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IEEE-SA Conformity Assessment Program for IEEE 1588™ in Mobile Networks

AUTHORS:

John C. Eidson
Tim Frost
Geoffrey M. Garner
Sebastien Jobert
Bob Mandeville
Michael Mayer
Michel Ouellette
Charles A. Webb III



IEEE | 3 Park Avenue | New York, NY 10016-5997 | USA

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PDF: ISBN 978-0-7381-9402-8 STDVA20020

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IEEE-SA Conformity Assessment Program for IEEE 1588™ in Mobile Networks

Introduction

Over the past few years, the IEEE 1588™ Precision Time Protocol (PTP) standard has been adopted by the telecommunications industry as a preferred solution for synchronizing mobile networks. A key challenge is ensuring that PTP equipment from different manufacturers will operate properly in a mobile network. This paper presents the scope and objectives of the IEEE 1588 Telecommunications Certification Program, launched by the IEEE-SA Conformity Assessment Program (ICAP) to meet this challenge.

ICAP, an IEEE initiative to help assure standards compliance

In the course of its 125-year history, the IEEE has produced many standards for a broad range of industries. Inspired by the need to drive standards compliance forward and to provide a basis for interoperability in an open marketplace, the IEEE decided to launch the IEEE-SA Conformity Assessment Program (ICAP). A key goal of the program is to verify that products are delivered to the marketplace in full compliance with IEEE standards by testing them against widely recognized test suites that are developed and reviewed by industry experts.

The ICAP initiative is expected to accelerate the adoption of new technologies like PTP because it can significantly reduce the overall time and cost of testing. This is a benefit for both network equipment manufacturers and mobile network operators. It will also simplify Requests for Proposal (RFPs) and augment existing acceptance and functional testing to help ensure a high level of interoperability once equipment is deployed.

Conformance testing consists of verifying that a product strictly complies with all applicable requirements defined in a standard. It greatly reduces interoperability problems and ensures that products are of high quality. A conformity test suite defines an industry-recognized set of tests that is run once for each product being tested. This is much simpler than having to exhaustively test each product against every other product with proprietary test plans and procedures for each deployment.

Conformance testing is very different from basic interoperability testing. Interoperability testing only verifies that the specific products can work together in a specific configuration and under specific test conditions. For example, industry “plugfests” give equipment manufacturers a way to perform informal interoperability testing on early-stage products. By contrast, conformance testing thoroughly and rigorously ensures that a product correctly implements the specifications of the standard. Figure 1 shows the difference between conformance and interoperability testing.

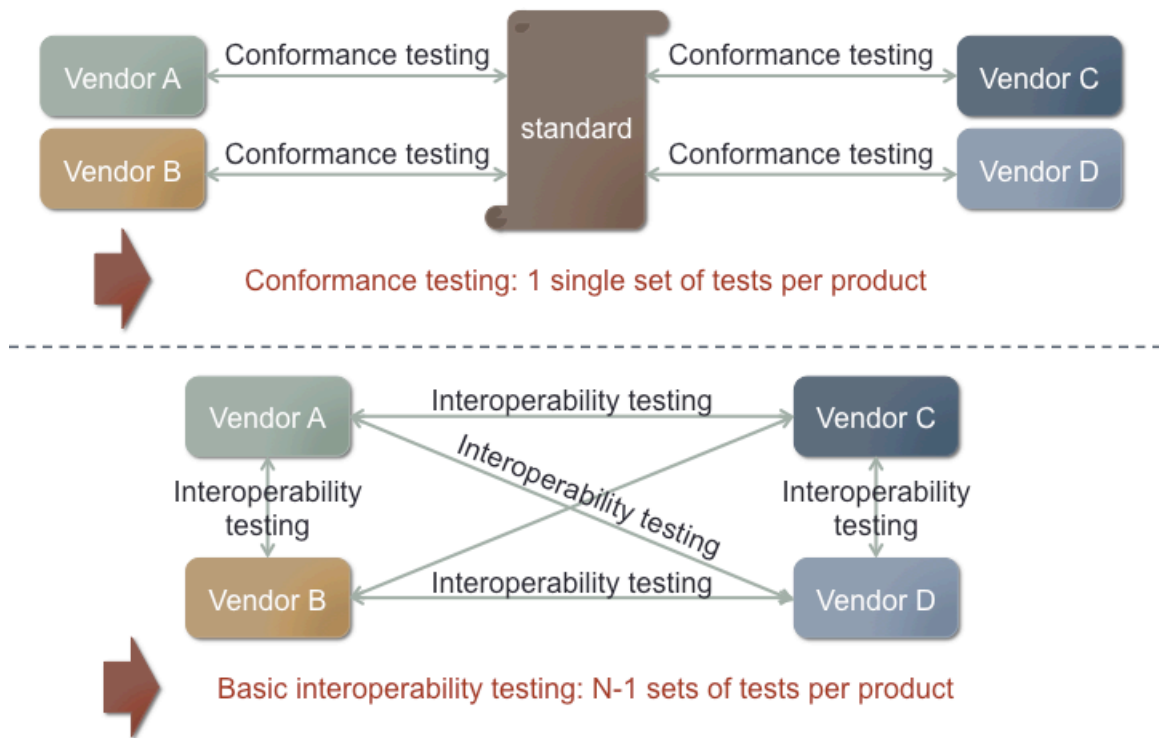


Figure 1: Difference between conformance and interoperability testing

Use of IEEE Std 1588 in Mobile Telecommunications Networks

IEEE Std 1588 [1] is a standard designed to deliver high-accuracy, sub-microsecond synchronization. It has been defined to avoid the proliferation of proprietary solutions and is widely used to support many industries and applications.¹

IEEE Std 1588 [1] can indeed address the needs of several industries and therefore defines various options. As an example, the protocol can be configured to operate using multicast or unicast transmission. The 2008 edition of IEEE Std 1588 [1] introduced the notion of “PTP Profiles”. A PTP Profile allows an industry to select a suitable subset of PTP options to be used in its particular environment.

For example, IEEE Std 1588 [1] has been adopted by telecommunications industry standards to address the needs of mobile networks. Current and future wireless technologies, such as 4G/LTE and 5G/LTE-Advanced, have stringent requirements for synchronization. Accurate synchronization of the air interface and its radio signals is critical to avoid signal interference and help ensure efficient radio spectrum usage. Poor synchronization results in poor user experience caused by dropped calls and erratic throughput.

¹ The numbers in brackets correspond to those of the citation list at the end of this document.

To address these industry-specific requirements, the ITU-T has specified PTP Profiles to define the PTP options to be used in the scope of a mobile backhaul network. The ITU-T standards defining these PTP Profiles are based on IEEE Std 1588 [1] and refer to the requirements it defines.

In mobile telecommunications networks, IEEE Std 1588 [1] can be deployed according to three main models:

- *No PTP support from the network:* Some packet networks do not provide support for PTP or physical layer frequency transfer. Hence a first PTP Telecom Profile has been defined by the ITU-T in Recommendation G.8265.1 [2], for the distribution of frequency synchronization over PTP-unaware packet networks. This PTP Profile is based on IP unicast transmission.
- *Full timing support from the network:* When it comes to distributing very accurate phase and time synchronization, having support for PTP in every node of the network can provide a very robust solution with high-quality synchronization. Hence, a second PTP Telecom Profile has been defined by the ITU-T in Recommendation G.8275.1 [3], for the distribution of very accurate phase and time synchronization. This PTP Profile is based on Ethernet multicast link-local transmission.
- *Partial timing support from the network:* Transferring phase and time synchronization over networks that do not support PTP clocks in every node is also required in some cases. Hence, a third PTP telecom profile is currently under definition by the ITU-T. It is expected that this PTP Profile will have many similarities with Recommendation ITU-T G.8265.1 [2].

IEEE 1588 Telecommunications Certification Program

Because of the high potential and wide acceptance of IEEE Std 1588 [1] in the telecommunications industry, ICAP has selected the PTP Telecom Profile for frequency synchronization defined in Recommendation ITU-T G.8265.1 [2] to initiate the first officially launched IEEE conformity assessment program.

IEEE Std 1588 is a detailed and well-specified protocol. The standard is a 269-page document that contains more than one thousand requirements. The standard defines state machines, datasets, and standardized behaviors for communication between PTP clocks. Conformance to the rules defined in the protocol is extremely important as it minimizes the risks of increased time-to-market and of interoperability problems when equipment from different vendors is deployed in the field.

The IEEE 1588 Telecommunications Certification Program is a unique environment where the combination of requirements defined in IEEE Std 1588 [1] and Recommendation ITU-T G.8265.1 [2] are rigorously verified, as illustrated in Figure 2. It completes the standardization process with a single and universally recognized conformity test suite.

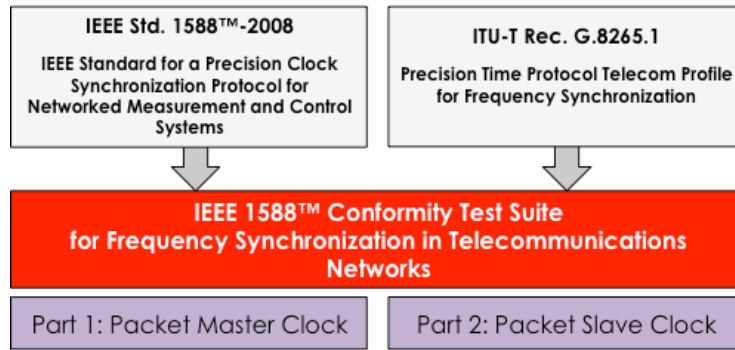


Figure 2: IEEE 1588 conformity test suite for frequency synchronization in telecommunications networks

The test suite defines test procedures for verifying the communication protocol between Packet Master Clocks and Packet Slave Clocks. It has been peer-reviewed by a committee formed by ICAP and composed of experts in the field of synchronization in mobile telecommunications networks. The test suite has the following two parts:

- *IEEE 1588 Conformity Test Suite for Packet Master Clocks:* This has 346 Test Cases to verify the options and parameters applicable to a Packet Master Clock, such as unicast negotiation mechanisms, protocol mapping, message formats and transmission rates, and clock quality level mapping and traceability.
- *IEEE 1588 Conformity Test Suite for Packet Slave Clocks:* This has 375 Test Cases to verify the options and parameters applicable to a Packet Slave Clock, such as unicast negotiation mechanisms, protocol mapping, message formats and transmission rates, Alternate Best Master Clock Algorithm, and slave protection functions.

Conformance testing is conducted by an ICAP authorized testing laboratory according to the testing procedures defined in the test suite.

The IEEE 1588 Telecommunications Certification Program intends to help mobile network operators select products that will work properly in their networks. The simplest and safest path to deploying IEEE 1588 in mobile telecommunication networks is to procure ICAP certified products.

IEEE 1588 Telecommunications Certification Program for Mobile Network Deployments

The main area in which the IEEE 1588 Telecommunications Certification Program will have direct application is in supporting mobile telecommunications network deployments. In this application, multi-vendor and multi-carrier environments are very common, so deploying products compliant with IEEE Std 1588 [1] is key in avoiding interworking problems in the field.

Figure 3 illustrates two deployment cases in which conformity to IEEE Std 1588 [1] and to the PTP Telecom Profile defined in Recommendation ITU-T G.8265.1 [2] is essential to improve interoperability.

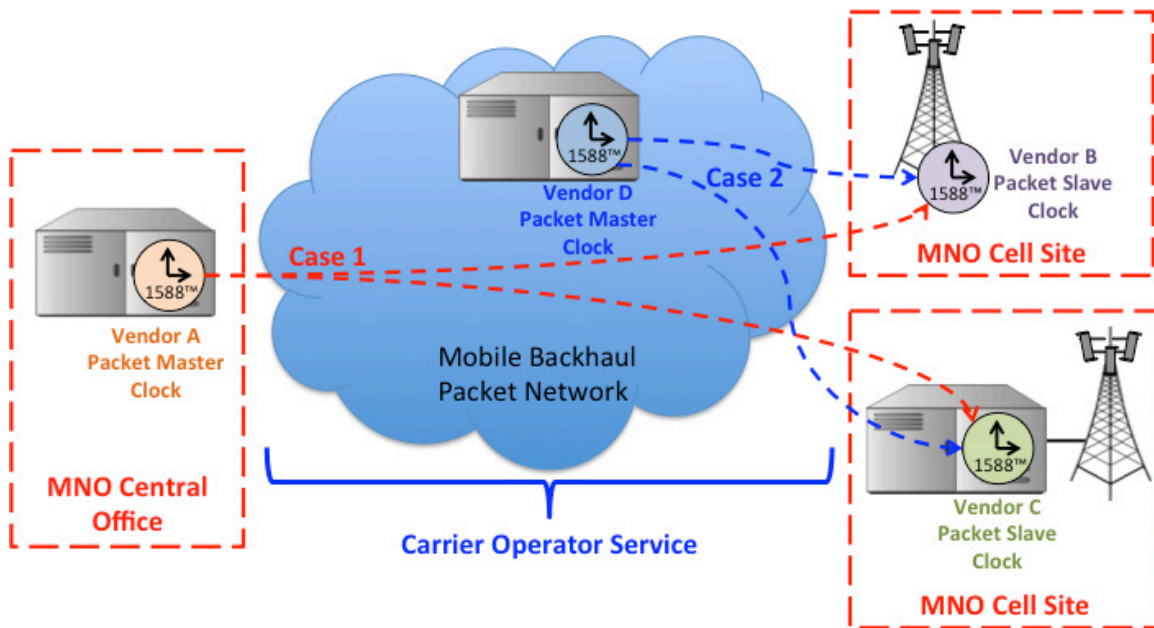


Figure 3: Deployment cases in which conformity to IEEE Std 1588 is essential for interoperability

- *Case 1, multi-vendor PTP products:* The Mobile Network Operator (MNO) deploys a PTP Packet Master Clock from Vendor A and PTP Packet Slave Clocks from Vendors B and C. The IEEE 1588 Telecommunications Certification Program verifies that all PTP clocks can communicate according to the standard using the same PTP options.
- *Case 2, multi-carrier PTP communication:* The Mobile Network Operator (MNO) uses an IEEE 1588 specified service provided by a Carrier Operator as part of an Ethernet Managed Service. The IEEE 1588 Telecommunications Certification Program verifies that the PTP Packet Master Clock used by the Carrier Operator can communicate with the PTP Packet Slave Clocks deployed by the Mobile Network Operator using the same PTP options.

In both cases, the Packet Slave Clock can either be embedded in a base station or in other mobile network equipment such as a Cell Site Gateway (CSG).

Next steps for the IEEE 1588 Telecommunications Certification Program

The current IEEE 1588 Telecommunications Certification program focuses on the PTP Telecom Profile for frequency synchronization. Beyond frequency synchronization, phase and time synchronization is also critically important for the next generation of mobile telecommunications networks. Therefore, the PTP Telecom Profiles for phase and time synchronization will also be considered by ICAP for future conformity assessment programs. Experience with the current conformity test suite can be leveraged to more easily develop future test suites.

The development and approval of the first IEEE 1588 Conformity Test Suite is an important step for ICAP and for the telecommunications industry. It fulfills the need to ensure that PTP equipment will operate properly in a mobile network and it is a firm foundation upon which to build robust mobile telecommunications networks.

Citations

- [1] IEEE Std 1588™, IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems.^{2, 3}
- [2] Recommendation ITU-T G.8265.1, Precision time protocol telecom profile for frequency synchronization.⁴
- [3] Recommendation ITU-T G.8275.1, Precision time protocol telecom profile for phase/time synchronization with full timing support from the network.

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⁴ITU-T publications are available from the International Telecommunications Union, Place des Nations, CH-1211, Geneva 20, Switzerland/Suisse (<http://www.itu.int/>).

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3 Park Avenue, New York, NY 10016-5997 USA

<http://standards.ieee.org>

Tel. +1 732-981-0060 Fax +1 732-562-1571