

THE MIGRATION TO PACKET-BASED AND VoIP NETWORKS



Building the better backplane: The marriage of TDMoIP and VoIP

By Tao Lang

The tide is turning, and businesses are increasingly ready to migrate circuit-switched voice services to their data networks to realize infrastructure and maintenance savings. One of the most common technologies for transporting voice traffic over IP/Ethernet packet networks is Voice over Internet Protocol (VoIP). In this article Tao says it's time to consider CES (Circuit Emulation Services) technology as a lower cost, evolutionary approach that supports a much wider range of applications.

CES is a technology for transporting voice over packet by tunneling TDM traffic, such as T1/E1 circuits, through any type of cell-based or packet-switched network, including ATM and IP/Ethernet. Compared to VoIP, CES supports a much wider range of applications, is a lower cost solution that allows service providers to maintain revenues from legacy TDM services, and lets enterprise clients maintain their existing network infrastructure investment. Rivaling the network overhaul of the 1960s and 1970s when digital switching and transmission systems swept aside analog technologies, today's telecom infrastructure is undergoing a radical revolution as networks migrate from a circuit-switched to packet-based infrastructure.

Driving this tidal change is the increasing pressure on carriers to reduce costs and rollout new revenue-generating services. As a result, more cost-effective and flexible packet-based technologies, such as IP (Internet Protocol), MPLS (Multi-Protocol Label Switching), and Ethernet, are increasingly prevalent across all segments of the telecom infrastructure. Packet is slowly dominating the core and metro portions and quickly spreading into access networks.

While this packet-based trend continues, years of TDM (Time Division Multiplexing) equipment deployments can't be abandoned. The evolving Packet-Switched Network (PSN) must support legacy equipment and the lucrative revenues still generated by circuit-switched services. The marriage of TDM and packet is a major issue to be resolved before any full-scale PSN deployment. Emerging convergence technologies such as VoIP and TDM over IP (TDMoIP) offer promising solutions.

The migration to new packet technology is also reflected in backplane applications, where the traditional TDM-based H.110 backplane is being steadily replaced by Ethernet or other types of packet-based backplanes. Having a specification for carrying TDM across any packet backplane between various boards is tops on the agenda now.

Introducing VoIP

After years of promise but dubious voice quality, VoIP is now well established as a mature technology with imminent full-scale deployment. Typically, a VoIP implementation encompasses three functional blocks:

- Voice processing
- Telephony signaling processing
- Protocol processing

The voice processing block is primarily responsible for processing voice data. It provides features like compression (G.726, G.723, G.729, etc.), echo cancellation, tone detection, tone generation, silence suppression, comfort noise generation, and more.

Telephony signaling processing terminates the PSTN (Public Switched Telephone Network) signaling. For example, Channel Associated Signaling (CAS) and Common Channel Signaling (CCS) translate the telephony signaling protocols into packet network protocols using H.323 or Session Initiation Protocol (SIP). To make an IP connection, the PSTN call setup and call control procedures are duplicated in the packet network.

Protocol processing adds protocol headers to both voice and signaling packets before transmission into the packet networks. For voice packets, it will use IP/UDP/RTP stack.

Introducing TDMoIP

TDMoIP, also known as Circuit Emulation Service over Packets (CESoP) or TDM Pseudo Wire (PW), transports both voice and non-voice TDM data over any IP, MPLS, or Ethernet packet network. By using techniques like trunking and tunneling, TDMoIP offers a very simple and cost-effective solution.

TDMoIP physically emulates an end-to-end TDM link to transparently tunnel traffic across the packet network. This *tunneling* technology requires no specialized call control procedures or signaling functions other than those already provided by the PSN (Figure 1).



Figure 1

Standards work on TDMoIP is already well underway. The PWE3 (Pseudo Wire Emulation Edge to Edge) working group within IETF (Internet Engineering Task Force), first launched standardization as part of an initiative to develop standards for emulating any Layer 2 services across PSNs. PWE3 pseudo wires allow point-to-point TDM, Frame Relay, or ATM connections over a single PSN.

Today, the MEF (Metro Ethernet Forum), the MPLS Forum, and the ITU-T (International Telecommunications Union-Telecommunications), are also working on standards for emulating TDM circuits across any type of packet network. This includes TDM circuits ranging from DS0 channels to T1/E1 circuits, through to T3/E3 circuits and beyond.

The ratification of the ITU-T Y.1413 recommendation, *TDM-MPLS network interworking – User plane interworking*, in April 2004 set the first milestone for TDMoIP interoperability. Y.1413 outlines the TDM timing, signaling, service quality, and alarm integrity required when legacy voice, data, and multimedia traffic are carried over an MPLS network up to DS3 or E3 rates.

VoIP versus TDMoIP

To easily understand the differences between VoIP and TDMoIP, one can consider ATM technology and ATM Adaptation Layers (AAL). Two AAL protocols, AAL1 and AAL2, have been developed by the ATM Forum to support two different services: Circuit Emulation Service (CES) and Loop Emulation Service (LES).

A look at ATM

ATM CES was developed by the ATM Forum with the specification *Circuit Emulation Services Interoperability Specification (AF-VTOA-0078.000)*, which specifies how to use ATM AAL1 connections to emulate the following types of constant bit rate or *circuit* traffic:

- Structured T1/E1/J2 Nx64 Kbps (Fractional T1/E1/J2) basic services
- Structured T1/E1/J2 Nx64 Kbps (Fractional T1/E1/J2) with CAS
- Unstructured T1/E1/J2/T3/E3 services

The initial ATM CES concept is simple. At the transmit end, a structure is constantly created containing all TDM samples col-

lected in one frame period for basic services, or one multi-frame period for CAS services. A cell is sent out when its payload has been filled up by the structures. To accommodate ATM cell size limits, a structure may straddle over two or more cells. At the receive end, fluctuations in cell arrival time are ironed out, and the TDM data is played out sequentially.

Later, the ATM Forum introduced Dynamic Bandwidth Circuit Emulation Service (DBCES), a special mode of CES operation that allows DS0 channels to be added to or removed from a CES trunk.

ATM LES was created to use ATM AAL2 for the efficient and transparent transport of narrowband (analog or ISDN basic rate) subscriber lines over a broadband link, such as DSL (Digital Subscriber Line). It has been tailored to support any traffic that may be seen on an ordinary telephone line, such as voice, fax, modem, DTMF (Dual Tone Multi-Frequency), dial tone, on-hook/off-hook state, or ISDN data.

Restricted by access link bandwidth, LES also employs various bandwidth-saving techniques such as voice compression, silence suppression, and idle channel removal. By replicating the call setup and call control procedures, calls will be individually routed to their destination by the packet network.

Migrating towards IP

As IP or other types of emerging networks slowly replace ATM networks, both ATM CES and ATM LES concepts are now being carried over into the packet world. In a simplified way, TDMoIP can be viewed as the counterpart of AAL1 in the IP world, whereas VoIP is the counterpart of AAL2. Both VoIP and TDMoIP inherited most of the characteristics from their ATM predecessors, as seen in Table 1.

Packet backplane

The scalability, efficiency, and cost advantages of replacing a TDM backplane such as H.110 with a packet-based backplane such as Ethernet are well recognized.

While expanding the capacity of a TDM backplane requires an architectural change, upgrading a packet backplane may be as simple as replacing a switching card. In terms of efficiency, in TDM a timeslot is always reserved for a particular channel regard-

	VoIP	TDMoIP
ATM counterpart	AAL2	AAL1
Type of emulation	Loop emulation	Circuit emulation
Traffic type	Real time variable bit rate	Constant bit rate
Link emulated	Analog loop	Digital trunk
Place in the network	Access network	Core network
Telephony signaling	Interpreted by the packet network	Tunneled through the packet network
Voice compression	Yes	No
Silence suppression	Yes	No
Call routing	By packet network	By circuit network
Applications	Switched voice	Trunking and leased lines
Latency	Large	Small
Synchronization	Less concerned	Critical

Table 1

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less of the channel activity. In comparison, in a packet backplane the available bandwidth is statistically multiplexed. Ethernet is also an extremely economical technology, with packet-based switching and transportation hardware readily available at a cost lower than traditional TDM devices or equipment.

Without question, a unified backplane carrying both TDM and data traffic is the way of the future. With data increasingly dominating network traffic volumes, converging both types of traffic on a data-friendly packet medium is the more efficient and cost-effective choice.

Though a packet backplane may work just like a switched Ethernet network, it offers some unique features and considerations when transporting TDM traffic.

Voice agnostic

All TDM backplanes transport and switch data at 64 Kbps DS0 level. No voice processing is required.

Protocol agnostic

An Ethernet-based packet backplane only deals with layer protocol and therefore does not require or consider network protocols such as IP, UDP, or RTP. In many cases, only MAC headers are necessary for TDM packets.

Trunking

A large number of DS0 may move from one board to the other, and need to be packetized in one packet in order to minimize the overhead as well as the processing load.

Grooming

The backplane should be able to combine several partially filled trunks into a smaller number of fully filled trunks.

Latency

Needless to say, latency is always an essential measurement for any voice-over-packet application. However, it is especially critical for the packet backplane since the latency budget inherited from a TDM backplane is extremely low. For example, traditional TDM switches or ADM (Add/Drop Multiplexer) equipment require less than 1.6 microseconds of latency over the backplane, which is a potentially strenuous demand for the packet backplane. Although gateway and mediation equipment allow more latency budget on the packet backplane, it must be tightly controlled to avoid using echo cancellation for local-to-local phone calls.

Density

A standard H.110 TDM backplane contains 4,096 DS0 channels, forcing system architects to move towards packet backplanes in an effort to boost capacity. In order to support thousands and tens of thousand of channels, a packet backplane must be able to move the traffic swiftly. One way of achieving this is to keep the TDM encapsulation method as simple as possible. Density is a weakness of ATM, because both AAL1 and AAL2 have a fairly complex Segmentation and Reassembly (SAR) sublayer that limits the capacity achievable in hardware implementation. The current TDMoIP proposals provide several options for TDM encapsula-

tion, from VoIP-like raw encapsulation to more complex ATM SAR-based methods.

Synchronization

Synchronization of TDM circuits over an asynchronous packet network is an enormous challenge for most TDM over packet applications. However, the packet backplane is one of the few exceptions. It is reasonable to presume that a dedicated clock distribution channel is always available on the backplane to synchronize all TDM circuits. Avoiding any clock recovery schemes simplifies both hardware and software implementation.

High rate DS0 switching

To support the increasing number of voice calls, a packet backplane must be able to add new channels, remove idle channels, or switch channels from one connection to another in a swift and uncomplicated fashion. This demands more intelligence from the packet header in order to carry not only channel identifications but also indications of channel status to ensure DS0 channels in a packet can be quickly identified and routed upon arrival without requiring too much out-of-band messaging.

Bandwidth over-provision

Typically, the packet backplane requires significantly less stringent bandwidth restriction than other applications do. Developers can afford to build a backplane with more bandwidth than is actually required. The excessive bandwidth can be used to trade off latency and the need for idle channel removal.

Building the perfect backplane

In consideration of the above points, an efficient TDM over packet backplane approach requires a mix of features delivered by both TDMoIP and VoIP technologies. For instance, TDMoIP offers low latency and simplicity but lacks the required flexibility on per-channel routing and dynamic channel allocation. On the other hand, VoIP is friendlier for individual channel routing but fails to meet processing power and latency requirements.

A desirable approach would be to combine both TDMoIP and VoIP features and develop a more customized solution for TDM over packet backplane. For example, adding a simple but efficient DBCES feature into current TDMoIP specifications would make it more appealing for the packet backplane. Recognizing this, several industry groups, such as the System Fabric Plane (SFP) workgroup within the PCI Industrial Computer Manufacturers Group (PICMG), are working on TDM over packet backplane standardization.

Conclusion

There are several solutions available today for carrying voice services and TDM traffic over packet. VoIP, as a mature technology, nicely supports voice switching and transportation over packet networks, whereas TDMoIP is a relatively new technology aimed at circuit emulation over packet. The features and differences of VoIP and TDMoIP can be better understood by relating them to their counterparts in the ATM world, namely, the AAL1 for circuit emulation and the AAL2 for loop emulation.

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AND VoIP NETWORKS**

As a special kind of packet network, a packet backplane exhibits some unique characteristics that require features from both TDMoIP and VoIP. Although TDMoIP initially appears to be more suitable than VoIP for the packet backplane, some improvement or customization is still required to make it the perfect choice. The industry has already started developing a consistent method for carrying encapsulated TDM data across any common packet backplanes.

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