ETHERNET TESTING: DETERMINING APPROPRIATE TEST CASES AND MODES

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Ethernet is now part of all network topologies and can be found in access, metro and transport networks. Depending on the Ethernet topology, different test scenarios can be used to certify network performance.

This article provides background on the different topologies used to deliver Ethernet services, their corresponding test methodologies and the selection of the appropriate test mode according to the topology.

Ethernet in the Service-Provider Network

The deployment of Ethernet started in enterprise networks, when the massive installation of personal computers (PCs) first began; the technology of choice to connect PCs was Ethernet. As Ethernet technology grew in rates, enterprise customers started to request Ethernet to access their wide-area networks (WANs). With the push from their customers, service providers proceeded to upgrade their own networks to support this new access technology. On the residential side of their business, service providers were also using Ethernet as a means to deliver high-speed Internet access.

As the core of their networks was SONET/SDH-based, the ability to transport Ethernet in its native format would provide a means to leverage the existing infrastructure, while providing new services. The Next-Generation SONET/SDH concept made this migration possible through the development of technologies like generic framing procedure (GFP), virtual concatenation (VCAT), link capacity adjustment scheme (LCAS) and optical transport network (OTN). Figure 1 provides a typical view of Ethernet in a service-provider network.

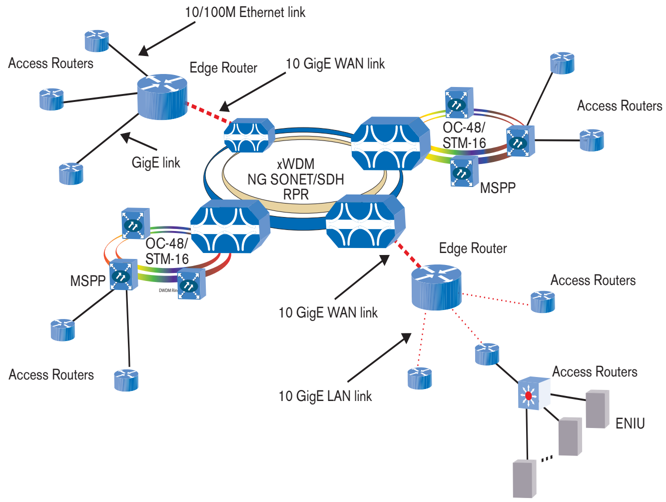

Figure 1. Ethernet in a carrier/service-provider network

Depending on the implementation, Ethernet technologies are deployed differently. When Ethernet is deployed in its native frame format, layer 2 switches will be connected to each other, forming a meshed network that provides Ethernet virtual-connection services to customers. A mix of protocols can be used to deliver these services: Virtual LAN (VLAN) or Q-in-Q, provider backbone transport (PBT) and transport multiprotocol label switching (T-MPLS). With these protocols, a service provider can architect an Ethernet-based core that is scalable and easily managed. In this environment, Ethernet frames are processed by each element in the network.

In a legacy environment based on SONET/SDH architecture, path-terminating network elements can be upgraded to support next-generation mapping protocols and provide Ethernet access to a SONET/SDH core. In this network architecture, Ethernet frames are processed by each path-terminating element. To the core of the network, it is just a normal SONET/SDH payload.

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In a DSL or FTTx residential network, Ethernet is used to connect to a DSLAM and OLT to the core network. Ethernet is also found at the ONT or DSL modem as a demarcation point between the service provider and PC or home network. In this application, Ethernet frames are processed by each network element. Depending on the access technology used, these frames can keep their native format (EPON/active Ethernet) or be carried over other protocols (i.e., ATM, GFP, etc.).

Finally, Ethernet can be carried on xWDM networks in its native format. In this scenario, a wavelength conversion takes place (optical-electrical-optical) and the signal transmitted along many other wavelengths. In this particular architecture, Ethernet frames can be carried transparently (no processing of Ethernet layer) or be aggregated into one wavelength. In more recent applications of this method, Ethernet frames are processed.

As each of these network topologies processes Ethernet frames differently, different test scenarios must also be used. Before considering the actual test scenarios that exist, however, it is important to review the Ethernet protocol to understand why one test scenario may be more appropriate than another.

Ethernet Protocols: Frame Formats and Basic Functionalities

The Ethernet frame is based on two different standards; the first one was created by the Digital Equipment-Intel-Xerox (DIX) consortium, while the second was introduced by the Institute of Electrical and Electronics Engineers (IEEE). Both frame formats are used in the industry (see Figure 2).

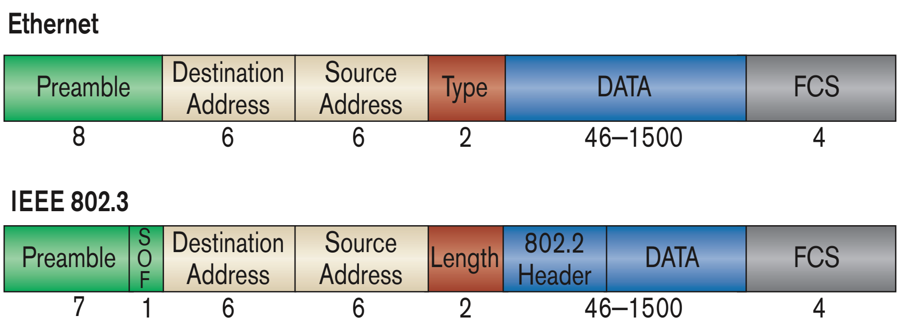

Figure 2. Ethernet DIX v2 vs. 802.3 frame format

Both frame formats have a preamble, destination and source address, a data field (where high-layer protocols are encapsulated) and a frame check sequence (FSC). The main difference resides in the Type or Length field. From an Ethernet perspective, the Type field (two-byte value) provides information on the encapsulated protocol. In the IEEE 802.3 format, these two bytes are used to know the length of the frame. The information on the encapsulated protocol is found in the 802.2 header that is part of the payload.

Once an Ethernet switch (or Ethernet processing equipment) receives a frame, it will compute the FCS value and verify with the one found in the frame. Should the calculation of FCS be different, the network element will then discard the frame. Retransmission is left to the higher-layer protocols. If the received frame is error-free, the switch will look in its table for the destination address and retransmit it on the appropriate port. Each time the Ethernet frames go through a layer 2 processing device, this verification and retransmission will occur. This will be done until the frame gets to its final destination.

Ethernet Test Scenarios

There are three test scenarios that are usually found in Ethernet test equipment: bit-error-rate test (BERT), Ethernet performance assessment (based on RFC 2544) and frame generation and analysis. We will cover each test scenario and explain when they should be used.

Ethernet Bit-Error-Rate Test Scenario

This test scenario is very popular, especially with users who have a SONET/SDH background. It is based on sending a pseudo-random bit sequence (PRBS) across an Ethernet-based circuit and measuring the ratio of errored bits compared to the number of sent bits. It is an adaptation of what was done in the PDH and SONET/SDH world. Unfortunately, this scenario does not apply to all Ethernet topologies. As stated before, Ethernet switches process Ethernet frames to look for errors. Should a transmission error occur, the Ethernet frame will be discarded. From a test-equipment perspective, this means that a full test frame was just discarded. As the receive PRBS engine just lost a large amount of bits, the measurement cannot be completed, and the test equipment will declare a pattern loss.

Figure 3 illustrates the behavior of a Layer 2 processing network.

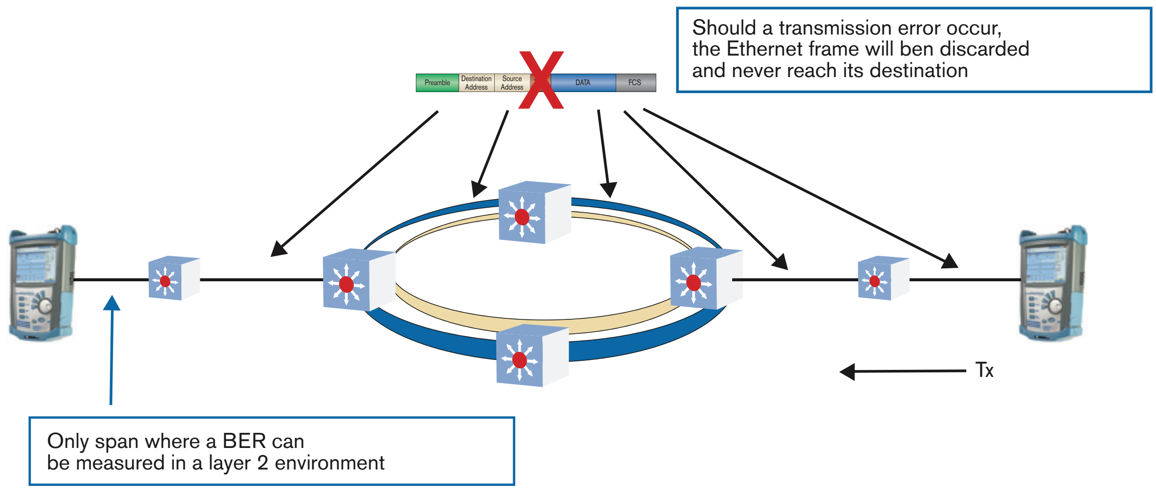

Figure 3. Example of a Layer 2 processing network

Because of its nature, a layer 2 processing network does not lend itself to BER-type tests. We will see that this type of measurement is better suited to the next two testing scenarios. Fortunately, in certain Ethernet network architecture, BER testing will be the test scenario of choice. In a transparent xWDM environment, Ethernet frames are carried without any layer 2 processing; therefore, should a transmission error occur, the error will be carried across the circuit to the receiving equipment. In this case, the PRBS engine will be able to detect errors and report them correctly. BER tests can also be used to validate the bandwidth capacity of dark multimode or singlemode fiber.

Ethernet Performance Assessment: RFC 2544 Test Scenario

This series of tests was introduced as a method to benchmark network interconnect devices. Because of its ability to measure throughput, burstability, frame loss and latency, this methodology is also used to test Ethernet-based networks. The test methodology calls for different frame sizes to be tested (64, 128, 256, 512, 1024, 1280 and 1518 bytes), the test time for each test iteration (latency should be set to at least 60 or 120 seconds), the frame format (IP/UDP), etc.

RFC 2544 defines the *throughput* test as the maximum rate at which none of the offered frames are dropped by the device/system under test (DUT/SUT). This measurement translates into the available bandwidth of the Ethernet virtual connection.

The next test in the methodology, the *burstability* or *back-to-back* test is defined as the fixed length of frames that are presented at a rate such that there is the minimum legal separation for a given medium between frames (maximum rate) over a short to medium period of time, starting from an idle state. The test result provides the number of frames in the longest burst that the device or network under test will handle without the loss of any frames.

The *frame loss* test is defined as the percentage of frames that should have been forwarded by a network device under steady state (constant) loads that were not forwarded due to lack of resources. This measurement can be used for reporting the performance of a network device in an overloaded state, as it can be a useful indication of how a device would perform under pathological network conditions such as broadcast storms.

The last test defined by RFC 2544 is latency. For store-and-forward devices, *latency* is the time interval that begins when the last bit of the input frame reaches the input port and ends when the first bit of the output frame is seen on the output port. It is the time taken by a bit to go through the network and back. Latency variability can be a problem. With protocols like VoIP, a variable or long latency can cause degradation in voice quality.

By nature, network performance assessment with RFC 2544 is aimed at ensuring the short- to medium-term health of a network. By going through multiple frame sizes and iterations for each test, trying to do long-term test acceptance (24- to 72-hour tests) before delivering to a customer does not fit with the philosophy of the test methodology. There is no direct configuration to achieve this and should an errored frame occur, the time to complete the test would be greatly affected.

The RFC 2544 methodology was created to assess different parameters found in service-level agreements. By providing performance availability, transmission delay, link burstability and service integrity measurements, a carrier can certify that the working parameters of the delivered Ethernet circuit comply with the contract.

The question now is how to validate the long-term integrity of an Ethernet circuit in an environment that processes Ethernet frames? The answer: using *the frame generation and analysis* test scenario.

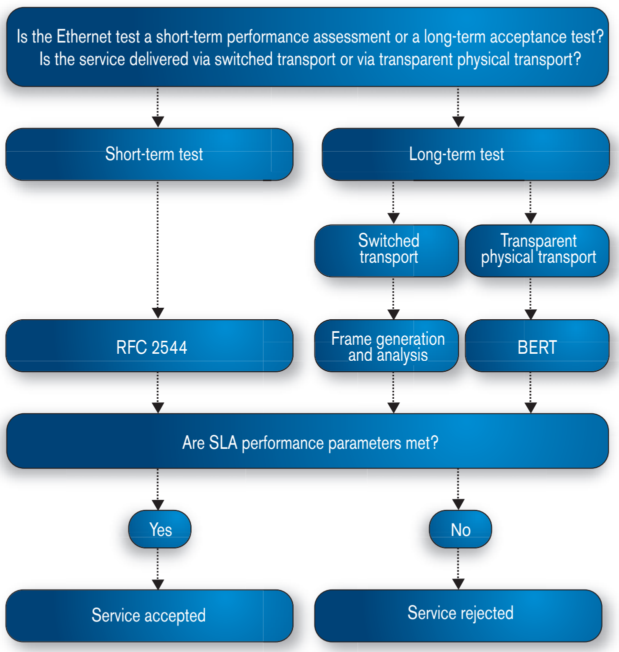

Figure 4. Test scenario depending on test duration and network topology

Frame Generation and Analysis Test Scenario

This test scenario provides the best of both BERT and RFC 2544 test methodologies. With its long-term test capability and ability to detect lost frames, service providers can test Ethernet virtual connections to see if they meet service-level agreements and keep the philosophy used in the SONET/SDH world.

This test scenario requires that the user configure a test stream (or multiple streams) and start the analysis portion to monitor for lost frames and errors. Once started, it can run for long periods of time and provide throughput information, frame loss and other error parameters as well as results to confirm that the Ethernet service being delivered is according to specification.

Conclusion: Which Test Scenario Should Be Used When?

Figure 4 provides a great summary of what test to use and when to use it. By asking two simple questions, the user will know which methodology to use to qualify an Ethernet virtual connection (EVC) service. A combination of test scenarios can also be considered to certify the performance of an EVC. By starting with an RFC 2544 test scenario, the user will make sure that the parameters defined in the SLA (throughput, burstability, frame loss and latency) are configured correctly. Once this scenario is completed, a long-term frame generation and analysis test scenario can be used to certify the service integrity over a long period of time.

In the transparent physical transport architecture (WDM or black fiber), the concept of RFC 2544 does not really apply, as the service is point-to-point without any protocol process. The long-term BERT test scenario applies very well to this type of architecture and provides the results to certify service integrity.

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