Recommendations for LXI systems containing devices supporting different versions of IEEE 1588

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Revision history

Revision	***Description***
1.0 xxx	Initial version was approved by the TC on xxx.

Recommendations for LXI systems containing devices supporting different versions of IEEE 1588

Prepared by the LXI Consortium Timing and Synchronization Committee
December 15, 2008

Background

With the passage of LXI Standard 1.3 [1], all future LXI Class A or B devices or LXI Class C devices implementing IEEE 1588 will conform to IEEE-2008 [2] and the LXI-1588 Profile [3]. LXI Class A or B devices conformant to earlier versions of the LXI Standard conform to IEEE-2002 [4]. There are numerous non-LXI devices on the market that implement IEEE 1588. Devices designed prior to the approval of IEEE 1588-2008 implement IEEE 1588-2002 (version 1, v1). Most non-LXI devices designed since this approval implement IEEE 1588-2008 (version 2, v2). In the very near future we can expect to see test and measurement systems containing LXI and non-LXI devices that implement different versions of IEEE 1588.

This white paper outlines recommended system design practices that will prevent degradation of IEEE 1588 performance due to unwanted interactions between devices implementing version 1 and version 2 of IEEE 1588.

The recommendations outlined are conservative in that they will ensure correct operation of IEEE 1588. There may well be less restrictive solutions applicable under some circumstances. There are two assumptions underlying these recommendations:

1. That boundary clocks designed to translate between version 1 and version 2 are not available. If these are available then they may be used to bridge between regions implementing version 1 and version 2
2. That the version 2 devices in the system do not implement auto configuration between version 1 and version 2. This is permitted but out of scope for IEEE 1588-2008.

If either of these assumptions is false then mixed systems can be constructed without the use of these recommendations.

The rules and recommendations presented in this white paper were tested at the LXI Consortium meeting in Toronto, Canada from May 20-23, 2008. The results are discussed in a paper presented at ISPCS 2008 [5].

Device selection

Only devices that meet the following requirements should be included in an LXI system implementing IEEE 1588:

1. All LXI devices should be conformant to:
    a. IEEE 1588-2008 and the LXI IEEE-1588 profile, or
    b. IEEE 1588-2002.
2. All non-LXI devices that implement IEEE 1588 should be conformant to:
    a. IEEE 1588-2008 and one of the following IEEE-1588 profiles:
        i. LXI IEEE 1588 profile, or
        ii. Default PTP profile for use with the delay request-response mechanism. Section J.3.1 of IEEE 1588-2008, or
        iii. Another profile compatible with and a superset of either of these. In this case the devices must be configured to meet the LXI IEEE 1588 profile, or

    b. IEEE 1588-2002.
3. Non-bridging and non-routing devices, e.g. computers, printers, instruments, etc. not implementing IEEE 1588 may be used subject to normal network design practice.
4. Bridging and routing devices not implementing IEEE 1588 may be used:
    a. Subject to the restrictions in the system layout section of this memo, and
    b. With the understanding that such devices may degrade the performance of IEEE 1588 below the required accuracy due to the network timing jitter introduced by these devices.

System layout

There are three sets of rules that should be followed to ensure that LXI systems containing both IEEE 1588 version1 and version 2 devices achieve the best possible synchronization performance.

The following rules should be followed in designing the network layout of a system containing IEEE 1588 devices:

1. Version 1 devices should be directly connected only to:
    a. Another version 1 device or a port on a version 1 boundary clock, or
    b. A non-IEEE 1588 end device or bridge.
2. Version 2 devices should be directly connected only to:
    a. Another version 2 device or a port on a version 2 boundary or transparent clock, or
    b. A non-IEEE 1588 end device or bridge.
3. There should not be any version 1 boundary clock in the path between any port on a version 2 device and the (version 2) grandmaster clock to which it and possibly other version 2 devices synchronize.
4. There should not be any version 2 boundary or transparent clock in the path between any port on a version 1 device and the (version 1) grandmaster clock to which it and possibly other version 1 devices synchronize.

This first set of rules ensures that PTP version 1 messages are not dropped or corrupted by version 2 devices between the version 1 grandmaster and its version 1 slaves, and similarly for PTP version 2 messages. However these rules do not preclude IEEE 1588 messages of one version actually reaching devices supporting the other version. This issue is dealt with by the second set of rules.

The following set of rules ensures that version 1 PTP messages are never processed by version 2 devices and vice versa:

1. In a mixed system all version 1 devices should be configured to use AlternatePTPdomain3 as defined in D.3.1 of IEEE 1588-2002. This results in the version 1 devices transmitting and receiving PTP messages on IP multicast address 224.0.1.132. All version 2 devices irrespective of domain use IP multicast address 224.0.1.129 as specified in D.3 IEEE 1588-2008. As a result of this configuration, version 1 devices do not process version 2 PTP messages and vice versa and this is enforced at a low level in the protocol stack. Note that both version 1 and version 2 conformant devices are required to ignore PTP messages from a domain other than the one in use by the receiving port.
2. An alternative, or parallel, technique is to place a bridge between the region containing version 1 and the region containing version 2 devices. This bridge should be configured to block all PTP traffic. Typical managed bridges are able to perform this function but inexpensive unmanaged bridges do not.

This second set of rules ensures that there are no unwanted interactions between version 1 and version 2 devices. However the timescale in the two regions are disjoint either because of the two domains or the physical separation. This last difficulty is dealt with by the third and final set of rules.

To synchronize the timescales in the version 1 and version 2 regions created by the first two sets of rules, the following rules should be followed:

1. A 2-port IEEE 1588 device configured to be the grandmaster clock should be included in the system. One of these ports should implement version 1 and the other version 2. Both ports should operate from a single internal IEEE 1588 clock with the result that the timescales provided by both ports are the same. This clock may be free-running or may in turn be synchronized to an external source of time such as GPS.
2. The version 1 port should be connected to a port in the version 1 portion of the system. The version 1 port should be configured with the 'preferred' attribute set to TRUE (7.4.2.8 and 6.2.4.4 IEEE 1588-2002).
3. All other version 1 ports in the system should be configured with the 'preferred' attribute set to FALSE.
4. The version 2 port on the aforementioned 2-port device should be connected to a port in the version 2 portion of the system. The version 2 port should be configured with the 'priority1' attribute set to 0 (7.6.2.2 IEEE 1588-2008).
5. All other version 2 ports in the system should be configured with the 'priority1' attribute set to 128 (or at least greater than 0).

This final set of rules ensures that version 1 and version 2 ports of the special 2-port clock become the grandmasters respectively in the version 1 and version 2 regions of the system. Since both ports share a common clock the entire system operates from the same timescale.

Example Systems Illustrating These Rules

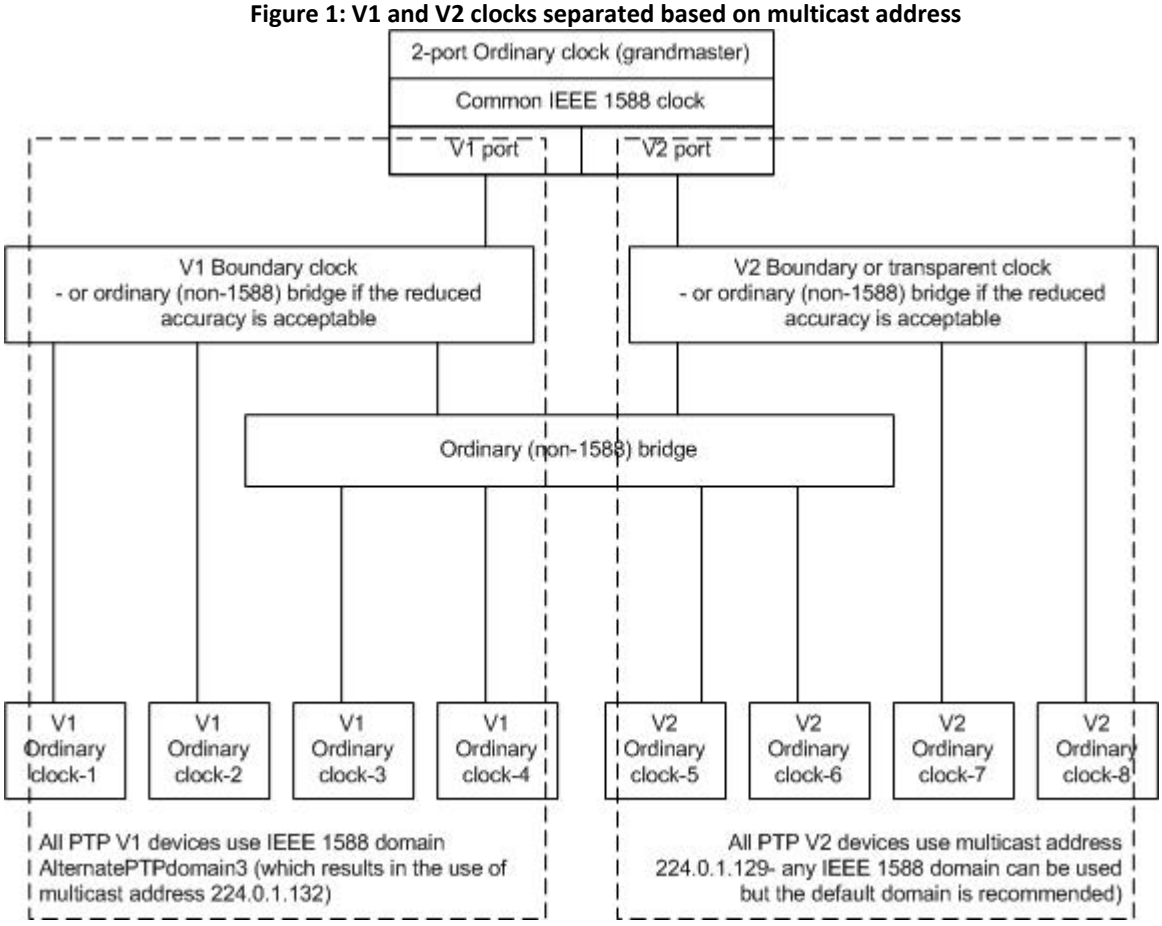
The following figures illustrate systems designed according to these rules.

In Figure 1 the first set of rules requires that the paths between a slave clock and its master traverse only 1588 devices of the same version. For example, version 1 ordinary clock-1 communicates to the version 1 port on the grandmaster via the version 1 boundary clock. Likewise version 1 ordinary clock-3 communicates to the version 1 version 1 port on the grandmaster via the ordinary bridge and the version 1 boundary clock. Note than none of the paths from version 1 ordinary clocks to their grandmaster traverse any version 2 device. A similar situation holds for version 2 devices.

The second set of rules requires that the version 1 and version 2 devices do not processes each others PTP messages. There is a path from all devices in the system to any other device. For example ordinary clock-1 can communicate to ordinary clock-8 via a path traversing in order the version 1 boundary clock, the ordinary bridge and the version 2 boundary clocks. In this case isolation between version 1 and version 2 devices is achieved by use of multicast address rule. In the system of Figure 1, all version 1 devices use multicast address 224.0.1.132 by virtue of being in PTP domain AlternatePTPdomain3. The version 2 devices all use multicast address 224.0.1.129 irrespective of the PTP domain. Thus messages from version 1 clocks are never processed by version 2 clocks and vice versa even though for non-PTP traffic there is full connectivity between devices by virtue of the ordinary bridge.

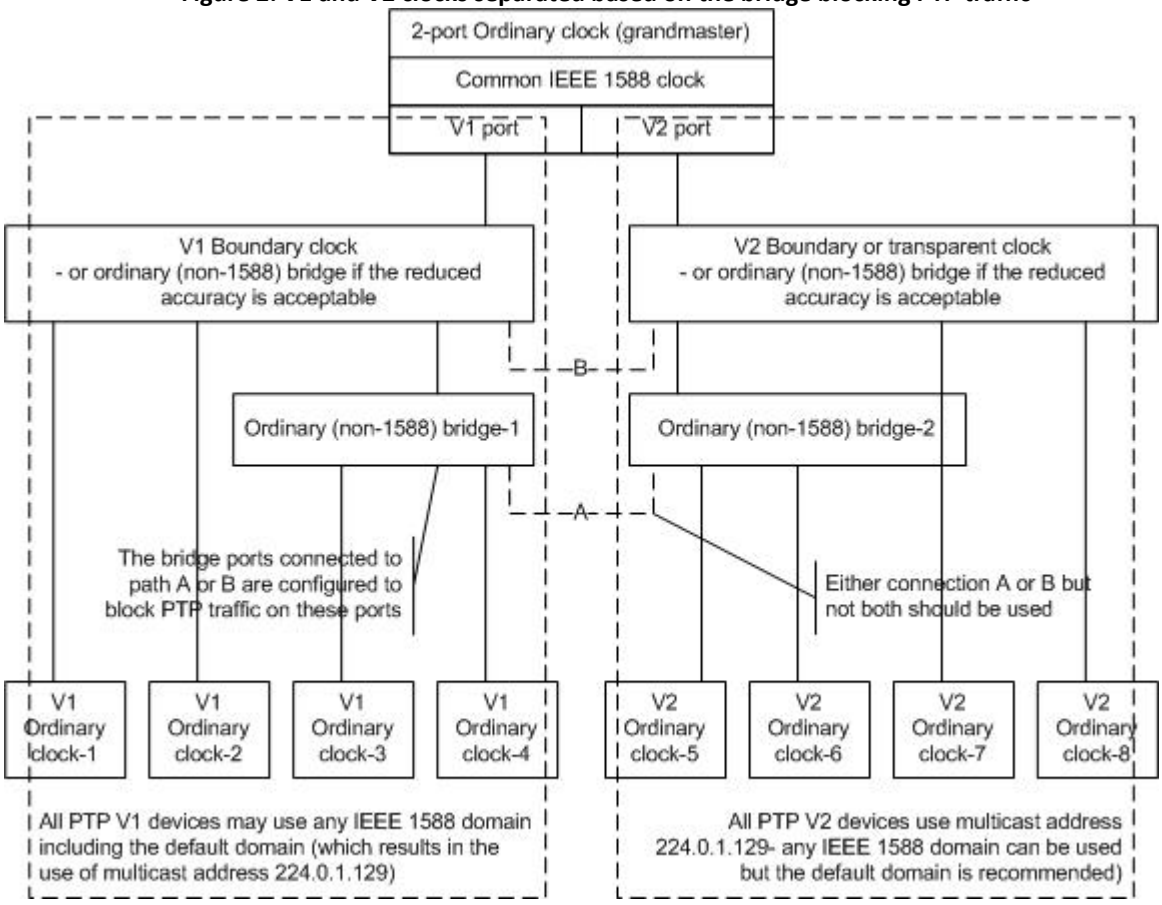
The third set of rules requires that the grandmaster in both domains be a 2-port clock with one port connected in each domain. Thus in Figure 1 the version 1 port of the grandmaster clock is connected to the version 1 boundary clock and similarly for the version 2 port. As required by the third set of rules the various attributes of all clocks are configured such that the 2-port clock is the grandmaster clock. This ensures that the version 1 and version 2 clocks both synchronize to the same time scale.

Figure 1: V1 and V2 clocks separated based on multicast address



The difference between the systems in Figure 1 and Figure 2 is that in the system illustrated in Figure 2 the port blocking alternative is used to prevent interaction between version 1 and version 2 clocks. In Figure 2 the version 1 clocks are free to use any domain including the default domain even though the default domain uses the same multicast address, 224.0.1.129 as the version 2 clocks. In Figure 2 the ports on the bridges linking the region containing version 1 clocks to the region containing version 2 clocks are configured to block all PTP traffic. This prevents interaction between version 1 and version 2 clocks. As before both version 1 and version 2 clocks synchronize to the same time scale by virtue of the 2-port grandmaster clock. Note that the connection between the two regions can be via either the ordinary bridges, shown as path A in Figure 2, or via the boundary clocks, shown as path B, provided that in each case the ports on these paths are configured to block PTP traffic. Normally only one of the two paths, A or B, will be used to prevent communication loops.

Figure 2: V1 and V2 clocks separated based on the bridge blocking PTP traffic



References

[1] LXI Standard Revision 1.3, October 20, 2008.
[2] IEEE 1588-2008, 24 July 2008.
[3] LXI IEEE-1588 Profile Revision 1.0, November 7, 2008
[4] IEEE 1588-2002, 8 November 2002
[5] *Synchronizing PTPv1 and PTPv2 Clients with One common Time Source*. Heiko Gerstung, September 22-26, 2008, Ann Arbor, Michigan. Proceedings of ISPCS 2008 on IEEE Xplore, http://ieeexplore.ieee.org/xpl/conferences.jsp