



Data Center Optics Market Volume I – Inside the Data Center

A New CIR Report Coming May 2014

PO Box 4353, Charlottesville, VA 22905
www.cir-inc.com
rick@cir-inc.com
Tel: 434-960-8479 Fax: 434-872-9014

Traffic from data centers are now a major driving force behind the Internet; even the smallest of businesses now rely on data centers for revenue generation. And the largest data centers today are orders of magnitude larger than the supercomputing centers of a few years ago. Until quite recently, for most data center managers, optical data centers were nice to dream about, but not really essential. Perhaps they needed an optical link or two, at most. Today, the all-optical data center – perhaps even an all-SMF data center -- is something that even managers of medium-sized data centers should be considering.

All of these trends means that the opportunities for selling optical networking systems into data centers have expanded considerably in the past few years. In this report, we identify and forecast just what these opportunities are. The markets and market trends discussed in this report include:

Page | 1

- **Next-generation Ethernet.** We discuss how the transition from GigE to 10G, 40G and 100G will lead to significant new revenue generation opportunities for firms with Ethernet products of all types and what the likely roadmap and timetables for optical Ethernet in the data center will look like
- **InfiniBand (IB) and Fibre Channel.** These standards are often declared dead; murdered by Ethernet. But they continue to find large addressable markets and have aggressive roadmaps promoted by their trade associations. This report will show how these standards will profitably fit into the optical data center that is expected to emerge over the next few years
- **Novel networking architectures.** The report will examine how SDN and virtualization will affect physical infrastructure deployment in the coming optical data center and which components and subsystems firms will be able to benefit from this.

This report will also include an assessment of the leading suppliers of optical components and modules and will provide guidance on how the product market strategies of these firms will evolve as the market for optical networking in data centers develops worldwide. The report also includes granular five-year forecasts of both optical transceivers and AOCs with appropriate breakouts by data rate, standards, wavelength and form factor.

Volume II of this report will be published in August, 2014. It will discuss the optical networking opportunities emerging in the access, metro and long-haul networks to support data center connectivity.

Provisional Table of Contents

Executive Summary

Chapter One: Introduction

- 1.1 Background to this report
 - 1.1.1 Enterprise, Internet, co-location
 - 1.1.2 Vertical markets within the enterprise network
- 1.2 Objective and scope of this report
- 1.3 Methodology of this report
- 1.4 Plan of this report

Chapter Two: Analysis of Data Center Networking Trends

- 2.1 Critical server trends driving optical networking in the data center
 - 2.1.1 “Ubiquitous” high-performance computing
 - 2.1.2 Virtualization

- 2.1.3 Changing trends in form factors
- 2.1.4 Tradeoffs in power density/cooling versus bandwidth density
- 2.2 Architectural trends creating opportunities for optical networking in the data center
 - 2.2.1 Top-of-rack (ToR) and End-of-Row (EoR)
 - 2.2.2 The TIA-942 data center
 - 2.2.3 SDN in the data center and its implications
 - 2.2.4 Converged networks
- 2.3 The future of networking standards and MSAs in the data center
 - 2.3.1 Ethernet: All the way to 100G
 - 2.3.2 InfiniBand
 - 2.3.3 Fibre Channel
 - 2.3.4 MSAs evolving
- 2.4 Key points from this chapter

Chapter Three: Product trends for the optical data center network

- 3.1 Fiber versus copper in the data center
 - 3.1.1 Cost analysis
 - 3.1.2 Optical roadmap
- 3.2 Optical products evolution
 - 3.2.1 Gigabit to 400G transceivers
 - 3.2.2 LOMF versus SMF
 - 3.2.3 Field-terminated versus pre-terminated
 - 3.2.4 Optical interconnects in the data center
- 3.3 Key points from this chapter

Chapter Four: Eight Component and Module Suppliers to Watch in the Emerging Optical Data Center

- 4.1 Avago Technologies
- 4.2 Cisco
- 4.3 ColorChip
- 4.4 Finisar
- 4.5 Fujitsu Optical Components
- 4.6 JDSU
- 4.7 Oclaro
- 4.8 Reflex Photonics
- 4.9 Other suppliers of importance

Chapter Five: Five-Year Forecasts of Component/Module Markets in the Optical Data Center

- 5.1 Forecasting methodology
- 5.2 Forecast of optical Ethernet transceivers
 - 5.2.1 Breakout by data rate
 - 5.2.2 Breakout by form factor
 - 5.2.3 Breakout by wavelength
- 5.3 Forecast of IB transceivers
 - 5.3.1 Breakout by data rate
 - 5.3.2 Breakout by form factor
 - 5.3.3 Breakout by wavelength
- 5.4 Forecast of Fibre Channel transceivers
 - 5.4.1 Breakout by data rate

5.4.2 Breakout by form factor
5.4.3 Breakout by wavelength
5.5 Forecast of AOCs in the optical data center

Acronyms used in this report
About the author

Chapter One: Introduction

1.1 Background to this Report

Data centers are the driving force behind the Internet. Some of the most sophisticated ones are known as high-performance computing centers. And, even the smallest of businesses now rely on data centers for revenue generation. This, along with people's insatiable need to always be connected, is driving equipment and bandwidth needs in data centers. With this need comes increasing reliance on fiber optics.

Page | 4

CIR will be presenting two new market research reports on data centers: Optics Inside the Data Center and Optics Connecting Data Centers. This first volume discusses how optics is used in data centers. Products stemming from the transition from Gigabit Ethernet to 10G, 40G and 100G are analyzed. Standard networking protocols, such as Ethernet, Fibre Channel and InfiniBand that are used in data center are detailed. Networking architectures and technologies like SDN, virtualization and disaggregated racks and how they affect physical infrastructure is presented. Assessments of top optical components suppliers are included.

1.1.1 Demands in Data Center Networks – Enterprise, Internet, Co-location

The data center is at the heart of every local area network (LAN), whether it is a large Internet service provider (ISP) or a small K-12 school. And, while each have different networking requirements, all contain at least some type of optics. The following table shows a summary of the types of businesses, relative size of their data centers, networking technologies and data rates that are used in each. Smaller data centers are just starting to adopt 10 Gbps Ethernet, while large ones are pushing for 100G.

In addition, smaller data centers tend to use Ethernet network-attached storage or iSCSI for their storage area networks (SAN), while larger ones use Fibre Channel. What is also interesting to note is that Internet Data Centers, like Facebook, Google and Microsoft, are quickly adopting 10G and above data rates, while co-location facilities will support 40G down to 1G for quite some time – a reflection of their enterprise customers.

Exhibit 1-1: Data Center Networks by Vertical Markets				
Business	Size (sq. ft.)	Number of Racks	Data Rates (Gbps)	Networking Technologies
Small Financial Manufacturing K12 Schools	<1,000	5-20	1 10	Ethernet, iSCSI
Banks Drug Co. Small Hospitals Higher Education	1,000- 10,000	20-100	1 4 8 10	Ethernet, iSCSI, FC
Large Financial Retail Insurance Large Research Labs Healthcare Web 2.0/IDCs ISPs Co-location	>10,000	>100	1 4 8 10 16 40 100	Ethernet, iSCSI, FC, InfiniBand

In 2012, 10G Ethernet finally surpassed Gigabit Ethernet in the number of ports shipped, more than a decade after the standard was released. But now that it has, its adoption acceleration continues, mostly for server connections in the data center. This drives 40G in the access and aggregation/distribution portions of the data center network as shown in the following diagram.

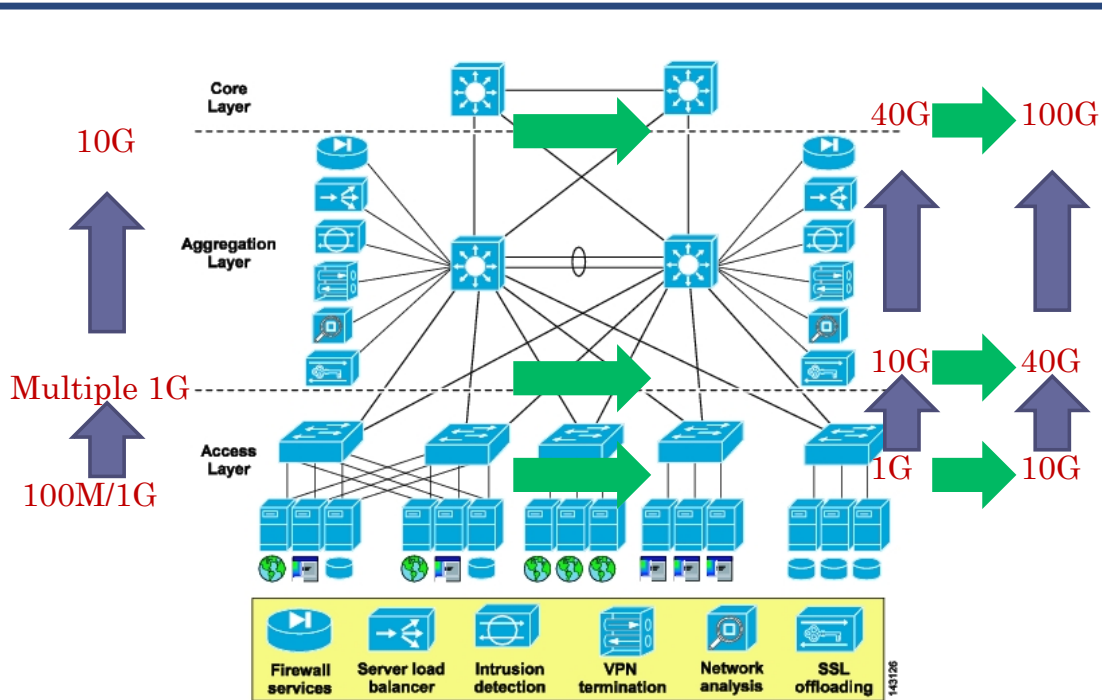


Figure 1: Data Center Network Architecture (Source: Cisco, adapted CIR)

Eventually, probably towards the end of the forecasting period, 100G will come into play inside the data center.

Demand in IDC networks is mostly driven by mobile applications – the fact that you want to upload the picture you just took to Facebook or you want to access a map from your mobile phone. How demand is driven in smaller data centers is similar, but is centered more upon how the particular businesses employees do their jobs. Worldwide, we have become a more mobile workforce and we need access to corporate assets wherever we are. This again drives demand back to “agile” enterprise or co-location data center networks.

1.1.2 Changing Architectures in Data Center Networks

Several years ago, the first change in architecture was incarnated as Fibre Channel over Ethernet (FCoE). It promised to collapse the SAN into the LAN and allow for one data center network. As CIR predicted then and contends now, this did not materialize. While some data centers have adopted FCoE, most still see it as too expensive – they can buy the separate Ethernet Network Interface Cards (NICs) and FC host bus adapters (HBAs) for less than they can buy one converged one. And as we will see later in this report, cost is the major driver in data center networks.

More interesting architecture changes are in the works now. Server virtualization, running many applications on a single server, is driving the data center network to become more flat. The need to move virtual machines from server-to-server on-demand has driven

network traffic from mostly north/south (client-to-server) to east/west (server-to-server.) The issue is that the network architecture has not caught up yet. However, as data rates increase, this is changing.

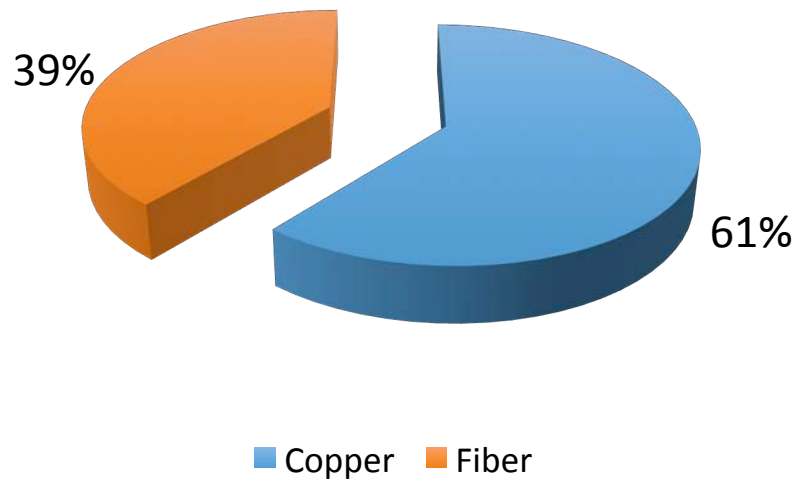
Another relatively new architecture that is being proposed for the very large IDCs are disaggregated racks. This breaks the server apart into its compute, storage and networking components so all of them can be utilized to their full extent. It remains to be seen whether this will be adopted for medium or small data centers, however, as currently these are custom for each type of business.

Page | 7

1.1.3 Data Center Optics

Current optical networks within the data center are evolving. At Gigabit data rates, copper is the prevalent connection media, but at 10G and above, fiber is increasingly chosen. Where fiber was used mainly to connect links longer than 100m in the past, as data rates reach 40G in access to aggregation/distribution links, fiber is used for channels longer than 7m. The share of copper versus fiber in the data center in 2013 and in 2018 is shown in the diagram below.

2013 Media Percentage (Revenue)



2018 Media Percentage (Revenue)

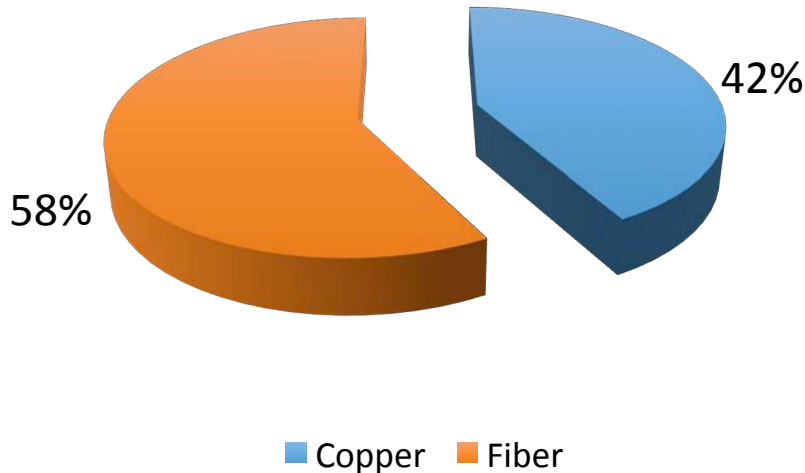


Figure 2: Data Center Media Mix Based on Revenue (Source: CIR)

Gains will be made for both laser-optimized multi-mode fiber (LOMF) and single mode fiber (SMF), which translate into both short-reach optical transceivers (850nm VCSELs) and medium-to-long-reach (1310nm and 1550nm) ones. This report discusses the opportunities for each and who the top suppliers will be.

1.2 Objective and Scope of this Report

The objective of this report is to help guide the strategies of network equipment manufacturers (NEMs), optical components suppliers that sell into the data center as well as a state-of-the-industry guideline for data center operators. By assessing how fiber optics is used in the data center, CIR provides an intelligent independent evaluation of the current and future market.

This report includes an evaluation of the fiber optics market and technologies used in data center networks. While software defined networks (SDN) is all the rage, its implementation in data center networks has been limited, but will continue to evolve. How it works with optics will be discussed. The age-old technologies like Ethernet, Fibre Channel and InfiniBand are reviewed and five-year forecasts are given.

This report is focused on optics used inside the data center. Volume II of the Data Center Optics series will deal with optics connecting data centers.

1.3 Methodology of this Report

We have been tracking data center networks for more than 20 years. It started when we called them computer rooms. By keeping abreast of developments in server technology, CIR's associates analyze the possibilities for data center networks. Whether it is Ethernet and its path to Terabit or InfiniBand and how it is used in HPC, we have a history with depth of knowledge. In addition, our experience comes from actually running some of the networks we cover, which in itself draws a great deal of expertise.

CIR prides itself on independent analysis of markets and technologies. Our methodologies include the entire value chain. For data center optics, our primary research includes speaking with chip manufacturers, optical transceiver manufacturers, connector manufacturers, NEMs, structured cabling manufacturers, data center managers, network equipment engineers and other industry analyst firms (those that cover equipment and service providers).

Secondary research includes attendance at industry trade shows and standards meetings where appropriate. In addition, extensive research is performed using articles, blogs, financial reports, conference proceedings, industry standards and corporate Web sites, as well as previous CIR reports.

1.3.1 Forecasting Methodology

For data centers, we start with the number of servers that are shipped and determine network connections. We examine the underlying addressable markets, for instance, how many 10G connections will be deployed. We develop a price matrix based on average selling price for each device then design a forecast accordingly. Our growth projections are based on both historical data and end user input. By reconciling what suppliers, NEMs and end users are saying and adding our conservative viewpoint, we present reasonable prognostications. These projections are constantly being updated based on actual data.

Page | 10

1.4 Plan of this Report

There are five chapters and an Executive Summary in this report. The Executive Summary highlights the market opportunities and timeline. It is derived from the evaluation that is presented in the rest of the report.

Chapter Two discusses data center and networking trends, which starts with servers and includes HPC, SDN, converged networks and standards. Emerging technologies like disaggregated racks are also discussed.

Chapter Three contains an in-depth analysis of the product trends. It includes a cost analysis between copper and fiber in the data center and presents a roadmap for optics in the data center. Gigabit Ethernet up to and including 400G Ethernet is examined. Alternate technologies to standards-based optics are also evaluated.

Chapter Four covers the top optical component and module suppliers to watch. These include long-standing companies as well as some newcomers.

Chapter Five comprises of the five-year forecasts. These will include Ethernet, Fibre Channel and InfiniBand with several permutations by data rate, form factor and wavelength.