ACTS GUIDELINE
NIM-G3

STRATEGIES FOR
THE INTEROPERABILITY OF
MANAGEMENT SYSTEMS

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Main contributing projects:
COBNET
METON
MISA
MOON

Other contributing projects:
DIFFERENCE
FLOWTHRU
MEPHISTO
PANEL
PROSPECT
UPGRADE
WOTAN.

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1. Executive Summary

This guideline addresses Network Management interoperability in a future (integrated) broadband network context. Network management evolution depends on the evolution of the Network itself and on the evolution of Software Technology.

Key network evolution issues are:
- Will SDH/SONET and WDM constitute the base for the entire future transport infrastructure?
- Will ATM dominate access, or will ATM backbones be seen as part of the transport infrastructure?
- Will increased globalisation and convergence between transport and access lead to new markets for global Transport Service Providers?
- What impact will the large investments that have been made in SDH/SONET have on the adoption of evolving technologies such as WDM and ATM?
- Will there be a pure optical layer? Or, will WDM elements continue to be integrated with current SDH systems?
- Is IP over SDH/WDM a rival or just a complement to ATM?

Key software technology trends are:
- TMN systems are becoming mature, but technologies such as CORBA and Java are bringing new aspects to the framework.
- “TINA similar” architectures are developing as the network and the software infrastructure become more sophisticated.
- The use of Software Components and object-oriented communications platforms, together with (simple) off-the-shelf GUI environments, is becoming a de facto choice for most management systems developers.
- Object-oriented Programming Interfaces (APIs) are being defined and standardised, as alternatives to traditional protocol oriented interfaces.

A scenario is used to provide a context for discussing the interoperability issues. It assumes that convergence between transport and access will lead to Virtual Transport Networks (VTN). In this scenario, new service providers, who may not have any infrastructure of their own, lease VTNs to build global transport networks.

The guideline introduces the ACTS projects working on management system interoperability and reviews the state of the art in network management technology. It then explores the implications of the Virtual Transport Network scenario, defines the requirements for interoperable and integrated management systems, and discusses the management information flows that are needed to achieve the desired levels of interoperability or integration.

It concludes that, in a Virtual Transport Network environment:
- interoperability on a Network Element level is not as important as Subnetwork-level interoperability.
- To achieve interoperability between subnetworks, uniform programming interfaces need to be specified.
- Integration, i.e., providing a single point of access for the management of several network entities, is a matter of customisation, but emerging component technology, like Java Beans, will likely create a de facto standard for Integration Frameworks.
- To identify the management level, on which interoperability vs. integration is required, it is important to specify a business process model and to identify management information flows. Both NMF and TINA-C have defined models for this.
- Full interoperability would require full standardisation of interfaces, protocols and information models. TMN will continue to constitute a “reference model”, while the implementation of management systems will take advantage of new possibilities offered by CORBA, Java, WWW.
2. Objective and Rationale

This guideline presents a possible scenario for the evolution of Broadband Transport Services, based on Synchronous Digital Hierarchy (SDH), Asynchronous Transfer Mode (ATM), and Wavelength Division Multiplexing (WDM). The objective is to identify network management requirements and issues.

Evolving transport networks are integrating different technologies that range from pure optical transmission to cell and packet switching. At the same time, the access network is offering bandwidth capacities that exceed those offered by legacy transport networks. The boundaries between transmission core, switching and access are becoming difficult to determine. A common question in this context is whether ATM is a technology for access, for transport or for both.

Looking at how Virtual Private Networks (VPN) have created new opportunities in the access network, leads to a scenario where a convergence results in Virtual Transport Networks (VTN). In this scenario, new service providers, who may not have any infrastructure of their own, lease VTNs to build a flexible (i.e., re-configurable, scalable and maintainable) transport network and offer global broadband connectivity and services.

A critical factor in this scenario is Network Management inter-operability, which is required both internally, for a VTN provider, to be able to create virtual networks that are equipment transparent, and externally, i.e., towards the VTN customer systems.

3. Background

The Photonics domain of the ACTS programme [i], contains a number of projects that have been looking into the realisation of different kinds of networks using WDM technology in combination with SDH, ATM and IP. These projects are generally “equipment-oriented” and management is often limited to the Network Element level. The High-Speed Networking domain mainly contains projects that focus on ATM and IP. However, within both these domains, several projects also address network management and inter-operability issues. The Services and Security domain, on the other hand, includes projects that specifically address network and service management (although with an emphasis on access networks).

When these projects came together in the NI Chains [i], network management inter-operability was viewed in different ways. Projects dealing with photonic networks saw inter-operability between WDM and SDH systems, in terms of protection mechanisms and fault propagation, as one of the main issues [ii]. Projects dealing with access networks focused more on inter-operability from a service and inter-domain management viewpoint. The definition and standardisation of technology independent generic information models [iii][iv], together with the adoption of common procedures for the development of management systems [v][vi], were considered fundamental to the achievement of inter-operability. Finally, interworking between different management platform architectures and protocols, e.g., TMN/CMIP, SNMP, CORBA, was one of the most debated topics [vii][viii].

4. Virtual Transport Network

Transport networks had their breakthrough with the introduction of SDH and the possibility to dynamically set up transport paths. As WDM entered the arena, new layered network models started to be created. A layer, based on a single transmission technology, was assumed to carry another layer based on another technology. ITU-T recommendation G.805 [ix], which is a generalisation of G.803 [x] developed for SDH, constituted the basis for this modelling.

As a result, models showing ATM over SDH over WDM could be seen in most R&D projects dealing with optical networks, including the majority of the ACTS projects that started in 1995-97, as well as in various standardisation groups. Much more complex models are now appearing, where well defined layers are hard to determine. This is because ATM is being deployed both in the core (transport)
network and the access network, and because of recent ideas about “IP over WDM”. This complex heterogeneity also tends to blur the boundary between transport network technology and access network technology.

This guideline is based on a scenario where convergence between Transport and Access leads to Virtual Transport Networks (VTN). In this scenario, new service providers, who may not have any infrastructure of their own, lease VTNs to build global transport networks. Figure 1 illustrates the scenario, showing how a service provider offers transport services, including value added services, to a global corporation distributed over three metropolitan areas.

Figure 1 - Contributing ACTS projects seen from a VTN perspective

The figure also shows a possible network hierarchy and indicates the areas where the ACTS projects contributing to this guideline are involved. The following section introduces each of these projects.
5 Contributing Projects

5.1. **COBNET, Corporate Optical Backbone NETwork**

This project looks at the deployment of WDM technology within and across, *customer premises networks* (CPNs). From a Network Management viewpoint, the project has adopted an SNMP approach focusing on Fault Management [xi]. Fault management is considered as one of the most critical issues for layer interoperability, due to the fault propagation problem. Focusing on the optical layer, COBNET defines three steps in Fault Management: *prevention, diagnosis* and *curing*. For each of the steps there is an exchange of information that is necessary for the inter-operability at different layers. The information flow changes direction at each of the steps: downwards in the first step, upwards in the second and in both directions in the third (see figure). The volume of the information that is passed depends on the size and complexity of the network.

5.2. **METON, METropolitan Optical Network**

This project looks at WDM networks in the metropolitan area. Although METON demonstrates ATM over WDM, the project only covers management of the optical layer. Its management strategy relies on the adoption of a layered model [xii] and on the adaptation of M.3100 [xiii] to WDM network elements\(^1\). However, the project questions whether NE management needs to be standardised on an Information-Model and protocol level. METON has pushed for the use of *WDM Add-Drop Ring entities* that function like “large NEs” and that expose a *programming interface* defined in IDL [xiv]. One of the project’s objectives was to evaluate the use of CORBA and Java for network management. This evaluation resulted in a demonstrator using two different ORB products running in different operating environments and accessed via web-based GUIs developed in Java.

Interoperability: The “Subnetwork Agent” Approach

![Figure 2 - The METON project scope](image)

5.3. **MISA (Management of Integrated SDH and ATM Networks)**

This project adopts an ‘umbrella approach to the ATM-SDH management-integration issue.

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\(^1\) METON has its background in RACE-MWTN, where an adaptation of TMN for WDM elements was demonstrated for the first time, using a Q3 interface.
5.4. MOON (Management Of Optical Networks)

This project has adopted a traditional TMN approach by defining Q3 interfaces for managed resources within an optical transport network (OTN), see Figure 4. The project has focused on domains within a universal OTN infrastructure. For this, a layered OTN architecture model [xii] has been followed, although, it has been concluded that this model needs to be enhanced with a business oriented domain view, which covers the operator domains and their internal and external interfaces.

The integrated network management of ATM and SDH is performed inside the MISA OS based on the information exchanged via Q3 interfaces with the ATM OS and SDH OS. These latter provide the network layer management functions on the ATM and SDH networks respectively and thus represent the legacy single technology management systems. The role of the integrated MISA OS is primarily alarm correlation.

An ATM OS may receive multiple redundant alarm notifications indicating a link failure without being able to identify the actual failed portion of the network if the affected link is carried by an SDH transport system. This results in a confined fault analysis that would require the operator to interface with distinct management systems to isolate a problem. This could be avoided by implementing the appropriate correlation algorithms in a higher-level management system (like the MISA OS).

Figure 3 - The MISA Approach

Figure 4. The MOON Architecture
The MOON implementation is using configuration tools for route validation and verification. These operate on a Network Element level and use information models based on M.3100 and G.872.

6. State of the Art

Although TMN is now mature, differing implementations can still be seen and by no means all the information models (as defined in TMN [xiii]) are standardised. TMN is becoming a good theoretical model that can be used as a reference for different management architectures and system implementations. The use of a specific communication protocol is no longer seen as the essential point.

Today, most commercial management platform products offer a framework for integrating a variety of protocols and distribution mechanisms, e.g., CMIS/CMIP, CORBA/IIOP, COM, Java RMI, SNMP, HTTP, etc. The abstraction level has moved from application protocols to Application Programming Interfaces (APIs). Thus, instead of dealing with different protocol primitives, the management application programmer uses class libraries (e.g. defined in C++ or Java) that represent specific services. This escalation is pushed even further by the definition of Java Beans, which are now widely adopted in the industry [xv].

A real software-components architecture, which is widely accepted within the industry, is probably the only way to achieve full platform integration. Nevertheless, the methods for interacting between different network layers in terms of operation, administration and maintenance (OAM) still have to be defined and standardised. These methods must be based on evolutionary strategies that allow legacy systems to migrate into novel ones.

7. Interoperability Requirements for VTN

On a physical (transmission) level, inter-operability between VTNs may be solved via converters and inter-working units. An important requirement though, in this scenario, is the ability to manage a VTN, i.e., the ability to dynamically change the configuration of the virtual network and the ability to perform fault and performance management. A second requirement is the ability to integrate management of different VTNs, which would be needed, for example, to set up end-to-end connections over several VTNs, or to re-route connections across VTNs. Another need is the ability to collect alarms and statistics from different VTNs, for correlation on a higher level. Interoperability between management systems is an issue both internally for the VTN provider and externally for the VTN customer. Internally, it consists in managing a heterogeneous environment from different manufacturers in a way that enables the creation of VTNs. Externally, the VTN management interface must inter-operate with customers’ integrated management systems.

In an ideally optimised solution, a service provider would operate the whole (virtual) network from one access point, independently of the underlying bearer technology. In a less ideal (though more feasible) solution, management components would be integrated into one or several subsystems, in analogy with how equipment from different providers is integrated into a network.

For evolving network technologies, such as WDM and ATM, the issue is then not about the choice of management technology or platform. The issue is more about a reconsideration of, for instance, the SDH management procedures and models, in order to create a transparent transport infrastructure. Transparency, in this context, refers to efficient mechanisms that allow management information to flow between layers and across domains, in order to provide a high level of abstraction of QoS. The information that is passed is required for transparent provisioning, fault and performance management.

8. Management Information Flow

The concept of management information flow, which is of special importance in the VTN scenario, is not commonly addressed in international standards. It is largely supported by analysis of particular problems and by generalising the interface definitions at specific reference points. In TMN this has
been restricted to the network and network element layers. The Network Management Forum (NMF)\(^2\) [vi] and Telecommunication Information Architecture Consortium (TINA-C) [xvi] are two of the bodies that have looked at the definition of management information flows.

**TINA** defines an overall software architecture for telecommunications systems, which is divided into four areas: the service architecture, the network architecture, the management architecture and the computing architecture. Together the overall infrastructure represents a fully object-oriented architecture for telecommunications systems. The detailed architectural specifications are aimed at supporting the TINA business model that identifies references points between Consumer, Retailer, Broker, 3rd Party Service Provider and Connectivity Provider organisational entities. Several projects are addressing the co-existence and convergence of TINA and TMN [vii].

**NMF** is working towards building industry agreement on interfaces that will support the flow of service management information across three inter-organisational interfaces, identified *Figure 5*:

1) The Customer to Service Provider interface
2) The Service Provider to Service Provider Interface
3) The Service Provider to Network Operator Interface

In order to define the requirements across such interfaces, NMF has surveyed service providers and, based on abstractions of their management processes, has developed the NMF Business Process Model. This summarises various business processes that occur within a service provider and gives an indication of the management flows that would need to occur between these processes. This model allows NMF members to clearly state which areas they consider suitable for industrial agreements.

The scale, heterogeneity and geographic distribution of network and service management systems across the value chain present great difficulties in the provisioning and configuration of new services and management functionality. For example, NMF has recently conducted a survey involving the principal Public Network Operators in Europe and has identified the main business drivers for these service providers as:

- cost reduction in provision of services
- improved process flow
- greater process automation
- greater customer control
- improved quality of service
- greater range of services

*Figure 5 - NMF Overall Business Model*

Consequently, the ability to easily integrate new business processes is seen as one of the most important competitive advantages.

\(^2\) NMF changed its name to TeleManagement Forum (TMF). Sept. 1998.
9. Conclusion

Broadband networks are integrating different transmission technologies and different transport protocols. To manage this kind of heterogeneous networks, there is a need for both interoperability and integration.

Interoperability between management systems is required on different levels and in different directions, depending on the scenario. In the Virtual Transport Network scenario, which has been described in this guideline, interoperability on a Network Element level is not as important as Subnetwork-level interoperability. Because of the heterogeneity of the network, it is hard to imagine distinct layers, e.g., WDM-SDH-ATM-IP, being implemented in a global scale. It is more likely that specific subnetworks will be implemented using a single technology, e.g., SDH, or using two or several technologies, e.g., WDM and ATM. To achieve interoperability between subnetworks, uniform programming interfaces need to be specified.

Integration, i.e., providing a single point of access for the management of several network entities, is a matter of customisation, but emerging component technology, like Java Beans, will likely create a de facto standard for Integration Frameworks.

To identify the management level, on which interoperability vs. integration is required, it is important to specify a business process model and to identify management information flows. Both NMF and TINA-C have defined models for this.

Finally, full interoperability would require full standardisation of interfaces, protocols and information models. However, the development of new TMN standards, e.g., for WDM elements, is still ongoing! TMN will continue to constitute a “reference model”, while the implementation of management systems will take advantage of new possibilities offered by CORBA, Java, WWW.

10. Acknowledgements

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