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ACCESS

ATN Compliant Communications

European Strategy Study

Network Implementation Issues - Systems Management

Systems Management in the European ATN Network

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EXECUTIVE SUMMARY

The document provides realistic and acceptable guidelines on the way European ATSOs can co-ordinate and cooperate in providing the essential network management needed for operating the European ATN. The document addresses global network management issues specific to the operation of the future ground European ATN infrastructure in a realistic near term perspective. It emanates from the need to understand the level of co-ordination required to ensure ATN operation, and to establish standards and requirements for ATN management capabilities.

The document primarily focuses on the network management of the ground and air-ground ATN infrastructure in Europe. It does not address the management of airborne ATN equipment.

The solutions developed in this document for the system management of the European ATN, have been developed with considerations to the current ICAO/ATNP activities on Systems Management, and taking into account current European network management practices and European specific requirements as regards this question.

A first part of this document provides an overview of the network management frameworks and architectures that are being developed for overall network management of 2 of the main international ATC data network in Europe: the **European CIDIN** Network and the **European ATSO** Packet Switched **Networks interconnection**. This overview shows that whereas, up to now, the majority of data interchanges and the associated technical, operational and organisational issues had been arranged on a bilateral basis between interconnected States, the requirements for a co-ordinated and dynamic network management between European ATSO data network facilities are recognised. There is a good will to develop overall network management solutions with centralisation of functions that are required for an efficient co-ordination. Progressive approaches are currently taken for the introduction of these co-ordination functions in the management of the CIDIN and of the ATSO Networks Interconnection.

In a following chapter, this document analyses possible organisational structures for the network management of the European ATN and the associated distribution of responsibilities. There are many options for developing the organisation for managing a multi-national ATN network. This could be vested in a central agency, distributed across all States and organisations, or a combination of the two.

A centralised approach has been proposed by the COPICAT study. With such an approach, the supervision and administration of the whole European ATN would be under the responsibility of a central entity.

With the assumption that States and organisations will be willing to keep the responsibility for the supervision and administration of their ATN infrastructure, this document investigates new approaches for the network management of the European ATN with distribution of the system management activities and responsibilities across States and organisations.

A first approach, referred as the **distributed co-ordination model**, is to form global management co-ordination via the chain of bilateral service level agreements between participants of the ATN. Each organisation establish service level agreements with each other, and is responsible for the co-ordination of network management issues with each of its partner organisations.

A second approach, referred as the **centralised co-ordination model** is based on the centralisation of the **co-ordination** activities, with the creation of a central body in charge of the overall co-ordination of the inter-organisation system management operations.

In Regions, such as Europe, constituted by many inter-adjacent organisations, the centralised co-ordination approach is considered to be more appropriate than the distributed co-ordination approach.

The implementation of a distributed or centralised co-ordination model requires the availability of mechanisms to support the co-ordination of system management activities distributed among different

organisations. A third part of the document analyses requirements for ATN system management co-ordination mechanisms and investigates potential solutions that could meet the requirements.

For performance management co-ordination, it is considered that the real time and off line exchange of operational statistics between European ATSOs would be beneficial to the health of the global European ATN and would facilitate real-time problem detection, near-term problem isolation and longer term network planning.

The general principles for the real-time exchange of operational statistics is that each organisation would provide other organisations with access to a ‘summary MIB’ on the characteristics of its ATN domain. This MIB would be periodically updated by the local organisations. Other organisations that have been granted authorisation to access this MIB, would then be allowed to poll, periodically, the value of performance metrics for which they have a particular interest. This scenario would rely on cross-organisation manager-to-manager communications

For off-line co-operation on the management of the performance of the overall European ATN, the exchange of raw data files and the exchange of performance reports are identified as potential requirements. These requirements can be met with file transfer tools and archive systems.

For Inter-domain troubleshooting co-ordination, cross organisation communication of faults should be network manager to network manager via the standard means of trouble ticket information exchange.

The sharing of the configuration information is considered to be mostly a non real-time activity, and which can be done in a number of simple ways (e.g. exchange of configuration files, exchange of questions/answers, use of a common archive system, etc...). If the requirement for a more automated cross-domain access configuration information was identified, the possibility to share configuration information using the principle of the summary MIBs introduced above is identified.

With respect to the co-ordination for configuration changes, it is considered that in most cases, the changes will be planned events. For those changes, co-ordination will mainly be an off-line activity, involving network administrators, and consisting in the analysis, agreement, and planning of the proposed changes. It is assumed that co-ordination meetings can be held between network administrators and result in the production of documents recording the agreements on the changes, and describing the schedule and the procedures for the modifications.

For configuration changes that are time sensitive (e.g. real time network reconfiguration), it is assumed that co-ordination between organisations will consist in the spontaneous set-up of dialogues between network operators for discussion of the problem, agreement on a correction, and synchronisation of recovery actions. The phone, the electronic mail, and the trouble ticket systems would be the tools used all along the co-ordination process.

With regard to accounting, European ATSOs could be willing to combine and centralise the accounting management activities so as to share the accounting management structure, minimise the billing interactions with common external users or service providers and simplify the internal redistribution of costs and benefits between partner organisations. Possible architectures supporting the centralisation of accounting management functions are described in this document.

In conclusion, co-ordinated system management with distribution of system management responsibilities among organisations can be achieved with minimum changes to the traditional network management approach. **The recommended approach for the system management of the European ATN is the one referred in this document as the centralised co-ordination model,** where responsibilities for the management of the national ATN is left in the hand of the ATSOs, (and other ATN organisations) while responsibilities for the co-ordination of some inter-domain system management activities (e.g. accounting management) are vested in a central co-ordination entity.

The recommended approach for the structure of such a central co-ordination entity is to implement a similar organisation to the one which has been proposed for the administration and management of the ATSO data network interconnection.

Finally, this document shows that there are a lot of questions to be answered, and activities to be undertaken before a satisfactory European system management co-ordination model is specified and implemented. A draft « road map » of the required further activities on the ATN system management subject is proposed.

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1. Introduction

1.1 Scope

The 'ATN Compliant Communications European Strategy Study' (ACCESS) project that is being run under the European Commission’s programme for financial aid in the field of Trans-European Transport Network (TEN-T), ATM Task UK/96/94, aims at defining the initial architecture of the ATN in EUROPE (i.e. selection of the initial applications, definitions of the initial network topology, definition of the routing organisations and of the addressing plan, etc. ..), and will propose initial solutions as regards to the security, safety/certification, network management, institutional, and other issues as well as a transition plan.

Part 1 of Access project focuses on ATN Implementation with the objectives of proposing a network architecture, solutions for network implementation issues and a plan for transition from the existing network infrastructure to the proposed ATN infrastructure.

Part 2 of the ACCESS project covers the ATSMHS Interoperability/Validation testing.

This document has been developed in the scope of Work Package 227 (entitled « Network Implementation Issues - Systems Management ») and represents one part of the ACCESS interim deliverable 2 in Part 1.

1.2 Purpose and scope

The purpose of this document is to provide realistic and acceptable guidelines on how European ATSOs can co-ordinate and cooperate in providing the essential network management needed for operating the European ATN. The document addresses global network management issues specific to the operation of the future ground European ATN infrastructure in a realistic near term perspective.

This document emanates from the need to understand the level of co-ordination required to ensure ATN operation, and to establish standards and requirements for ATN management capabilities.

The document primarily focuses on the network management of the ground and air-ground ATN infrastructure in Europe. It does not address the management of airborne ATN equipment.

The solutions developed in this document for the system management of the European ATN, have been developed with considerations to the current ICAO/ATNP activities on Systems Management, and taking into account current European network management practices and European specific requirements as regards this question (e.g. CIDIN Management).

1.3 Structure of the document

This document is organised as follows:

Chapter 2 provides an overview of the network management frameworks and architectures that are being developed for overall management of 2 of the main international ATC data network in Europe: the European CIDIN Network and the European ATSO Packet Switched Networks interconnection. The intent is to consider whether from these frameworks and architectures could be derived concepts for the network management of the ATN.

Chapter 3 analyses the possible overall organisational structures for the management of the European ATN and the associated distributions of roles and responsibilities.

Chapter 4 examines possible overall System Management co-ordination scenarios within an ATN region. The objective is to identify the system management functional areas that require cross-administrative domain interactions, the categories of information that need to be exchanged, and possible solutions for the exchange of information.

Chapter 5 concludes this document.

1.4 References

ACCESS Reference	Title
[CEC4]	COPICAT - Economic Assessment & Proposed ATN Organisation - Edition 1.1 - 10/02/97
[EUR20]	COM.ET1.ST13.2000-DEL-XX - CIDIN Management Manual - Issue 1.0 - 17/2/97
[EUR21]	REPORT OF COMT DRAFTING GROUP ON THE FEASIBILITY OF ATSO DATA NETWORK SERVICE INTEGRATION -
[ICA20]	ATNP/JWG/JSG1/WP8-4 - Preliminary Draft ATN System Management - Concept of Operations - Draft 0.2.p - 16/8/98
[RFC1857]	RFC 1857 - A Model for Common Operational Statistics
[RFC1856]	RFC 1856 - The Opstat Client-Server Model for Statistics Retrieval
[RFC1297]	RFC 1297 - NOC Internal Integrated Trouble Ticket System -Functional Specification Wishlist - January 1992
[RFC2063]	RFC 2063 - Traffic Flow Measurement Architecture
[ATNSI1]	ATN Network Management Concept of Operations - ATN System Inc. - Version 98.0.7 - August 1998

2. Current Systems Management Practices in Europe

2.1 Introduction

A recent survey on the current communication infrastructure of the European ATSOs, showed that ATSOs have mainly based the development of their networks on their own communication needs and organisational constraints. The resultant services and management solutions, in practice today, differ from one ATSO to another in many aspects. Each ATSO operates its own networks independently with its own operations staff, following its own specific procedures, and using proprietary tools.

Where international communications are required, day-to-day operations are currently based on bilateral co-ordination between pairs of neighbouring States, while network planning is performed by groups of the States concerned and subject to approval by ICAO or other regional planning meeting.

However, the lack of a co-ordinated and dynamic management between European ATSO data network facilities is recognised and the need for an increased operational effectiveness has notably been raised for the management of the CIDIN and of the ATSO Data Network Integration. For these two international networks, frameworks of Network Management procedures are being defined.

An analysis of these 2 frameworks is provided in this chapter. The intent is to consider whether from the frameworks that are being developed in Europe for the network management of the current international ATC Data communication network could be derived concepts for the network management of the European ATN.

2.2 CIDIN Management

2.2.1 Current Situation and Trends

The need for the introduction of network management into CIDIN arose, at least partly, from the way CIDIN is traditionally operated. Following ICAO principles (derived from the operation of the AFTN), each State is responsible for the operation of its own (one) COM Centre as dictated by ICAO SARPs and in accordance with all resolutions for the Region. This operational philosophy is based on a high level of co-operation among States. However this arrangement is not without its difficulties: any one State has a number of immediate neighbours with which it needs to co-ordinate intensively, but, in principle, it may need to co-ordinate also with any other State in the Region.

Except for various administrative activities performed by ICAO, there is no centralised co-ordinating, operating or management body for the CIDIN today:

- each Centre is operated independently with its own operations staff
- day-to-day operations are based on bilateral co-ordination between pairs of neighbouring States;
- network planning is performed by pairs or groups of the States concerned and subject to approval by ICAO Meetings; official network planning is performed in ICAO Regions, with a cycle time of the order of one year; matters affecting more than one ICAO Region are co-ordinated between pairs or groups of States concerned; occasionally supra-regional planning meetings are held.

The implementation of CIDIN has progressed to the stage where a significant number of switches form a highly meshed network carrying a large part of the AFS traffic in Europe. The growth of CIDIN is likely to continue. This trend indicates that the network management techniques taken over from the conventional AFTN will no longer be sufficient for CIDIN in the foreseeable future; a new CIDIN management concept, partly based on a centralised approach, has been specified in the CIDIN Management Manual ([EUR20]). This new CIDIN management concept is summarised in the following sections.

2.2.2 Off-line and On-line management

A basic principle underlying the structure of CIDIN management is the distinction between the two groups of functions designated as "off-line" and "on-line" management functions.

On-line management refers to functions that shall be executed in a short time period in order to maintain the level of service required from CIDIN. This necessitates the rapid exchange of management information between CIDIN Centres and a CIDIN Management Centre.

Off-line functions do not need to be executed in a short time period. These relate to medium and long-term requirements and include, e.g., collection and processing of information from CIDIN Centres (statistics, inventory, etc.), preparation of configuration proposals (capacity and routing) and provision of technical support (certification, consultancy, etc.).

The subgroup on CIDIN Management decided to focus on off-line management co-ordination issues. Depending on experience gained in implementing and carrying out CIDIN management in the off-line mode, the introduction of an on-line mode of operation supplementing the off-line mode will possibly be considered.

2.2.3 Principles of off-line Management for the CIDIN in Europe

The centralisation of some management functionality is a basic principle of CIDIN off-line management, i.e. some functions are defined which are performed at only one location in the network rather than at each CIDIN Centre.

The functional entity performing the centralised management functions is called the "CIDIN Management Centre", CMC.

By comparison with the CMC, the COM Centres participating in network management activities are called "Co-operating CIDIN Centres", CCC.

CIDIN management essentially consists of the transfer of information between each CCC and the CMC and its processing at those locations. A database maintained at the CMC describes the current and planned state of the resources.

Two groups of functions are considered within the scope of CIDIN off-line management:

- the « advisory » functions in which the CMC advises CCC on network operations
- the « support » functions in which engineering and administrative staff at CCCs are assisted by CMC staff, for example in network implementation.

There is no legal framework within which the obligations of participating States such as adherence to agreed procedures can be defined and enforced. It is not envisaged that formal, legal agreements be set up to control participation in management procedures.

For example, when the CMC issues advice to CCCs, such "advice" cannot be considered to be a legal obligation. However it is expected from the group of participating States that the advice be followed with good will. If there is a good technical reason why the advice cannot be followed, the CMC must be informed of this by the CCC or CCCs concerned; as a consequence the whole set of advice issued by the CMC to all CCCs may need to be modified.

2.2.4 Off-line management functions

The following off-line functions have been defined as an initial set, with the goal of simplified introduction of network management into CIDIN:

2.2.4.1 Network inventory

The network inventory is a database table maintained by the CMC containing information on the "static" configuration of the network. CCCs will provide the configuration data on a regular schedule to the CMC by mail, fax or e-mail. The data will then be entered into the database at the CMC.

2.2.4.2 Network Statistics

The purpose of the network statistics function is the collection, analysis and publishing of certain network statistical data. CCCs will provide the statistical data on a regular schedule by mail, fax or e-mail. The data will then be entered into the database at the CMC

2.2.4.3 Information provision

Six categories of information will be made available by the CMC:

- network configuration
- network traffic map
- current routing
- routing advice
- planned network events, and
- procedure and format.

The information will have the form of a fixed human-readable text, and will be distributed by the CMC according to a fixed schedule, or as a response to a « retrieval request » issued by a State.

2.2.4.4 Routing directory

The routing directory will be a database table maintained by the CMC containing information provided by CCCs on actual current CIDIN and AFTN routing in the network.

2.2.4.5 Routing Advice

The routing advice function will be a means of generating "optimal" routing tables from existing configuration data (network inventory), traffic patterns and their trends (network statistics function) and current routing data (routing directory). This function will be performed at the CMC. The results will be distributed to States as part of the information provision function.

2.2.4.6 Planning support

The CMC will maintain a list of all planned changes to the network configuration for a future period of at least one year in a database table “planned network events”. Any State wishing to make significant changes such as the introduction of a new centre or link, changes in capacity available, introduction of new applications or expected major changes in traffic sources or sinks will inform the CMC of such changes using a well specified form, to be transmitted from CCCs by mail, fax or e-mail.

Planned changes will be approved and entered at the CMC into the database together with planning dates. In addition, the CMC will distribute the network events list to all impacted States.

2.2.4.7 Interworking Support

States may request interworking support from the CMC. Interactions take the form of an enquiry concerning a specific aspect of the CIDIN protocols and its implementation. The CMC will provide advice based on its experience with the network and on its databases. The CMC will also maintain a list of all interworking problems and their solutions.

2.2.4.8 Certification support

States may request certification support from the CMC. The CMC may provide support in the form of conformance testing equipment and experienced test operating personnel for a restricted period of time. The CMC will maintain a list of all conformance problems and their solutions

2.2.5 Off-line management procedures

The CIDIN Management will consist in performance of the above off-line management functions by the implementation and application by the CCCs and the CMC of well defined procedures. The detail of these procedures (actions to be performed, when the actions have to be performed, the common data exchange formats for each type of information) is specified in the CIDIN Management Manual.

All procedures rely on the exchange by fax, mail or e-mail of well specified human-readable forms.

2.3 System Management in the scope of the ATSO Data Network Integration

2.3.1 Introduction

The « ATSO Data Network Integration » is the name of the current European activity on the establishment of a managed pan-European ATS data communication service through interconnection and utilisation of National and Regional (X.25) data networks.

The drafting group responsible for the study of the feasibility and benefits of this project already recognised that a lack of a co-ordinated and dynamic management between ATSO data network facilities would result in reduced capacities to satisfy user requirements and to plan new services for the benefit of ATSOs and new users.

In its report on the feasibility of ATSO Data Network Service Integration ([EUR21]), the drafting group considered the possible organisations required for managing the international network and identified the operations and planning activities that will be necessary to keep the interconnected networks in line with the committed Quality of Service and prepare them to support future user requirements in an efficient manner.

The proposed organisation is presented in section 2.3.2.

The operation and planning activities are presented in section 2.3.3.

2.3.2 Organisation

There are a number of functions which must be performed in order to deliver a managed European network service. The functions are

- Policy making, standard setting and investment decisions
- Operation and maintenance of the network
- Contact point for service enquiries (Help desk)
- Administrative activities
- Network development activities

The COM-T drafting group on the ATSO Data Network Integration proposes the creation of the 3 following bodies to perform the above functions:

2.3.2.1 Network Management Group

A Network Management Group set up with membership drawn from all participating states is proposed to be responsible for defining, maintaining and reviewing the agreed standards, agreements, terms of operation, charging policy, cost recovery, terms and conditions etc. The group will have the responsibility of the strategic control and development of the infrastructure.

2.3.2.2 Network Administration and Engineering Group

The Network Administration and Engineering Group would consist of a small permanent core staff, responsible to the Network Management Group for managing the administrative activities of the group and preparing the engineering changes to the network including maintenance and review of Service Level Agreements and Interconnection Agreements. Any changes which have policy or investment implications would have to be endorsed by the Network Management Group.

2.3.2.3 Tactical Operations and Help Desk

This group would operate on a 24 hour per day basis, providing real time support for network activities. Problems which are unable to be resolved by this group would be referred to the Network Administration and Engineering group and ultimately to the steering group.

2.3.3 Operations and Planning activities

2.3.3.1 General

The identified operations and planning activities include:

- network planning (strategic activities such as network evolution/extension, assessment of return on investment, planning of investments, evaluation of new user or application requirements). Most of the network planning activities go beyond the scope of system management and will not be considered further in this overview.
- network engineering (tactical activities such as network design and simulation, assessment of QoS),
- network and service management (real time activities such as fault management, performance management and off-line activities such as configuration management, accounting management).

2.3.3.2 Network engineering

Network engineering will be conducted at two different levels, on the one hand within each ATSO taking into account the national requirements and on the other amongst co-operating ATSOs that support a given application or set of users.

<u>Network engineering activities will cover :</u>

- Design of network topology (network capacity, interconnection scheme, network resilience, end-to-end transit delays, etc.) for a given service objective (defined at the network planning level);
- Design of network services (network and inter-network rerouting functions, security policy enforcement, priority scheme, fall-back features) to meet the service requirements;
- Provision for high reliability of underlying facilities, by setting adequate protections against circuit supplier failures;
- Development of implementation or migration plans;
- Evaluation of implementation costs;
- Assessment of network QoS;
- Monitoring of the spare capacities;
- Network upgrades to keep the QoS in line with the service objectives;
- Feasibility studies so as to introduce new services or technologies.

2.3.3.3 Network and Service Management

Network management activities will cover :

- Configuration of networks and gateways in order to connect users or applications;
- Monitoring of the interconnected networks, problem tracking, expertise and resolution, and in a larger extent maintenance of the network components;
- Monitoring of the network performance (resource utilisation rates, trunk and gateway utilisation rates, transit delays);

- Monitoring of the network behaviour as regards security and contingency aspects;
- Reporting on the network operations (resource utilisation and availability, outages, intrusion attempts, etc.) in order to either prove that the expected QoS has been delivered or determine areas which need improvements;
- Reporting on the network utilisation (traffic loads, peak traffic, utilisation times, spare capacities, etc.) in order to provide material for network consolidation or billing purposes.

It was decided that these activities will be achieved through a co-operative work involving the participating ATSOs' network management entities. However, it is recognised that in order to perform the tasks listed above in a consistent and efficient manner, participating ATSOs have to harmonise network service indicators, that is to obtain at least the same perception of QoS, priority scheme, safety and security levels for instances.

It was additionally decided to support a central help desk function to process user service requests and claims. The help desk will be assigned with co-ordinating the participating ATSOs' or other service providers' network managers for operation and maintenance (in particular user problems resolution) of the involved networks, and with consolidating statistics and accounting data for reporting and billing purposes.

2.3.4 Procedures

No common procedures have been defined yet. Although the objective is to reach for a pan-European network service management capability, it is not intended to achieve this objective from scratch, but by harmonising existing network management structures within ATSOs.

To ease this harmonisation, recommendations have been made to:

- start the collection and the maintenance of documentation on the topologies, the traffic flows, etc...
- study further the help desk assignments, the ATSO's network manager peer to peer relationships, and the minimum requirements for overall network service management in terms of network monitoring and reporting functions,
- provide for an overall network viewer tool that would be installed at the help desk so as to facilitate network monitoring activities, and study further advisability to have the tool set up in each ATSO's network management centre so as to ease overall co-ordination;
- study further the most adequate and acceptable organisation to back up help desk functions

2.4 Conclusions

European ATSOs are starting to develop experience in managing a widespread and multi-national network environment. Up to now the majority of data interchanges have been arranged on a bilateral basis and in technical, operational and organisational issues have been addressed on that basis.

Progressive approaches are taken to reach for network management solutions at European level. The target network management solutions consist more in the global co-ordination of the different ATSO network management activities than in the development of a centralised network entity in charge of the global supervision of the international network.

These approaches arise from the following technical, economical or institutional points:

1. The current/planned international networks rely on the interconnection of existing ATSO equipment and as a matter of fact will be multi vendor platforms, involving multi proprietary technologies. Management of such a platform is not straightforward since integrated network management tools are not available. Even for domestic usage, it has always been a resource

intensive activity to bring together disparate technical and service data and produce meaningful service management information.

2. The Network Management solutions differ from one ATSO to another in many other aspects: maintenance procedures and delays, support from industry, etc...

3. ATSOs have to preserve their investments and gain overall cost effectiveness. Modification to their current Network Management structures would incur capital expenditure which would need to be set against identified benefits.

4. ATSOs are reluctant to transfer responsibilities on the network management of their own network infrastructure. The proposed centralised structure have either a passive role (collecting global information for the benefits of the ATSO community, providing advises, etc...), or take the form of management or engineering groups with membership drawn from all participating states.

5. The harmonisation of the multi-national participation (e.g. resolution of language differences) would be important factors for certain critical network management operations (e.g. requests for intervention of the on-site maintenance).

Nevertheless, the requirements for a co-ordinated and dynamic management between European ATSO data network facilities are recognised and there is a good will to develop overall network management solutions with centralisation of functions that are required for an efficient co-ordination. The main characteristics of the proposed European Network Management frameworks are the following:

- There is a requirement for harmonising the network service indicators (transit delay, trunk utilisation, throughput, availability, etc.), the configuration parameters, the routing information structure, and more generally all information elements that need to be shared amongst ATSOs.

- There is a requirement for a central Help Desk function assigned with co-ordinating the participating ATSOs' or other service providers' network managers for operation and maintenance of the involved networks, and with consolidating statistics, and configuration data in a central database.

- The focus is put on the off-line co-ordination. A real time mode of operation with on-line monitoring activities on the overall network is desired, but the technical problems mentioned above prevent its short term implementation.

From this review of the current trends on the Network Management of the European ATC networks, the following lessons could have to be retained when considering the Network Management of the European ATN:

1. European (or ICAO) standards should be defined for the exchange of the management information elements that are required for the off-line management of the European ATN. This includes the standardisation of the definition of configuration, accounting, security, and performance parameters required to be exchanged between ATSOs, and of the mechanisms used for the exchange of the parameter values (e.g. fax, mail, e-mail, AMHS, SNMP, CMIP, ...)

2. European (or ICAO) standards should be define to allow for the implementation of an overall network viewer tool:

   - from which could be monitored the overall status of the network, such as the overall status of the Routing Domains composing the Network (current transit QoS, current load, etc...), of the boundary nodes and of the trunks between these nodes,

   - and which would also allow to co-ordinate the resolution of errors occurring at the level of these trunks, nodes or Routing Domains.

The above does not preclude the development of other standards, for instance for the management information or the information exchange mechanisms implemented at the level of the individual equipment. However, at this stage of the study, and from the review of the current trends in the domain of the management of international network in Europe, it is reasonable to limit the extent of the conclusions.

3. Overall organisational structure for the management of the European ATN

3.1 Introduction

Systems Management architecture is as much an organisational and institutional issue as a technical one. Before developing the technical aspects, there is a need to develop an ATN Management Framework which addresses the organisation of management into different roles and responsibilities and identifies and defines the information exchanges that need to be supported between the different management roles. This is the objective of this chapter.

There are many options for developing the organisation for managing a multi-national ATN network. Whatever option is chosen there must be a clear definition of responsibility for all the activities undertaken. This could be vested in a central agency, distributed across all States and organisations, or a combination of the two.

A centralised approach has been proposed by the COPICAT study ([CEC4]). The COPICAT study recommends the creation of a « Co-ordinating Entity (CE) » to act as the body for the promotion, implementation, and control of the European ATN. The main aspect of this proposal are summarised in section 3.2 below.

Sections 3.3 and 3.4 investigate new approaches for the network management of the European ATN with distribution of the system management activities and responsibilities across States and organisations. A distributed ATN network management organisational framework is developed based on the assumption that States and organisations will be willing to keep the responsibility for the supervision and administration of their ATN infrastructure.

3.2 ATN management organisation proposed by the COPICAT study

3.2.1 Introduction

One of the main recommendations of the recent COPICAT study was the creation of a « Co-ordinating Entity (CE) » which would act as a federative body with authority for the selection, implementation, control and promotion of the ATN ([CEC4]).

The main aspects of this proposal are summarised in the following sections.

3.2.2 Organisation - Roles

3.2.2.1 General

The Co-ordination Entity is proposed to be responsible for:

- setting up and monitoring technical system specifications for ATS and AOC (in relation to relevant organisations; ICAO, ETSI and Eurocontrol).
- selecting suppliers and ATN operators and negotiating contracts.

The airlines and the CAAs are assumed to retain total control over the assets and their maintenance (this is viewed as a crucial split of responsibility given the priority on safety in the aeronautical industry).

The proposed distribution for the financing responsibility between the parties involved is as follows:

- The CAAs would purchase : the application servers, and the national routers

- The Airlines would purchase : All the required airborne equipment and the application server for AOC purposes

- The ATN Operator that has been selected by the Co-ordinating Entity would purchase : the international routers (European backbone), the VHF subnetwork[1] and the leased trunks. It would also provide assistance to small CAAs who do not want to invest in the ATN network but would prefer to pay an annual fee for the « ATN service ».

3.2.2.2 Co-ordination Entity

The Co-ordination Entity would:

- Co-ordinate the provisioning of an interworking environment linking all players of the ATC and AOC aeronautical sector in Europe through the deployment of the ATN internetworking technology.

- Ensure a seamless signal across the ATN through.

  - the setting-up of standards

  - the definition of technical specifications.

  - the monitoring of implementation schedules and content.

- Minimise the cost of the infrastructure investment and network operation expenditure by providing an optimised network design and through promoting competition by issuing calls for tender for the implementation and operation of the ATN network.

- Monitor traffic and collect revenue contributions towards its operating costs from the CAAs and the Airlines.

- Define responsibility boundaries between roles.

3.2.2.3 CAAs/Airlines

The CAAs and Airlines would:

- Provide the Co-ordination Entity with a Pan-European licence to operate the ATN.

- Grant the Co-ordination Entity the power to define and set standards in relation to relevant institutions for equipment and applications.

- Allow rights-of-way to the ATN operators.

- Fund the Co-ordination Entity for its ATN related costs.

3.2.2.4 ATN Operator(s)

The ATN operator(s) would:

- Provide guaranteed seamless communication services for all required levels of Quality of Service.

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[1] The COPICAT report notes that some trade-offs may occur between CAAs and the ATN Operator as some CAA will prefer to keep full control on the VHF subnetwork

- Ensure the standards compatibility of the equipment used and the services provided.
- Provide guarantees for the interconnection schedule of the implementation phase to avoid delayed implementation of the ATN.
- Provide competitively priced services.

3.2.2.5 Ownership - Control

The Co-ordinating Entity would be controlled by the CAAs and the airlines

3.2.3 Implications of this organisational model for the management of the European ATN

Although issues related to the system management of the European ATN are not really investigated in the COPICAT report, it is possible to derive from the proposed organisation what would have been the likely recommended approach. In the organisational context proposed by COPICAT, the most appropriate scenario for the management of the European ATN is indeed the following:

- The Co-ordination entity would produce standards for the Management Information exchange protocols and the Management Information Base to be supported by all European ATN systems.
- The European ATN Network supervision would then be centralised and performed by the selected ATN operator from a central Network Management Station
- The European ATN Network Administration would be centralised and performed by the co-ordination entity.

3.3 A distributed European ATN management organisation

3.3.1 Introduction

The objective of this section is to propose an ATN network management organisational framework where responsibilities for the supervision and administration of the European ATN are distributed across the different organisations owning the ATN components, while ensuring that the European ATN continuously offers the target network service availability and performance to its users.

The current ATN Guidance Material for System Management ([ICA20]) provides initial structuring principles for the management of the ATN with distribution of the responsibilities. This organisational model will be used as a basis, and further developed and adapted to the case of the European Region.

3.3.2 The ATN Systems Management organisational model

3.3.2.1 ATN Regions

The model introduced in [ICA20], identifies two basic types of ATN Region which communicate with aircraft:

- the AIRLINE type
- the Air Traffic Management (ATM) type

Within Regions are 2 basic kinds of ATN entity, end users (e.g. CAAs or Airlines) and the ATN backbone which provides connectivity on the ground between end users.

Within ATM Regions are organisations:

- CAAs
- commercial telecommunications Service providers

Within Airline Regions are:

- Airline Authorities
- commercial telecommunications Service providers

3.3.2.2 Regional Institutions

Every Airline and ATM Region will have a REGIONAL INSTITUTION which has ultimate responsibility for the operation of the REGION. These institutions may delegate, by agreement, responsibility for active administration to managers at their disposal (e.g. those in the CAA domains of responsibility).

REGIONAL INSTITUTIONS are the responsible authority for:

- Establishing contracts, agreements and polices regarding the structure, integrity and internal administration of the Region as a whole. This will involve co-ordinating communication policies between CAAs, AIRLINEs and SERVICE PROVIDER participants that form the REGION.
- Negotiating policies for communicating with other REGIONs external to itself.

These agreements and policies will not be implemented or checked automatically by managers, responsibility for their active implementation is passed to the organisations in the region.

REGIONAL INSTITUTIONS may provide support facilities to enable the implementation of agreements and policies.

Every CAA, SERVICE PROVIDER and AIRLINE AUTHORITHY will have responsibility for its own area.

3.3.2.3 System Management activities within organisations

3.3.2.3.1 General

System Management activities are generally classified function of the level of urgency of the activities that need to be carried out. The following two levels are generally considered:

- **network supervision:** they consist of real time activities such as fault management, performance management and day-to-day off-line activities such as systems configuration, collection and log of statistics. These activities need to be carried out 24 hours per day, 7 days per week.
- **network administration:** these are tactical activities to be carried out in a short term (1 to 6 months), such as current network bottlenecks/problems analysis and enhancements to the current network design, and strategic activities to be carried out in a longer term (1 to 2 years), such as network evolution/extension, etc.

3.3.2.3.2 ATN network supervision activities

The main ATN network supervision activities are :

1. Problem tracking, expertise and resolution, and in a larger extent maintenance of the network components;
2. Monitoring of the network performance (resource utilisation rates, transit delays, routing convergence);

3. Monitoring of the network behaviour as regards security and contingency aspects;

4. Reporting on the network operations (resource utilisation and availability, outages, intrusion attempts, etc.) in order to either prove that the expected QoS has been delivered or determine areas which need improvements;

5. Reporting on the network utilisation (traffic loads, peak traffic, utilisation times, spare capacities, etc.) in order to provide material for network consolidation or billing purposes.

6. Configuration of the network components: principally the ATN routers (intra-domain ISs, ground and air/ground inter-domain BISs, backbone BISs) and the ATN ESs.

Network supervision is normally carried out by Network Managers. A Network Manager has responsibility for the detailed operation of the equipment in the network. It has access to the many pieces of distributed physical equipment. It collects data and administers the Management Information Base for groups of Host Computers, Routers and Subnetwork Components via « Management Agents » resident in those systems.

3.3.2.3.3 ATN network administration activities

ATN network administration consists of periodical activities performed in normal office hours and generally classified in 2 distinct groups:

- The tactical activities focusing on the analysis and enhancement of the current network performance

- The strategic activities focusing on network evolutions/extensions.

Tactical activities have be carried out periodically with periods ranging from 1 to 6 month. The main tactical network administration activities are:

1. Network performance analysis, and performance problems resolution study.

2. Network incidents and user problem investigation, and problems resolution study

3. Costs analysis, and costs reduction investigations

4. Accounting information processing, billing and payment collection activities

5. Verify compliance to service agreements and policy statements, and when necessary develop additional method of enforcement.

6. User approval and user affiliation/subscription activities

7. Network Upgrade planning, with evaluation of the associated costs.

8. Resources inventory

9. Software maintenance and commissioning

Strategic activities are performed in a period ranging from 1 to 2 years. The main strategic network administration activities are:

1. Trend analysis and identification of potential future bottlenecks

2. Evaluation of new user or application requirements

3. Design of the network topology extensions to meet the new service requirements or to keep the performance and QoS in line with the service objectives

4. Assessment of return on investment and cost prediction

5. Decision on the resultant investments

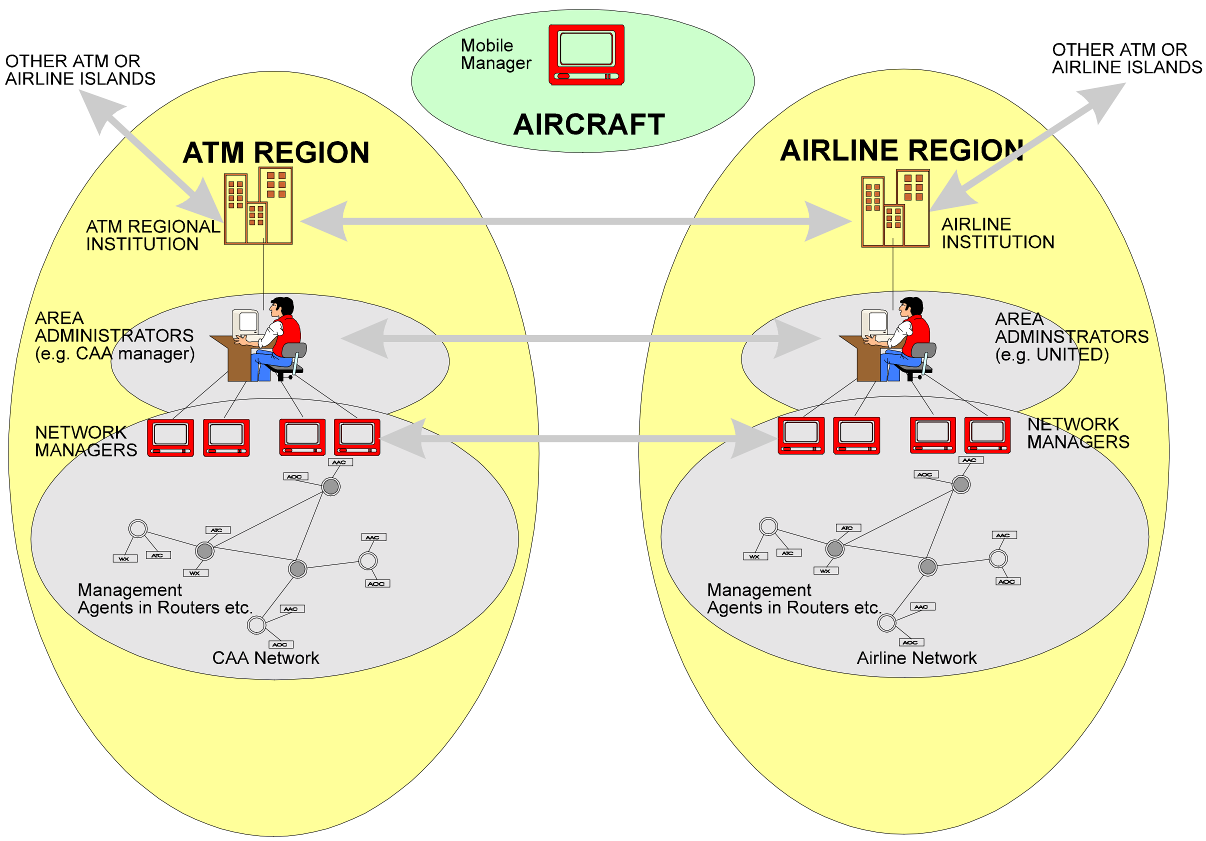
6. Planning of all investments both in operating staff and network upgrades/extensions.

7. Establishment of contracts, agreements and policies for interconnection and communication with other administrative domains.

8. Prospective work to support time to market for new services or technologies

3.3.2.4 The Structure of managers, Administrators and Institutions

Every CAA, SERVICE PROVIDER and AIRLINE AUTHORITHY will have a 2 level hierarchy of active managers: Area Administrators and Network Managers which operate according to contracts, agreements and policies made by Regional Institutions.



3.3.2.5 Area Administrators

Every CAA, SERVICE PROVIDER and AIRLINE AUTHORITY will have an ADMINISTRATOR which has responsibility for its own area. These Managers may use lower level managers/agents at their disposal (e.g. managers of networks) involving the collection and organisation of data concerning operations of the network.

The ADMINISTRATOR will be responsible for the ATN Network Administration activities within its area.

3.3.2.6 Network Managers

Every CAA, SERVICE PROVIDER and AIRLINE AUTHORITY will have a NETWORK MANAGER which has responsibility for the detailed operation of the equipment in the network.

The NETWORK MANAGER will be responsible for the ATN Network supervision activities within its area and will hide the details of the normal operation of network equipment from ADMINISTRATORs.

Centralised systems management of ATN equipment within organisations will be required. It will obviously be impractical to have operations staff manning each piece of ATN equipment, operating it from a local interface. It would also be unfeasible to guarantee equipment configuration and operation without such facilities.

3.4 Extension of the model

3.4.1 Introduction

The basic network management organisational model introduced in [ICA20], and summarised in the previous section, allows to define the activities and responsibilities of each organisation with regard to its own infrastructure, but does not provide any guidance on the way the network management activities of the different organisations must be co-ordinated to ensure the overall availability and performance of the ATN service in a region.

The model needs therefore to be further developed to include the additional activities and the possible additional organisational structures required for an effective network management co-ordination.

There are 2 approaches for establishing a network management co-ordination.

The first approach is to model the management co-ordination after existing business approach: two organisations engaged in business exchanges establish service level agreements with each other and explicitly state their expectations for the business endeavour. The agreement is enforced by the two organisations. When there is a change in business needs, re-negotiation of the agreement can be quickly established between the two organisations. An organisation may have more than one bilateral service level agreement established with multiple organisations. The intent is to form global management co-ordination via the chain of bilateral service level agreements between participants of the ATN. This approach is referred hereafter as the **distributed co-ordination model**.

The second approach is based on the centralisation of the co-ordination activities, with the creation of a central body in charge of the overall co-ordination of the inter-organisation system management operations. This approach is referred hereafter as the **centralised co-ordination model.**

The organisational principles characterising the centralised co-ordination model are developed in section 3.4.2.

The principles for a distributed co-ordination of the System Management activities in an ATN Region are discussed in section 3.4.3.

3.4.2 Centralised co-ordination for the System Management of the ATN within an ATN Region

3.4.2.1 General

The centralised co-ordination approach is based on the centralisation of the co-ordination activities, with the creation of a central body in charge of the overall co-ordination of the inter-organisation system management operations. The co-ordination of both supervision and administration activities is required; the responsibilities and activities of this central body must therefore be structured in a way which allows to meet this requirement.

The central co-ordination body is then logically proposed to be structured with 2 level hierarchy of management:

- the regional ATN administrator, and
- the regional ATN supervisor.

The splitting of responsibilities between the central co-ordination body and the area administrators and network managers of the different organisations will be based on the following principles:

1. The area administrators will be responsible for the ATN Network Administration activities within their area, as stated in section 3.3.2.5
2. The network managers will be responsible for the ATN Network supervision activities within their area, as stated in section 3.3.2.6
3. The central body will have a summary view on every area in the region. Every area will be considered as a "black box" ATN domain with summarised characteristics.
4. The regional ATN supervisor will be responsible of the supervision of a network (the regional ATN) which basic components are "ATN domains".
5. The regional ATN administrator will be responsible of the administration of a network (the regional ATN) which basic components are "ATN domains".

3.4.2.2 Role and responsibilities of the Regional ATN supervisor

The Regional ATN supervisor will have the responsibility for the global operation of the ATN in the Region. However the Regional ATN supervisor will not be assumed to have access to the many pieces of distributed equipment. Instead of managing interconnection and group of ATN routers and End Systems, the regional supervisor will supervise interconnection and group of ATN domains.

His view of the network will therefore not be the status and the performance of the individual network equipment but the status and performance of the Routing Domains or Routing Domain Confederations composing the regional network, the overall status of their access points (which are the BISs), and the status of the inter-domain links.

An interesting parallel can be made between the components managed by a network manager within an organisation and those managed by the regional supervisor:

- a network manager operates on a network of ATN End Systems and Intermediate Systems
- the regional manager will operate on a network of ATN End Routing Domains and intermediate (i.e. transit) Routing Domains.

In the same way, a parallel can be made between the supervision activities carried out by a network manager and those that will be performed by the regional supervisor:

1. Problem tracking, expertise and resolution: where a network manager will consider the cause of a failure at the level of a router (e.g. performance degradation, failure of the interface to a subnetwork) and its effects on the other network components, the regional manager will have to consider the cause and effect of a failure at the level of a domain (e.g. increase of the transit delay of routing domain, failure of the interface node of a domain) and its effects on the other domains
2. Monitoring of the network performance: the regional supervisor will have to monitor performance metrics at the level of the domains (e.g. transit delays, error rates, etc...) in the same way a network manager monitors the performance of the individual equipment.

3. Monitoring of the network behaviour as regards security and contingency aspects: in the same way a network manager will consider a security problems on one of its equipment as a potential threat for the security of other equipment, the regional supervisor may have to consider such a problem as a potential threat for the security of other domains in the region.

4. Reporting on the network operations in order to either prove that the expected QoS has been delivered or determine areas which need improvements: statistics on the overall performance of the regional ATN will have to be collected for analysis by the regional administrator.

5. Reporting on the network utilisation in order to provide material for network consolidation or billing purposes: statistics on the network usage will have to be collected for analysis by the regional administrator.

6. Configuration of the network components: although it is not assumed that the regional supervisor will have the capability for dynamically modifying the characteristics of the domains in the region, the regional supervisor will have an active role in the resolution of configuration incompatibilities between domains. Furthermore, with the collaboration of the network managers, the regional supervisor may have to co-ordinate dynamic reconfigurations of the overall regional ATN topology. In the process of resolution of a severe problems, it may for instance be assumed that the regional supervisor has to request and co-ordinate the establishment of a new, temporary, inter-domain link or the modification of the domain routing policies (e.g. to switch communication service providers according to operational circumstances).

3.4.2.3 Role and responsibilities of the Regional ATN administrator

ATN regional administration will consists of the tactical and strategic activities identified in section 3.3.2.3.3, and applied on the network of ATN domains that constitute the ATN Region.

The Regional ATN administrator will be responsible for the administrative activities associated with the Regional institutions (establishing contracts, agreements and polices regarding the structure, integrity and internal administration of the Region as a whole, negotiating policies for communicating with other REGIONs external to itself.), and for the control of the modifications, evolutions and extension of the overall regional ATN topology.

With regard to the management of engineering changes to the regional ATN topology, the process of maintaining the overall network performances at acceptable levels, will include ongoing evaluation of the current situation, and an understanding of what impact any modifications will have. Any changes that may affect the current operation of the regional ATN (e.g. creation or modification of an inter-domain link between 2 organisations, modification of the routing policies within an organisation, etc...) will have to be assessed and endorsed at the regional administrator level.

The modification, evolutions and extension of the regional ATN will be driven by:

- the user (i.e. organisations) requirements and complains
- the national and private organisation ATN implementation/evolution plans
- the service objectives
- the Network availability/performance/usage analysis report derived from the statistics collected by the regional supervisor
- the network management reports provided by the regional supervisor
- implementation and operating costs reports
- decisions on investments
- technology vendor and communication service provider portfolio

3.4.3 Distributed co-ordination for the System Management of the ATN within an ATN Region

3.4.3.1 Principles

The principle of distributed co-ordination is to form global management co-ordination via the chain of bilateral service level agreements between participants of the ATN. In the bilateral service agreements, the two involved organisations will be assumed to decide on the exchange of the minimum of System Management information that is required for a meaningful and effective management co-ordination.

An organisation having established such service level agreements with each of its multiple partner organisations will then have the capability to access or receive system management information on the ATN network of every partner organisation. The organisation will then use the system management information gathered from every of its partners as an input to its network operations and planning activities. With this information it will take the necessary actions to keep the service offered to internal or external users in line with the committed Quality of Service, and will co-ordinate these actions with its immediate partners. Its partners may possibly be organisations having themselves established service level agreements with other organisations, and being in turn in a position to co-ordinate among another group of organisations, inter-domain system management activities. Via this management co-ordination chain, will be achieved the system management of the ATN in the Region.

3.4.3.2 Implications of the model

With the distributed co-ordination approach, each organisation positions itself as a "central" system management co-ordination actor for the small group of organisations that it forms with the set of its direct partner organisations.

The model presents therefore some similarities with the centralised co-ordination approach: it results in the implementation of a multi-domain system management structure that performs overall administration and supervision activities on the ATN implemented by a group of organisations. The difference is that such a multi-domain system management structure will potentially be implemented within each organisation, and that the approach will result, for an ATN region, in having as many "central" system management co-ordination actors as there are organisations participating in the ATN.

The analogy with the centralised approach is of interest because it can be considered that every organisations will have the same requirements in term of access to and exchange of system management information, as the central co-ordination body has, in the centralised approach. Every organisation will indeed potentially develop system management supervision and administration activities on the overall multi-domain ATN topology existing around its own domain. And these activities will require the same kind of technical co-operation with the surrounding organisations as the one identified in the centralised co-ordination approach between the central body and the other organisations:

- For real-time supervision of the overall multi-domain context in which operates its own ATN domain, an organisation will need real-time access to overall information on the status and performance of the adjacent domains.
- For administration of the operation and evolution of its ATN network in this overall multi-domain context, an organisation will have to know the plans and requirements for the modifications and evolutions of the adjacent ATN domain, to analyse the impact on its own infrastructure and to discuss and co-operate for the resolution of any possible problem.

There are therefore no fundamental differences on the technical aspects supporting the centralised and distributed system management co-ordination approach. The difference lies only in the sharing of responsibilities.

From a technical view point, whatever the approach followed in the region, an organisation will ever have to make available the same kind of off-line and on-line system management information: this information will have to be made available to the central co-ordination body in the case where the centralised co-ordination approach is followed, or to each of its partners in case of the distributed approach. It must therefore be possible to decide on a common set of system management information and on common information exchange mechanisms that will be used whatever the nature of the co-ordination in the region.

3.4.4 Comparison between the distributed and centralised co-ordination models

The distributed co-ordination model is considered to be suitable in ATN Regions where a few number of non-interdependent bi-lateral agreements between the organisations are necessary to achieve global co-ordination. These are the ATN Regions including a few number of large organisations (e.g. possibly the North America region), or the ATN Regions where one organisation is contracted as the regional ATN communication service provider for the benefit of other organisations, and where bi-lateral agreements need only to be established between the service provider and each organisation (e.g. Airline Regions).

On the other hand, the distributed co-ordination model may be ineffective for the management of highly international infrastructure, involving a lot of organisations. This is particularly demonstrated in the European case by the management of the CIDIN, for which the co-ordination was distributed, initially, and is now proposed to be centralised for a number of activities. The same tendency is also observed in the case of the ATSO data network integration (see chapter 2).

In Regions, such as Europe, constituted by many inter-adjacent organisations, the centralised co-ordination approach might therefore be more appropriate than the distributed co-ordination approach.

3.5 Requirements for ATN system management co-ordination mechanisms

The co-ordination of system management activities is a process which differs from the usual well known model of centralised system management.

With a totally centralised European ATN system management organisation, as proposed by COPICAT, a classical system management approach can be implemented: it is based on direct system management protocol interactions between one central European Network Management System (i.e. a manager) and all managed systems (i.e. the agents) disseminated in Europe. Standard mechanisms exist therefore for supporting a centralised European ATN management organisation.

On the other hand, no standard system management solution seems to exist today as a way to support the co-ordination of system management activities distributed among different organisations. The next chapter (i.e. chapter 4) analyses requirements for ATN system management co-ordination mechanisms and investigates potential solutions that could meet the requirements.

4. System Management co-ordination scenarios

4.1 Introduction

This chapter examines possible overall System Management co-ordination scenarios within an ATN region. The objective is to identify the system management functional areas that require cross-administrative domain interactions, the categories of information that need to be exchanged, and the possible solutions for the exchange of information.

The system management functional areas for which there is a potential requirement for co-ordination, are the five standard OSI ones: performance, configuration, fault, security and accounting management.

4.2 Performance management in a multi-organisation context

4.2.1 Introduction

Every organisation participating in ATN communication and operating ATN equipment will be assumed to collect and archive network management metrics that indicate network utilisation, growth, reliability, etc.. The primary goals of this activity are to facilitate real-time problem detection, near-term problem isolation and longer-term network planning within the organisation.

However, the broader goal of co-operative problem isolation and network planning among ATN organisations is likely to become increasingly important as the ATN grows, particularly as the number of involved organisations expands, while the overall quality of service remains more of a concern.

There is therefore a likely requirement for the exchange of common operational statistics between organisations and following the agreed principles for system management co-ordination. This requirement is furthermore assumed to exist both for real-time supervision, and for off-line network planning activities. For real time supervision, information on the current overall performance on the ATN domain(s) of an organisation will have to be made dynamically accessible to one (central) or several external network managers. For off-line network planning activities, every network manager will have to gather raw performance data on the historical overall performance of its ATN network, and share these raw data with other managers or administrators. It is from this raw data , that a network administrator can perform current operation and trend analysis and produce the various types of reports.

A potential difficulty for co-ordination, when the responsibilities for system management are distributed among all the involved organisation, is that every organisation may use different network management tools for the collection and presentation of network management metrics, with different kinds of measurement and presentation techniques. Such a diversity could make impossible the comparison of system management data among organisations.

To allow for the exchange of meaningful performance management data, there must be a general agreement on what metrics should be regularly collected and on how their values must be presented and exchanged. More specifically, there needs to be an agreed-upon model for:

1. A minimal set of common network management metrics to satisfy the goal of co-operative problem isolation and network planning among ATN organisations,

2. a common interchange format and mechanism to facilitate the usage of these data by common presentation tools, and that will allow the real time monitoring of the metric value across domain boundaries.

3. a format for archiving the collected data, (Note: this may be necessary only in a distributed co-ordination context, to avoid that every organisation records the performance data of each other

organisations; it is indeed better to have each organisation recording its own performance data, and providing a copy of the stored data collection, on request by other organisations)

4. the metric values refreshment, storing period and retention periods.

4.2.2 General principles for the real-time exchange of operational statistics

4.2.2.1 Introduction

The purpose of this section is to define mechanisms by which the Network Operation Centre of each organisation could share most effectively their operational statistics in real-time with one (central) or several other organisations. The purpose of such mechanisms would be to facilitate on-line ATN performance problem detection and resolution at a multi-organisation scale.

The concept that is currently being investigated at ATNP for the exchange of Management Information across domains relies on the implementation by each different organisation involved in the ATN of an overall 'summary' MIB where would be gathered the elements of management information on the local domain that are shared with external organisations. This summary MIB would be made accessible to other organisations through the use of a Network Management Protocol.

This section describes and discusses the principle of using such a 'summary' MIB for exchanging management information across domains.

4.2.2.2 Principle of the summary MIB approach

The Summary MIB concept assumes that every organisation will operate, in its Network Operation Centre, a central Network Management Station that has the capability to collect, via local System Management procedure, management information from the ATN equipment distributed in the local domain.

It is then assumed that the information gathered from the individual pieces of equipment, can be filtered, and processed for updating one global MIB providing an aggregated summary of the management information.

The principle for the exchange of management information across domain assumes then that each organisation would provide other organisations with access to such a summary MIB modelling the overall characteristics of its ATN domain, and would update its content according to well defined accuracy and timeliness standards. Organisations that have been granted permission to access the Summary MIB of another organisation, would then be allowed to read, periodically or on specific need occurrence basis, the content of the Summary MIB (SMIB).

4.2.2.3 Requirements

The assumed requirements that could be met with the implementation of SMIB services are the following ones:

1. **Monitoring the status of the systems providing an ATN service**: In order to speed up trouble diagnosis activities, there might be some benefits for an organisation to have a real time view on the operational, administrative and performance (e.g. congestion) status of ATN ES and ISs in another organisation and via which the local organisation gets access to a given ATN service.

2. **Monitoring the performance of the ATN service that is provided**: In order to speed up trouble diagnosis activities, there might be some benefits for an organisation to have a real time view on the global quality and performance of the services provided by another organisation. The services for which there might be a requirement to monitor the quality and the performance can be classified as follows:

- ATN Internetworking service: it consists in the forwarding of CLNP packets from an input node of the organisation providing the service to the destination system or to the input node of another organisation on the path to the destination system.

- ATN Application services: there are potentially as many different application services as there are different ATN applications (e.g. CPDLC service, FIS, etc..)

System Management of Subnetwork services is out of scope of ATN System Management.

3. **Regional supervision**: For trend analysis, capacity planning and trouble shooting co-ordination in a region, there might be the requirement in a region that every organisation that participates in ATN service provision provides another organisation in charge of the overall supervision of the regional ATN with additional statistics on the performance and Quality of Service information on inter-organisation links or data-flows (e.g. status of inter-domain links, internet or application (e.g. AMHS) inter-domain traffic information, etc...)

4.2.2.4 Organisations having to provide summary system management information

The identified requirements show that these are the organisations providing an ATN service (an ATN internetwork service or an ATN application service) which will primarily have to provide other organisations with summary system management information.

On the other hand, there are no clear requirements for having organisations being simple ATN Service Users providing local summary system management information to other organisations. This can be explained by the nature of user-provider relationships: in general, users are affected by a failure of their providers and hence may have a requirement for real time monitoring of the activity and performance of their service providers. On the other hand, a service provider should never be affected by a failure on the service users side, and hence has generally no particular requirements for service users management information.

It results from this considerations that a Summary MIB may have to be implemented by any organisations providing an ATN services (namely, the ATSOs, the International Aeronautical Communications Service Providers (ARINC, SITA, etc...), and possibly the meteorological and military organisations and the airport operators). On the other hand, no clear requirements have been yet identified for ATN service Users such as the Airlines operation centres and the Aircraft, to implement a Summary MIB.

4.2.2.5 Functional architecture

The functional architecture for the SMIB-based cross-domain exchange of management information is based on several function blocks implemented either by the organisation providing access to its SMIB or by the organisations retrieving information from this SMIB. This is depicted in Figure 1.

In this document, the following definitions apply:

SMIB User: This function block is a Management System operating in the manager role and to be implemented by organisations willing to retrieve information from the SMIB maintained by other organisations

SMIB Agent: This Function block is a Management System operating in the Agent role which performs the CMISE operations on the local SMIB. The SMIB Agent handles information retrieval requests from SMIB Users and information Update Requests from the SMIB Manager. This system is implemented by the organisation providing SMIB services.

SMIB Manager: This Function block is a Management System operating in the Manager role which is implemented by the organisation providing SMIB services. It retrieves necessary management information from the managed ATN equipment in the local domain, processes it, and generates information update requests to the SMIB agent.

The SMIB Agent and the SMIB Manager must be co-located on the same system.

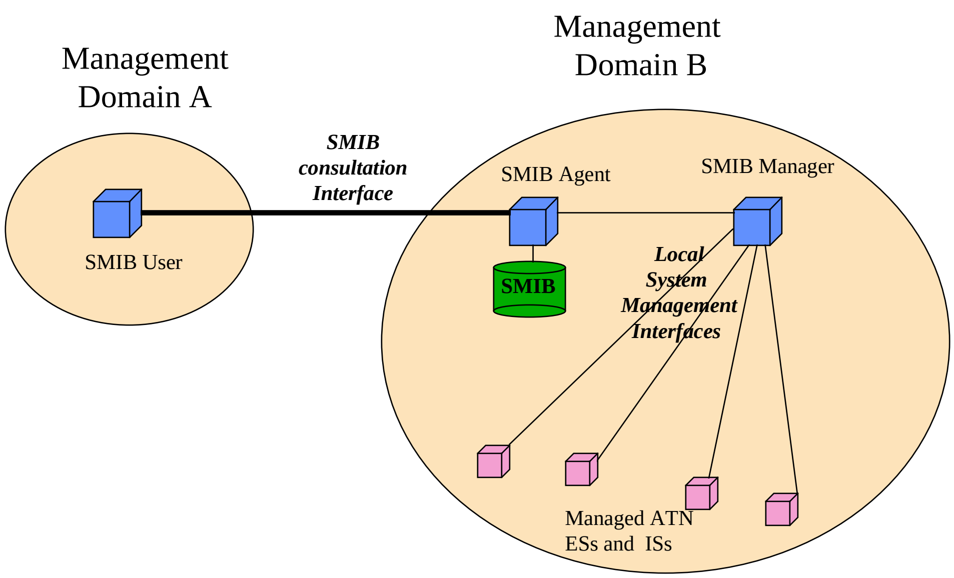


Figure 1: Summary MIB - Functional architecture

4.2.2.6 Characteristics of a SMIB consultation interface

The SMIB consultation interface relies on a direct manager-agent dialogue between the SMIB User and the SMIB Agent.

Between a SMIB User and a SMIB agent, the information will primarily be exchanged on a demand basis: a SMIB User willing to retrieve information from SMIBs of different organisations will have to send Management information « GET requests » to each of the associated SMIB Agents; a SMIB Agent will interpret what kind of requirement it has received and perform a management operation such as retrieval of an element of management information in the SMIB; the result will then be returned to the SMIB User.

The SMIB consultation interface may possibly be enhanced to support other types of management interactions, such as unsolicited event reports (notifications) and operations such as SET, CREATE, DELETE, etc...

4.2.2.7 Role of the SMIB Manager

The SMIB Manager is in charge of maintaining up to date information in the SMIB. This can be done in several manners:

1. On a periodical basis: Management Information is periodically transferred from the ATN equipment in the local domain to the SMIB Manager, which then filters/summarises the information and updates the SMIB.

2. event occurrence basis: any events (notifications) in relation to management information presents in the SMIB can be caught by the SMIB Manager. The SMIB manager may then update the SMIB information accordingly.

3. On demand basis: The SMIB Manager starts the action of updating the SMIB when a management information retrieval request is received by the SMIB Agent

The method of collecting and maintaining the SMIB information is local implementation choice for the individual Management Domains as long as they meet the timeliness and accuracy of the management information. A combination of the 3 methods can be envisaged, with a different method being used for a different type of data. For instance, status of ATN systems or links could be updated on an event occurrence basis, configuration information could be updated on demand basis, and performance statistics could be updated on a periodical basis.

4.2.3 Guidelines for defining summary system management information

4.2.3.1 Introduction

The purpose of this section is to discuss possible ways to structure a Summary MIB and to provide initial guidelines for the identification of the common management information elements of interest.

4.2.3.2 Approach

An organisation involved in the ATN will likely operate a complex infrastructure consisting of multiple components such as subnetworks, routers, End Systems, the whole being architectured to meet local and external requirements, and taking into account constraints of various types, including economical, geographical, and technical considerations. The process of summarisation of the management information will have as main objective to hide details which have no interest for external management information users and to focus on the main points.

The approach proposed for defining and structuring the summary information is to model in a simple and generic way the external view that an organisation may have on the services provided by another organisation, and then to represent each component of the model with a specific Managed Object Class, describing the main attributes of the component.

This approach is better explained with examples. The next section provides such an example: it includes a first proposal for the modelling of the external view of the domain of an ATN Internet Service provider and for the associated summary system management information.

4.2.3.3 A draft proposal for the SMIB information to be provided by an ATN internetwork Service provider

4.2.3.3.1 Introduction

The objective of this section is to develop an initial proposal for the SMIB information that could be required to be made available by an ATN organisation providing an ATN internetwork service. This section does not consider SMIB information germane to the provision of ATN application services.

4.2.3.3.2 Modelling

A simple model is defined for modelling the ATN infrastructure of an ATN organisation providing ATN internetwork service. The model makes use of the following definition:

- AISP: ATN Internet Service Provider

- AISP cloud: the ATN internetwork of the AISP . An AISP cloud consists of one or several interconnected ATN Routing Domains or Routing Domain Confederations

- Egress Router: An ATN Ground or A/G BIS located at the boundary or the AISP Cloud

- internal linkage: the logical representation of a virtual direct link between 2 egress routers. An internal link may be physically supported by an internal subnetwork (e.g. a leased line, an X.25 WAN, etc.) or an internal ATN internetwork (e.g. a group of subnetworks interconnected by non-egress AISP ATN routers).

- external ground linkage: a link connecting an AISP cloud to another AISP cloud or to the ATN system of an ATN Internetwork service user.

- external mobile linkage: a mobile subnetwork to which one the AISP egress router is attached

The approach proposed for summarising the management information pertaining to the ATN infrastructure of an AISP, begins then by modelling the whole AISP internetwork as a single "AISP cloud" with egress routers, internal linkages, and external ground and mobile linkages, as illustrated by Figure 2. The model hides the details of the internal architecture of AISP internetwork (e.g. internal routing architectures, internal routers, and subnetworks, etc....) but is believed sufficient for supporting the identified requirements on the exchange of operational statistics.

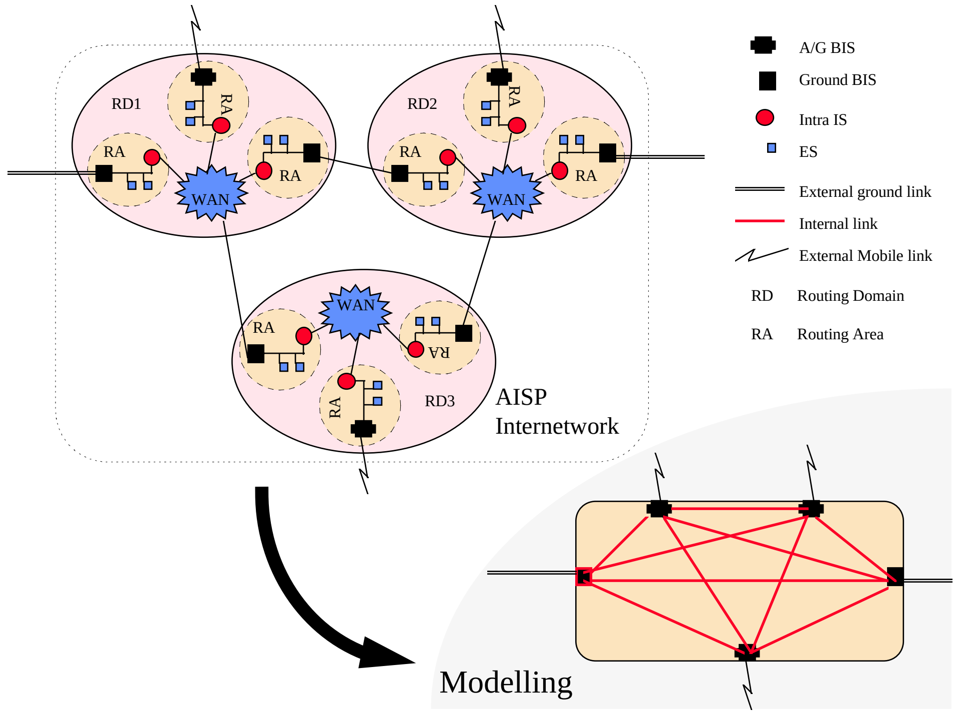


Figure 2: Modelling an ATN Internet Service Provider domain

The model can be recursively applied to a group of AISP internetworks, and can hence allow the summarisation of multi-organisations internetworks such as an ATN backbone or an ATN Island.

4.2.3.3.3 SMIB Containment tree

A possible containment (sub-)tree proposed for the SMIB of an ATN Internet Service Provider is the one represented on Figure 3.

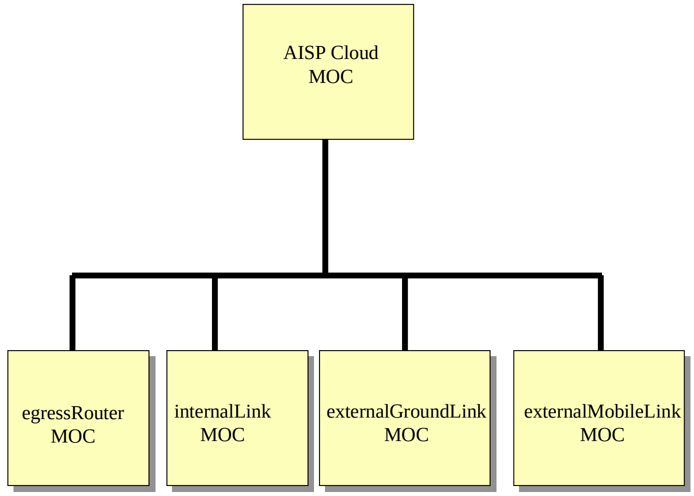


Figure 3: A containment (sub-)tree for the SMIB of an ATN Internet Service Provider

This containment tree has simply been derived from the model of AISP internetwork described in the previous section, by considering each element of the model as a separate object.

In the figure, the shadowed boxes represent Managed Object Classes which can have multiple instances.

The AISPCloud MO class is used to represent the whole ATN Internet Infrastructure of an AISP. Within a SMIB there should only one single MO instance of this class. Possible attributes of this class are:

- The name of the organisation providing the ATN Internet Service
- The type of the organisation: ATSO, AICSP, Airport Operator, etc...

The egressRouter MO class is used to represent one egress Router of the AISP. Within a SMIB there may be multiple MO instances of this class. Possible attributes of this class are:

- The Router type (e.g. A/G BIS, Ground BIS)
- The Router addresses
- The operational and administrative status of the Router
- The congestion status of the Router
- The number of CLNP Packets forwarded by the Router
- The number of CLNP Packets discarded by the Routers

The internalLinkage MO class is used to represent one internal linkage of the AISP. Within a SMIB there may be multiple MO instances of this class. Possible attributes of this class are:

- The address (Network Entity Title) of the egress routers at each end of the internal linkage
- The type of traffic permitted on this link -ATSC Only, non-ATSC only, or both ATSC and non-ATSC
- The operational and administrative Status of the link
- The level of congestion of the link
- The delay of transit and throughput of the link
- The number of CLNP packets and PDU octets having transited over the link (possibly for each direction of transfer, and per type of traffic)
- The reliability of the link

The externalGroundLinkage MO class is used to represent one external ground linkage of the AISP. Within a SMIB there may be multiple MO instances of this class. Possible attributes of this class are:

- The addresses of the egress router at the local end of the external link
- The addresses of the system at the other end of the link
- The type of traffic permitted on this link -ATSC Only, non-ATSC only, or both ATSC and non-ATSC
- The operational and administrative Status of the link
- The level of congestion of the link
- The delay of transit and throughput of the link
- The number of CLNP packets and PDU octets having transited over the link (possibly for each direction of transfer, and per type of traffic)
- The number of IDRP PDUs exchanged over the link
- The reliability of the link

The externalMobileLinkage MO class is used to represent one external Mobile linkage of the AISP. Within a SMIB there may be multiple MO instances of this class. Possible attributes of this class are:

- The addresses of the egress router at the local end of the external link
- The mobile subnetwork type (satellite, VDL, Mode S, etc...)
- The type of traffic permitted on this link -ATSC Only, non-ATSC only, or both ATSC and non-ATSC
- The operational and administrative Status of the link
- The level of congestion of the link
- The delay of transit and throughput of the link
- The number of CLNP packets and PDU octets having transited over the link (possibly for each direction of transfer, and per type of traffic)
- the total number of aircraft having been in contact over the link
- The total number of aircraft having closed the contact over the link
- The reliability of the link

4.2.4 Principles for the exchange of operational statistics to serve as a basis for trend and capacity planning

4.2.4.1 Introduction

The previous section focused on the mechanisms needed for the real-time exchange of operational statistics, for on-line performance problem detection, or near-term problem isolation.

Another objective of performance management is the use of the collected statistics for off-line longer term network trend analysis and capacity planning.

For off-line network planning activities, the value of the performance metrics that are periodically collected needs to be recorded for future use as historical raw data. It is from this raw data , that network administrators can perform current operation and trend analysis and produce the various types of reports.

When real-time access to current performance statistics is provided by an organisation according to the principles introduced in the previous section, other organisations can periodically poll the values of these statistics, record them locally and then constitute the raw data files that will later be used for network planning activities. For the following 2 reasons, this scenario is not however very satisfactory:

1. The partner organisations needing the data for network planning activities only (and not for real-time supervision) are compelled to perform the on-line periodic polling of the performance metrics, so as to have these data collected.

2. When the data are of interest for multiple partner organisations, the same data will be collected and recorded several times. This is a waste of effort and resources, since the data could instead be collected and recorded once for all in a unique reference archive, that could then be shared among the partner organisations as necessary.

A better approach would then be to have each organisation responsible for the recording of the performance statistics on its own ATN domain, and sharing the resulting raw data file with other partner organisations.

This approach necessitates the definition of a common format for archiving the collected data, and of common mechanisms for sharing the content of the archive.

4.2.4.2 Elements for the definition of operational statistics archive

4.2.4.2.1 Introduction

The specification of a common archive format and sharing mechanism is out of the scope of this document. This section will be used to provide informative elements on the subject.

The exchange of common operational statistics is an issue that has been studied by the internet community. Two RFCs address the subject:

- RFC 1857: A Model for Common Operational Statistics

- RFC 1856: The Opstat Client-Server Model for Statistics Retrieval

The 2 following sections provide a summary of the ideas brought in these papers.

4.2.4.2.2 Definition of an interchange file format

RFC 1857 defines an interchange file format. The model is not necessarily intended to be used for the actual data storage of operational statistics. Its goal is to provide complete, self-contained, portable files rather than to describe a full database for storing the data.

The proposed format is the one of a plain text, human readable file, with well specified labels to mark the beginning and end of the multiple sections and records. The file can be transferred from one Network Operation Centre to another one using conventional file transfer or message transfer mechanisms.

The specification of the interchange file format comprises the following aspects:

- the syntax used to describe the recorded data

- the definition of the recorded data

- the specification of the storing period of each data (within the same set of logged data, different data can be logged at different frequencies)

- the definition of aggregation rules: to avoid storing redundant data, some levels of pre-processing and aggregation of the raw data may be required. The volume of data that may be generated by short statistics collection period (e.g. every minute) makes indeed aggregation of the stored data desirable if not necessary. Aggregation refers to the replacement of data values on a number of time intervals by some function of the values over the union of the intervals.

- the specification of aggregation periods: e.g. over a 24 hour period, aggregate to 15 minutes, over a 1 month period, aggregate to 1 hour, over a 1 year period, aggregate to 1 day, etc.

- the specification of retention periods (i.e. how long will the data be archived)

4.2.4.2.3 use of a client/server based statistical exchange system

A client/server approach is proposed in RFC 1856 for the exchange of operational statistics. Such an architecture envisions that each Network Operation Centre should install a server which provides locally collected statistics for clients. Using a query language the client should be able to define the network object of interest, the metrics and the time period to be examined. The server would then transmit the requested data.

4.2.4.3 Elements for the exchange of performance reports

The raw data files will be used by network administrators to generate reports on the current network operations and trends. Another area of co-operation and co-ordination between organisations is therefore the exchange of such reports. Effort and resources could indeed also be saved if some basic classes of network performance reports were standardised: every organisation could produce periodically such standard reports on the performance of its own ATN domain and could share the document with the partner organisations.

The idea would then be to define at international level the structure and contents of basic classes of reports to be produced by the area administrators according to a well specified schedule.

As an example scenario, there could be:

- short-term weekly reports giving information about medium-term changes in network behaviour which could serve as input to the medium term engineering activities

- monthly and yearly reports showing long-term tendencies in the network

The content of these reports could be bar-charts giving a total value, for the period, of some major performance metrics, such as:

- the number of CLNP packets exchanged at the boundary nodes of the ATN domain

- the number of UPDATE PDU exchanged at the boundary nodes of the ATN domain

- the number of aircraft having been in contact with the ATN domain.

4.3 Fault management in a multi-organisation context

4.3.1 Introduction

Fault management is the set of facilities which enables the detection, isolation and correction of abnormal operation. Fault management includes functions to:

- Maintain and examine error logs
- Accept and act upon error notifications
- Trace and identify faults
- Carry out diagnostic tests
- Correct faults

Fault Management deals most commonly with alarm notifications emitted by network elements and with complaints from the network users.

Network fault management at the level of an administrative domain is a common practice. Data network elements are generally equipped with management agents that automatically emit fault notifications to the managing system. Network Operations Centres are generally equipped with a Help Desk that users may contact in case of problems and with some kind of problem tracking system that helps the operator all along the different steps required to correct the problem associated with the alarm or symptom (fault analysis, alarm correlation, etc...)

However, work to date in the area of fault management has concentrated on effectively managing the resolution of problems within an Administrative domain. To our knowledge, little has been done to address the problem of co-ordinated fault management across administrative domains, although the need for such a global co-ordination system is not specific to the ATN: in one recent informal study of routing stability in the internet, it was found that while the majority of catastrophic routing problems could be identified as software and configuration errors, about 10% of the problems could only be classified as « somebody else's problem », since all parties questioned pointed to another party as the cause. Such problems are the most difficult to resolve, and underscore the need for inter-domain co-ordination, so that the true causes of problems may be identified and such circular referrals detected and resolved.

A second important point is that the true cause of a problem may be distant from its effect. For instance the failure of an A/G communication may be the result of a problem located anywhere between the ground ES and the airborne ES. Contacting one's local help desk is unlikely to be of much benefit in this case.

This section investigates the problem of such inter-domain co-ordination of troubleshooting and repair efforts, and addresses more specifically issues such as:

- reporting network outages and other problems across administrative boundaries
- acquiring feedback on the problems across administrative domains
- inter-administration negotiation of solutions
- pre-notification, or notifying organisations of downtime scheduled in the future

4.3.2 Fault management within administrative domain

4.3.2.1 Introduction

The definition of possible inter-domain troubleshooting co-ordination scenario requires to make some assumption on the way fault management will be performed within each organisation.

We will make the assumption that every organisation will use some kind of central problem tracking system as this is generally required for professional quality handling of computing problems. Such central system is referred hereafter as a « trouble ticket » system.

This section gives an overview of the general functions of a trouble ticket system.

4.3.2.2 What is a trouble ticket system ?

4.3.2.2.1 General

Problem reporting and resolution is a multi-phase procedure. In the first phase, an error is reported and a first hypothesis on the cause of the problem is submitted to an expert whose area of expertise includes the network element which is experiencing problems. The expert next attempts to verify the existence of the reported problem. If the problem is confirmed, the expert then generates additional hypotheses about potential causes, which are in turn submitted to appropriate experts. This process continues until one or more problems are confirmed which have no causes. Repairs are then requested for these problems. If repairs can not be immediately initiated, repairs are then attempted at their immediate effects, and soon back down the cause tree.

A basic trouble ticket system co-ordinates the work of multiple people who may need to work on a problem.

4.3.2.2.2 Purposes of a trouble ticketing system

A good description of the desirable features of a trouble ticketing system is found in RFC 1297: a trouble ticketing system may serve many purposes:

1) SHORT-TERM MEMORY AND COMMUNICATION ("Hospital Chart"). The primary purpose of the trouble ticket system is to act as short-term memory about specific problems for the Network Operation Centre (NOC) as a whole. In a multi-operator or multi-shift NOC, calls and problem updates come in without regard to who worked last on a particular problem. Problems extend over shifts, and problems may be addressed by several different operators on the same shift. The trouble ticket (like a hospital chart) provides a complete history of the problem, so that any operator can come up to speed on a problem and take the next appropriate step without having to consult with other operators who are working on something else, or have gone home, or are on vacation. In single-room NOCs, an operator may ask out loud if someone else knows about or is working on a problem, but a trouble ticket system allows for more formal communication.

2) SCHEDULING and WORK ASSIGNMENT. NOCs typically work with many simultaneous problems with different priorities. An on-line trouble ticket system can provide real time (or even constantly displayed and updated) lists of open problems, sorted by priority. This allows operators to sort their work at the beginning of a shift, and to pick their next task during the shift. It also allows supervisors and operators to keep track of the current NOC workload, and to call in and assign additional staff as appropriate.

3) REFERRALS AND DISPATCHING. If the trouble ticket system is thoroughly enough integrated with a mail system, or if the system is used by Network Engineers as well as Network Operators, then some problems can be dispatched simply by placing the appropriate Engineer or Operator name in an "assigned to" field of the trouble ticket.

4) ALARM CLOCK. Typically, most of the time a trouble ticket is open, it is waiting for something to happen. A timer is then generally associated with every wait. If a ticket is referred to a public network operator providing subnetwork service, there will be an escalation time before which the

public network operator is supposed to call back with an update on the problem. For tickets referred to remote site personnel, there may be other more arbitrary time-outs. Tickets referred to local engineers or programmers may also have time-outs ("Check in a couple of days if you don't hear back from me"). A good trouble ticket system allows a time-out to be set for each ticket. This alarm generates an alert for that ticket at the appropriate time. Preferably, the system allows text to be attached to that timer with a shorthand message about what the alert involves (The full history of the problem can always be found by checking the trouble ticket).

5) OVERSIGHT BY ENGINEERS AND CUSTOMER/SITE REPRESENTATIVES. NOCs frequently operate more than one network, or at least have people (engineers, customer representatives, etc.) who are responsible for subsets of the total network. For these individual representatives, summaries of trouble tickets can be filtered by network or by node, and delivered electronically to the various engineers or site representatives. Each of these reports includes a summary of the previous day's trouble tickets for those sites, a listing of older trouble tickets still open, and a section listing recurrent problems. These reports allow the site representatives to keep aware the current outages and trends for their particular sites. The trouble ticket system also allows network access to the details of individual trouble tickets, so those receiving the general reports can get more detail on any of their problems by referencing the trouble ticket number.

6) STATISTICAL ANALYSIS. The fixed-form fields of trouble tickets allow categorisations of tickets, which are useful for analysing equipment and NOC performance. These include, Mean Time Between Failure and Mean Time to Repair reports for specific equipment. The fields may also be of use for generating statistical quality control reports, which allow deteriorating equipment to be detected and serviced before it fails completely. Ticket breakdowns by network allow NOC costs to be apportioned appropriately, and help in developing staffing and funding models. Data such as the number of specific models of hard drives that have been repaired or replaced over the last month, quarter or year, allow the administrator to weed out those devices that cost too much to repair. Analysis of this sort typically drive the cost of maintenance down.

7) ACCOUNTABILITY, FACILITATING CUSTOMER FOLLOW-THROUGH, AND NOC IMAGE. Keeping user-complaint tickets facilitates the kind of follow through with end-users that generates happy clients (and good NOC image) for normal trouble-fixing situations. But also, by their nature, NOCs deal with crises; they occasionally find themselves with major outages, and angry users or administrators. The trouble ticket system documents the NOC's (and the rest of the organisation’s) efforts to solve problems in case of complaints.

4.3.2.3 What is a trouble ticket ?

A trouble ticket is simply a well defined form with fixed and/or free fields, and which is used as the representation of an event for problem report. A ticket is opened when a problem is raised; it is then held by the right responsible of the problem; and finally closed when the problem has been solved.

A trouble ticket consists generally of the following 3 parts:

1) HEADERS. Inevitably, a trouble ticket begins with a number of fixed fields. These generally include:

- Time and Date of problem start.
- Initials or signon of the operator opening the ticket.
- The unique trouble ticket number
- Severity of the problem (possibly separating the "customer severity" and the "NOC priority", since these could be different).
- A one-line description of the problem for use in reports.
- A status (e.g. OPENED, HELD or CLOSED)

There can be many other fixed fields for specific purposes. There may also be different kinds of tickets for different problems, where the ticket format differs mainly in fixed fields. These include:

- Who reported the problem? (Name, organisation, phone, e-mail address)
- Machine(s) involved.
- Network involved (for multi-network NOCs).
- User's machine address.
- Destination machine address.
- Next Action.
- Time and date for alarm on this ticket.
- Who should the ticket be dispatched to?
- Ticket "owner" (one person designated to be responsible overall).

2) INCIDENT UPDATES. The main body of trouble tickets is usually a series of freeform text fields recording the incident updates, and the date and time of these updates. The first incident update usually is a description of the problem. Since the exact nature of the problem is usually not known when the ticket is first opened, this description may be complex and imprecise. (e.g. it may include traces of PDUs exchanged, the dump of a Forwarding Information base, a copy of the original message for problems that are reported by electronic mail, etc...) . Generally, this section also includes an indication of what the next action for this ticket ought to be

3) RESOLUTION DATA. Once a problem is resolved, it is useful to summarise the problem for future statistical analysis. The following fields are generally found to be useful:

- Time and Date of resolution
- Outage duration
- Resolution (description of what happened and on how the problem was fixed).
- Key component affected (for MTBF and similar reports).
- Checked By -- a field for supervisors to sign off on ticket review.

4.3.2.4 Trouble tickets and incident reports

A single network failure might well produce a large number of individual user phone calls and hence « user complaint » tickets. In the same way, a failure may result in several « error notifications » received on the alert system.

As multiple events occur for the same problem, it is often most efficient to record only a single trouble ticket. However, it is still important to track all the individual incidents related to the trouble ticket to more accurately respond to the problem and to measure the total performance of the problem correction. NOC generally wants to use « special forms » to track each one of the user complaints (e.g. to make sure each user is informed and satisfied about the eventual resolution of problem) and error notifications. Such special forms are called « incident reports »: incident reports can be used to store the user view of a problem or to capture duplicate (correlated) error notifications received on the alert system.

An incident report is a well defined form which typically includes the following fields:

- the incident report unique number,
- the date and time when the incident report was opened
- the number of the associated trouble ticket
- the origin of the incident report: this field may contain information on the person who reported the problem or information received on the alert system
- A description of the place which are affected by the problem
- A title summarising the problem

- A description of the problem
- The time when the problem was detected
- The time when the problem was corrected

4.3.3 Inter-domain troubleshooting co-ordination

4.3.3.1 Introduction

From the previous description on the general fault management process within administrative domain, it follows that inter-domain troubleshooting co-ordination should be based on the exchange of trouble tickets and incident reports across domains.

The basic scenario is the following:

- a fault occurs within a domains that impacts other ATN domains (e.g. a BIS or an ES failure). This error is likely to result first in error notifications or user complaints received by the Network Operation Centres of each organisation impacted by the problem (including the NOC of the organisation where the fault has effectively occurred).

- In a first phase, each of those organisations is assumed to open a trouble ticket for the problem, and to investigate the causes. All but one organisations should then conclude that the origin of the problem is external to their domain (those are referred hereafter as the impacted organisations). One organisation should conclude that it is responsible for the resolution of the problem (it is referred hereafter as the faulty organisation).

- The impacted organisations may then be willing to report the problems. If they have identified the faulty organisation, the following 2 scenarios are conceivable:

  1. The impacted organisations report the incident to the faulty organisation, and need feedback on the resolution of the problem (e.g. time to repair, notification of the resolution of the problem, etc...)

  2. The impacted organisations report the incident to the faulty organisation, and do not need feedback on the resolution of the problem. This may occur when the organisations have detected a problem that has no real impact on their own domain (e.g. the failure of the ATN equipment on board of an aircraft for an ATSO). In these cases the organisations are simply willing to help other organisations in the process of identification and resolution of their problem.

If the impacted organisations do not know which organisation is at the origin of the problem, the following co-ordination scenarios could be envisaged:

  3. If there is a central co-ordination entity within the ATN region, the impacted organisations report the incident to this entity, which is then in turn assumed to investigate the problem, and co-ordinate its resolution.

  4. If there is no central co-ordination entity, the impacted organisations report the incident to one or several of its immediate partner organisations which are then assumed to investigate the cause of the problem and either deny it, or accept to participate in its resolution. In the latter case, the partner organisations may have to propagate the incident report to other organisations, and this process may continue until the true responsible is identified.

- The faulty organisation may be willing to:

  5. Warn every partner organisation about the problem.

  6. Acknowledge the receipt of incident reports from those of the partner organisations that have detected and reported the problem.

7. Inform the partner organisation on the status of the problem resolution

Inter-domain troubleshooting co-ordination addresses therefore issues such as:

- The definition of common inter-domain trouble tickets and incident reports.
- The definition of common mechanisms for the exchange of trouble tickets and incident reports
- The definition of common operational procedures governing the exchange of the trouble tickets and incident reports.

4.3.3.2 Definition of common inter-domain trouble tickets and incident reports

All ATN organisations should agree on a common specification of the content and the structure of ATN trouble tickets and incident reports. The specification on the content should include:

- **a common definition of the severity of a problem** (e.g. 'critical' when the problem causes widespread interruption in the ATN communication service, 'Major' when a work-around can be applied to the problem and the service can continue in a degraded mode, 'Minor' for problems that should be fixed in the normal course of business and for which the change can wait until the future for correction)
- **a common definition of the status of a problem**:
- **a common definition of the types of problems:** this may be a catalogue of well identified error cases to which an organisation may refer when reporting an problem or the diagnostic of a problem.
- **the list of all other information elements to be provided** (e.g. time when the problem was detected/corrected, who reported the problem, who is responsible for the problem, expected repair time, etc...)

The specification on the structure of the trouble ticket and incident report should describe how the information is encoded. Possible structures are:

- a plain text form that can be exchanged in the body of an electronic mail
- an EDI/EDIFACT document
- CMIP notifications
- others....

4.3.3.3 Definition of common mechanisms for the exchange of trouble tickets and incident reports

The ATN organisations should agree on common mechanisms for:

1. the exchange of trouble tickets and incident reports,
2. and possibly for the real time monitoring of the status of trouble tickets

Possible mechanisms for the exchange of trouble tickets and incident reports are:

- AMHS
- CMIP (there are apparently TMN standards, addressing the issue of inter-domain trouble-ticketing, and based on the use of CMIP)

Real-time monitoring of the status of trouble tickets would require the implementation in the Network Operations Centres of an information server accessible by remote clients. Possible architectures for such services are:

– the use of a data base manager (with SQL interactions between the clients and the server)

– the use of http-based servers and browsers (e.g. Netscape)

4.3.3.4 Definition of common operational procedures governing the exchange of the trouble tickets and incident reports

Common operational procedures should be defined and specify:

- in which cases an inter-domain incident report is to be issued,
- to which organisation(s) the incident report should be delivered,
- which reporting actions have to be taken by an organisation on receipt of an incident report (acknowledgement of the report, acceptance or denial of the problem, notification on the opening of a trouble ticket, possible reports on the change of status of the trouble ticket,....
- Which reporting actions have to be taken by an organisation on failure of one of its equipment, vis a vis the other organisations
- etc...

These operational procedures will certainly depend on the organisational principles (centralised or distributed). adopted in the ATN region to achieve overall co-ordination among the ATN organisations. In ATN regions where a centralised co-ordination entity is in place it may be assumed that this central entity will take a preponderant role in the handling and redistribution of incident reports and trouble tickets.

4.3.3.5 Recommendation

The specification and implementation of an overall trouble ticketing architecture is a complex problem. However, trouble ticketing is a domain which has long been considered by the industry and there are today numerous COTS products and solutions that answer most of the requirements.

It is therefore recommended that the ATN community builds and specifies a trouble ticketing architecture that can be based on and integrate COTS trouble ticket systems. The ATN inter-domain troubleshooting co-ordination requirements should be specified by the ATN community by making in parallel a survey of the current trouble ticketing systems available on the market, and of those currently used by ATSOs, Airlines and IACSPs, and by analysing how these COTS tools could be interfaced with the ATN.

4.3.4 Off-line fault management

ATN organisation will normally mitigate the effects of faults, by taking preventive actions that are planned as part of the network/application design and that consider the cost and the criticality of the services. Preventive actions may include built-in redundancy such as automatic switch to backup system, or a complete change in application such as switching from data exchange to voice exchange of pertinent information.

The prevention of fault is a domain which may require co-ordination among the different ATN organisation. This domain may comprise the following aspects:

- Establishment of bilateral or multilateral procedures to be performed on the occurrence of well-identified error cases (e.g. switch from one subnetwork service provider to another one).

- Bi-lateral or multi-lateral agreement on normative time for, the detection and report of problem by an ATN organisation (mean time to detection), the recovery of problem with backup or redundant components (mean time to recover), and the restoration to original configuration (mean time to restoration)

- The co-ordination and planning of downtime for routine maintenance

- Liability issues

4.4 Accounting management

4.4.1 Introduction

Accounting is a complex problem. The ATN will consist of networks of varying sizes and capacities, operated both by administrations and commercial organisations. Subsidies and funding mechanisms appropriate to non-profit organisations often restrict commercial use or require that "for profit" use be identified and billed separately from the non-profit use. Tax regulations may require verification of network usage. Some portions of the ATN will be distinctly "private", whereas other ATN segments will be treated as public, shared infrastructure. Each of the administrations may have different policies and by-laws about who may use an individual network, who pays for it, and how the payment is determined. Also, each administration will balance the OVERHEAD costs of accounting (metering, reporting, billing, collecting) against the benefits of identifying usage and allocating costs.

Different billing schemes may be employed. In certain cases a flat-fee, usage-insensitive model, similar to the monthly unlimited local service phone bill, could be sufficient and could be preferable for financial, technical, or other reasons. In other cases, usage-sensitive charges may be preferred or required by a local administration's policy. The wishes of ATN users with low or intermittent traffic patterns may force the issue (note: flat fees are beneficial for heavy network users. Usage-sensitive charges generally benefit the low-volume user).

The exact requirements for ATN usage accounting will therefore vary from one network administration to the next and will depend on policies and cost trade-offs.

Accounting issues have normally to be considered on the following 2 different aspects:

1. institutional issues on cost recovery: this addresses the construction of tariff (who gets billed, how much, for which things, based on what information, etc...). Tariff issues include fairness, predictability (how well can subscribers forecast their network charges), practicality (of gathering the data and administering the tariff), incentives (e.g. encouraging off-peak use), and cost recovery goals (100% recovery, subsidisation, profit making). Issues such as these are out of the scope of System Management and are not covered here.

2. technical issues on the possible ATN usage measurement and reporting architectures that will permit the ATN organisations to perform accounting in a private or co-operative way and according to a personal or a commonly agreed accounting policy . This technical aspect of the accounting is considered in this section.

Accounting management only deals with the technical aspects. This section will therefore be used to provide background and tutorial information on accounting management architecture that may have to be implemented within organisations and addresses the issues of the possible accounting co-ordination requirements between organisations.

4.4.2 Accounting Architectures

4.4.2.1 Introduction

The accounting management process is likely to vary among organisations based on billing practices. However, in order to identify the areas where accounting management co-ordination across organisations may be required, we will describe a general accounting management model and assume that this model will not be very different from the accounting management process performed within the organisations participating in the ATN.

The following sections outline the model for traffic flow measurement that has been developed by the Internet community and which is currently proposed in RFC 2063. This accounting architecture has been derived and developed from the working drafts of the OSI accounting model (ISO 7498-4 OSI Reference Model Part 4: Management Framework).

The architecture is based on the definition of the following basic entities:

1) the METER, which examines streams of packets on a communications medium or between a pair of media and aggregates the results of those measurements. Meters count certain attributes (such as numbers of packets and bytes) and classify them as belonging to ACCOUNTABLE ENTITIES using other attributes (such as source and destination addresses). An accountable entity is someone who (or something which) is responsible for some activity on the network. It may be a user, a host system, a network, a group of networks, etc., depending on the granularity specified by the meter's configuration. Meters are placed at measurement points determined by network Operations personnel (e.g. in Routers or dedicated traffic monitors). Each meter selectively records network activity as directed by its configuration settings. It can also aggregate, transform and further process the recorded activity before the data is stored. The processed and stored results are called the 'usage data.'

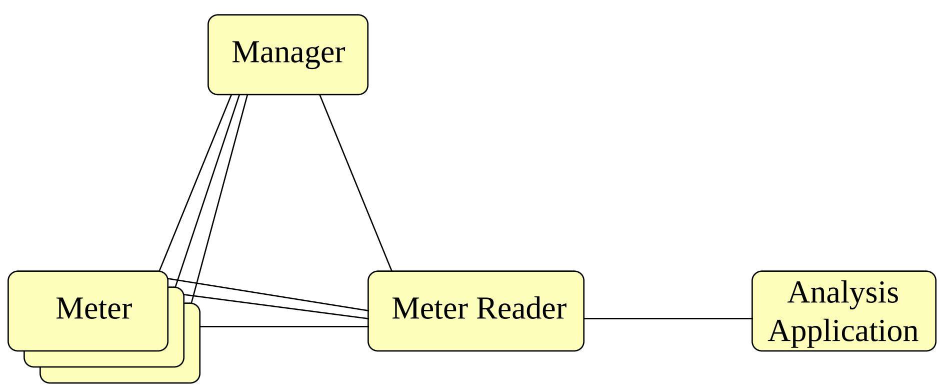
2) the COLLECTOR, or METER READER, which is responsible for the integrity and security of METER data in short-term storage and transit. A meter reader reliably transports usage data from meters so that it is available to analysis applications.

3) the ANALYSIS APPLICATION which processes the usage data so as to provide information and reports which are useful for network engineering and management purposes. Examples include:

- TRAFFIC FLOW MATRICES, showing the total flow rates for many of the possible paths within the managed portion of the ATN.
- FLOW RATE FREQUENCY DISTRIBUTIONS, indicating how flow rates vary with time.
- USAGE DATA showing the total traffic volumes sent and received by particular systems.

4) The traffic measurement MANAGER: it is an application which configures 'meter' entities and controls 'meter reader' entities. It uses the data requirements of analysis applications to determine the appropriate configurations for each meter, and the proper operation of each meter reader. The meter reader and the manager may be combined within a single network entity.

The relationships between these 4 entities are shown in the following figure:



4.4.2.2 Interaction Between METER and METER READER

The information which travels along this path is the usage data itself. A meter holds usage data in an array of flow data records known as the FLOW TABLE. A meter reader may collect the data in any suitable manner. For example it might upload a copy of the whole flow table using a file transfer protocol, or read the records in the current flow set one at a time using a suitable data transfer protocol.

A meter reader may collect usage data from one or more meters. Data may be collected from the meters at any time. There is no requirement for collections to be synchronised in any way.

4.4.2.3 Interaction Between MANAGER and METER

A manager is responsible for configuring and controlling one or more meters. Each meter's configuration includes information such as:

- Flow specifications, e.g. which traffic flows are to be measured, how they are to be aggregated, and any data the meter is required to compute for each flow being measured.
- Meter control parameters, e.g. the maximum size of its flow table, the 'inactivity' time for flows (if no packets belonging to a flow are seen for this time the flow is considered to have ended, i.e. to have become idle).
- Sampling rate (when the local accounting policy does not require the observation of every packets)

4.4.2.4 Interaction Between MANAGER and METER READER

A manager is responsible for configuring and controlling one or more meter readers. A meter reader needs to know at least the following for every meter it is collecting usage data from:

- The meter's unique identity, i.e. its network name or address.
- How often usage data is to be collected from the meter.
- Which flow records are to be collected (e.g. all active flows, the whole flow table, flows seen since a given time, etc.).
- Which attribute values are to be collected for the required flow records (e.g. all attributes, or a small subset of them)

4.4.2.5 METER READERs and APPLICATIONs

Once a collection of usage data has been assembled by a meter reader it can be processed by an analysis application. A possible application may be the automatic generation of bills. Other applications may be dedicated to the generation of network usage reports for network planning activities.

4.4.3 Accounting management co-ordination

4.4.3.1 Introduction

For a number of organisations participating in the ATN, accounting management will be considered as a private process which does not require any technical co-ordination with other organisations. These organisations will perform the usage data collection and analysis activities on their own and interactions with other organisations will be limited to the exchange of bills between finance departments. Upon occasion, requests for verification of bills will arise; but this is typically handled through the finance process rather than the network management process.

On the other hand, other organisations may be willing to enter into partnership so as to share the accounting management structure, minimise the billing interactions with common external users or service providers and simplify the internal redistribution of costs and benefits between partner organisations. This may typically be the case of European ATSOs, which could be willing to combine and centralise the accounting post-processing tasks of maintaining the accounting database, generating reports, distributing bills, collecting revenue, etc ...

For those organisations accounting management co-ordination will be required. This section analyses possible co-operation scenarios with the intent to identify the possible requirements for specification of common standard accounting information exchange procedures.

4.4.3.2 Accounting Management co-ordination scenarios

4.4.3.2.1 General

Each scenario considered in this section presents the following common characteristics:

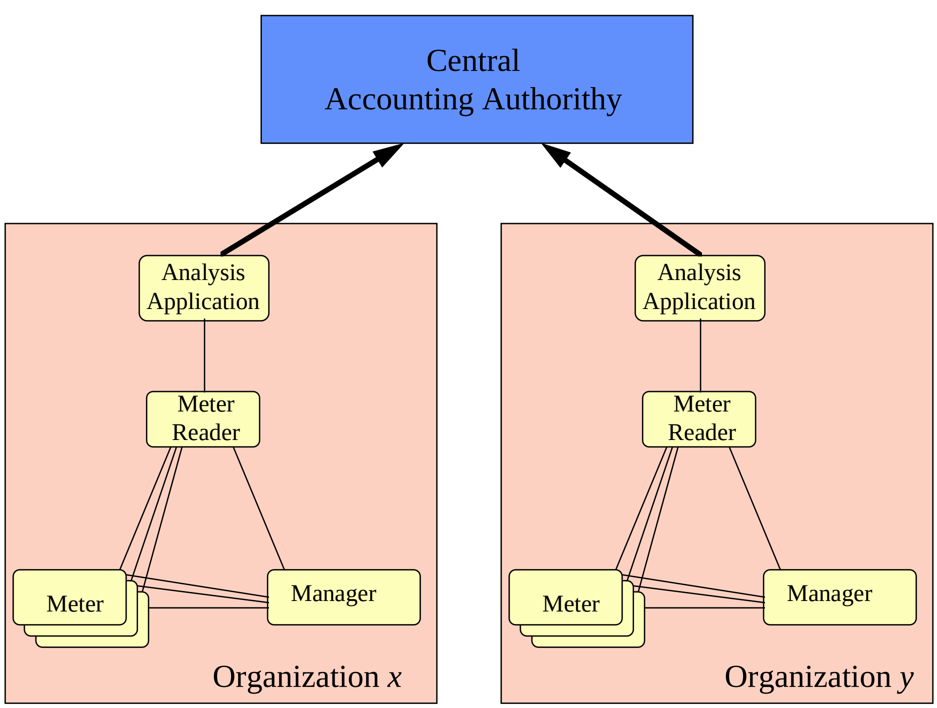
- It is assumed that there is a central accounting authority, the ultimate goal of which is to perform the post processing billing and revenue collection activities on behalf of all partner organisations.

- The overall accounting management architecture is based on the implementation of meters, meter readers, traffic measurement manager and analysis applications as introduced in the previous section

The variations between the different scenarios arise from the difference of location of the meter readers, traffic measurement managers and analysis applications. Depending on the scenario, these entities are either assumed to be centralised and under the responsibility of the central accounting authority or distributed within organisations and under the responsibility of each of those organisations. The meters are distributed by nature, and are assumed to be under the responsibility of entity which is responsible of the traffic measurement manager.

4.4.3.2.2 Scenario 1: maximum distribution of the accounting management activities

This first scenario assumes that meters, meter readers, traffic measurement managers, and analysis applications remain under the responsibility of every partner organisation. The central accounting authority is then assumed to perform its billing and revenue collection activities on the basis of information elements resulting from the analysis applications operated by the individual organisations. This scenario is depicted in the figure below:



The implication of this scenario is that accounting analysis reports will need to be exchanged between the organisations and the central accounting authority. This will require the specification of common standards for:

1. The content and forms of these reports;

2. The mechanisms of exchange of these reports (e.g. fax, mail, electronic mail, file transfer programs, etc...);

3. The issuing periods of these reports

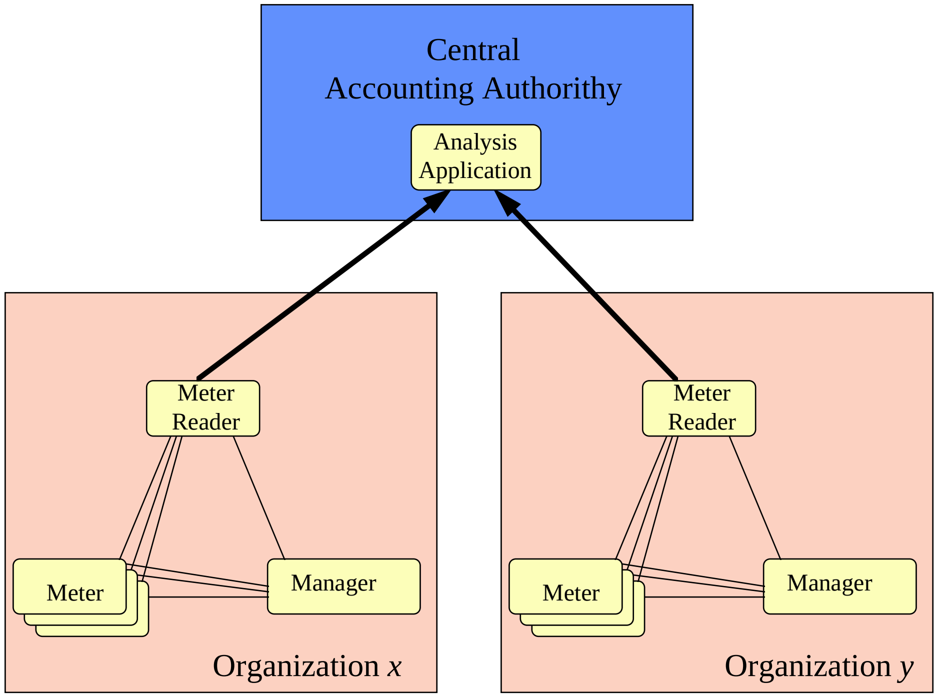
This scenario is very simple with regard to the interactions involved at the boundary of administrative domains. On the other hand, this simple scenario presents the following drawbacks:

1. The accounting data collection, collection management and analysis processes need to be performed within each organisation.

2. The analysis reports processed by the central accounting may hide details that would be required for an accurate and truly equitable accounting.

4.4.3.2.3 Scenario 2: centralisation of the analysis applications

This second scenario assumes that meters, meter readers, traffic measurement managers remain under the responsibility of every partner organisation, while the analysis application is in the hands of the central accounting authority. This scenario is depicted in the figure below:



With this scenario, the collected usage data, that is assumed to be stored periodically in flow data files on the meter reader, will be exchanged between the organisations and the central accounting authority. This will require the specification of common standards for:

1. The content and forms of the flow data files;

2. The mechanisms of exchange of these files (e.g. file transfer programs, etc...);

3. The interval of times at which the meter readers must collect usage data accumulated by the meters.

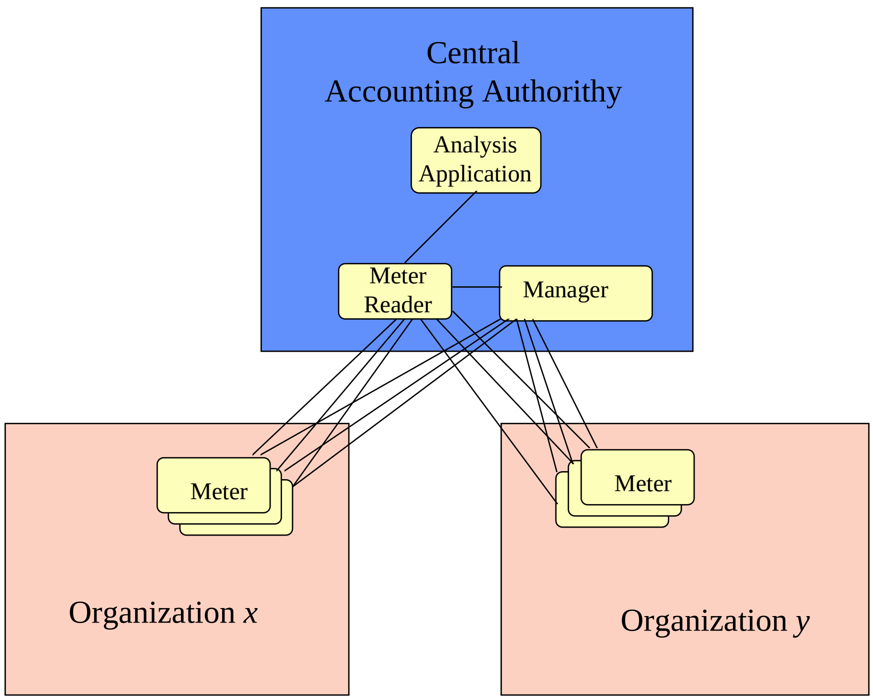
4. Usage data retention periods

5. Access control functions for protecting data integrity and confidentiality

This scenario is more complex than the first one with regard to the interactions involved at the boundary of administrative domains. On the other hand, it allows to alleviate the individual organisations from their independent accounting data analysis activities and makes possible the global automation of the accounting process.

4.4.3.2.4 Scenario 3: maximum centralisation of the accounting management activities

This third scenario assumes that meter readers, traffic measurement managers and analysis applications are operated by the central accounting authority. This scenario is depicted in the figure below:



This scenario requires the specification of standard mechanisms for the management of meters and for the collection/reporting of usage data. This assume the definition of a common Network Management Protocols (e.g. CMIP, SNMP) and of common accounting metering functions and managed object (e.g. ISO/IEC 10164-10, RFC 2064).

This scenario allows to alleviate the individual organisations from all accounting management activities. Its main drawback is to force the implementation of a specific network management protocol within the systems supporting the meters. This approach may therefore remove the freedom that organisations have on the choice of the technology used internally for Network Management. The solution to overcome this problem would be to agree on a set of several possible metering management and collection interfaces (e.g. CMIP with ISO/IEC 10164-10, and SNMP with RFC 2064) and to ask each partner organisations to select one of the possible alternatives. The Central Accounting Authority would then have to support each of these multiple possible interface but this seems preferable to constraining the partner organisation in their choice for a network management technology

4.5 Configuration Management

4.5.1 Introduction

Configuration Management is certainly a domain which will require co-ordination between the different organisations involved in the ATN. This is because certain aspects of the configuration of an ATN system within an organisation will often impact or depend on the configuration of other ATN systems in other organisations; then, if we assume, as it is likely, that the responsibility for the setting and update of the configuration of the individual ATN systems will be distributed among different and multiple organisations, the requirement for co-ordination of the configuration management activities becomes obvious.

Co-ordination for configuration of the ATN systems will be required on the following aspects:

1. The attribution of values to the ATN systems configuration parameters

2. The exchange of information on the current configuration of ATN systems

3. The modification to the current configurations

4.5.2 Co-ordination for the attribution of values to ATN systems configuration parameters

The attribution of value to certain ATN system configuration parameters may be dependent on or impact the configuration of ATN systems of other organisations. In certain cases, co-ordination will therefore be required among group of organisations for reaching agreements on values of interdependent configuration parameters. This is an off-line activity which will likely be performed by the network administrators. The co-ordination should simply result in the production of documents recording the agreements.

4.5.3 Exchange of information on the current configuration of ATN systems

With the exception of some parameters, such as the addresses of the systems, the requirements for the exchange of configuration information between organisations are difficult to identify.

It is however commonly observed that the sharing between organisations of information on the current configuration of their ATN infrastructure facilitates a number of network operation and planning activities: information on the configuration of partner organisation is typically useful for the control of coherence of configurations, for the analysis of the behaviour of the network, for the understanding of problems, etc...

This is why it is assumed that the organisations participating into the ATN will be ready to share configuration information with other organisations.

There are several possible scenarios for the exchange of the configuration information, ranging from the exchange of questions/answers by mail between the network administrators, to inter-domain manager-agent interactions for dynamic consultation of the content of the MIB of the ATN systems.

Between European ATSOs, the most likely scenario for the exchange of configuration information is the one which is currently proposed for the management of the CIDIN: each European ATSO would provide the configuration data on a regular schedule to the regional administrator, and these data would then be entered into a central database which would then serve for the production of reports on the overall European ATN network configuration.

This approach would require the specification of common standard for:

1. the identification and definition of the configuration parameters which value has to be provided by each organisation
2. the format used for the configuration data exchange (e.g. plain text forms)
3. the mechanisms for the exchange of the configuration data (e.g. electronic mail)
4. the issuing periods

A possible alternative to this scenario could be to follow, for the exchange of configuration information, the same approach as the one identified for the exchange of operational statistics (see section 4.2.2): the configuration information would be provided as part of the 'ATN domain summary MIB' maintained by every organisation. Other organisation could access this information by browsing the summary MIB content. This approach would require the specification of common standard for:

1. The Managed Object Classes used to hold the configuration information
2. The Management Information exchange protocol (e.g. CMIP, SNMP)
3. The information update period

4.5.4 Co-ordination for the modification to the current configurations

4.5.4.1 General

Changes in the configuration of the ground ATN infrastructure occur for the following scenarios:

1. Evolution/extension/enhancement of the ATN network
2. Network reconfiguration in case of problem
3. New aircraft are equipped with ATN systems and need to be recognised by the ground and air/ground systems

The third scenario is considered to be a security management problem. It is analysed in section 4.6.

4.5.4.2 Changes in the configuration due to expansion and improvement of the network

Changes in the configuration due to expansion and improvement of the network is an activity which will mainly involve network administrators. Changes that have cross-domain repercussions will necessitate co-ordination between the network administrators. Co-ordination will mainly consist in the analysis, agreement, and planning of the proposed changes. It should simply result in the production of documents recording the agreements on the changes, and describing the schedule and the procedures for the modifications.

4.5.4.3 Reconfiguration in case of problem

When a problem occurs in the network (e.g. failure of a router) it may sometimes be necessary for the network operators to switch from the current configuration to another backup one. Changes that have cross-domain repercussions will necessitate co-ordination between the network operators and possibly the regional supervisor, if any. Co-ordination will consist in the spontaneous set-up of a dialogue for discussion of the problem, agreement on a correction, and synchronisation of recovery actions. The phone, the electronic mail, and the trouble ticket systems will be the tools used all along the reconfiguration process.

4.6 Security Management

4.6.1 Introduction

The purpose of security management is to support the application of security policies by means of functions which include:

1. the creation, deletion and control of security services and mechanisms,

2. the distribution of security-relevant information; and

3. the reporting of security-relevant events

Security management assumes that security mechanisms are implemented. At the time this report is produced the security mechanisms for the ATN are still under definition. It would therefore be premature to try develop scenarios on security management issues, while the ATN security mechanisms, that will be standardised in the Package 2 ATN SARPs, are not developed further by the ICAO technical committees.

There might however be security management issues to be considered in the context of the management of an ATN Network consisting of Package 1 ATN systems. Indeed, although the Package 1 ATN SARPs do not specify any overall security mechanism for the ATN, they include at least one basic function that will provide some levels of security in the initial stage of the ATN implementation. This function concerns the validation of airborne routers address by Air/Ground router. Security management issues pertaining to this function are discussed in the next section.

4.6.2 Management of authorised airborne routers addresses

The « NET validation function » implemented within ATN A/G BIS allows the A/G routers to validate the acceptability of the connection with an airborne router. If an A/G router does not validate the airborne router address, it must terminate the connection.

The ATN SARPs do not specify exactly how the NET validation function must determine the acceptability of the airborne routers addresses, but the most likely procedure will be the comparison of the address received from the airborne router with a list of authorised addresses configured at the level of each ATN A/G Router.

This pauses the problem of the maintenance of this list of authorised airborne addresses in the A/G routers. A likely scenario is simply that network administrators will receive regularly announcements on the existence of a new ATN-equipped aircraft, with information on their configuration (addresses, support or non support of IDRP, etc..). The network administrators will then plan the reconfiguration of the A/G BISs, and the network operators will later on perform this reconfiguration using their local ATN system configuration mechanisms.

This scenario would require the definition of standard procedures and forms for the announcement of new airborne router addresses. In Europe, it is assumed that the regional administrator could be in charge of collecting these announcements from the airlines, and of publishing regularly the new list of addresses.

4.7 Conclusion

Co-ordinated system management with distribution of system management responsibilities among organisations can be achieved with minimum changes to the traditional network management approach. The scenarios proposed in this chapter are simple, realistic for the near term, workable using existing system management tools, and consistent with the expected size of the European ATN in the next 20 years. It is indeed considered that the ATN will be progressively deployed and, as such, requirements for sophisticated and more complex mechanisms will also only arise progressively; in addition, the specification of such sophisticated mechanisms can only be designed when sufficient operation experience of initial ATN deployment is gained.

The solutions for supporting the previous scenarios should be based on the combination in the Network Operation Centre and the integration with the ATN technology of existing Network Management products such as trouble ticket systems, COTS Network Management Stations, Archiving systems, Expert Systems for the analysis of faults, Network simulation and planning tools, etc...

It is therefore recommended that the initial standards developed for the system management of the ATN, allow the use and interoperability of a large number of COTS SM products.

4.8 Protocol architecture standardised at ATNP

The scenarios developed in this chapter have been considered as a baseline material for the production by ATNP of an ATN System Management Concept of Operations document. The ATNP technical group on System Management is currently defining the protocol architecture that will support the cross-domain exchange of system management information.

The protocol used for manager-to-manager exchange of summary MIB information (and other types of management information when applicable) will be CMIP. Additional protocols will be considered if required in support of other exchange of management information (e.g. EDI above AMHS, a file transfer protocol)

The ATN SARPs will define two distinct CMIP profiles: The FastMIP Profile and the standard AOM12 profile

The 'FastMIP' profile consists in operating the CMIP protocol over the « Fast Byte » session and presentation layers specified in the Subvolume 4 of the ATN SARPs. More specifically, the FastMIP profile requires CMIP with the short/null encoding options of Sessions and Presentation layers, PER-encoded ACSE Edition 2, and PER-encoded application information.

FastMIP will be the required profile for the exchange of management information over the air/ground link. The FastMIP profile has been defined so as:

- to avoid multiple Upper Layer protocol stacks in Airborne systems (and possibly in Air/Ground systems)
- to use highly bit-efficient protocols over mobile subnetworks
- to simplify the certification requirements

The standard OSI AOM12 profile is currently proposed for the exchange of Management information on the ground. AOM 12 includes the operation of CMIP above full session and presentation protocol, ACSE Edition 1 and BER encoding.

5. Conclusion: organisation, roles, and interactions for the Systems Management of the European ATN

5.1 Introduction

The objective of this chapter is to derive from the discussions in the previous sections, some general recommendations on the regional organisation and on the distribution of roles and responsibilities for the system management of the European ATN.

5.2 Recommended organisational structure for the management of the European ATN

Chapter 3 identifies three possible organisational approaches for the management of the European ATN:

1. A centralised approach, with a central regional body responsible for the supervision and administration of the whole European ATN (see section 3.2).

2. A distributed co-ordination approach, with total distribution of the responsibilities for the supervision and administration of the European ATN to the organisations owning the ATN components.

3. A combination of the 2 above options (referred as the centralised co-ordination approach) with distribution of the responsibilities for the supervision and administration of the ATN to the organisations owning the ATN components but delegations from these organisations of certain responsibilities for the overall co-ordination of inter-domain system management activities to a central European body

The review of current system management practices in Europe (see Chapter 2), shows that ATSOs are reluctant to transfer responsibilities on the network management of their own infrastructure onto another central organisation. Furthermore, chapter 4 shows that system management co-ordination mechanisms can be implemented for achieving management of the global European ATN to maintain quality while holding individual organisations accountable for their network management roles and responsibilities. It appears therefore unlikely that a purely centralised approach will be acceptable to the European ATSOs for the system management of the European ATN.

On the other hand, the distributed co-ordination principles that have been followed up to now for the management of the international ATC networks such as the CIDIN or the national PSN interconnection in Europe, have been proven ineffective for the management of highly international infrastructure, involving a lot of organisations. The current trend for the management of the CIDIN as well as for the management of the ATSO interconnected networks is in the centralisation of certain co-ordination activities and responsibilities (see chapter 2)

The recommended approach for the system management of the European ATN is therefore the one referred in this document as the centralised co-ordination model, where responsibilities for the management of the national ATN is left in the hand of the ATSOs, (and other ATN organisations) while responsibilities for the co-ordination of some inter-domain system management activities (e.g. accounting management) are vested in a central agency

In practice, it is assumed that a combination of the centralised co-ordination and distributed co-ordination approaches will be followed; it is indeed considered that even if an agreement can be reached for the centralisation of the main system management co-ordination activities, direct bi-lateral co-ordinations are indeed likely to go on, on certain aspects.

5.3 Role and organisation of the central co-ordination body

Implementing the centralised co-ordination model for the system management of the European ATN necessitates the establishment of a central co-ordination body in charge of the overall co-ordination for the administration and supervision of the European ATN.

The recommended approach for the structure of such a body is to implement a similar organisation to the one which has been proposed for the administration and management of the ATSO data network integration (see section 2.3.2). The ATN central co-ordination body would then consist of the following three groups:

1. The European ATN Management Group

Set up with membership drawn from all participating states this group is proposed to be responsible for defining, maintaining and reviewing the agreed standards, agreements, terms of operation, charging policy, cost recovery, terms and conditions etc. The group will have the responsibility of the strategic control and development of the infrastructure.

2. Network Administration and Engineering Group

The Network Administration and Engineering Group would consist of a small permanent core staff, responsible to the European ATN Management Group for managing the administrative activities of the group and preparing the engineering changes to the overall European ATN network including maintenance and review of Service Level Agreements and Interconnection Agreements. Any changes which have policy or investment implications would have to be endorsed by the European Management Group. This group would monitor the evolution of the European ATN, consider changes undertaken by the organisations in the region, perform analysis of the consequence and simulation studies, propose solutions for potential regional routing, performance or other problems, process accounting information, generate the bills, collects and then dispatch the revenue, etc.. To summarise, this group would be in charge of the off-line fault, performance, configuration, security, and accounting management co-ordination activities for the overall European ATN.

This function would require a permanent group working normal office hours. These tasks could however be delegated as a specific responsibility to one or several of the ATSOs.

3. Tactical Operations and Help Desk

This group would operate on a 24 hour per day basis, providing real time support for network activities. Problems which are unable to be resolved by this group would be referred to the Network Administration and Engineering group and ultimately to the steering group.

5.4 Role and responsibilities of the organisations in the region and interaction with the central co-ordination body

Each organisation has full control of its portion of the ATN network and is expected to establish internal system management processes and procedures to ensure the expected operation of its ATN infrastructure.

In addition, each organisation is expected to establish the means for external interactions for co-ordinating ATN Management functions across organisations:

- for sharing management information electronically from network manager to network manager, each organisation is expected to implement a standard-based approach. This standard based approach should be compliant to the Subvolume 6 of the ATN SARPs, or to a regional standard derived from the ICAO standard. For instance, it will consist in the implementation of a Summary MIB accessible by other organisations, a cross-domain trouble ticket system, a « public » archive of performance reports and raw data files, standard accounting meter readers, etc...

- Each organisation is expected to ensure the accuracy and timeliness of its system management information
- Each organisation is expected to designate points of contact for daily management functions across administrative domains.

The detail of the co-ordination procedures between organisations and between an organisation and the central co-ordination body is out of the scope of this study. This should be specified and endorsed by the European ATN Management Group. Some general principles are currently being developed by ATN System Inc., in [ATNSI1]. Examples of these general principles, derived from the ATNSI document and applied to the European case, are listed bellow:

- Each organisation is expected to present to the central co-ordination body its planned configuration changes, and the planned evolutions of its ATN infrastructure when those modifications may affect other organisations or the overall behaviour of the European ATN.
- Each organisation is expected to advise the central co-ordination body of expected and unexpected performance changes that would affect the European ATN.
- Each organisation is expected to inform the central co-ordination body of detected faults that originate from other organisations
- Each organisation is expected to inform the central co-ordination body of potential security violations originating in other organisations

5.5 System Management functions implementation in the ACCESS time frame

The requirements for co-ordination of system management activities across organisation will become more and more critical as the European ATN expands This document provides an embryonic description of what could be the System Management of the European ATN., and shows that there are a lot of questions to be answered, and activities to be undertaken before a satisfactory European system management co-ordination model is specified and implemented.

In the very first stage of the implementation of the European ATN, it can be assumed that the system Management of the global ATN to maintain uniform quality will be achieved with minimum changes to the current network management practices. The ATSOs will first focus on solutions for the system management of their own infrastructure.

Initial co-ordination requirements will then need to be fulfilled. The first priority in the implementation of cross-domain system management functions is likely to be related to real-time exchanges of trouble tickets for co-ordinating fault and performance issues, and to basic off-line exchange of configuration and accounting information. During this stage, the role of the co-ordination body would be minimal (e.g. configuration control) and would mainly focus on the preparation on the next step.

As the network expands, the ATN data traffic increases, and the type of applications using the ATN becomes more safety critical, it will become desirable to share management information through integrated electronic means so that to reduce errors and delays in disseminating information affecting the network, and minimise the workload of the ATN network operators and administrators. This is the stage where a centralisation of the co-ordination on some system management functions will become necessary.

5.6 Concluding remarks

As mentioned in the previous section, there are a lot of questions to be answered, and activities to be undertaken before a satisfactory European system management co-ordination model is specified and implemented. This document provides only baseline considerations that may serve as a starting point for developing a complete European ATN system management architecture and detailed requirements.

As a draft « road map » of the required further activities on the ATN system management subject, ACCESS proposes the following initial selection:

1. Completion of ATN SARPs on System Management: the development of SARPs on ATN System Management is underway and the SARPs are expected to be completed by ATNP/3 in February 2000. However, it must be noted that there is not a real enthusiasm from the ATSOs and other organisations participating to the ATNP to invest effort in the development of these SARPs. This may cause a delay for the completion of the SARPs. This situation is rather surprising considering that it may not be possible to implement the ATN if ATN system management solutions do not exist.

2. Resolution of institutional issues on the creation of a central co-ordination body, and production and endorsement by the States of a document specifying the roles and responsibilities of each organisations.

3. Validation of SARPs with implementation and test of SARPs compliant Network Management Systems.

4. Integration of the SARPs compliant Network Management System within the Network Operation Centres of the European organisations

I. ACRONYMS

ACC	Area Control Center
AFTN	Aeronautical Fixed Telecommunication Network
AISP	ATN Internet Service Provider Service
AMHS	ATS Message Handling System
AOC	Aeronautical Operational Communications
ATC	Air Traffic Control Center
ATM	Air Traffic Management
ATN	Aeronautical Telecommunication Network
ATS	Air Traffic Services
ATSC	Air Traffic Services Communications
ATSO	Air Traffic Services Organisation
BIS	Boundary Intermediate System
CAA	Civil Aviation Authorithy
CCC	Co-operating CIDIN Centre
CIDIN	Common International Data Interchange Network
CLNP	Connection-Less Network Protocol
CMC	CIDIN Management Centre
CMIP	Common Management Information Protocol
COTS	Commercial Off-The-Shelf
EATCHIP	European Air Traffic Control Harmonisation and Integration Programme
ECAC	European Civil Aviation Conference
ES	End System
IACSP	International Aeronautical Communications Service Provider
ICAO	International Civil Aviation Organisation
IDRP	Inter Domain Rrouting Protocol
IS	Intermediate System
MIB	Management Information Base
MTBF	Mean Time Between Failure
NSAP	Network Service Access Point
NOC	Network Operation Centre
OSI	Open System Interconnection
PSN	Packet Switched Network
QoS	Quality of Service
RD	Routing Domain
SARPs	Standard And Recommended Practices
SM	System Management
SMIB	Summary MIB
SNMP	Simple Network Management Protocol