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The Evolution of Technologies for Mass Market Optical Networking

A White Paper from CIR

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The following paper was drawn from a CIR report, "Data Communications Transceiver Markets: The Next Five Years"

Optical Integration

We have now reached a point in the evolution of the data networking market where millions of optical networking interfaces are being sold. The growing need for bandwidth, especially for digital video applications speaks to the demand side while a variety of technical trends ranging from new approaches to optical device integration to the widespread adoption of new MSAs drives supply side.

Interestingly – perhaps ironically – some of the technology that has is enabling the transition to high volume optical networks can be traced back to developments in electronics as much as in pure optics. For example, while dispersion compensation was once seen mostly as an optical processing technology, it is *electronic* dispersion compensation (EDC) that has proven to be the enabler for one of the great leaps forward in 10 GigE networking, namely the LRM module. As EDC continues to evolve; the next generation of EDC may be deployed in order to lower power consumption requirements.

However, integration is where optical networking will borrow most extensively from electronics in order to enable the first mass market optical networks. Optical integration processes will be the means to radically reduce optical transceiver costs in much the same way that VLSI produced powerful microelectronics at throw away prices.

Optical integration using non-silicon semiconductors—for example, InP—is already fairly standard in the form of integration of lasers and modulators. However, CIR believes that in the future, optical integration solutions will increasingly be targeted to cost, performance and footprint issues in high-performance communications; it is often seen as a way forward for 100 GigE, for example. But it also may be a way to bring down the cost of 10 GigE, helping to bring about the mass markets for 10 GigE that CIR believes will emerge in the next five years.

One direction that this kind of integration will take will use InP to draw out the economies implicit in large scale integration of any kind through the integration of a DFB laser with a PIN diode and EDC, for example. But, another direction for optical integration is to use standard CMOS processes and materials, not so much to build lasers, but in other parts of the transceiver. Advocates of this approach believe that it can substantially lower the costs of high-volume transceivers while still using off-the-shelf InP lasers. Luxtera, for example, is claiming that this approach can produce 10-Gbps transceivers that operate at just 1 W four lane QSFP InfiniBand applications. The cost savings would in part come from the silicon detectors that Luxtera says can be fabricated for less than $0.01 and in a very small size—40 sq. microns. Luxtera further claims that its technology will go a long way to drive the cost of 10-Gbps optical ports to well below $100, which would mean that 10 Gbps can be deployed on almost any server that needed one.

Active Optical Cabling

Although this technology will be a key enabler for mass market 10 GigE start to happen, one of Luxtera's first products is actually aimed at a niche market, the InfiniBand replacement market, where Luxtera's Blazar is an optical replacement for the bulky copper InfiniBand cabling. Blazar is used for rack-to-rack connections under 300 meters, but Luxtera believes the technology could be extended to 2 km.

In fact, Blazar is an example, of a relatively new product type that has emerged over the past couple of years; active optical cabling. And some transceiver manufacturers believe it is also applicable to Ethernet and Fibre Channel networks and not just the high performance computing (HPC) networks in which this type of cabling is currently being deployed.

In addition to Luxtera, there is an impressive list of firms that have entered this space, including Finisar and Intel, whose presence adds legitimacy to this new product category. Finisar, for example, has a product in this space that is a currently uses LOMF, but Finisar is pursuing using POF as well. Finisar sees multiple applications for this product including LAN on Motherboard (LOM), PCIe, HDMI and all speeds of FC and Ethernet. Other firms in this space include Reflex Photonics and Zarlink

Cabling and Connectors

While important developments are occurring in the optics and optoelectronics space, the cabling and connector side of the business is also seeing significant activity.

Pre-terminated passive optical cable assemblies have been available for quite some time now but are now achieving volume shipments as the data center market is healthy again. These products can be either MPO cassette-based or trunk cables that have an MPO connector on one end and simplex or duplex connectors (typically SC or LC) on the other end. By purchasing these pre-term assemblies, data center managers save time and rework associated with field-terminated fiber. The reliability of these factory-terminated assemblies is much better as well because of the much cleaner controlled environment.

Other improvements in dispersion in the LAN have really been in the form of improved differential mode delay in LOMF. There are now fibers available on the market today that have a specified bandwidth of 4,900 MHz●km that can reach as far as 600 meters at 10 Gbps.

The Standards Question

As these technology trends progress, clear trends are beginning to emerge as to how they will be packaged together. As is usual, the IEEE has come up with numerous physical standards for 10 GigE and, as is equally usual, only a few of them are really going to matter from a dollars and cents point of view. Three of them, 10GBASE-LRM, 10GBASE-SR and 10GBASE-T are, in CIR's opinion, most likely to attract major attention from vendors in the next five years as they all seem to address the needs of a substantial proportion of likely purchasers of 10-GigE in the data center.

10GBASE-SR has enabled the growth of the technology; much like its predecessor 1000BASE-SX. Because LRM uses serial technology as opposed to CWDM-like LX4, they are quickly replacing the LX4 in legacy infrastructures that would like to upgrade to 10-Gigabit Ethernet. 10GBASE-T on the other hand, really has not started to grow, yet due to difficulty in obtaining transceiver chips that can be incorporated in multi-port switches. The digital signal processing required to run this variant on 100 meters of cable has proven to be very difficult and high in power consumption. However, CIR believes that when chip manufacturers settle these issues and switch manufacturers adopt 10GBASE-T ports, CIR anticipates that 10-Gigabit Ethernet will see a surge in growth.

Meanwhile, a new and interesting opportunity that seems to be emerging is that of Energy Efficient Ethernet. The relevant IEEE Task Force was formed late in 2007 and its primary focus is to help in the "greening" of data centers. The fiber optic versions of this will be worked on after the copper version is complete which is not expected to happen until 2009.

When looking for opportunities in the MSA side of the equation one is immediately drawn to SFP+. SFP+ modules have already been introduced for short-reach 10GigE and 8 Gbps Fibre Channel continuing the tradition of placing lower-end transmission subsystems in an SFP-style module. For a brief period it looked as if the MSA savior would be XFP but then along came SFP+ which was even better designed for short reach applications. By default this automatically repositioned XFP as the MSA for the next generation of longer-reach applications but XFP has several technical challenges and has never received been blessed by Cisco.

SFP+ was originally aimed at the 8/10-Gbps Fibre Channel space, but now seems to have broader applicability. It seems to be well liked by equipment vendors, including the all-important Cisco, it is 30-percent smaller than XFP, lower on power consumption, simpler (requires fewer components) and is potentially less expensive. A particularly attractive feature of SFP+ is that because of its small size and low thermal output, it can offer densities comparable to GigE, something no other 10-Gbps MSA can boast.

Putting all of the above together, we can see that there are a number of key technical trends that are making the possibility of mass market optical networking possible namely, new approaches to device integration, better media choices, and an optimization of physical layer formats and MSAs. Similar trends brought us mass market high-speed electronic networking a few decades back and so CIR believes there are encouraging sign for the optical future.

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