WHITE PAPER

Circuit Emulation over Packet Switched Networks

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Voice over Packets

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Abstract

Changing over to a single, converged network doesn’t have to be a radical, revolutionary step. Circuit Emulation is a technology that allows the network to evolve in the direction of a single converged network without risking either customer revenues or requiring wholesale replacement of all parts of the network. This white paper explores where and how circuit emulation may be best exploited

Carrying TDM Services over a Packet Network

The volume of data traffic on the world's telecommunication networks has now outstripped the volume of voice traffic. Most predictions state that it is still rising fast, even as much as 80-100% per year despite the current economic slowdown.

This growth in data traffic has been much heralded over the last few years. The logical conclusion, according to the prevailing wisdom of the time, was that the world was going to go IP. Since data is the dominant traffic type, the world's telecommunications networks should be of a type best suited for carrying data, easing the engineering problems and operational expenditure associated with running the networks.

The theory was that voice traffic, while still accounting for much of the revenue, could be carried across the data network using Voice over IP (VoIP) technology, thus delivering a single, converged network that was easy to run and maintain.

However, voice traffic still accounts for over 75% of carrier's revenue. Revenue from data traffic is increasing only slowly, possibly as low as 11% this year. VoIP has not taken off in the manner predicted, in part due to the technical challenges of carrying voice over networks that were not designed to carry it. Many of the CLECs (who might have installed VoIP networks) have gone under, leaving the incumbents with their large traditional telephone networks. These carriers are understandably reluctant to move away from networks that generate 75% of their revenue to a revolutionary new style of network when growth in data revenues are falling.

An Evolutionary Approach

One of the issues for carriers in changing their networks is how to connect existing customers with existing TDM-based equipment to a radical new network. VoIP is one way to handle this, but it is not the only way. Furthermore, it is not a complete solution, since not all TDM connections are voice based. Most companies' data networks are currently connected via TDM connections, e.g. T1 or E1 connections.

The revolutionary approach is to convert the traffic right at the edge of the network. This would replace the class 5 voice switch with a VoIP gateway controlled by a softswitch. It would terminate a company's data traffic at the edge of the network, and route this onto the data network. However, this is a radical change, endangering the carrier's primary revenue stream if it fails.

The evolutionary approach is to replace the parts of the network under the most pressure due to volumes of traffic. Most often, this is the access network, especially in concentrated locations such as the metropolitan area. For instance, the access network could be replaced by a packet based network, such as metropolitan ethernet, or resilient packet ring (RPR).

However, this does not necessarily require replacing the entire existing equipment base. The packet-based MAN can be used to carry the TDM traffic up to the existing central office equipment, rather than converting directly to packet-based formats.

For instance, instead of converting the voice traffic to VoIP at the network edge, the TDM traffic stream could be carried using circuit emulation up to the central office. From there, the carrier can choose how to handle the traffic

This enables the customers to maintain their existing infrastructure, and the carriers to evolve their network gradually, replacing only the parts that need replacing. Hence it reduces the risk to the existing revenue stream that the revolutionary, disruptive replacement model represents.

Standards

Circuit Emulation originally came from the ATM world, for much the same reason: carriers were trying to upgrade their TDM networks to ATM, but needed to maintain support of customers using TDM-based equipment. Therefore the ATM Forum defined a means of "emulating" a TDM circuit across an ATM network, such that at the ends of the network it appeared as though the circuit was being transmitted across a conventional TDM network.

The idea has been taken up in the packet switched world by a number of bodies, including the IETF, the Metro Ethernet Forum and the MPLS Forum. The basic idea is to create a "tunnel" through the packet network, and carry packets containing the TDM data across the tunnel, recreating the TDM network at the other side (see Figure 1).

Figure 1 Circuit Emulation across a Packet Switched Network

The main standards are being set by the PWE3 working group (Pseudo-Wire Emulation Edge to Edge) in the IETF. This group is chartered to develop methods to carry layer 1 and layer 2 technologies across a packet switched network (principally IP or MPLS). Hence the group is looking at TDM circuit emulation, and also carriage of layer 2 technology such as ATM, Frame Relay and Ethernet across the PSN.

The Metro Ethernet Forum is looking to extend the work of the PWE3 group to make it applicable to a metropolitan ethernet context. Similarly, the MPLS Forum is also looking at the same standards from the point of view of an MPLS network.

Comparison of VoIP to CES

Granularity

CES is a more coarse grained technology than VoIP. Essentially, instead of switching at the individual channel level, it switches at the circuit level, where the circuit can be T1/E1, T3/E3 or even OC3/STM-1 or higher. This gives rise to efficiencies in terms of network management and control.

By comparison, VoIP gives much greater control over the destinations of the individual channels. These are switched individually, and hence each channel can be routed to a different destination node in the packet network. Circuit emulation is used where there are multiple channels to be switched together between the same two end points.

Latency and Bandwidth

The latency of an emulated circuit is generally lower, since a large packet can be built up over a much shorter period of time. For instance, a T1 connection consists of 24 channels, so to build a payload of 96 bytes takes four frames (0.5ms). To create the same sized payload in conventional VoIP will take 96 frames (12 ms), or 24 times longer. This 12 ms packetisation delay has to be added to the end-to-end latency of the connection.

However, while the bandwidth overhead in CES is low, due to the larger packet sizes relative to the header overhead, the bandwidth efficiency may be better in VoIP. This is because working at the individual voice channel level allows the use of bandwidth saving techniques such as silence suppression, or other compression solutions (e.g. ADPCM, CS-ACELP etc.).

Circuit emulation, on the other hand, is still constant bit rate, and therefore does not exploit the statistical multiplexing capabilities of packet networks (i.e. the statistical likelihood that peaks of activity in different packet streams will not occur at the same time).

Flexibility

Circuit emulation makes no assumptions about the type of traffic being carried across the network. The traffic could be voice, video, or packet data. The bits are carried transparently, and the recreation of the TDM link at the far end is as faithful to the original data as it is possible to make it. This makes it very flexible in the types of data it can handle.

VoIP on the other hand makes the assumption that the data being carried consists of voice samples. For example, echo cancellation will almost certainly be required because of the increased latency, and compression techniques may be applied to reduce bandwidth. These techniques are particular to voice, and would destroy other types of data.

Timing

One of the main technical hurdles to overcome with circuit emulation is timing. The bits must be played out of the packet network at the same rate as which they entered it, otherwise the jitter buffer at the destination node will either fill up or empty. The net result is the same: loss of data integrity. In a TDM network, the circuit itself carries the clock. With a packet network, this is no longer the case. Therefore, unless a common clock can be distributed to either end by an alternative means, some kind of clock recovery is required, e.g. recovering the frequency of the original clock from the arrival rate of packets at the destination node.

VoIP is also a constant bit rate service, and similar considerations apply. However, it is usually dealt with by occasionally dropping or inserting a single sample of voice data. Provided the clocks are similar enough, this has a negligible effect on voice quality. Use of the same technique on data would have a more severe impact, causing re-transmission to occur and hence dropping the effective data rate.

Circuit Emulation Applications

Carrier Applications

The main carrier application of circuit emulation is the provision of support to existing customers who are operating TDM services. For example, a service provider operating a metropolitan access network based on packet technology such as Ethernet or RPR will still want to support customers operating TDM connections. This saves both the customer upgrading their own equipment to accept a packet-based service, and the carrier from having to upgrade the connection medium over the last mile (or last few feet) between their point of presence and the customer.

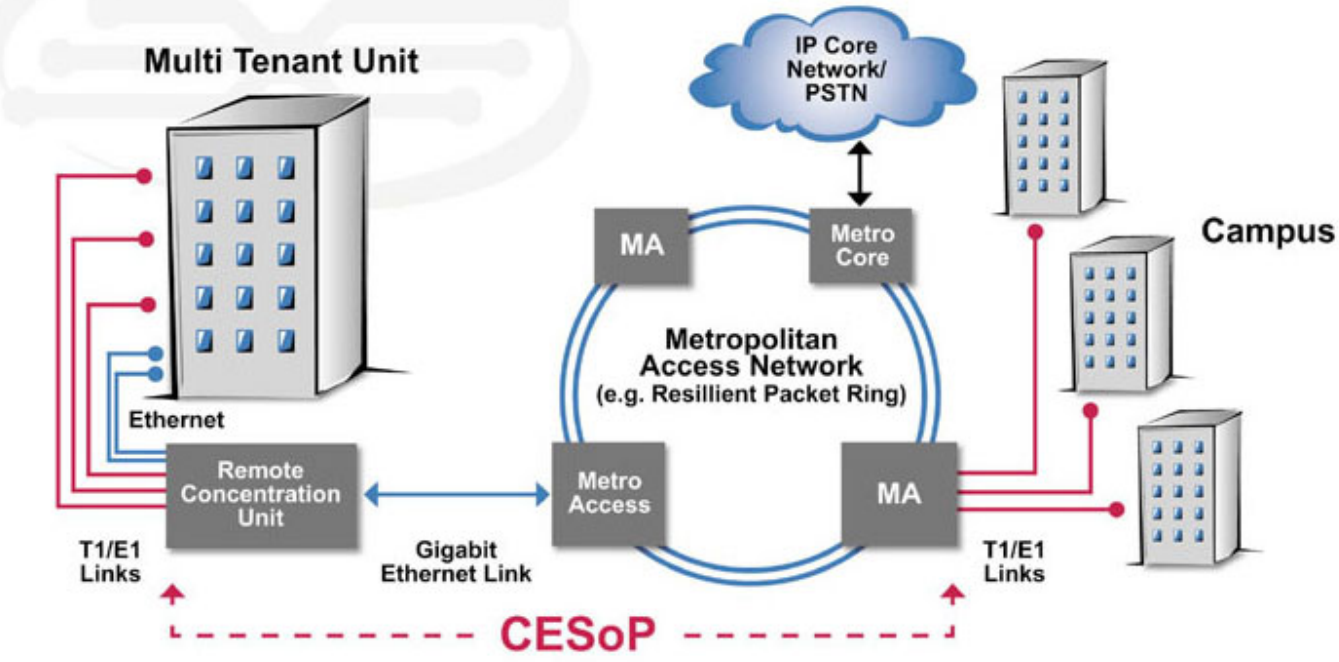

Figure 2 Circuit Emulated Access Network

These services take two main forms – private leased line, used to connect directly between two customer sites, and access lines, where the link is used to connect the customer site to the central office. Figure 2 shows an example of a packet-based

access network, with TDM links being emulated between the various access points and the interface to the core network.

In some cases, e.g. service of a multi-tenant building or campus, a remote concentrator may be provided close to the customers. This aggregates the TDM and/or packet services provided to customers within that building, and circuit emulates them back over a point-to-point link to the nearest metropolitan network access point.

Enterprise Applications

Circuit Emulation can also be used within the enterprise. For instance, where an organisation has two or more sites connected by a packet network, they could replace the telephone links between the sites by circuit emulating across the packet network connection. The limitation of this approach is that unless there is adequate quality of service over the packet network, the quality of the phone service may degrade. Where an external service provider is operating the packet network, a higher grade service level agreement may need to be negotiated.

This “toll bypass” application is the basis of most needs for customer-operated circuit emulation. Another example is cellular phone operators. Typically a T1/E1 circuit is used to provide the link between the base station and the radio network controller. This line is often leased from the incumbent wireline supplier. Circuit emulating the link over a packet network from an alternative service provider can often reduce the cost associated with the leased line.

Conclusions

As both carriers and enterprise seek to upgrade their networks from traditional TDM to packet networks, circuit emulation is a technology that allows networks to evolve, rather than having to replace the network entirely. As such it is a useful step along the road towards a single, unified, converged network, and the reduction in operational costs this affords.

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