Itembanking Infrastructure: A Proposal for a Decoupled Architecture

Mhairi McAlpine, Brendan Tierney, Linn van der Zanden

Scottish Qualifications Authority

Linn van der Zanden

Computer Assisted Assessment
Scottish Qualifications Authority
Hanover House
24 Douglas Street
Glasgow G2 7NQ
Scotland

Linn.vanderZanden@sqa.org.uk
Abstract

The paper aims to provide an outline of the elements which make up the architecture of a decoupled itembanking system. We have divided the system into four main elements: the storage of items, the generation of items, item delivery and test construction. Within the four main elements, sub elements will be identified. These will be explored with a view to defining the functionality of each element independently to allow autonomous development – fitting in with a standards based decoupled system. The paper will focus on a ‘reference’ diagram which will provide an overview of the elements and associated software, the relationships between them and the overall interaction of the system.

1. Introduction

With recent developments in educational technology and emerging standards, item banking is coming to the fore as an efficient and cost-effective method of re-cycling expensively produced examination material. Although awarding bodies internationally have used itembanking for decades and computerised systems for over 30 years, the advent of XML and a standardised way of describing assessment data encoded in the IMS QTI specification - together with the technological possibilities opened up by large scale distributed systems, have given people confidence in the stability of the technological approach.

Although computerised itembanking is nothing new, existing systems tend to be monolithic entities with fixed functionality. Revamping or adding additional functionality is prohibitively expensive, however as we enter the brave new world of computerised assessment – taking advantage of the increases in assessment approaches and validity enhancements that this will bring, requires a flexible technological architecture.

This paper proposes a decoupled architecture, based on international standards and a webservice approach to the integration of functionality. This paper envisages the itembank as a unit made up of two components; a database which facilitates metadata storage, retrieval and search functionality, and a repository which facilitates the storage of items, resource files and manifest files. However, this bank is merely the datastore for a larger system which sits around the bank, feeds into it, interrogates it and exports from it.

2. Rationale for a decoupled system

Diagram 1 below suggests a potential architecture for a decoupled itembanking system. At its centre is the core itembank – comprised of a database and linked repository together with content unpackaging functionality. To the right are services associated with the generation and input of items; to the left are services associated with the export and delivery of items and in the bottom area of the diagram are services associated with test construction.

Most existing systems conflagrate a number of these pieces of functionality into one software system, locking a user in to one provider and therefore requiring compromise to establish the best overall fit. Decoupling the system in this way facilitates a “mix and match” approach, so long as each element conformed to international standards and specifications. Furthermore, elements may
be replaced on a rolling basis with continual evaluation – proving an ability to keep up with new assessment approaches without periodic major upgrades. Particular advantages include:

- It can be easily adapted to accommodate a change in the model or workflow processes.
- With a modular approach small chunks can be built and used immediately, with existing processes used to fill in the gaps until the next pieces are built.
- As the specifications grow and develop, pieces can be upgraded in line. Furthermore, it can be developed cross-institutionally ensuring community involvement.
- As CAA beds in and people become more sophisticated in the use of itembanking, additional demands will be placed on the system. A modular architecture allows for these to be slotted in at the appropriate points.

There are however consequences and implications of adopting a modular approach:

- There is a need to ensure standards compliance. Not just to the strict specifications, but where the specifications are loose to ensure that the manner implemented is in line with existing or best practise.
- As a workable system will not be developed in one go, manual processes and pre-existing software systems will have to be built into the workflow, this may require developing additional functionality that will not be required once the full system is in place.
- Where a piece of the architecture is faulty, the possibilities for computer interaction with little user input may lead to difficulties with early
detection of errors. System testing of each piece must be highly robust before it goes live.

3. What does itembanking entail?

3.1 Storage of items: the Itembank
In essence, the itembank consists of two elements: the database and repository with integrated content unpackaging to de-aggregate the elements of the content package and deposit them into the repository and database.

3.1.1 Database
The database stores the metadata and QTI metadata and houses the search and retrieval functionality.

3.1.2 Item repository
The repository stores the QTI files, any associated resources from those files and the manifest files from the imported content packages.

3.2 Generation of items
The software associated with the generation of items for an itembank would depend on the content of these items. The IMS Question and Test Interoperability (QTI) specification is a standardised format for exchange of assessment item data – as such it makes sense for this to be the native authoring output. There also may be additional specialist software required associated with authoring items which have particular requirements – such as the inclusion of mathematical notation or multimedia elements.

Apart from the authoring of the questions, metadata associated with these questions is necessary to enable searching. Application profiles can simplify data entry particularly where there are a large number of similar questions being entered at once, increasing both speed and accuracy of metadata entry. Such profiles could be generated by an additional piece of architecture.

3.2.1 QTI Authoring Software
This allows questions to be created and exported in QTI 2.0 format. It requires no input other than manual, although may take in code/links from specialist authoring tools. It would output files in a QTI 2.0 format for use in a packaging tool or direct use in assessments.

3.2.2 Specialist Authoring Software
This develops parts of the items which cannot be directly encoded in QTI 2.0 but are instead either embedded or called in the item.

3.2.3 Metadata Tagger
This attributes data to the items held in the bank, such as the author, the subject area of the question and the type of item and enables metadata to be entered and items to be linked with metadata which conforms to the international standards available for tagging learning objects in general (LOM) - an international standard for metadata - and items in particular (QTI metadata).

3.2.4 Application Profile Development Software
This facilitates the development of application profiles (or customised templates) based on the LOM, which prefill or restrict the entries that are allowed into the fields, although it is recommended that the entire data schema is implemented even if many elements remain hidden to the end user, in order to ensure interoperability.

3.2.5 Content Packager
This packages together the elements of QTI 2.0 items according to the specifications of the IMS content packaging guidelines, facilitating import into any repository which recognised such standards.
3.3 Delivery, Marking and Result Processing

Delivery, marking and result processing are post-itembank activities. After delivery, the marked items are fed through the Result Processing Service which informs the Candidate repository and may interact with additional Services such as candidate profiling or administration and certification software. In turn, the Delivery system will submit all candidate interactions with questions to the Master Results Databank.

3.3.1 Delivery Software
This imports the assessments from the itembank in the form of a QTIv2.1 package. On completion of the assessment, the delivery software sends the recorded responses to the Marking Processing software.

3.3.2 Marking Processing Software
This software consists of several elements which each facilitate the processing of different item types.

There are three major approaches to mark processing; the first marks items entirely automatically, the second refers the items to a system where they are entirely human marked and the third uses a mixture of computer based and human marking.

Question types which are best marked entirely by computer include Multiple Choice, Multiple Response and hotspot questions- each with their individual response processing template. Questions to be human marked, such as essays, would include a human readable mark scheme, while those using a mixed model- either human marked with a computer check or computer marked with human support- would use both.

3.3.3 Result Processing Service
This software aggregates the marked items according to the requirements of the qualification, implementing the pass mark or grade boundaries which may be in force.

3.4 Test Construction

3.4.1 Glossary Development Software
This element would produce a glossary which defines the statistics to be used in the test construction system, providing the basis for the item analysis to take place, outputting a glossary in a standardised QTI format.

3.4.2 Test Construction Software
The test construction software consumes application profiles together with the glossary to produce an algorithm, comprised of metadata (both LOM and QTI) and statistical terms which define the rules for test construction. These are then split – with the metadata first being sent to the bank, which identifies an item pool which meets the defined criteria.

The items are then matched with candidate interactions from the master results databank, to produce a dataset which is sent to the item analysis software together with the statistical conditions from the algorithms being sent to the item analysis software.

3.4.2 Item Analysis Software
This software runs the required analyses from the algorithm, identifying items from the pool which meets the conditions. Those items which meet the conditions of the algorithm are then passed back to the itembank for retrieval and packaging into tests.
4. Conclusion

This is a first attempt at scoping the potential for a decoupled architecture for itembanking using webservices for data exchange. It is not designed to be a finished system nor to provide a complete solution. Beyond the definitions of services and their interactions, the precise requirements for each of the elements must be scoped. The roles of users interacting with the system need to be defined and the workflow processes likely to be used must be identified.

This is intended to build on the existing work that has been done in the field and suggest the potential of webservices in this area.

4.1 Establishing Requirements

One of the first tasks in the development is establishing the requirements for each of the elements of infrastructure, which systems it will interact with and how this might be facilitated.

A first attempt has been made with the SPAID project [1] – particularly in the areas of metadata generation and content packaging.

4.2 Roles

This area is yet to be defined, in particular with regards to an overall system. Previous attempts to capture user roles and processes include the IBIS report [2] and User requirements for the ultimate online system [3].

Each of the four elements discussed throughout the paper would have different users interacting with them. These roles and their interaction with the system is briefly explained. It should be noted that the same people/users of the system may take on several ‘roles’ i.e. an author of items could be the same person as the author of tests. Each role would have administered rights and access to the bank.

4.3 Workflow Processes

Again, this is an area which requires further consideration, although some workflows on the generation of items (left hand side of diagram) have already been established in systems. One of the advantages of a decoupled architecture however is that workflow processes may be changed as demands placed on the system change over time.

Business Process Execution Language (BPEL) may be used to orchestrate and manage the workflows, in which partners in the process are identified and declared, the workflow is designed and defined and business logic is added using BPELConstructs before validation and deployment take place, giving a clear overview and relationship between the processes in each element of the Infrastructure.

5. References