Design of IT-Collaboration-Platforms with Fuzzy Logic

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Globalization and interdisciplinarity are current trends in engineering fields, nevertheless such engineering projects, implying different companies, cultures and disciplines are complex and require interaction and communication between the people involved. Collaboration-platforms are instruments to lead successfully distributed, multi-disciplinary projects. However designing an appropriate platform can be difficult and influenced by many factors. That is why this work proposes to classify engineering projects with the help of these influencing factors using the fuzzy set theory. After building the sets, an empirical research has been made to establish fuzzy rules between the factors and chosen IT-functionalities, which permit to design an appropriate IT-Platform to support communication, information, coordination and collaboration processes. To verify the methodology, it has been applied to 2 industrial projects, what points out the barriers of this system.

Keywords: Fuzzy Logic, Social Networks, Knowledge and Information Management, Web-based Information Systems, Web-engineering.

1 INTRODUCTION

Nowadays it’s evident that the migration from purely mechanical to mechatronics products connects all the various design disciplines much stronger together, namely with respect to integration at process level as well as through communicative and informative support. Moreover globalization has created a need to collaborate and compete with counterparts thousands of miles away. The observation of these current trends points out two important aspects of nowadays engineering: in the first place, the distribution aspect, i.e. development in geographically distributed environments, with cross-enterprise engineering and, in the second place, the interdisciplinarity or cross-domain engineering, which alludes to the interaction of specialists from different domains.

When a development project is distributed and/or interdisciplinary, unconnected islands of knowledge need to be merged. Nevertheless the involved persons have to cooperate with each other on common tasks. To coordinate their activities communication and exchange of information is indispensable [1]. Information and communication systems help such projects being a success supporting exchange between multiple partners. However it’s obvious that every project has a specific character and that only one communication system on its own cannot support every engineering activity. Therefore the characteristics of the project have to be defined in order to develop an appropriate collaboration platform.

2 MATERIAL AND METHODS

This paper will first propose a method to classify engineering projects in a classification grid, whose axes are cross-enterprise and cross-domain engineering projects. The grid will use influencing factors for the considered engineering process and so detail the project profile.

The classification’s goal is to bring out the specific characteristics of development projects to design an appropriate supporting IT-platform, not the whole IT-system, but its functionalities. To this end an analysis of existing systems, like for example Hypertext-, Document-Management-(DMS), Groupware-, and Knowledge-Management-Systems, has been made regarding cross-enterprise and cross-domain aspects (based on [2], [3], [4]). Each system, more precisely its functionality, is described regarding the defined influencing factors. These factors as well as the description of the various modules give us the possibility to build rules designing an appropriate IT-platform.

2.1 Classification of Cross-Domain/Cross-Enterprise Engineering projects

For the cross-enterprise part we work with the characterization system of Gierhardt and Anderl ([5], [6], [7]]. On the basis of theoretic reflections as well as experiences acquired by industrial development projects, they have developed a characterization system (MMS, Merkmalsystem) to classify cross-enterprise projects. Every factor has a parameter value that characterizes the degree of distribution which is specific to the project or the process. To characterize the development project on the cross-domain level, we will base our analysis on Hartmann’s work [8]. This study about controlling interdisciplinary projects, a theoretic work, as well as an empirical one, presents recommendations to organize such projects. This work shows influencing factors for interdisciplinary projects with their impact on the global project organization. The evaluation system developed by Hartmann nevertheless had to be adapted to our needs. In fact, not all factors match with industrial development projects and concern more academicians. We have first extracted the factors corresponding to industrial development projects and then organize our classification system.All in all the system works out 16 influencing factors with their parameter values.

Table 1 Influencing factors of distributed and interdisciplinary engineering projects with their parameter values adapted from [5], [6], [7] and [8].

N°	Factor	Possible Values		
1	**Cooperation partners**	2	2 --> 5	>5
2	**Location**	Same Location	Same company	Other country
3	**Common Language**	Insufficient	Satisfying	Excellent
4	**Engineering process**	Parallel	Sequential	Mixed Form
5	**Organisation and companies´culture**	Same Business Unit	Same company	Other company
6	**Size of the organisation**	50	500	5000
7	**Intensity of collaboration**	Low&irregular	Integrated	
8	**Distribution Model**	Equal	Unequal	
9	**Interfaces**	Low	Average	High
10	**Access to data**	Very Difficult	Difficult	Easy
11	**Skill Level in the use of IT**	Low	Average	High
12	**Influence of time**	Sufficient	Insufficient	
13	**Terminology**	Same	Different	Contradictory
14	**Methods and Instruments**	Same	Different	
15	**Standards and Laws**	Same	Different	
16	**Dependencies**	Yes	No	

2.2 Fuzzification of the variables

The goal of this work is to design an appropriate IT-platform to support given configurations of industrial projects. In the practice the project's configuration is defined by the project leader. With the help of a questionnaire he will determine a value for each one of the factors. As certain factors aren't exact values, we will use at this point the fuzzy logic.

For instance, it's quasi impossible to globally say that your team has an insufficient level in the common project language (factor 3). For this factor we will use the following graduation. According to Andreas Richei [9], the level of comprehension of a common language can be illustrated with a fuzzy LR-number, a special case by the formation of fuzzy sets introduced by D. Dubois and H. Prade in [10] and [11]. Furthermore the LR-intervals will take this form: $A = < m1, m2, \alpha, ß >_{LR}$, where A is a fuzzy set, α and ß are the left and right ranges of A and the amplitude m1-m2 is defined as range of tolerance for A (see [9]).

Going back to our example, the comprehension of a common agreed project language is therefore defined with fuzzy logic as described in Fig.1. The factors Common Language, Engineering process, Intensity of collaboration, Distribution Model, Interfaces, Access to Data, Skill Level in the use of IT, Influence of time, Terminology, Methods and Instruments, as well as Standards are defined as fuzzy sets. The other ones are considered as exact factors.

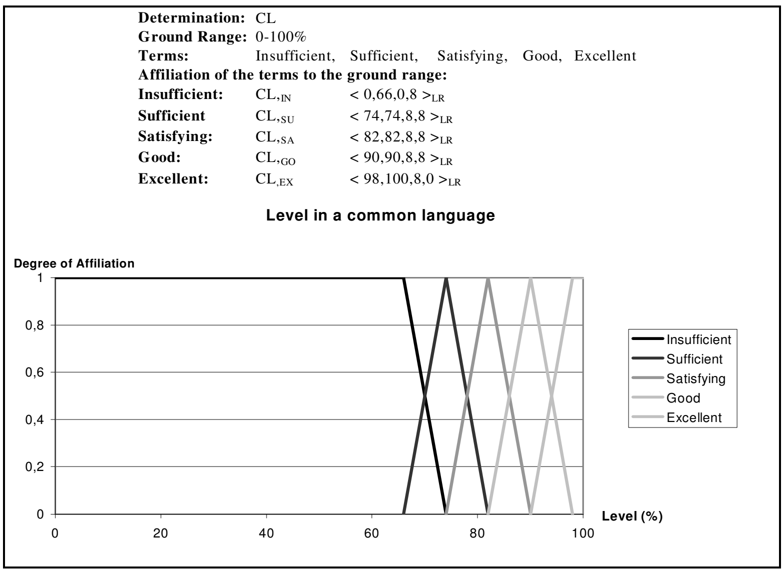

Fig. 1. Fuzzy sets for the influencing factor "Skill level in the agreed project language".

2.3 Building fuzzy rules connecting the influencing factors and the IT-Tools

With the help of an empirical study, 20 IT-tools supporting collaboration and communication have been rated regarding the different influencing factors. The results of this study permit to create fuzzy associative matrices like for example for the subsystem “Knowledge-Management” (these are not the whole rules, only an abstract of it):

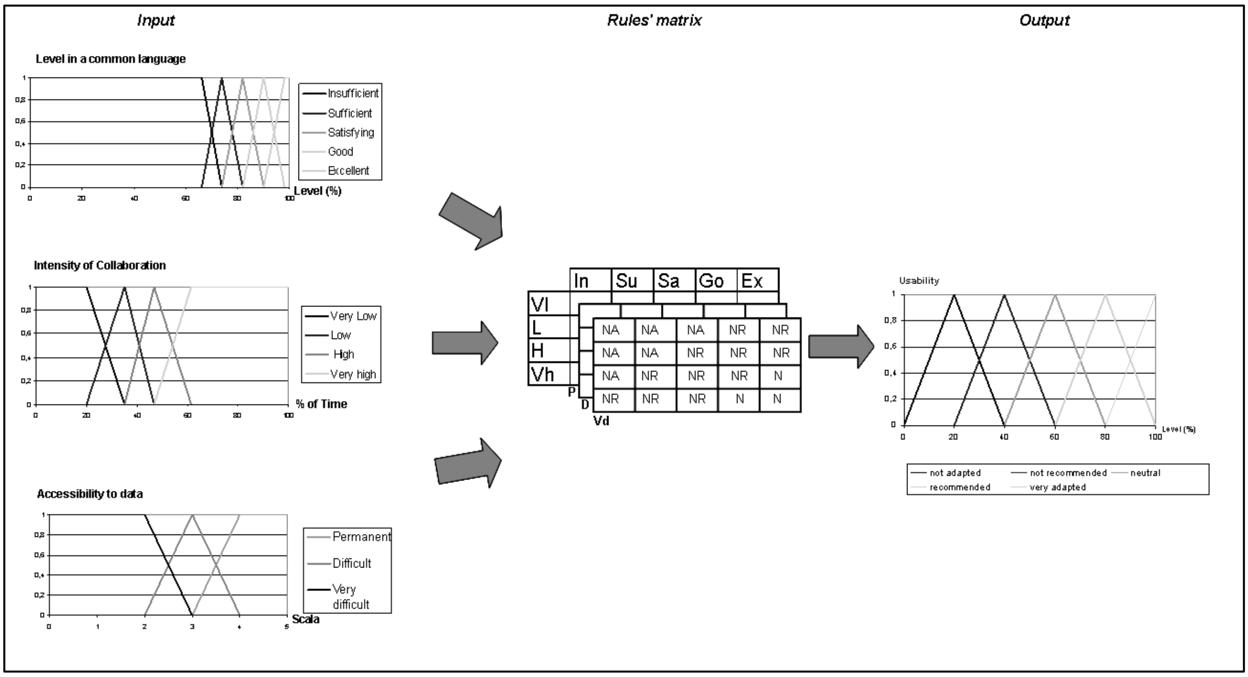

Fig. 2: Fuzzy rules for the subsystem Knowledge-Management-System.

The combination of all rules gives the possibility to design an appropriate IT-System, more exactly its functionality, corresponding to one of the circa 4 Millions possible project configurations.

3 RESULTS AND DISCUSSION

3.1 Results

The empirical research points out that the preferred tools are Electronic Calendars, Project-Management-Systems, Workflow-Systems and E-Mails. It points out that the majority of the users would use IT-support-systems to support organization and coordination activities, rather than purely communication processes.

Communication and collaboration tools like Online-Conferencing or Electronic-Meeting-Systems are often seen as too complex, and make sense only in a not-interdisciplinary context according to the results. For small projects with participants speaking the same language and in a trusted environment, these tools are often rated as very useful.

Instant-messaging and chat-rooms have been rated as inappropriate for almost every project configuration. First these tools enable synchronous communication, which is very complicated to manage for cooperation projects above different countries and different companies. Finding by chance the right person at the right place and at the right moment is for the users a too big challenge. Moreover they often make by users a futile impression.

Whiteboards, forums, social-software, co-author-systems and Problem-Solving systems find a middle acceptance. In fact users seem to be attracted by these tools, because they partly offer new opportunities but on the other side fear that no one will use them because, they aren’t part of the daily work.

Knowledge-Management-Systems and Document-Management-Systems are generally well-seen by participants in cooperation projects, especially by complex projects, with important cultural differences, interdisciplinary or sensitive work contexts. Change Management Tools and Discipline Specific Tools are privileged by small projects with participants from the same discipline.

3.2 Application to industrial projects

To verify the method it has been applied to two engineering projects at BMW. First the projects have been classified in one of the clusters; second, a requirement profile for IT-systems, more precisely for their functionalities, has been derived from the results of the classification. A very important point to verify the method is that the two projects have to be dissimilar from another, and they are. On the one hand, the method will be applied to the development of an entertainment system, and on the other hand, to an engine development project.

The development of the entertainment system has a cross-enterprise character first because it is made by a supplier, directed by BMW, and furthermore tested within the enterprise's laboratory, as well as off site, by suppliers and in collaboration with different partners, from different organization, in geographically distributed spaces. Requirements, specifications and processes have to be clarified for every partner. The cross-domain context is characterized by the fact that the team constituted of specialists in different fields has to collaborate with other teams having other processes, methods, terms, definitions, tools and so on. Especially for requirement and risk management is this cross-domain context a difficulty.

The engine development project has another profile. BMW neither is responsible for the global engineering process, nor for the definition of requirements or testing of the product. The responsibility is distributed between BMW and another OEM (original equipment manufacturer), which makes the decision process more difficult. The engineering process is embedded in a complex organization matrix, which often requires the creation of SE-Teams (Simultaneous Engineering). Such an SE-Team is responsible for the project and encloses specialists for various disciplines, like manufacturing, design, production, electronic, testing, purchasing, quality, and so on, which makes the complexity higher, because they have beside the common goal, other requirements, other focus points, other terms, and other methods.

Applying the method on these projects resulted in 2 differents IT-Collaboration-Platforms with for the entertainment system: Calendaring, Whiteboard, Conferencing, DMS and a discipline specific solution for online collaborative testing; and for the engine development system: Workflow-System, Project-management System, Announcements and DMS (see figure 3).

The resulted requirement profiles have been used to build an IT-platform, based on the Virtual Project Space (VPS). The VPS is a web-application for collaborative engineering integrated in the collaboration portal for BMW partners, which supports in principle management, informative and communication processes with functions like workflows, tasks-management, conferencing, shared folders and so on. The VPS has been designed and extended to support the entertainment system development and the engine development processes.

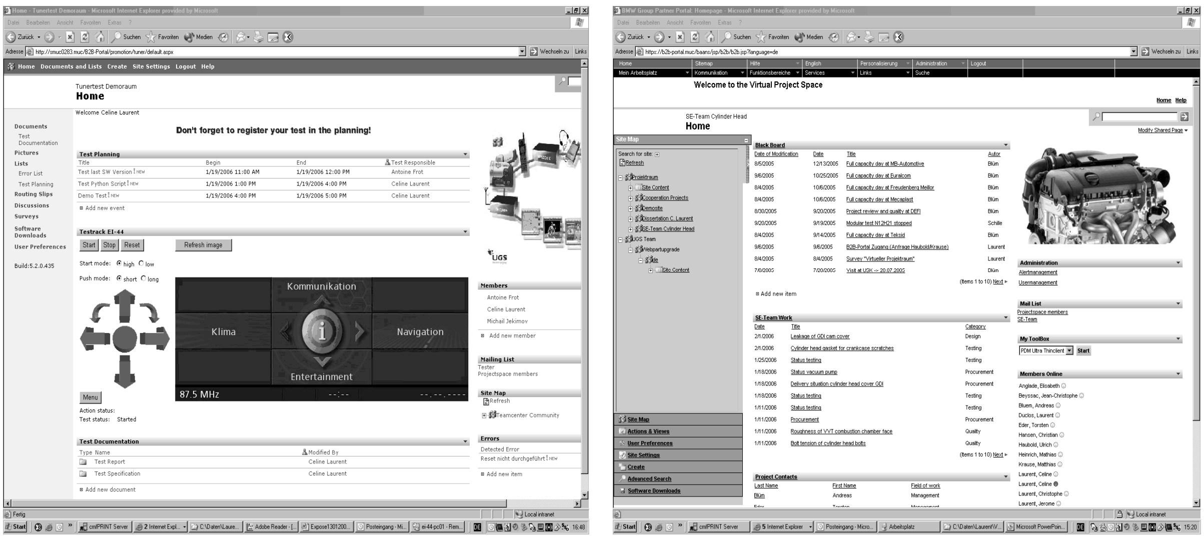

Fig. 3. Collaboration platforms for the two engineering projects. On the left side the collaborative environment for testing and on the right side the engine development platform.

These case studies give us the possibility to evaluate the method to design IT-support systems. Implementing the designed platform highlights where the barriers of this method are, and which points have to be kept in mind by applying it. An important point is that even if the collaboration platform is very efficient and corresponds to the project's needs, its success depend on the users, their acceptance, the way to introduce the new tool and more importantly the new processes to be followed.

4 CONCLUSION

Designing an appropriate IT-Tool to support collaboration processes, namely communication, information and coordination processes is complex and depends strongly on the project to be supported. Interdisciplinarity and cooperation between different cultures, organisation, and disciplines demand particular requirements regarding the tool's functionalities. For that reason the developed method works out influencing parameters of distributed and interdisciplinary engineering projects with the help of the fuzzy set theory, and provides rules to configure IT-Collaboration-Platforms.

An important conclusion of this work is that no tool will find acceptance if it doesn't follow the actual business and engineering processes. Therefore it's of great significance that IT-platforms are based on flexible architectures permitting a free configuration of functionalities and tools to guarantee maximal users satisfaction.

ACKNOWLEDGMENT

This research is financially supported by the BMW Group.

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