CHAPTER 4

NEXT GENERATION TECHNOLOGIES, NETWORKS, AND SERVICES[1]

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4.1 INTRODUCTION

This chapter presents an overview of Next Generation (NG) technologies, networks, and services with particular reference to their architecture and Management (FCAPS[2]) requirements. It is argued that *convergence* is the driving force behind the emerging generation of technologies, network elements, architectures, services, and their management. Therefore, both networks and services management must take an end-to-end view in design, implementation, and operations. For example, the IP Multimedia Subsystem (IMS) is being incorporated at the core of all NG services architectures, be it wireline (cable and telco) network evolution or for supporting fixed-mobile convergence in wireless networks. Similarly, NG network elements are becoming more aware of the functions across their usual layers of operations. Finally, devices are becoming fully capable of supporting any media, i.e., voice, IM/SMS (instant messaging and short message service), real- and non-real-time video, etc. These applications and services must be supported and offered in an access-agnostic fashion.

Consequently, the overall architecture and service operations/management are becoming increasingly complex. These call for the utilization of appropriate normalization and interworking modules for effective operations and management of services without directly affecting the ongoing workforce development and deployment in corporations. Consequently, industry is witnessing a newer mode/paradigm of networks and services management.

A brief overview of each of the above-mentioned trends is provided in this chapter.

[1]The ideas and viewpoint presented in this Chapter belong solely to Bhumip Khasnabish, Lexington, Massachusetts, USA.

[2]FCAPS stands for 'Fault, Configuration, Accounting, Performance, and Security.' It is ISO's (www.iso.org) model and framework for network management.

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4.2 NEXT GENERATION (NG) TECHNOLOGIES

As suggested before, convergence at all levels will be the driving force behind NG telecommunications technologies. At the device level, customers want to use the same device (cell phone, TV, computer, wireline phone) for voice, data, video (both real-time and streaming), and gaming services. At the network element level, the edge and core routers are becoming more aware of applications and services (like security, fire-walling, and service adaptation). In addition, optical networking devices will be more aware of IP-based services and will need to support alignment with NG networks and services management, e.g., bandwidth-on-demand. Figure 4-1 shows high-level interaction among NG technologies, services, and workforce with push and pulls. The push usually comes from the marketing and technology groups within a company to introduce new technologies and services with an objective to generate new streams of revenues. The pull comes from the workforce (personnel) that maintains the legacy networks, elements, and the operations support systems. They like to stay within their comfort zones of network management and maintenance and are usually reluctant to take any risk.

4.2.1 Wireline NG Technologies

Wireline-based NG technologies include both NG wireline access technologies and NG devices that seamlessly support emerging converged services, irrespective of whether these services are hosted in wireline domains or in wireless domains. Telco's NG wireline access and transport technologies will include the following options. However, other technologies for packet-based NG wireline services can include advanced cable modem, NG multimedia terminal adapter, cable modem termination system, and high-end set top box as well (see, for example, Ref. [10]).

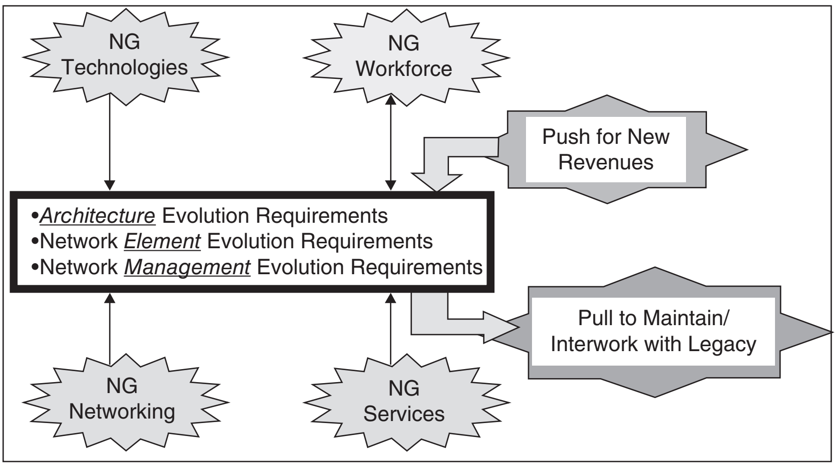

Figure 4-1. Interaction between legacy and emerging forces of network and service evolution

4.2.1.1 Fiber to the Premises (FTTP) FTTP service includes *mostly* passive optical network (PON) fiber based all-/any-purpose communications services to single-family homes, multi-tenant apartment buildings, business and education campuses, LTE[3] towers (for backhauling), etc. Broadband PON (BPON) has been specified in ITU-T's G.984 standard with the following bands and speeds: 1310 nanometer for upstream data at 155 Mbps (1.2 Gbps with Gigabit PON or GPON), 1490 nanometer for downstream data at 622 Mbps (2.4 Gbps with GPON), and 1550 nanometer for radio frequency (RF)-based (excluding IPTV) video with 870 MHz of bandwidth. In addition to supporting a higher rate and a choice of layer-2 protocol, GPON also supports enhanced security and reliability. IEEE's 10 Gigabit Ethernet PON (10G-EPON, IEEE P802.3av) will be backward compatible with Ethernet PON (EPON or GEPON, IEEE 802.3ah) and will use separate wavelengths for 10 Gbps and 1.0 Gbps downstream, but will continue to use a single wavelength for both 10 Gbps and 1.0 Gbps upstream with TDMA (time division multiple access) separation. If a hybrid TDM/WDM (time/wavelength division multiplying) system with each wavelength to feed a GPON or EPON is used, then utilizing 32 wavelengths and 1 : 64 split-ratio GPONs, more than 2000 customers can be served.

GPON and GEPON based FTTP are being deployed today in the United States, Europe, and Asia. The NG PON (NGPON) including 10 Gigabit Ethernet PON (10G-EPON) and wavelength-division multiplexed PON (WDM-PON) will be available within next three to five years.

As of year-end of 2009, Japan had more than 15 million FTTP/H (home) sub scribers (with more than 50 million homes passed). Europe and the United States have installed wiring and infrastructure to support more than 10 million homes with subscriber numbers around the 3 million level.

4.2.1.2 Long-Haul Managed Ethernet (over Optical Gears) This is being driven by at least two key factors. First is the emerging economic requirements to reduce the complexity (and hence capital and operational expenses) of long-haul transmission by incorporating lightweight provisioning and packet-routing capabilities in the optical transport layer. This cross-layer mechanism enables cost effective and efficient management of switching and transport resources. Second is the advancement of key photonics technologies including commercial support for higher-speed modulation, forward error correction, and wideband filtering as well as availability of standardized photonic integrate circuit modules. Once deployed, these 100 Gigabits/sec (or more) capabilities will eliminate a large number of intermediate network elements and interfaces, essentially reducing overall power/space requirements and streamlining the provisioning, operations, and management of end-to-end service quality.

NG wireline devices will support convergence, not only in terms of interfaces but also in terms of supporting features and functions to maintain seamless services. For example, routers and switches will be increasingly aware of application (including media) and service layer features and functions. Physical layer elements like optical transport devices will be increasingly aware of Ethernet and IP layer features

[3]LTE: Long Term Evolution, as defined later in this Chapter.

and functions. Application and consumer layer devices will be increasingly aware of any or all types of human machine interfaces (HMIs). For example, televisions will support bidirectional voice communications and video conference calls in addition to supporting instant messaging and email services. Wireline phones will support Web services and low-bit-rate television services in addition to continuing to support plain old telephone service (POTS). Devices that are used commonly to perform adaptation and integration functions will be more integrated with the terminal devices or will be supporting a multitude of features and functions inherently.

4.2.2 Wireless NG Technologies

Wireless NG technologies (near and beyond third generation) find their home mostly in the new generation of hand-held or wearable devices supporting real-time voice/data/video, gaming, and high-bandwidth access to location-based services and health/pollution/traffic monitoring services. Technologies that support high-bandwidth wireless access and interconnections are discussed in this section. In addition, since these devices are increasingly becoming aware of the Internet protocol, along with context, proximity, and data-driven services in both home and foreign domains, they create tremendous challenges for both handset and network equipment manufactures.

4.2.2.1 Broadband Bluetooth and ZigBee The emerging Broadband Bluetooth (IEEE 802.15.1 standard, www.ieee802.org/15/pub/TG1.html) will utilize multi-band orthogonal frequency division multiplexing (OFDM) over unlicensed 2.4 GHz frequency band to support secure, high-speed (up to 480 Mbps) and low-power communications over short distances[4] for personal/body area networking applications. These services will range from high-definition phone conversations to file transfer to gaming to highly secure transactions, as in Near Field Communications (NFC). Major challenges are related to automated device pairing, privacy and security, topology management, and preventing hijacking of the service.

Zigbee (www.zigbee.org), the IEEE 802.15.4/4b Standard, as can be found at www.ieee802.org/15/pub/TG4.html, and grouper.ieee.org/groups/802/15/pub/TG4b.html, is another low-power and low-complexity wireless communications. Zigbee operates over unlicensed 2.4 GHz frequency band for interaction between smart gadgets/toys, home automation, sensors, personal home/hospital care, etc., supporting a data rate of up to 250 Kilobits/sec. Current challenges include reducing ambiguities and complexity without compromising (a) performance over the newly available frequency bands and (b) flexibility in security key usage.

4.2.2.2 Personalized and Extended Wi-Fi Wi-Fi (see, for example, www.ieee802.org/11/ and www.wi-fi.org) can use both single-carrier (the direct sequence spread spectrum one) and multi-carrier (the orthogonal frequency division multi-

[4]Class-1 Bluetooth devices can support communications over a distance of 300 feet using power of no more than 100 milli-watts. Class-3 devices use up to one milli-watt for communication over three feet distance.

plexing one) wireless radio technologies. Wi-Fi supports both secure (using, for example, Wi-Fi protected access version 2 or WPA2) and unsecure wireless communications typically over a personalized local area (or the last mile with WiMax as the wide area network or WAN link), wirelessly over unlicensed spectrum for a variety of services. The services include automated (or with minimal human intervention) inter-device communications within home, at office, or in designated hotspots (public spaces) like airport waiting areas, parks, shopping malls, trains, planes, etc. Devices include any Wi-Fi enabled gadget like cameras, laptops, printers, digital storage, photo display devices, TVs, cell phones, alarms, utilities, and monitoring systems. Devices within the home may include hygrometers, refrigerators, etc. The objective is to support communications, e.g., upload/download files, check the status, or update of a system, tetherlessly and without the hassle of setting up of connections at designated spots (home, office, and waiting areas) in order to save time and improve lifestyle.

Although Wi-Fi has been originally designed and performance-optimized for communications over the local area using high-gain, multi-input–multi-output antennas and repeaters, researchers and early adopters have demonstrated Wi-Fi communications over tens of miles. Traditional cellular service providers may use Wi-Fi for voice/data/low-resolution-video communications for fixed-mobile convergence or FMC (see for example, www.thefmca.com) and femtocell-based[5] service at home and at service hotspots. However, the problem of fitting the antennas for a variety of wireless communications services over the surface of a mobile device (e.g., a handset) becomes very challenging. Therefore, the problem of fitting antennas for Wi-Fi, GPS, Bluetooth, WiMax, 3G/4G, etc. communications must be resolved before it can be reality. In addition, although the performance and availability of devices and services matter, ultimately the price of the device and its seamless interoperability determine the overall acceptance of the technology. It is expected that the price will drop as the technology and specification mature, and the Wi-Fi enabled devices are mass-produced. The Wi-Fi alliance (www.wi-fi.org) is focusing on testing and certifying Wi-Fi capable communications and monitoring devices in order to ease interoperability related problems.

4.2.2.3 Mobile Worldwide Inter-operability for Microwave Access (M-WiMax) Mobile WiMax is based on the IEEE 802.16m standard (www.wimaxforum.org, www.ieee802.org/16).It has evolved from the point-to-point microwave data communications standard, IEEE 802.16. It can use both licensed and unlicensed spectrums (2 to 6 GHz), and has widespread support from both chipset manufacturers and end point/system suppliers. M-WiMax use of OFDMA based access, and with 256 OFDM (scalable from 128 to 2048 with OFDMA), can support up to 15 Mbps with 5 MHz channels. NG M-WiMax will use MIMO to improve throughput. Many of the M-WiMax features (security, frame format, QoS, etc.) are based on cable TV service operators' requirements and specifications.

[5]See for example, 3GPP's Release 8 and Broadband Forum's TR-069 based Femto Forum's spec. at www.femtoforum.org.

4.2.2.4 Long Term Evolution (LTE) This telecom wireless technology is expected to provide further simplification of the radio access and core packet network with an objective to support greater spectrum efficiency and reduced latency in over-the-air interfaces. LTE uses a multiple-input multiple-output (MIMO) system in which up to four antennas can be used in both terminals and evolved edge-nodes to support a downlink (to the user terminal) data rate of 100 Mbps using orthogonal FDMA[6] (O-FDMA) and an uplink (to the network) data rate of 50 Mbps using single carrier FDMA (SC-FDMA) over 20 MHz of bandwidth. The orthogonal frequency division multiplexing or OFDM utilizes digital modulation based frequency division multiplexing or FDM. In addition to supporting space and frequency, multiplexing MIMO also supports beam forming and beam steering to improve throughput and reduce latency. In terms of architectural support and evolution, LTE is expected to reduce IP network complexity significantly so that end-to-end latency can be reduced and throughput can be simultaneously improved, thus reducing network costs.

4.2.2.5 Enhanced HSPA This represents an evolution of wideband CDMA for enhancing HSPA (High Speed Packet Access). HSPA utilizes time-domain sharing of a 5 MHz wideband CDMA channel and 16 QAM modulation. E-HSPA uses MIMO antennas and higher order (64 QAM) modulation in order to achieve higher bitrates in both up and downstream. It is expected that the target downlink speed of 42 Mbps will be supported by E-HSPA (and uplink speed would be approximately 11.5 Mbps).

4.2.2.6 Evolution Data Optimized (EVDO) and Ultra Mobile Broadband (UMB) EVDO is a part of the CDMA2000 family using a 1.25 MHz channel for Revision A (actual downlink speed is less than 1 Mbps), 5 MHz channel for Revision B, and up to a 20 MHz channel for Revision C (or UMB). UMB is based on the widely used CDMA, TDMA, OFDMA, and spatial division multiple access (or SDMA) based MIMO techniques, and is expected to improve the data-rate supported by CDMA2000's 1xEVDO Revision C. The target downlink speed of up to 280 Mbps (over up to 20 MHz) is expected to be supported. However, since CDMA carriers are aggressively moving toward LTE deployment, there may not be any widespread use of the EVDO-Rev. C technology and network.

4.2.2.7 Mobile Ad Hoc Networking (MANET) and Wireless Mesh Networking (WMN) These are purpose-built networks that are made to fit in the existing terrain irrespective of whether the application is sensor networking, personal-/body-area communications, vehicular communications, or battlefield communications. The challenges include determining appropriate placement of the nodes with an objective to guarantee signal strength, facilitate topology sharing and maintaining quality of service, security, and robustness. Many experimental testbeds and early prototypes are being developed to further investigate these issues (e.g., see the

[6]FDMA: Frequency division multiple access, a multi-user access scheme where each user is assigned a channel within a frequency band with adjacent channels separated by a guard band to avoid interference.

IETF website on Mobile Ad Hoc NETworking or MANET at http://www.ietf.org/html.charters/manet-charter.html for details).

Wireless mesh networking (WMN) is a special case of MANET. For example, the wireless nodes (access points, routers, gateways to the Internet) can be bridged using a regular or irregular mesh topology as defined in IEEE 802.11's specifications (grouper.ieee.org/groups/802/11/Reports/tgs_update.htm). The objective here is to install a self-organized, self-healing, secure and high-bandwidth metro-area wireless backbone network for private or public use without the hassle and cost of deploying fiber over the wide area. WMN can be implemented using various wireless technologies including 802.11, 802.16, cellular technologies or combinations of more than one type of radio communications technologies. WMN uses directional smart antennas, flexible spectrum management, and cross-layer design to achieve power- and cost-efficient routing.

4.2.2.8 Cognitive (and Software Defined) Radios and Their Interworking

In this scheme, wireless devices are provided with intelligence to utilize the available spectrum, i.e., allocated but not being used, spectrum in the surrounding areas with an objective to improve QoS. Consequently, a convergence of heterogeneous radio communication services is achieved by continuously monitoring the dormant and idle spectrums and adjusting the transmission and reception channels, including parameters. Although the cognitive radio system uses mostly the unlicensed wireless spectrum, it may use licensed spectrum through special arrangement with the title-holder of the spectrum. Technical challenges of implementing a cognitive radio system include spectrum sensing with use of the pilot channel for joint and dynamic spectrum management, wireless-enabled context awareness, neighborhood and local resource discovery, embedded and instantaneous sharing of spectrum information, self-organization, and wireless/mobile peer-to-peer sensing/networking. Although the cognitive scheme sounds very effective and useful from technology viewpoints, there are many regulatory, policy, and socio-economic issues that need careful resolution for deploying the cognitive radio-based interworking capable appliances.

For cognitive radio-based handset manufacturers, the challenges are: (a) support of multi-band transmission and reception, (b) efficient management of power consumption, (c) cost-effective service (including error and noise) management without sacrificing antenna size, and (d) testability and certification for seamless operation.

For networking equipment manufacturers, the challenge is to find innovative ways to utilize the same hardware and even the radios irrespective of the supported Standards and networking methods—(be it WiMax or LTE) by simply updating the modules' configurations and software. In addition, the fact that different carriers will prefer different sizes, varying level of smartness, location of antenna, base stations, and amplifiers, etc. will remain valid in the near future.

4.2.3 Software and Server NG Technologies (Virtualization)

With an objective to accomplish efficient utilization of resources, virtualization will be heavily utilized in emerging systems, and NGNs are no exceptions. Although it is commonly used in semiconductor and Information Technology (IT) and Web-based services design, virtualization is rapidly gaining popularity among networking and communications system design engineers as well. Virtualization not only offers flexibility, convenience, and improved performance; it also reduces power consumption and achieves the same results or goals. For example, support of virtualization can help run multiple instances of application-/service-specific utilities, implementing border-wares and/or middle-wares, in the same router blades (line cards).

Similarly, a hand-held device supporting virtualization of storage, processing, and interfaces can be reconfigured for communications to entertainment to remote medical diagnosis purposes. Consequently, any software-defined service can reap the benefits of virtualization techniques and the network elements can be made aware of both the services being offered and the media that these services are carrying. The major challenges in implementing a cost-effective virtualized storefront include network-, service- and secrecy-/privacy- aware management of computing, communications/networking and storage resources.

Many organizations are enthusiastically working to resolve these issues. They include ATIS Service Oriented Network or SON Forum (http://www.atis.org/SON/index.asp), Cloud Computing Interoperability Forum (CCIF, http://www.cloudforum.org/), and the OpenCloud Forum (http://opencloudmanifesto.org/).

4.3 NEXT GENERATION NETWORKS (NGNs)

There is no doubt that Internet Protocol (IP), Ethernet, and optical technologies will dominate the NGN scene for some time in the future. For wireline broadband access, digital subscriber loop (DSL) technology may still have a few years of lifetime left. However, optical fiber is going to be the dominant technology. In addition, for mobile broadband access, both LTE and M-WiMax look promising. Existing investments and knowledge of technology may very well determine future direction and evolution. As always, operators will make significant attempts to reduce overheads resulting from deployment of competing and complimentary networking technologies. As a result, a new look at the FCAPS requirements is required.

Figure 4-2 shows NGN architecture where functions are divided into applications, service, and transport strata [1–4]. In this architecture, the end user functions are connected to the network by the user-to-network interface (UNI). UNI includes both transport and control functions. Other networks are interconnected through the network-to-network interface (NNI). NNI also includes both transport and control functions. Interoperability between different domains can use NNI functionality. The application-to-network interface (ANI) facilitates third-party application developments. With suitable programmability and network policies, new applications can be developed at a faster pace for consumption by users hosted in any network/domain [2, 3].

4.3.1 Transport Stratum

The transport stratum provides the physical termination, adaptation, bearer functions, and port functions for signal and bearer traffic connections. Within the transport

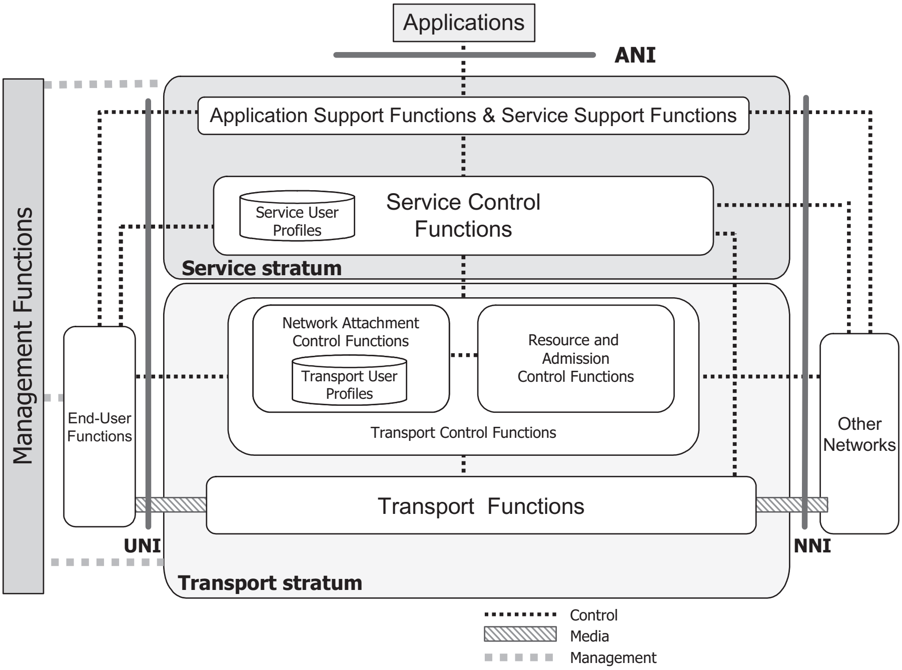

Figure 4-2. NGN architecture overview (Source: ITU-T Y.2012, 2006)

stratum, adaptation elements are responsible for providing interconnection to the large variety of access and trunk interfaces that the Switching/Routing plane may support. This layer provides IP-based connectivity and can support the QoS. It is divided into access and core networks. Other components of the transport function include the following:

Access Functions: These functions manage access to the network. A variety of wireline and wirleless accesses must be supported by the NGN.

Access Transport Functions: These functions manage transport of information across the access network. Based on service requirements, a variety of QoS control mechanisms may be invoked by these functions.

Edge Functions: These functions process signaling, media and management traffic for further aggregation (if needed) and delivery to the core network.

Core Transport Functions: These functions are responsible for carrying traffic over the core networks. QoS control mechanisms invoked by these functions must be light weight in nature. This is equivalent to saying that the core transport is equivalent to a multi-lane highway, and that no traffic control signals are required there.

Gateway Functions: These functions provide and support capabilities to interwork with other networks.

Transport Control Functions: These include the functional entities as described below:

Resource and Admission Control Functions: These functions are involved in admission control and gate control activities for voice, video, data, and mobile sessions. Admission control commonly involves authentication and authorization. Gate control may involve enforcement of policies in a service-specific fashion.

Network Attachment Control Functions: These functions provide initialization of end-user functions for accessing NGN services.

Transport User profiles: These functions are commonly specified and implemented using a set of cooperating databases. These data are utilized during control of transport of information from the user.

4.3.2 Service Stratum

The service stratum stores service profiles for users and provides service control functions. Applications and service support functions also reside in this stratum. These functions transparently support services from applications and other domains to the end user.

Service User Profiles: These functions are commonly specified and implemented using a set of cooperating databases. These data are utilized for allowing and managing access to NGN services by the user.

Service Control Functions: These functions include service level registration, authentication, and authorization functions and may include NGN session control data as well.

4.3.3 Management

Management functions include the network and service management functions, management information base (MIB) and interfaces within the network. The objective is to guarantee expected level of security, reliability, availability, and QoS for the billable NGN services. This provides the following services across the network:

4.3.3.1 Fault Management Fault management refers to the management of services and sessions at the agreed-upon levels even when there are faults, including overloads and disasters, in the service, application, and transport strata. Functions may include monitoring and control of utilization of resources during setup, maintenance, and release of sessions for NGN services. Since NGN supports a multitude of services, it is recommended that appropriate filtering and correlation be used to manage service- specific faults. When services span multiple technology and administrative domains, as would be the case for networks and services interoperability, one or more fault management mechanisms are required per bilateral agreement. This will help maintain service transparency across the NNI.

4.3.3.2 Configuration Management This refers to developing, monitoring, and managing hardware and software configurations of devices, elements, and systems with an objective to maintain network operations without negatively affecting services and revenues. For example, it is often desired to store the tested and approved configurations of the end-user terminals in a networked server so users can download them as they sign in for new features and services. Although this practice is very common in the cellular phone industry, Internet and IP-based television (IPTV) service providers are also finding it increasing useful. Similarly, for network elements' configuration management, specialized on-line and off-line servers are commonly utilized.

4.3.3.3 Accounting Management Accounting management in the context of NGN commonly refers to recording the utilization of services and network resources with an objective to create a billing record. The recording can be done in various formats including the raw comma-separated-values that can be fed to format data in other acceptable standard formats in order to create customer readable bills. Measurement of the use of services and resources can be done in multiple ways. For example, per-service per-user paradigm is routinely utilized for cell phone users for voice data/text-messaging, video download, gaming, etc, unless flat-rate billing is assumed. For enterprise customers, recording of network and service utilization and events like service outage and repair time for managing the service level agreement (SLA) are more important than documenting the service usage.

4.3.3.4 Performance Management Performance management is concerned with monitoring the performance of networks elements, both transmission links and nodal devices, with an objective to maintain the desired level of service quality or SLA. Both active and passive monitoring devices and techniques are commonly used in NGNs. The challenge, however, is to locate and harden performance monitoring and management systems uniformly in the network without overburdening service creation, management, and delivery modules.

Passive monitoring requires the use of splitters in the transmission links, and special-purpose hardware for off-line filtering/storing/analyzing the captured data. Active measurements can be conducted without significant overhead, at any desired time, and for any desired time period. For transmission links, the parameters of interest are throughput and utilization, uptime and downtime, time to recover gracefully from overloads and disasters, etc. For nodal device like switches and routers, parameters like delay, response time, local or remote switchover times for service quality maintenance during failures and overload, are of paramount importance.

4.3.3.5 Security Management NGN security management includes managing the user's identification, authentication, authorization, certificate, etc. in an access-neutral fashion. Otherwise, it will be very difficult to maintain service continuity when the user (or session) moves from one access network to another or roams from one service provider to the other. Since NGN uses IP-based transport, additional mechanisms are required to protect both service and network from worms, viruses, intrusion, denial of service, etc. Simple monitoring-based mechanisms may not be sufficient. Proactive measures must be invoked. ITU-T Study Groups 13 and 17 addresses these issues. Once again, when services span multiple technology and administrative domains, as would be the case for networks and services interoperability, one or more security management mechanisms are required per bilateral agreement. This will help maintain service transparency securely. In terms of the Telecommunications Management Network (TMN) functions, this encompasses both the Element and Network Management layers.

4.3.4 Applications Functions

This functional block supports service application programming interfaces (API), session control, service logic, translation, and routing logic, directory and policy management functions across the network. Some of the specific applications functions provide:

1. Messaging services, such as those used in e-mail and voice mail
2. Processing services, such as automatic speech recognition and credit card processing
3. Value-added IP telephony services, such as virtual second line, Web-based toll-free calling
4. Directory enabled services, such as Freephone/8xx number translation, local number portability, and single number follow-me services for voice telephony
5. IP naming and addressing services including DNS, DHCP, and RADIUS (DNS stands for Domain Name System, as defined in IETF RFC 1035, Dynamic Host Configuration Protocol or DHCP has been defined in IETF RFC 2131, Remote Authentication Dial In User Service or RADIUS as defined in IETF RFC 2865)
6. CLASS-5/CLASS[7] services, such as call waiting, call forwarding, conference calling for voice communications service (telephony applications)
7. Virtual Private Networking (VPN) for voice and data
8. Bandwidth Services, Optical VPN (IETF RFC 2547), etc.

4.3.5 Other Networks: Third-Party Domains

Domains are defined by network administration to give structure to the network, and to make management of the network as simple and easy as possible. Domain structure may:

1. represent the reach of a domain-specific address allocation
2. define the reach of an Interior Gateway Protocol (IGP)
3. define the boundaries of an Exterior Gateway Protocol (EGP)
4. define a level of traffic aggregation and management
5. correspond to a region of guaranteed QoS
6. correspond to a region defined by a level of guaranteed security ("trust" domain).

[7]CLASS: Custom Local Area Signaling Services [5].

Domains should be defined hierarchically. If they are "multi-domain," management shall act as the highest-level domain, managing resources and supporting traffic that must traverse multiple domains. Multi-domain management also should be capable of acting as a back-up resource for any individual domain under its management.

Third-party networks include other service providers and carriers as well as medium to large enterprise customers who maintain their own networks and IT departments. The borders or boundaries define the transition points for signaling, media, and OAMP[8] messages. It is very important to manage signaling, security, policy, QoS, and SLA in order to support end-to-end transparency of the services across borders or boundaries.

4.3.6 End-User Functions: Customer Premises Devices and Home Networks

Traditionally this domain contains equipment, wiring, and functions that are required in the residential customer premises or in small/medium business' premises. Since traditional Telcos are entering the entertainment business, they have upgraded their twisted copper wire pairs to high-speed DSL or fiber- or coaxial cable-based links so that they can offer broadband services (video and Internet) to their customers as well. These call for installation of additional modems, router, security devices, video converters, and set-top boxes to homes. Similarly, traditional cable TV service providers are offering digital telephone and Internet-based services using the emerging version of the DOCSIS (Data Over Cable Service Interface Specification) and others standards (for details, see www.cablelabs.com). These types of evolution to support multimedia services create a multitude of networks and devices inside home, making the problem of debugging, diagnosis, and service installation difficult.

4.3.7 Internet Protocol (IP): The NGN Glue

Irrespective of whether it is wireline or wireless at the physical layer, the networking[9] layer is going to ubiquitously use the Internet Protocol or IP (IETF RFC 791 for IPv4, and RFC 2460 for IPv6). The following variants of IP and the add-on features are currently available in the industry to keep it as the most useful glue at the Networking layer.

4.3.7.1 Internet Protocol version 4 (IPv4) IPv4 (IETF RFC 791) uses a 32-bit dotted decimal based addressing scheme (e.g., 132.197.34.181), and can support up to 4 billion (2^{32}) addresses including those reserved for private networks and for multicast communications. However, by using network address translation (NAT, which converts private IP addresses to one or more public IP addresses, IETF RFC 2766 and 2767), the possibility of address space exhaust can be minimized. The

[8]OAMP: Operations, Administrations, Maintenance, and Provisioning.

[9]The third layer from the bottom of International Standards Organization's (ISO's) seven-layer Open System Interconnection (OSI) model.

problems related to manual configuration and to supporting privacy, security, quality of service, and mobility remains open for IPv4. In most cases, these issues are resolved by using additional adjunct devices or network element, but these add to complexity and overhead of both network and performance management mechanisms. Consequently, the emerging NG networks would most likely avoid using IPv4-only elements and devices.

4.3.7.2 Internet Protocol version 6 (IPv6) IPv6 (IETF RFC 2460, and 4294) uses a 128-bit addressing scheme expressed using (colon-separated) hexadecimal strings (e.g., 4ffe:4700:2100:3:510:a4ef:fda0:ba97), and can support up to 2^{128} addresses for devices using IPv6-based communications. IPv6 has built-in support for stateless auto configuration, mobility, efficient routing, and traffic engineering, security, quality of service, privacy, and multicast services. However, since IPv6 is not backward compatible with IPv4, the network elements (including routers) and devices must be upgraded to support the additional processing and memory requirements in order to support IPV6 address-based communications.

4.3.7.3 Mobile Internet Protocol version 6 (MIPv6) In order to better support the mobility of devices, a set of extensions to the original IPV6 has been proposed in IETF (RFC 3775 and 3776). The extensions include caching the binding of a mobile node's home address with its care-of address, and then sending packets directly to the care-of address. This helps an IPv6 device to transparently (via tunneling) maintain transport layer connection when it moves from one subnet to another. Additional mechanisms to support local handoff and global mobility using a network-based mobility management entity called proxy mobile IPv6 (as defined in IETF RFC 5213) are also being discussed in IETF.

There are some discussions in the industry forums about the complexity, and hence the delay and costs it adds, of the IP layer. Attempts are being made to explore cross-layer optimization. This may make the upper (applications and transport) layer devices smarter and lower (link and optical) layer elements more capable and cost-effective.

4.4 NEXT GENERATION SERVICES

This section presents a high-level description of Next Generation (NG) services. The architectures that are required to support these services are briefly discussed along with essential transport and application plane requirements. Only a sample of emerging NG services is presented below. It is prudent to remember that given the openness of emerging technologies and the flexible regulatory environment we live in, it is only inventors' imaginations that can and will determine future innovative services [6].

4.4.1 Software-Based Business Communications Service

A new trend in the Communications industry is enabling complete separation of the capability to support Business communications services, i.e., telephony, autoattendant, video/Web conferencing, instant messaging, white boarding, etc., from the hardware platform or device that is hosting the service. This allows traditional software companies to focus on developing business/office communications software suites that can be installed in general-purpose Internet connected servers for service-specific execution and service implementation. As a result, knowledge workers can enjoy the benefit of leading-edge communications services, cost-effectively, irrespective of where they are and when they want to use the services.

4.4.2 High-Definition (HD) Voice

A combination of availability of wide-band voice codecs (like G.722 and adaptive multi rate, wide-band, or AMR-WB) and ubiquitous broadband access in both wireline and wireless network will be making widespread availability of HD and stereo voice communications service. These codecs support a sampling rate ranging from 14 KHz to 22 KHz to reproduce very clear and highly intelligible voice sounds. To support HD voice service, it is required to maintain codec-transparency and bandwidth availability (by enforcing transmission policy) across all segments of network access and transmission. Current industry activities are directed toward making availability of the codecs and their settings (configurations) uniformly in handsets, soft-clients, and IP phones in a standards manner over all segments of the network so that the consumers can enjoy the benefits of using this service seamlessly.

4.4.3 Mobile and Managed Peer-to-Peer (M2P2P) Service

Traditional P2P service is used for applications ranging from file sharing to real-time streaming and video communications (file sharing). Since these contents are distributed throughout the Internet nodes, unmanaged P2P can generate tremendously large volume of redundant traffic especially in the transport links. Managed P2P service attempts to alleviate this problem by allowing *trusted* (through a broker) sharing of information related to the nearest logical location of the content and the best path (topologically and from routing viewpoint) to deliver the content to the requester. It is expected that service provider, content provider, and network provider will all benefit from using the mobile and managed P2P.

4.4.4 Wireless Charging of Hand-Held Device

Viable commercial technologies are being developed to recharge hand-held communication and entertainment device wirelessly over a few miles via for example electromagnetic induction and other beams, as has been demonstrated by Nikola Tesla in 1893. Once these radiation-receiving and recharging interfaces are incorporated in the hand-held and other devices, consumers will be able to get rid of the variety of power cables that they need to carry with their hand-held devices. These hand-held devices must be equipped with wideband (500 MHz to 10 GHz) receiver to capture the electromagnetic radiations that are emitted from mobile and TV antennas. MIT Labs recently conducted experiments to demonstrate wireless charging of hand-held devices. University of Washington in Seattle and Intel jointly demonstrated the use of TV signal to power a small sensor over a distance of few miles. A Wireless Power Consortium is being formed to develop viable business and regulatory models to commercialize this technology.

4.4.5 Three-Dimensional Television (3D-TV)

The NG television (TV) systems will utilize viewer-controlled clusters of cameras to capture scenes and views including depth and shadows in real-time and will transmit these images over very-high-bandwidth access and transport lines to the users. Researchers have recently developed a system to capture live scenes by using a cluster of 64 video cameras connected via a local area network to a PC. The PC converts input from all of these HTTP-enabled video cameras into JPEG sequence of images for display per user-controlled viewing requests. Challenges remain in the areas of capturing 3D images, processing, and storing these images without losing information and fidelity, and visualization without impairments (parallax, segmentation, etc.) for applications like virtual reality-based gaming and entertainment, remote collaboration and tele-diagnosis, etc.

4.4.6 Wearable, Body-Embedded Communications/ Computing Including Personal and Body-Area Networks

These are being enabled by miniaturization of computing and communications devices due to the emergence of nanotechnology. These devices can be worn and/or implanted in the human body, effectively to support unidirectional (monitoring) and interactive sensing or communications. Potential applications and business opportunities include (a) monitoring and diagnosis of patients' conditions, (b) graceful rehabilitation, (c) automatic dispatching of first responders in case of emergency, and (d) tactile sensing and interactions for advanced entertainment (gaming) and education services. However, many biomedical and bioethical challenges remain to be resolved before making these happen in reality. These include development and commercialization of (a) intuitive interfaces, (b) extremely low-power implantable circuits, and (c) physiological and ambient intelligence gathering sensors. Some of the short-reach, ultra-low-power communications technologies like ZigBee and Bluetooth (as discussed earlier in this chapter) may be useful for this purpose.

4.4.7 Converged/Personalized/Interactive Multimedia Services

Convergence of services refers to the ability to deliver real- and non-real-time voice/data/video/tactile information to a single device in a context-sensitive and interactive manner. The device could be wired or wireless or could be a hand-held phone or portable computer or a television. The context can be a combination of network, content, location/social environment, etc. The interactivity can be dictated by user-preference, social setup, adaptive semantics, etc. One such example is the mobile TV and infocast service using the digital video broadcast-handheld (DVB-H, www.dvb-h.org) standards. DVB-H device uses low power (less than 100 milliwatts) transmission of coded OFDM, OFDMA based access, and transmits digitized IP packets in 100 milliseconds time slots. A DVB-H terminal can receive a 15 Mbps bit stream over an 8 MHz channel in the 700 MHz band. Note that the DVB-H system can be easily adapted to operate with 5 MHz bandwidth in L-band (1670–1675 MHz) as well.

4.4.8 Grand-Separation for Pay-per-Use Service

This refers to supporting separation among access, transport, application, services, networked-resources (CPU, storage, etc.), networked-contents (generated and managed by anyone), security services, content subscription and exchange, transaction capability, etc. with well-defined open interfaces. This will drive users and developers alike to continuously build and market innovative services to improve the lifestyle of human beings for both work and play.

4.4.9 Mobile Internet for Automotive and Transportation

This refers to the use of high-bandwidth wired communications among different sensors and devices within the vehicle, and wireless communications between vehicles, between vehicle and curb-side fixed or mobile units, and between neighboring vehicle and infrastructure or fleet maintenance units (for vehicle maintenance, locating vehicles), etc. Note that high-speed mobility of the vehicle adds to the existing challenges of supporting delay- and fault-tolerant communications in different weather and road conditions.

4.4.10 Consumer- and Business-Oriented Apps Storefront

This refers to the opening of the network and application programming interfaces (NPIs and APIS) to the developer community so that anyone with access to the Internet can develop and upload an application for a useful service, to consumers and businesses. The applications can then be downloaded to wired/wireless handheld devices including cell phones for games and entertainment, learning, health-care, or business. This enables an applications developer, in, for example, a remote village in India or Brazil or China, with Internet access to develop and upload an application to the storefront of a service or network provider for downloading by using wireline or wireless access. A host of computer and software companies, handheld device manufacturers, and service providers, have announced their enthusiasm and participation in this effort (see, for example, www.appstoreapps.com, forge.betavine.net, plaza.qualcomm.com/retail, www.BlackBerry.com/AppWorld, www.jil.org, etc.). Some service providers are developing alliances to support all of the services one can think of; gaming, communications, mobile-TV/entertainment, wellness, mobile wallet/payment, home security, hotel check in including door key (yes, that can be uploaded when check-in to the hotel is completed!) and remote control services.

It is interesting to note that popular APIs like Amazon's eCom and payment, eBay's buying/auction/checkout, Facebook's markup/query, Google's Maps, Calendar, OpenSocial, and Android, etc. are very much proprietary in nature.

However, standards activities, along the line of network and service API development, are making progress as well, and these activities include ATIS SON (www.atis.org/SON/index.asp) group, Parlay group's Web services and presence API, OMA's (www.openmobilealliance.org) Web and mobile service enabler (with APIS yet to be developed), etc. These standards will provide guidance on creating and delivering services rapidly and seamlessly using enablers in multi-domain (Web, IMS, IT, Telco, etc.) environment with reduced costs.

4.4.11 Evolved Social Networking Service (E-SNS)

Today's social networking services use audio, image, video, and data files along with Skype-based (www.skype.com) communications services over the Web for sharing of unverified information of common (among those in the group) interests. This essentially helps build an online community of geographically dispersed Internet users where there is no strict boundary between consumer and producer of information and content. Facebook, Twitter, MySpace, and LinkedIn are a few popular SNS Websites. If used properly, SNS can be great way to instantly disseminate context-sensitive information in an orderly fashion to organize teams and activities. These can be any one of the following: development of a business model, accelerating experiment-based research works that are conducted non-stop by volunteers spread all over the world, providing medical and/or education services to the underdeveloped communities anywhere in the world and connecting a summer intern to a prospective employer. However, many issues related to privacy, authenticity of information, safety of the users of SNS and abuse and misuse of SNS services for subversive activities must be resolved.

4.4.12 NG Services Architectures

It is rapidly becoming apparent that all versions of NGN architectures are using, or will be based on Third Generation Partnership Project's (3GPP's) IP Multimedia Subsystem (IMS) architecture. In addition, since it is based on IP and supports multimedia services (voice, video, gaming, conferencing, etc.), IMS can seamlessly integrate with other systems via appropriate adapters/mediators or interworking elements. These other systems could be based on Web or any legacy system.

The concept of IMS originated from 3GPP to support seamless mobility and user identity across wireless carrier domains. IMS is currently being touted as the *de facto* standard[10] for the signaling and control plane of the emerging NGN architecture for converged mobile, fixed, and fixed-to-wireless services. ITU-T defined NGN as an IP-based network. The target is version 6 of the Internet Protocol, or IPv6. IPv6 will seamlessly support QoS, mobility and provisioning for Telecom and other broadband revenue-generating services. The functional entities (FEs) in the IMS layer interact with the applications and feature/services layer FEs to provide advanced or enhanced services to the endpoints. Interconnection of the FEs in the

[10]Almost all of the national and international standards organizations (ATIS, ETSI, Cable Labs, WiMax Forum MSF, ITU-T, etc.) are using IMS as the basis of their NGN architectures.

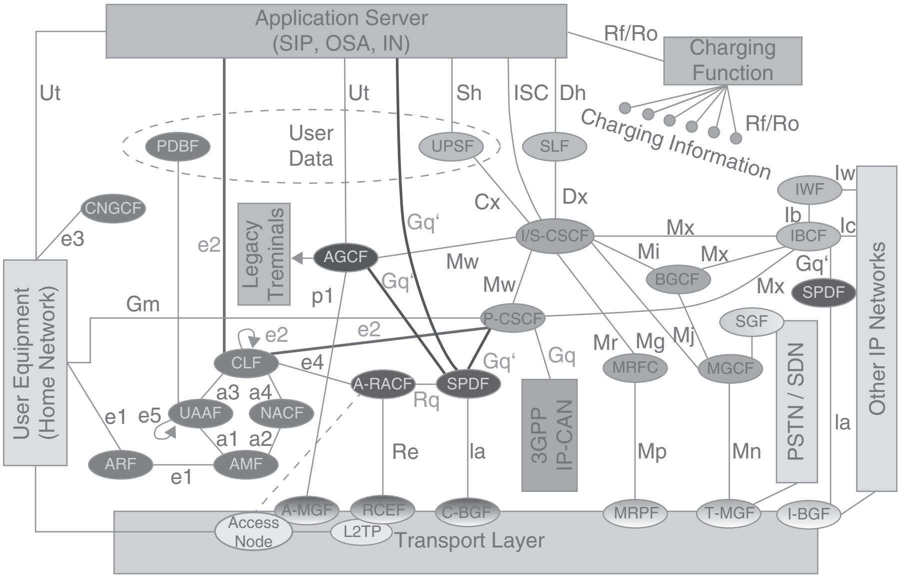

Figure 4-3. A common IMS for Next Generation Networking (Source: 3GPP and ETSI. Please see http://www.3gpp.org/ftp/Specs/html-info/21905.htm for a detailed vocabulary of 3GPP specifications)

IMS layer with NGN transport, legacy PSTN, and IPv4 transport systems is supported by using appropriate border, gateway, and middle-ware functions. In addition to mobility and seamless provisioning, there is a need to support reliability/availability, security/privacy, and regulatory requirements as well as to achieve realistic deployment of new/NGN services using IMS.

Figure 4-3 shows common IMS where IMS core is being augmented by a select set of interfaces and functional elements in order to satisfy wireline, wireless and mobile users requirements. The IMS core consists of user database (user profile server function or UPSF, subscriber location function or SLF, etc.) and proxy/edge, serving, and interrogating call sessions control functions (or P-, S-, and I-CSCF).

Further details on IMS can be found in the 3GPP Website (ftp://ftp.3gpp.org/specs/latest). In addition, note that the following technical specifications (TSs), noted in parentheses, contain information on Architecture (23.002, 23.221), Interworking (29.162, and 29.163), Charging (23.815), Security (33.102, 33.103, 33.203, and 33.210), Evolution of Policy and Charging (23.803), WLAN access (23.234, 24.234, and 29.161), and Fixed Broadband access (24.819). These documents can be readily obtained from the FTP site, ftp://ftp.3gpp.org/specs/latest. ETSI also updates the IMS-based NGN specifications as the requirements change and technologies to implement the requirements are updated (e.g., see portal.etsi.org/docbox/TISPAN/open).

With a common IMS core, it is expected that issues related to Interoperability, i.e., when services cross wireline to wireless domains and vice versa, will be minor. The results of interoperability-of-services when IMS is used in both wireline and wireless domains can be found in MSF's (MultiService forum's) Website (www.msforum.

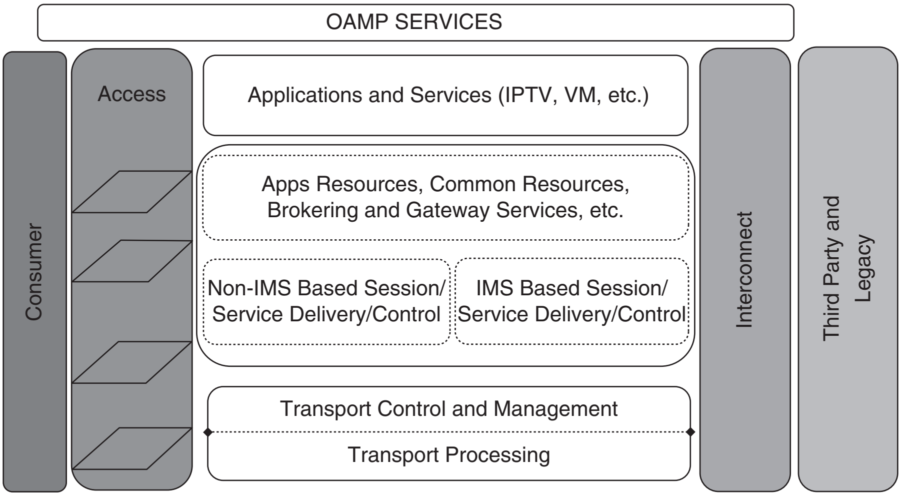

Figure 4-4. MSF Release 4 (R4) architecture template (Source: Multi-Service Forum)

org/interoperability/GMI.shtml). Figure 4-4 shows the planes (strata) and domains of MSF's Release 4 architecture template for converged services implementation across multiple-domains with the option to support consumer access over a variety of wireline and wireless technologies (as shown by the tiles in the access domain). Elements in the interconnect domain provide peering-of-services over untrusted network boundaries and sometimes even support disparate technologies. For voice service interconnection, these disparate elements include voice over IP (VoIP) to time division multiplexing (TDM) voice interconnection, VoIP to VoIP interconnection for different IP addressing (version 4 and version 6) mechanism, and so on.

4.4.13 Application Plane's Requirements to Support NG Services

This section discusses application plane requirements to support NG services, primarily in one administrative and/or technology domain. The network elements in this domain include, for example, location and presence servers, voice mail server, calendar and instant messaging server, call redirect server, IPTV applications server including enhanced program guide server, etc. Users registered in the IMS and non-IMS domains interact through standard interfaces with the servers in this domain via brokers and/or resources/service gateways in order to receive the services they subscribe to or are authorized to use (as shown in Figure 4-4).

4.4.14 Transport Plane's Requirements to Support NG Services

This section discusses transport plane requirements to support NG services primarily in one administrative and/or technology domain. Elements in this domain administer access control and resource management with an objective to satisfy end-to-end service quality management, effectively guaranteeing a higher quality-of-experience (QoE). As shown in Figure 4-4, transport processing is managed from transport control and management, either by using router-/switch-embedded access/resource controller or by using adjunct devices. The adjunct or embedded devices could be policy server, and session border gateway/controller, as discussed in MSF technical reports and implementation guidelines (available at http://www.msforum.org/techinfo/reports.shtml and http://www.msforum.org/techinfo/implementation.shtml).

4.5 MANAGEMENT OF NG SERVICES

As discussed before, development and deployment of Next Generation services, in a cost-effective manner, is becoming increasingly complex. This is because users are demanding a multitude of services over various traditional (wireless and wireline) access and device Interfaces irrespective of the capability or domain of the service providers. NG service providers are expected to deliver voice and video calls over regular TV screens in addition to continuing these services seamlessly to screen-based POTS phone and hand-held devices (PDA, cell phones, etc.) per user's convenience. The task of managing security, quality-and-continuity-of-service, mobility, and billing therefore become enormously convoluted [7].

4.5.1 IP- and Ethernet-Based NG Services

This section discusses next-generation services over IP and Ethernet. Services that are of interest include VoIP, IPTV, and mobile multi-media services and their evolution. Real-time audio, video, and data services demand predictable delay, jitter, and loss (and recovery from loss) in addition to reliability and scalability so that the expected user experience can be satisfied.

IPv4 and IPv6 have many capabilities to support QoS and transmission resiliency for real-time services like voice and live video transmission. Multi-Protocol Label Switching (MPLS), a sub-IP-layer-protocol, has a set of built-in capabilities to support transmission of real-time services. However, the EoS or Ethernet over Synchronous Digital Hierarchy (SDH) or Synchronous Optical NETwork (SONET) is getting more attention recently.

EoS uses encapsulation based on Generic Framing Procedure (GFP) and a combination of virtual concatenation (VCAT) and Link Capacity Adjustment Scheme (LCAS) protocols to efficiently transport real-time traffic over wide area networks. This may help service providers migrate to purely packet-based layer-2 networks. In addition to using the bonding technologies with existing SDH/SONET based circuits, both pseudo-wire-based circuit emulation and synchronized-Ethernet and timing standards such as IEEE 1588 v2/v3 can be used for seamlessly transporting VoIP and IPTV traffic over carrier Ethernet (both wireless and wireline) very reliably. Since EoS is based on layer-1 and layer-2 protocols, it does not need any intervention of higher-layer protocols or equipment to support hitless restoration for maintaining higher service availability.

Since EoS uses GFP with fixed overhead, it is more efficient for bandwidth utilization. GFP supports the ability to send management frames that are used for OAM. In addition, the use of VCAT and GFP can provide byte-level granularity of data to lower latency and jitter by reducing the buffering needs.

The end points in EOS typically do not require expensive and extensive buffering and memory within the equipment because they operate as pure layer-1 and layer-2 transport termination devices to maintain the connections and perform reconvergence using traditional SONET or SDH protocols. EoS can also multiplex bandwidth to deliver higher speed carrier Ethernet based WAN (Wide Area Network spread over geographically dispersed regions) services over multiple service providers networks when used in conjunction with the virtual private LAN service or VPLS.

EoS can offer quality and reliability based on the types of services being supported. For multimedia applications such as streaming media, interactive gaming, or broadcast TV, features like hitless bandwidth adjustment, low latency, and efficient use of bandwidth are of critical importance and EoS can readily support these features.

4.5.2 Performance Management of NG Services

This refers to monitoring and maintaining an acceptable level of performance, not only for the network, but also for the services that are being supported by the network.

Since emerging services use a combination of real- and non-real-time sessions, it is becoming a norm to utilize the deep packet inspection (DPI) feature to securely monitor and manage end-to-end performance of both enterprise and service providers' networks. DPI offers visibility of the session and service, i.e., peer-to-peer, music/game/video download, voice over IP or VoIP, IPTV, etc., that are generating the packets, so that these can be throttled or prioritized. Throttling prevents unauthorized and illegal use of network resources. Prioritization helps maintain appropriate quality of experience for a variety of services to the premium customers. DPI features can be embedded in the existing network elements or separate appliance-based system can be used.

Traditionally, network-level performance parameters that need to be monitored include throughput, utilization, information loss, information transmission delay or response times, variation of information transmission delay, mean-time-to-failure (MTTF), mean-time-to-repair (MTTR), etc., of network links under both nominal and overload conditions. However, since emerging IP-based networks carry both signaling and media (payload) traffic for both real-time and non-real-time sessions and services, the performance management requirements get a bit more complicated.

Commonly used reactive mechanisms are not sufficient. A combination of predictive and proactive performance management mechanisms is required. This is because the emerging converged services networks are expected to support mobility across a variety of wireless and wireline access networks, service quality as the session and/or device roams from one administrative or technology domain to the other, and authentication and security of services seamlessly, without affecting the performance requirements of the session/service.

Finally, interworking with the legacy performance motoring system is also mandatory because it may be frequently required to use data from, or to feed data to, the legacy performance management system for one or more segments of the service.

4.5.3 Security Management of NG Services

Managing security in emerging NG networks is a very complex task. This is due to the drive to support IP-based convergence in both networks and services areas at the same time that hackers are becoming increasingly smart due to openness and ubiquity of the Internet.

Information security solutions must address user, end-point, service, and administration level security without compromising the flexibility and simplicity of use of the network and service. Certain popular networking and service developments or offerings, e.g., peer-to-peer services over Internet, create more vulnerability in networks. Legislative measure alone cannot protect consumers, networks, and services because attacks on networks and services are often triggered by personal frustration and other factors. The challenge is how to operate the networks and services efficiently and cost-effectively without compromising privacy, security, and vulnerability of the services.

What is required here is an open and flexible framework to define service-specific network security requirements, incorporate these requirements into network nodes' and transmission links' design and performance specifications, and test and certify the network and nodal security solutions before deploying these in an operational network. Then continuously upgrade the deployed protective mechanisms to *outsmart* the hackers and network attackers as the technologies evolve!

4.5.4 Device Configuration and Management of NG Services

Managing capability and configuration of customer premises NG devices remotely, including those in enterprise, is an overwhelming task. The situation is more manageable in medium and large enterprises because of an existing process that is routinely followed for upgrading and adding new devices to the system or network. However, in small business and residential locations, the users add/move/modify devices sometime knowingly and on other occasions download plug-ins for the target services even without any direct knowledge of those plug-ins. The latter situation often causes malfunction and system-level crashing of the devices.

To overcome these problems, various standards organizations are creating forums and focus groups, and a few of these are described below. ATIS recently established the Home Networking or HNet Forum (www.atis.org/HNET). The objective is to develop specifications and guidelines for interconnecting IP-based NG home appliances/devices/system by using the emerging technologies so that the services can be delivered seamlessly.

The Broadband Forum (www.broadband-forum.org/technical/trlist.php) has released a number of technical reports (see, e.g., TR-064, TR-069 and its addendums,

TR-098, TR-104, TR-106, TR-111, TR-135, TR-140, and TR-196) covering networked server-based management of configuration of customer premises devices including those at homes. Home-based devices include voice over IP gateway, set-top box (STB), etc.

The HomeGrid Forum (www.homegridforum.org) is working to promote ITU-T's G.hn Standards for using unified wireline MAC/PHY specifications for enabling service providers and consumer electronic device manufacturers to deliver services to connected homes cost-effectively. These will allow the network access and service providers (Telcos or cablecos) to actively monitor home networks and devices at home to identify and resolve problems proactively.

Note that for wireless devices, service providers commonly utilize proprietary mechanisms to activate and upgrade devices through over-the air interface to the device and by using special codes (keys) and ports, and this trend probably needs to be reversed to provide more flexibility to the customers.

4.5.5 Billing, Charging, and Settlement of NG Services

Various paradigms of billing and charging are being discussed in Standards organizations, i.e., online (real-time) and offline (batch processing) methods of charging are the most common and useful ones. In this era of globalization, no service provider is an island, and hence it is highly desirable that one unified settlement scheme be used among service providers to support seamless mobility and consistency of services. Both policy-based service management and service-type based policy can be used to openly settle payment among the service providers. However, utmost caution must be exercised to avoid any sort of service degradation due to irregularity of settlement mechanisms.

4.5.6 Faults, Overloads, and Disaster Management of NG Services

The distributed mode of operation of emerging digital packet-based networks makes networks less vulnerable (an advantage) and at the same time less manageable (a drawback) in a centralized manner. However, certain technologies and their advancement are simplifying faults, disaster, and overload (FDO) management. These technologies include software as a service (SaaS) and platform or hardware as a service (P/HaaS), driven by virtualization and the emerging grid-computing methodologies. These enablers allow service providers to have a tool-kit based approach to end-to-end health and welfare monitoring, including analyzing the collected data. The objective is to provide service-level reporting, and management of the network, making the assurance of service delivery a minuscule derivative of the entire scheme.

4.6 NEXT GENERATION SOCIETY

With the advancement of next generation technologies and their deployment in networks, services will be more sensitive [8] to the media, context, personality, and location of the user, in addition to being more automated in operations. These are expected to contribute to developing a more relaxed and enjoyable lifestyle irrespective of whether the computing and communicating services are being used for work or play or entertainment. Societies must pay close attention: these capabilities must add to human development, not subtract.

Both technologist and policy maker will have roles to play in this new technology-dominated society and environment. For example, employees of the NG service providers must learn and demonstrate both depth and breadth of the subject matter of concern. A router engineer must also have working knowledge of the optical transport layer and storage or data center requirements. In addition, the technology life cycle is also shrinking every year, and sometimes the first-generation technologies (ISDN, analog hi-definition video, ATM, etc.) are nothing but false starts! Technology transformation drives both the communications and entertainment transformations, and these in turn make the entire society more vulnerable, unless these are transformations implemented/executed cost-effectively and responsively.

4.6.1 NG Technology-Based Humane Services

As NG technologies mature, we will see increasing use of automation. Application of these new technologies in services that humans touch and expression of and reaction to feelings, are of utmost importance. These include patient care in hospitals and elderly care in nursing homes, hospitality services' attendants, and first responders in harsh environments. One feasible option would be to continuously augment—not completely replace—these service attendants' jobs by automated NG technology based gadgets. Of course, the human attendants must be continuously trained to keep themselves up-to-date to compliment their NG-technology based counterparts—the machines and gadgets.

4.6.2 Ethical and Moral Issues in Technology Usage

It is often said that conscientious minds will always develop technologies and utilize them for harmonized evolution of civilization [9], maintaining proper sustainability of the society. Since peace and harmony really matter in this globalized era, societal progress must happen through harmonized use of technologies and services in a peaceful manner. For every technology, and the system based on that technology, there must be a set of methods and mechanisms to trace and prevent abuse and misuse of the NG technology-based services. NG digital copying technologies must have built-in copyright protection and audit trail support mechanisms to prevent theft, and so on.

Yes, of course, the technologist must stay a few steps ahead of social progress but not at the cost of social discontentment. For example, would not it be great to invest in developing a workforce that is optimized to satisfy evolving societal requirements? Why not invest in educating the emerging workforce in areas in which there will be demand for jobs and services in the society. A statement of caution is that cross-pollination of ideas and techniques from one discipline to others is acceptable only when it is executed with moderation. Recent development and subsequent smashing of the economic bubbles in Internet working, real estate, and financial sectors should be treated as painful reminders and lessons from irresponsible behaviors and irrational expectations.

To that end, development of technologies that reduce waste and utilize more of (a) recyclable materials and (b) renewable energy sources should be encouraged. This may call for development of (a) recyclable components based network elements and (b) wind-, solar-, and other ambient-source-based energy cells which are more efficient for use in network elements and communication/entertainment devices. It will also be extraordinarily helpful to encourage the use of more of the earth-friendly, i.e., free from harmful toxic supplements and materials in manufacturing network elements, connection servicing devices (human-friendly wireless links may be the best), customer premises equipment, and user (e.g., hand-held) devices.

4.7 CONCLUSIONS AND FUTURE WORKS/TRENDS

Telecommunications is over a trillion-dollar industry today. The growth of ubiquitous high-speed wired and wireless broadband access coupled with high-definition audio, video, and other digital multimedia services across a multitude of devices will cause meteoric rise of traffic in the network over the next five years. A tremendous socio-economic opportunity therefore lies ahead, and everyone involved must act *responsively*.

Communications being done via texting today will be achieved using variable resolution video and multimedia messages over adjustable (flexible) extended-size screens. Consumers will increasingly play the roles of producers of information and entertainment, and these activities will make the traffic flow across the access lines more symmetrical. In addition, many users may be uploading and downloading contents at the same times, and that will significantly reduce the bandwidth utilization gains from traditional statistical multiplexing. This mode of operation may call for a revised design of the traditional capacity planning methods and tools.

Next generation networks, therefore, must be capable of supporting features and functions beyond supporting merely the emerging IP networking technologies and offering the legacy PSTN and TV services. Of particular interest are the following: (a) reduction of cost and complexity and cost via unified support of self-managed (or autonomous) scalability of network and services, (b) graceful deployment of open, ubiquitous, and transparent networking with high degree of support for privacy and security, (c) seamless support of virtualization to offer location- and identification-independent on-demand applications, (grid computing) services, and entertainment—including gaming, super-high-definition, and three-dimensional movies, using the already deployed and available networked resources, and (d) increasing the use of earth-friendly materials in communications and entertainment devices, and simultaneously making these devices and the supporting elements more energy-efficient.

The emerging next generation of businesses and services will be based on secure personalized broadband social networking applications supporting human-to-machine and machine-to-machine communications in context-sensitive fashion. The personalized communication devices will be media and service aware, just like the network elements will be, and will continuously adapt the configuration (via virtualization) and communication bandwidth in order to maintain the quality of experience for the service being used. The service can range from monitoring premises to the health of a patient, sharing stored and live video sessions with friends remotely, taking the personalized network and service to anywhere in the world using, e.g., the evolved DLNA (Digital Living Network Alliance, www.dlna.org) specifications, and so on.

4.8 REFERENCES

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