Solution Brief

TDM Migration – SONET/SDH Replacement

Introduction

Telecommunications services and networks are driven by technologies such as Packet Switching, Software Defined Networks (SDN). Leading packet switching technologies being deployed nowadays are Carrier Ethernet, MPLS with Segment Routing on the horizon. However, entrenched TDM deployments are still found and may remain for many years, wherein TDM deployments can be summarized into TDM infrastructure (for both Service Providers and Critical Infrastructure entities and legacy TDM-based Customer Premises Equipment. By TDM we include PDH, SDH and SONET technologies.

Many factors impact a fast migration to packet switching networks and services for service providers, utility companies, governmental agencies, and transportation companies:

- Lack of alternatives to specialized TDM devices with legacy interfaces and the strict, deterministic performance delivered by TDM technologies. Security and regulatory controls.
- No clear financial justification for replacing functional TDM equipment.
- Losing customers and facing services degradation when decommissioning TDM networks.

On the other hand, the migration trend is inevitable due to the following:

- Equipment becomes obsolete as vendors (end-of-life) EoL their legacy products.
- Legacy equipment's unsustainability (power and energy, cooling and rack space, etc.).
- Older experts retire

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- Aging copper infrastructure along with high maintenance and operational costs.
- Outdated management tools and technologies (legacy OSS vs. dynamic network orchestration).

This solution brief will cover 2 major migration scenarios: Service Providers Leased Lines and OT migration for Utility companies. In order to better understand those migration strategies, we must take a deeper look to gain knowledge and awareness on 3 major background topics as follows:

- Pseudowire Capabilities – Circuit emulation technologies, SATOP, CESoPSN and TDMoIP
- Packet Technology of Choice – Comparing Carrier Ethernet with IP/MPLS and MPLS-TP
- Legacy interfaces Availability on packet switching devices.

Pseudowire Capabilities

Pseudowire Emulation (PWE) technology enables ethe encapsulation and transmission of TDM and analog data over packet-based networks. It allows service providers and utilities to maintain traditional/legacy TDM and analogue services, while introducing newer packet-based technologies. TDM and packet technologies have fundamentally different requirements for maintaining determinism and predictability.

RAD has pioneered TDM pseudowires and introduced TDM pseudowire technology in 1998. Known as TDMoIP®, this implementation extended the original pseudowire definition into the access network and to the customer premises, enabling carriers and corporate customers alike to provide TDM connectivity and services over a packet network. TDMoIP pseudowire supports all types of TDM services: framed, unframed, with or without Channel Associated Signaling (CAS), enabling a smooth migration to packet networks.

Following the successful deployment of TDMoIP gateways by RAD, other flavors of TDM pseudowires have been developed under the aegis of the IETF. These pseudowires are known as Circuit Emulation over PSN (CESoPSN) and Structure Agnostic TDM over Packet (SAToP).

CESoPSN TDM pseudowire technology supports framed and channelized TDM services over packet switched networks. The main difference between TDMoIP and CESoPSN is the way CESoPSN packetizes the TDM data. Where TDMoIP packetizes TDM data in multiples of 48 bytes, CESoPSN uses multiples of the TDM frame itself. SAToP (RFC 4553), or Structure Agnostic TDM over Packet, is a TDM pseudowire technology that differs from TDMoIP and CESoPSN in that it treats the TDM traffic as a data stream and ignores the framing or the timeslots (DS0). It provides functionality similar to TDMoIP in its unframed mode.

The choice between the different Pseudowire types depends on the following criteria:

- Service offered – what type of service is being offered, unframed, framed or channelized?
- Network bandwidth constraints - what is the overhead that can be sustained by the available bandwidth?
- Single or multiple technologies – is the carrier able to handle multiple pseudowire technologies to achieve optimal results, or will it sacrifice some performance for the sake of simplifying its network operations?

A Word on Clock Recovery...The main challenge with any of the TDM pseudowire standards is the issue of clock recovery. There is no standard definition as to how to perform the clock recovery itself, and each vendor implements a proprietary solution. Specific TDM services have distinct clock recovery needs; the most demanding one is that of cellular backhaul. Additionally, clock recovery performance is highly dependent on the underlying packet network. The ITU-T has defined a standardized way to measure clock recovery performance under the G.8261 specification. Advances in synchronization over packet networks have been made with IEEE1588v2 and synchronous Ethernet defined in G.8261. These technologies are an important contribution to establishing a robust mechanism for distributing clock and synchronizing packet networks.

Packet Technology of Choice

Deploying Carrier Ethernet, IP/MPLS or MPLS-TP replacing SONET and SDH had been a subject of debate in the industry. Equipment designs seek to obtain the better of two worlds through specific management tools to simplify the implementation of IP/MPLS, or through integrating L3 interface capabilities into MPLS-TP platforms.

The present section is therefore only a temporary assessment, made at a given instant of time. Deploying MPLS is not a “build from scratch” practice, but part of an evolutionary transformation plan. Again, the word “migration” is key in deciding upon technologies. If the present network is SDH or SONET-based, time-sensitive legacy services are designed for circuit mode operation, and synchronous data streams such as E1/T1 often need to be emulated across the packet core. Moreover, TDM services deployed throughout the network are managed from a central network management platform with processes and skills which are adapted to such operation. Carrier Ethernet and MPLS-TP in this context seem to be a more appropriate technology combination than IP/MPLS with or without traffic engineering. Some of the main reasons are summarized below:

- Maintaining full control of the network — in Carrier Ethernet management, provisioning and MPLS-TP forwarding, labels are produced by a central network management system (NMS). This allows end-to-end main and alternate route definitions as presently done through SDH/SONET. In IP/MPLS, on the other hand, the proper operation of the network depends upon control plane communications. Moreover, if a deterministic behavior is necessary for some data streams, then adequate traffic engineering must be introduced to govern nodes decision. Adjusting traffic engineering parameters in an IP/MPLS network (MPLS-TE or RSVP-TE) is complex and requires tuning and adjustments rendering the network subject to non-optimal settings.
- Quality of Service (QoS) and deterministic behavior— To ensure optimal performance, the PW flow over the network should receive the highest priority to prevent jitter caused by queuing. Additionally, it should follow a deterministic route without rerouting to avoid network bottlenecks.
- Size of network and type of traffic—by its SDH/SONET-like behavior, MPLS-TP and Carrier Ethernet respond to all existing service requirements, as well as new packet-based services in utility-sized networks. Deploying MPLS-TE or RSVP-TE on the other hand, is suitable for public networks with highly dynamic data traffic characteristics and too many nodes for centralized control: Traffic rules are hence given to nodes so that they can build the forwarding labels at any moment (TE).

- Capability versus complexity—IP/MPLS provides numerous technical capabilities but with increasing complexity. Implementing QoS through Dynamic Resource Reservation (RSVP) can be done in IP/MPLS. However, when you have a large number of connections It can be complicated. This level of dynamic complexity for a “static by substance” service seems unnecessary. Similarly, performing any meaningful Traffic Engineering in IP-MPLS (MPLS-TE) requires knowledge of the traffic characteristics, which is far from being the case for a lot of new services over a TDM network.
- Migration from SDH/SONET—transition to packet for networks having extensive SDH/SONET infrastructure, management tools and skills is almost smooth for Carrier Ethernet and MPLS-TP because of its SDH/SONET-like behavior and network management. IP/MPLS represents a departure from traditional network operations. While IP/MPLS suppliers offer tools and features to address fundamental challenges, their solutions often lack standardization, leading to increased reliance on a single supplier.

Carrier Ethernet highlights

Mature technology, widely deployed by carriers and utilities. Provisioning through management system (not routing protocols). Deterministic and connection oriented like SDH/SONET in terms of architecture and terminology. State-of-the-art security mechanisms available such as access authorization (802.1X), source authentication, integrity, and optional encryption (MACSec). Carrier-grade operations mechanisms such as service activation testing (Y.1564), fault management (Y.1731), performance monitoring (Y.1731) and automatic protection switching (G.8031, G.8032).

Summary on PSN technologies available for SDH/SONET replacement:

	SDH / SONET	CE	MPLS	MPLS-TP	Conclusion
1. Resiliency	+	+	-	+	• CE at least as good as SDH/SONET • MPLS uses non-deterministic local FRR • MPLS-TP is like CE
2. Cyber Security	-	+	CE/IP	CE	• CE is more secure than SDH/SONET • MPLS and MPLS-TP are not secure • Optional ETH Security can be added to MPLS
3. Timing Frequency and Time of Day	+	+	CE	CE	• CE better than SDH/SONET (SDH – only frequency) • MPLS and MPLS-TP are using Ethernet standards for timing
4. Technological Maturity	+	+	+	+	• SDH/SONET is mature • CE & MPLS are mature • MPLS-TP is mature but no further developments are being done
5. Future-Proofing	-	+	+	-	• SDH/SONET is reaching End-of-Life • CE, IP are all future-proof • MPLS-TP no future standards are planned
6. Manageability	+	+	-	+	• CE at least as good as SDH/SONET • MPLS uses routing protocols • MPLS-TP is like CE

When considering mission-critical services such as Teleprotection:

	SDH / SONET	CE	MPLS	MPLS-TP	Conclusion
7. Low Latency (< 6 msec end-to-end)	+	+	+	+	• CE at least as good as SDH/SONET • MPLS uses non-deterministic local FRR • MPLS-TP is like CE
8. Delay Consistency (constant end-to-end)	+	+	-	+	• CE is practically as good as SDH/SONET • MPLS suffers from delay changes • MPLS-TP is similar to CE
9. Delay Asymmetry (< 250 µsec)	+	+	-	+	• CE better than SDH/SONET (SDH – only frequency) • MPLS and MPLS-TP have no standard support for IEEE 1588
10. Troubleshooting	+	+	-	+	• CE is practically as good as SDH/SONET • MPLS complicated Control plan (involving many protocols) • MPLS-TP is similar to CE

In addition to the technological considerations outlined above, NERC-CIP (North America) strictly advises the use of non-routable protocols for critical infrastructure operational networks. Furthermore, CIGRE, an important regulatory body for Europe and the other regions outside North America, recommends Carrier Ethernet and MPLS-TP as technologies for replacing TDM, SDH, and SONET.

Legacy Interfaces Availability in PSN devices

Legacy interfaces such as E3, T3, E1, T1, serial (such as V.35, X.21, RS232/V.24, RS485, RS530) and analog interfaces such as E&M, FXO, FXS are becoming increasingly difficult to deploy and find in PSN devices. This is because the bulk of services today are mostly being served by 10Mbps, 100Mbps, 1GB, 10GB up to 100GB Carrier Ethernet interfaces. This trend is driving chipset and component manufacturers to End-of-Life and End-of-Service legacy components, thereby limiting support. Consequently, only a few vendors are able to commit to the medium and long-term availability of these critical components for an efficient migration from TDM to Packet.

Legacy Services Migration over PSN for Service Providers

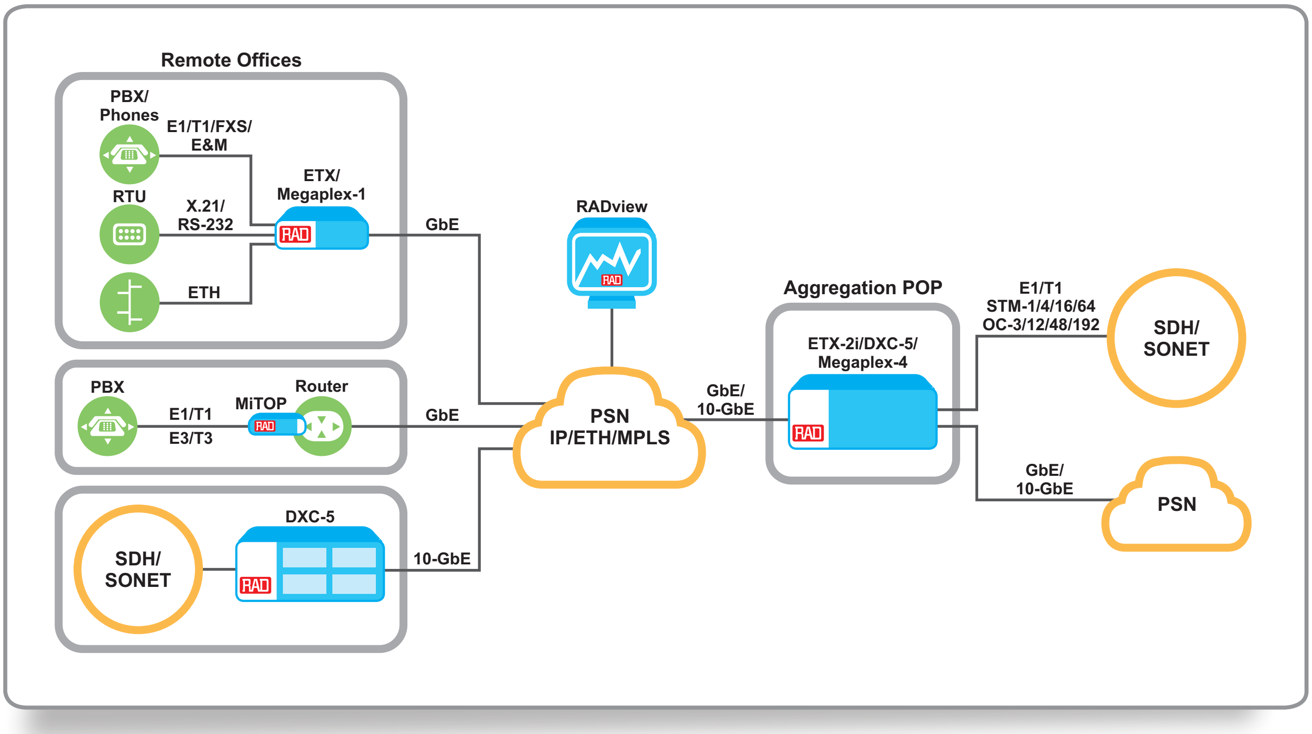
Ethernet and IP services are growing rapidly in numbers and capacity, with leased line trunks and access wholesale services moving from TDM to PSN, but legacy services are being phased-out very slowly. Services providers are reluctant to maintain legacy transport network and keep existing services alive. Also, some customers are not willing to swap to new packet services for security reasons, or because they are satisfied with legacy services Service Level Agreements (SLA) and reliability. In addition, legacy services offer in many cases much more revenue per bit compared to Ethernet and IP services.

There is no denying that TDM, PDH, SDH and SONET equipment are reaching End-of-Life and End-of-Support. Maintenance costs are increasing, and yet a migration solution is still under high demand and RAD can deliver it.

RAD has the most comprehensive, mature, and scalable portfolio in the market for TDM migration.

Solution Brief

TDM Migration – SONET and SDH replacement



RAD CPEs and Smart SFPs offer unique capabilities:

- Scalable from 1 up to 64 x E1/T1 interfaces
- Support of all TDM-over-PSN standards and a leader in MEF-compliant Carrier Ethernet solutions
- Variety of legacy interfaces and services still available and supported.
- SFP-based solutions for enhancing existing CPEs supporting up to 8 fractional E1/T1 services with CAS, ACR and DCR clock recovery (Sync-E based) schemes and E3/T3 services.

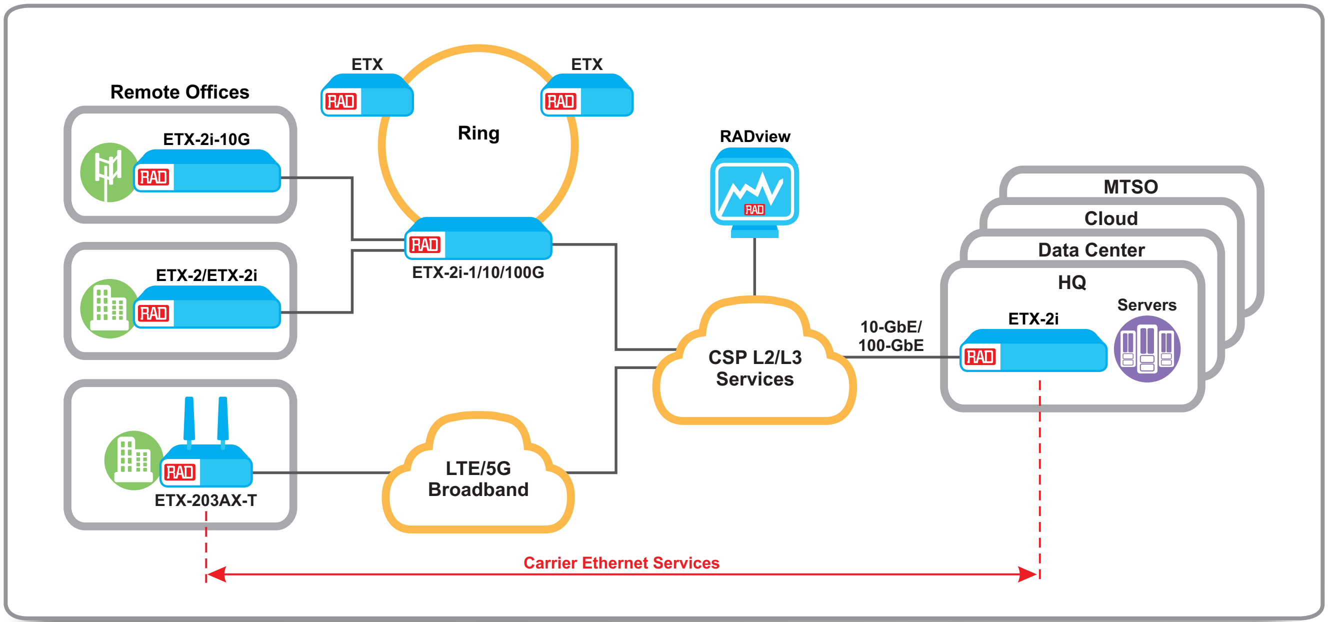
RAD's aggregation solution unique value:

- Addressing multiple vertical markets with 1GB, 10GB and 100GB products combined with MEF Carrier Ethernet attributes.

Solution Brief
TDM Migration – SONET and SDH replacement

RAD's MEF 3.0 Carrier Ethernet

- Service Assured Access and Aggregation
- 1G/10G/25G/40G/100G port offering
- Any access, including over LTE/broadband.
- SDN-ready, NETCONF/YANG enabled.
- FPGA-based, future-proof architecture
- ZTP for low-touch deployments

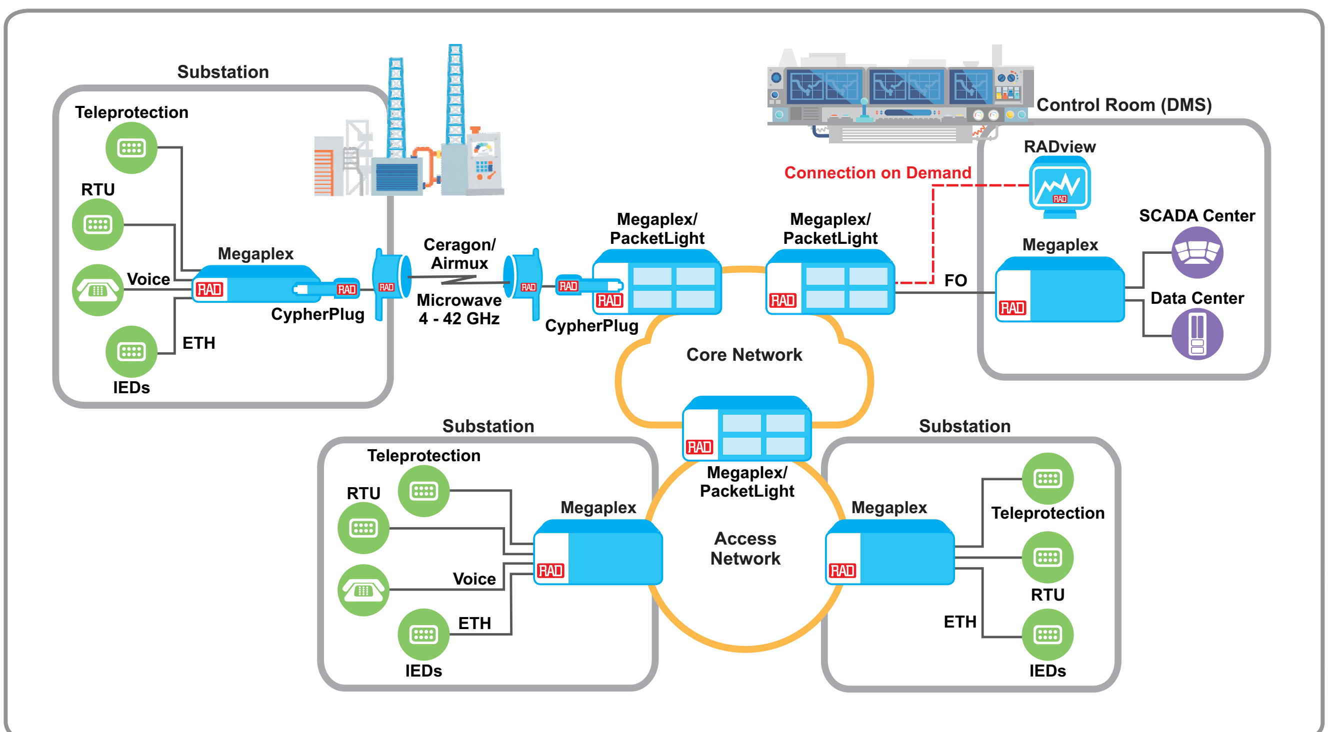


TDM Migration for Critical Infrastructure

When dealing with migrating critical infrastructure operational networks, additional criteria should be further considered:

- Determinism and Latency: Circuit-switched networks, such as TDM, PDH, and SONET/SDH, are deterministic, meaning that the path the information takes from source to destination is constant and well-known. Even if a fault occurs and protection switching kicks in, the protection path has been pre-configured, and the jump from the working path to the protection path is minimally intrusive. Furthermore, bits always arrive at a known constant rate in circuit-switched networks.
- Resiliency: The most important service characteristic is path continuity, which can fluctuate between up or down states. The service objective is for continuity to be up 100% of the time. Nevertheless, faults are inevitable and can be tolerated if they are rapidly detected and rectified.

- Monitoring and diagnostics: Guaranteeing communications in a network depends on continuously monitoring the service level objectives. Even if planning is carefully carried out, without monitoring, one can never be sure that the objectives are being met. Furthermore, if some objective is found to be inadequate or deteriorating, a set of diagnostic tools is needed to find the root cause of the problem.
- Traffic conditioning: In circuit-switched networks, information sources have constant bit rates, while in packet-switched networks, information sources are free to send information, or not, as they see fit. Objectives can't be guaranteed if information sources start sending at much higher-than-expected rates, as the required physical resources would not be available. In such cases, packets need to be deliberately discarded.
- Security: By now, it is well known that network infrastructures can be hacked. This can be to provide information or services illicitly, or to deny information, or services to legitimate users. The principal objectives of network security mechanisms are authorization, establishing security associations, authentication, and confidentiality.
- Timing support for power utilities: Teleprotection systems may require accuracies at the level of microseconds. Modern synchrophasors need to maintain 1-microsecond time accuracy even when they lose GPS reception. Also, smart grid applications have also been targeting 1-microsecond absolute time accuracy.

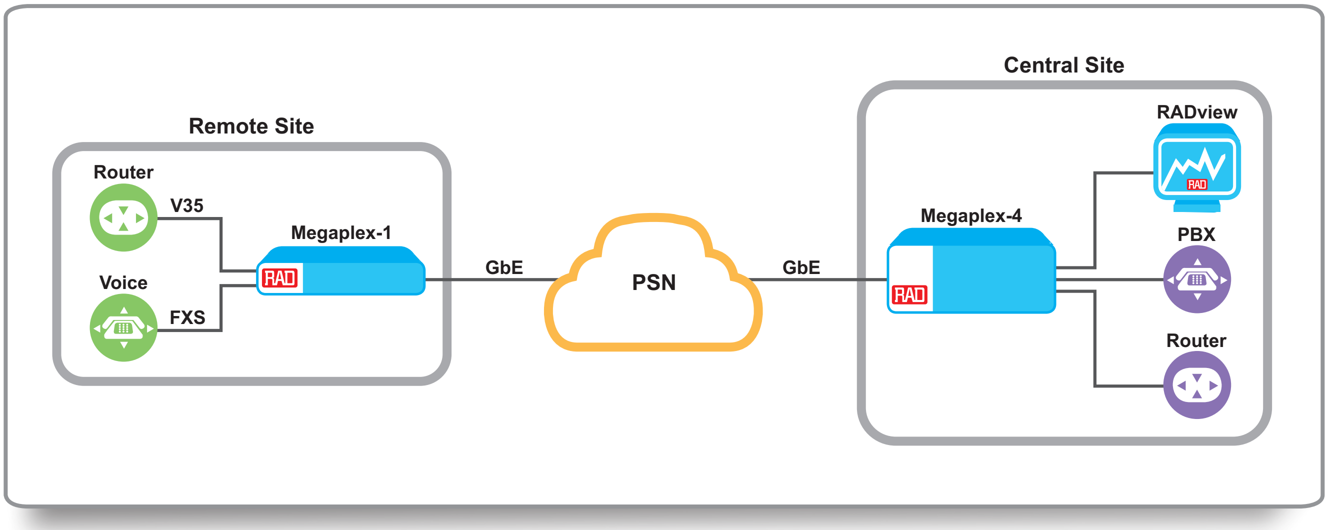


Solution Brief

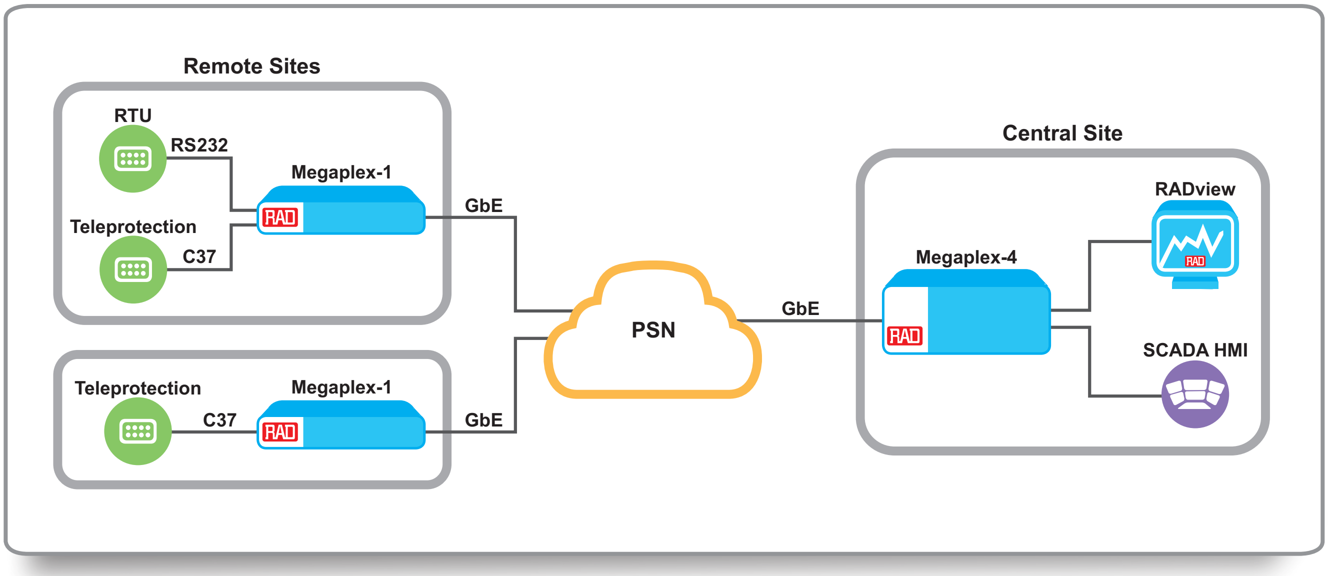
TDM Migration – SONET and SDH replacement

RAD's multiservice platform, Megaplex, offers unique capabilities for migration scenarios.

- Combination of Distance and Differential Teleprotection in one product.
- Low Latency: Less than 2msec end-to-end – FPGA-based design focusing on latency-sensitive services.
- Hitless recovery: Network failure recovery with zero-bit errors on TDM level – hardware-based redundancy mechanism allowing service recovery without downtime.
- Traffic Duplication: Traffic protection by using routes over different network technologies (for example, SDH/SONET + Packet)
- Multiple Protection levels: Path redundancy and port redundancy (equivalent to Path Protection and APS)
- Transparent transport: (Timing and framing of) E1/T1 over PSN (Like in SDH/SONET)
- SATOP and CESoPSN schemes.
- Multiplexing several TDM services to the same pseudowire (increases bandwidth utilization, simpler network control, and monitoring)
- End-to-end pseudowire service interval-based counters (Like in SDH/SONET) – allow long term monitoring of the service.
- Scalable solution with a variety of products with increasing port counts (starting from 1 x serial port in SecFlow and ending with 160 x serial ports in Megaplex)
- Point-To-Multipoint and conference capabilities for serial and voice services.
- 802.1x – Ethernet access control
- Routing, L3 encryption, TDM processing by virtualization module.
- Fan-less ordering option.
- Adaptive Clock Recovery accuracy is ± 0.016 ppm.



TDM to PSN Migration



Packet Based Operational WAN

In terms of service reliability RAD solutions ensures maximum reliability as required in a mission-critical environment. The Megaplex multiservice pseudowire access gateway was designed for exactly this purpose. The Megaplex allows critical infrastructure operators to safely transport analog and TDM traffic originating from legacy circuit-switched devices, over Carrier Ethernet or MPLS links. With a scalable TDM over packet pseudowire engine, it offers comprehensive support for Ethernet, PDH, high and low speed data, analogue voice, and even teleprotection devices. Maximum service uptime and reliable resilience with ultra-fast, hitless service restoration—everything mission-critical networks require for a seamless migration to PSN communications!

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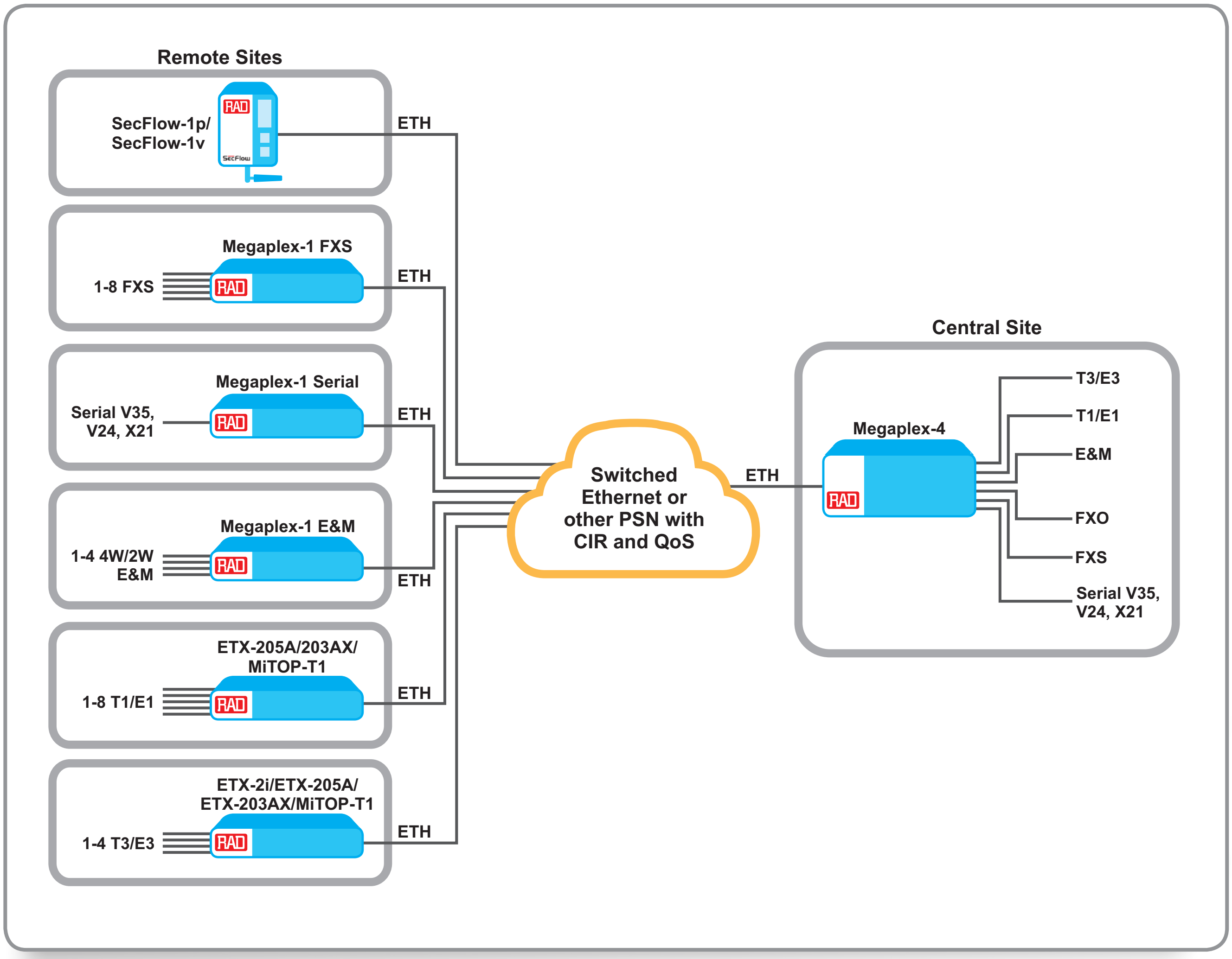
TDM Migration – SONET and SDH replacement



Migrating Voice and E1/T1 Leased Lines to a Packet Backbone

Solution Brief
TDM Migration – SONET and SDH replacement

Products in Focus

Solution Brief
TDM Migration – SONET and SDH replacement

RAD solutions ensure seamless migration from TDM to PSN. We address all communication needs for both service providers and utilities with best-of-breed tools.

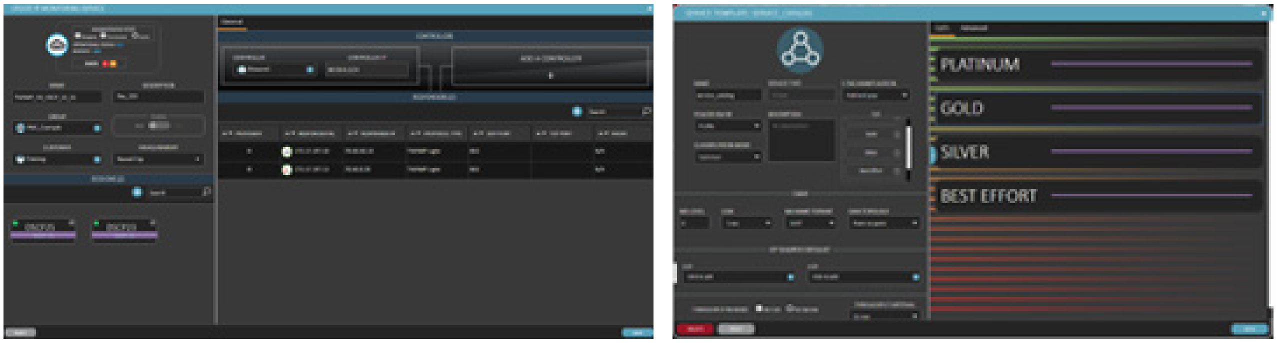
- Secure networking for the inevitable digital transformation to allow for fast, secure and economical migration of legacy services into next generation PSNs.
- Multiservice, packet and deterministic operational technology WANs (OT-WANs), supporting operational, mission-critical data, voice and video applications.
- Licensed and license-free radios for point-to-point and point-multipoint mission-critical applications.
- Edge computing capabilities for a variety of add value applications and functionalities such as protocol conversion, cybersecurity, IoT agents and video control and storage.
- Rugged L2, PoE industrial switches for a variety of outdoor and indoor applications, IEC 61850, IEEE 1613 certified.
- Smart SFP’s for unique applications, such as timing, pseudowire encapsulation, encryption and muchAdaptive Clock Recovery accuracy is ± 0.016 ppm.

About RAD’s RADview Suite

RADview suite is composed of four several modules:

NMS-Network Management System, responsible for inventory, shelf view, task management, zero touch provisioning and FCAPS, fault management, including a variety of automation modes such as auto-discovery for new network elements, auto-configure for devices with Zero-Touch and auto-execute for task and job management.

Service Manager – enables the creation of Ethernet and IP monitoring services. It supports powerful Point-and-Click features for fast services provisioning (from planning, creation, launch and activation), as well as auto-discovery of new services and template of repositories for quick activities.



Performance Monitoring (PM) – this is a PM portal, complete with TWAMP (Two-Way Active Measurement Protocol) statistics, Layer 2 monitoring performance reports (Y.1731), alarms and events reporting. It offers a comprehensive view in a single dashboard for all KPIs, analytics, and endless options for customizations. It also allows service availability assurance by monitoring traffic trends.

Solution Brief

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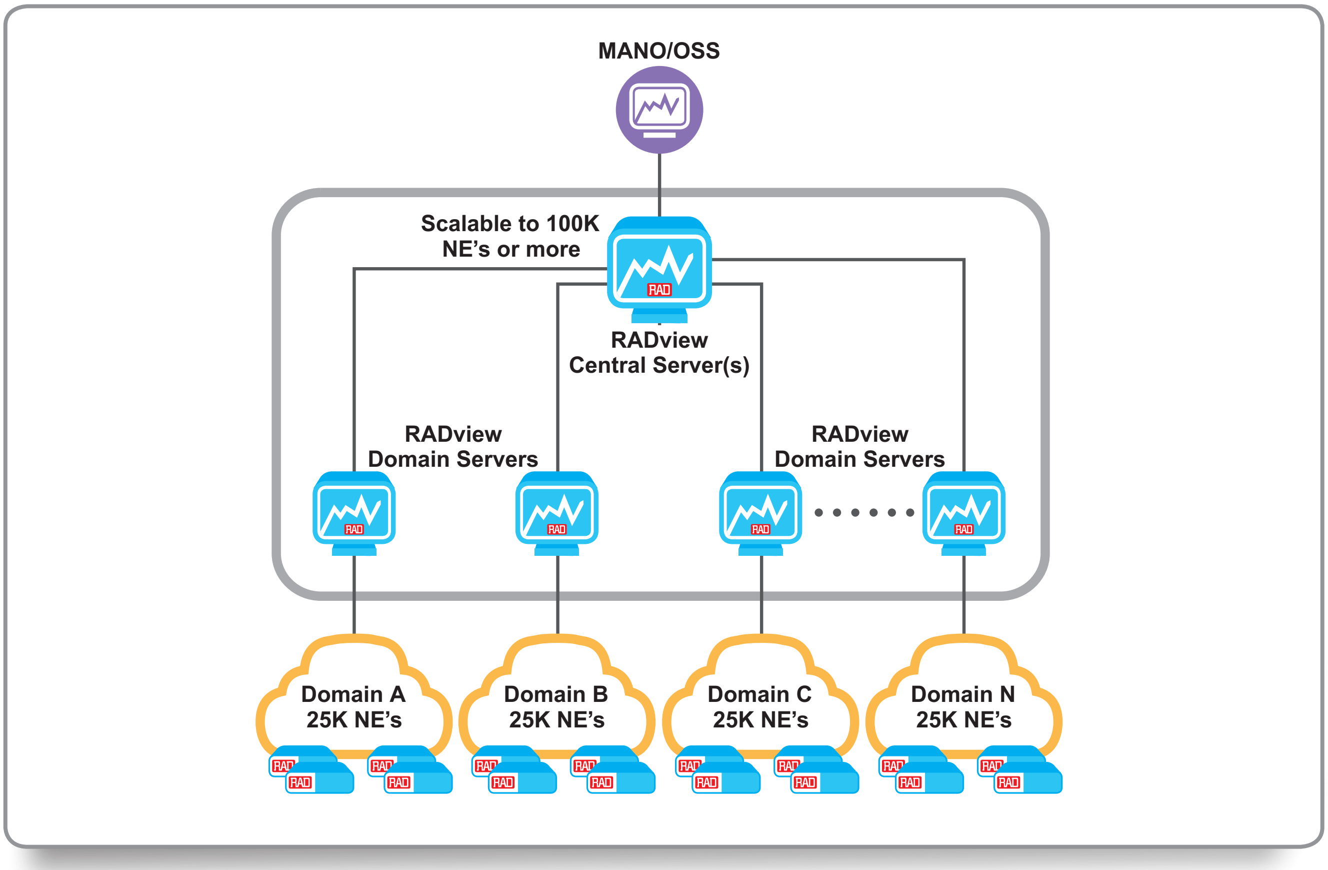
RADview Central for high scale NMS requirements enables virtually unlimited network scalability by providing a central entity that manages multiple RADview domain servers. It allows users to manage an unlimited number of network elements, under a single pane of glass. RADview Central features an easy-to-use GUI and a REST NBI:

- Controls the assignment of network elements (Nes) to domain servers.
- Performs tasks (e.g., software upgrades, configuration backups/restorations) across the entire network.
- ZTP: Automation of NE deployment and provisioning in both VPN and public network deployment scenarios.

RADView Central provides global inventory management of domain managers, wherein each domain can support up to 25,000 NEs, per server, with multiple servers per logical domain and logical domain partitioning through IP addresses, geography, or other criteria.



For more information on how RAD can help you with your TDM migration process, contact us at market@rad.com

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