Using Semantic Web Technologies and Non-Procedural Programming Language for Selecting Team members

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Abstract: - Semantic Web Technologies have proven their great potential in realizing the knowledge management solutions, as it is their vision to provide means for the unification of information resources. However, when used for real-world applications, sometimes there are some puzzles missing for effective implementation. In this paper, we study and present an approach to implement a knowledge management system with the use of semantic web technologies in combination with a non-procedural rule-based programming language. We used the both to develop a prototype system that should assist in project team building activities. In this manner, a system is proposed that enables project managers to build project teams of highly skilled, personally compatible and interested individuals.

Key-Words: - semantic web, knowledge management, non-procedural programming language, team building approaches

1 Introduction

With modern transportation, communication, and business connections, distances are becoming narrower and competition tougher. Therefore, successful companies nowadays need to adapt to changes in environment more rapidly than they used to. Besides ever rapidly changing environment, an organizational shift towards customer has been noticed. For the last ten years or so there has been a steady international move towards changing the way customer services are delivered, financed and regulated, with the main purpose being the improvement of efficiency so that more customers could receive better service more quickly without reducing (and possibly increasing) the quality.

Many a time it has been proven that the proper use of proper knowledge is the best way of optimizing work processes. As the evolution of information technology and software design progresses the possible solutions to the optimization of work processes could be knowledge management and web-based software services. Based on our experiences in developing software solutions, it is our belief that semantic web technologies (SWT), properly combined with alternative existing solutions wherever the stack of SWT is somewhat deficient, could solve this task. In this manner, we propose a new approach to solving the inferring part of semantic web application. Due to lack of inferring technologies promised by the semantic web designers, we decided to use a non-procedural rule-based programming language rule-based Clips, mainly used for the development of production rules based expert systems, to implement the inferring system.

This particular combination allowed us to develop an effective prototype system that is able to propose project team members based on their personal profiles and the requirements of a specific project.

2 Semantic web technologies overview

The idea behind semantic web is fairly simple. According to Passin [1], the vision of semantic web is that computers would be able to find, read and understand the meaning of data. Tim Berners-Lee sees semantic web as “web of data” compared to web of documents as we know world wide web today [2].

Semantic web technologies (SWT) are based on XML language that enables them to be platform and program language independent. They are built in layers (Figure 1), where each upper layer provides additional functional aspects and is based on the lower one, with which is fully compatible (http://www.w3.org/2001/sw/). The layers, from bottom up, include URI, XML and namespaces, RDF as the core technology for the semantic annotation of data [3], RDFS and OWL being languages for describing ontologies [4], SparQL as a language for querying semantic data and RIF as a rule interchange format for describing logical rules of the data being semantically described. The two top most technologies (trust and proof) are not supported yet.

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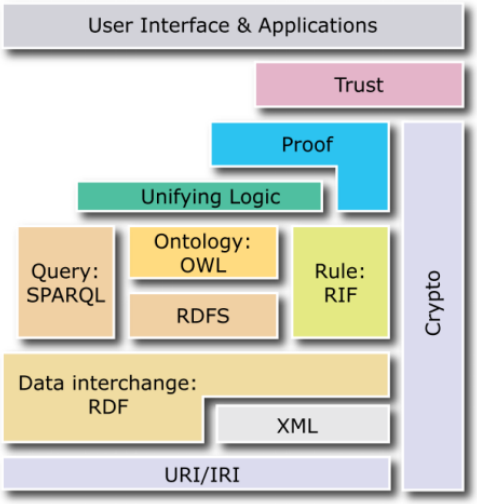

Fig 1. The layers of the semantic web technologies.

2.1 Describing resources within SWT: RDF and ontology

Most bottom layer includes Unicode and URI/IRI technologies. Unicode enables SWT to be platform and language independent and URI (Uniform Resource Identifier, IRI stands for Internationalized Resource Identifier) is used for general resource identification – each resource is in semantic web represented with an URI descriptor. The second layer of enabling technologies for SWT includes XML technologies – each semantic web document is basically an XML document.

Above the enabling technologies is RDF layer. RDF is the core SWT and is acronym for resource description framework [5]. Basically, it is used for semantic description (or annotation) of data. Because of RDF's flexibility and its simple structure, it can be used to describe practically any resource. Because of its structure, an RDF document can be represented as a directed graph, where subjects and objects are represented as nodes, while predicates are represented as edges.

Above the RDF layer in SWT stack is ontology layer. Ontology is a rigorous and exhaustive organization of some knowledge domain that is usually hierarchical and contains all the relevant entities and their relations (Wordnet, http://wordnet.princeton.edu). For ontology description there exist more languages, most common nowadays is OWL (Web Ontology Language) that is derived from DAML and OIL Web ontology language [6]. OWL is an extension of RDF – rules and characteristics of RDF also apply to OWL [1]. OWL uses description logic to classify resources defined in a RDF document. Different subsets of OWL are known with different ratio between performance and expressiveness – OWL DL (description logic) being the mostly used one, as it was designed for existing description logic business segment and is fully decidable [6].

Next important layer in SWT stack is the logic layer. W3C consortium has released a member submission called SWRL (Semantic Web Rule Language) – a rule-based language that is a combination of OWL (subsets OWL Lite and OWL DL) with Datalog RuleML sublanguages [7]. With SWRL language, knowledge engineer can define rules that are then applied to OWL knowledge database.

The two top most technologies (trust and proof) in SWT stack are not supported yet. As long as we are concerned with a closed information environment – for now the lack of methods and tools on these two layers should not represent too much of a problem. For the SWT based solutions on an inter-organizational level the implementation of appropriate tools on these last two levels would be very important. Anyhow, the appropriate level of security is achieved by available cryptography technologies, depicted in Figure 1 as a parallel layer called Crypto.

2.2 The Key Role of Ontology in Knowledge Management

What is the purpose of ontology in semantic web? Ontology describes the subject domain using notions of concepts, instances, attributes, relations and axioms [8]. Ontology is a useful way to organize and share information while offering intelligent means for knowledge management. Ontology also enhances semantic search in distributed and heterogeneous information services.

There are several benefits of using ontologies for information solutions. Semantic search engines return instances that constitute answers to queries rather than documents containing search strings as in keyword search engines. Semantic search uses meanings (semantics) of the query terms defined in the ontology. The data of ontology constitutes precise answers to user questions. Users can further browse related concept because answers are interconnected through semantics.

3 Team building overview

For a technical project, let's say in software engineering, to be successfully implemented there is a need for bright, skilled individuals with good technical skills and exceptional attention to detail. However, the real world projects nowadays normally require more than just good individuals. Even a group of great individuals is not

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enough, what we really need is a team – a team of cleverly selected individuals, who will combine their personal technical skills with their teamwork skills in order to achieve the project goals. What we need to compose great teams is a proper team building approach and a supporting technology to implement the approach. It is our believe that adopting the SWT for describing a personal skill record, consisting of technical skills profile and teamwork skills profile, using an ontology, is a good and valid approach to project teams building.

Team building is an effort in which a team studies its own process of working together and acts to create a climate that encourages and values the contributions of team members. Their energies are directed toward problem solving, task effectiveness, and maximizing the use of all members' resources to achieve the team's purpose. Sound team building recognizes that it is not possible to fully separate one's performance from those of others. Team building works best when the following conditions are met [9]:

1. There is a high level of interdependence among team members. The team is working on important tasks in which each team member has a commitment and teamwork is critical for achieving the desired results.
2. The team leader has good people skills, is committed to developing a team approach, and allocates time to team-building activities. Team management is seen as a shared function, and team members are given the opportunity to exercise leadership when their experiences and skills are appropriate to the needs of the team.
3. Each team member is capable and willing to contribute information, skills, and experiences that provide an appropriate mix for achieving the team's purpose.
4. The team develops a climate in which people feel relaxed and are able to be direct and open in their communications.
5. Team members develop a mutual trust for each other and believe that other team members have skills and capabilities to contribute to the team.
6. Both the team and individual members are prepared to take risks and are allowed to develop their abilities and skills.
7. The team is clear about its important goals and establishes performance targets that cause stretching but are achievable.
8. Team member roles are defined, and effective ways to solve problems and communicate are developed and supported by all team members.
9. Team members know how to examine team and individual errors and weaknesses without making personal attacks, which enables the group to learn from its experiences.
10. Team efforts are devoted to the achievement of results, and team performance is frequently evaluated to see where improvements can be made.
11. The team has the capacity to create new ideas through group interaction and the influence of outside people. Good ideas are followed up, and people are rewarded for innovative risk taking.
12. Each member of the team knows that he or she can influence the team agenda. There is a feeling of trust and equal influence among team members that facilitates open and honest communication.

4 Semantic web based team building approach

Currently available knowledge management tools suffer from the following limitations for designing knowledge management (KM) systems (Lai et al 2003).

- Information searching is mainly based on keyword searches that may retrieve irrelevant information due to term ambiguity, and omit important relevant information when it is stored under different keywords.
- Manual methods such as browsing and reading are the main methods to extract relevant information from textual or other representation.
- Maintaining large repositories of weakly structured information remains a tough and time-consuming task.

It is our belief that a semantic web technologies offer the answer to those problems. The semantic portal serves as an entry point to our information solution in project team building. Semantic web portals enable users to find relevant sources for the problem at hand and provide knowledge resources for resolving it. In our case, the semantic web portal supports one in building project teams effectively and efficiently. The architecture of the portal is presented in Figure 2.

This architecture provides a mean to manage both members' and projects' profiles through a web server by members themselves, by project leaders and by project administrators. The inference engine uses the profiles together with previous projects' data in order to propose members for any new project regarding the requirements. The system's inferring capabilities can be improved by managing the skills matching database which is used to reveal the hidden skills of members, not provided directly by them or the project leaders.

During the project cycle the portal should not be used too frequently. If we would push users to use it over and over again, we would disturb project activities and waste

team's energy. However, we want results from the portal – so we designed it to be used only on beginning and ending of a project. If project team uses information support for their project activities, portal should integrate their existing data, so no changes in work are necessary. When using some groupware to support project work, the data could be gathered automatically.

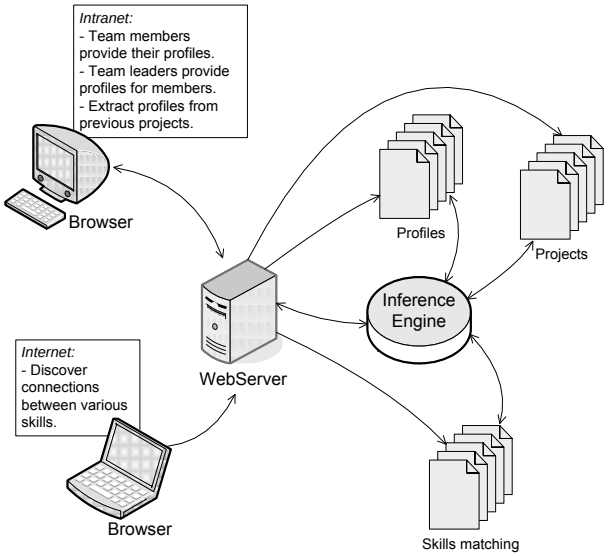

Fig 2. Architecture of semantic web portal for project team building.

4.1 Ontology-Based Personal Skill Management

An overview of the related work in ontology-based personal skill management is presented in [10]. Already [11; 12] promoted the idea of ontology-based modeling of personnel skills and job requirements – as part of comprehensive, workflow-oriented enterprise modeling. There, the following potential applications of ontology-based skill profiles are listed:

- skill gap analysis – at the enterprise level, as a part of strategic HR planning,
- project team building,
- recruitment planning – again a part of strategic HR planning,
- training analysis – at the level of individual personnel development.

Those approaches were mainly technology-driven and were – to our knowledge – never realized in a large-scale industrial environment. Nor have they been accepted by the HRM departments, translated into HRM people's terminology, embedded into more comprehensive models and procedures of HRM people, and integrated with existing software infrastructures.

After those first publications, there were a number of interesting technology-oriented researches which showed that in particular skill matching can benefit from interesting technological approaches, such as background knowledge exploitation. For instance, [13] employs declarative retrieval heuristics for traversing ontology structures. [14] derives competency statements through F-Logic reasoning and developed a soft matching approach for skill profile matching. Colucci [15] and others use description logic inferences to take into account background knowledge as well as incomplete knowledge when matching profiles.

4.2 Personal Skills and Project Team Ontology

There have been many approaches to describe personal skills within an ontology. They included both technical skills (like knowledge of programming languages, development methods, specific tools) and inter-personal skills (like communication skills, affableness, teamwork). Based on the team building theory and our own experiences from performed projects the main items that have to be included in such ontology should be:

- formal and informal education,
- experiences,
- practical skills,
- performed projects,
- preferred tasks,
- preferred role within a team,
- communication skills,
- teamwork spirit.

As far as we could find within the recent literature, there have been some approaches to describe project teams with ontology. However, they have not been used for project teams building. For this purpose the existing project team ontologies, which include basic information about team members, resources, purpose of the project, etc., should be extended with the following information:

- the priorities of the project,
- the importance of specific phases (regarding the current stage),
- complexity of the project (regarding the previous ones),
- the technical type of the project (prototype, research, production, etc),
- special knowledge requirements,
- preferred personnel,
- the type of the product/service being developed,
- the relation with other (especially previously successfully performed) projects.

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The resulting ontology is used in portal to help a reasoner to use metadata and construct the proper team for performing the project.

4.3 The use of non-procedural inferring

The project team building system prototype is implemented mainly in Java programming language using open source Jena semantic web development library [16]. It provides us with a straight-forward development system, very appropriate for semantic web portal application. The most important deficiency is the lack of an efficient inferring engine, which can be easily integrated within an existing application and would easily scale up to the real-world requirements. As such a technology is not available in this moment, for the inferring part of the prototype we chose CLIPS programming environment [17], a production rule-based programming system mainly used for developing expert systems. CLIPS is a productive development and delivery expert system tool which provides a complete environment for the construction of rule and/or object based expert systems. As it turned out, it enabled us with powerful inferring possibilities on semantic data. Additionally, it is very easy to execute CLIPS rules within Java applications using open source libraries such as JClips [18], what further enables one to integrate the inferring rules within an information system.

```
(defrule selectPersonBasedOnRequirements
  (IS_DONE_BY ?project ?projectTeam)
  (REQUIRES ?project ?knowledgeReq)
  (or
    (and
      (HAS ?person ?education)
      (SATISFIES ?education
?knowledgeReq)
    )
    (and
      (MASTERS ?person ?workArea)
      (COVERS ?workArea ?projectArea)
      (IMPLIES ?projectArea
?knowledgeReq)
    )
  )
=>
  (assert (HAS_MEMBER ?projectTeam
?person))
)
```

Fig 3. An example rule in a CLIPS programming language for inferring on the ontology.

To demonstrate the inferring capabilities of CLIPS, an example rule that selects persons for a project team based on project requirements is presented on Figure 3; it is based on the main ontology. In this example we can see that project team members can be selected based on the project requirements in two ways:

a) using the information about education of a person (which knowledge requirements are covered by some education), and
b) using the information about work areas mastered by a person (a work area covers several project areas and a project area implies several knowledge requirements).

In this way a team member can be automatically selected based on the requirements of a project. The knowledge base for the CLIPS program is induced directly from the ontology and/or the corresponding database (Figure 4).

The system itself does not consist of several different technologies, which is in our belief good. As mentioned before, fundamentals for the system lies in J2EE platform and XML enabled database (we used the Oracle 10gR2 database).

On Figure 4 there is an excerpt of data, automatically collected by the locator and transformed from RDF into CLIPS facts set to be used by the developed inferring engine. CLIPS facts represent the initial knowledge base for the CLIPS production rules. Usually, they need to be collected manually by a knowledge engineer. However, in our case we took the advantage of semantically annotated data which actually represent the actual knowledge, needed to construct the knowledge base.

```
(deffacts knowledgeBase

  (IS_A_PROJECT Kalimo
DevelopmentProject)
  (IS_DONE_BY Kalimo KalimoTeam)
  (REQUIRES Kalimo FishPhilosophy)

  (HAS Luka CompSciBSc)
  (HAS Vili CompSciPhD)

  (SATISFIES CompSciBSc programming)
  (SATISFIES CompSciBSc ISdesign)
  (SATISFIES CompSciBSc ISdevelopment)
  (SATISFIES CompSciMSc FishPhilosophy)

  (MASTERS Luka TeamWork)

  (COVERS TeamWork TeamMotivation)
  (IMPLIES TeamMotivation FishPhilosophy)
)
```

Fig 4. An excerpt of data, transformed from RDF into CLIPS facts.

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5 Conclusion

More and more people are realizing that there is a high potential in using SWT for back-office solutions even in closed enterprises. Presented paper proposes a new way of helping large project-oriented enterprises on building project teams.

For building project teams of highly skilled, personally compatible and interested individuals we combined existing knowledge management solutions with semantic web ideas and technologies. For this purpose we have proposed a portal system with the use of SWT such as URI, RDF and OWL in the background. Due to lack of inferring technologies we introduced the use of non-procedural rule-based system as an inferring engine. In this manner, the main ontology for project team members selection together with the rule-based system for reasoning is also presented.

To summarize, the paper proposes an approach to select project team members based on semantically annotated distributed profiles, connected with an intelligent service and ontology in the background. For now, it works for simpler cases. However, in order to make it appropriate for real world everyday use a number of features should be improved. In this manner we plan to improve the inferring capabilities of the system by including an advanced component for collecting personal skills information automatically from the existing data (performed projects, research reports). Similarly, a web mining component for collecting data to infer about similar work areas should improve the overall system. And not the least, the improvement of the presented ontology itself is anticipated as we will proceed with our work.

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