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Scenarios for Evaluating a Semantic Project Management Approach

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***Abstract* – Knowledge regarding closed projects is not sufficiently reused while planning new projects to improve the quality of project management processes. The reason is that current project management systems mainly support the ongoing project phase and do not explicitly consider the initiating and closing phase of a project management life cycle. By implementing semantic technologies within an existing open source project management system, these weaknesses can be improved. This system incorporates and links historical project knowledge that contributes to a more effective setup of upcoming projects. To design, develop and implement such a system we conducted interviews with IT companies regarding the strengths and weaknesses of the project management systems in use. On the basis of the interviews we identified three scenarios, which deal with the most common problems of project management, such as consistent data storage and how to retrieve information. These scenarios, described in this paper, are used as requirements and to evaluate the designed prototype.**

***Keywords* – project management, scenarios, semantic technologies, ontology**

I. Introduction

Today, existing knowledge of closed projects, like lessons learned or well working teams, is still not sufficiently reused. This is validated by literature, such as [2], [8] or [16] and interviews we did with eleven IT companies concerning current project management (PM) systems [5]. This problem is based on the fact that current project management systems mainly support the ongoing project phase and do not explicitly consider the initiating and closing phase of a project management life cycle [13]. Thereby, PM systems are not flexible enough to react, e.g., on lessons learned which would improve ongoing projects.

The initiating phase of a project management life cycle covers the initialization of a project, such as fixing up the project idea, the input of the project relevant data into the PM system or the composition of the project team [17]. The ongoing phase or intermediate phase handles the process of the project; for instance, in case of an IT project, the process of developing software. The closing phase includes the finalization of the software as well as storing information concerning lessons learned and final reports.

For example, if information of the closing phase of project A, like lessons learned, is stored and related to already finished project knowledge, the initiating phase of project B could consider new acquired knowledge and reuse it; for instance, to compose an optimal team for the new project or propose the most suitable employee for a task.

In the project *"Semantic based Project Management" (SemProM)* we deal with the difficulties of project management, such as data storage and the reuse of knowledge within the domain of IT. Our approach is to enhance an existing project management system with semantic technologies, such as an ontology or ontological reasoning, and implement a prototype for evaluation. The planned outcome is to obtain a knowledge base with project relevant information to improve the project management life cycle.

With the use of semantic technologies, PM systems should be easily extensible and flexible enough to tackle these problems; assuming that the self developed project management ontology [6] is modularity designed and thus it can be easily extended. In addition, by linking any kind of information, knowledge can be retrieved more easily.

The purpose of the prototype is to answer the question whether semantic technologies can tackle the most common problems of project management (processes). To achieve this goal we designed scenarios, which contain these problems. The scenarios serve as a basis for the requirements concerning the prototype and the ontology and in addition for evaluating them.

Within this paper we identify three scenarios, which focus on the most current PM challenges. For instance, the fact that companies miss a well structured and central data storage and that they are not able to include lessons learned of finished projects into ongoing and new ones [5]. These scenarios mainly cover the initiating and closing phase of a projects life cycle as well as interfere with the implementing phase or ongoing project process.

The scenarios identify processes, which are not completely covered by current PM systems. They outline common PM problems, such as how to annotate information to recover it as well as how to recover the correct information out of a knowledge base.

This paper is structured as follows: section two provides a detailed description of the project SemProM and the methodological approach. In section three, we deal with state-of-the-art while in section four a detailed description of the scenarios is given. Conclusion and future work are discussed in the last section.

II. The Project "Semantic based Project Management - SemProM"

Within the project SemProM we argue that the incorporation of semantic technologies within current project management systems is able to tackle the shortcomings of current project management solutions. Semantic technologies,

such as ontologies, semantic search and ontological reasoning, will enable a better search functionality and information retrieval as well as the reuse of already stored information for the purpose of reducing time and costs. Knowledge of finished projects can be reused for ongoing and new projects and to observe process and risks of project management life cycles, which will increase the quality of project management. In addition, ontologies improve the integration of information; for instance, between different systems.

Our main research question is: "Do semantic technologies improve current project management processes?". To answer this question our approach comprises the following main steps:

1. Literature review about similar work concerning project management enhanced with semantic technologies, existing ontologies and methods, which can be used for our approach; for instance, an ontological engineering approach.
2. Interviews to get an overview of current PM solutions as well as their weaknesses, strengths and standards.
3. An evaluation of open source project management systems to analyze the capabilities of current solutions and to select a system for prototyping.
4. Based on the interviews, specification of the scenarios.
5. Design of an ontology containing, e.g., project management, competences of employees and document information.
6. Implementation of the prototype, containing
   - the project management ontology,
   - ontological reasoning,
   - semantic annotation of information and
   - semantic search.
7. Evaluation of our approach based on the prototype and the scenarios.

The methodological approach of the project SemProM follows Hevner et al. [12] guidelines for design science in information systems research. We only outline the guidelines, which are essential for our work. This points at:

Problem Relevance: We used 11 face-to-face interviews and a desktop study to identify the problem relevance. Most of the interviewed companies are located in the domain of IT and their working range contains software development and services [5]. The contact persons were mainly project manager. The interviews contained questions regarding data storage, reusing knowledge and strengths and weaknesses of current PM solutions in the domain of IT. To clarify the main results, the recordings of the interviews were transcribed and the main content was outlined [5]. As a result, the key findings are [5]:

- Companies lack a central, well structured and standardized data storage.
- Most of the companies do not reuse knowledge of already finished projects to improve ongoing and further projects.
- Project manager as well as project members miss an up-to-date cockpit of ongoing projects.
- Companies often have more than one system for project management; hence they would need interfaces between those systems to prevent redundant work.

Design as an Artifact: For our work we identified two artifacts; an ontology and a prototype.

The aim of the software prototype is to evaluate our research question whether semantic technologies improve current project management processes. Therefore, the existing open source PM system 'dotProject' (http://www.dotproject.net) will be enhanced with semantic technologies; more precisely, with the PM ontology, semantic annotations of the information and ontological reasoning. To validate the system, the scenarios, described in this paper, will be applied.

The prototype will improve processes, such as information retrieval or the setup of a new project team.

The project management ontology represents the relations and connections between the different information items regarding project management. For instance, tasks, employees and their competences. Foundations of the ontology are the outcome of the interviews as well as the scenarios. Our ontology consists of the main concepts project, task, persons and their competences, documents and lessons learned.

Design Evaluation: Based on the scenarios the prototype will be evaluated. Thereby, the ontology artifact is part of the prototype; they can be evaluated at once. The implementation as well as the evaluation of the prototype is part of the future work.

Research Rigor: Concerning our project, we use the following research methods.

As already mentioned above, the project SemProM, as a whole, is covered by Hevners guidelines for design science in information systems research [12].

For the conducted interviews we used a qualitative approach. Qualitative research is characterized by more flexibility and is in its essence explorative [23]. The main focus is to get lots of information of a small group. To translate it to our work, we did face-to-face interviews with eleven companies to get useable information about current project management.

For the implementation of our ontology we rely on the methodologies of Uschold and King [21], [22] and Grüninger and Fox [9]. While Uschold and King [21] describe four steps:

1. Identify purpose,
2. Building the ontology,
3. Evaluation and
4. Documentation.

Grüninger and Fox [9] define six steps to implement an ontology:

1. Motivating scenario,
2. Informal competency questions,
3. Terminology,
4. Formal competency questions,
5. Axioms and

6. Completeness theorem.

While implementing our ontology, we used a mixture of both approaches, including the following steps:

1. Identify purpose,
2. Motivating scenarios,
3. Informal competency questions,
4. Building the ontology & terminology,
5. Formal competency questions & evaluation and
6. Documentation.

The workflow in detail is described in [6].

The rough architecture of the prototype is depicted in figure 1. Within the 'SemProM' server the open source project management system dotproject (http://www.dotproject.net) requires the web server Apache (The Apache Software Foundation http://www.apache.org) and a MySQL (http://www.mysql.com) database. dotproject is written and can easily be extended in the programming language PHP (http://www.php.net).

We enhanced this system with our self developed project management ontology [6], which covers the main concepts, relations and properties of a project management knowledge base; furthermore it is complemented with semantic annotations, semantic search and ontological reasoning. In addition, the stored project documents are related to information within the ontology. Thus, information retrieval gets improved and simplified.

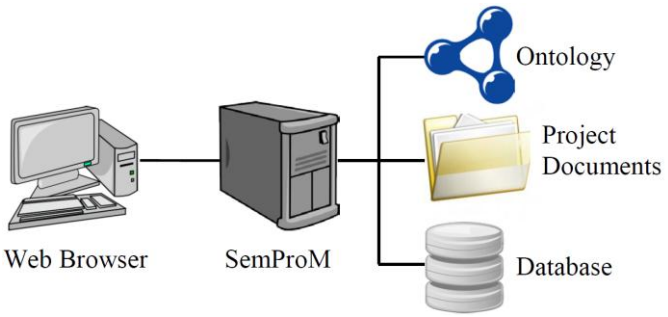

Fig. 1. Architecture of the prototype

Figure 2 outlines the application programming interface (API) between the project management system dotproject and the PM ontology.

We use two different APIs for the ontology access. The ARC API for SPARQL (Simple Protocol And RDF Query Language) Queries and the rdf_handler (`rdf_handler.php`) for editing and updating instances in the ontology. Whenever an information item, like a project or a task, is stored the system dotproject activates the script `do_<modulename>_aed.php`, which again includes the script `do_<modulename>_rdf.php`. This script contains functionalities to store new information items. If an information item is changed, updated or viewed, the system executes the script `<modulename>.functions.php`.

III. Related Work

In this section we discuss project management ontologies as well as semantic project management systems.

In addition, examples of similar approaches of semantic systems are given.

PROMONT, [1] is a project management ontology that formalizes the typical elements for project structuring. It was further developed as PR²ONTO within the project PERMETER [10] by the Department of Business Information Systems of the University Oldenburg. The ontology PR²ONTO is divided into a project and a product ontology. Considering our requirements, depicted by the scenarios, the PROMONT ontology is too general for our purpose.

Another ontology related to project management is described by Kwon et al. [14]. An ontology for R&D project meetings was designed at the Korea Institute of Science and Technology. Therefore, they analyzed and classified meetings and related data. We will not use this ontology, because our project management ontology will not cover the aspect of meetings.

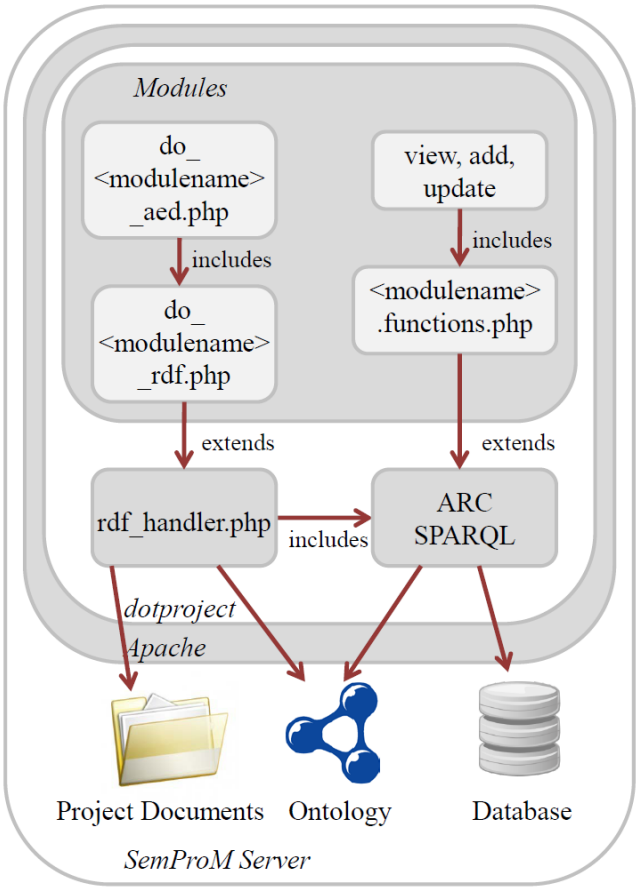

Fig.2. API Architecture of the prototype

Dong et al. describe in their work [7] a multi-site project track and trace ontology. It contains a hierarchy of project organization, an employee, project and criterion ontology. While the project organization hierarchy describes and classifies different roles of employees, the employee ontology identifies the employee's name and his responsibilities within a project. The project ontology contains all relevant information regarding a project, such as name, date or status and is related to the criterion ontology, which can be

compared with tasks of a project [7]. Despite the fact that this ontology covers some aspects of our PM ontology, it does not implement our required terms, relations and properties. Thus, we do not use this ontology.

In the field of semantic project management, Mohammadi and Khalili [15] developed a semantic project management system with the main focus on semantic web services. They also used the ontology PROMONT as a base ontology. The difference to our approach is that they implemented a new project management system with the use of semantic web services, while we are enhancing the existing open source project management system dotproject. In addition, our focus lies on reusing already stored knowledge.

The Semantic MediaWiki [11], which is distributed by Ontoprise (http://wiki.ontoprise.com/wiki/index.php/Main_Page), is also related to the field of semantic project management. They implemented a project management ontology and provided collaborative knowledge management. This work influenced some relations and properties within our ontology.

Another semantic system which influenced our work is the Semantic Desktop, which provides a personal information management. Within such a system, the stored information is represented by triples. In addition, the information is related to each other and the metadata regarding information is stored in an ontology.

There are already some existing implementations, such as IRIS [3] or Gnowsis [20, 19]. While IRIS belongs to the CALO research project at SRI International [3], Gnowsis is part of the NEPOMUK project [20]. Current work in the field of Semantic Desktop is to enable collaboration between such systems [4, 18]. For our work interesting aspects of the Semantic Desktop are parts of their ontologies, such as date and time or documents.

IV. Scenarios

In the following section we describe three scenarios which cover the most common problems of current project management solutions, identified in our interviews [5]. These scenarios demonstrate the functionalities of a possible PM system and outline project processes, which are not covered by current project management solutions. The scenarios focus on problems like central and standardized data storage as well as the search functionality to recover already stored information, independent of the type of information, e.g., documents, competences of employees or lessons learned.

Figure 3 outlines the most important functionalities, their dependencies and correlations regarding the scenarios. Thus, the basis of the pyramid is the "Central Data Storage" to enable the 'universal' access to the information and to guarantee the consistency and availability of different information items. The second layer contains the "Standardized Data Storage". This layer is closely intertwined with the first one and is geared towards standard guidelines for storing all information regarding project management. "Information Recovery" deals with information retrieval. The "Cockpit" mainly displays the information of all ongoing projects, such as their status and information of project changes, problems or delays. We assume that with the implementation of all four layers a project management system is getting a project knowledge base.

The focus of the scenarios is "how do I have to store and collect the information" (layer one and two) and "how do I retrieve the information for reusing" (information access, layer three and four).

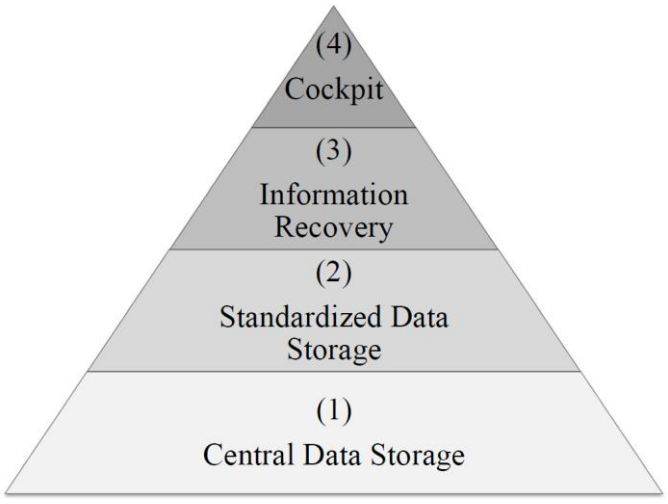

Fig.3. Problem Pyramid of missing functionalities improving the project management quality

The scenarios are described as follows: first, they will be described as use cases, just to cover the main ideas behind the scenarios. Second, the scenarios are highlighted as graphics. These graphics do not underlie any standards, such as UML, because we want to illustrate the interaction between project manager and system as well as the rough process within the system. Thus, we decided not to use a use case or/and activity diagram, but to merge both ideas into one reader-friendly graphic. Third, weaknesses of PM solutions, which are covered by individual scenarios, are explained. Fourth, questions, which are derived from the scenarios, are specified. And fifth, additional comments are given.

A. Scenario 1 – "Bob needs Holidays"

Description: Bob is working as software developer at the IT company "Holidays". He is currently working on the project "Example" where he is responsible for work package (WP) 4. The actual date is March, 14th and Bob is thinking if he could go on holidays in August for two weeks. But in August the deliverable 4.3 of WP 4 has to be finished. So, the question is: Is he able to go on Holidays in August when he should work to finish the deliverable?

The technical aspect of this scenario is as follows: The project leader inserts the scheduled period of holidays and the name of the employee into the project management system. The system checks the assigned work packages, deliverables, tasks and projects of the employee. Furthermore, it monitors the process status of the work as well as possible milestones, dependencies and relations between different tasks. In addition, the PM system checks employees, who are able to do

the tasks of the person. Preconditions are that these employees are not on holidays and have the same or similar competences as the colleague. Furthermore, they must be free during the holiday period of the person. Figure 4 displays the operating procedure of this scenario.

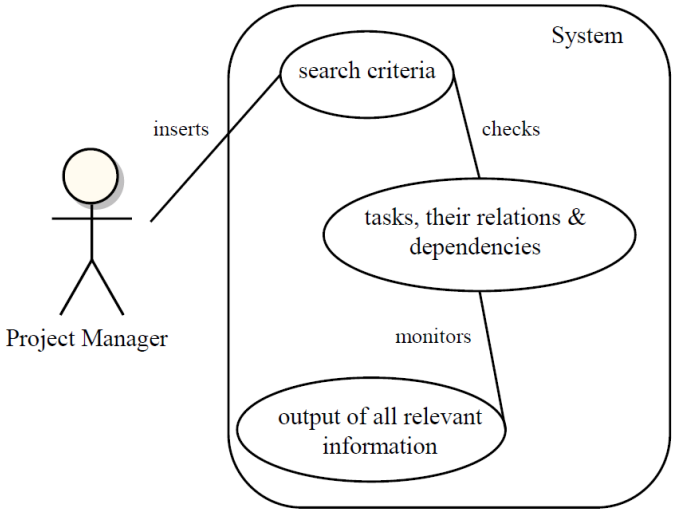

Fig.4. Operating procedure of the scenario "Bob needs Holidays"

Weaknesses: The weaknesses covered by this scenario:

- Detailed information of relationships between projects/tasks, time-management, staff members and competences is missing.
- Current PM systems do not provide up-to-date information; a kind of "cockpit" which offers all relevant information regarding ongoing projects (e.g.: are the projects meeting the deadline, is a task not finished in time?,…) is missing.

Questions: The following questions are the results of the first scenario and must be answered to tackle the question whether the employee is able to go on Holidays in August?

- What is the process status of the deliverable?
- What is the effective and planned end date of this deliverable?
- Does the deliverable have any dependencies to other deliverables, tasks or work packages?
- Is Bob's deliverable a milestone?
- Does the company have employees with the same competences as Bob? In what projects do they work? Do they have deliverables and/or tasks during the holidays of Bob?
- Is Bob responsible for any other deliverables, work packages or tasks? What are the effective and planned end dates of these deliverables, work packages and tasks? Do they have dependencies to others?

Additional Comments: Scenario 1 covers the layer "Information Recovery" and "Cockpit". Causes for this purpose are that information about ongoing projects, their tasks, employees and their competences must be recovered.

The scenario described above can also be applied, for instance, in the field of sick certificates. In this sense the scenario becomes even more relevant, because if an employee gets ill there is often no time to delay appointments. Thus, a colleague with the same competences must be found. In fact, a deliverable or WP must be finished in time.

Another domain for this scenario can be employee turnovers. In this connection, the time period to react is shorter than in the case of holiday substitution.

B. Scenario 2 – "A new Project"

Description: Frida is the project leader of the new software project "Easy Life" within the IT company "Parallels". She inserts the new project into the project management system. Therefore, Frida provides all relevant project information, such as name of the project, project description and used technologies. While storing the data all the supplied information is checked against similarities to existing project knowledge. The system seeks similarities between, e.g., task descriptions, task names, lessons learned and competences.

If similarities to stored projects are found, the information of, e.g., lessons learned or tasks, will be displayed as advice. Now Frida, the project leader, has the choice to decide whether relevant information is contained in the advice or not. If there is relevant information she connects the new project part to the information advice of the stored project knowledge. This check can also be repeated later on. With this check information loss can be avoided. The operating procedure is depicted in Figure 5.

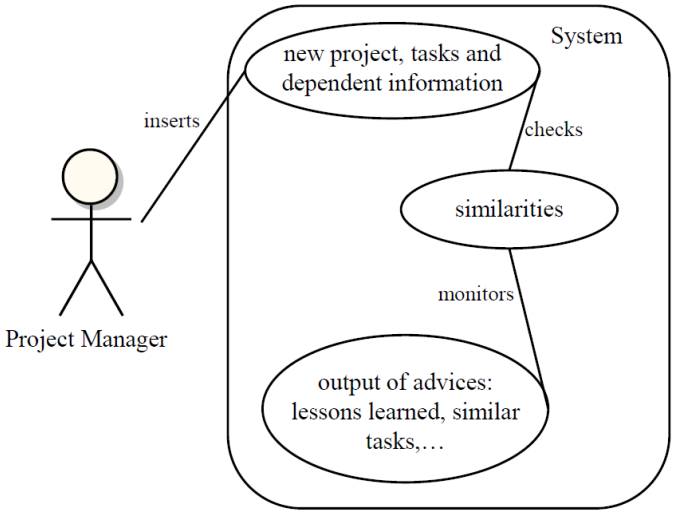

Fig.5. Operating procedure of the scenario "A new Project"

Weaknesses: The weaknesses resolved by this scenario can be described as:

- Search through archived information is difficult (different storage, no standardized and consistent annotation, no existing relations between different information items)
- The project management life cycle consists of five phases: initiating, planning, execution, monitoring & controlling and closing. While the execution and monitoring & controlling part is more or less covered by existing project management systems,

the initiating, planning and closing phases are still badly covered.

Questions: Questions regarding scenario 2 are as follows:

- Are there similar projects/tasks to the project "Easy Life"? (e.g., name, descriptions, software in use)
- Are there already lessons learned which can be used for this project?
- Can already stored information be reused for this project? (e.g., software modules, documentation)

Additional Comments: The layer "Central Data Storage" and "Standardized Data Storage" are included in scenario 2. However, layer three "Information Recovery" is also part of this scenario. While layer one and two deal with the data storage, layer three covers the retrieval of already stored information.

C. Scenario 3 – "Team suggestions"

Description: Frida, the project leader of the project "Easy Life", enters the PM system with information regarding work packages, deliverables and tasks. For setting up the optimal team, the system checks all employees, their capacity for teamwork as well as their competences and report recommendations regarding the project allocation. Furthermore, the system monitors if employees, who might be considered for this project, are already assigned to other projects and tasks. If employees are already completely allocated to another project or task, they will not be considered anymore. If employees are not working with full capacity and their competences fit to the necessary project, they will be listed as available.

At the team allocation of the system all employees are assigned to their possible functions in the new project. Furthermore, it is marked if employees collaborate well with each other or if they have some problems while working together.

If Frida does not agree with the recommendation of the system, she is able to search for other proposals regarding the project allocation. For instance, Frida wants someone else as a project manager. Figure 6 displays the operating procedure.

Weaknesses: The weaknesses highlighted by this scenario are:

- Detailed information of relationships between tasks, time-management, staff members and competences is often missing.
- Search through archived information is difficult (different storage, no standardized and consistent annotation, no existing relations between different information items).
- The project management life cycle consists of five phases: initiating, planning, execution, monitoring & controlling and closing. While the execution and monitoring & controlling part is more or less covered by existing project management systems, the initiating, planning and closing phases are still badly covered.

Questions: Questions, which can be deduced from the scenario 3, are:

- What employees have the most adequate competences for the projects/tasks?
- Do the employees already work in other projects? For how long do the personnel work in other projects/tasks? In what projects and tasks are the employees already working? Are they responsible for tasks or projects? What are they doing in the projects or tasks?
- Do the chosen employees work well with others? What are their competences?
- Do the competences match with competences needed in the new project?

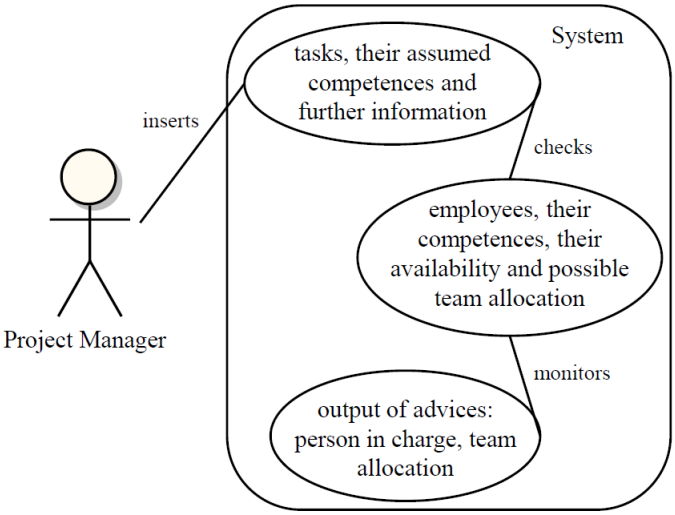

Fig.6. Operating procedure of the scenario "Team suggestions"

Additional Comments: Scenario 3 deals with all layers depicted in Figure 3.

To retrieve already stored information, the annotation of information plays a decisive role. In addition, the relation between different information items is also an important part. By means of ontologies the relations can be easily set and the search queries can be optimized. Thereby, the search queries can be more complex and interlaced.

V. Conclusion and Future Work

In this paper we described our project SemProM, which focuses on the question whether semantic technologies improve current project management processes. Therefore, we conducted interviews with 11 project managers within the domain of IT projects to get an overview of weaknesses of current project management solutions. Based on the interviews, we developed three scenarios. They are also used as requirements for a project management ontology and a semantic based project management prototype. Additionally, they are used for evaluating our approach.

The scenarios outline the following shortcomings of current PM solutions:

- PM systems do not contain a central data storage.
- There is no standardization in how to store and annotate project relevant information.

- Project manager and members often miss an up-to-date information cockpit to get all relevant information of ongoing projects.
- Often, stored information cannot be retrieved, because it is not stored centrally and cannot be retrieved due to lack of annotations.

In future work, to tackle these problems and cover the scenarios described in this paper, we extend the open source project management system dotproject with semantic technologies; i.e., a PM ontology, semantic annotations, semantic search and ontological reasoning. The developed project management ontology [6] represents the relations between projects, tasks, documents, employees and their competences and lessons learned.

In addition the evaluation of the software prototype will be handled with the help of project managers. They will test the prototype by going through the scenarios by using a detailed guide. While testing the prototype, the developed PM ontology will also be reviewed. That is because the relations of PM relevant information are stored in the ontology. Afterwards, the test results will be interpreted, whether the use of semantic technologies improves the project management processes.

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His research interests include semantic technologies, E-Tourism and B2B integration.