Intel in Communications

Case Study: National Instruments* Corp.

Intel® Bridge Speeds Development of PCI Express* Instrumentation Solutions

Summary

As the PC begins its transition from PCI and PCI-X parallel bus technologies to PCI Express* serial I/O interconnect technologies, industry vendors are moving with varying degrees of haste to support this emerging high-performance interface. Servers, workstations and desktops enabled for PCI Express began shipping in late summer of 2004.

National Instruments*, which has been delivering virtual instrumentation solutions built on high-performance, low-cost PC technology for decades, understands the need for haste. Customers are counting on National Instruments (NI) to provide sound, powerful PCI Express-based measurement and automation products as soon as possible—just as they did when ISA gave way to PCI in the mid-1990s.

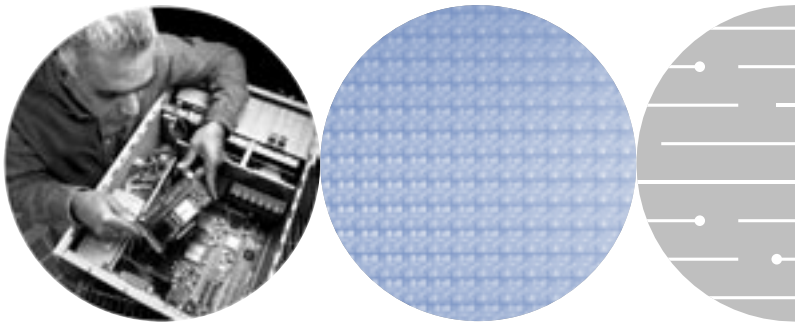
NI developers have addressed this customer expectation by using the Intel® 41210 Serial to Parallel PCI Bridge to implement PCI Express quickly. By translating from the serial PCI Express I/O architecture to the PCI/PCI-X parallel bus architecture, the Intel bridge chip offers hardware vendors a fast way to port their solutions to the new interconnect as an interim step until native-mode PCI Express devices can be developed.

This case study examines how Intel's bridge helped NI developers streamline their time to market and deliver the first PCI Express-based Test and Measurement (T&M) product, as well as develop a compelling machine vision solution that makes the most of PCI Express bandwidth.

Background: Virtual Instrumentation

Since its founding in 1976, National Instruments has pioneered a new method for controlling instruments and making instrumentation systems. Called virtual instrumentation, this concept has transformed the way in which engineers and scientists measure the world by converting standard PCs into industrial automation and T&M systems.

The cornerstone of virtual instrumentation is low-cost, high-performance PC computing. NI capitalizes on PC technologies to design measurement and automation solutions that increase productivity and lower costs in research, automotive, aerospace, military, academic, manufacturing and other applications. NI developers focus on easy-



to-integrate software, such as the NI LabVIEW* graphical development environment, and modular hardware, such as PXI modules for data acquisition, instrument control and machine vision technology.

Gearing Up for PCI Express

To stay at the forefront of PC-based measurement and automation, NI has consistently adopted new platforms and brought customers the latest PC technologies. Just as the shift from the ISA bus to the PCI bus in the mid-1990s helped drive the virtual instrumentation revolution, the emergence of PCI Express is seen as key to the development of more efficient and powerful T&M and industrial automation solutions.

PCI Express is a high-performance, low-voltage, differential, point-to-point serial interconnect that improves upon its parallel predecessor, PCI, by providing scalable bus bandwidth. For example, a x4 PCI Express interface provides more than three times the bandwidth of the PCI bus, while a x16 PCI Express interface provides more than a twenty-fold performance improvement. PCI Express features a layered model that offers backward compatibility with existing PCI applications at the operating system and utility level. The new I/O interface also provides much-needed features such as guaranteed bandwidth for demanding data acquisition applications; reliability, availability and serviceability (RAS) features; and "future-proofing" for the next decade or so in terms of scalability.

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NI recognizes that it must step up quickly with PCI Express implementations to stay on top of customer demands for industry-leading T&M and industrial automation solutions.

"Customers look to NI to deliver instrumentation solutions on whatever platform they choose," explains Tim Fountain, manager of hardware product strategy, instrument control, at National Instruments. "PCI Express gives us the opportunity to develop next-generation measurement and automation products, and to address high-performance applications that were previously not possible on the PC."

As a leading supplier of plug-in cards that use the industry-standard General Purpose Interface Bus (GPIB) to control instruments, NI sought to deliver the first PCI Express-based GPIB controller board for the T&M industry. The goal: have product ready to deliver when PCI Express-equipped servers, workstations and desktops started shipping in late summer of 2004.

Bridging Solution: Availability Plus Confidence

After weighing the options available to them, NI developers chose an Intel bridge to help customers take early advantage of the latest I/O bus to control instruments via GPIB. NI used the Intel 41210 Serial to Parallel PCI Bridge to quickly port an existing PCI-based GPIB design to PCI Express. Developers successfully bridged PCI Express to the existing design's single custom ASIC—which implements both the PCI interface and the GPIB interface—achieving rapid implementation with no software changes.

The availability of Intel's bridge, coupled with full confidence in its abilities, were key factors in NI's decision to rely on Intel for PCI Express enabling technology. Availability was the top imperative because NI intends to maintain its reputation for providing a GPIB interface for virtually every I/O bus used worldwide. But availability alone wasn't enough, or NI might have chosen a different solution. As Fountain points out, the other solutions that NI considered were "compatible but not fully compliant" with PCI Express at the time NI commenced development. By contrast, Intel's bridge is fully validated for compliance and listed on the PCI SIG Integrators List, inspiring a higher comfort level.

"The Intel bridge chip allowed us to get to market quickly with a product that we were very confident would work for our customers," Fountain says. "The bridge had been through all the conformance testing for PCI Express, and the design was already proven, so we didn't have to worry about being a guinea pig. Plus, there's the fact that Intel is leading the charge on PCI Express and was very early into the marketplace with silicon."

Due to be released in August 2004, NI's newest GPIB controller board is the first plug-in product in the T&M industry based on PCI Express. The interface is the latest in a series of NI products designed for GPIB, the IEEE-488.2 standard that governs how instruments are linked to a computer

to enable automated measurements. A backbone protocol for PC-based instrumentation, GPIB plays in everything from measuring temperatures, pressures and flows during the building of a jet engine to taking complex RF measurements in cellular phones. Measurements taken this way can be stored, plotted or otherwise manipulated and analyzed by the host computer to extract valuable information.

NI developers also used the Intel 41210 bridge to design a PCI Express-based solution for Camera Link*, an industry-standard interface used to connect high-end digital video cameras to PCs for image acquisition in data-intensive applications. NI's PCI Express to Camera Link card is expected to ship in early 2005. In this case, the rationale for bridging to PCI Express was higher throughput as well as faster time-to-market.

"Our machine vision product needs high bandwidth to sustain the high frame rates and resolutions that very high-performance digital cameras generate," Fountain explains. "In this situation, we could definitely use all the bandwidth that was afforded to us by PCI Express."

High-end video cameras and Camera Link cards are typically deployed in research, medical and industrial computing applications. Scientists connect cameras to PCs to study, for example, the body compression in a head-on car crash test, the impact of a projectile on its target, or the scatter of particles in a nuclear experiment. Because such events occur in fractions of a second, cameras must capture images at a rate of 200–300 frames per second (vs. standard cameras that operate at 24-30 fps). This tends to generate huge amounts of data. The advantage of PCI Express bandwidth in such scenarios is much better acquisition of video data: the more data researchers can capture, the better they can analyze it later using image-processing and pattern-recognition software, and the greater insight they gain.

Because NI's existing PCI-based Camera Link card couldn't support the necessary speed, developers instead used the Intel bridge to port PCI Express to a Camera Link design they built from the ground up in PCI-X 2.0 mode 1 (PCI-X 133 MHz mode).

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Seizing a Time-to-Market and Performance Advantage

NI has relied on Intel bridges in the past, so the technology and its capabilities were not only familiar but proven. As with previous experiences, using Intel's shortcut solution for PCI Express product development helps NI maintain a leading edge in a competitive industry.

"We shave six months to a year off our development time using Intel's bridge," Fountain says. "By shortening the process, we achieve significant cost reduction in the development cycle of our product. We also get savings from the fact that we didn't have to debug it."

NI is also realizing compelling performance benefits from porting its image-acquisition solution to higher-bandwidth PCI Express. Compared to the PCI-based Camera Link card, which supports 100 megabytes per second (Mbps) data capture, NI has benchmarked its PCI Express card at 800 Mbps—an eight-fold improvement.

In addition, NI benefits from the Intel bridge's broad compatibility—from the highest-performance 133 MHz PCI-X interface all the way down to the 33 MHz PCI interface. NI has already derived two diverse products from this single bridging solution—the x1 PCI Express GPIB board and the x8 PCI Express image-acquisition board—further reducing its development overhead.

"The Intel bridge allowed us to use a common component to match two sets of product requirements, one for high bandwidth and one for lower bandwidth," Fountain explains. "We didn't have to use two different parts, even though we used a different number of PCI Express lanes. That's a good feature, because we could leverage our experience and the mechanical layouts we'd already done with one product for the other."

The Intel bridge has also demonstrated that it is highly reliable from a design and development perspective, proving itself through NI's extensive battery of stress and life testing. "We have a very stringent set of environmental tests that we put our products through, as well as regulatory tests for safety and emission," Fountain says. "There were no issues with the Intel bridge. It surpassed all our expectations."

Along with feeling confident in the availability of Intel's bridge, NI developers knew they could count on Intel for support. NI developers worked actively with Intel engineering teams during the GPIB product development process—a crucial asset for any early-to-market endeavor. "We got the information when we needed it, we got the help when we needed it, and the product worked the first time," Fountain says. "So we know we're reducing the risk factor for our customers."

As the person responsible for getting the rest of NI to sign up and port products over to PCI Express, Fountain says the easy first experience with Intel's bridging solution holds strong promise for areas of the organization beyond GPIB and image-acquisition cards.

"Overall, we were very happy with the performance and support that we got with the Intel bridge, and we will consider it for future designs of PCI Express products," Fountain says. This outlook builds on NI's longstanding commitment to Intel architecture, a relationship that includes using Intel processors and chipsets exclusively in the design of its PXI modular hardware product series.

Conclusion

As PCI Express rolls out and starts becoming prevalent in the marketplace, NI's continued success depends on being completely on top of this new interface and having excellent products to offer. By choosing the Intel 41210 Serial to Parallel PCI Bridge, NI was ready with a robust, next-generation plug-in solution for T&M customers in conjunction with the first shipments of PCI Express-based servers, workstations and desktops. Being in the marketplace early with its PCI Express GPIB card, and subsequently its PCI Express to Camera Link card, solidifies NI's reputation as a leader in the virtual instrumentation industry.

For more information:

For more information about National Instruments, visit:
http://www.ni.com

For more information about Intel bridges, visit:
http://developer.intel.com/design/bridge/index.htm

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