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Ten questions to ask before implementing Circuit Emulation Services over Packet Switched Networks

A WHITE PAPER FROM TELCO SYSTEMS

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Circuit emulation technology enables TDM traffic to be transported transparently over modern packet switched networks (PSN), including Ethernet, IP, MPLS and PBT.

Circuit Emulation Services over Packet-Switched Network offers a different approach to transport TDM traffic over IP, Ethernet or MPLS networks. One main benefit of the technology is its ability to transport many TDM trunks from one location to another over a packet network.

Before implementing this bridging technology between your existing TDM infrastructure and pcket-switched networks, there are some questions you should ask.

This paper will try to answer the top ten questions about CES over PSN.

What is CESoPSN?

Circuit Emulation Services over Packet-Switched Network (CES over PSN) is basically a method by which a TDM circuit (such as T1 or E1) is "tunneled" transparently through a packet-switched network (PSN). An interworking function (IWF) on each end of the PSN transforms

TDM data into packets on ingress and reverses this process on egress. As a result, the TDM equipment on either end of the PSN (Figure 1) perceives a direct connection to the opposite end and is unaware of the intermediary network that is used to emulate the behavior of a TDM circuit.

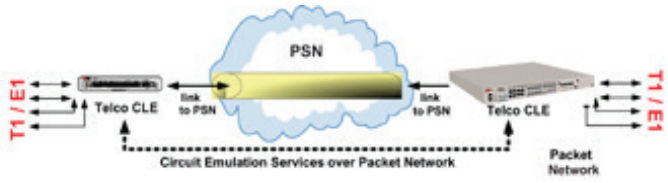


Figure 1: Circuit Emulation Service over Packet

TDM data may be transported over the IP, MPLS, or Ethernet networks, by simply choosing the right encapsulation method and assigning the address of the target device. Figure 2 illustrates a point to multipoint CES over PSN scenario.

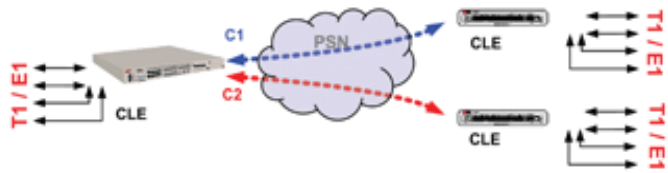


Figure 2: Schematic View of the CES Concept

Is CES over PSN technology relevant only when a packet switched technology is implemented over the carriers' network?

In todays' deployments it is typical to find both legacy SDH/SONET and new PSN infrastructures coexist at the point of presence (POP). Many customers wish to receive legacy TDM services in parallel to new Ethernet based ones.

In the Figure 3 scenario CES circuits can run over the first mile and handed off at the point of presence (POP) of the PSTN while Ethernet traffic is transported natively, without any unnecessary encapsulation over the first mile and than switched to its destination over the PSN.

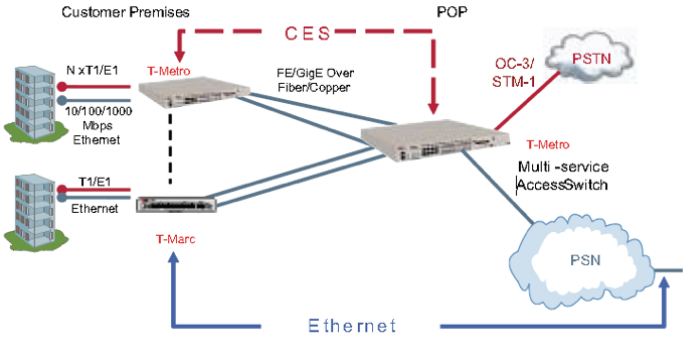


Figure 3: CES Transport to Destination over the PSN

What is TDMoIP and how is it different from CESoPSN?

TDMoIP technology is also a method for transporting TDM traffic over packet networks. However, TDMoIP is using the technology developed for ATM networks, but instead of transporting the ATM cells over ATM it multiplexes multiple ATM cell payloads in common frames and transports them over a packet-switched network.

CES over PSN, on the other hand, maps DS0 timeslots over PSN frames. Although TDMoIP and CESoPSN supply similar functionality, CESoPSN has been implemented by more vendors since its implementation is simpler and straight forward. Today CESoPSN has become the defacto standard.

What are the advantages of using pseudowire (PW) to transport CES?

Pseudowire emulation technology has been designed to provide a transparent tunnel over the packet switched network. Running circuit emulation services (CES) over pseudowire enables the migration of legacy TDM-based services to modern packet switched networks which are optimized for offering new revenue generating services. The customers enjoy the benefit of continuous support in the currently used services alongside the option to use new revenue-generating services.

When scaling of the network is required, hierarchical VPLS (H-VPLS) is critical. H-VPLS eases provisioning and simplify the packet network. With VPLS, end-to-end provisioning becomes intuitive and straight forward. H-VPLS helps reducing the overall number of pseudowires and relieves the replication and signaling burdens of the provider equipment by using MTU switching to aggregate customer VPLS traffic before sending it to the provider edge. The MTU and PE devices connect via a single pseudowire per VPLS instance.

How is QoS ensured for PWs over Ethernet networks?

Having guaranteed QoS is crucial for CES PWs to become a valid replacement for the traditional TDM circuits. TDM networks are connection-oriented, and network resources are allocated along the transmission path for the sole use of the provisioned circuit. Modern carrier Ethernet networks are equipped with prioritization mechanisms that can ensure top priority for the transmitted data flow across the network. But Ethernet networks are connectionless and shared by multiple traffic flows. Attributes such as guaranteed bandwidth and constant bit rate do not exist, unless more sophisticated mechanisms such as MPLS traffic engineering are used.

How is the PDH timing distributed in pseudowire deployments?

Pseudowires use multiple methods to distribute PDH timing. The most common method today the adaptive method in which the PDH clock is regenerated at the far end of the PSN using a sophisticated adaptive mechanism. Other methods are now under development such as differential timing, out-of-band timing-over-packet (based on IEEE1588), and synchronous Ethernet.

What type of OAM features does the CES device support in the access network to the customer?

Protection measures such as dual homing, link aggregation or Carrier-class Ethernet-based ring should be taken to protect the first mile segment and in-service tools for advanced OAM (Operation, Administration and Management) and service assurance should be integrated (Figure 4) in order to manage, control and monitor the customer equipment and the delivered services remotely.

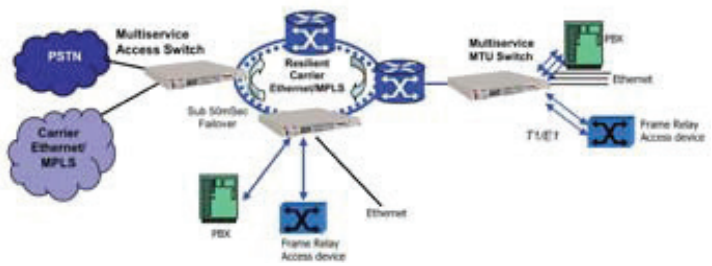


Figure 4: OAM features of CES over PSN

Fast reroute

Fast Reroute (FRR) is a mechanism that facilitates fast local repair of protected Label Switched Paths (LSP) in case of link or node failures. FRR redirects user traffic onto backup LSP tunnels in 10s of milliseconds, a failover time that matches the capability of SONET link restoration. While the speed of repair is the primary advantage of FRR, the feature has two noticeable benefits – increased reliability and high scalability. Scalability is achieved by supporting the mapping of all primary tunnels that traverse a link onto a single backup tunnel, limiting the growth of backup tunnels to the number of links in the backbone.

End-to-end service assurance

End-to-end service assurance provides an Service Level Agreement (SLA) measurement tool for Ethernet services and integrates with the IP/MPLS core. External and internal test heads can be used for service turn-up, fault isolation, and on-going customer SLAs.

Link oam (IEEE 802.3ah)

The IEEE 802.3ah Ethernet in the First Mile (EFM) standard defines the operations, administration and maintenance (OAM) mechanism needed for the advanced monitoring and maintenance of Ethernet links in the first mile for both network operation and troubleshooting. The IEEE 802.3ah OAM-EFM standard covers discovery, link monitoring, remote fault detection, remote loopback, MIB variable retrieval and vendor-specific enhancements. This was the first step toward including inherent management capabilities in Ethernet equipment for public network deployment and transforming it into a highly reliable technology.

Connectivity fault management (IEEE 802.1ag)

IEEE 802.1ag Connectivity Fault Management (CFM) refers to the ability of a network to monitor the health of a service delivered to customers as opposed to just links or individual bridges. The standard defines proactive and diagnostic fault localization procedures for point-to-point and multipoint Ethernet Virtual Connections (EVC) that span one or more links. It is end-to-end within an Ethernet network. IEEE 802.1ah provides improved troubleshooting tools at Layer 2 between multiple vendors and multiple providers. This Layer 2 ping and traceroute features will provide capabilities for detecting, verifying and isolating connectivity failures in these networks.

MEF services OAM

The Metro Ethernet Forum Operation, Administration and Maintenance (MEF OAM) is defining a standard which describes the implementation of bridged-Ethernet per- VLAN network-wide for estimating service assurance metrics and specific connectivity tests.

By using an MEF OAM network, operators gain the ability to monitor the activity of the single-link/entire bridged Ethernet network by using a built-in mechanism that enables real-time testing of connectivity, latency, jitter and frame-loss parameters on the bridged network without need for higher-layer implementations. MEF OAM also offers the ability to perform automatic periodic network-wide service assurance and quality verifications.

How does the number of hops affect the end-to-end clock accuracy?

The number of hops will increase the packet delay variation (PDV). In practice the effect of the increase in the PDV in high performance Ethernet networks would not affect the clock accuracy, but it may affect the clock acquisition durations, which becomes longer as the end to end delay and jitter become bigger.

How does circuit emulation behave in the presence of packet loss?

CES is not sensitive to reasonable packet loss rate (below 1%). The clock can still be recovered but CES has no means to recover the lost data. This is the reason why most users of CES technology choose to implement it over high performance PSN with almost no packet loss when high priority is given to the CES flow across the network.

What industry standards apply to CES devices?

Intensive work has been done in multiple standardization bodies:

- IETF PWE3 (Pseudo-Wire Emulation Edge–to-Edge) working group
- MEF (Metro Ethernet Forum)
- ITU-T
- MPLS Frame-Relay Alliance

The result is the following set of TDM over PSN protocols:

- SAToP (Structure-agnostic transport over packet)
  - Simply encapsulates N consecutive bytes into a IP, MPLS or Ethernet
  - Supports unstructured TDM (if there is a structure, it is ignored)
  - IETF Standards track (RFC 4553), ITU-T Y.1413, MEF 8, MFA 8.0.0
- CESoPSN (Circuit Emulation Services over Packet-Switched Network)
  - A method to encapsulate structured (N x DS0) TDM signals over Packet Switched Networks (PSN).
  - Emulation of NxDS0 circuits saves PSN bandwidth when non-active timeslots are not transported or for dynamic timeslot allocation.
  - Supports DS0-level grooming and distributed crossconnect applications
  - Conforms with ITU-T Y.1413, MEF 8, MFA 8.0.0 and IETF PWE3 CESoPSN draft
- TDMoIP (TDM over IP)
  - Encapsulates structured (NxDS0) TDM signals and voice with/without CAS signaling using 8-bit timeslot resolution
  - Static timeslot allocation according to ITU-T Y.1413, MEF 8, MFA 4.1 and IETF PWE3 TDMoIP draft
  - Dynamic timeslot allocation according to ITU-T Y.1414 (clause 10), MFA 5.1 and the IETF PWE3 TDMoIP draft.
- MEF-defined CES Services

Metro Ethernet Forum (MEF) has defined four general CES service types for the Metro Ethernet Network (MEN) provider. The services are defined for Ethernet networks but may be provided over all types of packet networks:

- TDM Access Line Service (TALS) – in which the MEN provider provisions and manages TDM leased lines via CESoE, and at least one endpoint terminates at the PSTN (Public Switched Telephone Network).
- TDM Line Service (T-Line) – in which MEN provider provisions and manages TDM private lines via CESoE between enterprise endpoints.
- Customer operated CESoE, in which enterprises or cellular providers manage TDM private lines via CESoE over point-to-point Ethernet (E-Line) service from MEN provider.
- Mixed service, which is combination of any of the three services above.

Telco Systems' Carrier Ethernet product line implements the following industry standards:

Standardization Body	Target Network	CES Standard	Notes & Standards Names
IETF	IP	SAToP CESoPSN	
ITU	MPLS	SAToP CESoPSN	Rec. Y.1413
Metro Ethernet	MPLS	SAToP CESoPSN	Rec. Y.1413
Forum	Carrier		
Ethernet	SAToP CESoPSN	MEF-8	
MPLS Forum	MPLS	SAToP CESoPSN	MFA 8.0.0
MPLS Forum	MPLS	SAToP CESoPSN	MFA 8.0.0

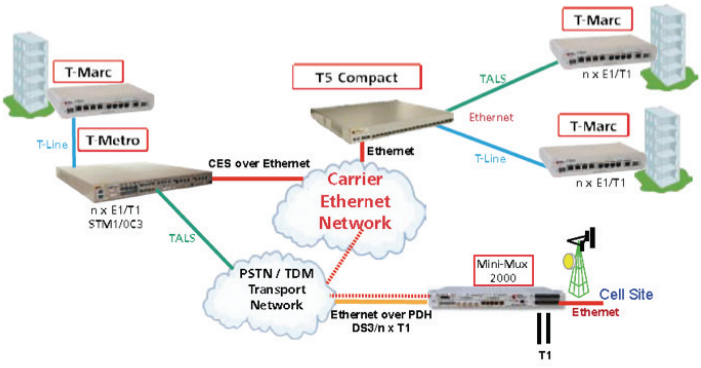
AccessTDM™: Circuit Emulation Services over Packet

AccessTDM™ enables service providers to extend their reach and addressable customer base to include both voice and data without sacrificing revenues from existing TDM services AccessTDM conforms to IETF, MFA, and MEF standards for flexible deployment, provisioning, and delivery of TDM/PDH services over Ethernet. Based on Circuit Emulation Services over Packet (CESoP) standards for T-Line (T1/E1) services, AccessTDM protects users' legacy equipment investments (i.e.: PBX's and routers with T1/E1 interfaces) while cost effectively enabling Ethernet service providers the ability to offer revenue generating services over dedicated, managed next-generation packet networks for end-to-end service assurance.

Service providers can increase enterprise cost-efficiency and productivity by offering a combined voice and data network to business users who want to protect their investments in robust, fully-featured TDM equipment yet enjoy the benefits of a high-performance Carrier Ethernet network. Circuit emulation technology addresses this requirement by placing TDM interfaces side by side with high capacity Carrier Ethernet services.

Incumbent operators can utilize their lucrative E1/T1 services while converging their underlying transport infrastructure on new, high performance, cost-effective Ethernet, IP and MPLS technologies. Alternative operators, including Multi-Service Operators (MSOs), which primarily use packet switched infrastructure, can utilize CES to offer high value TDM services, while leveraging their new high performance packet-based networks.

Subscribers benefit not only from additional high-speed services but also by being able to purchase a service package based on one cost-effective access link with simplified billing, allowing them to achieve toll quality voice connectivity with all the functionality developed around E1/T1 over the last several decades. TDM services based on CES also have advantages for the cellular backhaul market, allowing the transport of the Radio Access Network over cost effective and bandwidth rich Carrier Ethernet.



Telco Systems' CES over PSN product offering

Telco Systems has developed a comprehensive CES over PSN solution using TDM pseudowire technology. The Telco Systems' CES over PSN solution is purpose-built to address the needs of carriers and service providers. It enables a smooth migration to PSN and capacity upgrade, supports multiple grades of service to address the different applications cost-effectively, and addresses all networking needs required to support operating in a Carrier Ethernet environment.

Telco Systems' Carrier Ethernet family of switch-routers and PWE3 gateways comprises of a diverse mix of devices, from small customerlocated equipment (CLE) to higher capacity aggregation units for the carrier's central office or point-of-presence (POP). The Telco Systems' family of products facilitates a wide range of applications, including simple end-to-end circuit extension over IP/Ethernet/VPLS/MPLS, and guarantees the delivery of a variety of legacy services over packet-switched networks using a set of integrated OAM tools to assure the service integrity and delivery. When combined with Telco Systems' residential/SOHO ATA-CPE and VoIP IAD product line, these solutions support a wide range of legacy and emerging services, delivering voice, fax and data services over IP/Ethernet/MPLS networks without compromising traditional PSTN quality.

Telco Systems CES over PSN solution supports the following applications:

- Cellular backhaul over a packet-based network.
- Branch and Campus PBX connectivity to the PSTN over PSN.
- Extension of all PSTN Class 5 services over PSN
- T1/E1 leased-line services over PSN
- Broadband wireless voice/data access

T-Marc™ 254

Telco Systems' T-Marc™ 254 is a cost-optimized, fully-managed Ethernet and circuit-emulation (PWE3) gateway, which performs Ethernet and TDM service demarcation allowing carriers and service

providers to offer business customers a mix of legacy TDM-based services together with enhanced fully managed Carrier Ethernet services.

T-Marc™ 254 supports up to four digital T1/E1 trunks and four 10/100Mbps copper links over Ethernet/IP packet-based network. The platform supports differential grades of service, while providing traffic isolation for multiple services or applications using advanced QoS mechanisms.

The T-Marc-254 utilizes AccessTDM™ to deliver legacy TDM over Ethernet enabling service providers to extend their reach and addressable customer base to include both voice and data without sacrificing revenues from existing TDM services. Based on Circuit Emulation Services over Packet (CESoP) standards for T-Line (T1/E1) services, the T-Marc protects users legacy equipment investments (e.g., PBX's, routers with T1/E1 interfaces) while cost effectively enabling Ethernet service providers the ability to offer revenue generating services over dedicated, managed next generation packet networks.

T-Metro™

Telco Systems' T-Metro™ is an advanced Metro Ethernet Access CPE / CLE platform that support Ethernet LAN / Line services and TDM backhauling with Circuit Emulation (PWE3), through the use of

advanced Hierarchical QoS (tens of thousands of queues) as well as Hierarchical Virtual Private LAN Services (HVPLS) hubs-and-spokes and MPLS based rings support. T-Metro is a compact 1RU 19" enclosure that is NEBS 3 compliant.

T-Metro can host a variety of TDM CES modules to support:

- 4 T1/E1
- 8 T1/E1
- Channelized OC3/STM-1*

T-Metro platform is also equipped with fixed eight (8) 10/100BaseTX ports, twelve (12) SFP-based 100BaseFX ports and two (2) SFP-based 1000BaseX ports.

Telco Systems
A BATM Company

Contact information

International Headquarters
13 HaYetzira St., Yokneam Ilit,
20692, Israel
Tel: +972-4-993-5630
Fax: +972-4-993-7926

North & Latin America
15 Berkshire Rd
Mansfield, MA 02048
Tel: +1-781-255-2120
Fax: +1-781-255-2122

Asia Pacific (APAC)
10 Anson Road,
#17-03 Intl Plaza
Singapore, 079903
Tel: +65 6224 3112
Fax: +65 6220 5848

Europe, Middle East & Africa (EMEA)
Peterstr. 2-4,
52062 Aachen
Tel: +49 241 463 5490
Fax: +49 241 463 5491