

Billing Issues when Accessing Personalised Educational Content

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Abstract

The increased affordability of mobile devices combined with the availability of the latest wireless technologies have made mobile devices an attractive tool for learning. Nowadays learners can choose between multiple wireless networks with different characteristics, belonging to the same or to different mobile operators. Unfortunately, the Internet billing plans are still difficult to predict and control by most users. This paper presents an algorithm which aims to determine the best network, from a list of available ones (in terms of price), for delivering the selected educational content.

1. Introduction

Mobile device popularity has increased tremendously in the last years. For example, more than half of the world population has a mobile phone [1]. Mobile devices are present everywhere and they have become more and more accessible. Their prices dropped, their portability has increased and the performance offered by mobile networks has improved a lot. Due to their pervasive presence as well as to the tremendous development of new features and capabilities they have become an attractive tool for education.

Owning a mobile device that has connectivity to one or more wireless networks makes the access to educational content easy at any time and from anywhere. Mobile devices ease the learner's access to information, helping them to have access to the right resource at the right time. In the same time, they are particularly useful for learners that do not have the time to plan a learning session and they are usually studying in unplanned situations. Difficulties due to time constraints have been observed especially for part time students. Becking et al. [2] noted that these phenomena, giving examples of unpredictable situations where learners could benefit from having

access to the educational content. Among the examples given is the one of a salesman who travels a lot and may learn while s/he is on train. Another example is of a mother who is waiting for her turn in the doctor waiting room.

Even though mobile devices offer new opportunities for learning, they have some restrictions: small screen size, limited number of buttons, battery life limitations etc. Therefore, offering guidance to the learners and providing them with the adequate educational content suited to their needs is an important issue addressed by learning systems. Adaptive e-learning systems offer solutions to these problems, by providing guidance and personalised material suitable to the learner. Different user's characteristics have been taken into consideration in the adaptation process such as: knowledge [3], goal [4], learning styles [5], prerequisites and experience [6], network performance [7], etc. Lately, learner device characteristics were also considered in the personalisation process [8, 9, 10].

However, to the best of our knowledge, none of these e-learning systems have considered that the learner may choose between different networks, when the mobile device offers access to more than one wireless network. For example a number of mobile devices that include these features are listed below:

- PDA O2 XDA Zinc has access to 3G, WiFi and GPRS;
- HTC TyTN II has access to HSDPA/UMTS, WiFi, GSM, EDGE and GPRS;
- HTC P3300 has access to GSM/GPRS/EDGE and WiFi;
- Mobile Pocket PC-i-mate Jasjar has access to GPRS, WiFi, etc

Each type of wireless network may have both different delivery performance and billing plans. Cheaper alternatives may trigger the learner to switch manually between the networks.

This paper presents a Performance Aware and Cost Oriented e-Learning Framework (PACO-eLF) that supports content personalisation by taking into account

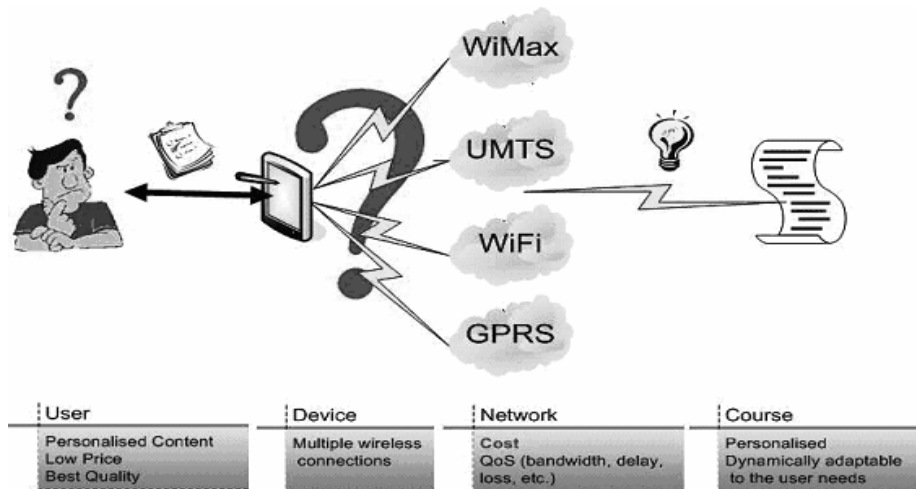


Figure 1 Multiple network selection

learner's profile, the device used, the network characteristics and the cost they have to pay for accessing the content. An algorithm that determines the best network, from a list of available ones (in terms of price), for delivering the personalised educational content is also described.

The rest of the paper is organised as follows. Section 2 presents an overview of the existing billing models for Internet access through mobile devices. Section 3 briefly introduces the PACO-eLF and presents the network selection algorithm. Section 4 presents the conclusions we arrived so far and describes new directions to continue our research work.

2. Billing models for Internet access through mobile devices

Access to multiple networks offers to the learner more possibilities of retrieving the educational content,

by choosing a given mobile service (Figure 1). Ideally the learner selects from the available networks, the one which offers him the best price and performance, or at least the best trade off between them. Unfortunately this is not always the case. Mobile data billing systems are still difficult to understand by most users and determining the best network in terms of performance often requires engineering knowledge. This problem becomes even more important in the context of the wireless channel where network resources are limited.

The diversity of billing schemes that currently exists on the market (Table 1) does not help the learner in making a decision. The most common data billing plan in mobile communication is the flat rate bundle [11]. Other billing plans include, but are not limited to:

- Time based billing (paying for the amount of time that is spent using the Internet, for example 0.005€/minute)
- Data based billing (paying for the amount of

Table 1 Mobile billing plans diversity

Operator	Time billing	Data billing	Bundle billing	Monthly flat rate	Other services included
T-mobile(USA)			X	X	X
Meteor(Ireland)			X		
Three(Ireland)			X		
Vodafone(Ireland)			X		
O2(Ireland)			X		
Indosat(Indonesia)	X	X	X	X	
Mobility(Saudi Arabia)		X	X	X	
Vodacom(South Africa)		X	X		

data consumed, for example 0.2€/MB)

- Monthly flat rate (unlimited Internet access, paid monthly)
- Free Internet access

Sometimes billing plans are much more complex. Depending on the carrier policy, a user can pay more by visiting some websites or not pay at all (e.g. when visiting the carrier portal). The price may also depend on the connection speed or on the time of the day when the Internet is accessed. Most of the time, mobile data traffic is charged separately from other services such as SMS (Short Message Service), MMS (Multimedia Messaging Service), calls etc. Each particular service may have a different cost associated. However there are times when they are included in one single package.

Time based billing is relatively easy to understand, but the attention of the user is on optimising his actions in order to spend less time on the Internet when retrieving the actual information s/he is requesting [12].

Data based billing, is not so easy understandable for the users. Most of them do not know how to predict the amount of data downloaded. Sometimes there is no way to find how much the users spend. Even when the mobile operator facilitates this process by providing a counter for the data used so far, some of the users do not know that it exists or how to use it [12].

The data bundle has the advantage of offering data at low price. However when the user passes the data limit the price becomes quite high. Most of the users do

not realise when they exhaust the amount of data available in the bundle. This leads to high bills, discouraging users to access the Internet through their mobile devices [12, 13].

Choosing the right network in terms of price and controlling the cost may distract the learner's attention from the educational content he is presented with. Therefore, there is a need for an automatic mechanism that assesses the billing plan. This paper presents an algorithm that aims to help the learners in selecting the right network in term of cost.

3. Cost oriented adaptive e-Learning system

PACO-eLF (Performance Aware and Cost Oriented e-Learning Framework) (Figure 2) aims at offering adaptive educational content to learners by taking into account their profile, the device they are using, the network performance and the cost they have to pay for accessing the content. The classical architecture of an adaptive e-learning system that consists of UM (User Model), DM (Domain Model) and AM (Adaptation Model) has been extended by adding the PM (Performance Model) and CM (Cost Model).

PACO-eLF consists of a *Client Application* and a *Server Application*. The *Client Application* maintains the CM. It stores the billing plans for every network the

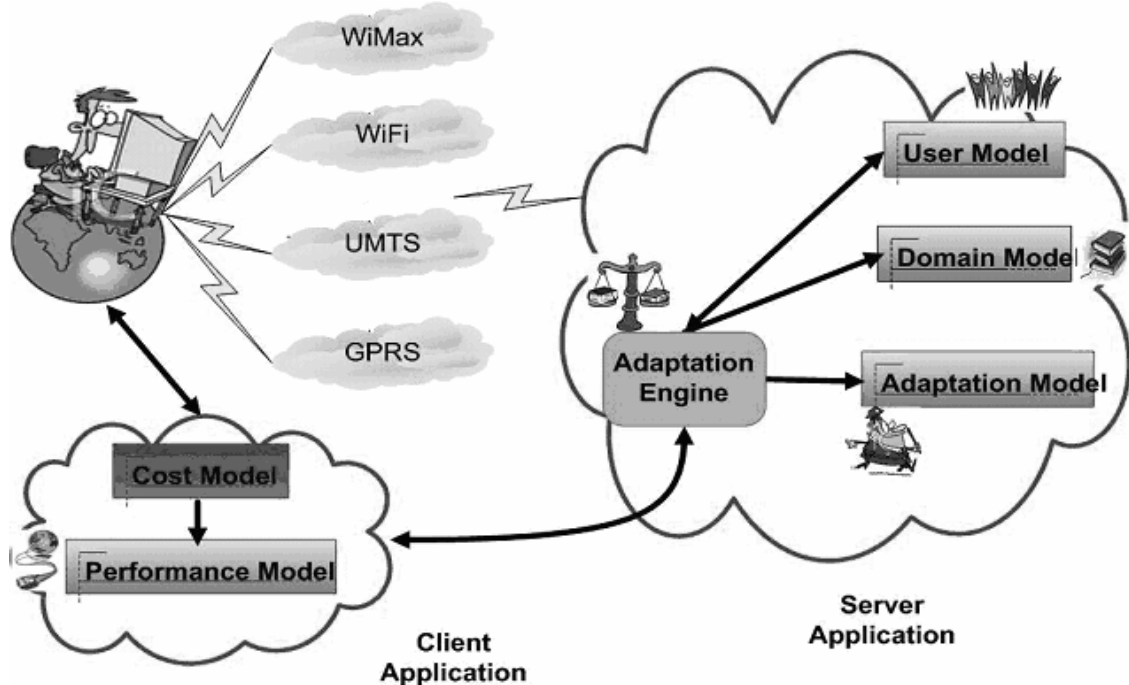


Figure 2 PACO-eLF

learner device has access to. It also estimates the price for each available network when a document is required. It interacts with the *Server Application* to get information with respect to what changes occur in the characteristics of the network currently in use that may affect the price that will be paid for the data retrieval. If the total price increases over a certain threshold imposed by the learner, the learner is prompted and provided with an alternative network to be used that would offer a better price for retrieving the educational content.

The *Server Application* maintains information about learner profile (UM), available courses (DM), network performance (PM) and adaptation rules that describe how to personalise the educational content based on the user profile and the network conditions (AM). The rules are interpreted by the Adaptation Engine (AE).

User Model (UM) holds the learner profile. It consists of:

- demographic information (e.g. address)
- personal data (e.g. name, password, etc)
- learner preferences
- learner goals
- knowledge about the concepts contained in the DM
- device characteristics
- how much the learner is willing to pay in order to retrieve educational content, etc.

Device characteristics considered by the UM are:

- *Screen size*: width and height in pixels;
- *Screen colour depth*: bits/pixel;
- *Screen mode*: it refers to whether the screen has portrait or landscape mode and if it supports switching between the two modes;
- *Capabilities*: whether the device is capable of displaying video, audio, images, etc;
- *Supported mark-up or scripting language*: e.g. not all mobile devices support all JavaScript functions;
- *Memory*: capacity.

Device Model (DM) stores and organises the educational content, divided into fragments between which relationships exist. For example a *link*: indicates that between two fragments navigation can be done and a *prerequisite* relationship indicates that there is an order in which the fragments should be delivered to the learner (e.g. a learner should not read about a certain concept if s/he has no knowledge or if s/he did not read first about the *prerequisite* concept). The educational content fragments can be grouped together based on these relationships in order to form complex concepts.

Performance Model (PM) contains information about the performance of the different networks that

the learner has access to. For every enabled network the device has, performance characteristics are maintained and continuously monitored, in order to determine the quality of the transmitted content. It also provides suggestions on how the educational content should be adopted so that it is suitable for transmission over the active network.

The *Adaptation Model* (AM) holds the adaptation rules based on which the content selection and personalisation is done. The rules combine information on learner profile, device, network conditions and cost.

Adaptation Engine (AE) interprets the rules from the AM and selects the most suitable educational content.

The *Cost Model* (CM) maintains the learner billing plans. It also has the role of suggesting to the learner the best network to be used in terms of cost and performance in order to assure that the threshold imposed by the learner is not surpassed. The based network to be used is determined by an algorithm that is presented in the next section.

4. Cost oriented network selection algorithm

The main goal of the algorithm is to determine the best network, from a list of available ones on the device (in terms of price), for delivering the personalised educational content.

We consider that the learner has one or more mobile network operators and s/he may have one or more billing plans currently in use. The plan types the learner may have are: free Internet access, flat free billing, data bundle billing, data based billing and/or time based billing.

For the data bundle billing the quantity of information contained in the bundle is usually available for a specific period of time. Sometimes, the mobile data operator does not allow a new bundle to be acquired if the learner has a bundle in use for the current time period. For example, if the learner chooses a data bundle over a period of 30 days which contains 500 MB of data, s/he may not choose another data bundle billing plan if the 30 days period has not expired. This leads to the situation in which the other plans are unavailable for the user. Therefore, they should not be considered by the algorithm when the learner is provided with the cheapest alternative to access the educational content. An algorithm for selecting just the available plans for every operator/network the learner has access to is presented in Figure 3. It takes as input all the available operators

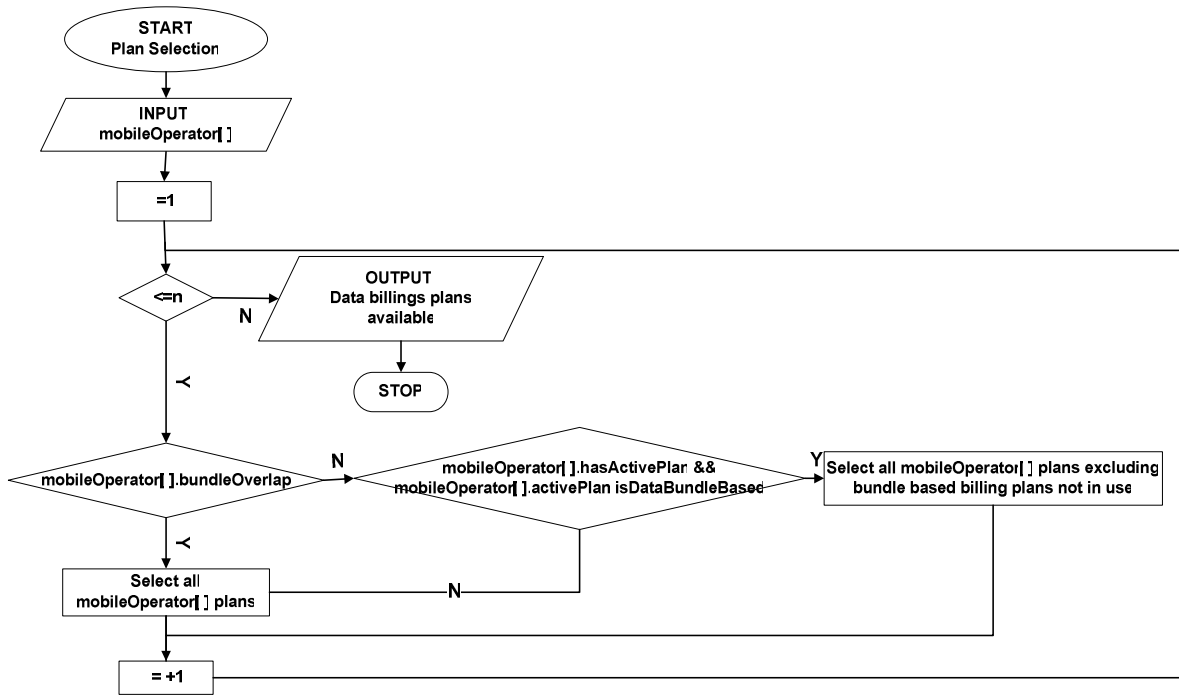


Figure3 Operators Plans Selection

and returns billing plans the learner has currently access to.

Based on the selected plans, on the lecture size and on the network connection speed, the price for accessing the educational content is computed (Figure

4a-d). The lecture size is provided by the AE (Adaptation Engine) after selecting the educational material suitable to the learner profile. The connection speed for each of the available networks is provided by the PM (Performance Model).

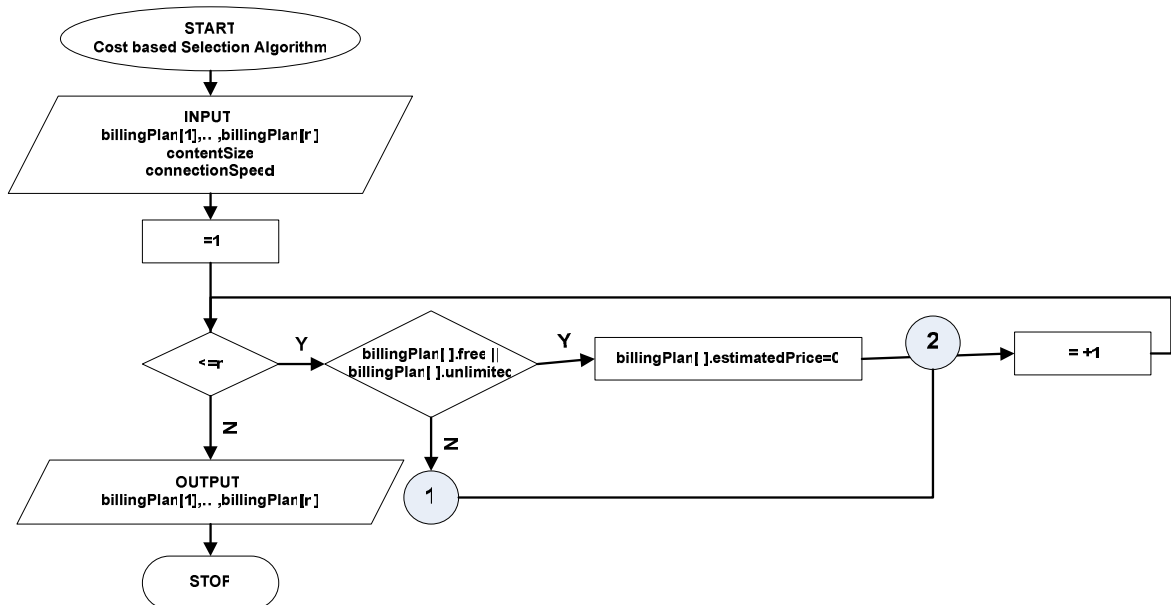


Figure 4a Cheapest algorithm selection3

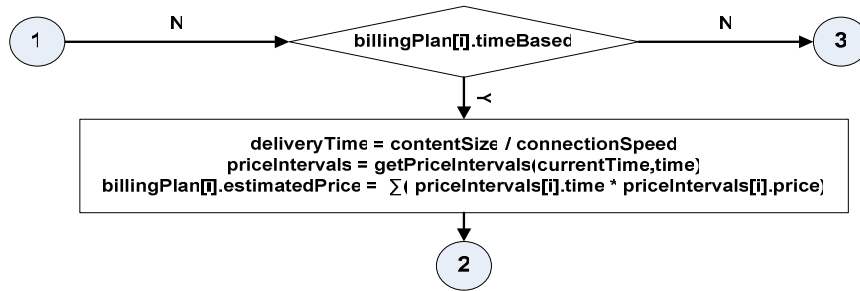


Figure 4b Estimated price for time based plan

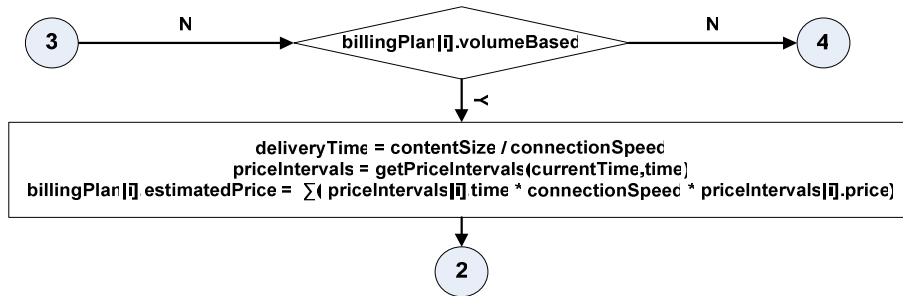


Figure 4c Estimated price for volume based plan

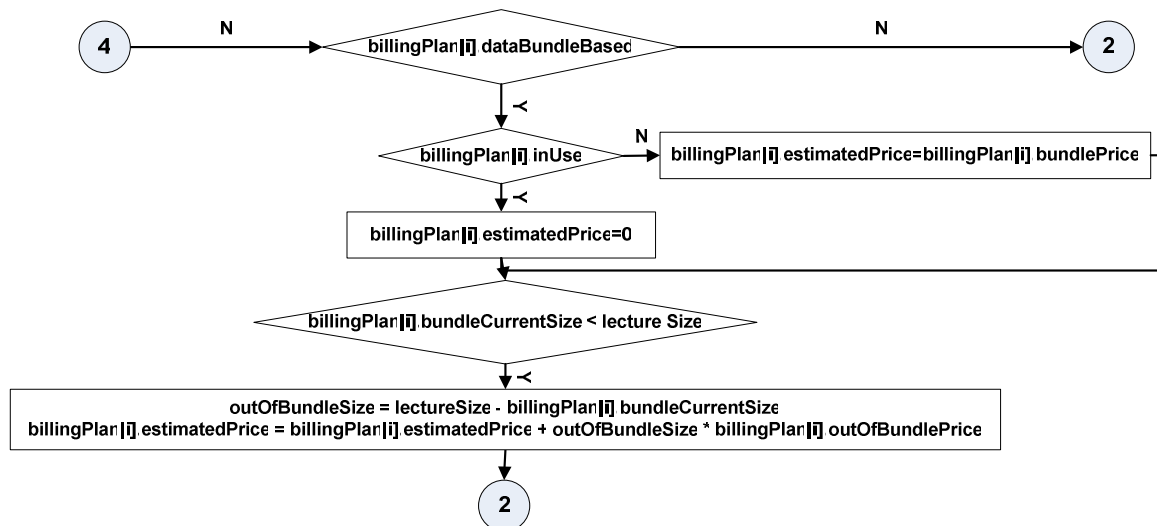


Figure 4d Price estimate for data based bundle plan

The estimated price the learner has to pay may be null in three cases:

- the learner has access to a free network
- the learner has a flat free plan
- the learner has a bundle data plan already in use and the remaining size of the bundle is less than the total size of the requested document.

Otherwise:

- if the learner has a data bundle plan already in use and the size of the lecture exceeds the remaining quantity of data from the bundle, the price for the quantity of information which

exceeds the limit. This is calculated and that is considered the estimated price the learner has to pay (Figure 4d).

- if a data bundle plan is available but not in use, the price will include also the price of the bundle (Figure 4d).
- if the learner has a time based plan (Figure 4b), the estimated price will be computed based on the price per time and the average network speed.
- if the learner has a data volume based plan the estimated price is computed based on the

lecture size and the price per quantity of information(Figure 4c).

Having all these prices computed, a ranking can be made based on the amount of money the learner has to pay. Two other cases are taken into account when the data bundle based plans are classified: the expiring date for the data bundle or the quantity of information contained in a bundle. The first case is useful when there are two bundles already in use that have the same price. Probably most learners would choose to use the bundle that is going to expire first. For example if there are two bundles in use, first having a remaining data bundle of 500Mb and expires next day and the second one has 1Gb and expires in a week and the lecture size is less than 500Mb, the first network will be displayed for the learner as the first option. The second case is when the bundles are not in use yet, but two mobile operators offer at the same price data bundles with different limits on the quantity of information to be transferred. In this case the plan which has the bigger quantity of information in the bundle may be chosen. For example if an operator offers a 1Gb data bundle for 15 Euros whereas the second one offers 5Gb for the same price, the most advantageous for the learner would be the plan offered by the second operator.

After ranking the plans the top three plans in terms of cost are displayed to the learner and s/he will choose among them. However, the learner has the option to see the other plans, if s/he wishes to do so.

5. Conclusions and further work

This paper presented and discussed various billing plans that currently exist on the market for accessing the Internet. PACO-eLF – an adaptive e-learning framework was briefly presented and an cost oriented network selection algorithm was described in details. The algorithm assesses the billing plans of the active networks on the learner device and computes the price when downloading a given document, for each network. It provides the learner with information related to how much s/he needs to pay when the educational content is retrieved.

We are currently working on an improved version of the algorithm that provides a better estimation on the price the learner has to pay. We achieve this by taking into account also other messages/information sent over the network that are not included in the lecture size. The algorithm will also take into account network conditions, in order to provide the learner with the best network alternative over which the educational content can be sent. The PACO-eLF framework is currently under implementation. Tests will be performed to see

the effects of the algorithm on the learner QoE (Quality of Experience). The results will be presented in another paper.

ACKNOWLEDGEMENT

This research work is supported by IRCSET Embark Postgraduate Scholarship Scheme and SFI Research Frontiers Programme.

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