

Performance evaluation of Internet via satellite for electronic business applications

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Abstract

Internet via satellite is already available as a service, but it has not grown to a competitive level. The advantage of a wireless link is the ubiquity, while the drawbacks are high cost and scarce availability of dedicated services. We discuss the problems found in setting up a complex environment for many users involved in telemedicine and the framework for a bank service using Telecom Italia IperSpace service on HOT BIRD 4 satellite. The results show that careful planning and detailed tuning must be accomplished to reach the main goals, while there are still unsolved issues.

Keywords: Internet via satellite, electronic business, performance evaluation, IP multiconferencing

Introduction

Cellular and satellite telephony uses a small portable antenna while Internet via satellite needs now a fixed 60 cm or larger dish just for receiving. Transmitting is a more difficult task and requires a larger dish. This comes from the use of geostationary satellites (GEO) that can ordinary provide downwards channels of 2 Mbits/sec. Low orbit satellites (LEO) for Internet are going to start their service in some months, but they are now affected by some technical and financial problems. The advantage of using a portable device for connecting to a LEO seems to be counterbalanced by high running costs. The Iridium consortium, dealing mostly with satellite mobile phones, but giving also a 2,400 bits/sec data speed, shows that the original business goals could not be achieved.

There are a number of issues when deciding which of the two systems is better: delays are normally higher in geostationary satellites because they are placed in an orbit 36,000 Km high, but the need of switching among different moving low orbit satellites can produce worse results. The terrestrial link in receive-only systems is usually an ISDN line for best performance, but it can be any Internet ground connection.

Two-way systems are still too expensive and not yet available for most running services. Announcements of commercial offerings in Europe are quite recent¹.

When talking about advantages of satellite versus ground connections, three points are addressed: speed, location and multicasting.

Speed can be higher using a satellite connection because there are fewer bottlenecks, especially if the content is located on a site linked via a high-speed line to the service provider.

Location means that if you are in a remote site where it is difficult to have good fixed lines, the only way of getting fast Internet access is via satellite. In places where no telephone links are available, only a two-way system would solve the problem.

Multicasting makes the big difference in favour of the satellite link: you can send a single wide stream to many users at the same time, saving bandwidth. Ground based multicasting, like MBONE, needs that every router between the content provider server and the end user be multicast-enabled, which is not always possible for Internet Service Providers.

Costs are still in favour of leased lines when there is a continuous use. When you need a fast and not frequent access to Internet resources, DirecPC² with a maximum speed of 400 Kbits/sec can be affordable at an average 5 EURO for every 10 Mbytes downloaded.

A service implementation

A running project called HERMES (High transfEr Rate Medicine and Education service by Satellite), sponsored by ESA ARTES3 initiative³, aims at implementing pilot operations both in Telemedicine and in Tele-Education, using asymmetrical Internet via satellite, dedicated hardware and software platforms and content providing databases and services. It is based on the IperSpace service by Telecom Italia.

We shall describe the problems arisen while setting up the Telemedicine network among twenty medical centres all over Europe.

The first goal was to prove that the installation of the satellite kit could be easy, so that any user would be able to set it in a short time. It was thought that the hardest part would be the dish installation: as it was in charge of specialized technicians, there was no difficulty at all in doing it. Problems started when trying to install the boards on existing on a PC connected to a LAN, running other applications. Interrupt conflicts and software incompatibilities in many sites led to the decision of installing the board on brand new PC's with CPU over 300 MHz and 128 Mbytes RAM, using Windows 95 or 98. There are reasons for not using NT4 as it is explained later.

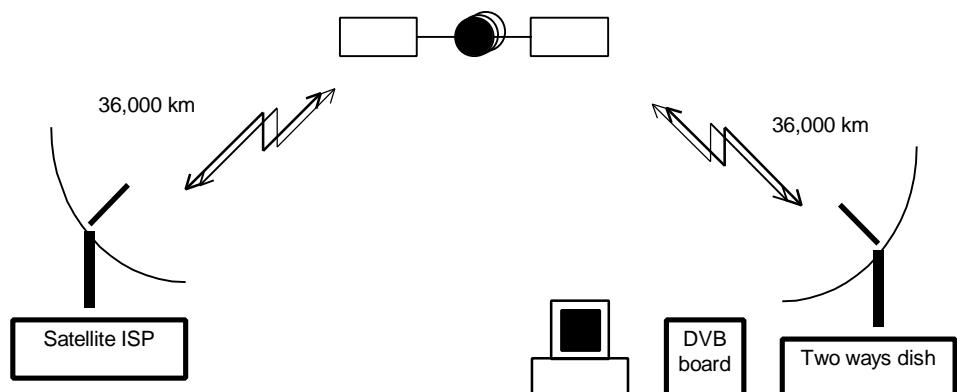
Many services have been tested on the HERMES platform: fast downloading, multi-user videoconferencing, application sharing, streaming video. The experience of the first months show that fine tuning is needed to properly run the applications and get the best results.

Speed limits for Internet via satellite and tuning the applications

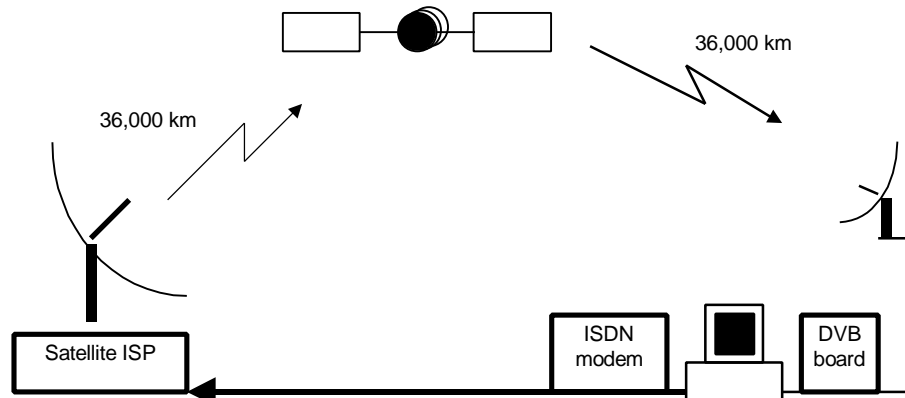
We have not yet used the reserved bandwidth of 512 Kbits/s, which will be allocated to the project. The available system so far is the "best effort" mechanism on the 4 Mbps band. As the downlink of IperSpace was not very busy, this wide band could be greatly used for short or medium periods of time, which made it possible to test high-speed transmission.

RTT (round trip time) over a GEO satellite is greatly determined by the speed of light (300,000 Km/s) and the distance from earth (36.000 Km): therefore the minimum for a connection using only satellite Internet would be $36,000 \text{ Km} / 300,000 \text{ s} = 0.12 \text{ seconds}$ multiplied by 4 (because the round trip path is up, down, up, down), that is almost half a

second. The side picture shows the network configuration of a two-way system.



With a geostationary satellite like HOT BIRD 4 and the ISDN return path of IperSpace, the measured RTT is a little less than 400 msec, which can be considered the sum of 0.12 + 0.12 + 0.03 (pinging over the ISDN line) + other delays. The drawing illustrates the transmission path.



The following formula determines the theoretical available speed, for the IperSpace service, with the maximum TCP window size of 64 Kbytes, used in Windows 95 and 98.

$$\text{Throughput} = \text{window size} / \text{RTT} = 64 \text{ Kbytes} / 0.4 \text{ sec} = 160 \text{ Kbytes/sec} = 1.25 \text{ Mbits/sec}$$

This limit is for TCP/IP connections, like web browsing via http or file downloading via ftp. We had to manually set the default receive window value by creating the registry parameter

HKEY_LOCAL_MACHINE\System\CurrentControlSet\Services\VxD\MSTCP\DefaultRcvWindow

assigning the value 65535, in both Windows 95 and 98 clients. We also set the similar parameter at the same value into the Windows NT 4 server registry

KEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\Tcpip\Parameters\TcpWindowSize

Before tuning, our highest recorded transfer speed via http was only a little over 160 Kbits/sec. This value is compatible with the default Win 95 TCP receive window of 64 Kbits (64 Kbits / 0.4 sec = 160 Kbits/sec) and a RTT which sometimes was lower than 0.4 sec.

After setting the TCP window size at 64 Kbytes (that is 8 times larger), we boosted to 500 Kbits/sec, still far from the theoretical over 1 Mbit/sec limit. In any case, there is no way of using the full 4 Mbits bandwidth with a single TCP connection. DVB board manufacturers declare that the maximum TCP throughput is around 1.5 Mbit/sec, using multiple sessions on the same client.

In all our test, the files downloaded were on an NT server connected via LAN to the remote access server of the satellite provider and the uplink transmitting apparatus: therefore there were no significant additional delays.

If all systems involved in the transmission could use “large windows” as defined by RFC 1323⁴ there would be an increase in the maximum throughput. A window size of 128 Kbytes would double the theoretical limit. Unfortunately Windows NT 4.0 does not support RFC 1323. Version 5.0 beta supports it, therefore in the future better performance can be achieved using Windows 2000. Windows 98 already supports it, and winsock2 implementation updates Windows 95 to be RFC 1323 compliant. In order to make use of it, both sender and receiver must be enabled to use “large windows”.

“Slow start” and “congestion avoidance” are other problems to face with the long delays of satellite transmission. Recovering the full speed after lowering it for the detection of a lost packet can be very slow, up to two minutes⁵.

Another improvement can therefore come by using Selective ACKnowledgment (SACK)⁶ in both sender and receiver, in order not to transmit information about every single acknowledged packet. Windows 98 and winsock2 for Windows 95 support SACK even though there are some differences in behaviour. Windows NT 4 does not support it, while NT 5.0 beta does it.

A working group of the IEFT, called TCP over satellite (tcpsat)⁷ has been created in order to coordinate the efforts in this field and to produce the Internet-Drafts and Request For Comments.

The situation for UDP transmission is different. By not checking the integrity of delivered packets, its transmission is not affected by a fixed delay, like the one in satellite links. UDP is the preferred method for streaming video and audio, where the application gets the burden of quality control with more efficient methods than TCP ones.

Our tests with UDP were accomplished using RealNetworks RealSystem G2 that uses RTSP⁸. A Real G2 basic server was installed in the NT machine at the satellite provider’s location and videoclips encoded at different rates were streamed, up to 1024 Kbits/s, which is the highest limit for the current release of RealProducer G2. No tuning at all was necessary to perfectly play a few minutes stream. We tested a lower bandwidth of 300 Kbits/s for hours, with good results. RealServer has an adaptive buffering which

compensates the possible temporary lowering of the bandwidth, keeping quality at the best level. By monitoring the buffering, we could also see that the RealPlayer could reach up to near 2000 Kbits/s while receiving the 1024 Kbits/s stream. This rate means a high quality image at 352x288 at 25 fps. With UDP we could theoretically fully utilize the full 4 Mbits/s bandwidth.

We tried to reproduce the same results by using Microsoft Windows Media Services, a streaming video system for Windows NT. We used the beta version available in July 1999. Unfortunately the system could not stream more than 32 Kbits/s over the satellite connection, while on ground connection the same server delivers up to 1024 Kbits/s and more. We are studying the problem with Microsoft's technicians to understand the reason of the behaviour. Windows Media Technology uses the MMS proprietary protocol to deliver the UDP stream. The 32 Kbits/s limit shows up also if using TCP transport instead of UDP. On the contrary, via http (which means not using MMS) the same stream can reach the speed we achieved for file downloading, that is around 500 Kbits/s. We'll test again the system using the coming final release of the software.

Videoconferencing

The videoconferencing advantage of an asymmetrical transmission, with a high bandwidth receive channel, is great when more than two users are connected in what is called "continuous presence mode". This means that all users are watching and listening to all the other participants into the conference. Each one is providing his/her own image and audio at the ground connection speed, in our case 128 Kbits/s of the ISDN bonded channels. On the receiving side, via satellite, each one is getting N-1 streams, which results in high bandwidth requirement.

Multipoint videoconferencing was tested using Cu-SeeMe 3.1.2 clients and MeetingPoint 3.5.1 server as a reflector⁹. Up to eight participants in "continuous presence" mode took part in some tests. Every user could see and hear all the others, who could also talk at the same time. Obviously comprehension is helped by a moderated conference, when each participant raises his/her hand to start talking. The ISDN connection delivered 80 to 100 Kbits/s, which did not seem to feed the reflector with enough video quality. Audio underwent strange behaviours, from perfect to unintelligible and the delay times changed often. After a careful

tuning of each client, using all the same version of the software and the same codec at the same maximum speed, and after some settings of the reflector we got better results, but the overall situation is still far from the quality reached by any H.320 multiconference, using ISDN connected to a MCU. Using version 4 of Cu-SeeMe caused more problems: very slow operation on the clients and codec incompatibilities with previous version. We have been in touch with the White Pine support team, and it seems that many problems rely on the H.323 implementation.

Application sharing was tested in two ways. The first was using standard T.120 programs, like Microsoft NetMeeting that is now used also by Cu-SeeMe. Performance is good, but it's already acceptable at 64-128 Kbits/s therefore the satellite downlink does not add any value. Moreover, application sharing is a typical symmetrical activity, which does not fit perfectly into an asymmetrical framework like one way satellite Internet delivery. The second test was using a proprietary application called NES-J¹⁰, running on each client. The data, medical record information, were on the server at the satellite service provider and each participant could browse it while the others were watching the same results. In this scenario we could test the fast image download.

Results

Physicians were positively impressed by RealVideo clips running (using UDP) at 600 Kbits/s from the operating theatre which means that a live transmission can be multicast very effectively to many concurrent users all over Europe.

An innovative way of MRI examination was also implemented. The radiologist comments the MRI showing on a LCD monitor while a video camera takes picture of the whole. The clip is encoded and linked to the original DICOM (the format used in radiological equipment)



images and placed on the satellite-connected server. The remote user can therefore see the examination while watching the uncompressed images on the browser (using a free plug-in) as if the radiologist were there. This scenario opens also a new way of teleconsulting as a service from high level hospitals to small locations in remote places. Using this system, the explanation of the examination could also be shown directly to the patient. The use of http for downloading an uncompressed DICOM image of around 500 Kbytes (512x512 pixel x 16 bits greyscale) and viewing it with the plug-in means that, in order to have it shown in due time (maximum 10 seconds) while the radiologist is speaking, the transmission speed must be at least 400 Kbits/s, which can be reached by tuning the TCP window size as previously explained.

Videoconferencing was disappointing for the many problems encountered. Further studies are needed to reach a quality comparable to ISDN H.320 standard at 128 Kbits/s. Costs can be lower when using a satellite link for multiconferencing with many partners scattered all over Europe, but audio must be perfect and video sufficiently clear at least at QCIF (176x144) size.

Sharing application was considered good, with whiteboard and collaboration tools. The quality of the NES-J application was fair, but we think that it can be improved by further tuning the clients. Its main use is during a videoconferencing, for a teleconsulting.

In a typical multiconference for telemedicine consultation, previous downloading of relevant data, like huge image files, by means of a multicasting push, would add value to the live discussion of a pathological case. We have plans to test this form of delivery.

Multicasting is being enabled on the internal IperSpace network. The next tests will be able to assess the quality of multipoint videoconferencing in order to bypass the mentioned quality problems.

An advanced service for banking

The experience in the HERMES project has been useful to propose a new framework for advanced service in a banking environment. The aim is not to reach the bank clients, but to support all the branches in a faster and more effective way. Banks are interested in trying new multimedia communication tools but are often afraid on the impact that this traffic can have on their network. The use of satellite delivery can bring the multimedia benefit without interfering with the existing ground network.

The operational functions identified by the Bank involved in the project see at higher priority the Intra-enterprise Network. Some of them are:

- Dissemination of multimedia business statistics data
- "Training on the job", and on line help desk on working procedures and business re-engineering
- Software updating
- Dissemination of corporate data
- Collaborative environment, including synchronous and asynchronous collaborative computing, multi-user conferencing and virtual meetings.

Training on the Job is aimed at maximising acceptance by bank staff about reengineered procedures and related tools and at setting up a more cost-effective human resources promotion and motivation process.

Software update is becoming more and more frequent and sometimes it takes hours to deliver it to all branches via leased lines. It has to be scheduled during the night even when it is urgent, because of heavy traffic in the ground network. By delivering it via satellite, it can be multicast in a few minutes to all branches at the same time.

All other applications for collaborative computing are similar to the telemedicine environment. Also streaming video can be successful for example for transmitting new marketing tools or for video on demand of relevant information by the board of directors.

User authentication and data encryption are a must in this environment.

Conclusion

Satellite connections are indeed useful where ground connections are not capable of high speed. Even though, for the end user, setting up a satellite receiver can be faster than establishing a leased line connection, there a number of problems to overcome: integrating the receiver in an existing environment (hardware and software) is not always possible and fine tuning and adoption of new standards¹¹ for the TCP parameters may be required. Streaming video, live or on-demand, seems to be easily set up. Multicasting adds more value to live events.

The project is still running and some of the described issues may be solved in the future. They will be useful for future development of advanced services.

In order to become a commercially interesting platform, Internet via satellite must guarantee some standards in delivering rich content which cannot be achieved easily through normal ground connections. Moreover two way satellite connection is the only viable solution must in some remote locations.

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