An Approach for the Development of Agent-Oriented Distributed eLearning Center

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Abstract: *The paper presents the approach for the development of the agent-oriented version of DeLC (Distributed eLearning Center). A re-engineering proces supported the transition from the object-component to the agent-oriented version is described. The communication between the agents and eServices will be based on the DAML-S (OWL-S) protocol.*
Key words: *e-learning, intelligent agents, e-services, DeLC, DAML-S (OWL-S)*

INTRODUCTION

E-learning aims at replacing old-fashioned time, place, and content predetermined learning with a just-in-time, at-work-place, customized, and on-demand process of learning [1,2]. It builds on several pillars, namely management, culture and information technology (IT) [3]. An IT platform, which enables efficient implementation of learning infrastructure, is also needed. Current web-based solutions don't meet the above-mentioned requirements. Some pitfalls are information overload, lack of accurate information, content that is not machine-understandable. The Distributed e-Learning Center (DeLC) [4,5,6,7] aims to provide a distance e-Learning and e-Teaching facility available at any place and at any time to individuals and groups of students/lecturers both in synchronous mode (on-line) and asynchronous mode (off-line). The DeLC project focuses at the development of a common concept for the creation of e-Learning information systems and a theoretical and conceptual base of service-oriented e-Learning infrastructure for the integration of electronic services (e-Services). A significant part of this project is dedicated also to the development of a suitable technological environment and architecture that is independent from the embedded e-Services. Authors' current plan is to enhance the DeLC in order to make it suitable for better organization and functioning of the entire e-Learning/e-Teaching process within a University campus. An initial outline proposal for this was given in [6,7]. Thus the second agent-oriented version of the center focuses more at providing m-Learning/m-Teaching facilities by allowing an access virtually from any user device (both stationary or mobile). The DeLC service architecture is developed as a consumer-oriented one in line with the trend in mobile communication services based on the Consumer-oriented Business Model (CBM) [8,9], which will be a much more pro-active business driver for the evolution of next fourth generation (4G) wireless world vision [10]. This model provides more choices for users as regards the access wireless networks and price-performance issues, and enables an always best connected and served (ABC&S) wireless networking. When applied to e-Learning/e-Teaching, the CBM will provide flexible opportunities for reach m-Learning/m-Teaching environment.

OUR APPROACH

The creation of real-functioning eLearning systems used for distance/remote education is a complex problem for the solution of which besides the variety of technological aspects also the following factors have to be taken into account:

- Education must follow certain pedagogical approach and model;
- Education must be personalized, i.e. tailored to the individual needs of each student;
- National traditions and particularities may influent significantly the educational process particularly in certain courses/modules like national history, geography, folklore etc.

Another difficulty is related to the different nature of influential factors, which predetermines their possible level of formalization and degree of technological and software-technical support. Due to this reason we use an approach, which allows creating a whole e-Learning environment for remote education, with the following scheme:

- Decomposition of the DeLC functionality, where:
  - The functionality is represented by a set of electronic services;
  - The center consists of different structural levels, i.e. common infrastructure, e-Learning nodes, e-Services;
  - Possibilities exist for creation of virtual structures such as e-Learning clusters;
  - Different models presenting DeLC mission are used, e.g. infrastructural model, e-Services model, pedagogical model, customer model etc.
- Integration of DeLC components by means of suitable infrastructural framework, which allows accomplishment of complex educational transactions as responses to customer/user requests. To achieve this the developing infrastructure must be independent of the functionality of the e-Services integrated into it in order to allow easy addition and removal of e-Services.
- DeLC interoperability provision –aimed at support of two types of interoperability:
  - Internal interoperability, which to guarantee correct and synchronised co-functioning of the DeLC components – this is achieved by means of a specification of internal interfaces and standard protocols for interoperability such as DAML-S (OWL-S);
  - External interoperability[1], which to allow exchange and identical interpretation of e-Content – through the use of standards (SCORM, DAML-S (OWL-S),) and development tools , ensuring good portability and effective support of heterogeneous system configurations (e.g. Java, J2EE, etc.)
- The development of DeLC goes through different versions each with different modifications. Two basic versions are envisaged by today focusing on different aspects of the system. In addition we are looking for possibilities for an effective technological transition from the first version to the second one by following the re-engineering ideology.

TWO DELC VERSIONS

The first DeLC version (object-component and client-server oriented) placed special emphasis upon the solution of infrastructural and architectural problems. This version aimed at the creation of a basic DeLC infrastructure and realization of the main e-Services provided by the distributed center. The support of the eLearning standard SCORM [11,12,13] was of first priority. Another task was the development of initial pedagogical and consumer models and their integration in the infrastructure. Very important here was to find a suitable mappings of these models into the SCORM specification. In an addition the first version of eLearning authoring tool is developed based on an adapted version of the Reload editor [14].

The second DeLC version (an agent-oriented one) aims at the reinforcement of the infrastructure in order to transform it in an effective technological framework for the realization of sophisticated e-Learning scenarios. For this the infrastructure will be extended with a system for the control and support of mobile e-Services (Fig.1.). Special emphasis is laid upon ensuring semantic compatibility (through the use of ontologies) and needed flexibility (through the use of intelligent agents). In this version we plan to develop an authoring intuitive and user-friendly tool for the creation of e-Learning content.

[1] As regards the compatibility and interaction with external systems conformant to the SCORM standard for the exchange of eContent and communication through the DAML-S (OWL-S) specification.

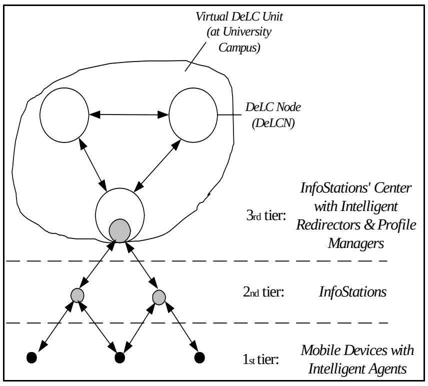

Fig.1.

TRANSITION TO AN AGENT-ORIENTED DELC

For the supporting of real e-Learning and e-Training a significant enhancement of the flexibility of the existing DeLC architecture is required along with introduction of possibilities for intelligent interaction and interpretation of the data and contents exchanged between the different parties involved in the process of execution of e-Services. To achieve this goal, we are developing the second version of the DeLC system architecture on the basis of the first version (in which services are implemented as Web-services) by using a re-engineering process, described below, which will lead to more open environment, supporting context-based discovery and access to user's personal information. The flexibility and intelligence of the system will be enhanced through an introduction of intelligent agents, which will communicate with the functional modules, implemented as Web-services. For the interaction between the agents and the Web-services we use the DAML-S (OWL-S) specification [15,16,17] because it offers a good opportunity for the realization of software architecture with sufficient flexibility and also provides a suitable environment for the support of a variety of mobile services.

Our re-engineering process includes the following steps:

- Re-engineering of the DeLC Node server - expanding the set of services (deployed on DeLC nodes) with additional services needed to provide interfaces respectively to: the existing server parts of services, e.g. central academic time schedule, intelligent diaries etc; the InfoStations; the users' mobile devices.
- Re-engineering of the DeLC Node client – intelligent agents will be integrated in the client part of the first DeLC version (developed as a portal), which will act as personal assistants for consumers/users.
- Development (new process) of the mobile services architecture:
  - InfoStation software concerning intermediate processing of information needed for identification of users and services. The software could be agent- or service-oriented according to the model chosen in the server part;
  - Creation of the client part of the mobile services, i.e. development of personal assistants for consumers/users implemented as intelligent agents;
- Re-engineering of the DeLC communication (ensuring internal and external interoperability) – communication between the different part of the distributed center will based on the DAML-S (OWL-S) protocol, which offers very good opportunities for effective interoperation between the client part (personal assistants) and the server part (Web-services).

According to the DAML-S (OWL-S) specification, each e-Service could be described in three abstract levels:

- *E-Service profile* – showing what the e-Service performs (including information about the e-Service's inputs, outputs, preconditions, and other features, that can be used for advertising, discovery, and matchmaking of the appropriate e-Service);
- *E-Service model* – indicating how the e-Service works; this is an expansion and more detailed specification of the service profile;
- *Grounding* – suggesting how the e-Service can be used and what communication protocol can be used for its direct activation, e.g. SOAP [18, 19], Java remote call, KQML [20,21], CORBA IDL [22,23].

DEVELOPMENT OF DELC AGENTS

Two approaches will be investigated for the development of the transition to the agent-oriented DeLC version:

- 'Thin agent' approach (Fig.2.) - server parts of e-Services (functionality) interpreted as stand-alone autonomous agents. In this case they can autonomously process the user requests coming through the personal assistants. Before finalizing the request for a particular e-Service, a personal assistant must first negotiate arrangements with the appropriate server for all aspects of the rest of service execution. The personal assistants will mainly process the users' profiles, whereas the server agents will process the e-Services' profiles and their models (if needed), which are DAML-S (OWL-S) records;

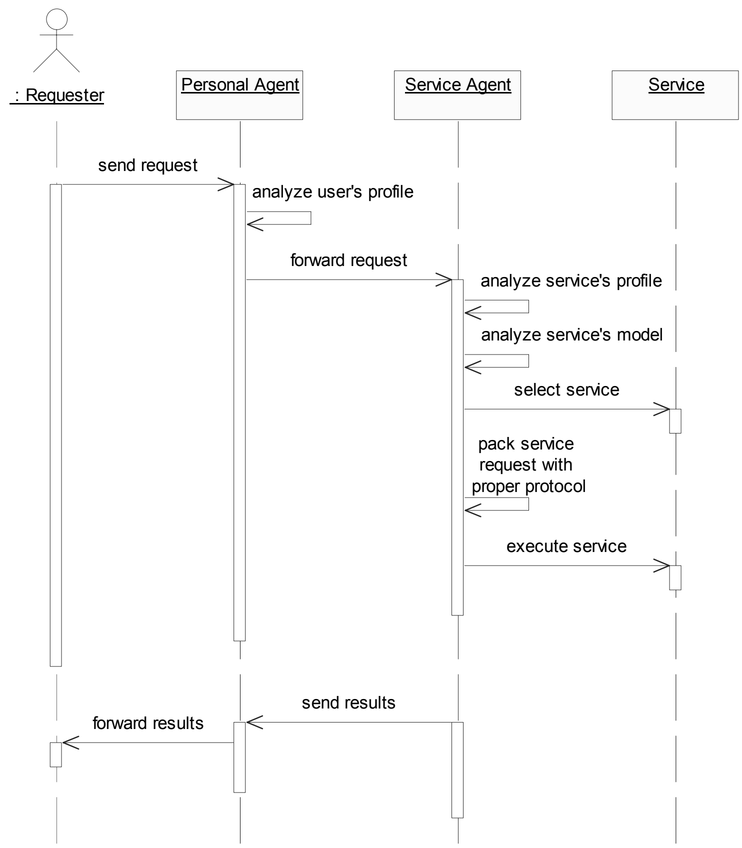

Fig.2. Thin Agent

- 'Thick agent' approach (Fig.3.) - server parts of e-Services considered as a dynamic extension/enhancement of the functionality of the personal assistants. The personal assistantscan activate the execution of the server functionality ('adopt' the functionality) by means of the server part of respective e-Service. These will make a decision about what e-Service has to be activated. In this case the personal assistants have to process not only the users' profiles but also the e-Services' profiles and e-Services' models (DAML-S records).The advantage of this approach is that the personal assistantsare in possession of finer granularity of control. For instance if there are different ways for processing of a particular request, a personal assistant (i.e. an intelligent agent) can pick up the one which better suits the user needs (specified in the user profile).

We intend to treat the DAML-S (OWL-S) specification in a distributed fashion, where the exact scheme of distribution will depend on the chosen approach. In both cases however the third abstract level of the e-Services (Grounding) will be supported and processed in the DeLC nodes, because the run-time module of the nodes is aware of the physical location of the eServices, and activates and controls their actual processing.

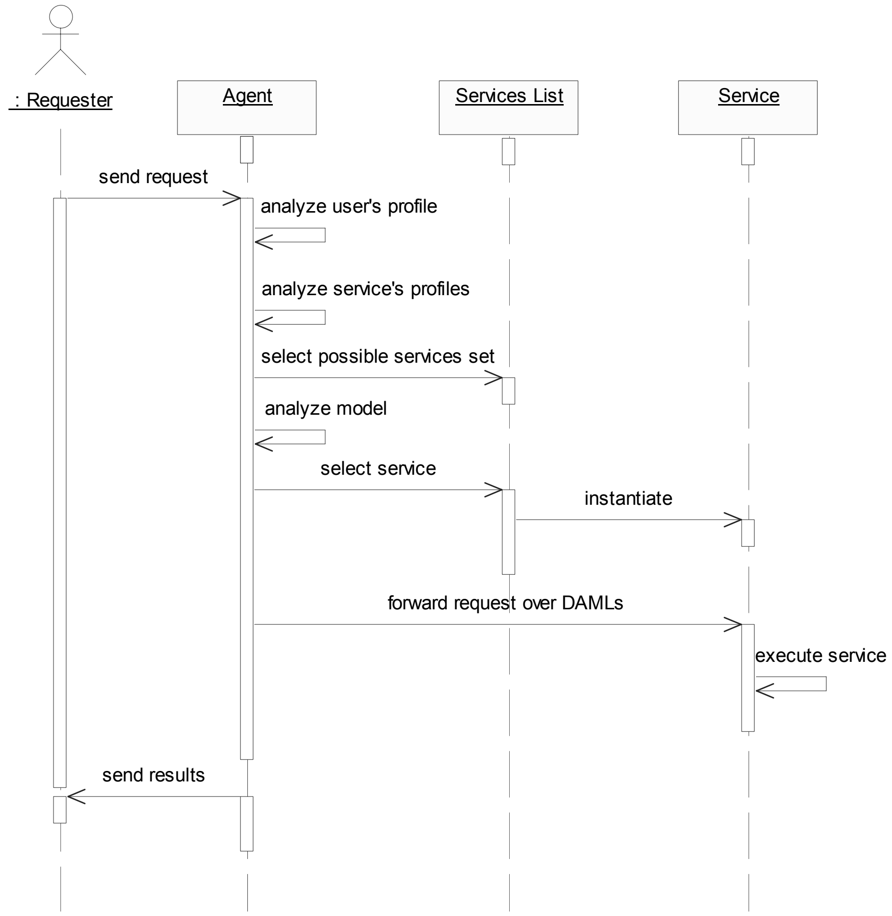

Fig 3. Thick agent

IMPLEMENTATION REMARKS

The system architecture will be implemented by means of the JetSpeed framework, which uses XML based meta-structures (e.g. users' profiles and e-Services' profiles). This is similar to the DAML-S (OWL-S) specification. A kernel consisting of tools and appropriate interpreters will be developed as a first step. This will satisfy the requirements of the JetSpeed and DAML-S (OWL-S) specifications in respect of shared structures. This will then be followed with implementation of the steps proposed above for finalizing the system architecture.

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