Challenges in Locating Content and Services for Adaptive eLearning Courses

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***Abstract* — Efficiently locating learning content and web services for adaptive and personalized online courses is a demanding research area. This paper identifies the key challenges that need to be addressed. An approach is then presented that empowers educators to locate relevant learning resources and services through domain expertise and semantics that are meaningful to them. This approach utilizes the existing SARA, SABer and Adaptive Engine systems, in order to support an application that educators can effectively engage with to form adaptive courses. A compelling case study in the Technology Enhanced Learning domain is detailed, as well as an overview of the architecture that the AMAS project uses for supporting such a scenario.**

Keywords - Technology Enhanced Learning; Semantic Attributes; Domain Expert; Personalization; Adaptation; Web Services

I. Introduction

Technology Enhanced Learning (TEL) is a challenging application area for adaptive and personalized web services and content. TEL involves a broad range of learning activities, the use of rich multimedia content, as well as a broad range of users with differing expertise e.g. learners, teachers, mentors, parents, publishers, etc. Accordingly, the task of trying to locate appropriate learning content for sequencing into a personalized online course as an educator is far from trivial. The AMAS project (Adaptive and Adaptable Media and Services for Dynamic Personalisation and Contextualisation) aims to support dynamic adaptivity and personalization of existing web media and services. Thus, a key goal is to enable this learning content to be sequenced into an adaptive online course that can be personalized to learners of different abilities and with different learning styles. The AMAS project proposes an application to support this process which will work in tandem with SARA (Semantic Attribute Reconciliation Architecture) [1], its authoring tool SABer (Semantic Attribute Builder) and the AE (Adaptive Engine) [2].

II. Background And Key Challenges

There are some limitations to current approaches for efficiently locating learning content and web services, and directly supporting their sequencing into effective online courses that can be adapted and personalized. For instance, current adaptive hypermedia systems, apart from the Adaptive Engine [2] (AE), are not capable of supporting dynamic service adaptation which is required for personalized activities/services on the web. Likewise context aware web applications generally cannot provide the sophisticated levels of adaptive navigation and presentation pioneered in adaptive hypermedia systems. Hence a key challenge is to provide a technical infrastructure that enables dynamic service adaptation, without limiting the availability of the adaptation techniques that are central to providing users with a more personalized and satisfying learning experience. The integration of adaptive services into online courses is a complex research area, with the challenge involved highlighted by the difficulties that current systems can have in seamlessly integrating less complex and static digital content (text, images, video, data sets etc.) into an effective unified course. AMAS directly addresses this challenge through the AE component of the overall architecture described in section four.

In terms of eLearning courses, the level of personalization and adaptivity that they can facilitate is largely determined by the richness of metadata associated with the individual learning objects. Furthermore, the metadata in the system must store information that is valuable to all the stakeholders involved. These stakeholders include learners, teachers, mentors, parents and publishers. The difficulty of having sufficient and appropriate metadata is exacerbated by heterogeneous learning content and web services, and by having to support the different needs of individual learners in order to be an effective eLearning system. Hence, a major challenge in this area is to ensure that the learning object metadata used by online courses is rich enough to support sophisticated personalization and adaptation, and that this metadata is made available to course creators in a manner that is accessible to them. Moreover, a successful system should provide benefits for all stakeholders involved in the process, not just the learners.

In order to help tackle the problem of metadata richness, AMAS is examining the process of augmenting learning objects with information from freely available Linked Data, as demonstrated by Softic et al [3] and Svensson et al [4]. This extra metadata is beneficial in terms of providing educators with additional axes in which to personalize their adaptive eLearning courses. Through SARA [1], which is a central technology in the AMAS project, such RDF data can be accessed and aggregated with existing learning object metadata. Furthermore, AMAS also enables statistics from the use of completed online courses (success, popularity etc.) to feedback into the individual learning objects. This provides further metadata and scope for personalization of any services or assets that are to be integrated into an adaptive course by educators. There is a risk that the significance of such low level metadata or statistics may not be fully understood by educators, and the potential benefits not being realized. Hence AMAS supports domain experts to create reusable rules that are labeled with meaningful concepts (called semantic attributes [1]) that make such metadata more accessible to educators wishing to create courses. This feature is described in more detail in sections three and four.

As well as describing the underlying metadata associated with learning assets in a more accessible way, it is another challenge itself to present this information in an intuitive fashion so that effective eLearning courses can be constructed as efficiently as possible by educators. Presenting and comprehending complex systems and their constituent data in a visual manner makes it much easier for the viewer to elicit knowledgeable conclusions from the information presented. Hence a useful component of the AMAS architecture is its visualization tool that uses domain expertise and the learning content metadata to support teachers in locating appropriate content for inclusion in adaptive online courses.

Another challenge in this research domain is to reduce the duplication of learning objects by increasing support for reusability. Currently reusability approaches in this domain are centered on building centralized repositories of learning objects, and adherence to one of multiple standards (e.g. SCORM or LOM), whose metadata describe the object and the context for its use. The lack of agreement and adherence to standards with both the creation of learning objects and their inclusion in learning management systems results in a negative impact on reusability, flexibility and functionality [5]. One of the key features of AMAS is that it supports the co-existence and reconciliation of learning objects described in multiple data schemas in different locations. Hence it is possible for learning objects to be reused from different repositories and combined together seamlessly into an individual course.

III. CASE STUDY

This section describes a case study which highlights how the AMAS project can support a teacher in selecting learning resources, defining the parameters on which they may be personalized, selecting appropriate teaching plans, and assigning them to different groups of students.

Step 1 Build initial resource pool(s): AMAS offers a user interface that enables teachers to search across several varied web services and heterogeneous repositories of content simultaneously. They are offered several predefined semantic attributes to enhance their searches. These semantic attributes provide a consistent vocabulary to search the heterogeneous sources, such that the search results may be consolidated in a meaningful manner. Each semantic attribute may be tailored to meet the teacher's needs. For example, a teacher searching for *Highly Challenging* resources may wish to alter the definition of *Highly Challenging*, so that the domain experts view (the semantic attribute) is tailored to the teacher's own interpretation of *Highly Challenging*. The semantic attributes are intended to support the search process, but the ability to tailor them gives teachers more fine-grained control if they wish. Through combining and refining several semantic attributes, the teacher may select resources and add these to one or more resource pools (to be assigned to students in a later step). AMAS automatically builds a model of how different resources have been used, and this information helps to inform users on appropriate selection of content or services.

Step 2 Select teaching plan(s) and define personalization axes: AMAS offers several different pedagogical strategies that correspond to different styles of teaching plans. Each strategy can personalize to different aspects of the student e.g. their prior knowledge, learning preferences, motivation level, or specific learning needs they may have. The teacher may select one or more teaching plans that they wish to apply to the different pools of resources. Within these plans the different personalization axes may be selected e.g. the teacher may not want the content or service adapted to motivation level, but only to prior knowledge.

Step 3 Refine resource pool(s): This step gives the teacher the opportunity to refine the resource pools to ensure there are appropriate resources to fulfill the teaching plan and apply the personalizations desired. AMAS automatically indicates when there are insufficient resources available to complete the teaching plan and personalizations and suggests appropriate resources that should be added to the pool. This step can be completed for each resource pool.

Step 4 Establish group(s): A key benefit of setting up several pools of resources is that they apply teaching plans and personalizations that are suited to different students needs. For example, if a cohort of students is struggling with a particular subject matter the teacher may set up a group and pool for them that contains more introductory resources. Groups are optional, but allow teachers to fine tune how personalization is offered to their students.

Step 5 Deploy the course: Once happy with the resources, teaching plans, personalizations and groupings, the teacher can deploy the personalized course to their students. Deployment may be offered in an existing virtual learning environment either in the school or to the students in their homes. When individual students interact with the course, anonymous usage statistics are generated to help determine the effectiveness and suitability of the resources used. This information is used to help the selection of resources in the future. This overall case study has described one scenario in which the AMAS architecture can be deployed, though it must be stressed that the system can easily be tailored to support multiple scenarios, such as pupils developing their own personalized course in an informal learning environment.

IV. AMAS ARCHITECTURE

In order to support the case study just outlined a visualization application is being developed for teachers to help them in finding appropriate learning content and services for personalized courses. This application is part of a larger architecture (see Fig. 1) that employs the existing SARA [1], SABer and AE [2] systems. These systems will now be discussed with reference to the case study previously outlined.

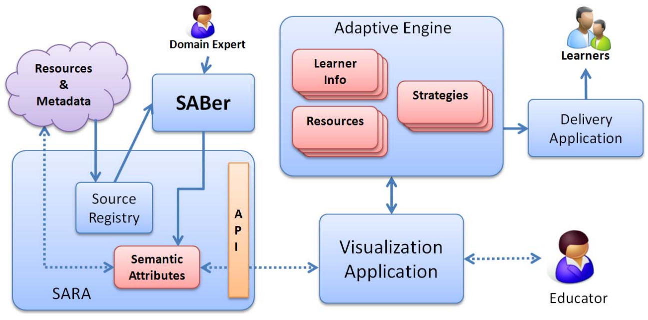

Figure 1. The AMAS Architecture

SARA is a domain independent framework that semantically reconciles heterogeneous information sources, such as databases and web services. Currently SARA supports data encoded as XML, RDF or accessible through a Web API. It works by first registering the metadata schemas of learning resources and services to its Source Registry. SARA also enables extra metadata on usage statistics of learning objects, or metadata stored on the Web of Data to be registered. This provides additional richness, and all these metadata schemas registered are then displayed in SARA's authoring tool called SABer. This authoring tool is a fundamental component of SARA, as it allows non-technical domain experts to encode their expertise (e.g. in learning resources) and for this knowledge to support users (e.g. teachers) wishing to locate and correlate useful information from that domain (e.g. TEL).

Firstly the expert uses SABer to browse the metadata elements and then selects items to form a semantic attribute. Semantic attributes are discrete encodings of domain expertise that can be combined together and tailored to support user exploration of an information domain. They often act as abstractions and simplifications from the raw data that are intended to make it more accessible for the teachers using the visualization application. Thus the semantic attribute *"Highly Challenging Material*" may encapsulate multiple ambiguous metadata fields from a learning repository in order for educators to quickly identify the most relevant sources for their course. Semantic attributes can be objective or subjective in nature, and SARA supports the tailoring of their expert rules to an end users perspective through parameter controlled variables. When the educational expert is satisfied with the rules they have generated, they submit the semantic attribute to SARA. The semantic attribute is then made available to the visualization application through SARA's API.

The dashed lines in Figure 1 show the runtime interaction between the visualization application and SARA. The visualizer contains all the semantic attributes that the domain experts has generated for the multiple learning repositories and these semantics allow teachers to form complex queries easily by compounding individual semantic attributes into bespoke queries using set operators. Thus a teacher could look for all *highly visual algebra content, which is popular with 12 to 14 year old students, and highly rated by teachers*. This query gets sent to the learning repositories and web services via SARA and any matching resources returned to the visualizer for rendering to the teacher. By exploring the resources available to them, the teachers can easily create pools of content and services that have adaption axes. These axes can be used to help personalize and sequence the overall course to individual students or pools of students.

Once the educator is satisfied with the pool of resources for a specific course, the relevant metadata is sent to the AE to be compiled and sequenced. The AE is responsible for the reconciliation of the available metadata models through the execution of the narrative (adaptive sequencing rules), which strategically guides the adaptation process. The AE makes use of an AI planner as it sequences the adaptive content and services. Once the learning resources and services are reconciled, the delivery application that the students use renders the course. It can then communicate with the AE to facilitate the adaptation and personalization of the content and services as students progress through a course.

V. Summary and Future Work

This paper has described the challenges associated with efficiently locating learning content and services for sequencing into an adaptive and personalized online course. How SARA, SABer and the Adaptive Engine are being applied in the AMAS project to tackle these key challenges was also described, along with a case study highlighting one of the scenarios that this infrastructure supports. The next steps for the AMAS project are to fully integrate the existing systems (SARA, SABer and the Adaptive Engine) with a visualization prototype, in order to provide a complete end-to-end system that can be evaluated in an authentic environment. Users in both K-12 and university settings have been identified for these experiments and their feedback will inform future design iterations of the visualization tool and the overall architecture.

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