♦ The PathStar™ Access Server: Facilitating Carrier-Scale Packet Telephony

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The maturation of large-scale Internet protocol (IP) routing and the standardization of voice over IP (VoIP) protocols have accelerated the deployment of packet telephony products in the public network. Service providers such as the Regional Bell Operating Companies, competitive local exchange carriers, multiple system operators, and Internet service providers (ISPs) are beginning to seek out next-generation products to consolidate voice, video, and data onto converged packet-based networks. To address this market, Lucent Technologies has developed and introduced a suite of data networking and packet telephony products, one of which is the PathStar™ Access Server. This revolutionary new product integrates Bell Labs software innovations such as the Inferno® operating system with access and interconnection technologies developed by the Switching, Access, and Data Networking areas of Lucent Technologies. The PathStar Access Server combines the functionality and features of traditional circuit switches with advanced packet routing techniques to enable end-to-end converged network solutions. This paper presents an overview of the PathStar Access Server and briefly explores its hardware and software architectures.

Introduction

This paper explores a product that enables network convergence to a greater degree than previously possible with either traditional voice switches or newer voice over Internet protocol (VoIP) products. The PathStar™ Access Server is the result of computing innovations from Bell Labs and the application of telecommunications expertise from Lucent Technologies' Switching, Access, and Data Networking groups. This equipment provides an end-to-end data and voice solution, which begins at the customer premises. As this paper will demonstrate, the PathStar Access Server is—unlike most VoIP or data products—a complete package: it terminates local subscriber loops, provides routing and switching, interconnects data and voice networks, and also offers the sophisticated administrative and billing tools desired by service providers.

The next two sections briefly examine the carrier network architectures in place today and describe the challenges service providers face in providing customers with enhanced voice and data solutions. The later sections of this paper present a description of the PathStar Access Server, a system overview, a high-level look at its hardware and software architectures, some sample configurations, and a look at future directions.

Background

Historically, voice traffic has been carried on circuit-switched networks consisting of digital switches and time division multiplexed (TDM) interoffice trunks. Subscriber "plain old telephone service" (POTS) calls are routed within the public switched telephone network (PSTN) by an intra-exchange network or handed off to a long-haul toll network using tandem switches. With the need to interconnect corporate local area networks (LANs) in the early 1980s, separate overlay packet networks—many specifically built to carry the transmission control protocol/Internet protocol (TCP/IP) suite—were put into place by ser-

Panel 1. Abbreviations, Acronyms, and Terms

AAL-5—ATM adaptation layer, type 5
ADSL—asymmetric digital subscriber line
AFM—ATM feeder multiplexer
AMA—automatic message accounting
ASIC—application-specific integrated circuit
ATM—asynchronous transfer mode
BAF—Bellcore Automatic Message Accounting Format
BGPv4—border gateway protocol, version 4
BORSCHT—battery feed, overvoltage protection, ringing, supervision, codec, hybrid, testing; loop plant switching functions
BRI—basic rate interface
CDR—call detail record
CE—Common Enterprise
CLIP—classical IP over ATM
COMDAC—common data and control
CP—call processor
cPCI—compact peripheral component interconnect
CPU—central processing unit
CSP—communicating sequential process
DLC—digital loop carrier
DMA—direct memory access
DRAM—dynamic random access memory
DS1—digital signal level 1, transmission rate of 1.544 Mb/s
DS3—digital signal level 3, transmission rate of 44.736 Mb/s
DSP—digital signal processor
DTMF—dual tone multifrequency
DVMRP—distance vector multicast routing protocol
E1—European carrier
EM—element manager
EOC—end of call
IETF—Internet Engineering Task Force
IGMP—Internet group management protocol
IP—Internet protocol
ISDN—integrated services digital network
IS—intermediate system
ISP—Internet service provider
ITU-T—International Telecommunication Union-Telecommunication Standardization Sector
LAN—local area network
LANE—local area network emulation
LCOS—Line Card operating system
MIB—management information base
MOSPF—multicast open shortest path first
NIC—network interface card
OA&M—operations, administration, and maintenance
OAM&P—operations, administration, maintenance, and provisioning
OSPF—open shortest path first
PBX—private branch exchange
PCI—peripheral component interconnect
PCM—pulse code modulation
PHY—Open System Interconnection physical layer
PIM-sparse—protocol independent multicasting, sparse mode
POTS—"plain old telephone service"
PPP—point-to-point protocol
PRI—primary rate interface
PSTN—public switched telephone network
QoS—quality of service
RAS—remote access server
RFC—Request for Comments, a standard of the Internet Engineering Task Force
RIP—routing information protocol
RSVP—resource reservation protocol
RTP—real-time protocol
SBC—single-board computer
SNMP—simple network management protocol
SOC—start of call
SONET—synchronous optical network
SS7—Signaling System 7
TCP—transmission control protocol
TDM—time division multiplexer
TOS—type of service
TTP—trunk-to-trunk protocol
UDP—user datagram protocol
VoIP—voice over Internet protocol
WAN—wide area network

vice providers. At first, these "overlay networks" were easy to manage, because the base of business users needing wide area network (WAN) services was at that time small.

The picture began to change in the late 1980s, however, with the ballooning desire to interconnect corporate backbones. This in turn drove the development and implementation of new technologies such as

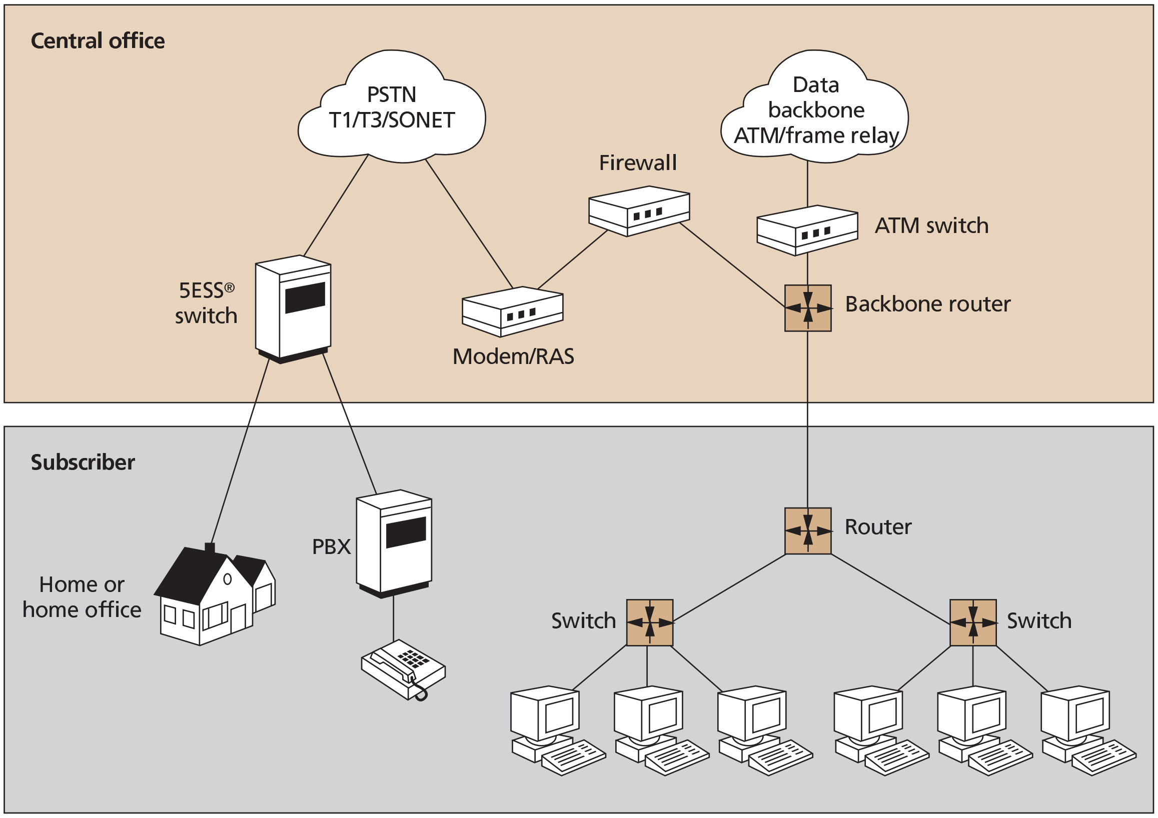

Figure 1.
Today's network architecture.

frame relay and asynchronous transfer mode (ATM). During that period, packet-based data equipment gained a respectable foothold in the historically voice equipment-centric central offices of service providers. More recently, however, the explosive growth of individual Internet usage has greatly accelerated capital investment in data transport hardware. Attending to this rapid growth has led the service providers to the following reactive, iterative process. First, service providers purchase additional circuit-switch-based subscriber access equipment to handle the large influx of requests for second POTS lines. Second, routers, switches, and similar "data-specific" equipment are brought in to manage the flow of Internet traffic from individual subscribers to Internet service providers (ISPs) and to the Internet. Finally, separate operations, administration, maintenance, and provisioning (OAM&P) systems are introduced to manage customer traffic, to provision equipment and data transport facilities, and to perform call routing, billing, and fault recovery. This process is then repeated every six months. More access lines lead to bigger switches and routers, and to additional administrative systems.

For example, dial-up remote access currently requires a large investment in both packet switching and circuit switching hardware. In today's network architecture, shown in **Figure 1**, a remote access server (RAS) functions as a bridge between a traditional circuit-switched network and a data network. A class 5 circuit switch, such as Lucent's 5ESS® switch, provides local loop access and converts analog signals into pulse code modulated (PCM) data samples. The

RAS takes inbound PCM channels, terminates point-to-point protocol (PPP) using banks of digital signal processor (DSP)-based modems, and then hands off IP data to a router for interconnection with the Internet.

Implications

In the last decade, service providers have constructed massive overlay data networks specifically suited to transporting packet-based data traffic. This situation poses serious economic issues. For example, this second infrastructure is expensive, in terms of equipment and operational administration. These factors appear on the bottom line of a service provider as increased operating costs. As Internet growth continues on a trajectory analogous to Moore's Law, it is clearly necessary to offer both voice and data services in a more economical fashion than the overlay network scheme currently allows. However, a service provider's goal of ubiquitous converged voice and data services using common equipment appears distant in light of today's product offerings. Even worse, current VoIP solutions generally entail interconnecting various pieces of equipment from numerous vendors. Meanwhile, existing multiservice products lack the system scalability, voice or data flexibility, hardware robustness, and OAM&P sophistication needed by service providers.

Finally, all the presently available "converged" voice and data solutions miss the mark in one important area—access. The packet-based telephony hardware currently being marketed does not terminate copper subscriber loops. Instead, service providers continue to rely on circuit-switch-based equipment for customer access—a situation Lucent's competitors are focused on changing. Clearly, something better is needed to address access for multiservice networks.

The PathStar Access Server

Lucent's answer to the need for subscriber access to converged voice and data networks is the PathStar Access Server. This product combines the functionality and features of traditional circuit