Circuit Emulation in Broadband Access: Converging TDM/Data on the Last Mile

by Tao Lang, Zarlink Semiconductor

The "last mile" has advanced into the broadband era, thanks to higher bandwidth demands from enterprise and residential customers. There are few technologies that can boast the same adoption rate as broadband access. In the 12 months to June 2004 alone, 43 million broadband lines were rolled out worldwide. More than 50% of homes in South Korea, Canada and Hong Kong have a broadband connection.

However, the broadband revolution is posing last mile challenges for today's carriers, as they juggle the need to support traditional voice and TDM services with growing demand for new packet-based applications. Circuit Emulation Services (CES)-over-Packet is one approach offering a promising solution.

Today's broadband access services are delivered through copper, fiber or radio links, using technologies such as DSL, HFC (Hybrid Fiber/Coax), PON (Passive Optical Network) and Wi-MAX (Worldwide Interoperability of Microwave Access). With data services driving increased bandwidth demand, most broadband access technologies are built on a packet platform.

While carriers roll out broadband services, they cannot ignore the lucrative revenues gained from traditional voice and TDM services. With the goal of converging all services on one access line, a TDM circuit's distinct synchronization and constant bit rate demands are incompatible with the asynchronous, "bursty" packet network.

As part of our series introducing CES-over-Packet and potential applications, this article looks at how this technology can solve last mile challenges today.

CES-over-Packet

CES-over-Packet is a simple and cost-effective solution for "tunnelling" TDM circuits through a packet-switched network by encapsulating TDM content into IP or Ethernet packet payloads. Both TDM signaling and synchronization are carried along with the data, eliminating the cost of complex signal translation or external timing distribution. A CES-over-Packet Inter-Working Function (IWF) connects TDM circuits to a packet network, where the TDM circuit could be a T1/E1 link, a T3/E3 link or NxDS0 channels.

Fig. 1 illustrates a generic broadband access network with CES-over-Packet deployment. Between the remote terminal (RT) and the central office terminal (COT) is the broadband access line. Circuit Emulation is running between the CES-over-Packet IWF blocks located in both RT and COT. Depending on its location, the RT usually provides T1/E1, fractional T1/E1 or POTS interfaces, along with some Ethernet drops.

The COT, upon receiving packets from the RT, first separates data traffic and CES-over-Packet traffic. Data traffic is routed to the WAN or MAN data network, while CES-over-Packet traffic is reassembled back to the original TDM circuits. These TDM circuits are further aggregated into a high-speed PDH or SONET/SDH link connected to the PSTN. The two traditionally separate paths -- one for accessing the PSTN, and the other for accessing the WAN -- are merged on to a single broadband link.

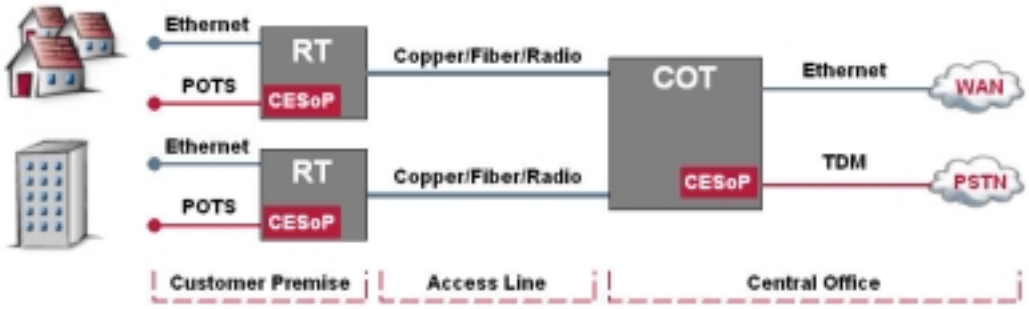

Fig. 1: Broadband Access Network with CES-over-Packet

Although CES-over-Packet can be deployed in a wide range of networks, its commercial and technical capabilities are well suited for broadband access networks.

Carrier Benefits
The access business is a carrier's "cash cow," and it tries to squeeze every last penny from its access lines by offering as many services as possible.

With CES-over-Packet, convergence is only happening on the access link, or the so-called last mile. Using CES-over-Packet, the two PSTN and WAN access lines that were previously required can be replaced with a single cable or fiber line. TDM circuits still enter the traditional PSTN for call processing and switching.

For incumbent carriers, this allows them to maintain their investment in the PSTN until they are absolutely ready to move to a VoIP infrastructure. In greenfield developments the technology allows a single cable or fiber to replace the two PSTN/WAN access lines.

For CLECs (Competitive Local Exchange Carriers) or ISPs, CES-over-Packet allows them to offer "triple play" services without requiring a TDM or circuit-switched infrastructure. All they need is a broadband link and access to the PSTN. For example, a CLEC who once offered just DSL service could now offer T1/E1 leased line service through CES-over-Packet, although they would have to lease another T1/E1 from the PSTN to complete the connection. The key point is that, by offering more than one service or a service bundle, the CLEC now owns all revenue from the customer.

Enterprise Benefits
CES-over-Packet provides the enterprise customer with a longer-term return on its TDM equipment investment, from its PBX to the phone set on the employee desk. With more and more carriers, or ISPs, able to offer TDM services, customers can evolve towards VoIP at their own pace.

Technical Feasibility

The performance of CES-over-Packet relies heavily on the underlying packet network. Characteristics such as packet loss rate and packet delay variation play a large role in the performance of emulated TDM circuits. Characterizing a large-scale packet network, such as a public Metro Ethernet network, is sometimes difficult, resulting in some skepticism on the viability of CES-over-Packet deployments.

However, such skepticism evaporates in the case of a broadband access network, where the packet connection is either point-to-point, or point-to-multipoint. The access link between the CPE and CO is typically a structured, fully-managed, high-bandwidth, low-latency packet network: an ideal situation for CES-over-Packet implementation.

Maintenance
CES-over-Packet technology operates at a minimum cost; a feature inherited from the underlying packet network and the provision of a T1/E1 circuit is almost like plug-and-play. In comparison, provding a T1/E1 circuit in a SONET/SDH link is not trivial.

Interoperability
The framework of a CES-over-Packet implementation agreement was initiated by the IETF PWE3 group. Currently, ITU, IETF, Metro Ethernet Forum and MPLS Forum have either ratified, or are in the last stage of proving, the standards for implementing CES over IP, MPLS or Ethernet networks. These standards warrant the interoperability of CES-over-Packet implementations from various CPE or CO vendors, making it economically sound for broadband access applications.

CES-over-Packet In the Broadband Network

CES-over-Packet can be deployed across virtually any broadband access line or network that transports IP packets or Ethernet frames. Three technologies are illustrated below.
EPON (Ethernet Passive Optical Network)

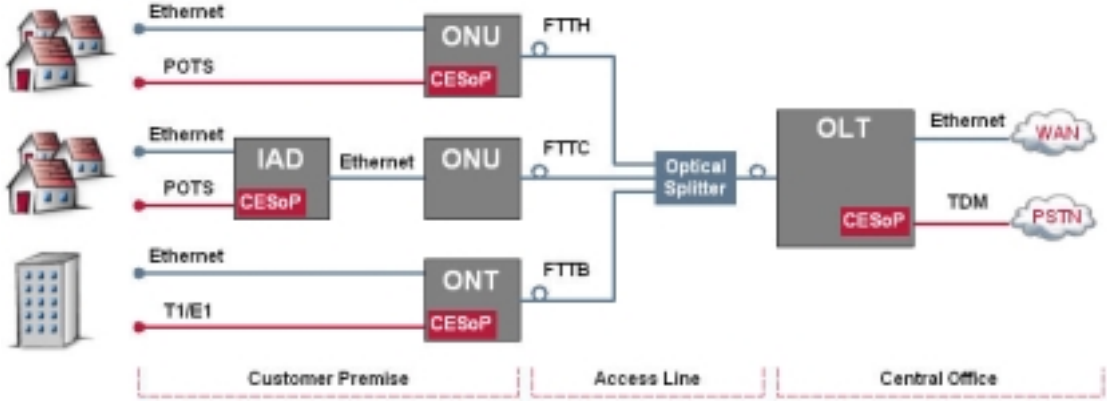

Fig.2: EPON with CES-over-Packet

Among the various PON technologies, EPON is best suited for CES-over-Packet due to its Ethernet nature. An EPON system provides much higher bandwidth than copper-based broadband access, making it ideal for delivering multiple T1/E1 or even T3/E3 circuits. The delay in EPON is usually small: less than 1 ms from OLT (Optical Line Terminal) to ONU/ONT (Optical Network Unit/Termination), or less than 2 - 3ms for the reverse path.

Through dynamic bandwidth allocation and transmission scheduling, EPON also supports Quality of Service (QoS) demands that allow CES-over-Packet traffic to meet carrier-grade TDM performance requirements.

For fiber-to-the-home (FTTH), CES-over-Packet is implemented in the home ONU to provide POTS interfaces. For fiber-to-the-business (FTTB) or fiber-to-the-curb (FTTC), CES-over-Packet is either implemented in the ONT to provide T1/E1 interfaces, or in the home IAD (Integrated Access Device) to provide POTS interfaces. In the latter case, residents can connect IADs to the ONU by using Fast Ethernet and RJ45 cable, the most economical copper solution.

DSL (Digital Subscriber Line)

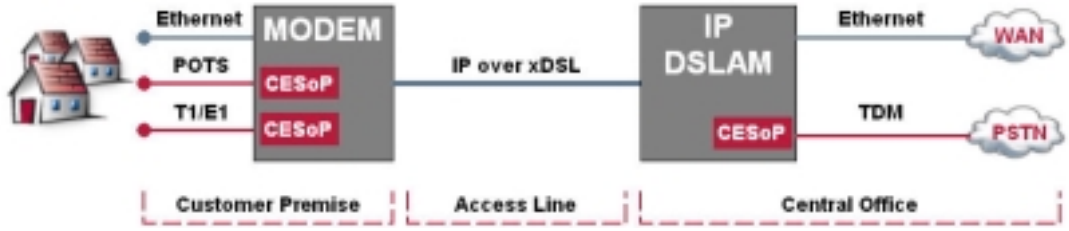

Fig. 3: DSL with Circuit Emulation Services-over-Packet

DSL is the world's mostly widely deployed broadband access technology, and is currently migrating from an ATM to IP-based infrastructure. For IP-based DSL, CES-over-Packet fits nicely between the modem and the DSLAM. For asynchronous DSL (ADSL), multiple POTS or Nx64K services seems more appropriate due to the uplink bandwidth limitation. Although ADSL itself can also provide one POTS line through the use of a splitter, CES-over-Packet over DSL is more attractive to SOHO and small enterprise users requiring more than one telephone line.

Wi-MAX (Worldwide Interoperability of Microwave Access)

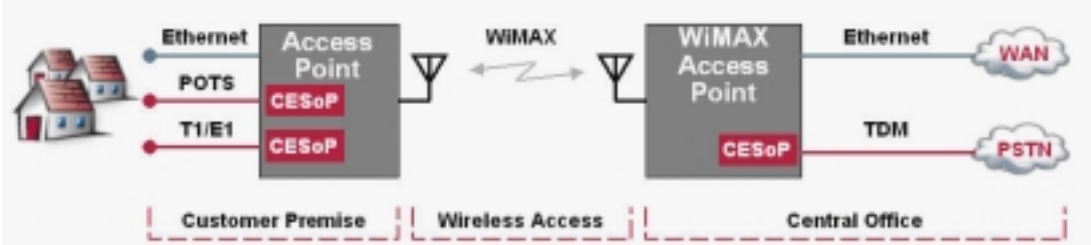

Fig. 4: Wi-MAX with Circuit Emulation Services-over-Packet

Fixed wireless broadband access is gaining ground on other solutions, thanks to the maturity of Wi-Fi and Wi-MAX technologies. Not only is the wireless link able to

support a competitive data rate close to 100 Mbit/s, but the falling cost of Wi-MAX also makes it more financially appealing. It is predicted that a Wi-MAX unit should cost less than $500 in 2005. Marrying CES-over-Packet and Wi-MAX allows the wireless transport of T1/E1 links at a lower cost than the traditional PDH-over-microwave link, with the added benefit of transporting Ethernet traffic as well.

Wi-MAX also embeds a VoIP-capable end-to-end QoS that lays the foundation for CES-over-Packet adoption.

A Word About VoIP

VoIP is an approved technology for voice and data convergence, and represents a different business model than CES-over-Packet. To implement VoIP carriers and customers need to upgrade their infrastructure. Carriers need to add QoS and soft-switch capabilities into the WAN to support VoIP calls, or deploy expensive media gateways for the PSTN connection. Customers need to either invest in IP-phones, or upgrade the legacy PBX to IP-PBX.

From an implementation perspective with no need for voice compression and call control blocks, CES-over-Packet costs less than VoIP. The shorter delay introduced by CES-over-Packet also eliminates the need for voice echo-cancellation, another savings when compared with VoIP infrastructure requirements.

Another problem that VoIP has yet to resolve is synchronization. In comparison with voice calls, fax and modem equipment requires better synchronization to avoid slips or data corruption. Because VoIP can’t adequately address synchronization issues, additional Fax-over-IP modules must be added to modulate/demodulate fax/modem signals before they’re forwarded to the IP network. This adds more complexity and cost. In comparison, CES-over-Packet provides solid synchronization for fax and modem calls.

VoIP will prevail when all customer terminals and equipment are IP-based. However, there’s no timetable for this massive infrastructure upgrade. In the meantime, CES-over-Packet supports the continued demand for TDM-based services, and the considerable revenues still generated by legacy services.

Conclusion

By enabling TDM and data convergence without requiring any infrastructure change, CES-over-Packet is a sound technology that finds its niche application in broadband access links. Applying CES-over-Packet technology in a broadband access system, an ISP can easily deliver TDM service without investing in a circuit-switched network, while avoiding media gateway or soft-switch server costs associated with a VoIP deployment. The simple architecture and broad bandwidth associated with a broadband access link makes it a perfect environment to run CES-over-Packet.

A simpler and more economical alternative to VoIP, CES-over-Packet will co-exist with VoIP until everything is purely IP-based.

About The Author

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