An Initial Framework for Implementing and Evaluating Probabilistic Adaptivity in Mobile Learning

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Abstract

The needs of mobile learners change dynamically with the various requirements of their wireless environments highlighting the need for implementing adaptivity in mobile learning. This paper introduces a new approach for adapting content in a mobile environment. This approach suggests adapting the delivery of granules of supplementary learning content to mobile devices using Bayesian belief networks. We describe a framework for producing content granules and controlling the preferences of adaptivity over various probabilistic techniques. The result will be a tool for the deployment and evaluation of adaptivity in a distributed mobile learning environment.

1. Introduction

With the continuous evolution of wireless technologies and the spread of internet-enabled mobile devices, mobile learning holds significant potential for education and lifelong learning. In the meantime, the diversity of the existing wireless technologies with their known limitations creates a set of requirements in different circumstances to which a mobile learning environment should adapt [7].

In this work, we focus on adapting content presentation and pre-fetching according to selected elements from various sources in a mobile environment, for example, elements from the learner's profile, mobile device requirements and connectivities. In this paper, we describe ongoing work to build a mobile learning environment that relies on probabilistic adaptivity for content adaptation. The environment is integrated with a framework for generating granular representations of supplementary learning material that are suitable for delivery and display through a lightweight java (J2ME) client. In order to implement probabilistic adaptivity, the framework supports the use of various techniques for Bayesian learning and inference. Bayesian belief networks (BBNs) are graphical models that encode relationships between variables of interest in a problem domain for reasoning and prediction [4]. Using Bayesian networks makes it possible to effectively combine collected evidence from different sources to adapt granules' presentation and pre-fetching in mobile environments.

We start this paper by a general overview of the system. We introduce a granular approach for content representation in section 2.1, followed by a description of the distributed environment. Section 2.3 discusses how Bayesian networks can be modelled for content adaptation. We conclude this paper with a brief discussion of related work and a summary.

2. System Overview

In this work, the adaptive mobile learning environment consists of three main components: a granule generation component, a distributed mobile environment and the probabilistic adaptivity component. These components can be controlled and customized through one main framework. Figure 1 shows a general overview of the system architecture identifying clearly the system components.

2.1. Granular Representations

Mobile content representation should fit into granules of meaningful information that are simple enough to work with technologies as simple as SMS. The framework can be used to represent a standalone block of material as a two way linked structure of granules while preserving its logical sequence. A granular approach for data representation could reduce the complexity of the learning environment [8] and allows efficient content adaptation.

Although the described granular structures could be applied to any type of learning content, we are only considering material that supports learning, such as news, quizzes, messages, revisions, calendar of deadlines or events…etc, as it is practical for mobile use. Supplementary learning material could be easily divided into small chunks of data to suit the requirements of mobile devices and in the mean time, make efficient use of their mobility and immediacy. For example, taking

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multiple choice quizzes or skimming some revision tips on a train before an exam could be a very valuable option to a student rather than the actual act of studying to understand the main course content.

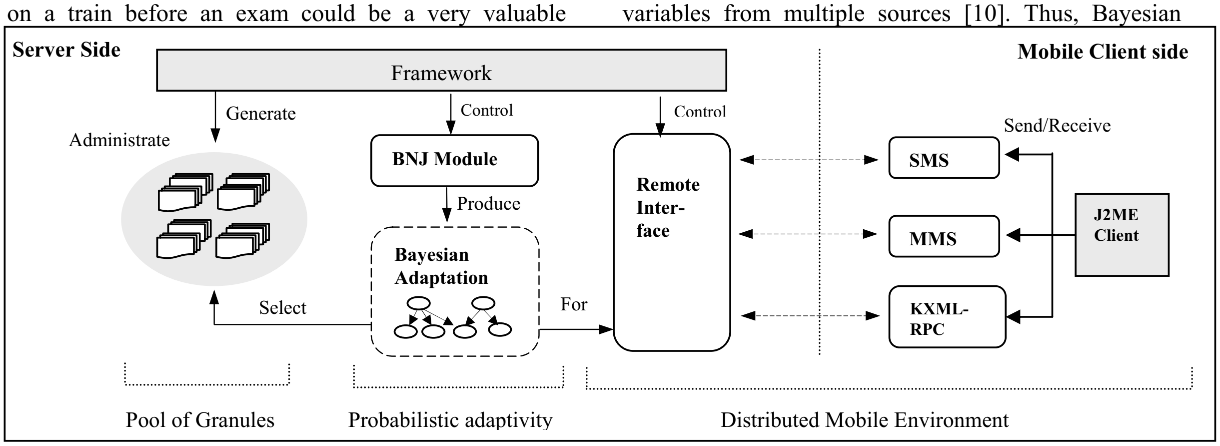

Figure 1. A General overview of the system architecture showing the server side learning environment and the mobile client.

2.2. A Distributed Mobile Environment

In this work, a user can communicate with the learning environment through a specialized lightweight java client. Using a specialized client that communicates with a remote interface in a granule-per-call approach is very cost effective compared to using a normal browser on the device. Moreover, the client supports communication through SMS and MMS since it is preferable for a wide range of users. Thus, a user can request to receive information over SMS through the client which gives even more control over the cost involved in using the system. Besides being cost effective, a specialized client can communicate effectively with the system for synchronization and granule's presentation.

XML-RPC is chosen as the communication protocol between the mobile client and the server-side environment. This arrangement allows efficient retrieval and adaptation of granules. Moreover, it ensures the system's scalability and reusability by providing standardized means of communication that could be extended by other clients. The J2ME client uses KXML-RPC [2] to make procedure calls to the server environment unless it is using SMS or MMS which will alternatively be interpreted as a procedure call on the server side (see figure 1).

2.3. Probabilistic adaptivity

Bayesian networks' reasoning and inference capabilities are said to resemble the human ability to produce an expert interpretation of data by integrating variables from multiple sources [10]. Thus, Bayesian networks encoding of causal relationships among selected variables can be very powerful in mobile learning. There are four main categories of attributes that are considered for adaptation in the proposed environment: device limitations, connectivities, learner's profile and content types.

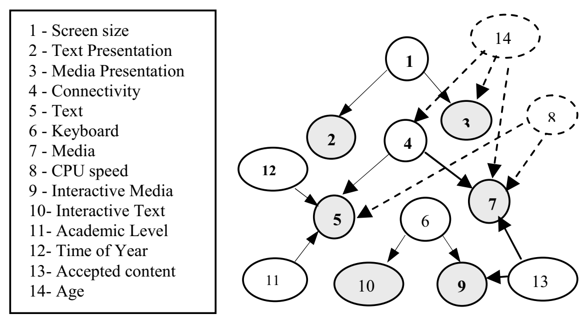

Figure 2: A potential model showing dependencies among possible adaptation attributes. Shaded nodes are decision nodes and unshaded ones are evidence nodes. Dotted lines represent possible variations.

Many possible variations of Bayesian models can be constructed from the different assumptions about the dependencies among selected attributes. Figure 2 shows a possible model reflecting certain assumptions about cause and effect in our problem domain.

In order to implement learning and inference as an embedded component in the mobile learning environment, we will use BNJ [5] (Bayesian networks tools in Java). BNJ supports a variety of well known algorithms for exact and approximate evaluation of Bayesian networks which gives a proper space for experimentation.

3. Related Work

The need for adaptivity and profiling of content for mobile environments has become widely recognized among researchers [7, 12, 11, 3]. Accordingly, many approaches appeared for modelling user preferences combined with technologies used for content adaptation. XSLT can be used to implement and switch among several representations of XML [9]; thus, it is suitable to adapt content presentation for a browser on different devices. Most of the work done in this area relies on XML, XSL and XSLT to adapt learning content for a browser client according to a repository of profiles [3, 12]. The differences between the existing efforts in this domain are in their profile representation and the elements considered for adaptation. Another approach uses agents to retrieve needed information about the user and the client for content adaptation [3, 6].

Bayesian networks were specifically used by [11] in modelling learner's needs combined with mobile device requirements to predict learner's preferences. Moreover, utility networks and BNs were used to automatically customize the presentation of a webpage according to a user's history of use and preferences [1].

4. Summary

In this paper, we have given a general description of a framework for implementing an adaptive mobile learning environment. In order to find the best model to suit the mobile learning domain, the presented framework is designed to provide the capability for evaluating approximate and exact probabilistic techniques for learning and inference. Accordingly, the framework can be used by three types of users:

- **Tutors** are able to prepare the desired supporting material and services for their students. Moreover, they can predict the type of material that is more beneficial for their students.
- **Developers** can manage the adaptation process and control the functionalities of the remote interface.
- **Researchers** can experiment with various probabilistic algorithms for learning and inference in a mobile learning domain. Having the privileges of a tutor, they can analyze the sensitivity and the value of the information with respect to the desired variables.

From a java mobile client, students and tutors will be able to browse and interact through the mobile environment created by the tutor beforehand.

Currently, a prototype of the described framework integrated with a mobile learning environment is being developed to collect data from the students' actual use of the system. The collected data sets will be used to investigate the best probabilistic algorithms for learning and inference. Further, the system will go into an evaluation stage, in which we can test the overall performance and whether the system provides an improved mobile learning experience for the students.

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