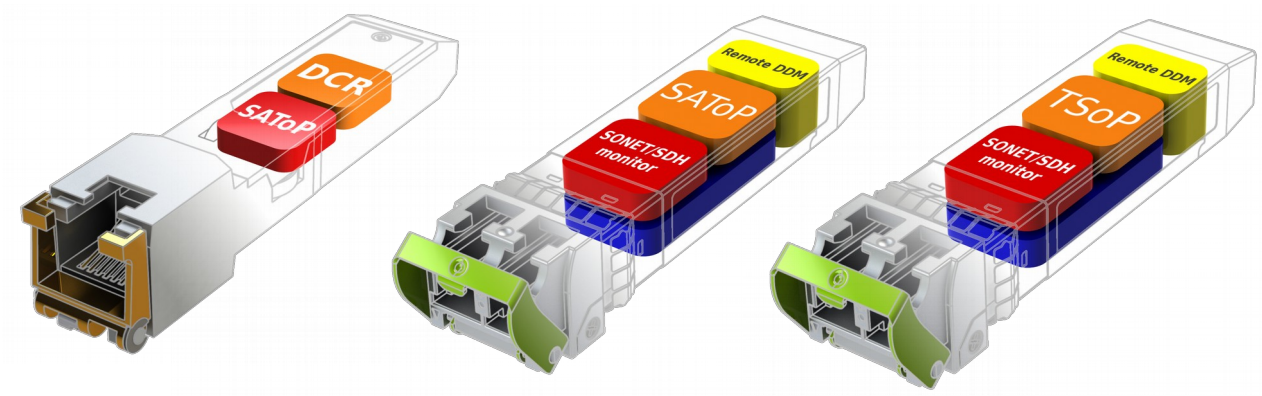
Simplify Network Migration with Smart SFP™

Transport of TDM services in a Packet Network



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1. Executive Summary

With many network operators transforming their networks to all packet transport, TDM over Packet emerges as the key enabler to migrate legacy services to the packet network. Using a single unified network for both data and TDM transport they can streamline operations, and reduce capital and operational expenditures.

OE Solutions and AimValley enable a smooth transition from legacy TDM towards all packet networks with a family of Network Migration Smart SFP™ modules. These SFPs convert DS1/E1, DS3 or SONET/SDH signals to a packet stream. Operators now have a cost-effective alternative: instead of upgrading systems with dedicated TDM over Packet cards or installing new equipment they can simply add the Smart SFP to any router or packet switch where a TDM service is demanded.

The Network Migration solutions are delivered in an SFP module form factor, combining the optical or electrical line interface with protocol conversion. This integration enables operators to reduce cost in access and edge networks, and allows for significant savings in rack space. Furthermore, due to its low power consumption, the Network Migration Smart SFPs can be an effective tool for operators that want to reduce their carbon footprint and electronic waste.

This white paper describes how Network Migration Smart SFPs can be used in various network applications. The key aspects of the TDM over Packet protocols are reviewed and how operators and network providers will benefit from the use of these Smart SFP modules in their networks.

2. Market Motivation

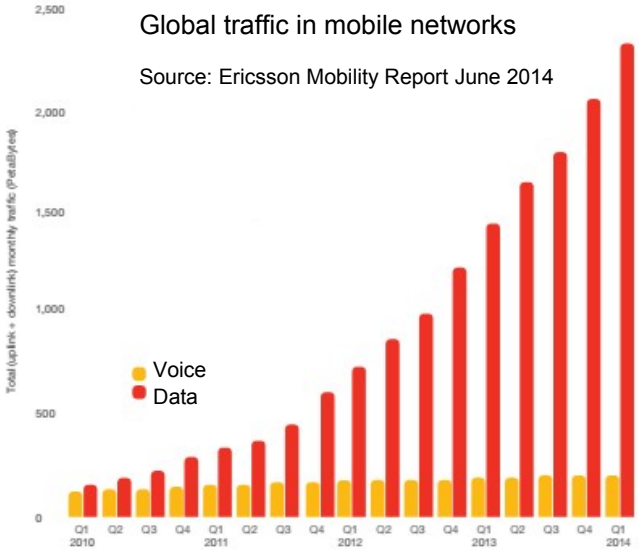
It is estimated that about half a million SONET/SDH rings are in operational use worldwide. The majority is installed by Telecom network operators, but these reliable and versatile TDM networks are also popular in other industries, such as power utilities, transportation, mining, broadcast, and governmental networks.

A common trend for both Telco and other industries is that data is becoming the most significant traffic type on their networks. This forces operators to transform their networks to all packet which is better suited to data transport. Streamlining their operations on a single network reduces both capital and operational expenditures.

In addition, these network migration initiatives can generate cost optimizations in other areas such as: reducing the amount of Telco offices, freeing up and selling off high valued real estate in downtown locations, or re-purposing Telco offices to datacenters.

Global traffic in mobile networks

Source: Ericsson Mobility Report June 2014



These are all very clear and sound business drivers, and transformation to packet is a necessary step for all network owners. However, a part of the client traffic remains TDM based, forcing operators to maintain a TDM transport capability on their packet networks:

- customers use TDM client signals and are not able to migrate to a data service (yet)
- backhaul applications require TDM signal format, e.g.: GSM or LTE depend on E1/DS1
- legacy enterprise voice equipment such as PABX relies on E1/DS1
- operators prefer to prolong the revenue stream from high-valued TDM leased lines
- wholesale SONET/SDH transport
- clients require highest reliability and mission-critical SLAs for their TDM circuits, e.g.: tele-protection
- services that are legally obliged to be offered via TDM, e.g.: governmental services

3. Applications

Operators are transforming their networks to all packet in order to optimize for data traffic and to streamline their operations, taking advantage of a single unified packet network. Transport of legacy services over a packet network typically requires an upgrade of existing systems with dedicated TDM over Packet cards or installation of new equipment. These are costly operations, that involve detailed planning, truck rolls, allocation of rack space, and power for the new equipment. The Smart SFP provides an alternative which enables a smooth transition: simply add the Network Migration SFP to any router or packet switch where TDM service is demanded.

This section describes various Network Migration scenarios for telecom operators and other network industries, based on typical network topology, specific client TDM services or unique application requirements. Before we dive into the applications and transformation scenarios, let's quickly review the applicable Smart SFP types for Network Migration:

Product Name	*Description*	*Line Interface*	*Channelization*
TPoP Smart SFP	Transparent PDH over Packet	DS1 or E1	Single channel
VCoP DS3 Smart SFP	Virtual Container over Packet	DS3	Single channel
TSoP Smart SFP	Transparent SONET/SDH over Packet	OC-3/STM-1, OC-12/STM-4, OC-48/STM-16	Single channel
CPoP DS3 Smart SFP	Channelized PDH over Packet	DS3	Channelized to DS1
CSoP Smart SFP	Channelized SONET/SDH over Packet	OC-3/STM-1	Channelized to DS1/E1
VCoP optical Smart SFP	Virtual Container over Packet	OC-3/STM-1, OC-12/STM-4	Channelized to STS1/VC4

All Network Migration Smart SFPs are complemented with a Gigabit Ethernet system interface. A detailed description and comparison of the SFP types and protocols can be found in section 4 “TDM over Packet protocols”. In this paper we use the generic term TDM over Packet; Circuit Emulation Service, CEM, CES or TDM pseudowires are alternative names for the same concept. SAToP is a popular protocol to provide TDM transport over packet.

3.1. Application: Network migration in the Mobile Backhaul Network

Mobile network providers worldwide see a tremendous demand for higher bandwidth, and are forced to upgrade capacity on their networks. In addition, the interface towards the mobile handsets changed from GSM to UMTS and LTE. These protocols enable higher data rates on the mobile devices, which drives the transformation in the backhaul network from TDM to packet. With the extension to mobile 5G comes the natural drive for packet-based backhaul.

3.1.1. Migrate DS1/E1 circuits to Packet Network

In GSM and UMTS networks the access link from a basestation to the mobile core network is typically built with DS1 or E1 circuits. Today, these legacy interfaces are carried as native TDM traffic over copper or microwave links, or are multiplexed and transported via a SONET/SDH network.

As network operators are looking to simplify their backhaul infrastructure and build a single unified packet network, the legacy TDM backhaul links need to be upgraded as well. A popular approach is to transport TDM signals via SAToP. Some equipment has native support for this protocol; in other cases the system can be upgraded with a costly SAToP service card. The TPoP Smart SFPs provide an easy and cost effective alternative: the operator can upgrade the network from TDM to packet backhaul by inserting TPoP Smart SFP on both ends of the TDM link.

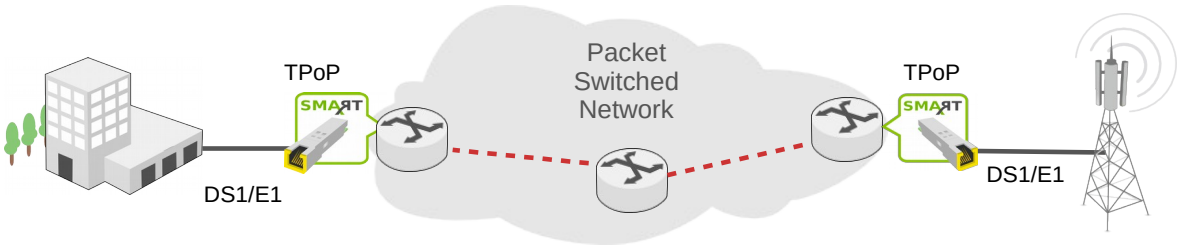


Figure 1: Mobile backhaul of DS1/E1 via Packet Network

Benefit	*Background*
Simplified migration	No need to install a dedicated DS1/E1 Circuit Emulation card or costly new equipment
Lower OPEX	Plug-and-play upgrade from legacy to packet network
Operational flexibility	Additional DS1/E1 TPoP Smart SFPs can be deployed in pay-as-you-grow fashion
Frequency transparent	Mobile operators rely on basestation synchronization via the DS1/E1 interface

3.1.2. Upgrade SDH microwave links to Gigabit Ethernet packet radio

Mobile backhaul networks in Europe are mostly based on microwave technology. Single or multiple E1 signals are multiplexed on a microwave radio carrier in rural areas, while SDH STM-1 radio is often used in metropolitan areas and on aggregation links to the Mobile Switching Center. Due to the tremendous growth of data traffic from mobile phones and other internet devices the capacity of these TDM backhaul links become a bottleneck.

Operators are now looking to upgrade from STM-1 to Gigabit Packet radio links: it serves the demand for more capacity, while at the same time providing a better fit for data traffic from LTE mobile base stations. But the upgrade forces additional changes for the 'in-door' equipment in the microwave backhaul. An operator may consider to replace the existing E1 to STM-1 multiplexer equipment with other equipment that supports E1 to Ethernet/MPLS protocol conversion using TDM over Packet with SAToP protocol as described in the previous section.

The TSoP Smart SFP provides an alternative upgrade scenario: connect the STM-1 fiber from the existing equipment via TSoP Smart SFPs directly to the packet switch, see figure 2. The TSoP SFP provides a clear-channel fully transparent STM-1 over packet. This greatly simplifies Microwave network upgrades: no need to re-wire the E1 connections on the 'in-door' equipment, and no changes on the configuration and management of the TDM equipment. The legacy equipment can remain in the network as is, while LTE base stations are directly connected to the packet radio link via Ethernet/MPLS.

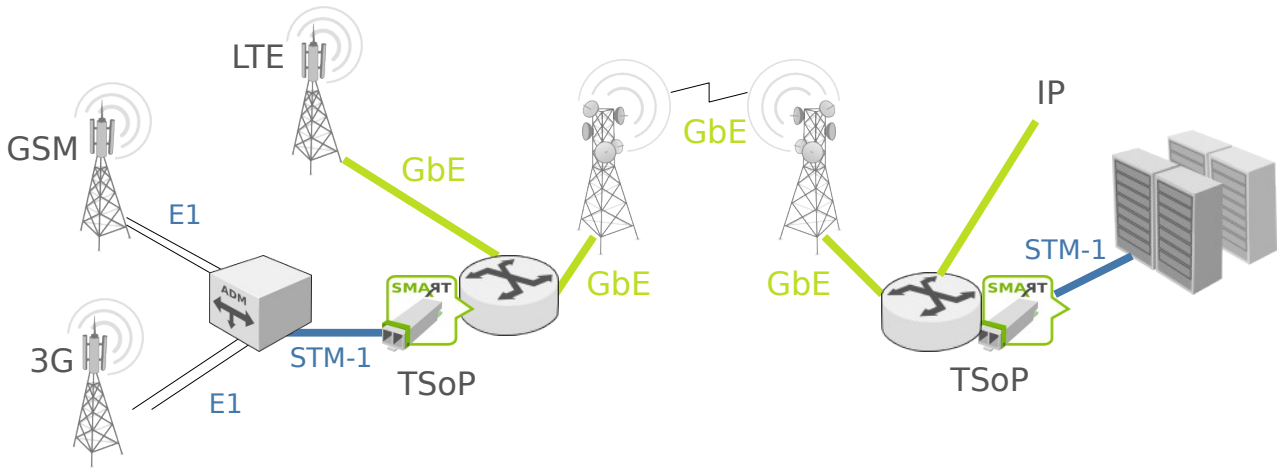


Figure 2: Mobile backhaul with Gigabit packet microwave and TSoP SFP

Benefit	*Background*
Simplified migration	No need to deploy and configure dedicated DS1/E1 Circuit Emulation cards
Lower OPEX	Simplified upgrade from legacy to packet networks
Operational flexibility	Additional OC-M or STM-N ports can be added as needed
Lower e-waste	The TDM mux is still in used after the migration to packet: no waste of equipment

3.2. Application: Enable efficient use of DWDM wavelengths or free-up fibers

DWDM systems use transponder cards to convert or multiplex various end-user client signals to a transport wavelength. Dedicated transponder cards are used to efficiently manage these clients:

- Gigabit Ethernet client signals are often processed and aggregated in a switched Ethernet transponder card, to efficiently multiplex 10 or more Gigabit Ethernet client signals on a single DWDM wavelength.
- Client signals with other bit rates can be carried by a rate independent (any-rate) card, supporting client signals with a bit rate of 1..10 Gb/s. Lower bit rates are possible as well, but the mapping is very inefficient and costly because the capacity of a full 10 Gb/s DWDM wavelength is used.

The TSoP Smart SFP enables an alternative method for very efficient transport of OC-M/STM-N signals on DWDM systems. Instead of using a separate any-rate transponder card, a port on a switched Ethernet transponder card can be used. The TSoP Smart SFP is inserted in any free slot on such a switched transponder card, mapping the OC-3/STM-1, OC-12/STM-4 or OC-48/STM-16 signal to a packet stream. This mapped signal requires a bandwidth of about 170 Mb/s, 680 Mb/s or 2.7 Gb/s at the Ethernet link, resulting in a very efficient transport method. The same switched transponder card can manage multiple TSoP SFPs at the same time, further enhancing efficient use of the available capacity on the same DWDM wavelength.

Similarly, Smart SFPs can be deployed to elegantly manage fiber shortage. Dedicated STM-1, STM-4 or STM-16 fibers can be freed up by simply inserting TSoP SFPs in a packet switch and multiplexing the TSoP traffic over a single Ethernet fiber.

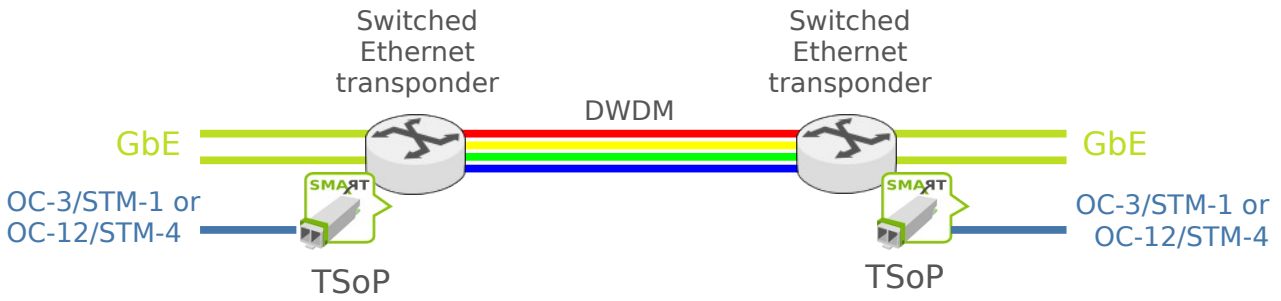


Figure 3: Efficient SONET/SDH via TSoP on Ethernet Switched Transponder

Benefit	*Background*
Easy upgrade	No need to install a costly transponder card type, just insert a TSoP Smart SFP
No new card type needed	SONET/SDH transport can be added to existing switched transponder card
Lower OPEX	Prevent waste of complete wavelength for low bit-rate client signals
Low power	Replace a dedicated transponder wavelength card with a TSoP Smart SFP
Operational flexibility	Additional OC-M/STM-N ports can be added as needed
Free-up fibers	Aggregate traffic from low rate SONET/SDH fibers onto a single Ethernet fiber

3.3. Application: Transformation of the TDM access network to Ethernet/MPLS

Network operators that plan to upgrade their networks from SONET/SDH to packet switched technology need to consider how to migrate their customers' existing DS1/E1 and DS3 services. In some scenarios the end customer may accept to change their end-equipment and migrate their environment at the same time that the network operator changes to the packet switched network. However, often these network transitions can not be aligned in time or the customer can not change his network due to operational hurdles, legal obligations or cost reasons.

Let's review various network scenarios, and how Network Migration Smart SFPs can be deployed to enable the transition from legacy TDM to packet networks.

3.3.1. Channelized OC-3 with DS1 SAToP

The TPoP Smart SFP uses the standard SAToP protocol (IETF RFC4553), enabling interoperability with other equipment. This allows operators to deploy TPoP SFPs at the edge of the network and aggregate the packet streams on multichannel SAToP equipment at a central location where TDM hand-off is done to other networks.

In large access networks operators typically use SONET equipment at the hub as interface to the core network. The DS1 hand-off from SAToP links to SONET can be done via separate copper cabling, but this is costly and error-prone due to the high amount of cable connections.

The CSoP Smart SFP (Channelized SONET/SDH over Packet) offers an excellent fit for this network scenario: it directly converts multiple SAToP DS1 streams from the packet network into an OC-3 optical interface. There is no need for separate SAToP equipment, and at the hub no DS1 copper cable connections are needed. Instead, the CSoP SFP is inserted directly into a packet switch port and provides OC-3 optical interface that connects directly to the next SONET core node, with 15 km reach, see figure 4. This greatly reduces the amount of equipment at hub the location and allows the operator to remove local SONET multiplexers, reducing space and power consumption.

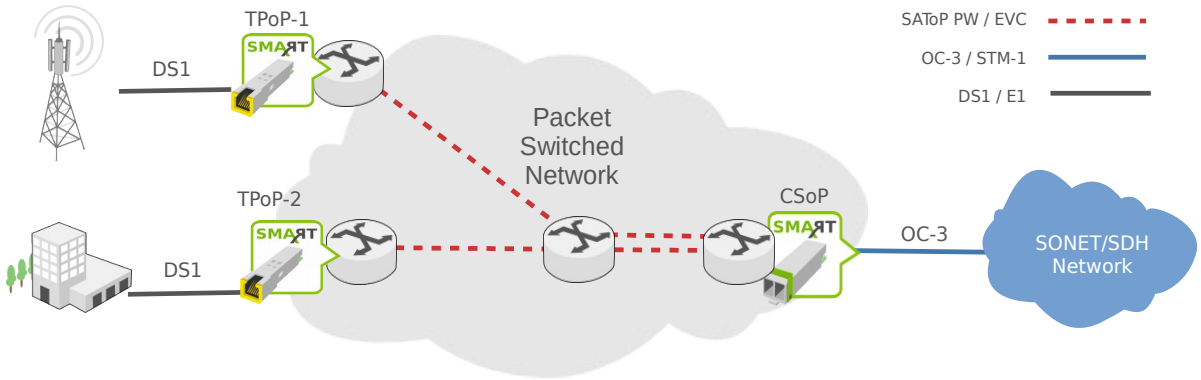


Figure 4: Efficient hand-off with Channelized OC-3

Benefit	*Background*
Simplified migration	Simply insert CSoP SFP in packet switch
Lower CAPEX	CSoP Smart SFP replaces DS1/E1 SAToP equipment, cabling and SONET/SDH node
Operational flexibility	Configure additional DS1/E1 SAToP streams as needed, without truck rolls on-site
Lower OPEX	No need to install and connect dedicated DS1/E1 copper cabling

A similar application is shown below in figure 5, where DS1 traffic from edge locations is already multiplexed into a OC-3 signal by the local access provider. The backhaul network operator can deploy a packet network and use CSoP Smart SFPs, both at the access and hub sites to transport the embedded DS1 traffic via SAToP packet streams.

Each DS1 SAToP packet stream is handled as a separate stream, enabling fine-grained switching and aggregation at DS1 level. Furthermore, due to the use of standard SAToP protocol, a mix of CSoP SFPs, TPoP SFPs and other SAToP equipment on the same network is possible as well, enabling a versatile and easily extended configuration.

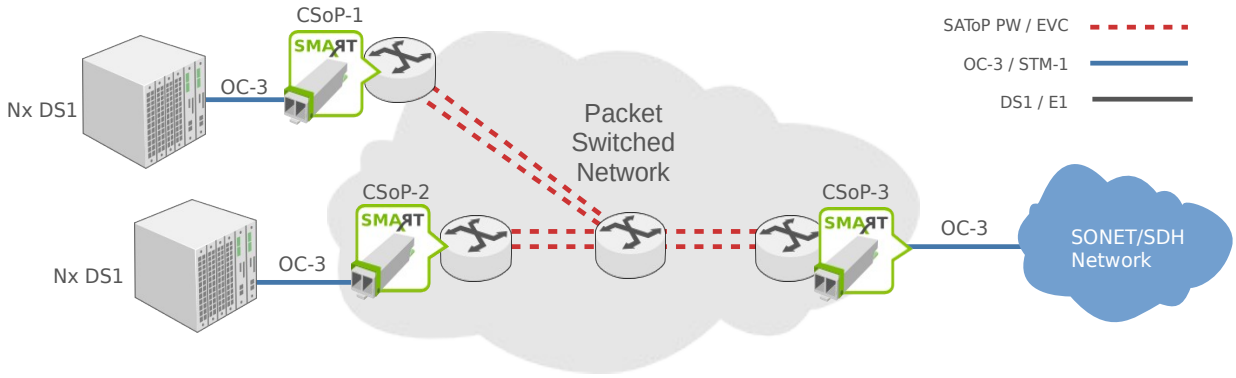


Figure 5: Aggregate low-fill OC-3 from network edge

Benefit	*Background*
Simplified migration	Simply insert CSoP SFP in packet switches at edge or access locations
Lower CAPEX	CSoP Smart SFP replaces DS1/E1 SAToP equipment, cabling and SONET/SDH nodes
Operational flexibility	Fine-grained switching and aggregation of individual DS1/E1 SAToP streams
Lower OPEX	Modify DS1/E1 connections remotely, preventing truck-rolls or cable patching

3.3.2. Channelized DS3/T3 with DS1 SAToP

Several Communications Service Provides in America use DS3 (also known as T3) as an intermediate channelized interface, connecting DS1 interfaces from the access network via a DACS to the core network. The CPoP Smart SFP (Channelized PDH over Packet) supports migration of this application to a packet network: traffic via the DS3 line interface is (de-)multiplexed via M13 to 28 DS1 signals which are then transported via SAToP protocol over the packet network. The DS1 SAToP traffic from the CPoP Smart SFP is compatible with TPoP and CSoP Smart SFPs, enabling DS1 pseudowire connectivity between DS1, DS3 and OC-3 interfaces, see figure 6.

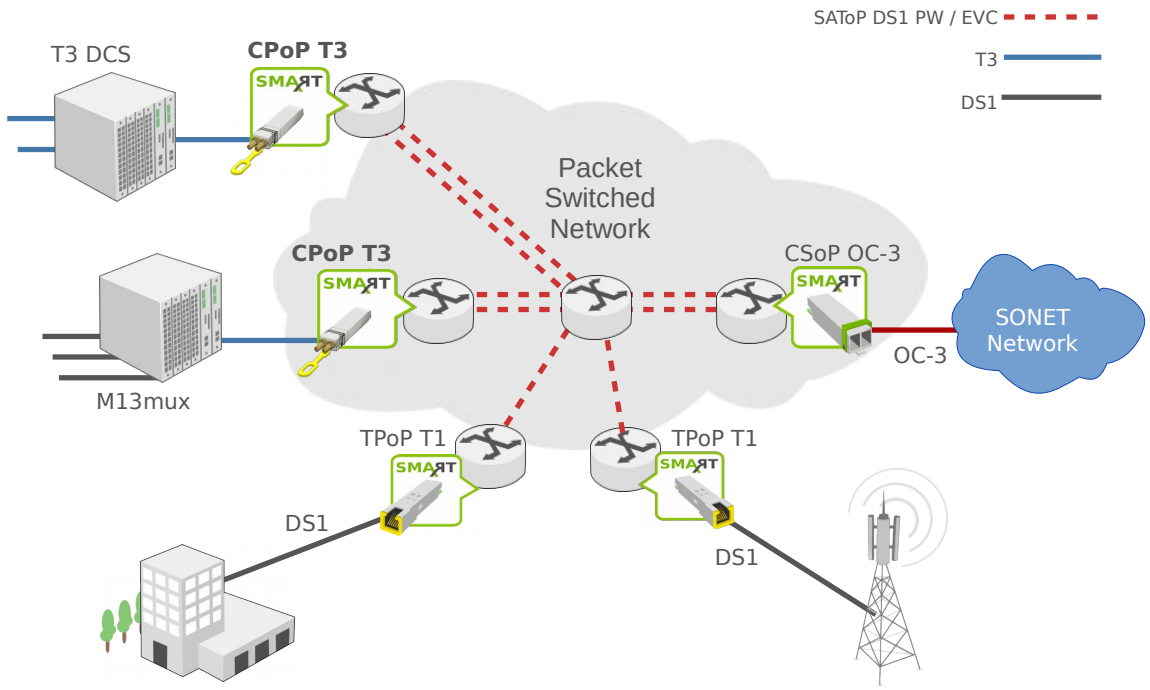


Figure 6: Aggregate DS1s from different locations with CPoP Smart SFP

3.3.3. DS3, STS1 and VC4 transport with VCoP Smart SFPs

In some network scenarios the payload traffic is not DS1/E1 or it is too much hassle to configure individual DS1/E1 pseudowires on the network. The VCoP Smart SFPs provides an alternative: they use the CEP protocol (IETF RFC 4842) to transport STS1 or VC4 Virtual Containers. The VCoP DS3 Smart SFP maps DS3 traffic to STS1 and then transports the STS1 via packet network using CEP protocol. The VCoP optical Smart SFP provides a OC-3/12, STM-1/4 line interface, demaps the embedded STS1s or VC4s which are then transported via CEP protocol. This Smart SFP also supports STS3c, STS12 or VC4-4c concatenated traffic.

The VCoP Smart SFPs support 2 main applications:

- Point-to-point transport of DS3 mapped to STS1 via CEP protocol
- Channelized transport of STS1/VC4 or concatenated STS/VC4 via CEP protocol

Figure 7 shows how DS3 and optical VCoP Smart SFPs can be deployed together to efficiently aggregate signals from DS3 and OC-N/STM-N interfaces.

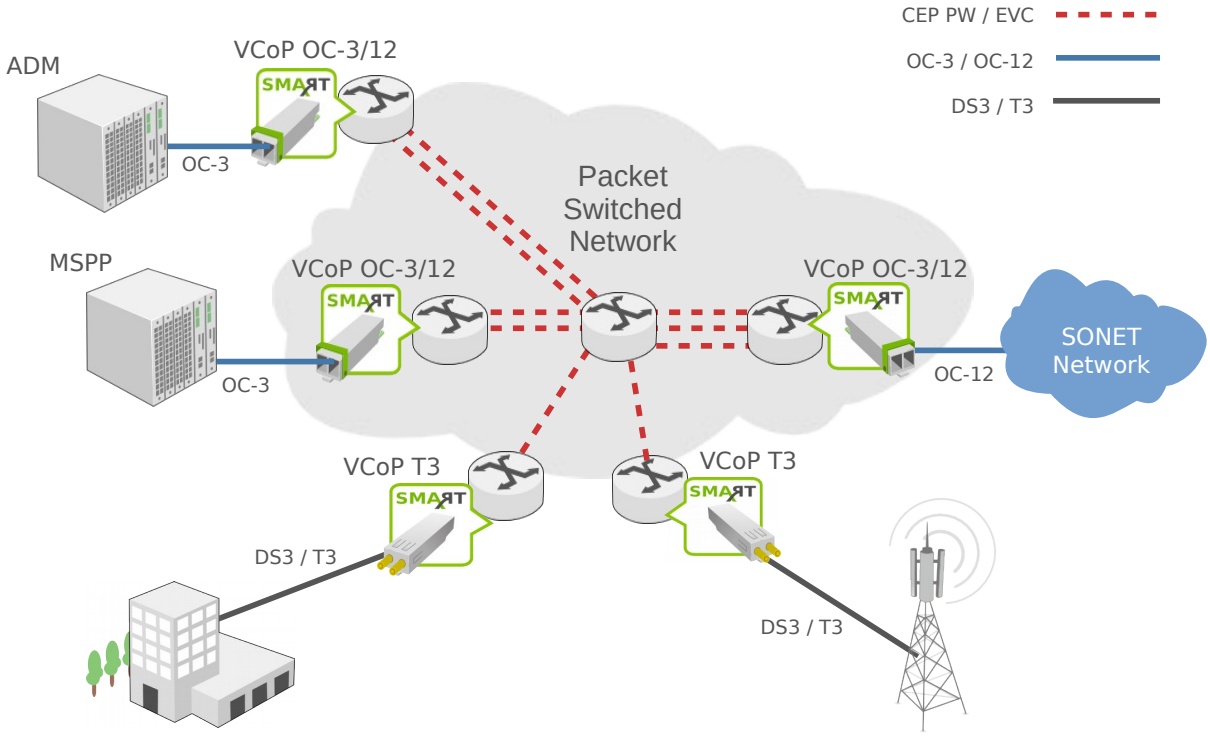


Figure 7: Aggregate DS3 and OC-N signals with VCoP Smart SFP

3.3.4. Clear Channel transport with TSoP Smart SFP

As shown in sections 3.3.1and 3.3.2above, migrating DS1/E1 signals to SAToP streams is straightforward, and the packet network enables forwarding of individual TDM signals. However, when large scale migration is planned, it may become too complex to manage each DS1/E1 SAToP stream individually. And, in the case of SONET/SDH access networks, not all payload is DS1/E1; there could be a mix of DS1/E1, STS1/VC4 and other payload which can not be transported with SAToP.

The TSoP protocol offers an interesting alternative that allows the network operator to transform their SONET network to Packet, while preserving OC-3, OC-12 or OC-48 connectivity for those customers that can not yet migrate their network or equipment to Packet. The upgrade to Ethernet/MPLS is done by adding TSoP Smart SFPs on the packet switch equipment, see figure 8. The TSoP SFP transports the SONET/SDH signal as clear-channel across the packet network towards the SONET/SDH node at the far end of the link.

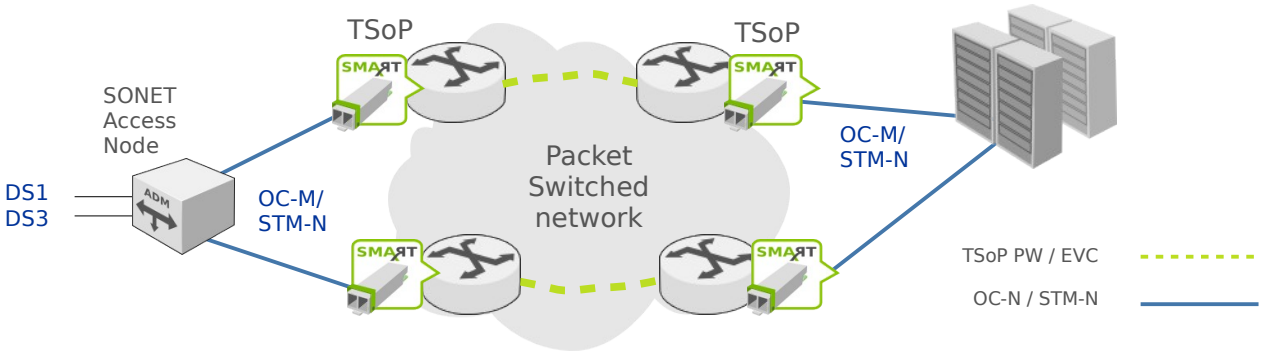


Figure 8: SONET access via Clear-channel TSoP SFP

Benefit	*Background*
Simplified migration	No need to configure individual DS1/E1 TDM over Packet connections
Lower OPEX	Simplified upgrade by using clear channel TSoP protocol
Operational flexibility	Fully transparent for SONET/SDH: independent of protection, overhead, or payload
Lower e-waste	TDM access nodes are still used after core migration to packet: no waste of equipment

3.4. Application: Other Markets and Industries

While the majority of SONET/SDH and DS1/E1/DS3 equipment is installed by Telecom network operators, these reliable and versatile networks are also popular in other industries, such as power and utility, transportation, mining, broadcast and governmental networks.

A common trend in these industries is that data is becoming a significant portion of traffic on their networks due to e.g.: new edge equipment, sensor and signaling equipment, growth in video surveillance, and lastly, the increase of IT traffic between offices and private or public datacenters. This forces their network operation departments to transform their networks to an all packet network, better suited to data transport, allowing to streamline operations and reduce capital and operational expenditures. However, a portion of the traffic is still TDM based, and can be transported via the same packet network using Smart SFPs.

Most of the applications mentioned in the previous sections for Telecom Network Operators are equally valid for other markets and industries, however each industry has their own set of unique requirements:

- *ultra-low latency*: signaling, control and tele-protection equipment rely on low latency; with TSoP Smart SFPs latency far below 1 ms can be achieved.
- *frequency synchronization*: all Smart SFPs support frequency transparency of TDM signals and enable TDM frequency distribution between end points.
- *transparency*: the TPoP, VCoP and TSoP Smart SFPs provide full clear-channel and bit-transparency for DS1/E1, DS3 or SONET/SDH signals respectively.
- *uni-directional traffic*: legacy TV and radio broadcast equipment use TDM transport signals; when carried over a packet network, only downstream TDM over packet is needed.
- *traffic multicast*: multi-drop SCADA circuits for power utilities, and TV and radio broadcast rely on multicast capability; using TDM over packet, the multicast replication is easily handled natively by the packet network itself, see figure 9.
- *extended temperature range and ultra long fiber reach*: Smart SFPs serve a range of electrical and optical line interfaces with reaches up to 80 km at industrial temperature range (-40/85° C).

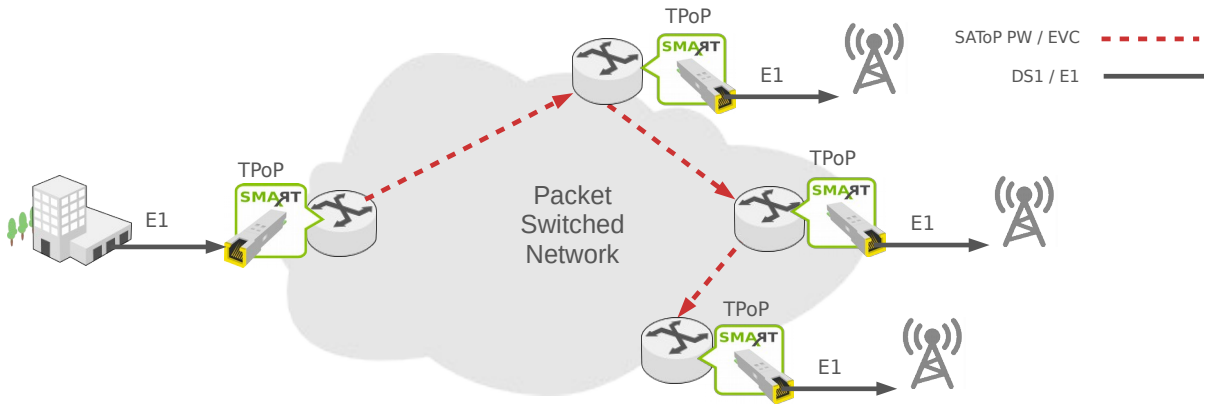


Figure 9: Multi-drop application for broadcast and utilities

4. TDM over Packet protocols

TDM over Packet transport is a well known and established method in multi-protocol environments. ATM based systems where among the first to enable transport of TDM signals over a cell based network. The term Circuit Emulation Service (CES) was introduced to indicate that it offers a TDM circuit-alike transport for client signals.

The Network Migration Smart SFPs use modern standard protocols to ease introduction of the TDM over Packet technology; furthermore, the standardized implementations enable interoperability between equipment of different suppliers.

Table 1 lists the key parameters, the target applications and functional benefits of the various TDM over packet Smart SFP types.

	TPoP	***CSoP, CPoP***	***VCoP***	***TSoP***
Description	Transparent PDH over Packet	Channelized SONET/SDH or PDH over Packet	Virtual Container over Packet	Transparent SONET/SDH over Packet
TDMoP protocol	SAToP	SAToP	CEP	TSoP
IETF standard	RFC 4553	RFC 4553	RFC 4842	draft-manhoudt-pwe3-tsop
Line rate	DS1 or E1	OC-3/STM-1 or DS3	DS3, OC-3/12, OC-12/STM-4	OC-M or STM-N
Multiplexing or channelization	Clear-channel	DS1 in OC-3 or DS3, E1 in STM-1	STS1/STS3c/STS12c or VC4/VC4-4c	Clear-channel
Line interface	Electrical - RJ45	Optical - dual fiber or electrical DS3	Optical - dual fiber or electrical DS3	Optical - dual fiber
Key applica-tions	Mobile backhaul Leased lines	Backhaul aggregation Aggregate low-fill SONET/SDH or DS3	Clear-channel DS3 SONET/SDH aggregation	Clear-channel SONET/SDH Microwave packet radio Efficient use of WDM lambdas
Configuration complexity	*low*: single operation mode, plug-and-plug possible	*medium*: channel configuration needed	*medium*: channel configuration needed	*low*: single operation mode, plug-and-plug possible
Benefits	Transparent DS1/E1 transport	Aggregation and efficient hand-off	Aggregation and efficient hand-off	High capacity, fully transpar-ent

Table 1: Overview of Network Migration Smart SFPs

The standard protocol for DS1/E1 transport over packet is SAToP (IETF RFC 4553), but it lacks support for SONET/SDH signals. The TSoP protocol was defined analogous to SAToP, tailored to bulk clear-channel transport of SONET/SDH over packet networks. AimValley has published an IETF draft standard, disclosing details of the TSoP technology, see draft-manhoudt-pwe3-tsop

TSoP provides full transparency for SONET/SDH embedded payload signals, protection and synchronization. Table 2 lists the background of these aspects.

Benefit	Background
Transparent for Payload	Any structure or any service can be supported, without having to configure or know the embedded signal structure. Independent of payload structures: e.g.: DS1/E1, DS3, or VT1.5/VC12, STS1 Independent of dynamic changes in the end-users' payload configuration
Transparent for Protection and Overhead bytes	Network protection and end-to-end monitoring are maintained end-to-end. Independent of protection method: APS 1+1, MSP, UPSR, or SNC Fully transparent to proprietary use of reserved or undefined Overhead Bytes Maintain end-to-end SONET/SDH Fault and Performance Monitoring
Transparent for Synchronization	No changes needed in existing SONET/SDH network timing topology Compliant with GR-253/G.825 jitter and wander requirements The SONET/SDH clock is forwarded transparently across the packet network

Table 2: Benefits of TSoP - Transparent transport

5. Deployment scenarios

5.1. Stand-alone operation

The Network Migration Smart SFPs can be deployed without active monitoring during operational life. During installation of a TDM over Packet connection two Smart SFPs are inserted on the switches at each end of the connection, and a point-to-point Ethernet/MPLS Private Line service is configured between the Smart SFPs.

Typically the factory default configuration parameters are applicable, enabling a true plug-and-play deployment. The Network Migration Smart SFP will automatically handle TDM link failures, and signal those across the packet network towards the far end; similarly, any packet network defects are signaled towards the TDM interface. The operator can use the existing monitoring capabilities on the packet network to determine the operational status of the point-to-point link.

In some scenarios it may be necessary to configure specific parameters during installation; e.g. to enable interoperability with other equipment, or to support specific packet network headers. The Smart Device Manager (SDM) is a user-friendly tool with an intuitive GUI that can be used for configuration and diagnostics during deployment of Smart SFPs. The SDM also provides access to the inventory, digital diagnostics, fault status and performance monitoring.

5.2. Management via Titan

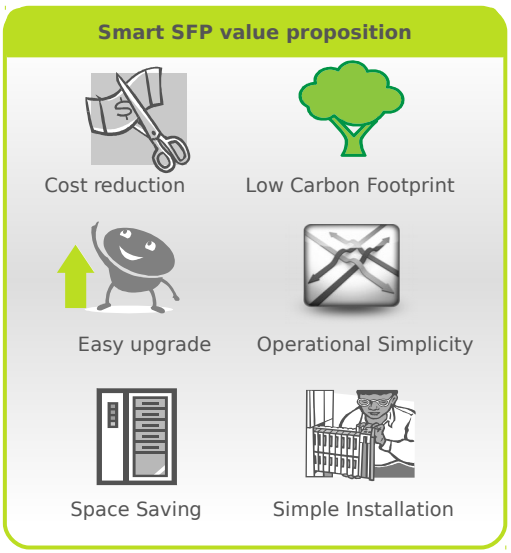
Network equipment manufacturers that require a specific configuration or access to fault and performance monitoring of the Smart SFPs installed in their systems can integrate the Titan software into their equipment. This enables plug-and-play discovery and automatic configuration, access to all parameters, fault, and monitoring functions for all Smart SFPs installed in a system. Integration of Titan software into the existing management concepts of the equipment provides a user-friendly and consistent approach to configuration and management of Smart SFPs, very similar to management of other ports, cards and services in the equipment. This results in faster end-to-end configuration of TDM migration projects and easier maintenance during the life-cycle of configured TDM services.

Benefit	Background
Ease of deployment	Plug-and-play discovery and automatic configuration of Smart SFPs
Consistent management	Similar configuration and management concepts for Smart SFPs as for other system ports and cards
Network level visibility	Single management plane enabling consistent view of Smart SFPs, TDM clients and packet streams
Centralized diagnostics	Fault, Performance Monitoring, including Inventory Management and Optical Power level monitoring

6. Conclusion

OE Solutions and AimValley enable a smooth transition from legacy TDM towards all packet networks with a family of Network Migration Smart SFP™ modules. These SFPs convert DS1/E1, DS3 or SONET/SDH signals to a packet stream. Operators can now transport TDM traffic across a packet network by simply adding a Smart SFP to any router or packet switch.

The Network Migration solutions are delivered in SFP module form factor, combining the optical or electrical line interface with protocol conversion. This integration enables operators to reduce costs in access and edge networks, and allows for significant savings in rack space. Furthermore, due to its low power consumption, the Network Migration Smart SFPs can be an effective tool for operators that want to reduce their carbon footprint and electronic waste.



This white paper shows how operators can benefit from the use of these Smart SFP modules in their network. The Network Migration Smart SFPs can be used in various applications or organizations:

- Network migration in the Mobile Backhaul Network
- Enable efficient use of DWDM wavelengths and free-up fibers
- Transformation of the TDM access network to Ethernet/MPLS
- Utility organizations and broadcast industry

OE Solutions and AimValley provide a set of Network Migration Smart SFPs, each supporting a unique set of functions targeting different scenarios:

- TPoP Smart SFP, Transparent PDH over Packet with electrical DS1 or E1 interface
- CSoP/CPoP Smart SFP, Channelized SONET/SDH or PDH over Packet
- VCoP Smart SFP, clear channel DS3 or STS1/VC4 based transport over Packet
- TSoP Smart SFP, Transparent SONET/SDH over Packet for clear-channel OC-M or STM-N

The Network Migration Smart SFPs are complemented with a Gigabit Ethernet system interface and remote management capability. The Smart SFPs serve a range of electrical and optical line interfaces with reaches up to 80 km at industrial temperature range.

The integration of TDM over Packet inside an SFP module greatly reduces system and network complexity, and offers lower carbon footprint while generating CAPEX & OPEX savings.

The use of industry standard protocols, SAToP, CEP and TSoP, simplifies the introduction of TDM over Packet technology; furthermore, the standardized implementations enable direct interoperability between equipment of different suppliers.

7. Acronyms

ATM	Asynchronous Transfer Mode
CEP	Circuit Emulation of STS1/VC4 over Packet (IETF RFC4842)
CPoP	Channelized PDH over Packet
CSoP	Channelized SONET/SDH over Packet
CWDM	Coarse Wavelength Division Multiplexing
DDM	Digital Diagnostics Monitoring
DWDM	Dense Wavelength Division Multiplexing
LOS	Loss Of Signal
LTE	Long Term Evolution (4G mobile network)
MSA	Multi Source Agreement
OAM	Operations, Administration and Maintenance
PDH	Plesiochronous Digital Hierarchy
SAToP	Structure-Agnostic TDM over Packet (IETF RFC4553)
SDH	Synchronous Digital Hierarchy
SFP	Small Form-factor Pluggable transceiver
SONET	Synchronous Optical Networking
TDM	Time Division Multiplexing
TPoP	Transparent PDH over Packet
TSoP	Transparent SONET/SDH over Packet
VC	Virtual Container
WDM	Wavelength Division Multiplexing

8. References

CEP	IETF RFC4842, Circuit Emulation of STS1/VC4 over Packet
DDMI	SFF-8472 Specification for Diagnostic Monitoring Interface for Optical Transceivers, Rev 11.0, September 14, 2010
MSA	INF-8074i Specification for SFP (Small Formfactor Pluggable) Transceiver, Rev 1.0, May 12, 2001
SAToP	IETF RFC4553, Structure-Agnostic TDM over Packet
TSoP	Transparent SONET/SDH over Packet; IETF draft draft-manhoudt-pwe3-tsop

9. Contact

Smart SFP™ is a Trademark of OE Solutions and an intelligent transceiver product family developed jointly by OE Solutions (www.oesolutions.com) and AimValley (www.aimvalley.com). You can find more information on our Smart Transceivers on www.smartsfp.com.

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