Element Management Systems (EMSs)

Definition

An element management system (EMS) manages one or more of a specific type of telecommunications network element (NE). Typically, the EMS manages the functions and capabilities within each NE but does not manage the traffic between different NEs in the network. To support management of the traffic between itself and other NEs, the EMS communicates upward to higher-level network management systems (NMS) as described in the Telecommunications Management Network (TMN) layered model. The EMS provides the foundation to implement TMN–layered operations support system (OSS) architectures that enable service providers to meet customer needs for rapid deployment of new services, as well as meeting stringent quality of service (QoS) requirements. The TelManagement Forum™ common object request broker architecture (CORBA) EMS to NMS interface heralds a new era in OSS interoperability by making the TMN architecture a practical reality.

Overview

This tutorial provides a comprehensive understanding of the role of the EMS in the telecommunications network; the functions that are within the domain of EMSs; and trade-offs between various approaches to element management. It is hoped that this information will assist readers by enhancing their basic understanding of these multifaceted components of the evolving network.

Topics

1. Position of the EMS in the Telecommunications Network Architectures
2. The Role of EMSs in the Five-Layer TMN Hierarchy
3. The TMN FCAPS Model of OSS Tasks
4. A Four-Function EMS Model
5. Service Provisioning
6. Service Assurance

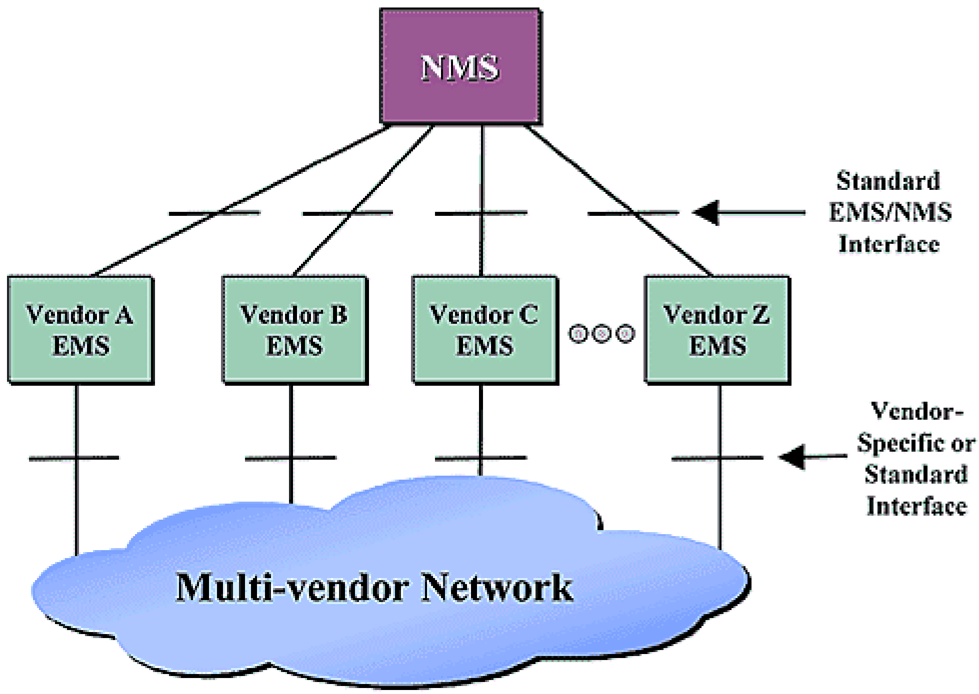
7. EMS and NE Operations Support
8. Automation Enabler
9. Network EMS Software Architecture
10. EMS–Related Standards and Standards Organizations
11. Considerations of Network-Element-Vendor-Provided Versus Independently Developed EMSs
Self-Test
Correct Answers
Glossary

1. Position of the EMS in the Telecommunication Network Architecture

Over the last decade the telecommunications network has been in transition. The old network was primarily designed for switched-voice traffic and was relatively simple. It was based on copper loops for subscriber access and a network of telephone exchanges to process calls. This network is evolving into one designed for integrated access, transport, and switching of voice, high-speed data, and video. The network will be based on a variety of complex technologies. As a result of its complexity, each network element technology is accompanied by an EMS that harnesses the power of the technology while masking its complexity.

Figure 1 is a conceptual view of where EMSs fit in a network. Networks today are composed of a wide variety of NEs from a large number of vendors. The machine-to-machine communication protocol between the NE and its EMS varies from NE to NE and ranges from vendor-proprietary (few new NEs have proprietary interfaces) to protocols such as TL1, premise distribution system (PDS) Snyder, signaling network management protocol (SNMP), and common management information service element (CMISE). As shown in *Figure 1*, the NEs in the network each communicate with their respective EMS. The NE–specific EMSs communicate via either proprietary or, preferably, an open, standard, northbound interface to a higher-level NMS that provides integrated multivendor network management.

Figure 1. Position of EMSs in the Telecommunications Network



One EMS will typically be deployed for a group of elements of the same type or system of NEs, such as digital cross-connect systems (DCSs), a ring of synchronous optical network (SONET) add-drop multiplexers (ADMs), or a hybrid fiber/coax (HFC) cable-telephony system. The role of the EMS is to control and manage all aspects of the domain and to ensure maximum usage of the devices' resources. The EMS then abstracts relevant aspects of the detailed knowledge it has of the NEs into an information model that communicates this information via the northbound interface to higher-level management systems.

The EMS is a critical piece in the total telecommunications-management solution. Only the EMS is exposed to the complete management-information content of all the NEs in its domain. The EMS is the sole mediator of this information and the control of the NEs to the network management layer. Therefore, an EMS is intimately matched to a particular network-element type and must accompany the deployment of those NEs in the network in order to enable and manage the functioning of the NEs.

2. The Role of EMSs in the Five-Layer TMN Hierarchy

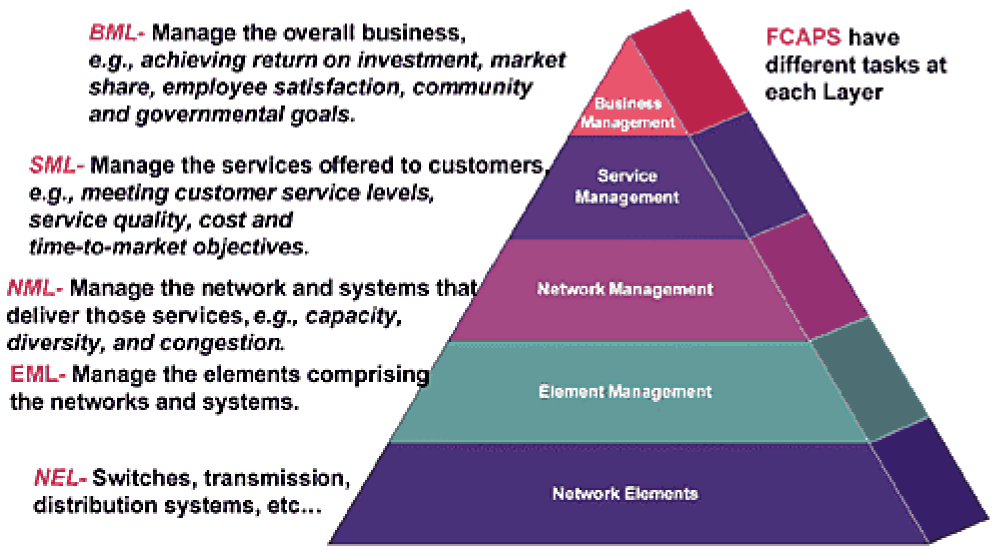
The TMN architecture is a reference model for a hierarchical telecommunications management approach. Its purpose is to partition the functional areas of management into layers. The International Telecommunications Union–

Telecommunications Standardization Sector (ITU–T) defined the TMN architecture in 1988 and it is described in Recommendation M.3010 and other documents.

The key benefit of this architecture is to identify five functional levels of telecommunications management: business management layer (BML), service management layer (SML), network management layer (NML), element management layer (EML), and the (increasingly intelligent) NEs in the network element layer (NEL). TMN segregates the management responsibilities based on these layers. This makes it possible to distribute these functions or applications over the multiple disciplines of a service provider and use different operating systems, different databases, and different programming languages.

TMN calls for each layer to interface with adjacent layers through an appropriate interface to provide communications between applications, and as such more standard computing technologies can be used. The TMN M.3010 document allows for the use of multiple protocols. This means that open standards such as SNMP and CORBA are consistent with the TMN framework.

2. The Five-Layer TMN Network Management Architecture



As seen in *Figure 2*, the TMN model is simple but elegant and has been effectively used to represent the complex relationships within network-management architectures graphically. Originally based on common management information service element (CMISE), the object-oriented technology available at the time of inception in 1988, the model now demonstrates its flexibility with the recent adoption of technologies such as common object request broker architecture (CORBA), as we drive toward a more generic data-processing type of computing. This evolution of CORBA progressed in much the same way as SNMP led its generation of protocol adoption.

EMSs should, by strict adherence with the TMN model, communicate with their NEs by using the common management information protocol (CMIP). This however, takes no recognition of the fact that most devices deployed in the marketplace use other protocols such as TL1, SNMP, and a variety of proprietary mechanisms. An efficient EMS communicates with its NE using whatever protocol is native to the NE. The effective EMS will also communicate with other higher-level management systems using protocols that are the most cost-effective to implement. Therefore, the TMN layering is achieved by using whatever protocols are appropriate.

3. The TMN FCAPS Model of OSS Tasks

In addition to the TMN–layering structure, the ITU–T also splits the general-management functionality offered by systems into the five key areas of fault, configuration, accounting, performance, and security (FCAPS). This categorization is a functional one and does not describe the business-related role of a management system within the telecommunications network. The idea of FCAPS stems directly from the ITU–T recommendations and describes the five different types of information handled by management systems. Portions of each of the FCAPS functionality will be performed at different layers of the TMN architecture. As an example, fault management at the EML is detailed logging of each discrete alarm or event. The EMS then filters the alarms and forwards them to an NMS that performs alarm correlation across multiple nodes and technologies to perform root-cause analysis. A subset of the FCAPS functionality is listed in *Table 1*.

Table 1. A Subset of the FCAPS Functionality

Fault Management	Configuration Management	Accounting Management	Performance Management	Security Management
alarm handling	system turn-up	track service usage	data collection	control NE access
trouble detection	network provisioning	bill for services	report generation	enable NE functions
trouble correction	autodiscovery		data analysis	access logs
test and acceptance	back up and restore			
network recovery	database handling			

For a more comprehensive understanding of FCAPS, it is necessary to examine their role in the context of actual use in the EMS.

4. A Four-Function EMS Model

Introduction

> You don't have to know anything about the telecommunications management network framework to take advantage of EMSs. Although the element management layer is a chief component of the five-level TMN pyramid, all carriers really have to know about EMSs is that they make the job of managing networks of multivendor elements a whole lot easier.
>
> —Dan O'Shea, Supplements Editor
> "Taming the Elements," *Telephony*, September 14, 1998

The TMN FCAPS model of OSS tasks is a useful construct and is often referenced. It is, however, too abstract to use to understand the operational contribution and economic value of EMSs.

Service providers (SPs) think in terms of work (and the related cost and time) that must be invested to provide service to customers. A good example of this is a 1997 study by the TeleManagement Forum (formerly the Network Management Forum [NMF]). This study, based on interviews with service providers, identified a number of high-level processes and supporting subprocesses that should be accomplished by each layer of the TMN architecture.

The TeleManagement Forum–defined, high-level processes for which the EML must provide the base data and operations are the following:

0 service provisioning

1 network development and planning

2 network inventory management

3 network provisioning

4 service assurance

5 network maintenance and restoration

6 network monitoring and control

It is important to understand that EMSs make the link to the NML for tasks such as integrated fault management and flow-through provisioning. The EMS also often provides planning and analysis data directly to the higher-level SML and BML applications via bulk-data-transfer-protocol interfaces. The NML basically has three primary functions:

- integrated fault management and causal analysis of multivendor and multitechnology networks
- integrated, single screen, end-to-end service provisioning of multivendor and multitechnology networks
- integration layer between the EML and the SML; this role is to bring together information from the EMSs that support it, and then integrate, correlate, and in many cases summarize that information, so as to pass on relevant information to service management systems (SMSs); that information generally relates to the characteristics of the network technologies involved but should describe an end-to-end view that is consistent across the (multiple) technologies that are usually required to support a specific customer service; in the reverse direction, the NML receives information from the SML, processes it, and passes on relevant commands and data to the appropriate EMS; the EMS then sends specific commands to the NE

EMSs with open, standard, northbound interfaces provide the solid foundation required for service providers to deploy the TeleManagement Forum–defined, high-level processes by applications at the TMN framework network, service, and BMLs. EMSs also offer significant value via cost- and time-reducing tasks provided in addition to enabling cost-effective development of the TeleManagement Forum high-level processes.

This tutorial supports and represents the value contribution of the EMS with a four-function model. This model incorporates all tasks performed by an EMS and includes the following:

Function 1: service provisioning

Function 2: service assurance

Function 3: EMS and NE operations support

Function 4: automation enabler

Topics 5 through *8* describe typical tasks that legitimately belong in the four-function domain of an EMS. These tasks represent significant potential cost savings and revenue generation for service providers. EMSs are now valuable components of the network in their own right and not mere extensions of the NE craft interface as EMSs have often been perceived in the past. Not all EMSs will perform all of these tasks; some will perform these tasks and more; and some will perform unique tasks that target the requirements of a particular NE.

This four-function model is meant to serve as a useful guide to service providers for evaluating the array of choices for managing the NEs in their own unique operating and business context. A user working through the EMS graphical user interface (GUI) may accomplish some or all of the tasks within each of the EMS four-function model. Whether or not a specific function is accomplished via the EMS GUI depends upon whether or not the task is subsumed in an application performed at a higher level.

5. Service Provisioning

Service provisioning is the overall process of making services available to subscribers or users of the telecommunications network. This process is multifaceted and encompasses those tasks related to installing equipment, planning capacity, provisioning capacity, and upgrading and protecting the database integrity of the NE. EMSs are key enablers of applications at the NML, SML, and BML to perform the TeleManagement Forum–defined high-level processes. The following links three of those high-level processes to their support by EMS service provisioning functions.

- network development and planning
- network inventory management
- network provisioning

These high-level processes are accomplished by these EMS–supported building blocks:

- **inventory management support**—involves maintaining a record of all the NE resources that are installed in the subnetwork to support the provisioning of services; it includes collection of locations, quantities of equipment, model numbers, serial numbers, versions, installation dates, and so on
- **configuration management support**—involves the gross control of subnetwork resources, topologies, and redundancies; it includes the installation and turn-up of new equipment resources; it may include the assignment of resources to trunk routes or service areas, the control of equipment, and network protection switching; it may also include the partitioning of the physical subnetwork resources into virtual private networks (VPNs) for shared use
- **provisioning support**—involves the creation of specific connections or the enabling of specific subnetwork features and the assignment of these to a specific subscriber for an extended period; the connections and features may take into account or be determined by a QoS level that is guaranteed to the subscriber

- **service usage support**—involves the measurement of the usage of the subnetwork resources by the various subscribers; this is the basis for billing and will apply only to NEs that provide a chargeable function, such as connection and call setup.

EMS Domain Specific Tasks

The following are examples of the specific tasks that are in the domain of an EMS.

Installing the NE

- Load the tables and parameters to install a new NE.
- Autodiscover the NE equipment and populate the EMS database.
- Build the shelf-level graphics based on the results of the autodiscovery process.
- Establish and verify connectivity with higher-level OSSs.

Provisioning and Planning Capacity

- Autodiscover circuit components such as cross-connects for existing equipment.
- Enter new circuit components from either the EMS GUI or on a flow-through basis from NML systems.
- Provide information on NE–module part numbers, serial numbers, and unused equipment for SML inventory systems.
- Provide information on available capacity of circuit components such as cross-connects.

Upgrading the NE

- Autodiscover new equipment.
- Download NE software patches.
- Download NE software upgrades.
- Maintain concurrency between EMS and NE software and hardware releases.

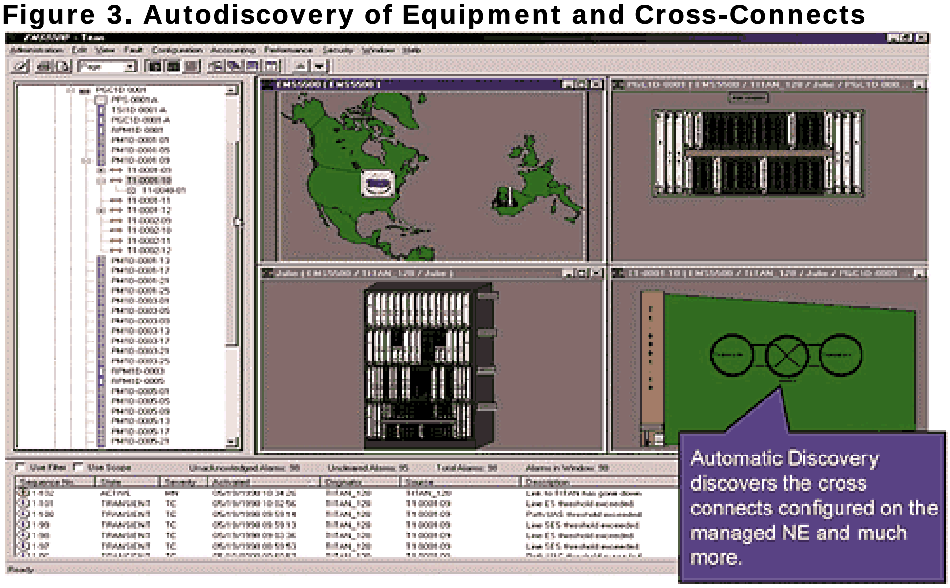
Protecting the Database Integrity of the NEs and the EMS

- Back up and restore NE operational databases.
- Check for loss of connectivity between the NE and the EMS. If connection is lost, when it is reestablished, the EMS resynchronizes its database with the current state of the NE.
- To ensure ongoing operational integrity, the EMS periodically resynchronizes its database with the NE using the autodiscovery mechanism.

Modern EMSs often improve accuracy and reduce the labor of costs of tedious data entry through a process called autodiscovery. *Figure 3* shows that the EMS has performed the following:

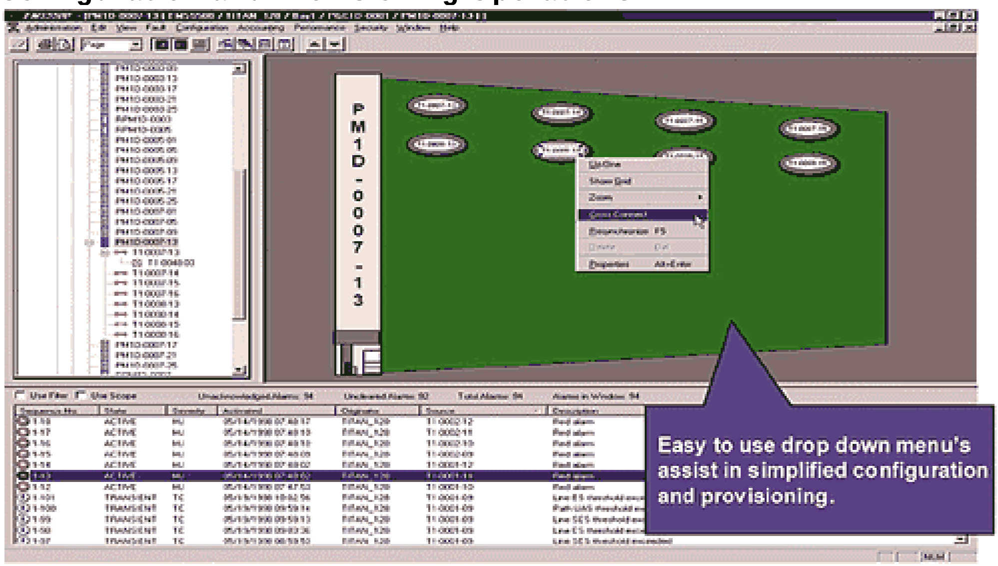
- automatically discovered all of the equipment and automatically drawn the graphics of the bay, shelf, and slot configuration
- automatically uploaded all outstanding alarms and events into the fault window (displayed across the bottom of the screen)
- automatically discovered all cross-connects and created appropriate graphic representations

Figure 3. Autodiscovery of Equipment and Cross-Connects



Not shown are autodiscovered equipment-provisioning parameters that are stored in the EMS database for use in other service-provisioning, service-assurance, and automation-enabler operations.

Figure 4. Use of Graphics and Drop-Down Menus to Simplify Configuration and Provisioning Operations



With most technicians, professionals, and business persons being familiar with applications based on the Windows type platforms, point-and-click operations with graphics, pull-down menus, and dialogue boxes make using an EMS interface an intuitive operation.

A well-designed user interface can combine technically diverse yet logically related functions onto a single screen that offers a simple workflow and includes default values and selectable options to save time and reduce errors. *Figure 5* is for an HFC–cable telephony system. It includes provisioning of both the remote service unit (RSU) on the side of the customer's house and the associated multipoint RF transceiver (MRF) located in the host digital terminal (HDT) equipment located at the cable telephony service provider's head end (central office).

Figure 5. Single-Screen Provisioning of Logically Related Functions

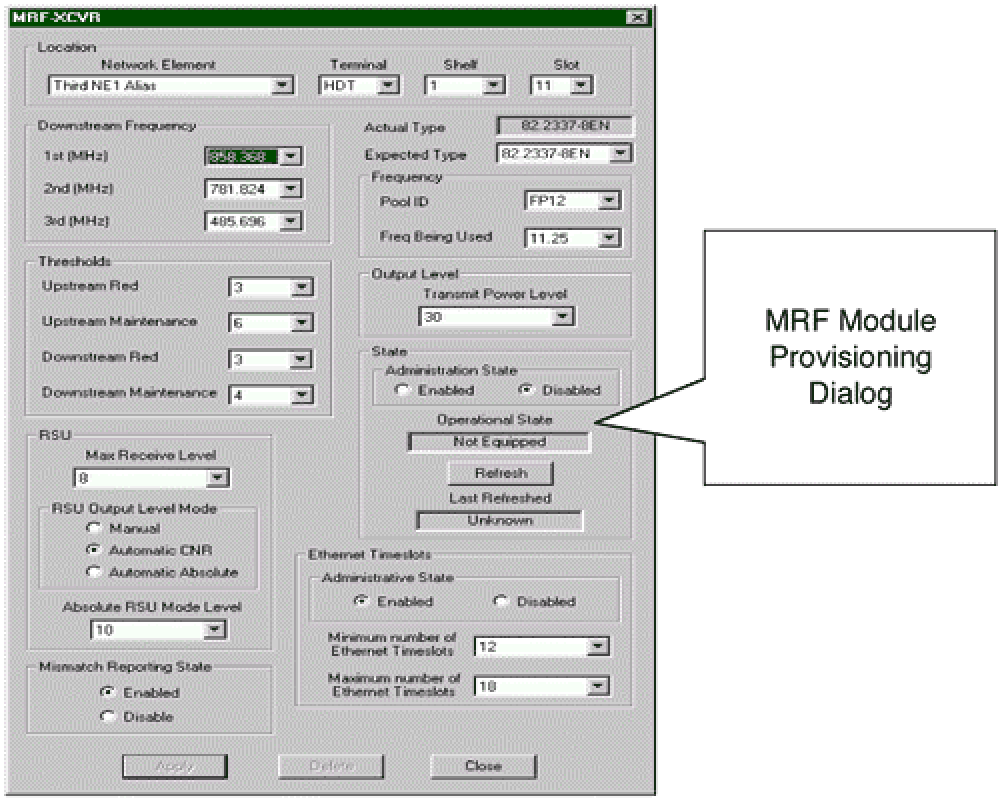
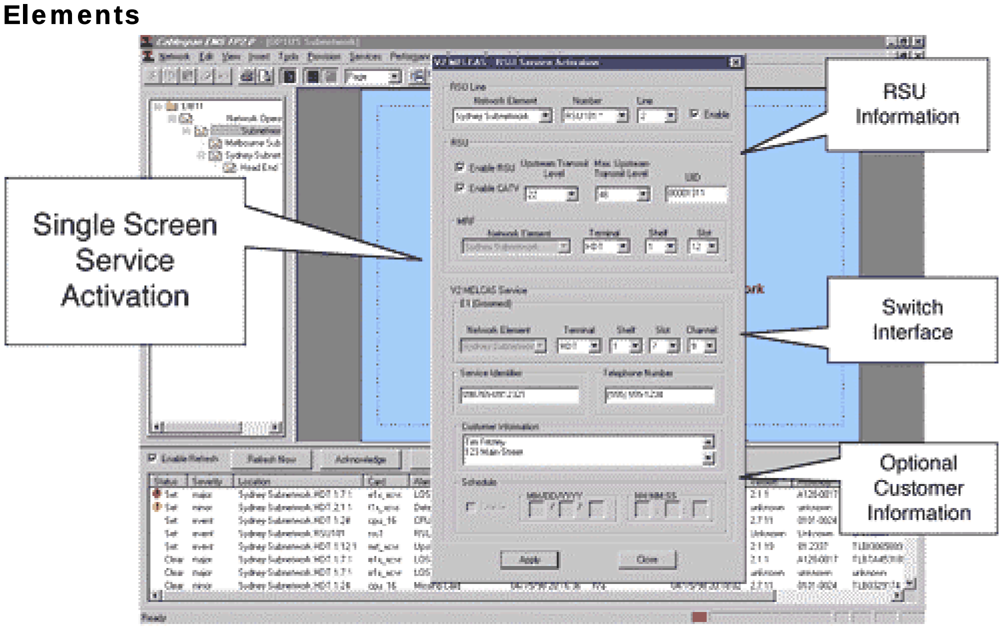


Figure 6. Single-Screen Customer Activation of Multiple Service Elements



The next step after completing configuration and provisioning of the RSU and its supporting MRF is to activate customer service. *Figure 6* shows a single screen that activates both the telephone service in the home and the voice-switch connection in the cable-telephony service provider's central office.

6. Service Assurance

After service is provisioned for a subscriber under a given QoS level, the service provider must ensure that the purchased level of service is delivered. In the EMS domain, this process involves the fault and performance management of the provisioned network resources.

The EMS plays a key role in maintaining the health of both NEs and transmission facilities. It does this in conjunction with other systems, typically at the NML and SML. The EMS can be the primary repository of detailed history of NE–specific faults, events, technicians' actions, and performance data. EMSs are key enablers of applications at the NML and SML to perform the TeleManagement Forum–defined high-level processes. The following links two of the five high-level processes to their support by EMS service-assurance functions.

- network maintenance and restoration
- network monitoring and control

The high-level processes are accomplished with these EMS–supported building blocks.

- **fault management support**—involves the monitoring of the network resources to detect malfunction, preempt failures, and detect faults. After faults are discovered, the operator must troubleshoot, repair, and restore the network as quickly as possible. Fault management ensures that service remains available.
- **performance data collection support**—involves the periodic collection of quality metrics that characterize the performance of the network resources over service intervals. It also facilitates the visualization of trends that can indicate periodic or gradual degradation of physical resources.
- **resource utilization data collection support**—involves the collection of data on the level of utilization of network resources assigned to subscribers. This data can be used to determine whether the service product is appropriately matched to the subscribers' usage characteristics. It can also be used to forecast demand and suggest service upgrades before QoS suffers.

- **QoS assurance support**—involves ensuring that the quality metrics characterizing network performance remain within the agreed limits. It requires proactive monitoring of the network fault, performance, and utilization parameters to preempt any degradation in service quality.

EMS Domain-Specific Tasks

Following are examples of the specific tasks that are in the domain of an EMS:

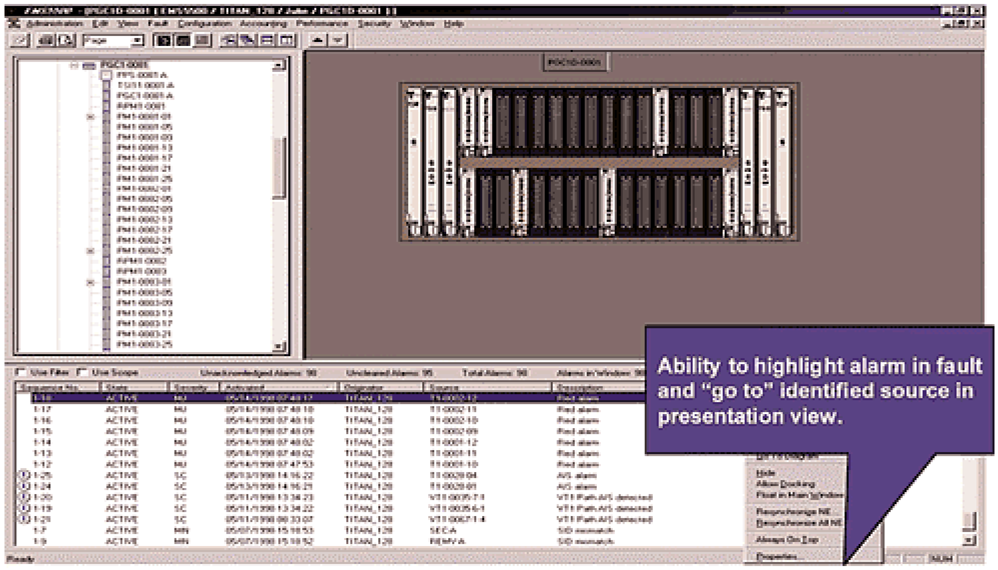
Fault Isolation

- Higher-level NML fault-management systems and SML trouble-ticketing systems provide a first alert and generally point to the source of a problem. Technicians can then use the EMS database and EMS tools to do a pinpoint diagnostic.

- Many EMSs provide an easy way to invoke and display the results of NE–diagnostic tools such as loopbacks to isolate faults.

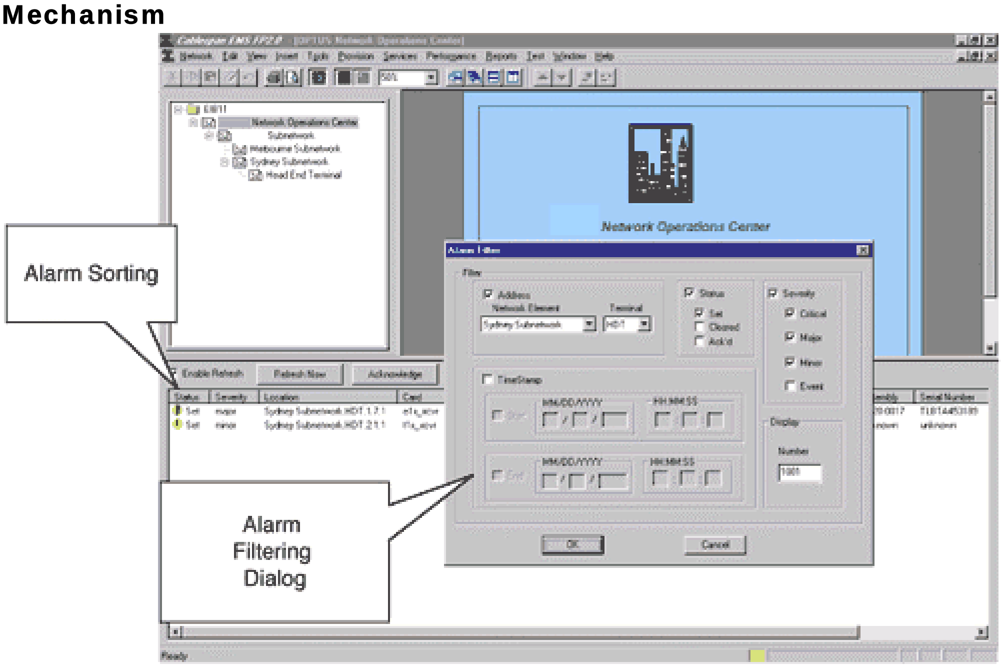
EMSs provide one or more fault windows that contain detailed information on each alarm or event generated by the NEs in its domain. An alarm is a specific problem indicator with predefined actions that trigger the alarm. Events are typically service provider–set thresholds that, if crossed, send a message that appears in the alarm window along with faults. A common use of the event mechanism is to detect degrading transmission facilities in order to alert network operations personnel to a problem before it becomes customer affecting. Example thresholds are bit error rate (BER) and SLIPS. *Figure 7* shows an advanced troubleshooting feature of clicking on an alarm and bringing up a drawing of the affected equipment. This enables a technician at the network operations center (NOC) to direct a generalist at a remote-equipment site to the proper bay, shelf, and slot to replace a failed port card.

Figure 7. A Comprehensive Alarm Window with Linkage to a Drawing of the Affected Equipment



Depending upon each unique service provider's methods, procedures, and organization, NOC technicians may be assigned different aspects of the service-assurance tasks. *Figure 8* shows an alarm-filtering screen that allows each technician to view and manage alarms and events in a way that is optimized for their responsibilities.

Figure 8. Alarm Window Customization via an Alarm Filtering Mechanism

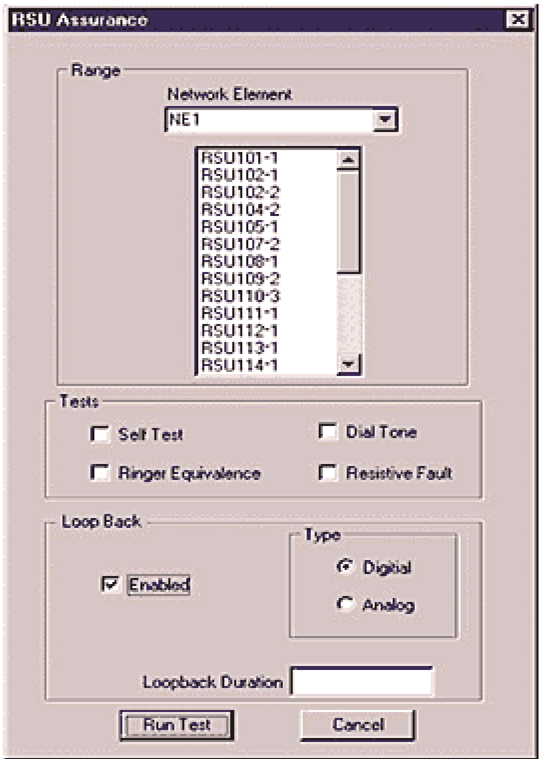


Quality of Service

- EMSs detect performance-threshold crossings such as SLIPS and BERs and forward those to the NML fault manager. This data can identify degrading facilities before they become apparent to the customer.
- EMSs can store the performance measurement (PM) data from NEs and make it available to either EMS report generators or to SML performance management and QoS systems.
- Depending on the capabilities of the NE and its EMS, EMSs sometimes provide the ability to perform diagnostics on NE equipment and even closely associated communication facilities on a scheduled or demand basis.

A key QoS component is the ability to pinpoint the cause of a problem quickly so that the proper repair resources can be applied quickly. The objective is to achieve the minimum mean time to repair (MTTR) possible. In some cases the repair can be done from the NOC or even by the customer under the direction of NOC technicians. *Figure 9* shows the ability in the cable telephony application to remotely diagnose the RSU on the customer's house and to also perform tests that can determine if the problem is in the customer's telephone equipment or inside wiring.

Figure 9. An EMS Diagnostic Screen for Cable Telephony Testing



7. EMS and NE Operations Support

Competition is driving service providers to minimize costs of network operations. At the same time, the complexity of new services is increasing almost exponentially. Service providers must therefore do more with less. One of the most significant sacrifices is the number of fully trained technicians available to do the work. This is further complicated by the following factors:

- There are an increasing variety of NEs from different vendors.
- The NEs are evolving rapidly.
- There is a general shortage of trained telecommunications technicians.
- Labor costs must be kept low while, at the same time, providing high-quality innovative services.
- Service providers know that they must send the super techs to hands-on NE vendor training.
- There are many less intense support activities that, nonetheless, require a large number of people to have knowledge of the NEs and the

EMSs. Therefore, service providers have a more intuitive system management process without a high training overhead.

Meeting these challenges requires the use of operations tools with the maximum efficiency and flexibility with respect to accomplishing tasks. Therefore, the EMS should have the following characteristics.

- **ease of use**—typically requires the use of an intuitive, task-oriented GUI to allow operations functions to be performed in the shortest possible time

- **context-sensitive help**—enables technicians to perform tasks that they do only infrequently or for which, in many cases, they have never been trained at all

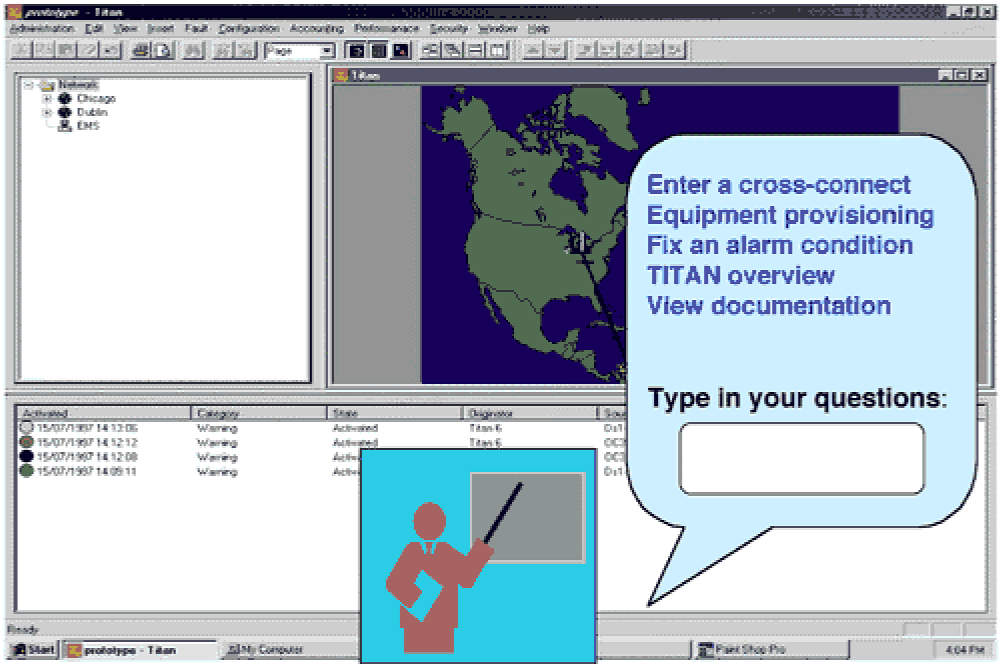
- **unified desktop**—enables a user working at the NML, SML or BML to open a window directly to any EMS desired and—from the EMS—to open a craft-user interface directly into any NE that an EMS manages

- **low-cost operations platform**—aims at minimizing the total cost to own and operate the computing platform on which the EMS runs; computing platforms such as Windows NT™ conform to telecom platform robustness, scalability, and performance requirements

- **remote access**—allows the operations staff to access management information and control from any location; this facilitates the utilization of a distributed work force that can respond rapidly to failure notifications. In today's Internet world, this means that thin client workstations operate over the Internet and service-provider Intranets.

Figures 3 through *9* provide examples of the reduced skill and training requirements, the improved accuracy, the time saving, and the cost savings that good human-interface design provides. *Figure 10* shows further skill and training requirement reduction through the use of aids such as context-sensitive help that lead technicians step-by-step through otherwise complex tasks.

Figure 10. Task Wizards Lead the Technician through Complex or Infrequently Performed Tasks



The EMS database contains a wealth of information that can improve service, save time, and save money. Most EMSs provide a library of standard reports and usually provide report-generator software and the ability to export data to other application tools that specialize in analysis and reporting (*Figure 11*).

Figure 11. An EMS–Provided Report Example

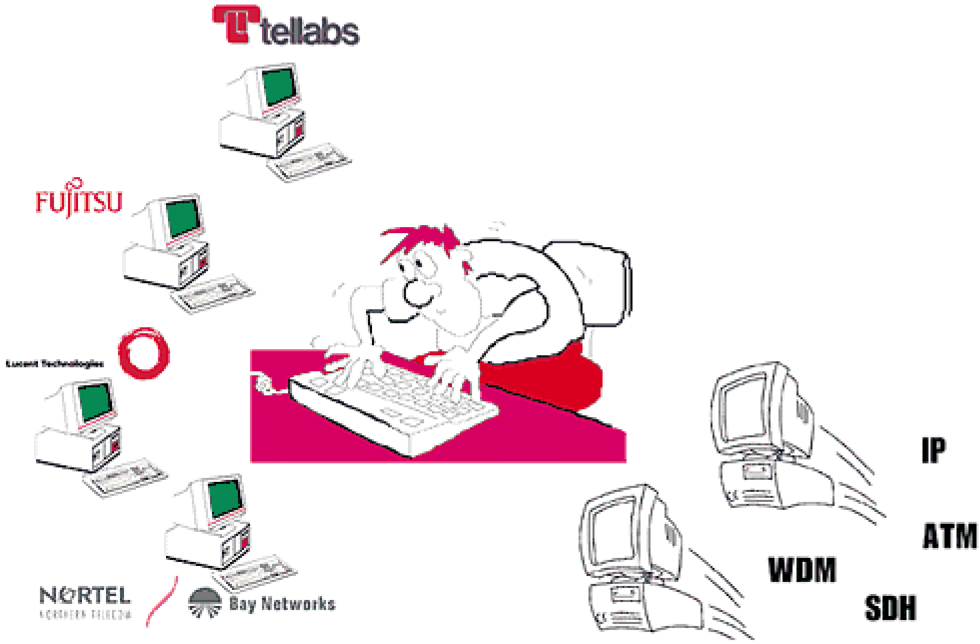
Unequipped Slot Report

June 19, 1998

TITAN Name	Port Type	Bay	Shelf	Slot AID
NOC1	DS1	1	1	2345-67
NOC1	DS3/1	1	2	2407
NOC1	DS3/3	1	3	4342
NOC1	DS3/31	1	4	1965
NOC2	EC-1	2	1	1509
NOC2	OC-3	2	2	1026
NOC2	OC-12	2	3	2665

8. Automation Enabler

Figure 12. The NOC as It Would Be if TMN Stopped at the EML



An EMS acts as the sole repository of all management information for its domain. It offers summarized views of that information as well as command and control capability to the NML via a northbound interface. Therefore, the EMS performs the following functions.

- **information storage**—requires the EMS to store all the management information collected from the NEs
- **modeling of EMS domain**—involves the creation of an appropriate information model with which to organize the storage of the management information and through which to offer control of the subnetwork
- **normalization of EML**—involves mapping the specific information model of the EML onto a generic subnetwork model recognized by the NML; this mapping effectively hides the unique specifics of the NE layer and exposes a generic subnetwork model that is technology independent.
- **northbound interface**—involves support for a specific protocol or mechanism for distributed communications between the EMS and the NMS; this interface is used to enable management-system automation

whereby NE resources can be controlled indirectly from the NMS GUI without the intervention of an EMS operator.

- **single screen multivendor cross-domain management**—requires the EMS to send over the northbound interface, the information required by an NMS to provide integrated multivendor end-to-end management from a technology and NE–vendor independent human interface; for those functions that are best provided by the EMS interface, a cut-through mechanism enables NMS NOC technicians to open a window on their NMS workstation screen directly into the EMS; this window can be on the screen at the same time as the related NMS screen.

Representative Northbound Interfaces

- **TL1**—northbound interface to send filtered alarms to an NML fault management system and, for some EMSs, a bidirectional TL1 interface for flow-through provisioning from an NML system

- **open database connectivity (ODBC)**—interface for bulk data transfer to either an EMS report generator or to external analysis and reporting applications and, for some EMSs, a bidirectional ODBC interface for flow-through provisioning from an NML system

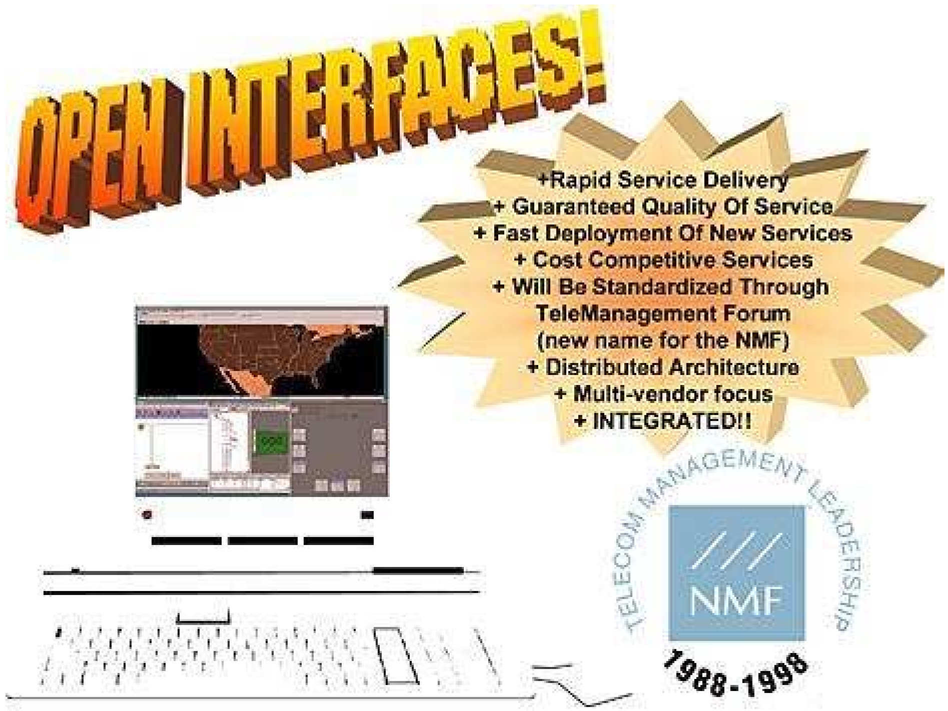
- **SNMP**—interface for less complex NE–EMS systems to send traps (faults) to an NML fault management system and, for some EMSs, a bidirectional SNMP interface for flow-through provisioning from an NML system

- **Q3/CMISE**—bidirectional CORBA interface from the TeleManagement Forum for advanced NEs to send filtered alarms to an NML fault management system to enable flow-through provisioning from an NML

A Breakthrough in Open EML–to–NML Interfaces

The TeleManagement Forum CORBA "NML–EML Interface for Management of SONET/synchronous digital hierarchy (SDH) Networks" project heralds a new era in OSS interoperability. This is a ground-braking effort in developing an interface that will make it easier for service providers to manage their multivendor networks from a single client workstation (see *Figure 13*).

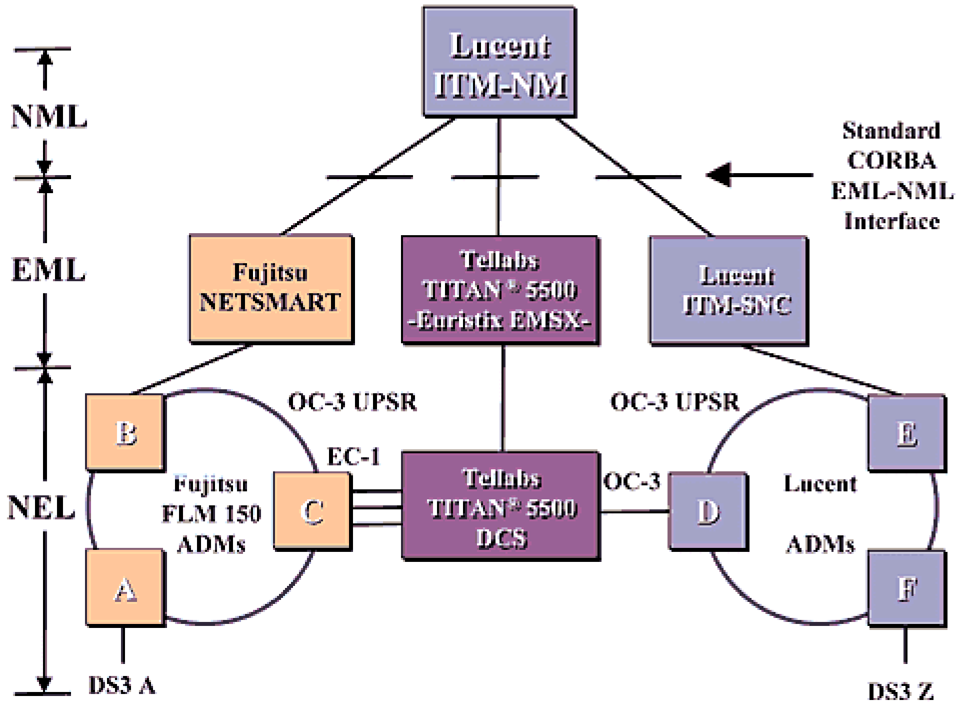
Figure 13. A Breakthrough in a Global Open EML to NML Interface Standard



The initial group of companies that developed the first draft specification included Fujitsu, Lucent Technologies, and Tellabs. This group of companies focused their joint effort on the element management layer to network management layer (EML–to–NML) interface using CORBA as the basis for the open interface. This was demonstrated at the NFOEC Conference in Orlando, Florida (September 1998) and the TeleManagement World Conference in Dallas, Texas (October 1998). The NML system was the Lucent ITM–NM network management system implemented on a UNIX platform (see *Figure 14*). It communicated via CORBA interfaces to the following:

- a Fujitsu NETSMART™ EMS implemented in Java on a Sun Solaris™ platform that managed an OC–3 UPSR ring with FLM™ 150 ADMs
- a Tellabs TITAN™ 5500 EME, using Euristix RACEMAN™ technology based on Windows NT™, that managed a TITAN 5500 SONET wideband digital cross-connect system
- a Lucent ITM–SNC™ EMS implemented on a UNIX platform that managed an OC–3 UPSR ring with Lucent DDM™–2000 ADMs

Figure 14. The NFOEC and TeleManagement World Multivendor CORBA Configuration



The demonstration showed point-and-click, A-to-Z provisioning on the Lucent ITM–NM network management system of a DS–3 circuit from the A point on an ADM on the Fujitsu ring through the TITAN 5500 DCS to the Z end on an ADM on the Lucent ring. This was an industry first and will lead the way to wide implementation of standards-based, easy-to-manage, multivendor networks.

As of August 1999, the draft working group included the initial three companies plus Nortel Networks, Siemens AG, and Telcordia Technologies (formerly Bellcore). The draft working group presents its recommendations to the TM Forum for comment and revision. As of August 1999, the TM Forum Information Modeling (SSIM) Team consisted of representatives MCI WorldCom (service provider sponsor), Tellabs, Fujitsu, ADA, Ciena, DSC, ECI Telecom, Lucent Technologies, Nortel Networks, Siemens AG, Telcordia Technologies, TTI–Telecom, and Vertel.

Note: that at the September 1999 NFOEC '99 conference, the demonstration in *Figure 14* was expanded to include NEs and EMSs from Nortel Networks, Siemens AG, and Telcordia Technologies (formerly Bellcore).

The initial TM Forum–approved CORBA model is TM Forum 509, released in September 1999. It is important to note that the TM Forum has approved development of extension to the SONET/SDH model to encompass support for asynchronous transfer mode (ATM) and dense wave division multiplexing

(DWDM) technologies. It is safe to predict that integrated, open, standard CORBA EML–to–NML modeled interfaces will support the emerging NE technologies.

Why is this important?

The rapid introduction of increasingly complex NEs has now made it virtually mandatory for providers of telecommunications equipment to offer a TMN–compliant EML–EMS application to support each unique NE type. Early versions of EMSs typically offered only a one-way fault management TL1 EML–to–NML interface. TL1 was offered because it provided a somewhat standard interface that NML system providers could reasonably implement in their multivendor NMSs.

To be competitive, SPs must quickly bring innovative services to market. This requires SPs to quickly deploy next-generation NEs and creatively apply them to meet end-customer needs. New NEs must be easy to integrate into the existing network management fabric for integrated fault management, flow-through service provisioning, QoS/performance management, billing, security, and—as applicable—end-customer network management.

Interconnecting the Upper Four TMN Layers

Typical pictorial representations of the TMN layered architecture as a pyramid or a vertical stack could lead one to believe that all transactions flow up and down and are processed at each layer. This is not necessarily true for the following reasons:

- Some applications, such as analysis and reporting of data collected by an EMS, may be retrieved directly via an interface such as ODBC protocol by an SML application.

- All TMN–layer applications may not be performed by the same corporate entity; for example, a service provider may own the physical network and sell products and services to end-customers; that same service provider may also sell wholesale capacity to other service providers that sell their own branded products and services to end-customers; in this case, each service provider has its own SML and BML systems.

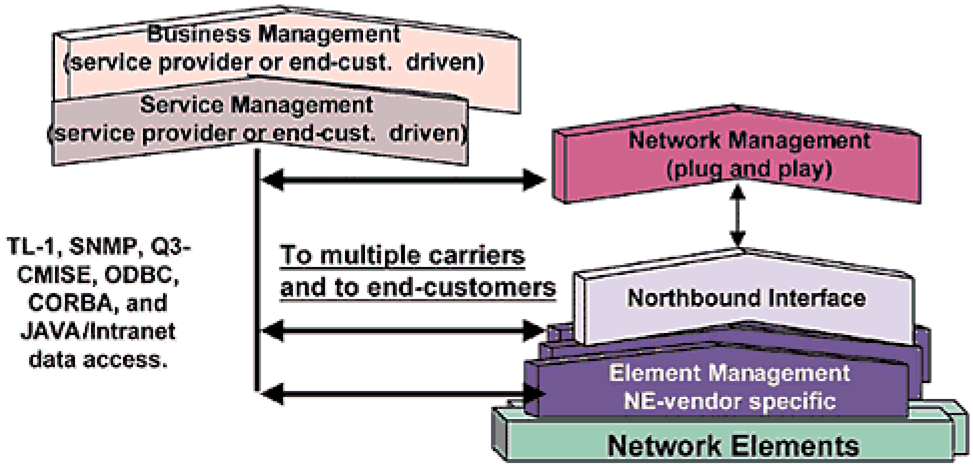
- Large-end customers increasingly want to buy network capacity and do the final stages of service provisioning via a service offering called customer network management (CNM).

- All service providers who buy wholesale from other service providers have QoS agreements that they must monitor and enforce; this requires

OSS–to–OSS communication interfaces that are far different from an "up and down the TMN stack" that was envisioned by the ITU–T when it developed the TMN architecture in 1988.

Figure 15 depicts the fact that task-specific OSS–to–OSS communications based on task-appropriate protocols must be supported by applications at all the TMN layers.

Figure 15. Use of Appropriate Interface Standards to Match Work Flow Processes



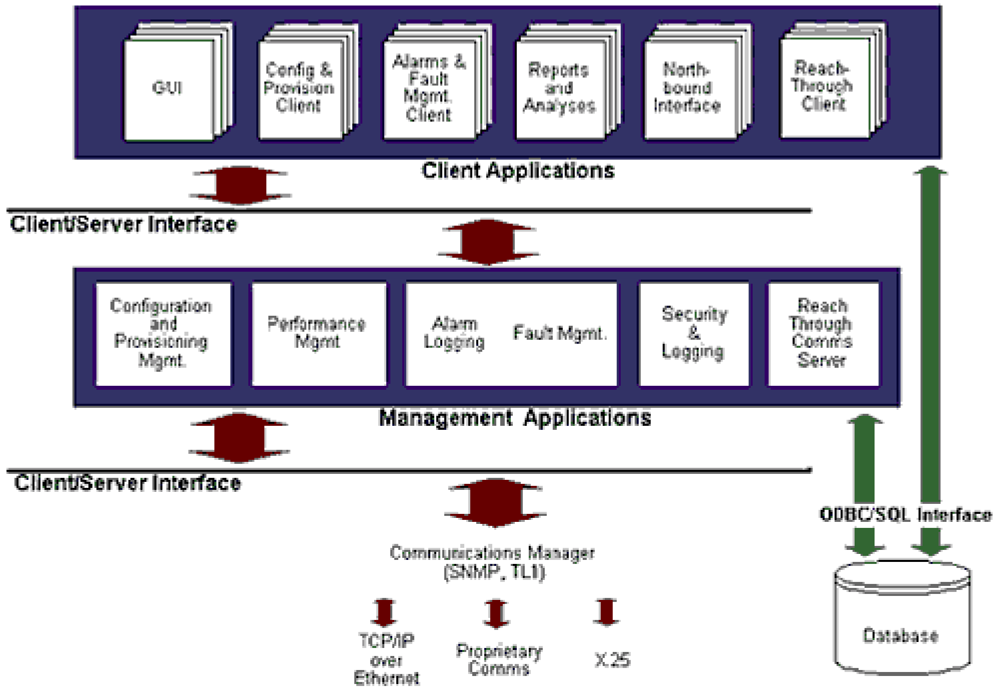
9. Network EMS Software Architecture

An EMS's architecture should meet some of the following basic requirements:

- It should provide the correct level of management functionality appropriate to the device and to the management environment.
- It should be scalable to grow with the requirements and complexity of the network.
- It should be distributable in order to support such scalability and to provide a level of high availability.

Database technology is a critical part of any credible EMS strategy. *Figure 16* shows an example of element management–software architecture that meets the above requirements. Client Server interfaces that were traditionally proprietary or remote procedure call (RPC) are now evolving toward CORBA, distributed component object model (DCOM), Java/Web Server, or other proprietary interfaces.

Figure 16. Layered View of Element Management–Software Architecture



10. EMS–Related Standards and Standards Organizations

ITU

The International Telecommunications Union (ITU) is the body charged with global responsibility for telecommunications standards. Their work is sponsored by service providers and PTTs from around the world, as well as large equipment vendors and national standards organizations. The ITU–T within the ITU has defined the TMN reference model for network management as well as the CMIP protocol and information models covering a range of technologies. The seminal reference document for the TMN model is M3010.
Web Site: http://www.itu.ch

The original seven regional Bell operating companies (RBOCs) originally jointly owned Bellcore in the United States. It had a dual role in providing software for telecommunications management and defining standards for adoption by the RBOCs. These standards covered all aspects of telecommunications from physical cabling specifications to network management information modeling. Telcordia is now independently owned by SAIC and is addressing the network management of telecommunications networks using its existing technologies combined with

advanced technology programs.
Web Site: http://www.telcordia.com

TeleManagement Forum

TeleManagement Forum, formerly the NMF, is a nonprofit, global organization that provides the telecom industry with leadership on the most effective ways to streamline the management of communications networks and services. The TeleManagement Forum SMART TMN program helps members develop pragmatic solutions for automating the key business processes necessary for success in today's competitive market.
Web Site: http://www.tmforum.org

OMG

The Object Management Group (OMG) has a membership of over 800 software vendors, software developers, and end users. The OMG promotes CORBA as the middleware that's everywhere through its worldwide standard specifications: CORBA/Object Services, Internet Facilities, and Interface specifications. Established in 1988, the mission of OMG is to promote the theory and practice of object technology for the implementation of distributed computing systems. The goal is to provide a common architectural framework for object-oriented applications based on widely available interface specifications. In addition to its initial use for diverse information systems (IS) applications, CORBA has gained widespread acceptance as the object-oriented distributed computing protocol for network management applications. For this reason, the OMG has a separate telecommunication subgroup to ensure that the tools and methodologies evolve to meet the unique needs of the telecommunications application environment.
Web Site: http://www.omg.org

SIF, ATMF, and ADSLF

These are industry bodies that, in general, promote standardization within their technology domains. In most cases, such standardization also covers management activities. The organizations typically define information models for managing the equipment and specify which management protocols are to be used.
SONET Interoperability Forum (SIF) Web Site:
http://www.atis.org/atis/sif/sifhom.htm
Asynchronous Transfer Mode Forum (ATMF) Web Site: http://www.atmf.com
Asymmetric Digital Subscriber Line Forum (ADSLF) Web Site:
http://www.adslf.com

11. Considerations of Network-Element-Vendor-Provided Versus Independently Developed EMSs

There are several options for service providers or end-customers to achieve various levels of EMS functionality. Two major factors to be weighed in an EMS analysis are the following:

- Concurrency: the old adage in real estate is that there are three factors to consider: location, location, and location. With EMSs, there are also three factors: concurrency, concurrency, and concurrency. What is concurrency? Concurrency means that a new release of the EMS software is available when a new version or release of an NE is ready to be deployed in a network. New NE releases usually add new alarms, commands, and other features that must be accommodated by the EMS. Concurrency is less difficult to achieve if the EMS and NE work together to produce a timely, consistent solution.

- The specific features of the four-function EMS components that are required; different providers of EMS software offer different levels of functionality. For example, see *Figure 16*, the Euristix RACEMAN EMS architecture.

Categories of EMS Software Providers

There are several categories of EMS software providers. Each category broadly defines the potential extent to which an EMS software provider in that category can provide various levels of functionality:

1. Independent software vendors (ISVs)—are software companies that specialize in network management software. There are two types:

- those that provide software products, usually at multiple TMN layers, directly to service providers and to end customers (Telcordia Technologies is a special case of this because of its unique historical genesis as Bell Labs, then Bellcore, a Bell System–owned network management software provider. Now privately owned by SAIC, Telcordia—while still an entrenched provider to the RBOCs—finds itself competing for business with both the RBOCs and other service providers to which Telcordia now markets its software and services).

- those that provide tools, core platforms, and turnkey applications on an original equipment manufacturer (OEM) basis to NE vendors who use these products in their branded products; these offerings are appealing to many NE providers because the development of an EMS can be quite complex; it requires a wide range of knowledge and skills related to protocols, data networking, GUI development, and database technologies as well as knowledge of the target NEs; an NE vendor, while having a complete knowledge of the target NEs and the management tasks required, may not have access to the other skills required; recently, a large number of tools and platform components have become available from independent software vendors; such tools include protocol stacks, manager development toolkits, EMS toolkits, and GUI modules; while these tools assist in the development of the EMS, a developer still requires lead-time and extensive skills to turn the tools and components into an EMS.

2. **NE vendors**—there are two types:

- those that provide EMSs only for their NEs and do not provide NML, SML, or BML systems
- those that provide EMSs for their own NEs and also provide offerings at the NML and possibly at the SML and BML

3. **SP and end-customer NMS development organizations**—Some large service providers and end-customers, responding to either the dearth (until recently) of NE vendor-provided EMSs or adequate ISV–provided NML, SML, and BML systems, have large in-house OSS development organizations

What Is the Typical Scope of Functionality Provided by Each Category?

The following are the typical expected levels of functionality for each category of EMS software providers. These statements reflect the general historical offerings of EMS software providers. EMS selection teams should determine the precise current offerings and planned enhancements for each EMS provider they are considering. The following observations correlate with the above numbering scheme for categories of EMS providers.

1. **ISVs**

- These software providers have had reasonable success with the fault and alarm-management tasks of the service assurance function. It is relatively easy to parse ASCII–TL1 alarm streams from multivendor NEs and present a composite view. They have had less success with the service provisioning function. They typically offer little with respect to the EMS and NE operational efficiency function. Automation enabling with respect to other OSSs is often done via proprietary interfaces.

Telcordia and TTI–Telecom have, however, successfully done some level of flow-through provisioning while working directly through the TL1 and PDS–NE interfaces. It is important to note that both companies now actively support the TM FORUM CORBA standards. They recognize that full-featured management of diverse technologies will only be feasible by employing a well-supported standard EML–to–NML interface.

- Tool and platform component providers and developers on an OEM basis typically provide their software and services to NE vendors who offer NE–vendor-branded and fully supported EMSs.

2. NE vendors

- Those that provide EMSs only for their NEs and do not provide NML, SML, or BML systems typically provide EMSs that offer rich feature sets in all four functions of service provisioning, service assurance, EMS and NE operational efficiency, and automation enabling. These NE vendors focus on using open, standard interfaces to NML, SML, and BML systems. Their approach with service providers is "We will collaborate with the NML, SML, and BML vendors that you specify to ensure that our NEs are well-managed in your unique multivendor NE and multivendor OSS environment."

- Those that provide EMSs for their own NEs and also provide offerings at the NML and possibly at the SML and BML have taken two approaches:

    - They act like an ISV and directly manage NEs from other vendors much like ISVs. They usually experience the same mixed results with respect to the level of features offered. For these software providers, managing other vendors' NEs directly was in response to the dearth of NE vendor EMSs with open, standard northbound interfaces.

    - This direct NE management approach is changing with the increasingly wider availability of NE vendor EMSs with standard interfaces such as ODBC and TeleManagement Forum–sponsored CORBA EML–to–NML interface. NE vendors who compete with each other now collaborate to have their EMSs interoperate with competitors' NML systems. Lucent Technologies, Nortel Networks, and Siemens AG are NE vendors that offer multivendor NMSs that support the TM Forum CORBA interface. They are also active in the evolution of the CORBA model.

Self-Test

1. The EMS manages the entire telecommunications network.

    a. true

    b. false

2. The TMN architecture recommends that specific aspects of network management functions be implemented within specific layers of the framework.

    a. true

    b. false

3. The EML is the second layer of the open systems interconnection (OSI) protocol stack.

    a. true

    b. false

4. EMSs are required to manage the copper loop from the central office to the subscriber.

    a. true

    b. false

5. Only the EMS is exposed to the full information content of the NEs in a given domain.

    a. true

    b. false

6. Any EMS can be used to manage any type of NE.

    a. true

    b. false

7. Inventory management in the EMS domain is the maintenance of records of the location, identity, version, and equipage of all NEs in the domain.

    a. true

b. false

8. To provide comprehensive service assurance, the EMS contains the detailed history of all faults and events within its domain as a source for service assurance applications in the other TMN layers.

   a. true

   b. false

9. Performance data collection is directly related to QoS assurance.

   a. true

   b. false

10. The TMN Architecture includes __________________ layer(s).

    a. element management

    b. business management

    c. service management

    d. network management

    e. all of the above

11. Which of the following protocols is a viable alternative to the Q3/CMIP protocol for communication between the EMS and the NMS?

    a. TCP/IP

    b. CORBA

    c. RS–232

    d. X.25

    e. all of the above

12. Which of the following message protocols can be used as the NEL–to–EML protocol?

    a. CORBA

    b. CMISE

c. TL1

d. SNMP

e. all of the above

13. Inventory management may include the collection of _________________.

a. serial numbers of circuit packs

b. NE software version

c. NE identifier

d. all of the above

e. none of the above

14. Configuration management may include __________________.

a. measuring the number of errors per packet

b. providing remote access to network operators

c. repairing the network resources

d. setting up a cross-connect

e. none of the above

15. Inventory data on both equipment and the service capacity (e.g., cross-connect termination availability by type of circuit) can be used to _________________.

a. switch from main to backup systems

b. detect faults in the network

c. forecast need for service provisioning changes

d. detect degrading circuits

e. none of the above

16. A northbound interface from an EMS is one that ________________.

a. connects to an NMS

b. provides a generic, normalized information model to an NMS

c. allows an NMS to control NEs through the EMS

d. all of the above

e. none of the above

17. Competition is driving network operators to use operations tools that _______________.

a. have elaborate, multicolored graphics

b. are based on the most expensive computing platforms

c. have remote access capabilities

d. are intuitive and task-oriented

e. use command-line interfaces

Correct Answers

1. The EMS manages the entire telecommunications network.

a. true

b. false

2. The TMN architecture recommends that specific aspects of network management functions be implemented within specific layers of the framework.

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b. false

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Glossary

ADM
add-drop multiplexer

ADSLF
Asymmetric Digital Subscriber Line Forum

ATM
asynchronous transfer mode

ATMF
Asynchronous Transfer Mode Forum

BER
bit error rate

BML
business management layer

CMIP
common management information protocol

CMISE
common management information service element

CNM
customer network management

CORBA
common object request broker architecture

DCOM
Distributed component object model

DCS
digital cross-connect system

DWDM
dense wave division multiplexing

EML
element management layer

EMS
element management layer

GUI
graphical user interface

HDT
host digital terminal

HFC
hybrid fiber coax

ISV
independent software vendor

ITU
International Telecommunications Union

ITU–T
International Telecommunications Union–Telecommunications Standardization Sector

MRF
multipoint RF transceiver

MTTR
minimum mean time repair

ITU
International Telecommunications Union

NE
network element

NMF
Network Management Forum (now TeleManagement Forum)

NML
network management layer

NMS
network management system

NOC
network operations center

ODBC
open database connectivity

OEM
original equipment manufacturer

OMG
object management group

OSI
open systems interconnection

OSS
operations support system

PM
performance manager

QoS
quality of service

RBOC
regional Bell operating company

RPC
remote procedure call

RSU
remote service unit

SDH
synchronous digital hierarchy

SIF
SONET Interoperability Forum

SML
service management layer

SNMP
signaling network management protocol

SONET
synchronous optical network

SP
service provider

TMN
telecommunications management network: a body of standards defined by the ITU–T as a reference model for the architecture, design, and implementation of telecommunication management systems

VPN
virtual private network