Cisco Internet OSS Element Managers Reduce Operating Expenses and Enhance Network Availability

To be competitive and profitable, service providers must continually work to decrease operating expenses (OpEx). A significant portion of OpEx is invested in the highly skilled personnel required to manage today’s complex networking equipment and to make use of associated management systems. Professionals with Cisco CCIE® certification and other certified network professionals are commonly deployed in first-line network troubleshooting positions as a direct result of this complexity.

Cisco Systems helps service providers reduce OpEx in two ways. First, it offers effective element management tools that reduce or eliminate the need for highly skilled network professionals in first-line network management positions (meaning that a lower level of network management expertise is needed to perform the same level of tasks). Personnel with higher skill levels can be redeployed to handle more complex problem-resolution tasks.

Second, Cisco element management tools simplify and expedite network troubleshooting within the network operations center (NOC). Network devices (elements) can be deployed faster, and any subscriber provisioning issues can be resolved with fewer overheads, ensuring accelerated service rollout. Troubleshooting tools reduce mean time to repair (MTTR), increasing NOC productivity, availability, and the level of service for service provider customers. Fewer personnel are required to manage the network devices, reducing ongoing OpEx and freeing staff up for other tasks. Service providers wrestle with another issue. Experts estimate that 30 percent of network inventory databases are inaccurate and out of date, hampering the ability to accurately determine capacity. Cisco element managers provide a range of tools for physical and logical inventory discovery, enabling service providers to precisely compare inventory databases with actual deployed equipment, and to more accurately plan network-capacity usage and upgrade schedules.

This white paper describes the features of the Cisco Element Manager product range, including the November 2002 upgrade features, and illustrates how the standards-based approach makes these element managers key tools for increasing NOC productivity.

Defining Cisco Element Managers

Cisco element managers are key NOC tools that support a range of troubleshooting, configuration, and data-collection capabilities. Focused on the needs of carrier-grade deployments, Cisco element managers offer carrier-class fault, configuration, accounting, performance, and security (FCAPS) and operations, administration, maintenance, and provisioning (OAM&P) functionality.
They share a set of common GUI applications, a common deployment platform, and administration tools to enable cost-effective, rapid element manager system (EMS) and network element deployment. Cisco element managers also help maintain service provider uptime targets with high-availability features to minimize disaster recovery time.

Cisco element managers cover a broad range of Cisco service-provider network elements, including core and edge series Internet routers, ATM switches, dial and voice access servers, and voice gateways. Among the Cisco hardware platforms and technology domains available today are:

- Access technologies for dial, DSL, and cable (the latter including management support for cable industry standard, Data over Cable Service Interface Specification [DOCSIS])
- Edge technologies such as the Cisco Catalyst ® 6500, 4000/4500, 2950, and 3550 Series switches and the Cisco 6400 Universal Access Concentrator
- Voice technologies such as the Cisco Media Gateway Controller Node Manager for voice-over-IP (VoIP) platforms
- Core and edge routing technologies such as the Cisco 12000, 10720, 7600, 7400, and 7200 series routers

The following sections detail the functionality typically found in Cisco element managers, and how the Cisco Element Manager architecture integrates with the other layers of the Cisco Internet OSS.

**Cisco Element Managers—Common Applications for the NOC**

One challenge for Cisco, as a supplier of a wide range of different networking technologies, is to achieve consistency across the Cisco EMS layer, both from an interface perspective as well as a NOC user’s perspective. This is achieved via the layered architecture of the Cisco Element Manager product set. Figure 1 shows the architecture of a typical Cisco Element Manager.
The architecture of the Cisco Element Manager supports its role as the network “information application,” providing the inventory coordination and information application set for the Cisco CNS Programmable Network components. This allows Cisco EMS users to perform NOC-based tasks, such as element troubleshooting and GUI-based element provisioning, while providing flow-through provisioning support and service assurance information to higher layer applications of the Cisco Internet OSS.

The Cisco Element Manager architecture consists of three layers:

- A set of GUI applications targeted for use by a NOC operator. These are central components of the Cisco EMS, and are common across the Cisco Element Manager product family. These GUI applications include the Event Browser, for viewing of alarm conditions, and the Map Viewer, for details of network alarm conditions, navigation across the network device inventory, and performance data monitoring.
- A set of northbound interface capabilities for both legacy and next generation operations support systems (OSSs), including Common Object Request Broker Architecture (CORBA) for provisioning, fault, and inventory system integration; Simple Network Management Protocol (SNMP) for fault OSS integration; and FTP/ASCII output of performance data.
- A set of southbound network element interfaces, using both the Cisco CNS Programmable Network and common interfaces such as SNMP and proprietary man-machine language interfaces where appropriate.

Cisco Element Manager Application Functionality

Cisco element managers provide management functions essential to any NOC or integrated OSS environment. These applications include:

- Autodiscovery and maintenance of network inventory, including physical network elements, line cards, interface ports, and logical inventory.
- A range of integrated FCAPS management applications that complement the collection capabilities of the Cisco CNS Programmable Network, so that fault information from the Cisco CNS Notification Engine is displayed in the Cisco Element Manager Event Browser, supporting NOC technician navigation to the Cisco Element Manager topology map and on to detailed network element diagnostics.
- OSS integration interfaces to higher layers of the Cisco Internet OSS and traditional OSS systems—for example, bidirectional fault management integration interfaces to ensure that Cisco element managers and higher layer applications, such as Cisco Info Center, display consistent and complementary information for network troubleshooting. Real-time intelligent events can also be used by a provisioning OSS to determine the network elements that should be used by the OSS to provision new subscribers for immediate live service.

Typical GUI-based FCAPS capabilities for NOC technicians found in Cisco element managers include:

- Detailed fault analysis via propagated alarm conditions in the graphical topology map application, and ‘scoreboard’ summary views of affected components based on traps and other alarm conditions from network equipment. Alarm conditions are represented in the Cisco Element Manager in a consistent manner, regardless of whether they originate from SNMP or Cisco IOS® Software syslog sources. These tools are illustrated in Figure 2.
- Performance data collection via scalable polling engines and (in the future) via the Cisco CNS Programmable Network and custom collectors. Performance data is stored, archived, and presented to support troubleshooting and diagnostics statistics.
Finally, Cisco element managers also provide OAM&P-related support for:

- Productivity tools such as “beyond IP” autodiscovery—from IP to individual (non-IP) port level for both SNMP and Cisco IOS Software devices
- Configuration and provisioning of the most commonly used features of the network element and Cisco IOS Software
- Tools for network element software image management and common disaster recovery functions such as element backup and restore
- EMS operations available both to northbound OSSs and to “exception” operators in NOCs via GUIs

Within the Cisco Internet OSS, Cisco element managers provide inventory integration of the Cisco CNS Programmable Network and detailed FCAPS capabilities to Cisco domain managers and interdomain managers, such as Cisco Info Center.

**How Cisco Element Managers Use the Cisco Networking Services Layer**

Cisco element managers make use of, and provide complementary functionality to, the Cisco Networking Services layer, shown in Figure 1. It is important to differentiate between the functionality and target audience of the Cisco Networking Services layer and the Cisco Element Manager common GUI applications.

The Cisco CNS Programmable Network is a set of network intelligence engines that collect data and perform actions upon Cisco IOS Software network elements. Not only can they be employed as data collectors for higher layer applications—especially in cases where there is limited value in overloading an EMS with information—but the Cisco CNS Programmable Network components can also be used directly by EMS applications. The primary
interface to the Cisco CNS Programmable Network is through a set of application programming interfaces (APIs) that are used, often by systems integrators, to integrate these components into layered application sets that are deployed in NOCs as integrated solution sets.

The Cisco Element Manager layer, on the other hand, is a set of applications that can be deployed as a standalone in the NOC (mini-OSS), or as part of an integrated OSS. Additionally, Cisco element managers have a range of interface options that allow them to be incorporated into the OSS stack for tasks such as inventory integration and flow-through provisioning. Cisco element managers also incorporate and use the Cisco Networking Services layer components, either by direct interaction or via the Cisco CNS Integration Bus.

For example, Cisco element managers use the Cisco CNS Configuration Engine. This Cisco CNS component provides a template-based mechanism for configuring Cisco IOS Software-based devices. Expert users within service provider organizations, or Cisco Professional Services, can define the parameters for their own Cisco IOS Software templates. As described in the Cisco CNS Programmable Network section of this document, the Cisco CNS Configuration Engine supports definition of the provisioning solutions. The Cisco Element Manager layer uses this capability to enable a “configure-to-order” definition of provisioning services by superusers in the NOC or service provider research and development group. These services can then be “plugged into” the range of northbound interfaces of Cisco element managers.

The Cisco Element Manager capabilities are enhanced by the components of the Cisco CNS Programmable Network, and also complementary in that they expose the programmatic tools of the Cisco CNS Programmable Network to the NOC operators via functionally rich, proactive troubleshooting and provisioning tools.

The Benefits of Cisco Element Managers

Cisco element managers bring added value beyond competitive EMSs and complement the capabilities of other layers of the Cisco Internet OSS.

Carrier-Class Requirements

Much of the road map direction of Cisco element managers is driven by the tenets of carrier-class management, including:

- **Telecommunications-class scale and performance**—Both in terms of the number of elements supported and providing management capability that enables operational staff to manage networks. Cisco has significantly invested in real-life, scenario-driven scale and performance testing to establish that Cisco element managers are capable of managing large-scale core, edge, and access technology networks.

- **Systems integration capability**—As described above, Cisco element managers support a range of CORBA, SNMP, and FTP/ASCII OSS integration mechanisms for inventory, provisioning, fault, and performance applications.

- **Standards-based systems**—Such as SNMP for northbound fault interfaces and CORBA for flow-through provisioning, as well as TeleManagement Forum (TMF) standard GUI presentations (discussed in more detail below).
• **Security**—Cisco element managers offer flexible security access, supporting secure and safe use of advanced management capabilities in the network operations environment. Cisco element managers provide straightforward configuration of user groups to reflect NOC policy and organization, such as separate fault and provisioning user roles. This helps to ensure that, for example, a new fault user does not perform potentially service affecting operations such as deletion of a permanent virtual circuit (PVC).

• **Resilience, availability, and serviceability**—To maximize Cisco Element Manager uptime, these products come standard with features such as online installation and backup. Additionally, a high-availability Cisco Element Manager server option is committed for release and will support failover from active to standby Cisco Element Manager servers across both LANs and WANs to minimize disaster recovery time between geographically distributed NOCs.

### Standards-Based Solution

Cisco element managers provide support for a range of industry and de facto standards, ranging from CORBA and SNMP for OSS integration, Cisco IOS Software and SNMP for southbound device communications, to TeleManagement Forum initiatives for network management graphical representation and usability.

One example is the use of ITU-T/OSI-based Telecom Graphics objects for alarm and state representation in Cisco Element Manager user interfaces (Figure 3). Using representations such as “1C+” (indicating that this site contains one critical alarm with additional alarms of lower severity), NOC operators can quickly and easily tell the severity and coverage of alarm conditions.

**Figure 3**

Use of TeleManagement Forum Conventions for Element Alarm and State Display
Complementing the OSS

Cisco element managers are often deployed in standalone situations as a “mini-OSS” because of their broad range of capability and intuitive GUI interfaces. This is particularly the case for managing small networks. For larger networks, the Cisco EMS still performs an important role.

For example, service provider customer service personnel usually make use of an automated service provisioning system to bring new subscribers online. When such systems are used, there are occasional errors where the new subscriber circuits are not correctly provisioned across the networks. In these instances, the Cisco Element Manager provides tools for NOC technicians to help investigate, troubleshoot, and provision these circuits again using a GUI-driven environment such as the typical Cisco Element Management GUI for PVC provisioning (Figure 4).

It is often estimated that, particularly in the early days of new service introduction, 75 percent of the provisioning effort is dedicated to verifying the results of the automated system. It is therefore essential that straightforward GUI-driven tools, like those in the Cisco Element Manager, be available to facilitate this checking process.

Figure 4
Cisco Element Manager GUI for PVC Provisioning
Cisco element managers include a range of fault management functionality, as well as northbound interfaces to enable EMSs to pass alarm conditions onto upper layer Cisco Internet OSS components. Cisco Element Managers can add significant value when deployed alongside other Cisco Internet OSS fault management components. This becomes very apparent when considering the ITU-T definition of the service provider fault management process. The ITU-T M.3400 and Bellcore GR-2869 standards define fault management as the detection, isolation, and correction of abnormal operation of the telecommunications network and its environment. This functionality is usually implemented at various layers of the Cisco Internet OSS and at various layers of the ITU-T Telecommunications Management Network (TMN) five-layer model. In many cases, it is the interaction of the different systems that presents a complete fault management solution.

These standards include the following processes as part of the overall fault management task:

- Reliability, availability, and survivability quality assurance
- Alarm surveillance
- Fault localization
- Fault correction
- Testing
- Trouble administration

Figure 5 illustrates the key tasks performed by Cisco element managers. The Cisco Element Manager detects faults by interpreting device traps or “syslog” messages, polling SNMP tables and devices for component removal, or detecting threshold breaches. All faults are logged to a database, and GUI applications such as Map Viewer and Event Browser clearly display these faults within the NOC. The fault can be easily found as the GUI applications allow the NOC operator to navigate to the location of the fault using maps and context-sensitive menus. Additional troubleshooting tools like the Performance Manager allow the NOC operator to look at historical and real-time data to check for trends, sudden changes, or other indications of the cause of the fault. Configuration details, power supply, temperature sensors, and other data can be checked using the Cisco Element Manager GUIs until the fault and cause can be found. Often the repair can also be carried out remotely from the NOC. A device can be restarted, reconfigured, or upgraded (software), for example.
The Cisco Internet OSS includes fault management toolsets such as Cisco Info Center and Cisco CNS Notification Engine (the syslog processing engine). These Cisco Internet OSS components primarily address alarm surveillance. Cisco element managers add value to these tools by covering each area (Figure 5).

**Reducing Complexity in the NOC**

Cisco element managers are primarily intended to simplify the management of complex Cisco networking technologies. NOC personnel can use Cisco element managers without placing advanced skill-set or training requirements on the operators. For example, Cisco element managers focus on providing graphical views of network statistics, for use in troubleshooting and re-provisioning operations, without requiring knowledge of SNMP Management Information Bases (MIBs), Cisco IOS Software command line interface (CLI), or complex programming APIs.

Cisco element managers help eliminate complexity and provide context-sensitive details to complement the higher-layer network general alarm collection mechanisms available, for example, within Cisco Info Center. Consider fault management within the Cisco 6400 EMS (for the Cisco 6400 Aggregator). Many fault or alarm conditions raised by the Cisco 6400 Aggregator are retrieved and verified by the Cisco EMS using trap-directed polling of an SNMP table in the Cisco 6400 agent rather than simply via SNMP traps. The EMS in this case is responsible for presenting such table-based fault information in a standard format for users of the EMS application, or for transforming into northbound SNMP traps or CORBA notifications to the network layer within the OSS. This enables the EMS to interpret traps and other network events in a network element specific manner, providing the network operator with more detailed diagnostic information.

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**Figure 5**

The End-to-End Fault Management Process

- **Detection**: SNMP trap resolution including network element interrogation and polling for more detailed information; provides alarm surveillance complementing the capabilities of Cisco Internet OSS, such as Cisco Info Center and C-NOTE
- **Fault Isolation**: TeleManagement Forum “Telecom Graphics Objects” chassis map view for fault isolation and localization (Figure 3) allows NOC operators to see the same view as the central office technician looking at the network element
- **Investigation**: Go from the chassis map to detailed network element statistics, such as interface performance statistics, presented in a GUI so that the operator need not require detailed SNMP nor Cisco IOS Software knowledge
- **Repair**: Using Cisco Element Manager Resource Management Essentials (RME) to upgrade to a new release of Cisco IOS Software to resolve a network element problem

- **Detect, Log and Display Fault**
- **Isolate Using Network Inventory and Topology**
- **Investigate Problem**
- **Drill Down to Note Detailed Analysis**
- **Effect Repair from NOC**
Proactive NOC Troubleshooting

Cisco element managers provide *thresholding* capabilities that proactively notify operators when key capacity metrics, such as bandwidth utilization, are exceeded, or when router CPU utilization exceeds a NOC warning level of 80 percent of maximum. This greatly contributes to fault prevention and increases service availability to customers.

This is another example of how Cisco element managers complement the Cisco CNS Programmable Network components. While the Cisco CNS Performance Engine component has the programmatic capability to support thresholding of network element attributes against predefined levels, Cisco element managers provide a GUI for the NOC manager to set up these thresholds in an intuitive manner, directly from the network element detailed attribute displays in typical Cisco element managers. Figure 6 illustrates how NOC operators can set up threshold conditions without knowledge of the complexities of the underlying SNMP MIBs or Cisco IOS Software attributes, and without the need to make use of complex programming APIs.

**Figure 6**
Graphical NOC Tools for Setting Threshold Breach Monitors

Network Element Administration Tools

Cisco element managers now include Resource Management Essentials (RME), a consistent toolset for managing Cisco IOS Software upgrades and network element configuration backup and restore. Also available for Cisco enterprise customers, Cisco element managers extend the capabilities of RME by providing a single GUI to access network elements distributed across a multiple RME server deployment. With rapid deployment tools such as autodiscovery, Cisco element managers can simplify RME deployment by discovering available network device inventory for resource management tasks. These benefits are summarized in Figure 7.
Cisco Element Manager Factory

A key challenge for Cisco, especially in light of the company’s rapid growth in the service provider market, is the timely development of a wide range of element management applications. Within software engineering communities, the concept of the “software factory” to overcome the challenges of complex software initiatives is well known. Cisco has extended this concept to the production of element managers by instituting the Element Manager factory.

The Cisco Element Manager factory has been designed to deliver many of the benefits of an automated “traditional” production line, namely:

- Consistency of functionality across the range of EMSs, so that service providers can rely on consistent NOC operational tools across Cisco hardware platforms as well as consistent functionality for northbound integration
- Consistent use of the underlying components (in this case, the Cisco CNS Programmable Network)
- Common look-and-feel guidelines to lower service provider deployment costs
- A rigid factory quality procedure that ensures all element managers are delivered to specification and tested together for co-residency prior to release
- Time-to-market delivery of EMSs to support service provider OSS and equipment rollouts

The Cisco Element Manager factory is in the process of delivering the next generation of Cisco element managers for new Cisco products such as the Cisco 10000 Series Internet Router. Additionally, the Element Manager factory is chartered to increase the coverage across service provider hardware platforms, such as popular Cisco products that include the Cisco 2600 and 3600 series. The end result is a more comprehensive Cisco Internet OSS that reduces service provider OpEx and increases management and network availability.
Summary

Cisco element managers include a range of NOC troubleshooting and provisioning tools to help reduce service provider cost of operations by:

- Lowering network implementation costs
- Lowering training costs
- Allowing certified network professionals to focus on value-added activities rather than day-to-day activities that could be handled by less experienced personnel
- Managing larger networks while maintaining computer hardware budgets
- Simplifying OSS integration

Cisco element managers and the Cisco Internet OSS are key drivers of operational cost reduction, and contribute to service provider profitability increases.
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