The Aus-e-Lit Project: Advanced eResearch Services for Scholars of Australian Literature

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Abstract:
For the past eighteen months, the eResearch Lab at the University of Queensland has been working with the Australian Literature community on the Aus-e-Lit project. Aus-e-Lit is a cross-disciplinary collaboration that is developing eResearch tools for scholars of Australian literature who are members of the AustLit consortium. The AustLit Web portal provides access to a comprehensive bibliographic and full-text collection that is considered the peak resource for scholars of Australian literary heritage. The portal also provides a mechanism for the dissemination and deployment of the eResearch services that are described in this paper. These include: text processing services, federated search services, annotation services, compound object authoring tools and advanced visualisation services. Within this paper we describe how we combine these services to represent semantic mashups of literary resources as OAI-ORE compound objects that can be discovered, re-used, adapted and displayed as rich multimedia presentations.

1. Introduction

Since July 2008, the eResearch Lab at the University of Queensland has been working with the Australian Literature community through the Aus-e-Lit project (Aus-e-Lit, 2009), developing eResearch tools for scholars of Australian literature who are members of the AustLit consortium (a non-profit collaboration between the National Library of Australia and twelve Universities). The AustLit bibliographic and full-text collection provides an important resource for scholars undertaking research into many aspects of Australian literary heritage and print culture history. It serves the research and teaching communities as a source of information about Australian literary works and the people, agents and organisations involved in their creation or publication. The AustLit Web portal (AustLit, 2009) provides access to the bibliographic and full-text collection and also provides a mechanism for the dissemination and deployment of eResearch services being developed through the Aus-e-Lit project. The eResearch services that have been developed and/or integrated to-date (Figure 1) include:

1. Annotation services: enable community users to annotate, store and share annotations and tags on bibliographic, image and full-text resources;
2. Text processing services: Calais is used to perform semantic analysis of full text documents. It identifies and semantically tags concepts such as people, places and events that are referred to in the text.
3. Federated search services: support keyword and full-text searches across both the AustLit collections as well as external databases including the Australian Digital Theses Database, Australian Biographies Online, Picture Australia, People Australia, Google Books, Library Thing and Flickr.
4. LORE (Gerber & Hunter, 2008): a light-weight tool for authoring and publishing OAI-ORE (Lagoze & van de Sompel, 2007) compliant compound objects that can be shared and re-used.
5. Multimedia presentation generator: a service that converts mixed-media OAI-ORE compound objects to SMIL (Synchronized Multimedia Integration Language) presentations dynamically, by mapping semantic relationships between resources to spatio-temporal relationships in the presentation.

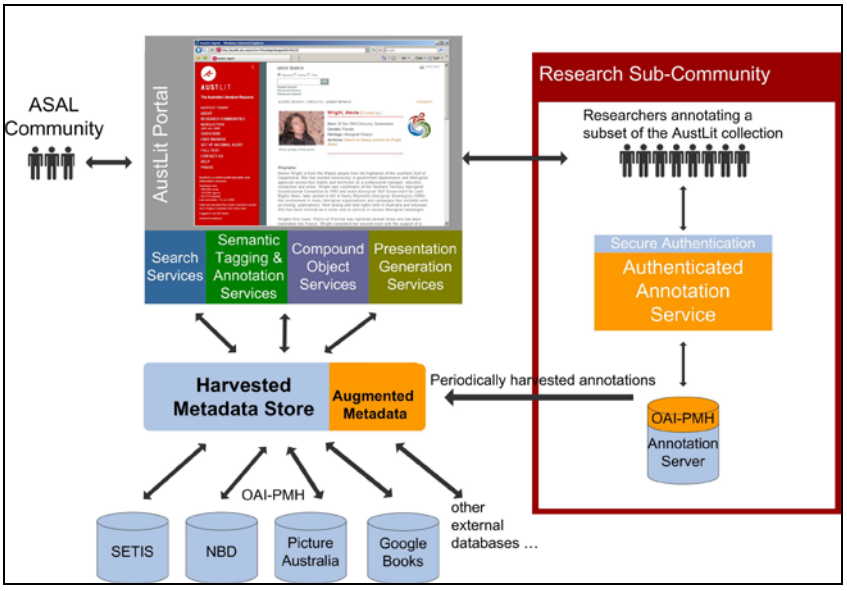

Figure 1: Overview of the Services being developed with the Aus-e-Lit Project

Within this paper, we describe how these services are being combined to streamline the capture, generation and visualisation of compound objects by literary scholars for the purposes of teaching and research. The result is "re-usable semantic mashups" that are extremely valuable to the community for: tracking the lineage of derivative works; relating disparate objects that are common to a particular theme; for discovering and capturing previously unrecognised relationships between digital resources, people, places and events; or for encapsulating related digital resources for teaching purposes. For example, using the Aus-e-Lit services, a scholar is able to relate the original edition of Patrick White's *Voss* to the illustrated edition, a radio recording and a digital version of the film. The different multimedia components are able to be discovered and retrieved through the federated search services, related to each other through the LORE interface and then saved as an OAI-ORE compound object that can be shared, re-used and displayed as a multimedia SMIL presentation. The interoperability of these independently developed services and data sources is enabled through the common semantic, ontological and technological framework that underpins the Aus-e-Lit system.

2. Background

2.1 IFLA Functional Requirements for Bibliographic Records

Underpinning all of these services is a common data model - the IFLA FRBR (IFLA 1998) model that was developed by the International Federation of Library Associations and Institutions (IFLA) in 1998 to represent bibliographic relationships. It uses an entity-relationship model that supports four levels of representation for bibliographic resources: *work, expression, manifestation* and *item*. It also supports additional entity types: products of intellectual or artistic endeavour (publications); entities responsible for intellectual or artistic content (a person or corporate body); and entities that serve as subjects of intellectual or artistic endeavour (concept, object, event, and place). For the purposes of Aus-e-Lit, we developed an OWL ontology that is based on the FRBR RDF model (Davis & Newman, 2005) and additional selected Bibliographic ontologies (D'Arcus & Giasson, 2009). The Protégé interface to this ontology is shown in Figure 2 (Protégé, 2009).

It includes the top-level classes of: *Works, Expressions, Manifestations, Items, Agents, Events, Places*. This ontology is used to describe resources in the AustLit collections. It is also used to label the relationships between components within compound objects. Section 4 describes the interface that enables users to create OAI-ORE-compliant compound objects by manually drawing arcs between digital resources (nodes) and labelling the nodes and arcs using terms from this ontology. A key advantage of this approach is that the top-level model/ontology can easily be extended to support new types of entities and relationships, specific to certain sub-communities. Examples of sub-communities within AustLit with their own vocabularies include: *Black Words*, *Children's Literature* and *Banned in Australia*.

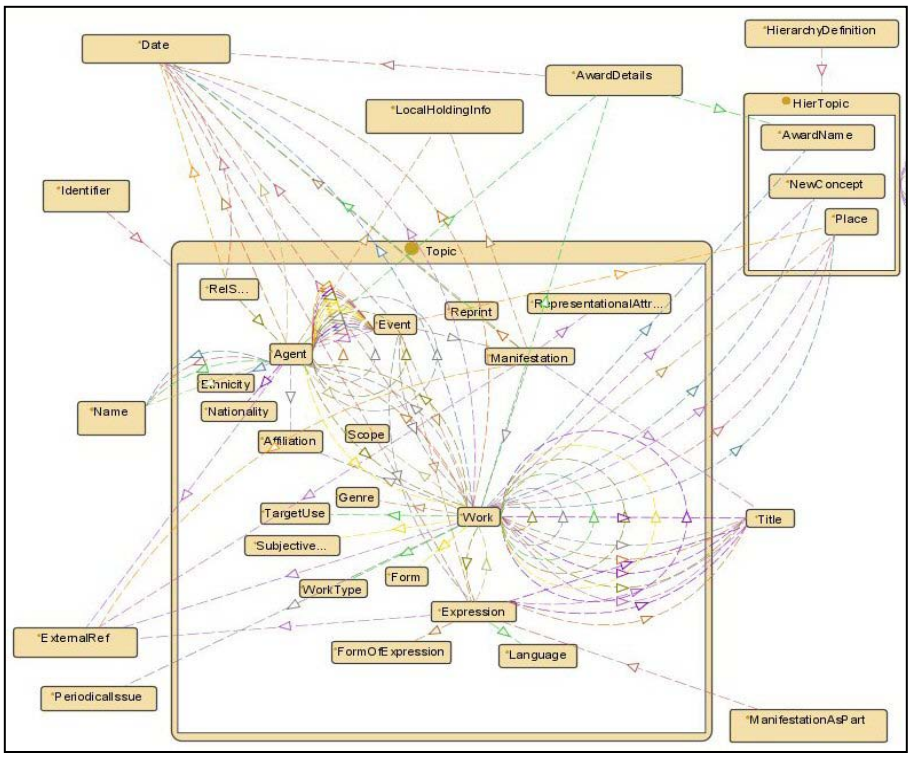

Figure2: Protégé Version of the LORE Ontology

2.2 OAI-ORE (Open Archives Initiative Object Re-use and Exchange)

The OAI-ORE initiative (Lagoze & Van de Sompel, 2007) defines standards for the description and exchange of aggregations of Web resources. It uses Named Graphs (Carroll et al, 2005) as a means of publishing compound digital objects that clearly state their logical boundaries. When applied to compound objects, the nodes in the Named Graph correspond to the individual aggregated resources, and the arcs correspond to typed relationships between those resources. In the terms of the OAI-ORE, compound objects correspond to ORE *Aggregations*, and the Named Graphs that describe them to ORE *Resource Maps*. Resource Maps (ReMs) and their component nodes and arcs are all web resources which can be identified and unambiguously referenced by HTTP URI handles, thus providing a basis for reuse and exchange. Resource Maps can be represented by different RDF serialisations (Atom XML, RDF/XML, RDFa). Our hypothesis is that OAI-ORE Named Graphs provide the ideal mechanism for representing literary compound objects that encapsulate the entities and relationships expressed by the IFLA FRBR. They do this in a way that is discipline-independent but provides hooks to incorporate rich semantics, metadata and discipline-specific vocabularies, ontologies and inferencing rules.

However, the OAI-ORE specification says nothing about the visualisation, presentation or display of compound objects, an aspect that is particularly important for large-scale and multimedia compound objects. Although OAI-ORE provides the concept of multiple alternate “views” through *Proxies*, it does not specify how these might be generated. To date, visualisation of OAI-ORE compound objects has been limited to “node and arc diagrams” that visualise the Resource Maps and RDF graphs associated with OAI-ORE compound objects. Typically, only one component at a time can be displayed by clicking on the corresponding node. This approach

does not scale for compound objects that contain large numbers of components. There are currently no mechanisms for: viewing multiple components in parallel; customising the display and layout of the components of a compound object; adapting the display based on different client capabilities; or generating coherent, multimedia presentations from compound mixed-media objects.

Our premise is that the knowledge inherent within many compound objects would be better exposed if presented to the target audience as graphical or multimedia presentations. More specifically, our proposal is to investigate the use of SMIL (Synchronized Multimedia Integration Language) (SMIL, 2008) to enable easy, semi-automatic generation of multimedia presentations from OAI-ORE representations.

2.3 SMIL (Synchronized Multimedia Integration Language)

SMIL (SMIL, 2008) is a W3C Recommendation that provides an XML markup language for authoring interactive multimedia presentations that combine images, audio, video, animations and text in real-time. Similar to HTML, it enables an author to describe the temporal behaviour of digital objects within a multimedia presentation, associate hyperlinks with media objects and describe the layout of the presentation on a screen. SMIL is also human-readable, easily edited and can be replayed via Web-browsers using players such as Ambulant (Ambulant, 2008). Additional advantages include platform independence, network and client adaptability and the simplicity of XML for generation. SMIL 3.0 was published by the W3C in December 2008, together with the Ambulant 2.0 player that supports SMIL 3.0. In the context of the application described here, the two main advantages that SMIL has to offer are: its use of URIs to reference digital objects and the simplicity by which OAI-ORE (XML/RDF) representations can be transformed to SMIL using XSLT. Our objective is to semi-automate the generation of the SMIL representations, by defining preferred rules for laying out and choreographing the components within a compound OAI-ORE digital object. These rules are specified via mappings between semantic relationships (as defined in the ontology) and spatio-temporal relationships.

Our hypothesis is that significant value can be added to OAI-ORE compliant compound information objects, through the provision of services that can dynamically and intelligently render an OAI-ORE compound object as a multimedia presentation that has been customised to take into account: the semantic relationships between the components; the scale, media type and size of the encapsulated digital objects, client device capabilities and the user's/audience's background and preferences. Moreover, **t**he use of multimedia technologies and emerging multi-tile, high resolution display walls to present compound objects, enables viewers to more rapidly understand, analyse and interpret the often complex knowledge and stories contained within compound objects – and to deduce and extract new ideas, knowledge and connections.

2.4 OptIPortals

Over the past 2-3 years, eResearch laboratories and visualisation groups around the world have been building large scale, next generation, visualisation platforms in the form of OptIPortals (OptIPortal, 2009). An OptIPortal is a visualisation cluster that comprises many tiled displays (LCDs) on a wall (typically 20-30) – where each computing node in the underlying cluster (5-10 PCs) can serve one or more display

tiles. OptIPortals can also be used for video-conferencing and collaboration with other OptIPortals or other compatible devices (laptops, H.323 conferencing devices, etc.). The video-conferencing interactions depend on the OptIPortal running SAGE or CGLX.

The multi-tiled display layout of OptIPortals appears to provide an ideal platform for visualising semantic mashups that involve a large number of high resolution, mixed-media objects. The system allows concurrent display of multiple video and image streams and the flexibility to quickly change the size, position and layout of objects depending on the interests of the audience. Past applications using OptIPortals have included: microscopy, environmental sciences, satellite imagery, medical and microbial sciences. To date, we have seen no examples of OptIPortal use in the humanities. For this reason, we are also interested to evaluate the use of the OptIPortal in the context of the AustLit project and user community.

3. Objectives

Our overall objective is to provide an intuitive method for the AustLit community (and literary scholars more generally) to collaboratively author rich scholarly content in the form of OAI-ORE compound objects that incorporate mixed-media components from the AustLit collections as well as from external databases. In order to meet this objective, the following specific aims were identified:

- Add semantic processing services to the Aus-e-Lit portal to enable automated and manual semantic tagging of full text documents using terms from an ontology configured at run-time;
- Use these semantic tags to invoke targeted searches across both the AustLit collections and external federated online collections (including SETIS, GoogleBooks, Australasian Digital Theses (ADT) database, PictureAustralia, PeopleAustralia and LibraryThing);
- Develop an easy-to-use, light-weight, in-browser tool (LORE) that enables semantically related resources to be incorporated within OAI-ORE compound objects and to support the bibliographic relationships (as defined within the IFLA-FRBR), as well as other more general relationships.
- Enable authors to attach metadata to these OAI-ORE compound objects and publish them in open access repositories (e.g., Fedora Lagoze et al, 2006)) to enable their easy discovery and re-use.
- Develop and evaluate alternate visualisation services for mixed-media OAI-ORE compound objects through semi-automated and customisable mechanisms that generate textual, graphical and multimedia views of mixed-media compound objects – by mapping semantic relationships between component resources to spatio-temporal relationships;
- Evaluate the OptIPortal at the University of Queensland, for its effectiveness in enabling the visualisation, collaborative discussion and analysis of semantic mashups and compound objects associated with the AustLit project and digital humanities research more generally.

4. Related Work

A number of previous efforts have focused on packaging multiple information objects through XML metadata schemas. These include: IMS Content Packaging format (IMS, 2009); the Metadata Encoding and Transmission Standard (METS) (Library of

Congress, 2009); MPEG-21 (Bormans & Hill, 2002); and OAI Information Packages (CCDS, 2002). More recently, Burger has proposed Intelligent Content Objects (ICO) to capture semantic mashups in a format that enables their discovery and re-use (Burger, 2008). ICOs define a package structure that includes the content, knowledge about its properties and several interfaces to interact with the smart content object. This approach is similar to earlier packaging standards, except that semantic technologies are explicitly used to provide machine understandable descriptions. Burger also claims that the Intelligent Content Object model provides better support for multimedia content – which OAI-ORE is lacking. In this paper, we aim to show that OAI-ORE is fully capable of supporting multimedia resources, and that the underlying RDF Named Graph facilitates the easy translation to multiple alternate views, including SMIL multimedia presentations.

Most previous applications of OAI-ORE to compound object authoring have focussed on eScience. These include FORESITE (Foresite, 2009), eChemistry (Van Noorden, 2008), UIUC (Cole, 2008) and SCOPE (Cheung et al, 2007). The SCOPE system was specifically designed to enable the authoring and publishing of Scientific Compound Objects that document the provenance of related scientific outcomes (e.g., data, models, publications). The aim of the LORE tool (Gerber & Hunter, 2008), as described in this paper, was to develop an OAI-ORE authoring tool for scholars of literature and related products. Although some previous work has been used RDF to represent multimedia and hypertext presentations for e-Humanities applications (e.g., CULTOS (CULTOS, 2003)), this work does not combine the complementary features of OAI-ORE and IFLA-FRBR to capture the precise relationships between entities. Previous research investigating the visualisation of OAI-ORE compound objects has developed “node and arc” diagrams for visualising “Resource Maps” and their evolution over time. Van De Sompel et al (2007) conducted an experiment that used the Internet Archive’s Wayback Machine to archive and display changes to Resource Maps (ReMs) over time. This work uses Webdot and GraphViz to visualise ReMs on the Web. Within LORE, we use Draw2d, a JavaScript graph component, for visualising ReMs (Gerber & Hunter, 2008). Although there has been substantial previous research investigating automated generation of SMIL multimedia and hypermedia presentations from semantic mashups of semantically-related digital resources (Little et al 2002), (Rutledge et al, 2003), (Hardman & Ossenbruggen, 2006) and using multimedia service adaptation (Oliviera & Carrapatoso, 2008) – none of these previous efforts have employed OAI-ORE to represent the content and semantic relationships. As far as we are aware, there has been no previous research investigating the capture of multimedia semantic mashups as OAI-ORE compound objects that can be discovered, re-used, adapted and presented as SMIL multimedia presentations.

5. Implementation and User Interfaces

Figure 1 shows the overall system architecture and the five main types of services that have been implemented or integrated within the Aus-e-Lit Portal:

1. Annotation services;
2. Semantic Text Processing services
3. Federated search services
4. OAI-ORE authoring service
5. Adaptive Visualisation services

These services have been implemented as extensions to the existing AustLit Web Portal as well as through LORE, a light-weight Firefox extension developed using XUL (XML User Interface Language) and AJAX (Asynchronous JavaScript XML).

5.1 The Annotation Services

The Annotation services within Aust-e-Lit are implemented using the Danno annotation server (Danno, 2009). The LORE Firefox extension uses the Annotea protocol (Koivunen & Kahan, 2001) to communicate with the Danno server. Annotations are created by selecting the 'Add annotation' button from the LORE toolbar. Figure 3 illustrates the annotation client being used to annotate an expatriate agent record from AustLit. Additional menu buttons enable deletion, updating of and replying to annotations.

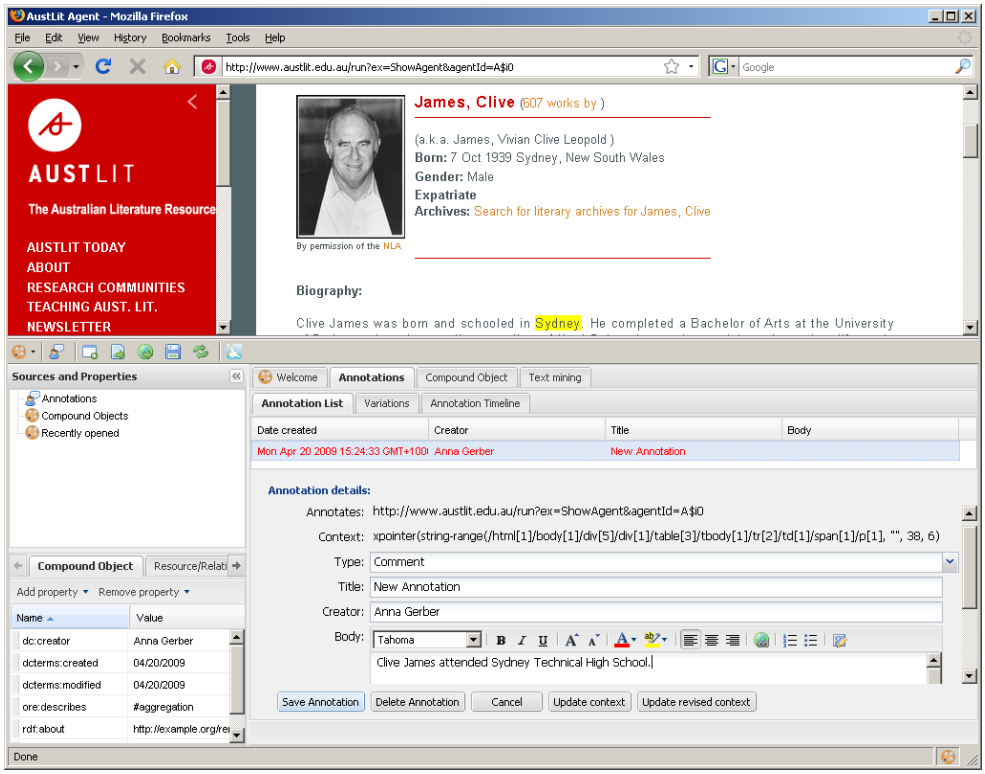

Figure 3: Example of the Annotation service being used on an AustLit Agent record

We have also extended the Annotea Schema to capture additional elements required to describe variations on a text: including the original and revised resource and context as well as the date, place and agent responsible for the revision. Figure 4 shows the interface for viewing variation annotations associated with related scholarly editions.

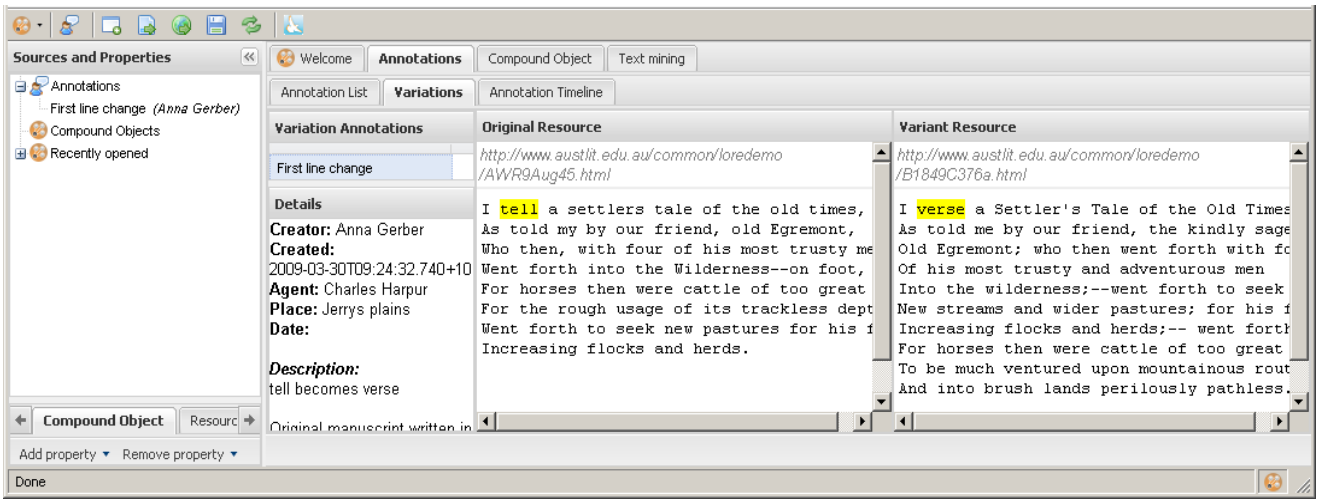

Figure 4: Variation Annotations View

5.2 Semantic Text Processing

The Semantic Text Mining within Aus-e-Lit has been implemented using the OpenCalais API (Gnosis, 2009). OpenCalais provides a web service that enables unstructured text to be parsed and the names of people, places and events to be semantically tagged. Figure 5 shows the results of processing the “Jerilderie letter”, the manifesto of Ned Kelly, using OpenCalais. Using a similar approach to Gnosis (2009), we have integrated the OpenCalais web service within LORE, to enable semantic tagging of texts associated with significant manuscripts. After the text is tagged, users can select type-appropriate actions from a context menu. For example, Figure 5 illustrates that if a piece of text is recognised as a person name, the user can: invoke a Federated Search across all collections; search PeopleAustralia; search PictureAustralia; or add this name as a subject for the resource within the ORE resource map.

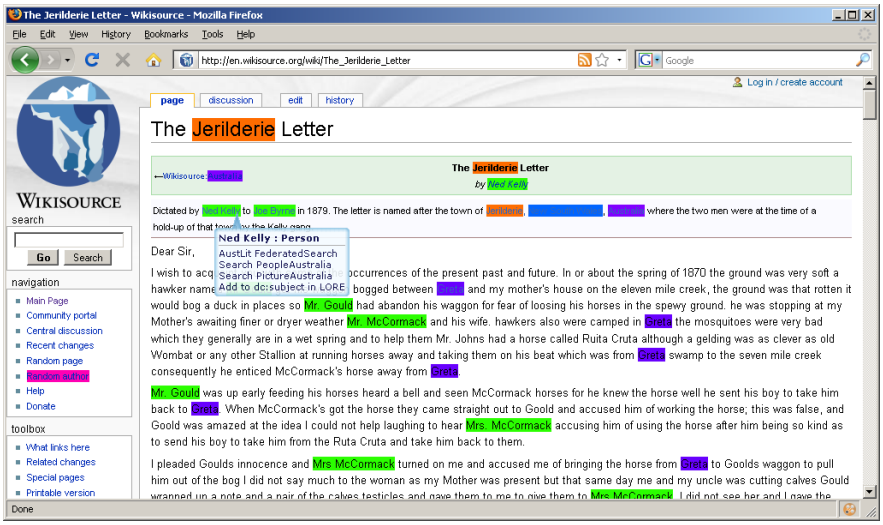

Figure 5: Semantic Tagging of the Jerilderie Letter using OpenCalais

5.3 Federated Search Services

In addition to the existing search services implemented across the AustLit bibliographic and full-text resources, we have implemented Federated search services across a number of external collections including: the Australian Digital Theses Database, AusStage, Picture Australia, People Australia, Google Books, Library Thing and Flickr. This federated search has been implemented by leveraging existing SRU (Search/Retrieval via URL), OpenSearch and other site-specific search services and by harvesting available metadata from these external sources using OAI-PMH and incorporating it within our indexed AustLit metadata store. Figure 6 shows the front-end user interface to the Federated search, through which users can enable/disable sites.

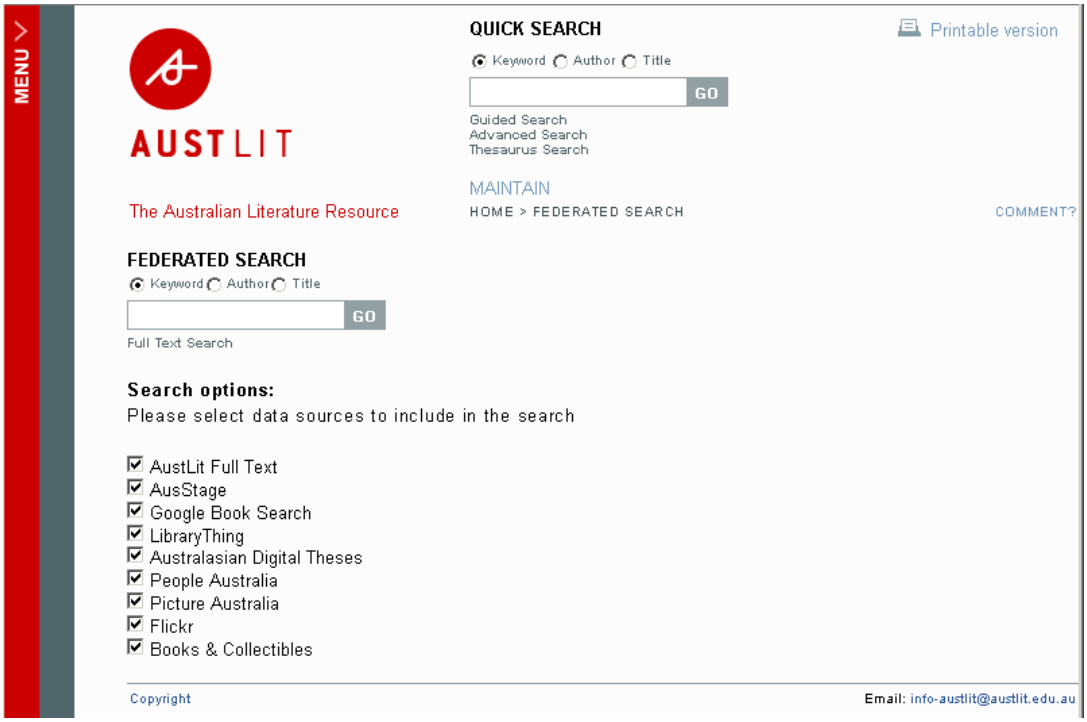

Figure 6: User Interface for AustLit Federated Search

The retrieved search results are organised and displayed in multiple categories. Figure 7 illustrates the results of a search for “Ned Kelly” across the Federated collections. This search retrieves 582 images from PictureAustralia, 10 full text works from AustLit, 591 results from GoogleBooks and over 2000 images from Flickr. Users also have the option to visualise the results via a map or a timeline and to add any retrieved resources to the currently open OAI-ORE compound object.

Figure 7: Results of a Federated Search for Ned Kelly

5.4 LORE – Compound Object Authoring Tool

The LORE OAI-ORE authoring and publishing tool uses a Sesame 2 RDF data store running as a Tomcat Java Servlet for storing and querying the Named Graphs that represent compound objects. Figure 8 shows the editing interface provided by the LORE Firefox extension. The AustLit Web Portal is in the top panel and the OAI-ORE authoring tool is in the bottom right panel. This panel in Figure 8 shows an OAI-ORE resource map displayed in graphical form.

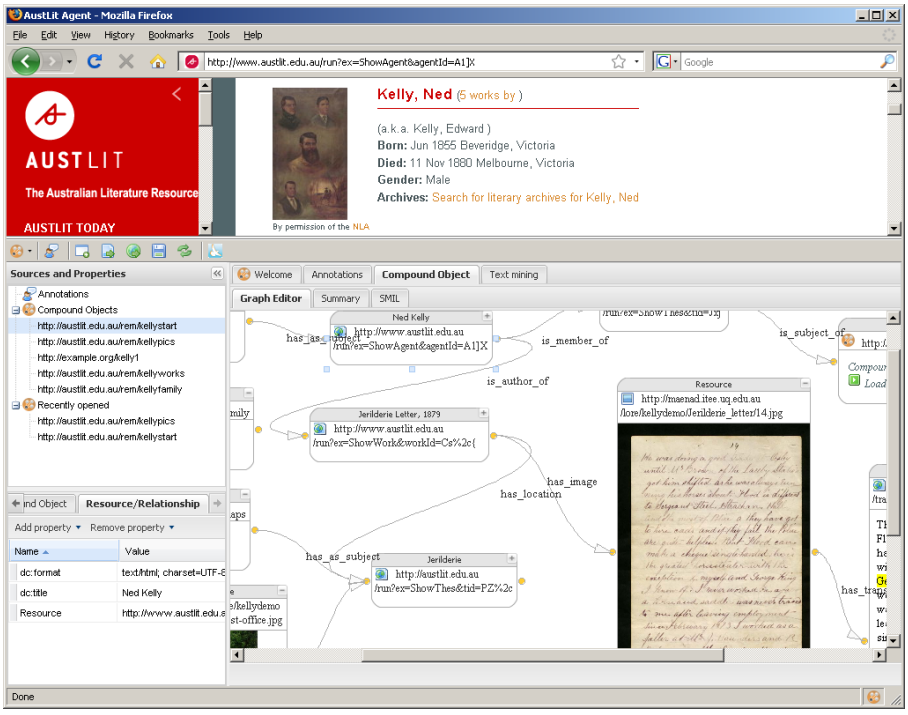

Figure 8: LORE editing interface: compound object about Ned Kelly's Jerilderie Letter

In the graphical representation, the *nodes* represent the individual atomic resources and the *arcs* represent typed relationships between the aggregated resources. Each node in the graphical view provides an interactive preview of the resource that it represents, allowing resources to be easily visually distinguished. The preview can be collapsed so that only the URI of a resource is visible. Nodes can also represent other Resource Maps that have been aggregated into the compound object – thus forming nested compound objects. Resources to be added to the Resource Map may be discovered by browsing or searching the AustLit collection. A resource loaded in the browser can be added to the Resource Map by selecting the *Add Resource icon* from the toolbar or via browser context menus. Metadata about each aggregated resource can be viewed and edited via the *Properties* view that is displayed in the left-hand sidebar when the resource is selected. The properties sidebar also allows metadata about the Resource Map and the aggregation that it represents to be specified (Figure 9). The system supports DCMI Metadata Terms (DCMI, 2008), plus optional terms specified by OAI-ORE, as well as selected terms from FOAF (FOAF, 2007) and datatype properties from the domain ontology.

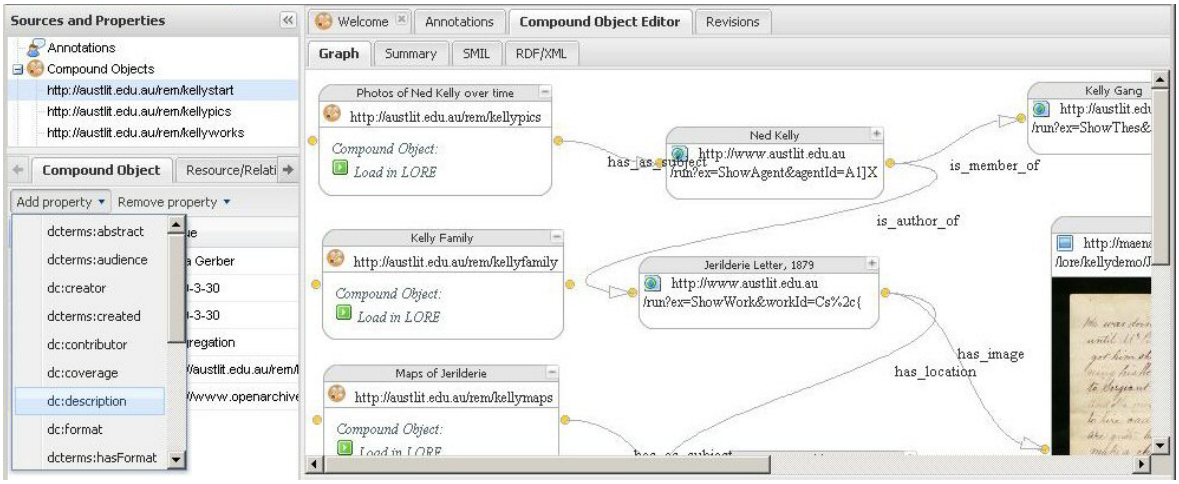

Figure 9: Attaching Metadata to the Compound Object

The types of relationships between nodes are indicated by labels on each arc. These can be changed by editing the properties view or by right clicking on each arc. The arc type options are populated from the domain ontology, which is specified in the LORE options. Resource Maps that have been created or modified using LORE can be saved (as named graphs in the RDF repository specified in the preferences) by selecting the *Save RDF* button from the toolbar. Resource Maps can also be retrieved and loaded directly from the repository or from a URL identifying an RDF/XML representation of the resource map via toolbar buttons.

5.5 The Adaptive Visualisation Services

LORE also provides tabs for generating and displaying a variety of different interactive views of a given OAI-ORE compound object, including:

- a graphical view (Figure 8) – in which clicking on a node displays the resource corresponding to that URI,
- a summary view - a list of the component resources;
- a trail view – which displays the historical relationships between resources;
- a SMIL presentation view – this dynamically generates a temporary SMIL file that is launched in the AMBULANT player.

The SMIL object below (Figure 10) shows a multimedia representation of an OAI-ORE compound object about the *Jerilderie Letter by Ned Kelly*. This manuscript is significant as it provides unique insight into the mind of Australia's most famous bushranger.The SMIL file comprises a sequence of images of the original manuscript (on the LHS), the annotated transcript in the upper centre, a photo of Ned Kelly in the centre, photos of the Kelly Gang in the lower left, a map of the Jerilderie area in the lower right and photos of relevant buildings/places in the upper right.

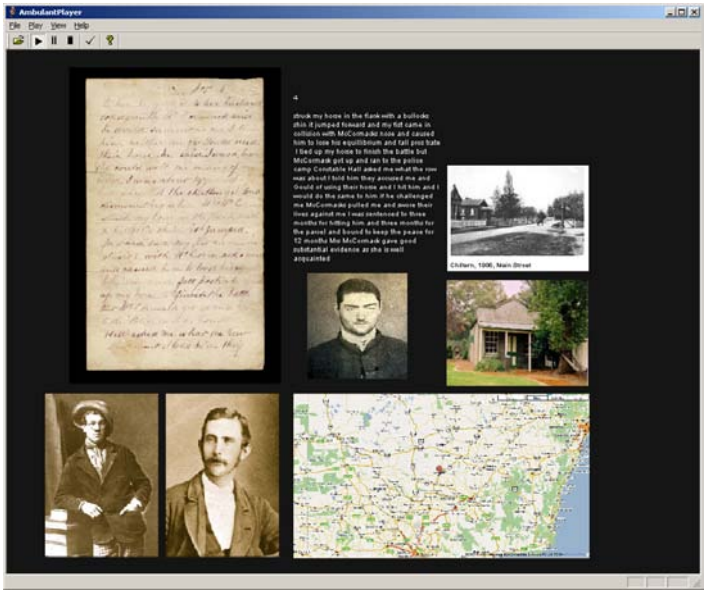

Figure 10: Screenshot of SMIL version of an OAI-ORE compound object

The SMIL file is generated by mapping the semantic relationships between objects in the OAI-ORE compound object to spatio-temporal relationships. Table 1 lists some examples of such mappings. These mappings are also inherited by sub-properties of the properties listed in Table 1. The semantic relationships between digital objects may either be specified manually during the OAI-ORE authoring phase or inferred from the metadata associated with the digital objects (e.g., *precedence* is inferred from *Date* metadata). Given these mappings, we are can dynamically generate a SMIL file from an OAI-ORE RDF serialisation using XSLT.

Semantic Relationship/ RDF Property	Spatio-temporal Relationship
X isExpressionOf Y	X RightOf Y
X isManifestationOf Y	X RightOf Y
X isItemOf Y	X RightOf Y
X isAuthorOf Y	X RightOf Y
X isColleagueOf Y	X Below Y
X isRelativeOf Y	X Below Y
X isAbout Y	X Above Y
X isDerivationOf Y	X RightOf Y
X isImageOf Y	X Below Y
X refersTo Y	X LeftOf Y
X precedes Y	X Before Y
X follows Y	X After Y
X annotates Y	X isBelow Y

Table 1: Relationship Mappings

5.6 The OptIPortal Interface

Figure 10 below shows the SMIL representation of the *Jerilderie Letter* displayed on the University of Queensland OptIPortal. The UQ OptIPortal comprises 20 LCD displays (5 wide and 4 deep). Anna Gerber is standing in front of the display, discussing the compound object with inter-state collaborators via videoconferencing facilities.

Figure 11. Displaying a Compound Object Presentation on the UQ OptIPortal

The OptIPortal enables the multiple objects (images, text, graphs and video) that comprise a semantic mashup, to be displayed simultaneously – but juxtaposed and synchronised intelligently to reflect the relationships between the objects. The high resolution display panels enable very precise details of documents (such as the handwriting and annotations on original manuscripts) to be closely examined and discussed by multiple, geographically dispersed collaborators.

6. Discussion

6.1 User Interface Feedback

Usability sessions were held with members of the AustLit community to elicit feedback on the e-Research services that have been developed. The users' response to the LORE system included positive feedback to: the interactive node previews; the direct integration of the editor with the browser through the Firefox extension and the ease with which they could customise the relationship types and metadata supported by the editor by loading different domain ontologies. In the "node and arc diagrams", they would like to see support for additional types of arcs with distinguishing visualisations, e.g. differently shaped line decorators or arrow types, use of colours or line types, to highlight specific relationships, as well as explicit support for bi-directional relationships. Other issues that arose during usability testing included the requirement that objects must have a URI to be added to a compound object in the LORE editor. Many objects that exist within institutional repositories only have local identifiers. We anticipate the need to incorporate a service to generate persistent URIs for objects that do not already have one.

Because the IFLA FRBR ontology (and by extension, the AustLit ontology) is quite complex, it can be difficult for a literary scholar who is not familiar with IFLA/FRBR to apply the metadata terms and relationship types in the ontology. For example, while they may understand the distinction between a FRBR *manifestation* and *item* in the case of a physical publication such as a book, they may not understand how these concepts apply to a digital resource, and may apply relationships or metadata from

multiple levels (work, expression, manifestation or item) to a single resource. Strategies for addressing this issue could include adding more semantic checks to the user interface to assist users in applying the ontology terms correctly, or simplifying the domain ontologies based on community needs and understanding.

The ability to dynamically generate multimedia SMIL presentations from OAI-ORE compound objects was seen as a very valuable tool particularly for teaching and learning “trails” and for rapid scanning of compound objects that contain a large number of components. Currently the mappings from semantic relationships to spatio-temporal relationships are hardwired. Users would like to be able to edit these through a graphical user interface (GUI) - in order to customise the layout and timing to suit their specific needs and preferences.

The main limitation of OptIPortals is the frame around each of the LCDs, which significantly obstructs the overall view (see Figure 10). Apparently there is currently research under way into building OptIPortals that employ frameless LCDs; however, they are prohibitively expensive. If this issue can be resolved, then AustLit researchers can see the benefits that OptIPortals offer for conducting highly productive research discussions between geographically dispersed collaborators, involving large scale mixed-media collections with complex inter-relationships.

6.2 Limitations and Future Work

The services that have been developed demonstrate how effectively OAI-ORE can be used to author, edit, publish and render compound objects from within a Web browser. On-going development (from January 2010) within the Aus-e-Lit project will focus on improving the robustness and usability of the system and on a number of improvements and extensions that include the following:

- Currently the OpenCalais semantic text processing service uses a generic ontology. We would like to investigate using semantic text-mining services customised with a domain-specific ontology and sets of tags that are configurable at run-time e.g., ontologies of Australian authors and the Gazetteer of Australian place names.
- Fedora (Lagoze et al, 2006) support is being implemented so that the OAI-ORE objects can be published to a Fedora repository in addition to the existing RDF datastore functionality.
- LORE’s graphical view currently only supports uni-directional relationships. We plan to extend the graphical displays to clearly distinguish between bi-directional, symmetric, transitive and reflexive relationships defined in the domain ontology.
- A rule engine can be used to infer additional indirect relationships between aggregated objects. For example, if a transitive property is asserted between objects A and B and also between objects B and C, we can infer that the same property exists indirectly between objects A and C. We intend to investigate how semantic inferencing capabilities can improve LORE’s compound object search and editing user interface.
- Semantic inferencing also enables compound objects to be visualized at different levels of granularity. For example, we are working on extending the interface so users can click on a link between two nodes to expose more complex intermediate relationships or a single node to display nested compound objects. We will also need to investigate how these richer, complex

semantic relationships can be mapped to spatio-temporal relationships and hyperlinks within SMIL files.

- The current implementation only allows a single domain ontology (defining the metadata terms and relationship types) to be configured, and requires the user to configure that ontology directly by URI. We plan to extend and refine the AustLit ontology to support terminologies and rules that are specific to sub-communities (e.g., Black Words, Children's Literature).
- We intend enabling users to attach CreativeCommons licenses to the compound objects and corresponding SMIL files, prior to publishing them, so the permitted types of re-use can be specified.
- XSLT and CSS are not well suited to transforming RDF. We intend to investigate semantic style sheet approaches such as (Berrueta et al, 2008) or including a Style Sheet in the header of an RDF/XML serialisation to provide sufficient information to render the SMIL file without conflating the presentation and content information within an OAI-ORE compound object.
- The process that we have described here for generating and rendering OAI-ORE compound objects may be able to be streamlined by representing it as a workflow that can automatically be executed and re-used. We aim to investigate whether the end-to-end sequence can be specified and executed using a workflow system such as Kepler (Ludaescher et al, 2009) or Taverna (Hull et al, 2006).

7. Conclusions

In this paper, we have described the suite of interoperable Semantic Web services that we have developed to enable scholars of Australian Literature to generate, store, re-use and present "semantic mashups" for teaching and learning. By basing these tools on the OAI-ORE specification and the IFLA FRBR model, we enable the community to relate heterogeneous bibliographic resources regardless of their location, media-type, format or metadata. Moreover, the resulting OAI-ORE Named Graphs capture and structure the inherent knowledge in a format that facilitates further discovery, sharing, re-use and extension. The dynamic mapping mechanisms that we have developed enable multiple alternate views of the compound objects to be tailored and rendered. In particular, the dynamic generation of SMIL multimedia presentations enables rapid understanding of large-scale mixed-media semantic mashups. Finally, we describe how we have enabled the full potential of these presentations to be exploited and shared, by enabling their display on a multi-tiled collaborative OptIPortal visualisation wall. This e-Humanities case study demonstrates how the combined adoption of Semantic Web technologies, multimedia visualisations and emerging cyber-infrastructure facilities enable maximum knowledge to be extracted from aggregates of digital resources stored in distributed repositories.

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