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T-Learning Technologies

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INTRODUCTION

Television (TV) is a ubiquitous consumer electronics device representing the traditional information and entertainment medium for the majority of the people.

Following the rapidly growing technology, TV started to switch-off from the analogue world to the modern digital technologies of broadcasting. Digital technology has the potential to offer the audience a variety of services apart from the common audiovisual stream. Many of the new services are inherited from the Personal Computers (PC) world, including on-demand features, games, transactions, and other interactive options.

Television has had a long history of performing an educational function for the mass audience, typically by broadcasting culturally-relevant movies, documentaries and news, as well as educational programmes. The idea of Distance Learning through a TV blossomed extensively in particular as a complementary educational option besides PC-based e-learning and traditional analogue TV educational programs. In particular, TV-based interactive education promises a huge potential due to its ability to support interactivity while compensating for the low penetration of Internet-enabled computers in comparison with the penetration of a TV in a household.

"T-learning" was the new term, which prevailed for the definition of TV-based interactive learning (Aarreniemi-Jokipelto, 2005).

BACKGROUND

The first forms of learning with interactive Digital TV (iDTV) have been little more than modified or enhanced videoconferencing. Today, iDTV platforms for learning provide a big amount of audiovisual and educational contents to the viewer through interactive and content personalization. iDTV is considered as the convergence of television and computer technologies by encompassing three important features typical of computer-based technologies (Lytras Lougos, Chozos, & Pouloudi, 2002):

- **Interactivity:** The control of the whole activity and of the elements of a single activity can be placed into the hands of the potential consumer (Watheieu & Zoglio, 2002);
- **Personalization:** Use of technology and viewer information, to tailor interactive content to each individual viewer profile (Lekakos & Giaglis, 2001); and
- **Digitization:** Technological advancements that allow better quality of sound and picture (Kenyon, Miles, & Rose, 2000).

In particular, considering the use of the media by its audience, TV has some features that make it different from PCs. First of all, TV is usually watched by more than one person (co-viewing), and usually triggers social interactions that are very useful for a more effective experience and interiorization of the contents. Secondly, the logic of broadcasting to a wide population enables social mass mechanisms that typically enhance the impact of the broadcast program.

Nowadays, there are signs that the TV providers are moving to interactive education by broadcasting educational programs that exploit the interactivity of iDTV. A characteristic example is the BBC channel, which offers a learning portal (BBC learning) that provides interactive learning services and covers all the most widespread media, such as radio, TV, iDTV, Web and broadband. Some of the Web interactive services of BBC are also available in BBCi Interactive TV as the ones devoted to preschool children (BBC CBeebies) and support "Learning through play"[1]. Although t-learning as a rather new concept has not been applied so widely in interactive TV, there is a number of projects that support and investigate the future penetration of t-learning as the Enhanced Learning Unlimited (ELU) project which is currently dealing with the iDTV technologies for the design and the implementation of an integrated t-learning system[2].

The article is organized as follows: the pedagogical aspect of t-learning is presented in the next section while the part "Technologies Involved in T-learning" is dedicated to a description of the available technologies and standards of iDTV which are exploited in an education-effective way by t-learning.

PEDAGOGICAL ASPECTS OF T-LEARNING

In defining a t-learning pedagogy it is crucial to deal with an active learning model, the constraints imposed by the actual development of the technology and the nature of the allowed interactions. Related research acknowledges active learning as an exceptionally effective teaching technique (Clark, Nguyen, & Sweller, 2006). More specifically, active learning strongly relies on the learners' interactions with their environment that lead to mental actions through which they construct ideas about what they are encountering.

In this context, the challenge is to exploit the added value of providing an interactive learning environment and the potential of allowing people to access learning activities and contents directly in their house, at distance, through media easy to access and simply to use.

This reflection produces a twofold vision that aims at balancing learning and teaching strategies:

1. Leave the control to the learner.
2. Guide the learner.

Thus, to draw a pedagogy for t-learning experiences, two dimensions have to be explored and taken into account as the drivers of the design process:

- The context where learning happens and the behaviour of learners in this environment;
- The specific features of the medium.

The interactivity, audio/video-based experiences, narrative learning environment and informal learning/edutainment are the key points that emerged from this exploration.

TECHNOLOGIES INVOLVED IN T-LEARNING

T-learning exploits in an educational manner the available technologies and standards for iDTV such as the broadcast technology, the supported middleware for applications and the variety of related tools.

Interactive Digital TV

iDTV has been pushed into the marketplace by the broadcast industry and the network operators in the last decade, introducing two major features, which will be presented in this section: the digitization of the broadcasting and the availability of interactive programs (Baker, Pulles, & Sasno, 2004).

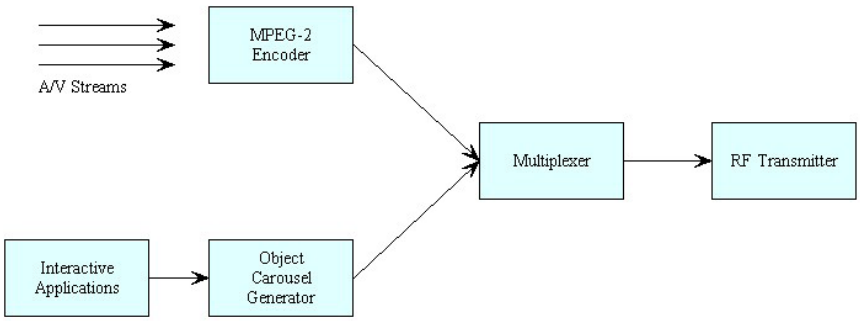
Audio Visual and Data Broadcast Technology

Digital television mostly relies on the Digital Video Broadcasting (DVB) standard, characterized as DVB-T for terrestrial, DVB-S for Satellite and DVB-C for Cable transmissions. DVB has been defined by a consortium of public and private organizations in the iDTV sector[3].

In the DVB schema, the digital TV signal is transmitted as a stream of MPEG-2 data known as a transport stream. This stream consists of a set of substreams (elementary streams), where each substream can contain MPEG-2 encoded audio, MPEG-2 encoded video or data encapsulated in MPEG-2 stream. The elementary stream which carries the application data is constructed using a Digital Storage Media-command and Control (DSM-CC) Object Carousel. Subsequently, the transport stream is passed to the multiplexer and then to a Radio Frequency (RF) transmitter in order to be broadcast. The overall broadcasting system for digital TV is illustrated in Figure 1.

The received signal is demodulated and afterward it has to be decoded appropriately. The common TV sets are manufactured to deal with analogue signals. Hence, a device called Set Top Box (STB) is used to transform the digital signal. Moreover, it also provides a middleware, based on an embedded Operating System (OS), which is an execution environment for running the interactive applications that are broadcast in a channel together with the main audiovisual stream. Execution environments are standard and the most common are: the European Multimedia Home Platform

Figure 1. Schema of the broadcast system



(MHP), the American Open Cable Application Platform (OCAP) and DTV Application Software Environment (DASE), the Japanese STD-B23/STD-B24. Because MHP is the standard in Europe and a subset of it, the Globally Executable MHP (GEM), is becoming the common reference worldwide, in this section we focus on MHP.

MHP

MHP is the middleware system for interactive TV development designed by the DVB Project[4]. The first draft of MHP was released in August 1999 and the first version of MHP 1.0 was approved by DVB in February 2000. MHP offers a standard platform for application developers. Applications are written in Java and HTML, so they don't depend on any single hardware platform or operating system. Due to the iDTV's special context, MHP-Java applications are slightly different from normal Java applications. However, due to the similarities with Java applets, MHP-Java applications are called Xlets.

On the one hand, MHP Java limitations are mainly related to the constraints given by the STB's hardware and OS in terms of computational power, memory size, storage, communication facilities, screen resolution, font and colour availability and their size is severely constrained by the limited bandwidth available. On the other hand, MHP provides support for those special features which are essential in the digital TV world such as low-level access to the transport stream, service information access, and support for the specialized graphics model of the digital TV. MHP can be extensively exploited by t-learning as it offers the proper middleware for learning interactive applications.

Tools for T-Learning

Based on the aforementioned technologies, a number of tools are appearing to support t-learning, such as authoring tools, games, personalization techniques and virtual tutor avatar.

Authoring Tools for T-Learning Courses

Authoring tools are software environments that support content providers in the creation of applications. There is a large number of authoring tools for the editing of e-learning courses in the market and in the last years, authoring tools for the creation of MHP applications appropriate for iDTV were developed.

On the e-learning side, authoring tools provide an environment that allows the insertion of learning resources (video, text, games, etc.) for creating the course. The structure of the course is organized usually with the definition of a sequence that relates these resources and allows different paths based on rules set by the author. The output of such kind of tools is appropriate to be used for learning purposes on a computer, but it is cannot be used for iDTV.

On the other hand, MHP authoring tools typically allow the creation of MHP-Java applications, suitable for iDTV but they are not learning-oriented. Up to now there are not any authoring tools dedicated specifically to the creation of t-learning courses. The tools that are used nowadays for t-learning purposes are the MHP authoring tools, which have to support the implementation of learning strategies suitable to TV-based education through the realization of MHP Java Xlets .

Games

Games in iDTV could play an important role to t-learning, although today they are used mostly for entertainment. Nowadays, there is a number of games for iDTV, covering various categories, such as arcade, adventure, puzzle and educational games. Quizzes, multiple-choice and memory games could increase the interest of the viewer-learner supporting the concept of relaxed-learning that seems suited to TV.

iDTV games are typically broadcast as applications resided inside the object carousel of a transport stream. Most of current games are stand-alone: they are not related with the A/V stream which is broadcast in parallel. This is because it is difficult to design and develop meaningful applications with a live, simultaneous interaction of games synchronized with the A/V stream. Even more important, synchronization drastically limits the use-timeframe of a game that can be played only at a given moment in time.

T-learning has the ambition of creating educational games for a wide range of users, in particular those with limited attitude to computers. The games are considered as an integral part of a t-learning course as they could support the learning procedure involving a wide audience through challenges and engaging activities that are anyway able to meet the typical user need for relax and sympathy.

Personalization

In general, the final goal of personalized learning is to provide a learning path that is matched to the learner's needs and abilities, resulting in a more efficient and high quality learning process. In order to obtain this matching of learner's profile and objectives, current learning context and available pedagogical resources, a well-defined description of each component involved in the process is needed, with specific focus on the user model. An additional interesting aspect of the personalization process is that, once the user model has been identified, the accuracy of the personalization can be iteratively improved with time, as more dynamic data are collected and stored regarding the ongoing interactions of the user with the system and the continuous monitoring and re-assessment of the user's satisfaction. This also allows for a classification and "clustering" of learners (Blanco-Fernández et al., 2004).

Personalization in terms of t-learning implies that a potential iDTV learner can easily be offered on his/her TV equipment a selection of available pedagogical contents and services according to his/her interests, skills and preferences.

From the conceptual and technological perspective, supporting personalization implies designing and developing suitable *services* to be integrated in the final t-learning application and able to provide contents and learning processes adapted to the user profile. The minimum set of such services includes:

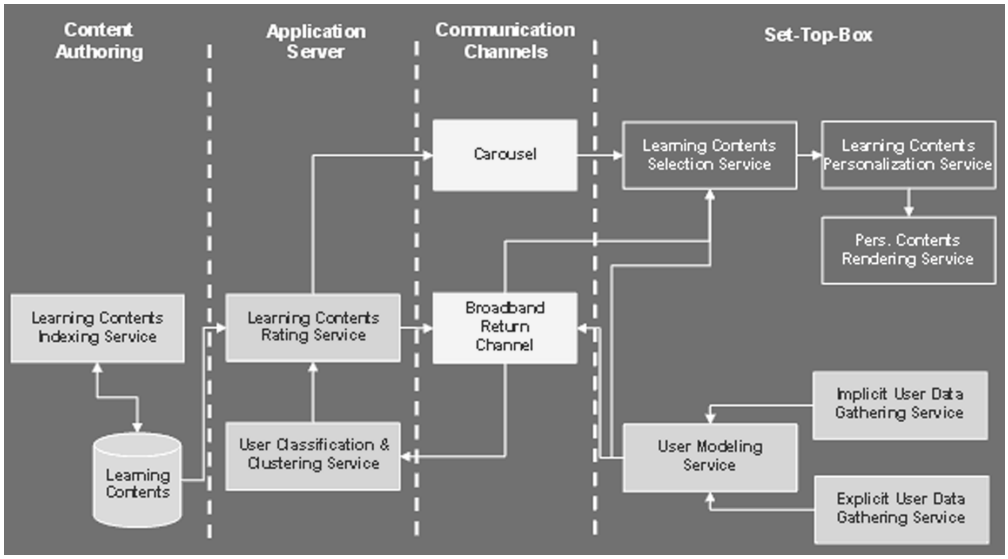
- **Implicit User Data Gathering Service:** Transparent acquisition of learner-related information through the automatic analysis of his/her behaviour while selecting/navigating learning contents.
- **Explicit User Data Gathering Service:** This service should offer to the user the possibility of providing personal information through an easy-to-use interactive interface.
- **User Modeling Service:** The information acquired by the two previous services need to be processed by the user modeling module, in order to produce a user profile that can be given as an input to other services in charge of automatically select and adapt available learning contents.
- **Users Classification and Clustering Service:** This service receives as input a set of user profiles, which are then classified and clustered. This would allow for the definition of "group" or "category profiles."
- **Learning Contents Rating Service:** The content rating engine is in charge of matching the existing available contents with the current user or category profile. The output is a list of relevant contents, among which the user is allowed to select interactively.
- **Learning Content Selection Service:** It allows for a selection of a subset of relevant contents coming from the carousel. This can be used to offer a limited degree of personalization on the Set-To-Box.
- **Learning Content Personalization Service:** When a specific learning object has been selected, a further personalization step is performed at the single content level, again according to the user or category profile.
- **Personalized Learning Content Rendering Service:** This service would be in charge of properly rendering the personalized content, for a better fruition by the user.

In Figure 2, a complex technological framework suitable to integrate, personalization services for iDTV-based knowledge management and t-learning/t-training applications is presented.

Besides the constraints coming from computational power and local storage features on the Set-Top-Box, the offered degree of interactivity in terms of available return channel has a strong influence on the personalization level. Having this in mind, three main profiles can be identified:

- STB without return channel (*basic profile*): includes local user profile processing, selection of relevant contents from the carousel and local processing of the selected content;

Figure 2. The personalization framework in t-learning



- STB with narrowband return channel (*advanced profile*): it offers the same features as the basic profile plus server side user profiles processing, dynamic adaptation of broadcast contents, server side synchronization of user behaviour, limited on-demand access to contents; and
- STB with broadband return channel (*full interaction profile*): same as advanced profile plus full on-demand access to contents through the return channel.

Virtual Teacher

A success factor in the distance courses is the simulation of an interaction between teacher and student. This can be achieved by using the figure of a tutor. It is generally accepted that the presence of the tutor is important for better understanding and motivating students. In particular, it was identified that a virtual teacher avatar could be a good means to achieve better audiovisual communication with the learner. An avatar is an intelligent agent with graphical representation, often humanoid and with speech capabilities (Ortiz, Aizpurua, Oyarzun, Arizkuren, & Posada, 2003).

Nowadays, avatars are used in the iDTV world mainly in online games in order to represent the viewer. However, they can also play the role of a virtual teacher (VT) in a t-learning course. The implementation of a virtual teacher for t-learning courses has to carefully react to the user behaviour and performance. Events can be generated from the AV stream and from other applications, and the VT may react to them on the basis of specific rules defined by the educational designer. In such a case, an events manager is needed by the system architecture to manage the incoming events and dispatch them to the VT.

User Interface and Synchronization Issues in T-Learning

During a t-learning course, the viewer-learner would be able to watch rich multimedia content accompanied by MHP applications. These applications can be either synchronized or not with the broadcast video. The screen can be divided in parts where every part could visualize different content as the video, the application or a virtual teacher including control instructions and help. Additionally, an application could overlay the A/V stream, also exploiting transparencies and semitransparencies. These display modalities can be supported in both synchronized and not synchronized courses. Synchronization of the video with the MHP application can be achieved with the insertion of triggers in the A/V stream that launch events to the listening application. In the case of a synchronized application, the viewer would have a specific amount of time to interact with the application. In a nonsynchronized application, the course would allow a more relaxed learning, but it would not benefit from synergies with the underlying A/V stream.

The user can provide inputs to an application through the remote control buttons. The arrows play an important role in the choice of preferences or the navigation, while the "OK" button would be usually used for confirmation purposes. The color buttons are typically used to provide access to

options. Text insertion is possible, in particular by using virtual keyboards on the screen, but its use is not encouraged as it is rather time-consuming and awkward because it is not directly supported by the remote control.

Architecture of an Integrated T-Learning System

The proposed architecture which is illustrated in Figure 3 is split in two parts: the production side where the content is prepared and the receiver side where the course is presented to the viewer through the appropriate terminal.

The production side is the area where the content and the applications are prepared. The educative A/V stream for the t-learning course is built by a TV producer, while the applications are developed in the authoring tool by the educators. The content including games, images, VT characters and text is used for the development of personalized courses and can be retrieved from a server where learning resources are stored. Eventual A/V-application synchronization is achieved with the aid of an authoring tool as well, where the content created is matched on specific time stamps inserted in the A/V stream. Subsequently, the A/V stream is fed into the MPEG2 encoder, while the content and the Xlet produced by the authoring tool are inserted into the object carousel. In this way the substreams are constructed and then multiplexed the final transport stream, which is broadcast.

The signal is received at the receiver side and processed by the STB where the A/V stream and the applications are restored from the transport stream. The Xlet that contains the t-learning course runs on the STB MHP middleware presenting the content of the course. The existence of an Internet IP return channel on the STB allows the use of on-demand features. Through this return channel it is possible to send requests regarding the retrieval of additional learning resources as well as information about the viewer in order to support more advanced personalization features.

FUTURE TRENDS

T-learning is based on modern technologies employed in Digital TV. Despite the fact that the world policies are supporting the switch-off from analogue TV to digital, there are still many analogue TVs in many homes and the people are not yet familiar with the new technologies and the interactive services introduced by iDTV. However, it is likely that the evolution of digital TV in the future years, accompanied by an increasing familiarity of users with its interactive services, will augment the penetration of t-learning into the households.

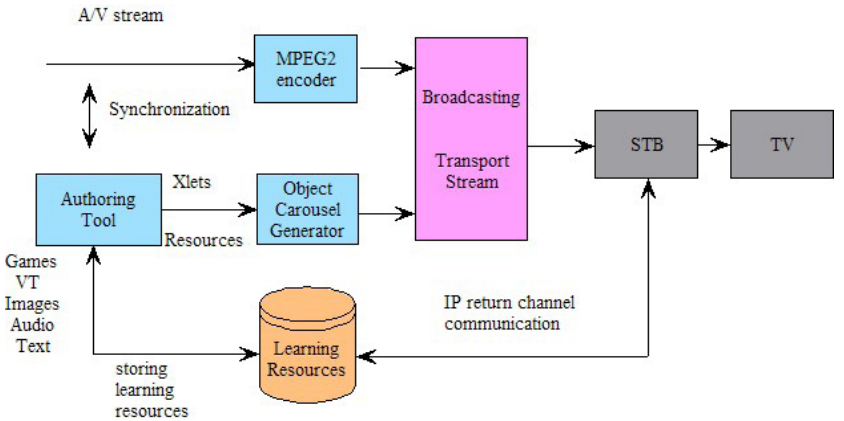
The spreading of the new technologies will further speed up the evolution of t-learning, as they will increase the recording, playing and computational capabilities of the TV-sets, increasing the scope and the quality of the offered services.

CONCLUSION

The most important technologies involved in t-learning were discussed and described in this article. These technologies are still evolving in order to support more efficiently t-learning and other interactive services for TV.

T-learning is a relatively new concept. It is a challenge for the world of interactive TV and distance learning with a potential to concretely complement e-learning, in particular given its potential to reach a much wider audience, and in

Figure 3. T-learning architecture system



different contexts (e.g., in relaxed situations). The ambition of more opportunities for learning in home may be fulfilled by t-learning as TV is still the medium that is present in every household. T-learning exploits the available technologies of iDTV and it can also spur them by introducing new needs and requirements.

The real potential of t-learning is promising, but the best ways to offer it to a wide audience and different target groups has still to be carefully investigated, in particular through extensive field experiments.

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KEY TERMS

Authoring Tool: Environment for applications creation without the need of programming and technical skills.

E-Learning: Distance learning with the aid of a personal computer.

iDTV: Interactive Digital TV is the evolution of the traditional TV set based on digital transmission and has the capability of running interactive applications.

MHP: Multimedia Home Platform is the common middleware for running applications for iDTV.

Personalization: The customization and categorization procedure of a viewer-learner.

Return Channel: Port that allows IP connectivity of the STB to support on demand features.

STB: Set Top Box is the device that decodes and processes the digital received signal.

Synchronization: This term is used to specify the time-matching between the t-learning content and the respective video.

T-Learning: Term that defines the TV-based interactive learning.

Virtual Teacher: Avatar that plays the role of a teacher during a t-learning course by providing instructions and help.

ENDNOTES

1 BBC, http://www.bbc.co.uk/learning/
2 Enhanced Learning Unlimited (ELU), http://www.elu-project.com
3 Digital Video Broadcasting (DVB), http://www.dvb.org
4 Interactive TV Web, http://www.interactivetvweb.org