A Device-Independent System Architecture for Adaptive Mobile Learning

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Abstract

Most of the learning content existing today is designed for high resolution screen. Only a fraction of contents can be utilized on a mobile device. Although some content may be specifically designed for mobile devices, content providers can not assure that this content can be accessed by all mobile devices, because of the wide variety of technical characteristics, and existing standards. In this paper, we propose a device-independent architecture for mobile learning, which provides contents based on characteristics of mobile devices and mobile learners. Delivering contents tended to adapt to not only learner's needs and preferences, but also to mobile device used.

1. Introduction

The rapid adoption of mobile devices with Internet capabilities makes us work or study at any time, at any place[5]. But as we know, there are many limitations of mobile devices, which greatly restrict the relevant application of mobile technology[2][3].

Although some contents have been designed for mobile learning purposely (non-adaptive text content[2], reading based on Java[5]), providers can't promise contents accessed by any mobile device correctly because there are many kinds of different characteristics among devices, which are not taken into account by most ubiquitous learning system[2][4][5].

So it is important for learners to provide adaptive contents based on characteristics of mobile learner and mobile device used. In our proposed system, we combine the learner's profile and his social network (such as blog, facebook, mail) to find his learning interest and recommend the adaptive contents for learners. Of course, contents are provided based on the capabilities of mobile device. Figure 1-1 compares the traditional adaptive learning system and our proposed adaptive learning system[1].

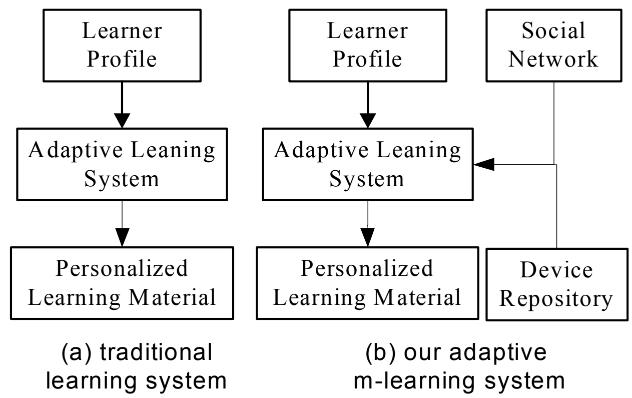

Figure 1-1 Comparison of traditional learning system VS. our adaptive m-learning system

The objective of our research is to construct the architecture which detects features of mobile device and provides adaptive contents for mobile device and to recommend adaptive contents for learners after analyzing their learning profiles and social networks.

2. System Architecture

We propose one adaptive contents architecture for mobile learners (Shown in Figure 2-1). The delivering contents adapt to not only mobile device, but also to mobile learners. The core components of architecture are *Contents Adaptor* and *Contextual Content Model*. *Contents Adaptor* creates adaptive contents for mobile device based on the capabilities of mobile device detected. *Contextual Content Model* analyzes learner's profile and provides needs and preferences of learner. At last, *Contextual Content Model* creates adaptive contents for mobile learners based on learner's capabilities and adaptive contents from Contents Adaptor. These components may cooperatively provide adaptive contents for mobile learners.

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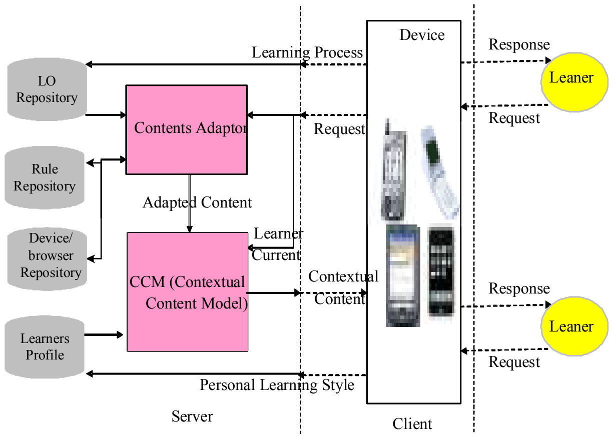

Figure 2-1 System Architecture of Adaptive Mobile Learning

2.1. Content Adaptor

The *Content Adaptor* is composed of *Device Detector* and *Adapted Content Model* (Shown in Figure 2-2). *Device Detector* takes responsibility for detecting the features (memory, screen size …) of mobile device and then sends the features to *Adapted Content Model*, which creates the adaptive contents based on Rule Repository (many conversion rules for different contents, such as image: PNG→GIF).

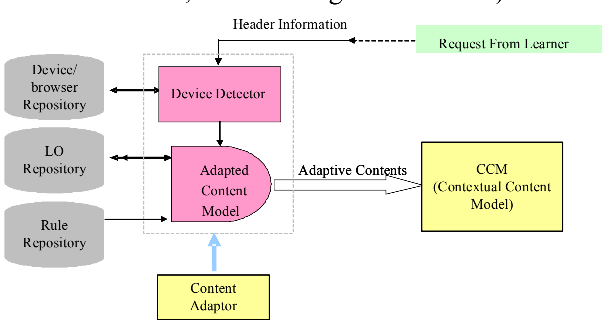

Figure 2-2 Contents Adaptor

2.1.1. Device Detector

Device Detector takes responsibility for detecting the capabilities (memory, screen size …) of mobile device and then sending capabilities to *Adapted Content Model*. *Device Detector* adopts the WURFL[3] model to detect the device, which collects the features of devices and mobile browsers in the wireless world. But as we know, there are many mobile devices emerging everyday. So we can not collect all the devices in the world, even in one country. So we should provide similar abilities for our users if we can not detect it. The detecting process is divided into two steps:

First Step: get features from device/browser repository based on User Agent from request of learners[3].

We can get user agent from the request of users. For example, from mobile phone of KDDI A1404S, we may get the User Agent: *KDDI-SN29 UP.Browser/6.2.0.6.2 (GUI) MMP/2.0*. The system adopts the algorithm of Levenshtein Distance to match the User Agent of devices from device repository (Shown in Table2-1).

Table 2-1 Levenshtein Distance

```
Input
    input s and t; // two strings of User Agent
    set lengths of s, t to n,m;
    construct a Matrix[n+1,m+1];
Output
    Matrix[n,m];
S1:  initialize the first row, column to 0..n, 0..m;
S2:  foreach character s[i] in s (i from 1 to n)
S3:  foreach character t[j] in t (j from 1 to m)
S4:  if(s[i] == t[j]) cost = 0;
S5:  else cost =1;
S6   endif
S7:  a= Matrix [i-1,j] + 1;
S8:  b= Matrix [i,j-1] + 1;
S9:  c= Matrix [i-1,j-1] + cost;
S10: set Matrix[i,j] = Min(a, b, c);
S11: endfor
S12: endfor
```

Another, features of device's browser are most important when user accesses learning contents from Internet by mobile device. We may use the features of browser instead of the features of mobile device when we can not detect mobile device (that is, not found in device repository). We try to find features of browser by Levenshtein Distance from browser repository. For example, based on user agent from KDDI A1404S, the system can detect that the browser is *UP.Browser*. So the system may provide adaptive contents based on capabilities of browser in stead of mobile device.

Although the system can detect the features of mobile device based on user agent from request, the system only gets most similar capabilities of mobile device at most times. In order to get more accurate capabilities of mobile device, an enhanced algorithm is proposed to improve features of mobile device at second step.

Second Step: modify the features based on other headers from request.

At most times, we may get other headers except for user agent, such as markup language and format of images supported, size of screen, etc. But different mobile service provider provides different header information from the request for same feature, such as screen size: *HTTP_X_JPHONE_DISPLAY* used by Softbank, which is third mobile service provider in Japan and *HTTP_X_UP_DEVCAP_SCREENPIXELS* used by KDDI, which is second mobile service provider in Japan. So we should define different rules to detect features based on these header information. Table2-2 provides the improving algorithm.

Table 2-2 Improving Algorithms

```
S1: input capability; // get based on user agent
S2: get header rules based on capability
S3: foreach header[i] in headers
S4:  if (header[i] in rule)
S5:     modify capability based on rule
S6:  else
S7:    submit to database for future improving
S8:  endif
S9: endfor
```

2.1.2. Adapted Content Model

Rule Repository contains many different conversion rules for media, such as text, image, and audio. After *Adapted Content Model* gets the capabilities of mobile device, it can create the adaptive contents for special characteristics of mobile device. These contents try to adapt to the device. For example, There is one learning object (format: JPEG, pixel: 200*200) in database. When the learning system detects some supported features (image format: GIF, max size: 128*120) of mobile device, the learning object will not be layouted correctly if the system sends original JPG file to user. We should create a new GIF images (128*120) based on original JPG image dynamically. The conversion rules in database will be described in other papers.

Another, mobile device supports different markup language (such as: WML, cHTML, XHTML). We should embed learning object with the right markup language. In our system, we adopt the WALL[3] to layout the learning contents. WALL offers a solution to provide adaptive markup language for wireless application.

2.2. Contextual Content Model

The *Contextual Content Model* contains *Personal Ability Analysis Model* and *Contextual Model* (shown in Figure2-3). *Personal Ability Analysis Model* provides the essential characteristics of learners by analyzing their social networks, such as facebook, blogs, registered on learning system. Combining essential characteristics with past learning ability and current learning state, *Personal Ability Analysis Model* recommends current learner's preferences and needs: what you can do, what you have done, what you are doing and what you want to do. Based on learner's preferences and needs, *Contextual Model* creates adaptive, contextual contents for learners.

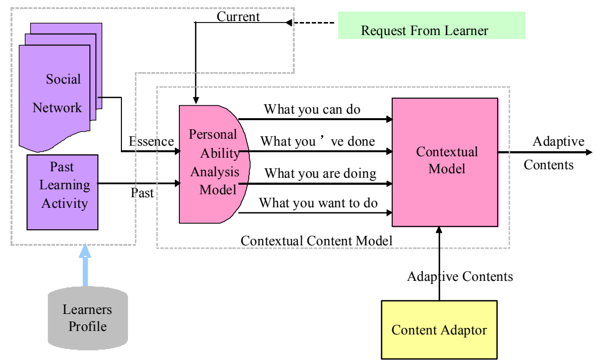

Figure 2-3 Contextual Content Model

3. Conclusions & future works

In this paper, we propose a device-independent architecture for mobile learning, which creates adaptive contents for mobile learners based on characteristics of mobile learners and mobile device.

In future, we will pay more attention to advanced algorithms to detect learning preferences and interest of learners based on social networks and contextual learning situation of learners and to create adaptive contents for mobile learners.

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