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A Service-oriented Information System for Collaborative Research and Doctoral Education

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Abstract

Currently supportive information systems for higher education and research are responding to specific information needs within institutes, departments and administration. These separated systems are mainly based on information and service portals or e-learning environments and have typically independently grown over the years. Information systems in the field of higher education mostly support undergraduate students as well as graduate students during their studies.

Apart from this there is no real support for special needs doctoral students demand for during their research work. An information system in the field of doctoral research should allow for collaborative work and should support different kinds of processes doctoral students participate in. Our approach is to develop an integrated information system for collaborative research and doctoral education based on a Service Oriented Architecture (SOA).

1. Introduction

Several initiatives on national and European level have been started in order to support and improve education at schools and universities as well as vocational education. On European level, the intention to build-up a European higher education area is based on the so-called *Bologna-Declaration* [10]. The implementation of this declaration is called *Bologna process*. The purpose of this process is to create a European Higher Education Area by harmonizing academic degree standards and quality assurance standards throughout Europe. This includes also the doctoral education.

Most doctoral students do not have the possibility to spend their whole working time for their doctoral studies. In fact, many doctoral students have to use a part of their working time for other tasks, which are often not directly related to their own research (e.g., teaching or research assistance). This extends the duration of the doctoral studies without improving the chances on the labor market [2].

Although comprehensive initiatives and programs exist at organizational level, there is still a substantial lack of IT-based systems for supporting the process of collaborative research and doctoral education.

2. State of the Art

Within the field of research and higher education the system landscape is very widespread, especially due to the organizational structure of universities and other research or educational institutions. Having a look at a university and its single departments in general, we can find a lot of different information systems that have been developed independently over the years for the same or specific purposes. Due to this there typically neither does exist any compatibility nor do exist any capable interfaces between such systems.

In the area of IT support for education there are general approaches of service-oriented environments like XLX [8], LearnServe [8], and ISETTA [7], but they are mainly targeted at learning support for education of undergraduate/graduate students. There is a lack in specific environments for the use of IT to support doctoral students.

Today many universities[1] make huge efforts in integrating their information systems within one single university portal and offering access to existing services as well as to modern high-level services for the support of undergraduate students during their studies. One outstanding approach of an overall integration is done by the University of Karlsruhe [9] that is realized

1 In Germany, e.g., the Technical University of Munich, the RWTH Aachen, the University of Hamburg, and the FU Berlin.

by a Service Oriented Architecture. Basic functionalities of diverse legacy systems on different platforms have been encapsulated by Web Services which are then orchestrated to high-level services.

Our challenge is to do a further step towards the support of graduate students by offering special services they need during their doctoral studies and research activities by considering all aspects of education and research as processes. By this, doctoral students and researchers may be able to use mandatory process models provided by the university (e.g., models for doctoral qualification regulations or administrative processes), to model individual processes (e.g., personal task plans) and to assign other persons for the purpose of collaborative work (e.g., for co-authorship or project membership).

3. Requirements

The tasks within doctoral studies comprise working at the doctoral thesis, preparing publications and participating in conferences, teaching and supervising, cooperating in other projects, other scientific or organizational tasks (e.g., care for libraries and equipment, work in scientific boards or conference committees, teaching assistance) etc. In order to increase productivity and to allow for working faster and more concentrated on the doctoral thesis in spite of such workload, a specific IT-based support for doctoral students is necessary. We have identified a set of basic functionalities to be integrated in an information system for collaborative research and doctoral education to support graduate students. Looking at doctoral studies from a process oriented point of view the relevant processes are generally defined by different kinds of regulations, rules or guidelines issued by the university. Several mandatory tasks and restrictions must be fulfilled by a doctoral student depending on the roles that are assigned to him (e.g., as a student, a researcher or an employee).

On the highest level the process of doctoral studies is defined by a doctoral qualification regulation. Such regulations generally specify the amount and the kind of work that has to be done by a doctoral student in a defined period of time, e.g., teaching, research activities, publication of results, project participation or final doctoral examination. Furthermore, each task is associated to various administrative tasks, such as a travel application or an application for leave, which may also be defined by several rules and restrictions.

For the support of collaborative work an information system has to represent a shared workspace for information and data exchange as well as for cooperation and communication between doctoral students and other researchers. Some general scenarios are planning, management and realization of projects, collaborative research, co-authoring, team reviewing, document sharing, etc. Concerning this a doctoral student in charge of a sub-process (e.g., a main author of a co-authorship or a project leader) has to be able to assign other actors to certain tasks (e.g., the assignment of colleagues to an internal review process). To each actor participating in a process various services are offered concerning monitoring, controlling and reporting the whole process or single tasks, like an alerting function to meet a deadline.

In fact, the realization of all these requirements supports doctoral students, by

- Shortening of the duration of doctoral studies.
- Improvement of the communication amongst doctoral students and their communication with other experts.
- Support for collaborative problem solving.
- Collaborative quality assurance (e.g., integration of external assessors into the supervision of doctoral students).
- Integration of digital libraries, context-dependent services, recommender systems for publications.

The system presented in this paper concentrates on process support. By the use of a hierarchical process model, as described in Section 5 and the encapsulation of certain processes by tasks we are able to offer a set of value-added and reusable services which we intend to realize as Web Services.

4. System Architecture

The integration of existing information systems is an important aspect of information management. The most popular concepts are derived from the area of Enterprise Application Integration (EAI) [4] and they are realized in common EAI frameworks. One of these concepts is the Service Oriented Architecture (SOA). The idea of SOA is to make functionalities of different systems available as services. These services may then be integrated in an EAI framework. A service itself, i.e., the service implementation and its interfaces, is described by the service contract. The service contract particularly assures that the interfaces for invocation are well-defined and consistent in cases of a change of the service implementation or the underlying system.

In general, SOA is just a concept that does not rely on certain technologies, platforms or standards. A result of this fact is that many proprietary SOA implementations are proposed which do not satisfy special

requirements for collaborative or inter-organizational scenarios [6]. These requirements basically refer to services that should be accessible across organizational, technological and infrastructural boundaries via the internet.

Web Services are platform independent, accessible via internet and founded on commonly used and well-established protocols and standards [1]. For this reason the use of Web Services has become an important issue in the area of system integration and in the implementation of the SOA concept.

Our approach complies with the concept of a SOA which is based on Web Services. It consists of four layers and is described from the bottom up as follows: The infrastructure layer covers hardware and network components as well as databases and host systems. The legacy systems and applications to be integrated as well as systems with own Web Service interfaces belong to the application layer. The integration layer contains all Web Services that enable access to systems of the application layer. Within the process layer Web Services are orchestrated as high-level services by the use of XML Nets (see Section 5). As a result doctoral studies are considered as one single process on the highest level consisting of several sub-processes and tasks. The presentation and the user interaction is not an essential part of the architecture and can be independently realized by a web application or a portal system by either directly invoking Web Services of the integration layer or by accessing a Web Service as part of an orchestration of the process layer.

5. Process Modeling with XML Nets

Petri Nets [5] are a formal description language with a mathematical foundation. XML Nets [3] represent a variant of high-level Petri Nets. In XML Nets, places are typed by XML Schema diagrams, each of which represents an XML Schema. Places can thus be interpreted as containers for XML documents representing relevant process objects. The flow of XML documents is defined by the occurrences of transitions, i.e., the activities being executed. A transition may be inscribed by a logical expression of the variables that appear in the labels of the adjacent edges. The expression evaluates either to true or false for an instantiation of the variables. So-called *filter schemas* label the adjacent edges and thereby describe the process objects that are relevant for the activity and the way these objects are manipulated (created, changed or deleted). An example of an XML Net is given in [3].

6. Use Case Scenario

A typical process during doctoral studies is the participation in a conference. On the one hand the participation can be active by submitting a paper and giving a presentation. On the other hand it can be passive by just joining the conference. Both kinds of participation offer the possibility for exchanging scientific ideas with other researchers. We have chosen the process "conference participation" as a use case scenario in order to illustrate our approach. Figure 1 depicts this use case scenario in a simplified way as a Petri Net. In this scenario a doctoral student decides for an active participation in a conference. Through this, a participation process is initiated, which can be seen as a process composed of several sub-processes. For example, a publication has to be prepared and submitted, a travel application has to be submitted, the organizational aspects of the participation (e.g., registration and payment) have to be organized, a presentation has to be

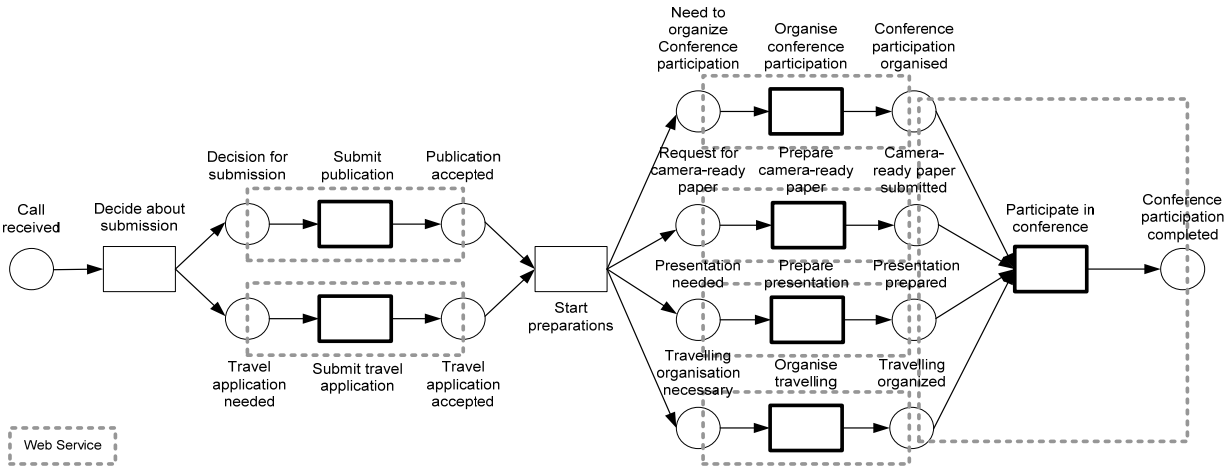

Figure 1. Conference participation process.

prepared, the travel has to be organized and, last but not least, the conference has to be attended. For reasons of clarity, the sub-processes in Figure 1 are modeled as aggregated transitions (drawn with thick lines). In the context of Petri Nets, *aggregation* means the replacement of a place- or transition-bordered sub-net by one single place or transition, respectively.

Of course, our process models show an "ideal process flow" (as the place "Paper accepted" shows). Normally, exception handling mechanisms have to be integrated into the process model in order to handle cases like loss of a co-author or rejection of a submitted publication or travel application. Furthermore, our use case describes active conference participation. A passive participation may consist of the sub-processes *"Submit travel application"*, *"Organize travel participation"*, *"Organize traveling"*, and *"Participate in conference"*. The technical implementation of our approach can be realized, if we encapsulate each aggregated transition as a Web Service (shown as a grey dashed box in Figure 1), whereby the places of the pre- and post-set of the transition act as interfaces for the communication between different services. Due to the fact that Web Services are based on XML technology, XML Nets are well-suited for modeling processes in general and the orchestration of Web Services in our approach.

With this approach, we increase the reusability of the different sub-processes. Furthermore, our approach allows for an efficient modeling and execution of specific processes occurring during doctoral studies.

Concerning collaborative research, the services described in this use case scenario can be used by several doctoral students, e.g., when they prepare a joint publication. The adjustment efforts amongst the participating doctoral students can be regarded as the communication between the individual publication processes (encapsulated in Web Services). Further possible use cases may be, e.g., the organization of doctoral seminars or the joint work on a scientific topic.

7. Conclusion and Outlook

In this paper we have shown that although several initiatives have been started for supporting education at schools and universities, especially across European countries, there is still a substantial lack of IT-based systems in this application field. Our approach is offering special services which are needed during doctoral studies and research activities by considering all relevant aspects of education and research as being parts of processes. For collaborative research and doctoral education we have presented a new approach based on a Service Oriented Architecture which allows for a process oriented integration of information systems within a heterogeneous system infrastructure.

As the globalization of education is increasing – on the one hand by means of the world-wide network of information and on the other hand by means of the international competition of universities – the support of educators and students must be intensified. In this context, our approach contributes to the requirements and aims addressed in Section 3. Our resulting system will be a basis for most fields of research and higher education to build a comprehensive information and communication infrastructure with high information, planning, and management potential.

8. References

[1] G. Alonso. *Web services: Concepts, Architectures and Applications*. Springer, 2004.

[2] B. Kehm. "Developing Doctoral Degrees and Qualifications in Europe. Good Practice and Issues of Concern". In *Beiträge zur Hochschulforschung*, 27(1):10–33, 2005.

[3] K. Lenz and A. Oberweis. "Interorganizational Business Process Management with XML Nets". In H. Ehrig et al. (eds.): Petri Net Technology for Communication Based Systems. LNCS Vol. 2472, pp. 243-266, Springer, 2003.

[4] D. S. Linthicum, *Next Generation Application Integration*. Boston, MA, Addison-Wesley, 2004.

[5] W. Reisig and G. Rozenberg (eds.). *Lectures on Petri Nets I: Basic Models*. LNCS, Vol. 1491, Springer, 1998.

[6] M. Stal. "Web Services: Beyond Component-Based Computing", *Communications of the ACM*, 45(10): 71–76, October, 2002.

[7] G. Vossen and G. Thies. "ISETTA: Service Orientation in the "Bologna Process" of a Large University". In A. G. Nilsson et al. (eds.), Advances in Information Systems Development: Bridging the Gap between Academia & Industry. Springer, 2006.

[8] G. Vossen and P. Westerkamp. "E-Learning as a Web Service (Extended Abstract)". In B. C. Desai and W. Ng, *Proc. of the Seventh Int.Database Engineering and Applications Symposium (IDEAS 2003)*. pp. 242-249, IEEE, 2003.

[9] Karlsruher Integriertes InformationsManagement (KIM). http://www.kim.uni-karlsruhe.de [last seen August 10, 2006].

[10] The Bologna Declaration. Joint declaration of the European Ministers of Education. Bologna, 1999.