PROMETHEUS: a web platform for supporting knowledge management in an environment based on experience factory

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***Abstract* — This paper presents a Knowledge Management System (KMS), called PROMETHEUS, which consists of a set of processes that constitute the Experience Factory (EF) and a platform that is the Knowledge Experience Base (KEB), which collects Knowledge Experience Packages (KEP). The KMS thus formed supports the formalization and packaging of knowledge and experience of producers and innovation transferors encouraging gradual explanation of tacit information of bearers of knowledge to facilitate the transfer. The KMS enables the cooperative production of KEP between different authors contributing to the production of KEP and users of the latter. The paper describes the approach outlined in the PROMETHEUS Project and the precautions taken in the design of KEP to ensure that: the experience contained in it, even when collected through projects executed by many person-years, can be quickly acquired by the user, contains the tools to facilitate the acquisition of knowledge innovation support to transfer.**

Keywords - Business mode; Experience Factory; Knowledge Management

I. INTRODUCTION

The knowledge of its software engineers and developers is the most relevant asset of a software company. However, handling such knowledge properly is a complex task. Several studies and experimentations have been conducted on how to share and increase such knowledge. "Among them there is the ground breaking work of Basili on the experience factory" [27]. In this paper, we present a knowledge experience factory, called PROMETHEUS, to enact a knowledge management system within a software company. The framework is made up of four major sections: Contents, Attributes, Educational and Training E-Learning, Taxonomy.

The PROMETHEUS (Practices Process and Methods Evolution Through Experience Unfolded Systematically) Project [1], [2], [21], [22], [23], [24], [26] is a model of Experience Factory (EF) to collect experimental knowledge in a repository Knowledge Experience Base (KEB) in the form of Knowledge Experience Package (KEP). The KEP is the vehicle suggested for the transfer of knowledge while the EF is the set of processes that make the Open Innovation.

This paper describes the structure of the KEP and the features that make the contents to be tailored and attractive for the target of the innovation.

The rest of the paper is structured as follows: the next section discusses related works and research activities; third section presents the major concepts implemented in PROMETHEUS, 4th section describes the incremental production of KEPs. Finally, in the conclusions some observations are made about PROMETHEUS and possible future research pathways are identified.

II. RELATED WORKS

The aim of experience factory [28] is to provide an infrastructure that supports project developments by analyzing and synthesizing all kinds of experience, acting as a repository for such experience, and supplying that experience to various projects on demand. Introduced in late eighties, the concept of experience factory has been implemented in many organizations [8], [10], [11], [15]. Unfortunately, there is still no exact well established technique that would lead to a guaranteed success in adopting the concept of experience factory in a company and to this regard the human factor is pointed out as the main cause [28].

Our approach focuses on a knowledge base whose contents make it easier to achieve knowledge transfer among research centres; between research centres and production processes; among production processes. The knowledge base must be hybrid, public, as we wish, or private, depending on KEP authors preferences. The public KEB allows one or more interested communities also included public administrations, to develop around it and exchange knowledge.

III. PROMETHEUS

The Authors use the term knowledge package to refer to an organized set of: knowledge content, teaching units on the use of the demonstration prototypes or tools and all other information that may strengthen the package's ability to achieve the proposed goal. The KEP must be usable independently of its author or authors and for this purpose the content must have a particular structure: distance education and training must be available through an e-

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learning system. In short, the proposed knowledge package contains knowledge content integrated with an e-learning function.

In PROMETHEUS, the KEP must include all the components shown in Figure 1. A user can access one of the package components and then navigate along all the components of the same package according to her/his needs.

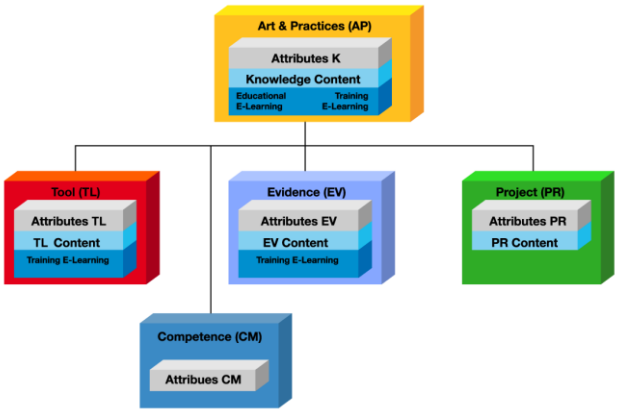

Figure 1. Diagram of a Knowledge/Experience package

The KEP does not contain the conceptual basis of the subject, because it is considered as the background of the user's knowledge, and can be found in conventional sources of knowledge such as technical reports, papers and books. Anyway, when users need some of the basic concepts for understanding the contents of KEP they can use educational e-learning course. And if users should need more information, they can use the "attachments" regarding reports, papers and books about basic topics of KEP. Instead, if the use of a demonstrational prototype is required to become operational, the same package will point to a training in e-learning course. As stated above, the use of these courses is flexible, to meet individual user's needs.

When a package also has support tools, rather than merely demonstration prototypes, Knowledge Content (KC) links the user to the available tool. For the sake of clarity, we point out that this is the case when the knowledge package has become an industrial practice, so that the demonstration prototypes included in the archetype they derived from have become industrial tools. The tools are collected in the Tools Component (TL). Each tool available is associated to an educational course, again of a flexible nature, in the use of the correlated training e-learning course.

Should the user need support from whom has knowledge of the contents of KEP, a list of resources is a reference. The list is collected in the Competence component (CM).

A. Knowledge Content

It can be seen in the Figure 1 that the Art & Practices KC is the central one. It contains the KEP expressed in a hypermedia form in order to include figures, graphs, formulas and whatever else may help to understand the content. The KC is organized as a tree that starting from the root (level 0) descent to the lower levels ($level_1$, $level_2$, …, $level_n$) through pointers (Figure 2). The higher the level of a node the lower the abstraction of the content, which focuses more and more on operative elements. The root node of KC is made up of the following sections:

- Thoughtful Index: tells the reader how the package suggested will practically change, with a list of processes and activities, case the whole process is not innovating or has to be modified.
- Problem (one or more): describes the problem of KEP. A problem may belong to one of the two following types: decision and optimization. If the problem is the decision there should be the possibility to make a choice, and the aim for this choice. If the problem is optimization, the resources you want to improve the performance and the objective function of optimization have to be indicated. For each problem, the context has to be defined, that is to say all facts and circumstances which cause and condition a certain problem.

The leaf nodes have the answers to the problems: the solution or solutions suggested for each problem set. Figure 2 shows an example of KC.

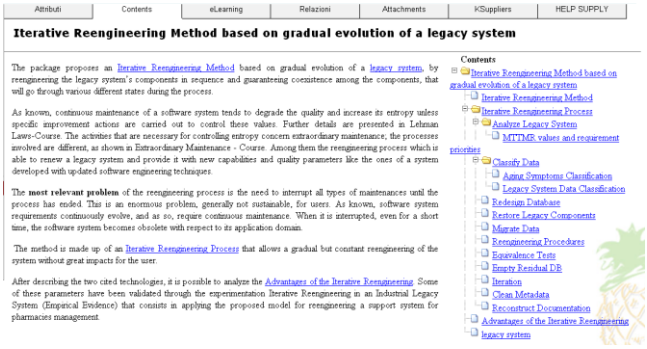

Figure 2. Sample of Knowledge Content of a KEP

To ensure control of completeness and lack of ambiguity in the contents of KEP, the vocabulary of KEP, i.e. concepts and relations between there meanings, has been formalized by the W3C XML Schema [20], in short XSD to obtain for each KC the following advantages:

1. The full list of concepts (elements) which have to be declared with obligatorily, multiplicity and default values of the elements / concepts, relationships between elements / concepts, type of elements, attributes defined for each element, type of attributes, ...;
2. Elimination of ambiguity, incompleteness, verbosity due to Informal definitions;
3. Verification of the correct syntax ;
4. Interoperability of the KEP, at the syntactic level between background of experience that share the structure proposed by us, leading to an independence of the software that produces them.

The research results integrated by a KEP may be contained within the same knowledge base or derive from other knowledge bases or other laboratories. If the knowledge package being read uses knowledge packages located in the same experience base, the relations will be

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explicitly highlighted. In Figure 3 is graphically shown the KEP structure.

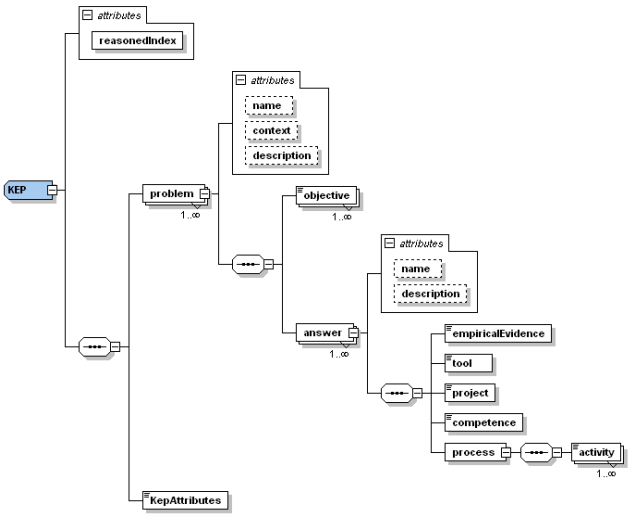

Figure 3. Sample of content of a Knowledge/Experience package

B. Attributes

Search inside the package starting from any of its components is facilitated by the component's Attributes. As shown in Figure 1, each component in the knowledge package has its own attributes structure. For all the components, attributes allow rapid selection of the relative elements in the knowledge base. Attributes have already been defined in [25], [2]. To facilitate the research, we used a set of selection classifiers and a set of descriptors summarizing the contents. The summary descriptors include: a brief summary of the content and a history of the essential events occurring during the life cycle of the package, giving the reader an idea of how it has been applied, improved, and how mature it is. The history may also include information telling the reader that the content of all or some parts of the package are currently undergoing improvements.

The classifiers include:

- The adoption risks of the technological innovation where it is provider;
- The mitigation initiatives of risk that assure a better performance of the KEP in the solution of main problems
- The impact that the KEP will have on the active processes of the production lines where it will be applied, supposed that the problems to solve correspond to the ones in the KEP
- A forecast of the Return of Investment that the new introduction will have in the company. For this reason the economical impact of the KEP as well as its impact on the value chain are specified;
- The acquisition plan of the methods of the KEP;
- The history of the KEP, i.e. the set of practices that have required the use and the results following to their application in order to assure a higher perception of reuse of the KEP.

The interested reader can find further details on the contents of the KEP and the management and use of KEB on the technical report [18].

C. Educational and Training E-Learning

PROMETHEUS, as shown in Figure 1, is made up of several sections for each component provided by the structure of the KEP. The division into sections enables beneficiaries to cut, and then adapt the learning to their training needs. In the interface for access to each section of PROMETHEUS there are links to resources and relationships of the component selected with the rest of KEP.

In order to support the beneficiaries for the acquisition of the KEP, PROMETHEUS helps them select a training program best suited to their knowledge. PROMETHEUS, in fact, provides for each KEP, in addition to training materials and training, tests to assess skills for the adoption of KEP by companies, research and government institutions interested in them. If tests were to detect any skill gaps, models are used to fill them, suggesting the more appropriate decision.

For each competence PROMETHEUS, in fact, provides a set of learning units. Each learning unit aims to train the user of a KEP on one or more items of the KEP of interest. Therefore, it is possible to attach to each teaching unit a test plan to verify that the user already has, or has acquired, the corresponding part of competence.

Such a model predicts that each jurisdiction has an associated evaluation questionnaire and a decision model. In the questionnaires the self-assessment tests result in the user evaluation of the KEP and guidelines to improve the training of the user. The test assesses the competencies and skills attained by the user and the gap between them and the ones expected. The model of decision interprets the level of acquisition of the skills of users receiving the evaluation questionnaires and suggests actions to be undertaken to fill any gap between skills expected and skills acquired by the learner. The model decision is made by the decision tables.

Operationally, for each competency $C_{(i)}$ a specific evaluation model is planned (Figure 4). In this model, the responses gathered by $QC_{(i)}$ the evaluation questionnaires provided, are interpreted by an appropriate set of decision tables DT (Figure 4). There is more than one DT where each DT aims to interpret the answers of the corresponding teaching unit UD.

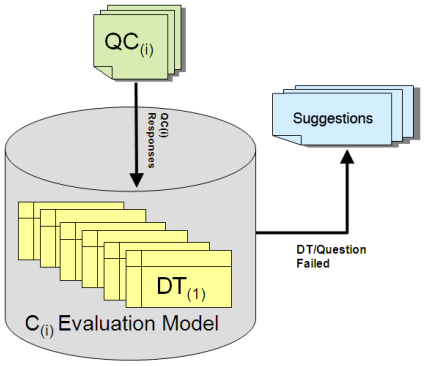

Figure 4. Evaluation Model

D. PROMETHEUS Taxonomy

Taxonomy is the practice and science of classification according to natural relationships. In PROMETHEUS, taxonomy is used by administrators to organize content and is created from 'Vocabularies' that contain related 'Terms'.

The PROMETHEUS logic implemented for taxonomy allows a vocabulary to be set up with either tags defined by user (also known as folksonomy) or terms defined by administrator.

When users view a KEP to which a term has been assigned, along with the KEP, many themes will generally display the node's term(s). Each term appears as a link. Clicking the link displays a page showing the other KEPs with the same term.

The PROMETHEUS Taxonomy organizes taxonomies into vocabularies which consist of one or more terms. Vocabularies group terms that describe an aspect of the content. Each vocabulary consists of a set of terms.

PROMETHEUS can have an unlimited number of vocabularies each containing an unlimited number of terms.

Within a vocabulary terms can be ordered into hierarchies. In PROMETHEUS, all vocabularies are hierarchical, in other words, you can simply arrange items in a hierarchy.

Vocabularies may be designated as “free” tagging in which users creating new content don't have to classify it with terms from a "controlled vocabulary", previously defined. Instead users can freely define terms, or "tags".

Vocabularies can be set to allow terms to define related terms. This function is similar to "see also" in a dictionary.

Vocabularies define whether users may attach only a single term to a node or whether users may attach multiple terms to a node.

Simple implementations might create a set of terms without hierarchies. More complex implementations, in the future, might use hierarchies of terms.

By using multiple vocabularies it is possible to classify an individual content in multiple ways. It’s also possible tie the vocabulary to particular content type: AP, TL, EV, PR, CM (see Figure 1) or whatever. Then when users create content of a particular type, they'll see a list of the vocabulary terms that go with it. Users can then categorize their post by choosing from the list (you can also give your vocabulary a help text to help your users choose).

Vocabularies can have hierarchies of terms. In PROMETHEUS, administrator simply arranges items to create a hierarchy: “single select” allows terms to be nested but each sub-term is associated on only one parent; “multiple select” allows a term to be associated to multiple parents. With either single or multiple a vocabularies can have as many levels as desired. If administrator allow "free tagging", when users create content they can make up their own terms as they go along, instead of having to choose from a list.

By choosing "multiple select", administrator can allow users to put a post into more than one category at once by tagging it with more than one vocabulary term.

Also, if appropriate, administrator can require to users that create content of a certain "content type" they assign at least one of this vocabulary's terms.

Administrator can decide the order in which vocabulary will appear in lists by assigning a "weight" to it.

Finally, administrator can delete the vocabulary altogether, thereby also deleting all its terms (but not the content to which they were assigned).

Administrator must assign your term a name (you have to do it. There's no such thing as a "nameless term").

Administrator can list synonyms for a term (this creates what is known as a "thesaurus"), decide the order in which the term will appear in lists by assigning it a "weight" and also delete a term altogether.

Moreover the menu of PROMETHEUS can call the KEPs that match terms of a specific taxonomy, those terms named categories by administrators.

IV. INCREMENTAL PRODUCTION OF KEPS

A KEP is generally based on conjectures, hypotheses and principles. As they mature, their contents must all become principle-based. The transformation of a statement from conjecture through hypothesis to principle must be based on experimentation showing evidence of its validity. The experimentation, details of its execution and relative results, are collected in the Evidence component (EV), and duly pointed to by the knowledge package.

Finally, a mature knowledge package is used in one or more projects, by one or more firms. At this stage the details describing the project and all the measurements made during its execution that express the efficacy of use of the package are collected in the Projects component (PR) associated with the package. A KEP is undergoing a process of incremental improvement that aims to reach all parts described above. The incremental completion is performed by different authors who cooperate but that are geographically and tempo rally spread.

As shown in Figure 5 Author(s) produce the KEP with their own knowledge. Researchers and practitioners, beneficiaries of the contents of KEP, reported as Recipient(s), acquire the innovation contents contained in KEP, whatever stage they are. The KEP evolve since then, through their research or their experiments becoming their own authors. The results of the research or experiments, properly formalized, enrich the KEP.

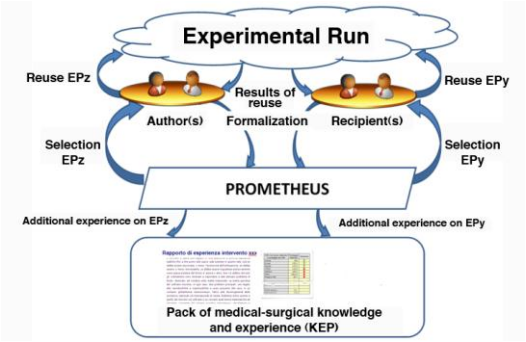

Figure 5. Incremental Production of KEPs

V. CONCLUSIONS

In this paper, we presented a web-based platform aimed for use in companies implementing the concept of experience factory. We provided a general overview of PROMETHEUS knowledge management framework, and described the main features and structure of KEP, which are Contents, Attributes, Educational and Training E-Learning, Taxonomy. We also showed that PROMETHEUS integrates a Knowledge Management System and a Learning System, allowing navigation among all its components.

We have already validated PROMETHEUS in academic environment [21], [24], [26] but it is necessary in order to generalize the validity of the KEP proposed in this work that it is validated by empirical studies in non-academic environments. Obviously, in order to demonstrate the validity of PROMETHEUS many other empirical investigations and studies are needed, in particular industrial context. For this reason, the authors intend plan and execute experiments, make instruments and material available to other interested researchers.

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