

Teleconsulting, Teleguiding and Teleteaching: Gigabit Network Applications In Cardiology

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Abstract

ABC4CarE (Advanced Broadband Communication FOR CARdiology care and Education) is a large ICT project, initiated by the Interuniversity Cardiology Institute of the Netherlands, in which on-line teleconsulting, teleguiding, and teleteaching are aimed at. The increasing bi-directional broadband possibilities have made new applications reachable and made it possible to improve applications that already were functioning in daily cardiology practice.

For teleconsulting, an application has been conceived in which cardiologists from referring and university hospitals can conduct the heart team meetings in geographically separated locations. For teleguiding an application is being constructed in which images are transferred with a maximal delay of one minute from referring to university hospitals, and for teleteaching a 'virtual classroom' is built where students from their own working environment can participate in the lessons given by a remote expert.

1. Introduction

The Interuniversity Cardiology Institute of the Netherlands (ICIN) coordinates the multicenter research of the Departments of Cardiology of all 8 participating Dutch university hospitals. Some years ago a project named ESCARIN (Electronic Highway for transport of Cardiology Information in the Netherlands) was performed, in which referring peripheral hospitals sent in information to expert centers (university hospitals) by means of an ISDN-30 connection. Limitations of this method are amongst others the maximum transfer speed of 2Mbit/second, which made it necessary to send mpeg-compressed data instead of DICOM3.0 images. The limitation that no diagnostic images arrive at the expert center, has been previously described [1].

With the recent increasing bi-directional broadband possibilities of so called Gigabit networks, new applications have come within reach. Not only the on line exchange of digital cardiology images (x-ray angiograms, ultrasound or magnetic resonance images) became possible to enable teleconsulting applications, but also fields of teleguiding and teleteaching suddenly came into focus.

2. Methods

2.1. GigaPort

In 1997, experts urged the Dutch government to drastically improve the capacity of the communication infrastructure for higher education and research. At the same time, Dutch trade and industry expressed their need to be connected to the new Internet2 and the Next Generation Internet activities in the United States of America. Both ideas culminated in the notion that by investing in information and communication technology (ICT) developments could enhance economic growth of this sector and others. This has culminated in an ambitious project, known as GigaPort, proposed by the Dutch Ministry of Economic Affairs. In its coalition charter of July 1998 the Dutch Cabinet has expressed its intention to create a considerable incentive for developments in ICT and to develop a 'third mainport' (Netherlands Brainport). The GigaPort project is well-attuned to this intention. In October 1998 NLG 142 million (some EUR 64 million) was allocated to the GigaPort project that formally started in April 1999 [2].

GigaPort consists of two sub-projects, GigaPort Network and GigaPort Applications. Within the context of GigaPort Network a highly advanced communications network is being developed with super-fast connections across the Netherlands and Europe and to North America and Asia. SURFnet bears overall responsibility for the implementation of GigaPort Network. SURFnet is the national computer network for higher education and research in the Netherlands that connects the networks of

universities, colleges, research centers, university hospitals and scientific libraries to one another and to other networks in Europe and the rest of the world.

GigaPort Applications offers the Dutch business community the opportunity to carry out large-scale research into new applications for the electronic highway. The Telematics Institute, which carries out strategic research for the business community in its capacity as a center of excellence in a network of many national and international competence-centers, is responsible for the implementation of GigaPort Applications.

Within the frame of the GigaPort project participants can use the fast GigaPort Network backbone to test innovative Internet applications. The current so called SURFnet4 backbone that is used in the GigaPort project is based on a 622 Megabit/s backbone. According to the plan, for the next generation, SURFnet5, this speed must be increased to 80 Gigabit/s by the year 2002. The capacity for customer connections must be increased from 155 Megabit/s (currently in SURFnet4) to 20 Gigabit/s by the end of 2002 in SURFnet5. Thanks to the vast capacities, these GigaPort Network infrastructures are innovative components in themselves. It will be essential to use new technologies and protocols to achieve the speeds mentioned above.

Until SURFnet5 is ready, participants will be able to use the existing, state of the art, SURFnet4 infrastructure to develop and test new applications and services (possibly in co-operation with other companies, universities, colleges or (commercial) research institutes). As soon as the new SURFnet5 infrastructure will be available, participants will also be able to use this new network [3].

2.2. ABC4CarE

The presence of the GigaPort Network using the SURFnet backbone, which as described above connects all university hospitals in the country, made the step to involve the ICIN a small one. Application of very broadband network connections can surely give an important contribution to solutions of ever increasing cardiology and cardiac surgery problems. The ICIN, being aware of these problems by its contribution in projects like ESCARIN, therefore has made an inquiry into the interest that the Dutch professional societies for cardiology (NVVC) and thoracic surgery (NVT) would take for a project concerning these kind of broadband applications.

After very positive reactions of both societies, a project, named ABC4CarE (Advanced Broadband Communication FOR CARdiology care and Education), was conceived. It is divided into three parts, starting with a specification phase. For this phase a subsidy from the Dutch government was obtained. During this phase, three

possible applications have been distinguished, concerning teleconsulting and teleconferencing, teleguiding and teleteaching [4].

3. Applications

3.1. Teleconsultation and teleconferencing

The specification phase of the project showed the following. The cardiologists and thoracic surgeons regard teleconsultation as an important tool to gain both quality and effectiveness of the patient care processes. Teleconferencing meaning 'distributed patient discussions' in which both doctors in peripheral hospitals as well as experts in hospitals that perform interventions can equally participate, is expected to yield significant benefits. In the applications used so far, no consultation using moving angiographic images can be performed because the bandwidth now available is much too small to send these images. Although applications like ESCARIN [1] are yet applied on regular basis, no real-time patient discussion can be planned over the network because a 2 Mbit/sec connection is approximately 10 times too slow to allow a workable application.

For the realization and installation phase, an application is made, based on software and hardware used in projects like GigaCoMed [5], a project in which radiotherapists on two locations in Rotterdam perform teleconsulting on a daily basis sharing both images, audio and video. Extra effort was put into the choice of the shared movie viewer, which had to be both intuitive and adequate.

The realization and installation phase is planned on the same two locations where also the ESCARIN software is installed and used. One connection is between University Hospital Groningen (AZG) and the referring hospital in Leeuwarden (ZNB) [6] and the other between the VU University Medical Center in Amsterdam (VUMC) and the referring hospital in Alkmaar (MCA) [1]. In addition to this the application will be tested between the Catharina hospital in Eindhoven and the Elkerliek hospital in Helmond.

3.2. Teleguiding

In teleguiding two modalities are being taken into account. At first echocardiography applications, but also interventions at the catheterisation laboratories show huge possibilities for broadband Internet teleguiding applications.

In Rotterdam, an ultrasound machine with real-time digital output will be applied in the oncology department of a peripheral clinic. 2 operators will be trained to perform a cardiovascular ultrasound investigation using a broadband connection of more than 50 Mbit/sec. From

the expert center, in this case University Hospital Rotterdam (AZR), guidance can be given during the investigation.

For teleguiding in the catheterisation laboratories, peripheral centers performing angio studies or that are starting to perform coronary balloon dilatations (PTCAs) are the first users. Instead of an experienced cardiologist from the expert center traveling to the peripheral center to be stand-by, in case of doubt or for a second opinion the medical staff in the peripheral center can thus be attended at a distance from the expert center.

Benefits of both these teleguiding applications regard quality (severe situations will be earlier recognized) as well as effectiveness (logistics and time of expert specialists).

3.3. Teleteaching

The Consilium Cardiologicum of the NVVC has stated that the Dutch post graduate education of cardiologists has to be renewed thoroughly. The largest problems concern the need for a relatively small group of cardiologists to train lots of new colleagues with ever increasing demands of quality, according to national and international directives. Especially new ICT aids are being put forward as the ultimate possibility to realize this restructuring of the material to be presented using for instance 'virtual classrooms'. By doing so, the training could be divided into smaller parts, with increasing effectiveness. By planning training sessions at fixed times, the logistics of the clinical process could be minimally disturbed. Also the possibility for trainees to bring in their own cases (images) and having the teacher react interactively would increase the participation of the trainees.

Not only the new cardiologists in training could take advantage of these solutions, but also whole cardiology departments in peripheral hospitals could thus be able to in real time attend colloquia and scientific meetings in the university hospitals (and vice versa).

In the specification phase of ABC4CarE, an inquiry has been performed into the infrastructure needed for such applications. Especially the fit up of conference rooms, regarding audio and video equipment on both sides of the connection, still has to take place in most centers. If full interactive meetings are planned, extra tools like bid boxes or 100 Mbit laptop connections per seat have to be taken into account as well.

For the realization and installation phase, a 7 months test is planned, after 7 months of preparation. In approximately 5 so called 'A' teaching hospitals, among which at least 1 non-university, at least one main virtual classroom session will be prepared and performed.

4. Discussion

For both the teleconsulting (teleconferencing) and teleguiding applications, the influence of data compression ratios has been investigated for both angiographic and digital cardiovascular ultrasound images [7]. This investigation showed that transfer rates of 7.5 Mbit/sec for 256² ultrasound images or 1.9 Mbit/sec for 512² angiographic images (25 frames per second) at least are necessary to send images with diagnostic and aesthetic quality equal to the original non-compressed images. For sending the uncompressed matrices, transfer rates of approximately 37.5 Mbit/sec for echocardiography and 50 Mbit/sec for angiography would be needed. Therefore although high framerates are possible nowadays, image compression still is a demand.

In the university hospitals the infrastructure is already present. 10 Mbit/sec connections at the workspace are common, and where needed '100 Mbit switched' connections can be provided in most cases. Also the university hospitals already have a connection to the GigaPort network using SURFnet. For the referring peripheral hospitals, this infrastructure is not as common. In the four regarded peripheral test-sites for teleconsulting, the Points of Presence (PoPs) to the GigaPort network exist in the colleges in these cities (Leeuwarden and Alkmaar). 'The last mile', the network from the school to the hospital, can be arranged using beam transmitters or optical fiber cables. The costs for this last mile however can still be considerable, have to be heard by either the peripheral hospital itself, or for instance by insurance companies.

In the ABC4CarE project plan, a substantial amount of time is reserved for the evaluation phase. This evaluation will take place before and after the implementation of the applications. Evaluation is planned by interviews of the potential users of the applications. Not only the attitude of the user towards computers and the use of computers in the hospital will be registered by means of an internationally validated list of questions, but also the user's quantitative expectations on the new applications will be asked. At the end of the project, the same persons will be asked how their experiences with the new applications have been. Furthermore 8 to 10 users will be interviewed more thoroughly, ranging from nurses to heads of departments.

A cost analysis on the project as a whole has been performed in the specification phase as well. Global results of this analysis were especially applied for the teleconsultation part of the project. The financial benefits consist mostly of reducing costs of courier services, ambulances, traveling time of doctors and shorter hospital stays for patients. The costs are mostly technical infrastructure implementations. These costs however can be tremendously reduced when e.g. more departments per hospital can use the broadband connections. Also the

fixed charges for the use of high speed connections are expected to decrease within the next couple of years. Both referring as university hospitals have to take into account these results for their own situation.

To bear the initial costs of the project, x-ray industries have been asked to provide hardware and software for the applications. Pilot projects have been started with imaging tools for teleguiding applications.

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