Personalized Multimedia Content Generation Using the QoE Metrics in Distance Learning Systems

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***Abstract*—Personalization of multimedia learning content means to classify the multimedia content to meet a specific user's individual interest, preference, background and situational context – captured by a user profile. Appropriate choice of multimedia learning content has become as one of the most important challenges in order to provide user with personalized distance learning material. The main contribution of this paper is the creation of new model for adaptive multimedia learning that dynamically changes the content depending of the mapping relations between the QoS and QoE metrics. The proposed model delivers personalized multimedia content tailored to user cognitive style and adapting the content according the context – aware network conditions. Main focus is given to tracking the context-aware user behavior in order to generate an appropriate and fine-grained user profile with personalized learning content. The simulation of different models of individual user profiles were developed using the OPNET network simulation software. The presented simulation results confirmed the correctness of the developed model.**

Keywords-personalized multimedia content; adaptive distance learning system; context-aware; OPNET; user profile.

I. INTRODUCTION

Current distance learning systems provide learning content that can be reused and easily shared regardless of the location of the student, anywhere and anytime. In this way, more emphasis is given to the process of indexing and manipulating of learning content in order to create multiple smaller packages called learning assets [1]. These assets are collected in a SCORM (Shareable Content Object Reference Model) compliant repository in order to create and deliver the learning materials [2]. Using the modern Web 2.0 technologies, as in [3], easy delivery of learning materials and increased interoperability among various e-learning platforms has been provided. In this way, reusable SCORM learning objects can be very easy imported and exchanged between various e-learning platforms if they are SCORM-compliant [9].

In the existing learning process, teachers handover their knowledge according to predefined learning schedule and do evaluation of student knowledge using different kinds of tests, quizzes and questionnaires. Therefore, it is imperative to create customized interactive process of knowledge transfer in such a way that students receive tailored course according to their reasoning preferences. In this process, it is important that learning material does not force them to split their attention between multiple sources of information. This way, combination of different media type can provide appropriate personalized learning environment. This can be considered as necessity to implement the multimedia learning, in particular that a mix of different media enhances learning experience [14].

Separation of cognitive learning styles using the visual and verbal perception has proven to be successful for different learner groups: undergraduate, postgraduate and as well educators in higher education. These groups prefer more visual perception than the typically available existing e-learning environments. The visual material includes images, graphics, simulations and videos in order to increase overall quality of experience for the learner. On the other hand, this does not imply however to neglect the verbal perception that consist of audio and text-based learning [14].

Developing a model for adaptive multimedia learning that will provide dynamic adaptation of a network's operation and performance (for example bandwidth) should be in line with user's profile dynamic requests. In this way, the multimedia content will be adapted according to available network resources and the user learning profile. Usually, environment is greatly influenced by user perception of quality that is measured by the QoE (Quality of Experience) metrics as a multi-dimensional construct of user perceptions and behaviors. In our proposed model, the QoE metrics is used for estimating cognitive learning styles of the end user, as visualizer, verbalizer or bimodal perception of information. If we consider the technological systems as "environments", their influence is quantified by QoS (Quality of Service) metrics. They lead to subjective and objective responses of users, both of which are considered as part of the "user experience" [5].

This paper is structured as follows. Section II describes the proposed context-aware multimedia learning model and discusses how QoE is perceived in current research. Section III presents our proposed scheme of mapping between QoS and QoE in order to deliver personalized learning content. In section IV, we will present our simulation results. Section V gives the conclusion and future work.

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II. CONTEXT-AWARE MULTIMEDIA LEARNING MODEL

In order to create a personalized multimedia learning content, we need to shift towards estimating the QoE. That is more associated to a specific user profile and the degree of user satisfaction from a given multimedia service or product. The International Telecommunication Union defines QoE as: "The overall acceptability of an application or service, as perceived subjectively by the end-user" [6]. Because QoE is something that is created by user's observance, it is more a qualitative measure than a quantitative one. Then, it needs comprehensive subjective quality assessment methodologies and objective quality assessment metrics that will model the human perception as closely as possible.

On the other hand, QoE offers a different way of measuring how users observe the existing applications. This measurement provides means how to measure overall user satisfaction of a service and hence, to enhance and adjust the existing multimedia delivery content when needed. In this way, in order to maintain a satisfactory QoE, certain threshold for QoS metrics during a communication session is needed. The adaptive mechanism has to provide personalized learning materials in real-time according to the context (user's knowledge and environment) and users previous feedback records. Therefore, we are encouraged to develop a QoE description method based on existing network parameters that are measured by QoS metrics in order to estimate user's profile. This way user profile stores learner's personal level of knowledge, cognitive style and current network conditions.

The area of distance IP-oriented learning, known also as e-learning, is growing very fast and rapidly. There has been different adaptive e-Learning Systems developed in order to support learning style based to user's level of knowledge, using the AHA (The Adaptive Hypermedia Architecture) [7] and Adaptive educational hypermedia systems [8]. The approach for adaptation in technology driven learning has significantly improved learning process by adapting course content presentation to user learning styles and has been implemented in the AEHS-LS system (Adaptive E-Learning Hypermedia System based on Learning Styles) [12].

In the research area for creating personalized multimedia content one of the existing solutions propose MM4U ("multimedia for you") software framework to support the dynamic creation of personalized multimedia content [16]. In the proposed generic and modular framework the authors need to choose, using authoring tool, the media elements that are suitable for the intended user. We have advanced this procedure of authoring in the new model for adaptive multimedia learning with the introduction of user profiling.

This was a motive to focus our research in direction to improve the process of learning by analyzing the impact of user *cognitive* style for the provided multimedia content type. Human perception in the learning process is enhanced by delivery of diversity of reach multimedia content. Many dimensions of cognitive learning styles are offered to the users, among which focus is given to Visualizer/Verbalizer presentation of information. The differences between Visualizers and Verbalizers are frequently not as great as some other cognitive styles. Indeed many bimodal users are equally comfortable using either modality [4]. Visualizers prefer to receive multimedia information via graphics, animation, video and images, whereas, mainly because their visual memory is much stronger than their verbal. On the other hand, verbalizers would prefer to process information in the form of words, expressed by audio or text based form.

Creating personalized multimedia content with the new model for adaptive multimedia learning and the context in which this content is delivered was taken into consideration. Besides it has also influenced by the network conditions. Therefore, the multimedia content has to be dynamically changed with the network conditions, in order to guarantee the quality of service parameters. On the other hand, we have the user cognitive perception of multimedia content that offers diversity in selection of the type of multimedia content. In addition, the context-aware transfer needs to be taken into consideration. Creating multimedia content that is personalized for a certain user profile will need appropriate weighted factors for each of the cognitive learning styles and appropriate context- aware factors. In order to ensure a better user experience for the delivered multimedia content, we propose the content to be network-aware and the network to be context- aware.

Process of creating personalized user profile includes gathering cognitive learning styles of the user that are later used to create dynamic content multimedia delivery. Modeling adaptive learning content that is dynamically generated from the available content is done according to the user profile. The estimation and preferences of users profile

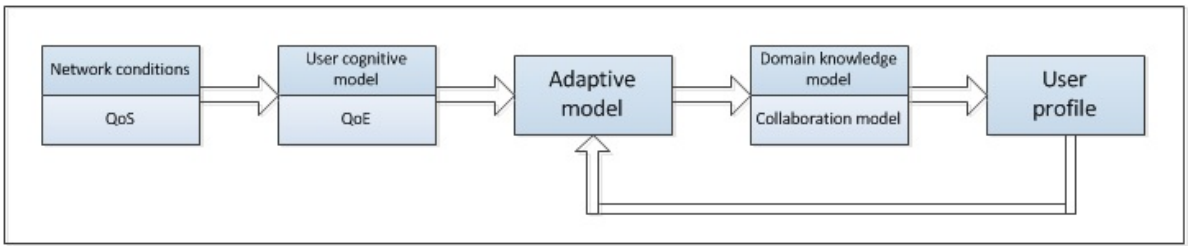

Figure 1. Model of adaptable dynamic multimedia context- aware (ADMCA) distance learning system

are modeled by assessment of its level of knowledge and learning style. In this way, we are able to personalize the multimedia learning course and provide content that is close to its cognitive reasoning preferences. QoE metrics is used for estimating cognitive learning style as visualizer, verbalizer or bimodal perception of information. This dimension is mapped with the context aware network delivery condition, measured by QoS in order to deliver adaptable multimedia content to the users.

In Figure 1, we present our Adaptable Dynamic Multimedia Context- Aware (ADMCA) distance learning model. Our model provides optimization of users profile by dynamically adapting the content, based on both user cognitive styles and current network delivery conditions. The Domain knowledge model is designed to store the level of educational content, being organized in a hierarchical structure of concepts, amongst which logical relationships exist. The model provides improved user multimedia interaction that is expressed by the Collaboration model. Role of the Adaptation model is to decide on personalization and adaptations of the multimedia content, based on the information feedback by the Domain knowledge model and Collaboration model. This architecture ensures an adaptive model for dynamically changing the appearance of media content that has been delivered to user. This will allow them to interact and automatically derive user profile from those interactions in order to dynamically update the resulting presentation according to these preferences.

The delivery of high quality personalized leaning content that is SCORM compliant is consisted from more small and reusable modules that can be combined with each other in order to create personalized multimedia content. This model is SCORM compliant, which is fundamental reference model for developing models of learning content and delivery [9]. The proposed ADMCA model for distance learning system extends the current SCORM framework and generates dynamic reusable multimedia learning content based on different cognitive preferences of the users, domain knowledge and collaboration model. This model provides real-time dynamic change of the multimedia content according to the user cognitive model and the current network conditions. Appropriate use of the bandwidth requirements proficiently is needed to make assessment of the current network delivery conditions. This assumes to provide adaptive intelligent user interfaces addressing diverse capabilities of device classes and an automatic adjustment of content regarding the measured QoS parameters.

The results produced by the simulations in this paper provide justification of the model that can be implemented in diversity of education areas. Demand starts from education in primary schools, through the special medical schools (such as autistic, Deaf & Hard of Hearing, etc.) to universities. The proposed model for adaptive multimedia learning that dynamically changes the content, is innovative because analyses the dependences of the mapping relations between the QoS and QoE metrics.

III. MAPPING THE RELATIONS BETWEEN QOS AND QOE

In the newly proposed model for adaptive multimedia learning that creates user personalized multimedia content, we explore the methodology of QoS to QoE metrics mapping and their correlation. The quality estimation part of the model is implemented with a mapping table between QoS and QoE metrics. Table 1 shows the mapping of the context-aware network QoS bandwidth to QoE - Cognitive learning styles in process of generating dynamic multimedia content in learning lesson. Focusing to the main research problem, profiling of system users is done by tracking the context – aware user behavior.

In order to adapt the multimedia content, firstly the context-aware bandwidth needs to be considered in the appropriate user profile. The increased network usage will result in poor available bandwidth and vice versa. We have assumed that the adaptation only considers available bandwidth as it is the parameter affecting most other network parameters as well.

In this context, other aspects need to be considered for improving the learners experience except the need of adaptation to available bandwidth. We go further and take into consideration the user cognitive perception. In this way, in order to generate dynamic multimedia content that will increase the experience that is not only depended from the QoS, we need to express the user perception of quality measured by QoE.

Users should prefer verbal information to be accompanied by visual information and it is more effective to present the verbal information as audio content rather than give an on-screen text. Learning is also improved if animation and audio content are combined in one source and therefore presented simultaneously [14].

TABLE I. MAPPING BETWEEN QOS AND QOE

QoS - Bandwidth	**QoE - Cognitive learning styles**		
	Verbalizer	***Bimodal***	***Visualizer***
good	HQ[1] dynamic Animation, Text with audio	HD[2] video with audio, Simulation, Text with audio	HD[2] video, 3D graphics, HQ images, Dynamic animations
medium	Images, Video with audio, more text description	Video with audio, Images/ 2D graphics, text	Animations, Images / 2D graphics, text
low	audio, more text description	Images, text	Images, icons, text

1. HQ - *High Quality*
2. HD - *High-Definition*

Classification of the multimedia type is done into 2 groups, static media, such as texts, images, graphics, and dynamic media, including audio and video data. In this way, according to the context preferences, the system is doing

adaptive change of the multimedia type. The assessment of the network conditions, expressed by the bandwidth is classified as low, medium or good. This classification is needed in order to adjust specific types of multimedia content, such as audio and video files, that require more bandwidth [13], that vary considerably in the context of the available bandwidth.

In an environment that has *poor bandwidth* the multimedia content that can be streamed is limited to a static media (text- based, images, icons) and audio samples. Other aspects should be also taken into account such as the user cognitive learning styles that limit the verbalizer users to have only text- based and audio learning assets. For visualizers, the enrichment is done in the multimedia lessons with simple images and icons to the text - based learning. The network that has *medium bandwidth* quality will only offer graphics and sample animations in the process of dynamic multimedia content creation. In this environment, verbalizers are introduced with **video and audio media** that is more important for them, than the images and animation learning content. On the other hand, the visualizers are provided with **animations and graphics** in the existing multimedia content. Bimodal users have access to this multimedia content: video with audio, images/graphics and text. Network with *good bandwidth* has opportunity to use: HQ – dynamic Animations, HD video with audio, 3D graphics and HQ images in order to adopt the multimedia content with high quality. To verify the correctness of the developed model we have compared the simulation results from three different scenarios that demonstrate low, medium and high load bandwidth environments.

IV. SIMULATION RESULTS

Multimedia content in particular, including audio and video files, consume a lot of network resources such as bandwidth and this pose stringent requirements on performance parameter levels such as e.g., load and delay [11]. We have used the clustering process of classifying the learning assets into user profiles that are significant in the context of network conditions. The classification has been done into 3 groups of user profiles: Verbalizer, Visualizer and Bimodal user profiles.

The simulation models of individual user profiles were developed using the OPNET network simulation software that provides virtual network communication environment. OPNET provides a comprehensive development environment with a full set of tools including model design, simulation, data collection, data analysis and supporting the modeling of communication networks [10]. Hardware and software resources used for running the OPNET simulations are as follows:

- Workstation ASUS, with CPU Intel Core i5-480M, 2.66 GHz that has Memory of 2 GB RAM
- Microsoft Windows XP® Service Pack 2 (SP2) and Microsoft Visual Studio 2008

This environment provides a way to model the network behaviors by calculating the interactions between modeling devices. We have used the Discrete Event Simulation (DES) because enables modeling in a more accurate and realistic way. It creates an extremely detailed, packet-by-packet model for the activities of network to be predicted [15]. The network simulator was configured to run 1 hour distance learning course.

To model an application in OPNET, the application definition is used to specify/choose the required multimedia types among the various available applications such as text, video conferencing, voice, images and animations. Profile definition was used to create custom user profiles, classified as Verbalizer, Visualizer and Bimodal profiles. These profiles where specified on three different client nodes: Student1, Student2 and Student3 in three different network simulation scenarios (see Figure 2). The Application server (APP_Server) was configured to be able to support all of the applications based on the predefined user profiles.

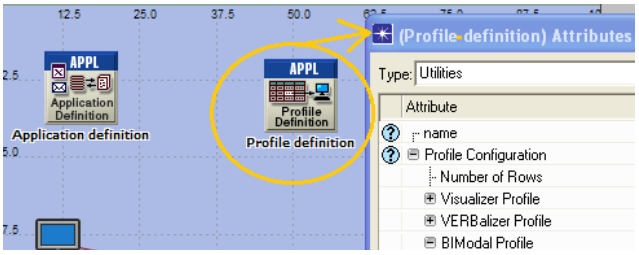

Figure 2. Profile definition model

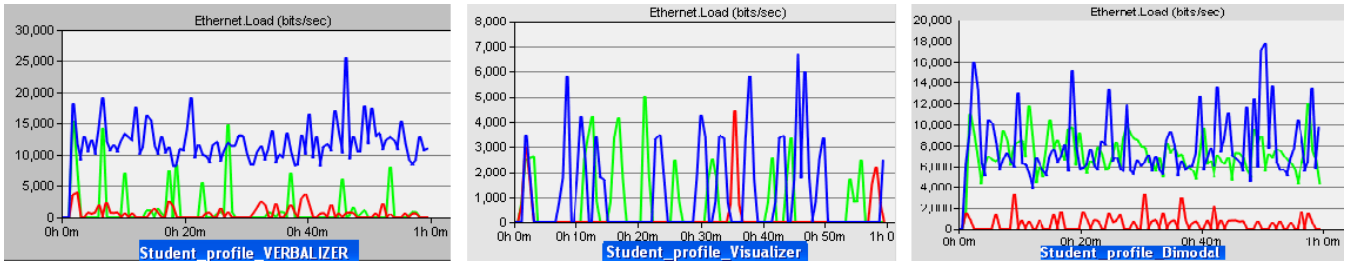

Figure 3. Verbalizer, Visualizer and Bimodal user profiles in different load scenario

Statistics that were collected from the whole network model during a discrete event simulation and the object statistics were collected from the nodes. For our analysis we have chosen object statistics of Ethernet that include delay, throughput and load in analyzing the performance of the proposed scenarios.

After running the simulation for the three different scenarios, with low, medium and high load bandwidth in OPNET simulator, we have done comparison of the traffic load. Represented by the blue line is the High Load scenario, green line shows the results from the Medium load scenario and red line is scenario with Low load.

From the results in Figure 3, we can conclude that in all defined Verbalizer, Visualizer and Bimodal user profiles, the high load consumes the biggest part of the bandwidth that is available. Also, the same results confirm that the three user profiles took the lowest part of the bandwidth during the Low load scenarios which confirms the established mapping between QoS and QoE. The Medium load scenario has a balanced distribution part of the bandwidth in all three user profiles.

Comparison of the throughput between user profiles in three different network simulation scenarios is given in Figure 4. Results confirmed that the network simulation scenario with high load carries the biggest throughput for all three user profiles.

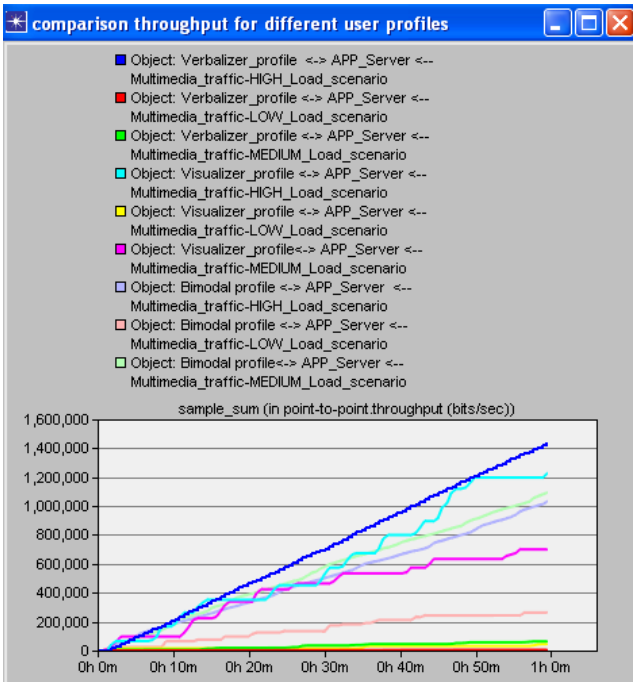

Figure 4. Comparison of the throughput between the user profiles

Results from average network delay comparison for three different network simulation scenarios are given in Figure 5. They confirmed that in Low load scenario we have biggest delay during the transfer of multimedia content that is within the expected conditions. However it is highly important in the high load scenario that the average network delay remains at low level in spite of the increase of number of simultaneous multimedia users.

V. CONCLUSION AND FUTURE WORK

We have developed new model for adaptive multimedia learning that has customized interactive process of multimedia transfer in a context- aware adaptation model that creates dynamic multimedia content. The proposed model is based on the QoE metrics, defined as user cognitive styles. Context-aware adaptation of network conditions should be in line with user cognitive styles in order to offer dynamic adaptation of the multimedia type. These conditions in the newly proposed model have been confirmed by mapping of the context-aware network QoS (in our case the bandwidth) to QoE - cognitive learning style as verbalizer, visualizer or bimodal conditions. This domain independent model supports the creation of personalized multimedia content by exploiting context-aware approaches for multimedia content adaptation. The dynamic model demonstrates the strong impact of the multimedia adaptation based on the user cognitive styles to available bandwidth condition.

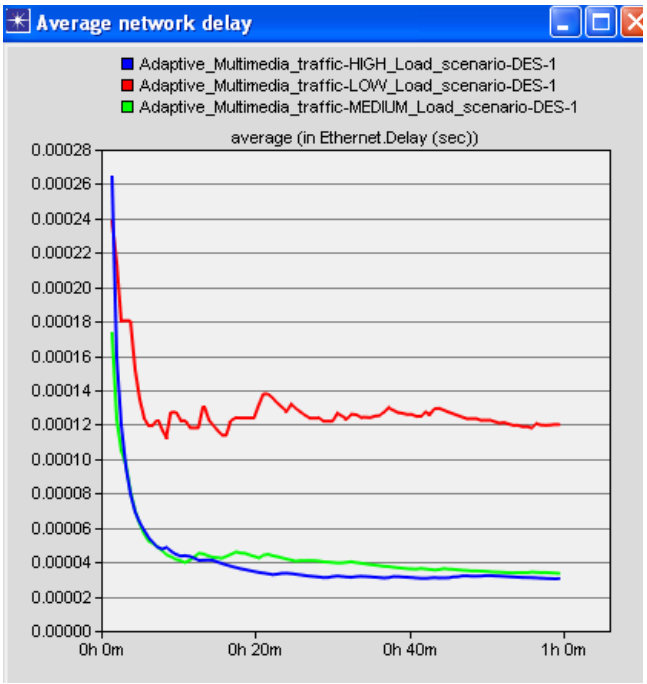

Figure 5. Average network delay analysis for three different network simulation scenarios

Results received from the simulation have confirmed the correctness of the newly proposed model for adaptive multimedia learning, and user experience is increased by using interactive learning process. In that way constant assessment is important to make appropriate adaptation of the learning content. Dynamic creation provides more personalized, context aware delivery and organization of the multimedia content types according to users learning style, knowledge progress and network conditions.

Challenging task is to analyze the influence of the context-aware conditions in the cloud computing environment and its influence in the process of personalized multimedia content generation.

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