Fostering Innovation in Extended Enterprising

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Abstract: The goal of the IMS AIM (Acceleration of Innovative Ideas into the Market) project is to develop a system managing the innovation process by supporting the collection of innovative ideas and relevant knowledge throughout the extended enterprise for new and existing process and product development. The AIM system supports the development of these ideas and knowledge into a means of fostering industrial innovations. AIM intends to optimise the innovation process in an industrial company by a combination of advanced methods for generating innovative ideas with "classical" methods for collection of knowledge on products/processes and their problems. The AIM system includes specific ontologies and WorkFlow tool needed to enable efficient exchange of ideas/knowledge between different experts/actors within the Extended Enterprise. In particular, the paper presents findings and achievements of the project up to date, including results of the validation by the industrial End-users enrolled in the AIM Consortium.

1. Introduction

In current Global Markets, it is generally assumed that one of the most critical factors for success in industrial firms is Innovation. Innovation is important for all companies, and just as important is the need to get innovative products to the market place quickly. People inside and outside the physical boundaries of the industrial organisation are an untapped resource for innovative ideas and knowledge.

This paper introduces the IST/IMS project AIM with the goal of fostering industrial innovations throughout the extended enterprise for new and existing process and products by supporting the collection of Corporate Knowledge and Innovative Ideas. These ideas and knowledge are later developed supporting industrial innovations. Such system provides a means to collect, store and use/develop innovative ideas over the extended enterprise, and it will "accelerate" innovation into the market. In addition, Team Work is enhanced by co-operation among manufacturers, customers and suppliers by means of the Internet facilities provided by the AIM System. The AIM system is described, focusing on the module for the assessment of ideas collected throughout the extended enterprise. In addition, the paper describes one of the technologies used to support this assessment, Case-Based Reasoning.

2. Business Cases

The project is based on three business cases, one from each end-user. These business cases are focused on innovations for product and process developments. The business cases will therefore use the AIM system in different ways, e.g. while some business cases are oriented to directly collect innovative ideas and knowledge, in some the motivation for collection of ideas is realised via identification of problems/potential improvements asking for

innovative ideas. This will enable to develop and test the AIM system for different scenarios, ensuring its general applicability.

Business Case 1: Product Innovation in SMEs. This business case concerns rapid product innovation in an SME, developing new innovative products internally by getting all actors involved, including field engineers working with customers to generate product ideas. This business case will focus on providing a structured and rapid approach to product innovation, so that the time to market is reduced. This is extremely important for most companies, particularly SMEs that have to produce innovative products for the marketplace, and where it is essential to have a minimal time to market.

Business Case 2: Multiple sites process innovations in high volume manufacturing. This business case will focus upon innovation in multiple sites manufacturing process based on the identified problems and potential improvements. The end-user is a large multiple site company producing high volume products. Currently, many innovative ideas from employees are not used since there is no system to collect such ideas, assess them and deliver them to process designers. In order to collect information on problems in production, for which innovative ideas are needed, the integration and expansion of the IT-Systems implemented in production will be applied. The special challenge of this business case is that it will address manufacturing process distributed over multiple sites. Several sites will be involved in this business case. The goal is to collect problems/potential improvements and innovative ideas from these multiple site manufacturing plants, i.e. to provide means to put together ideas from actors in different plants. The teamwork on developing the ideas across the multiple sites will be supported by the AIM system as well.

Business Case 3: Product and process innovations in engineering services and customer and supplier focus. A medium size company is a system provider to industry and is strongly oriented towards sales, service, marketing and after-market. The company is working closely with their suppliers/partners. Therefore, a system for collecting innovative ideas from both employees and suppliers is an urgent need. The business case scenario will involve collection of ideas internally and at supplier sites. Specifically the benefits from collecting ideas at supplier site could be high, taking into account a high interest of suppliers to provide ideas to improve services with their products.

3. System Concept

AIM system includes methods and tools (modules) for collecting innovative ideas and knowledge on products/processes. The system also contemplates another important source of innovative knowledge coming from problems and potential improvements. The system also supports assessment on these innovative ideas and helps to manage them in order to provide the best way of using them for innovative product and process designs. These ideas and knowledge will later be developed into a means of fostering industrial innovations. It will enable organisational learning by providing means to collect, store and use/develop innovative ideas over the extended enterprise.

Main RTD challenges faced along it contemplate basically the combination of advanced methods for generating innovative ideas with “classical” methods for collection of knowledge on products/processes and their problems. It also includes the development of specific ontologies needed to enable efficient exchange of ideas between different experts/actors within an extended enterprise. The AIM system comprehends several modules, as presented in Figure 1.

- Innovation Repository: This repository classifies ideas by using an ‘innovation’ meta classification, and will store them for rapid access. The overall meta classification of the ideas and innovations will be defined as a basis for all AIM modules. The problem is how to enable appropriate classification for different specific products and processes, as

well as within a specific company concept. This will include knowledge on products/processes, problems/potential improvements, (innovative) ideas and innovations.

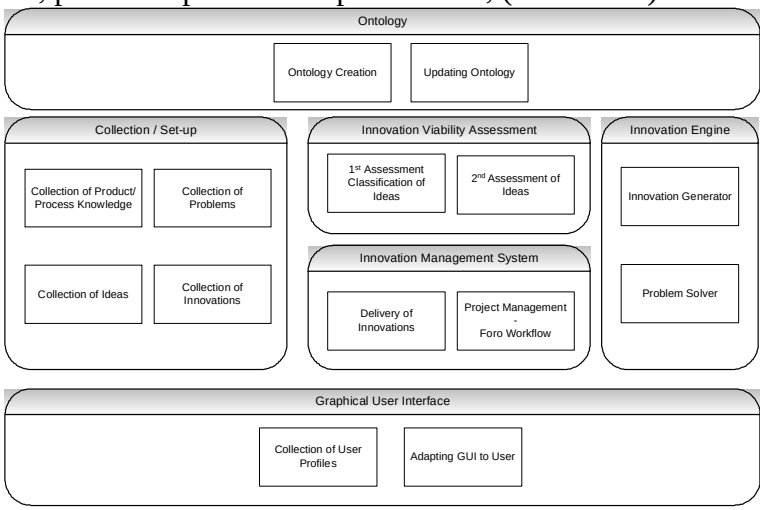

Figure 1: AIM System

- Collection of innovative ideas and product/process knowledge: This module is based on combination of 'classical' approaches/commercial tools together with new developments required to provide means to efficiently collect innovative ideas, but also to collect knowledge on product and process problems for which the innovative ideas are needed. This module includes an appropriate user interface to introduce ideas and knowledge on products/process and about the identified problems.
- Innovation Engine: This is a collection of methods oriented to finding innovative solutions following a systematic methodology. This facility provides a structured means for the development of ideas into innovation concepts, by sharing and working on these ideas in a structured framework. The ideas collected within previous module and stored in the repository will be further developed. The specific requirement is to provide robust solutions to be applied in the industrial environment. TRIZ methodology serves as a baseline approach for this module, where the in-depth analysis of technical requirements and manufacturing failure situations is performed, structured knowledge is delivered, and graphical aids for team working and creation of Concepts are provided.
- Innovation Viability Assessment: This facility provides a structure (based on rapid consulting within the company of evaluation of developments and risks, combined with a multi-criteria decision support) to assist users in assessing the feasibility of new ideas at the collection stage, and innovation assessment facilities for design teams. It is important to focus on feasible, good innovative knowledge, and develop this.
- Innovation Management System: This is a means of providing an efficient way for planning and monitoring the use of the innovation knowledge during design activities and a structured delivery of the innovations/ideas to the process and product Design Teams. This module will assist graphically the work of the Design Teams in designing new process and products in the companies.

This architecture has been finally deployed following a multi-level architecture based on Internet technologies. Integration with other tools inside each enterprise is carefully being studied and adapted to specific needs. Here the Innovation Viability Assessment module will be explained in more detail.

The Innovation Viability Assessment is the AIM module oriented to assist users in assessing the feasibility of new innovative ideas, developing them into concepts. Innovations that cannot be turned into reality, for technical, commercial or socio-economic

benefits are of little use. The assessment is realised in two distinct steps, both supported by the AIM system (see Figure 2).

The First Assessment consists of a rough classification, identifying the type of the "Ideas" collected throughout the extended enterprise, classifying them according to a scheme defined by each user during the set-up phase of the system (e.g. improvement to product/process, cause for problems identified, new product/process etc.).

The Second Assessment comprehends a detailed study of the new "Concept" developed before implementation. This assessment is based on strategic policy, including: technical viability, implementation cost, materials to be used, equipment, profit expected, corporate efforts, Return on Investment etc.

This module is nurtured by the Innovation Repository where all ideas proposed are stored. The ideas collected must be related to the problem or product/process that intends to improve, or to other Ideas to which they are related. Later, these ideas are filtered focusing on commercial or socio-economic interest, possibilities for turning them into reality.

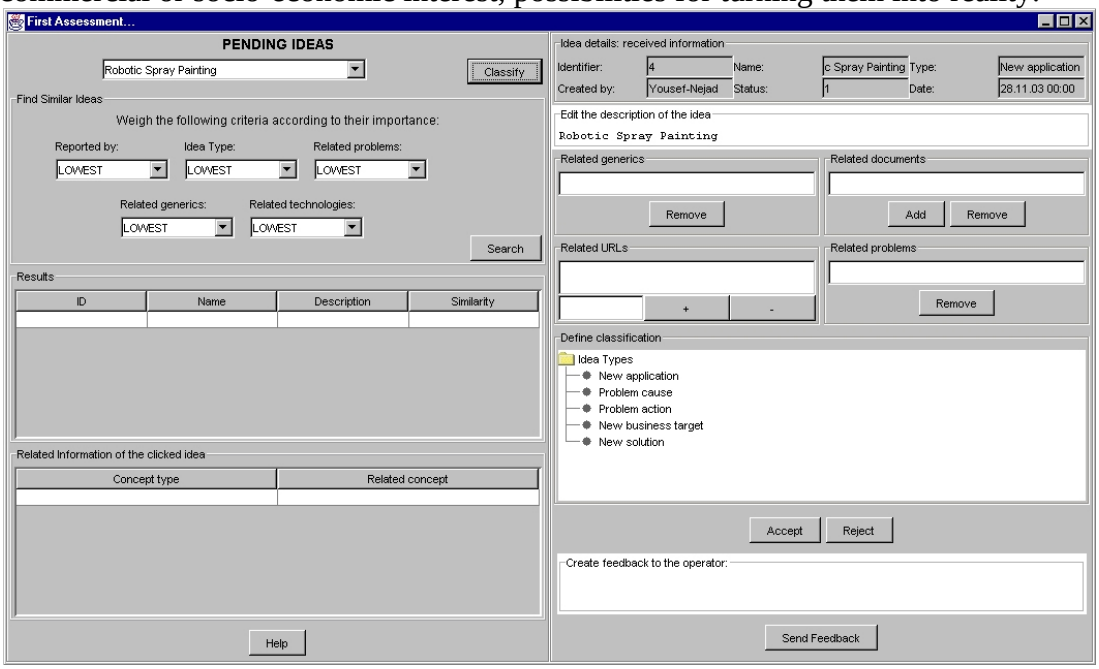

Figure 2: Assessment Screen Example

4. Technology and System Concept

The main asset of the AIM System is to provide means of efficient delivering Corporate Knowledge and Ideas (by integrating a WorkFlow Tool), collected throughout the extended enterprise (by offering web-based applications to customers, clients etc.) and stored in a structured repository. Therefore, the information and collective knowledge have to be structured in such a way that it is easy to access and re-use.

The AIM System combines existing tools and technologies in an innovative way, in order to fulfil the stated objectives. AIM fosters creativity by combining classical reasoning methods, Case-Based Reasoning (CBR) and Rule-Based Reasoning (RBR), which focus on the Company's Business Objectives with an innovation supporting method, Theory for Inventive Problem Solving (TRIZ), and graphical aids for combination of concepts, within the context of specific products/processes, formalised by the use of continuously adapted ontologies. Although the main technologies mentioned are available in the market, the results of the analysis of the state-of-the-art conclude that methods and tools for capturing and structuring knowledge and innovative ideas, over extended enterprise, in a way that enables product/process innovative practical means are missing.

CBR, for example, is used in three different modules of the AIM System: Collection, Innovation Viability Assessment and Innovation Engine. Therefore, the functionality of CBR has to be flexible and adjustable to fulfil the functionality in the different modules. CBR is used to search similar problems and/or ideas. For each of these entities, cases have to be built, with the information that will be considered to evaluate similarity. The functionality will be used for problems, to identify the respective causes, and in ideas to support an effective collection of knowledge and appropriate assessment. One of the main challenges of the AIM project is the great variety of problems, ideas or situations the system should be able to deal with. In many CBR applications, the domain is bounded in the sense that all influencing conditions (attributes) and their ranges are known and it is assumed that all occurring ideas/problems could be described by these conditions. This assumption may not hold in AIM. The system may not need only to learn possible problem/idea situations and their causes but also to learn possible descriptions of problems or ideas. For this reason, the common structure of cases has to be more generic than in conventional CBR systems.

In conventional CBR systems, the description of a problem or idea (case) is given in a "flat" table. When information has to be entered into the structure, where no attributes are defined, the structure needs to be extended. The problem in AIM is that it is not known in advance which information is accessible in case of a problem or idea and how it is structured. Therefore, a more generic approach is also considered, based on object-oriented Design. The generic structure assumes that every case occurs during an operation which takes one or more objects as input, provides one or more objects as output and is performed by one or more objects as operators (human operator, machines etc.). In one case, all the objects could be instantiated as often as needed to describe the current situation. For both operations and objects, different conditions could hold. Neither the type of significant conditions nor its value is known in advance. Therefore, these conditions could also be instantiated by objects and operations as often as needed.

The simple structure described seems to be sufficient to store all possible problems/ideas, but it is being further elaborated and refined. In classical flat structures, the similarity between cases is computed via similarity functions, attribute by attribute, and a weighted mean value over all outcomes of the functions. The difficulty lies in determining the similarity functions and the weights for the mean value. Another problem arises especially in the selected object-oriented approach because cases do not only differ in the value of their attributes but also in the existence of attributes.

Similarity of ideas is based on five fields of information: Idea Type, User who reported the Idea, Involved Generics (processes, products and tools), Involved Problems, and Involved Technologies. Similarity of Problems is based on the following information: Generics involved in the problem (processes, products and tools), and Actual State Items defined for the problem (values). When two ideas/problems are analysed to ascertain their similarity, each of the fields is compared to check if the respective information is the same in both cases. The comparison of each field provides a result (in percentage), which is afterwards computed in a total percentage, representing the similarity of the two ideas/problems. CBR considers that an undefined value is more similar to a defined value, than two different defined values. The several parameters that constitute the similarity criteria of each entity can be adjusted by the user, each time CBR is used to obtain similar ideas/problems. This allows the users to perform a more flexible search, and obtaining appropriate results. The priority given to each field is a value within Ignore, Lowest, Below Normal, Normal, Above Normal and Highest (see an example of Interface for this search in the AIM System, in Figure 3). Furthermore, it is possible to filter ideas on the similarity comparison by selecting specific status that should be ignored (e.g. the user can choose to ignore in the analysis all the ideas marked as Invalid).

AIM uses the tool ReCall from ISoft for the implementation of the CBR module. This decision was based on the analysis of the existing market available tools for CBR, and on laboratory tests carried applying this tool, which provided positive results.

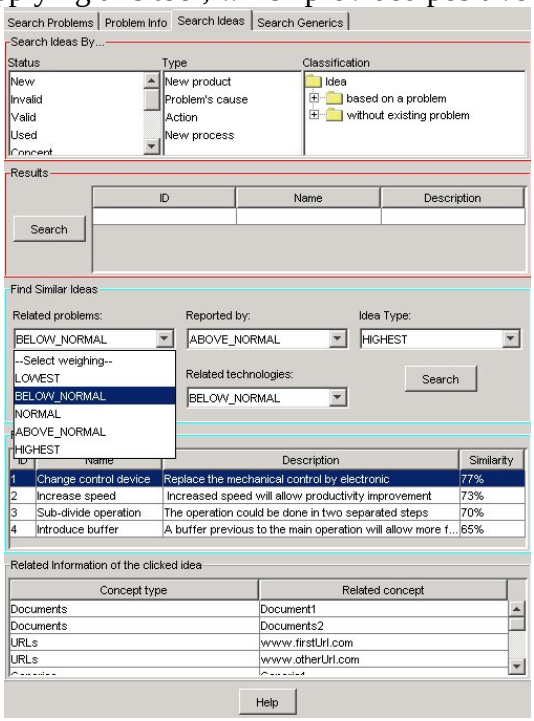

Figure 3: Searching Ideas Screen Example

5. Results

An early prototype of the AIM system has been developed and tested in the three business cases described. The Project is currently realising integration tasks of the modules already developed, so new results and feedback from the utilisation by the end-users of the integrated system are expected.

Related to the use of the CBR for efficient search of ideas and problems, through the Innovation Repository of the AIM System, the results from the tests performed indicated improvements needed. To test the developed CBR functionality, in Business Case 2 several problems occurred in the manufacturing processes were stored, as well as ideas, providing the system the necessary information to reason. CBR uses information from problems stored in the system to provide the results. For Business Case 2 the rather flat case structure is designed and filled with cases. The weighting for attributes has been specifically defined for each problem type. The same information was also filled in the generic structure. The objective was to prove that the generic structure does not yield a loss of accuracy. The list of problems from production was used to test the CBR module. An example of problems for one of the business cases is provided in Table 1. The problems were structured both in a specific structure and in a generic structure in order to enable a comparison of appropriateness of these two structures. The tests performed considered ca. 350 problems. The results obtained are sets of cases with a high similarity. When the specific structure is applied, CBR identifies the reasons of problems in more than 90 % correctly (even with incomplete information) and the similarity achieved in the range of 75-99%. In the case of the generic structure, the identified problem causes are correct in more than 88%, while similarity is between 83-99%. This indicates that the proposed generic structure is appropriate for the cases and that CBR approach is likely to efficiently solve more than 80 % problems in the companies (a conservative estimate, taking into account that the considered cases are very typical for the companies).

Table 1: Problems/Ideas

Error	Process Step	Product Part	State Items	Cause	Idea/Action
Broken can V-Crash	WIM, Coater, Decorator	Bottom of the can	manual check, where the damaged bottom is identified (no available measu-rement of the air pres-sure of the machines)	Coater/WIM too high Base deformed	WIM/Coater control/reduce
Falt Batwings/Line fold	used tinplate (supplier process)	tinplate	tinplate strengths; (problems with) the coil in the front end (cupper/wim)	Soft metal plate	Increase lubrication impulse Sedimentation in the plate
Falt Line fold	IBO	inside lacquer	visual inspection-> bubbles in the inside lacquer; temperature inside oven too high?	Temperature (inside oven) inner lacquerer	

6. Business Benefits

As a result of the tests performed, the following business benefits are registered.

Business Case 1. The essential benefits expected within this business case were defined in the beginning and were to increase the number of innovative suggestions on products from customers and suppliers by a structured link via Internet (50% achieved, 60% with large suppliers and customers), increase the number of innovative ideas on products from employees (field engineers), improving it by means of easy to use facilities (around 60% achieved up to now), establish a classification scheme for product/process knowledge to be used for further development, to increase the number of implemented innovation/new concepts of offers to customers (a 30% improvement achieved but it is expected to increase), to have a managed way of developing ideas into new practical concepts, shorten the time needed for collecting and implementation of new ideas, to reduce time and efforts for solving product problems (20% improvement achieved up to now but expected to increase).

Business Case 2. The expected results within this project for this business case are to establish a classification scheme for problems, problem causes and ideas and innovations to remove these causes and so improve the production process in the shop floor, to collect the Corporate Knowledge from the company and record and classify ideas, to shorten the time needed for collecting and implementation of new ideas in the manufacturing process, to reduce wastes and costs associated with problems, and support customers to reduce time and efforts for solving product/process problems (a 15% improvement was achieved up to now). This business case also expects to gain benefits from the focus given upon innovation in multiple sites manufacturing process based on the identified problems and in this way improve potential to foster the innovation process based on the experience.

Business Case 3. Also for this business case were set some goals in terms of expected benefits for their company. They are to increase the number of innovative ideas on products from employees and suppliers, improving it by means of easy to use facilities (50% achieved up to now), to increase the number of implemented innovation/new concepts of offers to customers (30% already achieved but more is expected), establishment of a classification scheme and IT based collection and evaluation for the problems, problem causes and ideas and innovations to remove these causes and to have a managed way of developing ideas into new practical concepts. Furthermore, benefits in a more general note can be expected. Among others they are to collect the Corporate Knowledge from the company, shorten the time needed for collecting and implementation of new ideas in the

business process, reduce wastes and costs associated with problems, and supporting customers and to have a structure to record and classify ideas.

7. Conclusions

The overall objective of the AIM project is twofold: increasing innovation and accelerating its introduction to the Market. This paper presents the approach developed in the project to fulfil this objective.

After the preliminary assessment of the benefits expected and already achieved, the three business cases are unanimous in presenting positive results. One of the common benefits expected is the reduction of time and efforts for solving product/process problems which already has achieved an improvement of 20% (15% in business case 2) but all expect to further improve this value. Other specific achievements expected out of the full implementation of the AIM system are the development of means of stimulating the creation of innovative ideas and collecting them from people at the extended enterprise level involved with the products and processes, the development of ways of processing these ideas and storing them into a structured knowledge repository (to ensure that all the useful knowledge, innovative information, is saved), the development of means of analysing innovative knowledge to determine which is useful, and which is not (to enable the viability of ideas to be assessed) and the development of means of delivering the innovative ideas to product and process designers for maximum effect. The changes on the companies to reach these specific achievements are still ongoing and can not still provide specific numbers on the overall improvement of the company, the assessment so far has shown signals of positive results. This should lead to important business benefits on the fields of reduction of product innovation cycle-time (by at least 30%) and the improvement of process efficiency (by at least 15%) and reduction of wastes (by 12%).

In the future, it is planned to finish integration with legacy systems, continue with the industrial testing and make the respective measurements to have the full assessment of the system.

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