Emerging Trends in Data Center Networking and Fiber Technology

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Belden’s Journey as Solution Provider

1902 - 2007

Data Transmission

Focused at addressing reliability issues that arise from passive connectivity

Production Availability

2008 - 2014

Data Acquisition

Focused at addressing reliability issues that arise from IT-OT integration challenges

Converged Automation

2015 - 2020

Data Security

Focused at addressing security challenges to ensure the confidentiality, integrity, and availability of the data

Secured Automation

2020 - onwards

Data Orchestration and Management

Focused at addressing operational challenges and optimizing OEE using the real-time OT data

Operational Excellence

Digitalized Automation
Orchestration of decisions based on the market pulse

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Trusted Brands

Data Acquisition & Transmission

- AlphaWire
- BELDEN
- CloudRAIL
- lumbergautomation — A BELDEN BRAND
- PPC — A BELDEN BRAND
- SICHERT — Your Partner
- thinklogical — A BELDEN BRAND
- WEST PENN WIRE

BELDEN

Data Orchestration & Management

- CloudRAIL
- GarrettCom — A BELDEN BRAND
- HIRSCHMANN — A BELDEN BRAND
- macmon — smartly simple
- NET MODULE
- OTN Systems
- ProSoft TECHNOLOGY
- thinklogical — A BELDEN BRAND
- TOFINO SECURITY — A BELDEN BRAND

LAN/RAN/AV End-to End-Solution

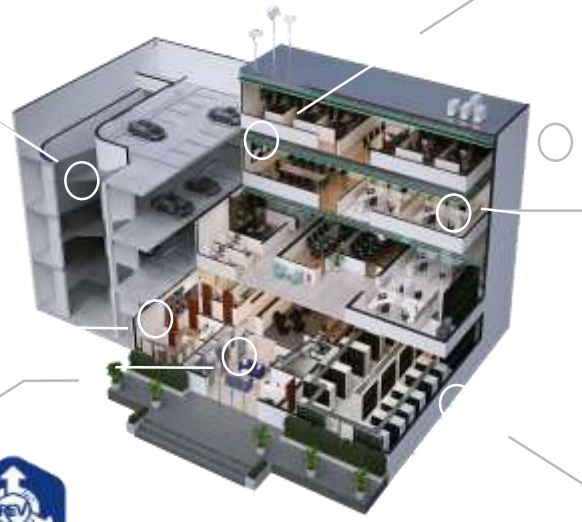
Indoor / Outdoor Security Camera – Hybrid Cable and FX Fusion

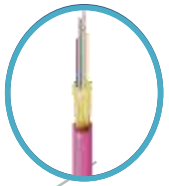
CCTV and Security Cable

Serial I/O RS485

Network Operation Center – FX Fusion, Patch Cords

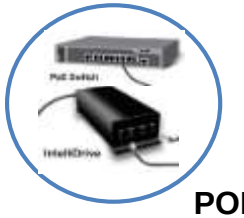
DAS / Small Cell – DE Hybrid Cable and FX Fusion

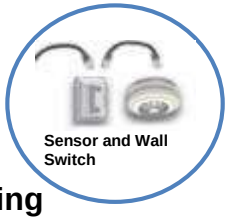




Audio / Video (AV) – Fiber Distribution or Breakout Cable

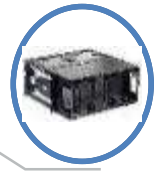
Network Backbone – Fiber Distribution Cable





POE Lighting
Digital Electricity System Hybrid Cables, Switches, Drives and Fixtures

LAN / Workstations – Fiber Workstation Connectivity / Patch Cords



Telecom Room (TR) – ECX Patch Panel, Pre-Term and Pigtail Cassettes,

Entrance Facility - OSP Cable & Wall Mount

REVConnect Copper Cabling Solution

WIFI / Wireless – Hybrid Cable and FX Fusion

Rack Space to Parking Space

NETWORKING INFRASTRUCTURE

OPERATION MANAGEMENT

SECURITY/SAFTY/ SURVEILLANCE

DIGITAL SIGNAGE

1 Data Networking

2 Car Park Management

3 IP & Traditional TV

4 IP & Traditional Telephony System

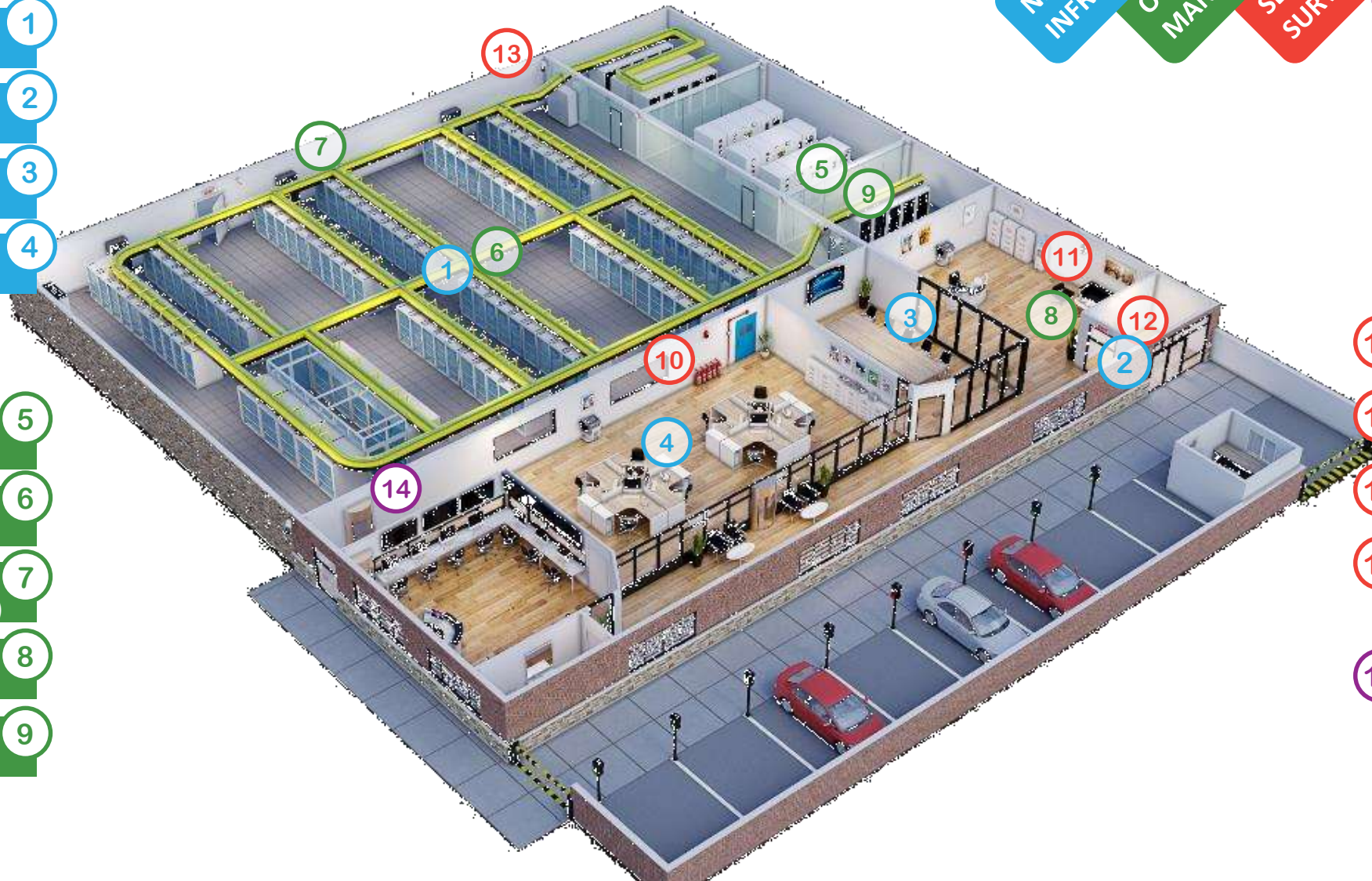
5 Building Management System (BMS)

6 Data Center Infrastructure Management

7 Heating, Ventilation and Air-Conditioning System (HVAC)

8 Intelligent Lighting Control

9 Power Management System (PMS)



10 Fire Alarm

11 Public Address & General Alarm (PAGA)

12 Access Control

13 CCTV – Indoor & Outdoor

14 Digital Signage

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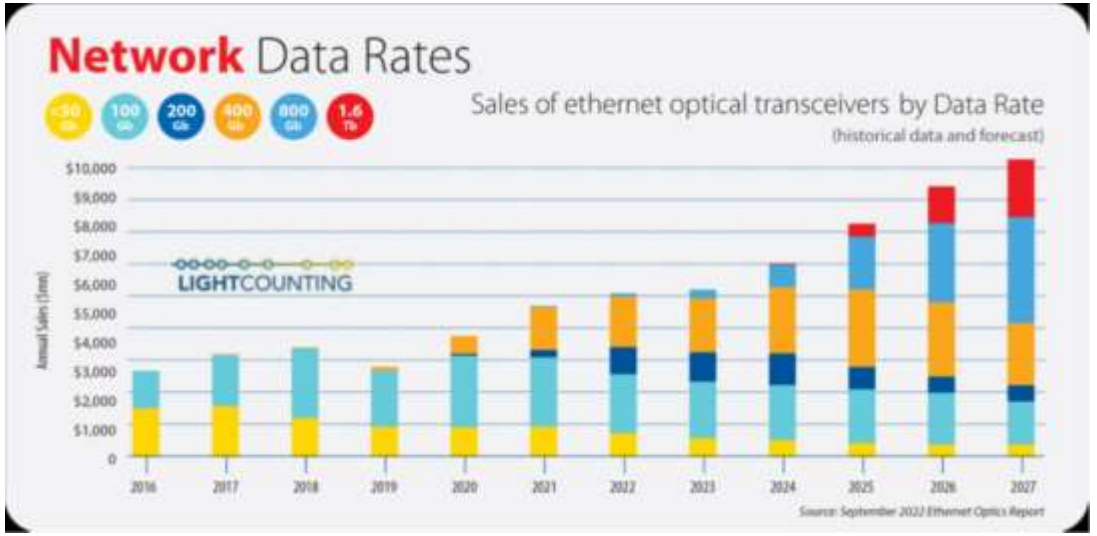
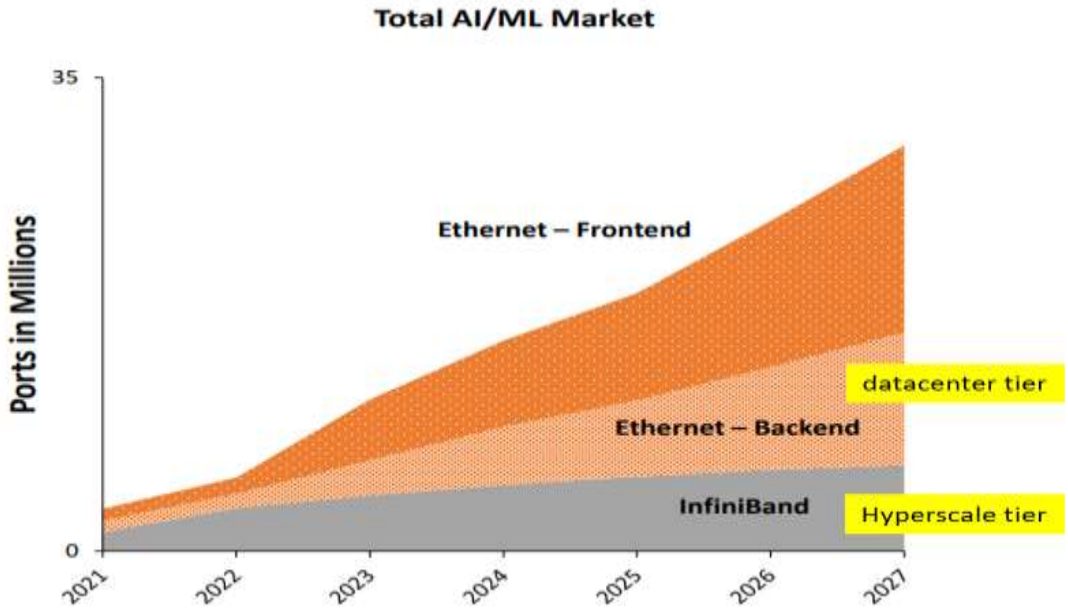
Industry Overview

- Data Center bandwidth needs continue increasing: driving the need for parallel Tx with increased fiber-pairs per link as lane-rate per lambda plateauing
- Networking architectures are transforming, especially with server to switch, and we will see migration from ToR to MoR, EoR switches with optical switch to server interconnects
- AI/ML typically operated as a cluster in the “backend” of large data centers at higher rates than the “frontend”. Choices vary between high-speed Ethernet or InfiniBand
- Multimode fiber Ethernet roadmap projecting to keep pace with SMF options to 1.6 Tb/s.
- Future networking technologies will continue driving the importance of high-density optical cable and connectivity
  - Multifiber connectors (including next generation VSFF)
  - Ribbon cable
  - MMF or SMF vs DAC





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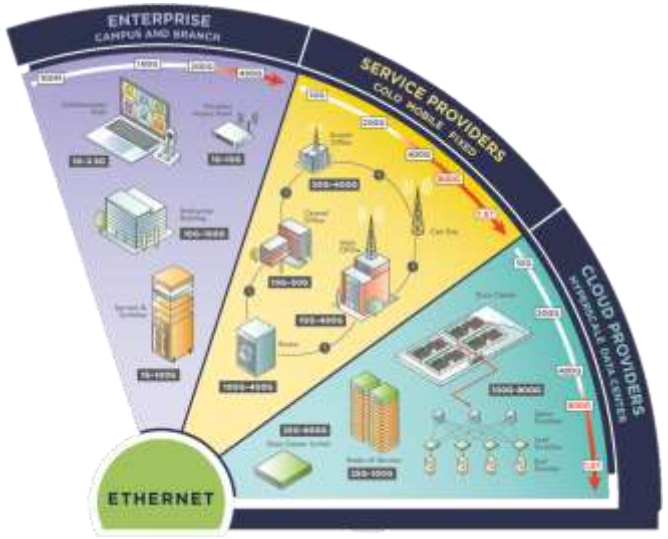
Ethernet Roadmap



Port data rate	MMF PMD	Lane Rate	#pairs	lambda	OM3	OM4	OM5
40G	40GBASE-SR4	10G	4	1	100m	150m	150m
100G	100GBASE-SR4	25G	4	1	70m	100m	100m
200G	200GBASE-SR4	50G	4	1	70m	100m	100m
400G	400GBASE-SR4.2	50G	4	2	70m	100m	100m
400G	400GBASE-SR4	100G	4	1	60m	100m	100m
800G	800GBASE-SR4.2	100G	4	1	45m	70m	100m

Port data rate	MMF PMD	Lane Rate	#pairs	lambda	OM3	OM4	OM5
800G	800GBASE-SR8	100G	8	1	70m	100m	100m
1600G	1600G-SR8.2	100G	8	2	45m	70m	100m

Figure 5-6: Shares of high speed (100G and above) MMF and SMF transceivers in terms of units

Source: LightCounting

Port Data Rate	SMF PMD	lane rate	#pairs	lambda	Reach (m)	Module	Conn
100G	100G-PSM4	25G	4	1	500	QSFP	MPO
200G	200GBASE-DR4	50G	4	1	500	QSFP	MPO
400G	400GBASE-DR4	100G	4	1	500, 2000	QSFP	MPO
800G	800GBASE-DR4	200G	4	1	500, 2000	QSFP	Quad SN/MDC

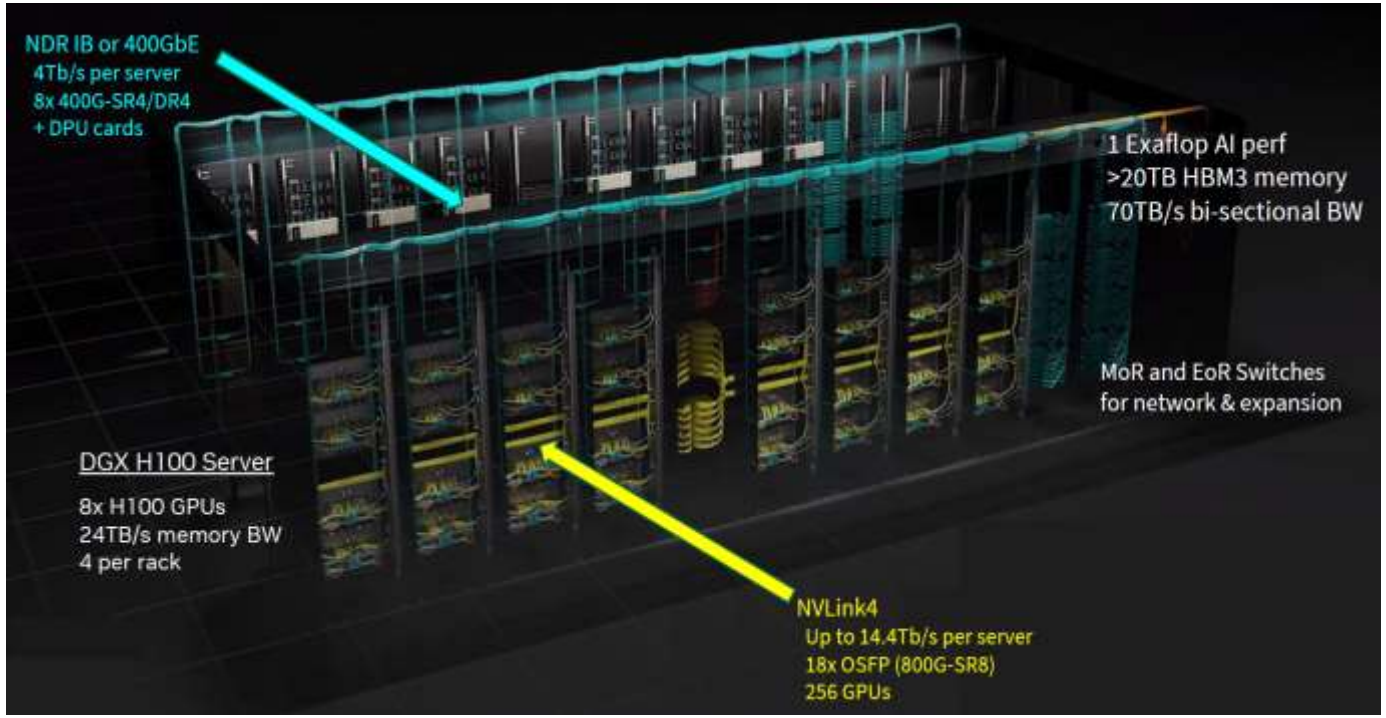
Port Data Rate	SMF PMD	lane rate	#pairs	lambda	reach (m)	Module	Conn
800G	800GBASE-DR8	100	8	1	500, 2000	OSFP	MPO-16 or Dual MPO-12
1600G	1.6TBASE-DR8	200	8	1	500, 2000	OSFP	TBD

Port Data Rate		SMF PMD	lane rate	#pairs	lambda	reach (m)	Module	Conn
SMF WDM	100	100GBASE-LR4	25	1	4	10000	QSFP	dual LC
	100	100G-CWDM4	25	1	4	2000	QSFP	dual LC
	200	200GBASE-FR4	50	1	4	2000	QSFP	dual LC
	400	400GBASE-FR8	100	1	8	2000	QSFP-DD	dual LC
	800	800GBASE-FR4	200	1	4	2000	OSFP	dual LC

[2] 200G VCSEL *in development*

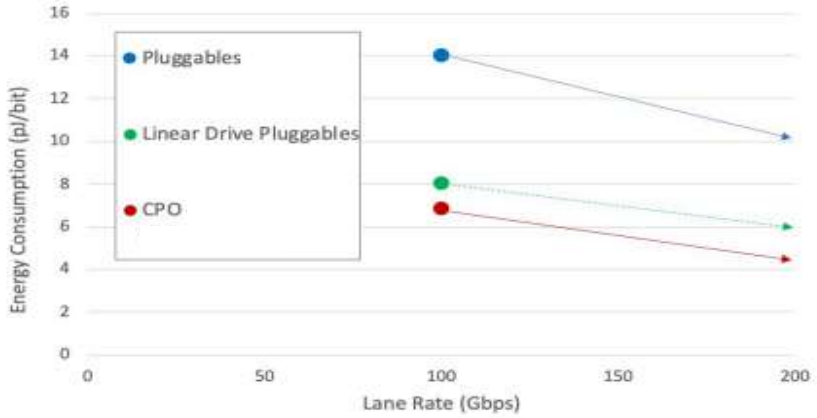
AI/ML

In AI/ML cluster, the network IS the computer



Source : NVidia

- The challenge for AI/ML clusters is to move the data out the GPUs as fast the data is moving inside the GPUs.
- The current optical transceiver solution creates a 50x to 100x bandwidth taper across the system.
- To leverage higher data rate (1.6Tb/s) or higher number of ports, energy efficiency (pJ/bit) must be improved significantly to mitigate impact on cost and energy consumption.
- Industry is seeking high energy efficiency optical technology targeting 5-7 pJ/bit to lower 1-2 pJ/bit for future



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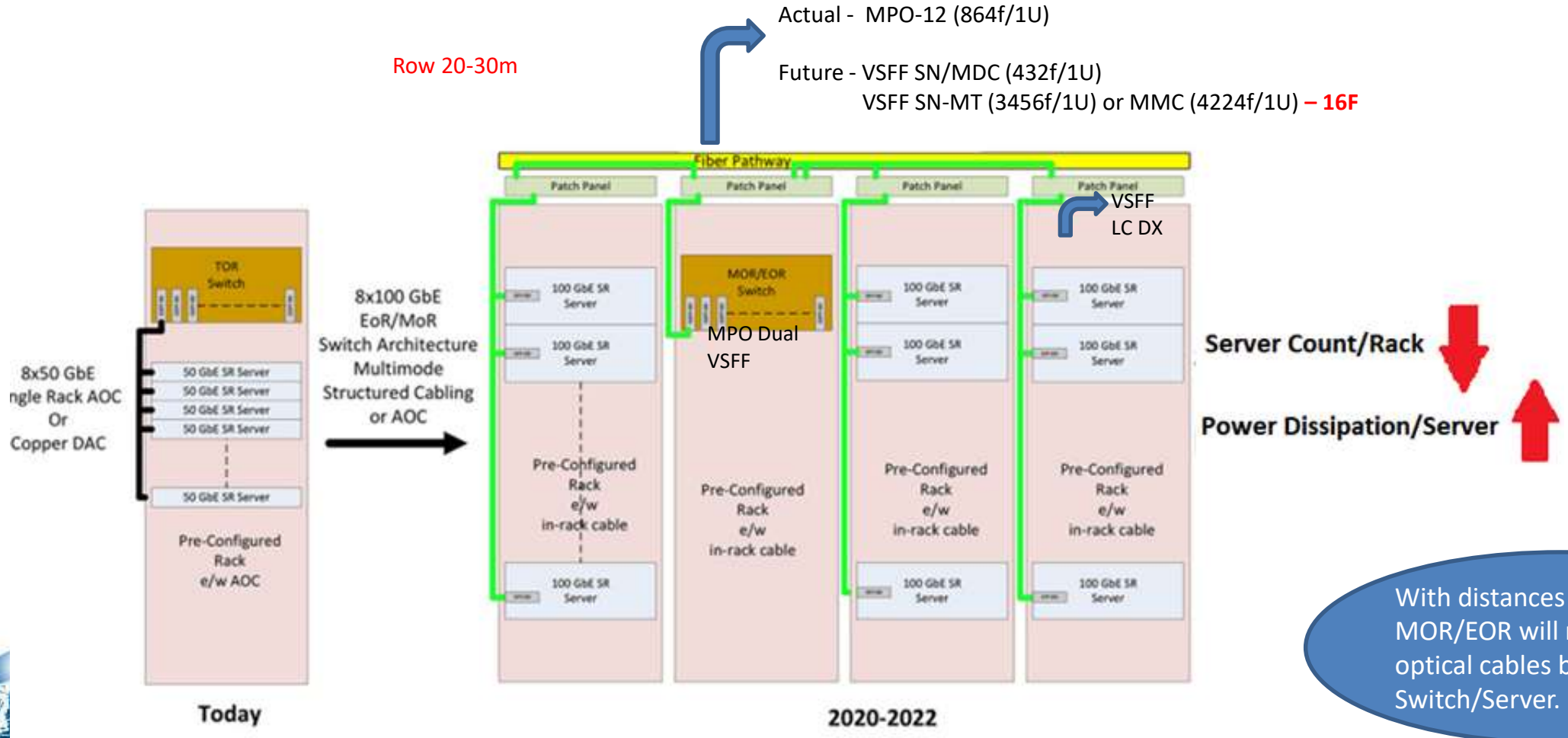
Mid-of-Row/End-of-Row Switches → Optical Interconnect Technology



With distances >3m, MOR/EOR will require fiber optical cables between Switch/Server.

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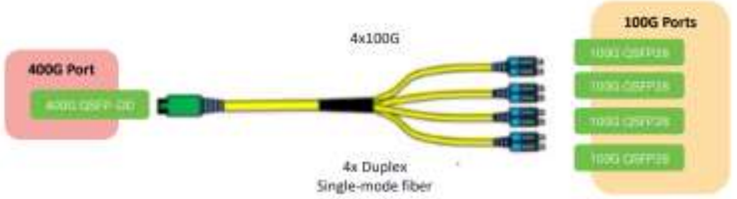
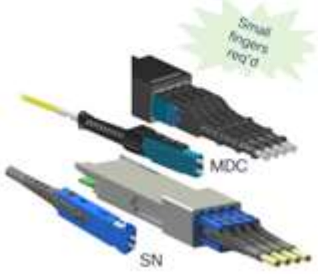
Route to 1.6T and AI/ML – Fiber Product Trends

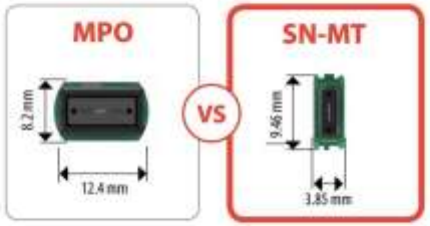
- As transmission lanes and data rate increase, there is a need for...

  … Smaller and modular connectors (VSFF = **V**ery **S**mall **F**orm **F**actor)

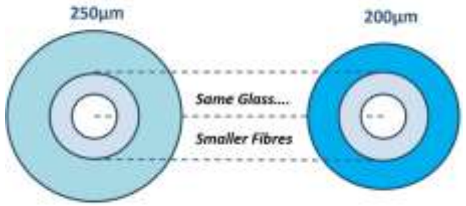




16f fibers

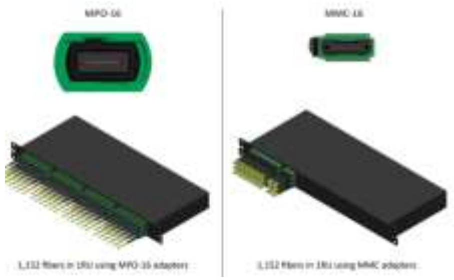


… Smaller cables and smaller fibers

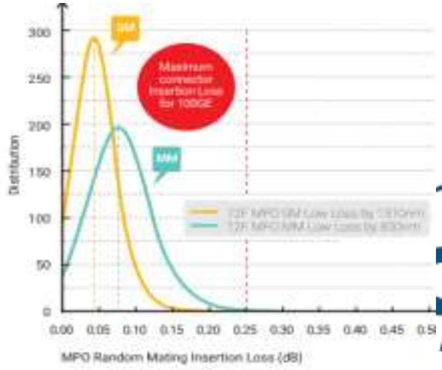


… Denser Cross Connect, Patch Panels

…Future-Proof/Upgradeable Modules



…better Assemblies performance (lower loss). More pre-terminated assemblies for quick installation.



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How to Simplify the Complexity

- User focus
- Define your benchmarks
- Agnostic strategy
- Holistic empathy
- Understanding the eco-system
- Awareness of the possibilities
- Understanding change is constant
- Having the right partners that are aligned with your goals
- Understanding risks and benefits

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Industry & Standards Leadership

Application Standards

Protocol standards

Digital Interface

Promotes network and equipment interoperability

Product Standards

Component standards

Link and Channel standards

Promotes Manufacturer Interoperability

Installation Methods

Training

Government Compliance

Legislative Governance

Marketing

Belden Corporate

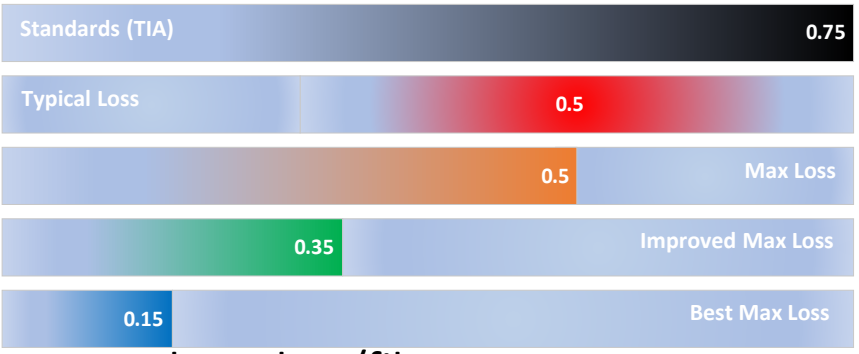
Consortiums

Organizations

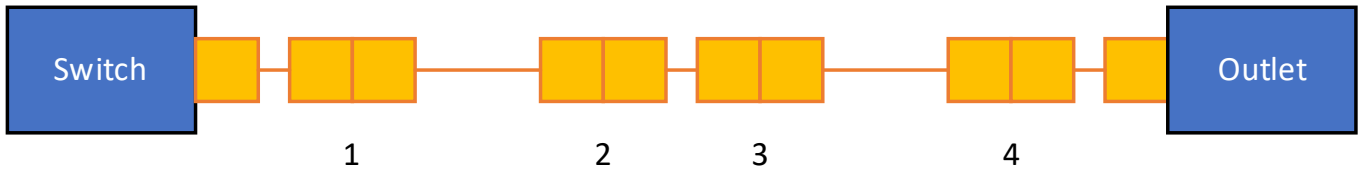
- What's in standards (ANSI/TIA-568.0)?
  - Nothing but application tables for length and loss?
  - We often just look at cable and connector loss
- What contributes to these values in a practical sense?
  - Facilities, layout, size, and network architecture, etc..
  - Infrastructure layout/architecture, topology, etc..
- Speeds are getting higher what does it mean?
  - Distances and budgets continue to shrink
  - This affects both multimode and singlemode

Application	Loss (dB)	Length (m)
10GBASE-S	2.9	400
25GBASE-SR	1.9	100
100GBASE-SR10	1.5	100
10GBASE-L	6.2	10km
40GBASE-FR	4.0	2km
400GBASE-XDR4	4.0	2km

Planning Challenges

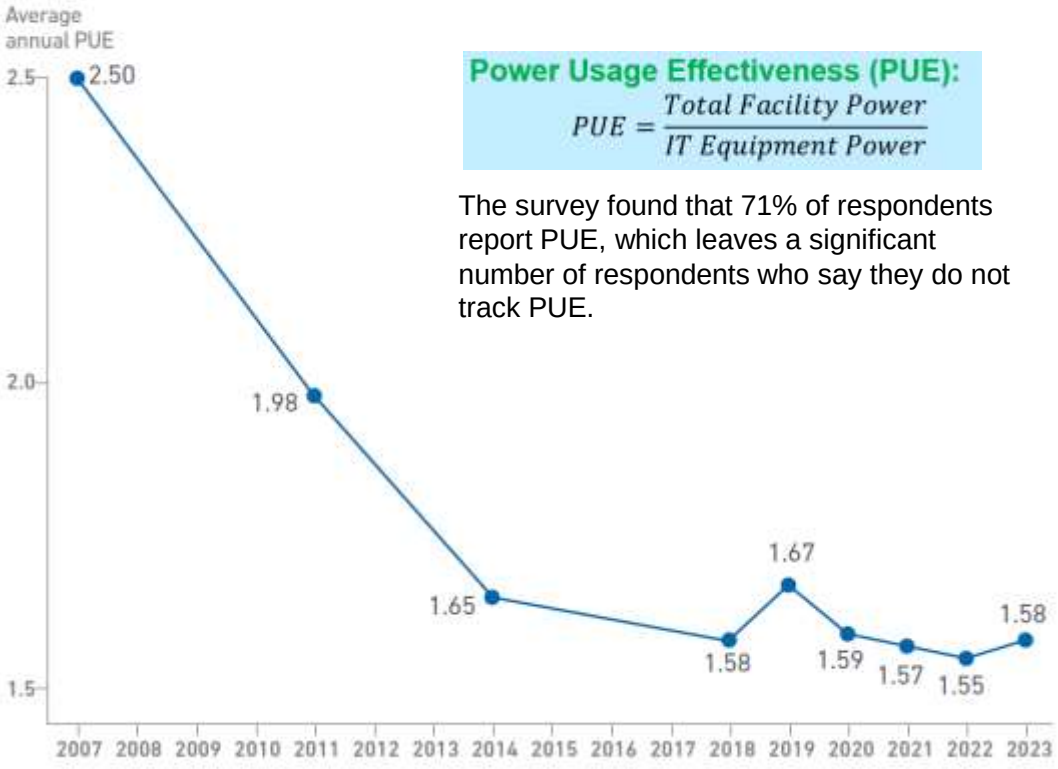


- Loss, performance, complex channels, multiple use cases etc..
- Understand your needs!
- Beware ‘typical’ loss, only use maximum loss, and go much better than standards
- Beware focusing on the wrong challenge (e.g. connector loss is more important than glass/fiber performance)
- Danger of false positives in testing
- Even a simple two-level hierarchy with simple connectivity may fail application testing
  - Using the above example even ‘improved’ max loss may be at the edge of certainty
  - Using the best possible loss profile, planned on maximum values is critical



Industry-wide PUE improvement slows, then stops

What is the average annual PUE for your data center? (n=567)



Power Usage Effectiveness (PUE):

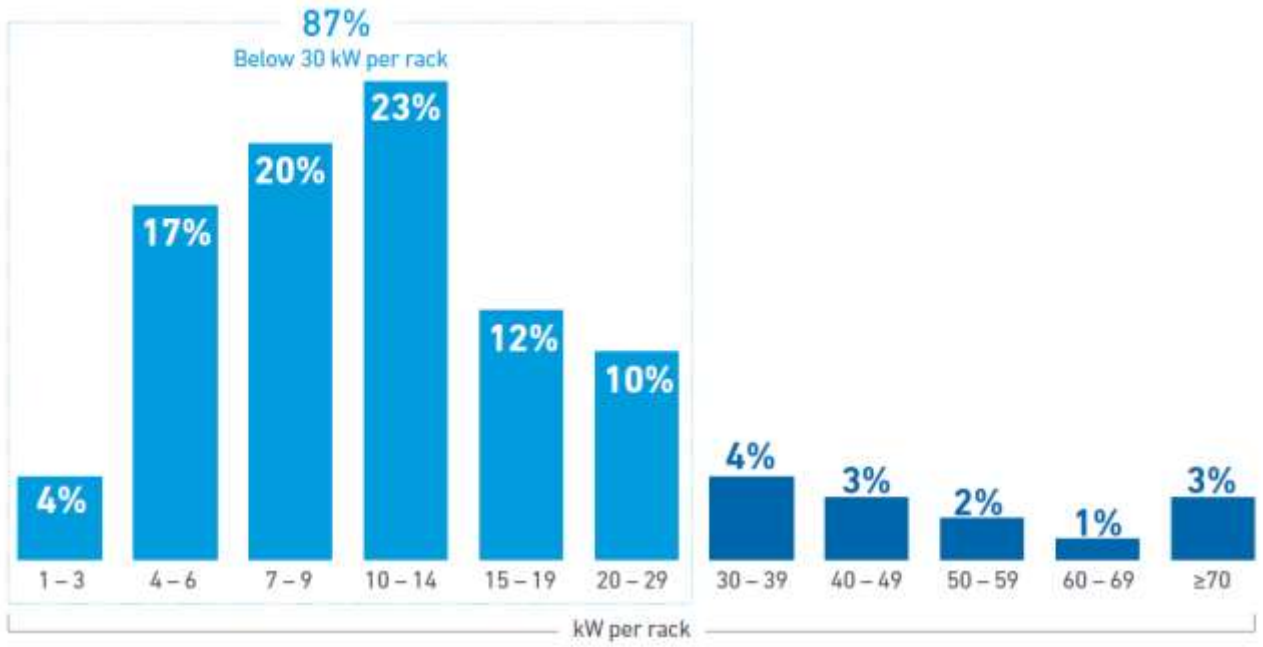
$$PUE = \frac{Total\ Facility\ Power}{IT\ Equipment\ Power}$$

The survey found that 71% of respondents report PUE, which leaves a significant number of respondents who say they do not track PUE.

- Compared with the previous study, fewer operators reported fast-paced increases in rack power, while a much larger group reported relatively stable densities year on year.
- Operators specify many new generic enterprise and colocation data centers to have design power density still in the region of 200 watts (W) per square foot (2.15 kW per square meter). **This translates to 5 kW to 6 kW average rack design power**, offering balance in accommodating a rich mix of densities..

Few have rack over 30kW, but extreme densities are emerging

What is the highest server rack density deployed in your site? (n=687)



REF: UPTIME INSTITUTE GLOBAL SURVEY OF IT AND DATA CENTER MANAGERS 2023

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UPTIME INSTITUTE REPORT

Uptime Institute's Global Data Center Survey Results 2023

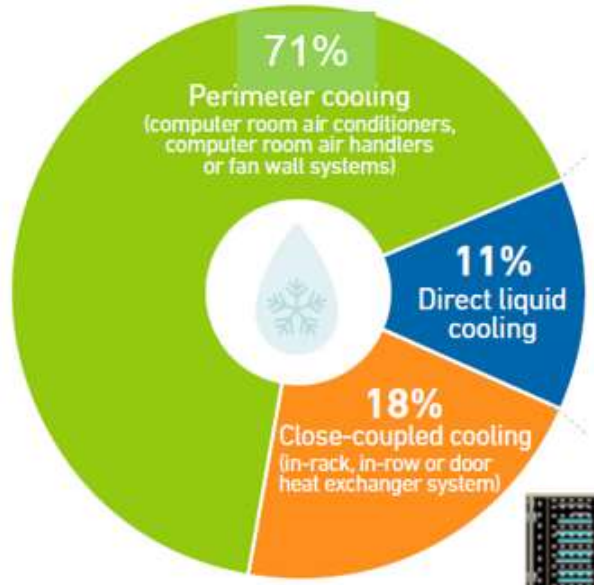
uptime INSTITUTE

Uptime's annual survey results are in. Read the executive summary of the data center industry's largest and most influential survey results report.

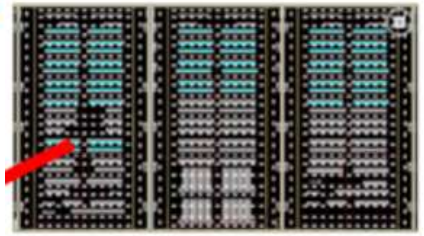
Server refresh cycles continue to slow

Even on the densest racks, perimeter cooling dominates

How do you currently cool your highest density cabinets? (n=572)

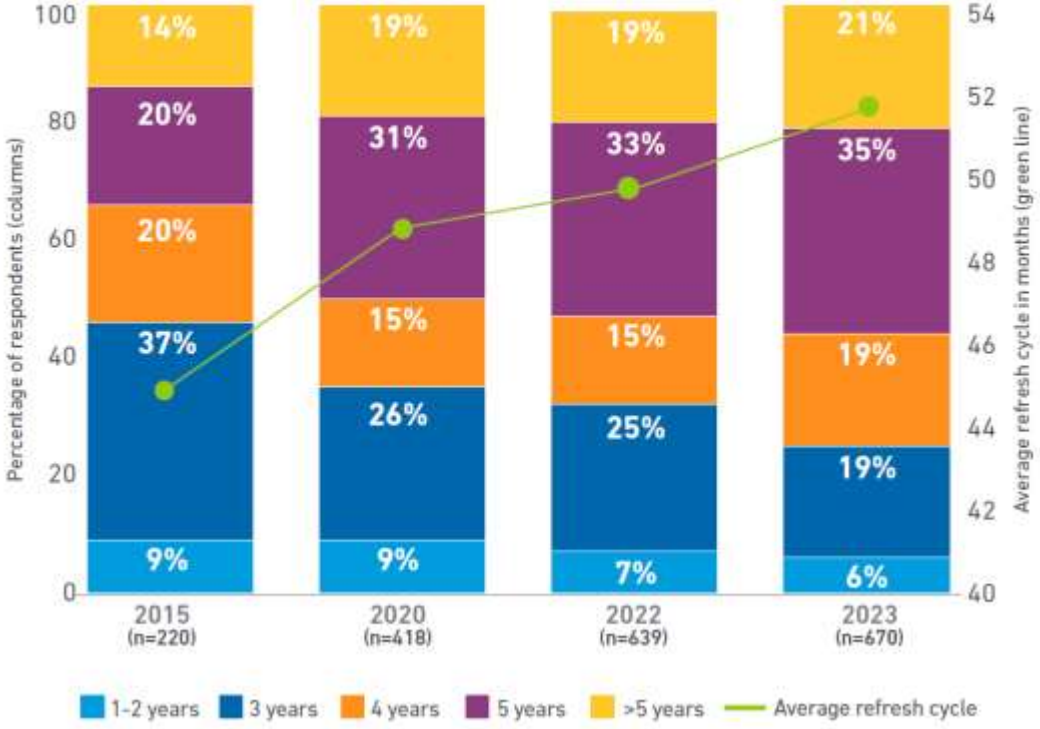


(All figures rounded.)



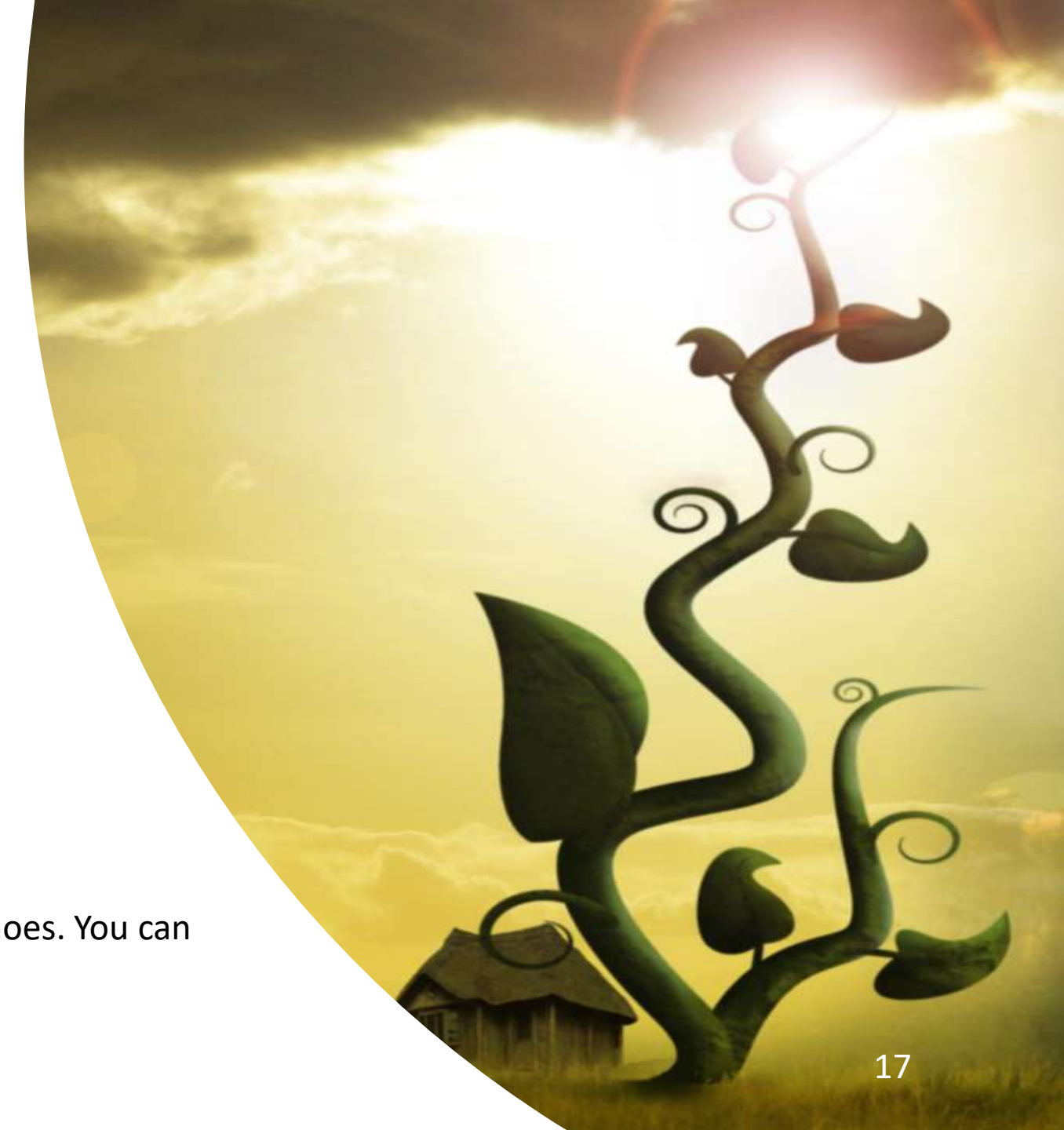
Operators are extending refresh cycles

How often does your organization typically refresh its servers?



REF: UPTIME INSTITUTE GLOBAL SURVEY OF IT AND DATA CENTER MANAGERS 2023

Lesson Learned from Childhood



"Fairy tales do not tell children dragons exist. Children already know the dragons exist. Fairy tales tell children the dragons can be killed." GK Chesterton

One Size does not fit all (there are no magic beans)

- Bigger isn't always better
- Less can be more
- Things don't always get faster
- Future proofing may be a waste

"You have brains in your head. You have feet in your shoes. You can steer yourself, in any direction you choose." Dr. Seuss

Thank you

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