AUTOMATED TEST OUTLOOK 2011

A Comprehensive View of Key Technologies and Methodologies Impacting the Test and Measurement Industry

Business Strategy + Architecture + Computing + Software and I/O

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Overview

This report details key trends, methodologies, and technologies impacting test engineering organizations in every industry. The outlook combines input from academic and industry research, business intelligence, and customer advisory boards.

Business Strategy

Organizational Test Integration

Integrating validation and production test requires a focus on changes to people, processes, and technology.

Architecture

System Software Stack

A highly integrated software framework provides a flexible architecture for adding measurement capability and reducing development time.

Computing

Heterogeneous Computing

Future test systems will require different types of processing nodes to address increasing demands from analysis and processing needs.

Software and I/O

IP to the Pin

Sharing FPGA IP between design and test will dramatically shorten design verification/validation and improve production test time and fault coverage.

"Electronics companies are emerging from the Great Recession with a portfolio of new products with higher performance and lower cost. The Automated Test Outlook is the resource for test organizations looking to invest in next-generation technologies and methodologies to test these innovative products."

Alex Davern,
Chief Operating Officer,
National Instruments

A Global Catalyst for the Automated Test Industry

Since 1976, companies around the world have relied on National Instruments products and services to build sophisticated automated test and measurement systems. By standardizing on NI tools, these test engineering organizations are improving the quality of their products while reducing costs. These benefits have been realized by industry-leading companies including BMW, Lockheed Martin, Sony, and Texas Instruments.

While continuing to serve as today's leading authority in instrument control technologies, NI is driving innovation in test system design with software-defined instrumentation. This approach combines the advantages of open, industry-standard PC technologies, modular instrumentation, and proven instrument control options – all powered by the industry's most comprehensive and widely chosen test system software. Through this approach, test engineers achieve savings in capital equipment and system development with lower maintenance costs and faster execution.

An important part of NI leadership is its involvement with multivendor consortia, including the PCI-SIG, PICMG, PXI Systems Alliance, and the IVI Foundation. These organizations impact business by delivering a common software and hardware architecture that simplifies test system development and provides vendor interoperability. National Instruments partners with industry-leading instrumentation vendors, such as Tektronix, to drive further advancements in the test and measurement industry. One of the latest innovations of the collaboration between NI and Tektronix is a high-bandwidth PXI Express digitizer that delivers unprecedented capability to the PXI platform. The product combines Tektronix's unique ASIC technology and high-bandwidth design experience with NI modular instrumentation, data streaming, and software expertise.

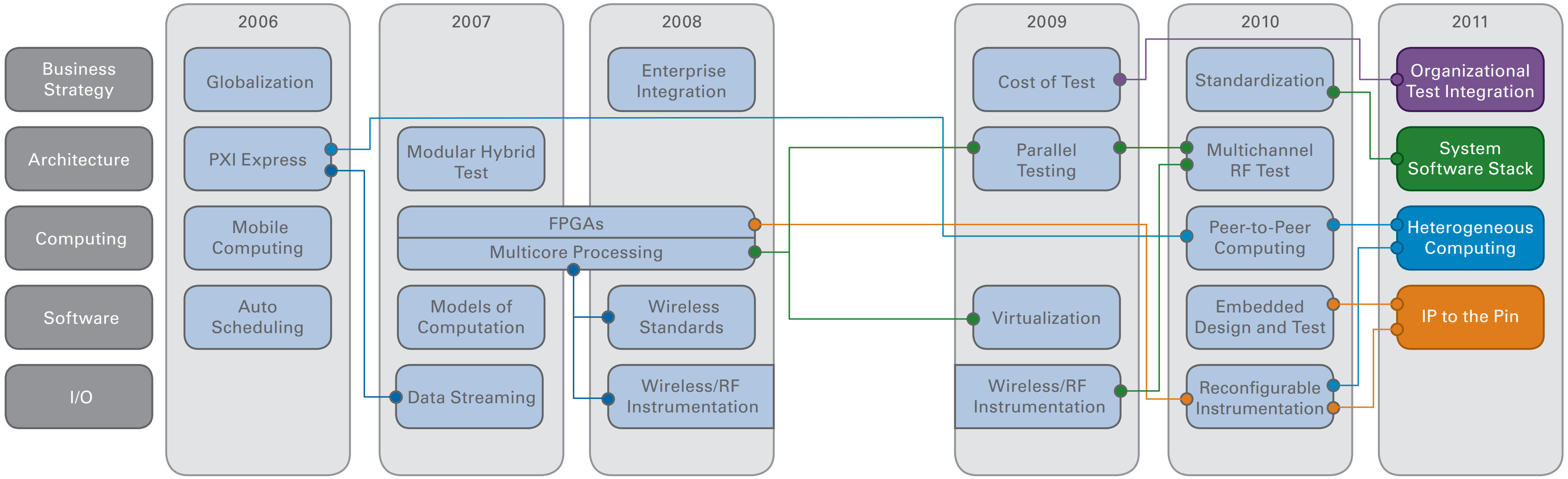
In addition to partnering with key instrumentation vendors, NI delivers innovative products through a strong investment in R&D. NI reinvests more than 16 percent of revenue in R&D, which is significantly more than the industry average. These investments are balanced between providing higher performance and greater ease of use. The latest enhancements include targeting field-programmable gate arrays (FPGAs) and multicore processors as well as advancing precision and high-frequency measurement capabilities. With these new products and technologies, test engineers can develop cost-effective test systems that are flexible enough to meet current and future application requirements.

A Technology and Business Partner

Test is a critical component of your product development and production process. It can improve a product's performance, increase quality and reliability, and lower return rates. It is estimated that the cost of a failure decreases by 10 times when the error is caught in production instead of in the field and decreases 10 times again if it is caught in design instead of production. By catching these defects and collecting the data to improve a design or process, test delivers value to your organization. Driving innovation into this process through technology insertion and best-practice methodologies can generate large efficiency gains and cost reductions.

We've found that one of the biggest challenges for test engineers and managers is staying current on the latest test trends. Keeping up with the changing technologies of the devices you design and manufacture is daunting enough; keeping up with all the technologies that drive test process improvements as well as new testing techniques is even harder. National Instruments has a broad knowledge of technology trends and interacts with companies across many sectors, which gives us a unique vantage point on the test and measurement market. This view has enabled us to be a strategic partner with leading companies in identifying trends and industry best practices. We try to be as transparent as possible in providing this information to our users to help them make the best business decisions for their organizations.

The goal of the Automated Test Outlook is to both broaden and deepen the scope of these existing efforts. We are documenting the information from our own internal research and key customer engagements and making it publicly available for a broader audience of test engineers and managers who are influencing test strategy. Our desire is to help educate you and your teams and give you the information you need to make key technical and business decisions.



Automated Test Outlook Topics over the Past Six Years

How We Arrived at the Trends

Predicting the future is hard work. Fortunately, we cast a wide net in terms of the inputs we use to arrive at the trends. As a supplier of test technology to more than 30,000 companies worldwide each year, we receive a broad range of feedback across industries and geographies. This broad base creates a wealth of quantitative and qualitative data to draw on.

We stay up-to-date on technology trends through our internal research and development activities. As a technology-driven company, we invest more than 16 percent of our revenue annually into R&D. But as a company that focuses on moving commercial technology into the test and measurement industry, our R&D investment is leveraged many times over in the commercial technologies we adopt. Thus, we maintain close, strategic relationships with our suppliers. We conduct biannual technology exchanges with key suppliers that build PC technologies, data converters, and software components to get their outlook on upcoming technologies and the ways these suppliers are investing their research dollars. Then we integrate this with our own outlook. We also have an aggressive academic program that includes sponsored research across all engineering disciplines at universities around the world. These projects offer further insight into technology directions often far ahead of commercialization.

And, finally, we facilitate advisory councils each year where we bring together leaders from test engineering departments to discuss trends and to share best practices. These councils include representatives from every major industry and application area – from testing fighter jets to the latest smartphone to implantable medical devices. The first of these forums, the Automated Test Customer Advisory Board, has a global focus and is in its 11th year. We also conduct regional meetings, called Regional Advisory Councils, around the world. Annually, these events include well over 300 of the top thought leaders developing automated test systems.

We've structured this outlook into five categories (see above figure). In each of these categories, we highlight a major trend that we believe will significantly influence automated test in the coming one to three years. We update the trends in these categories each year to reflect changes in technology or other market dynamics. We will even switch categories if the changes happening are significant enough to warrant it.

As with our face-to-face conversations on these trends, we hope that the Automated Test Outlook will be a two-way discussion. We'd like to hear your thoughts on industry's technology changes so we can continue to integrate your feedback into this outlook as it evolves each year.

Organizational Test Integration

Throughout the electronics design and manufacturing industry, test teams are improving integration across the organization to gain a competitive edge.

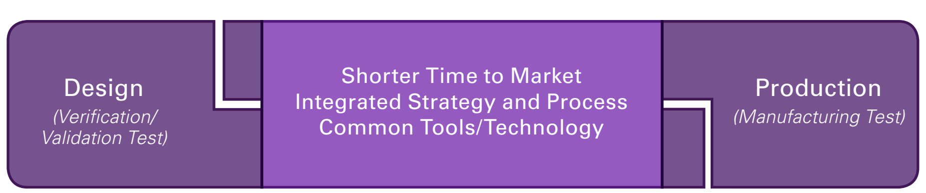
This integration strategy diverges from the common practice of improving test in design or production by drawing boundaries around these groups and allowing them to improve independently. While small test organizations that consist of three engineers or fewer might be well-integrated as a result of small team size, larger test organizations still mostly follow a strategy that improves teams independently. In the past, validation (the process of testing a product during design to guarantee that it meets feature specifications) and production test teams have seen few opportunities to work together. However, test managers seeking to decrease time to market and reduce test costs see that improving teams independently is providing diminishing returns.

Two big changes have shifted companies' focus to improve the integration of test teams across their organizations. This shift is exemplified by the result of a recent global test manager survey that found that the top goal for 45 percent of test engineering organizations over the next one to two years was to increase reuse between validation and production.

The first change is organizational. The differences between validation and production test teams are being blurred. To meet increasingly tight product development schedules, production test teams are forced to embed themselves in the product development process. Similarly, validation test teams are spending increasingly more time debugging designs using production test systems on the manufacturing floor. By formalizing the ad hoc relationship between the two teams, organizations are reducing time to market by accelerating test development and improving quality.

The second change is technical. Validation and production test tools have differed significantly in the past. However, the increased use of automation across both groups has shown validation and production that they can share common software and instrumentation. Organizations are reducing costs by using common platforms across both groups, decreasing the number of necessary instrumentation spares, consolidating training classes, and taking advantage of volume purchase pricing.

Even though many teams are looking to integrate validation and production test, few know where to start. Best-in-class organizations have found that there is no single silver bullet to make the integration successful. Improving the integration of these two phases requires a strategy that spans *people, processes,* and *technology.*



Best-in-class organizations improve integration by focusing on changes to people, processes, *and* technology.

> "*We created a MEMS test system that delivers 11X reduction in capital equipment costs, 15X reduction in footprint, 66X reduction in weight, and 16X reduction in power consumption. The same system is also used in other phases outside of production, including design, characterization, and metrology. This helps reduce our time to market and increase our product quality.*"

Woody Beckford,
Division Fellow,
Analog Devices Inc.

One of the main reasons for failure when integrating validation and production test is following a strategy that does not include securing executive-level support. This fact is exemplified in the enterprise software implementation literature, which investigates an organizational change of similar scope to organizational test integration. The literature found executive-level support to be one of the top three critical success factors across multiple studies. Executive-level support is best achieved by tying the organizational test integration project to a corporate-wide objective. Every organization has annual or multiyear corporate objectives that are created by the executive team. Demonstrating how this project can assist in achieving one of these goals helps secure executive support. The support from executive leadership then simplifies the resources and political capital necessary to accomplish the project.

Once executive-level support is secured, test managers can tackle improving *processes* that historically threw products "over the wall" from design to test. Understanding and influencing the new product introduction (NPI) process is one of the most effective strategies to improve the integration of validation and production test. It is important for test engineers, whether in validation or production, to understand who makes these decisions and when. Once the decision timeline and stakeholders are understood, engineers should seek out a seat at the table when the organization is making key decisions.

Historically, the differences between the instrumentation used in validation and production test have led teams to see little opportunity for *technology* reuse. However, the increasing use of automation in validation has shown design teams that instrumentation and software previously used mostly in production can meet the requirements of validation. Technology reuse through common tools across groups can reduce capital, development, and debugging costs, but the process can be challenging.

Deciding on a common test platform in validation and production test is best done in steps. Although creating a monolithic standard test system seems to make the most sense intuitively, it can ultimately be costly, inflexible, and challenging to implement. A key trend is to use a common architecture that standardizes on the architectural layers (such as the test executive, application development environment, or instrumentation) that make the most sense.

Finally, it is important to remember that integrating validation and production has a strong *people* element that must be addressed. Even though engineers perceive themselves as fundamentally rational people, they strongly rely on personal trust when reusing tools, especially software, from other engineers. Mark Keith, test software chief engineer at Honeywell, articulated this challenge when he said, "Engineers will not use code from people they don't trust." Therefore, building personal relationships between the validation and production test teams is key to integrating both teams.

Best-in-class organizations have improved relationships between validation and production test teams differently depending on the level of change that is possible in each organization. If the validation and production test teams report to the director leading the change, one trend has been to integrate production test into the design and validation groups. Making such a far-reaching change is beyond the control of managers in other organizations. Smaller changes, such as implementing a rotation program, have proven to be effective as well.

Much like any complex business problem, improving organizational test integration requires an understanding of the necessary changes to *people, processes*, and *technology.* It is rare for an organization to not have to focus any effort in one of these areas. However, most organizations need improvement in some areas more than others. Ultimately, taking a holistic approach to organizational test integration is critical to the success of the project.

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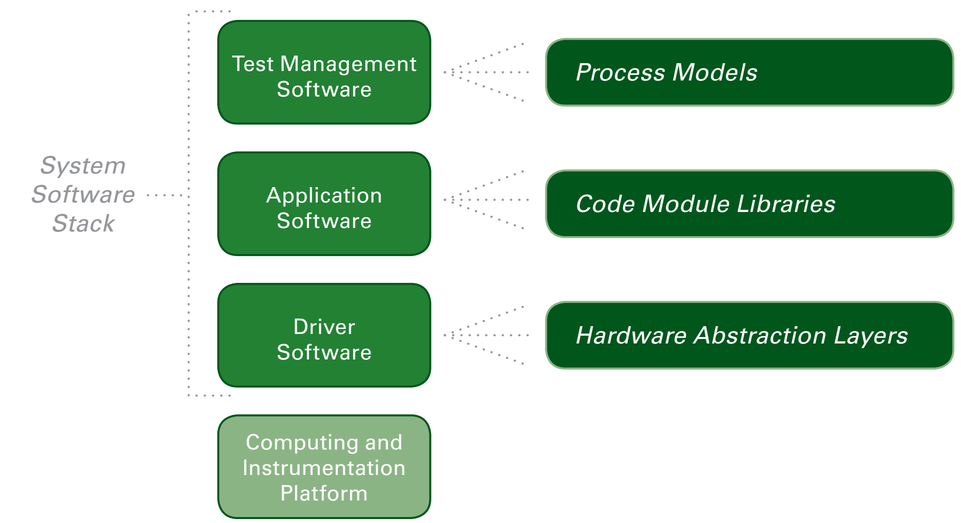
Architecture

System Software Stack

Software has been a critical component of automated test systems since it was first used to control stand-alone instruments more than 40 years ago.



A modular software architecture increases flexibility and shortens test system development time.

Since then the role of software in automated test has grown significantly. In fact, software development costs are often 2X to 10X more than capital costs in most test systems today. The makeup of many test engineering organizations reflects this trend of hiring more software engineers than hardware engineers. In response to rising software development costs and accelerated product development cycles, today's industry-leading companies emphasize designing a robust system software stack to ensure maximum longevity and reuse of their software investments. In fact, a test manager's survey conducted by National Instruments in 2010 showed that an increased focus on system software was the second-highest strategy for increasing the efficiency of their test development process in 2011.

From a system software perspective, most companies are moving away from monolithic software stacks that often contain fixed-constant code and direct driver access calls to the instruments. Alternatively, they are seeking modular software stacks in the form of separate yet tightly integrated elements for test management software, application software, and driver software. This type of system software stack helps engineers apply the optimal tools for each area and choose between standardized commercial off-the-shelf (COTS) and in-house tools at each level. A key trend is the extension of modularity into each layer of the software stack, including the increasing use of process models, code module libraries, and hardware abstraction layers.

Test management software defines the core automation and sequencing flow of a test system. The process model is a critical technology within the test management software layer because of its role in separating the test tasks from the non-test tasks so engineers can easily standardize and manage non-test tasks across different test sequences and stations. The non-test tasks include much of the connectivity with the enterprise for data inputs, logging data to quality databases, communicating with the shop floor, and generating actionable test reports. With this modular framework, organizations can maintain a few process models that they can apply across many different product lines and hundreds or more deployed testers. The process model also simplifies changes to non-test functions in a test station without impacting the test tasks, thus reducing the time needed to update deployed test stations. For example, engineers can quickly change the execution flow of a test station based on market demand by switching among sequential, batch, and parallel testing process models.

The application software layer is equally important because it directly impacts the test-related tasks of a test system. Many organizations have moved to developing modular test code, known as code modules. Called by the test management software, these modules perform the actual measurements and analysis used to determine the pass/fail status of a test step. Many code modules perform similar I/O functions across different types of devices under test (DUTs), so this is a key area for reuse and distributed development responsibilities using team-based development methods. Recently, the industry has seen an increase in companies adopting reusable test code libraries and more source code control (SCC) tools. Many application software vendors now include integration with SCC tools and advanced features such as three-way diff and merge to accommodate this test software development trend. Some organizations have even implemented gatekeeper milestones to ensure a certain level of reuse and team-based development to prevent reinventing the wheel and growing too dependent on a single developer for all code development knowledge.

Additionally, companies are increasingly integrating requirements management software tools in the application software layer. This helps ensure one-to-one tracking of test coverage against design requirements, which is critical in highly regulated industries. New requirements gateway software offers a link between the application software and requirements management environments, such as Telelogic DOORS, to greatly reduce the amount of time spent tracking requirements coverage in test system development.

A final component of the system software stack that is growing in need and usage is a hardware abstraction layer (HAL). A HAL resides within the driver software layer of the system software stack and separates the application software from the instrument hardware, which minimizes the time and costs associated with migrating or upgrading test systems. There are two approaches to designing a HAL: instrument-centric or application-specific. For an instrument-centric API, it helps to define an internal common instrument-centric API "standard" that can be used across multiple types of DUTs.

Interchangeable Virtual Instruments (IVI), an industry-standard HAL, takes an instrument-centric view of abstraction – that is, having top-level test applications call an instrument-centric API that makes all instruments look similar (for example, IviScope Configure AcquisitionType). In an application-specific approach, the test applications call an application-specific API that is aligned with the type of tests it needs to perform (for example, LED test). A HAL is a proven method to develop and maintain a loosely coupled test system. It better addresses mismatches between product and test instrumentation life cycles and avoids tightly coupled test code with test instrumentation. Loosely coupling test code and the test instrumentation improves the overall design of a test system, making it more maintainable and extensible over its lifetime.

Driving the modularity of the system stack into each software layer delivers additional flexibility and provides a framework to develop sophisticated life-cycle management strategies. These strategies help reduce software development time and mitigate obsolescence issues by addressing subjects such as feature road mapping, system upgrades, and instrumentation and technology insertion planning.

> *"We created an automated verification test framework that includes a hardware abstraction layer. This framework gives us the flexibility to set up various configurations of test hardware without having to change the test software code."*

Mohammad Ahmad,
Manager, System Test and Verification,
Thales Communications

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Heterogeneous Computing

Automated test systems have always comprised multiple types of instruments, each best suited to different measurement tasks.

"Next-generation test systems will increasingly use FPGAs, along with other processing elements, to efficiently distribute processing and analysis. System design software will be crucial in the abstraction and management of these systems."

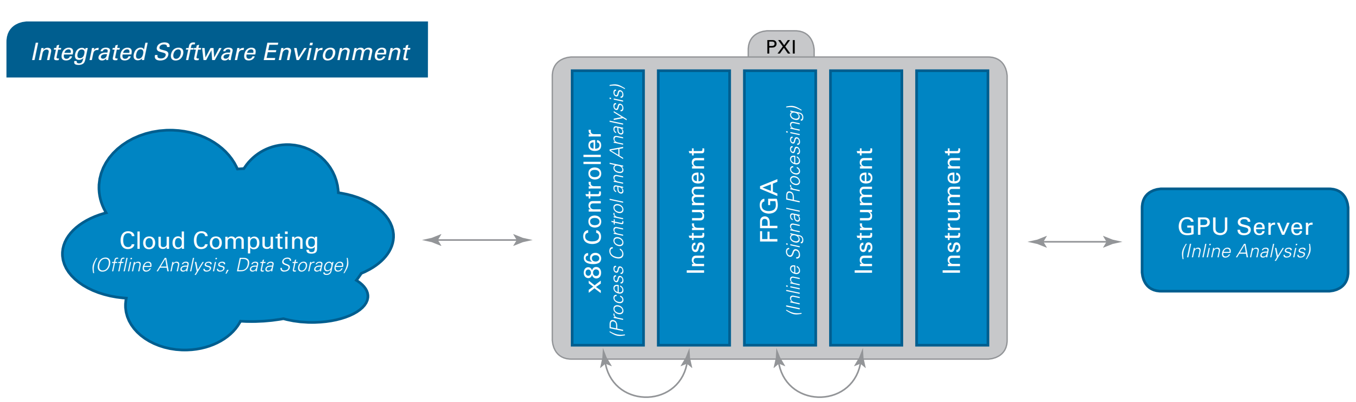
Vin Ratford,
Senior Vice President,
Xilinx Corporation

An oscilloscope, for example, can make a single DC voltage-level measurement, but a DMM provides better accuracy and resolution. It is this mix of different instrumentation that enables tests to be conducted in the most efficient and cost-effective manner possible. This same trend is now affecting how engineers implement computation in test systems. Applications such as RF spectrum monitoring, for example, require inline, custom signal processing and analysis not possible using a standard PC CPU. Furthermore, test systems are generating an unprecedented amount of data that can no longer be analyzed using a single processing unit. To address these needs, engineers have to turn to heterogeneous computing architectures to distribute processing and analysis.

A heterogeneous computing architecture is a system that distributes data, processing, and program execution among different computing nodes that are each best suited to specific computational tasks. For example, an RF test system that uses heterogeneous computing may have a CPU controlling program execution with an FPGA performing inline demodulation and a GPU performing pattern matching before storing all the results on a remote server. Test engineers need to determine how to best use these computing nodes and architect systems to optimize processing and data transfer. The following are the most common computing nodes used in test systems:

The **central processing unit (CPU)** is a general-purpose processor with a robust instruction set and cache as well as direct access to memory. Sequential in its execution, the CPU is especially suited to program execution and can be adapted to almost any processing activities. Advancements in the last decade have led to multiple computing cores on a single chip, with most processors running two to four cores with many more cores planned for the future. These multicore systems enable operations to occur in parallel but require the programmer to implement a multithreaded application with an eye toward parallelization to fully take advantage of these systems' capabilities.

The **graphics processing unit (GPU)** is a specialized processor originally developed for the rendering of 2D and 3D computer graphics. The GPU has seen tremendous advances due to the need for more realistic graphics in computer video games. It achieves its performance by implementing a highly parallel architecture of hundreds to thousands of cores specifically suited to vector and shader transforms. Engineers are trying to adapt these specialized processing cores for use in general-purpose processing. Performance gains have already been seen with the use of GPUs in the areas of image processing and spectral monitoring.



A Next-Generation Test System Using a Heterogeneous Computing Architecture to Distribute Processing.

Field-programmable gate arrays (FPGAs), unlike CPUs and GPUs, do not have defined instruction sets or processing capabilities. Instead, they are reprogrammable silicon of logic gates that allows users to build custom processors to meet their exact needs. They also provide a hardware-timed execution speed that enables a high level of determinism and reliability that makes them especially suited for inline signal processing and system control. This increased performance, however, comes with the trade-off of increased programming complexity and the inability to change processing functionality in the middle of program execution.

Cloud computing is not a specific type of processor but a collection of computing resources accessible via the Internet. The power of cloud computing is that it frees users from having to purchase, maintain, and upgrade their own computing resources. Instead they can rent just the processing time and storage space necessary for their applications. Cloud computing use has grown rapidly, with HP predicting that 76 percent of businesses will pursue some form of it within the next two years. However, while it does provide access to some of the most powerful computers in the world, cloud computing has the drawback of very high latency. Data must be transferred over the Internet, making it difficult to impossible to use in test systems that require deterministic processing capabilities. But cloud computing is still well-suited for offline analysis and data storage.

Heterogeneous computing provides new and powerful computing architectures, but it also introduces additional complexities in test system development – the most prevalent being the need to learn a different programming paradigm for each type of computing node. For instance, to fully use a GPU, programmers must modify their algorithms to massively parallelize their data and translate the algorithm math to graphics-rendering functions. With FPGAs, it often requires the knowledge of hardware description languages like VHDL to configure specific processing capabilities.

Engineers in the industry are working on a way to abstract the complexities of specific computing nodes. In the case of GPUs, they are developing the Open Computing Language (OpenCL). OpenCL is a programming interface designed to support not only multiple GPU vendor products but also additional parallel processors like multicore CPUs. Work is also under way to further simplify the configuration of FPGAs. "High-level synthesis" is an emerging process adopted by some vendors to use high-level, algorithmic-based languages in FPGA programming. Tools like the NI LabVIEW FPGA Module are abstracting away even further the complexities by enabling graphical, block diagrams to be converted directly into digital logic circuitry.

Computing node programming is not the only challenge in a heterogeneous computing system. Having more computing resources is not valuable if the data cannot be transferred and acted upon rapidly. PCI Express has emerged as the premier data bus for these peer-to-peer networks in test systems due to its high-throughput, low-latency, and point-to-point characteristics. As the backbone of PXI, the PXI Systems Alliance recently released the new PXI MultiComputing specification to guarantee PCI Express, peer-to-peer, heterogeneous computing capabilities between multiple vendors.

Heterogeneous computing will enable many new possibilities in test system development. By taking advantage of the latest advancements in programming abstraction and data transfer, engineers can truly benefit from using multiple computing nodes.

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+ Automated Test Outlook

IP to the Pin

For decades, the electronics industry has pursued its version of the Holy Grail – concurrent design and test.

Many have believed this an unattainable goal, considering how far apart the two worlds appear. In the design world, most engineers design at a system level using the latest electronic design automation (EDA) software, which has seen tremendous innovation over the last decade. The test industry has not innovated as quickly, and many companies have chosen to invest more in their design tools than their test engineering tools. The consequence is test engineers are typically outmatched when testing the latest software-centric electronic devices.

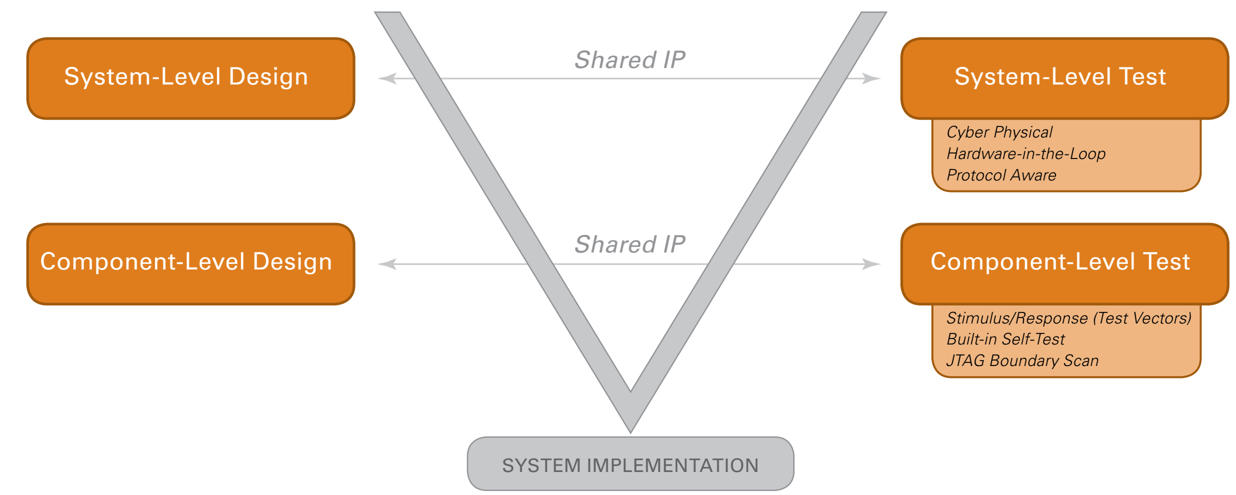
Pundits in every major industry have envisioned solutions to bridge this gap. In the semiconductor industry, experts have recommended the solution of protocol-aware test, visionaries in the U.S. Department of Defense (DOD) have proposed synthetic/virtual instrumentation, and the automotive industry has adopted hardware-in-the-loop and model-in-the-loop test. A closer look at all of these reconfigurable instrumentation architectures reveals some common themes: a system-level approach, the integration of design and test concepts, and the extension of software architectures into field-programmable gate arrays (FPGAs).

The next phase in integrating design and test is the ability for engineers to deploy design building blocks, known as intellectual property (IP) cores, to both the device under test (DUT) and the reconfigurable instrument. This capability is called "IP to the pin" because it drives user-defined software IP as close to the I/O pins of next-generation reconfigurable instruments as possible. The software IP includes functions/algorithms such as control logic, data acquisition, generation, digital protocols, encryption, math, RF, and signal processing.

To reuse IP requires both design and test engineers to operate at a certain level of abstraction and use a common design methodology. This technique is represented by the "V diagram," where each phase of design has a corresponding verification or test phase. In this way, design and test teams can work their way "down the V," from the highest-level modeling and design to lower-level implementation, and conduct tests at each stage.

For example, a multiple-input, multiple-output (MIMO) system on a chip (SOC) includes receivers, transmitters, converters, filters, switches, and a processor. In addition, this SOC features software IP such as coding, modulation, encryption, and communication protocols. To fully validate the functionality of the highly integrated hardware and software subcomponents of the SOC, engineers need system-level test capabilities to effectively emulate another communication device in the system, such as a base station. Because many of the IP blocks of the DUT and the test system are common, this presents an ideal case for concurrent design and test with IP reuse.

> *"The market shift to reconfigurable architectures will enable design and test engineers to operate at similar levels of abstraction. This is a key step to making concurrent system-level design and test a reality."*
>
> *Dr. James Truchard,*
> ***CEO, President, and Cofounder,***
> National Instruments



Sharing common FPGA IP between design and test dramatically shortens design validation and improves production test time and fault coverage.

The ability of a test engineer to directly embed the SOC design IP in the test instrumentation to perform system-level test can dramatically shorten design verification/validation and improve production test time and fault coverage. There are two key trends that will enable future reconfigurable test systems to deliver this IP-to-the-pin capability: the market shift toward FPGAs and the availability of high-level software to program them.

The electronics market is shifting to using an FPGA-based architecture for both electronic devices and test instrumentation. Moore's law has become a proxy for the tremendous increases in performance and reductions in cost for all semiconductor devices and electronics products. Besides the microprocessor, FPGAs have probably benefited the most from Moore's law because they have drastically increased in logic cell counts and functionality and decreased in cost per transistor. Engineers can now pack additional software IP in a single FPGA.

Vendors are also beginning to integrate FPGAs with devices such as processors, data converters, and transceivers to deliver increased performance and user programmability even closer to the I/O pin. This trend is made possible by Moore's law rendering the cost and size of programmable gates to nil. All of these advancements have brought FPGA capabilities more in line with those of an ASIC. This performance boost and the empirical advantage of being reprogrammable in software have created a market shift toward FPGA-based designs over the last decade for electronic devices. In a 2009 report, the Gartner research firm stated that FPGAs now have a 30 to 1 edge in design starts over ASICs. Every industry and application area is adopting FPGAs including consumer electronics, automotive electronics, and military/aerospace technology. Moshe Gavrielov, CEO of Xilinx, has called this migration to FPGAs "the programmable imperative."

Because of the programmable imperative, design engineers can turn to higher levels of abstraction in designing semiconductors and electronic systems. Increasingly, they are able to reuse existing FPGA IP as building blocks of a new design. Because of this abstraction, they can design at a system level and get new products to market with new features faster than ever before. This leads to the second market trend: the increase in availability and capability of high-level synthesis (HLS) tools for test engineers. These HLS tools provide an automated process that interprets an algorithmic description of a desired behavior and creates FPGA logic that implements that behavior. This abstraction increases the accessibility of FPGA design to more engineers and provides a platform for programming at a system level.

There are also emerging multivendor IP ecosystems that feature IP cores from all major FPGA vendors as well as their software and instrumentation partners. The National Instruments FPGA IPNet and the Cadence/Xilinx IP microsites are examples of these ecosystems. They contain hundreds of IP blocks and functions, including the Xilinx CORE Generator, serial communication protocol cores, and Advanced Encryption Standard (AES) components as well as peer-to-peer streaming algorithms.

These trends deliver design and test engineers the capabilities required to reuse IP and enable concurrent design and test. Moving forward, companies need to adopt an investment strategy that provides design and test engineers with comparable capabilities. In doing so, they can achieve the maximum business impact including shorter time to market, higher quality, and more profit.

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