TEJAS NETWORKS

White Paper

Circuit Emulation

A Best-in-Class Network Modernization Approach

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Executive Summary

Circuit Emulation enables telecom operators to translate legacy systems using TDM signals such as E1/DS1, E3/DS3, STM-n/OC-n to appropriate packet formats and carry them on a modern packet transport network. Tejas Circuit Emulation Service (CES) cards have one of the most advanced implementations of the circuit emulation function in the industry today. This paper provides an overview of Circuit Emulation technology, compelling reasons for legacy systems to upgrade and how CEM products from Tejas Networks can help with smooth transition to ensure a resilient and high-performance deployment.

The Issue

Many enterprise customers have systems that require a DS1 or DS3 to be delivered over the telecom network to a different site. The systems are almost always older systems such as PBX or video for studio to transmitter links or Point of Sale systems, to name a few. Since there is a demand, many Communication Service Providers (CSP) provide DS1 and DS3 services.

To deliver these services, the CSP uses a SONET Multi-Service Provisioning Platform (MSPP) and either own SONET fiberoptic infrastructure or lease SONET OC-12 or OC-48 or OC-192 fiberoptic connections from another carrier.

Over time these SONET networks have become more expensive, much of the SONET equipment is now discontinued, service contracts are not available, and service providers are often resorting to the gray market for equipment. This has led to the high cost of ownership of SONET networks. It has approached the point where providing these services are not profitable. Still, there is a demand for these services.

Potential Solutions

There are two solutions. The first solution is to move to a modern Ethernet/MPLS network, stop providing DS1 and DS3 services and get end customers to change to Ethernet based solutions. The issue with this option is that enterprises with equipment that use DS1 and DS3 don't want to absorb the cost of upgrading to modern ethernet-based access equipment. As one service provider we work with said, "Hospitals are not going to change out their phone system that cost them millions of dollars". In choosing this option, the CSP is risking the loss of revenue as the customers move to other providers to maintain DS1 and DS3 services.

The second option is to utilize Circuit Emulation (CEM) technology. The CSP can perform a Network Modernization project where he continues to provide DS1 and DS3 services but by migrating them using CEM technology to a modern, more cost-effective packet network. With CEM, a DS1 or DS3 can be carried over a packet network and the SONET equipment can be retired thus solving the economic issue while still providing DS1 and DS3 services. This is often called network modernization.

- **Limitations with the technology** - The highest deployed rate is limited to 40 Gb/s for the OC-768 or STM-256 circuit.
- **Non availability of components** - Spending on the SONET/SDH infrastructure and product development has rapidly declined with most equipment suppliers ceasing to invest in these products. With ageing equipment, telecom operators are saddled with expensive maintenance contracts, non-availability of replace parts, no new feature upgrades.
- **Reliability** - System reliability is questionable given the aging equipment. Maintaining existing SLAs for uptime with these drawbacks is impossible. Service degradation eats into the revenue stream and eventually leads to customer churn.
- **Higher OPEX** - SONET/SDH legacy infrastructure not only takes up larger space but also consumes large amounts of power in comparison to the next generation packet platforms. This results in increased operational costs.

- **Complex setup and maintenance** - Legacy SONET/SDH have complex manual management systems that require high setup time. This severely impairs the ability to dynamically configure the system for variable data demands.

Circuit Emulation

Legacy systems use circuit switched technologies such as Asynchronous Transfer Mode (ATM), Frame Relay, Ethernet or time-division multiplexing (TDM). The ideal solution is to replace the entire legacy infrastructure and make it packet based. This is however prohibitively expensive from the CAPEX standpoint. Even if operators may provide an end-to-end packet switched network, they still need to allow transport of circuit switched traffic over the packet network, since all legacy equipment may not be replaced at the same time. Globally, there continues to exist a large circuit based TDM network infrastructure built over many years for applications such as 2G backhaul, broadband services, enterprise leased lines, utility communications etc. Associated with these networks is a large, deployed base of customer access interfaces based on PDH/SDH technologies, which service providers want to retain for a few more years because replacing these overnight could result in customer churn or because they are bound by long-term service contracts. Circuit emulation service is a proven approach used to convert the circuit-based traffic into packets which are then transported over packet networks. Circuit emulation service leverages the strengths of the packet networks while using the existing legacy infrastructure.

Circuit switched equipment continuously transmits and receives data bits with fixed delay. The continuous bit stream transmission with a fixed delay is achieved by clock synchronization between the transmitter and receiver. For voice-based services, this worked well as the circuit switching ensured guaranteed permanent transmission. The drawback however is, the bandwidth and flexibility will take a hit. In contrast, packet transmission is not synchronous and transmission has a variable delay between packets. The circuit emulation service must ensure that the circuit switched equipment can continue to transmit and receive data bits with fixed delay even though the connectivity happens via a packet switched network.

The continuous bit stream generated by the circuit switched endpoint is converted into a series of packets by the CEM card for transmission over pseudowires on the packet network. The circuit switched data (payload) is encapsulated with SAToP or CEP control word, IP/UDP/MPLS headers before transmission. The pseudowires emulate a point-to-point connection over a packet switched network. The packet network may be Internet Protocol (IPv4/IPv6) or Multi-protocol Label Switching (MPLS).

The circuit emulation service is required to meet the below-listed requirements:

- Maintain accurate synchronization information for incoming circuit switched circuits
- Stringent latency, jitter and wander performance for end-to-end transmission
- Sub-50ms protection switching in the case of voice and other mission-critical services
- Real-time performance monitoring and fault management capabilities such as service loopbacks

The above requirements can only be achieved by guaranteeing adequate bandwidth, prioritization and buffering along the end-to-end path to minimize packet losses, delays or reordering.

Circuit Emulation Protocols and Clock Recovery Mechanisms

Structure-Agnostic Time Division Multiplexing (TDM) over Packet (SAToP) defined by RFC 4553 SAToP encapsulation method provides a simple emulation service. The RFC 4553 describes a method for encapsulating Time Division Multiplexing (TDM) bit-streams (T1, E1, T3, E3) as pseudowires over packet switched networks. It addresses only structure-agnostic transport. It is ideal for transporting a complete TDM stream without consideration for framing.

SONET/SDH Circuit Emulation over Packet (CEP) defined by RFC 4842 During normal operation, SONET/SDH payloads are fragmented, prepended with the appropriate headers, and then transmitted into the MPLS network.

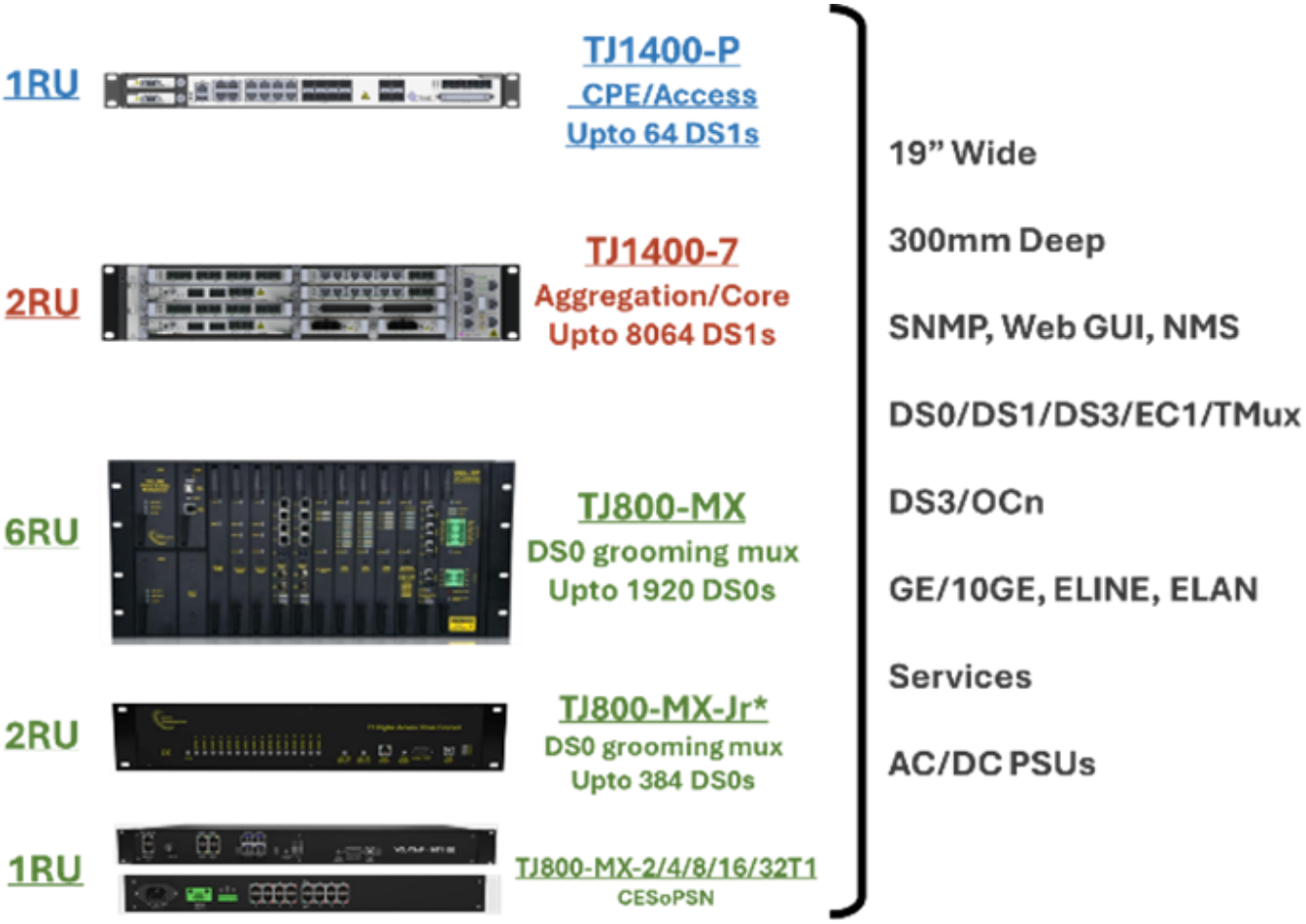
MEF 8 - Implementation Agreement for the Emulation of PDH Circuits over Metro Ethernet Networks. MEF 8 provides precise instructions for implementing interoperable CES equipment that reliably transports TDM circuits across Metro Ethernet Networks while meeting the required performance of circuit emulated TDM services as defined in ITU-T and ANSI TDM standards.

The key challenge of a circuit emulation service is to align the clock rate of the TDM transmitter and the TDM receiver to minimize jitter and wander. ITU-T recommendations G.823 and G.824 define the maximum wander for TDM interfaces.

- **Differential Clock Recovery (DCR):** A common reference clock is used for both the transmitter and receiver. The timestamp is inserted during encapsulation into the transmitted packet which is then used by the receiver for clock recovery.
- **Adaptive Clock Recovery (ACR):** The jitter buffer fill level is used in a control loop to adjust the TDM clock rate. Using the Jitter buffer fill level at the TDM transmitter and TDM receiver as the input variable, the TDM clock rate is adjusted. As the buffer fill level increases the TDM clock rate increases to prevent overflow and when the buffer fill level decreases the clock rate is decreased.

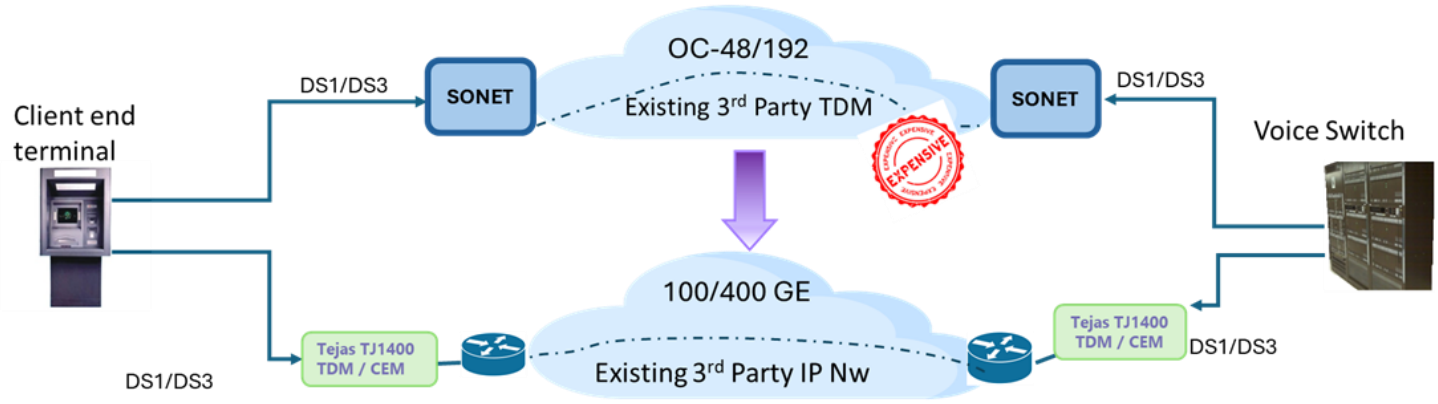
What is the Tejas Solution

The Tejas TJ1400 access solution has several chassis types with TDM Circuit Emulation capabilities. These nodes will accept TDM services and emulate them on an Ethernet or MPLS packet infrastructure.



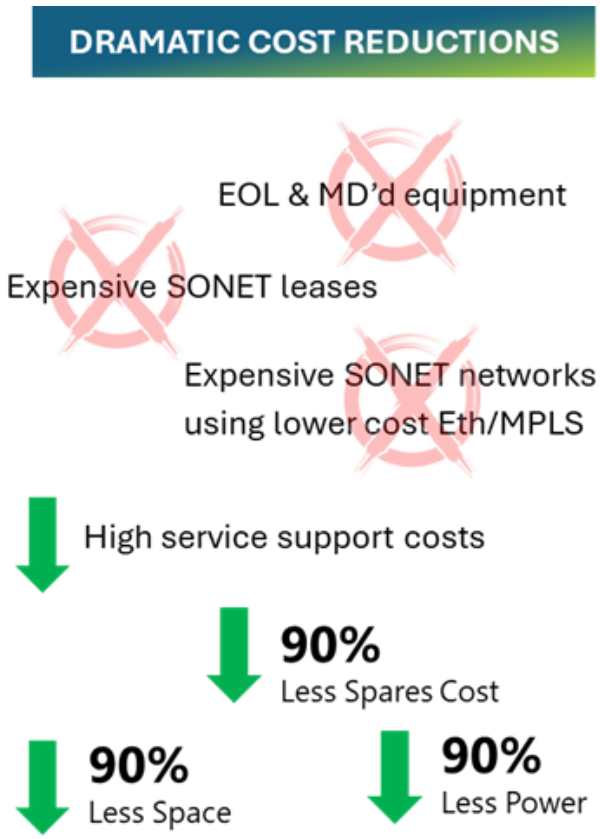
Value of Network Modernization to Packet Networking

A network modernization project migrates TDM services from a SONET network to a modern Packet/MPLS network using CEM, as shown in the diagram below.



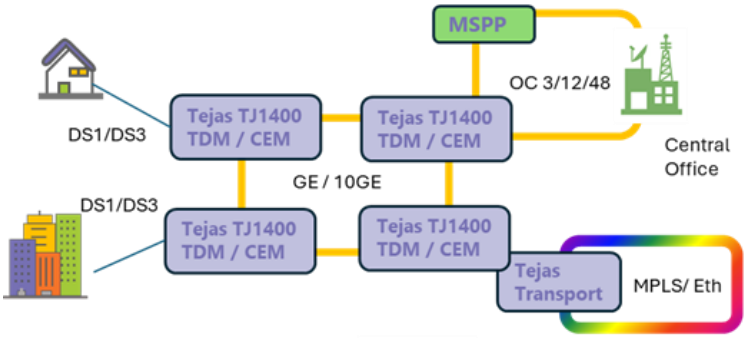
Network Modernization brings numerous drivers/benefits to the service provider:

- Retirement of EoL network equipment that may longer be supported.
- Elimination of costly unavailable spares to support the TDM network equipment.
    - And, if they can find spares, typically costs have gone up 10x+ due to supply and demand….



- Elimination of high lease fees for SONET OC-48/192 TDM transport replaced with higher capacity and lower cost 10GE services.
- Dramatic reduction in space and power requirements due to efficiency of modern packet/MPLS equipment vs older SONET TDM systems.
- Drive down the overall network cost of ownership, power savings, reduced footprint.
- Keeping TDM services running of the network and retaining business from these TDM customers.
- The new Tejas equipment also has the capability to provide Ethernet services. Thus an additional value is the possibility of providing Ethernet service on the same equipment.

Tejas is one of the few providers of CEM solutions utilizing our TJ1400 platform. The TJ1400 is versatile, providing options for small and large discontinued SONET / TDM equipment.



- Replace Digital Access Cross Connect Switch (DACS), such as Tellabs 5500, Alcatel 1631, etc. Resulting in up to 75% power savings and replacing 2 bays of equipment with a 2RU chassis.
- Replace SONET MSPP systems such as: Cisco 15454, Fujitsu FLM600, Fujitsu FLASHWAVE 4100/4500, to name a few
- Eliminate expensive leased TDM (OC-48/192) bandwidth
- Replace TDM PON OLTs

Tejas welcomes the opportunity to explore our CEM Solution and the value it brings to your situation. Just email us at sales_northamerica@tejasnetworks.com to get started.

About the Author

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Mr. Jeff Babbitt is a Solution Lead at Tejas Networks. Mr. Babbitt has more than 30 years of experience in the telecommunications industry. During that time, he has remained dedicated to staying on the cutting edge of technology and sharing his knowledge through forward-thinking product planning and product management, business development as well as technical marketing. Jeff Babbitt holds a BS in Electrical Engineering from Colorado State University and a master's degree from The University of Texas at Arlington.