Net-wiring the learning environments to address emerging organisational needs: virtual learning organisations and ventures

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Introduction

The shift from the industrial economy to the information economy that has happened over the years has led to an enormous increase in competitiveness among organisations. This in turn has led to the development of information technology to highly advanced levels. It is now able to support modern enterprise operation in extremely intricate environments where the changing needs of the business community forces firms to be more agile and responsive. The development of technologies that can efficiently handle complex information such as software agents, combined with the development of Internet technologies for learning process integration and automation such as Web Services, is causing considerable impact on the way economic actors and their roles are implemented in the worldwide market place. This technological evolution has lead to the development of the new value-creating economic paradigm of e-learning, which can exhibit its full potential if approached with modern tools such as the Living Labs methodology.

The network based Information economy and the virtual-yet-real learning environments are a promising reality. New theories and technologies such as Software Agent and Web-Services can be applied to customize learning service provision and support distant formation and operation, to plan requirements for Collaborative Learning, and to share Active Learn-ware and Learner-generated content. They are mature and flexible, forming a concrete framework for successful operation of learning environments. At the same time, serious challenges to the future effectiveness of these environments are also sensed and discussed throughout our paper.

Two main dimensions can be identified in this context:

- The Web service dimension - a very popular technology for learning environments integration and operation where the academic approach hasn't solved the fundamental problems of selecting the most appropriate learning service and coping with learning service discovery as yet. How do interested parties find the learning style and content they're looking for? How do they advertise? How can software do this on behalf (but without the intervention) of a person? Many proposals along these lines exist, ranging from content-based routing in the early 1990s to the use of DAML-S for agents in recent years but none of them has led to deployed, practical learning systems so far.
- The Software agent dimension - this includes Multi Agent Systems (MAS) technology, Mobile Agents, Intelligent Agents and other combinations of traditional agent technologies to support parts of the learning interactions (mainly) at the transactional level.

The aim of our paper is to discuss the main issues, trends and opportunities related to the application of agent and Web service technologies to networked learning environments, from the above-mentioned dimensions. The paper will take a comprehensive approach, and present practical solutions to promote the adoption of the Living Labs methodology for tackling with all different levels of the networked learning uptake and deployment process.

Our paper concludes with a discussion of the business integration requirements in the modern enterprise environment and other emerging inter-organizational models as well as the presentation of relevant and recent developments and solutions (both academic and industrial) addressing the several dimensions and issues of the addressed field.

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Technological background

Since 1996 when Service Oriented Architecture (henceforth SOA) was first introduced by Gartner (1996/1,2) a lot of effort has been put worldwide in this area. Gartner defined SOA as: "a software architecture that starts with an interface definition and builds the entire application topology as a topology of interfaces, interface implementations and interface calls. SOA would be better named interface-oriented architecture. SOA is a relationship of services and service consumers, both software modules large enough to represent a complete business function. Services are software modules that are accessed by name via an interface typically in a request-reply mode. Service consumers are software that embeds a service interface proxy (the client representation of the interface)."

SOA has excited many software architects and developers but only recently with the advent of Web Services, SOA has found its route to real applications. Other technologies have been tried in the mean time but undoubtedly Web Services is the most prominent technology that forms a solid base to develop robust SOA applications. Web Services are defined by Gartner (Plummer, 2002) as: "modular business services with each module fully implemented in software and delivered over the Internet. The modules can be combined, can come from any source, and can eventually be acquired dynamically and without human intervention when needed."

SOA and Web Services are complimentary technologies that represent the most recent step in the evolution scale, which started with distributed programming and object distribution technologies like CORBA, COM/DCOM, DCE and more recently J2EE. Web Services represent a technology specification- meaning that an application must use its standards like Web Services Description Language (WSDL), Simple Object Access Protocol (SOAP) or Universal Description, Discovery and Integration (UDDI) to be considered as Web Services. SOA on the other hand is more considered as a design principle (Natis, 2005) meaning that Web Services interfaces like WSDL (WSDL) and SOAP are suitable interface definition standards (UDDI, 2001, WSDL, 2001, SOAP, 2001, Atkinson, 2002, IBM, 2001).

A virtual learning enterprise is defined as a temporary alliance where different organizations that are positioned complementary or supplementary along the learning activities related value chain are combining their strengths to provide a specific learning related service traditionally provided by a single enterprise. They come together to share skills and resources in order to better respond to business opportunities, whose cooperation is supported by computer networks and adequate IT tools and protocols (Camarinha-Matos & Afsarmanesh, 1999). The life-cycle of a virtual learning enterprise is generally considered to be a four-stage process: creation, operation, evolution and dissolution. Among them, the first step (virtual learning enterprise creation) involves dynamically generated partnerships and dynamically composed service workflow in order for the successful operation of a virtual learning enterprise. The recent Excellence Initiative introduced by the Federal German state can be regarded as a step towards this direction, while the alliances that are developed amongst entities of the academic field in order to provide academic services (like MSc courses or certified vocational training) are also instances of the virtual learning organisation phenomenon.

We consider a virtual learning enterprise is dynamically created following a process of order generation, partner search and selection, bid negotiation and contract awarding. Workflow is used to define the business process logics that are shared by the participants of a formed virtual learning enterprise. If we consider the workflow definition as a "class" in programming, a virtual learning enterprise can be considered as a running instance of such a class which is triggered by customer requirements, created by its lifecycle, controlled by workflow management, executed by workflow engine and dismantled once its goal is fulfilled (Wang 2006).

SOA has an inherent ability to apply itself efficiently across enterprises, being the most promising technology to form and operate Virtual learning enterprises. Such a development will offer, in the long term, immense influence on the economy and enterprise development strategies. The availability, through SOA on the Internet, of standardised information, relevant for participating in Virtual learning enterprises, will dramatically multiply the number of business opportunities transformed into successful business ventures. The most important requirements for virtuality in Virtual learning enterprises are (Protogeros, 2005):

- Global visibility across the virtual learning enterprise. There is a need to have an overall visibility on the entire life cycle of the products and/or services produced, starting from its development to its launch into the market. Such a visibility must be permitted to all the companies' personnel involved in the Virtual learning enterprise operation and in particular to the Project Managers that often, in the traditional supply chain, cannot adequately follow the development of important sub-systems, which are supplied by a sub contractor.
- Uniform and consistent business model. Gou et al. (Gou, 2003) define a business process of a Virtual learning enterprise as a set of linked activities that are distributed at member enterprises of the virtual learning enterprise and collectively realize its common business goal. A uniform business model is very important for the viability of the Virtual learning enterprise. It should support the evolution of the product, process and organisation according to the increasing detail of the attributes representing the same concept (such as the status of an order, the categorization of the order, the customer contact information, the customer account representation, etc.) in a consistent manner.
- Uniform organizational model. The organizational view of enterprises captures information about departments, roles, employees, partners and entire organizations. The organizational model of the Virtual learning enterprise should encompass ownership, privileges and responsibility of messages, documents, and activities that are involved in the processes of the Virtual learning enterprise. It also has to involve extensive security as well as personalization requirements. Virtual learning enterprises can be thought of as an aggregation of processes. Thus processes use information, operations, roles, and sequencing of tasks to carry out specific objectives in the virtual learning enterprise.
- Consistent process and data model. The data model of the companies can capture various behavioural semantics of the business entities. Thus it is not sufficient to have just a consistent conceptual business model of the business entities for smooth operation (Setrag, 2002). Data semantics and operational behaviour must also be represented and applied consistently.

The large diversity in learning practices and activities reflected in the plethora of monolithic and legacy applications, along with the huge gaps in business scope and differences in working standards can make the integration process for Virtual learning enterprises a real headache for analysts and developers. What is a recommended practice from our experiences is to draw analogies from the corporate environment and research that has been conducted outside the e-learning territory, namely in the area of e-business and virtual (non-learning related) enterprises. By now a large number of projects are addressing various aspects of infrastructures for virtual learning enterprises including NIIIP (NIIIP), PRODNET II (Camarinha-Matos, 1999), VIRTEC (Bremer, 1999), Co-OPERATE (Azevedo, 2002), and BIDSAVER (Protogeros, 2005). Some of them are developing Service based reference architectures for example the NIIIP.

SOA technology and standards

In recent years a new trend has appeared related to the reuse of old applications in new type user-transactions. This style being an alternative to the development of purely new applications is known as composite development. In 2003 the majority of new business applications developed were composite applications (Natis, 2005). In taking that approach, wrappers are developed around legacy or other functionality that assemble those components into heterogeneous composite transactions. SOA is the natural place were these types of composite components fit together. SOA applications fit into two main types: user client oriented applications and system oriented applications.

In both types SOA provides the natural basis for reuse of the back-end business logic by multiple styles of clients. Various user categories (customers, managers, operators), in the office or at home, can use SOA to request access to the same functional set of back-end business services. In cases where Virtual learning enterprises operate there is a need of multi-channel, multi-client application and in that case SOA based application design is pushed forward.

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On the other hand, the baseline standards underlying Web services – XML, SOAP, and WSDL – are stable and mature since they have been used for many years now (since 1998, 2000, and 2001 respectively). According to Gartner Group, these standards have reached the "plateau of productivity," a term Gartner applies to technologies whose value is demonstrated and accepted.

An important step towards interoperability in SOA is the formation of the WS-I – the Web Services Interoperability Organization – an organization driven by vendors. This organization's role is to assure that the "common language" of Web services (and the entire supporting infrastructure around it) is interoperable among implementations.

The WS-I has published a "basic profile" which describes how to build and use the base Web services standards to ensure interoperability. In addition, a version of the "security profile" has also been published.

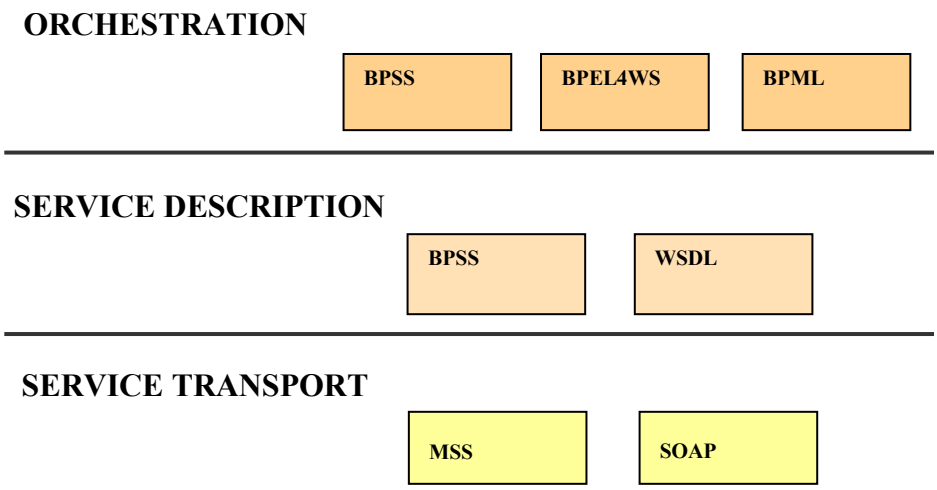

Figure 1 Various standards of Service Oriented Architecture

BPEL has emerged recently as an effective and highly interoperable standard for Web services orchestration. Since the BPEL specification has been donated to OASIS by Microsoft and IBM, a large number of major industry vendors (including Microsoft, Oracle, IBM, SAP, Siebel, BEA and Sun) have supported this standard; many of them having already commercialized products in the market (eg. Oracle BPEL Process Manager). As the standards war in the business process modelling space appears to be over many believe (Oracle 2004) that this is a great thing for enterprise interoperability and integration at the business process level. BPEL can become for business processes the same thing as SQL is for databases.

Messaging protocols and the Enterprise Service Bus

Since SOA was introduced in 1996, various protocols have been developed to allow services to exchange messages, both synchronously and asynchronously. Traditionally, messaging mechanisms have been built according to a queued architecture, that is, one in which incoming messages are held in a sort of electronic post office until the receiver is ready to retrieve and respond to them. This style of message exchange is suitable (and even optimal) for many non–real-time applications Microsoft's MSMQ,32 Sun's JMS,33 and IBM's MQSeries34 technologies are examples of this style of messaging. Other type of applications such as device command and control for laboratory instruments generally requires a more immediate mode of messaging (McIntosh, 2004)

A new messaging paradigm that is rapidly gaining in popularity is variously called a Messaging Service Bus or Enterprise Service Bus (ESB). A key concept of this idea is that messages (usually XML encoded) carry with them routing instructions that do not rely on a centralized server or rules engine to define how they are transported from one place to another. The bus infrastructure provides support for routing of these messages, along with service discovery, security, logging, and so on. In some implementations, such services are built into the core layer of the bus; in other implementations, some or all such services are provided as plug-in framework modules.

One very interesting open-source project that bills itself as an ''Enterprise Service Bus messaging framework'' is called Mule and can serve to integrate many disparate messaging technologies, such as JMS (Java Messaging Service), HTTP, e-mail, and XML-RPC. Mule is Java based and can interoperate with components running within the same Java virtual machine or with widely dispersed components communicating over the Internet (and everything in between). Mule is designed around a very clean architecture based on the idea that incoming messages trigger events within the Mule server and can operate in any of the three primary messaging modes: asynchronous, synchronous, and request–response.

A lighter weight alternative to Mule is the ''FreeSB'' project (FreeServiceBus), developed by Spherion. It defines a standard ESB client implementation (by using the Apache Axis code base) that allows a variety of specialized services to easily ''plug in'' to the service bus. The bus itself is designed around SOAP messaging and comes pre-packaged with plug-ins to provide logging, authentication, and supervisory or management services (which implement registry and coordination functions for clients).

SOA as a key driver for enterprise integration. The case of virtual learning enterprise.

Ashkenas et al. (2002) described the emergence of the ''Boundaryless Organization'' that increasingly requires organizations to consider four boundaries; vertical, horizontal, external, and geographic, in determining the shape of their enterprise. Web Service environments can support horizontal integration by delivering the standardized technological infrastructure that will enable organizations to more effectively share knowledge and collaborate within and beyond organizational boundaries (Estrem, 2003).

Composite applications deliver a form of integration and thus SOA and Web services can be the modern approach to the application integration problem for virtual learning enterprises. Moreover due to the many SOA benefits a lot of expectation has been put to this technology. The reality as always is in the middle. SOA is very helpful in some cases of integration such as real time composite transactions but is less helpful in other cases like in long-running transactions. In those cases additional integration technology is typically required to reconcile the business information differences of the participating applications. Typical benefits that SOA brings to virtual learning enterprise IT are:

- Interoperability. Through the addition of a thin and transparent layer to existing software, Web service–enabled components can communicate with each other via a platform-independent messaging protocol. This ability completed by a semantic interoperability, will enable two Web services to interact with each other despite their semantic differences. Only with semantic interoperability could different applications in members of a Virtual learning enterprise build a composite application that exchanges data with each other's business systems.
- Web Services can provide the infrastructure that would support virtual learning enterprise relationships (Estrem, 2003). This would provide the flexibility and agility that could support manufacturing approaches by reducing the complexity and driving down the transaction costs associated with outsourcing and extended value chain operations between principals and their agents. The ability to dynamically integrate functions that are spread across the value chain would reduce the time, cost, and complexity associated with establishing the relationships needed to support virtual business processes. These capabilities could also enhance the operational efficiency of internal functions. Web Services, which could be far less costly to support, could lower the barriers to entry and make it possible for small organizations to access and participate in sophisticated value chain activities.
- Wide industry acceptance and compliance with standards. Recently achieved standard in the orchestration layer: Business Process Execution Language for Web Services (BPEL) provides

enterprises with a powerful way for business process orchestration and execution. From a technical perspective, BPEL is a standard language for defining how to: interchange XML messages among remote services, manipulate XML data structures, receive XML messages asynchronously from remote services, manage events and exceptions, define parallel sequences of execution and undo parts of processes when exceptions occur (Oracle 2004). These are the constructs needed to compose a set of services into collaborative and transactional business processes. BPEL is based on XML Schema, SOAP and WSDL.

- Unlike process standards that have been proposed in the past, Business Process Execution Language for Web Services, driven by the OASIS standards body, has achieved the critical support and endorsement from the industry's leading vendors. While earlier fragmented efforts fell short in developing a single, comprehensive standard that meets the needs of customers, BPEL is a comprehensive standard that satisfies real-world requirements and has the support of major infrastructure and application.
- Flexible change and reconfiguration management. Conventional monolithic IT systems apply many technologies and exchange data and requests via multiple connections. The resulting dependencies between systems are so numerous that system reconfigurations—for example, to support a new business requirement—are often extremely time consuming. Tight coupling between applications may render conventional architectures so fragile that changes become prohibitively complex. SOA, in contrast, is much more flexible. Web services present many new potential opportunities to significantly reduce the complexity and costs of enterprise computing for developing and maintaining e-business applications (Huang, 2003)
- SOA permits fine-grained control over deployments across the virtual learning enterprise. Components within a process can be easily replaced by new or updated components, further reducing the time taken to modify or change an existing process in response to business requirements. Components are easier to develop because the semantics of each independent component are significantly less complex than the overall of a single, (usually large) monolithic application. Components can be developed by different teams of developers, each of whom focus only on their component without having to know the details of work done by others. Components can be dynamically deployed to remote nodes at runtime.
- Reuse of business components in multiple services. Since each component has well-defined interfaces, it can be developed, tested and debugged independent of the other components. This not only speeds up virtual learning enterprise project implementations but, in the case of well-designed business components, also leads to significantly enhanced reuse.
- Low-cost development of new business processes. In the traditional software development process, translating requirements into working distributed systems is both time-consuming and difficult, requiring several stages of manual development and deployment. This complex, error-prone task can be effectively streamlined using a higher-level, component-based SOA architecture. SOA's components ease of development considerably lowers total development costs. Development of new business solutions for the virtual learning enterprise is reduced to an assembly of service components that does not require the in deep technical skills when coding solutions from scratch.
- Business driven approach. Traditional application design bound by conventional architectures has pursued a technology-driven approach to the automation of the enterprise's business processes. Under SOA the emphasis is given to a business solution–driven approach where created services are more meaningful and hence more accessible to business users. This approach shifts effort to a much closer alignment between the IT function and virtual learning enterprise member companies' business units.

Future Trends

Virtual learning enterprise integration and operation will greatly depend on Web services and SOA standards adoption from a corporate perspective. How is corporate adoption progressing? An IDC's study from 2003 (just a few years after the SOA standards appeared) shows that among large organizations (those with more than 1000 employees), 96 percent were actively pursuing Web services technologies. Of these organizations, 50 percent already had at least one Web service project in production, while the remaining 50 percent were either evaluating or running pilots with the technologies. Of the organizations with Web services in production, 81 percent had more than one Web service project in production.

Given that trend, it is safe to assume that the adoption of Web services and SOA has progressed even further than these figures indicate. Organizations are embracing these standards (Ziff Davis, 2004) and deploying Web services for many internal projects and sometimes modern organisation schemes like Virtual learning enterprises. However, most organizations and specifically SMEs have yet to fully capture the value available to them through a strategic use and reuse of services through a service-oriented architecture. SOA's true value escalates when organizations harness the economies of scale of consolidation and reuse. When an organization moves from ad hoc use of collections of Web services to a more formalized SOA, the value of those services rises dramatically (Actional, 2004).

Furthermore the wide adoption by the industry of Oasis BPEL for the Web service orchestration layer will revolutionize business process integration the same way standards like SQL revolutionized access to structured data and HTTP and HTML standardized the way people access content and applications, Web services have the potential to transform the internet into a true distributed computing platform and allow heterogeneous systems to cooperate simply and reliably.

Conclusion

Companies that work together need their applications and services to work together. This is driving the industry move to SOA and Web services, which promise significant benefits in terms of adaptability, ease-of-integration, portability, and interoperability.

Projects deployed with Web services and SOA can achieve an important level of business process abstraction. The interoperability and integration issues can successfully be addressed through SOA in a two-step process involving publishing services and orchestrating them. Publishing means making the Web services available through a supported interface/protocol but does not require that all existing systems be "wrapped" with a new XML/SOAP Web service layer. Orchestration means assembling and coordinating these services into a manageable business application.

However, there is work to do, specifically to the wider standards adoptions between medium and small enterprises. The lack of custom and user friendly tools drives developers to manually recode services or provide "glue code" so that they can interconnect with one another. Such painstaking labour deprives SOAs of much of their virtue—namely, rapid integration and composite application.

Wider Virtual learning enterprise models acceptance tightly connects with the ease of integration at the business process level, and this in turn relates closely with SOA acceptance and adoption. BPEL promise for universal remote integration makes us more optimistic about the future of Virtual learning enterprises.

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