



Practical Considerations for Choosing a Network Speed That's Right for Your Business

Author Executive Summary

Shingi Marangwanda
 Ethernet Networking Division -
 Intel Corporation

In today's ever evolving data center, it is important to understand the myriad of networking speeds, as well as switch, cable, and connector combinations. All elements should be carefully reviewed in order to choose the solution that is right for your data center and workloads.

Until recently, the generally accepted migration roadmap was 1GbE to 10GbE to 40GbE. Since the approval of the IEEE802.3by 25GbE standard and the introduction of 100GbE capable switches, the transition to higher speeds has become more complex.

When it comes time to upgrade your network, what speed should you chose? There is no single answer to the speed and bandwidth question. The high speed networking market is wide and varied. The key is to take all variables into consideration when selecting the next speed for your data center.

- What does it take to upgrade to higher speeds?
- Will upgrading create new bottlenecks on my platform?
- What impact will upgrading have on my network and storage?

If your network is running on 1GbE speeds you can upgrade to 10GBASE-T and leverage your existing CAT6A Twisted-pair copper cabling. If you already have Direct Attach Copper Twinaxial, fiber cabling and optic connectors, you may be able to use some of the existing infrastructure.

Overall we expect to see speeds from 1GbE to 100GbE continue to coexist in the data center. There are network adapters on the market that support different speeds and share a common architecture, including drivers and firmware. These products help provide a smooth transition to higher speeds.

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High Speed Data Center Network Trends

A few years ago there were limited network speeds to choose from, but fast forward to 2017 and the choices are numerous, with 1/10/25/40 and 100GbE adapters and switches. Today, 1GbE and 10GbE represent almost 90 percent of the Enterprise market's Server Ethernet ports, while 25, 40 and 100GbE speed ports make up the remaining 10 percent.

The transition to 25GbE for large and high-end Enterprise is expected to happen faster than the previous transition to 10GbE, but not because the Enterprise needs more bandwidth - it has more to do with costs. Today, there is little to no price premium for a switch that supports both 10 or 25GbE speeds.

Overall, we expect to see speeds from 1 to 100GbE to continue to coexist in data centers for the foreseeable future.

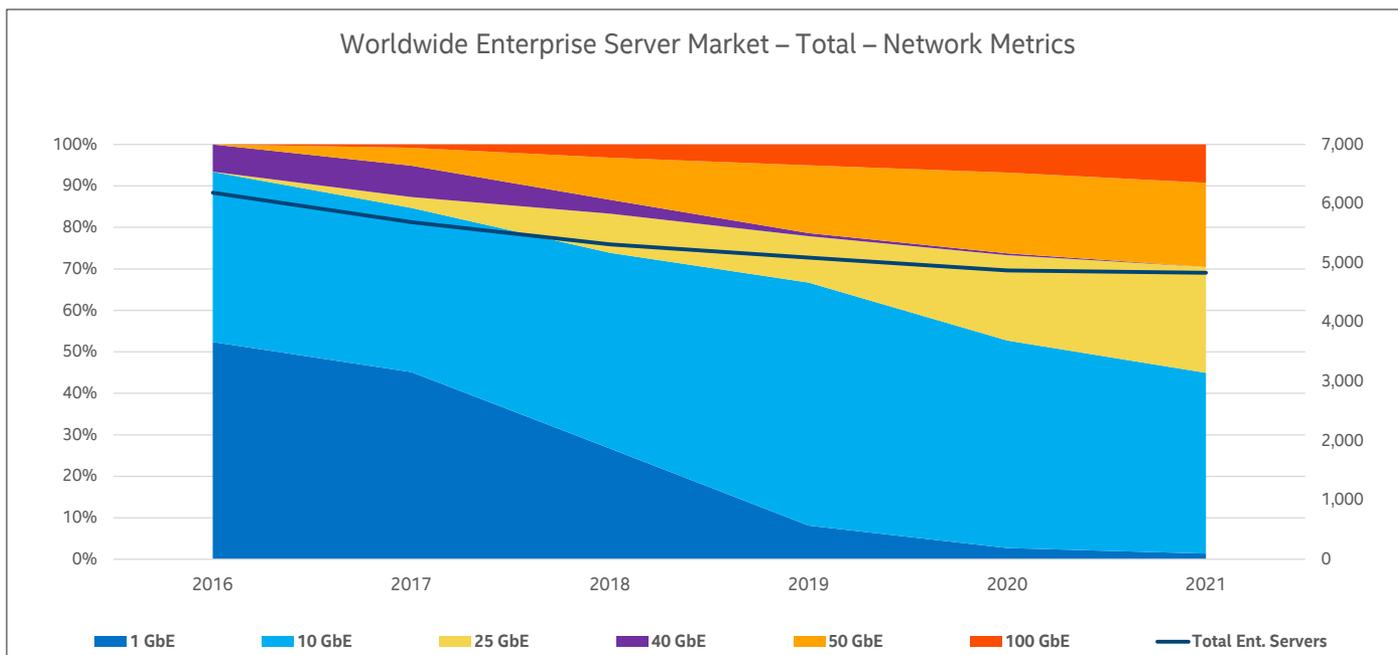


Figure 1. Server 5-year Forecast Report, Dell'Oro Group January 2017

Migration to 10GbE Will Continue for the Enterprise

Much of the Enterprise market is still running on 1GbE speeds and will be looking to migrate to 10GbE over the next 5 or 6 years. Data centers running 1GbE have an easy migration path to 10GBASE-T, because they can leverage existing copper Twisted-pair CAT6A cabling.

25GbE Will Begin to Grow in 2017

25GbE is expected to begin growing in the broader market in 2017, but it is not expected to outgrow 10GbE adapter shipments until well after 2021. In the Enterprise there is not much need for such high speeds except for some Virtualization and storage workloads. However, since some 25GbE adapters can also run at 10GbE speeds, these adapters present data centers with a future-proof opportunity for a later move to 100GbE switch infrastructure. This decision is made easier for those businesses with existing fiber cabling.

40GbE in the Enterprise

The 40GbE market will contract due to the availability of dual-port 25GbE adapter options, but will continue to show strength among the Enterprise where 10GbE and 40GbE switches are widely deployed. Servers with a network adapter that can configure a QSFP+ port as either 4 x 10GbE or 1 x 40GbE connection (with a QSFP+ to QSFP+ or QSFP+ to 4xSFP+ Breakout cable) can choose which port configuration makes the most sense, on an adapter by adapter basis. For those servers that require 4 x 10GbE this type of adapter provides an opportunity to reduce cabling costs.

Switch Vendors are Consolidating Offerings

Many switch vendors are already consolidating their switch product offerings. Instead of having multiple switch product lines, vendors are supplying switches that support 10/25/40 and 100GbE speeds. Since many SFP28 25GbE Direct Attach Copper (DAC) Twinaxial cables are compatible with 10GbE SFP+, and QSFP28 100GbE DAC with 40GbE QSFP+, some data centers will chose to run these multispeed switches at different port speeds based on cabling and adapter support.

Ecosystem Factors to Consider When Migrating to Higher Speeds

When evaluating whether to upgrade some or all of your network, there are several things to consider beyond network speed: existing cables and connectors, compatible switches, and the compute platform.

While some bottlenecks are resolved with upgrading your network alone, one also has to consider new bottlenecks that might be created by network speed upgrades to the compute platform, and to the overall network infrastructure.

10GbE Cables and Connectors

10GbE speeds can be achieved using either Twisted-pair copper CAT6/6A or CAT7 cabling with RJ45 connectors, Direct Attach Copper Twinaxial cables or optical fiber cables with optical interconnects.

A large portion of the Enterprise is still running at 1GbE speeds. If CAT6/6A or CAT7 cabling is already installed, then moving from a 1000BASE-T to a 10GBASE-T solution, such as the Intel® Ethernet Converged Network Adapter(CNA) X550 or Intel Ethernet CNA X710-T4, can be the most cost-effective upgrade path. Because you can use your existing cabling, the additional cost would be for 10GBASE-T adapters and switches.

25GbE Cables and Connectors

To achieve full 25GbE speed, you will need fiber cabling or Direct Attach Copper Twinaxial and SFP28 connectors. Existing SFP+ and QSFP+ connectors do not connect at 25GbE speeds.

Intel® Ethernet Network Adapter XXV710 supports SFP28 connectors enabling customers to have network connections via Direct Attach Copper Twinaxial cables, or using SFP28 SR or LR optical modules as prescribed by the IEEE standard. Depending on the length of the Direct Attach Copper Twinaxial both FEC and non-FEC cables can be used. Breakout type Direct Attach Copper Twinaxial are available, and can be used to split a single QSFP28 connection 100GbE port in to four independent 25GbE capable SFP28 connections.

Enterprises that are considering 25GbE must evaluate their existing fiber optic cable installation to make sure that all of the runs are within the shorter maximum cable length meet SR optic requirements. Existing SFP+ Direct Attach Copper Twinaxial cables should work but only at 10GbE speeds, even if the network adapter and switch both support 25GbE.

Examples of 25GbE Connections



Intel® Ethernet SFP28 Twinaxial Cable



Intel® Ethernet SFP28 Optic



Intel® Ethernet QSFP28 Twinaxial Breakout Cable

Network Speeds and Cable Distances

It is important to note that cable distance varies depending on the network speed and type of cable being used.

10GBASE-T for 10GbE



SFP+ for 10GbE



SFP28 for 25GbE



QSFP+ for 40GbE



Figure 2. Cable distance vs. Network Speed and type Cable used

Switch Vendors Moving to 100GbE Capable Switches

25GbE capable switch availability will continue to increase with switches that only have QSFP28 ports and switches that have both SFP28 and QSFP28 ports. Most of the switches that are 100GbE capable allowing connections per QSFP28 port of either 4x10, 4x25, 1x40 or 1x100GbE speeds. As mentioned previously, switch vendors are reducing the number of switches in their offerings by stopping production of their 10/40GbE only switches.

For those running 10GbE, this means that when it is time to end of life your current switches, you will most likely purchase a switch that is capable of configuring the ports to support 10/25/40/100GbE speeds. These multispeed switches allow you the flexibility to run some connections at 10GbE and other connections at higher speeds using the same switch, as shown in the example below.

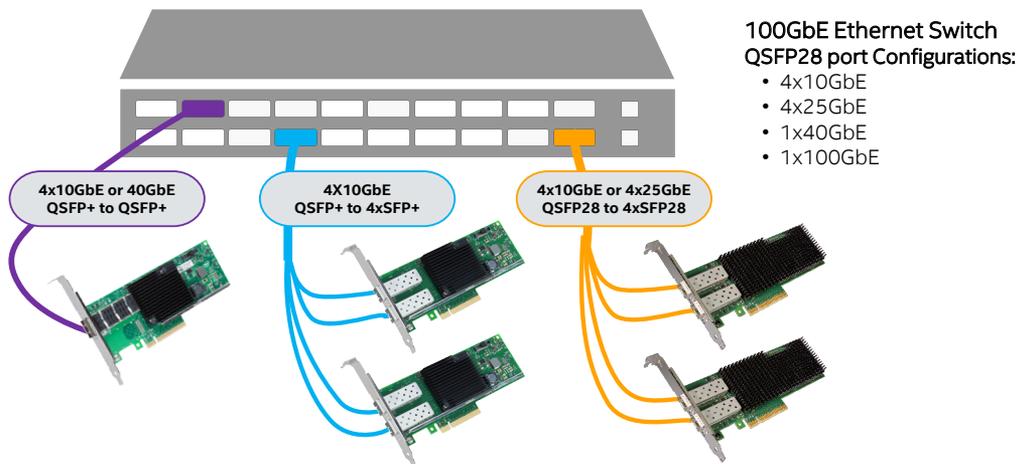


Figure 3. Port Speed Options

Impact of Network Speed Upgrades on Other Components of the Compute Platform

Upgrading the network adapter on your compute platform will solve some bottlenecks but can also create new ones. If you are running SSDs (Solid-State Drives) you will notice an increase in disk IO as the system can accept more bandwidth. However, if you are running spinning disks you run the risk of these becoming the new bottleneck in your system.

If you are moving from 1 or 10GbE to other speeds, drivers will need to be updated on the operating system and manageability software might need to be patched or updated, or both. It is important to budget time and resources to validate the changes to your platform and any impact to your applications.

Impact of Network Speed Upgrades to your Network and Remote Storage

Upgrading the bandwidth in and out of your compute platform can have a significant impact on your current network. Upgrading the platform's speed, and not upgrading all or some of the network, can negatively impact the overall speed of your network and access to storage. Your network architecture might have to be revised to keep pace, including top of rack switches and distribution switches. You might also need to upgrade your NAS or SAN storage as a result of increased bandwidth and IO demands from higher speed nodes.

Ethernet Speed Migration Guide

Migrating from 1000BASE-T on CAT6A/CAT7 cabling to 10GbE

This is a relatively straight forward migration. For adapters, 10GBASE-T solution such as Intel® Ethernet CNA X550 and Intel Ethernet CNA X710-T4 can be the most cost-effective upgrade path. You will also need to purchase 10GBASE-T switches.

Moving from 1GbE to higher speeds, enables you to take advantage of server and network Virtualization features. Benefits of Virtualization include workload consolidation, virtual machine migration, fewer adapters, cables, and less power consumption in the data center.

Migrating from 1000BASE-T or 10GBASE-T on CAT6/6A/CAT7 to 25GbE

You will need to use different cabling in your data center since 25GbE is not supported on most existing Twisted-pair copper cables. All adapters, cables, and switches will need to be upgraded.

Migrating from 10GbE or 40GbE on Fiber to 25GbE

It is important to understand that you can use your existing fiber cabling with 25GbE, but the maximum optical cable lengths have been reduced from 300 m on OM3 down to 70 m and from 400 m on OM4 down to 100 m on multi-mode fiber.

Table 1. Supported Cable Types, Speed, and Distance

Speed	Multi-mode Fiber (MMF) OM3	Multi-mode Fiber (MMF) OM4	Single-mode Fiber (SMF)
10GbE	Supports up to 300 m	Supports up to 400 m	Supports up to 10 km
25GbE	Supports up to 70 m	Supports up to 100 m	Supports up to 10 km
40GbE	Supports up to 100 m	Supports up to 150 m	Supports up to 10 km

If you are using SFP+ Direct Attach Copper Twinaxial, you will need to upgrade to SFP28 to realize full 25GbE speed. If you do not want to upgrade your Direct Attach cabling at this time, the existing cables will work, but at 10GbE speed.

If you are using QSFP+-to-SFP+ Direct Attach Copper Twinaxial Breakout cables, to realize the full 25GbE speed, you must upgrade to QSFP28-to-SFP28 breakout cables. Otherwise, your existing cables will work, but at 10GbE speed.

Table 2. Connectors and Cabling by Application

Applications	Intel® Ethernet Network Adapter	IEEE Standards	Maximum Speed	Connectors	Maximum Cable Length
10GBASE-T	X550/X710-T4				
		10GBASE-T	10Gb/s	RJ45	55 m (CAT6A) 100 m (CAT6A/CAT7)
10GbE	X520 / X710-DA				
<i>Twinaxial Copper</i>		10GBASE-CR	10Gb/s	SFP+	15 m (Direct Attach Passive)
<i>Multi-mode Fiber</i>		10GBASE-SR			300 m (OM3) to 400 m (OM4)
<i>Single-mode Fiber</i>		10GBASE-LR			10 km
10GbE or 25GbE	XXV710-DA				
<i>Twinaxial Copper</i>		25GBASE-CR	25 Gb/s	SFP28	3 m (Direct Attach Passive)
<i>Multi-mode Fiber</i>		25GBASE-SR			70 m (OM3) 100 m (OM4)
<i>Single-mode Fiber</i>		25GBASE-LR			10 km
4x10GbE or 40GbE	XL710-QDA				
<i>Twinaxial Copper</i>		40GBASE-CR4	40Gb/s	QSFP+	7 m (Direct Attach Passive)
<i>Multi-mode Fiber</i>		40GBASE-SR4			100 m (OM3) to 150 m (OM4)
<i>Single-mode Fiber</i>		40GBASE-LR4			10 km

25GbE Specifications

Early 25GbE products went to market before the IEEE 802.3by specification was complete, they were based on the 25G Consortium spec. Being early, many products did not comply with the IEEE spec, for example many did not implement auto negotiation. Intel® Ethernet Network Adapter XXV710 is based on the IEEE 802.3by standard that covers interoperability, backplanes and optic form factors.

25GbE Connectivity

- Enables similar topology as 10GbE and 40GbE
- The 25GbE standard leverages 25Gb/s single lane signalling developed to support 100GbE
- Single 25GbE SFP28 port or Quad 25GbE QSFP28 breakout implementations are possible
- Some 25GbE adapters work at both 10 and 25GbE speeds

25GbE Compatibility and Interoperability Concerns

Currently, not all 25GbE vendors are 25GbE-spec compliant:

- Some vendors do not support AN (autoneg CL-73) – this is required by spec for DAC cables
- Some support only Consortium AN but not IEEE802.3by
- Some do not support Forward Error Correction (FEC) which is mandatory for 25GbE link speed

To mitigate these issues, Intel® Ethernet Network Adapter XXV710 implements a built in Link Establishment State Machine (LESM). LESM allows the Intel Ethernet Network Adapter XXV710 to support all 25GbE link types, from the recently released IEEE 802.3by specification back through the 25G Consortium pre-standard products. Currently, Intel is the only company to have 25GbE adapters with a built in LESM.

Conclusion

Moving to higher Ethernet speeds can bring with it additional complexities. More than just the expense of upgrading adapters, costs involving cabling, connectors and switches need to be taken into consideration. It becomes critical to understand everything involved to help make the right decision for each area of your data center.

For those looking to move from 1GbE to a higher speed, there are a lot of options, with some being less disruptive than others. Enterprise data centers who are looking to migrate from 1000BASE-T to 10GBASE-T can do so by leveraging existing CAT6/6A/CAT7 Twisted-pair copper cables.

Dell'Oro forecasts that 10Gb Ethernet will continue to be strong in the Enterprise data center and be widely deployed, the addition of 25GbE provides another speed option to be considered. While the adoption of 25GbE capable adapters and switches will begin growing in 2017, many of them will connect servers to the network at 10GbE speeds while the cabling and switches are updated.

Although 40GbE connections are forecasted to ramp down over the next few years, adapters that support 4x10GbE on a single QSFP+ connection can be an effective way to reduce cable cost, physical port numbers and configuration complexities.

With all the speed and connectivity options, one answer to choosing the right network speed for your business, is to select a series of network adapters that can provide 10GbE with options for 25GbE or 40GbE connectivity.

Intel® Ethernet Network Adapters and Accessories

Intel® Ethernet 700 Series

The Intel® Ethernet 700 Series network adapters provide a wide range of speeds and connectivity options, with a common set of features and drivers.

PCI Express* Intel® Ethernet 700 Series Network Adapters	
QSPF+	<p>Intel® Ethernet Converged Network Adapter XL710-QDA1 Port Speeds: 4x10Gb/1x40GbE</p>  <p>Intel® Ethernet Converged Network Adapter XL710-QDA2 Port Speeds: 4x10Gb/2x40GbE</p> 
SFP28	<p>Intel® Ethernet Network Adapter XXV710-DA1 Port Speeds: 1x1Gb/1x10Gb/1x25GbE</p>  <p>Intel® Ethernet Network Adapter XXV710-DA2 Port Speeds: 2x1Gb/2x10Gb/2x25GbE</p> 
SFP+	<p>Intel® Ethernet Converged Network Adapter X710-DA2 Port Speeds: 2x1Gb/2x10GbE</p>  <p>Intel® Ethernet Converged Network Adapter X710-DA4 Port Speeds: 4x1Gb/4x10GbE</p> 
10GBASE-T	<p>Intel® Ethernet Converged Network Adapter X710-T4 Port Speeds: 4x1Gb/4x10GbE</p> 

Intel® Ethernet Accessories

The following are Intel® Ethernet Optics and Direct Attach Twinaxial cables are validated with the Intel® Ethernet Network Adapter XXV710. <http://www.intel.com/content/www/us/en/ethernet-products/optics-cables/overview.html>

SFP28 AND QSFP28 25 AND 100 GIGABIT ETHERNET

SPF28: 10GbE or 25GbE Connections

Intel® Ethernet SFP28 Twinaxial Cables
SFP28 to SFP28 direct attach copper cable
Product Code Cable Length (m)
XXVDACBL1M 1 meter
XXVDACBL2M 2 meters
XXVDACBL3M 3 meters



Intel® Ethernet SFP28 Optics
SPF28 25GbE Optical Transceivers
Product Code Optic Type
E25GSFP28SR SFP28 SR Optic



QSFP28: 4x25GbE Connections

Intel® Ethernet QSFP28 to SFP28 Breakout Cables
QSFP28 to (4) SFP28 direct attach copper breakout cable
Product Code Cable Length (m)
XXV4DACBL1M 1 meter
XXV4DACBL2M 2 meters
XXV4DACBL3M 3 meters



SFP+ AND QSFP+ 10 AND 40 GIGABIT ETHERNET

SFP+: 10GbE Connections

Intel® Ethernet SFP+ Twinaxial Cables
SFP+ to SFP+ direct attach copper cable
Product Code Cable Length (m)
XDACBL1M 1 meter
XDACBL3M 3 meter
XDACBL5M 5 meter



Intel® Ethernet SFP+ Optics
SPF+ 10GbE Optical Transceivers
Product Code Optic Type
E10GSFPSR SFP+ SR Optic
E10GSFPLR SFP+ LR Optic



QSFP+: 4x10GbE or 40GbE Connections

Intel® Ethernet QSFP+ Twinaxial Cables
QSFP+ to QSFP+ direct attach copper cable
Product Code Cable Length (m)
XLDACBL1 1 meter
XLDACBL3 3 meter
XLDACBL5 5 meter



Intel® Ethernet QSFP+ Optics
QSPF+ 40GbE Optical Transceivers
Product Code Optic Type
E40GQSFPSR QSFP+ SR Optic
E40GQSFPLR QSFP+ LR Optic



Intel® Ethernet QSFP+ to SFP+ Breakout Cables
QSFP+ to (4) SFP+ direct attach copper breakout cable
Product Code Cable Length (m)
X4DACBL1 1 meter
X4DACBL3 3 meter
X4DACBL5 5 meter



Additional Resources

Network Virtualization Overlay White Paper and Video

Enhancing Data center Agility with Network Virtualization Overlays White Paper

<http://www.intel.my/content/www/my/en/ethernet-products/334399-data-center-agility-paper.html>

Software Defined Infrastructure (SDI) can deliver unprecedented agility and responsiveness to business. Strategic direction and tactical implementation for network infrastructure should include evaluation of Network Virtualization Overlay technologies.

Transform the Data center with Network Virtualization Overlay Video

<http://www.intel.my/content/www/my/en/ethernet-products/converged-network-adapters/transforming-data-center-network-virtualization-overlays-video.html>

This video shows how Network Virtualization Overlays work and the key benefits that IT managers experience deploying a virtual network.

Intel Network Builders University Courses (Login Required)

The Road to Network Virtualization

<https://networkbuilders.intel.com/university/course/the-road-to-network-virtualization>

In this course, Intel Solutions Architect, Brian Johnson, looks at Network Virtualization Overlays (NVO) and provides an overview of how to set up VXLAN in a Linux* environment using an Open vSwitch*.

Single Root I/O Virtualization

<https://networkbuilders.intel.com/university/course/single-root-io-virtualization>

In this course, Intel Solutions Architect, Brian Johnson, looks at Single Root I/O Virtualization (SR-IOV) and reviews different network traffic connectivity scenarios.

Wired Ethernet Community

Wired Ethernet Tech Corner

<https://communities.intel.com/community/wired/blog/2016/05/25/intel-ethernet-tech-corner-how-tos-and-solutions>



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