Understanding Configuration and Performance of LXI Devices

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LXI IT Working Group Co-Chairs

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Overview

• Introduction
• LXI Tools and Documents
• Boosting performance with LXI Devices
• Wrap-up
Introduction
LXI - LAN eXentions for Instrumentation

- LXI brings consistency to LAN equipped instruments
- LXI devices have predictable behavior on LAN
- LXI devices provide an IVI driver
- LXI devices are built upon the LAN infrastructure
- LXI can replace GPIB with VXI-11/HiSLIP, GPIB Emulation
- LXI devices provide Web Servers

- Better system performance with overlap operation
Challenges to Users

- Users do not have a good understanding of LAN
- Users do not understand LAN behavior of LXI Devices
- Users need to determine the optimal LAN configuration for their LXI-based test system requirements
- Network administrators closely safeguard the security and performance of the company LAN
  - Users should work closer with IT department
  - Network administrators not familiar with LXI devices
- Users do not understand how to use overlap operations
LXI IT Working Group to the Rescue

- **LXI Discovery Tool**
- LXI Getting Started Guide
- Building LXI-based Test Systems
- Introducing LXI to your Network Administrator
- Maximizing Performance of LXI-based Test Systems

[http://lxistandard.org/Resources/GuidesForUsingLXI.aspx](http://lxistandard.org/Resources/GuidesForUsingLXI.aspx)
Guides for Using LXI...on the Web

Guides for Using LXI

These guides were written to aid the test system designer in building an LXI test system quickly and easily. They share best practices in key areas of interest connecting LXI Devices to LAN.

- **LXI Getting Started Guide**  
  (Released Aug. 3, 2013)
- **Building LXI-Based Test Systems**  
  (Released Aug. 3, 2013)
- **Introducing LXI to Your Network Administrator**  
  (Released Aug. 3, 2013)
- **Maximizing Performance of LXI-Based Test System**  
  (Released May 10, 2014)

Additional reference aids for the documents above:

- **LXI Networking Basics**  
  (Released Aug. 3, 2013)
- **Glossary of Networking Terms**  
  (Released Aug. 3, 2013)

http://lxistandard.org/Resources/GuidesForUsingLXI.aspx
LXI Discovery Tool

- Understands discovery methods for LXI devices
- Discovers LXI devices on computer subnet

<table>
<thead>
<tr>
<th>IP Address</th>
<th>Instrument Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>192.168.1.16</td>
<td>No description, open web page to view information</td>
</tr>
<tr>
<td>192.168.1.38</td>
<td>ABC Company 12345A Function Generator</td>
</tr>
<tr>
<td>192.168.1.57</td>
<td>XYZ Company 9997A Dual PowerSupply</td>
</tr>
<tr>
<td>192.168.1.105</td>
<td>ABC Company 53230A Universal Counter</td>
</tr>
<tr>
<td>192.168.1.83</td>
<td>XYZ Company 6789A Solar Array Simulator</td>
</tr>
</tbody>
</table>

**VXI-11 Protocol** - LXI Standard 1.0 and above
**XML Identification Document** - LXI Standard 1.2 and above
**mDNS (Multicast Domain Name System)** – LXI Standard 1.3 and above
LXI Getting Started Guide

• For the first-time LXI device user
• Explains LXI device behavior
• Explains basic networking principles
• Comprehensive troubleshooting
• Establishes test system foundation
Finding LXI Devices, Connecting, Viewing

Open System Configuration

Isolated System Configuration Using Router

IP Address → Web Page
Troubleshooting tips...
Building LXI-based Test Systems

- Next steps in learning
- LXI recommended configurations
- Benefits and cautions
- Insights into routers and dual NICs
- Troubleshooting
Test System Configurations – Open vs. Isolated vs. Remote

Methods for Remote Access of LXI Devices
Introducing LXI to your Network Administrator

- Insights into Test Engineer needs
- Recommended Configurations
- Just the facts about LXI Devices…

<table>
<thead>
<tr>
<th>LXI Device-specific Ports, Protocols, and Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protocol/Service</td>
</tr>
<tr>
<td>------------------</td>
</tr>
<tr>
<td>HISLIP</td>
</tr>
<tr>
<td>VXI-11</td>
</tr>
<tr>
<td>Scpi-raw</td>
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<tr>
<td>Scpi-telnet</td>
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<tr>
<td>LXI-eventsvc</td>
</tr>
<tr>
<td>Ptp-event</td>
</tr>
<tr>
<td>Ptp-general</td>
</tr>
</tbody>
</table>
Learn, Cooperate, and Build
Maximizing Performance of LXI-Based Test Systems

- Key Insights when using LXI
- Best Practices
- Measurement physics effects
- Understanding overlap operations
Performance of LXI
Key Assertions

• I/O latency has little impact in most test systems
• Overlap operation can greatly improve performance
• Test system best practices greatly affect performance
• LXI provides additional performance benefits
Test System Architecture
Smart and Simple Devices
Distributed Intelligence

Command or Results can be ASCII or binary

Overlapping Operations
Smart and Simple Devices
Computer Controlled

Very fast I/O
Key Performance Factors
Transaction Model

Send:
- Time to send command or driver call
- Time to Parse or Interpret what to do
- Time until hardware starts changing

Results:
- Time to initiate transfer from memory
- Time until all results in computer
Key Performance Factors
Serialized Operations

- Computer waits for operation complete result

Example 1: “ROUT:CLOSE (@1001);:ROUT:CLOSE? (@1001)”
Example 2: “VOLT:AC:RANGE 10”;*OPC?”
Example 3: IVI Driver call does not return until operation complete
Key Performance Factors
Measurement Physics

I/O Overhead

Send

Physical Factors

Meas/Output/ Switch/Settle

• Switch closing: 100usec to 25msec
• Settle time: 10 – 200msec
• Range change: 4 – 6msec
• Function change: 10 – 40msec
• Sweep time: 50msec to seconds
• DMM aperture: 16.667msec for 1PLC

I/O Overhead

Results

< 3msec
Enhancing Performance Case Study
Baseline Performance

Sequence

<table>
<thead>
<tr>
<th>20 msec</th>
<th>Send</th>
<th>DMM</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 msec</td>
<td>Send</td>
<td>Power Supply</td>
</tr>
<tr>
<td>25 msec</td>
<td>Send</td>
<td>Signal Gen</td>
</tr>
<tr>
<td>25 msec</td>
<td>Send</td>
<td>Switching</td>
</tr>
<tr>
<td>20 msec</td>
<td>Settle</td>
<td></td>
</tr>
<tr>
<td>20 msec</td>
<td>Send</td>
<td>Trig - Meas</td>
</tr>
<tr>
<td>3 msec</td>
<td>Results</td>
<td></td>
</tr>
</tbody>
</table>

Setup operations

- Function and Range
- Range and output Settle
- RF, Matrix and Multiplexor connections
- Wait to make sure all is settled
- Trigger and Measure at 1PLC

Serialized – talk, sync, talk, sync each operation

DMM | PowerSupply | Signal Gen | Switching | Settle | Trig - Meas | Results

Total time: 143 msec
Enhancing Performance Case Study
”Longest pole in the tent”
Enhancing Performance Case Study Using Distributed Intelligence

Overlapped – talk, talk, talk, then sync, sync, sync

Overlap Operations
Sent without waiting

Total time: 73 msec = (143 – DMM – Signal Gen – Switching)

Time Savings = 70 msec

LXI Serialized: 143 msec
LXI Overlapped: 73 msec
Enhancing Performance Case Study
What about Faster I/O?

- Faster I/O
  - LXI Serialized: 143 msec
  - Fast I/O Serialized: 125 msec
  - LXI Overlapped: 73 msec
LXI Example Performance
Transactional

*OPC?

Send | Results

High-end Spectrum Analyzer
Gigabit Interface

<table>
<thead>
<tr>
<th></th>
<th>usec</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPIB</td>
<td>500</td>
</tr>
<tr>
<td>USB</td>
<td>200</td>
</tr>
<tr>
<td>Socket</td>
<td>100</td>
</tr>
<tr>
<td>VXI-11</td>
<td>700</td>
</tr>
<tr>
<td>HiSLIP</td>
<td>200</td>
</tr>
</tbody>
</table>
LXI Example Performance
Transactional

*OPC?

Send
Results

![Power Supply 100Mbit Interface Chart](chart.png)
LXI Example Performance
Block Transfer

LAN vs GPIB Relative Throughput

Spectrum Analyzer - Gigabit
DMM - 100Mbit
Wrap up
Key Performance Learning's

- Measurements and Physics make up a large part of the overall time
- Overlapping setup operations are more effective than faster I/O

LXI Serialized: 143 msec
Fast I/O Serialized: 125 msec
LXI Overlapped: 73 msec

Time Savings = 70 msec
Wrap up
LXI Tools and Documents

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Links to **Sources of Information**

- **LXI Consortium Resources**

- **IVI Driver and SCPI-1999 Specifications**
  - [http://www.ivifoundation.org/specifications/default.aspx](http://www.ivifoundation.org/specifications/default.aspx)

- **LXI Synchronization and Triggering**

- **LXI – An Integrator’s View**
  - [http://ieeexplore.ieee.org/Xplore/home.jsp](http://ieeexplore.ieee.org/Xplore/home.jsp)
Backup Slides
Performance Review

- VXI-11 and HiSLIP provide GPIB emulation for easy migration
- GPIB vs. LXI Latency comparable: often < 1msec
- LAN Block transfers: often 2 to 10 times GPIB
LXI Example Performance
Continuous Block Transfer

Multiple instruments strategically located
Around the aircraft are wired to individual strain gauge devices
Best Practices

Key Performance Enhancements

• Device Synchronization – avoid Waiting
  – Polling of Status
  – Service Requests
  – Waiting for Operation Complete

• Incremental Device Setup – avoid Resets

• Device Triggering and Waiting for Trigger

• Use single I/O statement with compound statements
  – "VOLT:AC:RANGE 10;:TRIG:COUNT 10;:INIT"
Other Benefits of LXI
Built-in Web Server
Other Benefits of LXI

LXI LAN Events
Other Benefits of LXI
LXI Clock Synchronization