Integration of ATM Management Procedures into Native Integrated Network and System Management Architectures

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Abstract:

The paper considers the requirements for the integration of Asynchronous Transfer Mode (ATM) management procedures into native network and system management architectures. Other than the research into network and system management, the standardisation and realisation of management frameworks and the industry realisations of open integrated management platforms, network and system management remains mainly a collection of single solutions aimed at handling a limited amount of specific areas. Today the management standards, procedures and implementations for Local Area Networks (LAN) and Wide Area Networks (WAN) are completely different. There is no End-To-End Management for the interconnected systems that communicate via heterogeneous networks. Beside that, connections and applications handling delay-sensitive traffic require management procedures that are not required for asynchronous data applications. Asynchronous Transfer Mode uses one technology for transmitting diverse traffic types and for a number of various applications (e.g. data, voice or multimedia) across LANs and WANs. Beside pure ATM Networks, ATM is designed to operate as backbone technology or High-Speed Technology for interconnecting Server or workgroups with other networking technologies such as Ethernet or Token Ring. The paper shows that integrated management procedures for the various networking technologies are required to operate and manage these networks in an efficient and practicable way to ensure the different communication services and an appropriate solution is described.

ATM Management

Research and industry are currently in the process of developing a multi-layer (five-layer) ATM management model and an Operations, Administration and Maintenance (OAM) interface. The model consists of services and interfaces for the LAN as well as for the WAN and enables the distribution of management intelligence through the network. The problem is that there is still a long way to go before a final and suitable solution will be available. Even with ATM Networks being implemented in the Local Area Networks as well as in the Wide Area Networks, private and public network management systems will continue to maintain separate views into the network with different services and different functionality (Hershey,1997). Implementing a network management scheme that will enable both views involves the building of gateways between SNMP systems at customer sites and the CMIP and proprietary protocol systems used by carriers (Ahrens,1994). Standardisation groups, including the Internet Engineering Task Force (IETF), Network Management Forum and the International Telecommunication Union (ITU), have been working with the ATM Forum to negotiate interworking standards acceptable to both sides.

ATM Management Model

Research and industry (in the form of the Network Management Working Group of the ATM Forum) are investigating and developing an end-to-end management model that includes management services for LAN and WAN Networks and that lays out standards for the interworking between the two. The model will also define gateways between Simple Network Management Protocol (SNMP), Common Management Information Protocol (CMIP) and proprietary systems. Five management interfaces are defined to meet ATM management requirements (Varadajan,1997). All are essential to end-to-end monitoring and control. LANs are addressed by M1 and M2, which define the interface between the network management system and an ATM end station or an ATM switching system. M3 is the Customer Network Management interface. The merger of private and public networking technologies begins at M4, while M5 is the management interface between a carrier's own network management systems.

M1 and M2 embrace SNMP-based specifications defined by the Internet Engineering Task Force (IETF). These include Management Information Bases (MIB) II and relevant standard MIBs for DS-1, DS-3, and SONET connections. Also included is the experimental AToM MIB (RFC 1695) which, in particular, is expected to reduce the proliferation of widely varying vendor-specific ATM MIBs. M3 is the Customer Network Management (CNM) interface. M3 describes the interface between the customer and carrier management systems that gives the customer a view into the carrier's network, so that network managers will have real-time control over the services they use to be able to monitor the services end-to-end. The merger of public and private networking technologies begins at M4. This is the management interface enabling Network Management Level (NML) views and Element Management Level (EML) views to the carrier's network management system and the public ATM network. Both the private network manager and the carrier have to be able to monitor the WAN services, what is new for enterprise network management systems. The manager of the private enterprise wishes to take advantage of public services yet retain control over them to guarantee services for the enterprise network users. The carrier, on the other hand, requires an overview of customers' networks - which would then give it the ability to offer network management as a value-added service. The protocol-independent MIB for M4 supports SNMP objects defined in accordance with the SNMP Structure of Management Information (SMI), as well as CMIP objects that conform to GDMO (Guidelines for Development of Managed Objects). M5 is the management interface between a carrier's own network management systems and is the most complex interface. More research has to be done to finalise specifications defining interworking between SNMP and CMIP (Fowler, 1995).

Operations and Maintenance Services

Operations and Maintenance (OAM) cells will provide extensive management functionality. Services will be dynamically reconfigured in the event of failure to meet service requirements and network devices and end-stations will be able to negotiate and reconfigure themselves to guarantee service-level objectives. These architectures will be distributed, in the sense that management intelligence and functionality will be distributed throughout the network infrastructure. The OAM Flow Reference Architecture, also known as the Management Plane Reference Architecture, defines aspects of ATM point-to-point Virtual Circuit that can be monitored using specialised OAM cells. The Architecture divides a VC into five distinct layers, labelled F1 through F5 and defines the flow of ATM cells through these layers.

Research and industry are developing OAM cells for fault management, performance management, and activation/deactivation (for starting and terminating fault and performance management functions). OAM cells will give ATM network devices the ability to gather information about end-to-end connections, reduce the need to distribute MIBs throughout the network, and cut the amount of management-related traffic on the network. The ATM Forum Network Management working group has specified several OAM cells targeting fault management, including Alarm Indication Signal (AIS) cells and Far End Reporting Failure (FERF) cells, which communicate failure information throughout the network. The working group also has specified an OAM loopback capability, which uses a special loopback cell, for verifying connectivity and diagnostic problems that AIS or FERF cells cannot. There will also be a continuity check cell that ascertains whether idle connections are still up or have failed. Whenever an ATM switch fails and a virtual path or virtual connection is interrupted, each adjacent switch in the network automatically generates an AIS cell and sends it to all downstream switches. The AIS cell alerts the other switches in the network of the failure and gives them the opportunity to devise alternate routes for virtual connections that would normally cross the failed switch. When failure disrupts only one-half of the full-duplex ATM connection that traverses several switches, FERF cells are generated. If there is a failure of this kind, traffic can still move through the network, but only in one direction. In this instance, the switch closest to the failure will generate an AIS cell and transmit it back down the network to alert the source of the failure. Then the source switch sends a FERF cell to the destination via the remaining half of the connection. This alerts the destination that its traffic is no longer getting through and an alternate connection route should be set up.

In fault situations where an AIS or FERF cell would not indicate a problem, such as when a VC has been misconfigured, there would be no actual failure in the network, and traffic would get through to both source and destination-but the connection would not be between the right end points. The loopback cell goes from source to destination and requires that the destination switch or end-station mark the cell and return it. The ATM Forum also has defined a fault management cell for continuity checking. When a VC is idle for a certain period of time, end-stations or switches involved in the connection can send a continuity check cell to verify that the connection is still up.

OAM capabilities still have to be developed and built into ATM equipment. Beside that, ATM management will need to interoperate with native network and system management. Today, vendors are rolling out management applications based on proprietary solutions or implement current proposals and interim specifications. Some vendor-specific management implementations might always be necessary to cover areas not addressed (such as application management and interfaces between ATM and legacy technology).

Challenges and Integration of ATM and native Management

Today's Network and System Management Architectures enable an integrated view of the systems and the networking elements such as routers and switches through management consoles that implement different services and management disciplines (Figure 1). The major network management standards include Simple Network Management Protocol (SNMP), Common Management Information Protocol (CMIP) and Telecommunication Management Network (TMN). Network Management standards and protocols such as SNMP or CMIP or proprietary implementations enable the management of the elements in the network (Stratman, 1994).

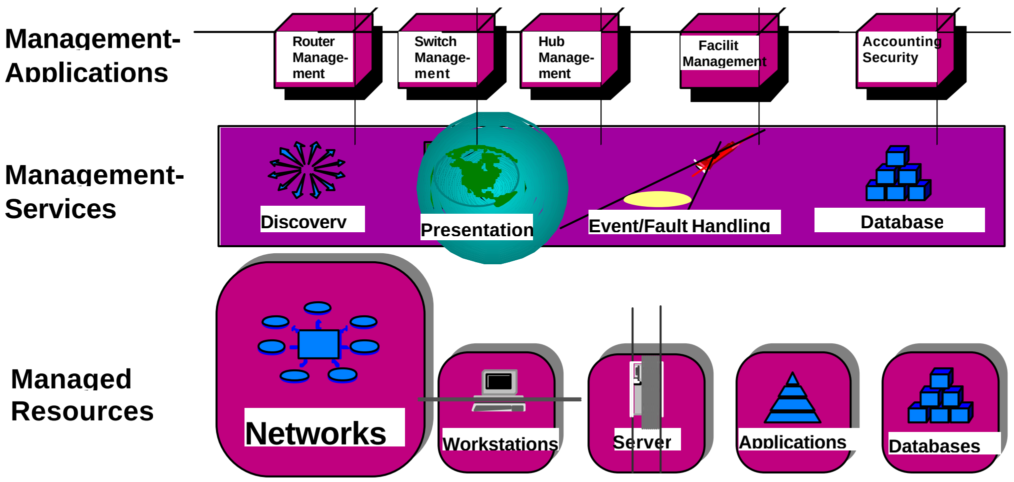

Figure 1 : Integrated Network and System Management Architecture

Implemented on industry-standard platforms, the network management system should also utilise an architecture with a flexible database system to ensure data integrity and to access, manipulate and display data from various management applications for ATM and non-ATM network elements or even for enterprise applications such as SAP R/3 (Figure 2). This is also essential for presenting a consistent view of network views and maps.

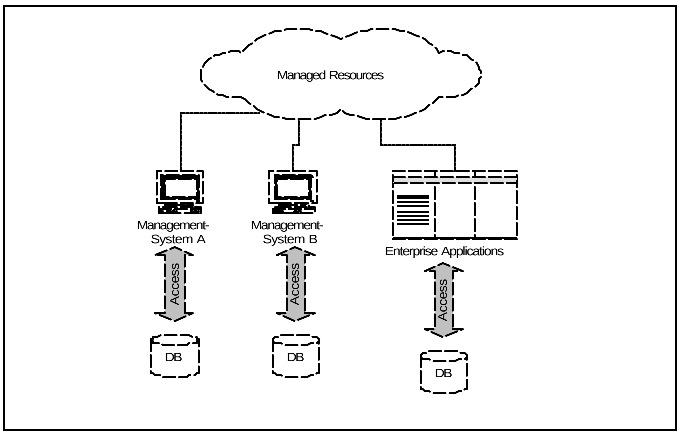

Figure 2 : Management and Data Distribution

Multi-technologies and multi-vendor environments also have the need for standards compliance. Standard protocols and standard interfaces from the network management system will help ensure that the system can continually support changes and enhancements to the underlying hardware. Different management services have to be integrated. The following picture shows the integration of two industry-leading network and system management platforms (Figure 3).

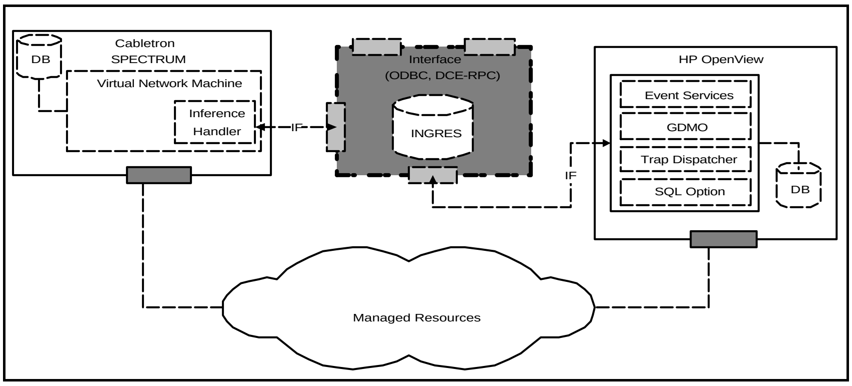

Figure 3 : Prototypical Integration with leading Management Platforms

Most networks consist of multiple locations and the network management system is also distributed. Typically, enterprise networks span time zones and continents (Strauss, 1995). Beside the standard requirements for integrated network and system management, different organisations have additional or even unique management requirements. One scenario could be that a central site wants to have the ability to manage the switches and active network components at all sites but give each site the ability to manage a particular functional or geographic domain from that site. The management system must have the flexibility to accommodate different access and control functionality. The integration of Management Systems could be built on CORBA services. Distribution of management tasks have to allow the backup and recovery of all sites within the WAN. Figures 4 and 5 illustrate different approaches for integrating management services (Bleimann, 1996).

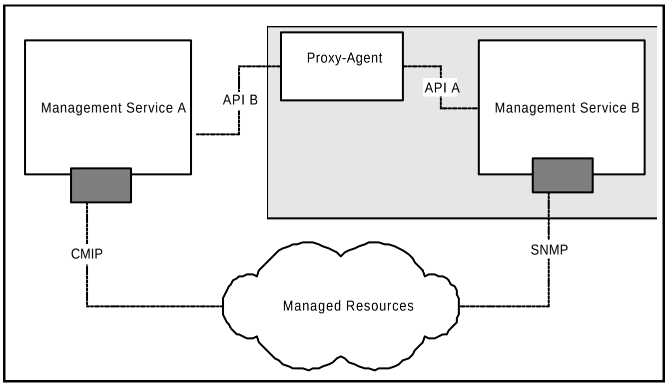

Figure 4 : Model of a Proxy Integration of different Management Services

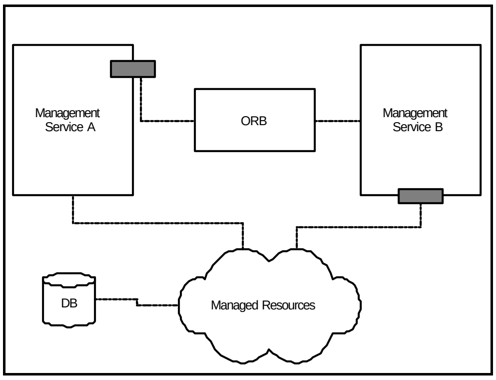

Figure 5 : Integration via CORBA Services

Conclusions

Our research has shown, that management standards such as SNMP or SNMPv2, or today's Management-Platforms like SunNet Manager, Tivoli TME 10 or HP OpenView Network Node Manager basically cannot handle the end-to-end management of ATM networks. The challenge for the network operators is how to migrate from these restricted systems to an architecture that integrates an ATM management model (Pathak, 1994) and that will help them meet the goal of providing seamless, end-to-end connectivity and management for tens of thousands of users across LANs and WANs (figure 6). We found that this seamless architecture presents problems and raises challenges in just about every area of network management (Cekro, 1997).

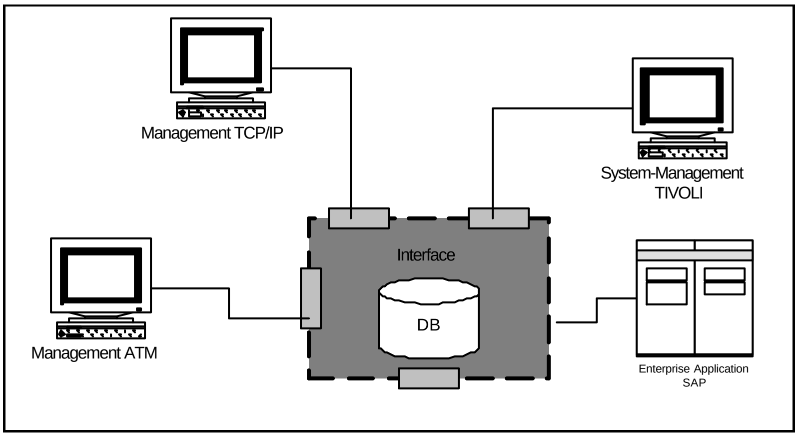

Figure 6 : Integration of different Management Services

Configuration management has to support the various networking equipment. A mechanism should be available that allows the sharing of configuration management data between different network management applications. The network management system must allow the set-up of end-to-end connections in response to user service requests and according to Quality of Service (QoS) parameters such as throughput and delay. The configuration services should incorporate a single view for easy browsing and changing of the various configuration parameters through a Graphical User Interface (GUI) for the different networking equipment. The network management system has to provide the tools to define routing tables to support the connections and to ensure that these tables in different switches and routers are synchronised. Existing tools and services do not provide network configuration that guarantees service provisioning involving ATM and native networking equipment. Four major classes of service are defined to choose from in ATM: Available Bit Rate (ABR), Constant Bit Rate (CBR), Unspecified Bit Rate (UBR) and Variable Bit Rate (VBR). Guaranteeing the desired service level for the users involves configuring optimal connection parameters on each switch in the network - which requires setting traffic priorities, choosing routes, and taking into account Wide Area lines availability and other factors describing the current network state.

ATM high capacity and ability to handle high amounts of different data types adds another dimension to fault management, network monitoring and performance management. For a network manager to keep information on what is happening, the ATM management architecture must enable the collection of a wide variety of statistics, reporting to class of service, fault, performance, and usage. Furthermore, carriers and end-user organisations require fault management services that provide network monitoring, fault detection and correlation, diagnostics, multiple views of the network and helps administrators analyse and resolve fault conditions. The integration of a new technology into an existing network such as ATM is complicating the fault management procedures. Because ATM is more complex than conventional TDM (time-division multiplexing) networks or LANs, network managers must have both a physical and logical (virtual) view of the network service. Complex network structures require dynamic visualisation tools instead of the static topology views of the physical network that are a feature of today's management platforms. Operators should be able to obtain different focused on network problems. Expert systems should guide the operators in diagnosing and resolving a problem.

The new end-to-end architecture of services and applications challenges the requirements of cost allocation and billing. The complexity of these procedures in a heterogeneous network incorporating ATM services and ATM WAN makes a powerful, reliable cost allocation and billing solution essential but complex. The billing system must give carriers and corporate networkers a way to identify the appropriate class of service for each connection and then measure usage. Usage-based billing will drive the cost of ATM down and make the service affordable for end-users, for whom the opportunity to buy ATM bandwidth according to actual usage rather than at a flat rate is interesting. Organisations with private networks need to determine how much traffic comes from one department and how much from another.

Complex networks require design tools to incorporate simulation and modelling exercises based upon real-world data capable of network modelling. These tools could run "what if" scenarios based on real-world data such as line cost, bandwidth availability and bandwidth utilisation, allowing customers to prototype new services and analyse how growth will affect the network and to control network planning.

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