The SatNEx Platform: A Pan-European Satellite Network for Integration, Spreading of Excellence and Training

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***Abstract*— Within the 6th Framework Programme of the European Commission, 22 major players in satellite communications research have joined forces in the European Satellite Communications Network of Excellence (SatNEx). This project is establishing a satellite-based communications platform to allow SatNEx to meet its primary goals of long-lasting integration and the spreading of excellence. This paper discusses the requirements and envisioned scenarios of the SatNEx platform, reporting on the current status of the implementation and the results of the first evaluation tests.**

***Index Terms*—Satellite Communication, Interactive meetings, Remote lectures, Multicast.**

I. Introduction: European Satellite Communications Networks of Excellence (SatNEx)

The relentless growth in the telecommunications industry has made a significant impact on the quality of life of both users and the global economy. New ventures and services are opening up rewarding career opportunities for engineers with the appropriate skills.

For the European economic area to prosper, it is essential that the workforce be armed with suitable expertise. The rapid evolution of today's technology means that there is an ever-increasing demand for knowledge transfer and continued professional development (CPD). Satellite communications represents a specialised, possibly niche, area of telecommunications engineering, which particularly lends itself to CPD. The rapid advancement of satellite systems requires practicing engineers to be regularly trained in the new evolving technologies and applications.

The Satellite Communications Network of Excellence (SatNEx) consortium brings together twenty-two Partners from nine European countries to join forces under the 6th Framework Programme of the European Commission (EC) [1-2]. The consortium is composed of Higher Education Institutions and Research Organisations. Industry Partners are integrated via an Advisory Board. Collectively, the SatNEx Partners have a critical mass of expertise that is currently distributed across Europe (Figure 1). Knowledge transfer to both the research community and satellite industry, are important objectives of SatNEx, including training courses, conferences and workshops, as well as briefings to industry.

Fig. 1: Location of SatNEx Partners [1]

A key goal of SatNEx is therefore the establishment of a common Pan-European Platform providing equitable access to real-time communication services by all Partners. This platform will provide a range of different opportunities 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 coming years.

The geographic dispersion of the 22 SatNEx Partners and disparities between national ground network infrastructure and/or local security policies place a high demands on the current network infrastructure for such interactive communication services. The requirements, usage scenarios, implementation and the results of the first tests using the Platform are described in the following sections.

II. SATNEX COMMUNICATIONS PLATFORM

The SatNEx Platform will allow communication to/from all Partner locations. The geographic dispersion of SatNEx Partners lead to a vision for a "federal" satellite-based system, dedicated to SatNEx communication and able to complement the existing ground connectivity.

Although SatNEx began its activities at the start of 2004, with a two-year contract from the EC, many SatNEx Partners already have many years of experience of collaborative research and training in satellite communications. It is therefore appropriate that the SatNEx Platform will exploit satellite communications technology.

III. SATNEX PLATFORM: FUNCTIONAL REQUIREMENTS AND USAGE SCENARIOS

To enable rapid deployment, and the necessary strong technical support, the consortium decided to issue an invitation to tender and to request the use of off-the-shelf products for the communications platform.

An IP-based approach was required that was able to support a range of collaborative applications, although the initial use of the Platform would focus on IP video/audio conferencing. A solution based on replication of unicast multimedia traffic would not make efficient use of the satellite capacity. Hence, multicast capability was also a major requirement to take advantage of the satellite native broadcast capability. This sends data to both active and passive users only once, as a single IPv4 multicast stream [4-5]. The functional requirements were expressed as a pair of scenarios to be supported by the platform:

A. Remote" Master Lecture" Scenario

In the first scenario, a Partner from the SatNEx community wishes to organize (and broadcast 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., to be answered at the end of the lecture).

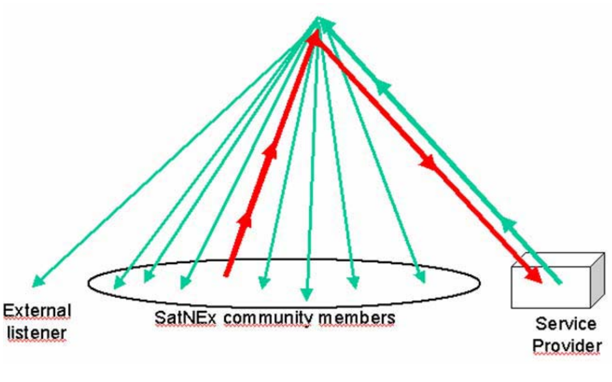

Fig. 2: Topology of the Remote Master Lecture Scenario

The interactivity in this scenario is low. This 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.

This scenario is ideally suited to the unidirectional broadcast nature of a satellite down-link, where any terminal within the satellite down-link footprint is able to receive the same signal. In such a design, the cost of operating the satellite uplink is the same, irrespective of the numbers of receivers. The service could therefore potentially reach a large number of European listeners (equipped with low cost receive-only terminals), far beyond the group of 22 SatNEx Partners.

B. Distributed "Interactive Meeting" Scenario

In the second scenario, a group of SatNEx Partners wish to organize a distributed conference on a specific topic. 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 foreground attendees. This scenario covers a number of cases with different levels of interactivity.

In the case of relatively low interactivity, several speakers contribute, but each takes their turn to contribute their view/presentation. In this case, there are very few changes of speaker, and each takes place in a controlled manner. An example would be a seminar to debate an important issue, where several contributions are made, and then the opinions of a panel of speakers and experts are sought in turn. The other attendees participate passively and are only interested in receiving the general information in this domain.

In the case of high interactivity, a number of speakers could provide contributions as a series of rapid exchanges and without any controlled sequence. Teleconference call, in which speakers seek agreement on topics, are the most interactive (where the speaker changes frequently). However, the dynamics of interactive teleconferences over GEO-satellite are strongly influenced by the appreciable satellite propagation delay and benefit considerably from coordination, for example the ability to ask for and grant access to the "floor". In some specific contexts, broadcasting towards "background attendees" or external listeners might not be acceptable and should be kept optional for this second scenario.

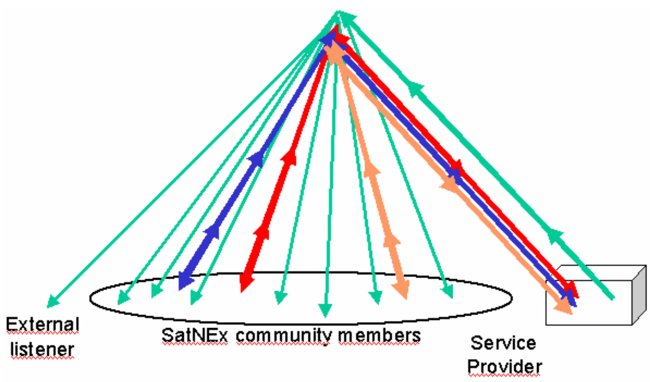

Fig. 3: The Distributed Interactive Meeting topology (with 3 foreground, 7 background attendees and 1 external observer)

This second scenario cannot be considered as a simple extension of the “remote Master lecture” scenario, because of the added complexity required for multipoint bidirectional topologies, multi-party contributions, multi-source mixing, interactivity processing, low latency constraints, full-presence or voice switching management, and multicast requirements. This scenario therefore requires specific architecture and hard/software components.

A bi-directional satellite terminal has benefits for the interactive meeting scenario, especially if the same forward channel could also be accessed by passive attendees with receive-only capability. However adding satellite return capability increases terminal cost and also needs a method to share use of the return satellite capacity. A range of options exist for such bi-directional satellite networks, and include systems using the European DVB-RCS standard.

IV. Communications Platform Solution

The SatNEx community decided to open a tender for the best satellite platform and service solution. Nine suppliers were invited for the tender (including SatNEx Partners and independent satellite operators). Finally, three proposals were qualified and evaluated. After evaluation, it was decided to accept the offer from Fraunhofer Institute (FhI) FOKUS – a SatNEx Partner. The FhI proposal used the Eutelsat SeSat Satellite [11] with coverage over all SatNEx Partner locations. At the same time, this was also the most cost effective offer.

The satellite communication platform provided a flexible solution, based on two independent modules:

- A satellite communication module
- An IP-based videoconferencing module

These modules were interconnected via a 100BaseT Ethernet interface, providing a flexibility that may easily be adapted and scaled according to future SatNEx requirements.

Both “star” and “mesh” topologies would have been possible, but a star/HUB design was preferable since this also was well-suited to the first scenario. The FhI satellite communication module uses the DVB-S standard for data delivery from the HUB towards remote sites. DVB-S data broadcast [6] allows sharing of satellite capacity between many users providing efficient transponder resource usage. The SatNEx Platform will initially support two types of Satellite User Terminal.

Although IP multicast multimedia applications have been available as public domain offerings for some time (many generated by the MBone project [7]), IP multicast was not widely supported by commercial videoconferencing manufactures until 2004. Currently VCON is a leader in IP Multicast solutions in the videoconferencing equipment market. VCON has developed the concept of IP multicast streaming video and audio delivery and implemented this in a PC-based system. For the SatNEx evaluation, it was decided to use VCON equipment as a foundation of the videoconferencing module (Figure 4).

Fig. 4 Typical VCON based client setup [3].

V. SatNEx Communications Platform

A. Central Master Station (FhI)

The Central Master Station (i.e. HUB), is provided by FhI, with the following resources available for the Platform:

- Broadband Internet connection (34Mbps connection to UUNET backbone and back-up link to local ISP),
- A 3.4 m. Andrew HUB antenna pointed to SeSat,
- SHIRON InterSky satellite access system [8],
- IP/DVB encoder and DVB modulator,
- VCON HD 5000 group conferencing unit,
- Rx-only VCON Broadcast unit [3] with IPricot DVB receiver for real time monitoring,
- Tunnel server (through which IP packets from terrestrial-connected receive-only remote sites are routed back to form the return path of the SatNEx network).

B. Bi-directional Satellite User Terminals

Bi-directional satellite connectivity was provided using a Shiron VSAT [8] employing Frequency Division Multiple Access (FDMA) technology. The FDMA return link provides full control of the Quality of Service, QoS. This is attractive for real-time applications, such as Video and Audio conferencing, where delay and jitter are key parameters determining the overall service quality.

The SatNEx platform plans to introduce these terminals at specific sites in mid-2005, although there is already existing experience at FhI of integrating this type of terminal with the SeSat transmission of the FhI HUB.

C. Receive-Only User Terminals

Receive-only sites were able to utilise cost-effective equipment for passive users (benefiting from common standard components developed for DVB satellite TV). The low-cost design also offers the potential for optional "community overflow" of external listeners). A Receive-only SatNEx terminal comprises the following system components:

- 1.2 antenna with professional Low Noise Block, LNB (to receive the SeSat satellite signal).
- IPricot Sc DVB Receiver with Ethernet interface to forward received IP packet streams from the satellite.
- Windows 98/2000/XP PC for VCON vPoint HD software client or VCON Broadcast Viewer.
- Tunnel Encapsulator to provide a terrestrial return IP path (e.g. Linux PC with UDPTunnel Client [10])
- Broadband Internet connection (with 2Mbps of available internet capacity)

VI. Evaluation Tests

Prior to full network roll-out to all 22 SatNEx Partners, an evaluation network was formed with a subgroup of Partners: FhI FOKUS, University of Aberdeen (UoA), Graz University of Technology (TUG) and Groupe des Ecoles des Télécommunications (GET). The evaluation network consists of a HUB station and three remote Satellite User Terminals (initially receive-only). The objective of the evaluation is to test and record functionality, interoperability, stability, scalability and the performance of the satellite platform and videoconferencing equipment, and to ensure that the software conforms to requirements and meets the acceptance criteria of the SatNEx platform.

The SatNEx Platform tender required both the scenarios to be reproduced during this evaluation:

A. *"Remote Lecture" scenario*

In scenario A, IP packets carrying the Video/Audio stream from the currently active lecturer needs to be sent to the HUB, for onward distribution to clients (using satellite IP multicast). Active terminals may contribute via a satellite return link. If the site is connected via a receive-only terminal, the IP packets need to be sent via a terrestrial broadband connection to Internet.

The use of a terrestrial Internet connection raises several issues: First, IPv4 multicast is not supported at all sites, many sites do not currently have a multicast peering with their local ISP (or national network). Second, Partners at sites that have native multicast support need to ensure multicast packets destined for the SatNEx platform are routed to the HUB site. Finally, many sites employ firewalls that need to be traversed to build an operational service. These features are not uncommon in satellite-deployment of IP multicast (some issues and a specific solution are described in RFC3077 [9]).

Within the evaluation network, multicast traffic is encapsulated in unicast TCP packets and forwarded to the satellite HUB using a method based on the open-source UDPTunnel software [10]. This was updated and modified for the SatNEx evaluation platform by UoA. Once packets arrive at the HUB station, they are forwarded over the SatNEx satellite platform to the lecture participants. The topology of this "Remote Lecture" scenario is shown in Figure 5.

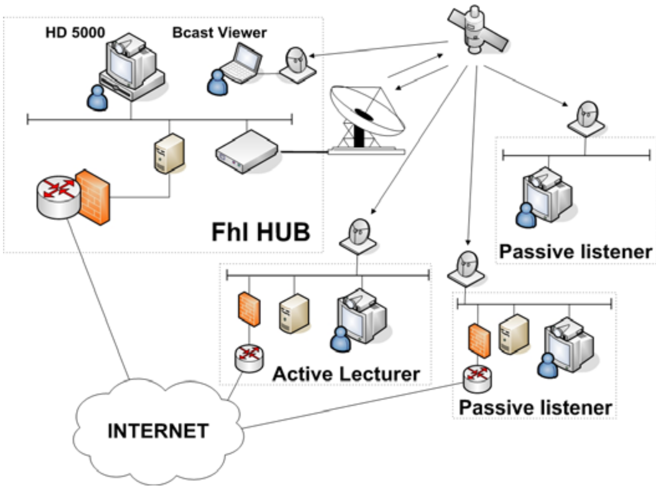

Fig. 5: Network topology for the "remote lecture" scenario

At the time of writing this paper, all participants in the evaluation network had used their installed receive-only terminal for successful tests using a return path via broadband Internet connection. The test Partners have received IP multicast videoconferencing sessions, and have participated in these actively by using the return path tunnel to the FhI HUB site (Figure 3).

B. *"Interactive Multicast" scenario*

The "Interactive Multicast" scenario requires real-time switching of active transmissions between the several contributing Partners. In this scenario, one Partner moderates the session (determines which contributor transmits via the Platform). This process is generally called "floor management". Various options exist for implementing floor management for multimedia sessions. The SatNEx platform employs a floor management protocol that uses a TCP connection from each active Partner to a moderator.

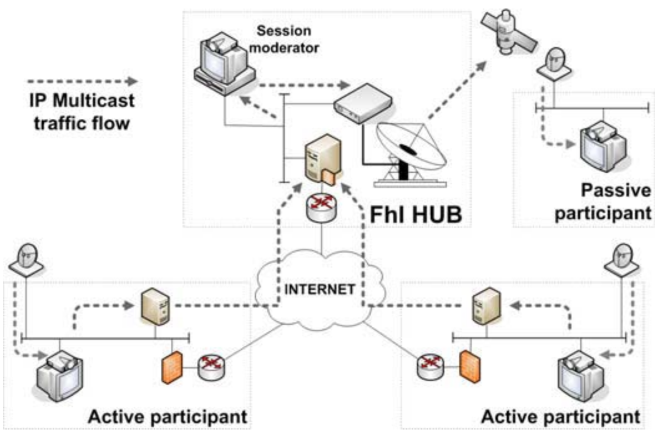

Fig. 6: Network topology for the "interactive multicast" scenario

Three remote sites were used (Figure 6), all with receive-only terminals, two had active participants (using a VCON vPoint HD), one had a passive observer (with a VCON

Broadcast Viewer). An active participant was also located at the HUB site (also with a VCON vPoint HD).

The session moderation was performed by the VCON station at the HUB site (to minimise the switching delay). Multiple sessions were initiated from the Moderator to each test Partner. During the tests, the Active “Floor” was passed to all Partners in turn and each test Partner was able to see and hear the currently active sender (Figure 7).

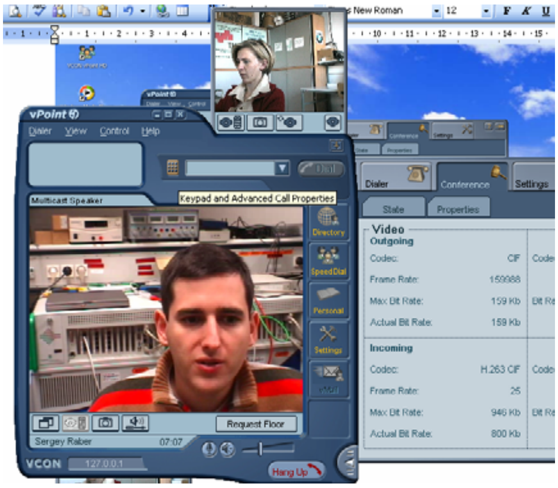

Fig. 7 An interactive multicast stream from FhI is displayed in the large video screen (bottom). After requesting floor by clicking on the “request floor” button, the local video and audio streams of TUG (top) were sent via UDPTunnel to FhI and then transmitted via satellite to remote attendees.

C. *Test Results*

The first results of the evaluation tests demonstrated that IP Multicast-based satellite videoconferencing systems with multiple passive receivers have a promising future. With limited satellite bandwidth, it is possible to deliver real time audio and video traffic to an unlimited number of participants located within the satellite downlink footprint. These evaluation tests will continue throughout the first half of 2005, as other aspects of the roll-out are investigated, including:

- Comparison of different codecs, to optimise video quality depending on data rate (including also H.264/MPEG4),
- Evaluation of the Multipoint Control Unit (MCU) with parallel streaming as an alternative to “Interactive Multicast” technology.

VII. FUTURE PERSPECTIVES

This paper has described the architecture and vision for a pan-European Platform connecting all 22 Partners of the Satellite Network of Excellence (SatNEx). This platform will provide a new collaboration and distance learning environment that is based upon IPv4 multicast networking. The network design permits both low-cost receive-only satellite terminal and bi-directional satellite user terminals.

The current design uses FDMA terminals for the bi-directional return links. However, the use of other access methods is also under investigation. DVB-RCS is also an attractive candidate, enabling very efficient use of spectrum resource. An interface with DVB-RCS networks will therefore be of major importance for the future.

Support for standard TCP/IP-based applications offers the potential for use of a wide range of collaborative tools. It also enables interoperability with other platform initiatives. In the future, "associated" peripheral platforms could collect and/or to re-distribute SatNEx contents. For example, collaboration with the Italian Skyplex network could be envisaged, with the SatNEx platform forming a central, unique and "federal" channel for academic institutions in Europe.

After successful completion of the current evaluation phase, final system roll-out to all 22 sites will take place, providing an operational service to the community. Operating the SatNEx satellite platform for training and spreading excellence will provide the SatNEx community with not only a unique tool for collaboration, dissemination and teaching, it will also provide valuable practical experience of operating IP-based satellite multimedia networks. This will present opportunities for new system improvement and stimulate future research and development.

The final success of the platform depends on the creativity and enthusiasm of all participants. Proposals to deliver lectures and seminars via satellite have already been received.

ACKNOWLEDGMENT

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