A Learner, is a Learner, is a User, is a Customer
- QoS-based Experience-aware Adaptation

Sabine Moebs
Dublin City University
School of Electronic Engineering
Dublin 9, Ireland
+353-(0)1-7007644
sabine@eeng.dcu.ie

ABSTRACT
This paper describes an outline of the doctoral thesis work concerning adaptation policies towards quality of experience (QoE) in performance-aware adaptive multimedia e-learning systems. QoE is considered to be mainly affected by the psychological concept of flow and learning-related factors. In turn, for multimedia systems, these factors can be heavily influenced by quality of service (QoS). In an ideal world, QoS would not be an issue and content optimally tailored to a user’s needs could always be perfectly delivered. Unfortunately, delivery conditions are not always ideal, and it may be infeasible to deliver certain multimedia content such as high quality video while maintaining an acceptable QoS. The goal of this research is to balance the constraints imposed by QoS restrictions with the requirements of flow and learning in order to produce the highest possible QoE for the learner using an adaptive multimedia system.

Categories and Subject Descriptors
H.5.1 [INFORMATION INTERFACES AND PRESENTATION (e.g., HCI)]: Multimedia Information Systems – evaluation / methodology
H.5.4 [INFORMATION INTERFACES AND PRESENTATION (e.g., HCI)]: Hypertext/Hypermedia - user issues
K.3.1 [COMPUTERS AND EDUCATION]: Computer Uses in Education - computer-managed instruction (CMI)

General Terms
Algorithms, Performance, Design, Human Factors

Keywords
QoE, QoS, Flow, Learning

1. Introduction
To learn with the support of an adaptive hypermedia system automatically makes the learner a user of a system. As a user of a system the learner will also be involved in a customer relationship with the learning provider. The learner therefore will not only have previous knowledge, a preference for learning styles and preceding learning experiences [1], etc. but also previous experience as a user and customer in a variety of (multimedia) e-commerce systems and e-games which raise and form their expectations [2]. These different relationships as learner, user and customer, in the end all influence the expectations and thus the Quality of Experience of the learner. To look at the Quality of Experience one therefore needs to consider all three roles of the learner.

The ultimate goal of this research is to first identify those factors which most influence QoE in an e-learning setting and then use these to develop an adaptive hypermedia e-learning system that best improves the user’s QoE.

2. QoE, QoS, Learning and Flow
We propose a QoE model (Figure 1) for adaptive hypermedia systems that considers the three roles of the learner previously mentioned. We conclude that QoE is affected by four main factors, flow, QoS, learning and usability [3]. Our QoE model acknowledges that QoE is different for every person [4], which requires the system to be able to include feedback and adjustment from the user to make it not only adaptive, but also adaptable by the user.

Figure 1: Proposed QoE Model
Flow is a psychological concept [5] and it describes a state where people are so completely immersed in an activity that they lose track of time and self-awareness, which leads eventually to very intensive interaction with the activity [6]. Flow as outlined above, is considered to be directly influenced by speed [7], which is defined as speed of the website and the time it takes to load pages. Both characteristics are closely related to the QoS parameter delay. Changes in QoS should result in changes in flow. Flow on the other hand is itself a direct indicator for QoE [8]. Learning is characterized by learning and teaching methods, learning styles, different learning theories, the quality of feedback and interaction influence as well as the ratio of skills and challenges. This research focuses on the theory of multimedia learning with its five major principles of how to use multimedia [9]. This provides a learning theoretical background that suggests that there is a direct impact of multimedia formats as well as their quality on the learning results. The multimedia learning theory is based on the dual coding theory [10], which is based on the concept that human cognition processes knowledge simultaneously in two sub-systems. Each of the two sub-systems processes either nonverbal (i.e., images, sounds) or verbal information (i.e., spoken or written words).
Usability is part of the QoE model but it is not considered for the adaptation. QoS is based on network and application parameters. The network parameters considered are delay, jitter, segment loss and segment order [4]. The application parameters considered are video, audio, text. This setup allows applying multi-criteria decision making [11].

3. Adaptive Hypermedia Systems
Adaptive multimedia e-learning systems usually have a basic architecture that consists of a user model, a domain model and an adaptation model [12], [13], [14].

Figure 2: Basic Architecture of Adaptive e-Learning Systems
The domain model represents the concept of the subject domain and it usually describes these concept structures as concept maps, semantic networks or concept graphs. The user model represents general characteristics of the user such as location, preferences for devices, previous knowledge, knowledge state, learning goals. It often contains an overlay model of the domain model. The adaptation model connects the two previously outlined models, using adaptation rules. It thus enables individualized content selection matching the preferences of the user [15].

4. Research
The adaptation of our system aims at a good QoE. Flow-related as well as learning-related aspects are the main components of the QoE, which are both influenced by quality of service (QoS) [3]. This relationship is represented by the function from equation (1).

\[ QoE = f(QoL(QoS), QoF(QoS)) \]  

(1)

Weight normalization is required; therefore the condition from equation (2) needs to be considered.

\[ \sum_{i=1}^{3} w_i = 1 \]  

(2)

The components do not carry identical weight in regard to QoE. The adaptation model therefore uses rules that strengthen the creation of flow experiences and support the learning process, while considering selected QoS parameters, adding to the previously outlined functions. The preliminary selection of criteria considered in the research is based on a literature review (see Figure 3).

Figure 3: Detailed QoE Model
QoS is based on packet loss, delay and jitter in background application, video, audio and data.

QoL is based on the user model aspects feedback, a clear set of learning goals, interaction, the balance of skill and challenges in learning, learning styles, assessment of the previous knowledge and the domain model.

QoF is based on feedback, a clear set of goals for using the website, interaction, the balance of skill and challenges, which include use of technology and emotions.

The adaptation has to consider two stages. Stage 1 aims at optimization for individual users, stage 2 targets optimization over multiple users.

Currently an online Delphi study [16] including 20 experts on QoS, adaptive systems and e-learning, investigates how important to flow the factors in Figure 3 are, in particular those which we can adapt. An algorithm for adaptation has to be developed, which can potentially take into account feedback we get from measuring QoL and QoF. Simulations to test the algorithm will be used to prepare a prototype to do extensive testing with users.

The user testing will include eye-tracking and face-recognition. The experience sampling method [17] will be used to evaluate the QoE. Once the relationship between QoS on flow and learning has been established, a method to integrate the assessment of flow to feed it into the adaptive system is required.

5. Acknowledgements
This work is supported by Science Foundation Ireland (SFI) Research Frontiers Project CMSF 696.

6. References


