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The Implementaion of the pan-European Research Network TEN-155

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The Implementation of the Pan-European Academic Research Network: TEN-155

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Abstract

This paper addresses the implementation of a pan-European network to support co-operative research amongst European researchers: TEN-155.
Predecessors to TEN-155 were TEN-34 and EuropaNet. TEN-155 supersedes these two networks not only in terms of capacity offered but also in terms of the Managed Bandwidth Service (MBS) offered. Besides providing a high speed IP service, the purpose of TEN-155 is also to support research in networking by providing an international test bed for advanced networking technologies (the Quantum Test Programme) and by providing VPNs, with dedicated and guaranteed bandwidth, for specific research projects in countries connected to TEN-155.
This paper will illustrate the use of ATM technology to support the MBS and the Quantum Test Programme in co-existence with the standard best efforts IP service and experiences gained from offering a pan-European Managed Bandwidth Service

KEYWORDS: TEN-155, ATM, Managed Bandwidth, VPN

1. Introduction

The success of EuropaNet [1] and TEN-34 [2] has demonstrated that a dedicated networking infrastructure to the European research community is essential for successful co-operation amongst European researchers. Both these networks have had a short life-time, mainly due to the excessive cost of international capacity. Nevertheless, with the help of funding from the European Commission (EC) it has been possible to deploy them and demonstrate their vital importance to the research community.
The paper will outline the Quantum project and describe in detail the resulting TEN-155 network which supersedes TEN-34 in terms of available bandwidth and above all in the ability to offer a Managed Bandwidth Service to guarantee end-to-end Quality of Service. TEN-155 makes use of ATM, considered the most effective technology to offer guaranteed capacity end-to-end.
A section is dedicated to the Quantum Test Programme, the purpose of which is to evaluate new and emerging technologies and investigate the possibility of their deployment on the production network.
Finally, the paper will focus on a description of the Managed Bandwidth Service (MBS), in terms of its organisation and development phase.

2. The QUANTUM Project

The Quantum Project [3] foresees the exploration and implementation of providing Quality of Service across a pan-European network of very high speed. The Quantum project also calls for experimentation of new IP and ATM technology using a Wide Area and international test network. TEN-155 is the operational network built as a result of the Quantum project. A group of sixteen national Research Networks and one regional network, co-ordinated by DANTE, are responsible for the Quantum Project which is co-funded under a joint initiative by DGXIII (Telematics Applications, Esprit and

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ACTS) of the European Commission.

DANTE is a not-for-profit company set up in 1993 by European National Research Network organisations. DANTE plans, builds and manages advanced networking services for the European research community.

3. TEN-155 physical topology

The physical topology of TEN-155 was dictated by a combination of the following factors:

- cost of international circuits;
- traffic flow requirements, derived from TEN-34 traffic analysis;
- traffic growth prediction;
- what the tenderers were able to offer;
- overall cost of the network;

Following the issue of an open tender, several offers from the tenderers were evaluated, and in August 1998 a contract was awarded to Unisource Belgium for the provision of a number of 155Mbps SDH circuits, the supply and management of an ATM service in all TEN-155 countries, and for facilities management in most of them. Unisource Belgium relies on KPN (the Netherlands) for the implementation and technical support of these services. Fig.1 illustrates the physical toplogy of TEN-155.
The figure outlines the existence of transit nodes (AT CH DE FR IT NL SE UK), interconnected via non protected SDH STM-1 circuits, to which NRNs are directly connected in addition to international circuits to peripheral sites (BE CZ ES GR HU IE LU PL PT SI) or other transit sites.

When comparing TEN-155 to TEN-34, a huge increase in available capacity is immediately noticeable. On TEN-34 the

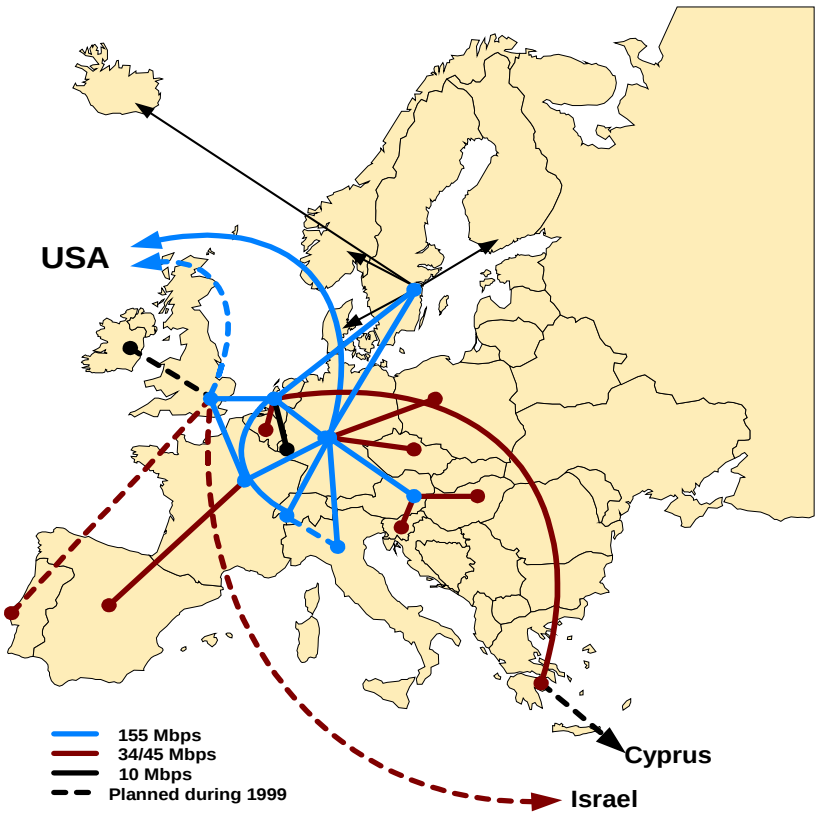

Fig. 1 TEN-155 physical topology in April 1999

highest bandwidth available was a 34Mbps leased line between Germany and Switzerland, now it is 155Mbps on many circuits. In addition, even in countries where capacity still has relatively high prices (Greece, Portugal, Slovenia) it has been possible to deploy 34Mbps circuits. As a result of the 1998 liberalisation of European telcoms services, the overall cost of TEN-155 is similar to that of TEN-34, but the amount of available bandwidth is much higher.

4. The Engineering of TEN-155

The engineering of the TEN-155 network took into account that:

- initially a best efforts IP service is to be provided, to ensure continuity of service from TEN-34;
- a MBS service is to be provided. Developments in the telecommunications market indicated ATM as the only reliable way to provide this end-to-end and across network management domains;
- ATM could also be used as a bandwidth management tool (for example, to distribute IP traffic across available circuits).
- it must be possible to setup, using the MBS, a VPN dedicated to the evaluation of networking technology. This evaluation is a component of the Quantum project and is implemented in the Quantum Test Programme;
- it must be possible to implement value-added services such as advanced monitoring and Mbone.

These requirements and conditions led to the following design decisions:

- as ATM was indicated as the most reliable way to provide MBS, the international SDH circuits are terminated on ATM switches dedicated to TEN-155;
- to provide an IP service to the NRNs, IP routers managed by TEN-155 are installed in the transit nodes of TEN-155. NRNs connect to TEN-155 by setting up BGP sessions between their access routers and the nearest TEN-155 router;
- to support at the same time best efforts IP traffic on TEN-155 and guaranteed traffic for MBS, UBR-like VCs between routers to carry the IP traffic are established whilst CBR VCs are established between the end points that require MBS. ATM switches that enable co-existence of the two ATM Traffic Classes (ATCs) in a dynamic manner have been deployed: best effort IP traffic (UBR) may take up the whole bandwidth if no guaranteed traffic (CBR) is flowing, whilst in cases of congestion the switch will drop the UBR-like traffic and let through the CBR or guaranteed traffic;
- to minimise the required capacity between switch and router (which in turn means minimising the number of STM-1 interfaces on switches and routers) a full mesh of UBR-like PVCs is set up between the TEN-155 routers in the transit nodes. In addition the full mesh allows to load balance the bandwidth usage independently of IP routing and provides more stability at IP level. Workstations are installed in the transit PoPs to allow implementation of advanced monitoring tools and deployment of Mbone.

5. TEN-155 US service and connections to other networks

DANTE organised the procurement of 2 SDH/STM-1 circuits from Frankfurt and London to New York to offer transtalantic services to several NRNs. The transatlantic SDH/STM-1 circuits terminate on ATM switches (the TEN-155 switch in Frankfurt and London, and on another switch managed by DANTE in New York). The service offered to the subscribing NRNs is ATM directly into the NRN, so it is as if the NRN had their own transatlantic link on IP level.

Another add-on to the TEN-155 network is

the connection of Israel and Cyprus, as a result of the EC approved Q-MED project. DANTE is co-ordinating the connection of these countries to TEN-155 which in the case of Israel is being implemented by a E3 circuit from London to Tel Aviv. The connection is engineered in such a way as to offer to Israel the same services available to the NRNs taking part in the Quantum project. Planning of the connection to Cyprus is still in progress.

6. The Quantum Test Programme

As previously mentioned, the Quantum Test Programme (QTP) is a substantial component of the Quantum project. The main objectives of QTP are to carry out evaluation of advanced networking technology and network related technology on a dedicated test bed and migrate where possible the technology to the production service. The dedicated test bed is obtained by setting up a set of PVCs to create a VPN. QTP activities are carried out by a joint DANTE-TERENA task force, TF-TANT, which carries out evaluation of technologies that are also relevant to the TERENA working group on lower layer technologies (WG-LLT). The activities relevant to QTP are as follows:

- Multicasting (IP and ATM)
- IP QoS (diff-serv, RSVP, RSVP to ATM SVC mapping)
- IP over ATM
- ATM SVCs
- IPv6
- MPLS
- Route monitoring
- QoS and Flow based monitoring

7. The TEN-155 Managed Bandwidth Service

7.1 Introduction to the Managed Bandwidth Service

There has been a growing demand for guaranteed bandwidth resources to serve specific research purposes and experiments of the European academic and research community. The JAMES trial and the demand it generated from EC supported projects and other academic institutions was a solid indicator that providing a Managed Bandwidth Service (MBS) along with the general purpose IP service would be an interesting idea for the next European Academic Backbone, the successor of the TEN-34 Academic Network. Implementation would depend on the network architecture.

7.2 Service Overview

MBS allows the definition of Virtual Private Networks linking members of a project and supplying them with network resources defined as bandwidth requirements, lifetime of the established connections, traffic profile and a complete set of network parameters [4]. Due to the importance of the operational IP service within the TEN-155 network, available resources with regard to bandwidth and the number of connections destined to MBS may be limited. However, once resources are allocated, they are guaranteed.

MBS may use existing network resources of those National Research Networks (NRN), connected to TEN-155. An initial limit of 10% to 20% of the existing bandwidth between the NRN and TEN-155 is expected to be used to cater for service requests. NRNs will make these resources available under their acceptable use policy or ad-hoc procedures.

MBS is an end to end service. Its availability depends not only on the TEN-155

network but also on the NRN network infrastructure and the existing technical and human resources within the TEN-155 community. MBS' main goal is extending coverage of ATM based connections and virtual private networks to all NRNs connected to TEN-155.

Usage of a NRN access port must be authorised by a person responsible for the national ATM service. For the international path DANTE is the responsible organisation acting on behalf of the QUANTUM consortium and will also co-ordinate interaction with Access Port Managers (APMs) in the NRN for authorisation and other purposes. Connections can be established directly between network equipment belonging to the project and those of the TEN-155 network. In that scenario, national transit and access to the TEN-155 point of presence is the responsibility of the project.

port. In this case the TEN-155 port acts as the demarcation point between the national and the international paths.

Overall limits to allocated resources exist to prevent network “hogging”. These initial limits, subject to revision during the evolution of MBS, are implemented by restricting total usage between TEN-155 user access ports to no more than 10 concurrent VCC / VPC through any TEN-155 user access port. The maximum amount of bandwidth allocated at any one time at any NRN access port shall be no more than 20% of the access capacity.

7.3 Service Architecture

The definition of the end-to-end connection depends on the availability of the requested options all along the path

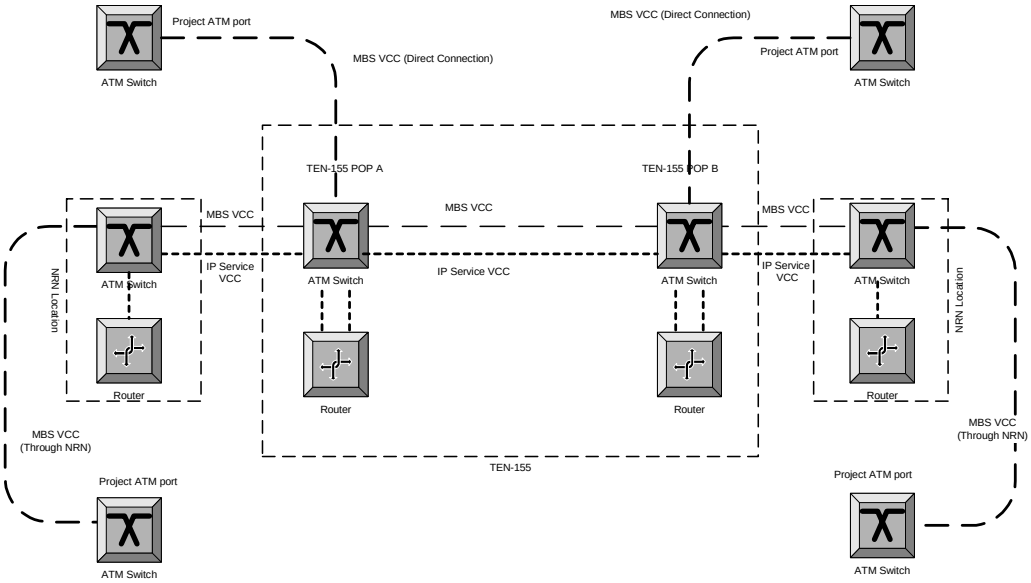

Figure 2: MBS administrative domains

through several different administrative

Figure 2 identifies the different network equipment involved (Routers, ATM switches) and the ATM links to be established when the connection is made directly to a TEN-155 port (located in the national TEN-155 Point of Presence) or when the NRN is used to provide transport between the project port and TEN-155

domains between end points. This means that available options for connections depend on the ATM service implemented or used in the NRN providing part of the resources. Support for the following elements has been built into the TEN-155 backbone:

- Depending on how the connection is established and released:

Permanent connections (PVC), established by the network operations center by using network management tools.
Switched connections (SVC), established by user ATM equipment using signaling (available during 1999).

- Depending on the duration of the connection (PVCs only):

Scheduled occasionally, start time and end time known.
Permanent static, start time known, end time open.
Permanent periodic, start date for period known, end of service date open, time pattern specified with periods of connection availability on a daily basis, weekly, etc.

- Depending on the ATM type of connection:

Virtual Channel Connections (VCC), the minimum element able to transport cells. Every ATM connection is composed of at least one VCC.
Virtual Path Connections (VPC), identifier of a set of VCCs. VPCs are only available for PVCs.

- Depending on the number of end points:

Point to point, one source, one end point.
Point to Multipoint, one source, many end points (available during 1999).

- Depending on the requested transfer capability (with specifications according to standards ITU I.371, ITU I.356)

Deterministic Bit Ratio (DBR) with QoS-1, traffic parameter: Peak Cell Rate (PCR)
Statistical Bit Rate (SBR2 or SBR3) with QoS-3, traffic parameters: Peak Cell Rate (PCR) and Sustained Cell Rate (SCR).
Available Bit Rate (ABR) with QoS-3, traffic parameters: Peak Cell Rate (PCR) and Minimum Cell Rate (MCR). This transfer capability is expected to be available during 1999.

7.4 Service Management

Being a new service, the interfaces are a critical component for the success of the service. Some important criteria include keeping the initial contacts limited to the project participants and DANTE until a clear project plan is outlined. From this moment, information can be presented to the NRN responsible person in an adequate way. Another important issue is to avoid being involved in national issues, by leaving NRNs the last decision. Three interfaces are needed, as persons and contact points during the process: A Group Network Manager (GNM) from the project side, an ATM service co-ordinator from the NRN and a single contact for the ATM TEN-155 service provided by DANTE.

Organisations participating in a project identify a Group Network Manager whose role is the co-ordination of all the members in the project and communication with DANTE.

The primary channel of communication is between the GNM and DANTE. DANTE will contact the responsible person for the ATM service of the NRNs involved and will stay in constant contact with the GNM, as the single contact point to the project.

To make the initial request the GNM sends DANTE a minimum set of information aimed to help evaluating the project feasibility, the amount of resources needed and a cost estimation in case additional equipment or resources are necessary. Web forms or electronic mail are used as tools for requesting submission and tracking.

Similar services to the TEN-155 MBS have been deployed and are in operational or pilot status in some European Academic networks. When the project has sites in these networks, references to local procedures are given as the way to obtain service. In those networks without operational

service, initial contacts with ATM service co-ordinator from the NRN, to determine necessary and available resources (human and technical) to connect a project member, are established by DANTE. Information about the project, to describe the technical set-up, may be required for participants in different countries. The GNM is responsible for information gathering within the project.

Once the project feasibility is verified, necessary arrangements may be made directly between the NRN's ATM service co-ordinator and the GNM to implement the connection of each site with the NRN port. In case of difficulties, the GNM-DANTE channel remains the priority means of communication. This avoids overloading the ATM service co-ordinator in the NRN side.

The result of the service request process is an activity plan to be performed by the involved parties, identifying action points, resources, timelines and costs. This plan must be accepted by all parties and is the definition of the project. Contracts between the project and some parties may be signed as consequence of different policies in resource allocation.
Once the project is running, service management is done by the TEN-155 ATM Network Operations Centre (ATM NOC).

7.5 Service Deployment

As the Managed Bandwidth Service is new and untested, an alpha and a beta test phase were planned before the service would be made generally available. In the first instance, the service has been provided on a pilot basis to an alpha user in a limited set of countries (France, Germany, UK). ERCIM, an Associated Contractor in the QUANTUM project, has provided the alpha user in the form of the MECCANO project whose partners include several ERCIM institutes.

The dual objectives of the MBS alpha test were to demonstrate that the service works, and to develop a complete set of operational procedures and tools while verifying that the evolving procedures work well. The approach taken was determined with a view to doing something simple successfully. This was achieved by limiting the test to one project group, MECCANO, with connections to one site in each of three countries.

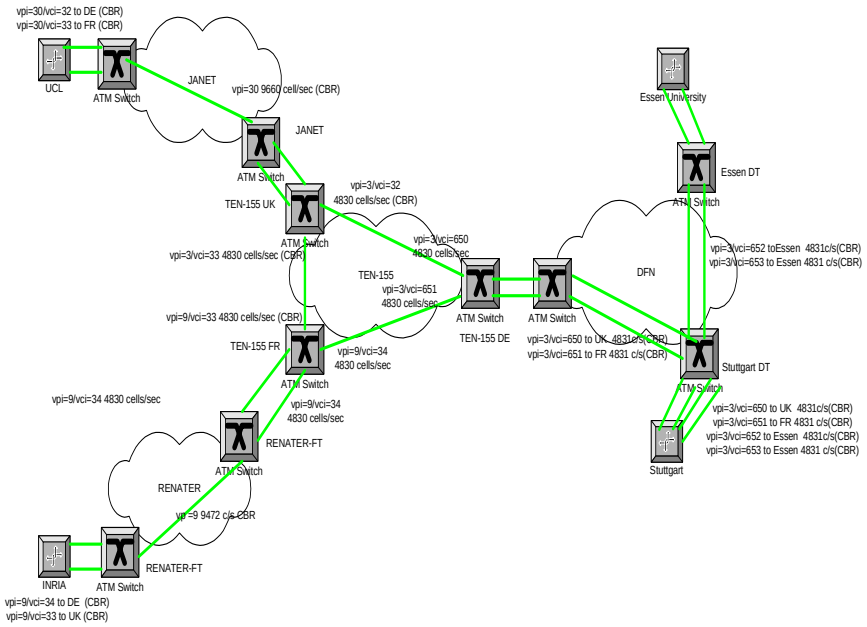

Figure 3: The MECCANO setup

MECCANO's [5] initial requirement was to connect its three sites with a 4 Mbps Virtual Private Network (VPN) for regular Monday afternoon sessions. In addition to the weekly sessions, the VPN was active from 22-26 February, and extended to include a conference centre in Essen, Germany, allowing DANTE and MECCANO to successfully demonstrate the TEN-155 Managed Bandwidth Service during the launch of the EU Fifth Framework Programme.

MECCANO found that the agreement phase for the requested VPN, whereby DANTE liaised with the NRNs to arrange connection for the project, proceeded smoothly. As was expected, the delivery stage of the VPN was considerably more difficult. This was caused by some confusion in the chain of responsibility within the NRNs and the difficulty in ensuring that each NRN configured the same level of service to each partner site. When all the MECCANO sites and the NRNs had agreed on a common service, connections between them were established smoothly. Once the connections were established, they performed well.

MECCANO concluded [6] that MBS, in general, performed well and the service had the potential to be very useful for the MECCANO project. MECCANO noted, however, that a pure ATM service, whilst allowing for great flexibility in terms of its use - since it is a level 2 service – placed a heavy burden on the users of that service, who must configure the IP level routing and set-up an IP VPN themselves.

Overall, the alpha test was successful. It accomplished the objective of demonstrating that the MBS service works, and it has provided the opportunity to develop the necessary operational procedures which will be put in place during the beta test. From the user's perspective it provided a valuable service, which performed well. However, it also highlighted certain problem areas where additional effort is required to ensure a smooth operation on a larger scale. Adjustments to the administrative aspects are being made to improve the efficiency of the service. In particular, an overview of the situation in each NRN with respect to the provision of ATM servicesis being compiled to facilitate the initial establishment of the VPN. The longer-term technical issues are also being investigated [7].

It was anticipated that there would be variations in the service that could be provided by different NRNs. At the start of the alpha test, DANTE did not have a sufficiently clear view of the administrative contacts and procedures for each NRN, the ATM features that could be supported by the NRNs involved, the time required within each NRN to implement the required VCs, nor what costs would apply for the national parts of the service. There did in fact prove to be differences between the NRNs; it was quickly confirmed that a complete set of information needs to be compiled with respect to the MBS contacts, possibilities, delivery time scales and charging mechanisms in each country.

7.6 Current Status and future evolution

After the initial steps, a second phase is taking place. Objectives of the beta phase are extending service coverage to more countries and national research networks and, by doing that, identifying the correct procedures and interfaces in those "new" participants. Allowing more density of project ports per country is also in the objectives of the beta phase, as well as having several projects running simultaneously on the network with different resources.

As a result of the experiences accumulated in the beta phase, a map describing the expected service across NRNs in the TEN-155 Network is to be produced. One lesson learned is that a global set of procedures is

not a good idea and a localisation of a generic procedure is the way to go.

Another important result of the beta phase is to obtain a list of prices for connectivity in every NRN. Price information availability is a very important information element for those EC funded projects evaluating the use of TEN-155 for their networking requirements.

Several users have used the TEN-155 MBS as part of the beta phase, EDISON [8], SUSIE [9], QTP [10] (mpls experiment); and others are waiting for production stage. The configuration and setup of these networks have been smooth and very fast, taking less than five days from the initial contact in the case of the SUSIE virtual classroom event.

It is clear that, to be successful, a Managed Bandwidth Service must achieve faster bandwidth brokerage from the set of provider invloved, ieVCs must be set up on a timescale equivalent to the lifetime of the link and should require no specific action on the part of the administrative domains involved in the set-up.

Another message has been received during the initial stage of the MBS service: While ATM can be seen as the tool to provide a managed bandwidth service, IP is the (almost) universal network protocol, and ways must be found of better integrating IP and ATM services avoiding the need for reconfiguration at the IP level.

Conclusions

The Quantum project has been successful in deploying a pan-European network for research, providing a huge increase in capacity when compared to its predecessors and at a similar price. This is mainly due to developments in the European telecommunications market. From the technical point of view, TEN-155 has been designed to make efficient use of the available bandwidth and fair sharing of the bandwidth in situations of congestion. These targets have been met by combining different ATCs, and the results obtained in test laboratories confirmed the theoretical expectations. Rollout of the MBS and the work carried out within the Quantum Test Programme is expected to enhance even further the capabilities of the network, with the deployment of native multicast and developments in the area of the co-existence of differentiated and integrated services.

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evaluation of networking technology in the Quantum Test Programme, who provide continuous input to the introduction of new services on the operational network.

Vitae

Roberto Sabatino joined DANTE in July 1997 and was initially involved in the development of TEN-34. He was then involved in the planning and engineering of TEN-155 with particular attention to the ATM level design. Roberto is Head of Network Engineering and Planning at DANTE.

Jose Manuel de Arce joined DANTE in August 1998 and his work has focused on the planning, development and deployment of the TEN-155 Managed Bandwidth Service. Jose works in DANTE Network Operations and is involved in IP and ATM support of TEN-155.