Towards Integrated Network Management for ATM and SDH Networks supporting a Global Broadband Connectivity Management Service

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Abstract

This paper reflects the initial work of the ACTS Project AC080 MISA, a three year project, started at the beginning of 1996, whose main task is to accomplish and validate an integrated end-to-end management of hybrid SDH and ATM networks in the framework of open network provision (ONP) via European field trials.
This paper provides the initial description of an integrated network management of ATM and SDH networks and the definition of a new Service called Global Broadband Connectivity Management (GBCM), enabled through TMN. The enterprise model supporting both topics is described.
The GBCM service offers the required functionality to establish and manage end-to-end broadband connections in a multi-domain business environment. Its implementation by the MISA project, within trials across Europe, aims for an efficient management of the network resources of SDH and ATM infrastructure, while meeting the quality of service and the needs of a number of telecommunications actors: customers, value-added service providers and network providers.

Acknowledgements

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Keywords

ATM, ACTS MISA Project, Co-operative Network Management, Global Broadband Connectivity Management, Integrated Broadband Communications, Open Network Provision, SDH, and TMN.

Introduction

The end-to-end management of broadband connections has been found to be very complex, especially in a multi-provider, multi-domain environment.
Typically, today, the setting up and re-configuration of such connections are performed through manual actions using faxes and telephone calls.
One of the main goals of the ACTS AC080 MISA project is to automate the operator configuration and maintenance functionality, so as to satisfy end-user requirements. This will be achieved by provisioning of open interfaces to the management centers for the necessary co-operation between management systems. This goal is vital to continue the development of the Integrated Broadband Communication (IBC) Infrastructure.
Currently, ATM and SDH are the most popular technologies for supporting broadband telecommunication. While ATM is designated by most standardisation organisations such as ITU and ETSI as the B-ISDN interface for end-user applications and is already used in LAN/CPN domains, the SDH transmission technology is more ubiquitous among the national carrier and bearer transmission service provider.
General efforts towards SDH network management (e.g. ITU-T G.784, G.774, G.774-01, G.774-02, G.774-03, G.774-04 and G.774-05) and ATM network management (e.g. ITU-T I.751, ETSI NA5-2210, ATM Forum M2 and M4 interface specifications) are largely uncorrelated. The availability and provisioning of Broadband Services on top of hybrid SDH/ATM networks require a uniform and integrated network management system to control such different network resources.

The paper is structured as follows: first the enterprise model supporting the provision of the GBCM service is described highlighting the requirements fore ATM and SDH integration from the different actors' points of view, then the reference architecture for the management of broadband connections spanning hybrid ATM & SDH domain is presented, identifying the reference points and the interactions among the system components and system interfaces; finally, a more detailed description of the components responsible for integrating the management of ATM and SDH networks at the network management level of the TMN is provided.

The Global Broadband Connectivity Management (GBCM) Service

The development of the Global Broadband Connectivity Management (GBCM) service is one of the main themes of the work of the MISA project. MISA assumes that Integrated Broadband Communication Networks (IBCNs) will consist primarily of ATM and SDH equipment providing basic ATM bearer-services. The MISA GBCM service will allow these network resources to be used in a co-operative and efficient manner, addressing the needs of:

1. customers requiring connectivity services,
2. network providers needing to make optimal use of their own resources and requiring timely identification and notification of performance or quality of service (QoS) changes and faults,
3. network providers who need to negotiate co-operative services with their peers.

GBCM Enterprise Model

In the MISA project, a number of actors and roles have been identified as relevant in the context of provision of the GBCM service [2]. The following subsections are devoted to present the enterprise model.

Actors

The actors composing the GBCM Enterprise model are Public Network Operators (PNOs), Business Customers and Value Added Service Providers (VASPs).

Public Network Operators

PNOs are the owners of the network infrastructure and thus are able to provide broadband connections through their ATM and SDH networks.

They need to manage their network resources and the bearer and tele-services (basic services) supported by the network. The interactions with their customers (VASPs or Business Customers) and with other PNOs, should be performed through management activities covering the standardised general functional areas of Fault, Configuration, Accounting, Performance and Security.

In the case of GBCM, the management differences of ATM and SDH networks are hidden, providing the service management layer with a common, homogeneous view of the underlying management systems and network resources This helps to satisfy the PNO's requirements concerning the integrated management of broadband networks. Below a non exhaustive list of such requirements is provided.

In many PNO's domain an SDH network exists or is planned to exist in the near future. It is expected to be used as the transport network for carrying the ATM traffic originated by the customer's applications.

In such a scenario, where ATM equipment is connected to SDH equipment, integrating ATM & SDH configuration management is necessary for a PNO.

In order to satisfy the QoS requested by the customer, PNOs may adopt SDH resources to protect ATM connections (i.e. exploring the protection capability defined for the SDH layer; this should happen transparently to the customer).

On the basis of a request for bandwidth modification for an ATM connection, the PNO may have to reconfigure the route between two end-points using a different SDH path as server trail.

In the case of connections spanning both ATM and SDH networks, the integration of ATM and SDH fault management would not give any additional benefit in determining that a fault has occurred (someplace), but might help to say more precisely why or where a particular fault has occurred (single SDH faults may cause multiple ATM failures).

The PNO requires to identify the layer (ATM and SDH) at which failures occur to activate the appropriate restoration mechanisms.

An operator needs to gather and correlate performance information from its underlying ATM and SDH networks, as input to its network planning activities. This can be useful for determining whether their SDH and ATM networks are over/under utilised, how to plan for future growth of these networks, and what types of physical connections to their customers will give the greatest return for money invested

Business Customers

A business customer is a collection of users, using various advanced network services mainly for the purpose of their work activities (e.g. tele-conferencing, advanced voice and data transfer services).

Communications within large organisations (e.g. companies, enterprises) with various location spread world wide, have become crucial to their effective operation.

Instead of a customer organisation itself establishing and maintaining its own private network, the responsibility for network and service provisioning has passed to third parties, the VASPs, who may provide: network facilities, end-to-end services as well as service management facilities to potential customers.

In MISA framework, it is assumed that the services offered to the customers are provided either by the network providers directly or through VASPs.

As far as the integration of ATM and SDH is concerned, the following requirements can be identified from the point of view of a business customer:

The lower layers at the customer access point in terms of protocols and line speed should be provided according to the preference of the customer: the access point can be both ATM and SDH.

The customer by means of the same management interface should be able to request both SDH leased line and semi-permanent ATM connections.
The customer should be able to specify the traffic and quality of service parameters for all layers that he is using. In case of using ATM on top of SDH he might want to choose a protected underlying link, for example.
The GBCM service should provide management information (status, performance data etc.) about all connections of the customer, covering the whole distance from customer access point to customer access point via the management interface of the GBCM service provider the customer is registered with.
Notification of reconfigurations due to faults should be sent to all customers affected by the connection failure.
The GBCM service should try to avoid multiple notifications due to the propagation of faults from lower layers within a transmission network to the upper layers or due to multiple transmission systems involved in case of a broken link. This implies the capability of a network provider to correlate multiple redundant alarms.

Value Added Service Providers (VASPs)

As the telecommunication market increasingly follows an open network provision policy, Value Added Service Providers (VASPs) are likely to appear, satisfying the user needs for one-stop shopping, one-stop accounting and one-stop complaining.
VASPs rent physical resources from one or more network providers, services from one or more service providers, add value to those services by guaranteeing better performance, by lowering subscription and operation costs and by offering user-management facilities and providing these value-added services upon a customer’s request, as a homogeneous service package. The customers of a VASP (VASP users) are business or residential users.
The general objectives of a VASP are itemised below:
the service provided to the customer should appear homogeneous, even if several parties are involved in the provisioning of the particular service.
Provide one-stop shopping, accounting and complaining facilities to the customer. The multi-provider, multi-operator nature of today’s networks and the consequent negotiation between customers and several providers, is difficult and un-satisfactory. That is why one-stop shopping for configuration control, billing etc. is demanded.
Provide the customers with the ability to manage, to some extent, their own service.

Roles:

The GBCM Enterprise Model identifies and defines different roles the above mentioned actors may recognise in.

GBCM/GBC Service Provider

This role is played largely by the PNOs. They provide a GBC (Global Broadband Connectivity) service through the network infrastructure. GBC Management provision is through the associated GBCM service. Thus this entity provides both GBC and GBCM services to users.

GBCM Users:

Four different users of the GBCM service have been identified.

GBC-SP (GBC Service Provider)

This role is played by the PNOs. The establishment of a GBC service, when the broadband connection involves more than one administrative domain, requires that a GBC-SP co-operates with one or more other GBC-SPs, using the GBCM, through a co-operating reference point. The GBC-SP requesting the co-operation of the others will play the GBCM User role, while the GBC-SPs replying to the co-operation requests will play the GBCM Provider role.

VASP, Non GBC-SP (Value Added Service Provider, Non-GBC - SP)

This role provides value added services using the GBC (e.g. Video Conference Service, VPN Service). It does not, by itself, provide the GBC, but uses one or more GBC-SP to do this. This type of VASP is likely to offer the selection of the most economical GBC-SP for its users or one stop shopping for this and other services.

VASP, GBC-SP

Such role is played by a PNO who offers to its end-users Value Added Services on top of its network (e.g. a PNO offering a VPN Service). This role is clearly different from the one presented above since, in this case, the VASP is co-located with the GBC-SP.

GBC Consumer

The entities which connect to the GBC network service are consumers of the GBC. They may put information on the network, take information off the network, or both. The GBC consumer interacts directly with a GBC-/GBCM-SP to whom they have subscribed and who is responsible for the establishment, maintenance and billing of the GBC service. Such entities are expected to be, for example, big companies offering to their members services (e.g. video-conference) that require the establishment of broadband connections between far located premises, i.e. require the interaction with a GBC-SP.

Thus this role is expected to be played by business customers.

The above described roles are represented in Figure 1.

MISA Reference Functional Architecture

On the basis of the Enterprise Model presented in the previous section, the following reference model can be derived, showing the identified roles and the interactions among them [3].

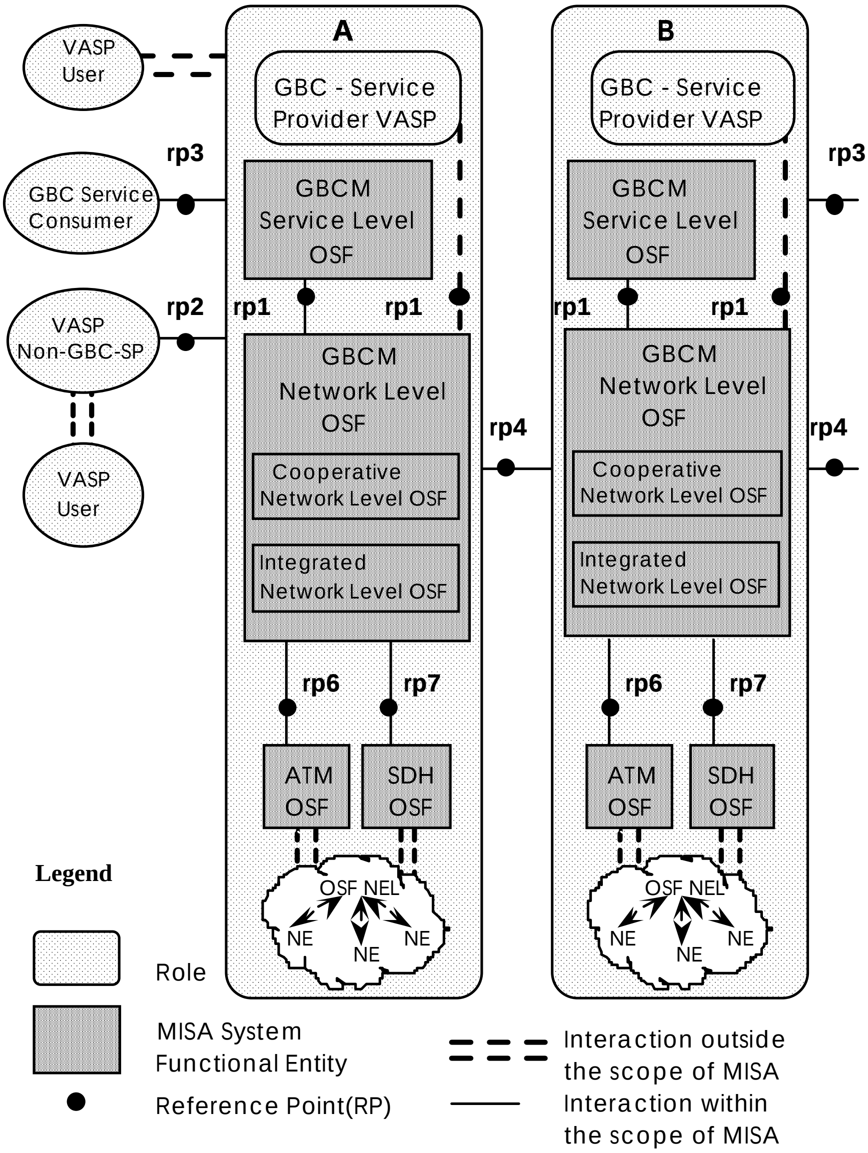

Figure 1: MISA reference functional architecture

The system is decomposed into Operation System Functions (OSF) with reference points (rp) among them compliant with the TMN architecture [4].
At the reference points rp2 and rp3 the interaction between the customer (VASP and business customer respectively) and the GBCM service provider takes place at the service management level of the TMN. Here the customer subscribes to the GBCM service, requests GBC connections, gathers information and receives notifications about them.
The rp1 lies between the service level and the network level of the TMN. The connection requests coming from the customer and their responses pass through this reference point to/from the GBCM Network Level OSF.
As evidenced in Figure 2, the network management layer has been split into two sub-layers: one technology independent, the other one technology dependent. The separation between these layers is at the rp5 reference point. This enables satisfaction the customers connection requests without being bound to a particular technology (ATM or SDH): the technology independent layer is able to employ, according to the

network operator policy, the resources and functionality made available by both, the ATM and the SDH networks. As a consequence, GBC connections can be established spanning only the ATM network, only the SDH network or both.

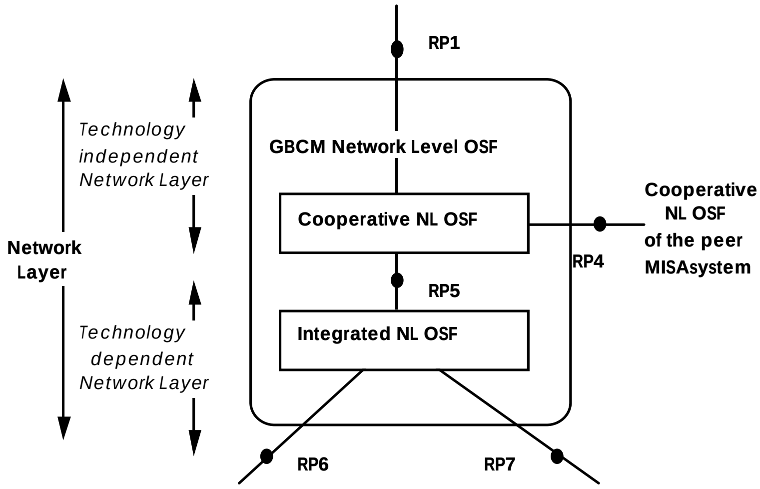

Figure 2: Internal decomposition of the GBCM Network Level OSF

The Co-operative Network Level OSF is in charge of interacting with other peer entities when the destination of the GBC connection requests belongs to other administrative domains. The interactions between peer GBCM Co-operative NL-OSFs applies at the reference point rp4.
The Integrated Network Level OSF performs the integration of the management of ATM and SDH and interacts with the underlying ATM OSF and SDH OSF through the reference points rp6 and rp7 respectively.
The ATM OSF implements the network level management of the ATM network resources, while the SDH OSF implements the network level management of the SDH network resources.

MISA Interface Identification

On the basis of the functional model presented in the previous section, the GBCM management system architecture can be derived.

Figure 3 shows the interfaces identified in the MISA project and the mapping of reference points into interfaces.

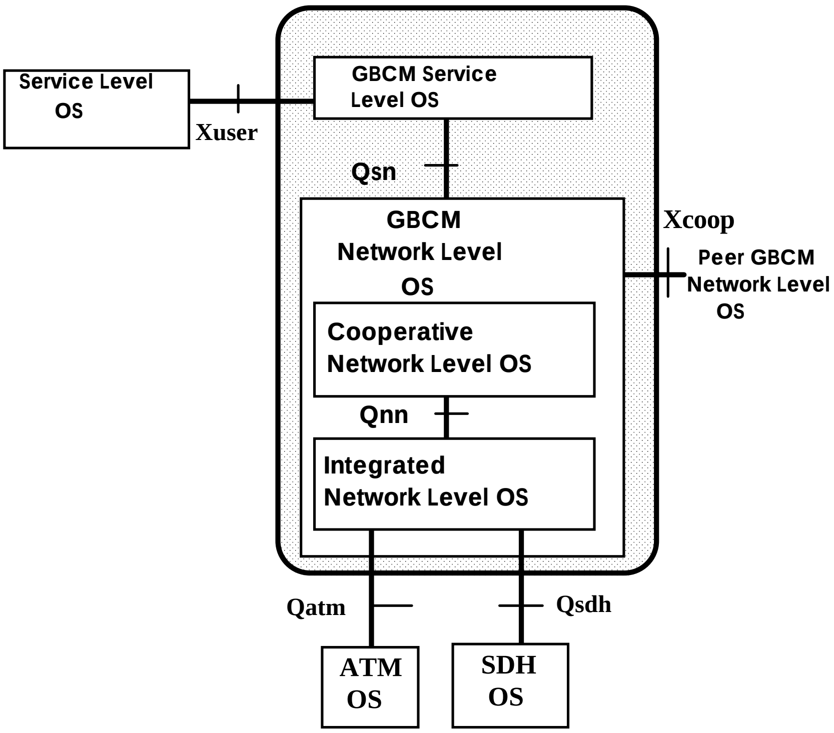

Figure 3: MISA system Interfaces.

In Figure 3 the following components can be identified:

• *Service Level OSs* perform the Service Level OSFs in the management systems of the following GBCM user categories: VASP GBC-SP, VASP Non-GBC-SP and GBC-Consumer.

• *GBCM Service OS* performs the GBCM Service OSF, i.e. it offers the GBCM service management level functionality.

• *GBCM Network Level OS* performs the GBCM Network Level OSF, i.e. it implements the network management level functionality for the provision of the GBC (global broadband connectivity) by managing the local network domain and by co-operating with other peer entities belonging to different domains.

• *SDH Network OS* performs the SDH Network OSF, i.e. it provides the functions for the management of the SDH intra-domain network.

• *ATM Network OS* performs the ATM Network OSF, i.e. it provides the functions for the management of the ATM intra-domain network.

Between these blocks, the following interfaces can be identified:

• *Xuser* is the realization of reference point rp3 and lies between the GBC-Customer Service Level OS and the GBCM Service/Network Level OS; it supports customer access to the GBCM service.

• *Xcoop* is the realization of reference point rp4 and lies between two GBCM Network Level OSs. It allows the co-operations between the GBCM Network Level OSs to establish and manage the global connectivity.

• *Qsn* is the realization of reference point rp1 and lies between the GBCM-Service Level OS and the GBCM Network Level OS.

• *Qnn* is the realization of reference point rp5 and lies between the Cooperative NL OSF and Integrated Network Level OSF.

• *Qsdh* is the realization of reference point rp7 and lies between the GBCM Network Level OS and the SDH OS.

• *Qatm* is the realization of reference point rp6 and lies between the GBCM Network Level OS and the ATM OS.

For the implementation of the MISA system, the GBCM Service OS and GBCM Network Level OS can be realised as a single physical entity (MISA OS). In this case the Qnn interface becomes an internal interface.

Integration of ATM and SDH network management

Key topics for the integrated management of ATM and SDH networks are the correlation of the alarms emitted by the ATM and SDH networks and the definition of appropriate routing algorithms to find paths satisfying the requested QoS. These aspects have been taken into account in the design of the Integrated Network Level OS. Figure 4 depicts its functional components.

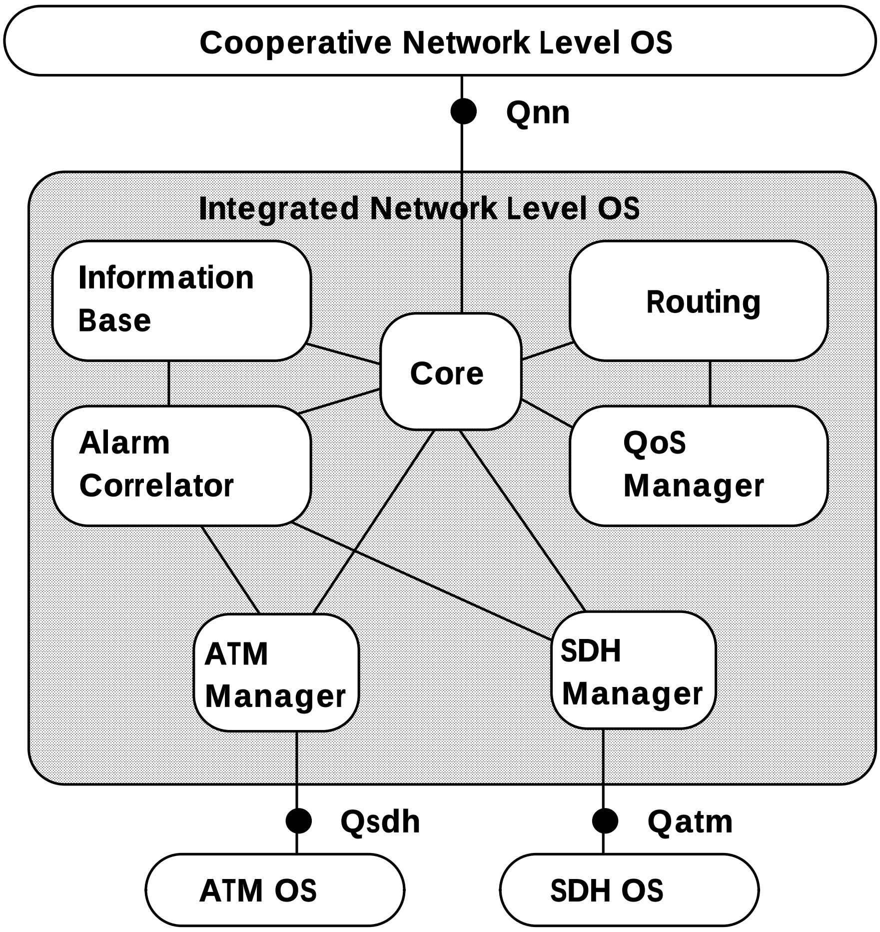

Figure 4: Integrated Network Level OS functional components

Here just a brief description of the functionality supported by each functional block is provided.

Core functional component: it interacts with the Co-operative Network Level OS (through the Qnn interface) by receiving requests and by providing their results. Such requests concern operations on the ATM and SDH resources of the network. Moreover it reports to the overlying OS the relevant notifications affecting the connections requested by users.
In order to accomplish its job, the Core exploits the functionality provided by the other functional components and co-ordinates the execution of the tasks within the Integrated Network Level OS.
The Core is also able to activate a procedure which enables to retrieving all the MIB information from the underlying ATM and SDH agents within the ATM and SDH OSs respectively.

Information Base functional component: it permits the access to all information necessary for the other functional components to perform fault, configuration and QoS management operations under their responsibility. The Information Base contains in particular the end-user access points to the network, the end-points of the links connecting two adjoining administrative domains (inter-domain access points), the configuration of the intra-domain network in terms of access points interconnecting the ATM and the SDH networks (inter-technology access points), the status of the connections established in the network, the event notifications sent by the underlying ATM and SDH OSs and the measured or estimated values of the relevant QoS parameters related to the connections between the access points viewed by the Integrated Network Level OS.

Routing functional component: it is invoked when hybrid ATM/SDH intra-domain connections have to be established. This happens when an ATM connection or part of it has to be supported by an SDH path or when the Co-operative Network Level OS requests a connection between an ATM end-user access points and an SDH inter-domain access point. The routing functional component is in charge of identifying the set of routes between the intra-domain connection end-points satisfying the network provider’s routing schema. It interacts with the Information Base to take the needed topology information about the interconnection points between the ATM and SDH networks. The result of the routing algorithm is the input of the processing activity of the QoS Manager functional component.

QoS Manager functional component: it is in charge of selecting, among the routes calculated by the Routing component, those routes that satisfy the QoS requested by the user. In order to perform this job, it interacts with the Information Base in order to retrieve all available information concerning the QoS values guaranteed by the network.

Alarm Correlator functional component: its aims at the correlation of the alarm notifications coming from the SDH-OS and ATM-OS the Qsdh and Qatm interfaces. A set of rules have been defined to identify the alarm root cause, taking into consideration the network configuration (i.e. the relationship between SDH and ATM network layers) and alarm notification types. The objective is to emit towards the Co-operative Network Level OS (through the Qnn interface) the minimum possible number of notifications providing the most useful and fruitful set of information about the original causes of the faults.

Atm Manager functional component: it interacts in the manager role with the ATM OS and adapts the commands received from the Core (e.g., the establishment of a connection over the ATM network) to the specific Qatm interface. The results of the operations requested by the Core are reported to the latter; the alarms coming from the ATM OS are transferred to the Alarm Correlator block, while the other event reports are transferred to the Core.

Sdh Manager functional component: it interacts in the manager role with the SDH OS and adapts the commands received from the Core (e.g., the creation of a protected SDH connection) to the Qsdh interface. The results of the operations requested by the Core are reported to the latter; the alarms coming from the SDH OS are transferred to the Alarm Correlator block, while the other event reports are transferred to the Core.

MISA System Validation

The validation of the MISA architecture specified for the integrated management of ATM and SDH networks is being realised using and adapting the resources (physical equipment and management systems) available in some European experimental ATM and/or SDH networks called National Hosts (namely Germany, Greece, Italy, Portugal, Spain, United Kingdom). The realisation of the MISA system is being performed by using two different commercial management platforms.
At the end of 1996, ACTS MISA milestone CRISTINA [5] established a partial (test-lab) demonstration of the MISA components and testing systems. It shows our architectural design concepts and reflect the status of the implementation work, that is geared towards achieving the ultimate MISA project goals of a trial of integrated end-to-end management of hybrid ATM and SDH networks.
In particular, CRISTINA features implementations of X.700 agent/managers running on full Q3 stacks and based on the implementation of the interfaces mentioned in this paper. It includes snapshots of the management information models specified in the interface ensembles for configuration and fault management, and will emulate the real resources of the eventual trial environment. The prototype is able to demonstrate features related to the integrated management of ATM and SDH networks and the co-operative management of the network infrastructure.
Web-based access to the ME15 CRISTINA demonstration allows a high degree of location and platform independence. The translation between the full Q3 stack access to managed objects and the Web is achieved with management servers offering high-level symbolic CMIS interfaces for languages including HTML and JAVA.

In the CRISTINA demonstration of the MISA system (see Figure 5), the Webbin CMIP and Java language/environment are used for the integration of the demo components with the graphical user interfaces. Webbin CMIP is a gateway that converts http requests to CMIP requests and it can be used for communication with the designed agents/managers.

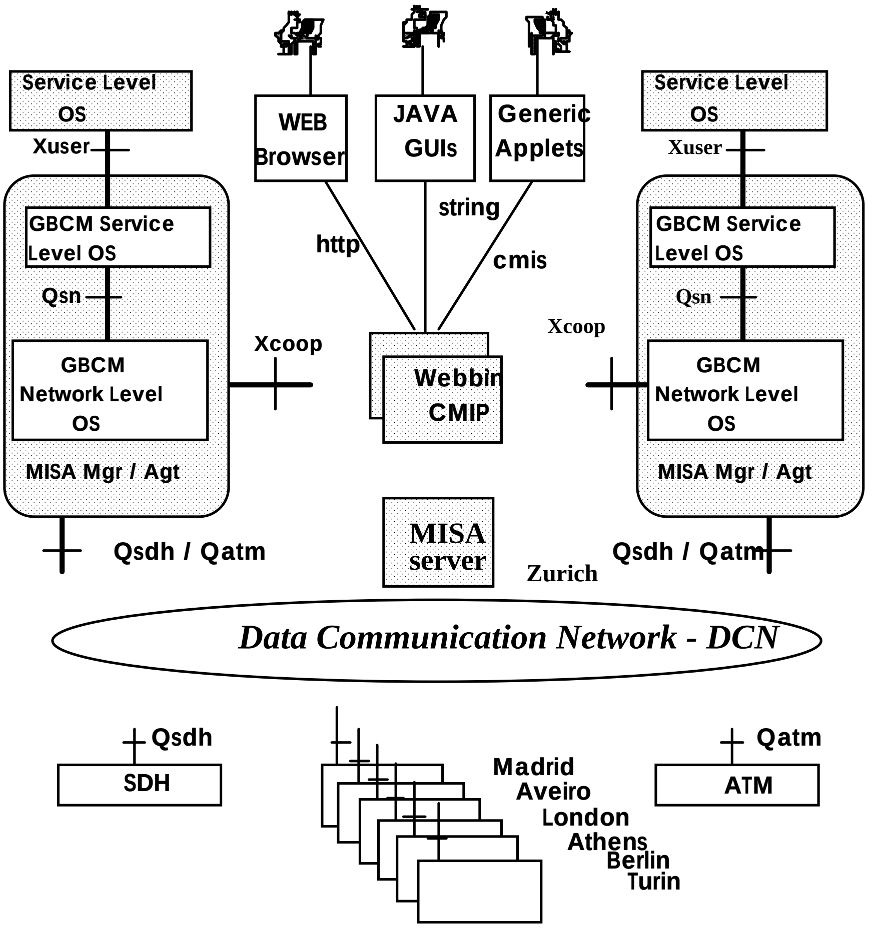

Figure 5: MISA Demonstration Scenario

The development is progressing in the MISA project towards a full implementation of specified components and interfaces.

Conclusion

We have described in this paper an approach to integrate the network management of ATM and SDH networks to support the provision of the GBCM service. It will be validated and demonstrated by the MISA project, in a multi-domain environment, through Pan-European trials.
The proposed architecture and enterprise model make possible the development and provision of the GBCM and integrated network management as distributed system. This will allow many PNOs to co-operate in providing end-to-end manageability of their broadband networks.

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Abbreviations

CPN	Customer Premises Network
GBC	Global Broadband Connectivity
GBCM	Global Broadband Connectivity Management
IBC	Integrated Broadband Communication

OS	Operation System
OSF	Operation System Function
PNO	Public Network Operator
QoS	Quality of Service
RP	Reference Point
SP	Service Provider
TMN	Telecommunication Management Network
VASP	Value Added Service Provider