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ORGANISATIONAL IMPACT AND EXPLOITATION OF THE RESULTS OF AN ITALIAN RESEARCH PROJECT FOR E-HEALTH AND MEDICAL TRAINING

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Abstract

The paper describes the final results and the organisational impact of the HERMES project: an on-line integrated web-based platform to provide multimedia services in tele-medicine and tele-education fields. The project is part of a European Space Agency programme to promote the market of broadband satellite services and the role of satellite systems in the tele-education and tele-medicine domains. The project implemented a pilot to demonstrate the effectiveness of the overall system (application and communications platforms), and to promote the use in real scenarios of innovative telemedicine and tele-education via satellite services in the Italian healthcare system. After five years, the project concluded its trial phase and the results of such a trial have been analyzed. The high level of investment in the initial phase suggested a very accurate market assessment with several pilot demonstrations. This approach is allowing to minimize the risks connected with the further significant service provisions and is now orienting the market deployment.

Keywords: Medical training, clinical trial, tele-consulting, healthcare information processing.

1. INTRODUCTION

Telemedicine has a great potentiality, however there are unfortunately Today few examples of large commercial services. The benefits of expanding its use are threefold: it can improve the quality of healthcare services; it allows a better exploitation of limited hospital resources and of expensive medical equipment; and it helps to address the problem of unequal access to health care. Throughout Europe and other developed countries the number of people requiring special care is increasing as the proportion of elderly people rises, at the same time, in a high-tech age the expectations of the society for a better healthcare are also rising. Telecommunications offer the opportunity for improving health services and for making health care expertise available to underserved locations.

The HERMES project (High transfer Rate Medical and Educational Services by Satellite) implemented pilot operations both in tele-medicine and in tele-education, utilising asymmetrical Internet via satellite, dedicated hardware and software platforms and providing databases and services. The project is part of ARTES Element 3 Theme 1.2-1, a European Space Agency (ESA) programme aimed to promoting the development of a European market of broadband satellite and the role of satellite systems and services in the tele-education and telemedicine domains. ARTES encourages the implementation of pilot projects, operations in real scenarios, innovative services and educational and medical applications. The HERMES

project partecipants have been: Telespazio (the main Italian satellite telecommunication company, coordinating partner), Citec (a software house), Nettuno (a large academic consortium for tele-education), several hospitals and CeRSI-Luiss. HERMES aimed at demonstrate the effectiveness of the overall system (application and communications platforms) to promote the use of telemedicine and tele-education via satellite in several environments by the compliance to the DVB standard. The main goal was to prove flexibility, cost effectiveness and organisational impact of this kind of services for medical organisations, by developing a community service useful and profitable in three fields: clinical data management, cooperative clinical information management, broadcast of multimedia contents between several medical centres for tele-consulting and training purposes.

2. DESCRIPTION OF THE PROJECT

The probability of an incorrect handling of a relevant pathology, is still dangerously high, mainly due to:

- *Environmental factors*. Many medical organizations are not fully able to face every disease, e. g., in a peripheral hospital only the most frequent pathologies for that geographical area are treated;
- *Instinctive factors*. The decision making of a physician is usually mainly based on the limited number of cases in her/his experience and/or on a static medical knowledge available from databases of main published studies. This factor is very variable between different specialists and general practitioners;
- *Emotional factors*. Medical decisions are often influenced by the opinions and the decisions that have been taken by the physicians that already have examined the same patient.

As a consequence the probability of an serious error occurrence could be high and the probability of its recognition and correction very low. This frequently causes a repetition of exams in the same or in different medical units and it slows down the diagnostic process (resources waste) and the proper treatment. So, proper actions for improving the working procedures have to be taken.

Correct medical information management and transmission is a key point, hence the introduction of innovative ICT can be relevant. Furthermore ICT performance, and in particular the TLC bandwidth requirements are high and rather asymmetric (there are more often needs for retrieval than for entry or update a medical data). Multimedia clinical record transmission is a suitable topic for the satellite DVB networks. Each actor connected to a network need to be driven towards the most proper resource available on it, e.g., an important objective of clinical data management is the availability of common and precise data about patients treated in medical centres connected to the network: a TLC network and a proper software can make the patient data available in remote sites: this is the HERMES goal (Warr, 1998).

The HERMES project also provides a new teaching/learning service based on collaborative and bi-directional communication processes. Interest in co-operation does not affect only teaching but all intellectual and cognitive activities, “collaborative learning” refers to a method in which actors work together towards a common task. Physicians are traditionally responsible for their own and their fellows’ learning; in this way, individual success helps all others to achieve positive results. In fact an active exchange of ideas in between small groups does not only improve the interest in communicating but also promotes a development of a more critical thinking.

HERMES main telemedicine applications concern: reference data and medical support services, multimedia patient record handling and tele-consulting (one to one and/or multipoint). On the other side the main applications that have been implemented for tele-education are: video lessons (live and/or on-demand), a media library, and a laboratory collaborative learning environment. The satellite technology helps in building a network of medical and research centres participating to these kind of trials, that it have a huge economical impact on the medical market.

Since the request for more effective health services is increasing over the years, the health delivery system needs to focusing on:

- improving the performance of the health services;

- optimising the running costs of the health structures and the allocation of resources.

For this reason, health is now following a "delocalisation" process: information, i.e. knowledge and skills, should be moved, rather than people or tools. The HERMES project wish to provide an answer to such an evolution to e-health. In particular, it offers hospitals the chance to extend their information services to a larger medical community (possibly the entire Italian one) thanks to a total coverage of the country (Casalino, D'Atri, 2005). The HERMES target market is mainly composed by hospitals in remote sites, where the satellite is the unique solution to provide broadband services. Such organizations are medium and small hospitals which need a professional support by the centres of excellence through teleconsultation sessions. Table 1 shows the size of the target market the service is focusing on.

HOSPITALS	Bed sites	Number
Centres of Excellence	>600	98
Large-sized Hospitals	>200	197
Medium-sized Hospitals	>120	412
Small-sized Hospitals	<120	674

Table 1. A classification of the Italian hospitals.

Following this market identification, during the project trial phase the platform has been supplied and evaluated in 14 hospitals spread all over Italy, with the following specialisations:

- Cardio-surgery (Ospedale di Treviso; Policlinico "Umberto I", Roma);
- Haematology (Biotecnologie Cellulari ed Ematologia dell'Università "La Sapienza", Roma; Ospedale "S. Maria Goretti", Latina; Ospedale di Montefiascone, Viterbo; Ospedale "S. Camillo", Roma);
- First Aid & Emergency Medicine (Istituto di Oftalmologia del Policlinico "Umberto I", Roma; Ospedale "S. Filippo Neri", Roma);
- Oncological Surgery (Ospedale Civile di Asti and Istituto di Ricerca e Cura del Cancro di Candiolo, Turin, both with two departments: Radiological and Oncological Surgery);
- Radiology (Policlinico "Umberto I", Roma);
- Experimental Medicine Department (Università degli Studi di L'Aquila).

3. OBJECTIVES AND ADVANTAGES

Reference data and medical support services provided by the HERMES pilot are complying in a cost-effective way to the continuously increasing pysichians' needs for a faster access via Internet to data and services supporting decision making in clinical practice and medical education.

In particular, the services provided by HERMES are:

- Access to clinical and educational data, tutoring, and distance learning functions: reference data (clinical data, 2D and 3D images) and text databases for diagnostic and patient care decision support and for undergraduate or postgraduate courses and professional continuing education schemes support; educational tutoring and learning progress assessment; off-line and on-line consulting on specific issues;
- Support to tele-consulting sessions with the above mentioned data and workgroup functions as: forum and whiteboard. The high integration in the HERMES platform allows a satellite based IP access, therefore providing the needed cost-effective fast downloads and the availability of a comprehensive medical information services platform with a relevant commercial exploitation potentiality. Most patient data are stored in large files. For this reason, the transfer rate of the multimedia contents in the websites is a qualifying element to satisfy the needs of physicians, scientists and students in the various medical areas.

Faster downloads on a scheduled basis have also been exploited using multicast file transfer. A multimedia medical record collects data items from direct patient examination and from medical instruments. These “events”, representing significant episodes in the patient's medical history, belong to two classes: analytical events and descriptive events. This core functionality of the HERMES system has been implemented by TELESPAZIO in collaboration with a software house specialized in telemedicine and e-learning software (Kell S.p.a. - Rome). This module, already used in some Italian hospitals and validated by several years of everyday work, has been customized to improve satellite effectiveness and speed: patient data are stored in a central database, hosted by a server, and are shared immediately before the collaborative work or off-line for successive independent work by participants involved in the study of that patient. Compared to others telemedicine procedures this brings several advantages:

- The collaborative work is more than a videoconference with data transfer, being the medical data already validated and centrally stored. This information is permanently available and is a major asset for patients and institutions;
- Data are stored according with well-defined guidelines, reducing the probability of the need of asking for additional diagnostic procedures on the same patients;
- Off-line consultation is also possible (and is actually one of main scopes of HERMES);
- Stored data can be also used for statistical analysis of similar cases and for medical treatment of patients with similar pathologies;
- The logs of the invoked operations on stored data provide a legal protection for medical practice;
- Both cryptography and the possibility to retrieve anonymous data, are used to enforce the patient privacy according to EU privacy regulations and laws.

The platform allows to satisfy learning requirements and to create “interactive virtual classrooms” with information exchange between physicians by means of: virtual shared board, textual chat; Voice Over IP technology; documents exchange. The tutor carries out a live session, with traditional teaching tools (blackboard, overhead projector, etc.) using other technological tools as: short films; electronic documents; html documents; web sites.

In Europe, US, and Japan the healthcare staff need to certificate their participation in continuing medical education (CME) programs. These courses have traditionally been done in the past either face-to-face or via reading materials. Web-based technologies allow courses be available on-line, this enables healthcare operators to train themselves at any time and from any location and available information to be greatly increased. Traditional web systems are too simple to be really effective (Hasman, 1995) and the commercial e-learning platforms require a complex configuration and are too “technical” for customers (Rose, 1998), furthermore the focus of these system is often on on-line interactivity, while a structured arrangement of educational contents must be the first priority. For this reason a new system, called J-Study, have been developed having the following features:

- *Structured Courses*. Stored in a relational database maintained by a suitable administration tool. Each course is multi-language and is integrated with evaluation forms. The course structure (lessons, concepts) is easily editable and the results are immediately available;
- *Innovation in content.* The system is based on a multimedia object called “concept”, an innovative way to build a lesson. This concept encloses images, videos and texts that are needed to communicate educational concepts;
- *On-line interactivity*. Learners communicate with teachers by using multicast audio/video/whiteboard interaction in multi-user sessions (virtual classrooms). The quality of audio/video depends on the network but multicast allows the exploitation of asymmetrical ADSL and of satellite networks;
- *Minimum configuration* of the clients. The system is developed in Java, it runs on most hardware and operating systems and it needs no configuration of the user workstation, apart from downloading the Sun Java run time. Also the server runs open software products to reduce costs and to increase portability and performances.

The main HERMES objective is the availability of a common base of multimedia medical data relevant to any Institution connected to the web. A telecommunications network and a proper software provide patient data in remote sites enhancing the co-operation between physicians belonging to different Institutions. The system guarantees:

- *Patient Assistance*. The underlying idea is that the information collected during the contacts with healthcare organizations has a great importance for the future treatment of patient diseases. Data have to be accessible by authorized medical personnel only. The patient must not be bound, as far as possible, to working and travelling contraints. So the patient could have contacts with other Institutes, possibly abroad, and her/his data must be easily accessible, provided the security permissions are verified. Medical and paramedical personnel store and retrieve relevant data coming from exams, anamnesis, therapy, and any other event that is relevant to patient contacts with any Institut joining the system;
- *Decision Support Based on Large Statistical Samples*. The availability of a wide collection of medical cases can be very useful in determining the best decision about a new patient. A query can be restricted to single data item stored for any patient. For example a physician can retrieve the number and the kind of patients with a given pathology and the systolic blood pressure lying in a given range. Once the statistical sample is extracted, data from any event in the patient records can be exported in a standard format (for example to be used in a spreadsheet application) for further statistical analysis;
- *Research Activities*. The dissemination of large number of medical data integrated in a single network implies that a huge amount of data be available. This information can be used as a common base for scientific statistical analysis for medicine and pharmacology;
- *Multi-language support*. The system can be used with different languages thanks to a multi-languages support. The preferred language is easy to be selected by each user;
- *Patient Privacy*. Patient privacy is a primary issue, that is enforced through strict security checks;
- *Economic Objectives*. The system gives relevant economical advantages. It allows patients be treated in remote sites, sharing with physicians in Centers of Excellence the relevant data for medical decisions support and diagnosis. Medical protocols and guidelines for disease treatment can be shared. Medical personnel in remote sites can join Centers of Excellence programs and associations. It enhances the autonomy of the remote sites hospital system, increasing efficiency and allowing quality assessment.

4. DECISION SUPPORT FUNCTIONS AND ORGANISATIONAL IMPACT

The HERMES patient-record is based on “events”, i.e., episodes that occur during the patient’s contacts with the hospital: a blood test, an objective test, an anamnesis. These events are stored in the patient’s history, in this way a clinical record is dynamically built up aggregating information delivered by different medical units. An innovative aspect of this multimedia medical record (MMR), is that different types of events can be handled by the same sequence of operations, thanks to the “objects” technology. Data are arranged in forms, representing logical views on the MMR and can be displayed and modified through a standard web browser running on the client station (Robey, 1989). The patient’s record is the collection of all his/her events, these medical data could be heterogeneous, ranging from numerical values to radiographical images to full motion video. The system stores these MMR in a relational database, a simple formal language and a multi-language aids enable a very easy customization and retrieval of medical fields without programming activities. Data are shown to the user by a synthetic view of all events, arranged as entries in a table through which the user is able to view details on a single event, or collection of data extracted from multiple events (Casalino, Di Persio, 2004). Physicians and technicians can directly store and retrieve the relevant data abot exams, anamnesis, therapy, and any other event relevant to patient. Queries can be specified by graphical windows, so that even software inexperienced

medical personnel is able to use it (Wong et al., 1996), the system also allows complex queries including "and - or - not" combination of events.
A relevant step forward is that information is gathered during routine patient treatment, not during activities explicitly dedicated to scientific research within Universities or research Institutes. Educational module slides are already collected in a central database. The particular importance of this point is:

- data flow is asymmetric, exploiting satcom operations;
- there is no requirement for the session leader workstation. The roles of the participants is logically assigned by the software and not dependent on the terminal features;
- slides are collected in a hierarchical form in a relational database. In this way structured access to courses are granted and large amounts of multimedia content are administered and maintained centrally in a well ordered way;
- access to contents is granted conditionally based on user privileges. The tutor grants access to the appropriate educational material. The system allows also dynamic on-line transmission of local images and even clipboard graphics paste of graphics in the virtual board. Of course the asymmetric nature of the network is not efficient in this case. The program allows user commands to be automatically sent to all the participants that see the same window and can give commands that will be broadcasted to the others.

For the hospitals there have been saving from:

- a operating cost reduction through the optimization of resources;
- a reduction in costs of training for the physicians through distance learning and access to medical database;
- a decrease in travel costs and time for physicians visiting other hospitals for consulting.

5. RESULTS AND FUTURE PERSPECTIVES

Perspectives and strategies for telemedicine are currently evolving, as emerging operative requirements would allow self-sustainable large scale exploitation while recent technological developments are available to support integrated and cost-effective solutions to such requirements. However, as far as we know few telemedicine services have proceeded to large scale exploitation, even after successful technological demonstration phases. Main exploitation drawbacks, problems and deficiencies have been:

1. partial solutions approach instead of integrated total approach to healthcare assistance needs;
2. lack of economical drive and consequently no self-sustainability for large scale exploitation;
3. insufficient H24 (24 hours/day 365 days/year) medical and social operators support;
4. insufficient networking approach for medical operators and scientific/clinical structures.

After five years, the HERMES project has concluded its trial phase in December 2003 and the results of such trial have been observed. It has been estimated, among the hospitals considered in the trial phase, that such a platform would reduce costs of approximately 30%. Such costs are identified in travelling expenses, consultancy expenses between different hospitals and lost working hours. In order to have a qualitative result an Evaluation Protocol for the HERMES project has been performed and distributed to the 14 hospitals that participated to the trial in the past five years. The questionnaire has been focused on achieving the following main objectives:

1. checking the effective usefulness of the Telemedicine service;
2. singling out imperfections of the service, in order to improve its efficacy;
3. finding out other users' needs that the service should meet.

In total, 14 physicians took part to the evaluation trial, with an age rising from 37 years old and 60 years old. In particular, to better identify the use of the teleconsulting system and the multimedia database during the trial phase, it has been asked users to communicate the number of times per week they have used the two technical tools, and if the teleconsulting sessions have helped them to change their previous decisions on their patients diagnosis and medical treatment.

Numer of times	Not at all	From 1 to 5 times	From 5 to 10 times	More than 10 times
Teleconsulting session (per week)	0	13	1	0
Multimedia Database (per week)	0	11	3	0
Change in the medical diagnosis and treatment decisions after the Teleconsulting session (times in the period of use)	0	0	3	11

Table 2. Number of times using the teleconsulting system and the multimedia database, change in the medical diagnosis and treatment decisions.

The table shows that the majority of the participants have used the teleconsulting system and the multimedia database with an average of three times a week. In particular the teleconsulting session has been very useful since it has changed, for most of them more than ten times, the previous decisions on the medical diagnosis and treatment of patients. For having a more complete evaluation of the service, it has been asked to the physicians to provide a general evaluation of the service by giving three adjectives that could describe the HERMES project. The following table summarizes the answers given by the users classified in positive and negative.

Evaluation of Teleconsulting system and multimedia Database	Positive	Negative	Total
Number	13	1	**14**
Percentage	93%	7%	100%

Table 3. Evaluation of the teleconsulting system and the multimedia database.

Concerning the technical problems encountered, the users have found some interferences during the teleconsultation sessions, due mainly to server imperfections, which have been soon overcome with immediate technical improvements. As shown by the table and by all the answers given by the sample, the service impact on the physicians activities is positive. They have demonstrated the utility of the service in supporting the medical decisions on the patient diagnosis and treatment. One of the major key success factor of satellites is their capability to cover wide territories and to reach remote areas where sometimes it is the sole solution for communication with a large bandwidth offered without specific limitation as it usually happens with the terrestrial solutions (i.e. telephone landlines). Therefore, one of the possible perspective of the HERMES project is its diffusion in other countries outside Italy, especially those that are not fully up-to-date in ICT applications. We took into consideration first of all several markets in the Eastern Europe. In particular we target Albania, Croatia and Romania. We selected these countries by screening among eastern countries and targeting those that seemed to be the most attractive in terms of market potential perspectives. Hence we targeted in particular those areas which have a less availability of Internet services and a worst terrestrial infrastructure in which satellite applications are the sole efficient solution for implementing a solid communication network. Besides the real market opportunities within the indicated countries, the high level of the investment in the initial phase suggests to perform a more accurate market assessment with several pilot demonstrations in order to provide further significant feedbacks and to orient the subsequent initial market deployment. This approach allows to minimize the risks connected with the project. The same policy may be developed in North Africa and South America where the satellite technology can play an important role since terrestrial infrastructures are even less up-to-date than in the Eastern Europe and relevant actions are required to improve both quality and access to

health care. The proposed value added services will bring benefits to the communities as contribution to the hospitals' professionalism, improvement in the health system and in the quality of life of their citizens, reduction of the gap between Eastern and Western European countries.

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