# CUSTOMER NETWORK MANAGEMENT

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***Abstract*—This article deals with an area of telecommunications service management known as customer network management (CNM). In the context of this article, CNM is defined as a value-added service offered to customers by a telecommunications service provider (Telco) that allows customers to access management information and functions existing within the Telco domain which relates to telecommunications services provided to the customer. Additionally, some specific CNM offerings may extend this basic definition by providing some functionality for managing the customer's own network as well.**

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## 1 INTRODUCTION

Up until recent times, carrier-provided services were largely thought of in terms of the provision of an access point to the network which provided the service. In the case of a point-to-point data service, for example, this was visualised as a pipe to which the customer connected at each end. Customer management of this service was achieved via the telephone, the post, or fax.

More recently, specialised customer network management (CNM) systems have been provided. Some examples of these are PABX management, multiplexer management, channel/circuit management etc. The important point being that each service had it's own specific management system. The Telco view was that CNM systems were provided on a per service basis.

Consequently, CNM has been seen as the icing on the cake, a gift from a Telco to it's most valued (that is highest revenue) enterprise customers. However this view is no longer true in developed (competitive) Telco markets.

Recent advances in broadband network technology, most notably ATM, provides the promise that enterprise network managers will be able to dynamically manage the broadband service mix within enterprise networks to carry all types of traffic. In this context, CNM needs to evolve to provide an integrated multi-service view in order continue to meet customer requirements.

In the general case, the role of CNM as an integral part of a Telco service offering is evolving rapidly. This is due to a number of factors, some of which are:

- network size and product proliferation
- increased service diversity and manageability
- improvement and standardisation in Telco network management (NM) capability
- availability of development environments which provide platform solutions to the integration problems inherent in CNM
- deregulation and competition between Telcos.

In this article, we will examine the drivers and requirements for CNM from both the customer and Telco perspective and also look at technologies and architecture for delivering these requirements.

## 2 CUSTOMER PERSPECTIVE

### 2.1 THE CURRENT SITUATION

Today, enterprises with large private networks must perform the following tasks on these networks:

- network management (including fault analysis, fault reporting, tracking and resolution)
- performance and quality of service (QoS) management
- configuration management (including inventory management, service control, service ordering and tracking)
- accounting management (invoicing, user/usage profiles, scenario analysis, trend reporting, exception reporting)
- securing the network and its management from both outside and within.

When the enterprise uses a Telco to supply components of that network, or joins networks using Telco services, most of the tasks above are duplicated for the Telco equipment and services.

Whilst the Telco performs many of the functions above, the enterprise needs to perform them in parallel. This can lead to inconsistencies between the Telco, the enterprise, and reality.

Moreover, without near real-time information about Telco parts of the network, it is difficult to build and maintain a coherent, end-to-end view of the network, its services, and performance.

Enterprises who buy services from more than one Telco find that the complexity of the problem multiplies.

Part of this management problem is the multiple interfaces with the service provider required by a enterprise: operational, fault reporting, inventory, service modification, accounting, and so on. However, even if these interfaces were coalesced into a single "one-stop-shop" at the Telco end, the problem of integration with the enterprise's internal management systems remains.

Although standards exist for low-level network management protocols, no such standards yet exist for service or customer management.

### 2.2 THE DESIRABLE SITUATION

Ideally, the Telco network and service management functions would be totally integrated with the customer's existing systems.

For this to happen, the Telcos must either provide per-customer, per-service integration facilities, or define a standard interface for the exchange of management information (network, configuration, accounting, etc.). Given the diversity of services that a single customer may use, and the variety of systems at the customer premises, a standardised interface is preferable.

Then, with a single, defined interface, it would be possible to enhance enterprise management systems to use the Telco CNM interface.

### 2.3 PROBABLE SOLUTIONS

A two phase evolution of CNM capability is foreseen. What is likely in the first phase is the extension of the "one-stop-shop" portion of the solution to the customer's premises, as described previously. That is, a system which gathers the multiple interfaces to the Telco into one. This system will be connected to a server inside the Telco, which accepts service order and fault information and supplies inventory, performance and accounting information to the customer.

This will be implemented as a CNM management information base (MIB) maintained by the Telco. The Telco *CNM agents* will provide the necessary adaption into existing Telco systems. The CNM applications provided to the customer will then can act as a *CNM Manager* which has read only and possibly limited write access to the CNM Agent MIB.

These systems will not integrate with existing customer network management systems (NMSs) and each Telco may offer a different solution (version of a CNM MIB). In addition, the write interface between the customer's CNM Manager system and the Telco's internal management systems will operate in an off-line or batch mode. It may even involve having an operator within the Telco whose task is to process service order requests and modifications received from the customer.

From these offerings, the second phase sees a consensus on protocols, information models and behaviour emerging, making the path to integration and real customer on-line management cheaper and more likely. Consequently, the interface to the Telcos management systems will be expanded with the customer being able to modify service behaviour (e.g. routing or bandwidth) in near to real-time, via the Telco's CNM interface. In order to achieve this level of standardisation, the development of CNM standards needs to be driven by an appropriate industry standards body.

### 2.4 REQUIRED CNM FUNCTIONALITY

In essence, what is required is a set of standard service interfaces for sending and receiving management data. For each of the functional requirements defined below, the CNM system should support an interface to

equivalent customer systems. An overview of the types of information required over the Telco/customer interface in Table 1:

| Fault | Configuration | Accounting | Performance | Security |
|---|---|---|---|---|
| Reporting, tracking and resolution.<br><br>Interface to customer trouble ticket or workflow system.<br><br>Fault domain identification. | View inventory of Telco provided CPE and services.<br><br>Order new services.<br><br>Reconfigure services and network. | Expenditure tracking on services in near real time.<br><br>Interface to customer accounting system.<br><br>Extract of histories and usage profiles by customer cost centre, budgets and authorisation.<br><br>Cost comparison of rival Telco services: ISDN, leased line etc. | Monitoring of QoS, namely throughput, delay and availability.<br><br>Ability to generate reports and verify against service contract.<br><br>Performance comparison of rival Telco services. | Access authentication, authorisation.<br><br>Separation of customer data.<br><br>Separation of Telco & customer data. |

Table 1: CNM functionality

Other desirable features are the ability to customise data presentation and produce end-to-end QoS analyses.

### 2.5 ISSUES

Clearly there is a large gap between current CNM systems and the functionality presented in Table 1. In network management, standardisation issues have been addressed so that different agents and managers can interoperate on a network. Currently, there is no higher-level interoperability (protocol, platform) for service description or modification. Unless *de facto* or *de jure* standards emerge, CNM vendor's offerings and their integration features will be proprietary and arbitrary.

There are a number of ways in which a CNM offering could integrate with customer systems:

1. Not at all the Telco CNM system could continue as an independent, stand-alone system which simply provides a convenient single point of access to Telco services.
2. By the Telco providing the customer with a standard interface which encapsulates a particular combination of protocol, information model, and behaviour (e.g. a CNM SNMP agent and MIB). This will be the integration point for the management applications at the customer premises. However, this will still cause problems if different Telcos define different interfaces with different information/object models for similar services.
3. Via a GUI. The Telco provides applications (a CNM system) to the customer which uses a (possibly) private Telco CNM agent MIB on the Telco side. This is really an extension of point 2 where the Telco provides more of the application functionality to the customer.

To some extent, these CNM issues are starting to be addressed with the advent of new broadband network services. In particular, frame relay and SMDS (switched multimegabit data service) services are developing CNM offerings along the lines of point 2 above. These types of services are also becoming available internationally to multinational enterprise customers as Telcos form continental special interest groups (American, European, Asian, Pacific Rim etc.) to support global interworking of these services. These groups provide a focus for the identification of CNM issues and hopefully the development of multiservice CNM agent MIB models.

## 3 TELCO PERSPECTIVE

The current proprietary single service solutions are not able to meet enterprise customer's needs for reasons outlined in Section 2. Many Telcos are now only beginning to address the enterprise customer's needs and provide solutions to the security and integration issues which are inherent in delivering CNM systems.

### 3.1 RESPONSE TO CUSTOMER ISSUES

CNM together with the existing enterprise network management (NM) systems provide a means of maximising the enterprise's return on investment on network infrastructure. This is because CNM allows better control of the Telco part of a enterprise network by improving enterprise network availability, cost accounting, and inventory management.

With competition, CNM has become a means of Telco differentiation, while simultaneously promoting customer loyalty and providing important functionality to enterprise customers.

CNM is a means of supplementing existing enterprise NMS functionality with the addition of management information and functionality from the Telco management domain.

Hence, the distinguishing factor between CNM and enterprise network management systems is the integration of CNM with the Telco's network and service management (NM & SM) systems.

Initially, many Telcos promoted CNM systems to their customers as replacements for the existing enterprise NM systems, advocating that all network management should be handled by the CNM offering. This cast CNM into the role of a super integrator.

This view ignored the enterprise need for security and the lack of desire to re-engineer existing enterprise systems to utilise this functionality. Telcos must acknowledge that enterprise NMSs provide better management control for all non-Telco owned equipment. These NMSs also avoid the inherent security worries of Telco CNM systems.

Telcos need to address these legitimate enterprise needs when providing new CNM systems, as CNM offerings represent growing opportunities in the Telco market. The resolution of these issues is becoming possible with the new generation of integrating products. Examples of these are workflow and meta-database applications and commercial NM platforms.

### 3.2 CNM PLATFORM REQUIREMENTS

For a Telco to support a CNM offering, they require a system which embraces a wide variety of applications, networks, and monitoring and control techniques. No single technology (e.g. SNMP) can meet all the differing requirements.

Consequently, the Telco CNM agent implementation needs to support a variety of technologies, protocols and database mechanisms, all interoperating under a common umbrella. Some of these core concepts and features can be readily identified. This identification is based on experience gained from previous CNM and NM system development. Common features required are open distributed databases, transaction processing (TP), support of TCP/IP, SNMP/CMIP, and interfaces to legacy systems.

Unix based platforms are being used as the base for many Telco NMSs, and are replacing the mainframe as the hardware platform for many new generation SMSs. CNM developments should follow this precedent. The main attractions of Unix in this role are the wide range of technologies supported, the availability of standard platform products, and the ease of integration with enterprise NM environments.

If the Telco is to provide CNM applications rather than expose a CNM agent interface, the use of a standard platform will allow these applications to interoperate and integrate with other enterprise systems more easily. Platforms can also enforce a common look and feel, and can support the management of both Telco-owned and customer-owned equipment and data from a single application.

A platform has a set of development and system integration utilities which speed the development process. Platforms also help prevent application programmers from redeveloping functionality common to all applications, time and time again.

Thus the role of the platform is important to CNM, independently of the type of CNM solution being offered by a Telco, whether the solution is an exposed CNM agent interface or a set of CNM applications.

Particularly important to CNM is a distributed systems approach (supporting physical security and appropriate sizing of systems) and object-oriented (OO) computing.

The need for distribution arises from the physical split between customer and Telco in a client server environment. This is coupled with the requirement for scalability and the need to provide integrated management for these distributed components.

The need for object oriented technology stems from the inherently OO nature of many CNM problems, and the increasing use of OO techniques in network management, service management, and associated standards. For example, network topology management maps very cleanly into OO concepts, and provides significant performance advantages over solutions based on relational technology. The manager-agent and MIB paradigm provides effective short-term solutions for CNM and represents a useful area upon which to focus current standardisation efforts.

In the future, common object request broker architecture (CORBA) based solutions are a promising approach. CORBA provides an interoperable, distributed-object-oriented framework, which is open to bridging and integration with a large number of legacy technologies. A commercial CNM framework including a CORBA based technology at each customer and carrier site would provide a communications and distribution infrastructure and the necessary front-end objects to promote rapid application development. The object implementation task, which provides the back-end interface to legacy systems, can be eased by the use of interfacing tools currently available. CORBA also provides the distributed transaction management functionality which will be of importance in evolving a highly distributed application like CNM. This type of capability is not available in current management protocols like SNMP.

### 3.2.1 CNM DATABASES

When the Telco offers a CNM system, security concerns usually rule out centralised solutions, as these are usually unacceptable to customers. This is because customers do not wish to have sensitive network data held offsite in a Telco database, side by side with other competitor's network data. To allow for physical separation of confidential information, distributed databases become essential.

When the Telco offers a CNM system, the CNM data could be stored in an object oriented database management system, (OODBMS) such as Versant or ObjectStore. These databases (apart from providing a cleaner match to the information model) readily distribute, and have adequate security mechanisms. Single service CNM systems, which are based on OODBMSs have been announced recently.

However, OODBMSs will need to interface with standard transaction processing architectures in order to provide the robust environment necessary for the phase 2 implementations of CNM. In addition, common interface standards for OODBMSs (similar to ODBC in the relational world) will need to appear in order to deliver standard vendor-independent interfaces. Many industry observers are looking to the Object Management Group (OMG) to deliver the answer here.

### 3.3 CNM ARCHITECTURE

Figure 1 shows the components and interfaces in a CNM environment.

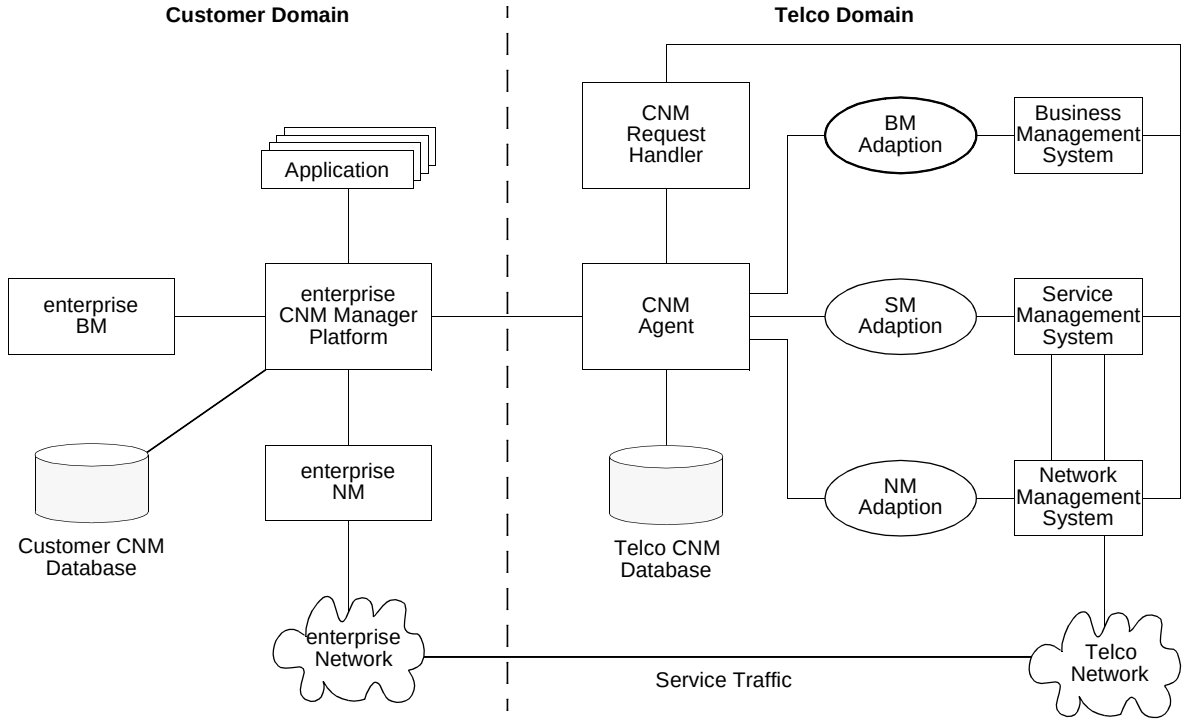


Figure 1: CNM architecture

The interactions in Figure 1 are explained below.

The Telco network is monitored and controlled via their own NMSs. Part of this network is leased to customers, which in turn forms part of their core enterprise network. Service related information is passed from the Telco NMS to the Telco's SMS.

Each of the Telcos systems interacts with an agent adaption function to update status in the Telcos CNM agent MIB. These systems include the Telcos Accounting, Enterprise, NMS, SMS or any other relevant Telco legacy system.

The function of the agent adaption is to extract data from the different Telco sources. This is merged in the Telcos CNM MIB. Whether the MIB is exposed as the CNM interface, or the Telco provides a CNM system, which interacts with the MIB does not affect this architecture.

The enterprise CNM manager platform receives alarms from the Telco CNM agent and the manager applications provide the necessary functionality to interface to the CNM agent MIB.

The first generation CNM sees platform applications provided by the Telco which act as the interface for the customer to the Telco's internal CNM MIB. Read access is supported for monitoring of performance, fault and accounting records. Limited write access for service parameter modification is also available. This typically involves routing and bandwidth modifications (within the bounds of the customer's network) for Freephone and data services.

On-line service reconfiguration and provisioning of new services will probably not be supported until the second generation CNM systems are available. These requirements are dealt with in phase one by providing a GUI to the customer, which allows them to make service order requests. These requests are deposited in the Telco's CNM MIB and processed by the CNM request application. Here requests are reviewed by service design staff. If accepted, they are passed onto the Telco business management (BM), SM and NM systems for implementation.

Hence the Telco CNM MIB provides a local repository for customer generated service order requests and Telco derived CNM data.

The customer will have additional network and LAN management systems which provide monitoring and control of the private and third party provided elements of the enterprise network. Examples of the other enterprise systems are process control, inventory, accounting and business management systems.

The functionality of the enterprise NMS has now been augmented with CNM functionality. These two systems should be integrated on the one platform if possible.

CNM implementations would typically be provided to the customer upon a Unix based platform. There are many NMS platforms, both Unix and PC based. Where common platforms are used by the Telco and the enterprise NMS, CNM integration is economically achievable. However having different CNM and enterprise NMS platforms may make integration uneconomic at the present time.

## 4 CASE STUDY IN ATM

In this case study, a CNM interface which supports an ATM broadband service is presented. This case study is based on the use of a published Telco CNM MIB. The extra functionality that will be available in a phase 2 CNM solution is highlighted. The study is based on an implementation recently delivered to a US telecommunications provider.

### 4.1 ATM TECHNOLOGY INTRODUCTION

Asynchronous transfer mode (ATM) is an emerging standard for multiple connection oriented, network services. ATM is very scalable, from kilobit to gigabit, and is applicable in both LAN and WAN environments.

There are two types of paths that can be established in an ATM network. Permanent virtual circuits (PVCs) are established by the network management system to provide a “trunk route” between two hosts. The second type is a switched virtual circuit (SVC), and is established on demand.

Information is communicated along the established path, which has been negotiated within the network. The negotiation concerns type, speed and other attributes, which jointly determine the end-to-end quality of service provided by the path.

Another key concept is that ATM is a switch-based technology. It provides connectivity through a switch or set or switches (instead of a shared bus like ethernet).

The advantage of ATM is that it can provide a single network for all traffic types, namely voice, data, and video.

### 4.2 ATM CNM

The development of ATM broadband networking technology and its provision to enterprises by Telcos is creating a new set of requirements for network management capability at both the enterprise and public network level.

This emerging trend of multiservice enterprise networks, supporting rapid establishment of virtual end-to-end connections with differing quality of service parameters is crystallising the need for CNM.

The management domains of a enterprise ATM network are shown in Figure 2 and described here:

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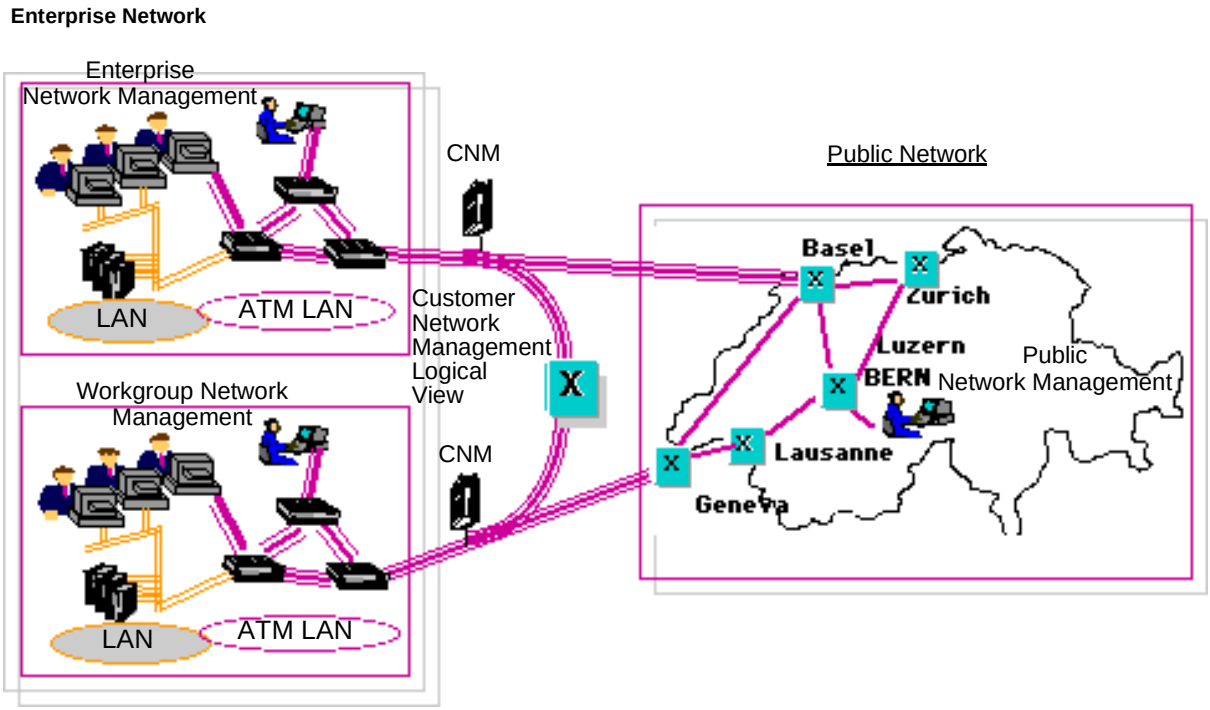


Figure 2: ATM Management Domains

- The Telco operates an ATM backbone service and supplies ATM network interfaces to enterprises. The Telco network is managed using an OSI infrastructure, which provides substantial fault, performance, configuration and service management systems
- The Telco supplies a CNM interface to enterprises using ATM services. The interface supports SNMP communications and provides a constrained vision of the Telco network. The logical network view provided to the enterprise has a single ATM switch in it. That is, from the customer's viewpoint, all their connection points are interconnected by a single ATM switch.
- The enterprise's NMS provides support for all components of the enterprise networking capability, including the installed ATM LAN and public ATM interfaces. It also interacts with both the enterprise network elements, and the public network elements, via the CNM interface, to facilitate provisioning and monitoring of enterprise-wide ATM communications.

### 4.3 ATM FORUM

As ATM continues to be deployed, the line between local and wide area networks blurs to form a seamless network based on ATM. This means that the interface between enterprise and telco must become more capable and dynamic. It was realised in the early stages of the evolution of ATM that a standardised management system infrastructure was required to obtain the full potential of this networking technology. It was also recognised that the management standards must evolve alongside the communications infrastructure standards.

With this in mind, the ATM Forum was started in October of 1991 by a consortium of four computer and telecommunications vendors. Since its inception, it has seen unprecedented growth, and as of June 1994, had over 500 members. The ATM Forum working groups produce specifications which are handed to the ITU-T standards body. The M3 interface defined by the ATM Forum refers to the customer control of their portion of the public ATM network. M3 allows a consistent view to be supported by multiple vendors.

Hence, for ATM CNM implementations, the interface between enterprise NM and the Telco systems CNM agent MIB conforms to the M3 interface definition. The M3 interface implementation makes use of the SNMP

AToMMIB (RFC 1695) defined by the Internet Engineering Task Force (IETF). Figure 3 shows the ATM Forum's management system interface model.

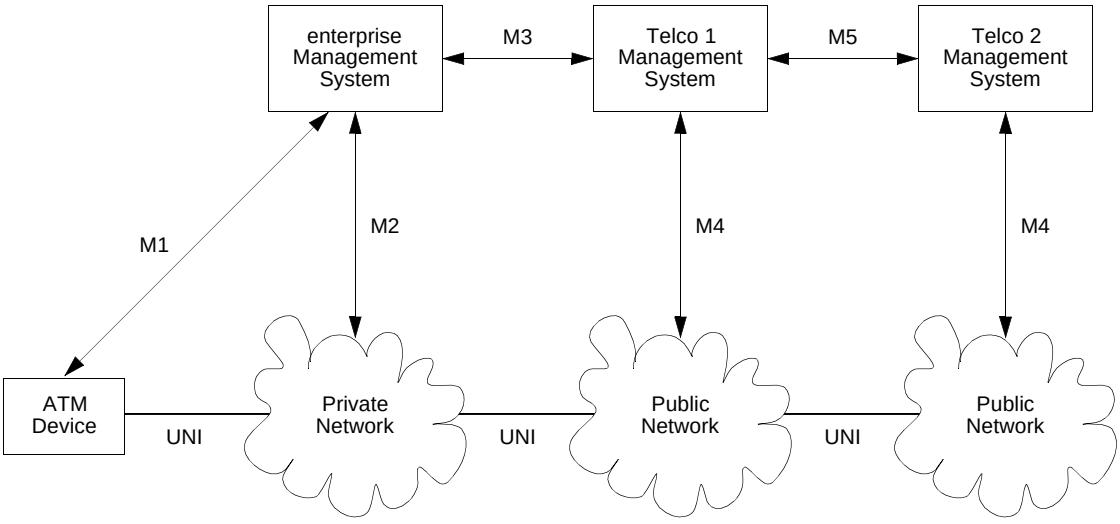


Figure 3: ATM Forum's Network and Management Model

### 4.4 FUNCTIONS OF THE ATM CNM INTERFACE

An important function of ATM CNM implementations is the direct interface to and control of the ATM configuration management information.

The CNM interface provides a constrained view of the telecommunications network to the customer. Usually this view represents the entire telecommunications network as a single ATM switch. The single switch view hides from the customer both the complexity of the Telco's network, and information about other customers who may be also using the Telco's network.

In some implementations of a CNM system, it is possible for a single SNMP agent to provide a CNM interface for a number of customers. In this case, the view of the network exposed by the agent will be based on the origin of the SNMP request.

The Telco may choose to provide a separate communications path for the CNM system access, or rely on in-band communication via the ATM connection.

### 4.5 CNM FEATURES OF ATM NETWORKS

The CNM phase two features, which will deliver interactive real-time management are:

- Provisioning of PVCs, with the seamless establishment of network segments via both the Telco and private network. In establishing the PVC, the CNM system may request the Telco NMS to provision a backup path through the network for the ATM services, ensuring uninterrupted communications in response to failure.
- Access and control of configuration parameters regarding SVC allocation, including the allocation of the range of identifiers assigned and various configuration timers.
- PVC or permanent pirtual path (VP) connection auto-establishment lists.
- Reception of (synthesised) fault alarm notifications.
- End-to-end quality of service management information.

Figure 4 shows a sample CNM implementation.

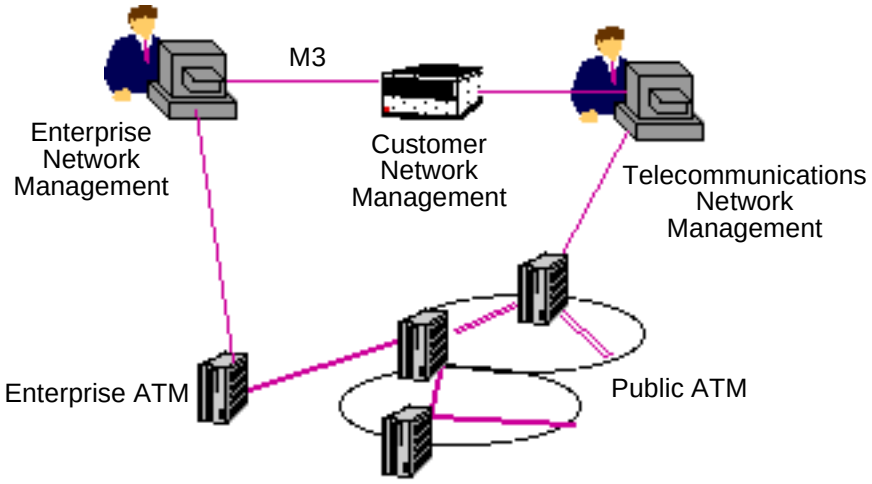


Figure 4: Sample CNM Implementation

In addition, performance management capability is provided by the ATM CNM interface, in order to allow monitoring of the service by the enterprise management system. Accessible performance parameters include:

- traffic and quality of service parameter counters, providing information about the utilisation and performance of various established connections.
- utilisation characteristics of SVCs

The ATM CNM interface also provides a fault management capability by issuing traps to the enterprise management system in response to circuit failure or recovery.

## 5 CONCLUSION

With the introduction of more advanced broadband services, the enterprise need for access and control of Telco-owned management data, provided by CNM systems, is more apparent than ever before. CNM also represents an opportunity to enhance existing Telco service offerings and provide better functionality for enterprise network managers. It will allow enterprise network managers to manage both the enterprise and Telco components of their networks more effectively, by improving network availability, cost control and by enabling more flexible service provisioning.