

Testing Transport Scenarios for Ethernet at 10 Gb/s

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Introduction

As a natural evolution, the typical test concepts borrowed from lower-rate Ethernet apply to 10 Gigabit Ethernet (GigE). For instance, the typical test concepts, such as Ethernet tests, simulate network data traffic by generating traffic streams or conducting performance tests such as RFC 2544. However, at data rates in the vicinity of 10 Gb/s, traffic in a metro or long-haul network is often carried in the network backbone. As a result, 10 GigE now forms an integral part of the transport environment. The best practical example comes from the Institute of Electronic and Electrical Engineers (IEEE) 802.3 10 GigE standard in the form of 10GBASE-R and 10GBASE-W. The latter, also referred to as 10 GigE wide area network (WAN), specifies the use of OC-192/STM-64 synchronous optical network(ing)/synchronous digital hierarchy (SONET/SDH) to transport an Ethernet payload down to the physical coding sublayer (PCS). The former, also called 10 GigE local area network (LAN), represents the natural ten-fold data rate evolution from GigE. The key rationale behind the adoption of 10 GigE WAN is the omnipresence of SONET/SDH transport networks. The following scenarios outline a number of possibilities on how to transport and test Ethernet traffic at 10 Gb/s.

Scenario 1: 10 GigE LAN Backbone

Scenario 2: Using the SONET/SDH Infrastructure

Scenario 3: Using the OTN Infrastructure

Scenario 4: Generic Transport with GFP

Scenario 5: Point-to-point with Forward Error Correction (FEC)

Scenario 1: 10 GigE LAN Backbone

By default, a 10 GigE service implies the use of 10 GigE LAN interfaces. The 10 GigE LAN can be used in a backbone configuration to interconnect multiple sites or within data centers. Figure 1 shows an example of a network diagram. The 802.3 standard provides clear guidelines for maximum transmission distance. More specifically, engineered links can reach up to 40 km at a wavelength of 1550 nm. In such a scenario, testing link and hardware interface integrity is important. As with any protocol, transmission integrity errors are detected at the lower layers, which in this case is at the 64B/66B PCS. In most cases, integrity errors will also be reflected at the upper layers and reported as media access control (MAC) frame check sequence (FCS) errors. However, sometimes the PCS sublayer provides better insight and a more accurate view of the conditions. For example, a PCS coding error that occurs while transmitting inter-frame gaps (IFG) cannot be detected at the MAC layer. PCS analysis details whether line errors affect the 2-bit synchronization (sync) header within each 66-bit block. Sync header errors are classified into isolated errors or more severe bursts causing a high BER condition (16 invalid sync headers in 125 μ s) or a loss of synchronization (link down). In addition, the analysis of PCS errors reports information such as block-type errors found in the 64-bit block payload. Such test indicators support the typical Ethernet tests run at Layer 2 or above. However, when using 10 GigE LAN, the PCS sublayer provides key indicators to validate transmission integrity.

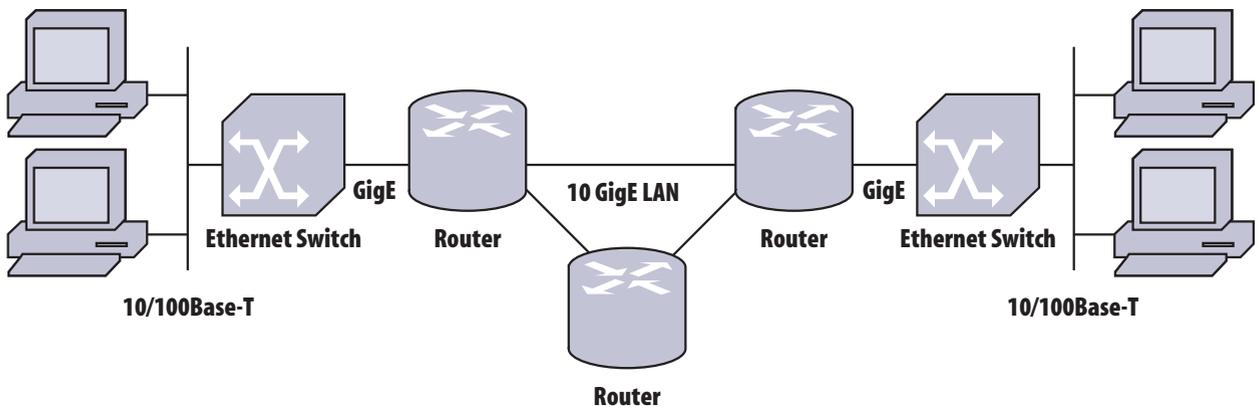


Figure 1. 10 GigE LAN in the Backbone

Scenario 2: Using the SONET/SDH Infrastructure

In Scenario 2 a service provider offers a 10 GigE service to its customers over an existing SONET/SDH infrastructure. Figure 2 shows how the service may be delivered on 10 GigE LAN end user interfaces and carried across the SONET/SDH backbone. The use of flow control is required because the maximum data rate of a 10 GigE LAN (10.3125 Gb/s) is greater than that of a 10 GigE WAN (9.95328 Gb/s). The maximum 10 GigE LAN data rate is 10.0 Gb/s for 64B/66B PCS encoding. The maximum data rate for 10 GigE WAN, after considering the SONET/SDH overhead and the PCS encoding, is 9.294 Gb/s. Flow control helps regulate traffic transfer and minimizes data loss. Each of these techniques consist of pause frames, which can be supported on any Ethernet interface, or Inter-frame Stretch (IF Stretch), which is specific to 10 GigE. A combination test case for this scenario involves a one-way bandwidth test across 10 GigE LAN and WAN ports. From a low-level transport perspective, the common line integrity indicators from SONET/SDH, such as B1/B2/B3 BIP errors, fully apply to this scenario.

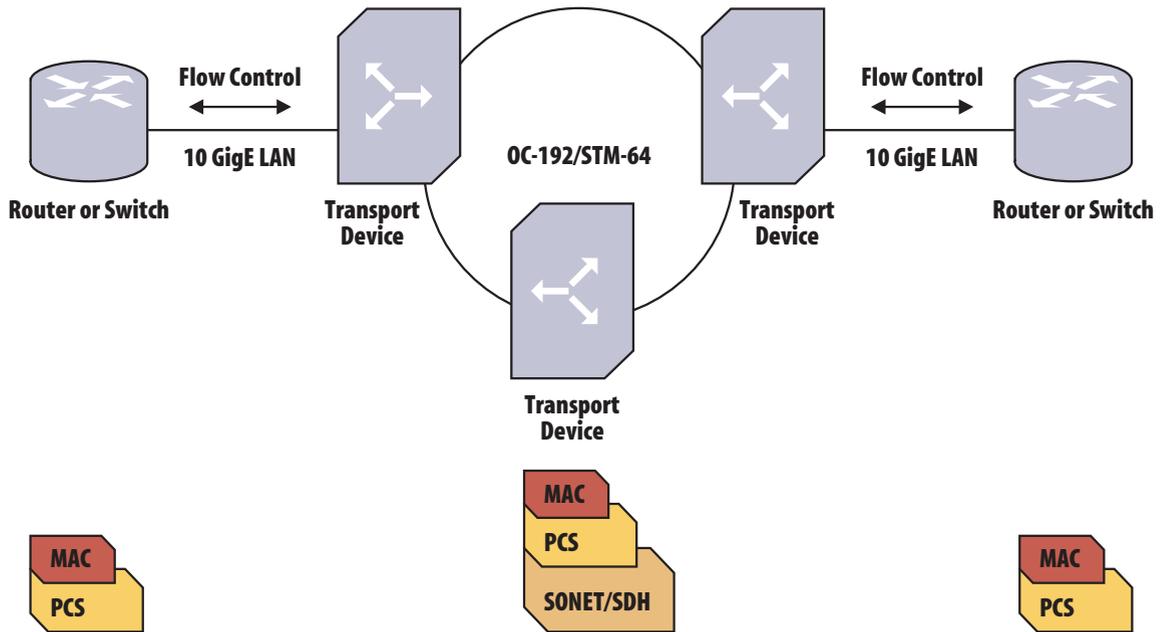


Figure 2. 10 GigE WAN Transport

Scenario 3: Using the OTN Infrastructure

Scenario 3 expands on Scenario 2 in that the backbone uses ITU-T G.709 OTU2 interfaces, better known as an optical transport network (OTN). OTU2 interfaces were primarily designed to transport OC-192/STM-64 client signals, although other client types may be used. G.709-based interfaces use FEC, which provides the key benefit of significantly increasing the distance between regenerators when compared to standard SONET/SDH interfaces. With OTU2 interfaces, a 10 GigE WAN signal can serve as the client signal across the backbone. Consequently, a service that originates as a 10 GigE LAN may be carried over an OTU2 transport core, which implies the presence of a device equipped with 10 GigE LAN and OTU2 interfaces that provides flow control capabilities. Figure 3 provides a sample diagram. Similarly, a test device with multi-rate interface support helps validate full Ethernet traffic compatibility across multiple interface types. One way to achieve this is to generate 10 GigE LAN traffic and analyze both Ethernet traffic content and link integrity directly on an OTU2 network interface. This way, OTU2 tests, including for example FEC and BIP-8 errors in addition to typical Ethernet tests such as RFC 2544, can run concurrently.

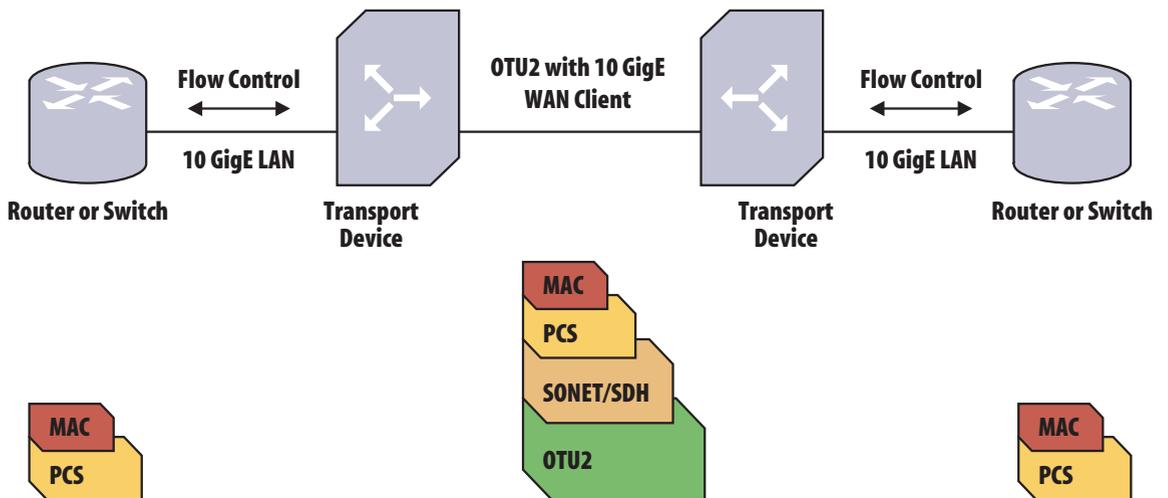


Figure 3. OTU2 Transport

Scenario 4: Generic Transport with GFP

As networks evolve, carrying multiple services and protocols over a common infrastructure becomes instrumental. A protocol developed to help achieve this goal is Generic Framing Procedures (GFP). GFP was conceived for use over different types of infrastructures including SONET/SDH and OTN. With GFP-F (Frame-mapped GFP), these protocols include Ethernet MAC, Point-to-Point protocol (PPP), and resilient packet ring (RPR). As a result, GFP-F provides one more option to transport Ethernet traffic at 10 Gb/s over an OC-192/STM-64 or OTU2 core. In this case, a network device equipped with 10 GigE LAN interfaces maps Ethernet MAC traffic onto GFP-F. Unlike Scenario 2 that uses 10 GigE WAN in the core, mapping to GFP-F removes the 64B/66B PCS sublayer while preserving the Ethernet MAC frame information. Figure 4 shows three different ways to map 10 GigE onto GFP using combinations of OC-192/STM-16 and OTU2. The standard GFP mapping into OTU2 follows the ITU-T G.709 recommendation. Other mapping methods exist, such as in prepublished recommendation ITU-T G.sup43, which allows for the inclusion of Ethernet preambles into GFP. The concept of testing one-way traffic between a 10 GigE LAN port and a port running GFP also applies in this scenario.

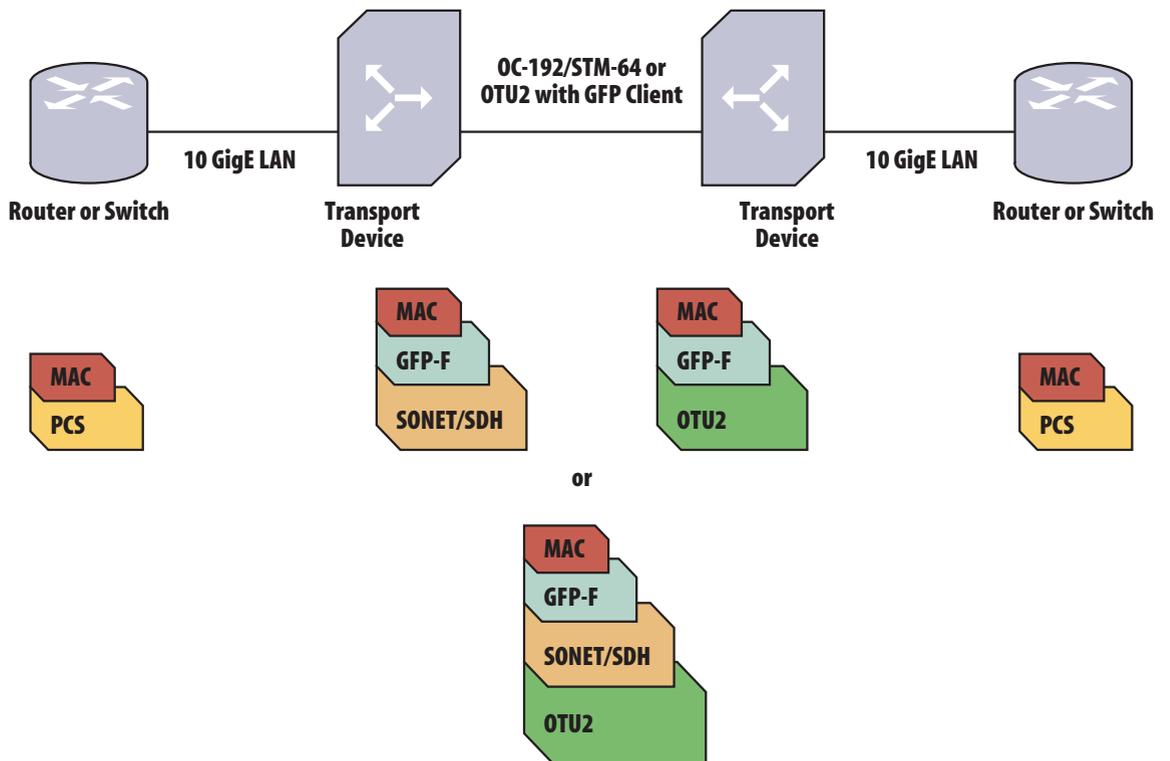


Figure 4. GFP in the Core

Scenario 5: Point-to-Point with FEC

When considering Scenario 1, one technique extends the transmission distance beyond the 802.3 standard. Quite simply, the same overhead and FEC used in G.709 OTU2 can be applied directly to a 10 GigE LAN client. The FEC algorithms defined in ITU G.975.1 can also be used because they provide different error correction capabilities, resulting in a line rate signal of 11.049 Gb/s or 11.095 Gb/s, which differ from the OTU2 line rate of 10.709 Gb/s.

The ITU-T G.709 recommendation for OTU2 documents the use of fixed stuff columns specifically for OC-192/STM-64 clients. With these fixed stuff bytes and the exact same overhead and FEC, wrapping a 10 GigE LAN signal results in a line rate of 11.095 Gb/s, also called OTU2e in G.sup43. Without these fixed stuff bytes, which means that the corresponding area of the payload is filled with data, the resulting line rate is 11.049 Gb/s also called OTU1e.

This scenario has the benefit of requiring no Ethernet flow control and extending the transmission distance for point-to-point 10 GigE LAN applications. Figure 5 illustrates the use of the 11.049 Gb/s and 11.095 Gb/s rates. Figure 6 shows a JDSU TestPoint which has been providing 10 GigE test solutions since 2001 and covers the five scenarios described.

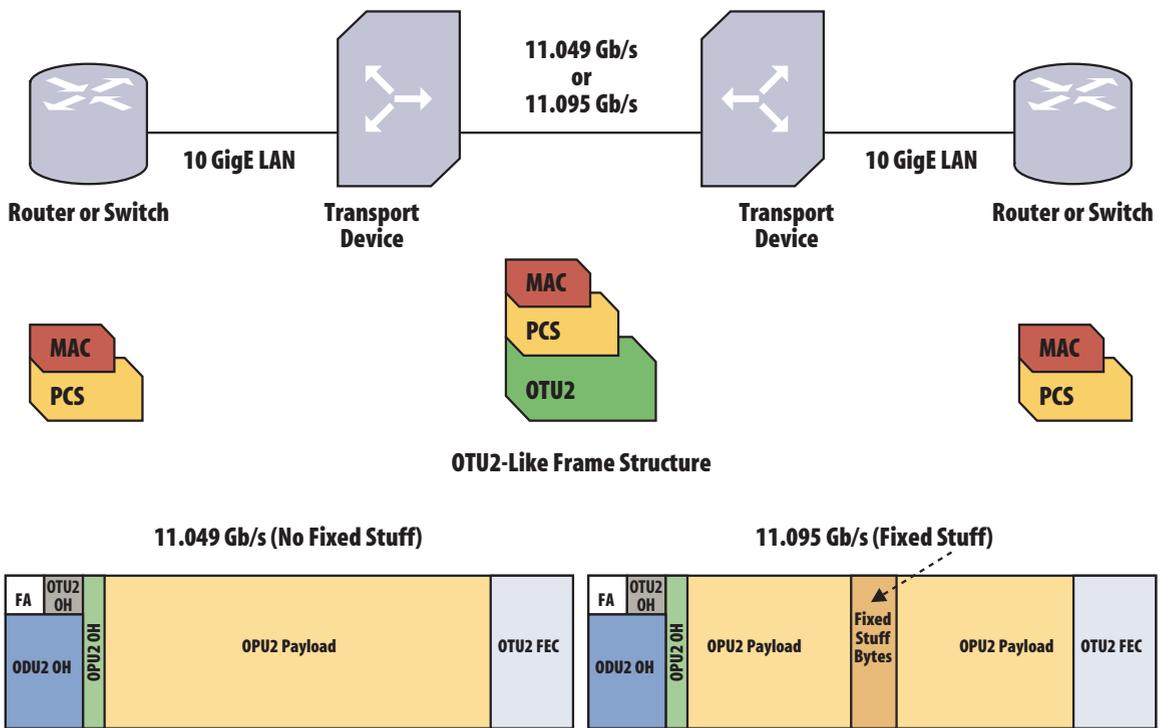


Figure 5. 11.049 Gb/s and 11.095 Gb/s Transport



Figure 6. TestPoint

The evolution of Ethernet at a higher data rate, or 10 GigE, currently sits at the top of the Ethernet hierarchy from a data rate perspective and is used in network backbones. The adaptability of Ethernet and global network evolution entails carrying 10 GigE traffic across a network in a variety of ways. This capability provides new opportunities for vendors and service providers and also implies that test techniques are required to help address these recent developments. The five 10 GigE transport scenarios described herein have all been field deployed. Service provider networks use these scenarios based on the specific advantages of each configuration. With 10 GigE as a vital component in data networks, it will be interesting to see the future impact of 40 and 100 GigE on the network core.

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