, LT-10223 Vilnius, Lithuania
povva@st.vgtu.lt

ABSTRACT

A lot of complicated optimisation tasks are solved with the help of computer technologies in the information age. It is necessary to solve the task of a multi-criteria selection and optimisation in order to reach the optimal selection and inter-coordination of the elements of Intelligent Ambient Assisted Built-up Living (in technological, as well as economic aspects) Environment. The article describes the method of the above mentioned problem by using the established multi-criteria decision support system.

KEYWORDS
ambient assisted living environment; multi-criteria analysis; decision support system

1. INTRODUCTION

While establishing a multi-criteria decision support system of the Intelligent Ambient Assisted Built-up Living Environment (MDSSIAABLE) the following most modern software and the most modern, as well as widely spread technologies have been used:

- Internal Microsoft Access programming language of a programme package, which is use in the programming of data-basis;

- HTML (Hypertext mark-up language) programming language is used in the following internet pages, where data from data-basis are not used or various calculations are done;
- ASP (Active Server Pages) programming language is used in the internet pages, where the data from data-basis are used and various calculations are done;

Java Script and ActiveX technologies are used while designing and creating separate modules and the user's interface. Java Script programming language is used for the creation of the implemented data; whereas the components created by ActiveX technologies are used in the creation of various programmes and components.

While creating the MDSSIAABLE the main principles and methods were regarded, which convey the purpose and functionality of the whole system. During the creation of this system the following principles and methods [1] were applied:

- Complex analysis;
- Interface of various sciences;
- Establishment of multi-criteria variants of the Intelligent Ambient Assisted Built-up Living Environment;
- Multi-criteria analysis of variants.

2. THE CONTENT OF MULTI-CRITERIA INTELLIGENT AMBIENT ASSISTED LIVING ENVIRONMENT

MDSSIAABLE combines the data and model basis, which are managed by the system-user through the user's interface. The system consists of (see Figure 1) [2]:

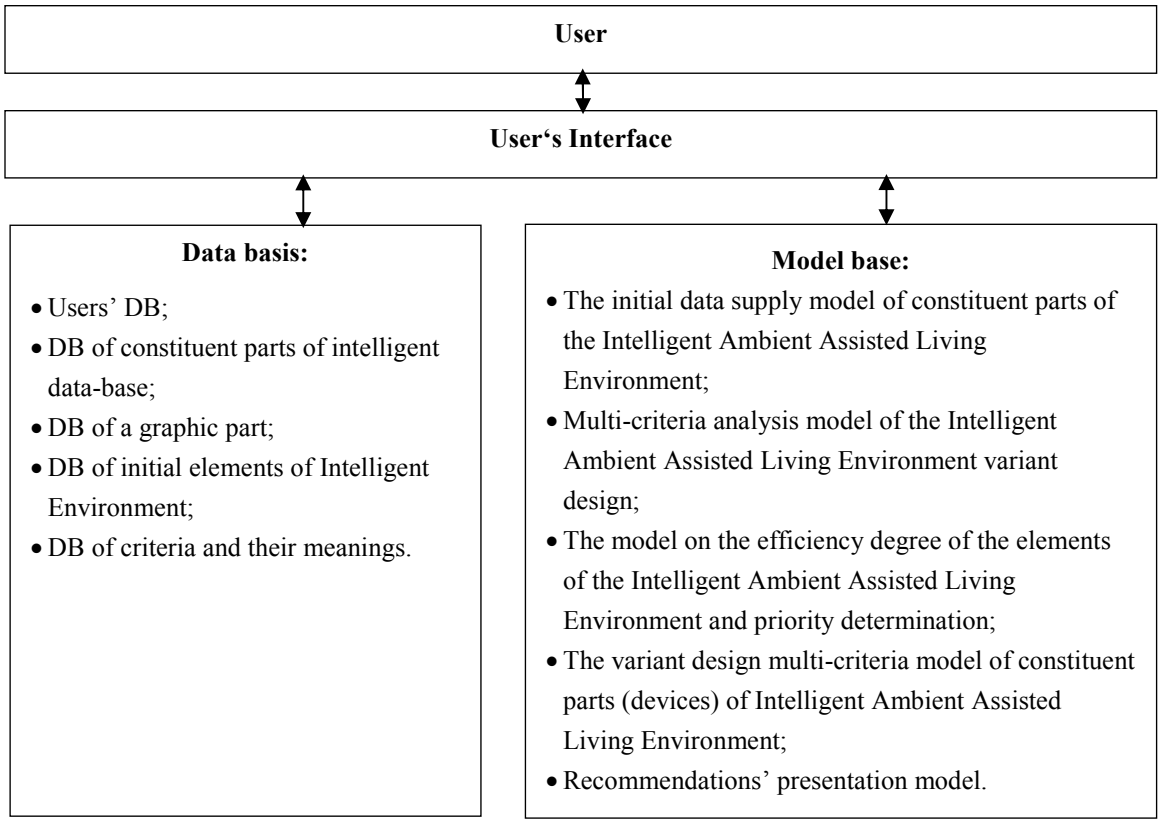

Figure 1. Constituent Parts of the Multi-criteria Decision Support System of Built-up Ambient Assisted Living Environment

- Data-basis and their management systems,
- Model base and its management systems,
- User's interface.

The above mentioned constituent parts are closely interrelated and join smaller constituent parts of the system. For example, the model base consists of the initial data supply model of constituent parts of the Intelligent Ambient Assisted Living Environment; the model for the determination of efficiency degree of IAALE elements and priorities; multi-criteria analysis model of IAALE variant design; recommendations' presentation model, etc.; and the data basis consisting of the tables on the users, intelligent environment and other data basis.

MDSSIAABLE is devoted for the use in the internet. Therefore, the user's system is rational, easily used and available for the users of different education and knowledge. Mixed user's interface is used in the system; different types of interface are used for the solution of different tasks.

Various interested groups participate in the process of the Intelligent Ambient Assisted Built-up Living Environment (customers, users, designers, suppliers, etc.); the aims, possibilities and experience of which differ [3,4]. Therefore, while taking decisions the outlooks of these interested groups do not coincide. In order to fully describe the discussed alternatives and take the most effective compromise decision these alternatives have to be described on the basis of quantitative and conceptual forms; present descriptive information on their various aspects (economic; technical; infrastructural; aesthetic; comfort; legal; and social). The information in MDSSIAABLE system is necessary for decision-taking' it may be presented in digital, textual, graphic (diagrams; schemes; drawings; formula; and photography); audio; video and other form. For example, using textual information presentation form the description of alternatives; description, reasons and grounding of their determining criteria is presented; the reason, why particular importance and meanings, etc. of the criteria were presented. Meanings and importance, which describe variants, are presented using the digital information form.

2.1. Data Base

One of the main functions of all systems is to collect and accumulate information. Accumulation and storage of information is easier because of computer technologies. Unlike traditional case, when all information necessary for the decisions is stored in records, books, various editions, etc., the information is stored according to various levels in the structured data basis. There are three fundamental structures of data basis: hierarchical, cellular and relative structure of data basis.

2.2. Model Base

Effectiveness of the variants of Intelligent Ambient Assisted Built-up Living Environment is evaluated from economic, technical, social, aesthetic, legal and other positions; therefore, MDSSIAABLE consists of the models, which help the user (decision-taker) to perform a complex analysis of the variants of intelligent environment and take appropriate decision.

While using model base management system for the needs of the user, various models are applied, in which artificial intelligence forms the basis. Due to the model base management system some models operate individually; and others provide initial information for other models, which is used as primary information for their calculations. While using model base management system, the calculation results of the variants of multi-criteria analysis in the Intelligent Ambient Assisted Built-up Living Environment become the determination of the resource data of efficiency degree and priority of the elements in the Intelligent Ambient Assisted Built-up Living Environment; and this type of data is used by a variant design model of complex parts in the Intelligent Ambient Assisted Built-up Living Environment.

The model base provides assistance to the user while formulating the alternatives. The users using the model base management can analyse various variants of decisions; correct the size of analysis, concentrate attention to the interested information. The functionality of the model base influences the functionality of the whole MDSSIAABLE. Therefore, during the process of MDSSIAABLE creation the model base management systems, as well as structure

of the models was changed and improved not for one time; mathematic calculation results; the information received during the work with the system was checked; the received results were compared with the results of expert calculations.

The more alternatives are examined before a final decision, the larger probability to receive a rational final result. On the basis of the accumulated information and using the above mentioned models, the multi-criteria decision support system of the Intelligent Ambient Assisted Built-up Living Environment may automatically create up to 100 000 combinations of complex elements (intelligent vacuum cleaner, etc.).

3. PRACTICAL APPLICATION OF MULTI-CRITERIA DECISION SUPPORT SYSTEM OF INTELLIGENT AMBIENT ASSISTED BUILT-UP LIVING ENVIRONMENT

In order to demonstrate the work of multi-criteria decision support system of the Intelligent Ambient Assisted Built-up Living Environment (see Figure 2); as well as operation and functions applied in it, the description of the work with the system is presented.

3.1. Short description of the work with the system

In order to start work with the multi-criteria decision support system of the Intelligent Ambient Assisted Built-up Living Environment, it is necessary to launch any type of internet browser installed in a computer. The system is best applied for the work with „Microsoft Internet Explorer“; however, it is smoothly working with the internet browsers created by other companies („Opera“, „Mozila FireFox“, etc.).

After selection of the item “The Main Information” in the tool bar, short information about the device is derived. All presented information is textual; i.e. a short description, device type of intelligent environment and its main data (Fig. 3).

After activation of the item “Description and Purpose of Ambient Assisted Living Environment” in the tool bar, a secondary level menu is derived in the main window, where five possible selection variants are presented:

Intelligent lock,
Intelligent cleaning robot,
Intelligent baby breathing observation monitor,
Intelligent security robot,
Intelligent key-board.

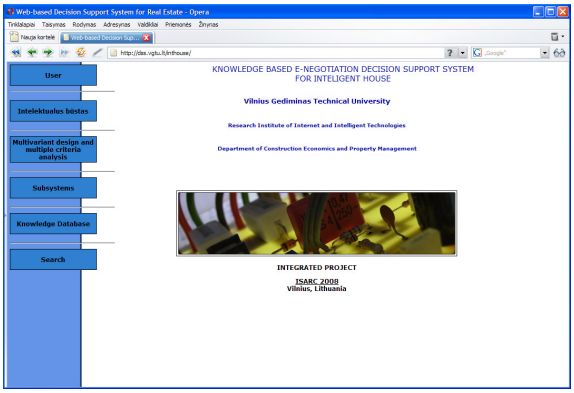

Figure 2. The main window of multi-criteria decision support system of the Intelligent Ambient Assisted Built-up Living Environment

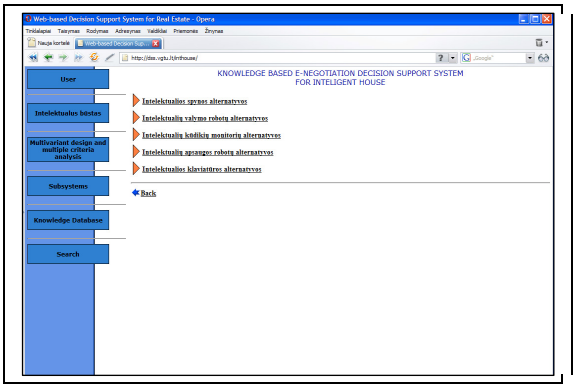

Figure 3. The window of the main information about the devices of intelligent environment

3.2. Multi-criteria analysis of the elements of Ambient Assisted Living Environment

After selection of the item “Multi-criteria analysis of the elements of the Intelligent Ambient Assisted Built-up Living Environment” the options of the secondary level menu of five Intelligent Ambient Assisted Built-up Living Environment complex parts (intelligent vacuum cleaner, intelligent security robot, intelligent lock, etc.) are possible (Fig.4). To make it clearer, a short description is derived in the window.

After activation of any of these elements with the help of a mouse, MDSSIAABLE activates the modules of multi-criteria analysis on the initial data submission of the constituent parts and elements of Intelligent Ambient Assisted Built-up Living Environment for a particular element of Intelligent House renovation (intelligent vacuum cleaner, intelligent security robot, intelligent lock, etc.) Let's analyse the multi-criteria analysis of intelligent environment for obvious reasons. For example, the multi-criteria analysis of an intelligent vacuum cleaner is performed in two stages:

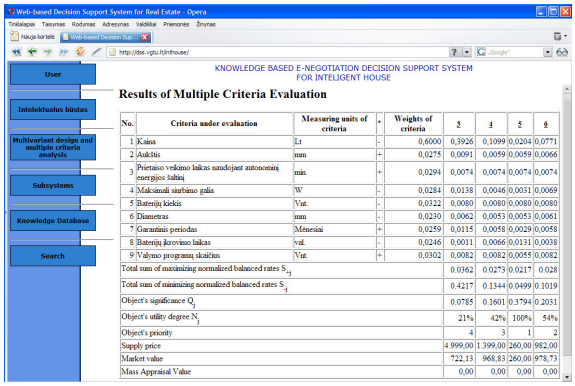

Figure 4. The main window of the elements of multi-criteria analysis of Intelligent Environment elements of the living house

In the first stage the analysis of alternative variants of locks are presented;

In the second stage the multi-criteria analysis is performed, during which alternative priorities and efficiency degrees are determined.

After clicking the mouse on the item "Intelligent Vacuum Cleaner" the system provides the user with the initial data necessary for the analysis (Fig.4). The main data on the compared variants are presented in the form of decision-taking matrix, where columns express the discussed alternative variants of intelligent vacuum cleaners; and quantitative information is presented in rows, which describes the discussed alternatives in detail. In this particular case, four variants of a vacuum cleaner are presented for further analysis, and which are described by 9 criteria in detail (Fig.5):

Figure 5 presents the criteria system, criteria measuring items, meanings and importance, which describe the discussed alternatives of intelligent environment in detail. A user may review all criteria and their meanings.

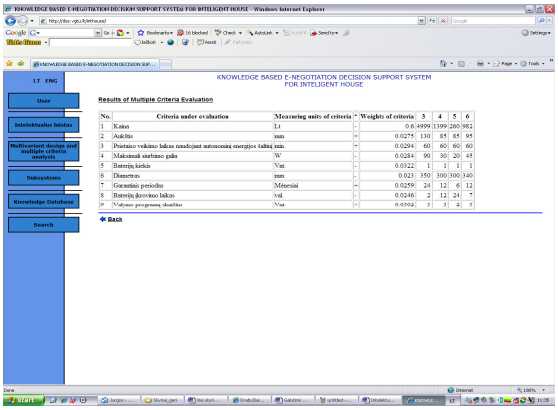

Figure 5. Multi-criteria analysis of an intelligent vacuum cleaner

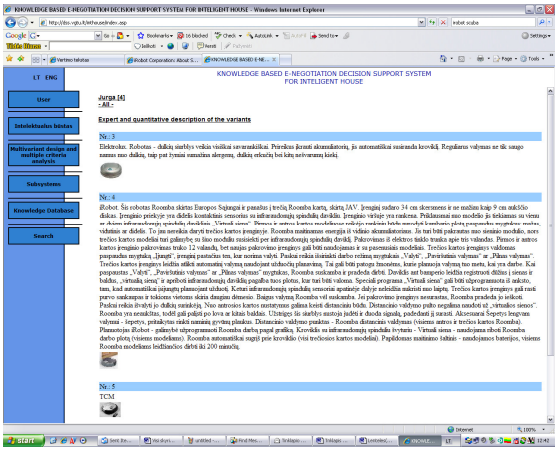

Figure 6. The window of internet browser, where detailed conceptual (textual, photographic) information on the elements of intelligent environment is presented

After clicking the mouse on the title of each discussed variant, a new window of internet browser is opened, which presents a detailed conceptual (textual, photographic) about this variant (Fig. 6). When a user activates a particular item, he/she may review additional textual, video and other information on each alternative.

The relation of various types of importance shows the number of times a particular criteria has a larger (smaller) influence on complex effectiveness of alternatives.

Clicking the third level menu item "Multi-criteria analysis results" with the mouse, the system performs the second stage of calculations, i.e. the model for the determination of efficiency degree and priorities of multi-criteria analysis methods' of Intelligent Ambient Assisted Built-up Living Environment, on the basis of initial data of intelligent environment variants; as well as performs multi-criteria analysis of IAABE. During calculations the efficiency degree and priorities of the variants was determined. It is obvious from the obtained results that the best of the discussed renovation variants of the intelligent environment in the table (Fig. 7) is the third; its efficiency degree is (N3=100 %). The first variant in the table is the second according to the efficiency degree (N1= 98,475 %). The second variant in the table is in the third position (N2 =96,707 %).

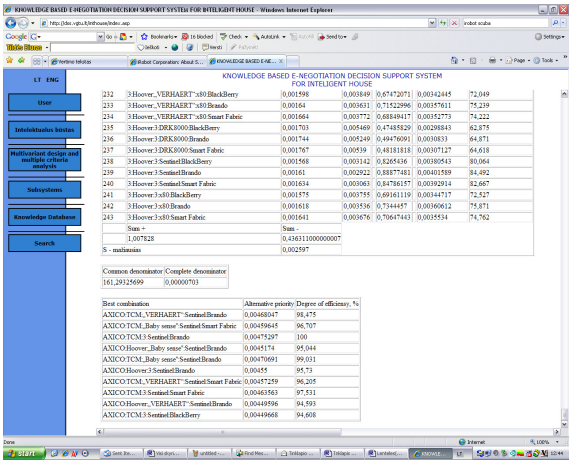

Figure 7. The window of internet browser, which presents detailed conceptual (textual, photographic) information about the elements of intelligent environment

In analogous way multi-criteria analysis of other elements (intelligent baby monitoring, intelligent security robot, intelligent lock, etc.) of Intelligent Ambient Assisted Built-up Living Environment is performed.

3.3. Multi-criteria analysis and variant design of intelligent living environment

After a multi-criteria analysis of intelligent locks, intelligent cleaning robots, intelligent baby monitoring, intelligent security robots and intelligent key-boards, alternative variants are established in an automated way; and the best alternative combinations are provided. For this purpose alternative multi-criteria variant design method is used [2,5].

After activation of the item "Multi-criteria analysis and variant design of intelligent environment" in menu toolbar, all elements of IAABE are derived in the main window (intelligent lock; intelligent cleaning robot; intelligent baby monitor, intelligent security robot and intelligent key-board). The system allows performing calculations with all alternatives describing intelligent environment. The system user may select alternatives and the desirable number of alternatives (Fig. 8).

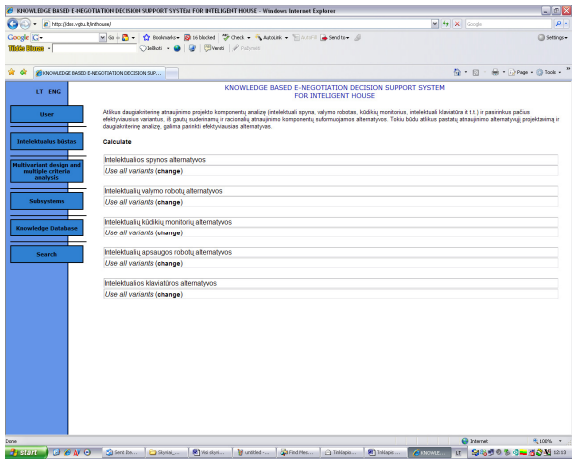

Figure 8. The window on the selection of the variants of constituent parts of intelligent living environment

After activation of the item "Multi-criteria analysis and variant design of Intelligent Environment" in the menu toolbar, all elements (intelligent lock; intelligent cleaning robot; intelligent baby monitor, intelligent security robot and intelligent key-board) of IAABE are derived in the main window. The system allows the performance of calculations with all alternatives describing intelligent environment. The system user may select alternatives and the desirable number of alternatives (Fig. 8).

After selection of the item of the secondary level menu "Calculate"; as well as using information and the models in the data basis (initial data supply model; multi-criteria analysis model; the model for the determination of efficiency degree and priority), the system selects the best four alternatives of the element combinations of Intelligent Living Environment (Fig. 9).

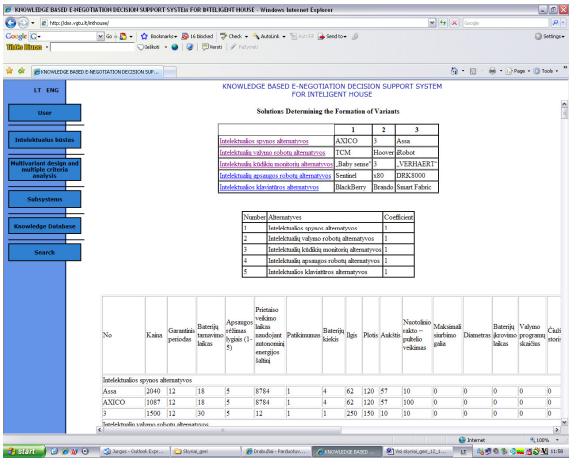

Figure 9. The best five discussed alternatives of the constituent parts of the Intelligent Living Environment

In this particular case variants of the Intelligent Environment were formulated by using the best four variants of each solution.

In the next stage the table is presented for the system user, where all alternatives of the Intelligent Environment and their descriptive information are presented (Fig.10).

Using multi-criteria analysis and the models for the determination of the project efficiency degree; as well as regarding previous calculations, MDSSIAABLE determines priorities and the efficiency degrees of the total variants of Ambient Assisted Living Environment.

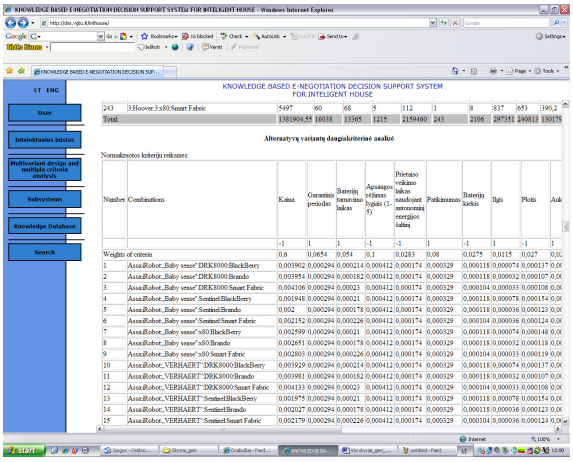

Figure 10. All variants of the alternatives of the Intelligent Environment

The best received variants are presented in Fig.11. It is obvious from the received results that the best variant is 131 variant, which efficiency degree equals 100 %.

Various types of information are used for the effective work of the system. The MDSSAAE system users after registration in the system may easily supplement, change criteria meanings with regard to the customer's priorities or expert survey results. While establishing possible variants of the Intelligent Living Environment various limitations may be introduced.

Other criteria may be evaluated as well. Every system user performs particular calculations with regard to his/her needs and targeted aims and provides information for other users.

DSSIAALE system is universal and may be used for solution of various theoretical and practical tasks; therefore, the facilities of this system may be used by various educational institutions, companies, consultants, end-users, experts and other interested groups.

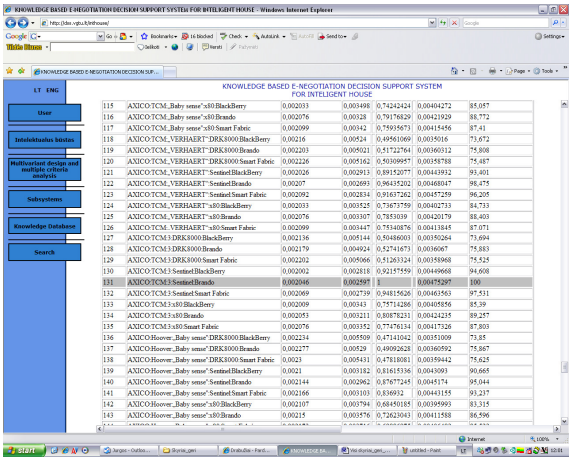

Figure 11. The most rational variant of the Intelligent Environment

4. CONCLUSION

1. On the basis of the analysis of current information, expert and decision support system; an in order to determine the most effective process of Ambient Assisted Living Environment, multi-criteria decision support system of the Intelligent Ambient Assisted Built-up Living Environment.

2. Original multi-criteria decision support system of the Intelligent Ambient Assisted Built-up Living Environment is established, which creates conditions for complex analysis of the process of the Intelligent Ambient Assisted Built-up Living Environment, its constituent parts, participating interested groups and external environment influencing this project.

3. The established system consists of their interface among the data basis and their management system, models and their management system and the user. It observes the main principles and methods, which convey the purpose and functionality of the total system.

4. The testing of multi-criteria decision support system of the Intelligent Ambient Assisted Built-up Living Environment was performed during calculations.

5. Feedback with the users installed in the MDSSIAABLE ensures constant need to improve the existing system in order to meet universally applied standards.

6. Multi-criteria decision support system of the Intelligent Ambient Assisted Built-up Living 7. Environment is universal and may be used for the solution of various theoretical and practical tasks; therefore, the facilities of this system may be used of this system may be used by various interested groups of people, producers of intelligent environment devices, consultants and end-users.

REFERENCES

[1] Europen Information Technology Observatory – EITO. Brussels: Europen Commision. 2005. 133 p.

[2] Kaklauskas, A.; Zavadskas, E. K. (2002) *Internetinė sprendimų parama*: monografija. Vilnius: Technika, 216 p.

[3] Friedewald, M.; Da Costa, O.; Punie, Y.; Alahuhta, P.; Heinonen, S. (2005) Perspectives of ambient intelligence in the home environment. *Telematics and Informatics*, Vol. 22, Issue 3, p. 221–238.

[4] Yang, J.; Peng, H. (2000). Decision support to the application of intelligent building Technologies. *Renewable Energy*, Vol. 22, No. 1, p. 67–77.

[5] Kaklauskas, A.; Gulbinas, A.; Krutinis, M; Naimavičienė, J.; Šatkauskas, G. (2007) Mokymo procese naudojamų pasirenkamųjų modulių daugiavariantės analizės metodai. *Ūkio technologinis ir ekonominis vystymas*, XIII tomas, Nr. 3, p. 253–258.