WHITE PAPER

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SUCCESSFUL STRATEGIES FOR NETWORK MODERNIZATION AND TRANSFORMATION

A Technology Evolution Perspective

Both fixed line and mobile service providers are facing a growing variety of challenges related to the high-capacity transport networks that underlie their communications infrastructure. These networks require not only increased capacity to support emerging high bandwidth applications, but also the adaptability to address continuously shifting traffic requirements and patterns. For many network operators, these challenges are becoming more difficult, as legacy technologies such as low-order TDM and SONET/SDH do not provide the efficiency or flexibility to cost effectively handle the increased load. And while infrastructure networks built exclusively on IP/MPLS technology provide excellent traffic management options, they do not cost effectively scale to support large bandwidth demands.

This white paper details successful strategies for network modernization and transformation, including solutions for network operators that cost effectively expand the capacity of transport infrastructure, while also enabling more efficient traffic management options and granular control over services.

A network operator must make two key decisions when planning a network transformation:

- Determine which technology to migrate to
- Establish a migration method

Each decision must be carefully considered, as it affects network efficiency, flexibility, and operational ease.

TECHNOLOGY CHOICES

Five technologies are available to modernize transport infrastructure. These choices include circuit-based options (SONET/SDH and OTN) and packet-based options (Carrier Ethernet, MPLS-TP, and IP/MPLS). Each technology has advantages and disadvantages relating to network results and the complexity of the transformation process.

UNDERSTANDING ENCAPSULATION VERSUS SWITCHING

Before exploring the various technologies available for network transformation, it is important to understand the difference between encapsulation and switching.

- **Encapsulation** involves taking a signal that is ready for transmission and placing it into another container – often a more transmission-friendly container. OTN encapsulation is often used due to features such as Forward Error Correction (FEC) and various OAM features.
- **Switching** refers to the format in which a signal traverses an electrical switch fabric. Regardless of the selected switching technology, all services can be OTN encapsulated prior to transmission.

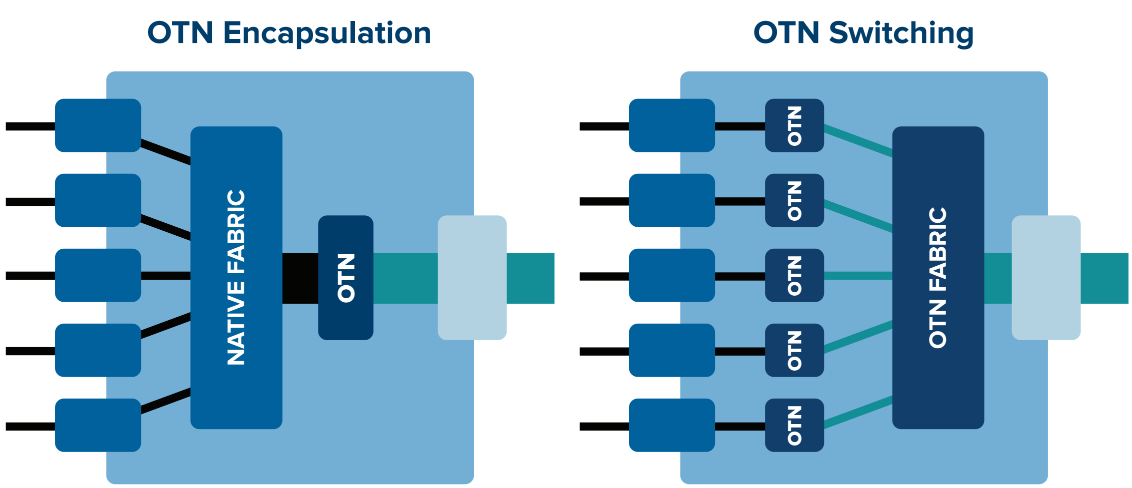

FIGURE 1 – Example solutions – native grooming and OTN encapsulation (left) and OTN grooming (right)

CIRCUITS VERSUS PACKETS

Packet and circuit networks offer substantially different capabilities and provide significantly different operational models.

Circuit-Based Networks

Circuit-based networks divide transmitted bandwidth into discrete and fixed size portions. In SONET, a single OC-192 transmission (~10G) is divided into 192 STS-1 containers at approximately 52M each. For OTN, a single ODU2 (~10G) is divided into 8 ODU0s at 1.25G each. Circuit-based solutions generally support per port mapping of client services, where all traffic from a single client interface is packed into a single container (sometimes comprised of a number of virtually concatenated smaller containers). These containers and all of their content can then be transported to a single destination. In SONET, for example, a GbE signal is packaged into a container with 21 x STS-1 virtually concatenated together, and the container, including 100 percent of the GbE, is transported to a single destination.

The advantages of circuit-based networks are:

- Operational simplicity
- Reliability
- Multi-service support

With fixed size containers and per port mapping, there are few provisioning options and no need for any type of traffic management in circuit-based networks. Therefore, planning and provisioning services is simplified. Similarly, because the rate of transmission is fixed and based on the container size (~52M for an STS-1), the destination can expect to receive a constant stream of incoming containers (8000 frames per second for an STS-1), even if some of those frames are empty. As such, transmission problems can be quickly identified if even a single frame does not arrive on schedule.

Circuit-based networks also have very efficient mechanisms of packing almost any type of service into their containers using either simple transparent mapping or a mechanism called Generic Framing Procedure (GFP). These mechanisms enable effective transmission of virtually any service including Ethernet, IP, Fiber Channel, SDI, etc. These operationally friendly features provide a relatively simple migration process.

The disadvantages of circuit-based networks – both SONET/SDH and OTN – are inefficiency and inflexibility. Inefficiency is the largest problem associated with circuit-based solutions and is the result of three factors:

1. Because circuit networks employ fixed size containers, any service that does not exactly match those container sizes (i.e., a 10M service into a 52M STS-1 or a 1.25G ODU0) will result in unused capacity and utilization rates that can often fall below 10 percent.

2. Most network traffic is bursty by nature with peaks and valleys in utilization. Since container sizes are fixed, even if peak utilization perfectly matches the container size, average utilization will often only include a portion of the container. A 1G service in a 1.25G ODU0 container uses nearly 100 percent of capacity at peak rate, but if the average rate is only 400M – which is typical – average utilization falls to just 40 percent.

3. Circuit-based networks can only manage traffic on a port-by-port basis, prohibiting the ability to provide or accept non-circuit aggregated handoffs. For example, a circuit-based device receiving 10 GbE in 10 different 21 x STS-1 GFP VCAT groups could not aggregate those into a single 10G interface. Instead, the device would hand-off 10 separate physical GbEs.

The result is a network with a large number of underutilized, low speed physical ports on both the transport devices and the devices connected to the transport network.

Packet-Based Networks

Unlike circuit-based networks, packet-based networks can manipulate traffic on a frame-by-frame basis from line and client ports alike. This process enables portions of a single physical interface to be steered into different pipes for transport, aggregation of traffic from multiple physical interfaces into a single shared pipe for transport, and efficient aggregation of multiple transport pipes into a single physical handoff to a subtending device.

The advantage of packet-based transport solutions is a significant improvement in efficiency and flexibility. The efficiency is due to the management of the traffic's bursty nature with a mechanism called statistical multiplexing. Statistical multiplexing is the ability to aggregate traffic based on the estimated average bandwidth requirements of numerous services. If you have 20 services, each with a peak rate of 1G, but with an average rate of 500M – assuming that not all of them will peak at the same time – it is possible to aggregate all 20 services into a single 10G pipe. The 20 x GbE packed into a 10G pipe would be a 2:1 oversubscription, as the actual transmission capacity is half the sum of the peak rates. This technique can be used to reduce the amount of transport capacity required by packing a large number of client interfaces into a single aggregated oversubscribed transport pipe. Statistical multiplexing also reduces requirements on subtended devices by taking numerous transport pipes and aggregating them into a single oversubscribed handoff.

The efficiency that can be gained from packet-based solutions in both transport capacity and physical interface savings on subtended devices can often exceed 50 percent. Lastly, with frame-by-frame decision-making and the ability to support multi-point services, packet networks enable the management of multiple types of services on a single port with different prioritization levels providing different classes of services and opening the door for a host of services with a variety of traffic management options.

The disadvantages of packet-based solutions are the increased complexity and limited support for non-packet services. Because you can have multiple services vying for the same resources, packet-based solutions require significantly more advanced traffic management mechanisms, such as queuing, prioritization, and policing. Traditional transport organizations may not be familiar with these mechanisms.

Another consideration for packet-based solutions is that they often struggle to effectively support circuit-based services. While most solutions include circuit emulation support, this feature is most effective at lower speeds and with only a relatively small amount of circuit-based traffic. Additionally, circuit emulation introduces a whole new set of protocols into the network. These protocols can result in significant challenges during migration from legacy circuit-based infrastructures.

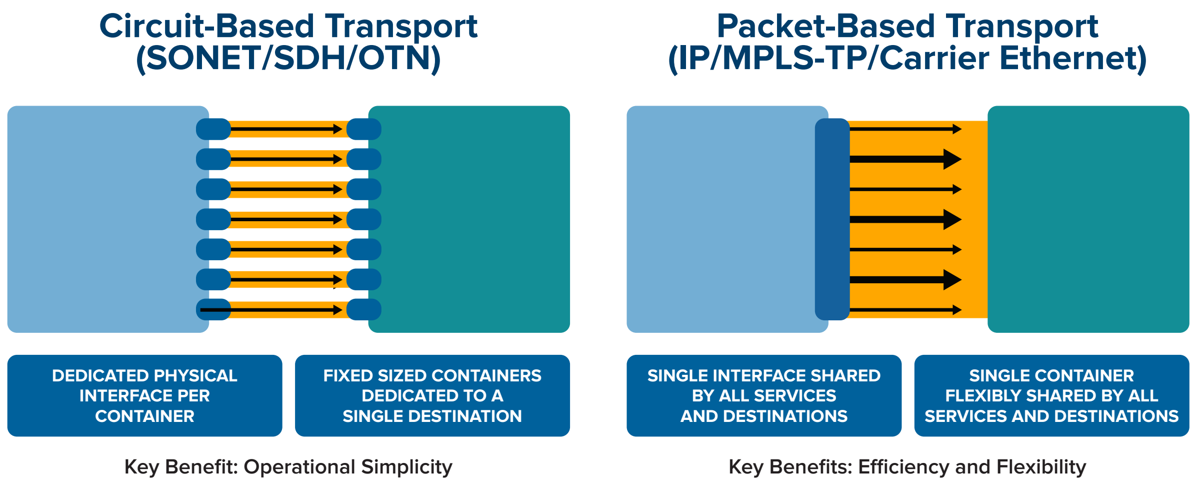

FIGURE 2 – Comparing Circuit-Based Transport and Packet-Based Transport

Choosing Between Circuit Options

The circuit technologies, SONET/SDH and OTN, present both benefits and challenges:

- **OTN** – Network operators often choose OTN simply because it is a relatively newer technology; however, OTN is not always the best choice. OTN provides better scalability at high bandwidths (multiple 10Gs), but because the smallest container size is 1.25G, OTN is extremely inefficient for services less than 1G. OTN does provide 100 percent true transparency and the most seamless transformation process, even in networks comprised of multiple vendors.

- **SONET/SDH** – SONET/SDH is less effective at supporting high bandwidth services or large traffic volumes when compared to OTN. But with container sizes around 50M, SONET/SDH does support lower bandwidth services much more effectively. For networks growing primarily with services around 1G or less, the best solution may be an upgrade to SONET/SDH.

Choosing Between Packet Options

Packet options include Layer 2 (L2) solutions with Carrier Ethernet and MPLS-TP and Layer 3 (L3) solutions.

1. L2 options tend to be simpler and less expensive. L2 solutions act more like a traditional circuit-based transport network and are often the choice of transport organizations. When comparing the L2 options of Carrier Ethernet and MPLS-TP, Carrier Ethernet is typically lower cost and supports a number of bridging options that can provide unique services. MPLS-TP, on the other hand, supports a larger number of unique service flows providing greater scalability. MPLS-TP is also typically better for transporting non-packet services with more effective circuit emulation and provides better dual homing solutions via multi-point VPLS capabilities. MPLS-TP offers the opportunity to seamlessly integrate into IP networks by running compatible networking protocols. The decision between these two technologies depends on specific applications and operational structure.

2. L3 options, while considerably more expensive, provide more features, better traffic management, and support for IP/VPNs. L3 solutions provide a natural extension to router networks and are often the choice of router organizations.

A BETTER SOLUTION: UNIVERSAL TRANSPORT PLATFORMS

Over the long term, a packet-based transport solution that can be expanded with DWDM provides the best level of efficiency and flexibility. However, many networks continue to require circuit-based services and to maintain operational environments that are currently designed around circuit-based transport.

The primary challenge with most traditional transport solutions is that they require network operators to choose one specific protocol, which makes it difficult to adjust to changing network requirements and problematic in the aggregation part of transport networks where many services come together. There are many instances where it is advantageous to choose a circuit-based technology to support a large number of legacy-based circuit services or to more seamlessly integrate into existing operational models. However, as services and traffic patterns change, a packet-based solution will ultimately be more beneficial.

To address this challenge, Coriant has developed the innovative Universal Transport Platform solution. The Universal Transport Platform is capable of switching traffic flows based on any protocol (L1-L2.5) and on every port, including multiple protocols on the same port simultaneously. The Coriant® mTera® Universal Transport Platform offers network operators the best of both worlds by dynamically controlling every flow on every port as a circuit or packet and providing the most efficient, future-proof solution for virtually all applications.

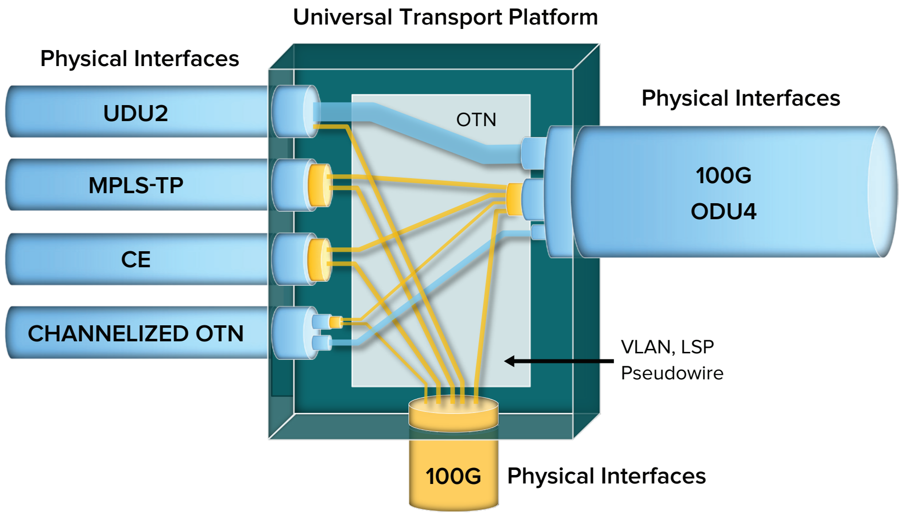

FIGURE 3 – With universal switching capabilities, the Universal Transport Platform can switch traffic at numerous layers irrespective of how the traffic was physically handed-off

CORIANT PROVIDES SOLUTIONS AND PARTNERSHIP

Technology solutions for network transformation can vary greatly depending on which part of the network is being migrated, what types of services are being transported, and future network plans. With a broad portfolio of transport solutions, Coriant is the ideal partner to provide an objective and consultative approach to transformation. We work closely with network operators to understand all the details of their network and determine the optimal transformation solution to meet the requirements of today and into the future.

NETWORK MIGRATION OPTIONS

Once the technology has been selected, the next choice is the method of migration. Three migration methods are available:

- Pure overlay
- Line-side roll
- Client-side roll

Pure Overlay

A pure overlay method involves deploying new technology in parallel to the existing technology and deploying all future services on the newer technology while leaving the legacy technology in place. The benefit of a pure overlay approach is its simplicity. With this method, there are no traffic rolls or any impact on existing services. It also enables selection of a solution based purely on future services and is unencumbered by the need to support legacy services. However, the pure overlay approach typically requires additional fibers or solutions that provide transmission options on different frequencies. This approach will also require ongoing support of the two separate networks. Finally, a pure overlay will not provide any improvements to efficiencies for existing services.

Line-Side Roll

The line-side roll method is the most common method of migration. The high speed interface on transmission systems that is typically connected to the external fiber is the line-side. The line-side roll migration method involves deploying the new higher speed technology and rolling the high speed line-side output of the existing technology to the client-side of the new technology. For this approach, existing services remain on the legacy platform eliminating the need for complex traffic rolls, and new services can be deployed with the newer technology. This option also gives operators the ability to optionally migrate some traffic off the legacy platform and onto the newer technology. The chosen technology must be able to support the line-side output of the legacy platform as a client-side input. This scenario is typically easier for circuit-based technologies, particularly OTN.

Client-Side Roll

The client-side roll method results in the cleanest overall network solution, but involves the most complicated and operationally taxing migration process. The low speed interfaces on transmission systems that are aggregated into the higher speed interfaces are the client-side. With the client-side roll method, the new technology is installed and each client-side service on the existing platform is rolled onto the new platform, one by one. Once the process is completed, the legacy platform can be completely removed alleviating the need for ongoing support. Depending on the technology chosen, both sides of a service may need to be migrated at the same time. This can be extremely complicated if a single location has client services that terminate at multiple destinations. Additionally, this process can involve extended downtime for any unprotected services. Due to the wide variety of client services on legacy devices, this method may have a significant impact on which technologies can be chosen for the transformation.

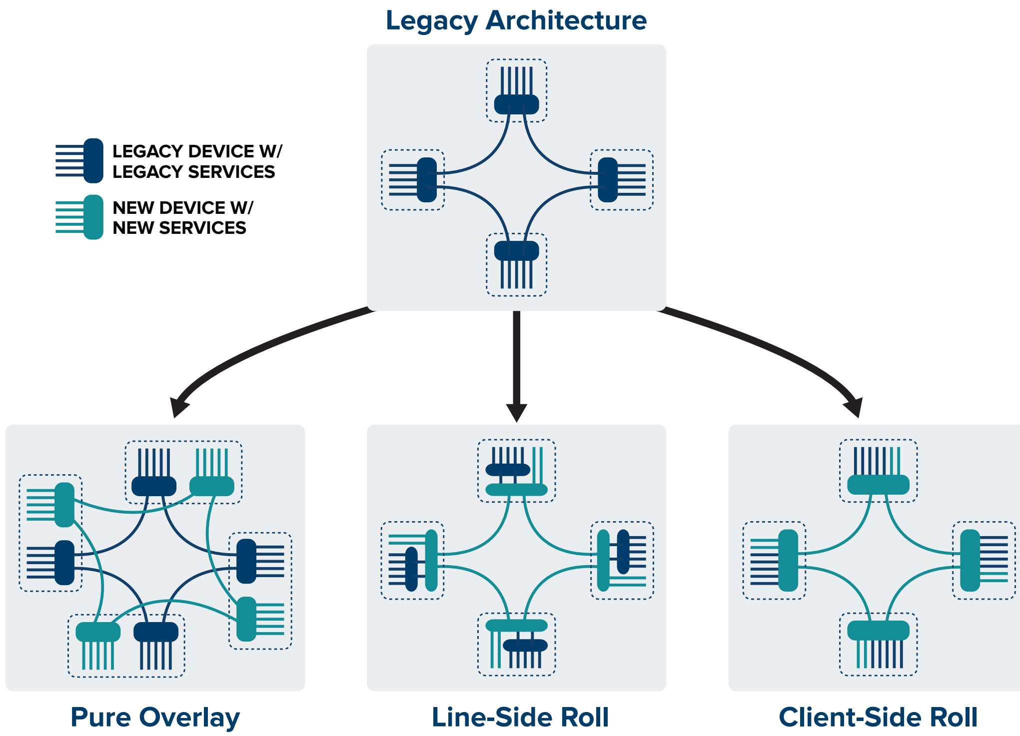

FIGURE 4 – Options for Network Migration

CORIANT PROVIDES THE EXPERTISE FOR EFFECTIVE TRANSFORMATIONS

All network transformations come with varying levels of complexity in the migration process and in updating recordkeeping systems to reflect the new network. Irrespective of which technology and methodology is chosen, it is important to develop a cohesive transformation strategy. Support from an experienced network transformation partner is a valuable resource that will save time and money and minimize impacts on existing services. With more than 35 years of experience with network modernization and migration in virtually every type of environment and backed by a host of automation tools to simplify the process, Coriant Global Services provides the means to a seamless network transformation. Coriant Modernization and Migration Services include all aspects of network transformation including planning, project management, installation, service transformation, and updating OSS records. Coriant's migration experts are trained on diverse vendor equipment and have deep transformation experience from and to numerous technologies, all to ensure a successful solution implementation.

MAKING THE RIGHT DECISION

Each solution and migration method has advantages and disadvantages. While there is no single best answer for all situations, the optimal solution for each network operator will depend on the legacy technology, the long term objectives of each network operator, and often, which organization is making the decision. As network operators determine their network transformation path, Coriant can provide the consultative support to make the right decisions, the networking solutions to meet short and long term network goals, and an experienced team to ensure a rapid and successful transformation.

ABOUT CORIANT

Coriant delivers innovative, dynamic networking solutions for a fast-changing business world. The Coriant portfolio of SDN-enabled, edge-to-core transport solutions enables network operators to reduce operational complexity, improve utilization of multi-layer network resources, and create new revenue opportunities. Coriant serves leading network operators around the world, including mobile and fixed line service providers, content providers, data center operators, cable MSOs, large enterprises, government agencies, financial institutions, and utility companies. With a distinguished heritage of technology innovation and service excellence, forged by over 35 years of experience and expertise in Tier 1 carrier networks, Coriant is helping its global customers maximize the value of their network infrastructure as demand for bandwidth explodes and the communications needs of businesses and consumers continue to evolve. Learn more at www.coriant.com.