AGGREGATING ASSESSMENT TOOLS IN A SERVICE ORIENTED ARCHITECTURE

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Abstract

Until recently assessment and other eLearning systems have tended to adopt monolithic architectures and this has restricted integration with other tools. The ELearning Framework (ELF) sets out to address this problem by creating an eLearning environment within which components with discrete purposes communicate via webservices. In order to help co-ordinate the design of the ELF, JISC has recently sponsored a number of Framework Reference Model Projects, and Frema is the Framework Reference Model for Assessment. In this paper we examine how Frema is facilitating a common understanding of the components of assessment and their interfaces, and we explain how this information is being elicited from the community by reference to tools which are already contributing to the model. We also present our approach to the adaptive website by which the emerging model is being disseminated to a range of stakeholders.

Introduction

Over the past two years Joint Information Systems Committee (JISC) funded projects have been developing web services to facilitate the construction of a service orientated eLearning environment. As part of the ELearning Framework (ELF) JISC has now funded several domain reference models to provide a map for service development. We report on early work in the Framework Reference Model for Assessment (FReMA) that is poised to become a key resource in coordinating effort in using, developing and aggregating assessment services

First we discuss some of the benefits of developing software inside a Service Oriented Architecture (SOA) as explained by (Blinco, Mason et al. 2004; Wilson, Olivier et al. 2004). In particular we identify the issues in Computer Assisted Assessment (CAA) development that a SOA will help to solve. Next we explain some of the structure of the reference model and how Frema is

making the appropriate levels of this structure visible to assessment domain stakeholders. Following this we highlight some of the projects included in Frema's scope. Finally as an illustration of Frema's value we present some ongoing work that will be able to use Frema's reference model to coordinate service definitions in the development of an application

The Benefits of a Service Oriented Architecture

A SOA has an important part to play in removing the barriers to wide-scale CAA adoption. When investigating these barriers, (Conole and Warburton 2005) found that institutional rather than technical issues are the greatest concern. Further development of the technology can help to remove these barriers particularly in the areas interoperability and ownership cost. Service architectures are well suited to an open modular development methodology that facilitates integration of sub-components and allows bespoke services to sit alongside those provided by core systems. SOAs may be used to help an organisation reduce its cost of ownership by facilitating software evolution, increasing interoperability and integration and avoiding the need to pay for unneeded modules in tightly integrated monolithic software products.

Some of the continuing problems in CAA that a SOA can address are:

- assessments that are locked inside their creation environment
- poor mechanisms for sharing and discovering questions
- authoring tools that require knowledge of XML to realise their full potential
- the prohibitive per-user cost of delivering high-quality systems to low numbers of users
- extracting results and inserting them into institutional records

Solutions to these issues exist already but poor integration or alternatively high levels of inter-component coupling mean that these solutions are not available in all situations.

Integrated Services in the Assessment Domain

Some of the barriers to achieving the benefits of SOA's are the difficulties of finding appropriate web services that match a defined requirement, are reusable and are designed for interoperability through compliance with appropriate standards. Furthermore it is difficult to identify where in the domain new web services are needed to fill gaps in functionality and when new web services are created, ensuring that they will interoperate with existing services.

(Wilson, Blinko et al. 2004) suggest that a reference model will provide a resource to address these difficulties. They describe a reference model as

"... a selection of Services defined in one or more Frameworks together with rules or constraints on how those Services should be combined to realize a

particular functional, or organisational goal. A Reference Model constrains the number of unique organisational infrastructures". Thus it is a description of how services behave in a particular domain.

Frema is one of five ELF Reference Model projects in the JISC e-Learning programme. The goal of Frema is to develop a reference model for systems in the Assessment domain of e-learning that are built on top of Service-Oriented Architectures, such as Web Services and the Grid, and in particular the JISC ELF. The Assessment Reference Model will describe how the assessment domain maps to the ELF and thus acts as a driver for implementation and evaluation. Once complete, the Assessment Reference Model will ease the development of further services and promote the re-use of existing ones.

Assessment is a large and complex portion of the e-Learning Framework, interacting with Virtual Learning Environments, Portals and Marking Tools at the User Agent layer, multiple Learning Domain Services including Sequencing tools, Grading, Marking, Reporting, Competency and Tracking and relying on most of the ELF common services.

The Assessment reference model will include:

- A domain definition that will describe the scope of the Assessment domain, including evidence that gives an overview of current practises, processes and systems.
- A set of use cases that describe common solution patterns in the Assessment domain area.
- Service profile definitions for both existing services and those that need to be developed for the Assessment domain area, their scope, behaviour, and data.
- Assessment reference model prototype implementations.

However, as we have seen, the size and complexity of the assessment domain means that for the reference model to be a usable community resource, the complexity must be hidden so that it is easy to locate resources within it and accessible to a variety of users with different needs. It must also be dynamic and evolving.

The Frema project view is that in order to ensure this usability the reference model should be an evolving, cross referenced, searchable web site. It should contain indexed resources and narrative descriptions of the domain, UML use cases and scenario documents, service profiles and service implementations for re-use. There should be different gateways into the model according to how a user may want to use it.

The creation of the Reference Model for Assessment resolves into two distinct problems both of which are tractable by software engineering methods; the first is the development of the reference model itself, the second is the development of prototype, exemplar web services for the assessment domain that will be published through the reference model.

In this paper we will describe our approach to solving the former problem.

More formally:

- We can describe a set of use cases for the reference model itself and show how they may be derived.
- We can describe a layered architecture for the Reference Model which has been specialised as a Service Oriented Reference model.
- We can show how techniques from adaptive hypermedia can be used to fulfil the goal of providing a searchable, dynamic website accessible from many gateways.

Requirements Elicitation

We chose use cases modelled in UML together with scenarios as a method of eliciting the behavioural requirements for a Service Oriented Reference Model. However with the wide range of potential reference model users, one software engineering problem is to identify and then design appropriate interactions.

We used an agile modelling technique 'Personas' (Cooper and Reimann 2003) in order to investigate the requirements of different users of the reference model. To place personas in a modelling context, if actors and use cases may be considered as abstract classes, then personas and scenarios may be considered instances of those classes where an actor is characterised in detail and their personal interactions with a system visualised in detail.

This technique is typically used to model interactions at the user interface level but here we have used it to model user interactions with the reference model as a system. With this method, we are using concrete instances to help us understand and define requirements at the abstract level. This enables us to focus clearly on creating the reference model as an adaptive resource that provides information according to the users' needs.

These two examples of personas, each with a scenario describing an interaction, demonstrate how we have applied the technique to designing the Reference Model.

Persona 1, Will:

'Will is an application developer in an academic institution. He is a 30-something post-graduate. He has a good knowledge of the assessment domain and has java and web services technical skills. He is developing an open-source application in the assessment domain focusing on feedback methods.

Scenario*:*

I want to lookup use cases and scenarios to help me design my application. This will help me to define my footprint in the assessment domain. I see there are some web services I could download to re-use but some are missing. What standards can I use when writing my own web services to ensure that I can interoperate with the web services I've chosen?

Persona 2, Yvonne

'Yvonne is a resource manager at a higher education institution with a background in academia and education. She is planning the institution's five year strategy for e-learning. She is responsible for ensuring that new systems meet quality assurance standards. She has a strategic grasp of the importance of e-learning but she is not an expert in the assessment domain.

Scenario

I want an overview of what this domain is all about. I want to know what standards are applicable in the domain to ensure that we comply with quality assurance requirements. I want to examine use cases and scenarios to understand the available footprints. I also want to know who the key players are and what the key projects are.

From these two personas at opposite ends of the user spectrum we can see the need to provide for very different interactions and access to very different levels of abstraction.

Publishing the Reference Model

Project findings are being used to populate a dynamically generated website, which will be personalised according to the level and scope of the user's interest in the reference model.

Different views of the reference model are generated through concept maps that categorise the domain and provide an overview and a way for users to orientate themselves within the space (an example of a concept map would be a taxonomy of the domain based on processes). From this users will be able to focus and drill down through levels of abstraction to get comprehensive details about one element in particular.

The detailed element pages will be adapted according to the concept map through which the user arrived. This allows our different types of users to engage with the model at the level at which they feel most comfortable (for instance, with code and WSDL descriptions, or with projects, people and standards).

We hope that presenting the reference model in this way will allow it to become an accessible and engaging resource that practically assists in the creation and aggregation of assessment services.

Placing Frema in Context

Here we describe a number of recent and current projects that all have a significant contribution to make towards assessment services. The results of many of these and others will be used to help populate Frema's reference model. Frema has an important role to play in helping to publicise these efforts and ensuring that future work can coordinate with, and make use of, them.

Remote Query Protocol (RQP) (Smith 2004) is being developed by the ServingMaths project, to create a protocol to support remote rendering and processing of question items in a SOA. This is a problem that has been a source of constant concern to those assessing the mathematically founded disciplines; very few available engines have the required sophistication to render mathematics. RQP is aware of the fragility of a distributed architecture and includes mechanisms for fail-over and load balancing. Demonstration systems using RQP to deliver mathematics questions have been able to use a choice of question renderers for an assessment depending on the demands of the question. This is an excellent example of how the SOA puts power in the hands of the assessment authors.

Assessment and Simple Sequencing Integration Services (ASSIS) builds on the work of TOIA (TOIA), APIS (APIS) and ISIS (ISIS) in connecting an item bank with an IMS Question and Test Interoperability (QTI) player and a service for running IMS Simple Sequencing (a method of specifying multiple paths through learning material). Item banking services are provided both by an open interface to TOIA and also by an interface to Samigo (Samigo), the Sakai project's assessment system (Sakai). ASSIS is using CAA to give formative feedback to students as they work their way through learning packages. By combining different and also equivalent services ASSIS is providing a small-scale fully functional test-bed of a SOA. One key decision in the ASSIS development has been the use of Business Process Execution Language for Web Services (BPEL4WS). This is an XML-based flow language that defines how business logic encapsulated in a number of remote web services may be combined to achieve some higher level process.

The Tools Integration Project (TIP) like ASSIS has successfully combined services from different systems to deliver end user functionality. This has been done by enabling the Bodington Virtual Learning Environment to consume web services provided by LAMS (LAMS) and TOIA and has included use of RQP.

Storage and Packaging of Assessment Item Data (SPAID), a collaboration between the University of Strathclyde and the Scottish Qualifications Authority is now building a service oriented itembank that will enable interaction with existing assessment services. SPAID will be capable of storing Learning Object Metadata (LOM) about each item and also the QTI usage data relating to each item.

D+ (Discovery+) is a service for conducting federated searches; it allows users to search for information hidden from simple searching mechanisms. D+ provides a service for searching the deep web hidden under database style indexing systems and other dynamic content generators. By being aware of a number of search protocols such as the Z39.50 protocol for searching libraries, D+ can present users with search results compiled from a number of sources. Federated search is important in the context of SOA CAA as it could be used to combine searches over a number of item banks that provide differing interfaces to their content.

The European Learning Grid Infrastructure (ELEGI) describes one of its goals as to define and implement an advanced service-oriented Grid based software architecture for learning Security in eLearning, and particularly assessment, is an important issue from a number of points of view, often summed up as "the three As"; authentication, authorization and administration. We must know that the student taking an assessment is authorized to take this test and has been authenticated as the person they claim to be, and when they have completed the test we must understand how to route the results. In existing SOAs based on protocols such as web services, the issues of security, identity, access management and managing transaction persistence are not managed at the protocol level. Having to address these issues whenever a new service is created is a cumbersome overhead and is currently causing enormous problems within the world of global campuses working with heterogeneous software systems. By deploying its services over grid middleware ELeGI will remove much of the burden on individual service developers in addressing these problems. Robust proven grid middleware will be a valuable tool for the VLE service author.

Future Work

In the Frema *application developer* role, we are using Frema to assist in communication between SPAID and ourselves. Examining Frema's initial survey of existing services has identified scope for further development in the way that users interact with item banks. By utilising SPAID services we seek to enhance the user interaction experience with an itembank inside the ELF. Feeding back the descriptions of our new service interfaces into Frema will make the results of our work available to all. Some of the rational behind and direction for this work is outlined below.

Supporting the User in Creating CAA

Question and assessment authoring is a significant proportion of the work in being able to deliver CAA, (Bull and McKenna 2000) found that computer anxiety was considered to be more of a problem for academics than for students. When creating questions and assessments a teacher will have to spend much more time interacting with the system than the students taking the test. Authors of computer based tests face additional hurdles not experienced by authors of paper based tests. Not only must they ensure that the tests are educationally sound but they must also be aware of the

affordances and constraints of the electronic medium. Supporting test and assessment authors with powerful and intuitive tools would appear to be an important enabling factor for CAA.

Item Banking

National level item banking was the most frequently mentioned development expected in CAA by educational technologists in Bull and McKenna's survey. The ability to re-use existing resources, rather than recreate their own provides a strong reason for a teacher to interact with such a repository, with the caveat that it must be possible for them to find material appropriate to their needs easily. The requirements of a national item bank are described in detail by the IBIS report. Basic facilities are item storage, search and retrieval. Extended functions include user rights management, the ability to assemble items into assessments and to deliver alternative but equivalent items. IBIS recognises the need to ensure that the items in the bank have been properly peer reviewed as part of a quality assurance process; it also recommends that the usage data concerning an item be fed back into the system. Usage data is crucial in maintaining quality assurance of assessments and we also aim to leverage it in enhancing item discovery.

Personalised Item Searching

Finding appropriate resources inside a large itembank is a significant challenge and sophisticated search and discovery mechanisms fall outside the scope of SPAID. Problems may be caused by inexact taxonomies, different opinions on classification, and through imprecisely expressed search criteria. Given the lack of agreement on the precise meaning of key areas of Learning Object Metadata (LOM) an item discovery solution that does not rely wholly on classification has potential to help users to find precisely what they need. A strong solution would offer both an intuitive user-focussed interface *and* an underlying system that was capable of identifying content particularly relevant to an individual user. We aim to research possible solutions through the application of recommender systems to the underlying services provided by SPAID.

An itembank user interface similar to that offered by Amazon the online retailer is described in the executive summary of the IBIS report (Sclater 2004). This builds on the E3an project's use of a shopping cart metaphor to help its users maintain a selection of questions for export. Using a familiar metaphor for engaging with a system helps to inform inexperienced users' expectations of how the system should perform. Examining the shopping website comparison further leads to consideration of how users discover the questions or goods they need. The use of recommendations and targeted advertisements aims to present users with the goods that they are most likely to buy. Collaborative filters or recommender systems as described by (Linden, Smith et al. 2003) can be used to examine the relationships between users and goods and make suggestions for purchases.

Much work on collaborative filtering has been carried out in the web/hypertext community to assist users in finding content. By utilising the results of this work it is hoped to provide a user interface that includes effective adaptive

filters to assist users in finding the questions that they need. It is hoped that ease of use of this interface into existing questions will foster greater uptake of CAA.

Conclusion

The future of assessment systems constructed by service integration holds much promise. Many of the core underlying services exist already and much work is taking place in combining these services to deliver complete end-user functionality. The Frema reference model has an important part to play in ensuring that service development in the assessment domain is coordinated. The service approach is enabling the development of small increments in functionality that can be utilised in conjunction with other systems.

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