Network Management Solution: Optimize Infrastructure for IPTV Services

Executive Summary

Cable and wireline operators stand to benefit significantly from the emerging IPTV service market. But deploying and managing reliable and profitable services requires diligent planning in order to confront the operational challenges along the way. This paper examines these challenges and outlines a network infrastructure and network management solution that will optimize your IPTV service delivery.

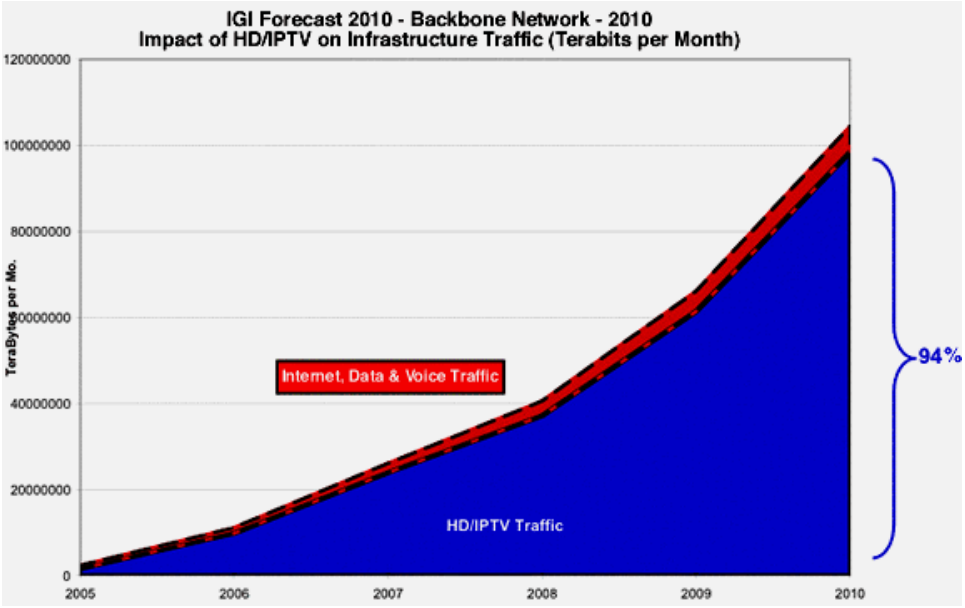
The Cisco Advanced Services assists Service Providers for assessment, planning, implementation and supporting their operations support system (OSS) for next-generation video-over-IP services. Cisco Advanced Services will help ensure that IPTV services can be brought to market quickly and operations staff is ready to manage the services. Also by helping Service Providers to deploy best-in-class network management tools, Cisco will see that you are poised to win customer loyalty through excellent service delivery.

Market Forecast

Today, customers demand the ability to access all types of content across different types of devices and expect a consistent, high-quality experience across all environments. Service providers are striving to deliver a versatile media experience that conforms to customers' lifestyles. However, to achieve this vision, they must transform from traditional providers of access-based services into all-inclusive "experience providers" that can offer voice, video, data, and mobility – or "quad-play" – services anywhere, anytime. At the core of the experience provider transformation is the ability to successfully deliver video entertainment over IP networks.

Figure 1 illustrates the year-by-year demand for network bandwidth, and shows how by 2010, most of the Internet traffic (94 percent) will come from video-related services. Many service providers are investing heavily in carrier-grade Ethernet networks to offer services such as IPTV.

Figure 1. Video Traffic on the Rise



IPTV Services Overview

The following IPTV-related services are commonly offered by service providers:

- Broadcast TV service corresponds to the classic form of television offered by cable, terrestrial broadcasters, and direct broadcast satellite providers, in which the program content is transmitted according to a schedule defined by the content provider and is intended for real-time consumption by the end user. The service therefore provides an essentially continuous stream flowing from the content provider to the terminal device in the consumer network.
- Video on demand (VoD) enables consumers to choose the content they want using an on-screen GUI menu (called an electronic program guide or EPG) and control the sessions with VCR-like functions on the set-top box such as stop, freeze, fast-forward, and rewind. Unlike traditional pay-per-view, the consumer can watch the video at any time. With VoD, the consumer has complete control over the session. VoD has been classified as follows, based on type of user access and level of user interaction:
  - Subscription VoD
  - Free VoD
  - Pay-per-view
- Interactive services include online gaming, T-commerce, etc.

IP NGN Architecture

The Cisco IP Next-Generation Network (IP NGN) architecture provides the ideal platform for delivering IPTV services. This open standards-based architecture combines superior video-to-network linkages, high availability, video-aware intelligence, scalability, and flexibility to accommodate new services as they evolve. A true multiservice convergence platform, the Cisco IP NGN allows carriers to converge entertainment and business-grade services onto a common infrastructure and to deliver a multitude of services to any market, over any IP-based high-speed access technology.

Figure 2. IP NGN Architecture for IPTV Service Delivery

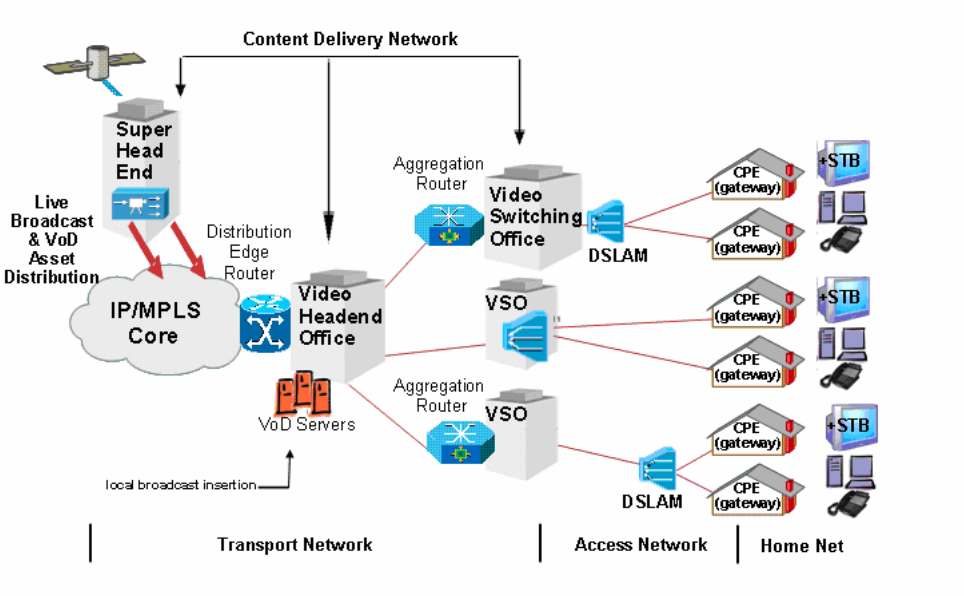


Figure 2 shows the network infrastructure involved in delivering IPTV service to end subscribers. The following sections describe the three primary segments of an IPTV infrastructure:

- Transport network
- Content delivery network
- Access network

Transport Network

The transport network infrastructure consists of high-bandwidth MPLS/IP core and distribution. The Cisco CRS-1 Carrier Routing System platform, which can process packets at terabit speeds, is used as core routers for video services. Cisco 12000 series Router and Cisco 7600 Series Router platforms are more predominantly used as distribution and aggregation routers. (Please refer to http://www.cisco.com/en/US/products/ps6557/products_ios_technology_home.html http://www.cisco.com/en/US/netsol/ns537/networking_solutions_solution_category.html for additional technical details about MPLS IP core/distribution.)

Content Delivery Network

Video Head End

The video headend consists of real-time encoders/decoders for local and national broadcast video channels, VoD libraries for on-demand video services, and video switching equipment for video transport. The real-time encoders take the live feed from a broadcaster in either analog or digital format and convert it to digital stream that is encapsulated in IP packets. The output of the encoder is a digitally compressed stream that is encapsulated in IP headers and sent to a multicast address. Each encoder produces three output streams: standard definition, high definition, and picture-in-picture. The compression method used by the encoder may be either MPEG-2 or MPEG-4, while the IP-based transport encapsulation used is MPEG-2 transport over UDP/IP/RTP. One encoder is required for every channel.

Video on Demand

The VoD servers implement the storage and real-time streaming functionality for on-demand services. These systems provide an intelligent, network-based platform for supporting video ingest, storage, content distribution, personalization, and streaming functions, allowing carriers to deliver customized, interactive, and local content. The solution supports the full range of next-generation video entertainment applications, including:

- VoD
- Near VoD (nVOD)
- Network Digital Video Recorder (nDVR)
- TV time-shifting
- Personalized ad insertion
- Delivery of the Public Access, Education, and Government (PEG) channels

Conditional Access Systems

The conditional access system (CAS) provides encryption and decryption services, as well as key generation and distribution functionality, for both broadcast and on-demand services. The CAS consists of the encryption resource manager, the encryption engine, and the video decryption process in the STB.

The CAS interfaces with middleware when session-based encryption is used for on-demand services. The CAS may also interface to middleware for encryption key distribution between the encryption resource manager and the decryption process on the STB. Finally, the CAS interfaces to VoD servers where pre-encryption is used for on-demand content.

Middleware

Middleware ties a number of logical components together into a more comprehensive IPTV/video software system. Middleware implements the user interface for both broadcast and on-demand services. (Note that there are several different middleware implementations depending upon existing/proposed OSS architecture.)

Billing server

Billing of content services can be either pre-paid or post-paid.

Post-paid: The actual bill amount of the service availed by the user is sent to billing system by the application server.

Pre-paid: On authentication request, a message is sent to the billing server to check the balance and reserve a fixed amount (based on service selected). The service is only provided if the user account has the required balance. When the user avails the service, fully or partially, the actual bill amount is sent to the billing server for deduction in the user's pre-paid balance.

Access Network

The end user access is DSL, Ethernet, or Fiber to the Home (FTTH) for wireline providers and QAM/coaxial for cable operators. (Please refer to http://www.cisco.com/en/US/products/ps6902/products_implementation_design_guide_chapter09186a00806ac3f0.html for additional technical details about access network design.)

Set-Top Box

The set-top box (STB) is the hardware and common software infrastructure component that is used by the on-demand and broadcast clients as well as by the video decryptor and the video decoder. The hardware may also include a hardware-based decoder and decryption subsystem. The STB software typically includes an embedded operating system, and may also include application infrastructure components such as a Web browser.

Network Management Challenges

Service providers face the following challenges when managing IPTV networks today:

- Multiple-vendor video components and Element Management Systems: In addition to network infrastructure, IPTV service requires other components such as video headend equipment, middleware/DNCS, VoD servers, CAS/DRM equipment, ad-splicers, multiplexers, etc. This presents a unique challenge in the collection of fault conditions and performance statistics, correlation of events, and analysis of root cause.
- Monitoring of video quality across different parts of the network: To ensure that subscribers receive acceptable video quality, it is critical to monitor video quality across different points in the network (headend, core, distribution, and access). Otherwise it is very difficult to isolate and fix the type of problems that commonly lead to customer turnover.
- Complex troubleshooting: In the converged network, troubleshooting any video issue involves both Video group and Network group. These are two different groups within the SP organization. Without proper management system in place it will be difficult to coordinate, isolate and troubleshoot the issues.
- Capacity planning and proactive monitoring: Transporting video services over IP infrastructure requires a considerable amount of network bandwidth. So, it is critical to monitor usage to avoid exceeding thresholds, and to plan network expansions in advance. In addition, to mitigate any network outages, the backup path should also have the required capacity to carry the video traffic.
- Provisioning: Provisioning video services requires configuring multiple systems and network devices. If proper procedures are not in place, customer services might not be activated properly, leading to post-installation issues.

Network Management Solutions

Cisco's Network Management solution for IPTV services, described in this paper is based on the TeleManagement Forum eTOM (Enhanced Telecom Operations Map®) [1] model and it addresses the challenges discussed in the previous section. Table 1 shows Cisco and partner products involved in offering IPTV service management solution and Figure 3 shows the integrated architecture of these components. The solution is primarily divided into two categories Service Fulfillment, deals with order to provisioning and configuration management activities, and Service Assurance, deals with fault and performance management aspects of the service.

Table 1. Cisco/Partner Products for IPTV Service Management

	Fulfillment	Assurance
Products	**Cisco Products** Cisco BAC (CPE Provisioning) **Cisco OEM** Cisco Network Compliance Manager (Configuration Management)	**Cisco Products** Cisco ANA Cisco Multicast Manager (CMM) SA ROSA NMS Cisco CDSM (VoD Server Management) VQE IPSLA **Cisco OEM** Cisco Info Center **Partner Products** Ineoquest (Video Probes) Infovista CA e-health

Figure 3. NMS/OSS Reference Architecture for IPTV Service Management

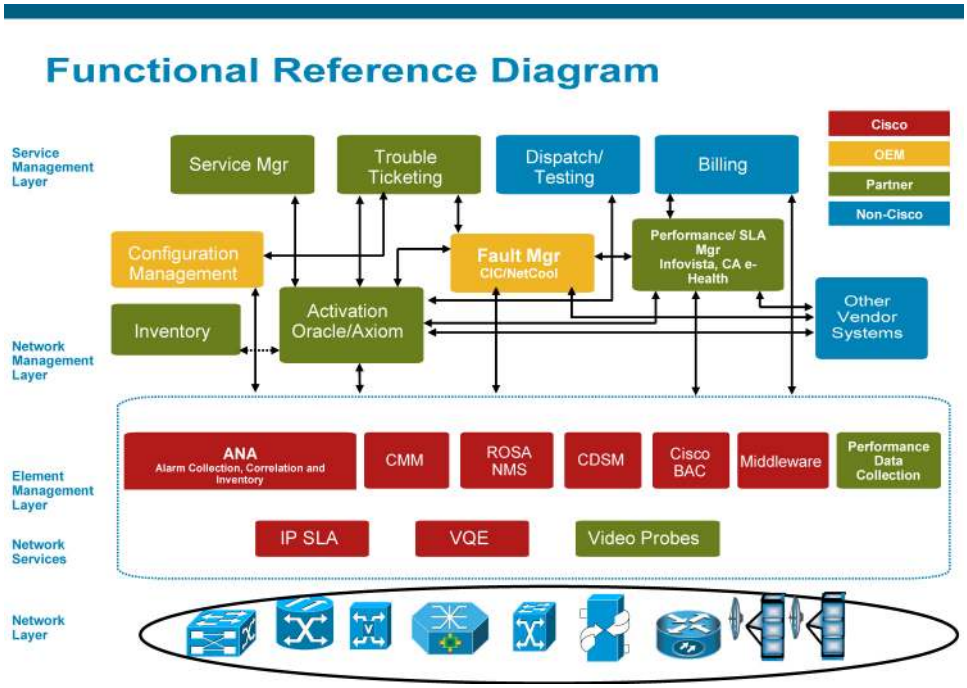


Figure 3 shows how different products indicated in Table 1 fits the over all service provider network management architecture. When these products are integrated with service providers' existing service level management systems a complete end to end IPTV management solution is available. Cisco offers these integration/consulting services through Advance Services group. Service Model and strategy is provided in "Cisco Advance Services Lifecycle delivery and support" section. Detailed description about these components, processes and models are provided in the following sections.

Fulfillment

The Service Fulfillment or Provisioning process is responsible for activating customer services on time and ensure that these services are activated properly. It translates the customer's needs into a solution delivered through specific products and services. This process informs customers about the status of their purchase order and ensures completion on time and customer satisfaction.

Service Activation

The service activation system is responsible for activating and configuring the service requested by customers. It should have the capability to receive the parameters required for activation either through a user interface or north bound interface from an order management system or CRM system.

The functionalities of a service activation system are:

- The system should provide a flexible user interface for configuring the service activation flows and rules for IPTV related services. It should be possible to handle error conditions and perform the defined roll back process in the event of an exception.
- Configuration on a device should be customizable as per the IPTV service requirements. It should be possible to associate these configurations to specific devices with specific firmware versions. These configurations should be field customizable.
- The system should maintain configuration state for all the services that have been configured. This configuration information has to be shared with order management and resource management systems based on system design requirements.
- An activation system should have the capability to integrate with the following systems for configuring IPTV services:
  - Element management systems - DSLAM EMS's.
  - Subscriber management (Middleware).
  - CPE provisioning system (Cisco BAC, CNR/DHCP).
  - Identity and access control (AAA servers).
  - Billing system for service enablement

Configuration Management

CiscoWorks Network Compliance Manager (NCM) [2] tracks and regulates configuration and software changes throughout a multi-vendor network infrastructure. It provides superior visibility into network changes and can track compliance with a broad variety of regulatory, IT, corporate governance, and technology requirements. CiscoWorks NCM helps IT staff identify and correct trends that could lead to problems such as network instability and service interruption.

CiscoWorks NCM key functionalities are:

- Discover the network devices that have to be managed. If the device physical inventory is available through a resource management system, the configuration management system should be able to integrate with resource management system for device inventory information.
- Track all changes to the network configuration and maintain configuration versions of all devices within the management scope.
- Provide facility to upgrade firmware on selected devices at predetermined configurable times.
- Provide approval flows for any network configuration changes.
- Provide varying access levels to multiple user groups. CiscoWorks NCM can integrate with external AAA systems for user authentication.
- Communicate with devices using different protocols like Telnet, SSH, SNMP, etc.

- Enable the creation of configuration templates using parameters, with the flexibility to download these templates to multiple devices.
- Provide standard APIs for other OSS systems integration.

CiscoWorks NCM is a versatile configuration management software application that is used by number of service providers and enterprise customers. This application is known for its scalability, high availability, and distributed deployment.

Service Assurance

Service assurance is the process responsible for execution of proactive and reactive maintenance activities to ensure that services provided to customers are continuously available and performing to service-level agreement (SLA) and quality of service (QoS) levels. These systems perform continuous monitoring of resource status to proactively detect possible failures. This process manages SLAs and provides performance reports to customers.

Fault Management

Fault Management allows the service providers to monitor for fault alarm conditions on various portions of the network/system, correlate and de-duplicate the alarms, perform service level correlation and perform troubleshooting and diagnostics procedure to fix the condition.

Device Instrumentation

All Cisco IOS® and IOS-XR Software-based routing platforms have elaborate SNMP and Syslog implementations to provide the necessary information for proactive and reactive monitoring. In addition, Cisco IOS Software includes the following integrated functionality:

- Cisco IOS IP SLAs use active traffic monitoring – the generation of traffic in a continuous, reliable, and predictable manner – for measuring network performance. Cisco IP SLAs sends data across the network to measure performance between multiple network locations or across multiple network paths. The information collected includes data about response time, one-way latency, jitter (interpacket delay variance), packet loss, voice quality scoring, network resource availability, application performance, and server response time. Using Cisco IP SLA service providers can measure and provide service level agreements.
- Cisco IOS NetFlow efficiently provides a key set of services for IP applications, including network traffic accounting, usage-based network billing, network planning, security, denial-of-service (DoS) monitoring capabilities, and network monitoring. NetFlow provides valuable information about network users and applications, peak usage times, and traffic routing.
- MPLS and Ethernet OAM functionalities

SA ROSA NMS

ROSA Network Management System (Copernicus) [3] provides the necessary Element Management functionality to manage the IPTV headend infrastructure. ROSA NMS is capable of monitoring the following IPTV infrastructure components:

- HFC networks
- DVB-T networks
- Digital CATV headends
- DTV distribution networks

- Analog CATV headends
- Distribution backbones
- Broadcast contribution applications
- Telco headends

It collects the fault conditions from the headend components and performs the necessary correlation to determine the root cause. Appropriate severity levels are also associated with these fault conditions. This system has the capability to forward these alarms as SNMP traps to a northbound OSS application. This functionality is used to integrate SA ROSA with Manager of Managers.

VoD Monitoring

The Cisco Content Delivery System Manager (CDSM) actively monitors the Cisco Content Delivery System (CDS) VoD environment for system, array, and server fault conditions. The Cisco CDSM collects stream traffic and content statistics and data from each server in the Cisco CDS and presents the data in reports on streams, bandwidth usage for each service group, content popularity, and vault content. In addition, it enables the configuration of SNMP trap destinations on the vault and streamer servers. The Cisco CDS has a well defined SNMP MIB for fault notifications.

Video Quality Monitoring

The Video Quality Monitoring Solution is a combination of Cisco Multicast Manager [4] and third-party video probes that support Media Delivery Index (MDI) measurement. In an IPTV service environment, monitoring of the video multicast flows across the different portions of the network (headend, core, distribution, and access) has been challenging. Some reasons include:

- Stringent IPTV service requirements on packet loss and jitter
- Multiple services running on the same infrastructure, making it hard to isolate IPTV-specific issues
- Number of subscribers affected due to degradation of video quality in a particular segment of the network
- High mean time to repair (MTTR) requirements for delivering good video quality

The Video Quality Monitoring Solution is a first step from Cisco to address the management challenges in an IPTV environment. In order to achieve the functionalities specified below, it uses Cisco Multicast Manager and external video probes. Currently, the solution supports only video probes from Ineoquest.

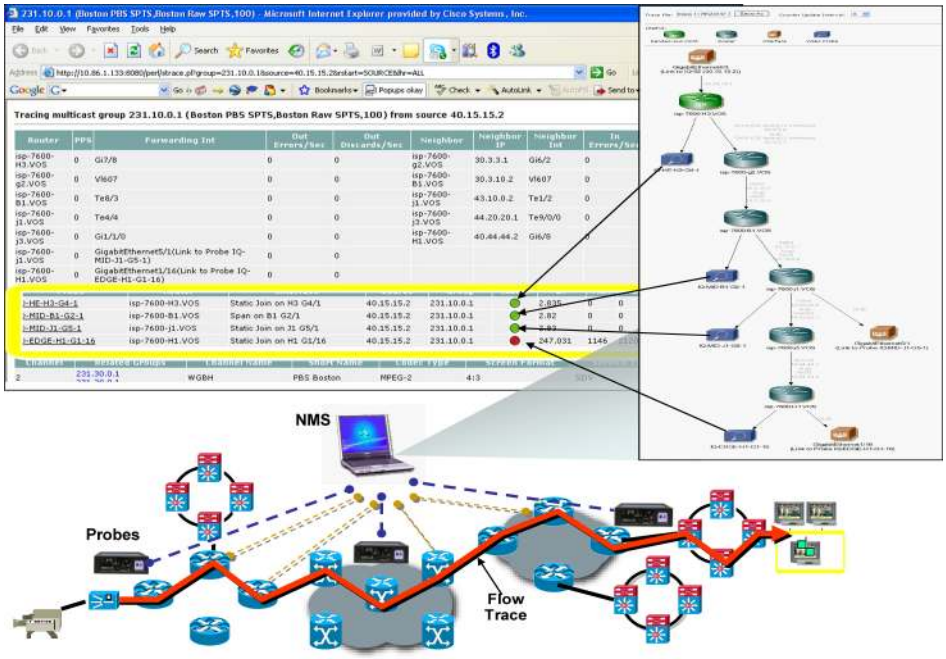
The current phase of this solution addresses the following:

- Monitoring of multicast flows across the network using Cisco Multicast Manager
- Monitoring of video quality for all the flows using external probes that support RFC 4445 (MDI)
- Integrating Cisco Multicast Manager and external probes to provide a unified view of the video performance
- Associating quality metrics with the multicast flows
- Correlating the video channel, multiplexers, and ad-zone with a specific multicast flow

- Identifying the end-to-end multicast flow relationships as they pertain to a channel or set of channels sourced by a multiplexer
- Providing granular view control based on user-defined geopolitical boundaries such as advertising zones

The Video Quality Monitoring solution is based on Media Delivery Index (MDI), which is a combination of Delay Factor and Media Loss Rate. MPEG video transport streams undergo time distortions known as jitter and are subject to packet loss when being transported by packet switched networks. Identifying and measuring jitter and packet loss in such networks is critical to maintaining high-quality video delivery. This solution interfaces with video probes which support MDI characteristics to collect the video performance across different points in the network and correlates with the Multicast network to identify the problem domain.

Figure 4. Cisco Video Quality Monitoring Solution



The integrated Video Quality Monitoring Solution is currently deployed at 3 large service provider environment and this solution has dramatically improved video issue isolation from days to minutes. In addition, this solution is being tested in a number of Tier 1/Tier 2 service provider labs.

Cisco Info Center

Cisco Info Center [5] is a fault Manager-of-Managers that provides a consolidated view of enterprise-wide events and status information. It collects event streams or messages from many different data sources and presents a single, consistent view of the current state of all Cisco Info Center managed systems. It distributes the event information to the operators and administrators responsible for monitoring service levels. A graphical display lists events in chronological order, and network operators can customize the views.

Cisco Info Center has the following key components:

- Info Server: The Info Server is a high-speed, in-memory database, optimized for collecting events and designing filters and views. It provides the core event-processing functions for the Cisco Info Center suite.
- Mediators: Cisco Info Center Mediators are lightweight agents that collect fault and availability information from APIs, databases, devices, log files, and other utilities, and push them into the Info Server for filtering and viewing.
- Impact Analysis: The Impact Analysis module performs the necessary correlation and root cause analysis to determine the service impact for the events received from network devices and application components. This is critical in an IPTV scenario because any outage can affect a large number of subscribers.

Cisco Info Center is deployed in many large service provider networks today.

Performance Management

Performance management is the practice of optimizing network service response time. It also entails managing the consistency and quality of individual and overall network services. The most important service is the need to measure the user/application response time. For most users, response time is the critical performance success factor. This variable will shape the perception of network success by both your users and application administrators. Table 2 lists key performance indicators (KPIs) for IPTV service.

Table 2. Key Performance Indicators for IPTV Service Management

KPI	KPI	Description	Measurement Methodology
IPTV Service KPI	Channel change time	The amount of time it takes for a subscriber to leave one channel and receive the video for a new channel	Video probes
	QoE	Quality of experience measured through Media Delivery Index (MDI)	Video probes
	Packet loss	Number of MPEG frames lost	Video probes
	Jitter	Delay variation	Video probes
	Latency	Time taken by the transport network to deliver the video packets to the end STB	STB/video client probes
Device KPIs	CPU	Device CPU	Device instrumentation
	Memory	Device memory	Device instrumentation
	Buffer utilization	Device buffer utilization	Device instrumentation
Network KPIs	CIR utilization	Customer utilization relative to CIR	Device instrumentation
	Queue drops	Queue drops due to congestion	Device instrumentation
	Dropped frames	Submitted to delivered. Also, [[spell out]] EBR/EBS	Device instrumentation

Several performance management systems such as InfoVista and CA eHealth provide applications that support theses KPIs.

InfoVista

InfoVista [6] provides a suite of products for service-centric performance management on complex IP networks. The InfoVista performance architecture can be divided into three layers:

- Collection layer: The InfoVista servers collect the performance statistics from network elements on a periodic basis. The polling interval is configurable depending on the customer requirements. The InfoVista servers collect the performance statistics using

SNMP MIBS. The collected values are passed to an analysis layer for threshold comparison The collection layer has different service modules:

- IP SLA to collect values from Cisco IOS IP SLA probes
- Metro Ethernet to collect Carrier Ethernet-specific performance metrics including QoS
- Server monitoring to monitor various IPTV-specific middleware and VoD servers

- Analysis layer: The analysis layer performs the correlation functionality by comparing the thresholds, interacting with the fault management system to notify the network operations center (NOC) of any threshold violations, and integrating with service inventory systems such as Cisco IP Solution Center to perform service-level correlation.
- Reporting layer: The reporting layer provides the NOC operators with comprehensive reports about network and service performance. The reports are customizable and configurable in the InfoVista system.

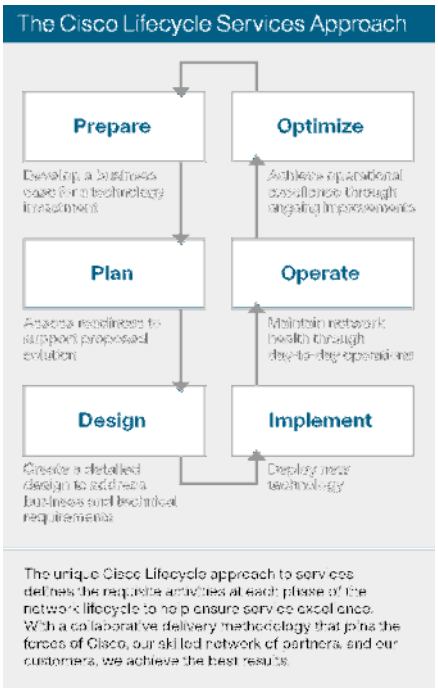
CA e-Health

The eHealth [7] E2E Console is the foundation component of CA's eHealth solution, which simplifies network performance management of today's complex network and system infrastructures. It collects and analyzes data from all areas of your business infrastructure and delivers sophisticated performance reporting and predictive analysis. The eHealth E2E Console integrates real-time performance management within the context of historical performance so that you can quickly identify, detect, and correct performance degradation before end-user service quality is jeopardized. CA's eHealth offers:

- End-to-end performance management
- Capacity planning
- Extensive reporting

CA eHealth also supports Cisco IOS IP SLA, NetFlow, and VoIP technologies.

Cisco Advanced Services Lifecycle Approach to Delivery



Cisco Advanced Services uses a structured lifecycle approach to support you from the planning through the optimization phase of your IPTV service network.

The Cisco Lifecycle Services approach defines the minimum set of activities needed to help customers successfully deploy and operate Cisco technologies and optimize their performance. Figure 2 shows a global operations support system/network management system (OSS/NMS) solution deployment model that has been succfully used by Cisco Advanced services for deployment at many service providers.

The Cisco Lifecycle Services approach includes the following phases: Prepare, Plan, Design, Implement, Operate, and Optimize (PPDIOO). These phases provide a blueprint for the customer network management architecture. The following sections briefly describe each phase.

Prepare, Plan

During this phase Cisco works with you to understand the business, technical, operational impact of your OSS and drill down into a more detailed understanding of your OSS/NMS solution. During this phase, OSS Readiness analysis is performed to understand the Current State Architecture (CSA), prepare Gap Analysis, and provide Future State Architecture (FSA).

Design

In this phase Cisco enters the detailed design process of the project. This phase encompass design of all technical aspects of the solution as well as the development of any operational processes. The activities in this phase encompass preparation of low-level design documents, test plans, and design workshop.

Implement

In this phase the OSS solution is deployed into a staging and/or the production environment and tested. Any system integration activities that have been identified and specified in the previous phases are also developed and tested in this phase. The phase marks the end of the solution implementation with the customer accepting the solution at the end of this phase.

Operate

In this phase Cisco can assist with the day-to-day operation of your OSS and work with you in the areas of troubleshooting, technical support, and operational consultancy.

Optimize

In the final phase Cisco will work with you to optimize the OSS solution in your environment. This can involve process review and streamlining, technology refinement, and systems optimization.

Benefits

Cisco Services for implementing your IPTV management solution will help you identify and address crucial technical and business issues before you expend time and resources creating a solution. Cisco Services help you to:

- Mitigate potential risks by analyzing the ability of the existing OSS infrastructure to monitor video services and identifying and deploying necessary upgrades early in the process
- Deliver quality services by making sure the design addresses IPTV management issues such as video quality monitoring, fault isolation, and troubleshooting
- Lower operating costs and improve staff productivity by increasing the knowledge base of your operations staff to support the Cisco IPTV solution

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