Executive Summary/Abstract

Reliance on networking permeates every aspect of our world, and data center bandwidth requirements are expanding at double-digit rates—along with an equally urgent push to contain costs. New technologies necessitate that data centers remain flexible and scalable enough to adapt to changing requirements. The rise of cloud providers changed the data center Ethernet landscape, creating a viable market for high-speed, reasonably-priced connectivity.

Leading cloud and telco providers are clamoring for even more network performance in order to meet the needs of their web-scale data centers and cloud-based services, without compromising the cost-to-performance ratio. To help address network performance needs, leading manufacturers have joined forces to define and drive 25 Gigabit Ethernet (25GbE) technology.

Ixia is a leader in validating Ethernet technology, securing networks, and visualizing applications. QLogic is a global leader and technology innovator in high-performance server and storage networking connectivity products. The two have come together to demonstrate end-to-end interoperability for 25GbE technology. Now, hyperscale, hybrid cloud and telco providers can deploy QLogic and Ixia’s upcoming 25GbE solutions and be confident that their services and products will be ready for the market, validated for interoperability, and deliver maximum performance.

Benefits of Deploying a Validated 25GbE Solution

- **Maximize Performance and Scalability**: Web-scale and cloud organizations can enjoy 2.5 times the network bandwidth performance of 10GbE. Since 25GbE is delivered across a single lane, it provides greater switch port density and network scalability, compared to 40GbE, which consumes four lanes.

- **Lower Capital and Operating Expenses**: Deploying 25GbE networks enables organizations to significantly reduce the required number of switches and cables, along with the considerations for the reduction of facility costs related to space, power, and cooling compared to 10GbE and 40GbE technology. Fewer physical network components reduce ongoing management and maintenance costs.

- **Validated by Industry Leaders**: IXIA and QLogic 25GbE solutions adhere to the in-definition standards, ensuring interoperability with a wide range of network solutions. Joint end-to-end interoperability demonstration provides customers the confidence to deploy 25GbE technology without compromise and risk.
25GbE: An Emerging Standard

Network engineers once marveled at the idea they could ever fill a 10GbE link. Then, virtualization and cloud computing created new networking challenges. Hyperscale data centers in companies like Google and Microsoft grew to tens or sometimes hundreds of thousands of servers. One of the main challenges was the insatiable hunger for more bandwidth.

Ethernet technologies largely kept up with demand. The IEEE ratified a 40GbE and 100GbE standard a few years ago, and launched a new study group to work on a 400GbE standard.

But the requirements of cloud providers and other large-scale data center operators are more nuanced than simple raw capacity. Top of Rack (ToR) switches, typically the largest number of connections in data centers, are rapidly outgrowing 10GbE. The next step up, 40GbE, isn’t cost-effective or power-efficient in ToR switching for cloud providers and others that operate at a similar scale.

It was under this backdrop that 25GbE was proposed as a standard for Ethernet connectivity that will benefit cloud and enterprise data center environments by delivering the best price per performance ratio. In June 2014, the 25 Gigabit Ethernet Consortium was formed to promote the technology, and subsequently an IEEE 802 workgroup was formed to develop the standard. Ixia and QLogic are members of the 25 Gigabit Ethernet Consortium.

The specification adopted by the Consortium uses a single-lane 25Gbps Ethernet link protocol that leverages existing 100GbE technology which is implemented as four 25Gbps lanes (IEEE 802.3bj) running on four fiber or copper pairs.

The proposed 25GbE standard delivers 2.5 times more performance compared to existing 10GbE solutions. It also provides greater port density and a lower cost per unit of bandwidth compared to 40GbE solutions for rack server connectivity.

25GbE is forecasted to reach two million ports, 2.5 times faster than 10GbE!
Key 25GbE Benefits

The 25GbE specification enables network bandwidth to be cost-effectively scaled in support of next-generation server and storage solutions residing in cloud and web-scale data center environments.

Using 25GbE with QSFP28 transceivers (described later) results in a single-lane connection similar to existing 10GbE technology—but it delivers 2.5 times faster performance. Compared to 40GbE solutions, the 25GbE technology provides superior switch port density by requiring just one lane (vs. four with 40GbE), along with lower costs and power requirements.

Key benefits include the following:

- Maximum switch I/O performance and fabric capability
  - 2.5 times the performance of 10GbE
  - Greater port density versus 40GbE (one lane vs. four lanes)
- Reduced capital expenditures (CAPEX)
  - Fewer ToR switches and fewer cables
  - Lower cost versus 40GbE
- Reduced operational expenditures (OPEX)
  - Requires less power, cooling, and footprint
- Leverage of existing IEEE 100GbE standard

### 3.2 Tbps Switch Based on 32 QSFP Ports

<table>
<thead>
<tr>
<th>Server I/O</th>
<th>Servers</th>
<th>100GbE Uplinks</th>
<th>Throughput per ToR Switch</th>
<th>Utilization (%)</th>
<th># of ToRs for a 100K Server Data Center</th>
</tr>
</thead>
<tbody>
<tr>
<td>40GbE (four lanes of 10GbE)</td>
<td>28</td>
<td>4</td>
<td>1.52</td>
<td>47.5</td>
<td>3572</td>
</tr>
<tr>
<td>25GbE (single lane)</td>
<td>96</td>
<td>8</td>
<td>3.2</td>
<td>100</td>
<td>1042</td>
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</tbody>
</table>
Ecosystem Support

Web-scale data centers and cloud-based service providers, who now require better speeds from servers than 10Gbps, must also keep an eye on the bottom line. Industry leaders, along with and standards bodies, can see the obvious value to providing a higher speed link that doesn’t require redesigning or recabling the data center—and see that it needs to be widely developed and productized as quickly as possible.

The movement to deploy 25GbE is already underway, and a vast and growing ecosystem is already answering the need for this technology, based on its obvious cost- and resource-saving advantages.

QSFP28 Transceivers

The movement to reduce costs has already produced the QSFP28 transceiver—designed for 100GbE speeds and using the 4x25 wiring specification. The “Q” stands for “Quad”: just as the 40GbE QSFP+ is implemented using four 10Gbps lanes, the 100GbE QSFP28 uses four 25Gbps lanes. In all QSFP versions, both the electrical lanes and the optical lanes operate at the same speed, eliminating the costly gearbox found in CFP, CFP2, and the CPAK. The QSFP28 module has an upgraded electrical interface to support signaling up to 28 1Gbps signals, yet keeps all of the physical dimensions of its predecessor.

The QSFP28 makes deploying 100GbE (and 25GbE) networks as easy as 10GbE networks. When compared to any of the other alternatives, QSFP28 increases density, decreases power consumption, and decreases price per bit. It is fast becoming the universal data center form factor, for the following reasons:

• The QSFP28 increases front-panel density over QSFP+. The form factor is the same and the maximum number of ports is the same, but the lane speeds are increased from 10Gbps to 25Gbps.

• Like the QSFP+, the same form factor supports both cables and transceivers. In the first generation of 100GbE switches and routers, the smaller CXP form factor was used for cabling and the CFP or CFP2 was used for transceivers. This forced huge equipment design sacrifices. A switch with CXP ports couldn’t be used in a data center with single-mode fiber (SMF). A router using CFP2 or CPAK ports had bandwidth limited by the 8-10 ports that could fit on the front panel.

With QSFP28, a one rack-unit (RU) switch can accommodate up to 36 QSFP ports. Many more varieties of transceivers and cables can plug into these ports. The cables can be either copper direct attach cables (DACs) or active optical cables (AOCs).

• QSFP28 transceivers can use either VCSELs (useful for shorter distances on multi-mode fiber (MMF)) or silicon photonics (for longer distances on SMF). Silicon photonics enables QSFP28 transceivers to support any data center reach up to two kilometers or more, and provides a high degree of integration. Silicon photonics is low power; even WDM designs can fit within the 3.5W maximum of QSFP.

With all of the technology choices available in the same form factor, the coming generations of high-bandwidth switches, routers, and adapters will all feature QSFP28 ports, ensuring data centers can scale to 100GbE (or 25GbE) networks with the simplicity available in 10GbE networks.
Switch Support

Several leading suppliers of Ethernet switching solutions are part of the 25 Gigabit Ethernet Consortium and have publicly announced plans for or are already shipping 25GbE-capable Ethernet switch platforms. Most Ethernet switching solutions include support for multiple Ethernet rates, including 10GbE, 25GbE, all the way to 100GbE, giving customers the ultimate in choice for network connectivity.

Notable announcements to date include, but are not limited to:

- **Arista:** In September 2015 Arista announced the immediate availability of the Arista 7060CX-32S, which offers multi-speed 10/25/40/50/100GbE on all 32 ports in a one-RU leaf switch along with flexible L2 and L3 features and wire-speed performance.

- **Cisco:** Earlier in 2015, Cisco announced Nexus 3200 ToR switches for next-generation 10/25/40/50/100GbE cloud data centers, which deliver 128 ports of 25GbE or 32 ports of 100GbE. The switches are expected to be generally available before end of 2015.

- **Broadcom:** In September 2014, Broadcom Corporation announced the availability of the StrataXGS® Tomahawk™ Switch Series high-performance Ethernet switch, delivering 3.2 Terabits per second (Tbps) switching capacity, providing 32 ports of 100GbE, 64 ports of 40/50GbE, or 128 ports of 25GbE. The switch enables the transformation of next-generation cloud fabrics to all-25Gb/s per-lane interconnect, enabling 25GbE and 50GbE networks.

- **Mellanox:** In September 2015, Mellanox announced that it is now shipping Spectrum, a 10/25/40/50/100GbE open Ethernet-based switch, to multiple cloud, Web 2.0, and enterprise data center customers world-wide.

Network Interface Cards (NICs)

The Ethernet adapter/NIC market for 25GbE is rapidly developing. Notable public announcements to date include:

- **QLogic:** QLogic is a leading supplier of high-performance network infrastructure solutions, and has demonstrated end-to-end 25GbE networking solutions at various industry events and early customers. QLogic’s QL45000 Series 25/40/50/100GbE adapter with low-latency Remote Direct Memory Access (RDMA) support on a robust and industry-proven networking stack provides the unique ability to deliver a heterogeneous RDMA transport comprising RDMA over Converged Ethernet (RoCE), RoCEv2 and Internet wide area RDMA protocol (iWARP). This accelerates cloud and hyperscale workloads without constraints.

Cables

According to the 25Gb Ethernet Consortium, the 25GbE and 50GbE channels must include all of the channel characteristics defined in IEEE standard 802.3bj, section “Physical Medium Dependent (PMD) sublayer and baseband medium, type 100BASE-CR4,” section 92.9. There are a number of connector and cable combinations that can meet these requirements.

The 25GbE and 50GbE PMDs specify low-cost, twin-axial copper cables, requiring only two twin-axial cable pairs for 25Gbps operation, and only four twin-axial cable pairs for 50Gbps operation.

Links based on copper twin-axial cables can connect servers to ToR switches, and as intra-rack connections between switches and/or routers. Fan-out cables (cables that connect to higher speeds and “fan out” to multiple lower speed links) can connect to 10/25/40/50Gbps speeds, and can now be accomplished on MMF, SMF, and copper cables, matching reach-range to the specific application need.
### Technology Standards

<table>
<thead>
<tr>
<th>Technology Type</th>
<th>Standards</th>
<th>Media</th>
<th>Reach Range</th>
<th>Power</th>
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</thead>
<tbody>
<tr>
<td>100GBASE-SR4</td>
<td>100GbE/ 25GbE</td>
<td>Multi-mode</td>
<td>100 meters</td>
<td>3.5W</td>
</tr>
<tr>
<td>100GBASE-LR4</td>
<td>100GbE</td>
<td>Single-mode</td>
<td>2km, or 10km</td>
<td>4.5W</td>
</tr>
<tr>
<td>PSM4</td>
<td>100GbE/ 25GbE</td>
<td>Parallel single-mode</td>
<td>500 meters</td>
<td>3.5W</td>
</tr>
<tr>
<td>CWDM4</td>
<td>100GbE</td>
<td>CWDM single-mode</td>
<td>2 meters to 2km</td>
<td>3.5W</td>
</tr>
<tr>
<td>100GBASE-CR4</td>
<td>100GbE/ 25GbE</td>
<td>Passive copper</td>
<td>5 meters</td>
<td>3.5W</td>
</tr>
</tbody>
</table>

### Test and Measurement

To accompany all of the ecosystem developments, and to verify the rapidly crystalizing specifications, test and measurement tools are needed. Equipment developers must be able to deploy products that meet standards, and will flawlessly interoperate with other Ethernet devices. Ixia has addressed this need:

- In March of 2015, Ixia unveiled the world’s first 25GbE validation solution at the Optical Fiber Communication Conference (OFC) in Los Angeles. Ixia’s native QSFP28 Xcellon-Multis is a next-generation architecture and test solution to satisfy equipment maker test needs ranging from basic interoperability to high-port count performance tests. As data centers, service providers, and large enterprises implement this same high-density network equipment in their own networks, they need this same test solution to verify performance and functionality prior to deployment.

Ixia and QLogic Validate of 25GbE

Without question, vendors at all levels of the 25GbE ecosystem need to validate that their products are in compliance and can interoperate with the 25GbE standard (which is undergoing definition). Ixia is an expert in the Higher Speed Ethernet (HSE) specifications.

In July 2006, the IEEE 802.3 formed a Higher Speed Study Group (HSSG) to define the objectives for the standards. In December 2007, the HSSG formally became the IEEE 802.3ba task force, with the goal of creating standards for implementing 100Gbps and 40Gbps data rates over optical fiber and copper cables. Ixia has been working in the HSSG and 802.3ba task force from its inception and is committed to supporting efforts to reach an industry-wide standard.

Ixia has helped advance the mission of HSE development by being the first to market with many of the HSE test solutions—from 100GbE, 40GbE, and now 25GbE. Ixia’s many successes provide a high value and benefit to customers:

- Ixia’s technical leaders contribute to the latest Ethernet standards (IEEE, OIF, various MSAs)
- Ixia provides up to date insights on the trends in the industry
- Ixia is well known for its many highly reliable and robust products
- Ixia’s 100/40/25/10/1GbE products are brought to market early
- Ixia works with early adopters of new technologies so when products are released they have been through many cycles of interoperability with all of the major network equipment manufacturers (NEMs)
- Ixia products are built so that customers will have a test tool that allows testing of products to ensure they meet industry standards
QLogic is a leading supplier of high-performance network infrastructure solutions, delivering Ethernet adapter/NICs designed for next-generation virtualized and hyperscale data centers and cloud providers. QLogic FastLinQ Intelligent Ethernet Adapters are optimized for virtualization with up to 100Gbps of performance to handle large numbers of virtual machines (VMs) and support for most demanding cloud applications with VM-aware network services.

- QLogic FastLinQ 3400 and 8400 Series 10GbE Converged Network Adapters are the solution of choice for workload-intensive computing environments, providing a reliable, high-performance 10GbE connectivity solution.
- QLogic FastLinQ QL45000 Series 25/40/50/100GbE Intelligent Ethernet Adapters with low latency RDMA support on a robust and industry-proven networking stack provides the unique ability to deliver a heterogeneous RDMA transport comprising of RoCE, RoCEv2 and iWARP, accelerating cloud and hyperscale workloads without constraints.
- QLogic is an industry leader and the first to demonstrate end-to-end interoperability for 25GbE and 100GbE solutions. Supporting 10/25/40/50/100Gbps Ethernet port speeds, the QLogic Ethernet portfolio is able to address all next-generation server and storage-to-TOR connectivity requirements in the data center.

Why Do We Need Testing?

New IEEE and industry consortium standards have added several new Ethernet speeds, such as 25Gbps and 50Gbps. These speeds come with advanced Layer 1 features that increase complexity and require purchasing new equipment, as well as tremendous engineering and QA resources to perform the work of testing and deploying equipment that supports the advancements.

Today a switch or NIC port may need to support 100GbE, 50GbE, 40GbE, 25GbE, or 10GbE—and all of these speeds must be tested.

In addition, the 100GbE ports can fan out (using fan-out cable technologies) to numerous configurations, such as:

- 1x50GbE
- 2x50GbE
- 1x40GbE
- 2x40GbE
- 1x25GbE
- 2x25GbE
- 4x25GbE
- 8x10GbE
- 10x10GbE
- 4x1GbE

All of the different fan-out and speed configurations must be tested over fiber optic and copper cable media.

New IEEE standards also require advanced layer features such as auto-negotiation (AN), Ethernet Forward Error Correction (FEC), and Link Training (LT) to establish and maintain the Ethernet link between network equipment. Needless to say, comprehensive testing of all of the combinations of speeds, configurations, and features requires precise and expertise help.

All of the different fan-out and speed configurations must be tested and qualified using various combinations for AN, FEC, and LT.

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**QLogic’s**

**QL45000 Series 25GbE**

**Ethernet Adapter**

accelerates cloud and hyperscale workloads.
Ixia and QLogic Demonstration Results

IXIA and QLogic engineers worked together at QLogic labs in Mountain View, California to perform extensive testing and evaluation of the 25GbE technology.

<table>
<thead>
<tr>
<th>Vendor</th>
<th>Components</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ixia</td>
<td>Xcellon-Multis</td>
<td>Xcellon-Multis 100GbE enhanced load module</td>
</tr>
<tr>
<td>QLogic</td>
<td>FastLinQ QL45000</td>
<td>Dual-Port 25GbE intelligent Ethernet adapter</td>
</tr>
<tr>
<td>Hitachi Metals</td>
<td>25BP30B-03</td>
<td>100GbE QSFP28 4x25GbE SFP28 breakout copper cable</td>
</tr>
<tr>
<td>Amphenol</td>
<td>NDACGF-0001 &amp; NDACGF-0002</td>
<td>100GbE QSFP28 to 4x25GbE SFP28 breakout copper cable</td>
</tr>
</tbody>
</table>

QLogic FastLinQ QL45000 Series 25GbE Adapters NIC Performance

Throughput (Gb/s)

- TX (1500B)
- RX (1500B)
- BD (1500B)
- TX (Jumbo)
- RX (Jumbo)
- BD (Jumbo)

Single Port | Dual Port
Ixia's Test Solution

Bandwidth requirements for enterprises, service providers, and global data centers are growing rapidly, straining 10GbE and 40GbE technologies. Service providers and hyperscale data centers are looking at high-density 100GbE and 25GbE networking infrastructure solutions to meet these demands. Equipment manufacturers are rapidly increasing port densities and delivering multi-rate switch ports to remain competitive. With Ixia's support of native QSFP28 interface technology, equipment manufacturers can use Ixia's high-density 100/25GbE load module to assist the move to higher density 100GbE, with four 100GbE ports per blade and up to 16x25GbE speed links. For data centers, native QSFP28 100GbE and 4x25GbE speed support provides a more efficient use of network bandwidth, and new multi-rate test requirements have emerged for testing 100GbE and 25GbE on the same port.

Xcellon-Multis is Ixia’s next-generation architecture and test solution that provides the world’s first 100/25GbE multi-rate test system to satisfy equipment maker test needs ranging from basic interoperability and functional test, to high-port count performance tests. As data centers, service providers, and large enterprises implement this same high-density network equipment in their own networks, they need this same test solution to verify performance and functionality prior to deployment.

Ixia 25GbE solution capabilities include:

- 4x25GbE speed
- 100GbE media support:
  - 100GbE passive copper DAC
  - 100GbE multi-mode AOC
  - MMF and SMF fiber optic transceivers
- 4x25GbE media support
  - 100GbE passive copper DAC up to three meters
- Auto-negotiation on 100GbE
- Ethernet FEC on 100GbE

QLogic 25GbE NIC Solution

QLogic’s QL45000 Series 25/40/50/100GbE Adapter with low-latency RDMA support on a robust and industry-proven networking stack provides the unique ability to deliver a heterogeneous RDMA transport comprising of RoCE, RoCEv2 and iWARP, accelerating cloud and hyperscale workloads without constraints.
Learn More

Ixia

www.ixiacom.com


QLogic

www.QLogic.com

QLogic 25GbE Technology: http://www.qlogic.com/Products/adapters/Pages/25Gb-Ethernet.aspx