REST Based Registry Framework for Service Oriented E-learning

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Abstract— **E-learning systems are required to provide universal access to educational resources regardless of the standards, protocols or platforms used. Such systems should allow maximizing the reuse of learning resources (objects) and supporting learning services via various technologies to enhance interoperability. For development of e-learning systems, architecture design is critical to ensure easy access to repositories of learning (services)/objects and (provide) robust discovery mechanisms. This paper has reviewed related work on e-learning and highlights the importance of adoption of SOA including REST to enhance reusability of learning resources for meaningful and interactive e-learning. As learning is resources oriented, we proposed REST architecture for delivery of e-learning resources on SOA platform. To deal with one of the major challenges of SOA in maintaining service registry & discovery of resources, we developed a framework for REST service registry and discussed the information required for learning services registration.**

Keywords- e-learning; REST; Service Oriented Architecture; Web Services

I. INTRODUCTION

E-learning is considered as online learning to provide any-time, any-place and personalized learning for students who are both in-campus and distance modes. It offers freedom from space and time constraints, increases interactivity, improves delivery of multimedia, and enhances curricula and personalized learning. In some respects, e-learning is perceived as a revolution of 'just-in-time' education. E-learning systems require communication, collaboration and creativity for facilitating the maximum reuse of learning resources among participants including teachers. Further, e-learning systems should be flexible and dynamic enough to suit the current ubiquitous educational environments.

Not all e-learning systems achieve these expectations [1]. Employment of just electronic devices will not solve the problems currently faced by e-learning systems due to various reasons such as poor standards, protocols and platforms. In addition, content repositories are mostly incompatible with each other and difficult to integrate easily to share information among educational providers. To solve this problem, it is necessary to adopt an approach that guarantees fast development of systems by integrating the abundantly available learning resources stored in various repositories.

Service Oriented Architecture (SOA) is an ideal mechanism for efficient integration of various applications. It has become a popular way of supporting business processes of organizations in both private and public sectors. The main goal of SOA is to design and develop applications in the form of reusable services. These services can be integrated in a loosely coupled manner to develop new applications. There are mainly two different technologies used to implement SOA based systems, Web services and RESTful services. Out of these two styles, Representational State Transfer (REST) style is considered to be the most suitable technology for resource based application delivery, where as Web services are considered to be suitable for functional based application delivery [2]. Interestingly, most of the services required in e-learning are resource based applications and therefore, REST architectural style would be ideal for implementation of SOA based e-learning services.

In a SOA environment service providers develop their services and make them available for consumers. On the other hand, consumers need to have a mechanism to find services to integrate into their applications. To deal with this situation it is required to have a service registry & discovery mechanism in which services are described, catalogued and can be found when they are needed. A service registry contains information required for integration of stored services to consumers' applications. By searching the repository many similar services can be found according to given requirements. Then, consumers will evaluate these services and choose the best one that meets their requirements. Therefore, in e-learning, such a service registry and discovery mechanism for REST services can be a solution to solve the problems of resource sharing and reuse, dynamically and effectively integrate necessary recourses or services as required. However, although there are enormous resource and services available for e-learning, there is no REST registry for e-learning services to make them utilized effectively.

This paper is to propose a framework for development of REST based registry framework for service oriented e-learning. The proposed framework allows the discovery of learning resources stored in different repositories and offers transparent access to learning resources stored at providers' site irrespective of the physical location and storage technology. The paper is divided into the following sections: Section 2 introduced the principles of E-learning and how technologies have been applied to e-learning; followed by discussion of SOA and REST and the benefit of incorporating them into e-learning in section 3. Section 4 presented the REST Framework for E-learning service registry and repository; Section 5 described the UML model for the framework and information required for E-learning service registration.

II. BACKGROUND AND LITERATURE REVIEW

A. E-learning

E-learning is the delivery of a learning, training or education program by electronic means. It involves the use of computers or electronic devices in some way to provide training, educational or learning material. E-learning is facilitated and supported through the use of information and communication technology in distance learning and classroom environment as well as blended learning.

One important aspect of e-learning is distance learning which allows learners to interact directly online with the digital resource without any face-to-face communication. In distance learning the interaction between teacher and student is minimal and often the student simply works successively through content in his or her own pace. However, the learning can be synchronous, where the online interaction between student and teacher takes place in real time, or asynchronous, where the student learning experience is not dependent on real time communication.

E-learning has been discussed widely by educators and researchers. Researchers have found that usually students have little or no communication with each other in their class via online chat or email as they do not have any reason to do so. There is also very little communication between teachers and students via electronic communication media. However, it is widely believed that quality of learning is adversely affected if there is no communication between teachers and students. Without interaction with students the teacher is unable to judge students' progress and is not in a position to change the teaching techniques to suite the requirement of the students. Furthermore, in the classroom setting, non verbal communication such as body-language, facial expressions, and eye contact helps instructor to understand the students' enthusiasm for learning and level of understanding of the lesson. Once that element is removed teacher and students have to entirely depend on electronic communication and if e-communication is lacking, the teaching and learning process will not be as effective as in a classroom environment. It is critical to easily integrate various electronically devices to enhance communication between students and instructions. McDonald [2] points out that distance learning, and especially online education opened the door to enhanced strategies in teaching and learning. She claims that distance education can be a frontier for new methods of communication giving rise to innovative teaching and learning practices. However, if the e-learning is only text-based, it makes online education more cumbersome as it takes more time than face-to-face learning. If the learner only has the written text and no any other non-verbal cues, students may get confused and cause misunderstanding. Therefore, it is necessary to have different types of collaborative and communication services which will enable to take advantage of the potential of online education by striving to use the new technology.

B. E-LEARNING TECHNOLOGY AND SYSTEM ARCHITECTURE

Reference [4] pointed out that computer based communication provides an opportunity for new development and understanding in teaching and learning. They found that computer based communication has provided new insight into the complexity and power of face-to-face interaction. In addition to reaching e-learners at a distance, e-learning are increasingly being used to enrich, improve, and expand face-to-face instruction, thus resulting in a convergence of educational practices.

Reference [5] found that to promote active learning and high level of student satisfaction in distance learning, course design should incorporate teaching strategies that produce teacher-student interaction in synchronous environment. A typical asynchronous communication creates a time lag between the transmission and reception of a message and this lag can have a dramatic impact on the ability of participants' interaction across time. Further, it is well known fact that the combination of course content, student-teacher interaction, and teaching techniques resulted in a higher level of student satisfaction. Therefore, distance education systems that do not employ two-way video transitions may need to promote different patterns of teacher-student interaction to achieve the expected level of student satisfaction.

Reference [5] stated that as new technologies become available in the support of instruction, questions are being raised concerning the effectiveness of traditional method of face to face learning environments. E-learning can be new methods of communication and innovative teaching & learning practices that may not be possible in traditional education environment.

Reference [6] described the infrastructure and the architecture of public e-learning platform which supports a learner centric interest-oriented e-learning environment. A framework has been established to help the development of tools to support the knowledge role of cartographer, librarian and composer which are very important roles especially in e-learning environment.

Figure 1 shows a typical e-learning environment where Learning Management System (LMS) contains learning objects & resources and required software to manage the system. Both students and teachers can access the content (learning resources) from LMS using a web browser. A web browser running on the client side invokes an instance of Application Programming Interface (API) provided by the LMS to access Learning Resources (LR). API instance works as a bridge between the LMS and LR since the LR lacks the capability to connect with the LMS server directly.

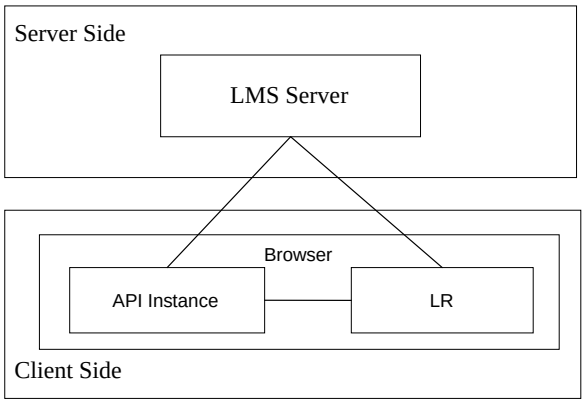

Figure 1 Typical E-learning Environment

The problem of delivering educational contents through the web and its integration with Learning Management Systems (LMS) has been widely studies. It has been argued that it is necessary to have a new generation of web-based education systems running on completely open middleware. These systems should be capable of communicating between systems enabling clients/users to request a service without knowing where or how that service is implemented. This kind of flexibility is critical as web-base education systems will be collection of heterogeneous devices and services located in different geographical locations. Issues of interoperability (content from multiple sources working equally well with different learning systems) and reusability (content developed in one context being transferable to another context) must be addressed [7].

Reference [8] and [9] proposed a system which is centered in reusability, accessibility, durability and interoperability of educational material based on a special types of labeled material called Intelligent Reusable Learning Components Object Oriented. Their system is based on the concept graph knowledge representation model which uses multi-agent architecture as a middleware for open web-based education system.

Reference [10] introduced learning object relationship patterns and illustrated how to use web usage mining methodologies to discover patterns based on learners' usage information. Their algorithm discovers learning object relationship patterns and recommends related learning objects to learners to make the learning process more attractive and adaptive.

Reference [11] explained how ontology can be used successfully to increase the effectiveness and usability of e-learning systems to serve the purpose of making e-learning systems easy, effective and efficient for learners. Ontology has been used to arrange metadata, and to define the relationships of metadata on learning objects belong to academic courses and user profiles. Their approach is people centric than location centric LMS. With integration of a typical LMS, the system can locate and retrieve learning resources satisfying user interests and capture user preferences into user profiles and matching them with corresponding learning object metadata in the proposed ontology. This proposed system enables students to retrieve only the learning content satisfying their learning needs.

Reference [12] compared between Shareable Content Object Reference Model (SCORM) and Common Cartridge (CC) standard and critically evaluated and discussed - controversial issues. SCORM aims to extend the interoperability beyond the conventional learning platform making no assumption about the nature of content or systems, but it fails. On the other hand CC is inferior in collaboration, content distribution, sequencing, application interaction and accessibility. However, there is no standard which satisfy all the needs of e-learning environment.

Researchers also tried to incorporate semantic web resources to their design. The main objective is to update the architecture to provide more adaptive ability, robustness and richer learning environment. However, the construction of such systems is highly complex and faces several challenges in terms of software engineering and artificial intelligent aspects. The educational semantic web is based on three fundamental affordances. The first is the capacity for effective information storage and retrieval. The second is the capacity for non-human autonomous agents to augment the learning and information retrieval of human beings. The third affordance is the capacity of the Internet to support, extend and expand communication capabilities of humans in multiple formats across the bounds of time and space. Reference [13] proposed a computational model for developing semantic web-based educational systems that promotes easy and efficient development of such systems. Their case study results showed that the approach facilitates the effective building of educational applications which satisfy above three affordances.

Reference [14] proposed a Web mining technique using a software agent supported e-learning system. In this system software agent is used to help the learner to better navigate through on-line materials and quickly find the needed resources. Reference [15] presented an experimental study to evaluate the performance of a system for retrieval of information on the Web by mobile agent technology. Reference [16] proposed a multi-agent system for e-learning and skill management to support different types of activities in

an e-learning environment. The system demonstrated how multi-agent system can be effectively used to help enriching, sharing, and circulating organizational knowledge in an enterprise e-learning environment.

C. Summary

A typical learning management system is built on component based architecture, usually runs on servers of the educational institute and provides different functionalities to learners. It has become a practice of educational organizations to have their own learning management systems to cater to their students. However, as there are large numbers of similar courses offered by different educational institutes with similar contents, duplications of work and resources all over the world in e-learning services are inevitable. On the other hand in addition to learning materials, learning requires not only communication, interaction, and teamwork but also having conversation and other kinds of interactions with fellow learners and teachers. E-learning systems should provide this multifaceted character of interaction by combining different media and tools to support and stimulate communication and interaction in learning. However, it has been found that predominantly focus on cognitive learning process and current e-learning systems lacks facilities required for communication and integration.. Therefore, to support the ever growing service requirements of e-learning, a new delivery mechanism of resources and services is required.

III. THE BASIS OF SOA AND REST

Services are either software components or resources that are self-described and self-contained applications that can be located and invoked across networks. They allow applications to interoperate in a loosely coupled environment enabling various consumers to obtain services from various providers. For these services to be found and used they need to be registered or published as services in a service registry. The services are owned and located in provider's application environment as per the service configurations. Service providers publish their services in the service registries. Once a service is registered, applications can discover and invoke the registered services. However, web services, an implementation of SOA is difficult to be used to build application as the complicated protocols (standards, rules and description languages) are adopted. Furthermore, web services are unable to deal with the heavy demands for various services. REST (Representational State Transfer) services have emerged to overcome these problems.

REST was originally introduced as an architectural style for building Internet-scale distributed hypermedia system. This architecture style embraces a stateless client-server architecture where web services are considered as resources which can be identified by their URLs. As an architectural style REST demonstrates how well designed web application behaves: a network of web pages (a virtual state-machine) where the user progress through an application by selection links (state transitions) resulting in the next page (presenting the next state of the application) being transferred to the user and rendered for their use [2]. The key abstraction of information in REST is a resource. Any information that can be named can be a resource. The resource is neither a storage object nor a mechanism that the server uses to handle the storage object. It is simply a conceptual mapping between URI and the physical resources. REST focus on the big picture of the web and does not deal with the internal implementation. It is noteworthy that REST as an architectural style does not specify technologies such as protocols (e.g. HTTP) or languages (e.g. XML). REST systems can be developed based on any technology as far as it conforms to the required constrains.

Information is an asset for any business organization and providing access to crucial business information itself is a services. According to [17] a convenient way of delivering this information is via the Internet as it gets rid of the problem of updating local databases. Therefore, providing information as a service over the Internet is going to be a big business in the future. Interestingly, information services do not need very complex APIs as there is no much functionality in the service and hence, REST architectural style is the most suitable way of delivering the service. Reference [18] have highlighted that one of the advantage of REST is that client does not need to know the routing information beyond the URI. However, once services are provided the burning issue for the organizations/users will be how to find such services (URIs) provided by various organizations.

REST architectural style has been proposed by researchers not only for information centric services, but even for activity centric services such as services oriented business process execution, business process modeling and decentralized systems [19, 20, and 21]. They have shown that how this particular architectural style can be used effectively in dynamic, flexible and scalable process executions where business process logic enforcement is required to reflect the behavior of business processes and activity dependencies.

Reference [22] identified the biggest strength of REST web services as the simplicity because REST architectural style leverage exiting well-know W3C standards. According to them, the necessary infrastructure has already become pervasive and available for all major programming languages and operating system/hardware platforms. According [18] the main advantage of the REST-based approach is the potential scalability of a REST-based system and the lightweight access to its operations due to the limited number of operations and the unified address schema. In such a situation where services can be provided in a simple lightweight manner with less infrastructure development and low investment, the possibility of adoption of the architectural style in large scale by organizations in the future is very high.

According to [23] deployment and use of applications in a distributed environment pose a service discovery challenge as resources need to be identified in terms of their location and features in a transparent way for the user or the client

application that is looking for them. Furthermore, [24, 25] emphasized that web services are meaningful only if potential users can find information sufficient enough to permit the execution. Therefore, when services are provided, it is very important to have a mechanism to discover available services without much difficulty. Without a discovery mechanism finding services from various providers will be harder, time consuming and inefficient. Hence having a registry for REST services is useful as it will make the service discovery easier, less time consuming and efficient.

To overcome the problems currently faced by e-learning solution providers which have been addressed in previous sections, we proposed a new framework which can be used to integrate different educational services provided by various educational resource providers in a SOA platform. Importantly, the proposed solution should be simple and cost effective which will undoubtedly improve the adaptability. Therefore, we proposed to have REST Architectural style for the new framework and would develop a registry to improve the discovery of available resources.

IV. SERVICES-ORIENTED E-LEARNING FRAMEWORK

This paper focuses on use of SOA for delivery of educational services to academics and students. In a service oriented environment there are three major components: Service Providers, Service Consumers and Registry Repository where Service Providers (authors and course material developers) register their services for discovery by Service Consumers (teachers and students). Figure 2 depict the proposed architecture for e-learning services and overview of how these components work together in an SOA environment. Here we suggest to introduce a new e-learning environment where traditional LMS is integrated with learning services provided based on Service Oriented Architecture.

The services can be used to integrate the content from LMS with services obtained from various provides and present to user through a browser. However, in a SOA environment educational resource developers need to find the required resources/services from providers before they integrate them into the system. That can be done by accessing the registry of the proposed framework.

Service providers can either provide Web Services or REST Services. This paper focuses on educational REST service registry and repository that facilitates the registration of learning services. Once the services are registered discovery of resources that satisfy the requirement of course developers, teachers and students would be possible. The figure 2 depicts the proposed framework of the REST service registry and repository. Service providers can register REST services in the registry and service consumers then are able to discover the appropriate services they need from the registry.

The core part of the REST Registry includes three layers; the top layer provides mechanism for service providers to publish/register their services and service consumer to discover the registered services; the middle layer contains an engine that handles the interaction between top layer and the middle layer and manage the details of registered services. The major tasks performed by the engine are: 1) Directing and coordinating the information flow and tasks between layers; 2) Data management such as handling the request for data from repositories; 3) Invocation of agreement logic and contact details services and implementation of security in the registry systems. Proper data management service of the engine ensures the registry's capability of dealing with wide range of database systems regardless of their location or data format. The strength of having powerful business logic processing capability ensures the efficient delivery of real-time services over the Internet. The bottom layer has different adaptors to access different repositories such as databases and file systems. Data repositories can be implemented using any DBMS or using file management mechanism. To use the registry, service providers publish/register the information of their service profiles to Registry where as service consumers access the registry, make a query to discover the URL of the service it wants. The service then can be invoked by using the discovered URL. The invoked service may work as a function of an application by forming as a part of business logic, which can be used by users via user interface.

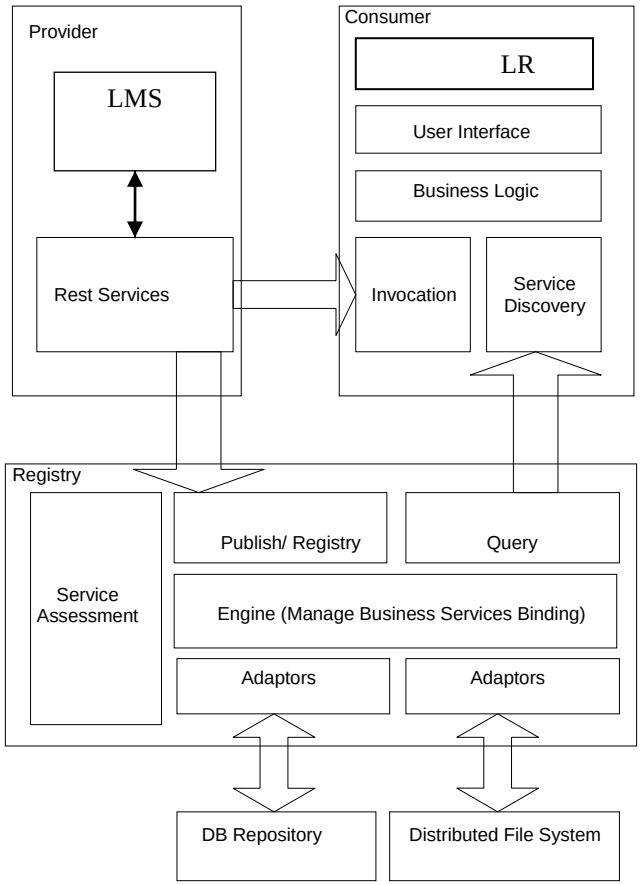

Figure 2: A Framework of REST service registry and repository

As a result of the interactions between service provider and registry, the information for registering REST services are obtained. The top layer provides the interface for the service provider to publish the profiles of the services in the registry. Once this interaction is established the engine interacts with top layer to direct and coordinate the registering process. Depending on the type of data format and the repository location the engine of the registry coordinate with relevant adapters to direct the information flows to the appropriate physical storage.

The discovery process is usually initiated by consumers (course developer). Consumers interact with the registry via query interface to discover the services they need. As explain in the example given below course developers will be able to discover the required services using different criteria such as business organization data, educational-level and program. Once the consumer execute the query using key words, the engine of the registry interacts with the query interface to get the details and pass them to adapters to be processed on different databases to obtain the service registry information which satisfy the criteria. After processing the query on different databases the results are forwarded to the engine. Upon receiving the queried information from different repositories, the engine consolidates result into a standard format and pass on to the top layer for display. Then the consumers (course developers) can analyze the result and choose the appropriate service for invocation.

V. REGISTRY REPOSITORY MODEL

The most general use of a registry is to have a domain-independent global registry which is public and open to all service providers and consumers. It functions as a service registry and search engine to establish contact and facilities between service providers and services consumers. On the other hand organizational specific registries can be used to register services related to a specific organization. Our proposed framework would facilitate the establishment of either public or private registries depending on the requirements. We focus on a lightweight approach in contrast to existing web service registry solutions where the application needs complex software installations. Our framework provides transparent, flexible extensions to the registry.

A. Description

In view of facilitating the creation of a universal registry for education services provided on service oriented architecture, the higher level information incorporated in the registry is related to business organization. Table 1 shows the attributes related to business entities. Here we assume that business organizations can provide deferent types of services in different business domains and the first level information is general description of the business organization and business areas where they provide services.

TABLE I. BUSINESS INFORMATION

Attribute	**Description**
BusinessKey	System generated key for identification of business organization
URL	Domain name of the business
Country	Country of the head office
Name	Name of the company (Multiple names possible)
Description	Brief description of the business
Contact	Contact details the services provider wants disclose to public
Service	List of services provided by the business

There can be various education services provided by organizations related to different programs in different levels. In such a case discovering the most suitable resources for a particular course is not going to be an easy task. Therefore, design of our registry framework is based on categorization and classifications at different levels. The model allows the definition of properties for each resource that are stored in the registry at different levels. To improve the efficiency of discovery the categorization and classification of services and resources at different level is proposed.

Course designers should be able to discover relevant resources offered by various providers. On the other hand providers have the responsibility of providing enough information about the resources that they offer. Therefore, to facilitate the incorporation of education program information another level has been introduced to our registry framework. The second level of the data structure of the registry contains learning service description information and related attributes are shown in Table 2.

TABLE II. LEARNING SERVICE DESCRIPTION

Attribute	**Description**
ServiceKey	System generated key for identification of services
BusinessKey	System generated key for identification of business organization
Name	Name of the learning service
Description	Brief description of the learning service
Category	Interface description(URL)
Agreement	Learning service agreement details
Conditions	Any applicable conditions
Resource	List of learning resources
EducationLevel	Education level/type (Multiple levels possible)
Program	Relevant education program (Multiple levels possible)
Tag	Any related key word
Version	Version of the learning service
Updates	New version update details

The learning services registry content should not contain invalid entries and must be tightly coupled with the service as long as it is available for consumers. However, the education

sector is very dynamic and changes to the content are taken place very frequently and it is imperative for service providers to update content regularly to keep up with new development. In such a situation one main concern of course designers would be the way of discovering the latest resources when changes are made to existing resource services. Therefore, it is very important to notify the service consumers the changes made to the existing services and providing a mechanism to discover latest resources. In our framework we allow the provider to change the version of the service with information of indicating the new version and updated details in the education registry.

Course designer's main concern is to find the relevant resources for courses/subject that they design. There can be vast amount of related resources available with providers and having a mechanism to inspect them for suitability with ease is very important. In this respect having a combination of browse and drill down search facility of resources in a registry is very useful. When a list of resources is found from the registry the search results can be inspected manually to check the suitability or refined the search through more specific search criteria in order to find more specific resources with certain properties. To facilitate the drill down search patterns and refinement a third level has been introduces and table 3 shows the related attribute of the third level. This level contains the specific details of learning resources available under each category which can be used in search criteria.

TABLE III. LEARNING RESOURCES DESCRIPTION

Attribute	**Description**
ResourceKey	System generated key for identification
ServiceKey	System generated key for identification of services
Description	Learning resources description
Subject	Subject category (Multiple categories possible)
ResourceType	Type of the resource available
URI	Specific URI of the learning resources
Update	New version update details
Version	Version of the learning Resources

B. Example

For course developers to be able to find the specific details of the education service, first of all, education service providers need to register their details such as business information, learning services description and learning resources description in a registry. Once the services are registered there can be various ways where course developers can find the services they need. There can be two scenarios. The first scenario is that developer looking for specific education level or program. If the developer searches for previously unknown providers or a new business entity, related learning services information can be found by searching on the Education level attribute (e.g. Postgraduate) or Program attribute (e.g. Information Technology). Searching will also be possible using different key words as the registry have tagging facility. Upon finding the business organizations which provides the education service, the developer can analyze the business organization details and decide on one or a few organizations for further considerations. For the selected organizations the drill down facility can be used to access specific information of educational services, such as pricing, service agreement and other details. If the course developer is satisfied with the educational service and its conditions, it is just a matter of drill down one level to get the URL of the required recourse. The correct URI will provide all the required information to make the decision. The second scenario is for a developer searching for already known business entities or services, the required information can be accessed either by using the business name or the learning service name (e.g. Normalization). That will deliver the required higher level information and thereafter find the exact resource will be the same as earlier scenario. Table 4, 5 and 6 show the sample data that is stored in a registry to facilitate the discovery process of learning services.

TABLE IV. BUSINESS INFORMATION

Attribute	**Description**
BusinessKey	000001
URL	www.abcbusiness.com.au
Country	Australia
Name	ABC Business Limited
Description	Education Services
Contact	+61 3 9999 1234, inquire@abcbusiness.com.au
Service	Course resources for undergraduate and postgraduate education
Category	Education and training

TABLE V. LEARNING SERVICE DESCRIPTION

Attribute	**Description**
ServiceKey	02213
BusinessKey	000001
Name	Normalization
Description	Demonstration of normalization process from 0NF to 3NF
Agreement	Minimum one year
Condition	None
Resource	Theory, Practice, Tests
EducationLevel	Postgraduate
Program	Information Technology
Tag	Database logical design
Version	1.1
Updates	01/01/2010

TABLE VI. LEARNING RESOURCES DESCRIPTION

Attribute	**Description**
ResourceKey	01100
ServiceKey	02213
Description	The use of functional dependency in normalization
Subject	Database design and development
ResourceType	Multimedia
URI	www.abcbusiness.com.au/postgraduate/IT/normalization.html
Update	01/01/2010

VI. CONCLUSION AND FUTURE RESEARCH

The original idea behind providing teaching resources using SOA was to improve the reusability and reduce the cost resulted in the duplication of resources. In order to achieve the above objectives it is necessary to have a mechanism which facilitates the discovery of teaching resources from their repositories. The proposed service registry and repository framework facilitate the publication and discovery of education resources represented by REST services. This framework provides a mechanism for e-learning systems to communicate under SOA architecture so that REST services can be easily found and utilised to develop teaching resources/materials efficiently and effectively. This paper demonstrated the information required for educational service registration and its structure that facilitates the service discovery. At the end the proposed framework has been also applied to a real-world example and demonstrated the mechanism.

The future work will be to evaluate and validate the proposed framework. Evaluation and validation of the framework will be done by developing a prototype of the proposed framework and testing it on an E-learning environment.

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