Revenue Opportunities for Optical Interconnects: Market and Technology Forecast 2013-2020

Vol. 1 Board-Board and Rack-Rack

Chapter One

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PO Box 4353, Charlottesville, VA 22905
www.cir-inc.com
sales@cir-inc.com
Tel: 434-872-9008 Fax: 434-872-9014

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Report Summary

Much has happened to spur opportunities in the optical interconnect (OIC) business in the past couple of years. Demand on the data centers and local networks has accelerated as entirely new kinds of data traffic such as 3D video, big dataand social networking has begun to predominate. At the same time we have seen the rise of cloud computing, a networking architecture that fundamentally changes the way that computing is done.

Some observers believe that the current generation of I/O technology isn't up to coping with this change and on its current roadmap is likely to find itself squeezed increasingly by the new kinds of traffic and new ways of doing networking. Conventional I/O technology development appears to be lagging traffic growth and to make matters worse, power consumption of traditional copper I/O is inconsistent with the goal of green computingand saving energy costs in data centers.

CIR believes that these trends will spur business for manufacturers of OICs and related products, who now face large addressable markets—corporate servers and large routers—where once they dealt only with niches. This report is designed to provide guidance to firms that are designing market strategies for future OIC markets, whether they be optical module and connector makers, fiber manufacturers or computing and telecommunications firms.

In addition, to showing how the markets for OICs will evolve, this report looks at the daunting challenges facing optical interconnection; primarily providing cost-effective optical technology in markets that are used to paying only minimal amounts for metal connectivity. Also included in the report is an analysis of the evolution of OIC technology including the role of AOCs in the optical interconnect space and the eventual shift to waveguide backplanes and other advanced optical technologies. In its granular eight-year forecasts, this report also quantifies how much those opportunities will be worth.

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PO Box 4353, Charlottesville, VA 22905
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Acronyms and Abbreviations Used in this Report

List of Exhibits

See Related Report:

Revenue Opportunities for Optical Interconnects—Market and Technology Forecasts 2013-2021: Vol. II

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Chapter One: Introduction

1.1 Background to this Report

1.1.1 The Market Bifurcates: Why Two Volumes

CIR last published a report on the optical interconnect market in 2010. The goal of the report at the time was to provide a full analysis of the optical interconnect business, which was taken to include:

- Optical cable assemblies inside equipment as well as between equipment, or defined as board-to-board and rack-to-rack, respectively;
- Motherboard/daughterboard and backplanes board-level optical interconnects;
- On-chip and chip-to-chip optical interconnects.

In this year's CIR analysis we are covering the market in two reports, focusing primarily on the products mentioned in the first bullet point (and some of those in the second bullet point) in this first volume and the balance of the products in the second volume. The markets into which these products are sold are principally data centers of one kind or another. However, optical interconnects also have a market in the rather specialized area of VSR telecom and the (possibly) emerging area of optical communications for consumer electronics.

The reason why we have chosen to split this report into two volumes is that, while the big drivers are the same throughout the optical interconnect market, optical interconnect solutions are increasingly of two kinds considered from the supply side of the equation:

- Optical assemblies for *macro* level interconnection at the rack-to-rack and board to board level. Roughly speaking this means interconnection at above 50 cm and up to a 1 km; although often a few meters. The point here though is not so much the range as the technology. The optical assemblies that we are talking about here are not—by the standards of today—all that technologically sophisticated and in some ways they are not all that different from the optical data links that could be easily bought in the early 1980s.

- Photonic chips and waveguides that are suitable for chip-to-chip and some on-chip applications. This is a research area that has been explored for the past 20 years and still has yet to see much commercialization. It is much more of a technology and materials play than the "optical assemblies" sector and this is reflected in the firms and research organizations involved in this part of the business. This part of the optical interconnect business is covered in the second volume associated with this report.

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1.1.2 Three New Drivers for Optical Interconnects: Power, Security and Content

As the above indicates, interest in optical interconnects at both the research and commercial level is decades old. Generally, this has been justified by the fact that higher data rate requirements and the inevitable march to higher processors would eventually make it all-but-certain that optical communications become ubiquitous at every level of the networking and computing hierarchy.

CIR still believes that these arguments hold true, but they are very general arguments and say very little about what the timeframe will be for their implementation. A cynic may also point to the fact that over the years the urgency that some vendors have placed on how important it is to move to local optical communications has been exaggerated. Fiber-to-home and fiber-to-the-desk are technologies that have been coming real soon now for decades. And in the area of interconnects specifically, it is interesting to recall that Intel-Apple Thunderbolt was once supposed to be an optical standard. But it turned out that even at the speeds that Thunderbolt now offers, copper would serve current needs.

However, CIR believes that in the past few years a new set of concerns has come into being in the data center that has led to an inflection point and leap in interest in optical interconnects. These concerns are of three kinds: power consumption, needs for security, and support for new kinds of content and content architectures. All three of these areas are factors that have been stressed since the earliest days of optical networking.

What CIR believes is that in the past two to three years, these three factors have reached a level of importance where they shape the market for optical interconnection and define the opportunities within the optical interconnection space.

Power consumption: CIR believes that this may be the main factor influencing the shift to optics in the data center. It is true that data centers have always been concerned with power consumption to some extent. But in the era of rising real prices for energy as a long-term trend this issue has suddenly become crucial, not just important; a qualitative, not just a quantitative change. A second aspect of all this is that energy supplies are very uncertain in regions where electricity is petroleum generated.

What lies behind this power consumption driver for optical interconnection, however, is the now classic architecture for data centers with a hierarchy of switches interconnected with multiple 10-Gbps connections. This shift to this architecture has been one of the great innovations in data communications, but it has been costly in terms power consumption by O-E and E-0 conversions.

Optical interconnection offers a potential solution to this problem and is therefore an opportunity, where it can be cost effectively deployed.

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Data security: Again, there is nothing new in relying on optics for enhanced security. Indeed, it has been one of the factors that made the military and intelligence services pioneers in the use of fiber optics as early as the 1970s.

However, in the past few years, data security has become a much bigger issue than it has ever been and a great deal of attention has been drawn to this issue by well publicized cyber security breaches. From a business perspective what is therefore happening is that the addressable market for cyber security has expanded dramatically, shifting from just government, aerospace, financial institutions and medical facilities to a much larger group of organizations.

While fiber optics is hard to tap into, security breaches on fiber networks are not impossible. Nonetheless, CIR expects the high level of interest in cyber security to fuel sales of local optical communications of all kinds, and optical interconnects in particular.

Content and content architectures: The almost inevitable mantra associated with any discussion of fiber optics over the past few decades is about fiber optics high-bandwidth and the claim that only optical networking has the bandwidth to support the coming revolution in video that was about to take place.

This was a nice story but hard to justify in reality. For many years there was more talk than action about video, and copper cabling solutions seemed more than adequate to do the job. However, in the past five years, digital video has become ubiquitous filling up bandwidth and the impact is beginning to show. Video providers have been at the forefront of those pushing for Terabit networking standards, for example.

And the trend towards video continues to accelerate. Its main impact is felt higher up the networking hierarchy than at the interconnect level, but it is already being felt there. In particular, it is not at all unusual these days for a data center to have to store large amounts of uncompressed video and this need will only increase as the video in question becomes increasingly high-definition, *ultra*-high-def and 3D in nature.

Incidentally, this brings data center-like bandwidth issues to the home, perhaps creating opportunities for interconnect-like products for the home. Making the need for bandwidth even higher is the need for real-time communications; and not just video communications, but also machine vision and the like. The need for optical communications in these applications environments is stimulated by more than just the need for more bandwidth. Latency issues are also paramount. And while optical interconnect demand has always been correlated with faster processors, the growing need to deploy high-powered video cards and video processors is another factor that is driving up the need for optical interconnects.

One of the newest data communications innovations—the cloud—may also have an impact on the optical interconnect business. Clouds are architectures in which applications are delivered as services over the Internet. Data intensive cloud architectures cannot help but push up the need for bandwidth, but clouds are simply too

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new to completely understand the intensity with which they might dive the optical interconnection business.

1.1.3 The Danger of Market Overshoot: Technology Change Moving Slowly

As all of the above suggests, there are a lot of good reasons to be bullish about the optical interconnect market and the opportunities within it. And CIR thinks that these reasons have increased considerably since CIR produced its previous report on this topic in 2010. However, we also think that there is a danger of optical interconnect firms overshooting the market:

- One reason for seeing this as a possibility is that the optical communications industry has had binges of over enthusiasm before and so, we believe, should always be wary about the market assumptions that it is making.

- Secondly, as we hinted in descriptions of the three main drivers for optical interconnects, these drivers represent problems for the data center community that cannot be entirely fixed by optical interconnects and to some extent these drivers also speed up the development and deployment of other technologies. The power efficiency issue, for example, is also derived from fast switching fabrics and there are many different ways of dealing with energy efficiency; optical interconnection is just one. As for security, there are many kinds of security breaches that cannot be dealt with using fiber optics.

- More controversially, we wonder aloud in this report whether the current technology is up to all it promises. Some of the technologies that have been promised for two decades that were supposed to lead to a ubiquitous optical network and to be especially relevant to optical interconnects have just not been commercialized as fast as some expected. These technologies include the interrelated areas of optical integration, silicon photonics, optical integrated circuits, etc. However, most of these technologies have their greatest relevance to chip-to-chip and on-chip interconnection that is discussed in the second volume of this report

The market is certainly looking for breakthroughs related to the issues outlined above. Any firm that can make a great leap forward in any of these areas with an interconnect play will most likely make a lot of money and expand the optical interconnect market at the same time.

However, even if somehow the trends that we have emphasized above turn out to be far less powerful in the optical interconnect market than we expect, the trend towards local optics—including optical interconnects—has a certain inevitability about it. At some point, processor speeds will reach a point where optical interconnects will be required in most standard business computers.

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1.2 Objectives of this Report

This report is intended to provide in-depth analysis of the optical interconnect market, other than chip-level developments. In particular, the report is designed to identify th opportunities in this space for makers of cables, transceivers, lasers and optica assemblies of various kinds. Interconnect implies that reach is short, but we haven't specifically defined what that reach will be, since there are a lot of variations with circumstances and the cost of an interconnect depends on the connectors and active components, not on the cabling.

The report also includes a eight-year forecast of the non-chip level with break-outs by type of product application and reach. Optical interconnect components covered in this report are detailed in Exhibit 1-1 below. From a geographical perspective this report is worldwide in scope. From an end-user market, the focus is overwhelmingly on the data center, but VSR telecom and consumer electronics is also covered.

Exhibit 1-1:
Optical Interconnection Components

Product Category	Description
Cable Assemblies	Inside equipment, between equipment within racks and between racks. Typical networking protocols include Ethernet, Fibre Channel, InfiniBand, PCI-Express
Cable	MMF, SMF
Connectors	Optical connectors used/needed

Source: Communications Industry Researchers, Inc.

1.3 Methodology and Information Sources for this Report

Sensible forecasting and autonomous thinking are the staples of CIR's analysis. CIR has been forecasting developments in the optical telecom and data communications business since 1985. The details of our forecasting methodology are provided in the main body of this report.

Extensive secondary research for this report was accomplished by reviewing many sources. These information providers included research journals, SEC reports, standards bodies (IEEE, T11), trade shows, conferences (OFCNFOEC, SC2009, ISSCC), marketing groups (Ethernet Alliance, FCIA), corporate Web sites and previous CIR reports.

1.4 Plan of this Report

In Chapter Two, we discuss the markets for optical interconnects, which will include VSR telecom, servers and SANs (data centers) cabling, and possible consumer applications. In Chapter Three we review the products and standards that are emerging around optical interconnects. Chapter Four includes forecasts for optical interconnect products by product type.

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