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ACCELERATING DATA CENTER TRANSFORMATION

October 27, 2016
NEWSEUM, WASHINGTON D.C.

Datacenter Dynamics

DATA CENTER TRANSFORMATION in the Cloud Era

- It's ALL about the App
- The Cloud Paradigm
- Next Generation Data Centers
  - Hyperscale
  - Enterprise
  - Multi-Tenant Data Centers (MTDC)
  - Modular ITC
- System Interconnects and HyperConvergence
- CAPEX and OPEX Opportunities
- Closing and Questions

Holistic Approach

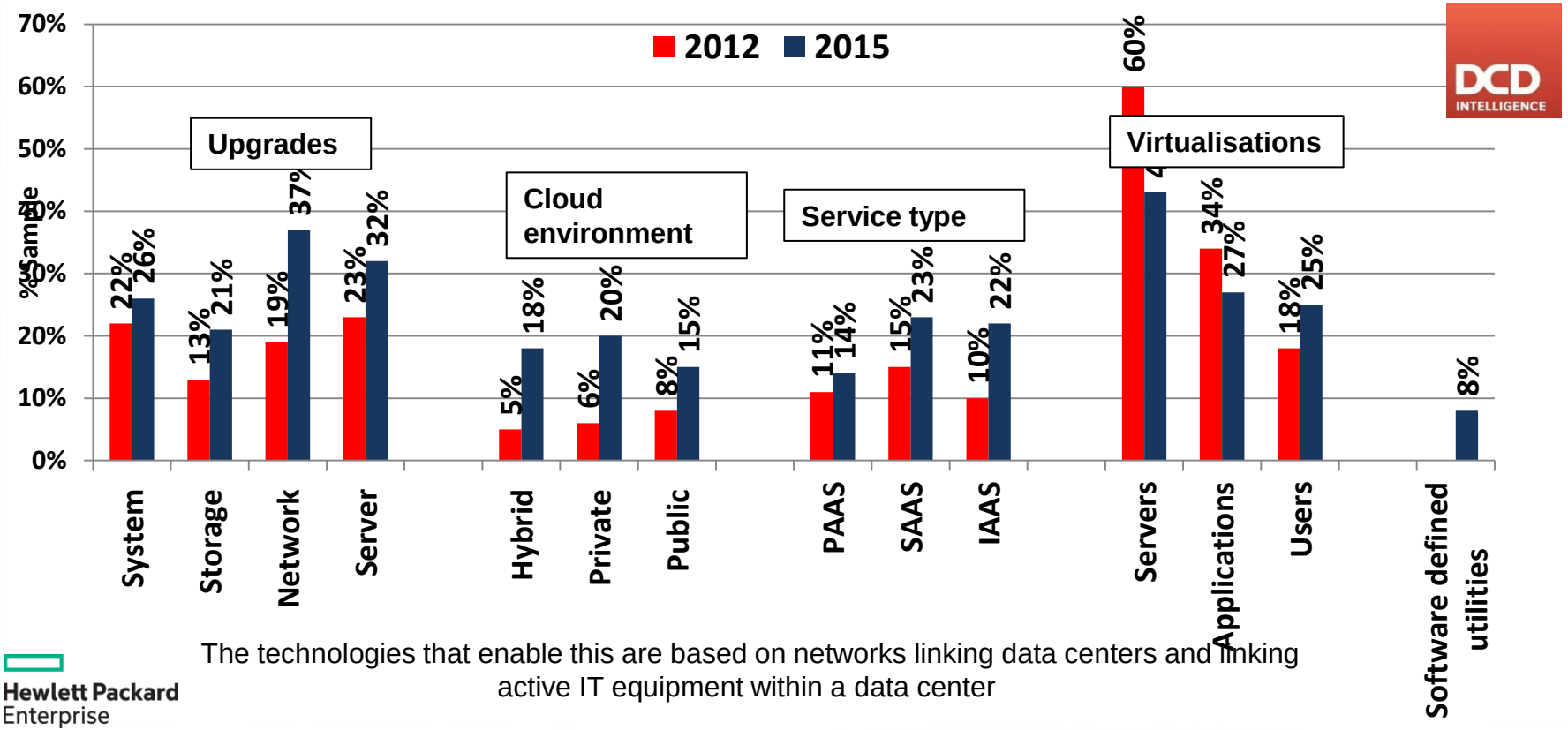
NETWORKING INFRASTRUCTURE

ENVIRONMENT

A DATA CENTER'S MISSION SHOULD BE TO CREATE RELIABILITY, MITIGATE RISK, AND PROVIDE UPTIME FOR THE TECHNOLOGY AND APPLICATIONS THAT IT ENABLES

APPLICATIONS

CAPEX/OPEX



The technologies that enable this are based on networks linking data centers and linking active IT equipment within a data center

These demands mean the need to invest to improve networking performance has increased from 2013 to 2016

DCD INTELLIGENCE

	2013	2014	2015	2016
Increased IT capacity requirements	35.4%	39.6%	42.2%	48.6%
To reduce operating costs	39.8%	38.6%	39.5%	45.3%
To enable virtualization / cloud computing, service development	25.6%	29.6%	32.5%	42.3%
To be 'greener' & more sustainable	29.8%	30.5%	32.5%	36.2%
To improve network performance	21.3%	26.5%	31.2%	35.4%
To improve space use	23.3%	25.4%	28.4%	35.1%
To improve security	24.5%	28.6%	32.5%	35.1%
To increase power into facility	32.5%	30.8%	31.1%	35.1%
To increase redundancy	29.6%	28.6%	31.5%	33.4%

An average 1 in 3 nomination = once every 3 years = frequency of IT refresh

What are the business drivers underpinning all of this?

Challenges Force Change

- Increasing power densities

(typically 4-6KW, now 12 up to 30, with possibilities of 70kW per rack)

- Improved cooling strategies
- Need for scalability
- Need for modularity
- Data center consolidation
- Server virtualization and demand from DevOps
- Energy saving initiatives and regulations

Apps Moving to the Cloud

Business Apps

Office 365 · salesforce · Cisco webex · CONCUR · yammer

zendesk · servicenow · ORACLE Taleo · workday · box

Consumer Apps

facebook · YouTube · LinkedIn · Pinterest

Gmail · StumbleUpon · flickr · vimeo · Google Drive

Business and Life in Cloud

23 billions smart devices by 2020
Internet of things

HPC maximum flops ×2 annually
93 petaflops/s (10^{15}) in 2016
Sunway TaihuLight (China)

Every 200 mobile devices =
1 more server in the cloud

Social network:
300 million pictures/day uploaded to Facebook

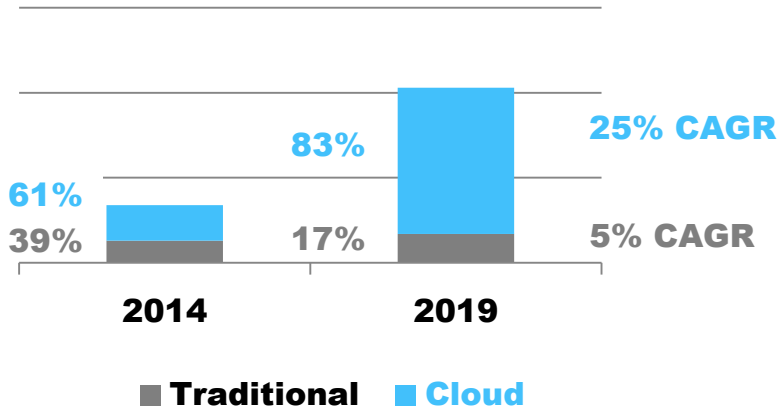
Hewlett Packard Enterprise

Source:
1. Cisco Visual Networking Index Forecast
2. Garner Worldwide IT Spending
3. Top 500 list Top 10 change
4. Gizmodo/Facebook

Next Generation Cloud Ecosystem

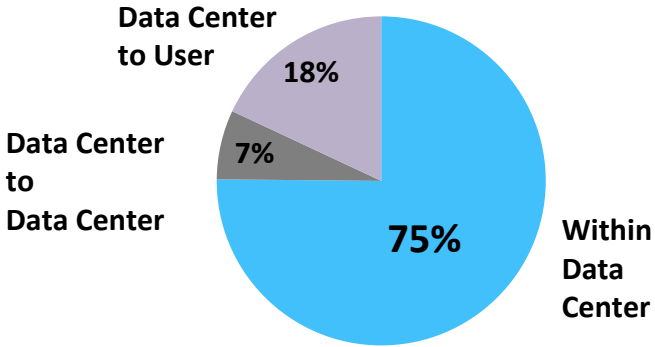
Traffic Moving to the Cloud

Traffic Growth



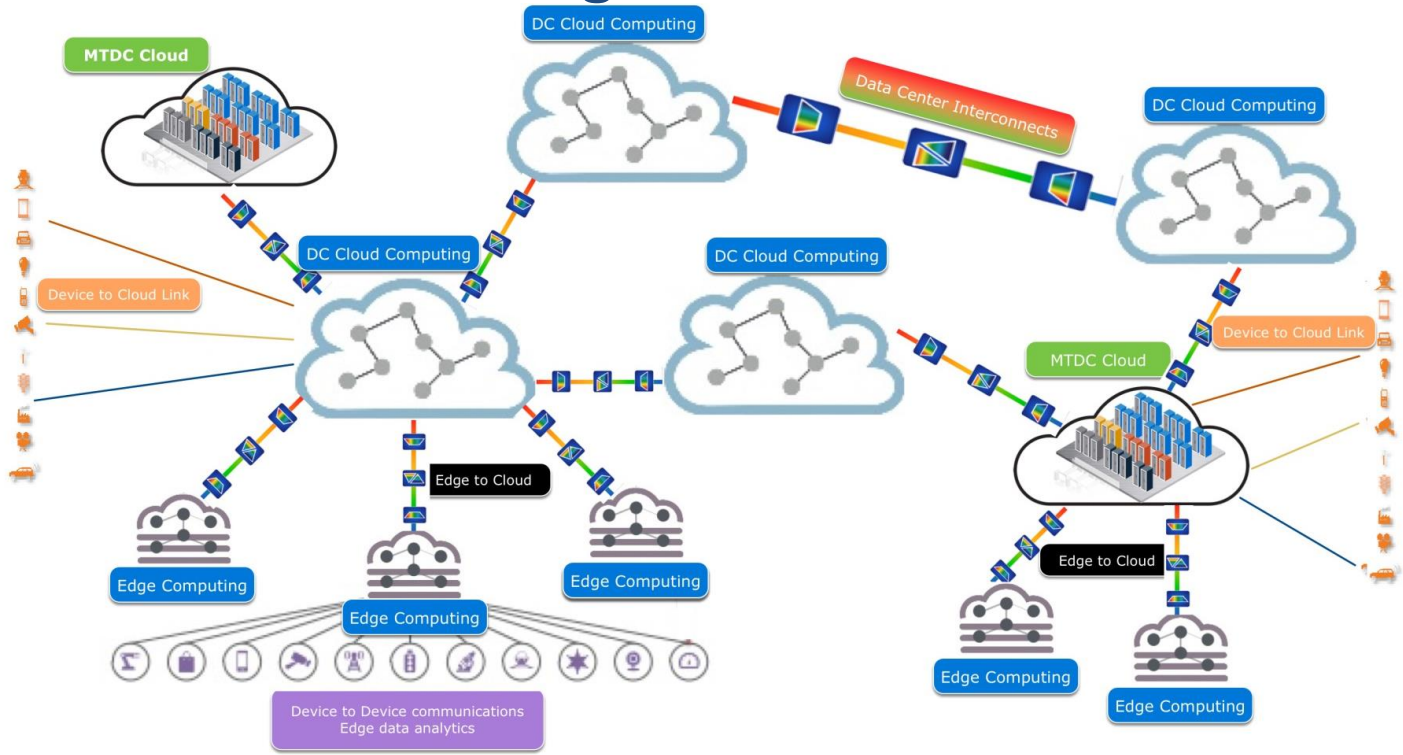
Dell'Oro, 2015

Traffic Destination



Dell'Oro, 2015

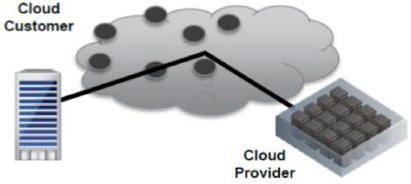
The New Cloud Paradigm



Belden 2016

Hybrid Cloud Solutions

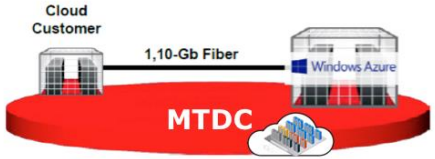
Internet Access to Cloud



Benefits:
- Anywhere access
- Flexible and dynamic
- Multi-cloud support

Challenges:
- Low throughput
- High latency
- Security and reliability

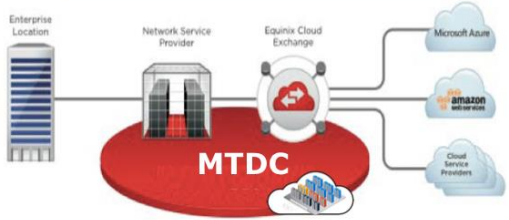
Cross-connect to Cloud



Benefits:
- Secure and private
- High availability BW
- Consistent performance
- Cost effective

Challenges:
- Physical installation
- One to one connections
- Scalability issue

Virtual Cross-connect to Cloud



Benefits:
- One to many connections
- Secure and private
- Consistent throughput
- Low latency
- Flexible, dynamic, scalable
- Reduced provision time
- Multi-Cloud support
- Pay-as-you-go

Challenges:
- New HW/SW implementation

Belden and Anixter 2016

Hyperscale Data Centers

Market Size is estimated to grow from $71.2 billion by 2022, with a CAGR of 20.7% from 2016 to 2022

Techresearchandanalysis, 2016

Source: Microsoft (Dublin, Ireland)

Source: Google

Source: Apple

New Cloud Challenges – Move to Edge Computing

IoT

Growing bandwidth

Energy Utility Co.	.5TB/day
Offshore Oil Field	.75TB/week
Large Refinery	1TB/day
Airplane	10TB/30 min of flight

Latency requirement

Cost/Power

IoT need to work even when the connection is temporarily unavailable

Cloud data center can not provide enough bandwidth to cover every corner of the world

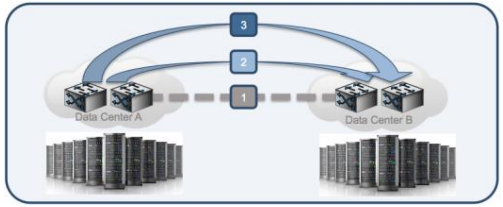
Centralized data center architecture cannot meet the requirements of instantaneous data analysis

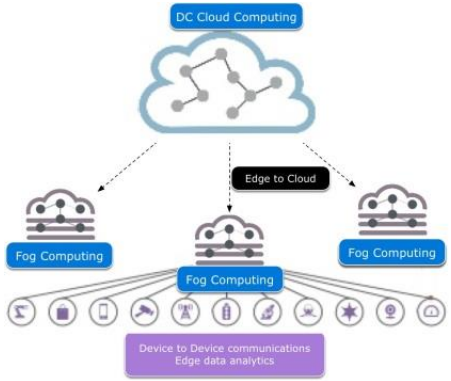
Power/Cost VS Scalability

Belden and Anixter 2016

Is Scale the Answer to Everything?

- Diminishing ROI for further scale increases…
  - Cost, latency and power consumption
- Resilience requirements
  - ITC DCs closer to the end users, and duplication
- Evolving workloads
  - More flexible orchestration and edge computing





Belden and Anixter 2016

Understanding 'As A Service' Data Centers

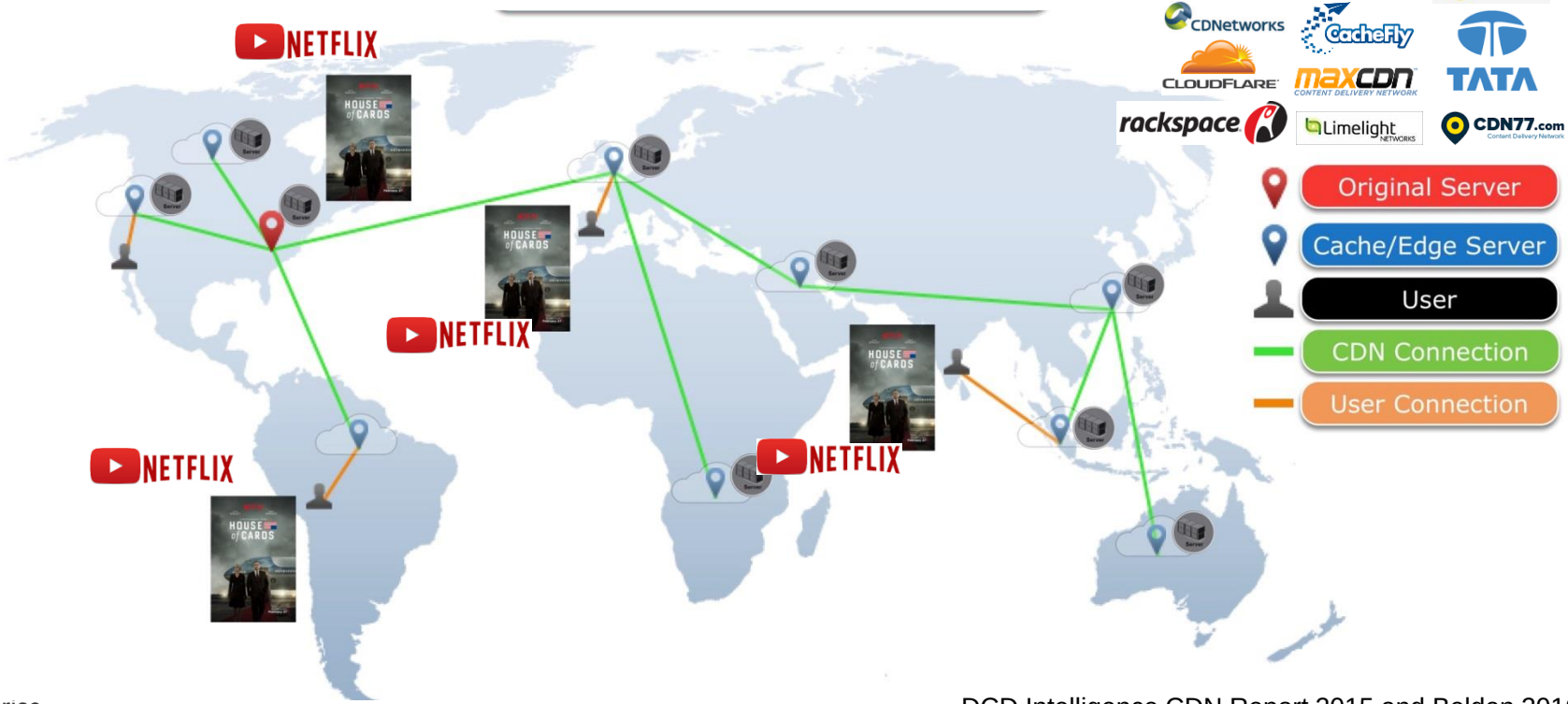
Enterprise Owned	Multi-Tenant		Hyperscale	
Internally Managed	IaaS	Infrastructure as a Service		
	SaaS	Software as a Service	SaaS	Software as a Service
	FaaS	DCaaS	PaaS	Platform as a Service

Traffic

Assets

Assets

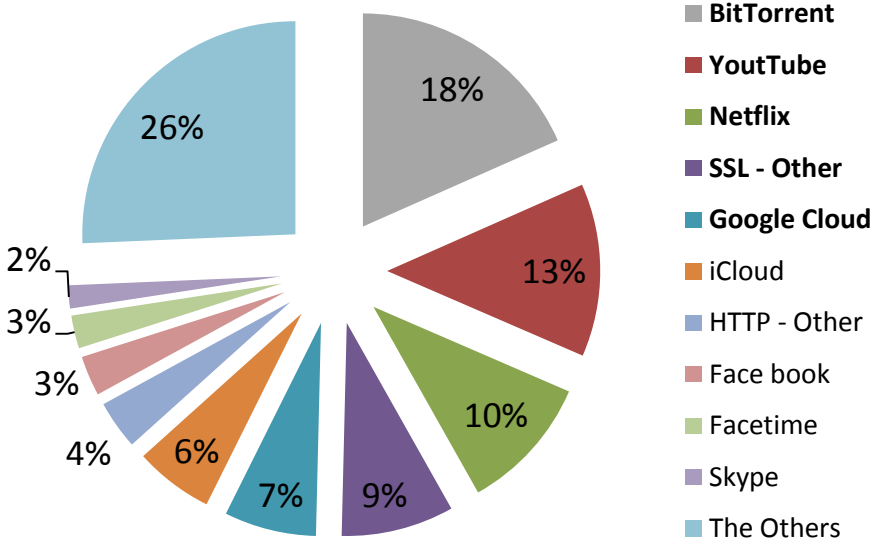
Content Delivery Network Services



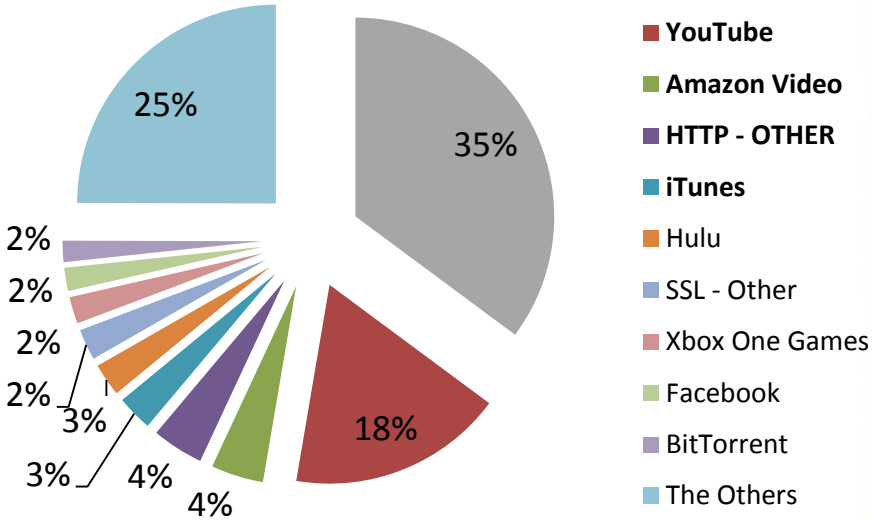
DCD Intelligence CDN Report 2015 and Belden 2016

Over-The-Top Data Traffic

Global Internet traffic Upstream



Global Internet traffic Downstream

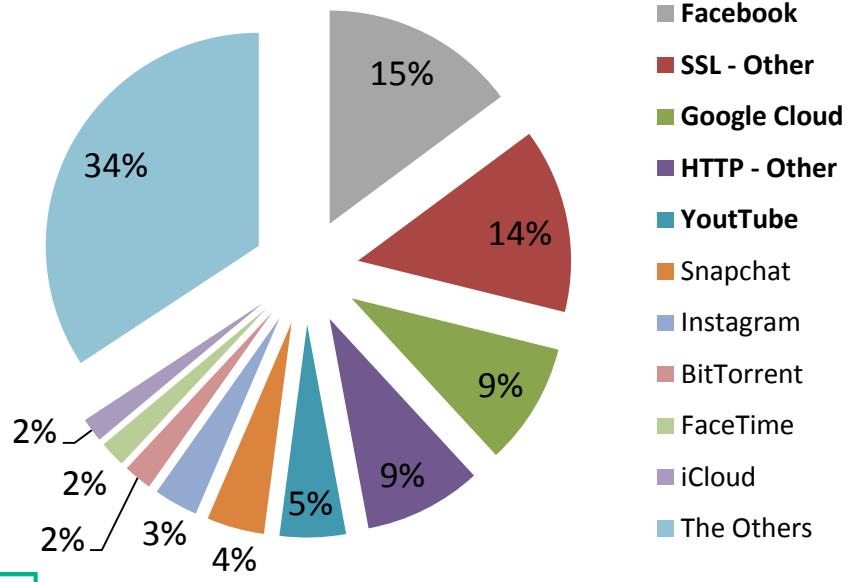


Top 10 Peak Period Applications, North America, Fixed Access

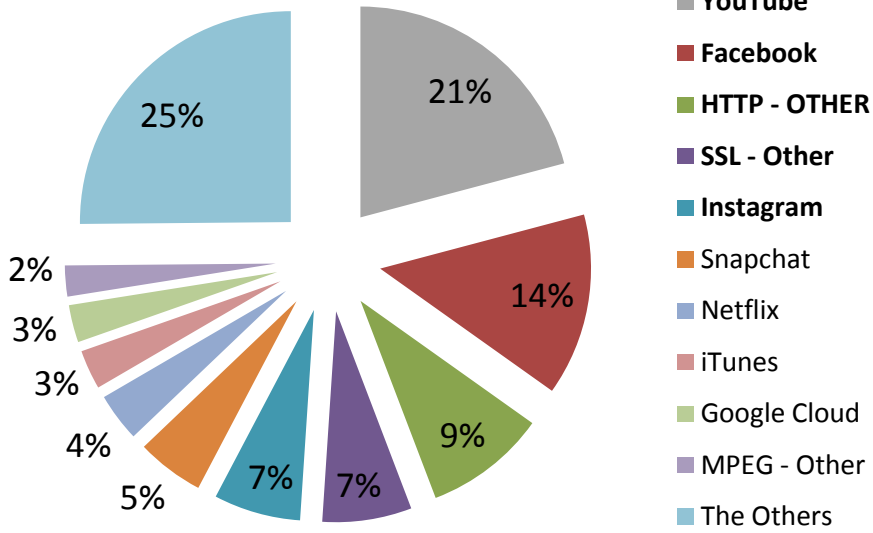
Source: Sandvine 2016

Over-The-Top Data Traffic

Global Internet traffic Upstream



Global Internet traffic Downstream



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Top 10 Peak Period Applications, North America, Mobile Access *Source: Sandvine 2016*

Latency Impacts

Source: EdgeConnex @ OFC 2016

Multi-Tenant Data Center Service Types

Infrastructure

MTDC owns
- Core and shell
- Power and cooling

Customers own
- Servers, storage
- Networking equipment

Network Services

BT verizon

AT& CenturyLink

NTT orange

Colocation

Cloud service local facility #1

Content delivery enforcement node #1
Content delivery enforcement node #2

Enterprise DC hosting #1
Enterprise DC hosting #2

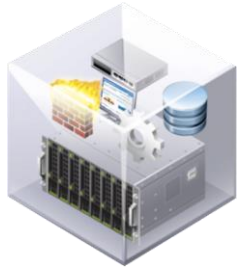
Cross-connect

Exchange and cross-connect to different ISPs

Hewlett Packard Enterprise

Belden and Anixter 2016

New Data Centers Ecosystem at the Edge

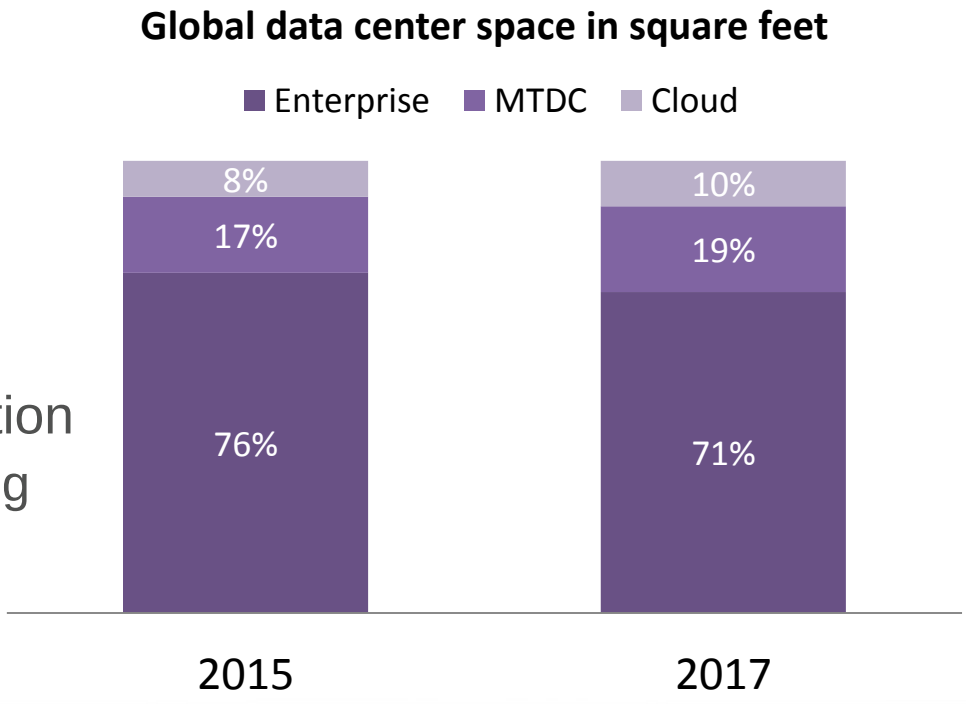


- Colocation/Edge data centers
  - Caching content closer to the end user
  - Smaller and more distributed locations
  - Enterprise end users prefer certain mission critical elements of their IT infrastructure to be physically closer to their offices
  - Edge-Computing nodes allow extending the Cloud and support low latency applications

- The emergence of secondary data center markets MTDCs, CDNs
- Provide direct connects
  - Being part of the Cloud value chain
  - Direct connectivity to Enterprise
  - Consumption-based pricing models
  - No more long term commitments – month to month pricing

Enterprise Data Center – Still a Significant Market

- Enterprise
  - Financial institutes
  - Health care
  - Storage, IT infrastructure
  - Small-medium enterprise
- Government, research/education
  - High performance computing
  - Big data analytics
  - Internet of things



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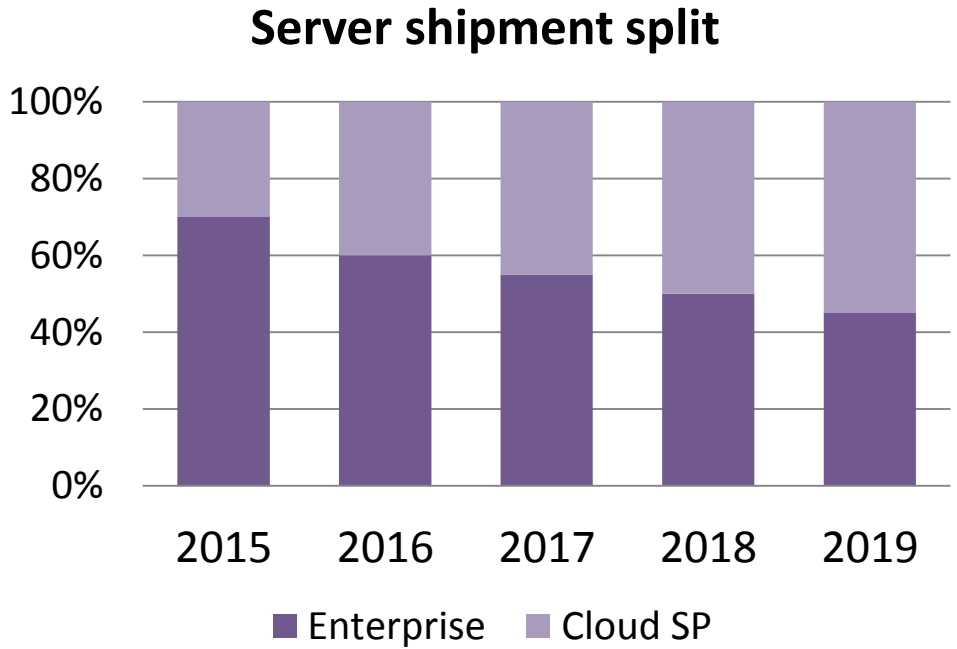
Source: 451 research

Server Shipment Forecast

- Current installed base
  - Enterprise >> Cloud
- Migration trend
  - From Enterprise to Cloud service provider
  - From Enterprise to MTDCs for Hybrid Cloud service



Source: Dell'Oro 2015

Traditional DC VS Modular DC

Traditional Datacenter

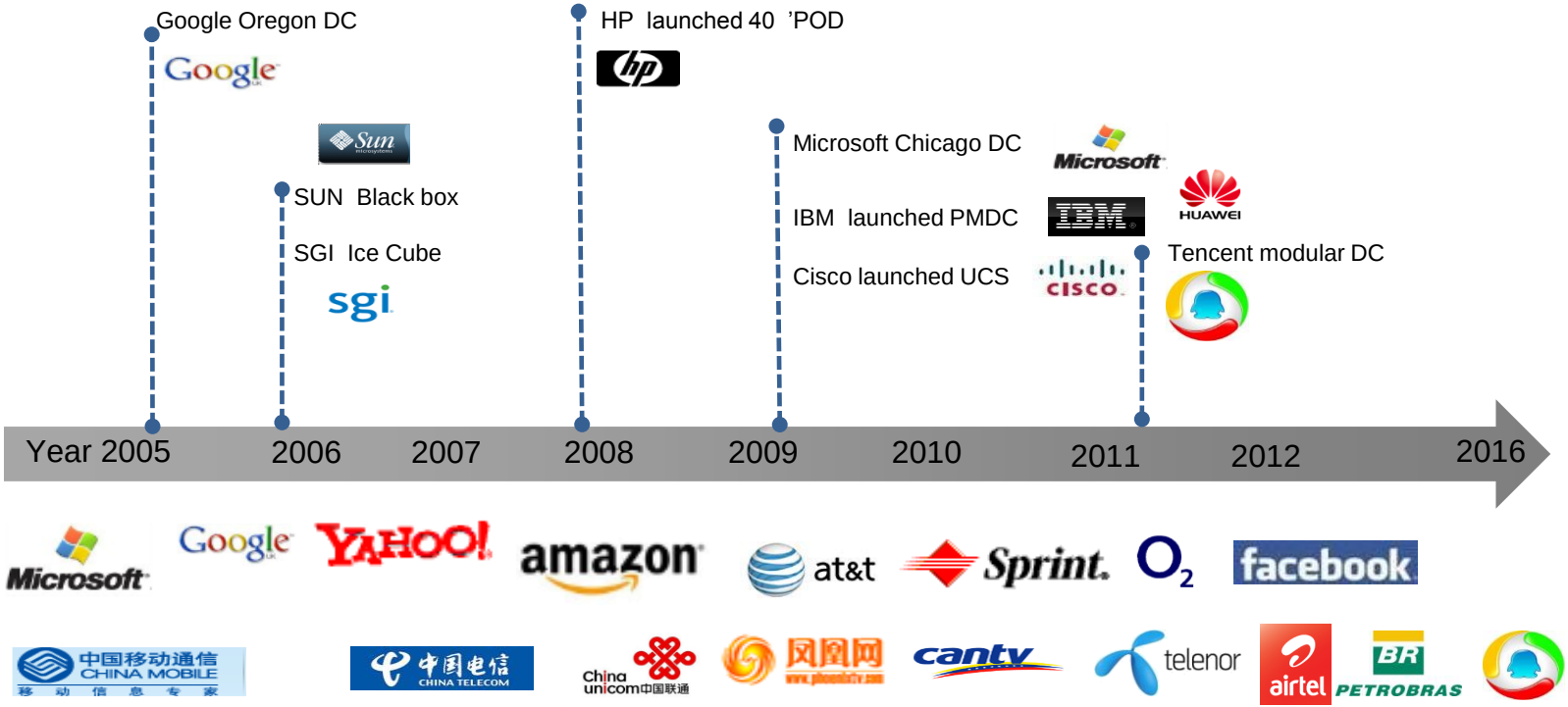
- Complex engineeringlong term construction, average 2 years
- Low infrastructure utilization, stranded capacity and PUE>2.0
- One-time construction, large Initial investment, Highly managed ROI
- Unused capacity high Opex and Stranded IT
- Fixed infrastructure structure, scalable， can be slow to business reacting
- Subsystem cross-management weaknesses across multiple systems. high cost of O&M

Modular Datacenter

- Standardized Design and Engineering
- Shortened Construction Period – 1 to 3 months
- High infrastructure utilization
- Balanced PUE<1.6 Based on IT Capacity
- Energy Efficienct: Improved power consumption and modular subsystems.
- Concentrated power & cooling improve infrastructure utilization
- Flexible structure, phased deployment
- Financial benefits, lower CAPEX and OPEX across all environments and subsystems
- Capacity and Location On Demand
- Decentralized Control with Centralized Mgt.
- DCIM and Predictive Analysis

Schneider Electric and Rittal 2016

Modular data center has been widely accepted



Modular Spaces

- Modular design is slightly different thinking
  - It can be as simple as a cabinet that contains individual modules or bays
  - Or as dynamic as an entire data center space
- Modularity could mean the ability to expand in a planned or standard sets
  - Converged Solutions
  - kW load
  - Compute/network/storage
- Modular spaces need to provide:
  - Support future technologies
  - Support cooling and power requirements
  - Increase energy efficiency
  - Create potential “Cookie Cutter” design, but matched to the building and customer needs

DCD Intelligence Modular Report 2015

Modular Design Challenges

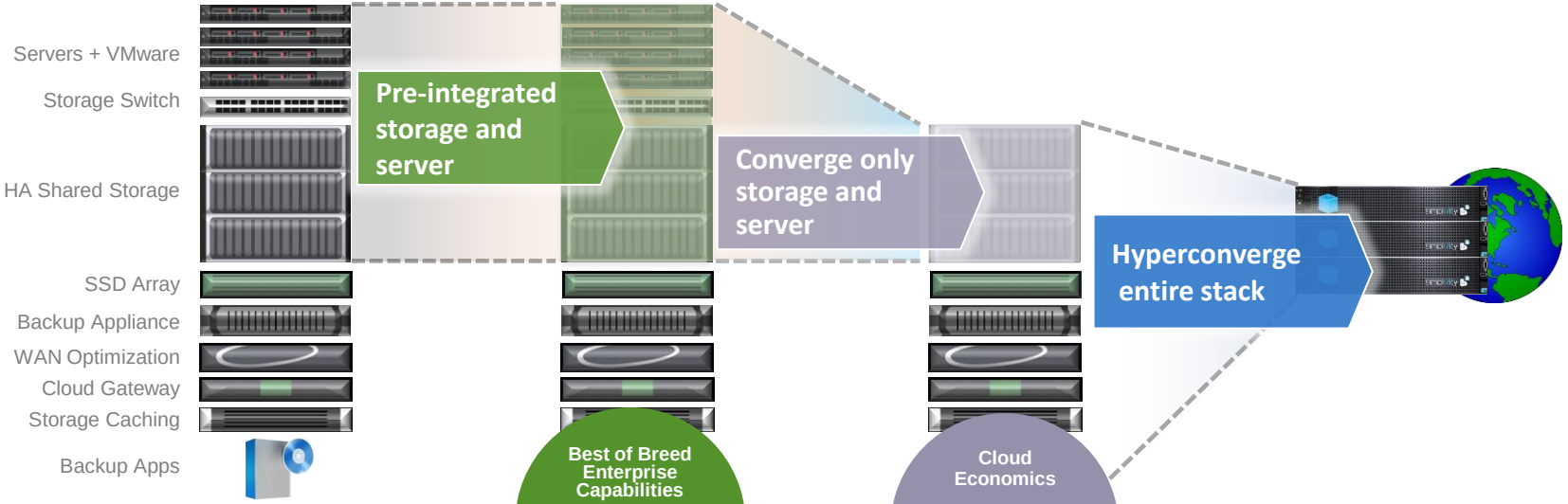
- Will it be flexible?
  - Designs are usually completed 3-4 years prior to product install
- Can it accept future technologies?
  - Equipment is changing from power requirements to cooling requirements – Ex. New Switches and Air path
  - Easily upgradeable
- Network Connectivity
  - Can it support current and future network demand and connections
- Space
  - Newer devices requiring greater space footprint, power and cooling.

DCD Intelligence Modular Report 2015

HyperConvergence

8 MONTHS in development	18 MONTHS in development	43 MONTHS in development

Legacy Stack → **Convergence 1.0** Integrated Systems → **Convergence 2.0** Partial Convergence → **Convergence 3.0** Hyperconvergence



Hewlett Packard Enterprise

Source: Simplivity 2016

Application/Cloud High Speed Connectivity Challenges

High speed migration challenges

- Power efficiency (pj/bit or mW/Gb/s)
- Port density ($Gb/s/mm^2$)
- Reach (M or KM)
- Cost efficiency ($/Gb/s)
- Sustainability (infrastructure reusability)
- Product availability (Standards, multiple vendors)
- System scalability (pay-as-you-go)
- System resilience (failure tolerance/recovery)

Signal transmission technologies

- 10GBASE-T technology Structured cabling
- Twinax cable Direct attached copper
- Single λ VCSEL transceiver Parallel multimode fiber
- Single λ DFB/SiP transceiver Parallel single mode fiber
- Colored VCSEL transceiver Duplex multimode fiber
- CWDM λ DFB/SiP transceiver Duplex single mode fiber
- Modulation formats NRZ or PAM4
- Signal equalization Error correction coding

BSRIA, 2016

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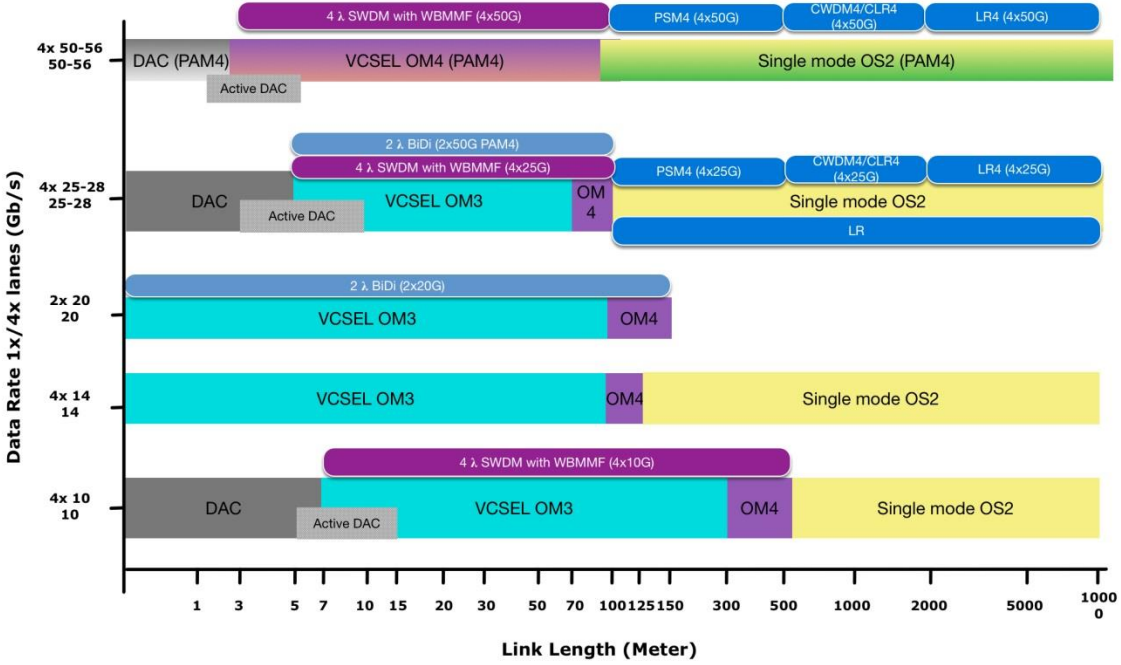
System Interconnects Speed & Media

BSRIA, 2015



Ethernet

Protocol	#Lane	Signaling Rate (GBaud)	Aggregate Data Rate (Gbit/s)	Modulation Format	Transmission Media
10GE	1	10.3125	10.3125	NRZ	DAC, MMF, SMF
25GE	1	25.78125	25.78125	NRZ	DAC, MMF, SMF
40GE	4	10.3125	41.25	NRZ	DAC, MMF, SMF
50GE	2	25.78125	51.5326	NRZ	DAC, MMF, SMF
50GE	1	26.5625	53.125	PAM4	DAC, MMF, SMF
100GE	4	25.78125	103.125	NRZ	DAC, MMF, SMF
100GE	*2*	*26.5625*	*106.25*	*PAM4 (Gen2)*	*DAC, MMF, SMF*
*200GE**	*4*	*26.5625*	*212.5*	*PAM4*	*DAC, MMF, SMF*
*400GE**	*16*	*25.78125*	*412.5*	*NRZ (SR16)*	*MMF*
*400GE**	*4*	*53.125*	*425.0*	*PAM4 (DR4)*	*SMF (PSM)*
*400GE**	*8*	*26.5625*	*425.0*	*PAM4 (FR8, LR8)*	*SMF (WDM)*

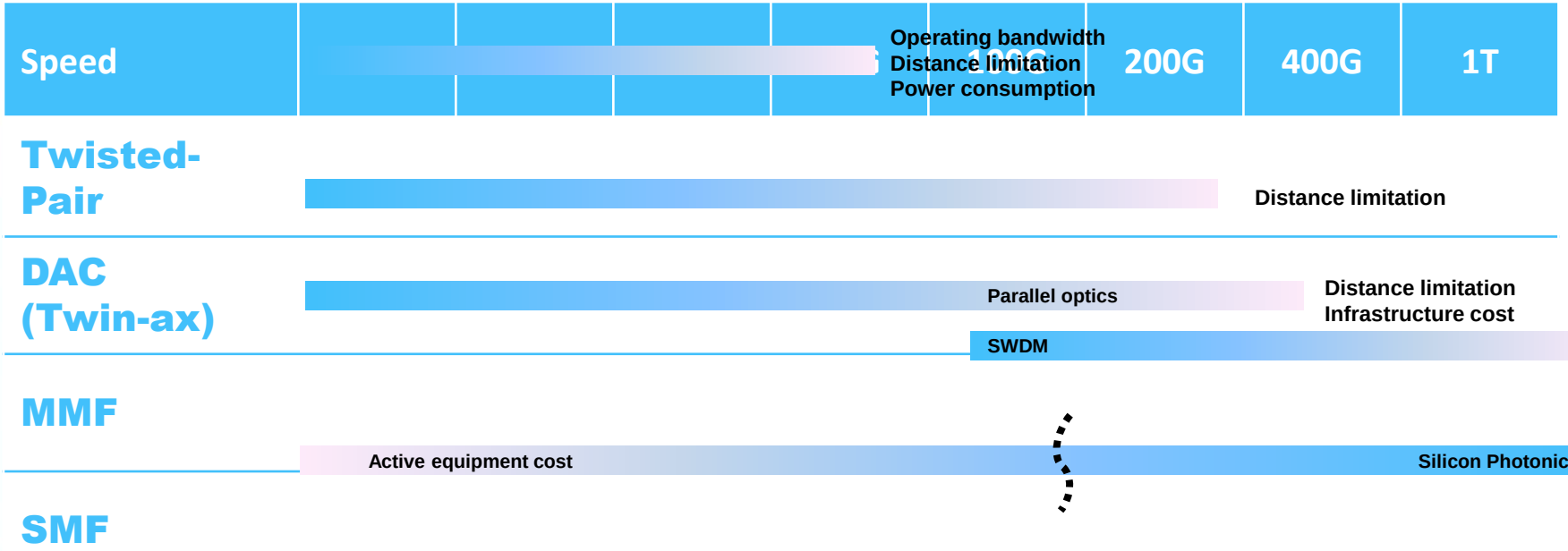
Fibre Channel

Protocol	#Lane	Signaling Rate (GBaud)	Aggregate Data Rate (Gbit/s)	Modulation Format	Transmission Media
8GFC	1	8.5	8.5	NRZ	DAC, MMF, SMF
16GFC	1	14.025	14.025	NRZ	DAC, MMF, SMF
32GFC	1	28.05	28.05	NRZ	DAC, MMF, SMF
*64GFC**	*1*	*28.05*	*56.10*	*PAM4*	*DAC, MMF, SMF*
128GFC	4	28.05	112.2	NRZ	DAC, MMF, SMF
*256GFC**	*4*	*28.05*	*224.4*	*PAM4*	*DAC, MMF, SMF*

InfiniBand

Protocol	#Lane	Signaling Rate (GBaud)	Aggregate Data Rate (Gbit/s)	Modulation Format	Transmission Media
QDR	1	10	10	NRZ	DAC, MMF, SMF
4xQDR	4	10	40	NRZ	DAC, MMF, SMF
FDR	1	14.0625	14.0625	NRZ	DAC, MMF, SMF
4xFDR	4	14.0625	56.25	NRZ	DAC, MMF, SMF
EDR	1	25.78125	25.78125	NRZ	DAC, MMF, SMF
4xEDR	4	25.78125	103.125	NRZ	DAC, MMF, SMF
*HDR**	*1*	*53.125*	*53.125*	*PAM4*	*DAC, MMF, SMF*
*4xHDR**	*4*	*53.125*	*212.5*	*PAM4*	*DAC, MMF, SMF*

Network Speed Technology Lifecycle



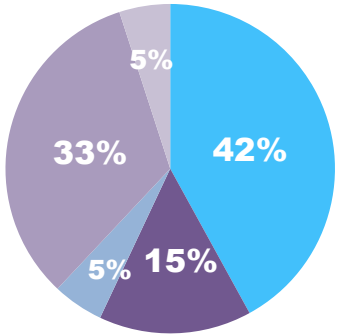
Hewlett Packard Enterprise

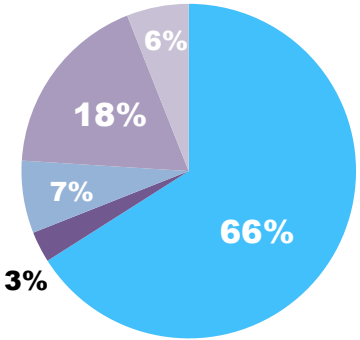
Source: BSRIA, Belden, Anixter

Switch to Server Connections

Topology	Reach	DAC	Twisted Pair	AOC	MMF	SMF
ToR	3 m	✓	✓			
Adjacent Rack	5 m	✓	✓	✓		
MoR / EoR	30 m		✓	✓	✓	
Centralized	100 m		✓		✓	✓

Enterprise Switching Architecture





ToR
EoR
MoR
Centralized
Other

MTDC Switching Architecture

BSRIA, 2015

Data Center Migration Paths

BSRIA, Belden, 2015 and 2016

Enterprise DC

BASE-T	BASE-SR4 BiDi
10G	40G
1G	10G
Access	Aggregation

MTDC

BASE-T/CR	BASE-SR4 PSM4 (DR4)
10G / 25G	40G / 100G
1G	10G / 40G
Access	Aggregation

Hyperscale DC

BASE-CR	BASE-SR4 /PSM4 (DR4) /CWDM4
25G / 50G	100G / 200G / 400G
10G	40G
Access	Aggregation

Closing and Questions.
Thank you

Datacenter Dynamics