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What Is LXI?

Overview

LXI (LAN eXtensions for Instrumentation) is a new, emerging standard based on Ethernet, Web interfaces, and IEEE 1588. The LXI Consortium was founded in 2004, and the LXI 1.0 Specification was released in September 2005. The LXI Consortium goals are to increase the interoperability and functionality of Ethernet-based instruments by standardizing common operations and interfaces and to develop, support, and promote the LXI standard. NI actively participates in the LXI Consortium technical working groups and marketing committee. Our efforts are aimed at simplifying LXI configuration and programming with NI software and maintaining LXI compatibility in hybrid test systems.

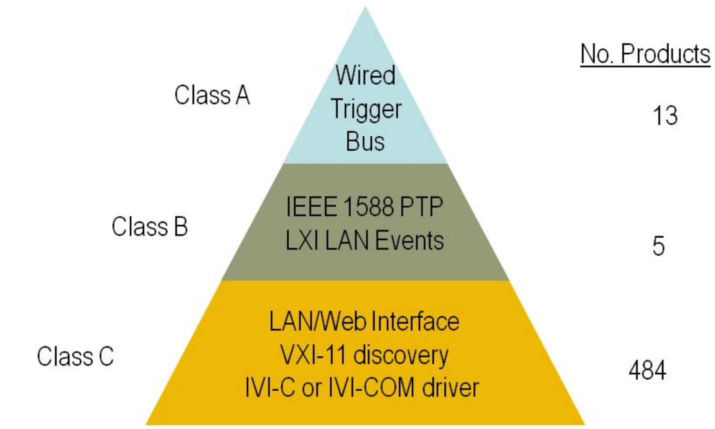

Figure 1

LXI Classes

The LXI standard defines three classes of devices. The base class is Class C. It requires an Ethernet port, a Web interface, VXI-11 for discovery, and an IVI-C or IVI-COM driver. Class B builds on Class C by adding IEEE 1588-2002 Precision Time Protocol and LXI LAN events through the IVI LXIsync API. Finally, Class A adds the requirement for the LXI wired trigger bus (WTB), a box-to-box cable with eight differential triggers.

As of April 2008, there were 502 LXI instruments certified by the LXI consortium.

Of these, 484 are Class C, 5 are Class B, and the other 13 are Class A (Figure 1). The majority of instruments are power supplies with a total of 292 or approximately 60 percent. The Class B instruments, produced by Agilent and Keithley, include a LXI Trigger box device and four switching multimeters, respectively. The Class A instruments are produced by Agilent and VXI Technology. Agilent offers LXI Class A signal generators, upconverters and downconverters, and arbitrary waveform generators, while VXI Technology Inc. offers a thermocouple instrument, a VXI-to-LXI bridge, and five microwave switch devices.

Types of LXI Devices

There are three types of LXI devices: devices, bridges, and adapters. LXI devices are single instruments that either don't have submodules (typical scope or signal generator) or have submodules connected via a proprietary interface (for example, digital multimeter with switch modules). These devices are fully LXI compliant and undergo the LXI compliance process. LXI bridges provide a bridge or gateway from LXI to non-LXI buses (for example, LXI-to-VXI bridge). The LXI bridge is fully LXI compliant, but the "downstream" non-LXI devices are not. LXI adapters, on the other hand, provide a fully compliant LXI interface for each of the downstream non-LXI devices.

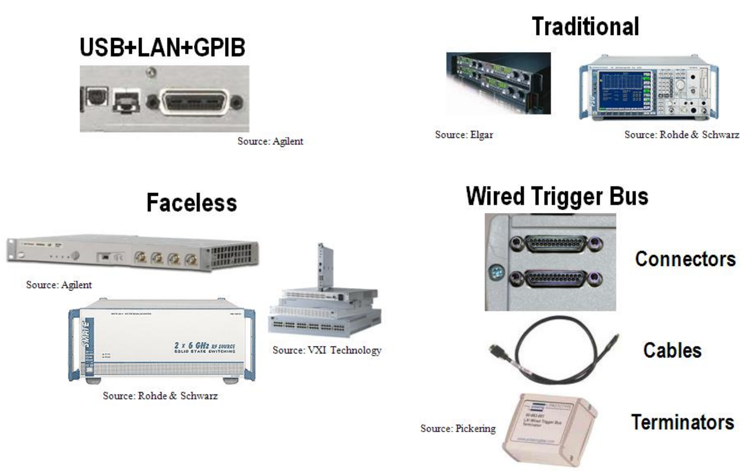

Figure 2

LXI devices, which come in many shapes and sizes (Figure 2), are required to use the standard RJ45 BASE-T Ethernet connector. Most LXI instruments are traditional box instruments that already had 10/100 Ethernet ports and then received updated firmware to become LXI conformant. Also, most LXI devices support GPIB and/or USB interfaces on the same device because there is no ideal bus for all user applications.

LXI devices can generally be divided into two categories: traditional and faceless. Traditional instruments have a fixed, vendor-defined front panel while faceless instruments remove the fixed front panel and use the LXI Web page as the primary interface. The Web interface is complemented with LEDs and an instrument driver. For a Class A device, LXI defines a wired trigger bus (WTB) to reduce the trigger skew compared to software and IEEE 1588. The WTB defines the connectors, cables, and terminators. Some examples from Pickering are shown. The WTB is required in Class A and is optional in Class C.

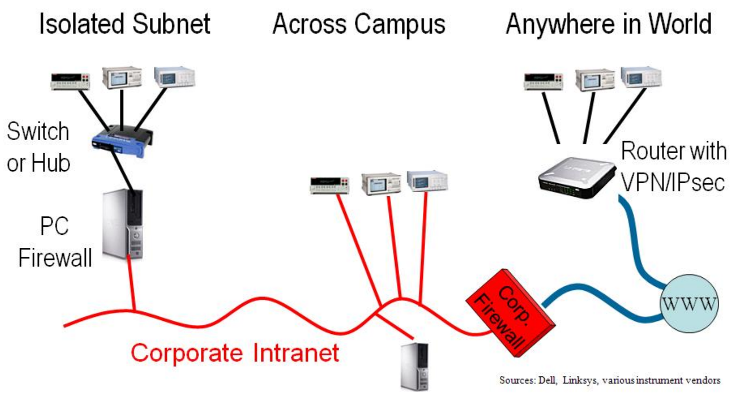

Figure 3

Typical LXI Use Cases

There are three typical LXI use cases that result in different LAN configurations (Figure 3). They are instruments on an isolated subnet, instruments connected across a campus, and instruments viewable anywhere in the world from either the public Internet or on a virtual private network (VPN).

The isolated subnet case uses a switch or hub to connect the instruments with the PC providing the firewall to the corporate network. Hubs, which are less expensive and simpler to install, provide less packet jitter but can potentially increase network collisions depending on the number of instruments and traffic load. Switches, on the other hand, cost more, are more difficult to configure, and decrease network collisions but increase packet delays and jitter.

The across-campus case involves directly connecting to a corporate intranet and usually requires involving the IT department. Besides opening up security concerns, campus networks also enable multiple clients to access the same instruments at the same time. This makes resource management an issue to ensure only one client at a time can change the state of an instrument. VXI-11 has a defined resource management. The LXI common resource management standard is currently under development. For most implementations, the instruments remain “hidden” inside a corporate firewall and are not available to remote users.

Remote access from anywhere in the world requires the use of a router with VPN and security features. The IT department usually installs and manages the routers. The benefits of access anywhere in the world are remote collaboration, debugging, and maintenance. The drawbacks include high packet jitter, router cost and maintenance, and resource management across many users.

LXI Synchronization Options

Bus synchronization options are another important bus evaluation criterion. Most ATE systems require some level of synchronization between the instruments and the DUT. The amount of synchronization is dependent on the DUT and the test requirements. The LXI Class B and Class A synchronization options for 1588 over Ethernet and LXI Wired Trigger Bus are discussed below.

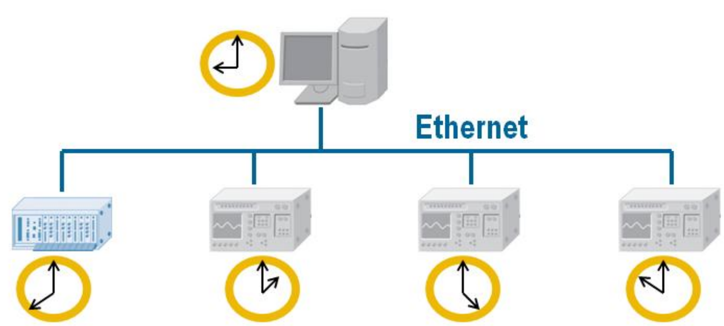

Figure 4

Class B LXI Synchronization – IEEE 1588

The IEEE 1588 precision time protocol (Figure 4) synchronizes time-of-day clocks on multiple devices to the same time (for example, all clocks are synchronized to 3:00:00.0001 p.m.). Having synchronized time-of-day clocks provides a common time base for the following:

Ø Event time stamping on multiple nodes for later correlation

Ø Phase-locked loops (PLLs) to local clocks and signals (for example, sampling clock)

Ø Execution of synchronized events using future time events

You can implement a software-only version of IEEE 1588 which usually provides tens of microseconds of clock skew. The more common option for test and measurement is the hardware-assisted implementation that provides sub-microsecond clock skew.

IEEE 1588 is usually deployed on a private subnet because normal routers and switches increase packet jitter which in turn degrades clock synchronization. The private subnet prevents the 1588 packets from loading other networks. Separating the 1588 from a larger LAN requires specialized 1588 hardware. Separating the subnet requires either a 1588 boundary clock or another Ethernet

NIC with 1588 support in the host PC.

LXI requires IEEE 1588 for Class A and B devices to ensure all such devices can support LAN events and 1588 events using the IviLxiSync API. A common trigger API makes it easier to use software, 1588, and wired trigger bus synchronization options.

For more information on 1588, see the white paper recommendations following the summary below.

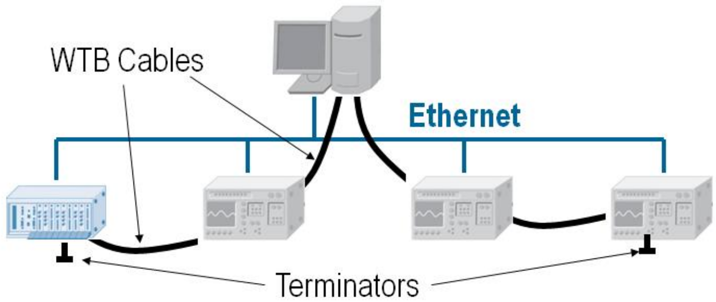

Figure 5

Class A LXI Synchronization – LXI Wired Trigger Bus (WTB)

The LXI wired trigger bus (WTB) is required for Class A devices and is optional for Class C devices (Figure 5). The WTB is defined in a separate specification to allow for changes in the WTB specification independent of the core LXI specification.

The WTB cables use eight low-voltage differential signal (LVDS) pairs with terminators at both ends to reduce reflections. The WTB supports both Driven and Wired-OR modes. In Driven mode, one device drives the pair while other devices monitor the state of the pair. With Wired-OR mode, multiple devices can drive the pair with the last device causing the state to change (for example, indicating a trigger condition).

The WTB provides a lower-latency and lower-jitter synchronization option than LXI Class B (IEEE 1588). The WTB supports a 5 ns pulse for 10 m or a 10 ns pulse for 20 m between devices. The challenges with the WTB are that cables and terminators are fairly expensive and daisy chaining cables negatively affects the trigger fidelity, latency, and skew (as do all daisy-chained cable trigger buses).

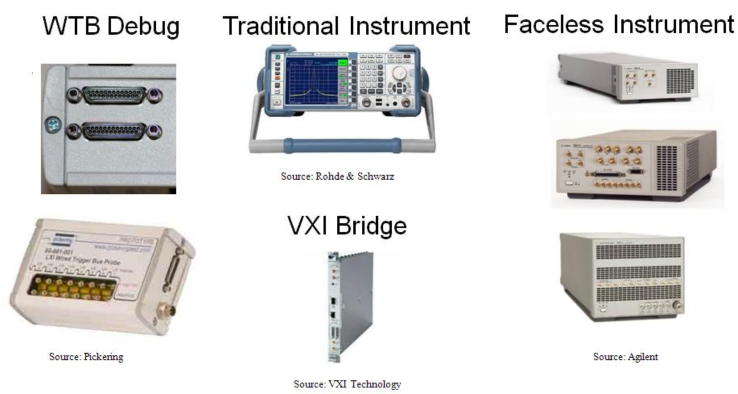

Figure 6

WTB increases debugging effort as the timing and fidelity of the trigger signals need to be tested during development. An LXI WTB breakout box (Figure 6) is recommended to measure the WTB on a scope for timing and signal fidelity analysis.

WTB is used with traditional box instruments (for example, the Rohde & Schwarz spectrum analyzer that is Class C with WTB), faceless instruments (for example, the Agilent N82xx family that is Class A), and LXI bridges (for example, the VXI Technology LXI-to-VXI bridge that is Class A).

Summary

Beyond the emergence of the LXI standard in the industry, it is important to remember that no single bus or technology is the *ideal* solution for *every* application. You should understand the specific instrument control needs of your application before choosing an instrument control bus. For your applications involving LXI, NI simplifies LXI and LAN complexities by offering a complete suite of instrument control software. Additionally, as the LXI Consortium continues to revise the standard with new options, NI software and hardware for LAN and LXI instrument control minimizes the changes to your test systems.

Recommended Links:

Understanding the IEEE 1588 Precision Time Protocol

Introduction to Distributed Clock Synchronization and IEEE 1588 PTP