Cisco General Packet Radio Service Performance Management

Introduction

This document defines a performance-management (PM) architecture that will allow service providers (SPs) deploying General Packet Radio Service (GPRS) wireless services to track the ongoing performance of their network from end to end. The solution should provide visibility not only into the Cisco IP domain, including the Gn/Gi links (links between the Gateway GPRS Support Node [GGSN] and the packet data network [PDN] and Serving GPRS Support Node [SGSN], respectively) within the GPRS Support Node (GSN) complex that comprises SGSN, GGSN, and Catalyst® Switches, but also into the radio domain of the wireless infrastructure.

Scope

The PM architecture focuses on the interactions between Cisco and third-party network-management systems and Cisco network elements (NEs).

The managed Cisco NEs in a typical GPRS network include:

- Cisco Catalyst Ethernet Switches (Catalyst 4000, 5000, and 6000)
- Cisco GGSN
- Cisco routers (Cisco 2600, 7xxx, and so on)
- Other NEs in the future

The following topics are covered in this document:

- Cisco GPRS Operations Administration Maintenance and Provisioning (OAM&P) architecture
- Performance management
  - Performance monitoring
  - Performance analysis

Customer Benefits

The Cisco Performance-Management philosophy delivers the following benefits to GPRS SPs:

- Assessment of quality of service (QoS) as experienced by customers
- Ability to offer key differentiators based on service-level agreement (SLA) monitoring
- Comprehensive network-performance analysis
- Cost savings with elimination of overprovisioning
- Sharp decline in unplanned network outages

The Cisco GPRS OAM&P Architecture

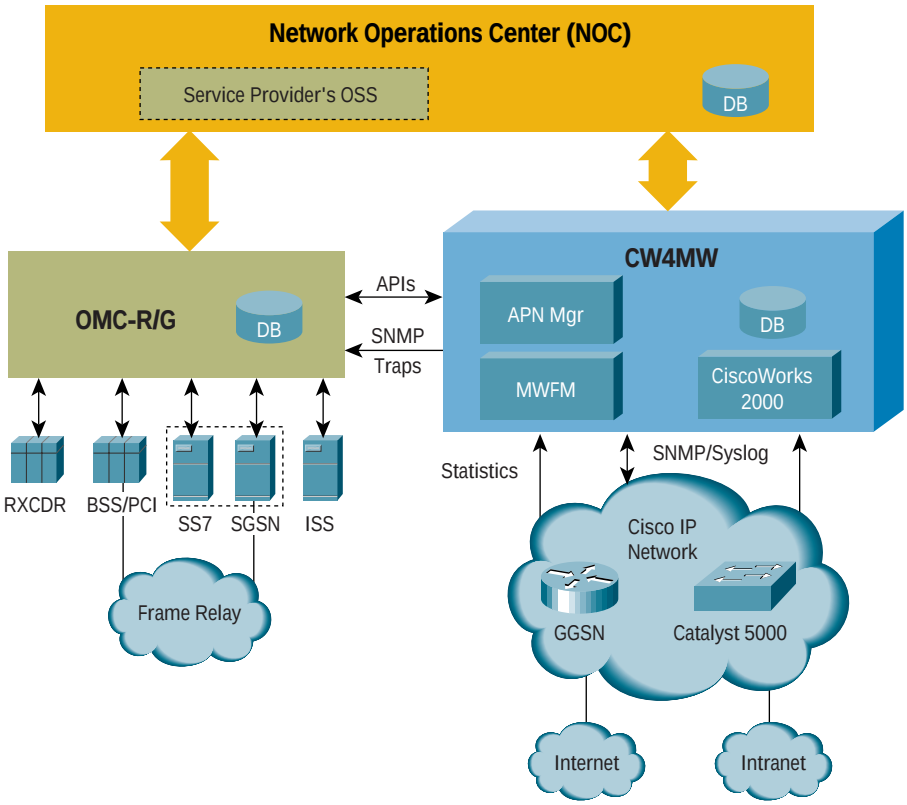
End-to-End Network View

Cisco GPRS NEs, including the GGSN and its neighbor Catalyst Switch, are managed through the CiscoWorks2000 for Mobile Wireless bundle (CW4MW), which is a suite of applications that enable wireless next-generation service delivery by Cisco mobility platforms such as the GGSN. It includes:

- *APN Manager*—This application provides a Common Object Request Broker Architecture application programming interface (CORBA API) to view and configure access point name (APN) profiles in the GGSN and Domain Name System (DNS) resource record from the operations management console-GPRS (OMC-G) and third-party Operations Support Systems (OSSs).
- *Mobile Wireless Fault Mediator (MWFM)*—This telco-grade fault solution provides intelligent device discovery, alarm filtering, and correlation of the Packet Data Service Node (PDSN) and GGSN and their neighboring Catalyst switches. In addition, MWFM seamlessly integrates with network- and service-layer fault OSS to provide a complete network monitoring solution.
- *CiscoWorks2000*—The CiscoWorks2000 line of products provides solutions targeted at the wide-area and local-area operations of communications networks.

Figure 1 shows a typical Cisco GPRS network alongside the radio infrastructure. The PM application is located in the Network Operations Center (NOC) area and is provided by Cisco ecosystem partners.

Figure 1 GPRS OAM&P View

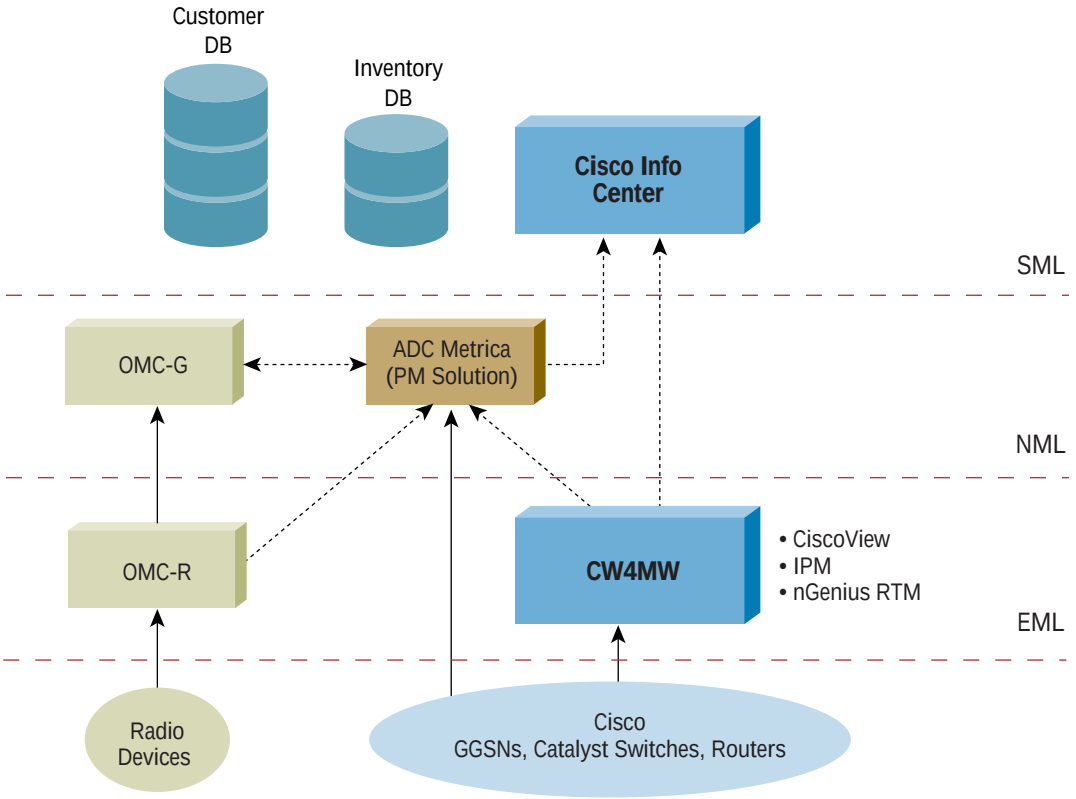


Cisco Mobile Wireless PM Architecture

The Telecommunications Management Network (TMN)-based diagram shown in Figure 2 illustrates the PM architecture. Network-level PM solutions such as Metrica/NPRcollect performance statistics either from the element management system (EMS) or directly from NEs and provide monitoring and analysis functions. As described in the following sections, CiscoWorks2000 also provides PM and troubleshooting capabilities with CiscoView, Cisco Internetwork Performance Monitor (IPM), and Cisco nGenius Real-Time Monitor (RTM).

Initially, the different PM solutions collect statistics directly from the Cisco devices. The dotted lines indicate future interfaces between management systems.

Figure 2 TMN-Based PM Diagram



The PM process involves several steps:

- Gather performance data on those variables of interest to network administrators
- Analyze the data to determine baseline levels
- Determine appropriate performance thresholds for each important variable such that crossing of these thresholds indicates a network problem worthy of attention

Management entities continually monitor performance variables. When a performance threshold is exceeded, an alert is generated and sent to higher-level management systems such as Cisco Info Center for further processing.

Table 1 shows the types of statistics that are available from Cisco platforms and the applications that provide the overall PM functionality.

Table 1 Performance Metrics from Platforms and Applications

Layer		Statistics	
		Generic IP	Wireless (GGSN)
Platforms	Cisco Catalyst Switches	X	
	Cisco Routers	X	
	Cisco GGSN	X	X
Applications	Cisco PM Monitoring Applications:		
	CiscoWorks2000 CiscoView	X	X
	CiscoWorks2000 nGenius Real-Time Monitor	X	
	CiscoWorks2000 Internetwork Performance Monitor	X	
	PM Monitoring/Analysis Application:		
	ADC Metrica/NPR	X	X

The IP and the wireless statistics that can be collected from Cisco devices are discussed in the next section.

Performance Monitoring

Performance monitoring is used for observing and collecting data on a specified set of attributes associated with network resources to measure network performance.

This section defines the statistics that can be collected from the Cisco devices in the mobile wireless environment and then describes Cisco PM solutions at the element-management layer.

Cisco Performance Statistics

Generic IP Statistical Data

The standard IP performance statistics for Cisco devices are defined in various Management Information Bases (MIBs), such as RFC 1213, CISCO-ENTITY-MIB, and so on. Table 2 provides a sample of statistics available from Cisco devices in a typical GPRS environment. They are from MIB groups such as if, ip, icmp, and tcp. The data is stored in the NE MIB table; PM applications retrieve the statistics from the Simple Network Management Protocol (SNMP) agent.

Table 2 Generic IP Statistical Data

PM Categories	Statistics Description
Congestion and Resource Utilization	Number of received/outbound packets discarded even though no error in packet (for example, out of buffers)
	Number of times an interface is internally reset
	Number of received/outbound IP datagrams discarded because of lack of buffer space
	Maximum number of seconds that received fragments are held while awaiting reassembly
Errors	Number of received/outbound packets discarded because of errors in packet or unsupported protocol
	Number of times the interface needed to be completely restarted
	Number of IP datagrams that have been discarded (for example, incorrect destination address, invalid protocol field, and so on)
	Number of received Internet Control Message Protocol (ICMP) messages with errors
Throughput	Total number of bytes transmitted/received
	Number of packets in output queue
	Number of packets transmitted/received to higher layers
	Number of IP datagrams delivered to appropriate protocol module
	Total number of received/output ICMP messages

Cisco GGSN-Specific Statistical Data

In addition to IP generic statistics, Cisco GGSNs also provide GPRS operating data to allow PM applications to periodically read throughput and traffic volumetrics.

Tables 3 through 5 describe statistics available from the CISCO-GPRS-GTP-MIB. This MIB is being implemented within Cisco GGSN Release 1.4. A new MIB (and variables) will be introduced with GGSN Release 3.0 and later.

Table 3 GTP Statistics

PM Categories	Statistics Description
Throughput	The current size of the received packet queue on the GSN (for data received from the APN, on the Gi interface)
	The current number of Packet Data Protocol (PDP) contexts established on the GSN
Errors	The total number of GPRS protocol data units (G-PDUs) received from a SGSN for a nonexistent or inactive PDP context since system startup
	Total number of packets dropped because of unknown GPRS Tunneling Protocol (GTP) header since system startup
	The name of the peer GSN whose PDP context is unexpected
Congestion/Resource Utilization	The total number of rejected PDP context activations due to an overload or other abnormal conditions since system startup
	The timeframe within which the number of GTP packets are dropped
	The number of packets dropped by GTP within a certain timeframe
Resource Utilization	The current amount of bandwidth resource used on the GSN
QoS Conformance	The mean throughput for “best-effort” class QoS users on the GSN
	The mean throughput for normal-class QoS users on the GSN
	The mean throughput for premium-class QoS users on the GSN
Path Availability	Name of the last peer GSN that does not reply to echo message

Table 4 APN and IP Address Allocation Statistics

PM Categories	Statistics Description
Resource Utilization	The current number of total allocated IP addresses on the GGSN
	The table for currently allocated number of dynamic addresses associated with a given APN
	Currently allocated number of dynamic addresses associated with a given APN

Table 5 Charging Gateway Statistics

PM Categories	Statistics Description
Resource Utilization	The current number of total charging messages in the queue
	The data volume in packets for uplink traffic from the time the Call Detail Record (CDR) was started until the time it is closed
	The data volume in packets for downlink traffic from the time the CDR was started until the time it is closed

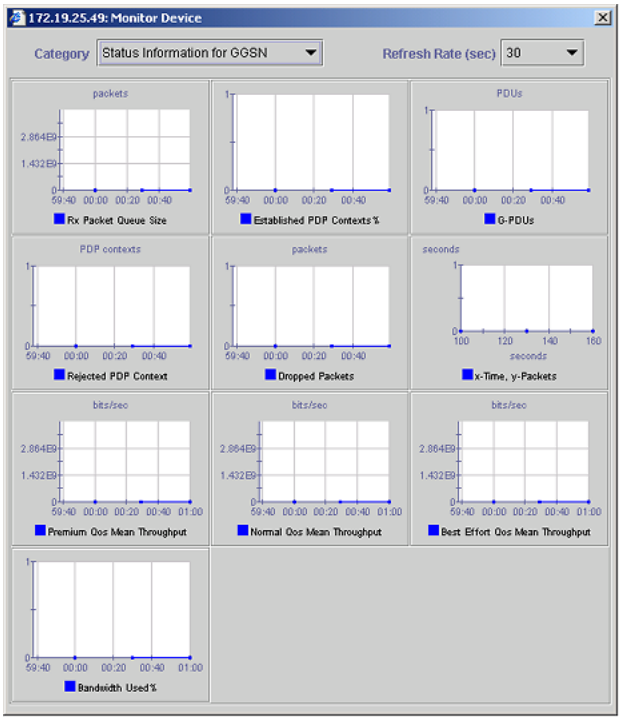
When the Cisco devices make the data available, the following two applications can provide some generic IP PM functionality at the element-management layer, as shown in Figure 2 earlier in the paper. These applications are part of the CiscoWorks2000 Routed WAN Management Solution (RWAN).

Cisco Performance-Monitoring Solutions

CiscoView

CiscoView is a Web-based device-management application that provides dynamic status, monitoring, and configuration information for the broad range of Cisco internetworking products. (See Figure 3.) CiscoView displays a physical view of a device chassis, with color-coding of modules and ports for at-a-glance status. It provides real-time monitoring of key information that relates to device performance, traffic, and usage, with metrics such as utilization percentage, frames transmitted and received, errors, and a variety of other device-specific indicators.

Figure 3 CiscoView



Specific to the GPRS context, CiscoView displays in a graph form the following GGSN performance statistics over a time scale:

- Established PDP contexts (%)
- Rejected PDP context (%)
- Dropped packets
- G-PDU
- Bandwidth used
- Mean throughput
- Charging gateway messages

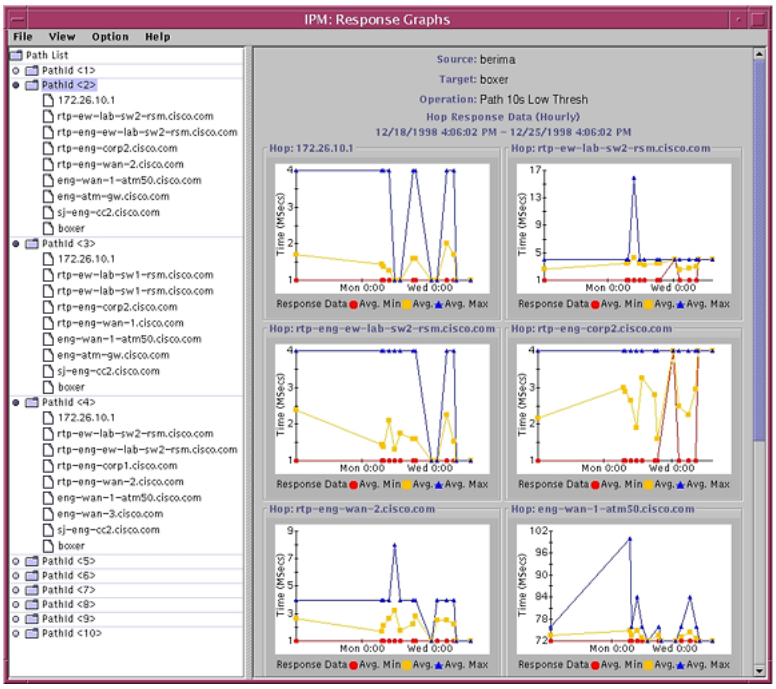
The user has the option to set the frequency at which the statistics are retrieved.

Cisco Internetwork Performance Monitor

Cisco Internetwork Performance Monitor (IPM) is a network response time and availability troubleshooting application. (See Figure 4.) This application empowers network engineers to proactively troubleshoot network-wide performance to diagnose congestion and latency problems utilizing real-time and historical statistics.

With Cisco IPM, network managers have the tool they need to identify performance problems, locate performance bottlenecks, diagnose latency and jitter, and identify performance trends in the network.

Figure 4 Cisco IPM



Cisco IPM enables the network manager to perform path and hop performance analysis, thereby simplifying the identification of network devices that are contributing to network-performance problems. Cisco IPM can determine the possible network paths used between two network devices and display the response time for each of the router hops in each path.

Cisco IPM measures network performance based on the “synthetic traffic generation” technology within the Cisco IOS® Software, which is known as the Service Assurance agent (SA agent). The use of synthetic traffic by Cisco IPM gives the network manager a high degree of flexibility in selecting the endpoints in a network between which network performance will be measured. This flexibility makes Cisco IPM a highly effective performance-troubleshooting tool.

Cisco nGenius Real-Time Monitor

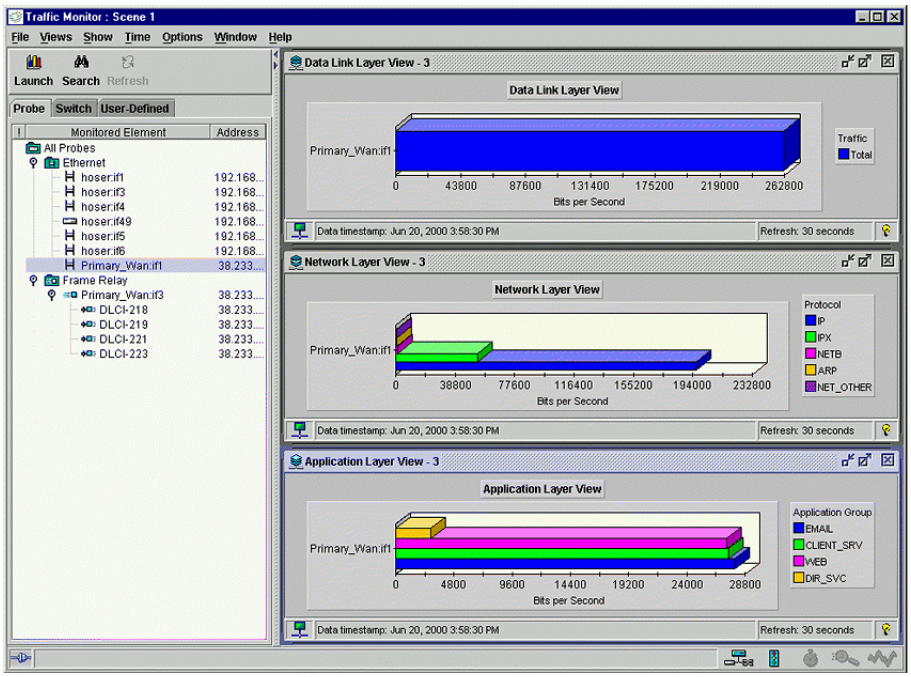
The Cisco nGenius RTM is a new Web-enabled system that delivers multiuser Web access to network-wide, real-time Remote Monitoring (RMON) information for monitoring, troubleshooting, and maintaining network availability. (See Figure 5.)

The RTM Traffic Monitor and Packet Analyzer applications graphically report and analyze

device-, link-, and port-level RMON collected traffic data from the following RMON-enabled devices:

- Catalyst Switches (Catalyst 5000 and 6000)
- Internal network analysis modules
- External Cisco SwitchProbes

Figure 5 Cisco nGenius Real-Time Monitor



The powerful graphic capabilities within this application offer both real-time analysis of traffic behaviors and network usage information, as well as proactive trending data for network planners and managers.

Additional information can be found on the following Web page:
http://www.cisco.com/en/US/products/sw/cscowork/ps2803/index.html

Performance Analysis

The second phase of PM is performance analysis, an analysis of the performance data collected during the performance-monitoring stage. This analysis provides information on whether network congestion is occurring and helps the management system to determine if performance is adequate for existing services and planned new services.

Cisco recommends that wireless SPs take advantage of the breadth of feature-rich PM applications available from Cisco ecosystem partners. The philosophy behind this approach is described below.

Ecosystem Approach

Cisco Systems, Inc. has worked with best-of-breed application vendors and systems integrators to define and deliver integrated solutions that will help wireless SPs speed time to market and revenue for Internet Protocol (IP)-based New World networks and services.

Cisco and its partners are dedicated to defining and delivering solutions and business processes for New World OSSs deployed in the wireless environment. The partnership brings together product and implementation services from alliance partners with best-in-class application software from third-party vendors to complete the integrated, end-to-end OSS offerings. The partners will also offer postimplementation support and testing to help SPs measure the effectiveness of their New World communications infrastructures.

Cisco ecosystem partners have developed performance systems with analysis that includes real-time historical plotting of the following data:

- Inventory
- Resource utilization
- GGSN, link, and path availability
- Throughput, congestion, and errors

ADC Metrica

ADC Metrica is an ecosystem partner that is developing a PM solution specifically for GPRS networks. The solution will monitor, analyze, and control performance management of the radio domain, the GPRS data domain, and the IP cloud.

Metrica/NPR, which is part of the Metrica Service Assurance family of products, consists of a set of equipment interfaces, a database, and reporting modules. Interfaces are available for major equipment suppliers, including facilities for mapping each vendor's counters onto a generic network-wide data model. Other NPR components allow for calculation of daily, weekly, and monthly summary data based on a rich set of analysis functions. Standard reporting modules are provided to allow textual and graphical reporting of raw and summary data. Included are modules for traffic forecasting and an ad hoc point-and-click query interface.

For additional information on the ADC Metrica/NPR solution, refer to the following Web page: http://www.adc-oss.com/products/npr.htm.

Conclusion

This white paper documents how Cisco Systems meets the key requirements of New World wireless SPs for their performance-management needs by providing:

- TMN-based open management architecture
- Relevant performance statistics available from Cisco GPRS devices
- Off-the-shelf CiscoWorks2000 applications to monitor the generic IP performance
- Best-of-breed approach that takes advantage of the Cisco ecosystem philosophy
- PM solution to support GPRS multivendor and multitechnology networks

Most importantly, Cisco wireless operations solutions have been developed and designed based on the unique insights, experience, and technical prowess of the leading practitioner of IP networking. The solutions are integrated with, and complemented by, the industry's most acclaimed infrastructure technology solutions, as well as by a comprehensive portfolio of support services.

Glossary

APN Manager	Cisco Access Point Name Manager
Catalyst 5000	Cisco Catalyst 5000 Switch
CW4MW	CiscoWorks2000 for Mobile Wireless
Datagram	A unit of information that travels from a sender to a receiver using protocols, such as TCP/IP protocol suites
DB	Database
EML	Element-management layer
Gi	Link between the GGSN and the PDN
Gn	Link between the GGSN and the SGSN
GGSN	Gateway GPRS Support Node
GPRS	General Packet Radio Service
ICMP	Internet Control Message Protocol
IP	Internet Protocol
MIB	Management Information Base
MWFM	Cisco Mobile Wireless Fault Manager
NE	Network element
NML	Network management layer
NOC	Network Operations Center
OMC	Operations management console
PDN	Packet data network
PDP	Protocol Data Packet
PDU	Protocol data unit
PM	Performance management
QoS	Quality of service
RFC	Request for Comments
RMON	Remote Monitoring
SLA	Service-level agreement
SML	Service-management layer
SNMP	Simple Network Management Protocol
SP	Service provider
TCP	Transmission Control Protocol
TMN	Telecommunication Management Network
UDP	User Datagram Protocol

Reference

Rayes, A., and K. Sage. “Integrated Management Architecture for IP-Based Networks.” IEEE Communications, April 2000.

For a complete list of Cisco device MIBs, refer to: http://www.cisco.com/public/sw-center/netmgmt/cmtk/mibs.shtml

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