Internet Extension to S. Caucuses and Central Asia
– *The 'SILK' Project*

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Abstract: In this paper, we outline the SILK Project, which is about to provide Internet connectivity on a regional basis to the NRENs of the eight countries in the Southern Caucuses and Central Asia. The project is mainly funded by the NATO Science Programme, under its Computer Networking Panel; but has additional contribution from Cisco Systems, DESY and DFN. The SILK Network is satellite-based; details of the equipment to be used is provided. It is quite state-of-the-art, including a separately manageable core network, clear interfaces to the NRENs, and an architecture which is expandable. We discuss the SILK Network, the technical activities to be undertaken and the management structure. It is made clear that we hope that this will be the basis for a substantially larger network in the near future.

Key words: Central Asia, Southern Caucuses, Internet Access, SILK, Satellite Nets, SPONGE, NREN

1. INTRODUCTION

The ancient Silk Road was not only a trade route but also an all-important road for the transfer of information and knowledge between major regions of the world. The SILK Project is bringing cost effective, global Internet connectivity to the Caucasus and Central Asia through state-of-the-art satellite technology, thus creating a virtual Silk information highway. Consequently, the project has been called the 'Virtual Silk Highway', in short: the 'SILK Project'. The aim of the SILK Project is to increase significantly the exchange of information with, and between, academic and educational institutions in these regions.

Since 1994, the NATO Science Programme, advised by the Panel, has been one of the major supporters of academic networking in these regions,

The original version of this chapter was revised: The copyright line was incorrect. This has been corrected. The Erratum to this chapter is available at DOI: 10.1007/978-0-387-35673-0_28

C. McDonald (ed.), *Converged Networking*

helping to create an appropriate infrastructure. This support has had, and continues to have, a very high impact on the communication needs of the scientific community. The improvement of the terrestrial infrastructure has now made the regions more dependent on basic Internet connectivity for research and education. Internet access promotes availability of content and information and thus contribute to open societies, democratic processes and the improvement of education. Closing the gap between information-rich and information-poor societies is expected to promote peace and security.

During recent years the Panel has been concentrating on the Southern Caucasus (comprising Armenia, Azerbaijan and Georgia), and Central Asia (comprising Kazakhstan, Kyrgyz Republic, Tajikistan, Turkmenistan and Uzbekistan. These countries are located on the fringe of the European Internet arena and will not be in reach of affordable optical fibre connections within the next few years. However, Internet connectivity via satellite is also an expensive, and therefore a scarce, resource for the science and education community in these countries. As a result the bandwidth available for the whole research and educational community in these countries ranged from 64 Kbps to 384 Kbps (Megabits/second) per country. To alleviate this, the Advisory Panel on Computer Networking (the Panel) of NATO has taken the initiative to launch the SILK project with a grant to DESY as the Western Co-Director, and the NRENs of the above eight countries (the grantees).

Figure 1 The Countries participating in the SILK Project

We have reserved $2.5m over the period 2001-2004 for this project; this represents 40% of the Panel's budget. It is the aim of the SILK Project to increase this bandwidth by at least an order of magnitude. With the NATO resources, and those provided from elsewhere, this will be achieved. We are discussing also with other aid agencies and NGOs for further increases.

2. THE SILK NETWORK

2.1 The Technical Characteristics

The academic and educational communities in the eight countries of Fig. 1 are being connected to the Internet by way of a common satellite beam. We chose to provide the international connectivity by using VSAT technology. This technology makes it possible for each of the eight countries to have its own minimum bandwidth capacity and at the same time to use unused bandwidth of other participating countries. In addition, the use of modern data caching techniques, enabled by the choice of satellite technology, should allow further improvement in the effective bandwidth achieved.

The choice of satellite system and earth stations was determined by formal tender. The EurasiaSat system finally chosen has a central hub in DESY (Deutsches Elektronen Synchrotron) at Hamburg/Germany, seen by one beam, with satellite dishes and network equipment in the eight countries, seeing another. In each country, we are putting in a standard set of equipment for connection to the National Research and Education Network (NREN) - the primary goal of the SILK Project being to connect the Internet to such NRENs. There has been a generous grant from Cisco Systems to make this possible. These components are shown schematically in Fig. 2.

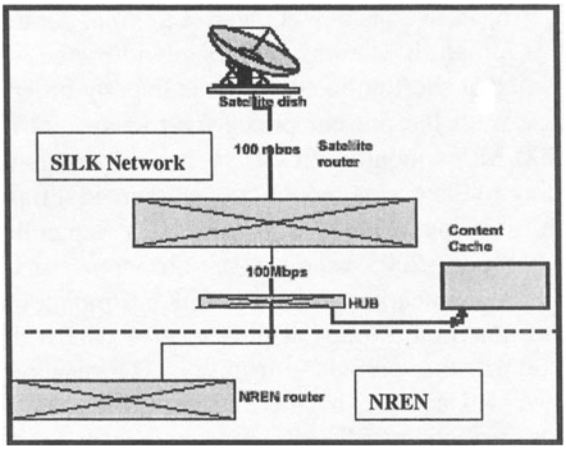

Figure 2 Schematic of the Configuration at each national SILK site

The satellite equipment is a 2.4 m dish with electronics from Kalitel (San Diego, CA, USA) - except at Almaty and Bishkek, which are near the edge of the satellite beam and operate with 3.8m dishes. The transmitter operates at 2W, and the equipment is capable of operating at a full transponder speed of 72 Mbps. The interface is V.35 to the transmitter, and 100 Mbps fast Ethernet on the receiver.

The equipment at DESY has a similar schematic to Fig. 2. It uses a dish, also from Kalitel, with a Fast Ethernet link into the DESY local network, hence via their 1.2 Gbps connection into the German National Research Network (DFN) and then via the European Research Network (GEANT) on to the research and other Internets.

There is a Cisco 7205 Router, Catalyst 3524 switch (with 24 10/100 Mbps ports) and a CE560 Content Engine with 144 GB of disk store at each site. All of these are considered as part of the SILK Network. They can be controlled and configured from a SILK Network Operations Centre (SNOC) in DESY. The NRENs, and other networks permitted to connect to the SILK Network will do so by siting a small router connected to the Catalyst. All the equipment can operate at the 100 Mbps, allowing the equipment ot work at full transponder speed.

The hub has been installed now (July 2002), and all the equipment tested at Hamburg. The Cisco components of the system have been installed in Tashkent (Uzbekhistan); we intend to bring up the first complete remote system in Tblisi (Georgia) during August, and the rest at roughly monthly intervals thereafter, as they obtain the relevant regulatory approval.

2.2 Satellite Bandwidth

For the SILK Project, we have negotiated a flexible contract, which will allow the number of earth stations, the bandwidth, the uplink and the downlink to be varied at short notice; the cost is linearly proportional to each of these variables. With the present prices for this special circuit, we can afford roughly 500 Mbps months. In our preliminary planning, and in the negotiations leading to the current contract, we assumed a traffic model, and hence bandwidth, growing from 2 Mbps/month in September 2002 to 10 Mbps/month in February 2003 as most stations come on line. Then the bandwidth will increase linearly by around 500Kbps/month until June 2005. This will lead to a maximum transmit plus receive bandwidth of about 24 Mbps by the end of the period – from NATO resources. The exact bandwidth that we will achieve by the end of the period for each of the countries depends on how rapidly the countries grant their licences, and whether the 1:4 ratio of transmit/receive bandwidth turns out to be optimum in the light of the experience gained from using the caching engines. Of course if extra resources are provided by NGOs and others, this could substantially increase the bandwidth available – at incremental cost up to the use of a full transponder.

2.3 Use of Broadcast Beam and Bandwidth Utilisation

We expect that the effective bandwidth to the individual countries will be substantially more than would be expected from 24 Mbps (3 Mbps per country) available by the end of the project. This is for three reasons: bandwidth sharing, caching and inter-country caching. Each will be considered in turn.

The technology uses is the same DVB coding as direct broadcast TV; it is in the same frequency band also. As a result, each Eastern earth station can receive the full information transmitted by DESY. While there is header information indicating for whom the information is meant, it is possible for each country to cache it. When this is combined with the content caches of Fig. 2, the national caches may be replenished more rapidly than would be expected from each cache being operated only nationally. Of course the national caches should further cut down on the need to bring over data from the West for each access; there will first be a check whether the information is already in the national cache.

2.4 The Regulatory Considerations

In order to operate the SILK Network, it is necessary for each participating country to permit up-link transmission. The satellite is using the TV bandwidth, to allow DVB coding; this is very convenient for multiple earth stations. Initial experience with the Hub station showed that even in Germany there was a delay in granting the transmit licence introduced by the frequencies used on the satellite. With Germany, these problems were resolved fairly fast; with some of the other countries we have no experience yet.

Another aspect of the regulatory consideration is for what sort of usage the approval is granted. Since the traffic passes through DESY and the DFN, it is necessary that the DFN/GEANT rules be followed; this prohibits the use of the SILK Network for commercial traffic. The grantee countries may put on additional constraints. Each of the NRENs must furnish the SILK Board (see Section 4) with the Acceptable Use Policy (AUP). We must then examine whether such any particular AUPs cause problems.

In Fig. 2, we indicated that the Catalyst Hub permitted up to 24 direct connections. We have already been approached by several organisations (mainly non-governmental ones) to connect in to the SILK Network; we will be discussing in a number of fora what criteria should be adopted in respect to such requests. Clearly the regulatory constraints in the individual grantee countries will impact these criteria.

2.5 The SPONGE Project and Technical Activities

The SILK Project is reasonably complex; it requires management and technical support. The NATO Science Committee rules preclude providing any finance to NATO country institutions. To fund these activities, the European Commission has agreed to support the SPONGE project, involving UCL as co-ordinating partner, Groningen U, and two grantee NRENs ARENA (Armenia) GRENA (Georgia). SPONGE activities will include:

a) Management of the SILK Project
b) Liaison with other EC and related initiatives
c) Providing infrastructure services like Web facilities and Help Desk; information on the project is already available on www.SILKProject.org.
d) Operation of a Network Performance Monitoring Centre (NPMC).
e) Investigation of the optimum parameters for, and the gains that can arise from, the use of cache stores.
f) The provision of facilities for voice/IP and multimedia/IP facilities for the SILK users.

In view of the management function of SPONGE and DESY, P. Kirstein (UCL and SPONGE) will be the Project manager of the SILK Project, R. Janz (Groningen U and SPONGE) will be the Service Manager, and H. Frese (DESY) the Technical manager. Janz will run the PNMC, Frese the SNOC.

2.6 Allocation of Earth Stations and Bandwidth

The huge differences in the population, size and Internet needs of the SILK grantee countries makes it very difficult to determine "fair" distribution of numbers of earth stations and bandwidth provision for each country. We have taken the policy decision that NATO will fund the provision of only one earth station per country, and Cisco of one set of LAN equipment and content engine (though Cisco has supplied also a ninth system as a maintenance spare). Similarly, we have agreed that each country will be allocated initially 500 Kbps of transmit bandwidth, with a total receive bandwidth of 2 * n Mbps, where there are n earth stations installed.

It may be that other organisations will add additional earth stations; this is essential in some countries where the distances are large, and the terrestrial communications facilities poor. These earth stations could be the same sort as we are installing; it would also be possible, however, to add receive-only stations, which would be somewhat cheaper. If this were done, it would impact the protocols used. This is discussed further in Section 3.

3. THE TECHNICAL PROJECTS

3.1 Introduction

The main purpose of the SILK Project is to facilitate Internet access for the participating countries. The stage of development of the different participants is, however, very varied; moreover the network facilities they have also differ broadly. Some of the partners would also like to pursue some technical network activities – if these provide improved services, without endangering the facilities of the other parties. In addition, some extra services are obligatory to meet the needs of the project. Four activities are described below: network management/monitoring, caching, personal communications services and remote lectures. The last could use Receive-only earth stations; their potential impact on protocols is described also.

3.2 Network Management and Monitoring

The SILK Network itself has been clearly defined in Fig. 2. It includes the earth stations, satellite routers, hub and content engine. These must be both monitored and managed. The monitoring is to ensure that the Quality of Service is maintained, to indicate when fault maintenance is needed, and to gather performance data on the system. This monitoring may also provide indications if Acceptable Use criteria were being abused – by commercial traffic being indicated between commercial sites either end. It may also provide indication of when upgrades in bandwidth are needed.

The management will be partially to ensure that the satellite bandwidth for each participant remains within acceptable limits – and that special events can be allocated bandwidth. This can be controlled remotely. It will include also the operation of the content caches – in which there is great latitude to change cache characteristics (like size, aging policies and even which data should be cached). It is planned to have most of the actual management done in DESY. Since the relations between some of the countries can be difficult, it is perhaps desirable that this choice of management site is followed.

When additional earth stations are installed, which are not part of the original plan, it is essential that the management of SILK resources be maintained. The current configuration allows this management to be applied.

Finally, in order to facilitate the sort of facilities mentioned in Section 3.2, it is necessary to be able to dedicate some bandwidth to high-priority real time services. It may even be desirable to enable multicast or some other one-to-many form of communication. This will also be facilitated by the central management of the SILK Network. Of course to enable some of these facilities to be maintained for end-users, it will be necessary to have close collaboration between the SILK Network management and that of the NRENs at other attached networks. On the European side such collaboration is much less necessary. First many such services like multicast and real-time services are being supported over the NRENs; second the availability of substantial bandwidth on the European side can cover up many deficiencies in the services provided.

3.3 Caching

We have mentioned in Section 2 that there will be a Cisco CE 560 caching engine at each remote SILK site – as part of the SILK Network. Even in Europe, a saving of bandwidth of up to 30% has been experienced by NRENs when using a national cache. In these, international web access requests are first routed to a national cache; only if they were not present there, are they fetched from their source. I will not go into full details of the British and other similar systems. One has not previously set up regional caches like those proposed in the SILK Project. Here we will use the broadcast nature of the satellite system to feed each of the national caches if anyone requests a web page. Whether there is enough similarity in interests of the users in each SILK country separately to gain more than the European experience will be investigated. Whether the different countries have sufficient similarity with each other to have a further gain from the broadcast nature of the reception will also be researched. We expect to have to experiment with the cache aging before discard, the importance of caching the requests in each country or only in some, and what may have to be done to alleviate privacy concerns.

3.4 Person-person communication

The question of person-to-person (or even more person to many persons) communications is particularly critical for this sort of community. We are not talking here of general telephone communications; that would be prohibited by the terms of most of the licences granted for the use of the satellite resources; we are talking about communications by the SILK community itself. Even many of us in Western Europe and North America will hesitate before we have long multi-country teleconferences; with the cost of telephone calls relative to salaries, and the lack of facilities for conference calls, it is essential to provide some person-person facilities as part of the SILK Network. At the least these should include voice; it would be more useful to include shared whiteboard and perhaps some video.

On the Kalitel earth stations, there is a minimal telephone capability to allow communication with the hub station; this is very useful for debugging problems in the satellite system. However, it does not reach any further. By contrast, the Cisco systems can be voice enabled. A diagram of the way that the Cisco voice/IP operates is shown in Fig. 3.

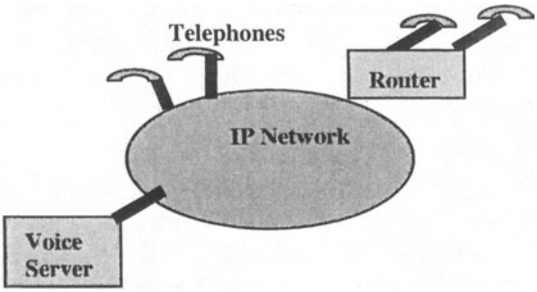

Figure 3 Schematic for Vice/IP Telephones

The individual telephones can connect in either directly as a host, or via a Cisco router. If it is via a Cisco router, more telephone-like services can be provided, including the ability to support Virtual Private Networks (VPNs). The Server need be at only one site, e.g. UCL in the SPONGE activity. All telephones participating in these teleconferences must be registered on the Server; this may be important from the licensing viewpoint.

The Cisco VoIP facilities can be initiated by two mechanisms – one of which is open source using the IETF SIP standard. We expect to extend this version to allow use of the MBONE tools of VIC and NTE, thus adding video and shared whiteboard. In this system the service may still look like Fig. 5 – but the boxes called "telephone" will be really multimedia workstations, and the workstations may be on the NRENs.

3.5 Use of Receive-only stations

We mentioned in Section 2 that some organisations had proposed using receive-only earth stations; these would be substantially cheaper than those being used. If there is a reasonable NREN in a country, but a limited national bandwidth on it, it would be possible to augment the NREN capacity for media transmission – like remote teaching – using receive-only dishes. It would be quite feasible, for instance, to have audio/data return go via the NREN and the SILK earth station, and video go via the normal channels to the receive-only stations. This usage can be by passive picking up of packets requested by another terminal through a transmit station; alternatively one can use an experimental protocol called Unidirectional Link Routing (UDLR) – which is supported on Cisco routers. This goes via the normal NREN, and deceives the sending station as to its real IP address.

4. MANAGEMENT

4.1 The Background

We have already indicated that we expect to undertake substantial network monitoring and management from a SILK Network Operations Centre (SNOC), and to monitor the overall performance from a SILK Performance Monitoring Centre (SPMC). This will deal with technical management. However there are many political and administrative aspects of the management of the SILK Project. Most regional networks like TEN-155/GEANT have grown from linking together existing NRENs. There may have been external funding – in that case the European Commission. However the partners have been quite clear at the outset. The SILK NRENs have been put in under specific bilateral national initiatives - involving UNDP, the Soros Foundation, the NATO Computer Networking Panel or some similar body. Here the control remained national, though the activities have to accord with the policies of the funding body.

The SILK Network is different. It is being set up under a grant from the NATO Science Programme, which is *ab initio* supposed to involve a number of different NRENs in sovereign countries. The grant is to provide only a kick-start for a larger regional network – even though many of the countries concerned will be unable to provide themselves the additional resources needed; however many international development agencies work in each of the countries, and have indicated potential interest in participation, Many of the SILK countries involved do not have a tradition, nor necessarily a desire, to collaborate with each other. It is a challenge to set up a management structure to operate in this environment while allowing flexibility to grow.

Even in the Western countries, there has been continuing concern that subsidised NRENs may hinder the emergence of commercial Internet providers. Similar concerns are present in the SILK countries. We will ensure that the policies for the usage of the SILK network from the SILK countries are sufficiently constrained to not impede, but even help stimulate, legitimate commercial development in the SILK countries. We are having relevant discussions with people in the countries concerned, and expect this matter to be of continued attention in the management bodies of Section 4.3.

We present here some of our preliminary ideas of how we expect a management structure to develop. Some of this can and will start under the auspices of the NATO Panel. Other parts must be developed with strong local participation.

4.2 The Initial Management Structure

The SILK Project was started by a grant from the Networking Panel of NATO Science Programme. For this reason, and because of the size and multi-annual nature of the project, there has had to be ultimate approval of the major aspects of the project from the Science Committee. Nevertheless most of the initiatives, including the approval of management structures, are the responsibility of the Computer Networking Panel. This panel has nominated the SILK Task Force to act as its interface to the SILK Project. The ultimate approval of financial arrangements, contracts, public relations and many aspects of policy remain, of course, with the NATO directorate.

4.3 The SILK Task Force

The SILK Task Force (STF) comprises: S. Berezhnew (Consultant on satellite technology), J. Butler (Cisco), H. Frese (DESY and Panel Member), R. Janz (SPONGE and Consultant on Central Asia), W. Kaffenberger (NATO Programme Director), P. Kirstein (Chair of STF, SPONGE and past Chair of the Networking Panel), A Kutonov (Panel Member and SILK grantee), R. Mkrtchyan (Panel Member, SPONGE and SILK grantee). R. Nordhagen (Chair of the Panel), R. Kvatadze (Panel Member, SPONGE and SILK grantee), Z.Wetzel (Consultant on Southern Caucuses).

Thus there is representation on the STF of the relevant Networking Panel management, the regional expertise from the NATO regional consultants, the Principals of the SPONGE project and representation from the NRENs. The STF will have a limited budget under its disposal – as part of the funds allocated by the Networking Panel. Major expenditures will continue to require approval from the Panel.

4.4 The SILK Board

The SILK Board (SB) is the main oversight body of the SILK Project. It is composed of some representatives of the STF, one from each of the NRENs, funders of the project, and the three managers (Project, Technical, and Service). They will meet occasionally, and use mainly electronic communication

There will also be SILK Technical Groups (STGs) and SILK User Groups (SUGs). These will be staffed by the NRENs, SPONGE, STF and users. They will operate mainly using electronic communications.

In view of the above, and the costs of communications for these participants, the deployment of the activities of Section 3.4 are vital.

5. CONCLUSIONS

We have outlined a new project, initiated by the NATO Science Committee Networking Panel, but with additional contributions from Cisco, DESY and the EC, which will provide Internet access to NRENs in eight countries of the Southern Caucuses and Central Asia. While some of the region is not too advanced in communications services, the provisions being made are quite state-of-the-art in equipment and services; only the bandwidths available are still limited because of financial considerations. Unlike most of the regional networks being provided elsewhere, this one has better facilities internationally than most of the national ones in the countries concerned.

The facilities being offered initially provide one earth station per country. The basic structure cleanly separates the areas under the control of the SILK Network from those belonging to national networks – both technically and managerially. All the countries have expressed agreement in principle; it remains to be seen how quickly operating permission is given in each. In each SILK country, its NREN will be connected; the connection of other networks depends on decisions made nationally and in the SILK Board. Expansion is feasible both of the networks connected to the original SILK earth stations, and by the addition of further earth stations. We expected that the present SILK Network will grow into a much larger co-funded network.

A number of important technical activities have been outlined; these will contribute to the optimisation of the services provided to the SILK NRENs and are interesting in themselves. None of the technical activities are fundamentally new, they should provide an insight on how well-known techniques will aid this sort of network in the environment of the SILK countries; this may well have relevance to other parts of the world. A management framework has been defined and is being implemented.

ACKNOWLEDGEMENTS

This paper is not the work only of the author; it represents the dedicated efforts of the members of the SILK Task Force (STF) in particular Butler, Frese, Janz, Kaffenberger and Wenzel. We acknowledge the enthusiastic support of the NATO Science Committee, the generous contributions from Cisco and DESY, and the support from the European Commission.

The project is completely dependent for its success on the activities by the SILK grantees. Even to reach its present stage, this has required many important contributions from representatives of the SILK countries and their NRENs in the meetings that have taken place over the past two years.