Circuit Emulation Services-over-Packet and Standards Adoption

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In a previous article, http://www.analogZONE.com/nett0809.pdf we introduced Circuit Emulation Services (CES)-over-Packet technology, also known as TDM-over-Packet. CES-over-Packet has many potential applications as a "bridging technology" between the existing TDM infrastructure and new packet-switched networks (PSNs).

Although the TDM infrastructure has an installed base with decades of pedigree, many predict packet technology will soon displace it. Until is does -- and there are still those who suggest TDM will never completely disappear -- there will be a continued need for TDM (T1/E1, T3/E3, unstructured and structured) service. Even as new IP/Ethernet/MPLS networks are installed, they will still need to carry circuit-switched services if carriers are to reach their goal of one unified network carrying voice, video and data.

The Need For Standards

Technology for the sake of technology will never achieve widescale acceptance if it is not supported by standardization. Standardization benefits the entire industry. It frees carriers from having to create their own standards, and ensures conforming products will interoperate. It provides design engineers with a standard that will be used across an entire network.

There are four industry bodies working on standards for CES-over-Packet technology, each with their own unique area of expertise. They are the:

- International Telecommunications Union (ITU) http://www.itu.int
- Internet Engineering Task Force (IETF) http://www.ietf.org/
- MPLS and Frame Relay Alliance (MPLS Forum) http://www.mplsforum.org/
- Metro Ethernet Forum (MEF) http://www.metroethernetforum.org/

In general there is no performance difference between the different standards; they are all intentionally very similar. There are two main reasons why there are so many different standards:

1. They address different layers within the network (IP, MPLS, Ethernet)
2. They each have a different emphasis, depending on the services they are concerned with

For example, the MPLS Forum and MEF create Implementation Agreements (IAs), which are designed to outline all of the implementation requirements for a technology. In comparison the ITU and IETF create standards describing protocols, with no reference to any implementation requirements. For CES-over-Packet technology the documents are remarkably similar, but the MEF and MPLS Forum Implementation Agreements do provide more detailed information not covered by the IETF and ITU documents.

The ITU has issued recommendation, Y.1413, for TDM-over-MPLS. The IETF is readying draft standards dealing with T1/E1 services over IP and MPLS. The MPLS and Frame Relay Alliance has two standards that have been released, or will be issued, covering TDM-over-an-MPLS network. Finally, the MEF has an initiative that covers TDM across Metro Ethernet networks. As of this writing in late 2004, the work being done in these bodies is nearly complete.

Understanding The Standards

IETF Standards

Within the IETF there are three standards that deal with CES-over-the-PSN. The first is the structured agnostic TDM-over-packet (SATOP). The SATOP draft supports unstructured data transfer, also known as clear channel. The second specification is the circuit emulation service-over-packet-switched network. This supports the "raw" mode of encapsulation. The third mode is the TDM-over-IP mode, also known as the "AAL1" mode.

1. SATOP: The SATOP draft is available from the IETF as specification draft-ietf-pwe3-satop-01.txt[1]. This draft specification "describes a method for encapsulating TDM bit-streams (T1, E1, T3, E3) as pseudo-wires over packet-switching networks (PSN)".[2] The structure of the TDM traffic is ignored and is treated as a bit stream that must be transported as a pseudo-wire.

The specification outlines the packet format for the pseudo-wires. Fig. 1 outlines the packet format for all of the standards, including IETF. The IETF header consists of two sections: the network layer headers and the adaptation layer. Within the adaptation layer, there are three components -- the UDP or L2TPv3 header, an optional RTP header, and the control word. The control word consists of three sections: the flags, length field and the sequence number.

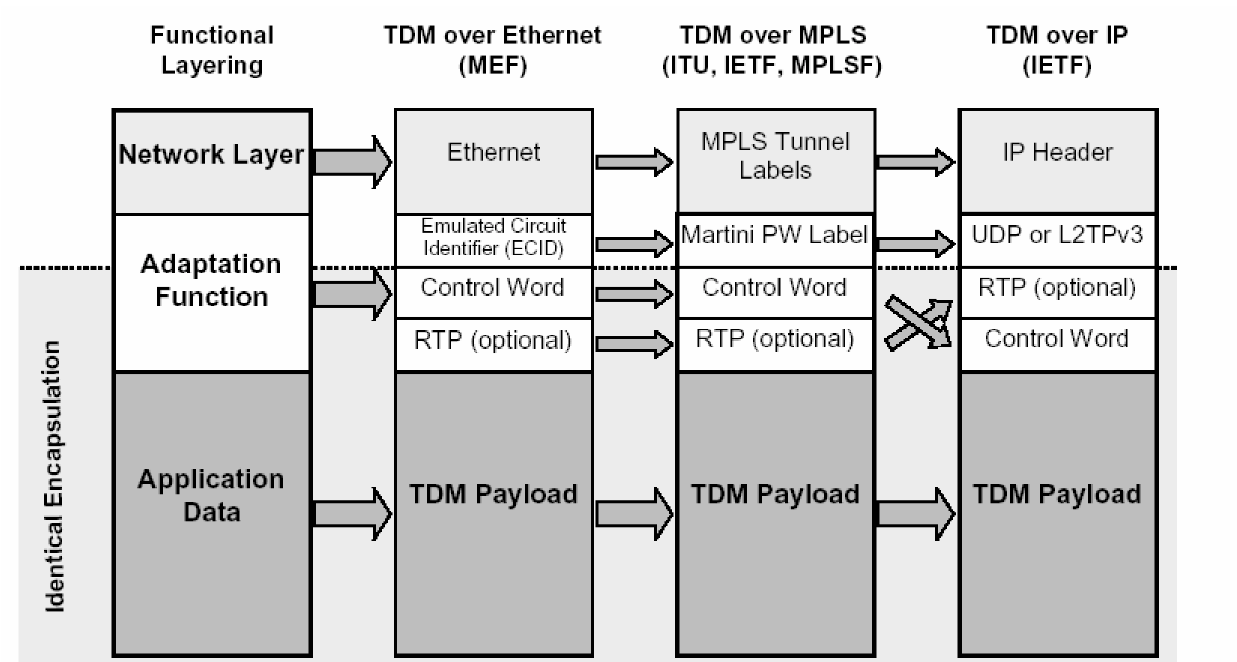

Fig. 1 Comparison Of Standards

2. Structure-aware TDM-over-packet: The structure-aware TDM circuit emulation service-over-packet-switched network(CESoPSN) is one of two standards that support structured TDM service. The service here is also known as "raw" encapsulation because it takes the voice data samples and translates them directly into a packet payload. Within this specification the size of the packet payloads are defined. The header information is shown in Fig. 1. The header is similar to the SATOP standard; however, the control word is different. There are six bits for flags, six bits for a length field and a sequence number field.

3. AAL mode: This draft specification is the TDM-over-IP standard. The specification can be found in draft mode on the IETF website as draft-ietf-pwe3-tdmoip-02.txt.[3] The standard describes methods to encapsulate TDM data into packets using ATM techniques. The TDMoIP standard supports different encapsulation modes that are equivalent to ATM cell structures.

The packet structure is similar to the ones shown in Fig. 1, where the packet consists of PSN headers, a control word and the payload. This draft standard also supports IP and MPLS network headers. The control word is more complicated than the other standards. The control word supports fields that define the format identifier, error flags, length, and sequence number. For details, consult the document draft-ietf-pwe3-tdmoip-02.txt.[4]

ITU Y.1413

The first recommendation (ITU’s term for standard) to be released and approved supporting all encapsulation methods was the ITU Y.1413 standard. It defines the formats for carrying CES across MPLS networks. This standard supports both structure-agnostic, and structure-aware transport. It also defines the two types of structure-aware transport -- structure-locked encapsulation and structure indicated encapsulation.

Structure-agnostic transport disregards any TDM structure. It is a bit-by-bit transport. This is the same concept as unstructured data transfer. The recommendation also supports a unique method of transport called octet-aligned T1 format. This approach maintains the format of a structured transport, but adds the capability to transport the framing bit in the packet.

Structure-aware transport maintains the structure and framing of the TDM traffic. There are two packet formats defined: structure-locked and structure-indicated.

In structure-locked transport, the TDM transport is structured and emulates complete frames or fractional service. The payload will consist of a number of frames or a number of channels, depending on the service supported. Optionally, the transport mechanism can also supports CAS signaling by appending a CAS substructure onto the packets.

In structure-indicated encapsulation, the TDM bit stream is adapted using the AAL1 standard.[4] The resulting 48-octet SAR PDU or multiple PDUs are then encapsulated into a packet for transport over the MPLS network. The encapsulation method can optionally support a CAS signaling substructure.

MEF

The MEF has produced a draft technical specification. This specification is called an implementation agreement and builds on ITU recommendation Y.1413 to provide the necessary information to operate over a metro Ethernet network (MEN). The implementation agreement supports structure-agnostic and structure-aware forms of the ITU recommendation. Within the structure-aware form, both the structure-locked and structure-indicated encapsulations are supported, although optionally.

The implementation agreement extends to the ITU recommendation. Not only does it provide specifications for the encapsulation of the various formats, but also for error handling, signaling and performance monitoring. Timing is mentioned in the implementation agreement, but it is outside the scope of this implementation agreement.

MPLS Forum

The MPLS Forum is creating two documents supporting the various inter-working functions. The MPLS Forum has released one implementation agreement (IA), with an imminent release of a second IA. The released IA covers the TDM transport-over-MPLS using AAL1 encapsulation. It is equivalent to the structure-aware, structure-locked format of the ITU Y.1413 recommendation. The second IA supports the structure-aware, structure-indicated encapsulation of Y.1413. This is referred to as circuit emulation service-over-MPLS (CESoMPLS).

1. MPLS using AAL1 encapsulation: The IA for transporting TDM using AAL1 supports a fixed AAL1 type payload. The reference model is outlined for the transport of TDM-over-an-MPLS network. The IA defines transport formats, alarm formats, header formats, signaling, and timing/synchronization.

As with all of the standards/draft standards/recommendations, the IA supports T1/E1 and T3/E3 circuits, as well as Nx64-kbit/s service. Full support is given for TDM transport across an MPLS network.

The header stack is defined as a tunnel LSP label and a CBID label. The LSP label supports the MPLS format, and the CBID is the circuit bundle identifier. The payload is identified as in the ITU Y.1413 recommendation; there is a TDM-MPLS header and the AAL1 cell payloads as defined in the ATM spec.[5] The header format is a 32-bit word consisting of alarm flags, payload length field and sequence number field. The payload can be 1 to 31 - 48 octet AAL1 PDU payloads.

2. CESoMPLS: The second standard within the MPLS Forum, CESoMPLS, defines the "raw" mode implementation agreement. This IA defines the structure-agnostic and structure-aware emulation.

Structure-agnostic emulation treats the TDM signal as a bit stream. No framing or alignment is assumed. There is an exception for the structure-agnostic emulation, the octet aligned T1 emulation. In this case 200 bits are used to emulate the T1 service instead of 192 bits as specified in the draft standard. The frame information consists of 192 bits, plus 1 framing bit, plus 7 bits of padding.

Structure-aware emulation assumes that TDM framing and control information is available, and uses this information to select the channel samples from the TDM stream.

The packet format is shown in Fig. 1 for MPLS networks. The control word for this service is a 32-bit word that supports error flags, L,R, and M, FRG flag, length field and sequence number field. The first four bits are reserved.

The RTP header is optional in this emulation. The RTP header is primarily used to transfer timing information in the time stamp field. (See clock recovery, below.)

Signaling is supported in two ways within this draft. The first is via signaling packets. These are special packets that are created and carry the signaling information to the far end. In the second method, signaling information is appended to the voice packet. The CAS or CCS structure is provided so one packet contains all the information for the trunk that it is emulating.

Clock Recovery

Within all of the standards, reference is made to transporting the timing element over the PSN. None of the standards define the timing transport mechanism, or how it should be accomplished. There are currently no standards that support timing; however, the ITU has started to review this topic. We will further discuss this issue in a future article.

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2. Ibid, page 2.
3. TDM over IP. Y Stein, et al. July 19th 2004.
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