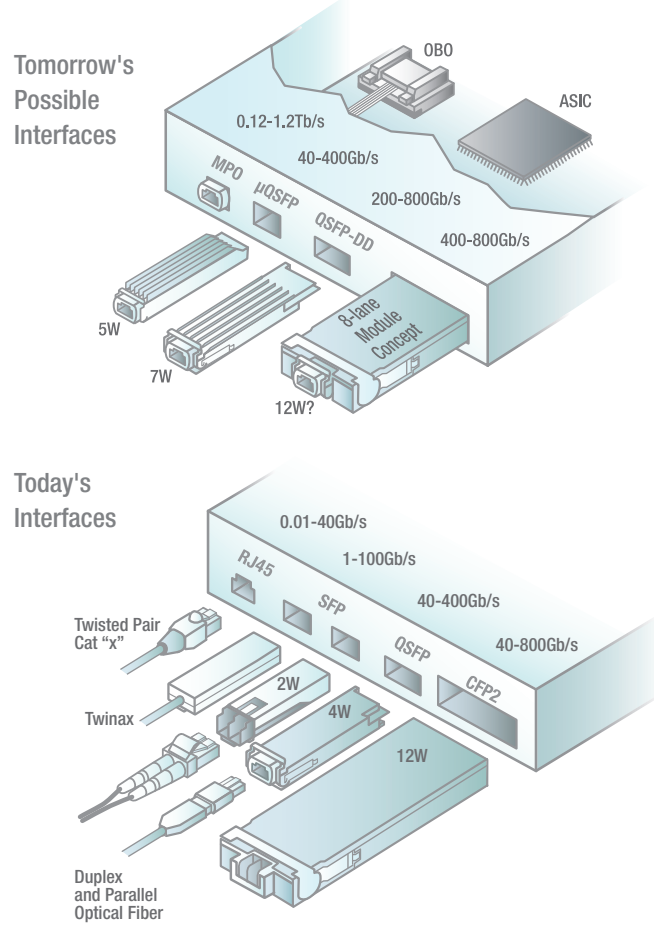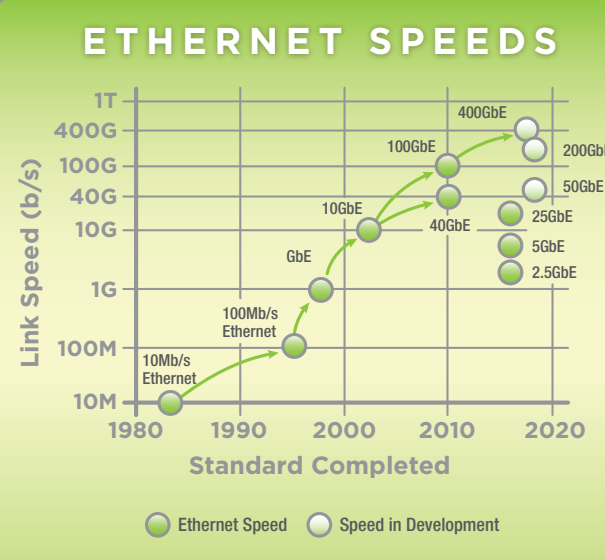# 2016 ETHERNET ROADMAP

MEDIA AND MODULES

Ethernet is wired technology and supports a variety of media including backplanes, twisted pair, twinax, multimode fiber and single-mode fiber. Most people know Ethernet by the twisted pair or Cat "x" cabling with RJ45 connectors because close to a billion ports a year are sold.

The graphic below shows multiple types of modules that may be used for copper or optical links. The upper modules are being developed to support ultra-high density port counts. The µQSFP shrinks the QSFP down to an SFP size while the QSFP-DD doubles the lane count to 8. On Board Optics (OBO) enable the highest port counts on switches.

Tomorrow's Possible Interfaces

0.12-1.27b/s
40-400Gb/s
200-800Gb/s
400-800Gb/s
µQSFP
QSFP-DD
OBO
ASIC
SW
7W
12W

Today's Interfaces

0.01-40Gb/s
1-100Gb/s
40-400Gb/s
40-800Gb/s
RJ45
SFP
QSFP
CFP
Twisted Pair Cat "x"
Twinax
6W
9W
12W
Duplex and Parallel Optical Fiber

2016 ETHERNET ROADMAP

THE PAST, PRESENT AND FUTURE OF ETHERNET

ETHERNET SPEEDS

Link Speed (b/s)
1T 400GbE
400G 1000GbE
40G 100GbE 2000GbE
10G 40GbE 500GbE
1G 10GbE 200GbE
100M 100Mb/s 50GbE 2.5GbE
10M 10Mb/s Ethernet

1980 1990 2000 2010 2020
Standard Completed

● Ethernet Speed   ○ Speed in Development

ethernet alliance — EST 2006
www.ethernetalliance.org
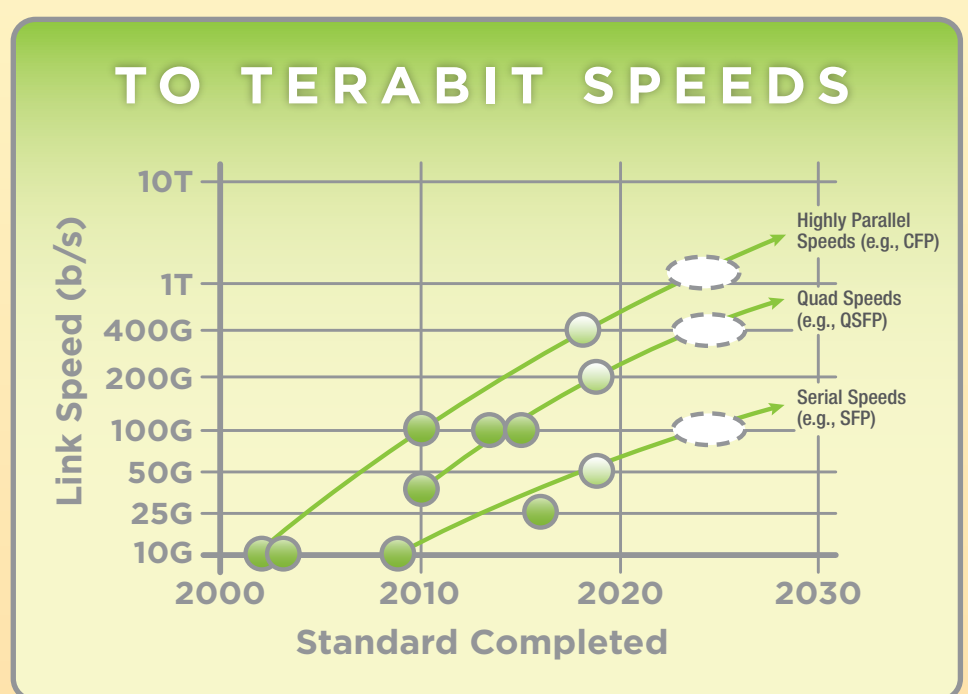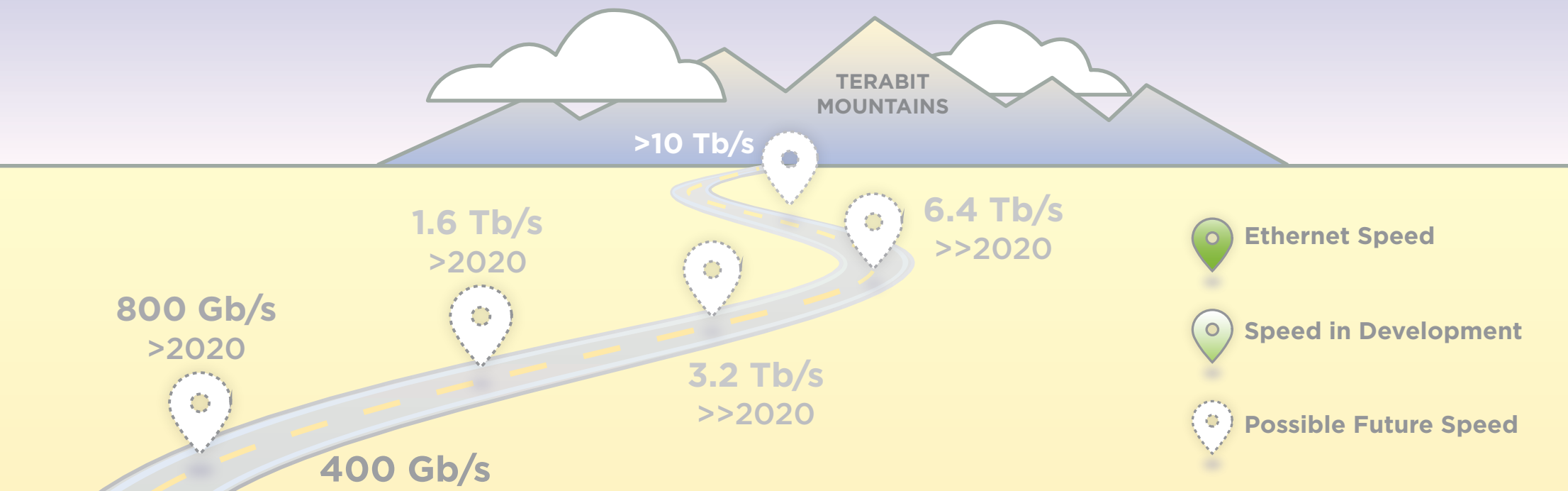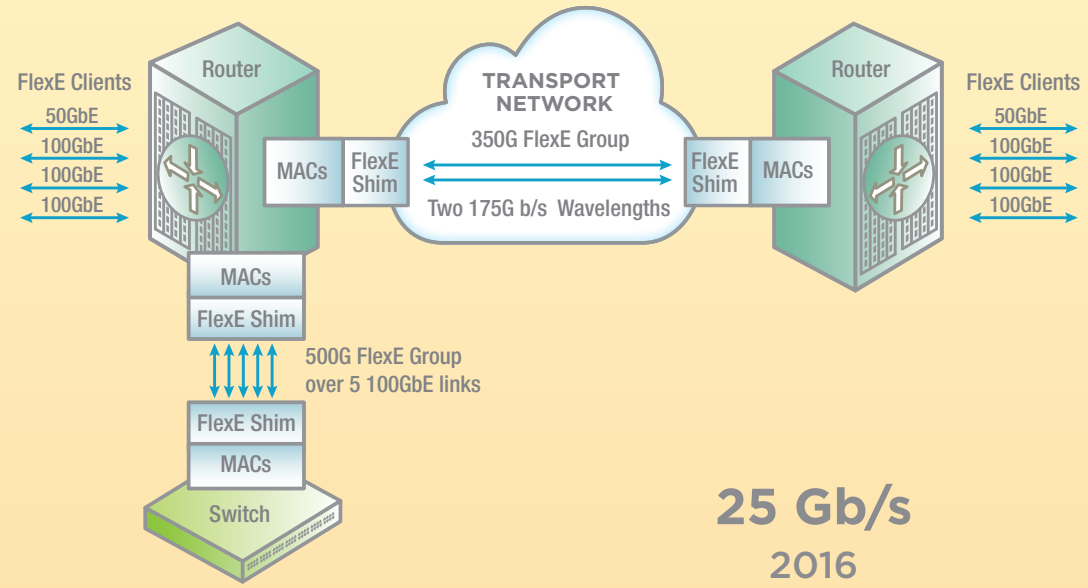
Designed by Scott Kipp
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$9.95

FLEX ETHERNET (FLEXE)

Defined by the Optical Internetworking Forum (OIF), FlexE is often called a new generation of Link Aggregation (LAG) and may provide a path to speeds higher than 400G without an IEEE standard. Proponents of FlexE claim that higher speeds like 800GbE are not necessary since these speeds just aggregate many lanes that run at lower speeds. FlexE can aggregate individual Ethernet links and creates a FlexE Mac that connects to another FlexE MAC. The illustration below shows a 500G FlexE group that bonds five 100GbE links together.

The FlexE Group refers to a group of from 1 to n bonded Ethernet PHYs. A FlexE Client is an Ethernet flow based on a MAC data rate that may or may not correspond to any Ethernet PHY rates. The FlexE Shim is the layer that maps or demaps the FlexE clients carried over a FlexE group. In the example illustration below, three 100GbE and one 50GbE FlexE clients connect over the transport network via a FlexE Group that supports 350Gb/s of bandwidth over 2 wavelengths of 175Gb/s.

FlexE Clients: 50GbE, 100GbE, 100GbE, 100GbE
Router — MACs — FlexE Shim — TRANSPORT NETWORK 350G FlexE Group, Two 175G b/s Wavelengths — FlexE Shim — MACs — Router — FlexE Clients: 50GbE, 100GbE, 100GbE, 100GbE

MACs
FlexE Shim
500G FlexE Group over 5 100GbE links
FlexE Shim
MACs
Switch

TERABIT MOUNTAINS

>10 Tb/s
1.6 Tb/s >2020
6.4 Tb/s >>2020
800 Gb/s >2020
3.2 Tb/s >>2020
400 Gb/s 2017 (est)
200 Gb/s 2018-2019
100 Gb/s 2010
50 Gb/s 2018-2019
40 Gb/s 2010
25 Gb/s 2016
10 Gb/s 2002
5 Gb/s 2016
2.5 Gb/s 2016
1 Gb/s 1998
100 Mb/s 1995
10 Mb/s 1983

● Ethernet Speed
◉ Speed in Development
✦ Possible Future Speed

TO TERABIT SPEEDS

Link Speed (b/s)
10T
1T
400G
200G
100G
50G
25G
10G

2000 2010 2020 2030
Standard Completed

Highly Parallel Speeds (e.g., CFP)
Quad Speeds (e.g., QSFP)
Serial Speeds (e.g., SFP)

ETHERNET INTERFACES AND NOMENCLATURE

	Electrical Interface	Backplane	Twinax Cable	Twisted Pairs	MMF	Parallel SMF	2km SMF	10km SMF	40km SMF
10BASE–				T					
100BASE–				TX	FX			LX	
1000BASE–		KX	CX	T	SX			LX	
2.5GBASE–		KX		T					
5GBASE–		KR		T					
10GBASE–	SFI, XFI	KX4, KR	CR	T	SR			LR	ER
25GBASE–	25GAUI	KR	CR	T	SR			LR	ER
40GBASE–	XLAUI	KR4	CR4	T	SR4		FR	LR4	ER4
50GBASE–	50GAUI (-2?)	KR	CR		SR		FR	LR	
100GBASE–	CAUI10	KR4, KR2	CR10,		SR10	PSM4	10X10	LR4	ER4
	CAUI4		CR4,		SR4		CWDM4	10X10	10X10
	CAUI-2		CR2		SR2		CLR4		
200GBASE–	200GAUI-4	KR4	SR4		SR4		FR4	LR4	
400GBASE–	CDAUI-16				SR16	DR4	FR8	LR8	
	CDAUI-8								

Gray Text = IEEE Standard   Red Text = In Standardization   Green Text = Under consideration in IEEE
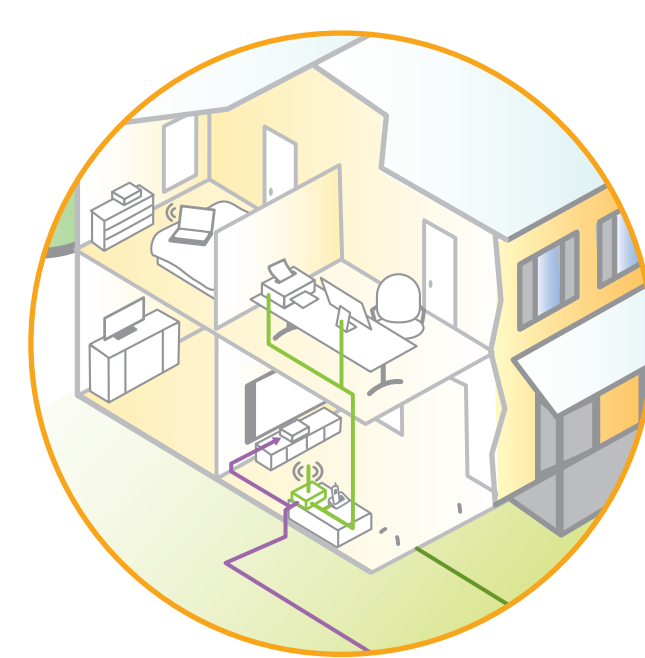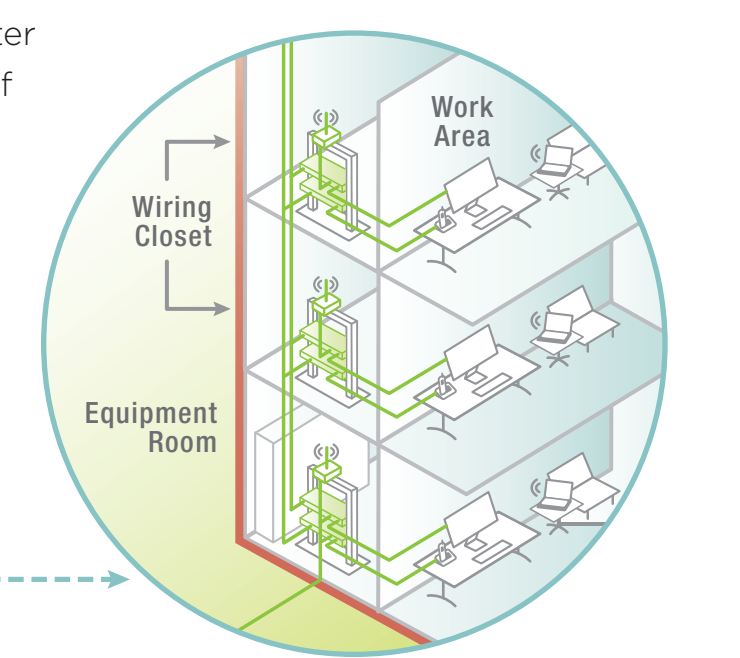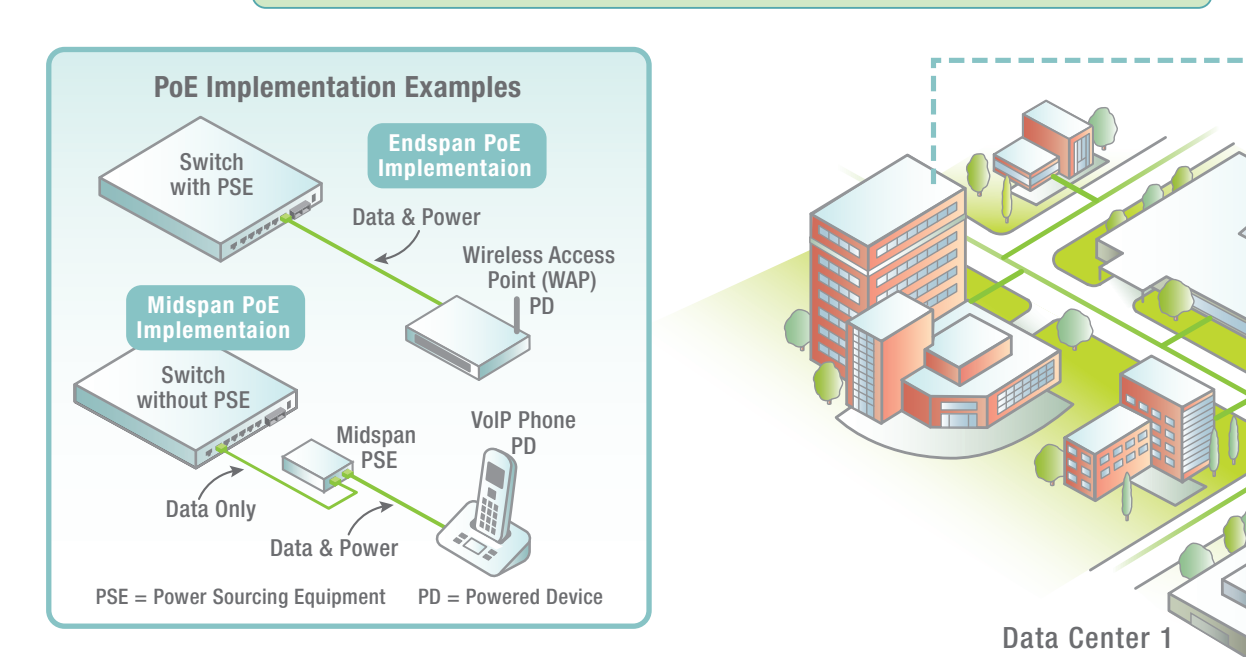Blue Text = Non-IEEE standard but complies to IEEE electrical interfaces

To get a PDF version of the roadmap and to find out more about the roadmap, please go to: www.ethernetalliance.org/roadmap/

ETHERNET ECOSYSYTEM

ENTERPRISE AND CAMPUS

Power over Ethernet is a growing Ethernet application that delivers power and data over Category cabling that has 4 twisted pairs of wires, with Cat 5 or better cabling recommended. 4-Pair PoE is being standardized to deliver over 70W of power over all 4 twisted pairs instead of the two pairs in PoE and PoE+.

PoE Types and Classes	PoE+ – Type 2				4-Pair PoE in Standardization			
	PoE – Type 1							
Class	0	1	2	3	4	5	6	7	8
PSE Power (W)	15.4	4	7	15.4	30	45	60	75	90
PD Power (W)	13	3.84	6.49	13	25.5	40	51	62	71

4 – Pair PoE–Type 3
4 – Pair PoE–Type 4

PoE Implementation Examples

Switch with PSE — Endspan PoE Implementation — Data & Power — Wireless Access Point (WAP) PD
Midspan PoE Implementation — Switch without PSE — Midspan PSE — VoIP Phone PD
Data Only — Data & Power
PSE = Power Sourcing Equipment   PD = Powered Device

Wiring Closet
Work Area
Equipment Room

Manufacturing Plant

Data Center 1
10,000 sq ft

BACKBONE TO OTHER CITIES

Data Center 2
>100,000 sq ft
POD 2
POD 1
HVAC Systems
POD 3
POD 4
POD 5
Main Distribution Area 2
Main Distribution Area 1

● Server Racks
● Ethernet Switch and Router Racks
● Patch Panels
● Storage Racks
● Transport Equipment

Row Design

Top of Rack (ToR) Popular because servers use low cost copper links within the rack.

End of Row (EoR) Popular for consolidating switches in the row.

Middle of Row (MoR) Only moderately different than ToR or EoR.

Centralized Popular because switches are centrally located and managed.

● Ethernet Switch   ● Server

Port Density Comparison
56 RJ45s/1U
56 SFP/1U
36 QSFP/1U
8 CFP2/1U
72 µQSFP/1U
100 OBO/1U
24QSFP +16 OBO
OBO = On Board Optics

Hyperscale data centers drive amazing Ethernet volumes when hundreds of thousands of servers are connected on one site.

HYPERSCALE DATA CENTER

RESIDENTIAL AND CONSUMER

Most homes have wireless access points (WAPs) with 4 or more Ethernet ports. Smart TVs, network attached storage (NAS) and other household products come with Ethernet ports that can be used to create the smart home.
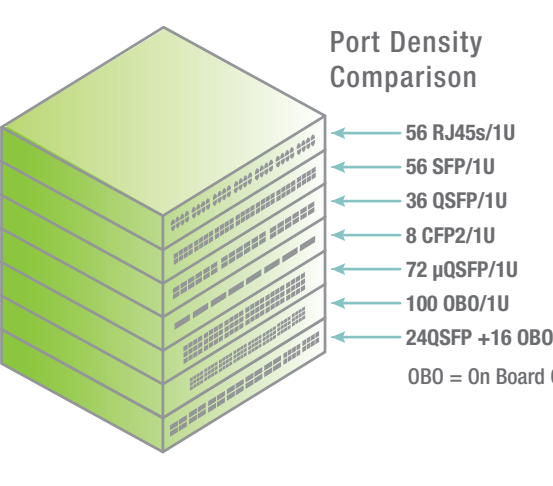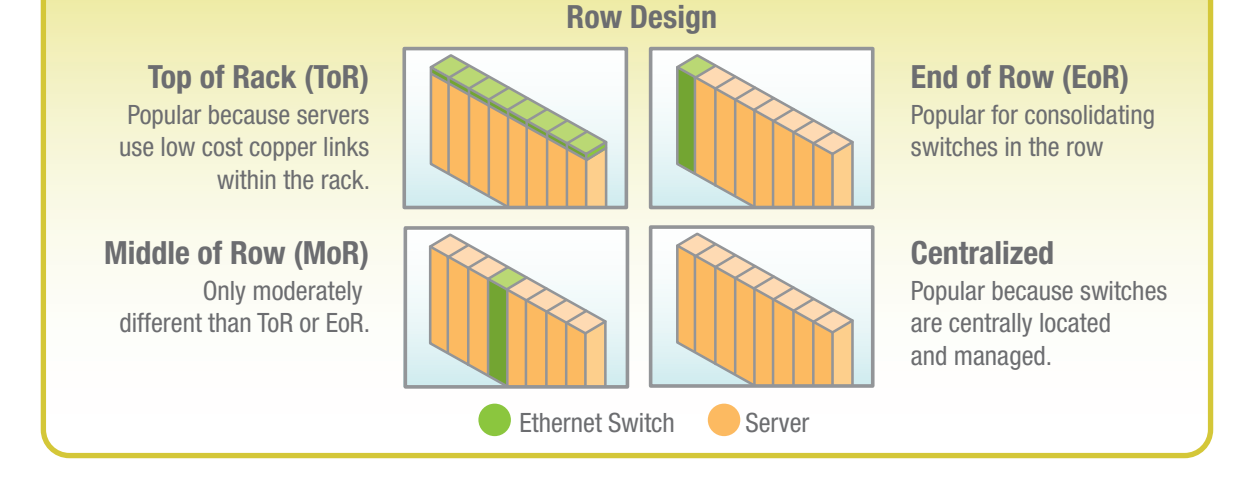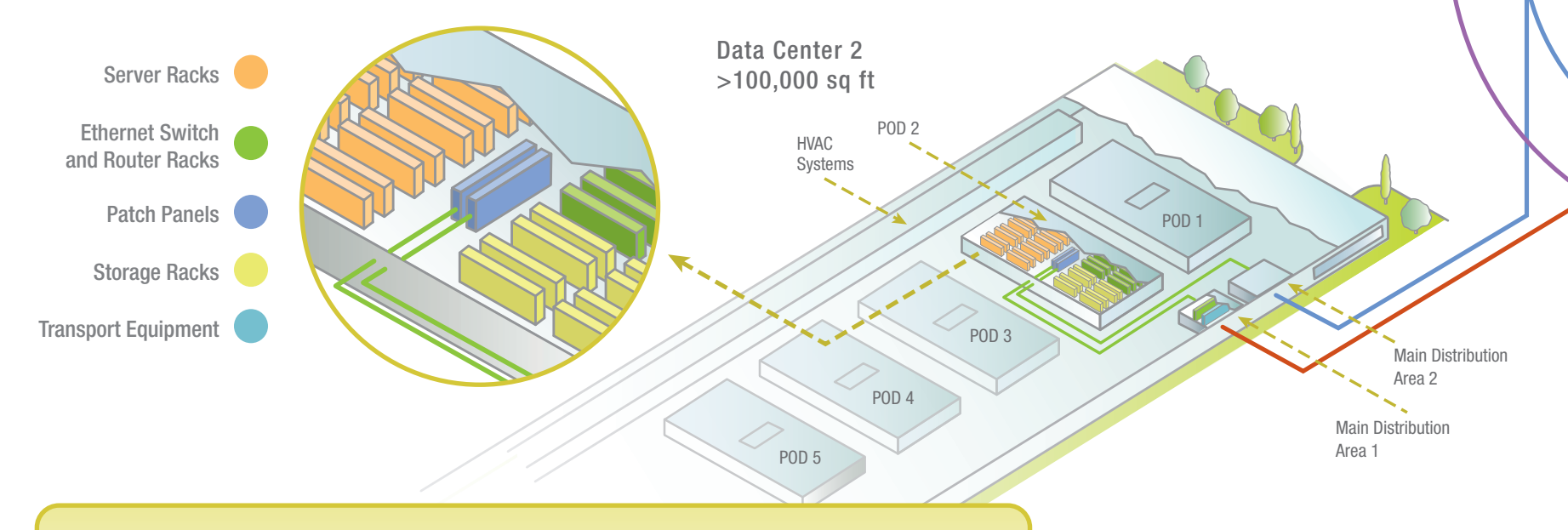
Automotive Ethernet
Ethernet is being deployed in automobiles and will become the defacto standard for automobile networks by 2020. Because of requirements for lightweight autos, Ethernet was developed to deliver data and power over a single pair of wires to distances of 15 meters at 100Mb/s and 1Gb/s.

Power Over Data Lines (PoDL)
PoDL delivers data and power to cameras, lights, entertainment systems, controls and other devices throughout the car.

Wireless Connectivity
Connected cars are expected to drive increased traffic to wireless networks that result in more wireless backhaul traffic over Ethernet.
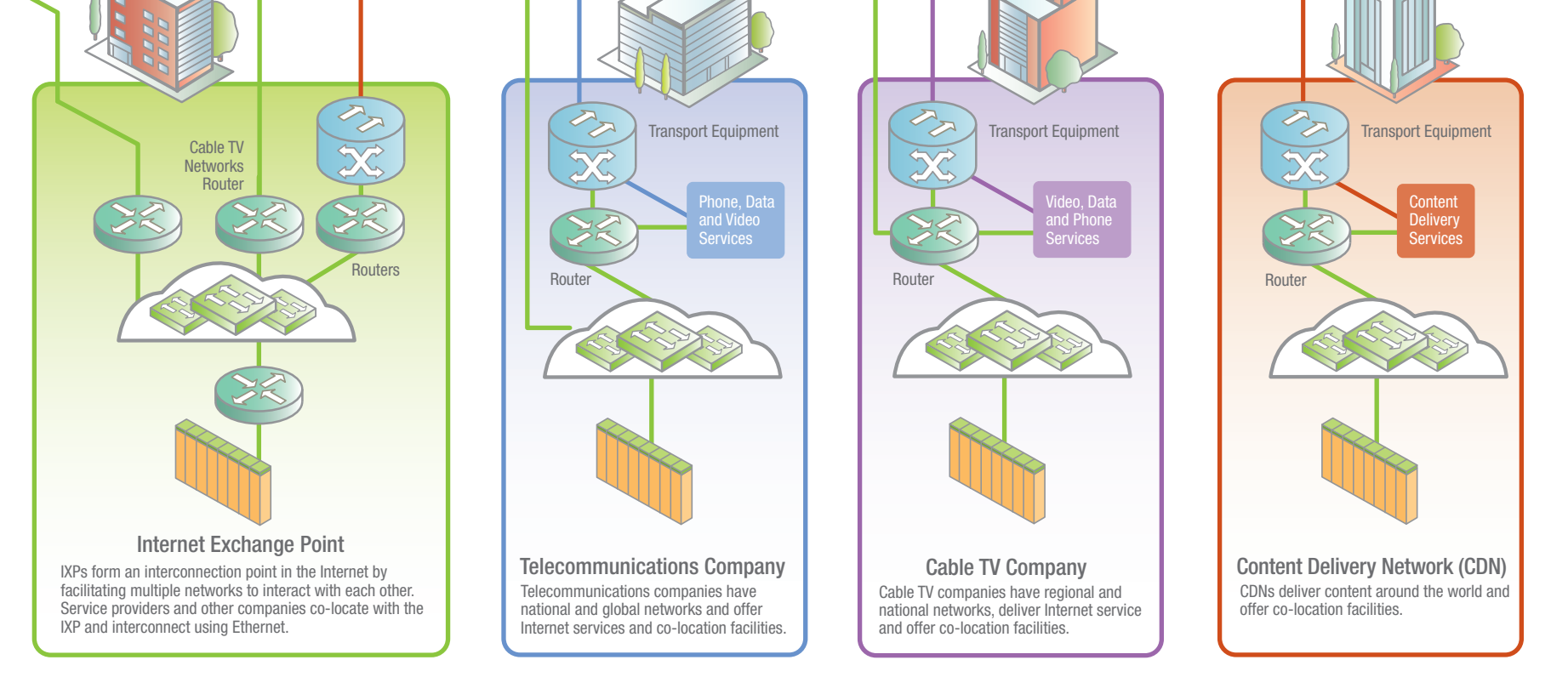
— Ethernet
— Telecom Network
— Cable Network
— CD Network

BACKBONE TO OTHER CITIES

MANs

Metropolitan Area Networks (MANs) come in many varieties and deliver services to a variety of enterprises, organizations and consumers. Some MANs are based on Ethernet, but the largest MANs are based on Optical Transport Networks (OTN) technologies.

Internet Exchange Point
IXPs form an interconnection point in the Internet by facilitating multiple networks to interact with each other. Service providers and other companies co-locate with the IXP and interconnect using Ethernet.

Cable TV Networks Router
Routers

Telecommunications Company
Telecommunications companies have national and global networks and offer Internet services and co-location facilities.

Transport Equipment
Phone, Data and Video Services
Router

Cable TV Company
Cable TV companies have regional and national networks, deliver Internet service and offer co-location facilities.

Transport Equipment
Video, Data and Phone Services
Router

Content Delivery Network (CDN)
CDNs deliver content around the world and offer co-location facilities.

Transport Equipment
Content Delivery Services
Router

Service Providers deploy MANs and WANs to connect businesses and consumers. Some carriers deploy hyperscale data centers as well.

SERVICE PROVIDERS