Using Satellite-based Videoconferencing to Integrate the SatNEx Research Community

Sergey Raber, Robert Rumeau, Laurent Franck, Tomaso De Cola, Ulla Birnbacher, Georg Egger, Anton Donner, Ray E. Sheriff, Gorry Fairhurst

***Abstract*— The SatNEx Project provides a pan-European multimedia network that may be used to rectify fragmentation in satellite communications research, by bringing together Europe's leading academic institutions and research organisations in a cohesive and durable way. The resultant network provides a collective grouping of expertise and state-of-the-art laboratory facilities that would otherwise remain dispersed throughout Europe. This paper describes the Platform developed by the SatNEx community for use by the community to provide high-quality videoconferencing facilities, based on a satellite connectivity.**

***Index Terms*— SatNEx, video conferencing, satellite communication, IP multicast, tele-learning, tele-education.**

I. Introduction

REMOVING Barriers, Integrating Research and Spreading Excellence are the primary objectives of SatNEx, the Satellite Communications Network of Excellence [1]. SatNEx is supported under the EU Framework Programme 6 with the overall goal of rectifying the fragmentation in satellite communications research by bringing together Europe's leading academic institutions and research organisations in a durable way. The creation of the Network aims to establish critical mass and allow access to a range of expertise currently distributed across Europe. Mobility is an important aspect of SatNEx's work, with academic staff and researchers being encouraged to move between institutions to allow access to specialised research equipment and to facilitate knowledge transfer and research integration.

The philosophy underlying the SatNEx approach revolves around the selection of focused actions that capitalise on the expertise present within the Network and ensure a durable and effective integration. The focused actions are performed jointly by the partners. .

A key goal of SatNEx is to achieve effective communication between partners. This requires establishing a common pan-European Platform to provide equitable access to real-time communication services for all partners [2].

A range of different services are required for day-to-day communications, research, and training. The ability to deliver virtual meetings and lectures/seminars within Europe is expected to become increasingly important in the coming years. However, currently available network infrastructure is unable to satisfy these requirements for interactive services to the geographically dispersed set of SatNEx partners, with their respective disparities between the various national ground network infrastructures and/or local security policies. This has led to a vision for a "federal" satellite-based system, dedicated to SatNEx communication, with the ability to complement the existing ground connectivity by exploiting satellite communications technology. The remainder of this paper describes the technology and the extension of the SatNEx federal Platform to other satellite communications systems.

II. Platform Technology

A. Requirements

The purpose of the SatNEx platform is to demonstrate and deploy satellite-based virtual meetings and lectures/seminars services over Europe (Annex A contains a list of partners). This activity also promotes "by example" the added value of the daily use of SatCom technologies [2].

The platform uses Internet-based applications for

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communications and presentation of the meetings. An IP-based approach is indispensable to support a large number of collaborative applications, although the initial use of the platform will mainly be for audio/video transmission. A solution simply based on replication of unicast multimedia traffic would not make efficient use of the satellite capacity. Hence, multicast capability was a major requirement to leverage the benefits of native satellite broadcast capability.

To ease rapid deployment, the use of off-the-shelf components was necessary. Reliable support by the vendors also remains a key requirement.

There are two key scenarios in which the Platform may be used [2]: (a) a remote lecture scenario and (b) a distributed interactive meeting.

In the first scenario, a partner from the SatNEx community organizes (and broadcasts from its own site) a "Master lecture" on a specific topic. During the session, he/she needs to address all interested remote SatNEx partners and would appreciate real-time feed back to collect "instant" messages or questions (e.g., jabber messages with questions to be answered at the end of a lecture). The interactivity is low and therefore does not necessarily require bi-directional satellite connectivity for all the attendees, many may instead utilise their existing terrestrial Internet access as a return channel.

In the second scenario, a group of SatNEx partners wish to organize a distributed conference. A few partners, the "foreground attendees", are "active" while the others, the "background attendees", are only interested in "passive" observation, i.e. watching and listening to the session from the foreground attendees. This scenario covers a number of cases with different levels of interactivity where the speaker frequently changes.

When there is a frequent change of speaker, the dynamics of interactive teleconferences over GEO-satellite are strongly impacted by the appreciable satellite propagation delay combined with the video processing delay. The interaction is then considerably improved by coordination, for example the ability to ask for, and grant, access to the "floor".

Participation in both scenarios is supported using the same SatNEx Platform equipment. For an attendee that only requires participation as a background observer, a simpler setup may be sufficient. For example, sessions can be announced as SDP (Session Description Protocol) records using email or from a web site. The SDP records can be directly opened on a PC with standard multicast-enabled application software, such as Quicktime Player™. This approach is supported on a variety of different operating systems.

B. *Technical Approach*

The SatNEx Platform architecture combines an Internet-based terrestrial segment for collecting input streams and a satellite segment that aggregates the traffic into a feed and broadcasts the streams using DVB-S [2]. This achieves the best of both worlds. On the one hand, a terrestrial-only solution would raise the issue of multicast connectivity and the necessity to connect every partner to the multicast-enabled Internet backbone. On the other hand, a bi-directional satellite solution is not affordable because of the need to equip all 23 partners.

The MCU (Multipoint Control Unit) is the meeting point that translates unicast, terrestrial traffic into a single multicast stream that is suitable for satellite broadcasting. In addition, the MCU acts as a videoconference "babel fish", transcoding the different contribution media formats into a single standard supported by all receiver stations. For content transmission, from an active partner to the central MCU, a H.264 codec is preferable. H.264 has been optimised for transmission over networks without guaranteed bandwidth reservation (most current Internet paths).

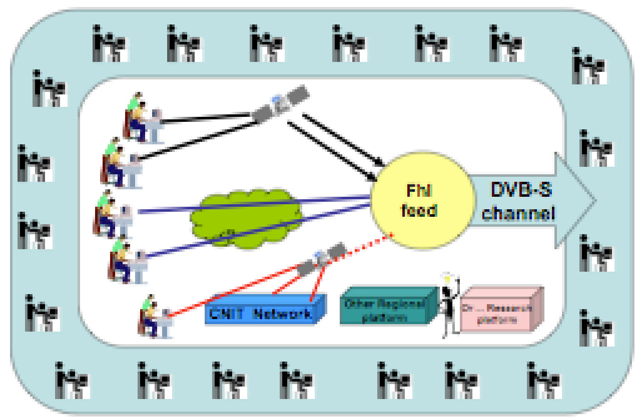

Figure 1: The SatNEx Platform Architecture

For multicast data transmission from the MCU over the satellite, SatNEx rents permanent capacity with guaranteed bandwidth. Currently, H.263 encoding is used to ensure successful decoding by all partners including PC systems that may have limited CPU resources. However, hardware requirements for H.264 decoding are constantly decreasing, and future transmissions plan to also use a H.264 codec over the satellite, decreasing bandwidth requirements and the associated cost.

To summarize, the journey of the communication flow (Figure 2) is as follows: (a) content is pushed via the terrestrial Internet from videoconference devices) to the MCU (Codian), (b) this is multicast and uplinked to the satellite, (c) received through an IP/DVB-S [4] router (IPricot [5]) and then (d) multicast onto the destination LAN for viewing (e.g. Quicktime Player). To make interaction possible among the platform users, a Jabber chat server was installed beside the MCU, and clients used at each site.

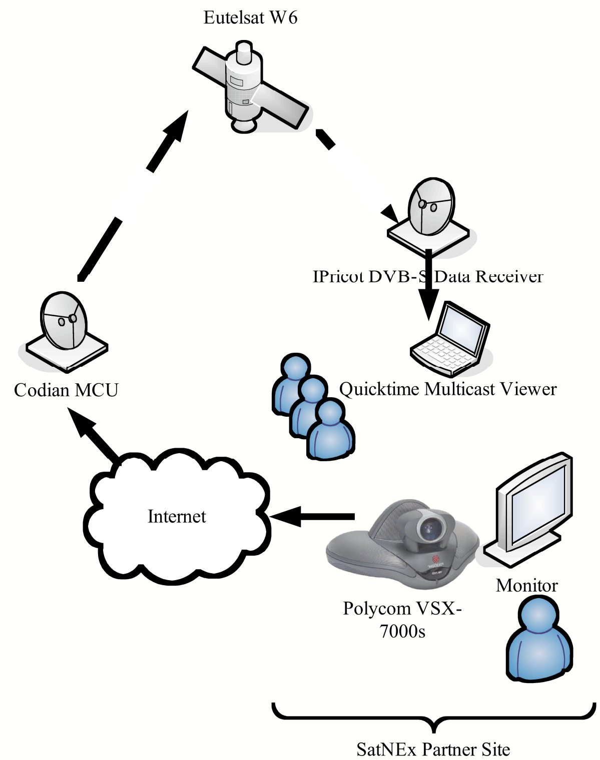

Figure 2. SatNEx Platform System Components.

C. User Terminal Deployment

The videoconferencing terminal selected for the SatNEx Platform had to fulfil a set of requirements. First, it had to operate independently of the satellite, because the system had to be able to continue operating beyond the lease of the satellite capacity (at which time terrestrial infrastructure may have improved, at least at some sites). Second, not all sessions require satellite broadcast (some face-to-face meetings could be performed by terrestrial connection). Third, the selected equipment had to be robust with a controlled configuration: (limiting software installation/removal/upgrade and changes to the operating system). This led to selection of an embedded videoconferencing terminal rather than a PC. After several month of use, it turns out to be one of the best decisions made.

Figure 3: 1.2m satellite antenna after installation at a Partner Site.

The complete SatNEx Platform user package comprises: a satellite dish (figure 3), an IPricot DVB/IP router [4,5], a Polycom VSX 7000 terminal [3]. This is supplemented by one or more PCs that allow display of the satellite multimedia stream. The PC also may also be used for other IP-based applications (e.g. the Jabber chat tool).

Figure 4 shows a user terminal setup with the Polycom camera module in the centre, the IPricot router to the right (the small box next to the loudspeaker) and a PC (concealed beneath the unit). The Polycom codec has a standard VGA output that supports an LCD monitor (shown at the top of the picture) or a VGA CRT. At many sites the codec is connected and/or PC are connected to a video projector to allow larger groups to view the screen simultaneously.

Figure 4. SatNEx Platform user terminal

All 23 partners have fully operational systems at the time of writing. The Platform is used for virtual meetings (joint activity meetings but also informal meetings between partners), regular SatNEx event broadcasts (including seminars from the SatNEx Summer Schools and other material contributed by the consortium), and cross-satellite broadcasts (e.g. the ESA/ESTEC Telecom Application Workshop 2005 [6], and the Italian Telecdoc2 programme [7,8]). Some of these are detailed later.

D. Deployment Experiences

After 9 months of testing, it is possible to pinpoint several interesting facts and caveats:

The first issue relates to the installation of satellite antennas. In several institutions, special clearance had to be granted to access the rooftop and to install an antenna. In other places, antenna installation was possible only when performed by a registered professional (even though the SatNEx antenna is receive-only). Finally, for partners that bordered the footprint of the Eutelsat W6 satellite, a 2.4 m antenna was needed with associated difficulties incurred by the size of the antenna (a change of satellite in 2006, has allowed this constraint to be relaxed in SatNEx-II). From this experience, it appears that affordable, automated antenna pointing has still to be invented!

The second issue relates to Partner site network security policies, and concerns the requirement for incoming UDP traffic or TCP connections (e.g. to the Polycom terminal). In this aspect, the use of an embedded terminal with dedicated hardware, instead of a regular PC, certainly helped to convince many network security officers to grant the appropriate firewall permissions.

The third issue was linked to the distribution of multicast traffic from the satellite router to the destination LAN. The Ethernet Layer 2 network equipment at many partner sites was unable to effectively constrain multicast traffic to parts of the network where the traffic was needed. Many installed Ethernet switches forwarded all multicast traffic to all network segments, with serious implications for low speed or heavily utilised links.

The use of a private, dedicated LAN (e.g. a small Ethernet switch) provided a solution that prevented flooding of the institution network with unwanted traffic. An isolated SatNEx LAN also helped alleviate security issues and eases the deployment of WiFi access. (WiFi network access is restricted in many institutions.) At least one site operated a network with Ethernet switches that provided multicast traffic control. It was also possible to link the IPricot into the terrestrial-based multicast routing infrastructure allowing the content to be delivered via IP multicast-enabled routers across the site.

Finally, there is a need to co-ordinate and announce the transmissions made via the Platform. In SatNEx, this scheduling uses a private web site in which all partners have access and through which they can register face-to-face meetings; broadcast seminars and teleconference sessions.

In summary, the time spent on the definition, testing and deployment of the Platform have revealed many obstacles, not all of them of a technical nature. For example, getting clearance to access a roof and install a satellite dish is as relevant as the proper configuration of a Layer 2 switch for multicast traffic filtering.

III. Interoperation With Other European Satellite Systems And Platforms

It rapidly became apparent that the Platform should be able to feed content from a range of different sources, and not just from the video conference terminals at each site. One approach that was adopted was to allow the platform to be connected to other systems.

Interconnecting the Platform with other systems provides added value from two standpoints: (1) it can extend the coverage of another system and (2) it can replay and/or benefit from external content based on a peer-to-peer agreement. The following paragraphs describe two interconnection cases.

A. ESA/ESTEC Telecommunication Application Workshop 2005 Re-Broadcast

The first global SatNEx platform event available for all consortium partners was the re-broadcast of the live ESA Telecom Applications Workshop (TAW) held on 3rd and 4th November 2005 at ESTEC, Noordwijk, Netherlands [6]. The workshop provides a forum for ESA projects to discuss the latest satcom developments, share their experiences and to explore possible synergies. The TAW was broadcast on the HellaSat 2 satellite (39 degree East). Reception by participants was using the PC-based DistLearn™ software [9].

The signal was received at the University of Aberdeen using a 1.2m receive-only satellite antenna pointed to the HellaSat 2 satellite, feeding a Linux-based DVB-S receiver [3] acting as a L2 bridge. The stream of IP packets were fed to a LAN and received using the DistLearn software running on a PC. The received video and audio were then re-inserted into the SatNEx Platform using an analog S-Video interface to a video encoder and sent as Internet video to the MCU via the Internet. The received content was broadcasted via satellite (originally using the Eutelsat W6 satellite and from 2006 using Eutelsat W 3) and made available to all SatNEx partners equipped with the standard SatNEx receive-only terminal.

SatNEx partners successfully followed the complete session. Questions from partners were sent via the SatNEx Jabber server and then relayed onwards at Aberdeen into the chat service provided by the DistLearn tool [9], allowing them to be relayed in the workshop and answered immediately. Since this was the first public use of the Platform, some problems were faced during the session. Some of them were solved online (such as audio level adjustment, video content layout, the various options for display of presentation slides etc.), others have raised questions that will shape the future evolution of the Platform (parallel multicast distribution of technical presentations).

ESA appreciated the SatNEx efforts in disseminating the TAW 2005 content and is planning to expand this successful partnership for future transmissions of similar public events.

B. CNIT Platform and Teledoc2 programme

Over recent last years, the Italian National Consortium for the Telecommunications (CNIT) has gained significant experience in the field of multimedia communications over satellite networks [7]. This has utilised the intrinsic capabilities of satellite technology to provide multicast communication facilities and ubiquitous access for e-education and e-training applications. Experience in videoconference applications and tools for distribution of multimedia content has culminated in broadcasting a series of teledoctorate lessons, as part of the Teledoc2 project [7,8], funded by the Italian Ministry for Instruction, University and Research (MIUR).

The Teledoc2 Platform comprises distance learning software and communication infrastructure in the form of a satellite-based network, connecting 24 sites using Eutelsat Skyplex technology operating in the Ka band. This provided a guaranteed bandwidth of 2 Mbps shared among the active terminals (Figure 5). The communication infrastructure employs Eutelsat HOTBIRD 6 satellite capacity, which guarantees 4 uplink European regions and allows a pan-European coverage, extending the boundaries of the project.

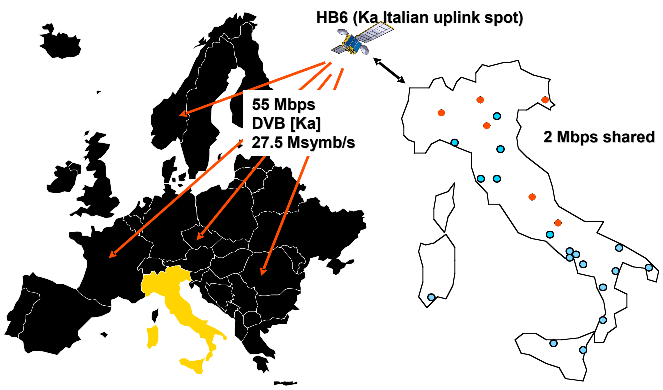

Figure 5. CNIT Satellite Platform.

The SatNEx Platform provided an opportunity to feed the teledoctorate lectures to the SatNEx community, encouraging long-lasting integration among the players, the distribution of the lectures throughout Europe. To achieve this, the satellite Platforms from SatNEx and CNIT needed to be integrated. The latter enables the transportation and the sharing of the multimedia content among the CNIT sites. The two different Platforms were connected via the Genoa CNIT site using a Multi Control Unit (MCU), placed by the Fraunhofer Institute, through the Internet connection (Figure 2), using a Polycom terminal, as in the ESA TAW rebroadcast that was described in the previous section.

Relevant issues regarding the quality of service perceived by the final users have been investigated. This examined the impact of the double satellite hop on the multimedia broadcast, also considering the trans-coding operations required to connect the different devices. The interconnection of CNIT site with the MCU devices required particular attention, since it raised many configuration issues. The teledoctorate service has been broadcasted by redirecting the multimedia flow, received from CNIT satellite receive antenna, into the S-Video interface on the Polycom device. The distribution of the teledoctorate service used an Internet connection, transported through H.323, towards the MCU.

A series of trials were performed to identify the most suitable configuration for the S-Video format media. To mitigate the loss of resolution caused by the encoding process

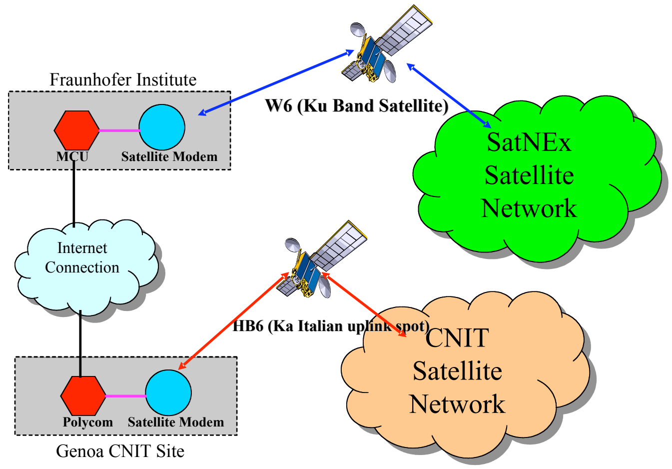

Figure 6. Interconnection of SatNEx and CNIT platforms.

from the VGA card to the S-Video format, the display settings were tuned: Screen resolution was set to 1024x768 pixels, while the refresh frequency was tuned to 60 Hz. The multimedia flow transmitted by teleconferencing terminal was encoded into H.263 format, using the CIF resolution (352x288 pixels). There was also the possibility of using a higher resolution in future transmissions.

The final configuration was evaluated by a set of tests to assess the overall performance of the audio/video broadcast in terms of information loss. These trials showed successful transcoding between the two networks. The reduction in the subjective user-perceived quality for both audio and video flows was acceptable and the analysis of the jitter also provided a satisfactory result.

The combined CNIT-SatNEx Platform has therefore been used to demonstrate the capabilities of increasing the interaction of scientist and researchers in the field of satellite networking, and continues to provide a powerful tool for the spreading of excellence and the dissemination of knowledge.

IV. EVOLUTION OF THE PLATFORM

The SatNEx Project continues to be used for both regular and special events. Following the successful interconnection of the Platform with two other systems (section III), there is interest in interconnecting the Platform with other “regional” or “special purpose” networks.

Another possible enhancement is to include a new service that would allow for the possibility of contribution of IP multicast content from remote partner sites. This would provide a way to directly introduce IP traffic from terrestrial multicast-enabled broadband networks. The range of available codecs and configurations suggests that content may need to be transcoded, as discussed in the previous sections to ensure the coding method and bit rate are compatible with the Platform. This method also could be used to introduce a range of other IP-based multicast tools (e,g, collaborative white-board, file dissemination, and other collaborative working tools). Integrating this “raw” IP traffic with the output of the

Codian introduces new engineering challenges to the network operation to ensure reliability of the overall service.

SatNEX-II plans to investigate a monitoring framework to allow the quality and usage of the Platform to be monitored. One option is to post-process the detailed logging information already collected by the Codian MCU, other possibilities are also being explored that could allow usage and performance statistics to be gathered from each remote site.

Another area to be investigated is the use of encryption to allow private meetings by restricted access to the broadcast content. The default status of the satellite feed will be for transmissions to be in the clear (unencrypted). When required a session-based encryption could be activated at the sender and receiver. A simple out-of-band "key management" scheme could be used which utilized pre-placed keys.

Parallel to the activities using the Platform, the SatNEx Project also has research activities focused on practical satellite trials – both at the lower-layers (physical, link) and also work on evaluation of the network/applications.

V. Conclusion

To achieve research integration, it is essential for the actors of a NoE to meet regularly to discuss and coordinate their efforts. It is also highly desirable to support meetings on an opportunistic basis. While travelling remains an available option, it is costly - both in cost and time. These considerations plus the motivation to demonstrate satellite usage in its most powerful personality (namely multicasting) have led to the creation of the SatNEx satellite Platform.

The SatNEx Platform is actively used and is one of the key components for research integration in the SatNEx II Project. This success was made possible because of a carefully crafted methodology for design, testing, and deployment.

VI References

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Annex I – List of SatNEx-II Partners

Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Germany
Aristotle University of Thessaloniki, Greece
Budapest University of Technology and Economics, Hungary
University of Bradford, Mobile and Satellite Communications Research Centre, UK
Centre National d'Etudes Spatiales (CNES), France
Consorzio Nazionale Interuniversitario per le Telecomunicazioni (CNIT), Italy
European Space Agency (ESA)
Fraunhofer Gesellschaft zur Förderung der Angewandten Forschung e.V., Germany
Groupe des Ecoles des Télécommunications (GET/ENST), France
National Observatory of Athens, Greece
Istituto di Scienze e Tecnologia dell'Informazione "Alessandro Faedo" (ISTI), Italy
Jozef Stefan Institute, Slovenia
Office National d'Etudes et de Recherches Aérospatiales (ONERA), France
Paris Lodron Universität Salzburg, Austria
TéSA Association, France
Technische Universität Graz, Austria
Universitat Autònoma de Barcelona, Spain
Universidad Carlos III de Madrid, Spain
The University of Surrey, UK
University of Aberdeen, UK
Università di Bologna, Italy
Universita Degli Studi Di Roma "Tor Vergata", Italy
Universidad De Vigo, Spain