DECISION SUPPORT SYSTEM BASED ON FUZZY KNOWLEDGE APPLIED TO A SOFTWARE FACTORY

F. Chamorro
Dpto de Informática
EPS, U. Carlos III
Avda. Universidad 30
28911 Leganés Madrid
felixcha@inf.uc3m.es

F. García
Dpto de Informática
EPS, U. Carlos III
Avda. Universidad 30
28911 Leganés Madrid
fgarcia,@inf.uc3m.es

A. Sanchis
Dpto de Informática
EPS, U. Carlos III
Avda. Universidad 30
28911 Leganés Madrid
masm@inf.uc3m.es

J. M. Molina
Dpto de Informática
EPS, U. Carlos III
Avda. Universidad 30
28911 Leganés Madrid
molina@ia.uc3m.es

Abstract

Development environments to DSS are evolving to open and distribute architectures. The main features of these new architectures are: Data Base Query Tools in clients, fast developments and better graphics interfaces. DSS developers need a set of functionalities as multidimensional data view, variable capacity DW, set of complex criteria in order to filter the required information access, quick queries, minimum reorganisation when the data model is modified, etc. In this work a fuzzy knowledge based system to make decisions inside a DSS system that supports the planning and production control in a software factory. The fuzzy system is developed to evaluate the appropriateness of different platforms to construct a software product. From the platform specifications given in the product definition, the fuzzy system calculates the appropriateness of each existing platform to develop the product.

Keywords: Fuzzy Decision, Knowledge Based Systems, Groupware, Decision Support Systems

1 INTRODUCTION

Two main business features are the base for the analysis and construction of a DSS tool: the strategic planning of the organization and the structure of the information system in a modern and competitive business. Software tools make easier the access to the necessary information The data obtained ought to be conveniently structured in time and following pre-defined patterns.

Knowledge and experience constitute the only truly durable resource of the whole organization. The ability to capture and manage such knowledge is necessary for the survival of any organization [4]. Recently, a new type of software has been developed, which under the title of groupware, allows to create, manage, share and take full advantage of resources in the same way that knowledge and experience light in a collective work [3]. These applications are characterized by:

- Considering communications as the central axis of decision and business management
- Contributing in a decisive way to the automation of processes that take place in the organization [2].

The introduction of strategic systems in business substantially improves the quality of the information used in processes. It drastically reduces the time spent in executing these processes and makes access to the information easier. The scope of these systems is:

- applications for sales management and accounting
- applications for product development
- quality control applications or applications for customer service

The information could be far from the point where these decisions are taken and, besides, business organisations keep their information distributed through different databases. These characteristic are relevant for DSS applications. Networks of information and communication allow the integration of DSS inside distributed strategic business systems [8]. The communication allows to capture the information for taking the decision and to distribute the results. The current network systems LAN/WAN and networks based on Internet are governed by groupware with workflow applications which provides the information, as well as carrying out the distribution of the already requested relevant information [3].

Another aspect that should not be overlooked is the usefulness that knowledge based systems can bring to these applications [1]. In general, at the level of support for decisions made in business, tools exist which could influence in a very positive way the decision making process. These tools belong to the field of knowledge engineering such as the aforementioned [6]. This article influences and aims at contributing to the development of this field of information technology in relation to the levels of tactical planning and strategy of the organizations.

The basic objective aimed at in the design of our prototype proposes to join the advantages and functions that the strategic systems offer with those that knowledge engineering can provide for Expert Systems (ESs) [7]. A prototype has been obtained that makes the choice of decisions to be made by the components of a department group or business dedicated to the manufacture of software. This application decides the most convenient platform (including hardware, software, cost, etc..) for a software development.

2 DESIGN AND DEVELOPMENT OF DSS WITH EXPERT KNOWLEDGE

The common objectives of pursuing an information technology tool of this type can be a innumerable from these we will select some of the fundamentals in the design of the prototype divided into five levels:

- Capturing information: connecting existing databases in the business through the Data Warehouse, using the transmission system of data which are used in the business and distribution of information from remote machines.
- Functional and generation of reports: generating their own stores of intervening information data marts, employing easy to use screens, interpreting and modifying, improving the execution of the application, making them easier to use, configuration of the different types of reports and flexibility and speed in the management of information.
- Distribution of information: connection to groupware, working information with workflow, connection to other applications of communication and electronic mail and base of sending and receiving reports.
- Projects control: Through those components from Lotus Notes 4.1 the integration with applications for planning and programming projects should be permitted, like Microsoft Project or CA Superproject, in order to offer the user all the information and functions that both types of application offer.
- Generals: ease of maintenance, possibility of dynamic level evaluation and bringing things up to date customer architecture.

The design and development of the prototype DSS system is based on the general objective of the system. This system supports the planning and production control in a software factory. With a system like this many advantages can be obtained [6] and the control of projects can be improved, helping the director of production to solve internal and external problems caused by resources and customers which occur in the factory in the development of plan and projects for the manufacture of software.

This prototype will help solve any problems which might occur in the course of the planning and production of software in the software factory. The system that will be developed will be known as ISESD (Intelligent System for Events during Software Development) and Figure 1 shows the main window of application. The person in charge of planning in the factory must confront the situations from the point of view of performance and from the perspective of achieving production targets and revision in the development and maintenance of software.

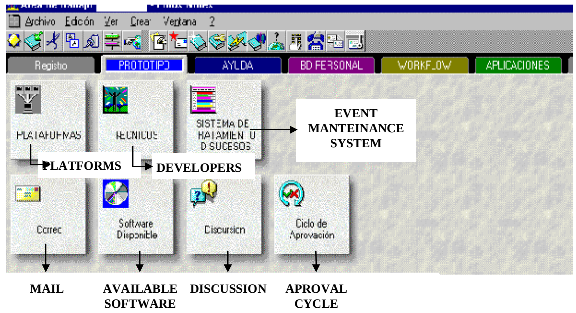

Figure 1: ISESD Interface.

3 PLATFORM FUZZY EVALUATION

To automate the pursued human-like platform evaluation process, the first step should be to select adequate descriptions of a platform, "analogous" to those formulated by humans when interpreting the requirements of software product. Artificial Intelligence representation schemes best suit these requirements. A generic platform will be represented as a set of characteristic, grouped in general features about platform as hardware, software, cost, availability, etc... This information could be represented by $(F_1,F_2,...,F_n)$, a set of values characterizing a platform; each $f_i \in F_i$, being F_i the range of possible numerical values of f_i.

Platform characteristics can then be related with a metric distance in the space of possible values. Given a numerical distance, d_i, between f_i (values of two different platforms, respectively), D_i is defined as the range of all possible values of d_i. To better cope with the intrinsic uncertainty of the perceived features, numerical values of the distances d_i will be mapped into qualitative symbolic descriptions. Thus, the computed distances will be transformed, through a fuzzification process, into linguistic variables. For each d_i, a linguistic variable, Ld_i, is introduced together with its set of values $\{ld_{i1},ld_{i2},...,ld_{ic_i}\}$, each one labelling a fuzzy subset in D_i (its meaning). The fuzzification operation applied to the numerical distances d_i, will result in their transformation into a fuzzy singleton [9], fuzzy subset whose membership function is the Kronecker delta, $\delta(d-d_i)$, in D_i.

A fuzzy relational algorithm (FRA) [9] will store the knowledge required to obtain the appropriateness of a platform with the desired platform, based on the linguistic similarities between the features of each one. The FRA will be composed by a finite set of fuzzy conditional statements of the form IF $AND^{n}_{i=1}(Ld_i$ is $ld_{ij_i})$ THEN

(APPR is ls_k), whose antecedents are conjunctions of fuzzy statements about the linguistic variables Ld_i (i=1,2,...,n), and their consequents fuzzy statements about APPR, linguistic appropriateness of the platform, whose set of values is $\{ls_1, ls_2, ..., ls_p\}$. The well known Mamdani implication [5] has been chosen to assign their meaning to these fuzzy conditional statements.

The compositional rule of inference (CRI) [8], (approximate extension of the rule of *modus ponens*) has been adopted as the inference mechanism to obtain the fuzzy subset induced in APPR (through each conditional statement of the FRA), by the fuzzy statement of the form $AND^n_{i=1}(Ld_i$ is $ld_{ir_i})$, linguistic description of the distance among platform features. The meaning of APPR will be the intersection of the intermediate meanings resulting from the application of the CRI to each conditional statement of the FRA (min of all the induced consequent membership functions). Finally, the adopted defuzzification process, applied to the final meaning of APPR, will be the traditional Centre of Gravity procedure [10].

4 FUZZY SYSTEM DEVELOPED

The final goal of this work is to develop a knowledge based system that using the fuzzy logic help project manager of a software factory to choose the more adequate platform for the accomplishment of a project. Each platform is defined by four numerical concepts that correspond, in order: hardware, software, availability and cost.

To verify the validity of this system, it is necessary to compare the results obtained with the fuzzy system with the results obtained using euclidean distance between the needed platform and the existing standard platforms.

4.1 INPUT VARIABLES

Four variables are considered and corresponding with the distances between the needed platform and the existing platforms: the distance between the hardware characteristics, represented by V1; the distance between the software characteristics, V2; the distance between the availability characteristics, V3; and the distance between the cost characteristics, V4. Membership functions of the input variables are the same type and each one is classified in three membership functions:

1.- Near (N): The distance is so small that the corresponding value of the standard platform is approximately equal to that of the needed one.

2.- Medium (M): The standard platform is approximated acceptably to the needed one.

3.- Far (F): The values correspond at greater discrepancy level, or separation, between platforms.

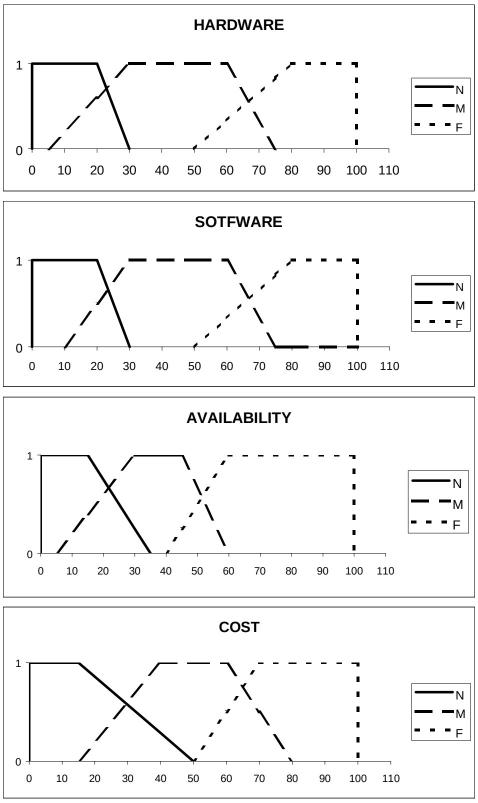

Figure 2: Membership Functions of Input Variables

4.2 OUTPUT VARIABLE.

An ouput variable (S) represents the degree of proximity of the different existing standard platforms to the needed platform for the project. The range of possible values for the output variable is 0 to 200, since this is also the range for the euclidean distance. This definition allows to compare the distances obtained by the two methods. To obtain a more detailed classification of the analyzed platforms, five membership functions are used. When distance is around zero the analyzed platform is near to the needed one, on the other hand, when is aorund 200 the analyzed platform is far from the needed one. The membership functions (Very Near, Near, Medium, Far, Very Far) are represented in Figure 3.

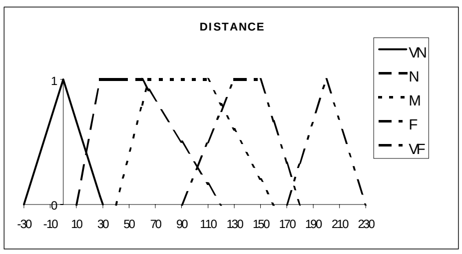

Figure 3: Membership Functions of output variable

4.3 RULES

In Figure 4, the resultant rules of the proposed system are shown.

V1	V2 = F, V4 = F	V2 = F, V4 = M	V2 = F, V4 = N	V2 = M, V4 = F	V2 = M, V4 = M	V2 = M, V4 = N	V2 = N, V4 = F	V2 = N, V4 = M	V2 = N, V4 = N	V3
F	VF	VF	VF	VF	VF	VF	F	F	F	F
F	VF	VF	VF	F	F	F	F	F	M	M
F	VF	VF	VF	F	M	M	F	M	N	N
M	VF	VF	VF	F	F	F	F	F	F	F
M	F	F	F	M	N	N	N	N	N	M
M	F	M	N	N	N	N	N	VN	VN	N
N	F	F	F	F	F	F	F	F	F	F
N	M	M	M	N	N	N	N	VN	VN	M
N	M	M	N	N	VN	VN	N	VN	VN	N

Figure 4: Rules of the system

Unfavorable situations have been taken into account, for example: a great distance in the availability of the platform in the requested time that makes impossible its use, a great distance in hardware or in software that gives a very high value. On the other hand, differences in the cost are considered less important, since this aspect could be almost always assumed.

5 RESULTS AND CONCLUSIONS

As it has been explained previously, the software factory has a data base with the values of the existing platforms. Some of these values are updated continually. As is the case of the availability that changed in function of the use of the platforms. The results presented in the Figure 5, 6 and 7 are obtained using the available values stored in the data base at the moment of accomplishing the experiments In Figure 5, the distance between the different existing platforms in the factory has been calculated. The white cells are the euclidean distance and the shadow ones are the fuzzy distances.

	UNIX	LINUX	NETWARE	WIN NT	WIN 9X	WIN 3X	MAC	AS400
UNIX	******	21,65	15,96	0	48,71	65,96	0	35,63
LINUX	40,69	******	44,02	39,87	30,01	63,64	33,36	107,37
NETWARE	22	54,44	******	0	41,42	65,04	0	43,05
WIN NT	16,79	43,89	13,93	******	40,06	56,42	0	44,88
WIN 9X	59,57	51,96	59,26	48,15	******	7,05	51,48	119,43
WIN 3X	88,19	72,95	85,88	76,27	30,45	******	56,42	157,55
MAC	31,83	40,36	27,77	23,9	52,79	76,02	******	37,44
AS400	50,06	83,37	46,2	56,44	104,36	131,08	59,82	******

Figure 5: Distance between existing platforms

In Figure 6, the distance between the existing platforms and the platform needed for a small bussiness is showed.

UNIX	LINUX	NETWARE	WIN NT	WIN 9X	WIN 3X	MAC	AS400
42,31	25,96	32,16	35,18	0	30,58	42,31	96,96
60,07	45,43	60,3	49,21	14,28	30,94	47,34	103,61

Figure 6: Distance for a small bussiness

In Figure 7, the distance between the existing platforms and the platform needed for a high bussiness is showed.

UNIX	LINUX	NETWARE	WIN NT	WIN 9X	WIN 3X	MAC	AS400
0	25,56	34,53	27,44	56,42	78,88	26,53	35,04
19,87	29,65	35,85	28,3	61,46	88,42	28,25	57,26

Figure 7: Distance for a high bussiness

From results showed in Figures 5, 6 and 7 following conclusions could be summarised:

1) For values under 100, the distance obtained with the fuzzy system are always less than the one obtained by euclidean distance. Therefore, the fuzzy system evaluates better the proximity between the characteristics of the analysed platforms and the requiered ones.
2) When the value of the distance is over 100, the fuzzy distance is greater to the euclidean one what means that from a value in middle of range, the analysed platforms could not be used in the project.
3) The improvement of the fuzzy system relies on the different evaluation that could make for each concept. In the euclidean distance all the components have the same importance.

References

[1] Adelman, L. (1992), *Evaluating Decision Support and Expert Systems*. New York, NY: John Wiley & Sons.
[2] Bankos, J. Y., y Treacy, M. E. (1986), *Information Technology and Corporate Strategy: A Research Perspective.* MIS Quartely..
[3] Coleman, D. and Khanna, R. (1995), *Groupware: Technology and Applications.* Englewood Cliffs, NJ: Prentice-Hall PTR..
[4] Kimball, R. (1996), *The Data Warehouse Toolkit: Practical Techniques for Building Dimensional Data Warehouses*. New York: John Wiley & Sons.
[5] Mamdani H., "Aplication of Fuzzy Logic to Aproximate Reasoning Using Linguistic Synthesis", IEEE Trans. on Computers, Nov/Dic. 1988.
[6] Mockler, R. J. (1989), *Knowledge-based Systems for Strategic Planning*. Englewood Cliffs, N.J.: Prentice-Hall, Inc.
[7] Olson, D. L. and Courtney, J. F Jr. (1992), *Decision Support Models and Expert Systems*. New York: Macmillan.
[8] Young, L. F. (1989), *Decision Support and Idea Processing Systems*. Dubuque, IA: Wm. C. Brown.
[9] Zadeh L. A., "Outline of a New Approach to the Analysis of Complex Systems and Decision Processes", Trans. on SMC, Jan. 1973.
[10] Zimmermann H.J., *Fuzzy Sets, Uncertainty and Information*, Kluwer 1985.