A FRAMEWORK FOR SUPPORTING DECISION MAKING IN EARLY PHASES OF PRODUCT DEVELOPMENT IN CONCURRENT ENGINEERING

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ABSTRACT

The paper presents a decision support system for engineering and management decisions, developed within the framework of CODESCO[1] - Communication and Decision Support Environment for Managing Concurrent Engineering (ESPRIT project no. 25455). The focus is on decisions in early phases of product development, when problems are generally ill-defined and ill-structured, and the information is usually either not available or incomplete and low quality [3]. The decision support methodology consists in reusing relevant past knowledge and experience, and the implementation relies on an Artificial Intelligence technique named Case Based Reasoning. The issues of analysing the industrial context, developing the knowledge base and the software are described here, as to-date achievements. The paper concludes by discussing the issues that emerge from this type of approach.

1. INTRODUCTION

In a Concurrent Engineering environment, different tasks are executed in parallel and collaboratively, especially in early stages, when multidisciplinary expertise is required. In these stages of product development, information usually tends to be incomplete, not available or not accessible, of low quality or even inconsistent. These problems, correlated with time constraints can bring the designer or the manager into a critical situation [4]. This is why decisions are sometimes made in an empirical manner, using only personal knowledge and experience, gained during past problem solving processes. It is widely cited that most designers refer back to previous solutions to related problems as a first step in the design process [5]. These solutions are usually difficult to access, especially where individual knowledge or memory is concerned, when making decisions in new projects. There is hence the risk that a problem or difficulty that was found on an earlier project, and subsequently resolved, could be repeated in a new project. Hence, for a competitive environment, efficient support in communication, information retrieval and decision making is important and to provide this support is the objective of CODESCO. In the following the decision support software system of CODESCO is presented.

2. APPROACH

The general project approach was user requirements driven. The system was developed based on industrial requirements formulated by the companies participating as partners in CODESCO. These companies are Thomson CSF (TSI), located in France and GDA Ltd., located in England. TSI, a ‘one-of-a-kind’ firm, produces electronics and information technology for commercial and military applications. GDA Ltd., a consumer goods company, produces domestic appliances. These partners have identified in their companies a lack of structured support, not only in review-type (management) decision points, but also in many decisions made by team members with respect to the detail design and development. These industrial organisations have stated that a large history of project cases, containing useful knowledge is available usually in disparate ‘data’ or ‘knowledge’ sources and many times only on paper format. The requirement for the system was to build a knowledge base in which ‘decision cases’ or scenarios could be entered and then recalled or reused when a new problem arises.

[1] The partners in CODESCO are University of Bremen – Germany, Fordesi – Portugal, GDA Ltd. – UK, TSI - France, IXI – France, University of Nottingham - UK

3. DECISION SUPPORT METHODOLOGY – CASE BASED REASONING

Complying with the requirements, the decision support methodology is based on reuse of knowledge and experience. Case Based Reasoning (CBR) is a computer technique which combines the knowledge based support philosophy with a simulation of the human reasoning when past experience is used. Traditional knowledge based approaches (rule-based) have not been found suitable for our problem, as they require strong domain knowledge and representation, and decision problems in CE are generally difficult to define and structure. Unlike these approaches, CBR uses unrelated but similar cases and does not require any knowledge about the problem domain. This was one of the main reasons for which the CBR methodology was adopted.

In CBR, cases are structured and stored in a database, which the user queries when trying to solve a problem. The system evaluates the similarity between each case in the database and the query. The most similar case(s) are retrieved and presented to the user as possible scenarios for the current problem. The user has to decide if the solution retrieved works in the present, i.e. the system doesn't make the decision, it only supports the decision making process. When the user finds the solution, the new case is entered in the same case base, for future reuse.

4. SYSTEM DEVELOPMENT

The project phases (see figure 1), from user requirements definition to pilot projects are presented in this section. The emphasis is on the developments to date.

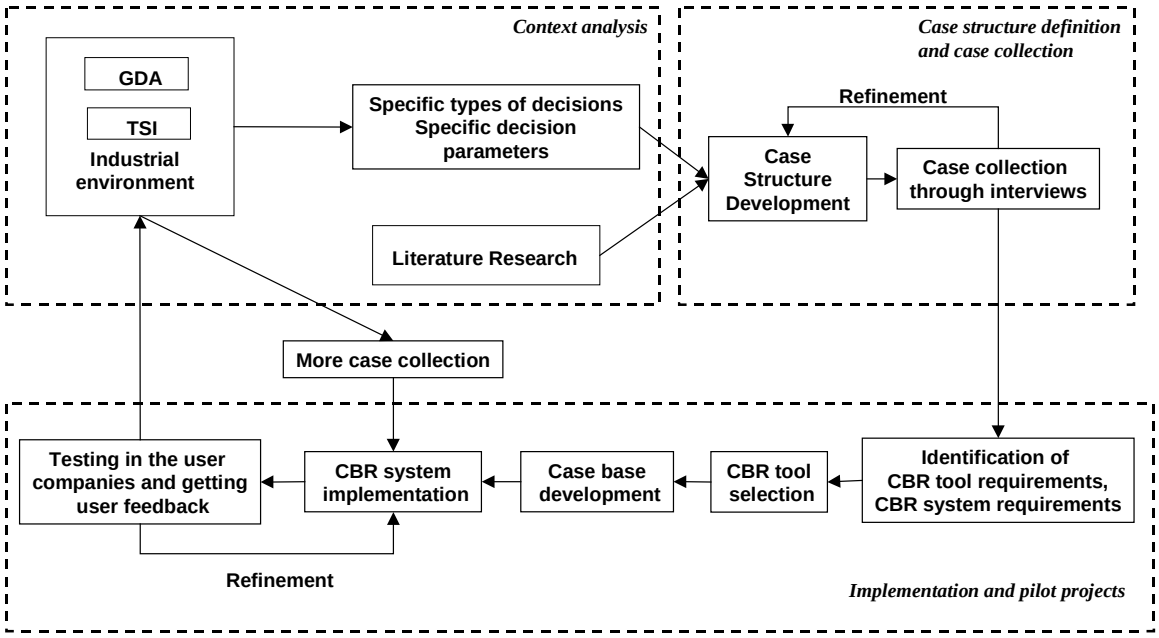

Figure 1 Project phases

4.1 Context analysis

A Case Based Reasoning implementation, in any domain, requires a detailed analysis of the environment, as it is strongly related to the type of problem is trying to support. For this reason, in CODESCO, the academic partners started by looking at the specific product development context of each company. Based on the general user requirements, focused workshops and initial interviews with project managers, design engineers and design managers, production and quality engineers have been carried out. Data analysis and synthesis revealed specific types of products, development and decision processes for the CODESCO context. For instance, in TSI the product is fairly complex (e.g. rugged computers, radars, display systems), the business is client-oriented type and the contracts include many times long-term maintenance and life-cycle support. This process permitted the authors to arrive at company specific requirements. In TSI these were: risk analysis, cost estimation, determining strategic indicators for the project, choosing between strategic alternatives. In GDA,

single products and market forecast type of projects determined a selection of more technical types of decisions, like choosing between design alternatives or technical alternatives, identifying technical risks.

4.2 Case Collection and Case Structure Definition

Semi-structured interviews were then used to collect decision cases in both companies. One aspect considered in our case collection was the decision making process. Based on the model of Benett [1] and mapping of real decision making activity during new product development at the industrial end users four phases of a generic decision making have been identified: (1) framing or problem understanding; (2) gathering intelligence and developing alternatives or solutions; (3) selecting a solution; and (4) learning from feedback. The diagram in figure 2 shows these steps and how CODESCO CBR system can be used in this process.

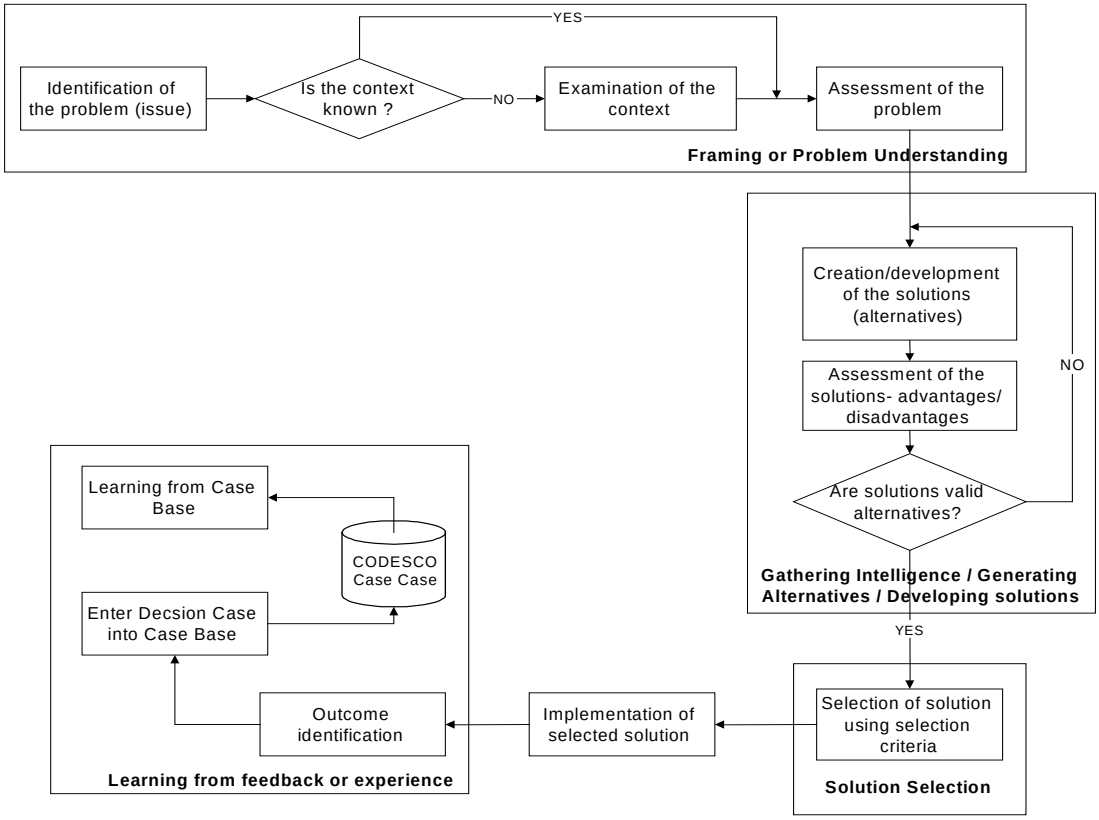

Figure 2 Decision Making Process

A case structure (representation) has been developed based on suggestions from literature on Case Based Reasoning (e.g., [2]) and on the main phases of the decision-making process. It was refined during the case collection. So, three main types of information have been represented in a case:

- *Problem*
- *Solution Development*
- *Outcome*

The *Problem Description* section, beside a textual description of the problem, incorporates details about the context in which the problem arose: product, project and development phase information, people involved or responsible for the decision making, decision parameters. The *Solution Development* section aims to record how the solution was found, what the available alternatives were, why one solution was preferred to the others. It was also found useful to record the *Outcome* of implementing that solution, in terms of performance, positive or negative consequences. In this way, retrieving cases was also useful for identifying and analysing 'what-if' scenarios related to particular problems.

Cases from the two companies have been compared and contrasted. Differences have been incorporated at a detailed level in the case structure (e.g. client information is included only in TSI cases). Also, the general decision parameters, referred in the cases as contractual or company constraints, have been found to be

different, i.e. decision-makers consider different aspects in making a decision. Cost to the client, delivery time, technical performance and technology are specifically akin to TSI, whereas quality and safety standards, company costs, marketing and production are the major decision constraints in GDA. Nevertheless, the general process of making decisions was the same, independently on people function, expertise, or type of company, and this reflected in the high level structure of the case.

4.3 Implementation

The cases collected and the case structure entailed further requirements for the system, i.e. must able to handle different cases structures, must be customisable to other of companies, and must be able to handle textual information. Data like "Problem description", "Constraints", "Solution" are free text and hence, case similarity assessment should be able to evaluate this kind of data. After an evaluation of some of the important CBR tools available on the market, a software with special textual retrieval capabilities was selected. Implementation has started, after cases have been entered in a database.

At the present a prototype is available and it will be tested during pilot projects in TSI and GDA. Refinements will be made based on the user feedback. One of the goals of the pilot projects is to customise the system interface for the two companies, in terms of terminology and language. The main target in getting the user feedback will be to assess the performance of the system, in terms of speed, accuracy of the results, and the ease of usage. Also more extensive case collection is planned during the pilot projects, as a considerable amount of cases is required to achieve good results.

5. CONCLUSIONS

This paper has discussed issues related to decision support for managers and engineers in product development, based on industrial user requirements. A user requirements driven approach and a Case Based Reasoning methodology for decision support have been presented. The phases involved in developing this project have been discussed, and these included case structure definition, case collection process, implementation and pilot projects. Commonalties and differences in the product development and decision making processes in TSI and GDA and their impacts on the CBR system implementation have been also presented.

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