CHAPTER 1

CHANGES, OPPORTUNITIES, AND CHALLENGES

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1.1 INTRODUCTION

Never have telecommunications operations and network management been so important. Never has it been more important to move away from practices that date back to the very beginning of the telecommunications industry. Building and connecting systems internally at low cost, on an as-needed basis, and adding software for supporting new networks and services without an overall architectural design will not be cost effective for the future. Defining operations and network management requirements at the 11th hour for new technologies, networks, and services deployments must also change. Planning and deployment of all aspects of telecommunications leading to Next Generation Networks (NGN) and services must be done in unison to achieve effective and timely results.

The need for new approaches can be seen everywhere in the global telecommunications industry. Competition in telecommunications can turn players into victims if functional and cost-effective operations and network management requirements are not deployed quickly. Technology advancements in this field have been enormous. Operations and network management technologies make new approaches a reality in designing NGN services.

The point of departure for architected network management systems will be NGN and services. Points of departure can't be expected to initially play out with incrementally lowest cost. There can be initial added costs, but the operations and network management setting put in place will make the next network and service less costly, with more rapid implementation than would otherwise have been the case. Telecommunications network and service providers will find themselves on a fully competitive playing field.

Next Generation Telecommunications Networks, Services, and Management, Edited by Thomas Plevyak and Veli Sahin

1.2 SCOPE

This book discusses NGN architectures, technologies, and services introduced in the last decade, such as Triple Play / IPTV [1] and services that are expected to become increasingly deployed in the coming decade such as Time Shift TV (TSTV), network Private Video Recording (nPVR), multi-screen video services, triple-shift services, location- and presence-based services, blended and converged services, etc.

In addition, this book also focuses on the Service Management Layer (SML) of the Telecommunications Management Network (TMN) [2]. In the past 30-plus years, the global industry spent considerable time and resources developing Element Management Systems (EMSs), Network Management Systems (NMSs), and Business Management Systems (BMSs). Changes in life style (expectations, viewing habits, calling habits, shopping habits, etc.), technologies, and the competitive business environment are now moving the industry to pay attention to Service Management Systems (SMSs).

Internet access, cellphones, laptops, and DVRs are integral to our lives today. How many of us can live a day without them? Daily personal and business lives are completely dependent on telecommunications services. End-to-end management of those services and Quality-of-Service (QoS) management and identification and management of Quality-of-Experience (QoE) metrics are very important to improve standards of living and increase productivity. Examples of QoE are quality-of-picture, channel switching time, easy use of user interface/programming guide, request response time, etc.

This is the seventh book in the IEEE Network Management Series. It follows the same approach as the first book in the series, *Telecommunications Network Management into the 21st Century,* published in 1994 [2], and the second, *Telecommunications Network Management Technologies and Implementations*, published in 1998 [3]. It is an orchestrated set of original chapters, written expressly for the book by a team of global subject experts. This is a technical reference book and graduate textbook.

1.3 CHANGES, OPPORTUNITIES, AND CHALLENGES

This section briefly discusses major changes and how service providers (SPs) and SMS vendors use this as an opportunity to develop solutions that address expectations of their customers. SPs work to offer new services such as IPTV, multi-screen, triple-shift, blended and converged services, etc. Vendors and SPs work to provide new SMS applications to manage those new services.

Today's users want to communicate, watch, shop and make payments, etc. anytime, anywhere, and with any device. This is a major paradigm shift and has major impact in designing NGNs and services as well as management systems.

1.3.1 Major Life Style Changes: Desktops, Laptops, and Now Handtops

We all know how personal computers (PCs) have changed our lives during the last two decades. First, we started with desktop PCs and then started using more and

more laptop PCs, especially in last 10 years or so. Laptops allow us to carry our PC with us anywhere we go and use it. With wireless and mobile Internet access, users access the Internet anywhere and anytime. We can send and receive e-mails and exchange files at any time, from anywhere. Voice applications allow us to call and talk with anyone in the world who has a PC or a phone. PC-to-PC calls are free and PC-to-phone calls cost less than traditional calls.

Many of our traditional daily habits have been changing too—watching, calling, shopping, making payments, and many more. These changes affect the way we do business in many industries.

It wasn't so long ago that we watched a movie, a video, or a program just using the TV and made phone calls using only wireline phones. Today, we also use PCs to watch programs and wireless phones to make a great many of our phone calls. In more and more families and businesses, wireline phones are used for special cases (conference calls, interviews, other business calls, etc.). Increasingly, people do not have wireline phones. They use their cell phones. They watch TV programs using their laptops and/or "handtops." Handtops are mini personal computers such as iPhones and BlackBerry phones. Even though we refer to them as phones, they are small laptops, used to access the Internet, send/receive e-mails, make phone calls, etc. Millions use the Internet to shop, pay their bills online and manage their bank accounts. As a result, security management (SM) has risen to become a first priority concern.

In the future, user-generated content (UGC) will play a major role in designing NGNs, service, and management systems.

1.3.2 Major Network Infrastructure Changes

The first major network infrastructure change was to shift from time-division multiplexing (TDM) to statistical multiplexing. NGNs are now based on packet switching technologies rather than TDM. Internet Protocol (IP) became the winner. Today, NGNs are becoming IP-based packet-switched networks, end-to-end, including backbone, metro, and access networks. This is important because it caused a paradigm shift in Fault, Configuration, Accounting, Performance, and Security (FCAPS) operations and network management applications and in SP concerns, which we will discuss later in this section.

The second major change is the use of more and more wireless and mobile technologies in NGNs. Billions of cellphones are in use worldwide, and the number will continue to grow. The concept of telecommunicating (via phone or e-mail) and Internet access at any time and any place has become a reality.

The third major change is just starting and will be rapidly taking place in the next few years. This change is IP Multimedia Subsystems (IMS)-based signaling and control to replace traditional signaling systems. IMS will provide an end-to-end platform to offer most new services and, therefore, will eliminate current silos. With IMS signaling and control, many advanced location- and presence-based services will become a cost-effective reality. IMS is also expected to solve the problem of rapid introduction of new services at less cost. Details of IMS can be found in Chapter 5.

Finally, development and deployment of Service Delivery Platforms (SDPs) with open Application Programming Interfaces (APIs) for third-party application

development will have major affects in introducing next-generation advanced services quickly and in more cost effective ways.

1.3.3 Major Home Network (HN) Changes

Residential customer premises networks, also called Home Networks (HNs), are now becoming extensions of SPs' networks.

Home connectivity is evolving from narrowband to broadband. SPs have deployed the technology needed to offer larger bandwidth with cable, xDSL, or fiber technologies. The Internet has been a major driver for evolution to broadband, creating a new experience for customers and offering new services, such as fast Internet browsing, video-on-demand (VoD), online shopping and banking, and digital video recording (DVR), while providing broadband connectivity among many devices at home such as PCs, TVs, Set Top Box (STBs), DVRs, residential gateways (RGs) / home gateways (HGs), game consoles, etc.

The main drivers for home networking that exist today are as follows:

1. As media become increasingly digital in nature (online music and video, digital photos etc.), consumers want to share content and listen to or display it on other, more consumer-friendly devices such as TVs, etc. This requires customers to connect their digital content storage devices (e.g., PCs, MP3 players, private video recorders (PVRs), and digital cameras/camcorders) to their entertainment systems over a home network.
2. More and more customers want to use digital voice and video. This is due mainly to the attractive price using triple play services. These new voice and video services should be capable of being received on a range of mobile consumer devices (laptops, mobile phones, etc.).
3. Devices such as laptops that are WiFi-enabled are encouraging consumers to access the Internet, work, and/or watch videos wherever it is convenient in the home.

Management and control of home networks have become a strategic challenge for SPs all over the world. Problems in home networks affect QoS and customers' experiences. Therefore, all SPs have been developing strategies to provide RGs / HGs as part of their triple play services.

1.3.4 Major FCAPS Changes

As stated previously, FCAPS stands for Fault Management (FM), Configuration Management (CM), Accounting Management (AM), Performance Management (PM) and Security Management (SM). Readers who are not familiar with basic FCAPS functions should read the FCAPS sections in [2] or brief further details in Chapter 4.

In the past, when networks were based on circuit switching, FM was a first-priority application, followed by CM, AM, PM, and SM. PM and SM functions were considered to have least priority in circuit switched/TDM networks. FCAPS has

been used for a long time, perhaps implying order of importance. Technically speaking, for packet-based networks, PM applications are now more important than FM. We are going through a transition period. When subscribers start using delay- and quality-sensitive services such as voice over IP (VoIP), IPTV, and VoD, SPs will pay more attention to PM-based applications.

QoS can suffer even if there is no failure in the network due to congestion and/or over-utilized resources such as Central Processor Units (CPUs), buffers, bandwidth, etc., in packet-based networks. Congestion and over-utilization of resources will result in delays, packet loss, and jitter, which greatly affect QoS and customers' experience, such as snowy screen, unsynchronized voice and picture, longer time to receive a requested video, etc. All of these impairments can be detected and corrected in advance by using PM and SM systems using trend analysis, data correlation, and SLA management (proactive management).

We might want to rethink FCAPS priorities. Security Management is, now, arguably the highest priority. The amount of confidential data that is transmitted, collected, and stored is very large and must be protected. SM needs to take its place as the number one concern followed by PM as opposed to FM and, in turn CM. The order now is probably SPxxx, not FCAPS.

1.3.5 Major Regulatory Changes

In this book, we will not discuss regulatory/legal changes even though they greatly affect the types of services offered (e.g., network- vs. home-based video recording), security, copyright, wireless spectrum allocation, content distribution and usage, etc.

1.3.6 Service Aware Networks to Manage Expectations and Experiences

NGNs and Management Systems (MSs) must be aware of traffic generated by each service as well as which subscriber generated that traffic. In some cases, this is done to manage customers' expectations and legally satisfy their Service Layer Agreement (SLA). NGNs must treat traffic generated by each service separately while transporting them through the networks. Networks must have the ability to use different priorities and policies for traffic generated by different services such as VoIP, Video, e-mail, file transfer, etc. Furthermore, they must also assign different priorities for traffic generated by the same service depending on who owns the traffic. Traffic belonging to a residential VoIP service does not have the same priority as VoIP traffic from a large business customer who pays more and signs an SLA.

Networks and SMS must also have the ability to handle special cases, e.g., during national disasters (earthquake, war, terrorist attacks, etc.). Some services will get higher priority than all other services based on predefined policies and rules. Examples of these services are Government Emergency Telecommunications Services (GETS) in the USA. Note that GETS and 911 calls have higher priority than many other services even during normal circumstances.

Figure 1-1 is an NGN example, capable of offering triple play services such as voice (VoIP), video (IPTV, interactive gaming, video conference, distance

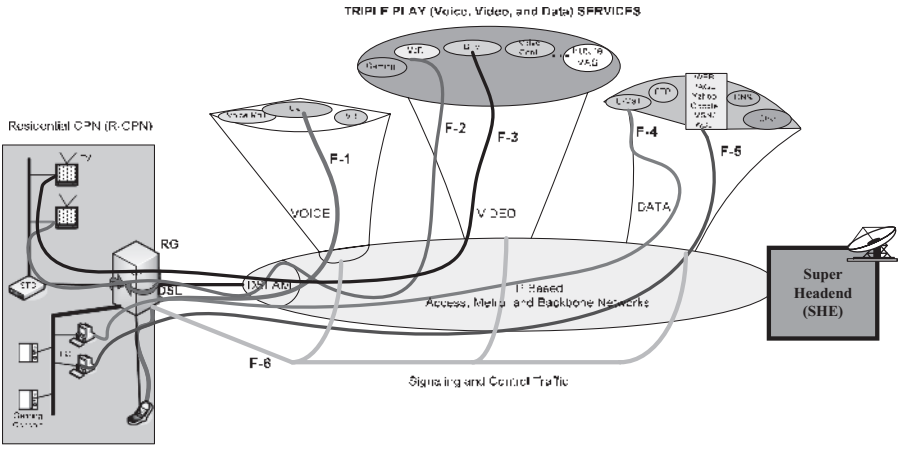

Figure 1-1. Example of triple play services and flows in Service Aware Networks

learning, etc.), and data (e-mail, File Transfer, Web page, DNS, chat, etc.). The architecture shows an example of metro and backbone networks common for most of the SPs. The biggest difference may exist in the last mile and access networks. A customer can have one, two, or all three services.

For example, the residential customer shown in Figure 1-1 uses ADSL in the loop and has VoIP, video, and high-speed internet access (HSIA) services. Traffic (or flow) for each service shares the limited bandwidth in the loop. In Figure 1-1, the residential customer generates six different flows using all three services at the same time. These are:

1. VoIP flow (F1)
2. VoD flow (F2)
3. IPTV flow (F3), also called broadcast TV flow (BTV)
4. E-mail flow (F4)
5. Web page flow (F5), and
6. Signaling and control flow (F6)

Also shown in Figure 1-1, triple play services will have shared resources such as the access, backbone, and parts of the Customer Premise Network (CPN). This will depend on each SP's network architecture. Customers have different expectations for each service. They can tolerate some delay for their data services but not for VoIP. VoIP is a real-time application, very sensitive to delay. It is important that SPs consider accumulated effects of impairments on the network to increase customer's satisfaction. For example, QoS requirements vary with each service. Voice services are stringent on latency and jitter, whereas data services are not. So each service has its own characteristics and it is not appropriate to treat them as the same. SPs must correlate and aggregate their customer's experiences across all services. Each service may be managed by different management systems but there is a need to manage a customer's expectation from one centralized place. This common

system could be a Service Management System (SMS) interworking with other management systems, especially PM systems/applications. When video and VoIP services are widely deployed, there is an important need for information exchange and sharing among SPs. This area might be an important application for the SMS.

Customers/subscribers and SPs have related, but different, experiences for the same event. For example, let's assume that for the F1 VoIP call, the customer is having a bad quality call, hearing clicks, echo, low volume, etc. Customers do not care why the call quality is not good, but SPs do. It is the responsibility of an SP to find out:

1. Where is the problem? Is it in the CPN or the SP's network?
2. If the problem is in the SP's network, where is it? Is it in the access network, backbone network, media gateways, or servers?
3. Why does this call have bad quality? Is it because of delay, packet loss, jitter, error, over-utilized resources, etc?

Therefore, SMS vendors need to know customers' and SPs' expectations as well as experiences so their solution can solve the problems. Problems get more difficult when traffic flows across multiple SP networks.

1.4 MAJOR MANAGEMENT CHALLENGES FOR A VALUE-ADDED SERVICE: TRIPLE SHIFT SERVICE

As illustrated in Figure 1-2, a triple shift service means that customers can access and control (pause, play, rewind, fast forward, etc.) service contents at anytime (time shift), at any place (place shift), and using any device (device shift). In other words, customers do not have time, place, and device limitations to access, control, and replay any content. Accessing the information, regardless of time, place and device has already been happening. Our e-mails and voice mails (messages) follow us no matter where we go.

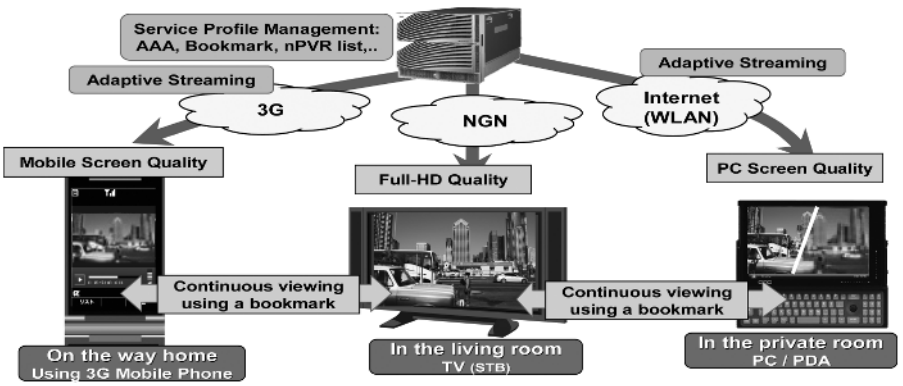

Figure 1-2. A triple (time, place, and device) shift service architecture

As an example, a subscriber starts watching a program on her mobile phone while in a taxi going to the airport. She pushes a button just before boarding the airplane and asks the system to record the program so it can be watched later. After a few hours of flight and while driving home, the system can be asked to start the program at the point where it was stopped. On arriving home, the program can be watched on HDTV.

Since several hours passed between stopping program and the replay, it is a time shift service. It is also a place shift service because the subscriber started watching in one place and finished watching in another place or places. Finally, it is also a device shift service because the program watching started on a mobile phone and ended on HDTV.

The triple shift service we just described creates many challenges for an SP. Let's briefly describe a few major tasks an SP must accomplish in order to provide triple shift services:

- The SP must check to see that the customer is authorized to use the requested services by BML applications.
- The SP checks to see that they can legally record the content and store it in their network by BML applications.
- When the customer requests a replay, the SP must make sure that content is suitable for the device that is being used. Each device requires different encoding because of size of screen, resolution requirements, type of service required (e.g., if it is TV then is it HD or SD?), available bandwidth, etc., by SML applications.
- Streaming and content distribution based on device, QoS, and SLA requirements by SML applications.
- While a customer is watching a program, SMSs must monitor the service to make sure SLA requirements are not violated.
- End-to-end PM functions at SML and NML monitor the whole network for impairments (packet loss, congestion, jitter, buffer overflow, etc.) so the SP can detect problems in advance and correct them before they affect QoS and QoE metrics [proactive management]).

1.5 THE GRAND CHALLENGE: SYSTEM INTEGRATION AND INTEROPERABILITY OF DISJOINED ISLANDS

Since divestures (1984 in the United States), large SP networks all over the world became collections of islands, such as shown in Figure 1-3:

- Merger and acquisition (M&A) islands (island of formerly different companies)
- Technology islands
- Cultural islands
- Regulatory islands

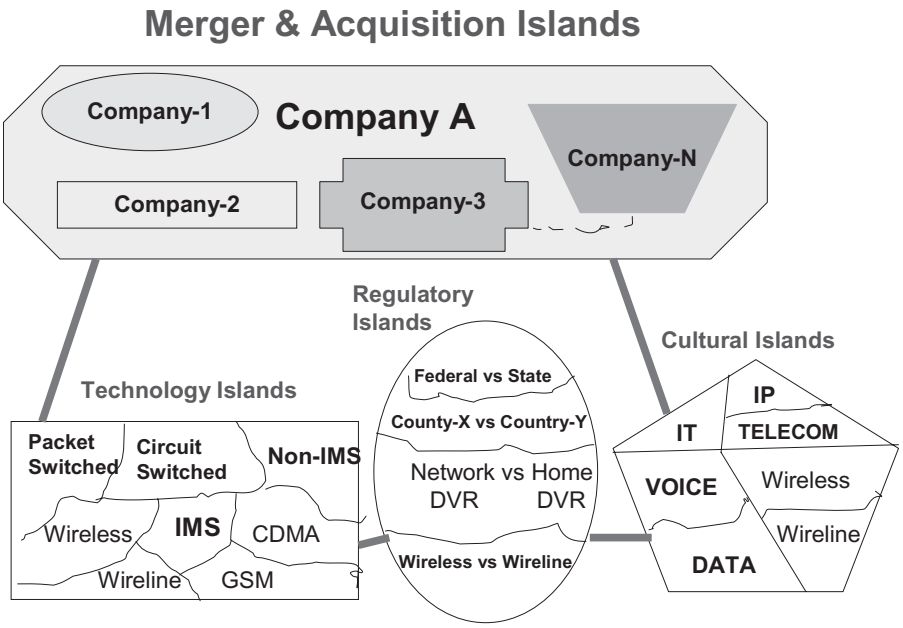

Figure 1-3. System integration and interoperability of disjoined islands

The grand challenge for SPs is to have end-to-end views and end-to-end management of services. With respect to networks and services management, SPs' networks may consist of disconnected islands.

Some of today's largest SPs, and even some smaller SPs, are the result of M&As.

For each case of an M&A, the former companies had their own networks, management systems, organizations, and cultures. They may also be using different architectures, technologies, standards, and products from many different equipment vendors.

The second important class of islands is the technology island, such as:

- Circuit switched networks and packet switched networks
- ATM networks and non-ATM networks
- CDMA networks and GMS networks
- Wireless and wireline networks
- IMS and non-IMS networks, etc.

Third, and perhaps the most important class of islands, is culture. In our professional backgrounds (e.g., Telecom, IT, IP, voice, data, etc.), we worked in different cultures. M&As can fail due to cultural differences.

These islands must be connected and/or interwork with each other in order to provide end-to-end services, meet QoS requirements, and satisfy customers' expectations and experiences.

1.6 SOME EXAMPLES OF MANAGEMENT SYSTEM APPLICATIONS

This section will briefly discuss some of the SMS and Performance Management System (PMS) applications.

1.6.1 Event Correlation

When an SMS detects a threshold crossing in a network that affects QoS, SMS has the capability to notify affected customers and the service provider. For example, if the voice router in the Business Customer Premises Network (B-CPN) shown in Figure 1-4 below exceeds a threshold, SMS can notify the enterprise customer via e-mail informing them that a) the voice router is having a problem, b) the problem is being worked on, and c) the estimated time to repair.

If SMSs can access contact information (e.g., e-mail addresses) of all the users served by the router in question, it can send e-mail to the complete list of users. If the number of affected customers is very large (e.g., several thousands) then SMSs can notify these users during non-peak hours when there is less traffic in the network, such as between midnight and 4:00 AM. Customers are informed proactively, which will result in a decline in new trouble tickets and a reduction in churn.

If an IP backbone network router, connected to a CPN, detects a threshold crossing violation (e.g., large delays or packet loss), the SMS can inform the business customer and all phone users (end users for that customer) by e-mail of the violation, as discussed above. If the CPN network has an alternate path to another router in the backbone and the system has the capability to re-route the

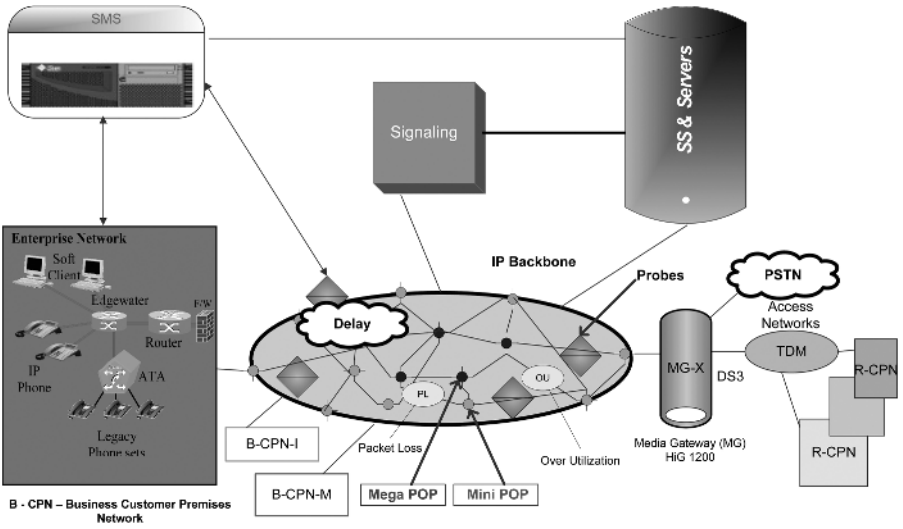

Figure 1-4. Event correlation and hot spots in a network

traffic using the back up router, the SMS will only notify the business customers about the violation.

Similarly, when a media gateway such as MG-X, shown in Figure 1-4, detects a threshold violation (e.g., a DS3 port threshold violation), SMS will inform all customers served by that DS3 port. It is important to understand that an SMS does not need to know which DS0 time slot is used and by whom. All that is needed is the list of affected customers and their phone numbers.

What an SMS does is similar to what cable TV companies do today when there is a problem in their network. They do not inform individual customers but send a broadcast message to all affected customers. In other words, a threshold violation is correlated to a group of customers, not to a specific customer in the case of MG threshold violation. On the other hand, a threshold violation in B-CPN can be correlated to the business customer and all of its employees (affected customers). So, the correlation event is dependent on network architecture and its location.

1.6.2 Hot Spot Identification and SMS Actions

With respect to SMS applications, a hot spot means that a part (a sub-network) of a network is not operating according to specified key performance indicators (KPIs) such as delay, packet loss, utilization, availability, jitter, etc., as shown in Figure 1-4. A sub-network can be as small as just a single node (e.g., a router, MG, IP PBX, an application server, a softswitch, etc.) or a single resource (e.g., a CPU, port, buffer, trunk, etc.). It is important to know that we can get bad QoS even though there is no infrastructure failure in the network such as cable cut, broken or burned equipment, CPU failure, etc., due to packet loss, packet delay, congestions, and over-utilization of physical resources (e.g., CPU, buffer, bandwidth, etc.) Therefore, a fault management system does not receive any alarms and it assumes that every thing is okay. However, performance management system SML applications can detect those impairments in advance before any SLA requirements were violated and inform other appropriate OSSs / BSSs to take the necessary actions. This is why PM now is more important than FM for packet based networks [4].

What an SMS will recommend to the appropriate OSSs depends on:

- Frequency of violation
- Duration of violation
- Location of violation (an MG, a backbone router, a softswitch, an application server, etc.)
- Time and day of violation

The effect of each KPI on service quality changes from service to service (VoIP, video, HSIA, data, etc.). VoIP QoS KPI dependencies are availability, delay (E2E delay up to 150 ms is acceptable), packet loss, utilization, and jitter.

VoIP service is more sensitive to delay than packet loss. Up to a few percentage points of packet loss does not affect quality and it is acceptable. If packet loss is evenly distributed, up to 5% packet loss is also acceptable.

1.6.3 SLAs, Contracts, and Policy Management

An SMS has a suite of tools that allow the SP to assess and report on service delivery, SLA contractual performance, service connectivity (including service layering), service reporting, and topographic information, in real-time through an SMS Web-based graphical user interface (GUI). Also, through service assurance, the service provider can automatically manage and correct service problems as they occur, creating a service operations center (SOC).

SOCs increase SPs' efficiency and reduce operational costs. By correlating customers, infrastructure, and service information, SOCs enable SPs to make smart decisions about subscriber services and infrastructure and manage service and contract incidents with the proper priority.

1.6.3.1 Service Assessment Service assessment monitors real-time service quality in the resource infrastructure and assesses it against specific SP-defined quality objectives. An SP can measure overall service quality against policy thresholds for specific services, or service segments, within their infrastructure. If policy thresholds are violated, service assessment initiates automatic actions that alert staff to service problems in the resource infrastructure. The Web-based GUI provides real-time graphical displays of policy violations, with a point-and-click drill down from top layer service violations to root cause resource violations, and specific KPI values and thresholds. Individually tailored service quality policies can automatically be applied to a service and assessed, based on the time of day, day of the week, legal holidays, and special events.

1.6.3.2 Contract Assessment Contract assessment monitors real-time customer committed service quality for end user services specified in customer SLA contracts. Contract assessment automatically measures the real-time performance of customers' delivered services against specific customer service quality commitments created with contract builder. If an SLA contract's thresholds are in jeopardy of violation, contract assessment initiates automatic actions that alert staff of specific customer service problems, so that prioritized corrective actions can be taken before SLAs are violated. By converting raw infrastructure performance data into business knowledge about end-to-end customer service quality, contract assessment gives a service provider the means to understand how well they are meeting customer expectations and commitments. The resulting knowledge can be used to assure the service for the customer.

1.6.3.3 Service and Contract Assurance Service and contract assurance enables the automatic restoration of service when service objectives, or SLA contract commitments, are violated. Service and contract assurance extend the capabilities of service designer actions to include connectivity to third-party provisioning and service activation platforms. When a resource infrastructure or customer service objective is missed, service and contract assurance requests third-party systems to re-route or re-provision resources, so that service is restored to normal operation.

1.6.4 SMS Integration with Planning and Engineering Systems

Network planning and engineering systems need historical data for expansion and reengineering of network. Therefore, it is very important that they have access to accurate historical data on important parameters such as utilization, traffic, delay, packet loss, call statistics, etc. Since an SMS collects and stores all that information, it is very important for SPs' planning and engineering systems to access an SMS database. Historical data will be very useful in modifying and improving routing algorithms, flow control algorithms, closing a point-of-presence (POP) that does not generate enough revenue, adding a new POP for growth, capacity / bandwidth planning, etc.

In addition to providing planning and engineering data to SPs' OSSs, an SMS will also make short- and long-term recommendations to the other OSSs to implement requested action or actions (re-routing, re-provisioning of resources, etc.), based on frequency and duration of threshold violations.

1.7 OVERVIEW OF BOOK ORGANIZATION AND CHAPTERS

This is an orchestrated set of chapters, written exclusively for the book by a team of subject experts from around the globe. As a technical reference book, users will find definitions and descriptions of every aspect of next generation telecommunications networks and services and their management. As a graduate textbook, students will have information that strikes at the center of where the telecommunications industry is going over the next 15 years and beyond.

In this chapter, the co-editors discuss changes, opportunities, and challenges in the field of next generation telecommunications networks, services and management and summarize the book. Chapter 2 and Chapter 3 address the nearly boundless arena of triple and quad-play services that have been deployed in the past three to five years and their management, from a Telecom and cable point-of-view, respectively. These services will migrate into more advanced next generation IP-based services such as IMS-based IPTV, triple shift, multi-screen, blended/converged services, social networking, shared video services, interactive advertisement with instant purchasing, etc. Chapter 4 goes into specific definitions of next generation technologies, networks, and services. Architectures are described. Importantly, for the purpose of this book, Fault, Configuration, Accounting, Performance and Security (FCAPS) requirements are addressed. Chapter 4 brings into clear focus the next generation point-of-departure for operations and network management.

Convergence is a key word in the telecommunications industry. Chapter 5 addresses convergence and an important convergence vehicle, IP Multimedia Subsystem (IMS), and associated management requirements. Chapter 6 is fundamental to steering the right course to the future. It defines next generation operations and network management architecture. This is the key for timeliness and functional and cost effectiveness. Ad hoc wireless and sensor networks and their management

is the key to home networking. Chapter 7 defines these technologies, networks, and services opportunities. Chapter 8 approaches next generation operations and network management standards from a strategic perspective. This chapter offers users and students the information needed to understand the global standards landscape of forums and their scope and processes. Perhaps most importantly, Chapter 8 instructs users and students how to engage in next generation operations and network management standards. It concludes with specific information on current next generation operations and network management standards, existing and/or under development. Chapter 9 forecasts the future in this field. It is for reading enjoyment. One thing is clear: the future will be rich with opportunities for the global telecommunications industry.

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