Discovering Space for Educational and Learning Purposes

I. P. Chochliouros[*,1], **A. S. Spiliopoulou**[1], **G.K. Lalopoulos**[1] and **S. P. Chochliouros**[2]

[1] Hellenic Telecommunications Organization S.A. (OTE), 99 Kifissias Ave., Maroussi, Athens, 15124, Greece

[2] Independent Consultant, 65 El. Venizelou Street, Veria 59100, Greece

The present article comprises an overview of the work performed in the context of the Discovery Space (D-Space) project, founded by the European Communities. The project aims to develop a global "virtual" network of robotic telescopes, appropriately interconnected by Internet-based broadband facilities, in order to provide an innovative set of services for the benefits of several categories of users, especially contributing to the aims for the promotion of e-Learning. We discuss the innovative character of the solution, the portfolio of the services offered and we distinguish several potential users and application areas.

Keywords: Robotic telescopes, e-Learning, broadband communications, digital convergence

1. Introduction - The Role of the D-SPACE Project in the Context of Modern European Policies

The **Discovery Space** (D-Space) project aims at adding its contribution to the main objective of the European eTEN Work Programme 2004, which **i**s the deployment of services for an Information Society for All, mainly following the targets of the e-Learning thematic activities. The prime purpose of the project is the development of a virtual science center that will integrate robotic telescopes from all over the world into one virtual observatory, through a web-based interface that will provide automated scheduling of the telescopes for students, teachers and researchers and furthermore access to a library of data and resources for lifelong learners. The potential users can benefit from professional-quality data from their local sites, using modern broadband (Internet-based) facilities [1]. In this way, the project will be able to serve the purpose of "making Astronomy a popular science for the non-professional users" and to eliminate travel and lodging expenses for the professional observers.

Following the echo from the market request for more cost-effective and compelling applications to be delivered over the currently launched broadband networks supporting the expansion of the global information society [2], the D-Space service aims to take advantage of the convenience of the high speed Internet access to involve its various users (originating from distinct thematic categories) in extended episodes of playful learning. The project aims to test and to fully present to the market an entirely interoperable world wide service, conformant to the specific aims of the contemporary innovative European policies (specifically aiming to support options for further enhancement of e-Learning facilities for teachers and students). The project is based on similar approaches performed in USA (e.g. the TIE (Telescopes in Education) initiative supported by NASA, Global Network of Astronomical Telescopes (GNAT) - *http://tie.jpl.nasa.gov*), Japan and South America. However, it introduces a specific revolutionary context, which forms the difference, if compared to previous attempts. In fact, there is an increased need for Europe's education and training systems to adjust to the needs of the rapidly evolved knowledge-based society. The penetration of innovative technological applications with Internet access in education may facilitate the accomplishment of this goal [3]. The D-Space service is directly addressing this objective by using the intense possibilities the Internet offers, in order to "transform the today's classroom to a research laboratory". Moreover, it intends to provide a better understanding of how e-learning can improve and enrich teaching and learning activities in science and technology; it performs

[*] Corresponding author: e-mail: ic152369@ote.gr, Phone: +30-210-6117718

further analysis and provides extra comment on both opportunities and obstacles for the future development of the e-learning market in Europe [4].

2. Robotic Telescopes for Educational Purposes in a Converged Digital Environment

2.1 Developing a Global Virtual Network of Robotic Telescopes

The project intends to investigate the feasibility of the business case of the online use of a specific thematic set of applications, mainly developed for educational (and informative) purposes. The corresponding services will bring to students, teachers, researchers and individuals (amateur astronomers, visitors of science parks, etc.) all around the world the opportunity to use remotely controlled robotic telescopes (in "almost real time" application) thus giving accessibility to a great variety of resources (as the sky is a "vast and unique laboratory" of science), always in operation, accessible at all times from everybody from everywhere, where several sorts of interesting physical phenomena take place, *most of which is impossible to reproduce in any scientific laboratory* [5]. Thus, the D-Space project is aiming at providing these specific services required to operate a "virtual science thematic park" comprising several distributed robotic telescopes, also including an interactive, constrain-based scheduling service, enormous databases of scientific data and other variable resource archives. The proposed service will take advantage of the tremendous synergistic potential of an international "virtual network" consisting of professional-grade, remotely accessible observatories, adequately interconnected via modern infrastructures and related facilities.

The suggested application is already cooperating with 5 telescopes located in various European countries and Israel. In fact, during the primary pilot stage, the two telescopes of the Skinakas Observatory (located on the Ida mountain in Central Crete, Greece), the Liverpool Telescope (the largest robotic telescope in the world located on the island of La Palma in the Canaries), the Ellinogermaniki Agogi Telescope (located in the area of Attica-Athens, in Greece) and the Sea of Galilee Observatory (located in Israel), will be operated remotely by educators, students, researchers, visitors of science museums and science thematic parks, as well as the wider public from different places in the world. In addition, two other telescopes will be joining the virtual network in the near future: one from South Africa (Boyden Observatory) and the other from Chile. The size of those telescopes ranges from a diameter of 30cm up to 2m, thus covering a wide range of future potential partners willing to adhere to the services offered. The most important aspect of a candidate participant Telescope is the need to provide the equipment and infrastructure for the successful completion of a series of requested astronomical observations, received from the central system's request distributor (i.e. a General Scheduler). Moreover, continuous Internet access must be available at a speed of at least 1.5Mbit/s, while the entire system has to possess enough computing power to handle web interfaces, ftp servers, storage space for images and logs [6].

2.2 Developing a Proper User (Web-based) Interface

The communication of the related telescopes is achieved through a proper system's interface (Fischer, 1993). Each telescope should communicate with the "D-Space interface" through the common File Transfer Protocol (FTP) server-client. The Master Control System (MCS) of each robotic telescope (i.e. a set of hardware, software and communication units, responsible for the management and operation of the telescope) considers the "D-Space interface" as a remote user. The service requests series of observations from the MCS using a text file (files). The following day, the system asks for the results from the FTP server of the MCS. Since the communication protocols of D-Space service are widely known and used, the addition of a robotic telescope to the current network will not be a complex task. The entire D-Space system sees a new telescope as a "black box", so any potential new candidate (robotic telescope)

can use any internal platform (software and hardware) to control its own instruments. The only requirement is that the MCS is connected to the Internet and the transfer protocols are observed. This freedom of platform makes D-Space an attractive service for educational and scientific purposes. The user requests observations through a proper web interface. This interface contains a list of telescopes, targets, weather conditions in the remote sites, and other useful information that can help the user perform his/her observations. The user interface has been developed to be an adding tool that bridges science teaching and technology. This educational software supports teachers and students in an innovative learning environment while at the same time is compatible with graphics and analysis software components, so that students can easily investigate trends and patterns of the data they collect by using the telescope (Sotiriou, and Vagenas, 2004). The user has to select the astronomical object to be observed, from an object list. The scientific team and telescopes administrators provide appropriate lists, properly updated (often for visible objects) and other helpful information, to perform valid observations. Then the user fills in the submission form with the details of the observations (like date, time, filters, duration etc.). When a user submits a request, it is stored in the local database, at D-Space web server. The system immediately informs the user, through electronic mail, that his request is submitted, while each request has its own unique identity (ID) feature. Every night, an automated program sends all the requests to the telescopes, for the necessary scheduling purposes. If the request is realized in the user's desirable night, then the image will be in the system's library the next morning (where the user can find it, after notification of realization of his request).I f there is a technical or any other problem (i.e. a big queue of requests, improper weather conditions, etc.) on the desirable date and so the request is not realized, then the user is informed about the realization delay of the request. (There is also an additional notification that the system will try again to realize the request within the next 10 days, before any final cancellation).

Project's aim is to provide an effective scheduling system, able to manage different kinds of requests in the most convenient manner, among all participating telescopes. In this way and taking advantage of the time difference among the separate location of the telescopes already involved, astronomical observations could be practically realised on a 24-hours basis, per day. Thus, images and other observations' data will be downloaded to the remote user of the telescope (after the submission and treatment of his demand through the system) and will be stored in the user's computer for later retrieval and further use.

3. Services Portfolio

In the near past, there were several similar attempts and "analogous" (either technical and/or commercial) efforts, *around the world*, to promote the usage of robotic telescopes for educational purposes. In particular, over the past few years about 30 observatories have been outfitted with specific software and hardware interfaces in order to be used remotely, by certain users. However, *in practice*, all these telescopes have been operated as "independent observatories" with little leverage of resources, communication and limited coordination. On the contrary, through the D-Space initiative, the basic aim is to develop an innovative application by taking advantage of the remarkable synergistic potential of an "international virtual network" of professional-grade, remotely accessible observatories, *appropriately interconnected*, on the basis of suitable (Internet-based) broadband infrastructures and other modern electronic facilities [7]. At the current stage, the D-Space set of services practically integrates 5 distinct robotic telescopes seamlessly into one "virtual" observatory and provides those specific services which are required to operate the suggested complete innovative facility; these also include a scheduling service, several tools for data manipulation and access to corresponding educational materials. Furthermore, the D-Space service intends to facilitate (and gradually to adopt) the usage of broadband communication channels as the "basic means" of interaction and data transfer mechanism between the telescopes and the remotely located users around the world [8]; in this way the effective and fast response of the service is adequately safeguarded, thus offering a variety of significant benefits to the end-user, originating from the wider framework of the digitally converged world. The "core" aim of the project is to establish a modern distributed network of science centres and robotic telescopes accessed by students, educators, researchers and the wider public (e.g. visitors of science parks, amateur astronomers, etc.) via the global Internet.

Such an extended "network" has several fundamental advantages: Weather is less likely to cancel (or to delay) an observing session if automated telescopes are available in widely different geographical locations. In addition, more telescopes will serve more users with fewer delays and *-to the extent possible-* on the preferred schedules. The entire effort concentrates on the realization of a well-designed business case, conformant to educational and research purposes. The detailed services portfolio consists of:

- On-line access to the complete "network" of the robotic telescopes (ability to submit on-line or scheduled requests) and access to scientific data and resource archives (e.g. data and images) created either from previous observations or from secondary treatment of already existing information;
- Access to a central data archive, making use of a common archive and distribution system, guaranteeing opportunity to make use of extended digital information;
- Access to educational material and interactive tools (allowing for data representation and analysis), properly designed, created and offered to comply with the expected project's instructive aims;
- Access to teacher resources (e.g. professional development materials, lesson plans), organised and updated to facilitate educational purposes;
- Student-centred materials (e.g. data library, communication area, student's magazines), occasionally offering full interactivity perspectives for further enhancement and/or expansion;
- On-line (updated) training courses at different levels (i.e. for school students, university students, or the wider public), appropriately designed on an always-on basis;
- Participation contests (these are expected to cover the levels of all targeted groups of users, i.e. scientific contests, best science project contests for students, best photo contest for the wider public);
- Provision of information on specific astronomical events (e.g. transit of planets in the solar system, observation of comets, sun or lunar eclipses, etc.).

4. Potential Users and Application Areas

Users from all around Europe will be able to access the D-Space platform. It will be the "window" into live scientific experiments and phenomena, ongoing research, and the personalities and stories of working scientists across the world. In this way science education will act as the "mediator" among people in different areas, reducing at the same time prejudices and stereotypes and increasing social cohesion. Users will experience the phenomena presented in their own terms, freely choosing what to attend to and interact with, depending on their prior knowledge, interest and expertise. The proposed services address several diverse categories of potential users/entities, listed as follows:

- Educational Institutions (e.g. primary and secondary education schools), and Universities. The end-users in this case will be students as well as educators and researchers.
- Research and Laboratory Institutes and Science Associations.
- Scientific museums, Science Centers, Science Parks and Planetariums (offering unique experience to the visitors, who will have the chance to perform on-line observations during their visits);
- The wider public (in the project's vision the way individuals will experience science through the D-Space services is expected to have a lasting positive impact on the general public attitude towards astronomy and science in general).

End users of the above target groups will be able to make astronomical observations through the use of the network of the robotic telescopes. It is rational that each group will be using some of the contents -and at different levels- according to their needs and expectations. Therefore, the benefits of its group vary. It is expected that students will principally use the application for observations, image analysis and data reduction, experiments and projects. Additionally, the proposed application can be used for pedagogical research reasons (e.g. exploring the introduction of informal learning methods in normal school curriculum). The service will allow students from different countries to work together on science projects and experience the excitement of science observation and discovery in exactly the same way as professional astronomers [9]. Educators will use it during teaching, being able to choose among a wide range of topics at different educational levels, conduct experiments, use data and supporting material. Scientists, whether in research institutes or in science centres will use the facilities to obtain data, conduct

experiments, and make observations as well as participate in international research projects. On the other hand individuals will use the suggested services in order to make their own astronomical observations, take pictures and get relevant information in which they may be interested in [10].

4. Conclusion and Further Information

The idea of using robotic telescopes for educational purposes is experiencing significant growth, in the global level, together with other efforts for the promotion and the dispersion of electronic communications facilities in a fully converged environment. The D-Space project's ultimate aim is to develop a virtual science thematic "network", which will connect, not only schools, universities and research centres but also science museums, planetariums and parks for educational purposes. This "network" will consist of a group of robotic telescopes all over the world, providing access to and sharing of advanced tools, services and learning resources between its users; the latter will have the opportunity to use in a remote way all the facilities (and the other relevant means) offered, in (almost) real time, through modern Internet facilities. The services offered will act as the main "hub" of resources available in the developed "network" that will serve as "distributor" of information and "organizer" of suitable didactical activities. The Discovery Space service demonstrates an innovative approach that crosscuts the boundaries between formal and informal learning environments. It also intends to support the provision of key skills to the users (collaborative work, creativity, adaptability, intercultural communication), while developing a better understanding of the role of science in society and bringing science and scientific subjects closer to the citizen. Simultaneously it intends to help increasing young people's interest in science and scientific careers. Last but not least the project could also act as an excellent example of the effective and advantageous use of broadband services, as it strongly requires high-speed transmission of significant amount of data. In this way it is expected to support both the national initiatives as well as the European ones, namely the widespread availability and use of broadband networks throughout the European Union.

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