Assessment of Internet-based Telemedicine in Africa (the RAFT project)

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Abstract

The objectives of this paper on the RAFT (Réseau Afrique Francophone de Télémédecine) project are the evaluation of feasibility, potential, problems and risks of an Internet-based tele-medicine network in developing countries of Africa. The RAFT project has started in Western African countries five years ago and has now extended to other regions of Africa as well (i.e. Madagascar, Rwanda). A project for the development of a national telemedicine network in Mali was initiated in 2001, extended to Mauritania in 2002 and to Morocco in 2003. By 2006, a total of 9 countries are connected. The entire technical infrastructure is based on Internet technologies for medical distance learning and tele-consultations.

The results are a tele-medicine network that has been in productive use for over 5 years and has enabled various collaboration channels, including North-to-South (from Europe to Africa), South-to-South (within Africa), and South-to-North (from Africa to Europe) distance learning and tele-consultations, plus many personal exchanges between the participating hospitals and Universities. It has also unveiled a set of potential problems: a) the limited importance of North-to-South collaborations when there are major differences in the available resources or the socio-cultural contexts between the collaborating parties; b) the risk of an induced digital divide if the periphery of the health system in developing countries is not involved in the development of the network, and c) the need for the development of local medical content management skills. Particularly point c) is improved through the collaboration between the various countries as professionals from the medical and the computer science field are sharing courses and resources. Personal exchanges between partners in the project are frequent, and several persons received an education at one of the partner Universities.

As conclusion we can say that the identified risks have to be taken into account when designing large-scale tele-medicine projects in developing countries. These problems can be mitigated by fostering South-South collaboration channels, by the use of satellite-based Internet connectivity in remote areas, the appreciation of local knowledge and its publication on-line. The availability of such an infrastructure also facilitates the development of other projects, courses, and local content creation.

Keywords—tele-medicine, developing countries, medical tele-teaching, low-cost equipment, communication infrastructure

1. INTRODUCTION

Tele-medicine tools enable the communication and sharing of medical information in electronic form, and thus facilitate access to remote expertise and knowledge [1]. A physician located far from a reference center can consult his colleagues remotely in order to solve a difficult case, follow a continuing education course over the Internet to improve his knowledge, or access medical information from digital libraries. These same tools can also be used to facilitate the exchange between centers of medical expertise at a national or international level and have been performed many times [2,3,4,5].

The potential of these tools is particularly significant in countries where specialists are rare and where distances and the quality of the transportation infrastructure hinder the physical movement of physicians and/or patients. Many of the French-speaking African countries are confronted with these infrastructure problems. In particular large and scarcely populated countries such as Mali (twice the size of France, 11 million inhabitants) and Mauritania (twice the size of France, 3 million inhabitants) are concerned by this problem.

The usefulness and risks of these new communication and collaboration channels have to be assessed before large-scale programs can be launched. Prior experiences in the field include ISDN-based video conferencing for tele-cardiology and tele-neurology between Dakar and Saint-Louis in Senegal, a demonstration project (FISSA, Force d'Intervention Sanitaire Satellitaire Autoportée [6]) of the use of satellite-based prenatal ultrasound tele-imaging between Dakar and the

Tambacounda region in Senegal, and tele-radiology experiences in Mozambique. However, there is little published material on the use of low-bandwidth, Internet-based tele-medicine applications, although there is a significant investment in these technologies in developing countries. The development of the national network for tele-medicine in Mali was used as a pilot case in order to get a better insight into these aspects.

Other research projects on tele-medicine have worked on the financial aspects and implications as well as [7]. Most of the published literature is actually on rather high-technology tele-medicine, most on tele-radiology [8]. Another article in the field of telemedicine is [9]

The RAFT project (Réseau Afrique Francophone de Télémédecine) [10,11] on the other hand is concentrating on low-cost tele-medicine in order to take into account local necessities and to create a sustainable development. This means that the investments necessary to keep the project running are minimal. Rather than investing in technology, investments are done to create local knowledge. The project has been supported strongly supported by the medical informatics service of the University hospitals of Geneva [12].

This article will first explain the RAFT project, its history and its foundations before highlighting the results and experiences gained by the project. Finally an outlook into the future will be given and critically discussed.

2. THE RAFT PROJECT

2.1. History

A pilot project in Mali, named «Keneya Blown» (the "health vestibule" in Bambara language [11]), was initiated in 2001 by the Mali University Medical School in Bamako, and financed by the Geneva government and the Geneva University Hospitals. Several goals were set:

- development and use of Internet-based connections between the national and regional health care institutions,
- implementation of basic services such as local e-mail access and a medical Web portal to train users,
- implementation of a low-bandwidth, Internet-based distance learning system to organize courses,
- evaluation of the feasibility for long distance collaborations for continuing medical education and tele-consultations.

The national network infrastructure is based on a wireless metropolitan area network in Bamako, and on the analog cable-based telephony network to reach regional hospitals that are outside of the capital. The e-mail and World Wide Web services are hosted on Linux-based servers [11], protected from the instability of the local electric power supply by a collection of truck batteries.

(Insert Table 1 here)

The distance learning system called e-cours [13] was developed at the University of Geneva and is specifically designed to minimize the use of network bandwidth while providing high-quality sound and display of didactic material, as well as feedback from the students to the teachers via instant messaging. The student can adjust the quality of the video image (the "talking head"), of which the educational value is limited anyways in order to save resources. A bandwidth of 28 Kbps reachable on the normal telephone cable lines is therefore sufficient to follow the course and enable remote areas to participate in distance learning activities. It is based on free and widely available tools such as Linux as operating system, Apache as web server, and Firefox as web browser. The entire tele-teaching system is browser-based, and works on most desktop operating systems (see Tables 1 and 2 for details on the required technique for server and clients).

(Insert Table 2 here)

The infrastructure has to be simple and adapted to local realities. The technical limits of the countries cause problems like the low bandwidth and the high price of Internet connections in remote areas, where no telephone lines are available. The stability of electric power remains a problem as well. Certainly, the means to circumvent these problems exist as shown in Figure 1. The image shows an antenna for the radio operator. It is stable and can be redistributed between several structures. Truck batteries are used as a backup in the event of electric power outages that are frequent in Mali. This maintains the servers for at least 72 hours. On the bottom right, the necessary equipment for remote teaching is shown.

(Insert Figure 1 here)

Similar projects using the exact same technologies have been deployed in Mauritania, Morocco and Tunisia, and more recently in other African countries including Cameroon, Madagascar, Ivory Coast, Niger and Burkina Faso, Djibouti, (see Figure 2).

(Insert Figure 2 here)

2.2. Objectives

The RAFT project has many objectives. One of the main goals is to motivate the talented medical professionals in the

developing countries to go to regions where they are most needed, medicine in first line in rural areas farther away from the capitals, where most followed their medical education. This was motivated by the accessibility of Internet in these regions and thus access to continuing medical education and contact to colleagues via email.

A second objective is to help with the creation of educational medical content adapted to local realities in the countries, as most information published on the Internet is not applicable in these rural settings. The accessibility of an infrastructure to publish and access medical knowledge from remote areas can strongly help the creation of locally adapted medical content.

The development of a South-to-South tele-medicine network in the countries of French-speaking Africa was another key objective to not only have a one way access to continuing education but to give the medical professionals also a possibility to express their ideas to other local colleagues, where the cultural differences and local necessities might be much much similar. This also increases sustainability of the project

The integration of the specific needs for the primary education care and the rural sectors in the network were regarded as another important part.

To increase the human capacity to develop, maintain, and publish medical content of high quality with the added local value was the last major objective. This content creation was improved by creating local knowledge on the publication of information on the Internet and on Internet technologies in general. These technical skills are important to create a sustainable use of the technology in developing countries.

2.3. Activities

Over the first 18 months, the project in Mali has enabled the development of a functional national tele-medicine network, which connects several health institutions in Bamako, Segou and Tombouctou, where medical teams were trained on the use of Internet-based tools. The medical Web portal to publish information is in place. Web-casting systems for distance learning have been implemented in Geneva and Bamako (for broadcasting). Continuing medical education courses are now broadcasted on a weekly basis. Several tele-consultations have taken place, to follow patients that were operated in Geneva and then returned to Mali. The tele-consultation system is also used to select appropriate cases and guide their work-up in order to optimize patient evacuation to hospitals in the North or to prepare humanitarian missions.

(Insert Table 3 here)

Various types of collaboration have been enabled by the project.

North-to-South tele-education: topics for post-graduate continuing medical education can be requested by physicians in the African RAFT countries. Courses are then prepared by experts in Switzerland and broadcasted over the Internet from Geneva. New courses are produced and broadcasted on a weekly basis (every Thursday) on a variety of topics (see Table 3 for some examples). The material is also stored on a web server and can be replayed from the medical Web portal, including the lides and the video stream. Typically, these courses are followed by 50 to 100 physicians and students in a specially equipped auditorium. Courses are also followed by smaller groups or individuals in the regional hospitals and in the rural community of Dimmbal, Mali, which is about 875 miles away from Bamako. Other French-speaking countries in Africa also join these courses: Senegal, Mauritania, Morocco, Tunisia, Ivory Coast, Burkina Faso, Madagascar, and Niger.

Web-casting of scientific conferences: several sessions of international conferences have also been broadcasted, with simultaneous translation in French, in order to make the presentations accessible to colleagues in the RAFT countries, where the practice of the English language is still limited. Using the instant messaging feature of the system, remote participants can intervene and ask questions to the speakers that are responded to instantly.

South-to-South tele-education: post-graduate and public health courses developed by the various health institutions in Bamako are web-casted to regional hospitals in Mali and to other partners in Western Africa. The content produced is anchored in local, economical, epidemiological, and cultural realities. It provides directly applicable information for the participants.

South-to-North tele-education: medical students training in tropical medicine in Geneva follow courses and seminars organized by experts in Mali on topics such as leprosy or iodine deficiency. The exposure to real-world problems and field experts enables a better understanding of the challenges for developing countries and implementing health care and public health projects in unfamiliar settings.(see figure 8)

North-to-South tele-consultation: the tele-teaching system can also be used to send high-quality images from one partner to another enabling the remote examination of patients or the review of radiographic images. Tele-consultations are held regularly, in medical fields where expertise is not available in Mali, such as neurosurgery or oncology (see Figures 3,4).

South-to-South tele-consultation: physicians in regional hospitals can request second opinions or expert advice from their colleagues in the University Hospitals via e-mail. This can include the exchange of images obtained using digital still cameras or scanned radiographs.

South-to-North tele-consultation: the case of a leprosy patient where the treatment is followed in Geneva has been discussed using the tele-consultation system. It enabled the expert in Bamako to adjust the treatment strategy.

Capacity Building: The projects around RAFT promote the development of local capacities and knowledge. Since March 2003, local coordinators of the various Member States follow a University certificate of continuous training in Medical Informatics remotely supplemented by workshop presentations. This insures that knowledge is well acquired. Practical exercises are carried out by participants and are corrected from Geneva medical informatics specialists. Finally, the module is evaluated by a one-week-long workshop in a Member State of RAFT. We developed the formation by local experts for local experts. The data processing specialists of Mauritania were, for example, were formed on Web site creation and medical web contents by Malian experts (see Figure 5)

(Insert Figure 3 here)
(Insert Figure 4 here)
(Insert Figure 5 here)

3. RESULTS

After almost two years of testing and trial implementations, the RAFT project has been successfully implemented and is in routine use since four years. The African and European partners are satisfied and new countries are joining the initiative regularly, so the development has not finished, yet. By 2005, over 150 tele-teaching sessions have been held from north to south and from south to north (see Table 3 for example topics). More than 20 tele-consultations north to south and 10 from south to north have been held. Currently, there is one to tree tele-teaching session once a week (Thursday morning at 9AM).

We have these indicators as of February 2006:

- Four to eight hours of course per mouth, half of which produced by the African partners. These numbers should double before summer 2006.
- On average 15 sites are connected during an e-course with a maximum of 30 sites in 12 countries and several hundred health professionals on line.
- E-courses are generally followed by a one hour discussion between teachers and participants.
- The cost of a e-learning production station is around 1500 Euros.

The cost of a satellite access point (solar mini-VSAT) is currently 15’000 Euro, with 300 Euro per mouth for the permanent Internet access (band-width 128/ 512 Kbps)

The experience gained in the RAFT project highlights the need for a strategy that is adapted to local needs and realities. Applications need to help locally; otherwise they will not get used and are not sustainable in the long run. In our case this means a very low limit of the available bandwidth. Still, the sound turns out to be the important part together with the slides. The video only has a minor importance for the outcome of the teaching and can thus be reduced significantly.

3.1. LESSONS LEARNED

At the infrastructure level, three kinds of problems were identified:

- the instability of the basic infrastructure and in particular of the electric power supply has caused many problems;
- the limitation of the international bandwidth, which is often misused, in particular by e-mail accounts hosted out of the country instead of in the country (Mali has less bandwidth for connecting the entire country with the rest of the world than some Western Universities alone);
- the unavailability of reliable Internet connectivity beyond the large cities.

These problems are improving with the overall development of a national telecommunication infrastructure, although the deregulation movements in the ICT sector and the deployment of mobile telephony will - at least initially - favor the most profitable markets. These are not those where tele-medicine tools are most needed. For instance, the focus on mobile telephony probably limits investments in wired infrastructures that are needed for Internet access particularly in remote areas to avoid expensive satellite connections. Similarly, the deployment of wireless metropolitan area networks provides rapidly the needed connectivity, but should probably be gradually replaced by a more sustainable wired, optical fiber-based communication infrastructure.

Basic communication tools such as e-mail are efficient and can be used productively. It is important to develop local capacity to implement and exploit these tools up to their full potential. This is important not only to improve the technical expertise and the reliability of tele-medicine applications but also to limit the use of international bandwidth for information transfer that remains local. Most physicians in Africa still use US-based email accounts for exchanges that remain local, due to a lack of reliable local e-mail services.

At the content level there is a steady demand for North-to-South distance learning, particularly on technical subjects. However, several topics for seminars, requested by physicians in Africa, could not be satisfactorily addressed by experts in Switzerland due to major differences in diagnostic and therapeutic resources and techniques, and due to discrepancies in the cultural and social contexts. For instance, there is no magnetic resonance imaging capability in Mali and the only CT-

scanner has been unavailable for months as of the end of 2005. Chemotherapeutic agents are too expensive and their manipulation requires unavailable expertise. Even though diagnostic and therapeutic strategies could be adapted, practical experience is lacking and other axes for collaboration have to be found. A promising perspective is the fostering, through decentralized collaborative networks of South-to-South expertise exchanges. For example, there is neurosurgical expertise in Dakar, Senegal, a neighbor of Mali. A tele-consultation between these two countries would make sense for two reasons: physicians in Senegal understand the context of Mali much better than those from northern countries, and a patient requiring neurosurgical treatment would most likely be treated in Dakar rather than in Europe.

Beyond content, collaboration between the stakeholders of tele-medicine applications must be organized, in order to guarantee the reliability, security, safety, and timeliness for exchanging sensitive information, in particular when the communication is not synchronized. Computer-supported collaborative work environments have been developed. For example, the iPath project [14] developed by the Institute of Pathology in Basel, organizes "virtual medical communities", which replicate organizational models of institutions in distributed collaboration networks, including clearly identified responsible experts and on-call schedules. These new forms of collaboration over distances, across institutions, and sometimes across national borders also raise legal, ethical and economical questions, questions that are beyond the scope of this paper.

The "induced digital divide" is another potential problem. The commercial development of the communication infrastructure implies that the remote areas, where tele-medicine tools could be most useful, will be served last. As in most developed countries, physicians are reluctant to practice in remote areas. The ability to interact with colleagues and follow continuing medical education courses can be significant incentives. Besides the accessibility problem, this also influences the content of the tele-medicine tools, which will typically be geared towards tertiary care problems. It is therefore important to make sure that the needs of the periphery of the health system are taken into account in these projects. An efficient way to do so is to have the periphery connected to the tele-medicine network early. Satellite-based technologies for Internet access, such as mini-VSAT, are sufficiently affordable at the moment to consider developing remote access points before the ground infrastructure becomes available.

Finally, there is a need to develop local content-management and other technical skills. Local medical content is a key for the acceptance and diffusion of health information, and is also essential for productive exchanges in a network of partners. It enables the translation of global medical knowledge to the local realities, including the integration of traditional knowledge. Medical content-management requires several levels of skills: technical skills for the creation and management of on-line material, medical librarian skills for appropriate content organization and validation, and specific skills related to the assessment of the quality and trustworthiness of the published information, including the adherence to codes of conduct such as the HONcode [15]. Now is the time for the development of a tele-medicine infrastructure in medical teaching centers and their connection to national and international computer networks in order to foster multi-lateral medical expertise exchange with a predominant South-to-South orientation.

The deployment of Internet access points in rural areas (Dimmbal in Mali, see Figure 6; Maata Moulana in Mauritania, see Figure 7)[20], with the use of satellite technology, enabling not only tele-medicine applications but also other tools for assisting integrated, multi-sectorial development. In particular, education, culture and the local economy can profit from these developments. The mini-VSAT technology, recently deployed over Western Africa, offers an affordable, ADSL-like connectivity. Sustainable economical models, based on the successful experiences with Internet cafes in Africa, are being developed to foster the adaptation of this infrastructure by rural communities.

(Insert Figure 6 here)

(Insert Figure 7 here)

4. CONCLUSIONS AND PERSPECTIVES

The use of asynchronous, collaborative environments enable the creation of virtual communities and the control of workflow for getting expert advice or second opinions in a way that is compatible with the local care processes. The open-source tool developed for tele-pathology at the University of Basel [14] is being implemented, not only for tele-pathology, but also for radiology and dermatology (see *Figure* 9).

The development and maintenance of locally- and culturally-adapted medical content in order to best serve the local needs that are rarely covered by medical resources available on the Internet is another important point. New tools are being developed: regionally adapted search engines, open source approaches [16,18], and adapted ethical codes of conduct. The Cybertheses project [16] and the resources from the Health On the Net Foundation [15] are used to train physicians, medical documentation specialists and librarians.

Tele-medicine tools have an important role to play in the improvement of the quality and efficiency of health systems in developing countries. They offer new channels for communication and collaboration, and enable the dematerialization of

several processes that are usually hindered by deficient physical infrastructures. They also expose some risks, and in particular the exchange of inappropriate or inadequate information and the potential aggravation of local digital divide between the cities and the rural areas. These risks have to be examined when designing tele-medicine projects and can probably be mitigated by the development of South-to-South communication channels, the use of satellite-based technologies to incorporate remote areas in the process and by fostering a culture and skills for local medical contents management [19]. These aspects are being further investigated by the RAFT project.

Acknowledgment

The RAFT project is supported by grants from the Geneva State government and Geneva University Hospitals. We also need to thank all participating persons in the various countries for their energy in overcoming all these burdens.

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Operating system: Windows 95,98,2000, Mac OS, Linux, Solaris, or Irix;
PC 166 MHz, 64Mb RAM;
Sound card;
Screen 1024x768 preferred, 800x600 possible;
Netscape 4.0 or Internet Explorer 4.0 or later, Java enabled;
28 Kbps Internet connection (56 Kbps bandwidth necessary for video images);
Real Player and Acrobat reader plugins

Table 1. Hardware and software requirements of the distance-learning client.

PC 500MHz, Windows 98, 128 Mb RAM, sound card;
Webcam server AXIS 2400;
Microphone;
Document video camera WolfVision or equivalent;
Ethernet hub or switch, 10 or 100 Mbps.

Table 2. Hardware requirements for the distance-learning server (web-casting equipment

Antiretroviral therapies in Africa;

Iodine deficiency, public health stratgies;
Shoulder radiology;
Arterial hypertension during pregnancy;
Ultrasonic evaluation of arterio-venous fistulae;
Herpes virus infections;
Hospital hygiene;
Thoracic traumatology;
Tomodensitometry of ENT pathologies;
Adjuvant therapies for breast cancer;
Drug prescription and dispensation;
Modern imaging of thoracic aneurysms;
Investigation of brain tumors in children;
Pharmaco-vigilance;
Hydrocephaly;
Obstetical vaginal Fistula:surgical approach.

Table 3. Topics of distance learning courses requested by the physicians in the RAFT project from the a University Hospital in Mali.

Figure 1: Antenna for the Internet connection, Backup energy source and e-learning and teleconsultation equipment

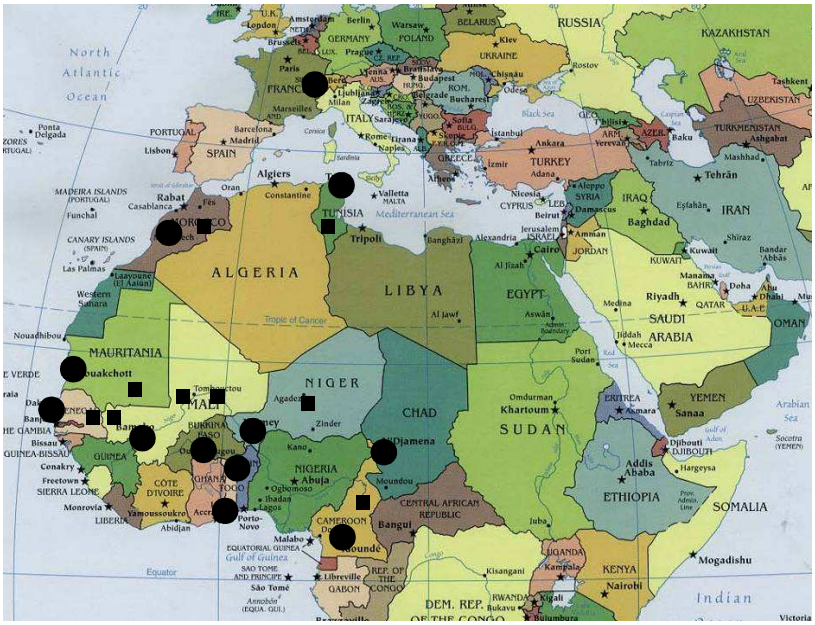

Figure 2. Geographic distribution of the institutions participating in the RAFT project. Circles represent teaching institutions located in capitals or large cities. Squares denote remote access points (fixed or mobile) connected via satellite links. Since 2005 Rwanda and Madagascar are also connected but not yet shown on the map.

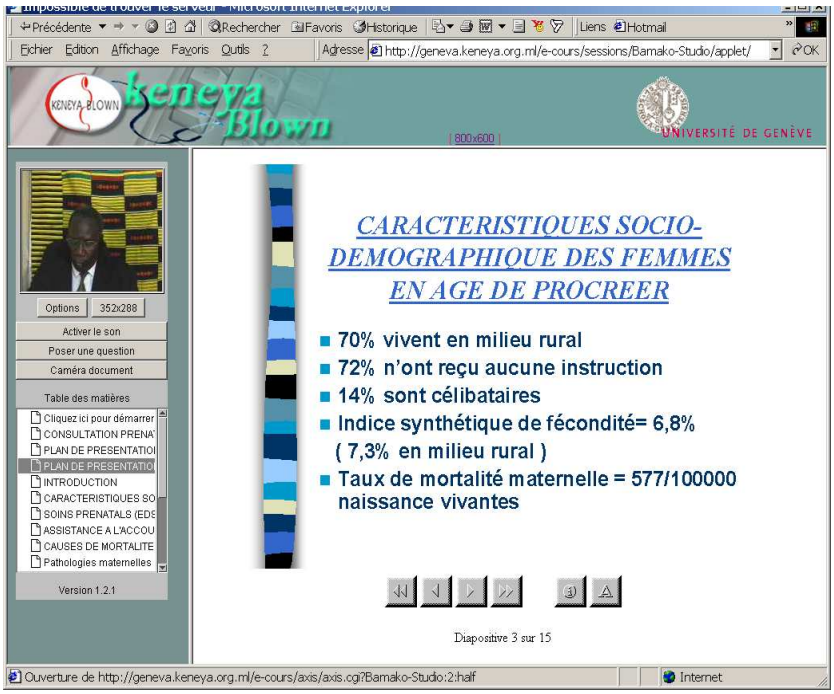

Figure 3. Screenshot of a student view of a course web-cast showing the teacher (top-left) in a small video frame, the didactic documents (main window) made available as html, and controls for the sound and the instant messaging tool (left column).

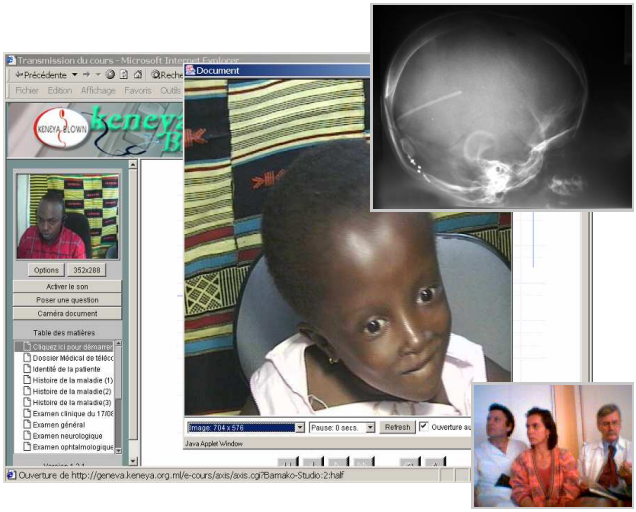

Figure 4. Screenshot of a tele-consultation session, showing the various documents available: the image of the patient, of the physicians, the radiographic images and other clinical data.

Figure 5: Training of the Mauritanian engineers by Malian experts(see red arrows)

Figure 6: Telemedicine in the first line, Dimmbal in Mali, 875 Miles away from the capital Bamako without telephone or electricity.

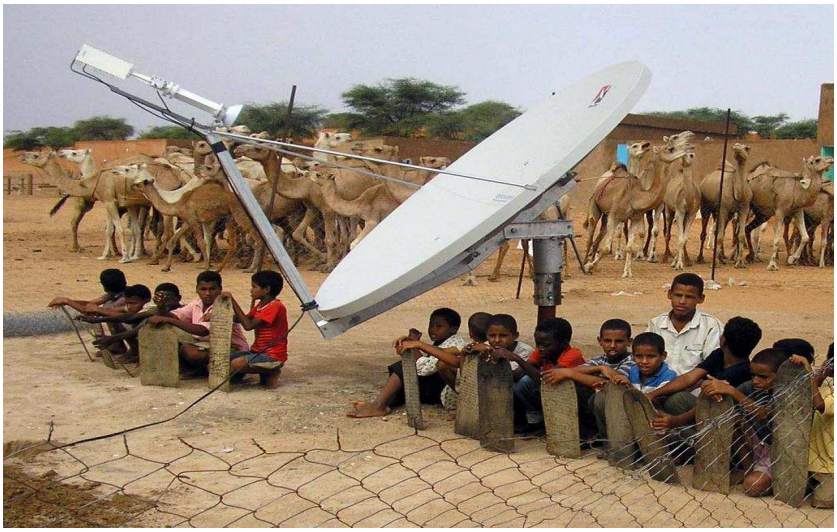

Figure 7: Rural tele-centre of Maata Moulana in Mauritania.

Figure 8: South-to-North tele-education in tropical medicine (leprosy)

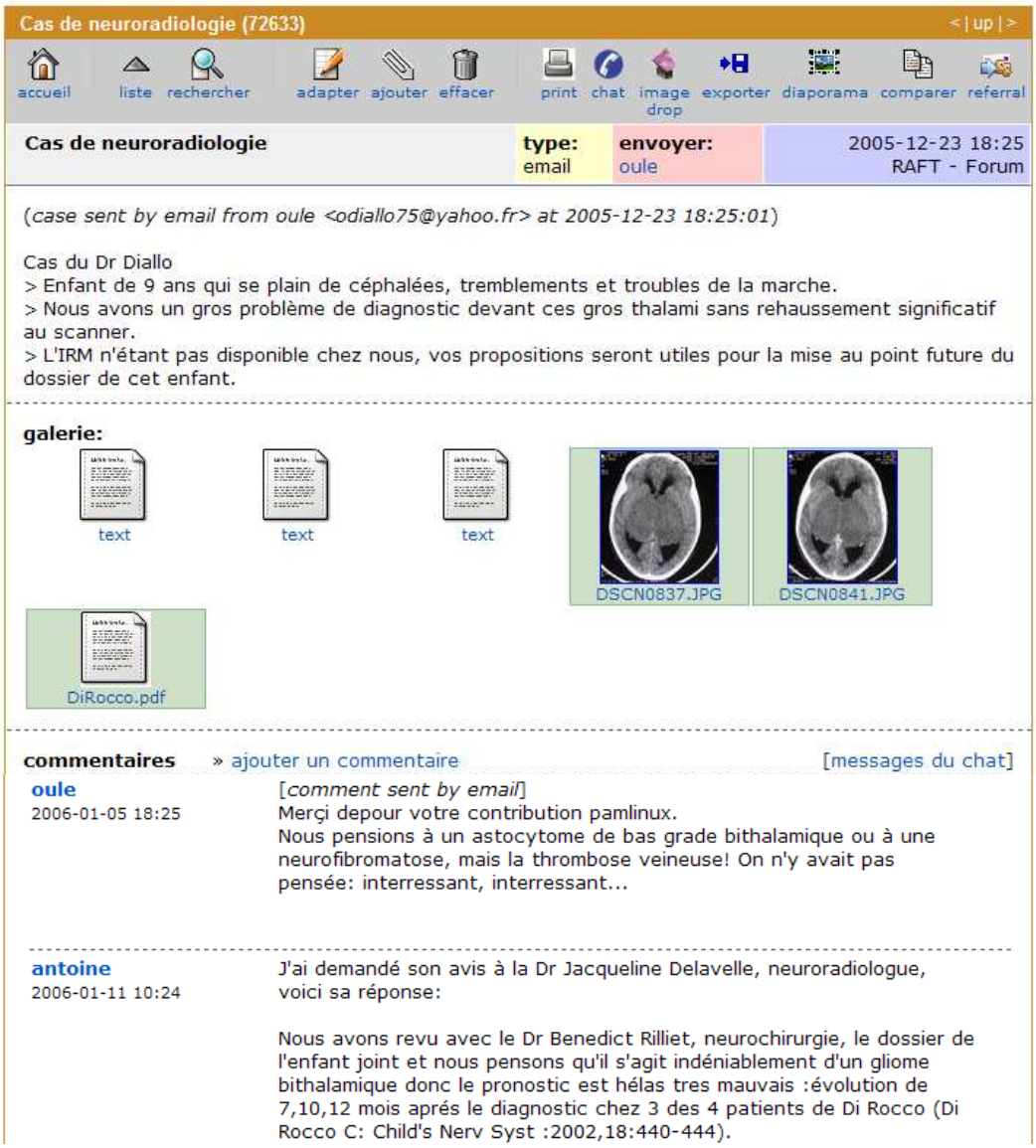

Figure 9: Asynchronous teleconsultation in neurosurgery case thanks to iPath environnement.