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Telemedicine on the Virtual Silk Highway: a project to improve pathology diagnosis

Gajewski, Jacek [1,]* and Atkins, Stella [2]

1 Jacek Gajewski is Secretary General of the Central and Eastern European Networking Association (CEENet) /ul. Pasteura 7, 02-093, Warsaw, Poland.
2 Stella Atkins is Professor in the School of Computing Science, Simon Fraser University, Burnaby, BC, Canada V5A 1S6.

E-Mails: jacek.ceenet@gmail.com; stella@sfu.ca

* Author to whom correspondence should be addressed; Tel.: +48 601440602; Fax: +48 228243894

Abstract: In June 2001 NATO agreed to fund a non-military project to bring Internet connectivity to the countries in the Southern Caucasus and Central Asia, using satellite dishes located at key academic institutions in each country. This "Virtual Silk Highway" project was ambitious, innovative and exciting, both technically and sociologically. We present the story of how we used this project to bring telemedicine to Uzbekistan and other countries in Central Asia, to improve pathology diagnosis.

.**Keywords:** Internet, Global Development, Satellite, telemedicine, telepathology.

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1. Introduction

A far-reaching decision by the Computer Networking Panel of the NATO Science for Peace and Security (SPS) Division 1 in June 2001, led to the development of the Virtual Silk Highway (VHS) project 2 to digitally connect the countries along the ancient Silk Road; countries which have fallen behind the digital divide since they have achieved their independence after 1991. These 8 countries connected to the Internet via the Virtual Silk Highway are shown highlighted in bold on the map in Fig. 1: from West to East: Georgia, Armenia, Azerbaijan, Kazakhstan, Turkmenistan, Uzbekistan, Tajikistan, and the Kyrghyz Republic.

The motivation for the NATO Science Programme 1 is that bringing scientists together for progress and peace may improve the world for all. The knowledge available on the Internet may help establish open and democratic societies in these countries, which were members of the former USSR, under Russian influence for more than 50 years. By providing the necessary (communication) infrastructure for the scientists and educators, they will be able to take part in the global academic society.

Figure 1. Countries connected to the internet via the Virtual Silk Highway (in bold)—from West to East: Georgia, Armenia, Azerbaijan, Kazakhstan, Turkmenistan, Uzbekistan, Tajikistan, the Kyrgyz Republic.

The first satellite dish was installed in Tashkent in Uzbekistan (2002), and the last hookups, to Ashgabat in Turkmenistan (2003) and Afghanistan (2004). Since then, the Silk project has taken a life of its own, although NATO is still providing funding for most of the bandwidth. An excellent overview and summary of the initial stages of the project can be found at 2. In 2009 the Caucasus, and in 2010, Central Asian countries were connected to GEANT by fiber via EC-funded projects *Black Sea Interconnection* (BSI) and *Central Asian Research and Education*

Network (CAREN). In June 2010 the Silk project for Caucasus and Central Asia have been successfully terminated, and will continue in 5 cities of Afghanistan.

We present in this paper some of the applications of the VHS, including the first use of telemedicine in the area, initially for telepathology.

1.1. Telepathology

Many pathologists, who work in remote regions in the developing countries such as in Central Asia, need help for diagnostic biopsies of tumors and infectious diseases. To deal with this issue, telepathology can be employed. With the use of telepathology, tissue biopsy slides are made locally in the region using microtome equipment, and for difficult diagnoses, the slides are digitised using a digital camera attached to a microscope. The slide images are then transmitted digitally using the internet to a centre for diagnosis by an expert (see Fig 2 for a picture of the system in use). Historically, biopsy patients or their relatives came to the capital city for consultations that demanded material inputs and time. With the use of telepathology, the patient has no need to travel to the capital.

Fig. 2: Regional pathologist adjusts a locally-prepared biopsy slide which is then transmitted digitally to the Center for diagnosis.

2. Approaches

2.1. Technical Approach in establishing the Virtual Silk Highway

Technically, the approach was straightforward and academic in nature: the research community in each country should have all the knowledge that is necessary to run their own network, so the project intended just to buy the various components that were required and build the network. Satellite equipment was bought from Kalitel (USA) 3, Cisco 4 donated the network equipment, EurasiaSat (Turkey/France) 5 provided the satellite connection and DESY (Germany) 6 offered facilities to host the Western hub. The satellite dishes and additional equipment were tested at DESY in Hamburg, and then shipped to each country, where they were usually installed at an academic institute to serve as national Internet entry point for the academic community.

Technical problems

There were of course technical problems, only one of which will be mentioned here.

This problem arose when two (frequency-wise) adjacent dishes were transmitting simultaneously. It was found that they interfered with each other's allotted frequency. This problem did not manifest itself in the early stages of the project while the dishes were being tested individually and installed, and only became apparent after the dishes were installed in the field. Tedious transport and custom procedures (in the Caucasus and Central Asia as well as in the United States!) stood in the way of a swift repair cycle, so the problem has taken an extraordinarily long time to repair.

2.2. Sociological Issues: Challenges and Successes

Establishment of NRENs

The local management of the project within each country was established before approval of the funding for that specific country. Each country had to establish a National Research and Education Network (NREN), representing most of the education and research institutions. Each NREN was to co-ordinate joint ICT activities for the academic community in each country. NRENs are responsible for determining the acceptable use policy for their networks, including who the users are and the eligibility requirements for the network. As these NRENs use the Silk Network, they must abide by the acceptable use policy applicable to the European academic NRENs through which traffic must pass. While these policies are not unduly restrictive, they do constrain the traffic to be non-commercial.

Several visits to each country were necessary in order to determine which academic institution could provide the leadership necessary to manage the satellite connection and manage a fair access to the (still limited) bandwidth.

However, establishing a single NREN in each country proved to be very challenging, and has been the cause of most grief, yet also, paradoxically, can be measured as one of the unexpected successes of the project. The first challenge to be overcome was to establish an organization, more or less independent of governmental structures and the national telecommunications monopolist, to provide Internet connectivity within the country. There is a long tradition of governmental management and censorship of the information that is available for the population in these countries, so free Internet was, and still is, seen as a threat to the central function of government. And, during the preamble of the project, the dotcom hype was still proliferating and the Internet was seen as a cash cow by the national telecom companies. As a result the establishment of the eight NRENs was not a sinecure; politics and commercial interests played significant parts.

Furthermore, in some countries the management of the Silk project was confronted with more than one party that claimed to represent science and education in the country. It proved to be impossible for the NATO Networking Panel to make a sound decision in such issues, so alternative decision structures were sought. With the assistance of EU funding a second project, parallel to the Silk project, was initiated that, amongst other issues, was to set up a management structure for the Silk project. SPONGE (Silk Project Operations Networking and Geant Extension) is funded as an Accompanying Measure, under the Research Networks portion of the IST Framework 5 Programme of the European Commission 7. As a result the Silk project is currently being governed by the Silk Board with representatives from the eight countries and from other bodies involved in the project, whereas everyday management of the project is done by the Executive Committee. The Silk Board meets three times per year, and decides on strategic issues such as usage and approves decisions made by the Executive Committee. The Silk Board also discusses the future sustainability of the infrastructure.

The upcoming universities

During the period of Soviet domination students went to Russia to complete their education beyond the level of undergraduate. As a result the universities were small and missed the teaching structure for graduate and Ph.D. level. On the other hand the Academy of Science with its many, Russia funded, scientific institutes was very powerful. Within the academic setting of the Silk countries the NATO Science Department was mostly dealing with research institutes, so it is therefore not surprising that most of their contacts were within the Academy of Science. But when providing Internet to the whole academic community, education activities are becoming increasingly demanding for bandwidth and services.

Within the Silk context it proved to be rather challenging to bring more balance into the use of the Internet connection by both these academic sub-communities, and also have universities play a more important role in the decision making fora of the NRENs. The Academy of Science was not only afraid of losing its dominant position in favor of the upcoming universities. Scientists were also afraid to see the sparse Internet bandwidth evaporate when all those thousands of students got connected (in most of the countries 50% of the population is younger than 20 years, all of whom are potential users of the Silk connection).

The scale is now gradually tipping over from the Academy of Science side to the university side: national funds for scientific research have diminished (on its own, reason for great concern) and the universities are becoming mature players at the decision making level. As a consequence the available bandwidth per user has fallen below any level that would acceptable in the west.

Expansion beyond the capital city

The ultimate objective is to make the Internet accessible to the whole country. Towards that objective, several countries including Azerbaijan, Georgia, Uzbekistan and Kyrgyz Republic are already providing Internet connectivity to the research and educational community not only in the capital city but in regional cities as well.

Collaborations with other development projects

Another huge success has been the collaborations with other development partners in these Silk countries. The Silk project under the NATO funding had a sound project plan and funding and a governing structure that guaranteed continuity for several years. This attracted several major development funding organizations to participate in the project, either directly by chipping in for the expensive satellite bandwidth, or indirectly by setting up projects within the countries to strengthen the knowledge capacity in the NRENs. For example the Open Society Institute (OSI) 8 and the United Nations Development Project (UNDP) 9 are jointly and separately supporting projects in Georgia, Azerbaijan, Tajikistan, Turkmenistan and Uzbekistan. These projects enable NRENs to hire staff, set up educational programmes and implement a national ICT infrastructure. These initiatives were only made possible with the Silk project providing the national focus point.

Networking between Technicians

Another unexpected benefit that has arisen during the early stages of the VSH, is that the technicians are working together across the region. The technical staff meets at the technical training workshops held in the common Russian language, and then continue to communicate using email over the Internet which they are supporting. As each new country joins the VSH, the technical staff already using the Internet in the other countries provides advice and encouragement to the newcomers to the VSH.

2.3 Implementation of Telepathology

In 2003 a department of telepathology (Telemedical System of Microscopy (TSM)) was created at the Institute of Endocrinology in Tashkent, Uzbekistan which uses the newly established VSH internet connections between the Tashkent Centre and the department of pathology in Nucus (Kharakalpakia, a distant region). The first connection was so successful, telepathology has now been extended to all 12 regions in Uzbekistan, with funding from NATO SPS and other NGOs. The NATO funding allowed 10 additional regions to the telepathology system to allow consultations to be carried out for diagnostic biopsies and autopsies in real time, and to provide remote training of young experts and students, and to carry out medical newsgroups.

The objective of the telepathology project is to enable the reception and transfer in real time of images (both macroscopic and microscopic) from biopsy and autopsy histological tissues, using the internet. This allows for real time diagnostic ratings of the disease, acknowledgement of the diagnosis of diseases, and consultations using real-time internet software such as ICQ and SKYPE. In addition, databases of complex biopsy and autopsy cases can be saved up on a server so that experts can prepare diagnostics of difficult cases, especially in oncological cases and other diseases of children and women of reproductive age.

The Centre of Pathology of the Ministry of Health in Tashkent performs about 600-700 autopsies and 70,000-80,000 biopsies every year for 40 hospitals located in Tashkent, which include 16 research centres. The Centre of Pathology also provides diagnostic pathology services to 12 provincial hospitals which are located in all regions of the country. The Centre also provides training for the department of pathology of the Medical Academy, for 3rd and 6th courses for students in the field of pathology, and postgraduate students for the Second State Medical Institute.

Extension of Telepathology into other Central Asian countries: NATO-funded workshop

In Fall 2010 NATO funded a workshop in Tashkent, Uzbekistan, to extend the Uzbekistan telepathology network into other CA and Caucasus countries. The workshop was designed to introduce the concepts and use of telepathology to mainly developing countries, with the focus on NATO Partner countries in Central Asia. Uzbekistan has experience in using the telepathology system iPath for several years in all the 12 regions thanks to a NATO grant in 2008-9, and they were in a good position to lead other countries in Central Asia to prepare them to start a telepathology network. This workshop was used to train a total of 40 pathologists in 4 more developing countries: Georgia, Kazakhstan, Turkmenistan and Tajikistan, other users in the Uzbekistan regions, and pathologists in Russia, to establish a telepathology centre in each country, which can be connected to the Tashkent Pathology centre for gaining experience[1].

This workshop provided the necessary training for the pathologists in each country to be able to use the iPath software to transmit images on the internet, and the laboratory techniques for preparing slides for remote diagnosis—the clinical component of the course.

Additionally, all the participants learnt about distance education techniques such as video and on-line chat, through using the freely-available General Pathology Certificate Course on the *Health Sciences Online* (HSO) certificate/online university page www.globaluni.info in a computer lab situation. The lab had been newly opened for our workshop in the Tashkent Pathology Centre, with 12 computers in a (small) room. The workshop instructors Dr. Kate Tairyan and Dr. Vahe Araklyan from Canada used this general pathology course to train the

[1] Unfortunately invited participants from Afghanistan, Azerbaijan, Kyrgyzstan and the Ukraine could not attend

participants in various diagnostic methods and techniques such as cell pathology, inflammation, infectious diseases, environmental and nutritional pathology, etc.

Finally, the participants learnt proper autopsy techniques through both face-to-face learning with Forensic Pathologist Dr. Vahe Araklyan, and also with videos. Proper autopsy techniques are not taught in the primarily Muslim countries such as Tajikistan, where same-day burial of a complete body is considered very important, so many infectious diseases may go un-diagnosed.

The working language of the workshop was Russian, as this is the common language of all the pathologists. The participants were informed about several telemedicine projects in South-East Asia and expressed their willingness for cooperation. One of the Uzbek pathologists, working in the area of gynecology, who is currently studying in Seoul, is looking for contacts with local telemedicine community.

3. Results

The pathology staff at the first 5 regional centres were trained in the use of the advanced microtomes (Leica) equipment, and the equipment was installed at the first 5 sites in early September 2008, when telepathology activity was started, together with continuous evaluation of its use. The data from the first two months of use are summarized in Table 1.

Table 1: Summary of data for 3 weeks, Sept-Oct 2008

Region	**Total Cases**	**No. digitised**	**% digitised**
Andijan	104	19	18%
Bukhara	102	27	26%
Namangan	100	31	31%
Samarkand	97	34	35%
Syrdaya	59	24	41%

The data show that the telepathology system was successfully used in all 5 regions, and on average about 1/3 of the patients had difficult diagnoses, mostly involving cancer. Note that each site diagnoses about 30 tissue biopsy cases/day, with many slides for each case, plus 1-2 autopsies.

The remaining 5 Leica systems were delivered in early 2009 at the remaining 5 regional sites. The equipment was in regular use at all these sites, with about 30 difficult cases per month from each site being transmitted to Tashkent for diagnosis. Hence in total from all 12 regions, about 360-400 cases/month are being diagnosed by experts in the Tashkent centre, with good quality control on the diagnoses, reducing errors by about two-thirds.

Problems encountered:

Only one minor problem arose, when one site stopped sending cases to Tashkent for diagnosis. The centre noticed that this site had stopped sending cases, and followed up. It transpired that the trained pathologist had been moved somewhere else, and furthermore, the computer equipment had then been moved into the emergency room. The Tashkent centre managed to restore the trained pathologist, and reclaim the equipment into pathology, where it is in regular use again.

4. Conclusions

The NATO funding was successfully used to lever training funds from the UNDP, and other regional systems from the WHO.

Telepathology in each region has improved the diagnosis of about 300-400 cases per month in Uzbekistan. Furthermore, the staff at each regional site are able to learn and improve their own diagnoses, based on feedback from the centre and also from other sites.

Finally, through regular use of this telemedicine system, expertise has been established in Central Asia for telepathology, which can readily be extended to other Central Asian countries as a step towards bridging the digital divide.

4.1. Future work: improving bandwidth

The satellites have limited potential for expansion, so fibre-optic land lines may be necessary in the future. At this moment the bandwidth provided by Silk, BSI and CAREN usually only reaches the research institutes and universities in the capitals where the NREN is situated. Various initiatives are underway to expand the scope of the project to the regions within the countries. The planned GEANT interconnection between CAREN and TEIN3 networks opens the technical possibility for cooperation with South-East Asia, which all Central Asian pathologists are very interested in.

4.1. Future work: use of Distance Education for Continuing Medical Education.

Recently an increase has been observed in the level of tumors among children and women of reproductive age such as sarcomas, congenital tumors of kidneys and brain, and cancer of the mammary gland. Also changes of clinical displays and morphology of diseases are observed for pregnant women, woman in childbirth, lying-in women and among newborns. Early diagnosis of pre-tumoral processes and pre-illnesses of children and women of reproductive age is of great importance for the prevention of diseases and their effective treatment. This points to the need for further efforts to diagnose illnesses efficiently and quickly, which can be achieved with the use of distance education for Continuing Medical Education. Future work will include the addition of content to the bandwidth, possibly in the form of distance education programs.

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