Service-oriented Knowledge Architectures – Integrating Learning and Business Information Systems

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Abstract. This paper presents a dissertation project on business-integrated, service-oriented learning architectures. The isolation of corporate learning management from core business functions at all levels of a coherent socio-technical enterprise system (task, technology and people) motivates the objective to integrate learning into business information systems. Connecting to related standards and frameworks, the thesis is to make a case why SOA qualifies not only from a technical but also from an organizational perspective. The paper sketches the problem situation of non-integrated learning and knowledge management and derives a research agenda that aims for a conceptual and technical reference architecture. The dissertation thesis is conducted in the context of the EC-funded research project PROLIX that promotes process-oriented learning and knowledge exchange in corporate environments.

Keywords: Service-oriented Architectures, Business Process Management, Web Services, Technology-Enhanced Learning, Interoperability

1 Motivation and State-of-the-Art

Enterprises of various sizes and industries have adopted business information systems for the past thirty years. Operational transaction systems (such as enterprise resource planning (ERP) systems) and strategic management information systems (such as business intelligence applications) have focused on the universal objective to integrate structured business data and business functions [16] [15]. Increasing flexibility demands on business processes and on supportive IT Systems have forced software providers and CIOs to evaluate possibilities to assemble IT-supported functions on-demand. The potential of service-oriented software architectures had been recognized previously. Looking back at a history of distributed communication standards such as DCOM, CORBA or RPC, service-orientation is not a new architectural pattern in itself [1]. The commoditization of internet communication and the strong demand for flexible distributed software systems, though, have pushed industry initiatives to develop web service standards, some of which have reached a

level of maturity in the meanwhile. Via web services business software applications can interoperate flexibly over internet protocols and standardized interfaces [24]. Their continuous dissemination has been promoted by the software industry's product portfolio (SAP with Enterprise SOA, Oracle with Fusion, IBM with Websphere, etc.) and the industry-wide provision and adoption of service-oriented business software is on the horizon.

Beyond the demand for flexible IT resources, the recognition of human resources being equally important business factors to achieve strategic objectives and maintain competitiveness has spread across industries [17] [5]. Harvesting and developing employees' knowledge and competences effectively is perceived as strategic HR management activity across industries. However, leaving corresponding tasks to HR departments often causes learning management being detached from overall business strategy. This misalignment affects four interdependent HR related functions – HR administration, knowledge management, personnel development and corporate training. Due to their isolation from core business functions they are often falling short of meeting learning and knowledge requirements of both day-to-day tasks and business strategy. This entails frustrated, little motivated employees on the individual side and negligence of a strategically aligned human resource development on the organizational side.

KM- and learning related functions and business management are not only segregated organizationally. Information technology has supported learning management so far only by isolated, monolithic learning and knowledge software [15], nearly cut off from any organization-wide integrated IT infrastructure. Additionally, there are only a few approaches to have learning systems and operational transaction systems or management information systems flexibly and dynamically interact [4]. In consequence, the following problems on the business level arise:

- *Informational Discontinuity* between business strategy and competency management: Lacking integration of competency-relevant systems (e.g. learning management systems, HR systems) and management information systems (e.g. ERP, business intelligence, business process management, etc. software) implicates gaps between business requirements and employee competences, which are managed individually according to job description, role profiles or career objectives [13].
- *Redundant Knowledge Explication:* Identification and explication of knowledge usually occurs locally and centrally [18] [19]. Both approaches entail redundancies, as knowledge is not only explicated for learning purposes but also for other business functions (e.g. documentation, marketing, R&D,etc.). Lacking any system integration, functionalities and data are often created and maintained redundantly.
- *Decoupled Knowledge Distribution and Acquisition:* The phase of distributing and acquiring knowledge during formal and informal learning processes are mostly separated from applying and developing knowledge (internalization and socialization) during the actual business activities [18] [19]. Business information systems detached from learning systems reinforce this segregation, hindering a context-driven, personalized and most of all need-driven knowledge distribution.

- *Redundant Administration Functionalities:* Similar or equivalent functionalities of learning systems e.g. resource and budget planning, competence management, employee data management are covered by multiple information systems. Redundant, inconsistent data and multiprocessing are the consequences.

Service-oriented architectures promise to tackle those challenges by offering standardized service interfaces that can be invoked by any software systems. Thus, they provide a mean to have single software functionalities flexibly integrate and interact along a process previously defined or dynamically composed. Business information systems – within and across organizational borders – are moving towards a distributed system of loosely coupled services, which needs to react flexibly and execute business requirements ad-hoc [24]. Equally, learning software providers are slowly adopting benefits of a SOA [6]. Existing approaches rest on proof-of-concept solutions and are limited to educational organizations without focusing on enterprise-specific challenges (vgl. [3];[2];[22];[9];[23];[21];[10];). Despite those approaches there is no initiative to be identified that explores the potentials of service-oriented architectures to integrate learning and business infrastructures both technically and conceptionally.

Other means of software integration would possibly also qualify to overcome the segregation of human resource management and core business management. However, the thesis is to argue that SOA offers not only a technological interoperability platform but specifically targets at a non-technical notion of integrating business functions across organizational borders. By introducing universal software paradigms (modularity, reusability, standardized interfaces etc.) to business design decisions, this conception propagates to fully align business and IT. Thus, unlike other integration technologies SOA proposes a shared syntax and semantics to align activities across domains vertically (e.g. HR and core business units) and horizontally by using services as universal entities.

2 Research Objectives

The gap between learning and business infrastructures appears to be approximately closed by the increasing adoption of standardized service architectures on both sides. In the context of this system evolution towards SOA the research question central for this thesis arises:

> *How does service-oriented architecture has to be designed in order to allow for flexible interaction between learning and business applications realizing integrated scenarios?*

Knowledge about a suitable design of corporate learning services in a corporate environment is – unlike business service design – still in a rudimental state. This deficit needs to be tackled by considering the interplay among learning services and business services (Enterprise Learning Service Architecture). Business processes provide the contextual basis both for business and learning activities. Moreover, they

are a central object of SOA since services can flexibly be assembled to business processes [14]. The objective is to realize the IT-supported alignment of individual learning and organizational knowledge needs by a process-oriented learning service architecture. The thesis is to go beyond a purely technical integration but develop an organizationally integrated service-oriented learning management. This vision motivates the following research objectives:

- *Analysis of existent service-oriented frameworks:* Existing concepts, frameworks and standards for either business or learning-related services are to be examined and checked for transfer and compatibility potentials for the specific case of business-integrated, service-oriented learning management.
- *Integration Requirements and Scenarios:* Integrating learning and business processes enabled by SOA asks for an in-depth study of synergy potentials in integration scenarios. Specifying the requirements for service-oriented integration of learning systems and business information systems encompasses elicitating and structuring domain-specific requirements and technical constraints.
- *Reference Architecture for enterprise learning services:* On the basis of existing standards and integration requirements identified, a reference architecture for enterprise learning services that closes the gap between learning management and business management is to be designed conceptually as well as technically and to be implemented prototypically.

3 Preliminary Ideas and Early Results

The dissertation is planned to be structured into seven chapters, which include five main chapters complemented by an exposition and a conclusion. The first chapter motivates the thesis and presents research objectives. The second chapter introduces basics of learning management, business process management and service oriented architecture, relevant for the succeeding analysis. Based on the terminology and state-of-the-art research introduced, the third chapter specifies the requirements for an integrated Enterprise Learning Service Architecture. The fourth chapter proposes a reference framework of learning service, events and data specifications that allow flexible interaction with business services composed to new types of business and learning processes. The conceptual and technical design is documented in semi-formal information models and implemented into a reference architecture in chapter 5. To validate and demonstrate the usage of the proposed service-oriented learning architecture, chapter six outlines up to four concrete case studies and prototypes of the telecommunication, pharmaceutical, social care and financial services sectors.

Research activities within two ongoing research projects contribute to the thesis' work. The EC-funded PROLIX project envisions a service-oriented environment for process-oriented learning and information exchange. The project work is based upon the PROLIX learning lifecycle (PLLC) and will lead to a reference framework named OBELIX. Pursuing the SOA paradigm, services can be orchestrated to flexible workflows one of them being the PLLC. Amongst others the thesis presents the PLLC as a reference example for a workflow composed by the learning services specified.

As a first result, the PLLC has been designed and documented according to the requirements of the industry parties and constraints of the component providers. It is a exemplary workflow of learning-related services consisting of the following five iterative phases:

- modelling competency-enriched business processes to specify the learning context
- deriving competency gaps
- deriving and designing suitable learning processes
- executing learning processes
- monitoring learning and business process performance

Generalizing this specific workflow into a more universal process model including a wide range of possible application scenarios, the thesis is to take such a universal PLLC as a basis to derive service, data and event specifications for the reference architecture. As OBELIX it builds upon existing standardization activities and connects to other reference architectures in both the learning/knowledge management community and the business (process) management community. The thesis will elaborate in detail on the OBELIX framework and break it down into various specific parts. To validate the OBELIX framework, a prototypical implementation will be presented as reference software architecture. Finally, case studies from PROLIX industry partners will demonstrate variations of the OBELIX reference framework and architecture. From a conceptual point of view the PLLC is adapted to a workflow that suits individual needs of the organization. From an implementation point of view the OBELIX reference bus architecture is configured to meet organization-specific needs.

4 Related Aspects

It is important to note, that PROLIX looks at business processes as a requirements basis for individually and organizationally suitable learning processes. Thus, it focuses only on the build-time of formal learning and structured business processes. The execution of learning processes (the actual learning) by employees may still take place independently – in terms of time and place – from business operations. Looking at integrated learning and business processes at run-time (i.e. the actual process of knowledge acquisition during day-to-day work) shifts the focus to informal learning activities that occur intermingled with business activities. Again, service-oriented computing promises to dynamically compose fine-grained learning services with business services to knowledge-enriched business processes.

Also, PROLIX considers only structured business processes and formal learning neglecting unstructured ad-hoc business processes often related with informal learning. Extending the approach by these aspects will bring Web2.0 into play as an innovative mean of informal learning and technologically related to SOA. It remains to examine how Web2.0 principles are to be applied to service-oriented learning

management. The nationally funded EXPLAIN project develops a web-based authoring management system and looks into service-oriented and Web2.0 related concepts. It provides the work with insights on distributed content production and delivery processes. Whereas PROLIX considers business processes as business context providing requirements on learning, business processes also include learning and authoring management activities and therefore organize learning-related operations within the company. In EXPLAIN, processes are not used to describe the business context of learning but rather to structure and organize supportive learning management activities such as authoring processes themselves. Thus, the dimension of integrated learning and business processes is further enriched by another perspective, which may complement the thesis additionally.

Whether such run-time and informal learning aspects will be covered by the thesis or left for future work, remains to be decided.

5 Research Methodology

The thesis is based on a socio-technical notion of business information systems that are made up of three interacting elements: work, technology and human [8]. Analogously information systems sciences understand themselves mediating between business management, computer science and sociology [12].

All three aspects are tackled by this thesis: The perspective of computer sciences contributes the concept of service oriented architectures, which promises an unprecedented degree of integration on the system and conceptual level. On the other hand, SOA is conceived as far reaching paradigm affecting management and culture of organizations; thus, holding business challenges and chances. In the context of business administration organizational theory and personnel development play a decisive role, as they embrace – in terms of change management principles – the continuous adaptation of organizational competency needs and individual competency profiles. Therefore the interdisciplinary approach includes ultimately also social sciences in general and psychology specifically. It provides the thesis with a psychological foundation in respect of knowledge processes.

Despite (or maybe just because of) this multi-dimensional perspective, the thesis is to be classified into the field of information systems. It applies the general question on how to design application systems and organizations correspondingly to requirements of their environment at the best to the specific case of integrated learning systems in the corporate environment and attempts to provide a solution via SOA.

The thesis adheres to the engineering phase model, well-established in information systems: specifying the problem situation, conceptual design, technical design and implementation [20]. In order to grasp the problem situation, analyzing and evaluating state-of-the-art SOA concepts both for business and learning systems is based on a profound literature analysis (and qualitative expert interviews). The requirements specification of the learning service architecture follows a deductive-dogmatic approach, i.e. deriving conclusions form generally accepted theories for the specific object of research [7]. The objective to integrate learning systems with business information systems via SOA puts the focus on a design-oriented perspective, which

concentrates on the design of innovative artifacts extending human and organizational abilities [11]. The implementation of a reference prototype and its enterprise-specific configurations acknowledges the application oriented character of information systems, as they demonstrate and validate the results of this thesis in practice.

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