

# Data center optics at the heart of the hyperdata world

white  
paper

**EXFO**

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white paper



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The development of new technologies was traditionally led by telecom and private industries. However, hyperscale data center interconnects have changed this trend dramatically (Figure 1).

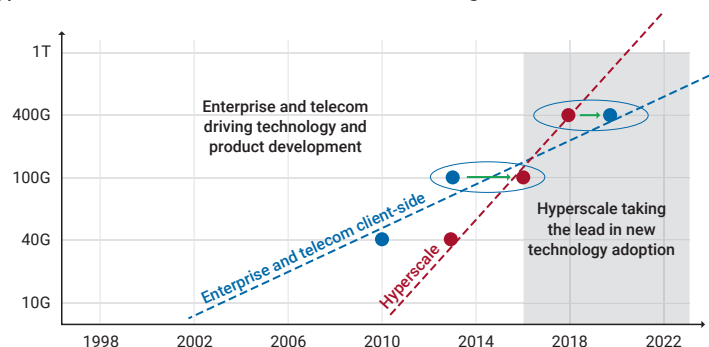


Figure 1. Telecom and datacom adoption timelines  
Source: Lightwave online



The development of new technologies was traditionally led by telecom and private industries. However, hyperscale data center interconnects have changed this trend dramatically.

The availability and increasing rates of Internet interconnections during the past decades have evolved into the Internet of things (IoT), with smartphones, tablets, security cameras and even smart cars driving the need for high-performance transport, storage and processing infrastructure more than ever before.

Growth in the number of interconnected devices is now exponential to the Internet. By 2020, they will exceed the 100 billion connected to Internet, which represents about 26 smart objects per person (source: Cisco, GE, Google). This will generate 600ZB (10x21 bytes), from 145ZB generated in 2015 (source: Cisco CGI).

Originally, interactions between network elements were mainly human to machine (H2M), such as digital voice and video conferencing. Currently, the amount of information processed by IoT, server virtualization and software designed networks is transforming the communication between network elements enabling machine to machine (M2M) interaction and communication.

The consolidation of Internet content providers (ICPs), such as search engines, streaming providers and social media companies that heavily invest in their own networks and interconnections, has caused a jump in server to server (S2S) interactions, which is an even more important type of communication than user to server. Performance, jitter, latency and costs have forced ICPs to locate data centers closer to end users, scaling the data center to data center interconnections and infrastructure, resulting in a larger number of widely spread centers per region—across countries and around the world.

Statistics reveal that traffic within hyper scale centers will quintuple by 2020, reaching 15.3ZB. Traffic within data centers and between them will represent 86% of total datacenter traffic (source: Cisco Global Cloud Index, 2015 - 2020).

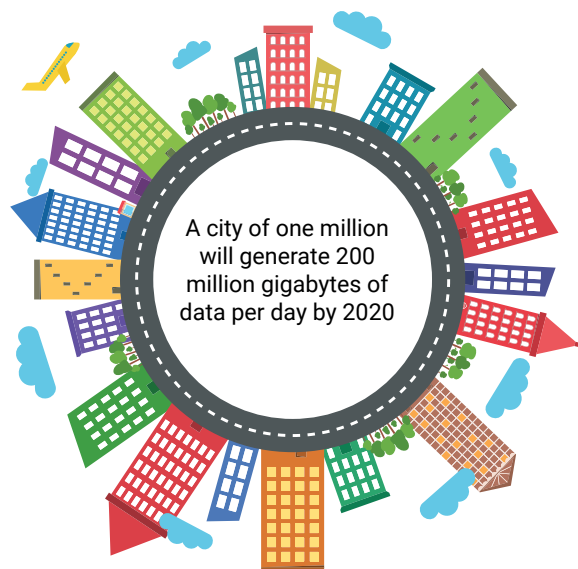
## What makes a smart city? Multiple applications create big data

**Connected plane**  
40 TB per day (0.1% transmitted)

**Connected factory**  
1 PB per day (0.2% transmitted)

**Public safety**  
50 PB per day (<0.1% transmitted)

**Weather sensors**  
10 MB per day (5% transmitted)



**Intelligent building**  
275 GB per day (1% transmitted)

**Smart hospital**  
5 TB per day (0.1% transmitted)

**Smart car**  
70 GB per day (0.1% transmitted)

**Smart Grid**  
5 GB per day (1% transmitted)

Source: Cisco Global Cloud Index, 2015-2020

Interconnection complexity and geographical access between ICPs and end users add more links to the chain. Although ICPs own a lot of fiber infrastructure and are constantly expanding their networks, they nevertheless need to work with other entities on the market, including carrier providers and communications service providers (CSPs), such as telecommunications, large broadcasting and cable television companies.

### Data center technology requirements

Specific aspects regarding the growth of the data center market are creating new trends regarding the elements being included in data center networks and interconnections.

The amount of information generated, transported and processed per fiber-pair in the upcoming years will demand maximum bandwidth, and transceivers will be a key requirement to address this demand.

Power consumption and the density of elements deployed per rack unit result in network components that are completely power efficient.

The speed in service activation and deployment for data center interconnections will be the key to success in this market—and operators will require tools that are easy to use and plug and play to help them meet strong standards.

Data center operators will need platforms and elements that are easy to integrate (programmability and automation) into their processes, new implementations and current environments; in addition, operators will have to adopt multipurpose tools that can in one unit that uses different types of technologies, features and rates at the same time.

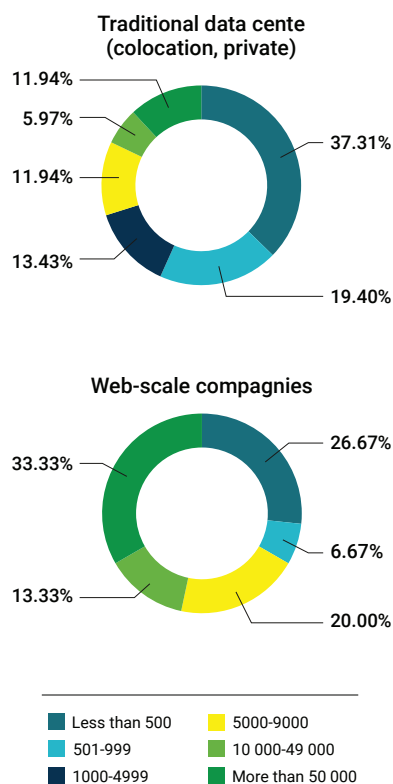


Figure 2. Density of transceivers installed  
Source: EXFO transceiver survey

## Data center transceivers

One component that has been directly impacted by data center market development is the transceiver. The type and density of transceivers used in data center interconnections, also known as pluggables, vary based on the data rates that they transmit and receive as can be seen in figure 2. Optical transceivers have also quickly evolved from low-rate SFP to SFP+, XFP and higher rates, such as CFP, CFP2, CFP4, QSFP+ and QSFP28.

The following table provides a description of the transceivers and rates used at data center interconnections:

Inter-building/long span			
SFP+	LR/CWDM	Enhanced small form-factor pluggable	Up to 16 Gbit/s
SFP28	LR	28 Gbit/s small form-factor pluggable	25 Gbits/s
QSFP	LR4	Quad form-factor pluggable	40 Gbits/s
CFP	LR4	C form-factor pluggable	100 Gbits/s
CFP2	LR4	C form-factor pluggable	100 Gbits/s
CFP4	LR4	C form-factor pluggable	100 Gbits/s
QSFP28	LR4/CWDM4/CLR4	28 Gbit/s QSFP+ quad form-factor pluggable	100 Gbits/s

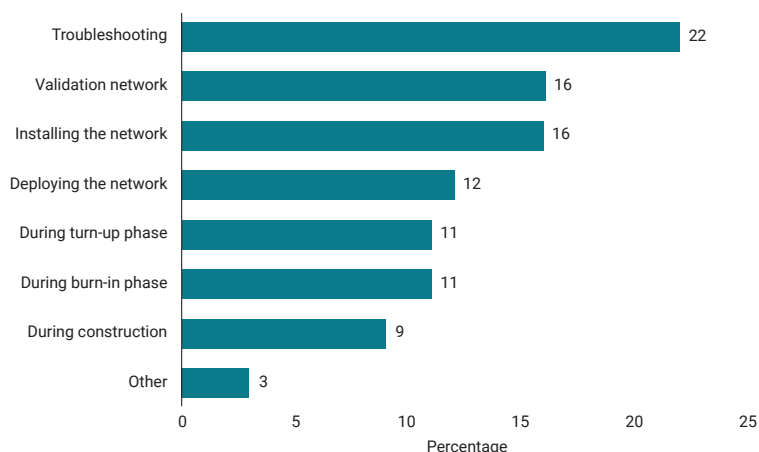
Intra-rack			
SFP+	SR	Enhanced small form-factor pluggable	Up to 16 Gbit/s
SFP28	SR	28 Gbit/s small form-factor pluggable	25 Gbits/s
QSFP+	SR	Quad form-factor pluggable	40 Gbits/s
QSFP28	SR	28 Gbit/s QSFP+ quad form-factor pluggable	100 Gbits/s

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SFP+	SR	Enhanced small form-factor pluggable	Up to 16 Gbit/s
SFP28	SR	28 Gbit/s small form-factor pluggable	25 Gbits/s
QSFP+	SR4	Quad form-factor pluggable	40 Gbits/s
QSFP28	SR4	28 Gbit/s QSFP+ quad form-factor pluggable	100 Gbits/s

Source: Finisar pluggables for data centers guide

The technology used in each one of these pluggables is complex and constantly evolving with the arrival of new manufacturers.

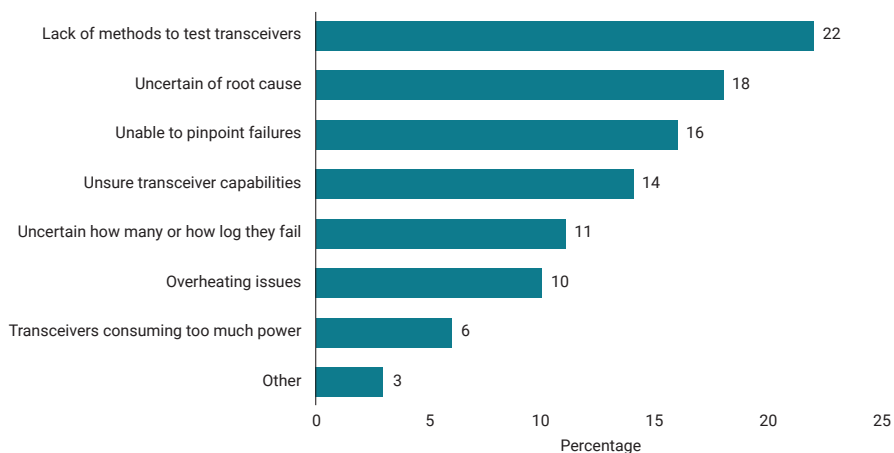
Moreover, these elements are often considered the weakest component of communication links and therefore require special attention. Some operators prefer just to replace them immediately without further testing whenever something looks unexpected. This is an expensive approach, because some devices may still work correctly—but not enough troubleshooting was performed during implementation as shown in Figure 3.



**Figure 3. Circumstances under which transceiver can fail**  
Source: EXFO transceiver survey

The cost of high speed transceivers operating at 40Gb, 100G, 200G and 400G is higher. Data centers cannot afford to have a significant number of spare units. The impact of faulty links in this specific market is critical. It is also worth mentioning that these devices are new to the market; therefore, their reliability levels have not yet reach an acceptable standard. For all these reasons, it's extremely important to acquire and use tools that quickly and accurately assess the quality of pluggable transceivers to ensure that deployment and service activations are done right—in a single test and in a reasonable amount of time. This will reduce the risk of future failures and the need to perform costly, time-consuming troubleshooting activities later on.

Surprisingly, data center operators and data center managers experience transceiver failures at any time during the network deployment cycle when installing, turning-up and troubleshooting. According to a recent EXFO transceiver survey, the top challenges that data center operators and data center managers face in relationship to transceivers are: the lack of methods or standards to test transceivers, uncertainty of root cause of transceiver failures, and the inability to pinpoint where the fault is occurring (Figure 4).



**Figure 4. Transceiver challenges experienced by operators**  
Source: EXFO transceiver survey



EXFO is playing a leading role in understanding the needs of data center operators, contractors, NEMs and CSPs with the launch of its iOptics intelligent pluggable optics test solution.

EXFO is once again playing a leading role in understanding the needs of data center operators, contractors, NEMs and CSPs with the launch of its iOptics intelligent pluggable optics test solution. It is designed to quickly validate the performance of currently available optical transceivers during any phase on the network deployment cycle, using minimal configuration providing key information for users to identify the root cause of their transceiver failures.

## User scenarios

### Video content

In the past, network infrastructure for video transmission relied on copper. However, HD and today's explosive bandwidth demands have incited more and more operators to use optical fiber as it is now being used by ICPs to transport video. Development in fiber optic technologies is making it easier and cost effective to migrate to 10G, 40G and 100G. This migration process generates aggressive deployment schedules requiring automated tools like iOptics to ensure the creation of optical high rate interconnections.

### Reliability

Considering the amount of information processed and transported in a data center, keeping it up and running at all times is a fundamental task; statistics reveal that the average cost of data center downtimes could rise to \$9,000 per minute (source: Cost of Data Center Outages Ponemon Institute). In some situations, any delay or loss in real-time processing may produce catastrophic results. In these types of environments, reliability becomes a priority. The need for troubleshooting tools that help data center operators to quickly identify problems will be the key to success: the iOptics intelligent solution offers an automated, powerful and easy-to-use tool to quickly identify the condition of transceivers within these interconnections.

### Power

Due the increasing density of routers, switches and servers inside hyperscale data centers, it's a fact that energy consumption within them is huge: their energy consumption has grown 90% during the last decade (source: Report to Congress on Server and Data Center Energy Efficiency, Berkley lab). The transceiver manufacturers have jumped on the bandwagon with the hyperscale companies that are developing smaller and more power efficient transceivers capable of maximizing the number of elements per rack unit. Recently, data center contractors, ICPs and CSPs have focused on the energy consumption of transceivers during installation phases; iOptics provides detailed readings of power consumption and voltage in a very graphical and easy-to-read manner for data center operators to plan and implement efficient network infrastructure.

## When and where iOptics should be used

The iOptics intelligent pluggable optics test solution is the industry's first solution to assess any deployed transceiver. It also serves to validate the optical device's proper operation. The iOptics test solution can be run in the following circumstances:

- Prior to installation of a pluggable in a network element
- Before the pluggable is used for a test
- During troubleshooting activities to confirm or discard failure on suspicious interconnection elements

The test uses a physical fiber loopback to validate the device signal continuity, integrity and excessive skews. Appropriate signal attenuation should be used to simulate network conditions and protect the optical device.

## What does the iOptics solution validate?

The iOptics test application performs a sequence of tests that is adjusted according to the

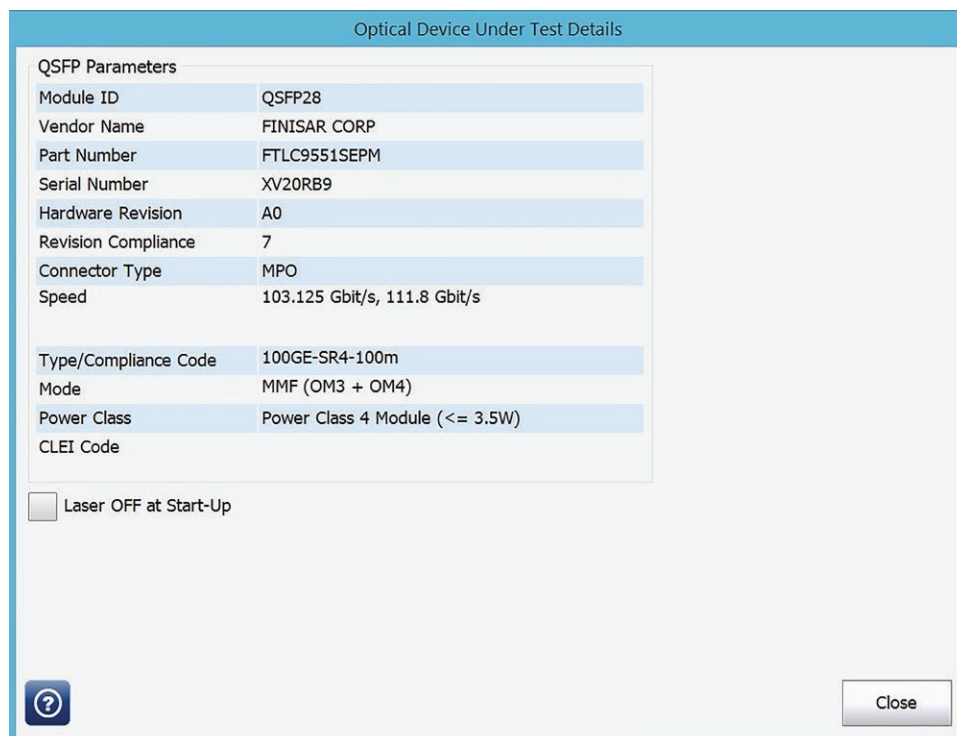


Figure 5. The QSFP details dialogue box

The series of tests is as follows, with the test application fulfilling two tasks: the monitoring and execution of each subtest.

### 1- Power consumption monitoring test

The power consumption monitoring test measures the current and the power drawn by the selected optical device. This monitoring is performed for the entire duration of the test, following which a pass verdict is obtained if the maximum power was equal to or less than the power threshold over the entire duration of the test.

### 2- Optical device I/O interface quick check

The optical device I/O interface quick check validates the MDIO/I2C and hardware-pin operation using a sample of common commands and controls applied to the selected optical device. The verdict provided by this test is therefore a combination of the MDIO/I2C interface test and the control/status pin check results.

### 3- Temperature monitoring test

The temperature monitoring test determines the internal temperature of an optical device in degrees Celsius until the end of the test. A pass verdict is obtained if the maximum temperature is equal to or less than the temperature threshold over the entire duration of the test.



iOptics

The iOptics app only requires configuration of a few parameters; the majority of configuration is done for the user by the application.

#### 4- Optical Tx power level range test

This test samples the Tx power level, compares it with the device's applicable Tx power range and provides a verdict. For devices that operate with multiple lanes, each lane is sampled and compared to the applicable Tx power range. Additionally, this test reports both the minimum and maximum Tx power levels (dBm) collected during the subtest. A pass verdict is obtained if the measured Tx power level is within the Tx power range defined by the device manufacturer.

A fail verdict indicates that the pluggable is not operating at the range specified by the manufacturer.

#### 5- Optical Rx signal presence and power level range test

A physical loopback is required for this test, which validates the presence of an Rx signal and samples the optical Rx power level. The test compares the obtained Rx level with the device's applicable Rx power range and provides a verdict. For devices that operate with multiple lanes, each lane is sampled and compared to the applicable Rx power range. This test reports both the minimum and maximum Rx power levels (dBm). A pass verdict is obtained if the measured Rx power level is within the Rx power range defined by the device manufacturer.

#### 6- Bit-error-rate test (BERT)

A physical loopback is required for this test, which validates the bit-error performance of the optical module. The validation is performed at the highest rate/protocol supported by the optical device. Additionally, the validation is performed with and without generation of a frequency offset at the respective protocol boundaries.

The user can configure the duration of the test, and a passing verdict will be assigned to the test if the following conditions are met:

- No loss of signal (LOS)
- No pattern loss
- Bit error count  $\leq$  BER threshold

For devices operating at multiple lanes, if any lanes present a problem, this will result in a fail verdict.

#### 7- Excessive skew test

This test is only executed for the validation of CFP, CFP2, CFP4, QSFP+ and QSFP28 optical devices. A physical loopback is required for this test, which measures the skew associated to each physical coding sublayer (PCS) lane. The intelligent iOptics test application automatically sets up an OTN BERT or an EtherBERT test based on the highest rate supported by the device.

The skew threshold is also automatically configured by the iOptics test application based on the rate/protocol used. A pass verdict is assigned to the test when the highest measured skew is equal to or less than the skew threshold.

In the event of a fail verdict during the execution of any subtest, the test is aborted and the fault is reported to signal that the faulty transceiver device should not be used.

### iOptics at a glance

The iOptics application only requires configuration of a few parameters; the majority of configuration is done for the user by the application. See Figure 6 for an example of the configuration page.



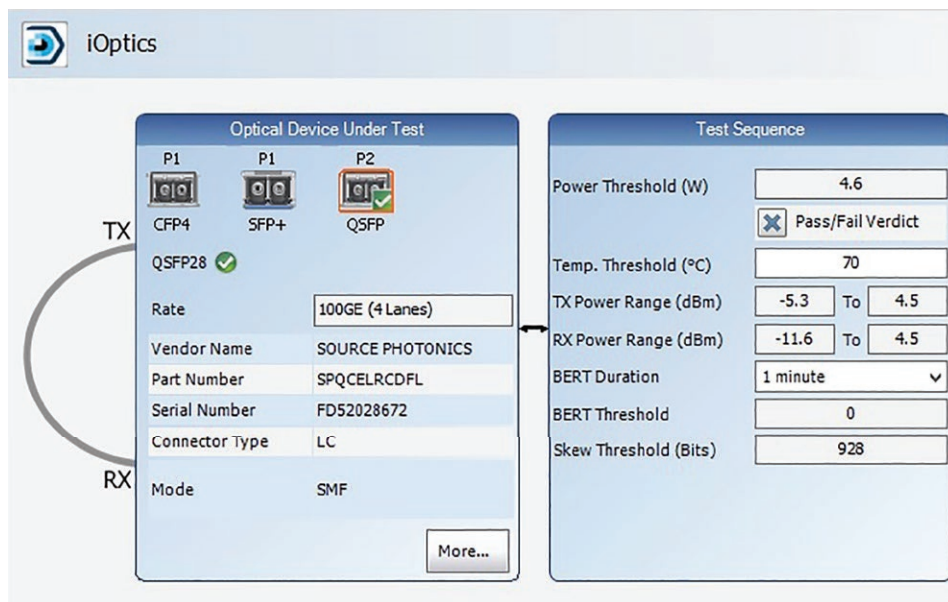


Figure 6. The iOptics test configuration page

Once the configuration has been completed, the user can start the test, which will bring up the summary page containing the key results and verdicts associated with each phase in the test sequence, as well as monitoring tasks related to each phase. A progress status is provided for each test. It is worth noting that several tests are executed quite quickly.

The summary page includes the following sections:

#### The start time of the test

#### Subtest sequence

- General (for each subtest)
  - Summarized verdict
  - Progress indication
- I/O interface quick check
  - MDIO or I2C pass/fail
  - Control/status pin pass/fail
- Optical Tx power range test
  - The minimum/maximum power value with a color status (green or red) indicating whether the value is in or out of range
- Optical Rx power range test
  - The minimum/maximum power value with color status (green or red) indicating whether the value is in or out of range
- Bit error test
  - Bit-error count, LOS or pattern loss indication
  - Green indicator status appears if the bit error count is equal to or less than the bit-error threshold
  - Red indicator status appears if the bit-error count is greater than the bit-error threshold

#### - Excessive skew rest

- Maximum skew (any lane) or LOS indication
- Green indicator status appears if the maximum skew is equal to or less than the threshold
- Red indicator status appears if the maximum skew is greater than the threshold

#### Monitoring

- Power (W)
  - Wattmeter representation with a pass/fail verdict region indication (green vs. red region)
  - Power (current/maximum)
  - Current (current/maximum)
  - Pass/fail verdict icon (power only)
- Temperature (°C)
  - Thermometer representation with pass/fail verdict region indication (green vs. red region)
  - Temperature (current/maximum)
  - Pass/fail verdict icon

**The iOptics test solution offers a multitude of benefits for players on data center interconnection market:**

- Quick performance check for next-generation network pluggables
- Support of a wide variety of rates: (SFP/SFP+/ CFP/CFP2/ CFP4 and QSFP+/QSFP28)
- Rapid, automated and easy-to-use analysis of optical interfaces and their power consumption (W), with quick pass/fail verdicts

## Conclusion

In summary, the exponential growth of the information generated, transported and processed by data center interconnections in the upcoming years has and will continue to dramatically change the market in ways never seen before. The manufacturers, elements and platforms used and deployed in these networks will be driven by ICPs and CSPs development and interactions.

The network elements and platforms introduced in this market will have to meet standards, including maximized usage and management of fibers, power efficiency, automation, simplicity of use, and multipurpose applications.