Multi-tenant enabled eLearning Platform: Blended with Workflow Technologies

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Abstract—**The popularity of Software as a Service is getting bigger in the space of the enterprise world. The features such as automation of the manual business process, multi-tenancy, shared upgrades, etc., are raising the adoption of SaaS applications. In the context of the eLearning applications, it is perfectly suitable to manage the eLearning application by automating the manual business process to effectively manage multiple tenants' ever changing requirements. This paper proposes a multi-tenant eLearning platform, that utilizes workflow technologies for modeling the eLearning process and for achieving the effective system in managing the multiple tenant's business requirements.**

Keywords-eLearning; LMS; SaaS; Business workflows; Multi-tenancy

I. INTRODUCTION

Software as a Service (SaaS) defines the application delivery model contrary to the traditional on premise software installation. With SaaS, software is maintained and updated on the cloud at one place and is delivered to the clients as service usually through the browser. Through this model clients do not have to worry about the resources required for application running, such as network, servers, middleware, system and network administration team and so on. The pricing model adopted in the SaaS is the subscription based, so the customers will go for pay per use and get relieved from product trails, installation, software upgradation and long term investment for application license.

Multi-tenancy being one of the key features of SaaS, the service providers are able to offer single application to multiple clients. A multi-tenant application caters a personalized customer experience improving performance and efficiency and provides a flexible space for customers to efficiently pursue new business demands. From the software vendor perspective, such multi-tenant applications, improve resource utilization and reduce the operational costs in delivering the software as a service. Each of the tenant may have unique requirements that differ from each other. Customization plays a vital role to converge specific requirements of every tenant. It is upto the vendor, what extent of customization to be offered to the tenant, either full automated customization or semi-automated customization.

Achieving business process customization using workflow Engines, to meet the demands of tenant's business requirements, is really a challenging facet. In the context of the eLearning applications, it is perfectly suitable to manage the eLearning application by automating the manual business process to effectively manage multiple tenants' ever changing requirements. The paper proposes a multi-tenant eLearning platform using Workflow engine to orchestrate the learning services.

The rest of the paper discusses:

1. An introduction to eLearning
2. Background Survey: SaaS Model for eLearning systems and Workflow Technologies

Proposed multi-tenant based eLearning System

II. ABOUT ELEARNING

In general definition, eLearning is a form of online learning in which the instructor and learner are separated by space or time where the gap between the two is bridged through the use of online technologies. This web-based learning makes the learner to learn from anywhere, anytime, at their pace. eLearning is the combination of learning services and technologies to provide quality and enhanced learning methods for the students and teachers. It includes all forms of electronically supported learning and teaching, ranging from CD-ROM based to satellite based. The information and communication systems, serve as specific media to implement the learning process [12]. The quality of learning services is much more important in the case of educational systems in most of the developing countries where student teacher ratio is very high and they lack the skilled instructors/ teachers.

A Learning Management System (LMS) is a web-based application that is used to centralize and automate the administration of the eLearning activities such as managing, tracking, and reporting on training events [8]. The main eLearning services of the LMS include user registration, content delivery, assessment capabilities, Query Answering system, reporting and Collaboration services. An effective LMS should provide an online environment to the administrators to easily manage user registrations and profiles, course creation, role assignments, manage content, and administer the enable other eLearning services in the requirements.

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III. BACKGROUND SURVERY

A. SaaS Model for eLearning systems

Perceiving the advantages and the sustained market size, eLearning vendors have started adopting cloud computing technology. There are three critical factors driving the popularity and growth of the SaaS model for eLearning:

1) Speed to implementation and ability to impact business immediately;

2) Direct cost and resource savings; and

3) Outsourced system and technical expertise.

When compared to traditional client-server installations, these factors offers the organizations lower total cost of ownership (TCO), and a substantially higher and faster rate of return on investment (ROI) [3].

Anwar and Xiaodi [4], proposed an eLearning cloud architecture, which is divided into the following layers: Infrastructure layer, software resource layer, resource management layer, service layer and application layer. The infrastructure layer offers a pool of dynamic and scalable physical hosts, the software resource layer provides an interface for eLearning developers, resource management layer accomplishes loose coupling of software and hardware resources, service layer, containing three levels of services: software as a service(SaaS),platform as a service(PaaS) and infrastructure as a service(IaaS)) and application layer provides the eLearning features such as content production, content delivery, virtual laboratory, collaborative learning, assessment and management. Pongpech, Sadiq and Orlowska [5], have presented the successful utilization of workflow technologies in eLearning domain and also presented a brief analysis of various classes of dependencies that can exist in eLearning processes. Gonzalez and Catillo [6] have discussed on how work flow technologies are suitable in an eLearning centre. The proposed eLearning system consists of a course manager that allocates the execution of a set of tasks among the existing human resources. Also the paper discusses how to store the most of an eLearning business model in XML Process Definition Language (XPDL), and to convert it into a planning representation, utilizing the Hierarchical Task Network (HTN) paradigm. Workflow Technologies

Multi-tenancy is the most required characteristic of SaaS applications, where each tenant may have their own set of services. These services need to be customized by each tenant based on their business requirements which involves defining the business process. Business process plays pivotal role in customizing the services as per client's requirements. "A business process or business method is a collection of related, structured activities or tasks that produce a specific service or product (serve a particular goal) for a particular customer or customers. It can often be visualized with a flowchart as a sequence of activities with interleaving decision points."

The business processes must be orchestrated by using business process orchestration tools or services to define a workflow. BPEL (Business Process Execution Language) is the industry standard for business process orchestration. BPEL is an XML-based language which is used to define and execute business processes and also Web services for scientific workflows. BPEL is utilized to orchestrate and publish business process by composing web services. The deliverable is composite web services which is a mixture of several web services.

Workflow is used to automate the repetitive business activities. A workflow is composed of orchestrated and repeatable pattern of business activity which is enabled by resources organized into systematic approach and these resources transforms materials, provide services, or process information [11].Main usage of Workflow Management System is to define, manage and execute "Workflows" by executing computer representation of the workflow logic.

Apache ODE (Orchestration Director Engine) software executes WS-BPEL standard based business processes. Apache ODE communicates and transacts messages to and fro to web services, handles data manipulation and error recovery as per process definition. Apache ODE is a Java based, reliable, compact, and embeddable BPEL execution environment and supports WS-BPEL2.0 and BPEL4WS1.1 (Business Process Execution Language for Web Services) standards. The key components of the ODE architecture which includes the ODE BPEL Compiler, ODE BPEL Engine Runtime, ODE Data Access Objects (DAOs), ODE Integration Layers (ILs), and user tooling. The job of ODE BPEL compiler is to convert BPEL documents into executable forms; runtime executes these forms by relying on persistent store accessible via the ODE DAOs. The ODE Integration Layer provides a context for run-time to connect the ODE engine to the execution environment.

WSO2 is an open source OSGi based components framework for SOA. WSO2 Business Process Server multi-tenant architecture provides tenant-resources isolation and sharing of system resources across tenants. WSO2 carbon platform is base for WSO2 BPS which uses Apache ODE as BPEL execution runtime. To achieve isolation in multi-tenant context, there are two mechanism used by Multi-tenant BPS. One is to have a Process Store per tenant. In this mechanism, Process store saves isolated data for each tenant in tenant's own registry space. Second mechanism proposes to use Axis2 multi-tenancy support for Multi-tenant BPS which isolates all external interaction for each tenant and also find and validate current tenant.

IV. PROPOSED SYSTEM

In a multi-tenant infrastructure, a LMS can be hosted for the large number of educational institutions within a single instance of the LMS application software. Multitenant applications are typically required to provide a high degree of customization to support each target organization's needs and quality of service. Customization typically includes branding, workflow, extensions to the data model and access control [13].

The proposed multi-tenant based eLearning system architecture enables in setting up the educational institutions/organizations to manage, assign and assess the groups of students with the help of eLearning services and

activities. It has the ability to create organization/educational institutions which can be placed on top of proposed system that provides a space where users, courses, activities can be created and managed based on the privileged roles. These are kept separate logically but can have their own branding and the users from one organization/educational institutions are isolated from another.

Each educational institution can then select their own users, courses, instructors and custom/predefined themes and are confined to each other. The dynamic template driven interface provides the custom theme branding and rearranging the view, positioning the widgets of each page, etc. whenever the user requires. The final customized theme will be stored and exposed to the users on request. Once the user (instructor/student) logs into this Multi-tenant based LMS platform they can choose and access the courses enrolled for.

Figure-1 renders the customization process of the eLearning services using a workflow designer unit, an Orchestration unit and a user interface Builder unit. The Tenant Admin of each education institution has the privilege to orchestrate the eLearning services using these units. Each tenant will have their own set of configuration files and workflow templates which would be used to process by the workflow engine during the runtime environment.

Now the users of each tenant group can access the learning activities that are designed by their tenant admin. The workflows designed by each tenant-admin can be updated or configured at any time without any source code compilation or deployment.

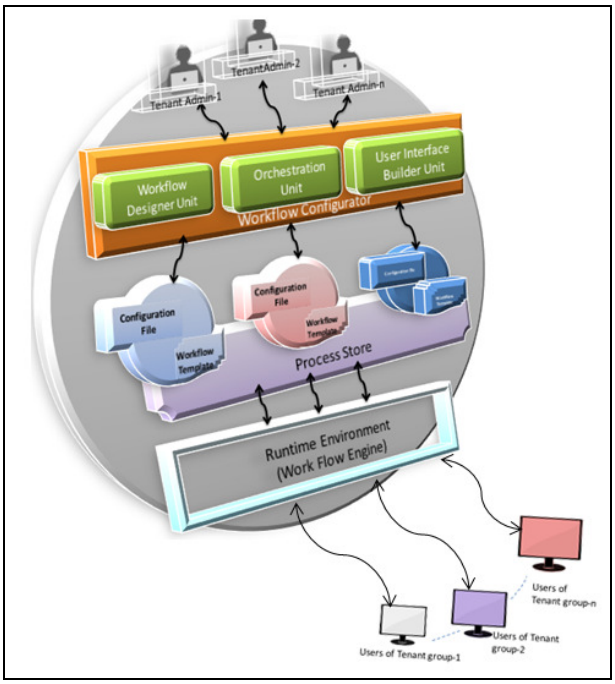

Figure 1: Workflow Configuration System of LMS

BPEL is used to automate these workflows, thereby increasing the efficiency and productivity of the organization. This occurs because the automated workflows drive the processes so that the organization can focus on doing work, rather than on managing the processes.

In this system (figure-2), the tenant admin has access to customize the eLearning application based on the configurable points allowed within the application. Tenant Admin can configure UI pages, organizational structure of the tenant, data models, workflows, and business logics in the form of containers and components. When a workflow activated by a user, the Workflow Engine retrieves the workflow from the Workflow Repository and executes activities in sequence from the Process Meta DB. Metadata Management System provides metadata API for Business Logic Tier. When these API calls are used by business Logic Layer, Metadata Management System converts the request to the optimized query to retrieves tenant specific UI pages and data.

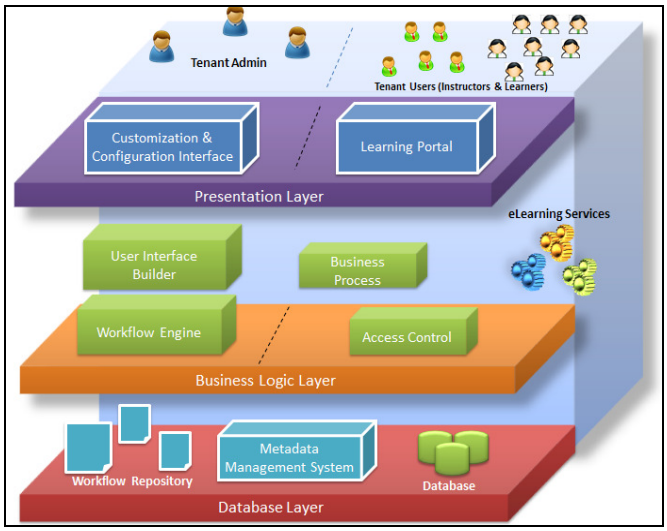

Figure 2: System Architecture of Multi-tenant based eLearning system

Data model and data fields cannot be predicted for each tenant Admin, therefore extended fields are provided when the data model is created. Information of extended fields for every tenant admin is managed by Metadata management system, and is used for retrieving tenant specific UI pages in runtime. Stores configured aspects of SaaS application by the tenant Admin. Manages codebase of applications and user generated data. XML-based workflow files are stored in Workflow Repository. A case study is presented below in this section to demonstrate the utilization of workflow engine for orchestrating one of the learning service namely assessment.

For web based solution, the business logic must be distributed into different services. This environment provides the flexibility to design all the possible workflows which can be preserved for different scenarios.

A. Case Study

A case study is described by using online assessment which is one of the eLearning services the web services. Online Assessment is the process used to measure certain aspects of information for a set purpose where the assessment is delivered via a computer connected to a network (LAN or WAN). This online assessment identifies the initial ability level that acts as

the quantitative evidence to show that some learning is occurred at student's side [13].

In this context of online assessment component, the complete set of functionalities required for conducting an online assessment were exposed using multiple web services namely Question Authoring, Quiz Authoring, Quiz Delivery and Result Processing services. Questions required to conduct the quiz are stored in Question Authoring service repository which were created under a specific topic/unit/course level by the instructor. Manually or randomly questions are picked up to formulate the quiz template under Quiz Delivery Service. These quizzes which are ready to deliver are assigned to the students or learners under the specific course as part of the learning activities.

This Online assessment component can be incorporated with any LMS to assess the students registered under a course. Using the web services of this component various assessment types such as pre, self and post assessments can be formulated but for each type the requirements and sequence may vary based on the workflow designed by the tenant/educational institution.

For example a tenant/educational institution holds the complete course information (such as course structure, course material and other activities) in the LMS side, and want to use the online assessment as a service into the LMS. It has the requirement for a specific course/learner group, during the learner registration the prior knowledge need to be captured or the learning style has to be logged to provide the recommended learning path during the content delivery.

Using this system the tenant admin can define this business rule and the constraints using the workflow designer, and finally can map the new workflow for the selected course/learner group without modifying the source code of the service.

In a scenario [figure-3], quiz need to be scheduled or assigned to a student or group of students based on certain rules defined by an instructor of a tenant group. Keeping this requirement in the mind, the assumed sequence of steps are mentioned below:

- Firstly the learner has to be registered to participate in the quiz
- And the readiness of the quiz is to be verified (the selected quiz is ready to deliver based on the quiz parameters like time bounded, hints allowed, navigation allowed, etc) to conduct the quiz.
- Based on the results of the above constraints the quiz has to be imported, specific attempt set is generated or not.

Mentioned web services are actually holding the business logic in the form of service operations that are actually mapped with rules using the workflow designer unit. Once the required workflow is designed the user input interface can be customized and integrated with LMS.

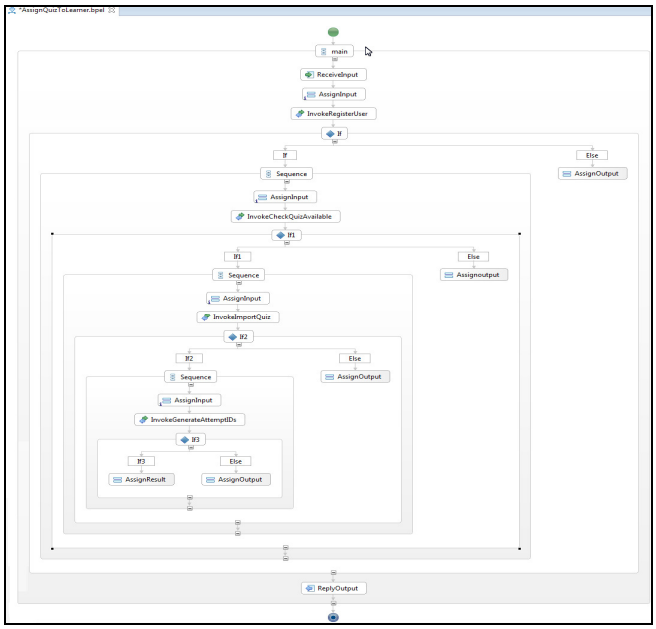

Figure 3: Workflow designed using Apache ODE, where all the criteria are drawn using if-else blocks

If all the constraints are met, then the student can participate in the quiz. With the need of such dynamism provides the flexibility for each tenant to choose the definite workflows/specific rules according to their assessment delivery models.

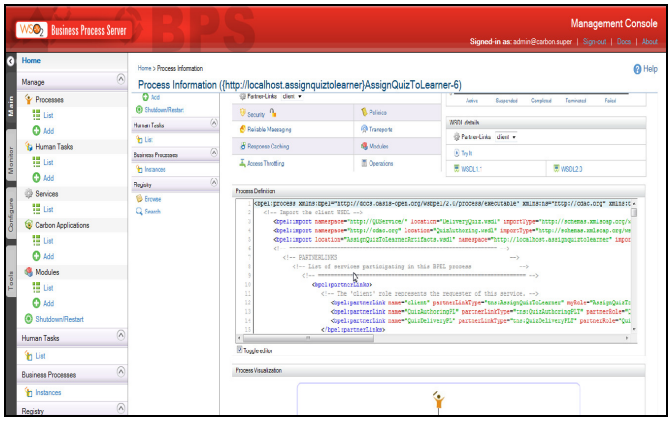

Figure 4: Workflow deployed in WSO2 Business Process server

This is the assumed criteria of the tenant which was presented by using the proposed system, the instructor of the specific tenant group can easily design his/her own workflow. In figure-5, the designed workflow is tested by proving the required inputs.

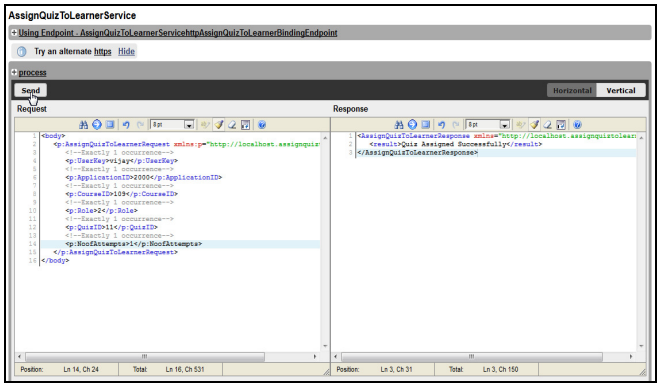

Figure 5: Screen shows how the newly created workflow can be tested with the required input parameters

CONCLUSIONS& FUTURE WORK

The key benefits of the workflow engines for automating the manual business process in the eLearning system have been presented. We implemented the customization feature of the assessment learning service in the proposed multi-tenant based eLearning system.

The current proposed system is conforming to SaaS maturity Level 3(multi-tenant efficient and configurable). In the future, it is planned to implement the system conforming to SaaS maturity Level 4, which is Scalable in nature leveraging the full benefits of the Cloud infrastructure capabilities for scaling up the application on demand basis.

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