Backhaul Migration
Pseudowire or Native^2?

Abstract

As the industry-wide migration from legacy TDM networks to packet-based networking gains momentum, network engineers are mulling over this migration as it applies to microwave-based mobile backhaul infrastructure. Should the IP cloud extend all the way to the network edge? Where should legacy technologies remain? Should all sites use identical technologies? Or should local optimization be implemented where advantageous?

In this paper, we weigh the various network models, and relate to the factors that influence implementation decisions – cost, performance, network size, and manageability. We introduce the Ceragon FibeAir® IP-10 as well as Ceragon's unique **Native²** ("Native Squared") migration approach, and their adaptability to the models discussed.

The Alternatives

Thanks to the market-proven efficiency of microwave communications technology, using wireless links for mobile backhauling has become an inexpensive, reliable alternative to copper and fiber based backhauling, allowing carriers to quickly upgrade the services they provide to the market.

With mobile backhaul systems playing an integral role in the evolution of network architectures from TDM to packet, microwave backhauling requires specific consideration. At present, three approaches are available for mobile backhaul deployment:

- **All Packet.** This pure Ethernet approach is ideal for Greenfield data-centric networks. It requires, however, the use of Pseudowire technologies[1] in order to map Legacy TDM

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[1] Pseudowire (PW) is an emulation of a native service over a Packet Switched Network (PSN). The native service may be ATM, Frame Relay, Ethernet, low-rate TDM, or SONET/SDH, while the PSN may be MPLS, IP or Ethernet based cloud

or ATM traffic over the packet-switched network (PSN) when legacy services must be supported.

- **SONET/SDH/PDH.** As dominant legacy technologies, SONET, SDH, and PDH provide a safe, familiar solution for the forwarding of TDM traffic. New generation platforms allow data traffic forwarding over the TDM infrastructure. However, SONET/SDH systems were designed to carry voice services, and lack the flexibility and enhanced scalability required for carrying data. Therefore, their price-performance effectiveness is in decline.

- **Hybrid.** Hybrid systems that combine the efficiencies of the above two approaches allow the carrier to optimize spectrum use without risking current and future services. Ceragon's **Native^2** ("Native Squared") migration strategy offers a unique hybrid approach, in which both Carrier Ethernet and TDM traffic are carried natively over microwave links without using expensive encapsulation methods – resulting in significant cost savings, while smoothing the way to a future all-IP network.

This following section will focus on an analysis and a comparison of the all-packet and the **Native^2** approaches.

Figure 1: Native2 - Multiple Services over a Single Microwave Link

Pseudowire

The "All Packet" strategy represents a fast-track approach toward the realization of tomorrow's all-IP network. However, since TDM-based systems are still in broad use among cellular carriers, backhaul networks are, and will most likely continue to be, required to support TDM traffic. Pseudowire technology facilitates this adaptation.

Pseudowire offers the following advantages to the carrier:

- **Reduced Cost** – Carriers can reduce operational expenses by converging multiple services over a single network, applying a unified management scheme.
- **Efficiency** – Pseudowire is well-suited for ATM service, having only to handle cells bearing customer traffic (as compared to partially-populated TDM traffic), thus freeing valuable spectrum resources.
- **Ease of Provisioning** – End-to-end pseudowire provisioning of TDM traffic does away with the need to perform cross-connections at each network site, reducing OPEX.
- **Investment Protection** – Investment in Ethernet transport equipment is preserved over the long term, while investment in costly legacy infrastructure is curtailed.

Drawbacks of pseudowire use include:

- **High Per-Link CAPEX** – The cost of pseudowire service is high on a per-link basis. Savings are realized mainly at the network level.
- **Additional Overhead** – Pseudowire encapsulation requires additional overhead, reducing bandwidth efficiency.
- **Clock Recovery Problems** – Increased delay and jitter lower the reliability of clock recovery mechanisms. The reliability of these mechanisms is further reduced when employing low-capacity links, especially as the number of hops in the path grows.

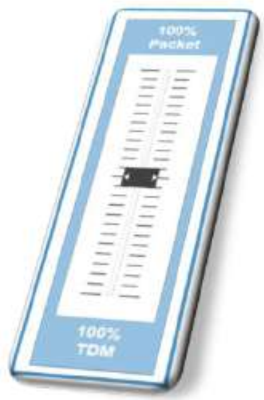
In general, pseudowire infrastructures are most efficient when utilizing pseudowire engines connected to high-capacity links, with a short path to a clock source.

Native^2 / Hybrid

In traditional hybrid systems, separate, dedicated TDM and Ethernet links exist side by side.

Ceragon's unique **Native^2** solution, however, implements a cost-effective logical hybridization scheme. **Native^2** solutions carry both TDM and Ethernet traffic natively and simultaneously over a single microwave link. This enables two separate logical networks to run over a single physical network.

The **Native^2** approach is supported by the Ceragon FibeAir® IP-10 platform. The FibeAir® IP-10 is a family of high-capacity microwave radio products, offering integrated Layer 2 networking capabilities. With its integrated Ethernet switch and integrated TDM cross-connect, the platform enables operators to build LTE-ready backhaul networks today - offering a risk-free migration all the way from 2G to LTE. The FibeAir® IP-10 platform delivers the high capacities and low latencies required for LTE on one hand, while providing carrier-grade synchronization, X2 interface support, Ethernet services, and management capabilities on the other. Ideal for IP networks, the FibeAir® IP-10 is MEF 9 and 14 certified, and was the first to publicly showcase end-to-end IEEE 802.1ag service OA&M (Operations, Administration, and Management).



The **Native**^{2} concept makes the evolution to all-IP networking simple. It supports full TDM networks, and continues to evolve with the backhaul network – as legacy TDM mobile networks are retired, more of the system bandwidth can be dedicated to carrying packet-based traffic. This approach lets mobile operators evolve at their own pace using multiple backhaul and networking alternatives.

The **Native**^{2} approach offers the following advantages to the carrier:

- **Reduced CAPEX and OPEX** – The FibeAir® IP-10 platform carries both TDM and Ethernet traffic natively, at no additional cost to the carrier. Reduced footprint, electrical, and cooling requirements save on operating expenditures.
- **Efficiency** –All FibeAir® IP-10 elements support both TDM Cross Connect and Ethernet switching, increasing efficiency both at the link level and at the network level.
- **Better Synchronization** – Native support for TDM systems ensures superior clock distribution. . Simplified Management – The FibeAir® IP-10 is deployed with a single management platform that supports comprehensive fault management, performance monitoring, and provisioning of all required services – microwave, switching, and cross-connection – resulting in significant OPEX savings.
- **Investment Protection** – The Ceragon FibeAir® IP-10 platform can be configured for all- packet deployment, supporting the highest possible capacities available in pure Ethernet microwave.

The disadvantages of **Native**^{2} solutions include:

Initial CAPEX Investment – the carrier must upgrade its network, rather than enhance it with next-generation SONET/SDH equipment.

Multiple Provisioning Solutions - In networks employing a combination of pseudowire and **Native**^{2} solutions, multiple provisioning and OA&M systems may be required.

Management of two separate transport networks - Hybrid implementations require separate end-to-end service management. In addition, E1 level awareness is maintained all along the path and not only at the edges (this drawback is addressed by the FibeAir IP-10 management system).

Based on this analysis of pseudowire and **Native²** approaches, it is apparent that each approach has distinct advantages and disadvantages. Clearly, an optimal and comprehensive solution for mobile backhauling involves a mix of the two approaches. In the following section, we introduce some representative scenarios for mobile backhaul migration.

Migration Models

This section is dedicated to describing 3 models for the migration of mobile backhaul networks from TDM to Ethernet:

- Service Stitching Model
- Service-Aware Packet Transport Model
- Overlay / Tunneling Model

All 3 models assume an aggregation/core migration to IP/MPLS. Our discussion focuses on optimization of 1st and 2nd mile backhaul segments. Maintenance of two separate aggregation networks – based on SONET/SDH and IP/MPLS - is also common, but is not in the scope of this document

I. Service Stitching Model

The Service Stitching Model, illustrated in Figure 2 below, is a basic model which involves the "stitching" together of two discrete network segments – a **Native²** hybrid TDM/Ethernet segment in the Access network, and an IP/MPLS-based segment in the Aggregation space.

Both Ethernet services and TDM services are stitched at the MPLS Router (or Multi-Service Router – MSR), maintaining the low-cost spectrum assets of the access segment on one hand, and the availability and manageability of the aggregation segment on the other.

Typically, in this model, we see a backhaul access network containing "radio clouds", in which each cell site uses minimal radio spectrum, and supports IEEE 802.1ag Ethernet OA&M. The **aggregation** network uses a hybrid fiber / microwave model and offers high-availability scenarios for data and management traffic. The Service Stitching Model offers the following benefits to the mobile carrier:

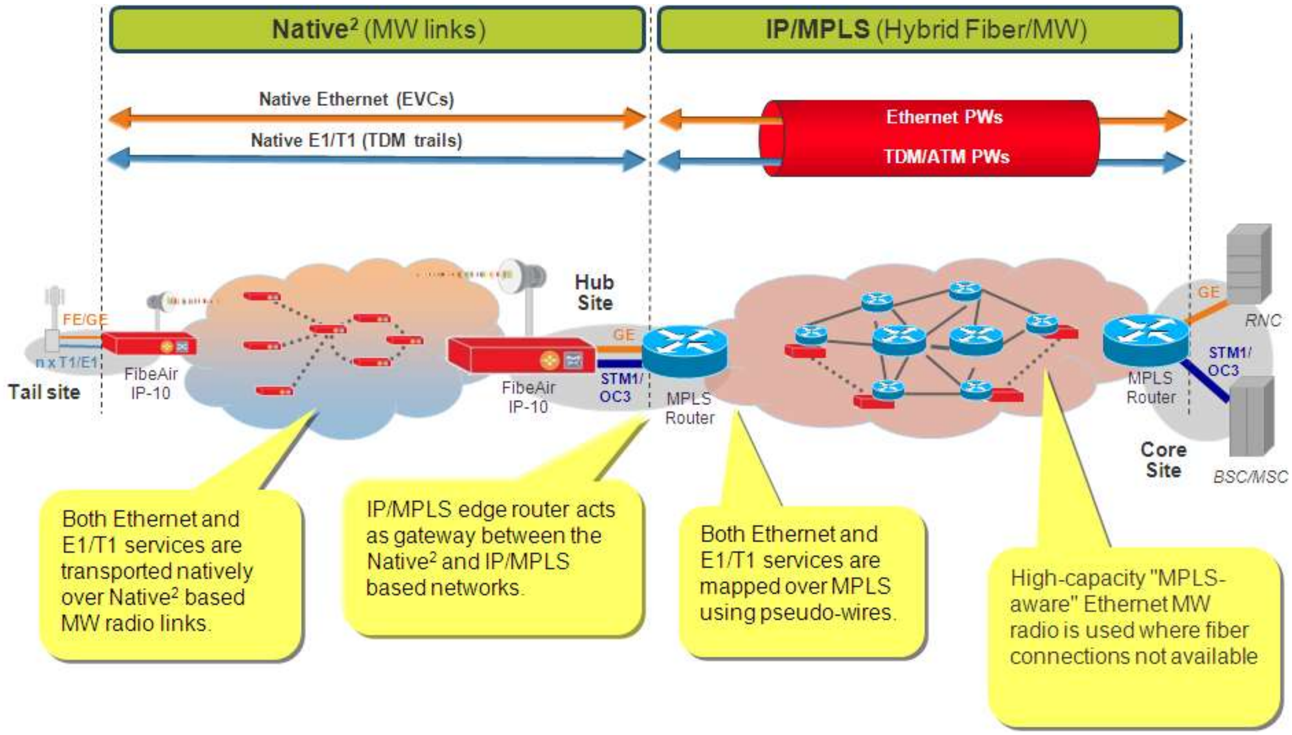


Figure 2: Service Stitching Model

- Optimal Spectrum Usage
  - Minimizes encapsulation overheads when using narrow channels (compared with the use of MPLS tunnels)
  - Incorporates Ethernet header compression o Addresses all 3 optimum service points – All TDM, TDM/Ethernet Mix, and All Ethernet
  - Utilizes service-aware adaptive power ACM (Adaptive Coding and Modulation) for both TDM and Ethernet
- CAPEX and OPEX Reduction
  - Employs a single element – modular and versatile – from tail to node, split or all indoor, all packet or **Native²**. Saves on inventory, warehousing, and staff training costs.

- Integrates seamlessly into Ethernet networks. The FibeAir® IP-10 features an industry-compliant Layer 2 interface for rapid deployment and ease of maintenance, including TDM cross-connect, supporting Sub-Network Connection Protection (SNCP), and Metro switching with MEF 9 and MEF 14 certification to enable direct interfacing at cell sites.
- Offers advanced and complete management capabilities for provisioning end-to-end services in the microwave cloud.

The Service Stitching Model is best suited for microwave-based backhaul networks. It provides optimization in all levels of the network, achieving lower overall cost while maintaining the highest effective traffic throughput.

II. Service-Aware Packet Transport Model

In the Service-Aware Packet Transport Model, Cell Site Gateways/Routers (CSG/CSR) are deployed in all access and aggregation sites. Aggregation and grooming are performed by Multi-Service Router (MSR) units while Ceragon point-to-point microwave links offer an inexpensive alternative to fiber use.

Both Ethernet service and TDM services are encapsulated and carried end-to-end over an MPLS-based pseudowire. In this model, the all-packet microwave delivers the highest possible capacity and reach at any given spectrum. Further optimization can be achieved using multiple- availability classes (for example, 5-nines availability for voice, sync, management, and real-time services, and 4-nines availability for internet access).

The Service-Aware Packet Transport Model offers the following benefits to the mobile carrier:

- **A single network concept.** Uniform provisioning, classes of service, and end-to-end OA&M.
- **A highly reliable, service-aware Ethernet microwave system.**
    - Performs hitless switchover and link-state propagation to ensure predicted behavior of fast reroute or MPLS OA&M functions.
    - Optional availability of ACM, enhanced with service awareness in case multiple service availability classes coexist in the network.

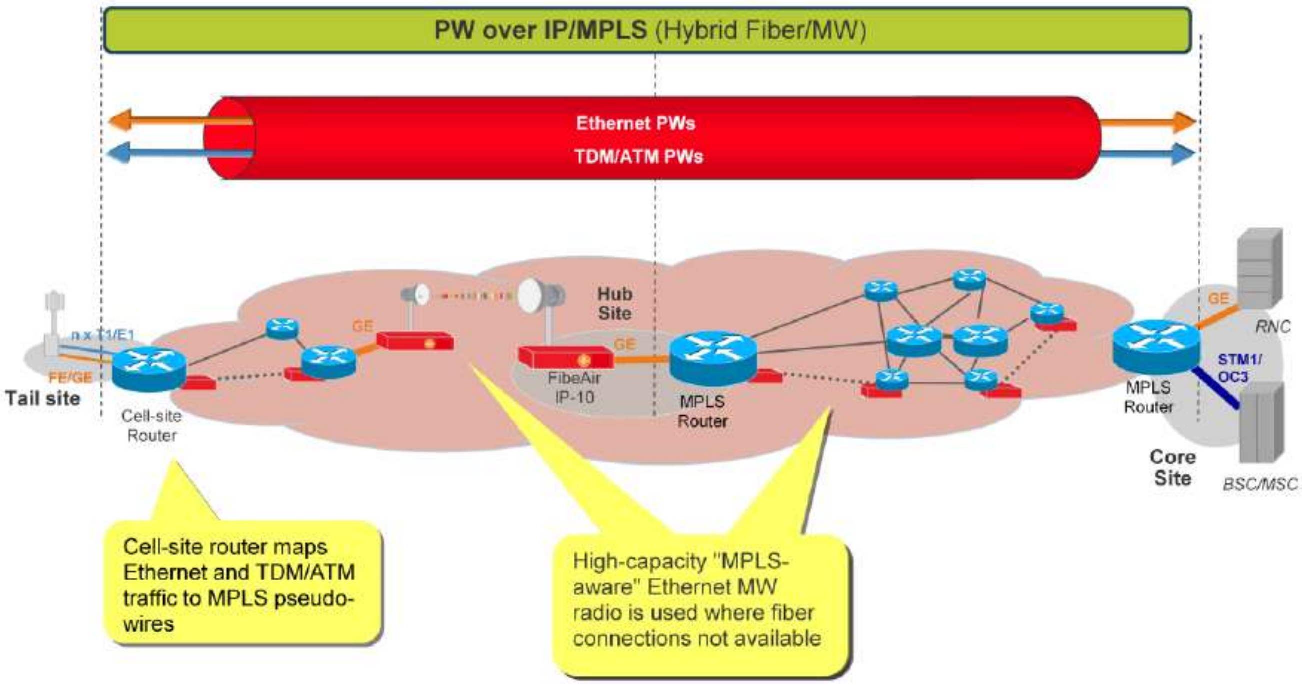


Figure 3: Service-Aware Packet Transport Model

The Service-Aware Packet Transport Model is a good fit for leased-line based backhaul networks with a limited number of self-owned microwave links. In this case, the overall gains stemming from a consistent management model might outweigh the advantages of local optimization in the microwave-only segments. Furthermore, by applying multiple availability classes for the traffic across the backhaul, additional gains may be achieved.

III. Overlay/Tunneling Model

In the Overlay/Tunneling Model, shown in Figure 4, the access backhaul network employs CSRs/CSGs at cell-sites, mapping all traffic into pseudowires that are carried over Ethernet Virtual Circuits (EVCs). The aggregation segment uses MSRs for implementing pseudowires over IP/MPLS.

Here, both Ethernet services and TDM services are encapsulated and carried in the access space over MPLS-based pseudowires. Both pseudowires are carried over EVC in the radio cloud and then stitched at the aggregation level. This model offers the following benefits:

- Similarity to the “Service-Aware Packet Transport Model”, but with the additional simplicity of standard EVC services for both point-to-point and optional multipoint-to-multipoint interfaces (for protection schemes or future deployment of X2 LTE handover interfaces).

- The segmentation of the MPLS tunnel improves scalability and offers better economies of scale at the aggregation level.

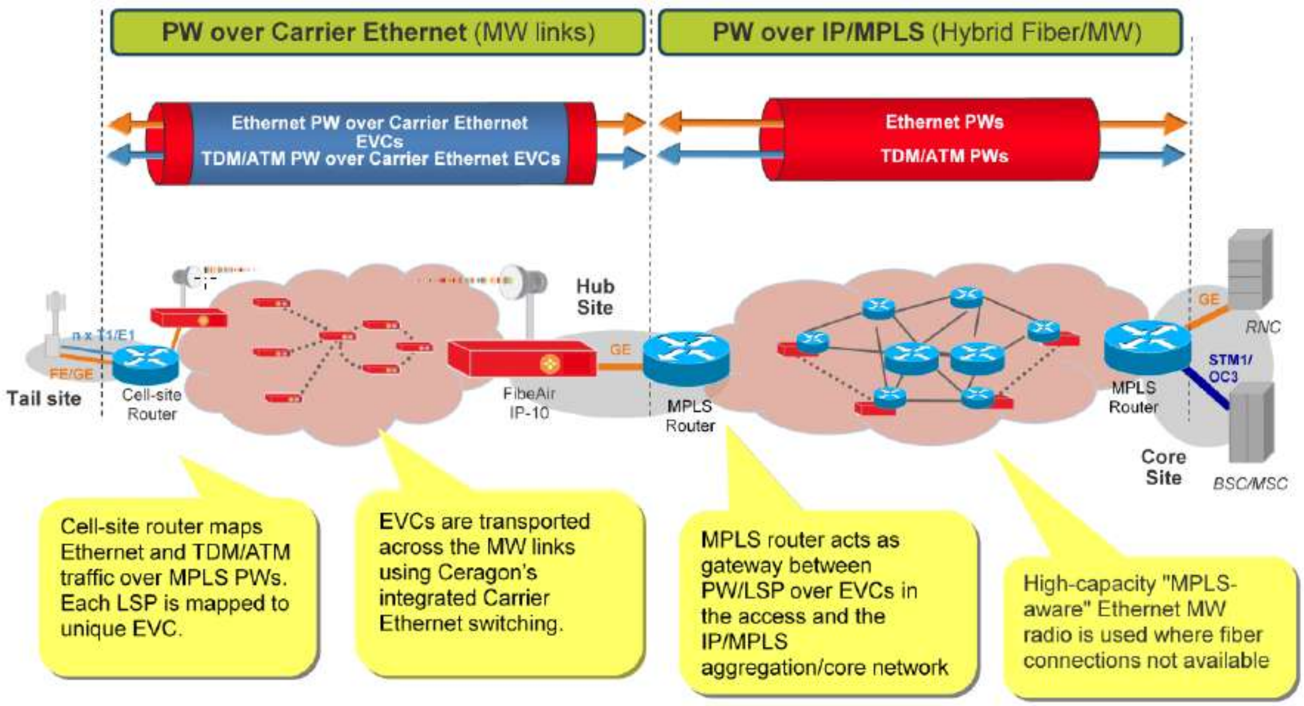


Figure 4: Overlay/Tunneling model

The Overlay/Tunneling Model is the most appropriate for leased-line based backhaul networks with a limited self-owned microwave portion. In this model all service providers and backhaul segment providers need to comply with MEF specifications. The overall gains in a consistent management model increase in this model due to the usage of a single, standard, Carrier Ethernet transport layer.

Additional gains may be achieved by applying multiple availability classes for the traffic across the backhaul network.

Conclusion

Efficient utilization of microwave technology for the access segment of a mobile backhaul network requires local optimization, using a mix of pseudowire and **Native^2** deployments. Such local optimizations should yield an overall cost reduction, simplify management, and allow the carrier to quickly and effortlessly provide new and profitable value-added services.

Implementation of Ceragon's **Native^2** technology in the access part of the backhaul network, together with pseudowire solutions in the aggregation segment, eases the migration to all-packet networking, and offers a field-proven foundation for LTE-ready backhaul.

About Ceragon Networks Ltd.

Ceragon Networks Ltd. (NASDAQ: CRNT) is the premier wireless backhaul specialist. Ceragon's high capacity wireless backhaul solutions enable cellular operators and other wireless service providers to deliver 2G/3G and LTE/4G voice and data services that enable smart-phone applications such as Internet browsing, music and video. With unmatched technology and cost innovation, Ceragon's advanced point-to-point microwave systems allow wireless service providers to evolve their networks from circuit-switched and hybrid concepts to all IP networks. Ceragon solutions are designed to support all wireless access technologies, delivering more capacity over longer distances under any given deployment scenario. Ceragon's solutions are deployed by more than 230 service providers of all sizes, and hundreds of private networks in more than 130 countries. Visit Ceragon at www.ceragon.com.