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APPLICATION NOTE 4102

Using Ethernet over PDH in SONET/SDH Networks

Abstract: This article discusses Ethernet over PDH over SONET/SDH (EoPoS), EoPDH, and Ethernet over SONET/SDH. The emergence in the 1990s and the history of Next-Generation SONET/SDH (NGS) equipment are described. The article explains that NGS could not provide ubiquitous interoperability with legacy systems, and thus was not universally implemented. Finally, today's emerging technology, Ethernet over PDH over SONET/SDH (EoPoS), is presented. EoPoS marries legacy systems with efficient transport technologies by using the International Telecommunications Union (ITU) standard Ethernet over PDH (EoPDH) in conjunction with SONET/SDH.

Introduction

Carrier Ethernet unlocks many potential revenue-generating services that telecommunications service providers, known as Carriers, must deploy to maintain their competitive position. However, most Carriers are not ready to convert to a pure Ethernet network because Ethernet lacks native support for link monitoring, fault isolation, and diagnostic testing. These three attributes, which enhance service quality, are native to the Plesiochronous Digital Hierarchy (PDH) and synchronous SONET/SDH networks. Consequently over decades, Carriers came to trust PDH and SONET/SDH networks as dependable platforms for delivering critical services to demanding customers.

The transparent and efficient transport of native Ethernet frames from network edge to network edge is challenging. In the past, overcoming these challenges was costly. Near the end of the 1990s, many Carriers forklifted some portion of their networks and replaced them with what was then called "Next-Generation" SONET/SDH (NGS) equipment. That next-generation equipment efficiently transported Ethernet and TDM services when the infrastructure approached 100% utilization. But NGS equipment had its own weakness: it did not interface with legacy systems. Each node that terminated or handed off a service needed to be replaced with a new system. While this replacement and update burden stimulated business for equipment makers, replacing legacy nodes was an inefficient use of Carriers' capital.

Today, however, new protocols allow the re-use of legacy equipment. The importance of these new protocols is significant, as they minimize the overall cost of delivering new Carrier Ethernet services.

Comments on Next-Generation SONET/SDH (NGS)

Before understanding the advantages of the newest methodology, it is important to understand a few details of NGS. When transporting Ethernet, NGS solutions place Generic Framing Protocol (GFP) encapsulated Ethernet frames directly into variable-bandwidth concatenated SONET/SDH virtual containers. This exchange is done primarily using the methods defined by the International Telecommunications Union's ITU-T G.707. By allowing a very fine bandwidth granularity for each service on a NGS network, this transport scheme promises to provide optimal bandwidth usage in an SONET/SDH link that is running at nearly full capacity. Many Carriers regarded this class of equipment as the ideal technological solution of the time.

When terminating or handing off a service, however, these concatenated virtual containers must be resolved into a physical interface such as OC-3, STM-1, T1, E1, or DS3. But NGS systems do not interoperate well with legacy systems because the concatenated virtual containers originating at an NGS node cannot be resolved to a standardized physical interface by a legacy SONET/SDH system. With legacy SONET/SDH systems unable to perform this task, NGS equipment is required at these nodes. Additionally, when a legacy network is used to transport a service that originates at an NGS node, typically an entire legacy SONET/SDH container is allocated to the path, thus eliminating the fiber bandwidth efficiency gained by using NGS. In short, NGS systems ignore interoperability with the established transport methods and instead promise bandwidth utilization that is rarely achieved.

Fundamentals of Legacy SONET/SDH and EoPDH

The new Ethernet over PDH over SONET/SDH (EoPoS) approach leverages, rather than deviates from, traditional transport methods. To grasp the importance of this approach, we must start with some fundamentals of legacy SONET/SDH systems.

All telecommunications equipment depends on protocol processing in silicon and software to perform the bulk of its duties. The basic protocol stack of a legacy SONET/SDH Add-Drop Multiplexer (ADM) is shown in Stack A of **Figure 1**. This protocol stack has been used for many years to carry the PDH Time Domain Multiplexed (TDM) services such as leased T1, E1, and DS3 lines.

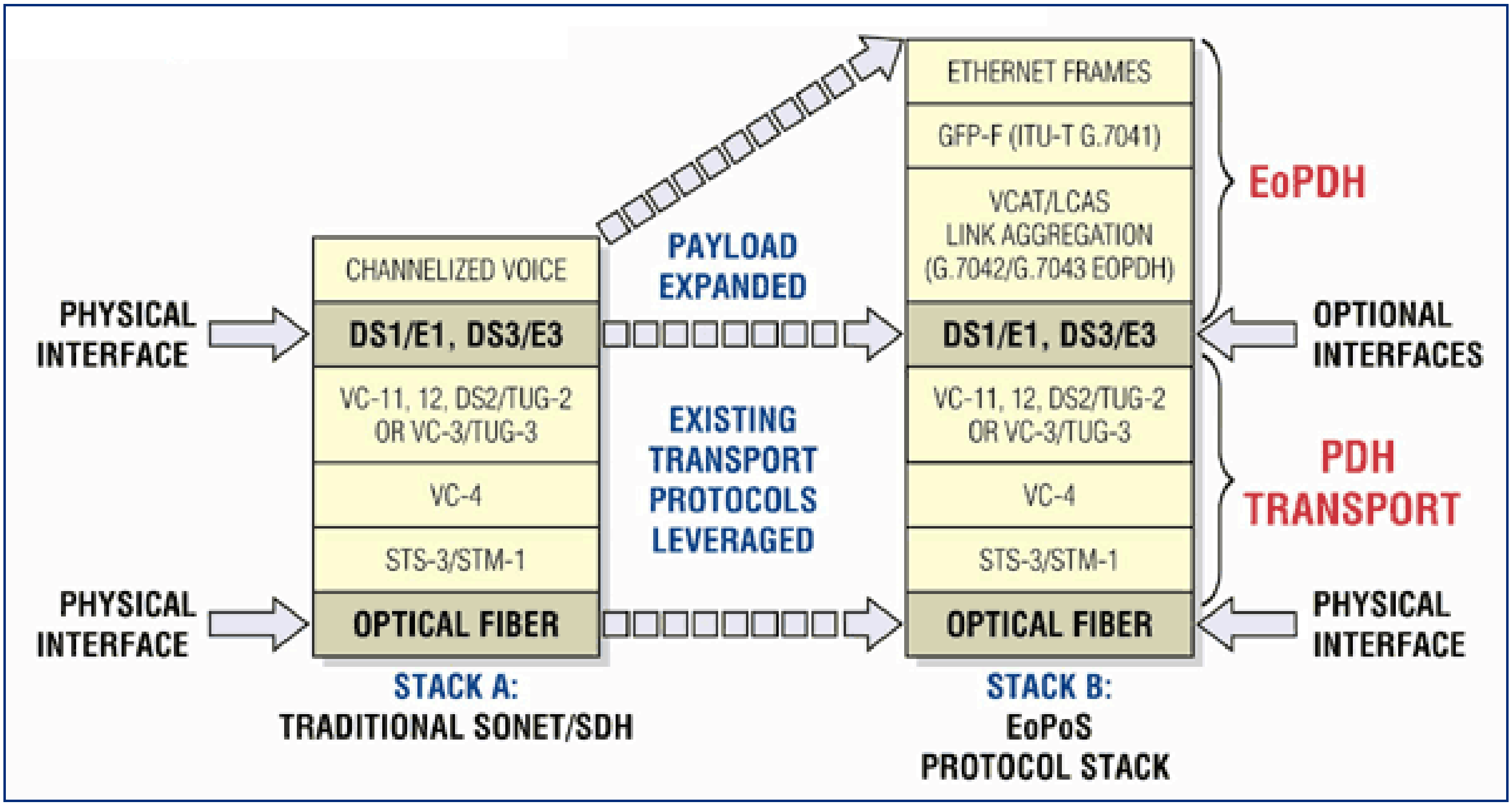

Figure 1. Protocol comparison of legacy SONET/SDH with Ethernet over PDH over Sonet (EoPoS).

These PDH services—T1, E1, and DS3—are well understood, globally deployed, and trusted. Therefore, it is understandable that the ITU would adopt these PDH technologies as the transport layer for new Ethernet services. Recently, the ITU developed new recommendations for Ethernet transport over single and multiple PDH links. The applicable standards are ITU-T G.7041, G.7042, and G.7043. Collectively, these recommendations are the fundamental building blocks of Ethernet-over-PDH (EoPDH) technology. The protocol stack used in EoPDH equipment is labeled and shown in the top portion of Stack B in Figure 1.

EoPDH is a collection of technologies and new standards that allow Carriers to use extensive existing telecommunications, copper infrastructure to provide new Ethernet-centric services. EoPDH standards enable interoperability and the gradual migration of Carriers to pure Ethernet networks. The standardized technologies used in EoPDH include frame encapsulation, mapping, link aggregation, link capacity adjustment, and management messaging. Common practices in EoPDH equipment also include: the tagging of traffic for separation into virtual networks; prioritization of user traffic; and a broad range of higher layer applications. Although EoPDH was created for point-to-point delivery of Ethernet over physical PDH tributaries, when combined with legacy SONET/SDH, EoPDH becomes an important element and cost-effective tool for Ethernet service delivery.

Benefits of Ethernet over PDH over SONET/SDH (EoPoS)

A new class of SONET/SDH equipment both maps Ethernet frames into virtually concatenated PDH tributaries using the EoPDH standards, and then uses traditional mapping techniques to transport the PDH connections over the existing SONET/SDH network. The protocol stack of this equipment is shown in Stack B of Figure 1. Combining EoPDH and PDH-over-SONET/SDH, this newest technology is called Ethernet over PDH over SONET/SDH, or EoPoS.

The point at which the two protocols are joined together is also the point at which legacy protocol processing sends data to a physical PDH interface, such as a T1 or E1 port. This small detail allows EoPoS protocol processing to be distributed between two pieces of equipment connected with any PDH link. By allowing protocol processing to be spread across multiple pieces of equipment, EoPoS enables a mixed environment of legacy and new equipment. The real strength of EoPoS, however, is that it leverages the existing infrastructure of systems and knowledge for transporting PDH tributaries over SONET/SDH networks. Unlike the NGS approach, which attempted to optimize bandwidth at all costs, EoPoS minimizes costs while still making efficient use of bandwidth. To understand these advantages, consider an example application.

In the Metropolitan Networks of most Carriers, services are delivered over interconnected SONET/SDH rings. One such network ring is represented in **Figure 2**. Although the legacy ADM is diagrammed as a single node in the figure (node C), it actually represents the bulk of telecom equipment deployed in the field. To place appropriate emphasis on the weight of this factor, the installed base of legacy SONET/SDH equipment is worth hundreds of billions of dollars. It is very important to note that a large portion of this equipment is fully depreciated, and only incurs ongoing operating expense. For a new piece of equipment to decrease total operating costs, the asset's depreciation expense plus the maintenance expense together must be less than the operating expense of the old, fully depreciated equipment. This single factor makes a strong cost argument for maintaining the operation of legacy SONET/SDH equipment.

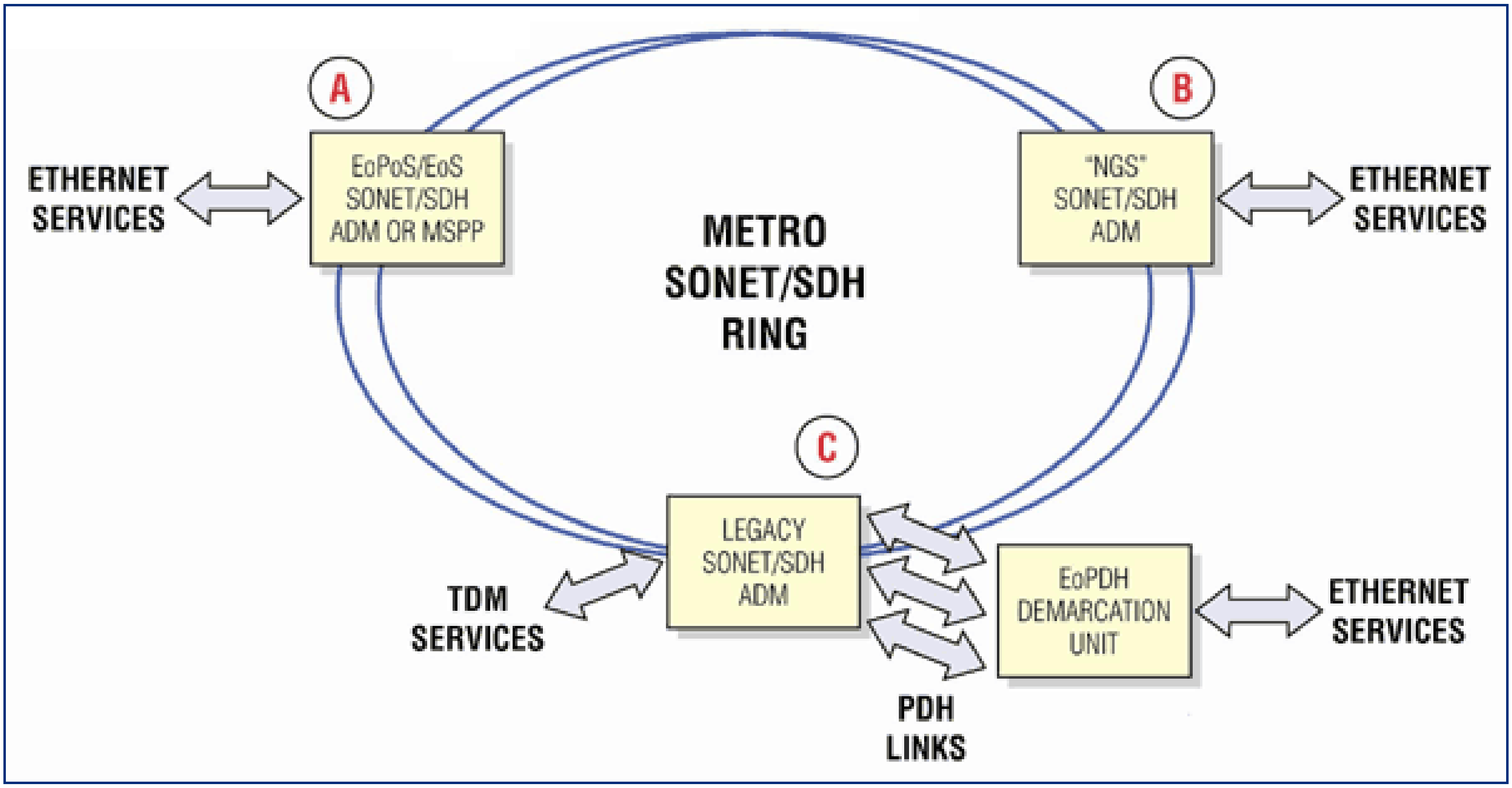

Figure 2. Example Metro SONET/SDH application diagram.

Node A in Figure 2 represents a new piece of equipment that uses EoPoS technology. In keeping with the principal of interoperability, this equipment typically supports the traditional Ethernet-over-SONET/SDH (EoS) and NGS protocols. Therefore, Ethernet traffic can flow from the new EoPoS node to the NGS system at node B, and from the EoPoS node to the legacy node. As discussed earlier, the legacy node's protocol stack does not include the NGS protocol. Because the NGS protocol does not provide a physical PDH interface, the legacy node cannot terminate an Ethernet flow sourced from the NGS node. The legacy ADM at node C can transport and hand-off the EoPoS flow from node A. The legacy ADM processes the bottom portion of Stack B in Figure 1 and provides physical PDH connection to a low-cost piece of equipment. A CPE supporting EoPDH processes the top portion of Stack B in Figure 1, and thus fully terminates the EoPoS flow. When an existing customer converts from a legacy TDM service to an Ethernet service, the incremental cost at the legacy node is only a low-cost piece of equipment compliant with the EoPDH standards, not an expensive NGS SONET/SDH box.

This natural division of protocol processing at the PDH layer is also useful in applications where leased PDH lines are required to reach a customer site at which the EoPDH equipment resides. Additionally, when the SONET/SDH network between nodes A and C consists of a complex web of interconnected legacy equipment, the legacy equipment can manage the component EoPoS flows as if they were simple PDH tributaries. While an ADM is used for this example, Carrier Ethernet equipment benefiting from EoPoS technology includes a broad range of equipment types, such as MSPPs, demarcation units, ROADMs, media gateways, IP DSLAMs, and microwave radios.

Summary

SONET/SDH equipment enabled with EoPoS technology not only delivers many of the benefits promised by NGS equipment, but EoPoS optimizes deployment expense. By using a standardized virtual concatenation method, the bandwidth consumed by a Carrier Ethernet service can be dynamically adjusted in increments as small as 1.5Mbps. The ITU-T G.7042 VCAT/LCAS protocol provides dynamic allocation and the flexibility to effectively use all the SONET/SDH bandwidth. Carrier Ethernet service subscribers can thus be allocated the bandwidth that they require. The system has little wasted bandwidth. By making intelligent use of the EoPDH protocols in conjunction with SONET/SDH equipment, costs can be minimized while transitioning a network to support new Carrier Ethernet services.

A similar article appeared in the April 12, 2007 edition of *Electronic Design*.

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