Draft Blog Post for 802.1AS-2020

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Work is underway in the IEEE 802.1 Working Group (WG) to expand the use of Time-Sensitive Networking (TSN) standards to industrial automation and automotive applications. One major part of this work includes the development of standards for the transport of synchronized time over Ethernet (IEEE Std 802.3) and WiFi (IEEE Std 802.11) networks. IEEE Std 802.1AS is the TSN standard that specifies the transport of time synchronization messages. IEEE Std 802.1AS includes a profile of IEEE Std 1588 Precision Time Protocol (PTP). The IEEE 802.1 WG recently completed work on IEEE Std 802.1AS-2020, which includes features of the also recently completed IEEE Std 1588-2019. These standards are significant revisions of IEEE Std 802.1AS-2011 and IEEE Std 1588-2008, respectively.

Prior to publication of the original IEEE Std 802.1AS (2011), IEEE Std 1588 was used for transport of precise time in local area networks. Although IEEE Std 802.1AS is based on IEEE Std 1588, the requirements in IEEE Std 802.1AS focused on two aspects that are very important for local area network applications:

- Appropriate cost: Use of a free-running clock allows for use of low-cost oscillators that are common in networks for applications such as industrial automation and automotive in-vehicle.
- Consistent performance: The IEEE Std 802.1AS protocol uses mechanisms to validate that all devices in its network (i.e., domain) operate the protocol. For example, if an Ethernet switch is detected and found to not operate IEEE Std 802.1AS, that switch is excluded from transporting time. This provides consistent performance, which is essential to many local area network applications.

The original IEEE Std 802.1AS was targeted at plug-and-play audio/video applications which the new IEEE Std 802.1AS-2020 maintains backwards compatibility to.

Due to the relevance of IEEE Std 802.1AS to many local area network applications, work is in progress to standardize use of IEEE Std 802.1AS in the following markets:

- Industrial automation: IEEE Std 802.1AS is specified as a requirement for time synchronization in drafts of IEC/IEEE 60802, TSN Profile for Industrial Automation.
- Automotive in-vehicle: IEEE Std 802.1AS is specified as a requirement for time synchronization in drafts of IEEE P802.1DG, TSN Profile for Automotive In-vehicle Ethernet Communications.
- 5G: For integration of the 5G System into industrial automation applications, IEEE Std 802.1AS is specified as a requirement in drafts for 5G technology in the 3GPP organization.

These applications previously used various other standards; the specification of time transport in the original IEEE Std 802.1AS and the new features of IEEE Std 802.1AS-2020 allow these applications to use IEEE 802-based synchronization with convergence to a single standard. Other applications are under investigation.

IEEE Std 802.1AS-2011 adds two techniques and related protocols that are not part of IEEE Std 1588-2008. These techniques are:

- The measurement of frequency offset of a local clock at a node relative to the grandmaster clock (i.e., the clock that all timing in the network is traceable to) by persistently measuring the frequency offset of the local clock relative to the local clock of each link partner, and the accumulation of the neighbor frequency offsets in a time synchronization message;

- An architecture that separates the IEEE Std 802.1AS protocol into media-dependent and media-independent layers, with the ability for the media-dependent layer to make use of native timing mechanisms already specified for a respective medium.

The first technique allows for fast convergence when there is a change in grandmaster or topology, because nearest-neighbor frequency offsets are persistently measured and therefore known when the change in grandmaster or topology occurs. The second technique facilitates the use of timing mechanisms that are already developed for media over which it is desired to transport timing, i.e., this technique avoids having to develop a new timing mechanism when one already exists. This technique is used in IEEE Std 802.1AS-2011 for the specifications of timing transport over IEEE Std 802.11 links, IEEE Std 802.3 EPON, and coordinated shared networks (e.g., Multimedia over Coax (MoCA)). Both techniques have been added to IEEE Std 1588-2019 so that they will be easily available to any PTP profile where they would be useful.

IEEE Std 802.1AS-2011 also specifies a model in which local clocks are free-running, rather than employing phase-locked loops or other filters. This avoids the need to tightly specify the filter parameters to control time error accumulation, which is helpful in a plug-and-play environment (e.g., consumer environment) where extensive network design capability is not present.

IEEE Std 802.1AS-2020 builds upon IEEE Std 802.1AS-2011 by adding:

- transport over IEEE 802.11 links that use the fine timing measurement (FTM) protocol, which allows for better time accuracy than the timing measurement (TM) protocol of IEEE Std 802.11 used in IEEE Std 802.1AS-2011;
- multiple domains, which are needed:
    - for professional audio/video and the newer industrial and automotive applications to help facilitate fault tolerance and redundancy;
    - to allow both working clock and global time for industrial applications
- improved facility to detect the presence of devices not compliant to IEEE Std 802.1AS-2020 and/or IEEE Std 802.1AS-2011, and not use these devices for timing transport; and
- Inclusion in the PTP profile of the new Common Mean Link Delay Service of IEEE Std 1588-2019, which allows a single PTP link delay measurement to be made for use by all PTP domains.

All of the above features were developed while satisfying the requirements for IEEE Std 1588 profiles.

During the development of IEEE Std 802.1AS-2011, there was significant collaboration with the IEEE P1588 committee to ensure that IEEE Std 802.1AS-2011, as a profile of IEEE Std 1588-2008, would be consistent with IEEE Std 1588 in order to meet the requirements of a profile. The collaboration continued with the development of IEEE Std 802.1AS-2020 and IEEE Std 1588-2019, to:

- ensure that IEEE Std 802.1AS-2020 would be consistent with IEEE Std 1588-2019;
- facilitate inclusion in IEEE Std 1588-2019 of the measurement of frequency offset relative to the grandmaster by accumulation of neighbor frequency offsets and the media-independent/media-dependent layer architecture;
- facilitate the development of the Common Mean Link Delay Service feature of IEEE Std 1588-2019 as, while it was initially IEEE Std 802.1AS-2020 that needed this feature, it was felt other PTP profiles might benefit from it.

The close collaboration between IEEE 1588 projects and IEEE 802.1AS projects helps to improve the IEEE standards portfolio as a whole. For example, when improvements in an IEEE 802.1AS project are

integrated back into the base IEEE 1588 standard, those improvements can be leveraged for applications beyond local area network (e.g. telecommunication technologies specified in ITU-T).

This work demonstrates IEEE 802.1's commitment to new applications and support of existing standards. New work on an amendment to IEEE Std 802.1AS-2020 has begun, to specify hot-standby as an option for improved fault tolerance and redundancy.