FRED: Ontology-based Agents for enabling E-Coaching Support in a large Company

Peter Smolle
Net Dynamics
Prinz-Eugen-Str. 68-70
A-1040 Vienna, Austria
peter.smolle@netdynamics-tech.com

York Sure
Institute AIFB, University of Karlsruhe
Postfach
D-76128 Karlsruhe, Germany
sure@aifb.uni-karlsruhe.de

ABSTRACT

We present FRED, an ontology-based agent and it's application in an E-Coaching scenario at a large company. We illustrate the architecture and underlying technology of our agent platform, e.g. ontologies, and present our methodology for ontology development as well as a brief cost-benefit analysis, thus showing also commercial aspects.

Keywords

Agent, E-Learning, Ontology

1. INTRODUCTION

Intelligent agents have become an important software paradigm over the last two decades. Although there exists plenty definitions of what agents are (cf. e.g. [2], [5]), one might focus on major roles for intelligent agents[1] including e.g. (i) the "Human Surrogate" that works autonomously without human direction in an actual or simulated environment and utilizes thereby the capability of intelligent agents to reason in a simple, rational manner and finally reports back results to humans, (ii) the "Intelligent Assistant" that supports humans in complex environments by performing tasks in cooperation with the human, and (iii), more general, the "Architectural Paradigm" for a software system that must integrate disparate subsystems.

There exist numerous agent based applications for various purposes and an active research community[2]. A large research project is the DARPA Agent Markup Language (DAML)[3] effort, it aims at developing a language and tools to facilitate the concept of the Semantic Web, in particular to provide a language for agents to facilitate communication through machine processable semantics (cf. [3]) provided by ontologies.

In this paper we present FRED, an ontology-based agent and it's application in an E-Coaching scenario at a large company. The outline of this paper is as follows. We start in Section 2 by illustrating our motivational scenario, i.e. E-Coaching support for a large company. We continue by explaining the underlying system architecture of the FRED platform in Section 3. Section 4 describes the ontology engineering environment and the applied methodology, gives an example for a FRED ontology and ends with a description for which purposes ontologies currently are explored in the FRED platform. We present briefly our cost-benefit analysis for the real world "Coaching FRED" application to show the commercial value of an agent-based system in Section 5. Before concluding we give a brief discussion of related work.

[1]cf. http://www.agent-software.com.au/
[2]cf. e.g. http://agents.umbc.edu/ and http://www.agentlink.org/
[3]cf. http://www.daml.org/

2. E-COACHING SUPPORT FOR A LARGE COMPANY

2.1 Background

A large company in the utility area with approximately 20.000 employees is in transition phase from state owned towards privatization. Most of the employees have long term civil servant behavior, which slows down transition speed. The general managers addresses a clear people development strategy: "Our employees are the most important assets of the company. Its our aim to know their skills and to develop them in such a way that they become a self driven motivated work force. In doing so they will contribute significantly to the success of our company in the future." The people education department was given the responsibility to execute this skill development strategy in the most employee driven way. They decided to use a new agent based platform which enabled the building of so called personal development agents which will act like coaches – FRED.

2.2 Objectives of the project

The key objectives were set to reflect the mentioned strategy: (i) Support the skill-transition strategy, (ii) bring active information towards employee, (iii) improve service level for large employee groups, (iv) support the education staff in reducing routine-tasks and (v) optimize the education process.

2.3 The coaching process

The "Coaching FRED" is an agent based application that is accessible through the intranet of the company. It supports employees to organize and coordinate their life long learning process. The Coaching FRED aims at increasing information dissemination of existing courses through delivering *the right course offer to the right employee at the right moment.* Therefore each employee might access his personal FRED through the intranet. Using the Coaching FRED starts with profiling the personal assistant by providing main topics of an employees tasks and interests. The profiling tasks is mandatory and the profiling of interests

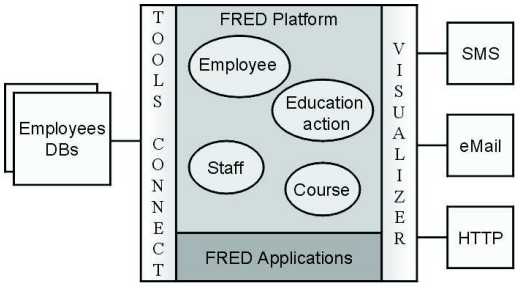

Figure 1: FRED solution concept

is mandatory. Immediately after this easy-to-go first step the Coaching FRED starts looking for appropriate courses. Naturally all information given to the Coaching FRED are stored safely and secretly through a security mechanism. The coaching process consists of eight steps resulting in a cyclic process:

(1) Initialize Coaching FRED. (2) The employee creates a personal task profile. (3) Coaching FRED offers the employee topics for courses. (4) Optionally, the employee creates a personal interest profile. (5) Coaching FRED offers additional topics for courses. (6) Optionally, the employee gives feedback to the Coaching FRED in form of relevant topics for courses that do not appear in Coaching FREDs offering. (7) Coaching FRED informs the employee about for him relevant courses from the course offerings of the company. (8) The employee is free to change her profile any time and to start the process again with (1).

Currently the main task of Coaching FRED is to create personalized course offerings according to an employees profile. For the future this might be extended easily by additional tasks like getting official permissions for attending courses or registering for courses.

2.4 The solution concept

All different FRED types were developed using the capabilities of the platform. In our scenario we have types for users (e.g. the staff members), courses and education tasks. Each FRED type has it's own ontology for communication (cf. Section 4). FREDs are populated with core data about the users and then given to every employee and to the related education staff members. Courses and education actions are represented by FREDs.

All FREDs are hosted on the FRED platform implemented at the computing center of the company. The access to FRED is given via the intranet browser environment. Once a FRED gets initialized, users have to register and the coaching process described above starts to work.

Figure 1 shows the solution developed for this scenario which contains in a nutshell the following items: (i) Each FRED-Type (e.g. `Staff` or `Course`) represents a role of an user or a process, (ii) a `FRED Platform` hosts the different FRED types with their `Application Plans`, (iii) `Visualizer` is the standard interface towards users of the system (typically via a browser by using http) and (iv) `Tools Connect` manages access to existing databases (e.g. pre-existing employee and course databases). The technical details of each component will be described in the following section.

3. FRED ARCHITECTURE

3.1 Preface

Net Dynamics Internet Technologies developed an ontology based software platform for delegation -FRED- populated by intelligent software agents which act on their owners behalf to address the following challenges (ordered from more general to more specific challenges): (i) Web content is by far faster growing than the amount of users, (ii) large parts of the content will not be usable because of the lack of security and easy to understand semantic based access, (iii) content suppliers want better methods to enhance their success in E-Commerce, (iv) reduce costs by using the power of agents technology to process tasks and workflows, (v) create a large and robust, scalable and secure platform which is able to execute in production environments and will be of use for a wide range of application areas which could benefit from the delegation principle and (vi) enable access to agents through mobile devices and browsers and make use of coming up technologies like UMTS or Blue Tooth. The FRED architecture addresses those challenges by using standards to create new semantic and ontology based methods which will then enable the benefits of delegation. The FRED architecture also enables a very productive way for building small reusable FRED applications, which will reduce development and integration effort for process oriented tasks significantly. This is done by using the development power of ontology based smart objects to build intelligent agents which are able to execute their tasks autonomously and can communicate with each other in a unambiguous way of mutual understanding using the FIPA ACL[4] agent communication language.

3.2 Key technologies of the FRED platform

To establish the `FRED Platform` with its capabilities, we have developed new concepts and methods:

Smart Objects. All information within FRED is stored and exchanged as `Smart Objects`. `Smart Objects` are based on ontologies, they are dynamic, reusable and can represent their content in various forms. They have built-in privacy mechanisms to make sure that data will only be passed from one FRED to another according to the privacy profile of a FRED's owner. Main features of the Smart Objects are the following: (i) Implement **"Real world view"** instead of "data model view", which allows for sharing and reuse of objects in different domains, (ii) cover **instances** of objects and constraints, (iii) have build in **security features**, which are implemented as Smart Objects Security Policies, for exchanging information between FREDs, (iv) **Meta Data** (e.g. "Importance") for reasoning (v) support of **multiple languages**, (vi) strategy based **persistence** supports windowing, delayed serialization, high performance persistence, etc., (vii) **"High Level Introspection"** supports AI-techniques (inference engine, reasoning systems etc.) and (viii) **Java** based components, suited for **graphical manipulation**.

Meeting Rooms. Interacting with each other, two or more FREDs perform their tasks in meetings, held in `FRED Meetings Rooms`. These meetings rooms ensure controlled and secure execution of FREDs tasks, they are scalable and optimized to perform as many meetings as possible to give FREDs the chance to meet as many FREDs as possible to achieve the best results.

[4]cf. http://www.fipa.org/repository/aclspecs.html

FRED Control. The potentially high number of FREDs in a FRED Location needs an efficient control mechanism. `FRED Control` provides robustness and high availability to the `FRED Platform`.

In addition to these technologies a FRED Location uses standard state of the art technologies.

Java. The development framework of FRED and application specific parts have been developed in JAVA. Critical components have been designed together with Sun Microsystems[5].

Agent-Technology. The proven concepts of agent technology[6] are the base technology for communication and interaction of FREDs.

Ontology. The Section 4 describes the ontology engineering environment the underlying OntoEdit and the applied methodology for developing ontologies for FRED.

4. ONTOLOGY DEVELOPMENT

Ontologies [1] aim at capturing domain knowledge in a generic way and provide a commonly agreed understanding of a domain, which may be reused, shared, and operationalized across applications and groups. Thus, ontologies are well-suited for enabling communication between agents in general, including software agents as well as human agents [4]. However, because of their size, their complexity and their formal underpinnings ontologies are still far from being a commodity. Developing ontologies is a non-trivial task. We relied on a well-known ontology engineering environment accompanied by a methodology for ontology development.

Ontology engineering environment. OntoEdit[7] [6] supports the collaborative development of ontologies by using graphical means. OntoEdit is built on top of a powerful internal ontology model. This paradigm supports representation-language neutral modeling as much as possible for concepts, relations, attributes, instances and axioms. Several graphical views onto the structures contained in the ontology support modeling the different phases of the ontology engineering cycle.

How do our ontologies look like? OntoEdit enables the user to edit (i) an *is-a* hierarchy of concepts or classes (e.g. *Employee is-a Person*), (ii) relations between concepts (e.g. *Employee* WORKS AT *Organization*), (iii) attributes attached to concepts (e.g. *Person* HAS NAME *STRING*), (iv) instances of concepts (e.g. Mary INSTANCE OF *Person*) and (v) axioms build on top. The concepts may be abstract or concrete, which indicates whether or not it is allowed to make direct instances of the concept. Each concept is uniquely identified but may have several names, which essentially is a way to define synonyms for that concept. Also, multiple languages are supported by that feature. The same holds for relations and attributes. The tool allows similar to the well-known "copy-and-paste" functionality the reorganizing of concepts within the hierarchy. An example ontology is shown in Subsection 4.1.

Methodology for ontology development Concerning the methodology[8], OntoEdit focuses on three main steps

[5]cf. http://java.sun.com/

[6]cf. e.g. http://www.fipa.org/

[7]OntoEdit is available from Ontoprise GmbH, cf. http://www.ontoprise.com.

[8]The methodology was initially developed in the EU IST-10132 project On-To-Knowledge, a detailed description of the methodology can be found in [7])

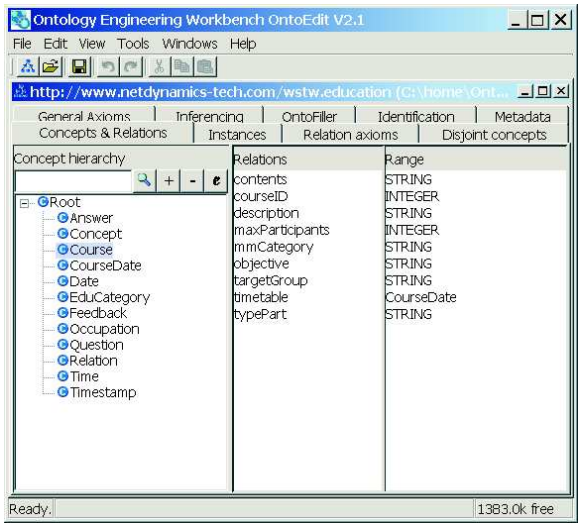

Figure 2: Ontology development for FRED with OntoEdit

for ontology development, viz. (i) ontology kickoff (basically a requirements specification), (ii) refinement, and (iii) evaluation.

Firstly, all requirements of the envisaged ontology are collected. Typically for ontology engineering, ontology engineers and domain experts are joined in a team that works together on a description of domain and goal of the ontology, design guidelines, available knowledge sources (e.g. reusable ontologies and thesauri etc.), potential users and use cases and applications supported by the ontology. The output of this phase is a semi-formal description of the ontology. Secondly, during the refinement phase the team extends the semi-formal description in several iterations and formalizes it in an appropriate representation language. The output of this phase is a mature ontology (aka. "target ontology"). Thirdly, the target ontology needs to be evaluated according to the requirement specifications. Typically this phase serves as a proof for the usefulness of developed ontologies and may involve the engineering team as well as end users of the targeted application. The output of this phase is an evaluated ontology, ready for the roll-out into a productive environment.

4.1 Ontologies for FRED

Ontologies are explored in the FRED platform for mainly two aspects: (i) enabling communication between different FREDs and (ii) defining security guidelines for a FRED world. Figure 2 shows an example FRED ontology developed with OntoEdit. On the left side the concept hierarchy is shown. On the right side attributes and relations (with their ranges) are presented for a selected concept (here: *Course*). This particular ontology is the basis for communication with "Course FREDs". It defines all relevant concepts and relations known by these FREDs. In general, each FRED type has it's own ontology for communication. Shared concepts and relations enable different kinds of FRED-Types to communicate with each other.

The security guidelines define which kind of information is allowed for exchange between FREDs according to the

profile defined by users. One example are different levels of authorization through users. A FRED might be authorized to look for offerings and return appropriate ones to the user or to look for offerings and book an appropriate one. Each security profile is instanciated according to a "security ontology" that contains the security guidelines. Different platforms might have different security guidelines.

For the future there might be FREDs that travel across borders of FRED Platforms. Ontologies provide a shared understanding of domains of interest and are potentially valuable to support the mapping tasks in this even more complex scenario.

5. COST-BENEFIT ANALYSIS

Attracting industrial customers for such an application requires a detailed comparison of costs and benefits, typically having a strong positive benefit as a requirement for a purchase order. A cost-benefit analysis is an approach to show the methodology which has been applied at this customer. The assumptions and numbers are therefore associated with this special case only and cannot be transferred to other situations without having a basic understanding of the special circumstances. A tight cooperation with our customer led to the following results (a detailed description is not within the scope of this paper). The **benefits** are based on current known efforts and to achieve improvements which will lead to manpower savings to be expected because of delegating tasks to FREDs. The number of education activities or courses are in the magnitude of 1.000 in this company. In particular, benefits are achieved in the following areas: (i) improving the productivity of the education staff, (ii) reducing the time for finding optimized education, (iii) targeted information about education and (iv) optimizing course attendance. The **cost** part represents a cumulated number and no detailed calculations, to make the order of magnitude of the real savings visible. We took two sets of employees numbers as a basis: an initial set of 4.000 employees organized in 200 units with 16 members of the educational staff for the first phase of the implementation and an expanded set of 20.000 employees organized in 1.000 units with 50 members of the educational staff. The **break even** of the project calculated with a base of 4.000 employees is during the **second year**. With a base of 20.000 employees the break even is already during the first year. The **total benefit** after 3 years for the entire company will be approximately **4.6 Mio EUR**.

6. RELATED WORK

E-Learning by itself addresses more the use of technology for teaching where E-Coaching has the power to represent a "teacher" in the process. Though there is plenty of work available, which describes software agent research and applications, the area of using intelligent agents for coaching an education process is just about to evolve. The interests increase due to the achievable productivity for very large communities. Still, this research area is rather new. A planned workshop at Carnegie Mellon University[9] will be of help to get an overview on current research in the area of using intelligent agents for coaching.

[9] "Coach Agent-, and Multi-Agent Modeling Workshop", planned for June 2002 at Carnegie Mellon University, USA.

7. CONCLUSION

We presented FRED, an ontology based agent and it's application in an E-Coaching scenario of a large company. The key objectives of our implemented system are: (i) Support the skill-transition strategy, (ii) bring active information towards employees, (iii) improve the service level for large employee groups, (iv) support the education staff in reducing routine-tasks, and (v) optimize the education process. Our system explores ontologies mainly for two purposes: (i) enabling communication between different FREDs and (ii) defining security guidelines for a FRED world. Ontologies for FREDs are engineered according to a well-known methodology with the help of the ontology engineering environment OntoEdit.

Our real world application is highly scalable and is targeted at serving potentially 20.000 users. A cost-benefit analysis for our project resulted in a break even during the first year and approximately 4.6 Mio EUR total benefits after 3 years for the entire company.

For the future the company will expand it's intranet but also it's internet websites with attractive delegation offerings. Internally, i.e. through the delegation tasks provided within the intranet, the goal is to optimize the life long learning process of employees. Externally, i.e. through the delegation tasks provided on the internet, the goal is to improve the customer relationship management by personalized offerings for each customer and by creating an innovative service image in general.

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