Tektronix Helps Intel Break the 20 Gbps Cable Barrier Resulting in World's Fastest and Longest Infiniband Cables

Solution Summary

Challenge	To help Intel develop and evaluate a new generation of 20 Gbps Infiniband optical cables for scaling out advanced computer clusters to distances of up to 100 meters.
Solution	A Tektronix AWG7102 arbitrary waveform generator is used to generate a high-speed 5 Gbps InfiniBand serial signal and transmit it down the cable, while a DSA8200 sampling oscilloscope with application software observes and analyzes the waveform at the far end of the cable.
Benefits	Intel was able to prove that the cable – the world's fastest and longest Infiniband cable - performed fully to specification and compared very favorably to conventional copper cable solutions. Intel also used the Tektronix instruments successfully to demonstrate the cable's performance to potential customers at a major international conference.

Intel (www.intel.com) is the world leader in silicon innovation, and develops technologies, products and initiatives to continually advance how people work and live.

On the 27th June 2007, in conjunction with the ISC 2007 annual high-performance computing (HPC) conference in Dresden, Germany, Intel Corp. announced Intel® Connects Cables: a range of high-performance (20 Gbps) optical interconnect cables designed to enable computing clusters to scale out substantially further (up to 100 meters) than existing 24 AWG copper cables, with impressive signal quality, a low bit-error rate (BER), the potential for increased reliability, and other advantages.

Clusters have almost single-handedly driven the recent rapid growth in the high-performance computing market and are now the dominant configuration for technical servers. At the same time, cluster sizes are growing very rapidly - with an average six fold increase in processor count and a three fold jump in node count in just the last two years.

With these larger processor and node counts come much larger physical footprints, plus new challenges in areas such as power supplies and cooling requirements. In addition, interconnect-related shortcomings such as latency, bandwidth, and the limited physical reach of existing copper cables further constrain the physical size and performance of cluster configurations.

Intel® Connects Cables

Intel Connects Cables are designed to address the limitations of 24AWG copper cables in several important ways. First and foremost, the Intel fibre-optic cables are effective at transmitting 20 Gbps double data rates (DDRs) at distances of up to 100 meters, compared with a typical range of only 10 meters using 24AWG copper cables.

The performance specifications of the optical Intel Connects Cables also top the specifications of their copper counterparts. Each Intel cable provides four 5 Gbps lanes in each direction (20 Gbps unidirectional total bandwidth) at InfiniBand DDRs, and somewhat lower rates with SDR or 10GbE CX4-powered sockets. The Intel cables add only 550 pSec of signaling latency per dual optical/electrical conversion, giving them latency characteristics on a par with 24 AWG copper cables. In addition, with a BER of 10^{-15}, the cables produce 1000 times fewer errors per day than copper cables rated at a 10^{-12} BER. This low BER is especially important for maintaining the stability of the computing fabric, and should contribute to increased cluster reliability.

Other notable advantages of the Intel Connects Cables are size, weight, the bend radius of the connectors, and the impossibility of EMI-related ground loops. Because they contain no copper cores, the Intel cables are far lighter (84%) and less voluminous (83%) than copper cables. The volume advantage is especially important

for alleviating the airflow issues that tangles of bulky copper cables can cause in scale-out clusters.

With smaller connectors (11%), a tighter bend radius (40%), and lighter cabling, the Intel Connects Cables will be easier to install, modify, and maintain. And with no copper wiring, unintended ground loops should not occur in the Intel cables. In sum, the Intel optical cables promise to provide substantially better data reliability than copper cables, an especially important consideration for large scale-out clusters with thousands (sometimes tens of thousands) of components.

The new cables also present an attractive economic proposition, with pricing close to copper cable pricing at 10-meter lengths and increasingly lower than copper at greater lengths.

With the Intel Connects Cables, Intel is driving optical interconnect technology into the HPC mainstream and making it harder for buyers/users of scale-out and scale-up technical clusters to construct rational arguments against taking the optical route.

"The ability to show actual signal diagrams and BER charts meant that key customers and decision makers went away totally convinced by the performance of our product"

- Tom Wills, General Manager, Intel® Connects Cables

Performance verification

A key element in the development process of advanced interconnect designs is verification of their performance and, in particular, compliance with the required industry standards. As multi-gigabit data rates become common in digital systems, signal integrity - the quality of the signal necessary for proper operation of an integrated circuit - is becoming a paramount concern for designers, and any new cable must be proved not to impact the quality of signals passing through.

Tektronix is well recognized as an expert in signal integrity with proven knowledge in addressing complex, high-speed measurements and analysis. The company also has deep expertise with cable testing, and has been the industry leader in the characterization and compliance validation of the SFF8470 cables used for InfiniBand systems since their initial release in 2002. This active involvement in the InfiniBand compliance and interoperability program, coupled with a strong focus on other emerging serial data technologies, made Tektronix an ideal choice for assisting Intel with the testing of the new Intel Connects Cables.

The Infiniband cable test specification requires that a signal with a specific impairment is provided from a signal source. This was done using the Tektronix AWG7102 arbitrary waveform generator transmitting a test pattern at 5 Gbps. The signal impairment is created using the Tektronix direct synthesis method.

The direct synthesis technique used in the AWG7102 is a sampling-based technology which creates analog waveforms from a series of sample points. The sample points in the AWG's memory can be used to define essentially any waveform, including digital pulses. In the Tektronix AWG7000 Series, this versatility is linked with an exceptionally high sample rate – up to 20 GS/s – which is supported by additional features including multiple outputs and ample memory to support long pattern sequences.

Direct synthesis techniques allow engineers to create any wave shape, including signals that embody the effects of propagation through a transmission line. Parameters such as rise times, pulse shapes, delays and aberrations can all be generated and controlled - which is exactly what is required for rigorous serial bus testing applications like the Intel cables.

Intentionally applied anomalies are not the only benefit of the direct synthesis AWG approach. The instrument can create multi-level signals containing high, low and idle states without the aid of external tools. It can produce data in any format with embedded jitter or noise, again without help from external modulators. Unlike other solutions, an AWG can originate a test signal with all the required timing, amplitude, and distortion characteristics rather than producing a clean signal and degrading it after the fact. In fact, the AWG7102 is capable of providing precise, programmable impaired signals at up to 6 Gbps, providing a unique solution for both cable and receiver tests in high-speed serial links.

To examine the signal after it has passed through the cable, a high-speed sampling oscilloscope equipped with eye-diagram analysis capabilities is required, and Intel used a Tektronix DSA8200 sampling digital signal analyzer to make these measurements. Tektronix 80SJNB Advanced jitter, noise and BER analysis software was used to analyze the BER down to the cable's 10^{-15} BER specification.

Intel first invited Tektronix to work with them on the launch of its new cable in Hillsboro, Oregon. The Tektronix testing team, comprising engineers from the company's Technology Solutions Group, the Electro – Optical Product Line and the Signal Sources Product Line used the AWG7102 arbitrary waveform generator to generate a high-speed InfiniBand serial signal, transmit it down the 100-meter Intel Connects Cable, and observe the waveform at the far end with the DSA8200 digital serial analyzer sampling scope and 80E10 sampling head. Results were analyzed using the 80SJNB jitter, noise and bit-error-rate software. From these, Tektronix engineers were able to prove that Intel's new cable performed fully to specification and very favorably when compared to conventional copper cable solutions.

Product launch

The official launch of the new cable followed at the ISC 2007 annual high-performance computing (HPC) conference in Dresden, Germany, on June 26th to 29th 2007. For the event, Tektronix provided the full test set-up, and Tektronix engineers worked alongside Intel's team to support the launch and demonstrate the cable's performance. Joint presentations were made to a number of major industry end users, OEMs and Integrators with impressive results.

"I want to express my appreciation and gratitude for everything the Tektronix InfiniBand products team did."

- Jon Putnam, Intel Launch & Communication Manager

Intel was delighted with the support they got from Tektronix, and in particular the quality of the engineering expertise available to back up the technical excellence of the products: "I want to express my appreciation and gratitude for everything the Tektronix InfiniBand products team did both before and at the ISC event to help Intel with the launch of the Intel Connects cable," said Jon Putnam, Intel's launch and communications manager. "The initial on-site demo was excellent and totally convincing, and the ability to show actual signal diagrams and BER charts meant that key customers and decision makers went away totally convinced by the performance of our product."