Broadband Integrated Services over Proposed Open CPE Architecture

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Abstract— **Over the decades, due to technology limitations and regulatory restrictions, information services have been delivered to subscribers through multiple service providers. In recent years, however, the advancement of digital communication technology, the passing of the 1996 Telecommunications Act in the U.S., and the emergence of the Internet are driving network convergence. As a result, the industry is calling for the consolidation of an integrated Customer Premises Equipment (CPE) in the customer's premises to provide integrated services, such as multi-media, voice, and data services. However, the ever-changing network standards and competing technologies not only confuse carriers, but also prevent them from committing to massive CPE deployment.**

In this paper, the problems carriers face in the deployment of integrated services over broadband are first described. In order to remove these deployment obstacles, and also to create new value-added services, service models are investigated and an open CPE architecture is proposed that will support the wide range of broadband access technologies and ever-changing network standards.

Index Terms—**Integrated Services, Broadband, VoIP, PSN, SoftSwitch Model.**

I. Introduction

The convergence of voice and Internet data traffic also calls for new Customer Premises Equipment (CPE) such as Digital Subscriber Lines (DSLs), modems, cable modems, and wireless modems that provide users with broadband access to the Internet. However, instead of adding new CPE to the home, the industry is moving towards consolidating CPE into an Integrated CPE (I-CPE) to help lower the cost, reduce network management complexities, and improve the efficiency of network resources. The I-CPE is also called an Integrated Access Device (IAD) and a Residential Gateway (RG) when used in residential areas. In this paper, the term I-CPE is used, because I-CPE is intended to serve multiple market segments including residential, Small Office Home Office (SOHO), and small businesses to provide integrated services such as voice, multi-media, and Internet access.

While the upgrade of the network infrastructure is well underway, the deployment of I-CPE remains a big obstacle to the delivery of integrated services over broadband due to the volume and time that are required for the deployment. It was believed that the lack of auto-configuration was the main roadblock to massive I-CPE deployment. However, the largest obstacle today is not so much how to deploy I-CPE but rather, which type of I-CPE the carriers should be deploying, because this telecommunication world is filled with too many standards, e.g., Media Gateway Control Protocol (MGCP), H.248 [7], H.323, Session Initiation Protocol (SIP), Voice over Internet Protocol (VoIP), Voice over ATM (VoATM), etc.; and competing technologies, e.g., DSL, Cable, Wireless, Fiber, Ethernet, HomeRF*, IEEE 802.11, Bluetooth, etc. As a result, carriers are facing great difficulties in choosing an I-CPE for deployment because they fear it being replaced in the near future.

II. THE NEXT-GENERATION NETWORK INFRASTRUCTURE

Unlike the dial-up modem, the introduction of I-CPE will require major upgrades in the infrastructure of the existing network. The new network is intended to support the convergence of the voice-centric Public Switched Telephone Network (PSTN) and the Internet, and it is commonly referred as the Next-Generation Network (NGN). The NGN is based on the distributed Softswitch architecture in which the call control is separated from the media transport. Figure 1 shows the role of I-CPE in the NGN infrastructure. It indicates that an I-CPE is the portal to a customer's premises and it acts as the gateway to interconnect the Local Area Network (LAN) with the Wide Area Network (WAN), which consist of the Access Network and the Core Network [6]. The Access Network, consisting of Access Nodes, Regional Broadband Networks, Transit Gateways, and Because of the passing of the Telecommunications Act in 1996 and the FCC's ongoing adventures in local loop deregulation, companies, including Inter-eXchange Carriers (IXC), Incumbent Local Exchange Carriers (ILEC), Competitive Local Exchange Carriers (CLEC), CATV service providers, and many other emerging service providers, are all eager to enter this lucrative broadband access business. Therefore, it is certain that I-CPE will support various broadband interfaces, such as wireless, cable, xDSL, and fiber optics, to target different market sectors depending on price, performance, environment, or the type of users. Then, the recent advancement of IEEE

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80.3ae 10 GigE standard [13] enables the Ethernet to work beyond the LAN. Thus, an I-CPE may also support Ethernet broadband interface to the WAN. Access Nodes terminate the broadband interfaces from I-CPE and aggregate multiple CPE traffic to the Regional Broadband Networks. Regional Broadband Networks provide transport and switching functions among Access Nodes and Transit Gateways. Transit Gateways may consist of Trunking Gateways and Signaling Gateways that perform signaling and bearer interworking functions between Regional Broadband Networks and PSN/CSN.

An MGC is also referred to as the Call Manager or Softswitch that typically runs call control software in a server to provide call-processing functions. In the distributed Softswitch architecture, the value-added services or applications can reside in an Application Server. A Media Server is controlled by the Softswitch to play tonal announcements or perform media streaming functions, such as Interactive Voice Response (IVR) and Conference Bridge. The media streaming is carried in bearer connections between the Access Node and the Transit Gateway for on-net calls, or between Access Nodes for off-net calls, while call control functions are provided by an MGC. GigaPoP (i.e., Point of Presence) aggregates the traffic from Ethernet CPE to PSN [14]. It should be noted that the NGN architecture shown above is meant to be logical, so the Access Nodes, Transit Gateways, Media Server, Application Server, and MGC are logical functional blocks which may be implemented as stand-alone devices or embedded in other network elements.

The Media Gateway Controller (MGC), provides the ramp to Packet-Switched Networks (PSN) and Circuit-Switched Networks (CSN).

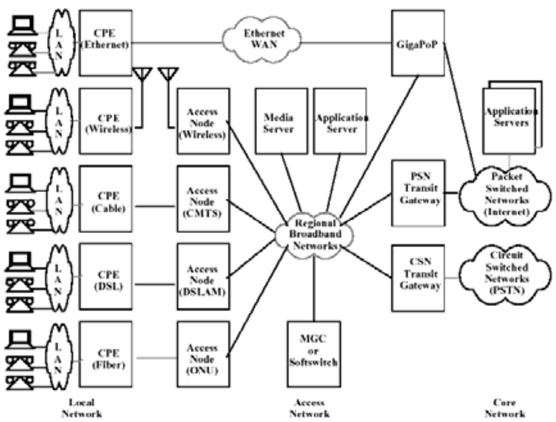

Figure 1: Next-Generation Network infrastructure

III OPEN CPE ARCHITECTURE

Broadband access is, for many, the solution to the "World Wide Wait" problem (slow Web performance), and it would also enable the creation of many new services that promise enormous benefits to subscribers and service providers. However, service providers are facing many challenges during the deployment of broadband access networks, not least of which is how to deploy the greatest number of Customer Premises Equipment (CPE) in the timeliest manner.

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A. I-CPE Characteristics

The following characteristics of the Integrated Customer Premises Equipment (I-CPE) architecture are important to the resolution of these deployment problems.

- *Open Architecture*–In the past several decades, open architecture has become the trend in the industry. It started with the computer industry in the early 80s, and it gradually spread to the telecommunication industry, where the monolithic central office switch is under great pressure from the Internet telephony to open up. The broadband CPE industry will not buck this trend since openness will only foster new services and product competition, which, in turn, will lower CPE cost, reduce time-to-market, and inspire innovation [3].
- *Flexibility*–The ever-changing network standards and infrastructures, the wide range of access network technologies, and the uncertainty of which value-added service will emerge in the future make it very difficult to have a fit-it-all CPE architecture. Thus, the I-CPE should be flexible to contain the must-have core features needed to support today's services, yet it should still be able to accommodate future upgrades. Flexible architecture will lower CPE costs, something that is crucial to I-CPE being accepted in the cost-sensitive consumer market. For example, an I-CPE might be designed to provide home automation and security services, but the interface standards as well as the functionalities to control home appliances have yet to be defined. The flexible architecture needs to be able to accommodate a Bluetooth wireless modem plug-in and the necessary software that will need to be added to the CPE to support this feature when the standard and technology become available.
- *Value-Added Services* - Each time a new service or technology is introduced, it needs to be perceived by the public as adding value in order that it will be bought and used. Due to the competition from Internet telephony, the cost of toll telephony services is continually decreasing. Soon, it is believed, you will be charged a flat monthly rate for telephone services instead of being billed on a per-minute basis. Therefore, the driver for the Next-Generation Network (NGN) is not about inventing a new way to provide existing services, but focusing on value-added services such as Presence, Voice Web, Voice Portal, Unified Messaging, and Voice Virtual Private Network (VPN), which hold great potential for generating additional revenue for service providers.

B. Integrated CPE Functional Decomposition

Figure 2 shows the Open CPE architecture that is intended to fulfill the requirements as listed above and to support multiple broadband access technologies and telephony protocol standards. It is composed of a CPE Controller Module (CCM), LAN Interface Modules (LIM), and WAN Interface Modules (WIM). The CCM consists of a CPE Controller, Flash, ROM, and RAM that contain a Real-Time Operating System (RTOS) and software to implement telephony call control, network management, and service logic functions, as well as third-party applications. The CCM may also include a Digital Signaling Processor (DSP) to implement media streaming processing functions, such as vocoder, echo cancellation, tone generation and detection. The CCM can be re-configured to support different protocols or telephony standards through software downloading.

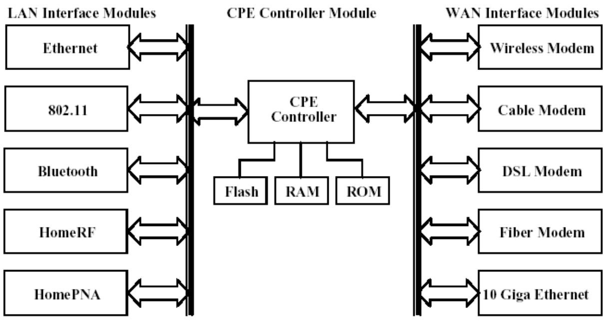

Figure 2: Open CPE architecture

WIM and LIM contain plug-ins to support various WAN and LAN interfaces. WIM may consist of a Wireless Modem , a Cable Modem, a DSL Modem, a Fiber Modem, and a 10 Gigabit Ethernet module that provide interfaces to the broadband access network. LIM may include interfaces to analog phones. There are two buses responsible for the distribution of user data, real-time voice streaming, control signaling, and the management data between the CCM Controller and the WIM/LIM. The interface specification should meet the requirements of transporting real-time and non-real-time data. The open CPE architecture as described above is derived from the abstraction of multiple CPE platforms that may use various broadband access technologies and standards. The goal of the abstraction is to find out what functions are common to all CPEs and therefore should be implemented in CCM, and what functions are interface dependent. and therefore are more appropriately implemented in plug-in modules. Figure 3 gives an example of the CPE functional decomposition. It depicts the protocol stacks of I-CPE supporting cable, xDSL, and 10 Gigabit Ethernet broadband interfaces to provide voice and data convergence services.

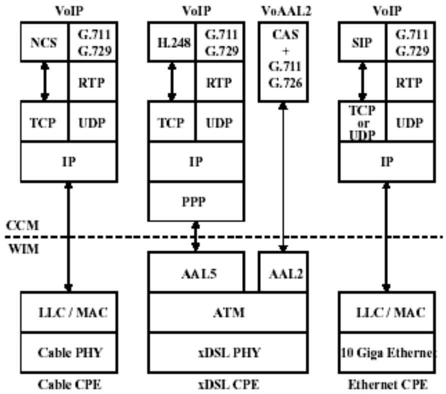

Figure 3: I-CPE protocol stack

The Cable CPE is intended to provide VoIP services. It uses Network-based Call Signaling (NCS) [4] as the signaling protocol to perform telephony call control functions, while encapsulating the voice streaming data in the Real-Time Protocol (RTP) packets to be sent to the Cable Modem Termination System (CMTS). xDSL CPE provides VoIP and Voice over AAL2 (ATM Adaptation Layer type 2) Loop Emulation Services (LES) [5]. It uses H.248 [7] and Channel Associated Signaling (CAS) protocols to implement telephony call control functions for VoIP and VoAAL2, respectively. The voice streaming data are encapsulated in either RTP or AAL2 packets to be sent to the DSL Access Multiplex (DSLAM). In this example, the Ethernet CPE acts as a SIP client to provide VoIP services. SIP is used to establish, modify, and terminate multi-media sessions and calls [10]. The voice streaming is encapsulated in the RTP packets transmitting to the terminating party via the User Datagram Protocol (UDP) connection.

In the Time Division Multiplex (TDM) networks, only call control and management functions are implemented by software in the processor, leaving the voice processing to be handled by the hardware, because of the latency concern.

However, the trend toward packet telephony, along with the advancement and increasing performance of processors in recent years, has made it possible for, and even demanded that, voice streaming be processed by software. Thus, as Figure 3 indicates, it makes good sense to locate the CCM-WIM interface between Layer 2 and Layer 3 of the protocol stack. The CCM contains software to implement voice processing, the signaling protocol, and management functions. WIM should implement Physical layer (PHY), Medium Access Control (MAC), Logical Link Control (LLC), Asynchronous Transfer Mode (ATM), and ATM. Adaptation Layer (AAL) functions that are closely coupled with each broadband access interface.

IV. CONCLUSION

The explosion of the Internet along with regulation and technology changes are reshaping telecommunication networks in many ways. The industry is moving toward the convergence of PSTN and the Internet. The converged network, the NGN, will operate in a very similar way to the Internet topology in which central office switches are decomposed into distributed systems that are based on the Softswitch model. As a result, the NGN will no longer provide transport services between telephone equipment (as PSTN previously did), but will provide personalized multi-media services. This convergence of voice and Internet data traffic also calls for the deployment of I-CPE to provide integrated services. However, the ever-changing network standards and competing technologies not only confuse carriers, but also prevent them from committing to massive CPE deployment, because they are afraid that the CPE just deployed will have to be replaced in a few years. Hardware replacement is very common in the PC and cellular phone business when new standards or technologies are introduced, but it presents a big threat to the wireline broadband business because CPE deployment is such a daunting task that it cannot be completed easily. In this paper, I proposed an open CPE architecture to solve the CPE deployment dilemma. The architecture is very flexible and can support multiple WAN/LAN technologies and IP Telephony standards. It also includes a common API to allow users to customize or even create new services and third-party developers to create new applications and services. The open CPE architecture will allow CPE vendors to lower costs and reduce time-to-market, and most importantly enable service providers to provide many value-added services that promise great potential for generating additional revenue

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Kushal Roy, born in M.P Republic of India on December 13th 1979, received his Bachelors Degree with *Honors* in Electronics and Communication Engineering form Government Engineering College Ujjain, M.P India, in the year 2002, achieved his Master’s Degree M,*Phil* in Instrumentation from Indian Institute of Technology Roorkee, U.A Republic of India in the year 2004 with nano scale instrumentation and opto instrumentation as major fields of study.

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