PTP Test Applications

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4G/LTE deployments and increased bandwidth requirements in Carrier Ethernet services are the driving force behind the new backhaul network technology. Synchronization is required for cellular and wireless network operations because base stations must be synchronized in order to hand off calls between base stations, minimize dropped calls and ensure proper billing. Since precision time protocol (PTP) provides both phase and frequency, it is quickly becoming the synchronization technology of choice for packet networks.

WHAT IS IEEE 1588V2/PTP?

PTP provides high clock accuracy in a packet network by continuously exchanging packets with appropriate timestamps. In this protocol, a highly precise clock source, referred to as the grandmaster clock, generates timestamp announcements. It also responds to timestamp requests from boundary clocks, thus ensuring that the boundary clocks and the slave clocks are precisely synchronized with the grandmaster clocks. By relying on the holdover capability, the precision of the integrated clocks and the continuous exchange of timestamps between PTP-enabled devices, the frequency and phase accuracy can be maintained within a sub-microsecond range, thus ensuring synchronization throughout the network.

The objective of PTP deployment is simple: by exchanging timestamps, the slave clock can determine its offset from the grandmaster clock and thus adjust itself. This provides frequency and phase synchronization through packet distribution.

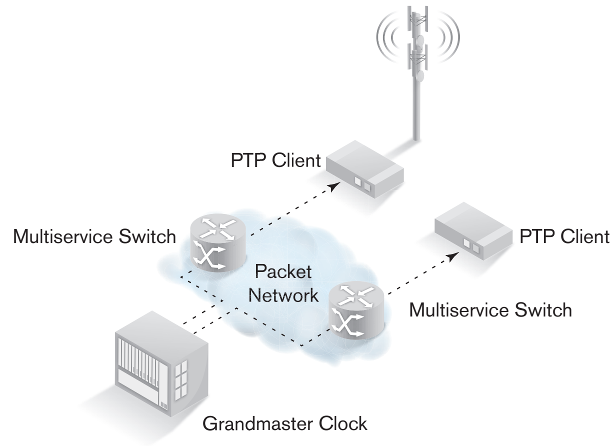

Figure 1. PTP network

PTP USE CASES

PTP is a packet-based technology. As the synchronization packets used by PTP are forwarded throughout the network between the grandmaster and hosts, they are subject to delay (latency), delay variation (packet jitter) and frame loss. Despite applying high priority to synchronization flows, synchronization packets will still experience congestion as well as routing and forwarding issues (e.g., out-of-sequence packets and route flaps). The host clock's holdover circuit must be stable enough to maintain synchronization in the event that synchronization packets experience these network events.

In addition to testing packet metrics to make sure they meet the service level agreement (SLA), in some cases, it may also be critical to validate the frequency measurements of the sync signal. A few use cases are detailed herein. Table 1 summarizes the different synchronization testing applications.

Service Turn-Up	When	Who	Tests	Duration	Product
Ethernet backhaul and PTP client turn-up	*Performed every time a tower is put to service*	*Field technician*	*- EtherSAM (Y.1564) - PDV, QL measurements - Client emulation*	*30 minutes to 1 hour*	 *NetBlazer Series*
Sync network installation	*Performed when a sync network is being deployed or when a new grandmaster is added*	*Network engineer*	*- Wander measurements - DV, PDV, offset - Slave/client emulation*	*24 to 48 hours*	 *SyncWatch-110*
Troubleshooting					
Basic troubleshooting	*Packet metrics issues/defective slave client*	*Field technician*	*- EtherSAM (Y.1564) - PDV, QL measurements - Client emulation*		 *NetBlazer Series*
Advanced troubleshooting	*Incorrect clock output/defective grandmaster*	*Network engineer*	*- TIE, MTIE - DV, PDV, offset - Slave/client emulation*		 *SyncWatch-110*

Table 1. Synchronization applications

SERVICE TURN-UP

Since PTP relies on a packet network, it is important to validate the packet metrics before any deployment. There should be two service turn-up phases: 1) packet-level SLA validation and 2) PTP metrics validation. These two tests should be performed every time a new tower is activated.

Packet-Level Testing

ITU-T Y.1564 simulates a multiservice scenario by simulating a PTP service and adding background streams that consume bandwidth. This method has the added benefit of providing metrics on background traffic, thus proving the PTP flow as well as the effect of the PTP flow during congestion phases.

Two EXFO NetBlazer series testers can be deployed at each end of the path where PTP traffic originates and terminates. This could be at the central location, where the grandmaster clock is located, and at a base station, where the PTP flows terminate. From here, key performance indicators (KPI) such as throughput, packet-delay variation and packet delay can be measured.

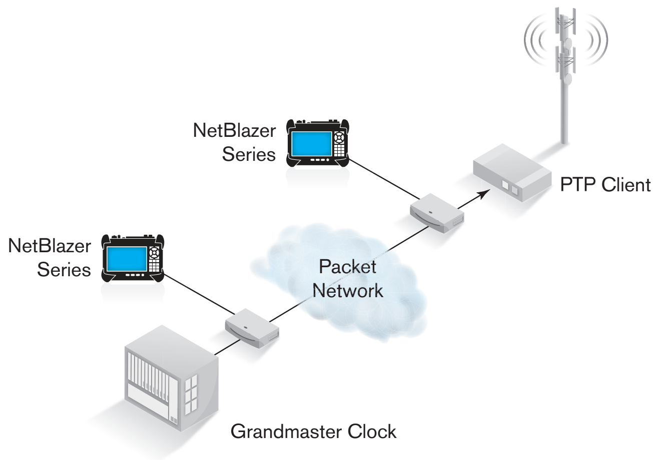

Figure 2. Service turn-up using the NetBlazer

PTP Testing

Once the SLAs are validated, the PTP service can be tested. The basic connectivity to the grandmaster is verified following the measurement of packet metrics to ensure proper communication between the grandmaster and slave clients. This test is used to validate key metrics such as packet-delay variation. The quality level of the grandmaster clock can also be measured to ensure that it is within the acceptable range.

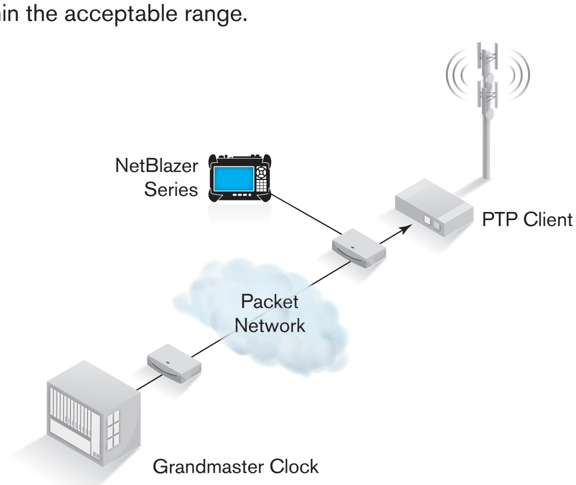

Figure 3. PTP testing using the NetBlazer

The two aforementioned service turn-up tests are the minimum requirements for any PTP client deployment.

EXFO's NetBlazer series is the best solution for these tasks. Its EtherSAM test (Y.1564) allows the user to validate the packet-level service turn-up by providing KPIs such as packet-delay variation, delay, frame loss and throughput in each direction. Its PTP test solution also validates the communication to the grandmaster and provides the delay variation and quality level of the received clock signal.

Clock Output Testing

The following test is used every time a new synchronization network is implemented or a new grandmaster is added. The objective of all PTP deployments is to transfer a clock through a packet network and to output to the client or edge device, the frequency and phase characteristics traceable to the grandmaster reference clock. For this reason, it is also important to measure the performance and stability of the output clock of the slave units. To do so, the output clock needs to be compared to a stable and very accurate reference clock. The maximum time interval error (MTIE), which is the maximum phase deviation between two clocks over a period of time, is used to predict the frequency stability of a clock. Subsequently, the PTP packet metrics such as packet-delay variation and delay must also be determined and validated. The typical approach to testing sync performance requires a stable reference and between 24 and 48 hours of continuous data measurement. This ensures that the long-term stability of the clock under various network loads can be estimated.

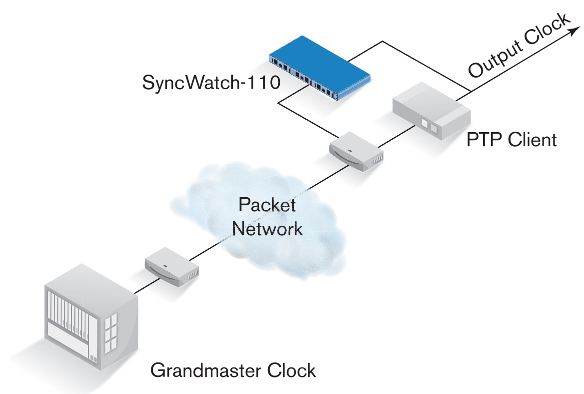

Figure 4. PTP performance testing with the SyncWatch-110

EXFO's SyncWatch-110 enables network engineers to measure clock performance via the time interval error (TIE) and maximum time interval error (MTIE) assessments. It is a powerful test solution that supports both PTP and legacy sync metrics and enables operators to carry out performance measurements against a host of stable references ensuring the highest accuracy possible.

TROUBLESHOOTING

Sync failure can be caused by many factors. In the case of PTP, the impact of packet performance and the reliance on the client algorithm makes troubleshooting more complex. A failure in the clock output can be due to:

- PDV or latency on the PTP flow
- Equipment failure (slave clock or grandmaster)
- PTP-to-signal-conversion algorithm

Basic Troubleshooting

A field technician can use the NetBlazer series to test packet-related issues and slave-clock failure. In this case, it should be connected either through the same Ethernet link as the slave under investigation or to the same Ethernet switch (see Figure 2).

The NetBlazer will then simulate a slave clock, connect to the grandmaster clock as well as perform delay and delay-variation measurements using the PTP protocol (see Figure 3). These metrics can then be compared to those obtained during the service turn-up to see if there are any discrepancies. If the metrics are outside the SLA parameters, then the issue is in the packet network.

If the delay variation is within the accepted performance range, the grandmaster clock or the slave clock can be considered at fault. In that case, the quality level of the clock, and other PTP metrics, could help determine the source of the problem and provide guidance.

Advanced Troubleshooting

Troubleshooting sync issues can also be complex, especially when the issue is equipment failure (grandmaster or slave clock) that was not detected by a simple troubleshooting technique, or a PTP algorithm issue. In these cases, a more sophisticated troubleshooting tool is required.

EXFO's SyncWatch-110 is also the perfect solution for advanced troubleshooting. To emulate a slave clock, the SyncWatch-110 can be connected directly to the edge slave clock, and the output clock can be measured and compared to a stable reference. As in the case of the slave, the SyncWatch-110 can be used to emulate a grandmaster and provide the timing to a client clock.

PTP slave performance is very dependent on the algorithm used to simulate the output clock. Typically, slave clocks will use some packets for clock adjustments in order to avoid high variations in the clock output. Since each algorithm is proprietary, performance can differ in identical network conditions. The SyncWatch-110 provides a simple way to troubleshoot the algorithm by internally simulating a clock signal based on the PTP packets exchanged with the grandmaster clock. This signal can then be compared to a stable reference for TIE and MTIE measurements.

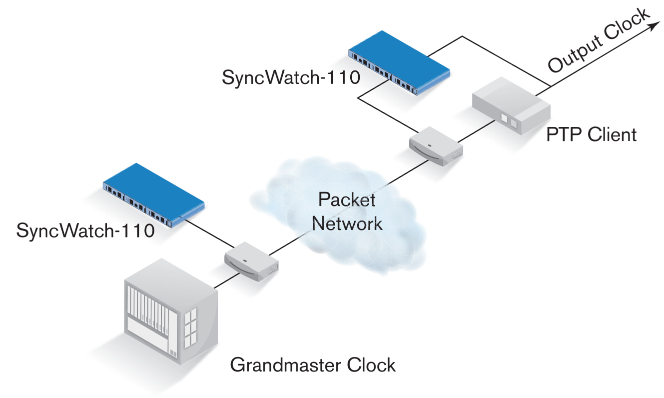

Figure 5. Advanced troubleshooting with the SyncWatch-110

CONCLUSION

EXFO has a complete solution for PTP network synchronization testing. The NetBlazer series provides all the metrics a field technician needs to deploy and troubleshoot Ethernet and PTP services. Furthermore, the SyncWatch-110 is the perfect solution for network engineers involved in PTP performance testing and advanced troubleshooting.

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APNOTE281.1AN

Printed in Canada 13/02

Assessing Next-Gen Networks