A Unified Approach to Adaptive Hypermedia Personalisation and Adaptive Service Composition

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Abstract. Adaptive Hypermedia is utilised in several domains, such as eLearning and professional training, where there is a growing movement towards the use of cognitively richer and more 'active' approaches to user engagement. In order to support this move, it is vital that adaptive personalisation systems, in these domains, are capable of integrating adaptively composed activities into adaptively personalised content compositions [1]. Through the integration of the approaches that are used in the automated composition of web services with those found in Adaptive Hypermedia, we believe that it will be possible to support a unified approach to the adaptation of content and services through the leveraging of the characteristics that are common to both adaptive application domains.

1 Introduction

Research in the area of Adaptive Hypermedia (AH) has focused on the adaptive selection, at run-time, of multimedia content in tandem with the personalised sequencing and presentation of that content. Examples of such systems include: AHA! [2], KnowledgeTree [3] and APeLS [4]. In parallel, the Semantic Web community has seen a growing focus on the application of adaptivity to Web Service Composition (WSC). Here the approach involves the dynamic selection, sequencing and choreography of services that is typically based on the completion of a desired application goal or objective.

Their is a growing move towards the application of pedagogical strategies, such as WebQuest and Action Mazes, in eLearning. Such strategies aim to provide cognitively richer learning experiences through the use of interactive activities, which engage the learner. This has highlighted a need for the integration of activities into more traditional hypermedia solutions. Furthermore, authoring tools such as LAMS [5] and ACCT [6] also promote the use of activities as the basis for eLearning. As such, they require learning environments that support both content delivery and the provision of interactive services [7]. By utilising web service technology and the associated service composition approaches it is possible to provide services that are adaptively selected and composed [8] in a manner that complements the goals of AH.

The necessary functionality can be achieved through the integration of adaptive web service composition techniques with those of AH. In order for this integration to carry significant benefits it should be carried out based on the common approaches to adaptation used in both domains and should also recognise the inherent differences that exist between AH and service composition. This leads to the need for an analysis of both domains to be carried out.

The rest of this paper is structured as follows, section 2 presents an overview of the approaches used in both AH and adaptive web service composition. This is followed, in section 3, by an analysis of the features that are common to both domains as well as those which differentiate them. Finally, section 4 discusses the conclusions drawn from this research.

2 Approaches to Adaptation and Personalisation

In both AH and Adaptive Web Service Composition (AWSC), the aim is to achieve a desired outcome through the composition of available resources while taking into account the requirements of the user, as well as other contextual information. In both application domains many different approaches exist, each of which has its own advantages and limitations.

2.1 Adaptive Hypermedia

Adaptive Hypermedia Systems (AHS) focus on providing two main adaptive behaviours, the adaptive selection and sequencing of content (adaptive navigation) and the adaptive presentation of resources to the user [9]. Traditionally, the goal of AH is to present the user with appropriate material from a much larger hyperspace while maintaining the associated benefits of hypermedia.

Adaptive navigation can be realised in several different ways, these include: direct guidance; link sorting; link hiding; link annotation. Adaptive presentation traditionally involves the use of techniques such as conditional text and stretch text to expand the verbosity of a piece of text as necessary. More recent AH systems have combined the use of adaptive navigation and presentation in order to provide more advanced personalisation behaviours, for example the application of learning styles [10, 11] or device attributes [12, 13] as adaptive axes.

AHS can be described using an abstract model consisting of four main components: a domain model, a user model, an adaptation model and an Adaptive Engine. The domain model provides the AHS with information about the knowledge domain in which it is operating. The user model represents the system's current view of the user, containing information about key attributes of the learner, which the system can use to inform the adaptation process. The final component is the adaptation model, which consists of a set of rules describing how the adaptation will be carried out. This is used by the Adaptive Engine to reconcile the user model with the domain model.

2.2 Adaptive Web Service Composition

AWSC aims to provide previously unavailable functionality through the composition of many heterogeneous services. Current work in this area can be generalised into two approaches, the use of workflow composition and the use of AI planning techniques. Workflow based approaches rely on the manual composition of services using languages such as BPEL4WS. AI planners, attempt to deal with the dynamic nature of service orientated environments through the dynamic composition of services based on their meta descriptions and functional properties as well as the initial state of the 'world' and the desired goal state. This paper will focus on the AI planning approaches to AWSC as these compliment those used in AH.

Planning approaches to service composition generally consist of four components, a planning engine, a semantically rich description of the available services, a definitions of the 'worlds' current state and the required goal state.

Service selection and composition is not only informed by the functional characteristics of services, but also by non-functional properties and it is these properties that allow the composition to be personalised [14]. Information captured in a user model can affect the selection process in order to ensure that the resulting composition not only has the desired functionality but that it also carries out that functionality in a manner that is most suitable to the user.

The planner described by McIlraith et al. in [15] uses situation calculus (preconditions and effects) to describe services and which uses a procedural programme to compose services based on these descriptions. The Unpop [16] system uses a rule based approach that infers over machine readable service descriptions which focus on the messages (parameters) sent and received by the service. SHOP2 [17] takes an alternative approach, using OWL-S ontologies to describe services and employing a Hierarchical Task Network planner to devolve a high level task/goal into atomic actions which can be mapped to individual services as described by the ontology.

3 Commonalities and Differences

It is clear, from the approaches described above, that AH and AWSC are very similar in some respects and that lessons can be learned from each. AH can be used to compose a set of concepts in order to facilitate the comprehension of a specific topic. Similarly, AWSC attempts to combine a set of services into a plan which will achieve a specific goal, for example to carry out a learning activity or to achieve a knowledge state. Prior knowledge and prerequisite knowledge are often used in AH as adaptive axes. In web service composition functional and non-functional service properties can be considered analogous.

At a more concrete level, AH and AWSC share several common features, key to both AH and AWSC systems is the utilisation of semantic models to describe the 'elemental' resources that are available for composition in the respective approaches, for example learning objects in adaptive content composition and

service descriptions in adaptive service composition. In both domains the composition process is based on the inference of sequencing logic to compose the respective elements. Furthermore, this inference process is influenced or 'informed' by external information, for example user or context models.

Despite the commonalities, AWSC and AH are not the same and as such there are some significant differences which must be accommodated in a system which combines both. Unlike traditional content, web services are parameterised, that is they take inputs and return values. This is important as the behaviour of a web service can be influenced by its parameters to the extent that a single service can have several very different outcomes. The existence of parameters also imposes requirements on a composition, it is necessary to capture the flow of information between web services in the composition as well as the sequencing of the services. Unlike traditional AH content, web services are capable of returning errors when they fail to execute correctly.

The integration of AH and adaptive service composition can be approached in different ways. Existing AH techniques could be utilised through treating the services as content, for example by embedding a service into a piece of content, and carrying out the composition as normal. However, this approach is simplistic as it ignores the differences that exist and as such cannot take advantage of the benefits that web service composition presents. For example, the parameterisation of the service must either be ignored or 'hand crafted' with little room for information to flow between services. A more transparent approach to the problem, based on the common feature of both, in which the differences between services and content are acknowledged would be a more interesting solution. This solution would allow the strengths of web services and of service composition to be fully utilised in conjunction with those of AH.

4 Discussion and Future Work

This paper has presented the approaches supported in AWSC and AH. Through an analysis of the existing approaches in both AH and AWSC, the commonalities that exist in both have been identified. Both domains adaptively select their respective 'elemental' components based on semantically rich metadata and combine these components by inference based on sequencing logic. Furthermore, in both cases the selection and composition are guided by information, for example user preferences or contextual data, that are modeled outside of the adaptation process. Although differences do exist, the common features identified suggest that web services and hypermedia can be adaptively composed in an integrated manner.

We believe that a combination of AWSC and AH techniques would be highly relevant in next generation eLearning, as we move to more 'active' learning events, where presonalisation is concerned not only with content composition, but also the personalisation and sequencing of activities. The ability to deliver interactive and engaging activity based, personalised offerings has many advantages.

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