# Active Optical Cabling: A Technology Assessment and Market Forecast

## *Chapter One*

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## Active Optical Cabling: A Technology Assessment and Market Forecast

The converging bandwidth and form-factor demands of data center, PC interconnect, and consumer electronics has led to an industry-wide drive to re-package parallel optics in an easy-to-use cable bundle; the active optical cable (AOC). Cynics may point out that there have been efforts like this before, but better lasers and improvements in both fiber media and the optoelectronics inside transceiver modules suggest that this time around AOCs will generate significant new business revenues for the optical networking business.

As a result, AOC technology is attracting interest from some of the biggest name in fiber optic networking components and modules including Finisar, Intel, and Tyco, as well as more specialist companies such as Lightwire, Luxtera, Reflex Photonics, Tyco and Zarlink. Meanwhile, the AOC "movement" has achieved added credibility through the decision of the Small Form Factor group within the T11 Technical Committee, to standardize a common module for Fibre Channel, InfiniBand, SAS, and Ethernet, called SFF-8436. By attaching such a physical device to an optical fiber during manufacturing, the developer of an AOC allows a customer to remove a copper-based pluggable transceiver and plug in an optical replacement. For the unsophisticated owner of a PC or server, clustering a device with AOC can be as simple as connecting an Ethernet cable. And while the initial markets for AOCs will all be very-short reach, several firms are already developing AOCs with reaches capable of supporting campus networks.

All this sounds very exciting; a new opportunity at a time when the optical networking business is going through hard times again. However, optical networking has overreached in the marketplace in the past and with disastrous results.

With this in mind, this report provides a realistic assessment of the prospects for AOCs in all the markets to which it is being targeted; data centers and enterprise networks, home theater and consumer electronics, signage, instrumentation, and personal electronics. As part of its goal to analyze and quantify the market for AOCs in this sector, CIR also compares AOC to other low-cost optical interfaces (including the simplified serial optics embodied in the new USB 3.0.) and also the latest in copper connectivity.

The report contains a granular five-year forecast of the AOC market with a consideration of multiple scenarios in new - but potentially large - markets such as personal computing and home video. It also considers supply chain issues and how firms that have traditionally supplied products for high-end data center or telecom applications can break into mass markets of this kind.

Although this report covers a new area, it draws on CIR's decades-long experience on covering opportunities in the transceiver/transponder and laser business and we believe that it will be essential reading for strategic planners and marketing managers at manufacturers of cabling, components, transceiver/transponders, equipment and consumer electronics.

 

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# Chapter One: Introduction

## 1.1 Background to this Report

### 1.1.1 AOCs: Opportunities and Risks

Active optical cabling (AOCs) is a black-box solution to creating a fiber optic connection and consists of a complete fiber optic data link (transceivers plus cable) can be plugged into existing ports, enabling a very rapid introduction of optical connections. AOCs do not need any great leaps of faith with regard to the adoption of new technologies. They simply provide customers with access to all the undisputed advantages of fiber (high-bandwidth, relatively thin, light-weight cable, etc.) in a plug-in format.

Although interesting new technologies (such as Luxtera's silicon photonics) may be employed inside the AOC, the AOC itself is a design innovation, not a technology innovation. This is surely comforting in some quarters, since the past decade has seen so many futuristic and much touted telecommunications technologies crash and burn in the marketplace. This low-risk look and feel that the AOC market has about it is also enhanced by the fact that the market that AOC business is currently most focused on lies in the replacement of copper cabling in large data centers and (to a lesser extent) among boards insider of supercomputers, large switches and core routers. With advent of 10 Gbps and above interconnection, copper cabling has simply become too bulky to be effectively managed.

Again there seem to few big risks involved here. No one really doubts that copper will quite quickly give way to fiber in the markets listed above and the requirements for cabling in these markets are fairly well defined. There are certainly other ways for network managers to move to fiber optic solutions, but none of them are as easy to handle as AOCs and this is a big market advantage for AOCs, since network managers tends to be managers before they are technologists; this is the nature of their job.

However, if this was all there was to the AOC market, it would probably have never have attracted the current level of attention. The real reason for all the excitement is that AOCs may find mass market acceptability in the personal computing and consumer electronics sector and this is suggesting to some firms that once implicit ceilings on their future revenue growth will be disappear within a few years. A company that once saw its growth limited by the fact that – like it or not – there are just so many supercomputer or core router interfaces that will be sold in any

given year might now have reasonable expectations of penetrating markets where unit volumes are measures in tens and hundreds of millions, not thousands.

There's a price to pay though, while the market for AOCs in the high-performance computing (HPC), data center and related markets is more or less a sure thing, the market for AOCs for personal computing, displays, digital signage and so on is highly speculative.

### 1.1.2 The Breadth of AOC's Market Reach

Thus it is the breadth of AOC's market reach that is really providing a lot of the excitement. As we have already noted, the first and most obvious area in which AOCs will be important is in several applications related to the data center and HPC cluster.

**Data center applications:** Such applications can include internal backplane interconnect, external "back of the chassis" board-to-board interconnect, short-reach box-to-box links, and longer links that may extend room-to-room, floor-to-floor, or across a campus. While Luxtera has demonstrated active cabling operating to 4 km, it is important to emphasize that the bulk of customer interest for AOCs is centered on cabling from 15 to 30 meters in reach.

Nevertheless, there are also markets that go beyond this reach. Vendors surveyed by CIR emphasize that distances from 30 to 100 meters also represent an area of interest for customers, albeit a nascent market. But distances from 100 to 1000 meters are seen as highly experimental; while reaches beyond 1 km are rarely encountered in HPC or Internet peering centers, except for specialized distributed centers studied in academia. CIR believes that the market for at least the next few years will be largely a copper-replacement market. And if a server designer or network planner already has developed a short-reach or long-reach 10G Ethernet fiber solution based on standard transceivers, AOC only displaces such standard fiber solutions in special cases.

**Beyond the data center:** The market challenges for AOCs to penetrate standard PC port and residential HDMI/DisplayPort applications, are, we believe, quite considerable. Certainly, AOC has strong points to make in regard to ease of end-user adoption and advantages of form-factor standardization. (These are mostly the same points that would be made in the data center.)

But a parallel optical port that competes with a fiber-based USB 3.0 will be a tough challenge for the desktop. Only a market push by the likes of an Intel, Dell, or HP that resembles Apple's push for FireWire seems likely to drive users toward a broad-based turn to AOC. In this case, "broad-based" may mean in practice only a quarter of all PCs shipped having an AOC port with this point

 

being reached only over a period of years. But this would still count as a huge success to firms that until now have been constricted to sell their products into the high-end data center market.
In the television market, users may be easily convinced of the need for high-quality connections for the digital den, but may not be so easily convinced that a pre-configured AOC cable for HDMI or DisplayPort will represent a solid improvement over standard copper links. Some video hobbyists may gravitate with ease to AOC, the same that would quickly choose a gold-terminated coaxial cable for signal quality. Whether this sector represents more than a small minority, however, is still very open for question.

### 1.1.3 AOCs and the Reemergence of Parallel Optics

While AOCs are currently being pitched as something new, which they are in a sense, they can also be viewed as the latest wrinkle in a decades-old debate pitting parallel interfaces against serial equivalents as backplane interconnects and short-haul external connections. An examination of this history is useful to explaining by AOCs have suddenly become so interesting to the market. Perhaps more importantly, it provides a guide to the kind of challenges that AOCs may face during their product evolution.

Although not all AOCs use parallel optics, most do and there can be little doubt that the re-emergence of parallel optics as an influential technology has proved a key enabler for AOCs. There has always been an inherent struggle between the more efficient data transport capabilities represented by channels operating in parallel, and the higher costs in power dissipation and noise from board-level traces caused by the use of such parallel channels. In essence, speed demons in the board-level and network-level communication world often advocated parallel interconnect, while serial proponents represented a so-called voice of practicality. Advocates of serial fiber interfaces also often claimed that their approach also lead to easier data management.

In any case, serial solution often won out as the most practical means of connecting supercomputers or network equipment, even though parallel optical coalitions often touted specialized interfaces, such as Optologic from Motorola (now Freescale Semiconductor), or POLO (Parallel Optic Link Organization) from Hewlett-Packard Co. When confronted with the problems of crosstalk and skew encountered in wide parallel buses, the IT industry largely abandoned parallel interconnect in favor of serial techniques borrowed from the storage industry. Virtually all major storage attachment standards, including Fibre Channel, Serial Attached Storage, and Serial SCSI, are therefore based on serial interfaces. Parallel signals within the

computer or server processor (or processor-chipset cluster) are preserved, but are converted to a serial stream using a SERDES (serializer-deserializer) device.

InifiniBand, again a serial interface serving the high end, tried to stick with copper interconnect alternatives and this was supported by InifiniBand's switch-fabric architecture. The Personal Computer Manufacturers Industrial Group, or PCMIG, tried to update PCI Express in the same fashion by defining a switch fabric extension to PCIe, though it did not gain enough momentum to approach critical mass. The breadth of chip-level switch and MAC architectures, however, allowed a range of high-end twisted-pair copper, coaxial cable, multimode fiber, and single-mode fiber solutions to compete for data center applications at different maximum-reach distances.

A reemergence of interest in examining the capability of low-profile *parallel* interconnects began with the unanticipated chaos created in drafting a Multi-Source Agreement (MSA) for 10-Gbit Ethernet. Because standards bodies like ANSI and IEEE do not specify details of an optoelectronic transceiver package, leading manufacturers have come up with common package agreements, beginning in the 1990s. Relatively recently, in order to support a mild degree of parallelism for high-speed applications, an MSA agreement has emerged for a four-channel SFP, or QSFP.

**QSFP and AOCs:** QSFP has built on the acceptance of earlier four-channel IEEE Ethernet standard interfaces such as LX-4 and CX-4. Four-channel support also will be extended to 40-Gbit Ethernet through the use of Coarse Wave-Division Multiplexing (CWDM) channels using the XFI interface, in the upcoming X40 MSA. For now however the availability of the QSFP package represents a key enabler allowing an AOC market to emerge.

Also, the availability of QSFP has happened just as server and switch manufacturers, as well as end users in data centers, are expressing dissatisfaction with existing options for short-reach interconnect. Coaxial cable used in CX-4 is too bulky, with a limited bend radius and large diameter, to serve in many space-restricted data centers or HPC clusters. Fiber in many cases remains too expensive, once the cost of both transceiver module and fiber itself was taken into account.

By purchasing QSFP transceivers and fiber optic cables in bulk, and manufacturing assemblies in advance, the early providers of AOC assemblies made it far simpler for OEMs and network integrators to pick the reach desired, as well as speed and characteristics, without becoming experts at fiber transmission. Of course, the availability of QSFP connectors could work to the

 

benefit of coaxial suppliers, too. In July 2009, W.L. Gore & Associates Inc. introduced a Low-Profile Copper Cable that combined QSFP connectors with four-channel copper ribbon. Such a product obviously represents a short-term tactical play for Gore, since fiber always will hold speed advantages over copper equivalents, but it demonstrates the universal utility of offering pre-configured cable assemblies based on low-profile transceiver modules.

This history raises a number of questions with which the emerging AOC business may have to cope. One is whether the old issues about parallelism may rear their heads again. Another is about the relationship of AOCs with current developments in MSAs and data communications standards. A third is about the way that copper active cabling may serve as a competitor for AOCs.

All these issues need to be dealt with by firms active in the AOC space. These firms also need to be clear about the business characteristics, size and growth of the many market segments in which AOCs can apparently compete. Some opportunities in the AOC market that appear tangential may actually emerge as volume leaders. AOC pioneers see digital signage, for example, as a market with growth potential as big as server-cluster applications. Strategies in this space are only just emerging and one must remember that the first two entrants to this market, Luxtera Inc. and Zarlink Semiconductor Inc., introduced their initial products as tactical responses to existing customer needs, with little strategic market analysis aforethought, which, of course, is not to suggest that these firms aren't thinking very hard about these markets.

### 1.2 Objectives of this Report

The main objective of this report is to analyze and quantify all the major market opportunities for AOCs. The focus of the report is principally on potential new business for components, subsystems and modules firms, but in order to understand where this new business is coming from we also examine the end markets in IT, PCs, and consumer electronics – as well as the special industrial and commercial markets often identified as tangential.

A subsidiary objective of this report is to set out a roadmap for the evolution and adoption of the next generation of serial and parallel interconnect in both networks and point-to-point applications. At times, the roles of serial and parallel links will represent a direct competition for ports, while at other times they may be complementary. This report also discusses the current activities of firms that have expressed an interest in competing in these emerging markets in one way or another and we have also provided an assessment of how well such firms are positioned to take advantage of these opportunities as these emerge.

### 1.3 Scope of this Report

This report primarily focuses on the opportunities for components and module manufacturers that we believe will emerge as the result of the emergence of pre-configured AOC assemblies. We do not discuss in detail the new kinds of equipment that could be built to take advantage of AOC links, nor do we dwell on networking issues per se. The emphasis on components and modules fits with CIR's mission, but also reflects the current stage of development of the latest high-speed networks, in which the focus is on emerging technology. As such, this report contains information and analysis that will be important to equipment firms, service providers, network managers and investors, as well as component and module firms.

The areas covered in this report include both the optical and electronic components used in AOC products. Not all of these components are given equal weight and the focus is on those components that will be important for AOC development. These include emerging fiber types, MSA modules, semiconductors used either within or outside (SFP+, QSFP+) the transceiver module, and physical-layer devices such as SERDES and CDR ICs.

### 1.4 Methodology and Information Sources for Report

The information and analysis contained in this report are based on an extensive interview program conducted over several months starting in Q2 2009, extending into late Q3 2009. Firms covered in this program included many of the networking equipment and components firms active in the standardization process for next-generation networks and some firms that have products that seem destined for this space as it emerges. We also talked with some large service providers.

While no claim is made that our selection of firms for interviewing is "scientific" in any obvious sense, we did try to include companies—and interviewees—that were either influential in the segments of the markets that they serve or could potentially be so. In our interviews, we did not use a structured questionnaire, but instead focused our discussions with the firms interviewed on their particular special area of activity. Thus, for example, the focus of our discussions with transceiver module manufacturers was on the characteristics of modules used in AOC assemblies. This approach, CIR believes, leads to the deepest insight into what is really driving markets, since it is based on an insider's perspective.

In addition to the primary research carried out for this report, CIR also conducted an extensive search of secondary sources including research publications, white papers, corporate web sites, SEC information, standards information and previous CIR reports. Lastly, CIR has been actively

 

researching and analyzing the optical market for over twenty years. This market is not new territory for us.

### 1.5 Plan of this Report

Chapter Two of this report reviews the rise of active optical cabling in the data center, and how it has replaced CX-4 media; and has revolutionized serial Ethernet architectures. In Chapter Three we look at the potential of AOC as the basis for a universal parallel optical port on the PC, used in both external connector applications and for LAN-on-Motherboard architectures. In Chapter Four we address consumer electronics in a broad sense, covering both "digital den" video utilizing both HDMI and DisplayPort, and the special commercial applications exemplified by digital signage. Finally, in Chapter Five, we present detailed forecasts of AOC opportunities in these three market sectors