

Autodiscovery Speeds Test-System Design

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The interconnection of instruments over LAN has created new capabilities and challenges in the areas of triggering, timing, and instrument discovery. For example, when connecting an instrument over LAN, a dynamic IP address may be assigned to that instrument, and a user needs to know the address to communicate with the device. This challenge is resolved by using the instrument discovery protocol described in the LXI standard.

The LXI Consortium was formed to create a new standard for instrument communication over LAN. The appeal of connecting instruments via LAN has increased over the last 15 years, and the need for a standard has become more critical. LAN-based instrumentation offers many advantages when compared to GPIB and proprietary interface hardware, including the wide acceptance of LAN and its low cost compared to other control interfaces.

The LXI standard builds on existing standards and protocols as well as specifies new capabilities. However, these protocols do not encompass all aspects of instrument communications over LAN. The goal of LXI is to incorporate today's best instrument standards, provide a roadmap for future development, and simplify instrument integration and test-system creation.

Autodiscovery

Instrument discovery as defined by the LXI standard implements the VXI-11.2 Instrument Discovery protocol. This mechanism allows the user to quickly discover instruments on a local subnet.

The LXI Instrument Discovery protocol mandates the use of an identification method defined by IEEE 488.2. Instrument discovery is invoked by the use of the familiar "*IDN?" query command, which ascertains the information about the device's manufacturer and model.

The LXI standard requires that each instrument on the network respond to a broadcast call stating that it is available. This allows the user to quickly determine which devices on the LAN are LXI compliant.

The standard also requires that each device provides identity information, such as instrument name and manufacturer.

These two mechanisms allow users to obtain information about all the devices listening without any prior knowledge of the devices or the network.

The VXI 11.2 standard implements Open Network Computer Remote Procedural Calls (ONC/RPC), a distributed computing protocol. The ONC/RPC protocol provides a means of communications without heavy reliance on a structured network.

A broadcast call is sent over the subnet to ONC/RPC servers listening on port 111 of the host machines as shown in **FIGURE 1**. The broadcast call asks on which port the VXI service may be running; then the ONC/RPC servers that have this service reply. After a port has been identified, communications with the instrument can begin.

After discovering where the instrument resides, the next step is to find out more information about the type of instrument identified at a specific location. This identification process is done by querying the instrument that will return the manufacturer, model, serial number, and firmware version. This identification method is based on IEEE 488.2, which is used in conjunction with the VXI-11.2 Instrument Discovery protocol. IEEE 488.2 specifies the set of instrument com-

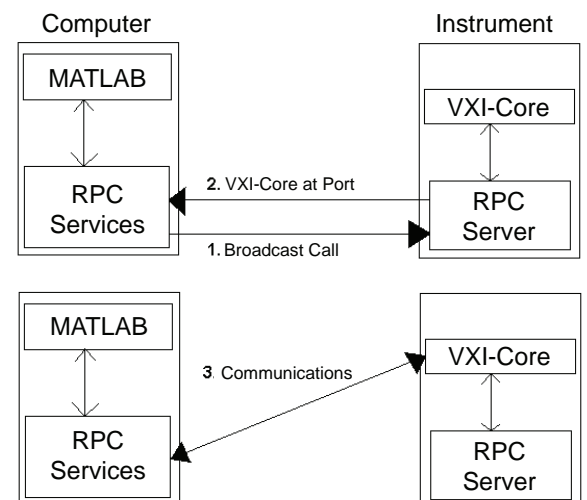


FIGURE 1. RPC DISCOVERY METHOD

mands that are to be used for controlling GPIB devices and is the origin of the "*IDN?" query.

One limitation of IEEE 488 for most instruments is associated with the use of the "*IDN?" query. For GPIB devices, this query is processed independently of what the instrument currently is doing, which is not a significant problem when all devices are interconnected via a simple daisy-chain bus such as one implemented with a GPIB cable.

But when instruments are connected across a wider network such as a LAN, this behavior can cause a fault in an instrument. This is one aspect of the LXI discovery protocol that is being addressed by future revisions of the standard (see sidebar).

Discovery Within the ADE

An application development environment (ADE) can provide users with the ability to discover and identify LXI-compliant instruments as well as a software environment and high-level computer language for data analysis and visualization, algorithm development, and numeric computation. In general, products supplied by software vendors will include a tool such as MATLAB's *InstrumentFinder* that will search for instruments on the network and provide a list of instruments located on a subnet, or it may run as a background process roaming other subnets. The *InstrumentFinder* uses the Open Source Java Remote Tea ONC/RPC library to send broadcast calls and the "*IDN?" command to query the instrument.

The *InstrumentFinder* discovery tool provides the functionality needed to discover LXI devices including timeout support. **FIGURE 2** shows the *InstrumentFinder* object being created and called to return a list of instruments after searching the local subnet. This list contains all the information associated with each instrument as specified by the LXI instrument discovery protocol. In addition, sufficient information is provided by the discovery tool to construct a driver using the resource string information.

The RPC protocol has a limitation: When searching for instruments outside the domain of a broadcast call, the discovery process requires additional work. Specifically, the discovery process must

```
% Invoke the MATLAB Instrument Finder
h = InstrumentFinder();
% Search for instruments on the subnet
% return with a list of instruments
InstrumentList = h.findLocalInstruments('LXI');
InstrumentList{:}

ans =

    Name: 'Agilent.dhcp.mathworks.com'
   Address: '144.212.219.89'
    Type: 'LXI'
Manufacturer: 'Agilent Technologies'
   Model: 'N9221A'
  Verison: 'US00000004'
  Firmware: '0.0.0.42'
```

FIGURE 2. AUTODISCOVERING INSTRUMENTS

sequentially search addresses and query them for information in the same manner as a broadcast call. Instrument discovery still will be successful, although this method will not be quite as fast as searching only a local subnet.

Using the Discovery Information

Once the address and information for an instrument are known, the next step is to control and configure the instrument to perform meaningful tasks such as acquiring data, transmitting data, performing data analysis, or some other function. Before the instrument can be set up for communications, an instrument driver capable of dealing with the particular instrument is needed.

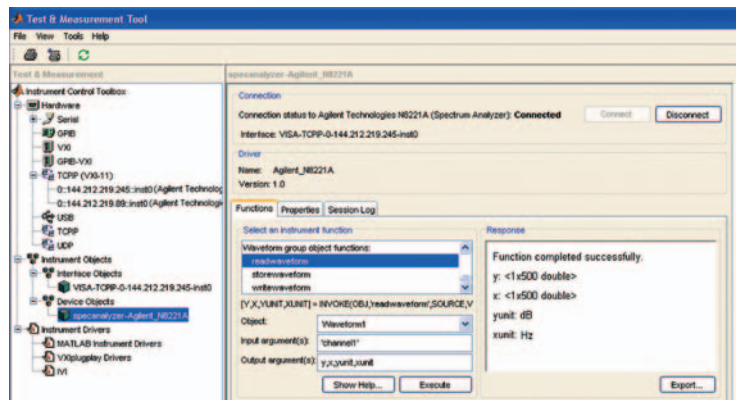


FIGURE 3. CONFIGURING AN LXI INSTRUMENT

The LXI standard requires that each instrument provide an interchangeable virtual instruments (IVI) instrument driver in either the IVI-COM or IVI-C format. The IVI Foundation defines how an application-programming interface (API) for an instrument driver is to be written and allows different instruments of the same type to be grouped together in classes by each manufacturer. The IVI Foundation also maintains the Virtual Instrumentation Software Architecture (VISA) standard that defines how the API is used with I/O libraries for instrument communications.

An ADE that can configure and control LXI-compliant instruments must support IVI instrument drivers. Most environments provide tools to help create and manage the interface between the instrument driver and an ADE.

For example, MATLAB supports IVI instrument drivers through its Instrument Control Toolbox. This toolbox provides a graphical tool to communicate with LXI instruments such as oscilloscopes without writing code.

Using the address provided by the *InstrumentFinder* tool, a VISA resource string can be constructed to communicate with LXI instruments directly over the network. The graphical tool also can use the VISA resource string to construct a device object by specifying the driver.

Once configured, communications with the LXI instrument now are possible, and parameters such as triggering and data acquisition can be programmed, as shown in **FIGURE 3**. The tool also

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automatically generates scripts that can be incorporated into a test program or a GUI-based application for automation of instrument communications.

Depending on how the IVI driver is implemented and what version

What's Next for Discovery in LXI?

The VXI-11 discovery protocol is a tool to help users locate and identify instruments over LAN. Given the popularity of VXI-11 in the LAN-based instrument world, it was a natural choice as the discovery mechanism for version 1.0 of the LXI standard. However, for future versions, the standard's LAN and Web working groups are evaluating a number of enhancements to support more advanced capabilities.

Currently under development is an XML identification schema that will provide more information via the discovery mechanism, such as:

- Instrument make and model
- LXI class
- Network configuration details
- Bridge configuration information about instruments such as GPIB, PXI, and VXI that are located on the other side of the bridge

There are opportunities to improve the out-of-the-box experience for users by moving to a more advanced discovery mechanism. In keeping with the LXI goal of leveraging existing standards, new discovery methods used by other industries are being considered:

- Bonjour, also known as Rendezvous, is an open-source, platform-independent standard from Apple widely used in printers. It provides decentralized assignment of TCP/IP addresses and notification when instruments are added to the network.

Today, LXI depends on the dynamic host configuration protocol (DHCP), which requires a device on the network to act as a central server, assigning addresses to instruments. Bonjour eliminates this central server in favor of a peer-to-peer solution. It also adds notification when instruments are connected to the network. This allows software to react when instruments are installed, much like when a user plugs in a USB mouse or printer.

- Universal Plug and Play (UPnP) is an emerging standard for peer-to-peer, self-organizing networks specifically targeted at industries with requirements similar to the instrumentation market. It provides definitions of services that are specific to a particular application or type of device such as cameras or HVAC systems.

UPnP is platform and protocol independent with a high degree of flexibility for future applications. It also offers discovery and address assignment mechanisms in a peer-to-peer way.

of VISA is installed on the system, the user may be required to run other utilities for the discovery to work. Some VISA implementations require execution of a separate user interface (UI) for the discovery process before a VISA session can begin. No VISA implementation currently available allows for programmatic discovery, which is why some suppliers of ADE products offer discovery tools that can programmatically perform instrument discovery.

Conclusion

Instruments interfaced over LAN can be of many different types and from many different manufacturers. They also may require distributed programming, making test-system development challenging.

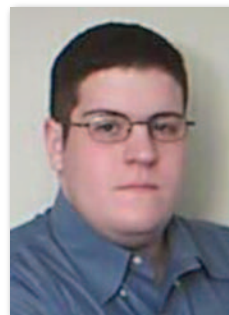
The LXI standard leverages existing standards such as those from the VXI standard and IVI Foundation to unify instrument communications over the network. Instrument autodiscovery and simplified instrument control and configuration are key components of the LXI standard. Efficient test systems can be created with LXI-compliant instruments and an ADE supporting LXI.

ABOUT THE AUTHORS

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Scott Frasso is pursuing a B.S. in computer engineering at Northeastern University. While interning for the Test and Measurement group at The MathWorks, he developed the LXI InstrumentFinder, software to assist users in MATLAB to configure LXI instruments on the network. Mr. Frasso is an active student member of IEEE at Northeastern. e-mail: ScottFrasso@gmail.com



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