

## **Making the Packet Connection with TDM-over-IP: A Technology Primer**

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In the heady days of the telecom boom, hype led many to believe a full-scale network revolution was underway. The common wisdom of the time was that circuit switched infrastructure was going the way of the dinosaur, the forklifts were ready and running on the frontlines, and IP networks were on the rise.

A few years later, economic realities have driven the forklift back into the garage. The boom years' buzz has become a more realistic hum, and revolution has turned into a manageable network evolution.

While even the evolutionary pace has slowed from what was predicted post-telecom crash, carriers still face the same challenges when planning a migration from a circuit-based to packet switched network (PSN) infrastructure. Primarily, they need an efficient and cost-effective solution for transporting revenue-generating legacy services over the PSN.

One emerging solution is TDM-over-IP technology. In this first in a series of articles on TDM-over-IP, we will outline some of the economic and competitive issues pushing carriers towards network convergence, and the key technology choices available to them.

In later articles we will take an in-depth look at timing and synchronization issues over the PSN, and the TDM-over-IP work currently underway with the standards organizations. Applications abound for this technology, and several will be examined in detail.

### **The Carrier Crunch: Driving Towards The Converged Network**

The TDM-based circuit switched network has been the heart of the Public Switched Telephone Network (PSTN) for decades. Some think TDM's days are numbered, while others believe that the reliability this venerable technology and longevity of the installed equipment base means that it will co-exist alongside IP for years to come.

Regardless, much of the world's voice traffic is still carried over the circuit switched network and accounts for a significant portion of carrier revenues. However, data now outpaces voice traffic on the network.

Carriers are caught in an economic and competitive crunch. Recognizing the tremendous growth in data traffic, carriers have started to build out IP networks on top of their circuit infrastructure. Fiscally, this is only a short-term solution. The bottom line makes it impossible to maintain two disparate networks for voice and data traffic, each with separate support staff, unique hardware and different management systems. Cable

providers and wireless operators are also aggressively moving off the sidelines, and are now circling the carriers' once secure voice dollars.

Carriers are fighting back, and clearly the path forward is convergence towards one single PSN. They are installing new data networks with VoIP to transfer revenue-generating services to a less costly network, and announcing more IP or Ethernet services based on true Ethernet networks, not on circuit switched networks. This trend will continue as carriers endeavor to reduce their costs.

But the major issue remains: carriers need to transport legacy traffic originating from the home, enterprise and campuses over the new network.

### **Introducing TDM-over-IP**

The challenge of transporting circuit switched trunks over connectionless networks has been met by both integrated circuit manufacturers and equipment vendors, with a solution that combines old and new approaches to transport TDM traffic over new IP, Ethernet or MPLS networks.

The agreed approach is patterned after Circuit Emulation Service over ATM. Some have taken ATM cells and packetized the payloads into IP packets. Others have put the TDM channels into the IP payload directly, thus eliminating the segmentation and reassembly step of ATM. Circuit Emulation Service over IP has parallels to ATM AAL1 transmission. Both are constant bit rate, both transmit uncompressed voice, and both support structured and unstructured circuit transport.

One issue with Circuit Emulation Service over IP or TDM-over-IP is synchronization. In the circuit switched network, timing and synchronization is inherent in the design of the technology. However, when this service is carried over a PSN, the timing element is lost and has to be transported by other means. We will look at timing over the PSN in a future article, but suffice to say that various vendors have their own solutions.

Standardization is in well underway on TDM-over-IP technology. The ITU's recommendation ITU Y.1413 deals with TDM-over-MPLS networks. The IETF, MPLS and Frame Relay Alliance, and the MEF Forum are also actively working on TDM-over-IP standardization. See the sidebar for more details on the standards organizations; their work will be fully discussed in a future article.

### **Comparing TDM-Over-IP With VoIP**

TDM-over-IP is not Voice over IP. Both are meant for different services and do not compete in the network. There are many similarities and differences between the two, as seen in Table 1.

	<b>TDM-over-IP</b>	<b>VoIP</b>
Service types	Voice, video and data	Voice only
Timing issues	Synchronization is critical	Less critical on synchronization
Signaling	No need for gateway signaling, as it is tunneled through the trunk	Complex signaling between PSTN and IP, eg. H.323 or SIP
Network transport	Can be over IP, MPLS or Ethernet	IP only
Standards	ITU recommendation released. Others to come from the IETF, MEF and MPLS Forum	Well defined by IETF, RTP, UDP, IP
Voice processing requirements	VEC depending on the service and packet delay variation	Compression or VEC.
Service	Trunking	Typically one channel per connection
Network characteristics to carry service	Needs managed network	Can run on the internet
Latency	Low latency	High latency due to packetization and compression algorithms.

**Table 1: TDM-Over-IP Vs. Voice-Over-IP**

As seen in the table, both services offer different strengths and weaknesses. VoIP is best suited to transporting one voice call over the PSN. TDM-over-IP can be used for different services, not just voice, and can transport multiple circuits. It's clear that TDM-over-IP service is attractive for the access side of the network for transporting multiple services across a PSN.

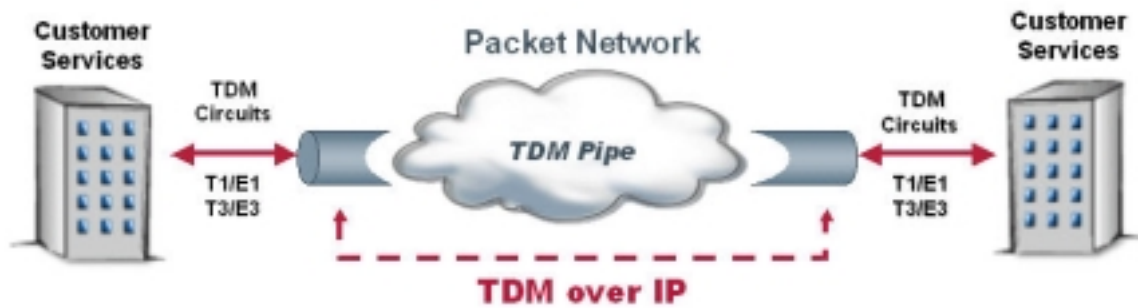
### **Potential Opportunities For TDM-Over-IP**

Now, let's turn to the opportunities for this technology. There are many applications in different networks, as the technology can run over IP, MPLS or Ethernet networks.

One main benefit of the technology is its ability to transport many TDM trunks from one location to another over a packet network. The technology is initially being adopted in the access part of the network, primarily to transfer multiple trunks across a medium such as a gigabit fiber, or a fixed-radio access network.

The simplest application for TDM-over-IP technology is to provide packet interconnection for existing TDM equipment, enabling legacy traffic to move across an IP/MPLS/Ethernet network (see Fig. 1). By doing this, TDM vendors can extend the

lifespan of their equipment, and generate years of income from older products. Evolving installed equipment to support new services, rather than a forklift upgrade, is something carriers are asking for now.



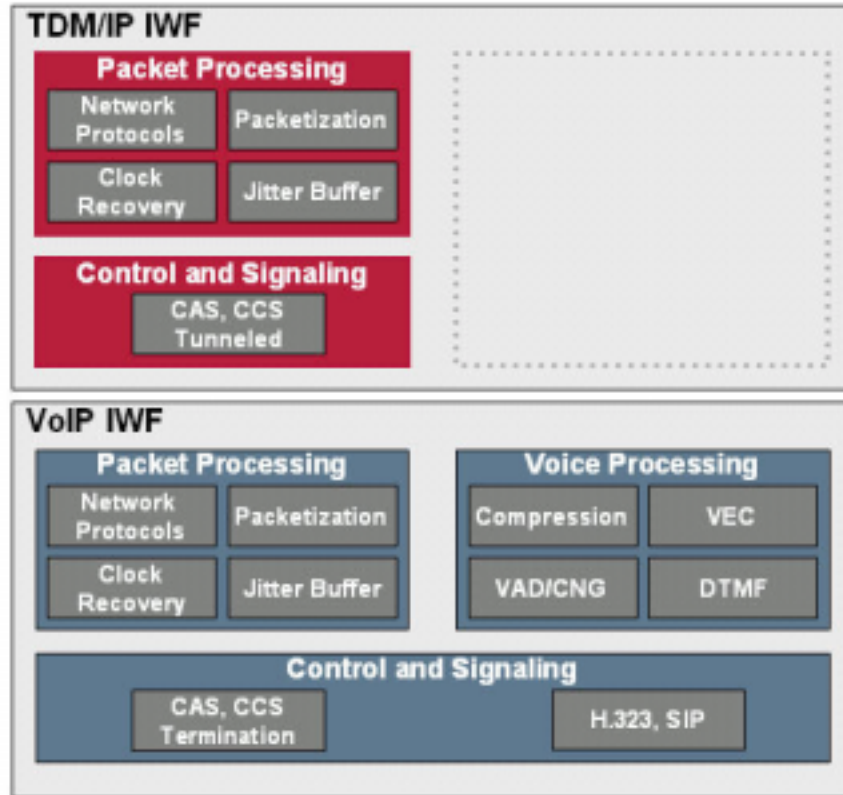
**Fig. 1: Making The Packet Connection With TDM-Over-IP**

There are many new potential applications as well, focused on moving TDM circuits across various PSNs.

For example, DLCs (digital loop carriers) can benefit from one specific feature of TDM-over-IP. One specifications DLCs must meet is a voice channel round trip delay of less than 1 ms. The technology does not need the voice processing functions usually associated with VoIP such as compression, DTMF and comfort noise generation (see Fig. 2). This means that TDMoIP systems enjoy much lower packet latencies with the only sources of delay coming from three parameters:

- the inherent delay of the semiconductor circuit
- the packetization delay
- the network transmission delay

DLCs are migrating to Ethernet over dedicated fiber, meaning network and low inherent delay in the product, TDM-over-IP technology performs very well in providing delay is kept very low. With a packetization scheme that provides for low delay legacy traffic support in a DLC application.

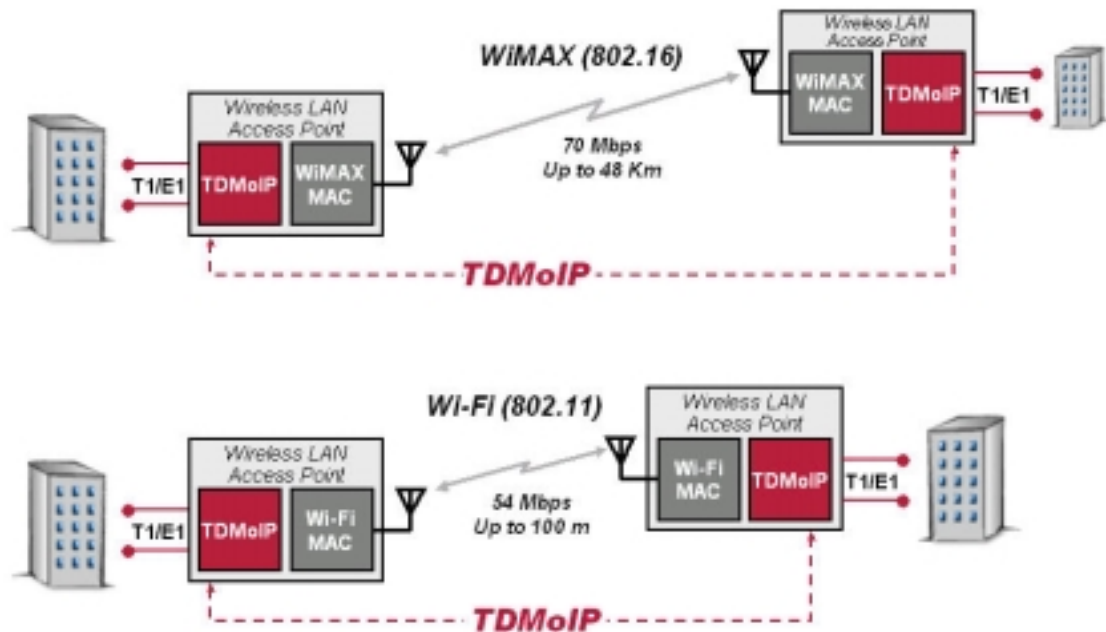


**Fig. 2: Comparing The Interworking Function Between TDM-Over-IP And VoIP**

Similar applications are in the Multi Dwelling Units or Multi Tenant Units market, often referred to as the MxU market. The function of an MxU is to transport TDM traffic and Ethernet traffic over a common link back to a central location, such as a central office. By using TDM-over-IP technology, the service provider can transport both voice and data across a packet switched link or network. The link or network can be Ethernet, IP, or MPLS.

Today's wireless backhaul market relies on TDM service being carried across microwave radio links and equipment that is far more expensive than an IP network. There is a growing movement to use a packet network for backhaul, and TDM-over-IP technology to carry the TDM traffic. This would reduce the cost of base band processing and provide more cost-effective service.

Newer wireless technology, such as Wi-Fi and WIMAX, can also use TDM-over-IP technology to transport T1/E1 trunks across a campus. This marriage of technology can provide a low-cost solution for transporting TDM services in a limited distance situation, while WIMAX can be used for longer distances (see Fig. 3).



**Fig. 3: TDM-Over-IP In WiMAX And Wi-Fi**

Other applications are in fiber-to-the-premises applications. An EPON (Ethernet passive optical network) system is based on Ethernet as the backbone. It is a natural to cement Ethernet and TDM-over-IP technologies, and carry legacy traffic efficiently across the passive optical network.

### Network applications for TDM-over-IP

TDM-over-IP technology is being used to carry SONET/SDH traffic across an IP or Ethernet network, such as a metro Ethernet network or a Resilient Packet Ring. The SONET/SDH sub rates are packetized and carried across the packet network. Thus a VT1.5 can be carried across the packet network and be reintegrated into a SONET/SDH ring.

We can see there are many applications for this technology in existing and new networks. Despite the best wishes of some, legacy TDM traffic will not disappear overnight, meaning carriers must find innovative and cost-effective ways to carry this traffic over the PSN.

TDM-over-IP is one viable approach. It simpler than VoIP, and can be complementary where VoIP technology is too complex or expensive to use. Connecting TDM equipment seamlessly across a packet network, TDM-over-IP delivers quality of service indistinguishable for the end-user.

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## **SIDEBAR:**

### **Learning More About The Standards**

The road to standardization is well underway, with four bodies that have already released or are currently working on TDM-over-IP standards.

The ITU has released its recommendation about TDMoIP technology, titled Y.1413. It is available from the ITU web site.

<http://www.itu.int/rec/recommendation.asp?type=folders&lang=e&parent=T-REC-Y.1413>

The IETF is developing three standards for TDM-over-IP or CESoPSN. The first standard addresses Structure Agnostic Transport over Packet (referred to as SATOP). This service is better known as unstructured data transfer or unchannelized service. The draft standard can be found at <http://www.ietf.org/internet-drafts/draft-ietf-pwe3-satop-01.txt>. There are two drafts for the structured mode. <http://www.ietf.org/internet-drafts/draft-ietf-pwe3-cesospsn-01.txt> <http://www.ietf.org/internet-drafts/draft-ietf-pwe3-tdmoip-02.txt>

The MPLS Forum/Frame Relay Alliance is developing a standard for TDM over MPLS. The standard is in final ballot and will be released in the fall of 2004.

<http://www.mplsforum.org>

The Metro Ethernet Forum (MEF) is the last body to be developing a standard. The draft standard is in final ballot and will be released sometime in the fall of 2004.

<http://www.metroethernetforum.org>

