# Enabling discovery of Adaptive Learning Resources for Mobile Learner

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**ABSTRACT**
The current advancements in mobile and communication technologies provide mobile users with unprecedented possibilities to learn on the move. The diversity in the capabilities of mobile devices as well as needs of mobile learners have, however, created many challenges for learning resource providers. To cope with these diversity problems, many content adaptation techniques have been proposed to adapt learning resources based on learner's needs, preferences, device constraints and usage context. These techniques enable the creation of Adaptive Learning Resources to provide personalized versions of learning resources. The one issue that has not been addressed is the discovery of the potentially most useful version of a learning resource in the adaptive space created by different Adaptive Learning Resources provided by different content providers. Existing search techniques are good enough to discover only static content which has one single version unlike adaptive content. In this paper, we address this challenge by providing an Adaptive Learning Resource Meta-Model (ALRM) to enable mobile learners discover the right Adaptive Learning Resource among the many Adaptive Resources which has the Potential Most Relevant Version (PMRV). We have implemented this model in a prototype application using RDF and used SPARQL query for resource selection.

**AUTHOR KEYWORDS**
Mobile Learning, Adaptive Mobile Learning, Adaptive Resource Discovery.

## 1. INTRODUCTION

Mobile Learning is becoming more popular with the increased availability and significant improvement in the capabilities of mobile devices in terms of processing, screen sizes, storage capabilities and network connectivity. The traditional one-size-fit-all approach towards learning resources is not suitable in the mobile learning paradigm, due to the diversity that exists in terms of mobile devices and network connectivity as well as learners' needs. Mobile learning can be more useful if a personalised learning opportunity is provided to learner. Personalised learning can improve the efficiency of the learning process and help the learner take better advantage of the limited time and resource constrained device he has while on the move.

There has been much research in adapting learning resources to the learner's needs and device constraints and it was in the field of adaptive educational hypermedia that first used learners' needs, preferences and background to adapt learning content. When mobile devices improved in specification and could employ multimedia resources, the role of Multimedia Learning Resources in Mobile Learning increased significantly. Universal Multimedia Access (UMA) (Vetro et al., 2003) techniques were used to adapt multimedia content based on the resource constraints of mobile devices.

These content adaptation techniques can provide different versions of the the learning resources which suit different needs and device constraints. This makes adaptive content different from static contents and therefore existing search techniques created to discover static contents cannot be used to discover (a version) of adaptive resources. The challenge of enabling the discovery of the potentially most useful version provided by one of the available Adaptive Learning Resources has not been solved. This potentially most useful version must meet the user's learning needs, is in the right modality and quality to meet the device and battery life constraints and the right duration to meet the time limitations. In this paper, we have addressed this issue by presenting an Adaptive Learning Resource Meta-Model (ALRM) which enables the enables the discovery of the right version among all the versions provided by many adaptive learning resources.

This paper is structured as follows. Section 3 briefly describes the role of Content Adaptation in Mobile Learning and mentions some Content Adaptation techniques. In Section 3, we then describe the concept of discovery of adaptive resource for mobile devices and highlight its importance. Section 4, we describe our proposed Adaptive Content Model and shows how it can support the discovery of adaptive learning resources and finally in, Section 5, we conclude our paper and mention our future work.

## 2. CONTENT ADAPTATION AND MOBILE LEARNING

The key to the success of accessing learning resources using mobile devices is personalisation and adaptation. Personalisation and adaptation has been addressed by Adaptive Hypermedia (Brusilovsky, 2001) and Content Adaptation (Md Fudzee & Abawajy, 2008) techniques. Adaptive hypermedia deals with adapting content based on user models. User models represent users' preferences and background knowledge. Brusilovsky in (Brusilovsky & Millán, 2007) discusses use of Adaptive Hypermedia and user models in educational systems.

A learning content can be adapted in two ways (Bunt et al., 2007).1) Selection of the most suitable content or information based on user needs and 2) presentation of the selected content to meet the device resource constraints. For example, an-hour long video tutorial for beginner level about a topic can be provided in multiple versions. A shorter version (say 40 minutes) can be provided to a learner who has some existing knowledge about the topic. Moreover, to meet device constraints the video can be delivered in multiple quality levels of high quality, lower quality, or audio or just plain text can also be provided.

Transforming multimedia learning resources in suitable versions in order to be efficiently delivered to meet the diverse needs of learners and mobile devices is a research area that is increasingly attracting a great deal of attention. Adaptive Mobile Learning uses content adaptation techniques to provide multiple personalized versions of the same learning content to meet the challenge of diversity in learners' needs and device constraints.

Qing Tan in (Tan et al., 2011) Proposes a 5R adaptation framework, the aim of which is to provide a learning resource "at the right time, in the right location, through the right device, providing the right contents to the right learner". (Zhao & Okamoto, 2011) discuss some issues arising due to the diversity that exists in learning using mobile devices and address these issues.

Over the years, many techniques and frameworks have been proposed to provide adapted versions of learning resources based on user preferences, devices characteristics and user needs. Some of these techniques can be found in (García et al., 2011; Nguyen et al., 2012; Reveiu et al., 2008; Yang et al., 2007; Zhao et al., 2008).

## 3. DISOVERY OF ADAPTIVE RESOURCE FOR MOBILE DEVICES

In this section, we introduce a novel concept of discovery of adaptive resources for mobile devices. As mentioned in Section 1, discovery of static content is different from adaptive resources. Static content has one version and can be discovered using existing search techniques. Adaptive Content is different because it does not have one single representation. It can be offered in many different versions varying in terms of both information and presentation. There is a need for a mechanism to enable discovery of adaptive resources. Such mechanism can be based on profiles of adaptive resources which describe all the possible versions of the adaptive resource.

The process of discovery of adaptive resource is shown in Figure-1. It shows that there are three adaptive multimedia resources. Each of the adaptive resources can be adapted and provided in different versions. These versions include adapted video, audio and text versions. A user can use an Adaptive Learning Resource Discovery Service to select an adaptive resource which has Potential Most Relevant Version (PMRV) which is a version that matches user's information needs, preferences and devices capabilities. The discovery service needs to perform the selection based on profiles the adaptive resources.

In a situation where a learner faces battery and time constraints, a learner would like to find a content which meet his learning needs at that particular time and which would consume less battery power. The Adaptive

Learning Resource Meta-Model that we present in this paper enables this process of discovery by enabling search of Adaptive Learning Resource that has a potentially most useful adapted version for a learner.

Recently, (Al-Masri & Mahmoud, 2012) have addressed the issue of discovery of learning resources for mobile device - however they have not addressed adaptive content discovery. The authors present a Mobile Learning Description File (MLDF) through which the mobile learning content provider can specify a set of minimum requirements that a device must possess in order to properly access the content. This enables the learner to select a resource which can be accessible using his or her mobile devices. This mechanism can assist the learner in saving precious time which in turn preserves the battery life of the device. One shortcoming of this approach however, is no inclusion of learning characteristics to meets learner's information needs.

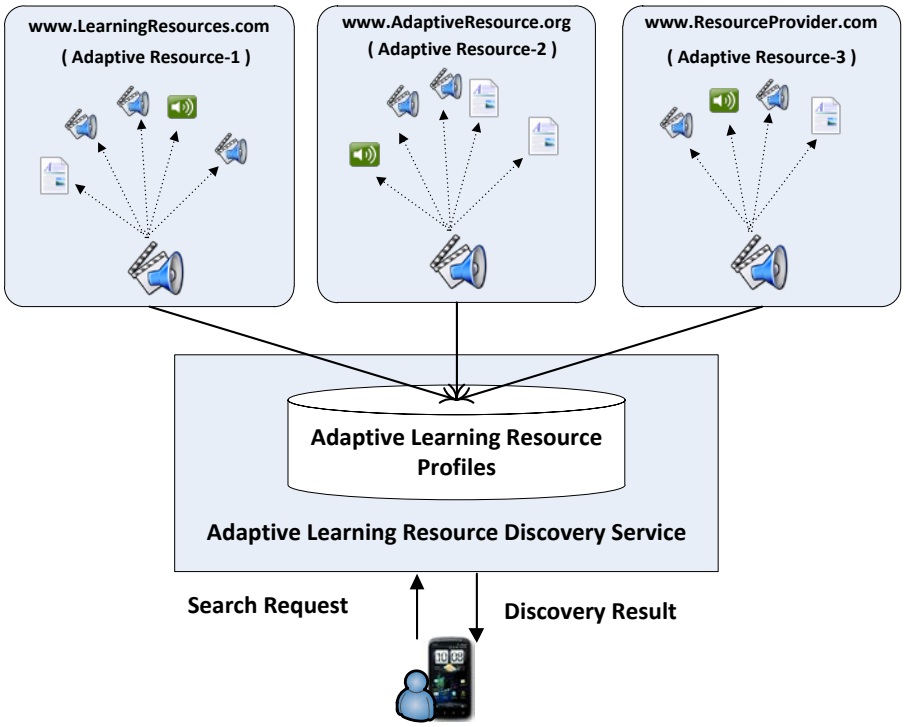


**Figure 1: Discovery of Adaptive Resource**

## 4. ADAPTIVE CONTENT MODEL

In this section, we present our Adaptive Content Model, which supports the discovery of the right adaptive learning resource which has a version that matches the learner's need, preferences and device characteristics. We have modelled our proposed model using Ontologies. We implemented our model using Resource Description Framework (RDF). As discussed in section 2 and 3, an adaptive content has many versions. Versions of learning resources vary in features which can be classified as either Presentation Features or Learning Features. Learning Features relate to information needs of mobile learner, while presentation features are related to the device and network characteristics. Learning Features include suitability level in terms of knowledge (Beginner, Intermediate, and Advanced), duration of learning and language. Presentation Features include modality and format of content, resolution and bitrates.

Our Adaptive Learning Resource Meta-Model (ALRM) models adaptive resources in terms of adaptive features. The model is shown in Figure 2. An adaptive learning resource or *LearningContent* has *LearningContentVersion* using *hasVersion* object property. LearningContentVersion will have one instance to represent each version of a learning content. A *LearningContent* has data properties like *identifier*, *subject*, and *creator* to represent URL, topic of learning resource and author of the content, respectively. These features are same to the entire adaptive content and are common to all versions.

*LearningContentVersion* has *PresentationFeatures* and *LearningFeatures* using *hasPresentationFeatures* and *hasLearningFeature* properties. *PresentationFeatures* represents the presentation of version. Presentation Features includes features like - *Modality*, *BitRate*, *Format*, *Resolution*, *FramesPerSecond*. Modality can be Audio,Video,Text or Image. If the resource is in Audio or Video format than *PresentationFeatures* contains both *BitRate* and *Format* of content. Video content has an extra Feature called *FramesPerSecond*. Image and Video can both have another feature Resolution. *PresentationFeatures* contains one data property which is *dataSize*.

*Learning Features* includes *duration* and *language* and *hasSuitabilityLevel* data property to link with *KnowledgeLevel*. *KnowledgeLevel* represents the background knowledge of the learner about the same topic, and has instances of Beginner, Intermediate and Advanced using *rdfs:type* property. *Duration* property represents duration of learning resource in minutes and language property represents the language of the learning resource.

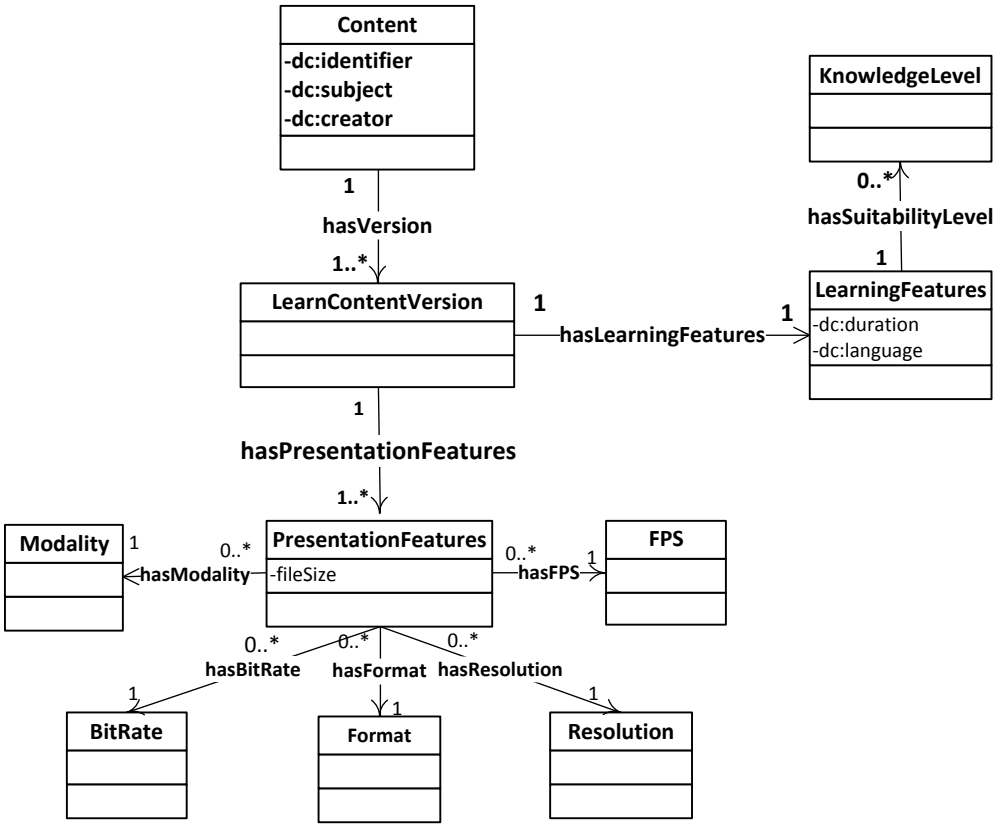


**Figure 2: Adaptive Learning Resource Meta-Model (ALRM)**

Figure 3, shows a graphical example of an instance of a model for one Adaptive Learning Resource, which is, for example, an adaptive video lecture resource on topic "Semantic Web". The actual discovery query will run across many such models of adaptive resources by different content providers to find the one with most suitable adapted version. We due to space limitation are showing only one model. Figure-3 shows four different versions of this adaptive video lecture resource. We have included only four versions due to the space limitations, in actual system this can be many. Version-1 and Version-3 are Video and Audio versions, respectively, of 50 minutes duration and are suitable for Beginner level. Version-2 and Version-4 are Video and Audio versions, respectively, for Advanced Learners of duration 30 minutes. Version-1 and Version-3 share the same Learning Features while Version-2 and Version-4 share the same Learning Features, while they have different Presentation Features.

**Example Scenario:**

*Bob has a job interview in 40 minutes and is waiting in the waiting area. The job specification mentions preference person having good understanding of semantic web technologies. Bob has some knowledge of semantic web but wants to know more about the topic to improve his chances of success in the interview.*

*Bob has a mobile phone connected to the internet. He is interested in a tutorial about semantic web technologies in English or French language. He has 30 minutes to learn. By looking at the remaining battery life of his mobile, Bob thinks that video will drain the battery power quickly so he should look for an audio version instead. Bob uses the Adaptive Learning Content Search system, and searches for a tutorial on in Audio suitable for Intermediate level knowledge of 30 minutes duration.*

*As a result, he receives a link for an adaptive resource that can provide an audio content of 30 minutes duration, which is shorter and Audio version full lecture in English of duration 60 minutes.*

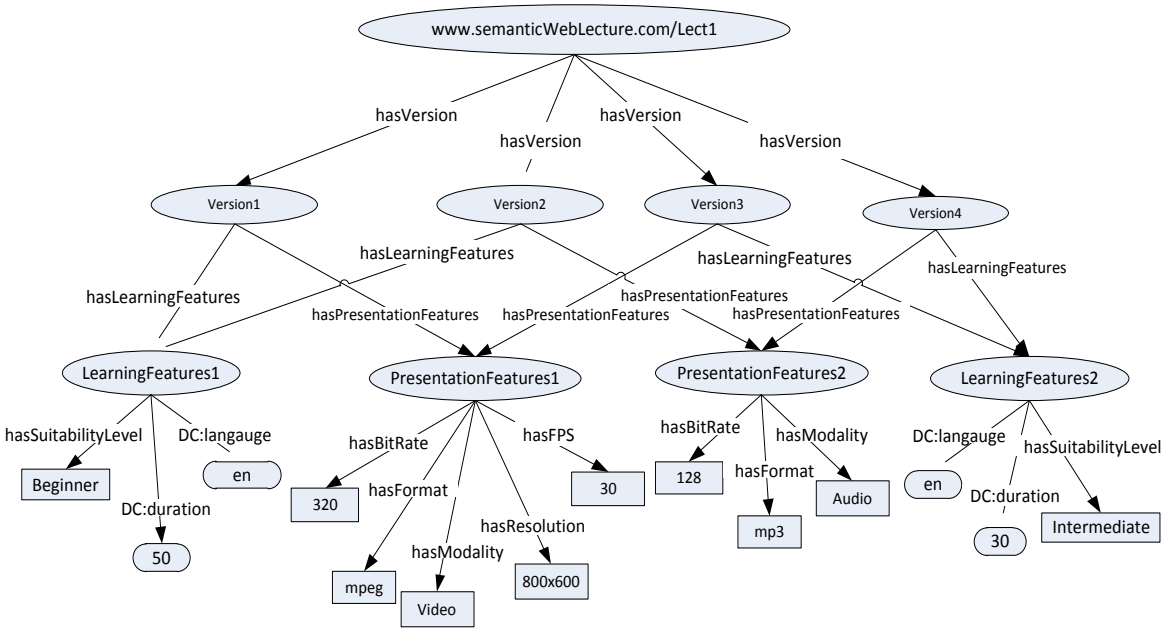


**Figure 3: Example of the model**

```
PREFIX DC: < http://purl.org/dc/elements/1.1/>
PREFIX ALRM: <http://users.ecs.soton.ac.uk/smaj08r/ontology/ALRM.owl#>
SELECT DISTINCT ?content WHERE {
?content DC:subject ?topic . FILTER regex( ?topic, "Semantic Web", "i")
?content ALRM: hasVersion ?learnCVersion.
?learnCVersion ALRM:hasLearningFeature ?learnFeatures .
?learnCVersion ALRM:hasPresentationFeature ?presentFeatures .
{ ?presentFeatures ALRM:hasModality ALRM:Audio . }
{ ?learnFeatures ALRM:hasSuitabilityLevel ALRM:Intermediate . }
{ ?learnFeatures DC:language “en” . } UNION
{ ?learnFeatures DC:language “fr”. }
{ ?learnFeatures DC:duration 30 . }
{ ?presentFeatures ALRM:hasFormat ALRM:AudioMp3 . }
```

**Figure 4: SPARQL query**

In the given scenario, Version-1 and Version-3 are not selected as they are of Video Modality, while Version 2 was of 50 minutes duration for Beginner level. Moreover, Version-4 was selected because the mobile phone was able to play an mp3 file and internet connection was good enough to play the audio of 128 kbps.

In Figure 4 - we present the SPARQL query we used to query the learning resource model based on the preferences we mentioned in the example scenario. Other presentation features like *FramesPerSecond*, *Bitrate* and *Resolution* can be included in the discovery query, but such parameters are not specified by mobile learner rather they are selected by the system for identifying constraints of the device and network connectivity condition.

## 5. CONCLUSION

In this paper, we discuss an important issue of discovery of Adaptive Learning Resources for mobile devices, which has not been previously addressed. We first highlight the importance of this issue and then propose a meta-model for adaptive learning resource. Our model enables the discovery of the right adaptive resource that has the potential most useful version for mobile learner to fulfil their needs, preferences and device capabilities. We have implemented the model using RDF and in the prototype application and used SPARQL for resource selection. We show usefulness of our model using a scenario and present an example model of learning resource based and a relevant SPARQL query. In future, we plan to build an adaptive resource discovery framework and build a mobile application to enable user to search adaptive resources for a right version by allowing user to specify his preferences and automatically retrieve device capabilities.

## ACKNOWLEDGMENTS

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