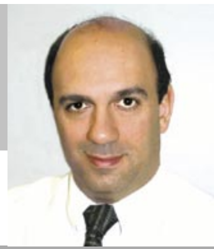
Life extension for automated test systems



By Ehud Shany

Test and measurement instruments and devices installed in legacy systems often face end of life, lack of replacement parts, and/or obsolescence. Ongoing maintenance and calibration cause countless project delays and costly waste of resources. Instrument substitution implies modifications and revalidation of the test and measurement software application mostly known as Test Program Sets (TPS). In most cases, changes to the software is impractical due to budget or scheduling impact (such as changes to hundreds of TPSs, recertification of the software, availability of source code, and/or secret clearance).

Whether it is a Commercial Off-The-Shelf (COTS) or a customized hardware replacement, there is a need for an economical life extension method to the automated test and measurement system without software changes.

Vast numbers of instruments and devices deployed in the manufacturing, prototyping, or research and development fields, with the purpose of testing products and processes, are frequently found to be obsolete.

These instruments are integrated with other pieces of equipment and share a common communication protocol forming as a whole what is usually known as a *test and measurement system or Automatic Test Equipment (ATE)*. These test and measurement systems frequently represent a substantial financial investment in terms of hardware and software and thousands of labor-intensive hours dedicated to validate the test system itself.

Common practice in the industrial and defense fields is to build test and measurement systems to outlive the product or products they were designed to test. Nonetheless, the hardware constituents of these systems become obsolete and replacement spare parts become unobtainable. Sometimes new hardware does not share the system's current communication protocol, or the manufacturers of said hardware stopped supporting and manufacturing it. Those who need to maintain these test systems are facing a great problems such as system downtime, recalibration of hardware after each repair, or lack of replacement parts.

The cost of replacing an obsolete piece of hardware often implies a software change (part or all of it) and communication protocols to accommodate different functionality. Additionally, changes to the software require system recertification.

For clarification purposes only, we may look at the IEEE 488 communication protocol[1]. For more than 30 years, engineers and scientists have widely used the IEEE 488 General-Purpose Interface Bus (GPIB) for automating instrumentation systems. The GPIB is a digital, 8-bit parallel communications interface with data transfer rates of up to 8 MBps. The bus provides one system controller for up to 14 instruments, and cabling is limited to less than 20 m. Because of its robustness and large user base, GPIB will be around for many years to come.

However, the instrument control industry started building new test and measurement devices with such buses as USB, Ethernet, and IEEE 1394 (also known as FireWire). The number of instrument manufacturers including built-in instrument control options for USB, Ethernet, or IEEE 1394 is growing on a daily basis. While instrument manufacturers have started using these newer buses, legacy test and measurement systems do not support them, and protocols such as GPIB remain prevalent.

IVI, PXI, and LXI

As legacy tester maintenance became a challenge, engineers made an effort to use the latest technologies possible while keeping the footprint of the tester as small as possible. In addition, the design engineer would have tried to use instruments that could be replaceable among several sources/vendors.

At the *software/drivers* level, Interchangeable Virtual Instrument (IVI) is the standard that is being incorporated in new testers. At the *hardware* level, PCI eXtensions for Instrumentation (PXI) instruments are the trend in the current market, while Synthetic Instruments (SI) are the future trend.

The IVI standard is trying to resolve the two main factors that affect the efficiency of test system setup and support: (a) The high cost of developing and maintaining test system software and (b) rapidly evolving technology[2].

The IVI Foundation addresses these needs through a new driver technology: The drivers define a new level of completeness and functionality that reduces the cost of test system development. Additionally, the drivers simplify upgrading or replacing components in test systems intended to be used over a long period of time.

Although this concept is working well for future systems, it is not solving the problems associated with legacy TPSs.

New PXI-based instruments are growing in number every day. The variety of vendors and the small footprint make them very popular in today's systems.

The availability of common modules such as Digital Multi-Meter (DMM) and RF modules from various vendors (and prices) make them attractive to tester designers[1].

SI became an important issue for test-equipment suppliers as soon as the United States Department of Defense (DoD) announced the award of the Agile Rapid Global Combat Support (ARGCS) contract in September 2004.

The goals of SI are to: (a) reduce the total cost of ownership of the ATS; (b) reduce time to develop new or upgraded ATSs; (c) reduce the test system's physical footprint; and (d) improve the test quality.

According to the Synthetic Instrument Working Group[3], an SI is a reconfigurable system that links a series of elemental hardware and software components with standardized interfaces to generate signals or make measurements using numeric processing techniques. In other words, it's a concatenation of hardware and software modules used to emulate a traditional piece of electronic instrumentation.

During 2004, a new standard was introduced – the LAN eXtensions for Instrumentation (LXI). LXI addresses the growing need for a standard interface to replace IEEE-488 GPIB and PCI variants[4].

LXI is based on industry-standard Ethernet and provides the flexibility and performance found on larger VXI-based systems to small and medium-sized PXI systems.

Technology description

The need for ATE life extension is fulfilled by the presented technology. The technology enables replacing common instruments such as DMM (spectrum analyzer, counter). It also supports common interfaces such as GPIB, USB, and TCP/IP and is not affected by the TPS programming language[5].

As the technology does not affect the source code, it does not require its availability either. This feature is very important for classified military projects that cannot provide the source code. Furthermore, the technology can be incorporated in the future Synthetic Instruments/LXI bus.

Figure 1 illustrates a traditional tester in which an old instrument is connected to a 2U CPU through GPIB bus.

Figure 2 illustrates a new instrument that replaces the old instrument through connectivity to the Real Time (R/T) emulator module on a GPIB bus.

In Figure 3, the *new* instrument is a PXI chassis with module(s) that communicate with the R/T emulator module via TCP/IP. The R/T emulator module communicates with the CPU via GPIB.

Commands and/or addresses sent by the CPU controller are analyzed and translated in real time to one or more command(s) of a new instrument connected to the bus (GPIB or other). The new instrument's reply is treated in the same way. The number of instruments supported by one R/T emulator module is limited by the communication protocol only (that is, native GPIB can support up to 14 instruments on the same bus). As the presented technical solution deals with the internal ATE communication level only, it is not required to have the TPS source code available, and the programming language of the TPS is not affecting this technical solution. The R/T emulator module, as part of its functionality, should resolve all GPIB (or other protocol) addressing and other special communication packages. It should support several modes, including "transparent mode," in which it passes the commands through without any action. This setup allows new instruments to be added to a legacy system while maintaining existing legacy code.

For flexibility and worldwide deployment, the R/T emulator module should support a variety of modes and features that enable it to capture commands, add a delay to the communication protocol, and communicate with an Internet client via a built-in Web server.

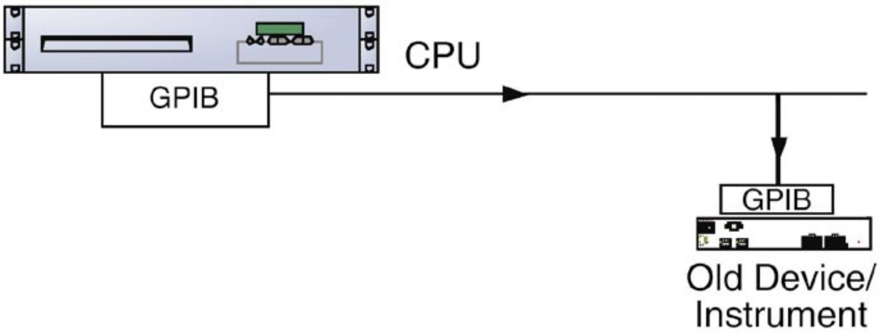


Figure 1

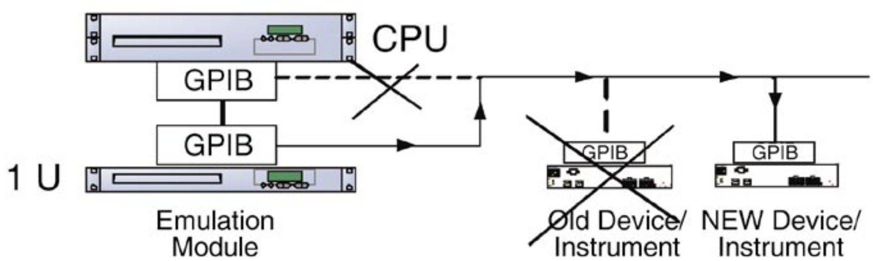


Figure 2

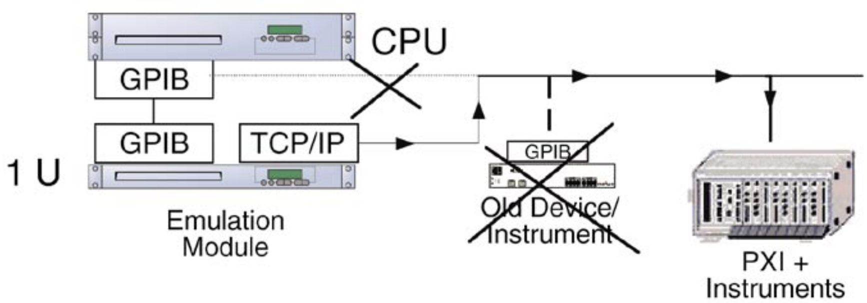


Figure 3

The previous example can also accommodate IVI, as shown in Figure 4. As previously mentioned, the old CPU/TPS are not aware of the existence of the new instruments or IVI classes/drivers, and they send/get commands to the "old" instruments via GPIB or other bus. The R/T emulator module translates between the new instrument via the IVI classes.

According to the LXI consortium[4], LXI modules will use IVI drivers. The application software will run on a PC and allow users to upgrade SI/LXI modules over time.

Figure 5 shows a typical mixture of GPIB/PXI/VXI/LAN-based and LXI/Synthetic Instruments in a future ATE. This new ATE utilizes a new CPU/controller.

In Figure 6, an old CPU runs *old* TPS with a similar configuration as illustrated in Figure 5.

The R/T emulator module is connected between the *old* CPU where the TPSs run and enables them to use a variety of instruments regardless of their type and manufacturer.

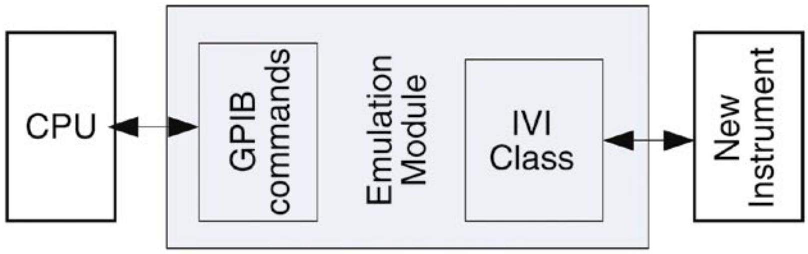


Figure 4

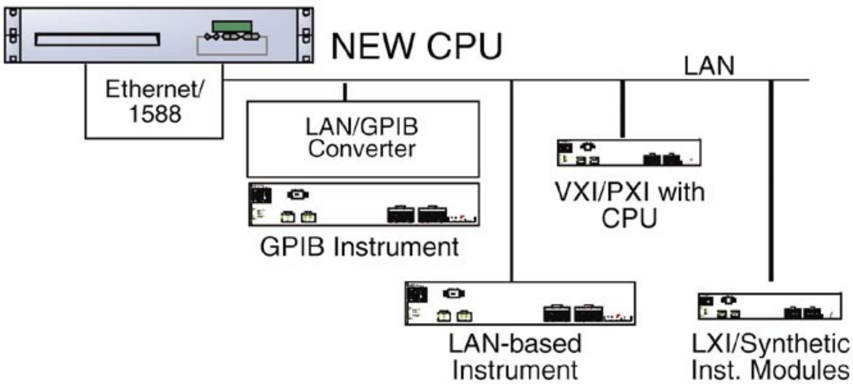


Figure 5

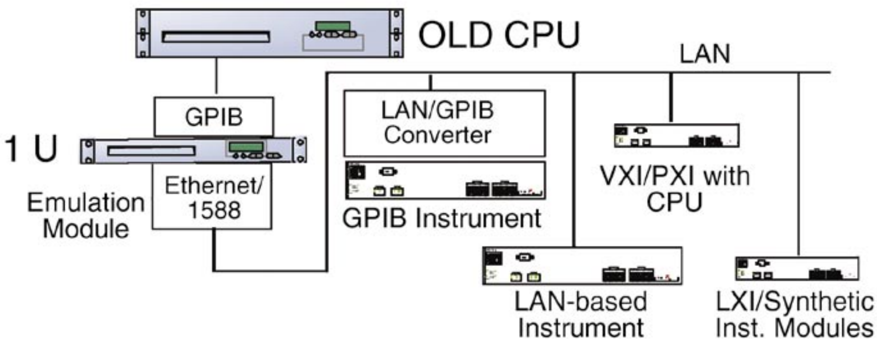


Figure 6

Customer/DoD translation/ Emulation history

A 2004 survey found that those who tried to provide life extension for Automated Test Systems faced countless problems such as: (a) Old TPS uses an undocumented command that is not part of the old instrument's manual but is supported by the old instrument or (b) the old TPS uses 160 percent over-range during measurement reading, but the new instrument supports only 120 percent. In addition, all the emulations required the source code in order to change it or the low-level drivers.

In addition, some instrument manufacturers released new instruments with a built-in emulation module. While testing several instruments, we discovered the following problems:

- The built-in emulator covers 60 to 80 percent of the command set.
- Changes to the emulation were released per firmware release schedule, which was not acceptable (one to two months average).
- "Illegal" commands that worked on legacy ATE did not work on these emulators, and the manufacturers had no intension to support them.
- ATE local problems such as delay and quality of signal were not being addressed.

The technology described in this article has built-in tools that handle these and other integration problems. Its tracing tool can look at the protocol low-level commands on both directions, and the Web server capability enables remote support and the capability of adding commands for a specific instrument in a specific ATE.

It is worth mentioning again that each R/T emulator module can be loaded with several instrument emulators (for example, a DMM, spectrum analyzer, counter) via simple TCP/IP communication protocols.

The type and number of instruments can be changed based on the ATE configuration. An internal utility can provide the configuration of all the instruments that are attached to the R/T emulator module, as this information is provided by the instrument's manufacturer. This information is accessible via the Internet.

Interface Test Adaptors (ITAs) and custom-made instruments are the most complex replacement objectives. The new device often needs to preserve the old signals and their characteristics. Even there, the R/T emulator module provides a replacement alternative.

US Navy case study

WinSoft Corporation installed more than 25 units of R/T emulator modules at SPAWAR Systems Center San Diego and replaced four legacy HP1000 computers, without any software changes.

However, some minor changes (such as TPS limits) may be required in those cases where the new instruments are not 100 percent compatible with the old instruments.

During Phase I of this replacement process, two legacy Grumman radio ATEs were upgraded. In each ATE, the following instruments were replaced: (a) HP6942 multi-programmer, including the HP59500A; (b) HP3495A scanner; and (c) Mantech International interface device. The replacement made use of multiple emulators and utilized a variety of PXI modules as the instrument's replacements.

During the second phase, the HP1000 original computer was replaced with a COBRA1000, and the instruments shown in Table 1 were also replaced.

Old instrument	New instrument
Racal DMM 6000S4599	Agilent 3458A
HP 8160 pulse generator	Agilent 81104A
Racal counter 9035-11A	Agilent 53132A with 3 GHz channel (option 030)
HP 8663 signal generator	Agilent 8648C with the following options: – Hi-output power option – Modulation generator option – High-stability option – Pulse modulation option
HP 8568 spectrum analyzer	Agilent E4402
HP1000 computer	WinSoft – COBRA 1000 system

Table 1

Schedule

Phase I lasted for six months, including replacement of all the tester's cables and RF switches, while Phase II took five months. The challenge of Phase II was because of the different upgrade levels performed on the ATE, which included replacing the CPU/controller and the instrument itself.

Price

SPAWAR, Systems Support Engineering division, calculated savings of $2.2 million during Phase I and more than $6 million during Phase II. This calculation is based on the DoD cost should there be a need for rewriting and revalidation of more than 150 TPSs. Future savings can be achieved by simple duplication of the R/T emulator modules, and the downtime of the station that utilized the presented technology went from 50 percent to less than 2 percent.

Reuse and preservation

The presented technology allows the reuse of legacy TPS in the next generation testers while preserving the old TPS. Current and future known technologies are supported. The cost associated with this technology is significantly lower than existing methods.

References

[1] National Instrument Corporation, www.ni.com

[2] IVI foundation, www.ivifoundation.org

[3] Agilent Technology, www.agilent.com

[4] LXI consortium, www.lxistandard.org

[5] E. Shany, WinSoft Corporation, "Method and system for software preservation and communication protocol expansion through hardware replacement," US Patent Pending, 2003, Ref. No. 004966.P002

Ehud Shany, *president and CEO of WinSoft Corporation since 1994, is an expert in test and measurement applications and has extensive experience in automation, robotics, networking, and real-time and database applications. For the past 10 years, Ehud's company has delivered software and hardware projects to companies such as Boeing, Raytheon, Northrop Grumman, the US Navy, and many others. Ehud holds a BS in computer science.*

To learn more, contact Ehud at:

WinSoft, Inc.
1932 E. Deere Ave., Ste. 110
Santa Ana, CA 92705
Tel: 949-428-4844, Ext. 202
Fax: 949-428-4842
E-mail: ehud@winsoft.com
Website: www.winsoft.com