EXPLOITING A UNIFIED INFRASTRUCTURE OF A FUSION NETWORKING ENVIRONMENT FOR THE SUPPORT OF NOVEL TELE-LEARNING APPLICATIONS

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ABSTRACT
This paper presents the capabilities of the new digital terrestrial television (DVB-T) in supporting tele-learning applications, where the lecturer and the students are virtually present in the same classroom from their own premises. Based on a concept for the transition from analogue to digital terrestrial broadcasting (Digital Switchover in UHF – DSO), the paper describes a novel unified infrastructure of a fusion networking environment and the realisation of a common IP backbone (present and available in the entire broadcasting area), that is capable to support tele-learning applications enabling lecturers and students to actively participate in the educational process using real time interventions (video/audio). By utilising the DVB-T stream in regenerative configurations, this broadband access infrastructure enables distant learners and professors to access/provide real-time interactive educational audiovisual material.

KEYWORDS
Digital Switchover, broadband access, virtual classroom

INTRODUCTION

Terrestrial digital video broadcasting standard (DVB-T) was used (until recently) mainly as a medium for broadcasting "bouquets" of digital TV programmes to a large number of viewers scattered over large geographical areas. The large coverage area, the high bit-rate capabilities and the intrinsic characteristic of DVB-T to combine MPEG-2 TV programmes and IP data traffic into a single transport stream [ETSI 1997], enabled for its usage as the "last mile" technology in networking infrastructures for the provision of heterogeneous services, such as digital TV programmes, Internet access, e-mail, multimedia on demand, IP-TV and IP-Radio, datacasts etc., constituting therefore, a very promising solution towards the realisation of broadband access infrastructures, capable to pave the way towards Information Society services access (i.e. e-Business, e-Inclusion, e-Learning, e-Health, e-Government, ect.).

The way, however, that the transition from analogue to digital broadcasting (Digital Switchover –DSO) will take place and the approach that the new digital television will be adopted, in each country/region/area, is of major and strategic importance, with evident results and implications over the social, cultural and economic life of citizens.

In this respect, and by taking into account the local and networking potentialities of the new digital television (DVB-T), ATHENA FP6-507312 project [FP6-507312] proposes the adoption of DSO in UHF by exploiting the DVB-T stream in regenerative configurations, for the deployment of a broadband access infrastructure (in a city) and the realisation of a common IP backbone, present and available in the entire broadcasting area. Access to this backbone, which is commonly and fairly shared among all citizens/users, is achieved via intermediate communication nodes (Cell Main Nodes – CMN). In this context, ATHENA has created such a UHF channel (Channel 40) in Heraklion city, Crete, Greece, which interconnects a number of CMNs for enabling users/citizens not only to receive but also to deliver any multimedia services from their own premises over wired or wireless based uplinks. This UHF channel operates in a 24-hour basis [Deliverable 6], [Deliverable 20], and:

- distributes a bouquet of three digital TV programmes, one of them is ERTSat's satellite TV programme retransmitted in real time after a special permission obtained from the Greek National Broadcaster (ERT), another is the TV programme of a local broadcaster, and the third one contains (among the others) the TV content provided by an ATHENA partner, who is a broadcaster (German) and who holds its Intellectual Property Rights.
- enables access to basic Information Society Services (Internet and e-mail) offered by an active user (ISP in figure1).
- enables access to multimedia on demand services provided by another active user (Multimedia on demand Provider in figure 1).
- provides access to IP-TV and IP-Radio multicasts, distributed by another active user (IP multicaster in figure 1).

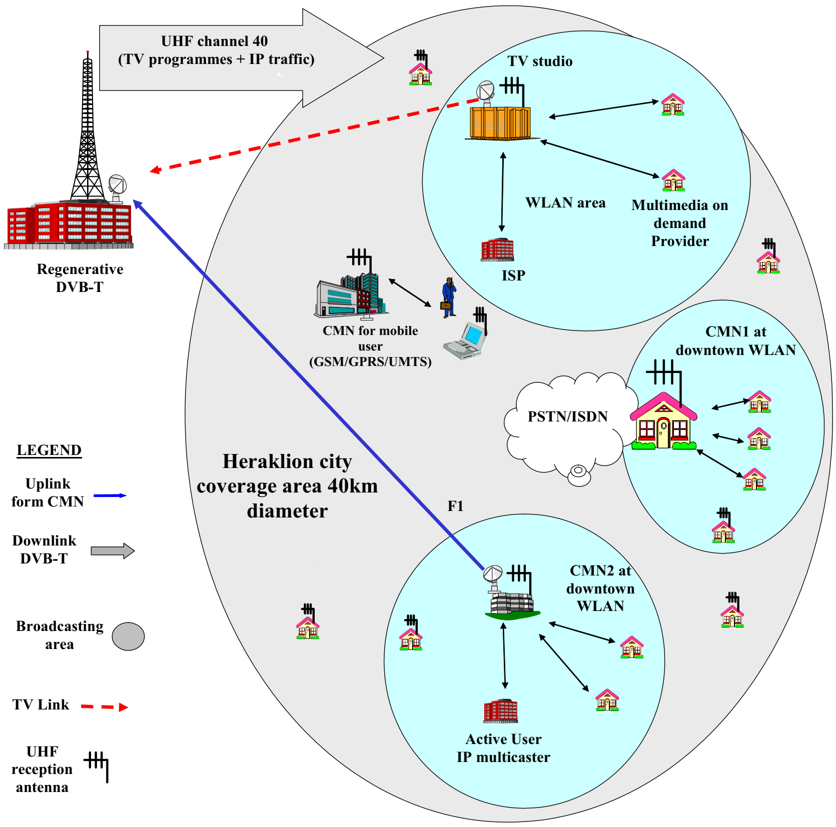

Figure 1. Overall ATHENA FP6-507312 architecture

Based on and by making use of the ATHENA infrastructure (see Figure 1), this paper presents the potentialities of the proposed DSO concept and the capabilities of the new digital television to support broadband interactive multimedia applications such as tele-learning ones. It describes the network configuration capable to support the Virtual Classroom where the lecturer and the students are virtually present in the same classroom from their own premises, by actively participating in it using real time interventions (video/audio). In this context, and following this introductory section, the rest of this paper is structured as: Section 2 presents the overall architecture of the Virtual Classroom, Sections 3, 4 and 5 analyse the main building blocks of it, while Section 6 concludes the paper.

OVERALL ARCHITECTURE OF THE VIRTUAL CLASSROOM

The overall architecture of the virtual classroom is depicted in figure 2 and comprises two core subsystems: i) a number of Cell Main Nodes (CMNs) located in the DVB-T's broadcasting area, and ii) a central broadcasting point. Each CMN enables a number of Distant Learners (DL) – active or passive – and the Professor (PR) to access and provide educational material (real time audio/video) to the entire network.

In this context an interactive application was created for the support of tele-learing activities in ATHENA demonstrator in Heraklion city. This service consists of two core subsystems: the Virtual Classroom Server at the Professor's premises (VCS) and the Virtual Classroom Client at the student's premises (VCC).

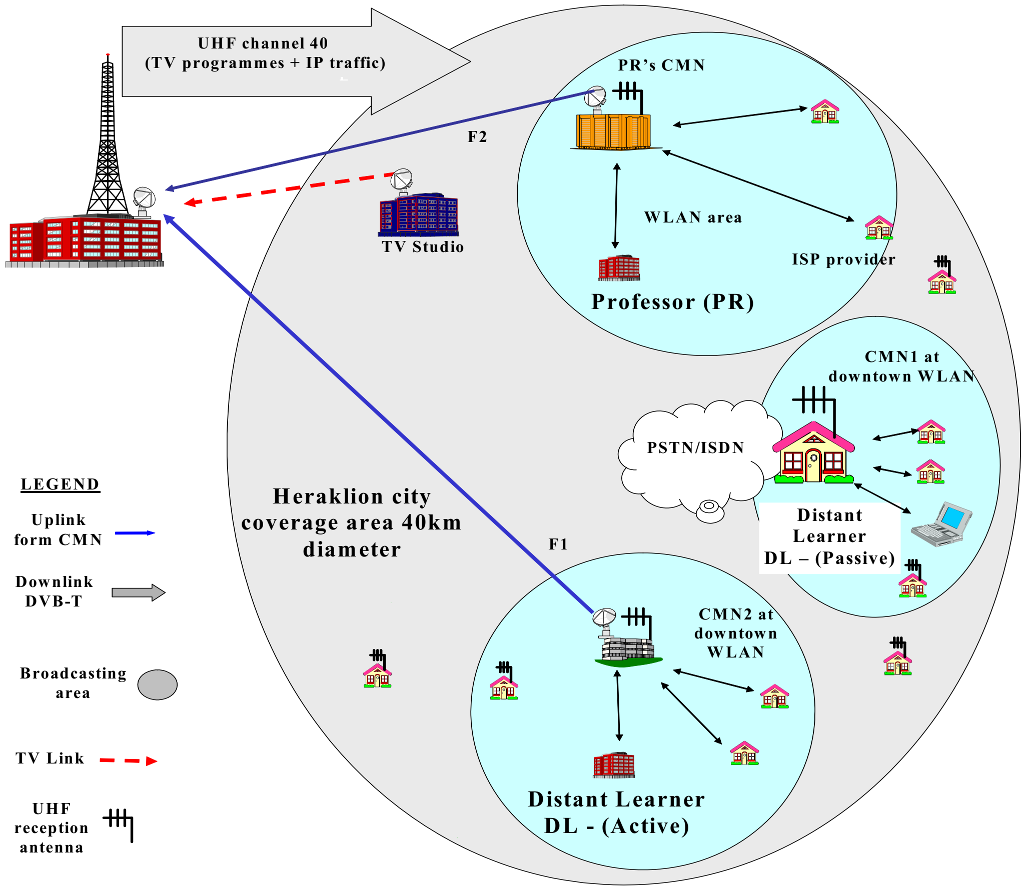

Figure 2. Overall architecture of the Virtual Classroom

The communication between the DL/PR and the corresponding CMN is achieved through broadband point-to-multipoint links (i.e. WLAN). IP traffic stemming from all CMNs is received by the broadcasting point (via point-to-point one-way uplinks), where a process unit filters, regenerates and multiplexes them into a single transport stream towards forming the final DVB-T "bouquet" (see Figure 3). In such a configuration all DLs can receive not only the PR's lecture (IP multicasts comprising audiovisual data) via the common DVB-T downlink and through the appropriate CMN, but also the interventions (i.e. questions for a specific subject on a given lecture, queries, etc.) stemming by active DLs and targeted to the PR. These interventions, which are provided via the corresponding CMN to the entire ATHENA infrastructure over the common DVB-T stream, are received at the PR's premises, where they are processed/filtered/edited before being provided/distributed to the entire ATHENA infrastructure.

CONFIGURATION OF THE CENTRAL BROADCASTING POINT

The configuration of the broadcasting point (depicted in figure 3) is capable to: i) receive the DL/PR IP traffic (audio and video interventions) over terrestrial uplinks (via the appropriate CMN), ii) regenerate them into a common DVB-T stream towards forming the final DVB-T bouquet, and iii) broadcast a common UHF downlink that carries the IP data targeting to all CMNs (located within the broadcasting area).

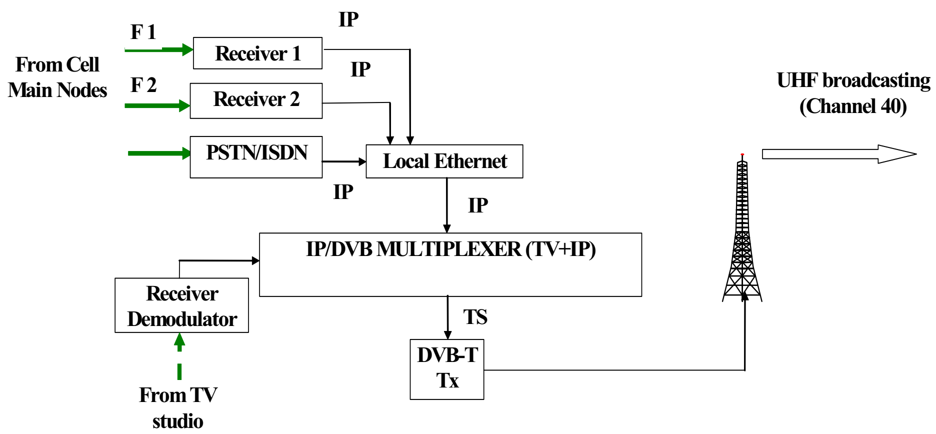

Figure 3. Regenerative DVB-T's configuration (broadcasting point)

In this context, and following the configuration depicted in figure 3, the multiplexing device is able to receive any type of data such as IP and/or digital TV programmes (the reception and distribution of digital MPEG-2 TV programmes is beyond the scope of this paper), to adapt any IP and MPEG-2 traffic into a common DVB-T transport stream (IP to MPEG-2 encapsulation), and finally to broadcast the common DVB-T stream following the DVB-T standard (COFDM scheme in the UHF band).

PROFESSOR'S CONFIGURATION

The configuration of the network that hosts a virtual professor is depicted in Figure 4. It comprises of the corresponding CMN and the virtual professor's equipment, including the PR's multicast equipment. Specifically, the multicast equipment at the PR's premises may comprise a Video/Audio capture device (camera, microphone), a multimedia PC equipped with the appropriate encoding software and hardware modules (e.g. MPEG4 encoder), and the appropriate software/hardware distribution tools, such as a multicast delivery system. The PR's audiovisual data (in IP format) are provided to the corresponding CMN (via a WLAN link) and from there to the central broadcasting point (regenerative DVB-T) via a dedicated one-way microwave link (communication between the CMN and the regenerative DVB-T). At this point, the PR's data are regenerated and encapsulated onto the common DVB-T stream along with all other data (i.e. DL's IP datagrams, digital TV programmes, etc.) and are finally broadcasted to the entire city over the common UHF channel.

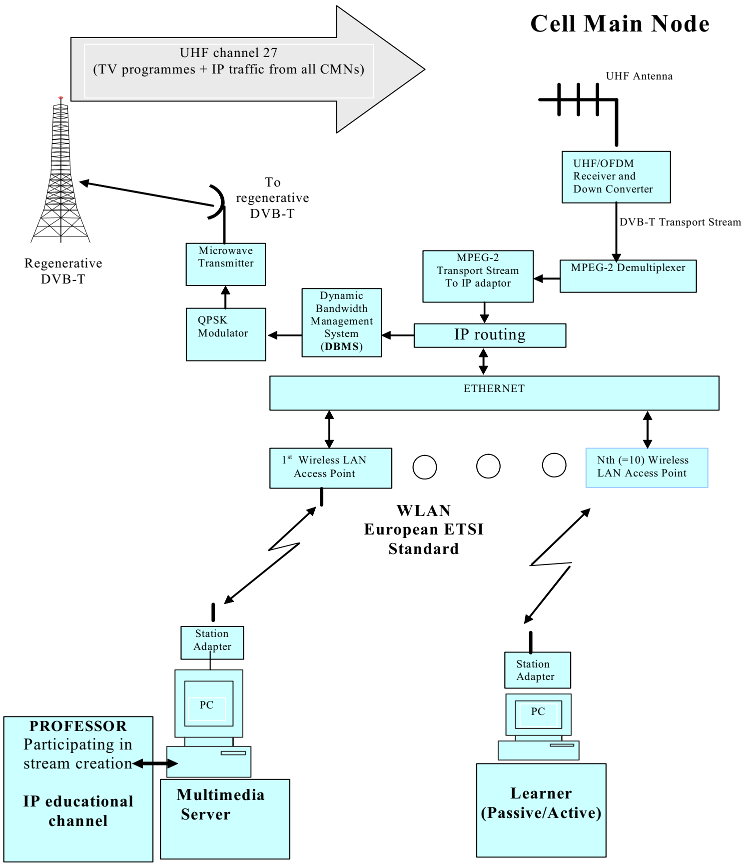

Figure 4. CMN configuration hosting the virtual professor

The VCS Java based application mentioned above, running on a custom multimedia PC enables the Professor to set-up and run a Virtual Classroom Session, by configuring the transmission and reception parameters of the audio/video data, such as the multicast IP address, the port number, etc.
From the "Tools" Menu of the main control window of the VCS applications (figure 5), the Professor can configure the "Server" parameters and the "VLC" parameters (i.e. the VideoLAN software used for transmitting and receiving audio/video data in multicast form).

Figure 5. The main control window of the VCS

Specifically, via the "Server" Tab, the Professor sets-up the Port Number, where the VCS will run (figure 6); this port number along with the IP address of the VCS's Host PC (i.e. 192.168.1.5 in the case of figure 6), is announced by the Professor to all students (e.g. via e-mail).

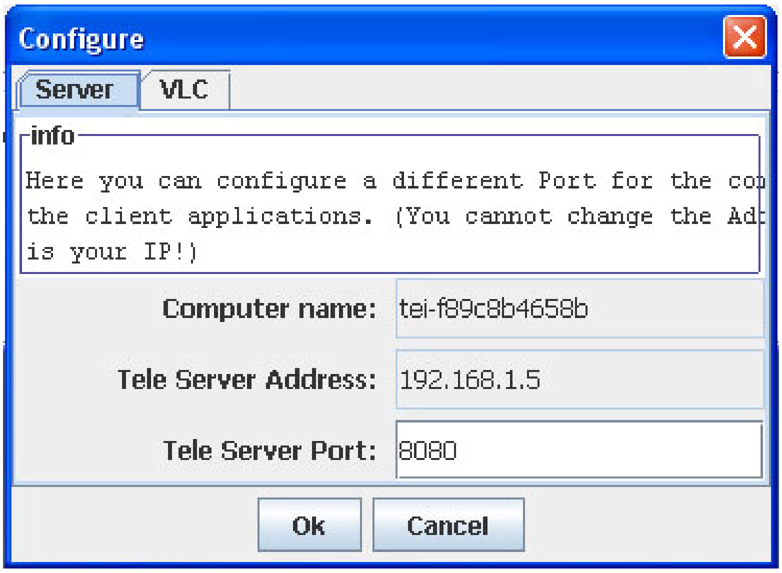

Figure 6. Configuring the port that the Server will run

Via the "VLC" Tab, the Professor sets-up the multicast IP address and port to which his video/audio data will be transmitted (Primary Stream Address and Primary Stream Port) and the multicast IP address/port from where he will receive the student's interventions (Secondary Stream Address and Secondary Stream Port), see figure 7.

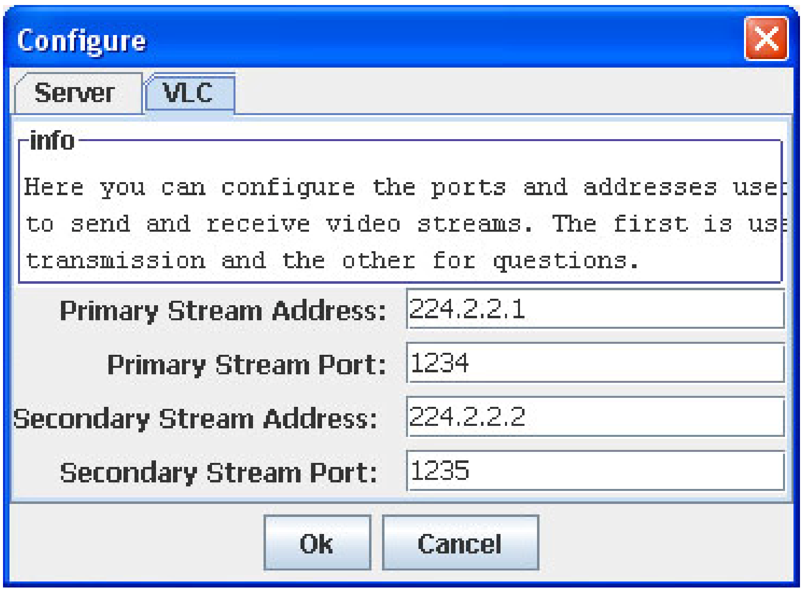

Figure 7. Setting up the IP multicast addresses and ports

As soon as the professor starts the VCS via the "File" Menu (figure 8), his audio/voice and video data (captured by the microphone and camera devices respectively) are transmitted over the ATHENA network in multicast form (225kbps of video and 64kbps of audio).

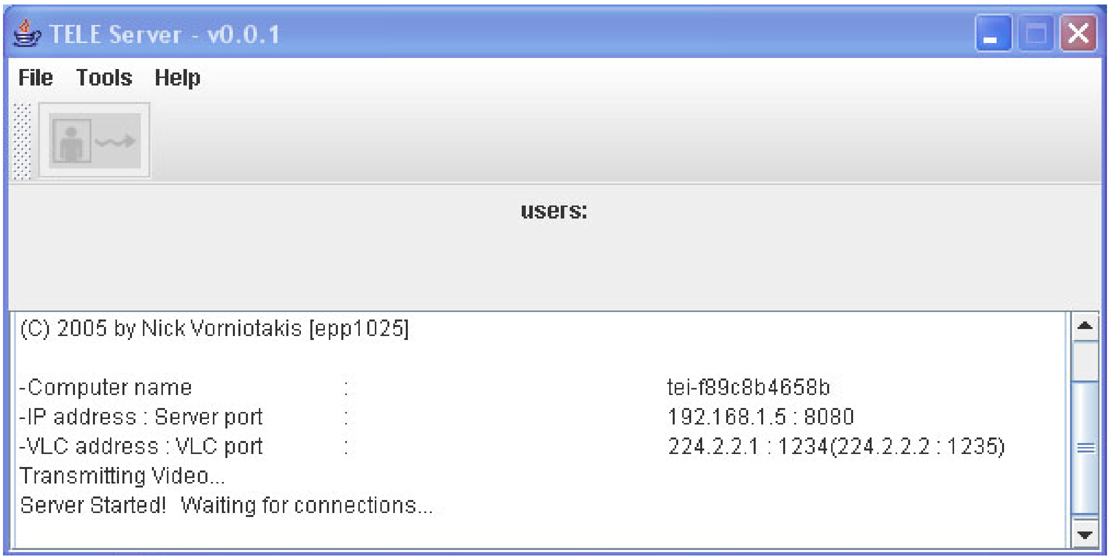

Figure 8. The VCS in running mode

DISTANT LEARNER'S CONFIGURATION

The configuration of an active Distant Learner is shown in figure 9. Such a configuration comprises an Access Point (AP) at the Cell Main Node site, which maintains a full duplex communication with the Station Adapters (SA) at the Distant Learners site. The output from each SA is in IP form, which can be processed by the upper layers of the software at the end user's terminal. Upon a user's request for inter-cell communication the AP and the local Ethernet, as well as the router and the Dynamic Bandwidth Management System (DBMS) at the CMN will provide the necessary information to the entire network via the common downlink backbone.

As already mentioned above, each DL located in the broadcasting area and has access to the ATHENA demonstrator through the appropriate CMN, can not only receive the PR's multicasts (passive DL) but can also intervene to the PR's lecture (active DL) by providing his questions/queries in audio/video format. In such a case, the active DL's equipment should comprise a multimedia PC and a video/audio capture device (i.e. a camera and a microphone) – ready available and at low cost from a custom electronic store – for creating and transmitting his intervention to the PR's premises via the appropriate CMN. This intervention can be either in real time (as a multicast stream) or in non-real time (as a file). The latter will be processed by the Technical Assistant prior to be broadcasted to the entire ATHENA infrastructure.

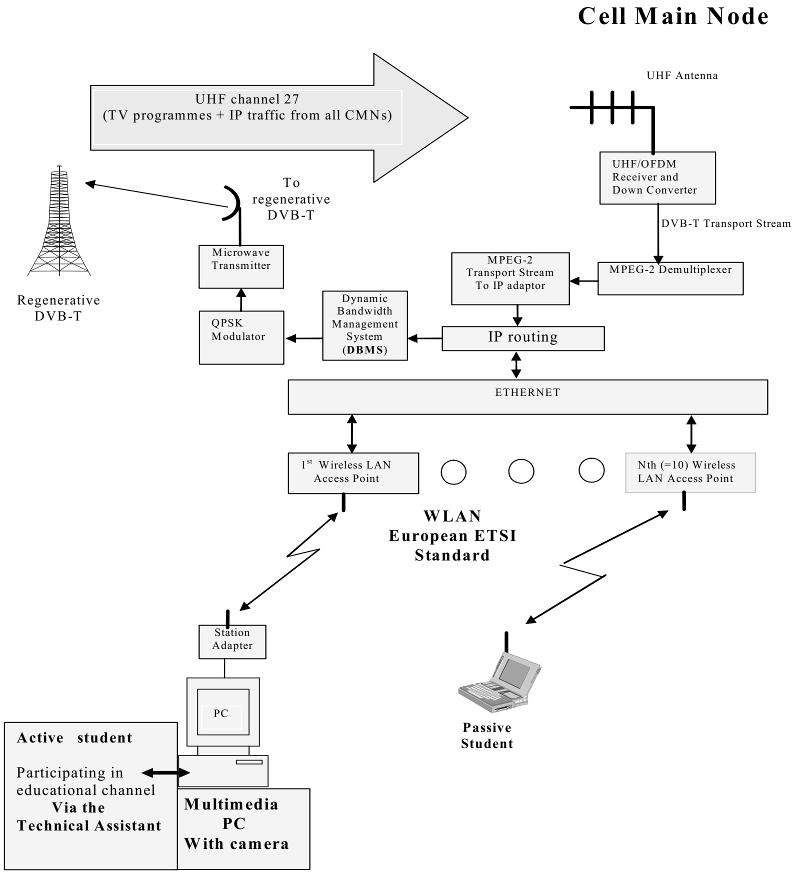

Figure 9. CMN configuration hosting Distant Learners (passive and active students)

The VCC mentioned above is a Java based application running on a custom multimedia PC which enables the student virtually to participate in the lecture that has been set-up by the Professor.
Prior to this, the VCC application (figure 10), initiates and establishes an IP connection with the VCS (the student sets-up the VCS's IP address and port number via the VCC's ConFigure Menu "Server" Tab – figure 11) and logs into the Server by providing his Username and Password (figure 12). Upon registration (log-in), the student starts receiving the Professor's audio/video multicasted data, via the VideoLAN application.

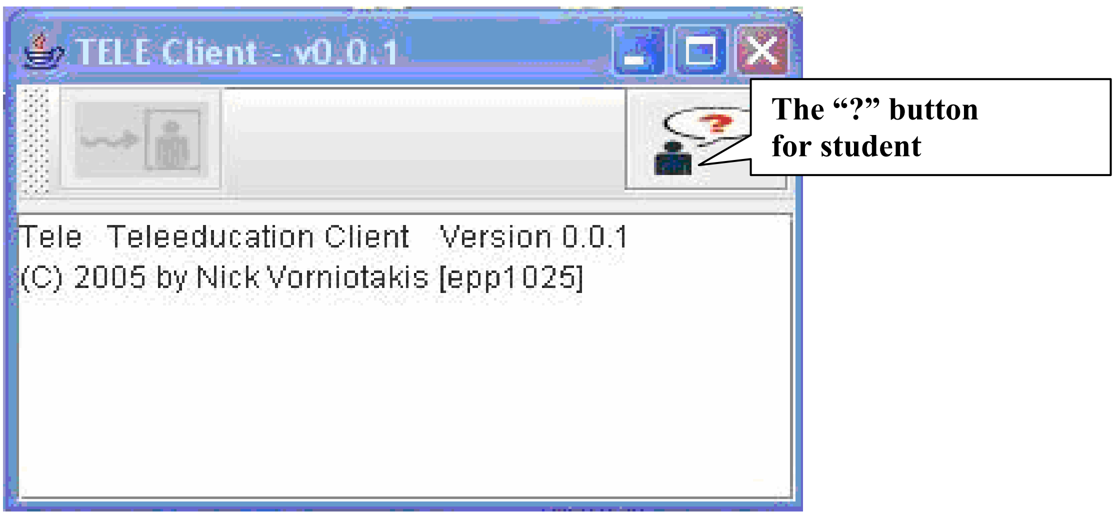

Figure 10. The VCC application interface at the student's PC

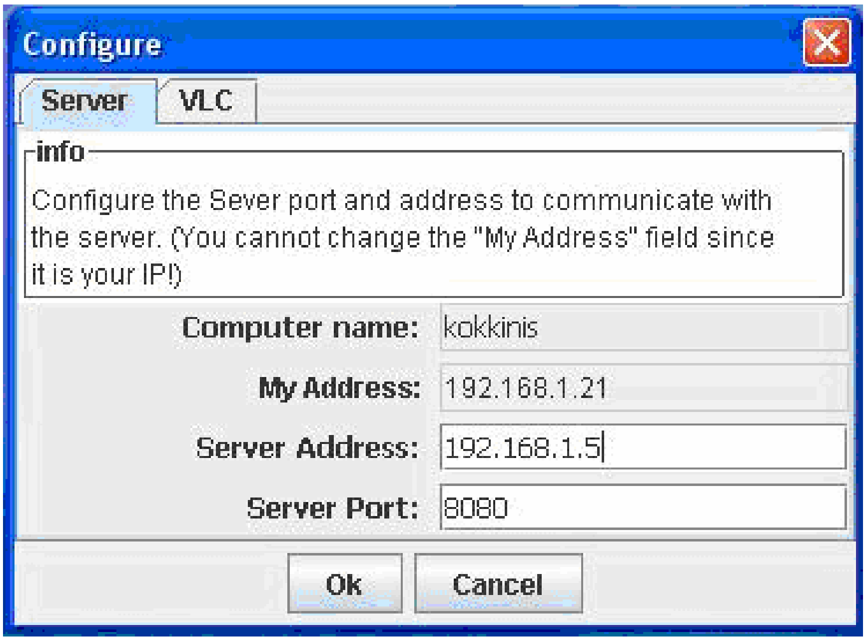

Figure 11. Configuring the VCC (at the student's PC) for communicating with the VCS

Figure 12. Student's registration in the Virtual Classroom session

As long as the session (lecture) is underway, the Professor is informed about the active students participating in his lecture, via the VCS main interface, which provides the Professor with visual indicators (lamps), each one denoting a different student (figure 13).

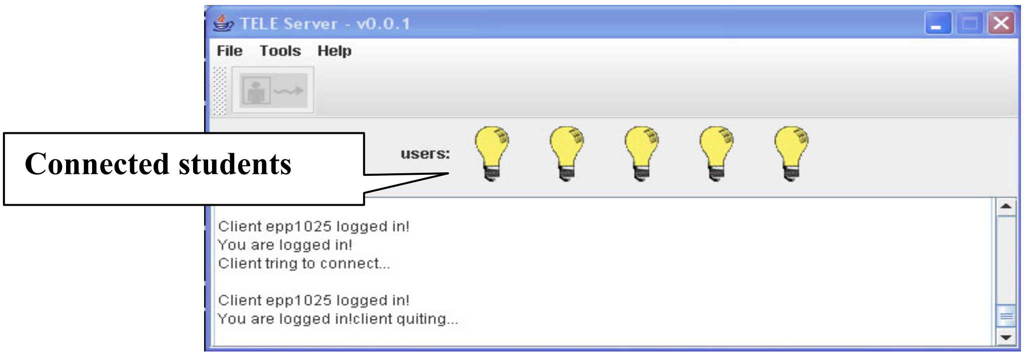

Figure 13. The VCS interface indicating the participating students

Upon a student's requests for lecture intervention (i.e. for asking a certain question concerning the lecture), the student informs the professor via the "?" (see Figure 10). Automatically this request reaches the VCS, which informs the professor via a flashing "lamp", accordingly to the student requested for an intervention (figure 14).

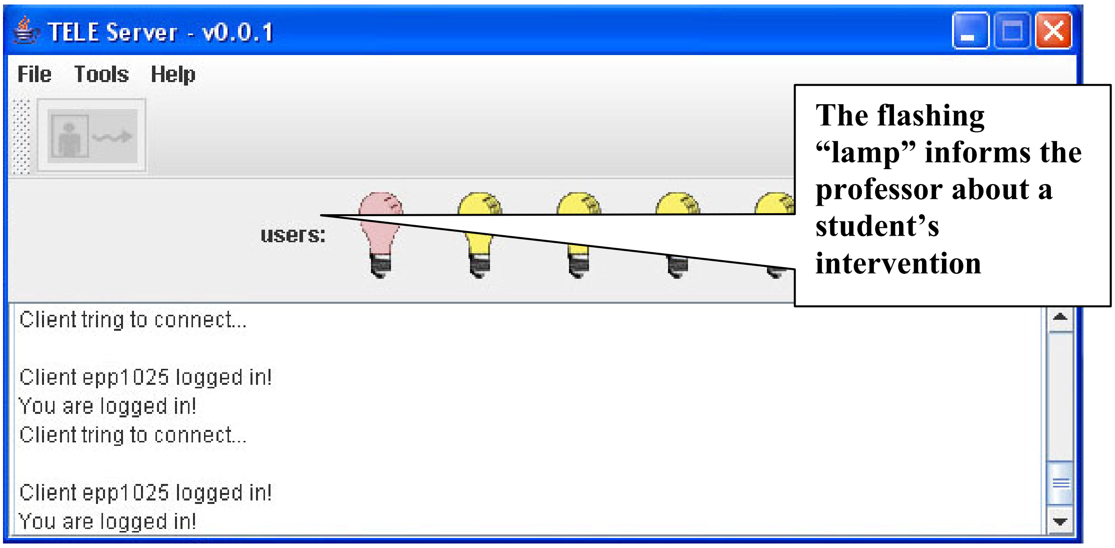

Figure 14. The VCS interface informing the professor for a student's intervention

The professor enables the student to intervene by double-clicking on the corresponding flashing "lamp". At this stage, the VCS provides the professor with a dialogue box, enabling him to allow the student's intervention ("ASK" button), and stop it ("done" button) when it is accomplished (figure 15). As soon as the professor allows the student to intervene, the student's audio/video data (225Kbps of video and 64Kbps of audio provided by the VLC application from the student's premises), are received and represented by the VLC application at the professor's premises. In such a case, a bandwidth of 578Kbps (289Kbps for the professor's data and another 289Kbps for the student's data) in the DVB-T stream is allocated for the Virtual Classroom application. Figure 16 indicates the Virtual Classroom environment at the Professor's PC, during a student's intervention.

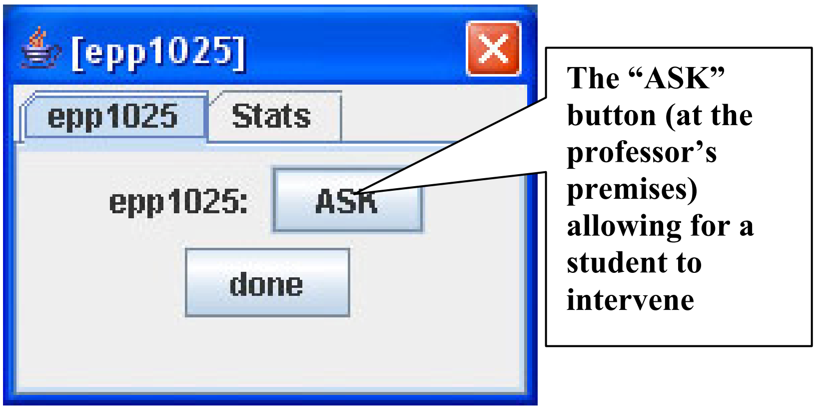

Figure 15. The VCS interface allowing a student's intervention

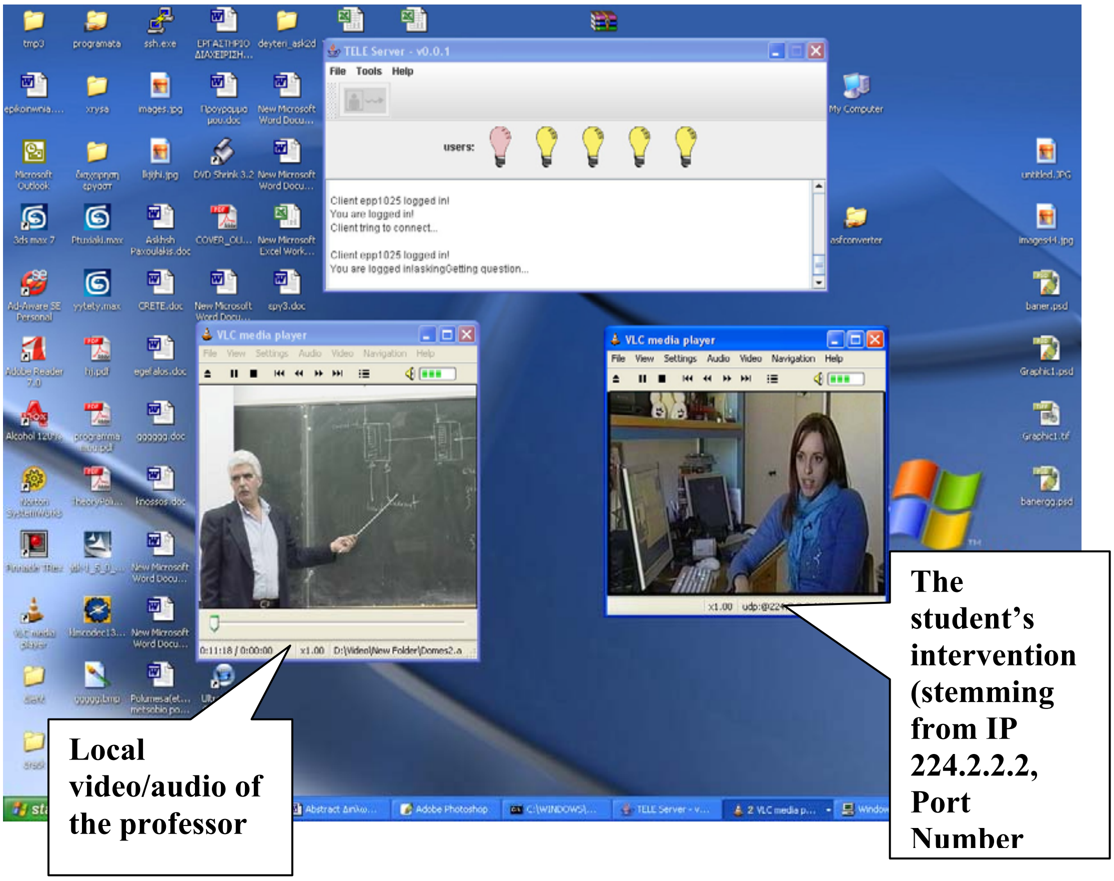

Figure 16. The professor's PC screen when a student intervenes

CONCLUSIONS

Based on and by making use of the ATHENA FP6-507312 concept for the transition from analogue to digital broadcasting, this paper presented a novel tele-learning platform that exploits the local and networking capabilities of the new digital television in UHF. It described the virtual classroom, where the lecturer and the students are virtually present in the same classroom from their own premises by actively participating in it using real time interventions (video/audio). By utilising the DVB-T stream in regenerative configurations, this broadband access infrastructure enables distant learners and professors to access/provide real-time interactive educational audiovisual material.

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Deliverable 6 d http://www.ist-athena.org/Deliverables/ATHENA%20D6%20Final%20version.pdf

Deliverable 20 http://www.ist-athena.org/Deliverables/ATHENA%20Deliverable%20D11.1%20Final %20Version.pdf.

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