TDM MIGRATION

A Tactical Strategy for Service Migration to a Packet-Optical Environment

Time-division multiplexing (TDM) networks have reached the tipping point at which a period of years of heavy investment has rapidly moved to one of much more limited investment. This has created a huge installed base that has end-of-life and customer migration issues.

Infinera has developed a unique response to these challenges that capitalizes on the strengths of the Native Packet Optical architecture and allows operators to migrate TDM services such as E1, STM-1/OC3 or STM-4/OC12 to a future-proof packet-friendly network. This approach allows controlled migration, as and when the operator chooses, without any change to the actual service.

TDM solutions, and predominantly synchronous digital hierarchy (SDH)/synchronous optical network (SONET) systems, have been the fundamental base of optical networks for most of the last two decades and have provided the stability, scalability and network economics that enabled incredible growth in communication, the Internet, applications and data.

The installed base of TDM equipment globally is huge and in many places it is starting to get old.

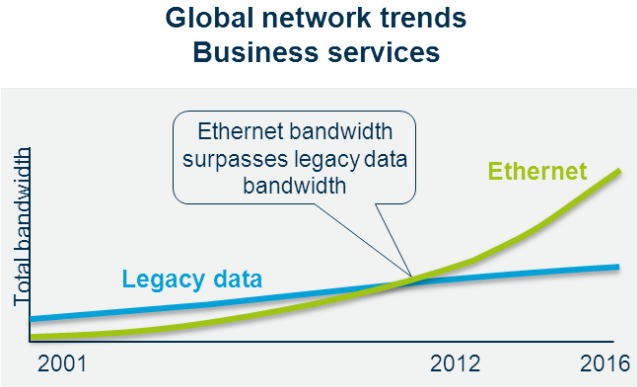
TDM solutions are not so well-suited to the modern Ethernet-centric world, and new investments in these systems are now in rapid decline.

From a traffic perspective, Ethernet bandwidth surpassed legacy data bandwidth in 2012 according to Vertical Systems and the Metro Ethernet Forum (MEF), as shown in Figure 1. The majority of future network investment will focus on this rapidly growing Ethernet traffic.

TDM Is Reaching End of Life

A lot of the services and traffic running over TDM systems are migrating to Ethernet and are therefore well-suited to the wavelength-division multiplexing (WDM) and Layer 2 Ethernet-based packet-optical transport systems (P-OTS) solutions that are available in the market.

However, there is a significant portion of traffic that cannot be simply migrated to Ethernet, creating a dilemma for network operators. The reason for this dilemma is that TDM systems are reaching end of life, and that large networks will have to be supported for a small number of services or customers. Naturally the level of this TDM-based traffic will vary from operator to operator and across geographic regions.



Source: Vertical Systems/MEF

Fig 1. Ethernet and Legacy Bandwidth Over Time.

Infinera has developed a solution to this challenge that capitalizes on the strengths of the XTM Series-based Native Packet Optical 2.0 architecture.

This document will look at the challenge of supporting TDM traffic as the underlying TDM network ages, and how Infinera addresses this challenge.

The Challenge of Migrating Legacy TDM Networks

Networks are moving to Ethernet-based services, often supported over P-OTS systems such as the Infinera Native Packet Optical architecture. For growing traffic and new deployments, the architectural decisions are relatively simple. But these become significantly more complex if older TDM services exist and if there are problems maintaining the older TDM network, whether due to cost for a diminishing number of services or end-of-life issues with any part of the network.

Some TDM networks now have issues where products in the network are reaching end of life, which creates problems in terms of growth capacity, sparing and ongoing maintenance and support.

Also, some networks are undergoing a period of transition in which customers are being migrated to Ethernet. However, customers certainly don't move at the same speed as the network operator, and some of these will take a very long time to migrate, leaving an ever-smaller number of customers on this older network infrastructure. This makes ongoing support for these customers ever more expensive as the network-running costs are amortized across the ever-smaller number of customers.

This presents the operator with a number of choices:

1 Leave the TDM network as it is, bearing the cost for the last few services, and hope that end-of-life issues don't force the operator to make a rushed decision later.

2 Force all services to migrate to Ethernet, which will address the issue, but might not be feasible or very attractive to the end-users.

3 Build a new multi-service provisioning platform (MSPP)-based TDM replacement network, which requires significant new investment that will only support legacy traffic, and only for an unknown period of time before the services do migrate to Ethernet.

4 Look at the packet-optical network for options that support the migration of these services in a simple and economic manner.

TDM networks are high-quality networks with good network synchronization, management capabilities and protection options. Any proposed solution must provide these capabilities at the same or a better level to ensure end-customer satisfaction with the service.

Network Migration Strategies – A View to the Future

Today, new Ethernet-based networks are being rolled out to support the rapid growth in new traffic generated by applications such as mobile networks, cloud services and data center interconnect.

Existing Layer 1 services are typically carried over TDM networks, which are sometimes totally separate or may use the same WDM platform as the Ethernet services with different wavelengths carrying traffic from the two system types.

The network of the future will be fully Ethernet and WDM-based, and there is an opportunity to build this today using new technology to migrate the legacy TDM services to the new infrastructure.

The Infinera Solution – Intelligent SFP (iSFP) Pluggable Optics and the Native Packet Optical 2.0 Architecture

Infinera proposes a future network built around the Native Packet Optical 2.0 architecture. This architecture is based on Native Ethernet with additional technology such as multi-protocol label switching—transport profile (MPLS-TP), Carrier Ethernet 2.0 and optical transport network (OTN) transport being used as needed by the network operator.

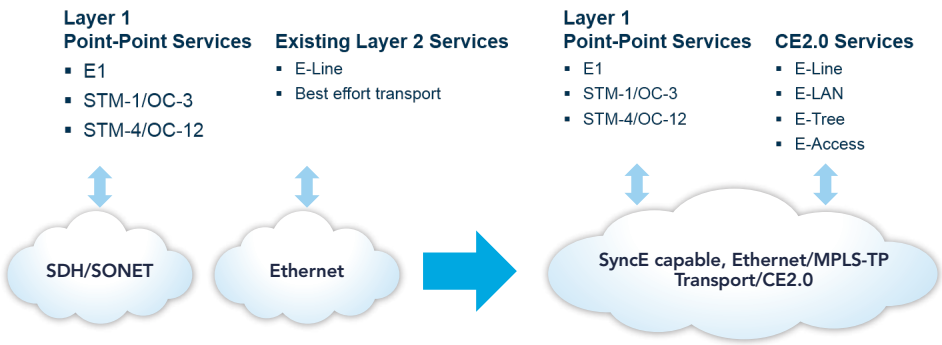


Fig 2. Service Migration Allows All Services to Be Supported Over a Single Packet-friendly Infrastructure.

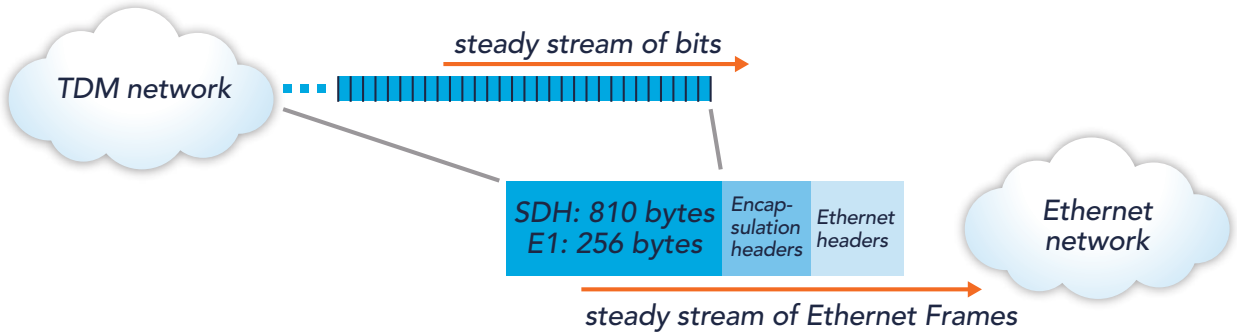


Fig 3. TSoP/SAToP in Action.

This architecture provides an extremely transport-friendly Layer 2 Ethernet network with superior sync performance, ultra-low latency and almost zero jitter. All these characteristics are key when offering TDM services.

This approach is focused on service migration and offers three main benefits:

- Packet-based for next-generation services using the Native Packet Optical 2.0 architecture
- Tactical migration creates a step-by-step approach to spending so that it is only required as the legacy network declines and requires migration.
- TDM services are maintained to ensure customer satisfaction.

This is achieved through the deployment of the Infinera range of TDM intelligent small form-factor pluggable (iSFP) optics that support emulated E1, STM-1/OC-3 and STM-4/OC-12 services over an Ethernet infrastructure.

The TDM iSFP modules can be fitted into any gigabit Ethernet port in the Infinera packet-optical transport switch, the EMXP IIe. The E1 iSFP module can also be used with the Infinera network demarcation device (NID), extending the packet-optical network in applications in which E1 services are required, for example mobile backhaul or enterprise services.

Altogether this enables a very flexible and tactical deployment of E1, STM-1/OC3 or STM-4/OC12 services.

TDM iSFP Modules for Converting TDM Services into Ethernet Streams

The TDM iSFP modules perform a packetization of the E1, STM-1/OC-3 and STM-4/OC-12 services, creating a transparent bit pipe between two locations in the packet-optical network. The different iSFP TDM modules perform this packetization as follows:

- The iSFP-E1 module converts the E1 service into approximately 2.2 megabits per second (Mb/s) of Ethernet capacity
- The iSFP-TDM155 converts the STM-1/OC-3 service into a 170 Mb/s Ethernet stream
- The iSFP-TDM622 converts the STM-4/OC-12 service into a 680 Mb/s stream
- The iSFP-VC12 has the capability to interface with the STM-1 equipment and treat each E1 channel on the interface individually

This migrates the existing TDM services to the Ethernet network with service adaption at the edge of the network and standard Ethernet traffic between these locations.

The traffic is mapped into an Ethernet virtual circuit (EVC) that can either be transported as an Ethernet service virtual local area network (VLAN) or via MPLS-TP services. The Infinera EMXP can be used to perform Layer 2 aggregation to ensure full utilization of higher-speed 10G Ethernet connections.

Transparent TDM over packet (TSoP for SDH/SONET and SAToP for E1) operation is outlined in open Internet Engineering Task Force (IETF) drafts/standards.

This transparent transport ensures complete transfer of the data and payload structure, all overhead bytes, protection protocols and synchronization at E1, STM-1/OC-3 and STM-4/OC-12.

The illustration above shows how the adaptation works.

This approach is significantly simpler than migrating TDM services to a new platform specifically deployed to support these services.

Building a new TDM-based infrastructure would increase dependency on older technology and also require complex IT and process development to manage the transition, whereas the iSFP-based

approach is a simple addition to the Ethernet network and provides a single management solution for all Layer 1 and Layer 2 services.

This can be summarized as a focus on service migration rather than network migration.

Ensuring Quality – Getting the Ethernet Layer Right

The quality of the underlying Ethernet layer is very important in TDM service migration. Simply adding iSFP-TDM modules to a lower quality Ethernet network would not suffice.

To maintain TDM protection, the existing automatically switched optical network (ASON) and subnetwork connection protection (SNCP) protection schemes are replaced by MPLS-TP and Ethernet protection options.

Protection is supported with MPLS-TP for topologies such as ring, mesh and partial mesh. Also, Ethernet protection is supported with Ethernet ring protection switching (ERPS) and point-to-point link aggregation group (LAG) options.

These provide comparable protection mechanisms with comparable switching time performance to traditional SDH/SONET protection schemes.

SUPERIOR SYNC DESIGN

Superior Synchronization in Ethernet Network

Network synchronization is the cornerstone of the TDM network. Here the quality of the underlying Ethernet network can be critical.The Infinera Native Packet Optical 2.0 architecture provides excellent Synchronous Ethernet (SyncE) and IEEE 1588 performance.

This performance has yielded results from field deployments where SyncE-based transmission has been able to improve sync quality by up to tens of times when compared to the previous E1 and SDH/SONET-based sync. This performance provides an excellent platform for TDM service migration.

In the Infinera solution, TDM sync transport is provided with the differential clock recovery (DCR) transferring the TDM clock to the transparent emulated service with SyncE as a reference in both ends.

DCR transfers the synchronization clock to the emulated service and is extracted again at the far end of the service. The two directions of the service can either operate as two independent timing domains or one direction can be frequency-locked to the other direction.

The Infinera Enlighten® multi-layer software management suite also supports synchronization management and monitoring with Enlighten Ecosystem partner Chronos Technology.

Chronos Syncwatch probes can be deployed in the network to monitor the SyncE quality in the network, which is used as a reference for both ends of the transparent TDM service.

It can also be used to monitor the sync quality of the connected systems to provide reassurance of the sync in the TDM service that is carried over the Ethernet network.

The use of these probes speeds up root cause analysis in the event of a network sync issue. They are often used today in TDM networks and are familiar to many network engineers.

The Infinera Native Packet Optical 2.0 architecture also provides the operator with a core network-agnostic Ethernet aggregation network that now also supports TDM services. The EMXPs will seamlessly interwork with Ethernet, MPLS/MPLS-TP or OTN core networks, or core networks built on the Infinera Intelligent WDM (iWDM®) solutions.

Deployment Scenarios – iSFP-TDM Modules in Action

The iSFP-TDM modules can be deployed in gigabit Ethernet ports in Infinera EMXPs. Here the units simply map the incoming E1, STM-1/OC-3 and STM-4/OC-12 services to the emulated service, creating a point-to-point service using the protection and synchronization options outlined above.

Layer 1 muxponders already support these line rates and therefore do not typically need to support the iSFP-TDM modules.

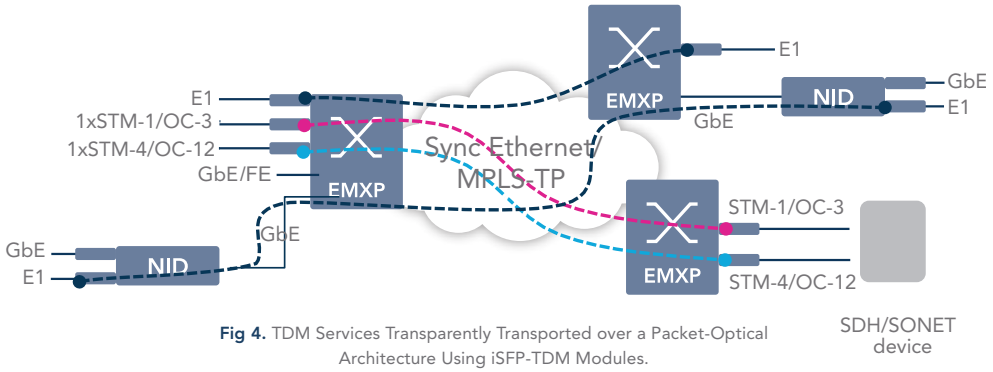


Fig 4. TDM Services Transparently Transported over a Packet-Optical Architecture Using iSFP-TDM Modules.

Migrating Channelized E1 Over STM-1

The iSFP-VC12 converts a fully channelized SDH signal to a packet stream. Each individual E1 within the STM-1 is handled separately and independently of all others throughout the network.

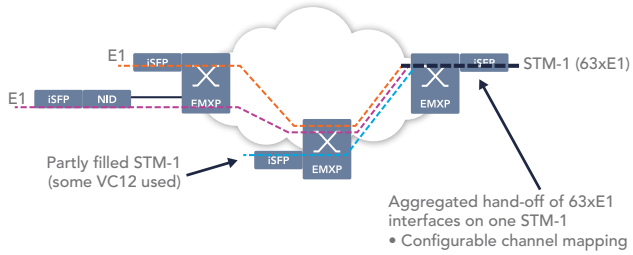


Fig 5. The iSFP-VC12 Enables Both Aggregation of E1 Traffic for Channelized Handoff and the Possibility to Aggregate Traffic from Partially-filled STM-1s.

Summary

The Infinera approach to TDM service migration allows network operators to take a pragmatic approach to challenges that arise from aging TDM networks now that some products are reaching end of life.

The solution also addresses another challenge that can occur when most customers migrate to Ethernet, leaving a small number of slowly migrating customers on the old network. This in turn leads to expensive network maintenance for a small and slowly diminishing revenue stream. In both cases, services can be migrated on a tactical one-by-one basis when it makes sense for the operator to do so.

Services are maintained over a packet-friendly network, while the older network can be retired in a controlled manner.

This approach fully supports the existing service characteristics of the TDM services to ensure customer satisfaction while basing the services on a future-proof Native Packet Optical 2.0 network with only the simple addition of the iSFP-TDM modules.

TDM networks can be retired in a safe and logical manner that fully takes advantage of the Native Packet Optical 2.0 network, allowing easy customer migration to advanced Ethernet services when ready, therefore providing the best possible solution for both service providers and their customers.

ABOUT INFINERA

Infinera (NASDAQ: INFN) provides Intelligent Transport Networks, enabling carriers, cloud operators, governments and enterprises to scale network bandwidth, accelerate service innovation and simplify optical network operations. Infinera's end-to-end packet-optical portfolio is designed for long-haul, subsea, data center interconnect and metro applications. Infinera's unique large-scale photonic integrated circuits enable innovative optical networking solutions for the most demanding networks. To learn more about Infinera visit www.infinera.com, follow us on Twitter @Infinera and read our latest blog posts at blog.infinera.com.

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