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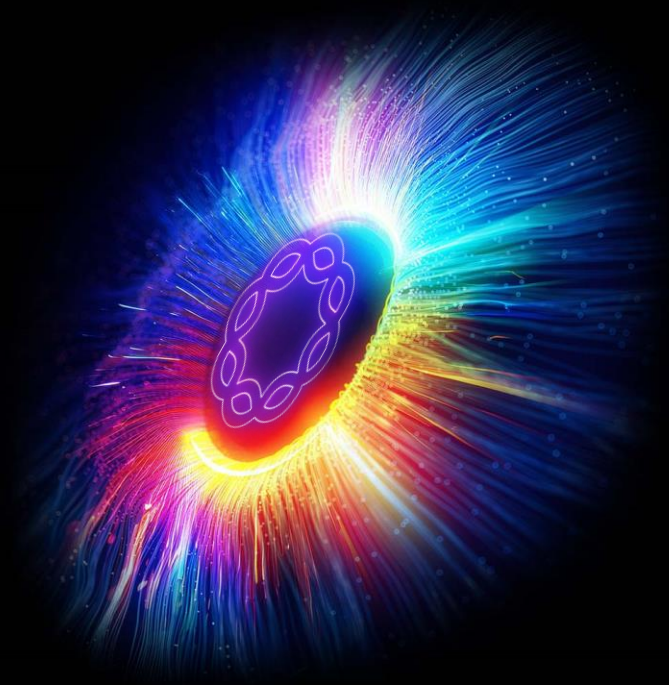


Data Center Interconnect

Ribbon Solution Overview

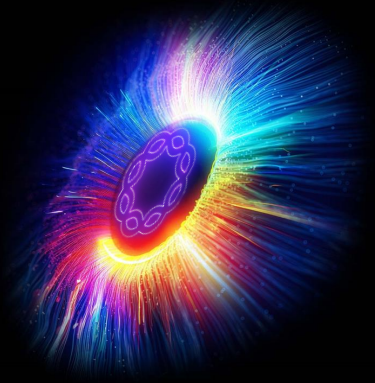
Filipe Correia

Sr. Solutions Architect

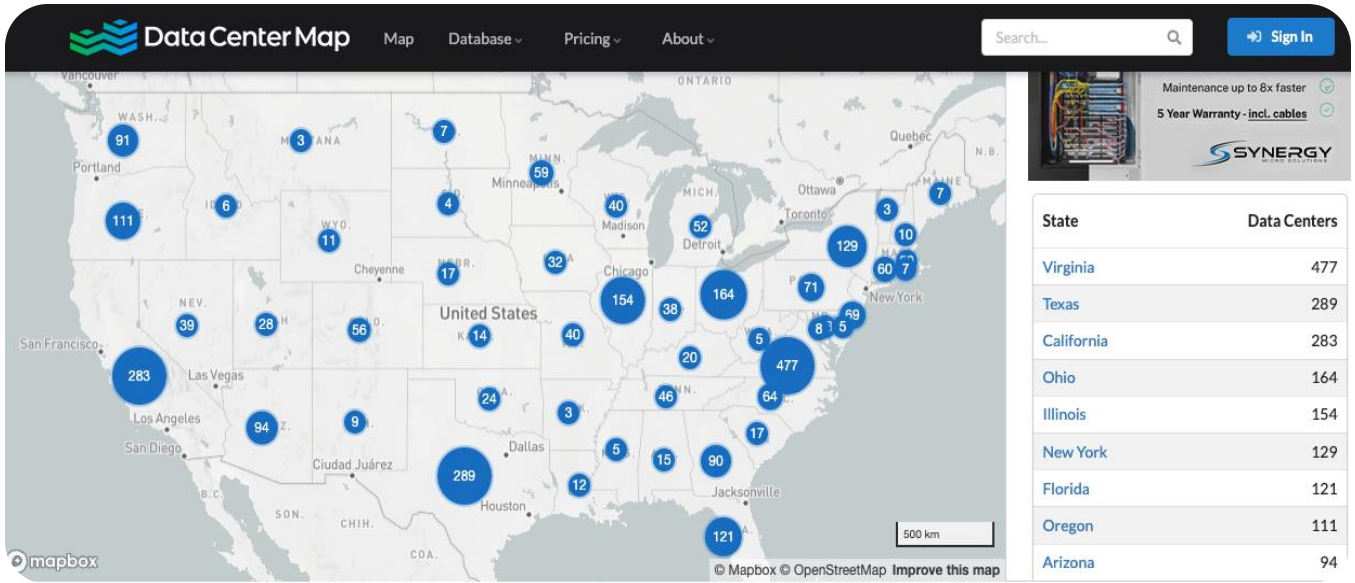
ribbon INSIGHTS

Data Center Market and Evolution

ribbon
INSIGHTS



US Data Center Deployment Growth



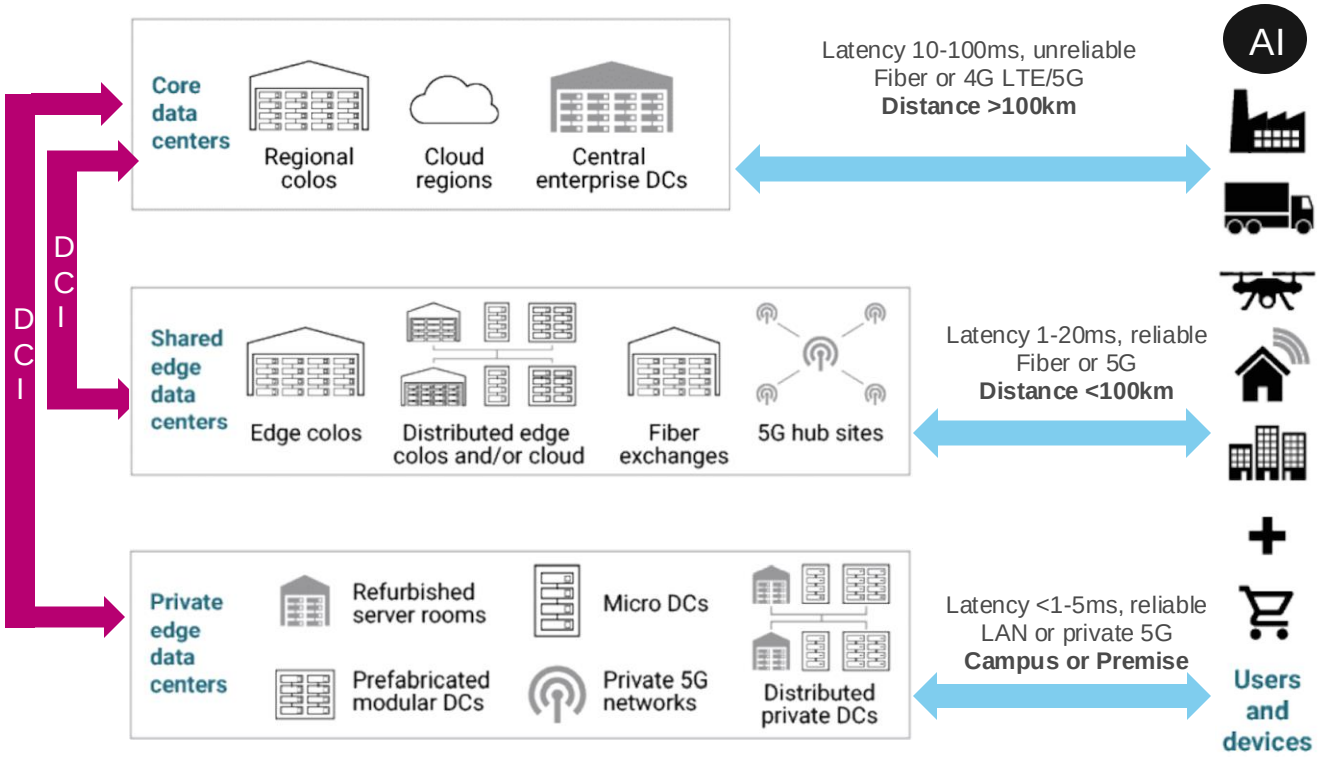
State	Data Centers
Virginia	477
Texas	289
California	283
Ohio	164
Illinois	154
New York	129
Florida	121
Oregon	111
Arizona	94

https://www.datacentermap.com/

Data Center deployments growing exponentially

What Is Driving Data Center Interconnectivity

- Storage and Compute drive Data Center need
- OPEX savings driving CoLo services to cloud DC
- Applications (5G, IoT,) driving requirements
- Distance (latency) driving Edge DC and DCI demand
- AI accelerating DC demand and infrastructure increase



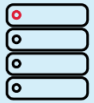
Three Main Types of Data Centers

Cloud Services

Used by cloud services providers like AWS, Azure, Google, IBM Cloud, and other public cloud providers, to host data and application services.

Colocation

Provides infrastructure such as space, cooling, bandwidth, and security to companies, who install data center elements including servers, storage, and firewalls.



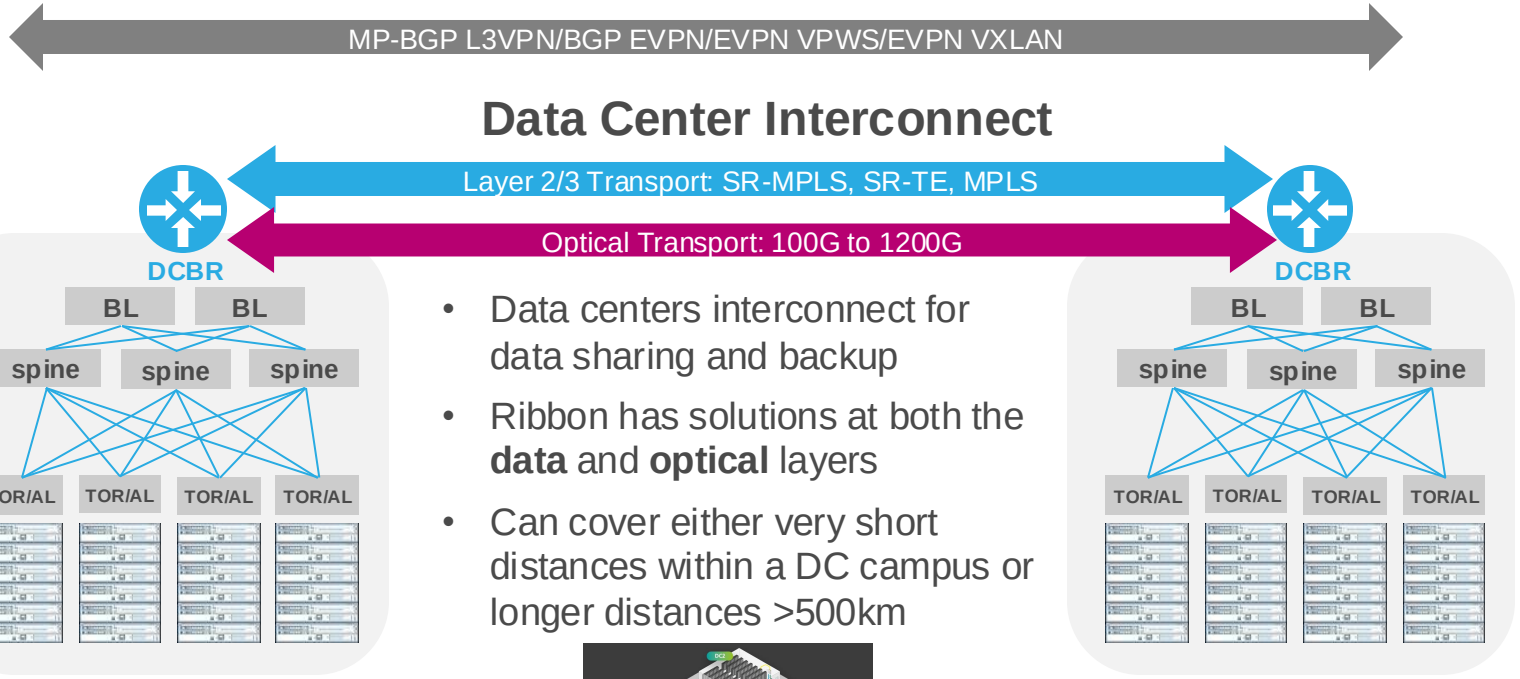
Enterprise

Built, owned, and operated by companies for their internal use. Often they are housed on the corporate campus.

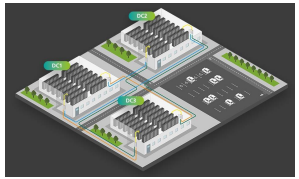
10 **100** **1000**

Approximate number of target customers

Inter Data Center Communications



- Data centers interconnect for data sharing and backup
- Ribbon has solutions at both the **data** and **optical** layers
- Can cover either very short distances within a DC campus or longer distances >500km



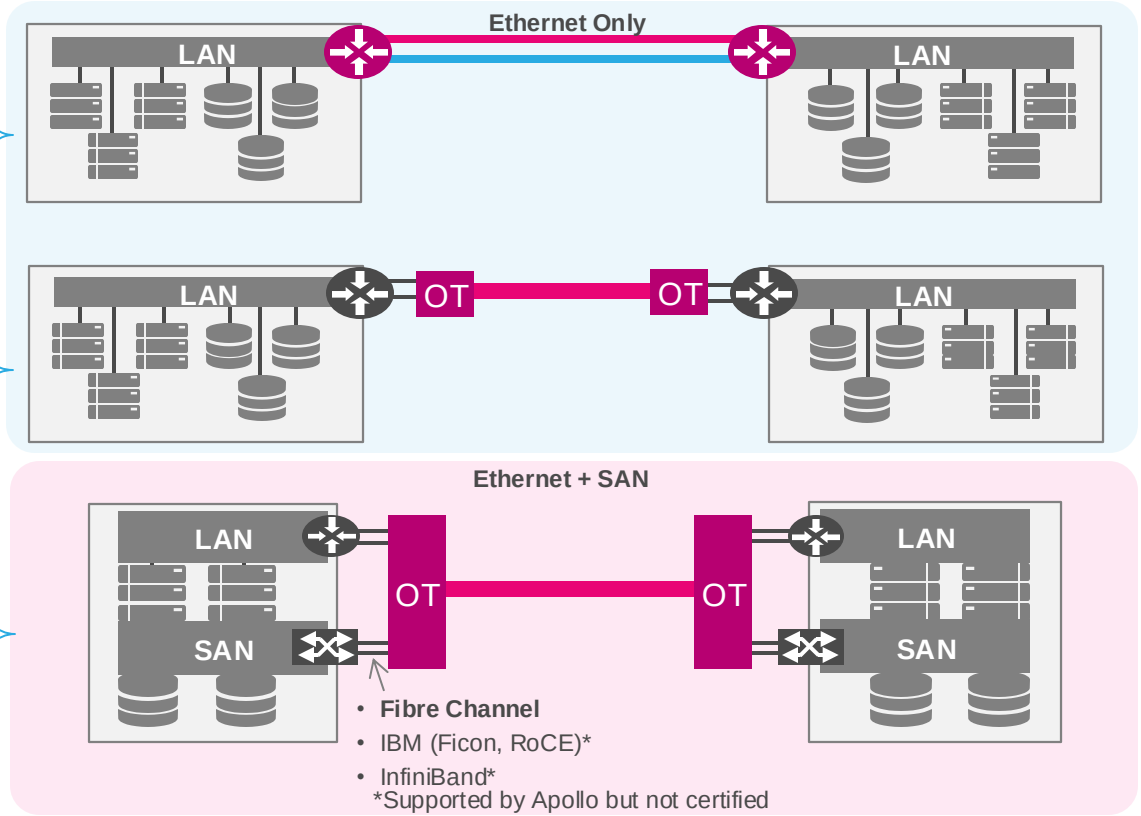
OT – Optical Transport
DCBR – Data Center Border Router
AL/BL– Access Leaf/Border Leaf

DCI Options (Ethernet and SAN storage)

Data Center Border Routers (DCBRs) communicate with each other using integrated coherent optics (IPoDWDM)

Multiple DCBR ports can be consolidated on a single wavelength

The typical approach is to consolidate all Ethernet and SAN connectivity on consolidated OT



Ribbon Solutions and Bundles

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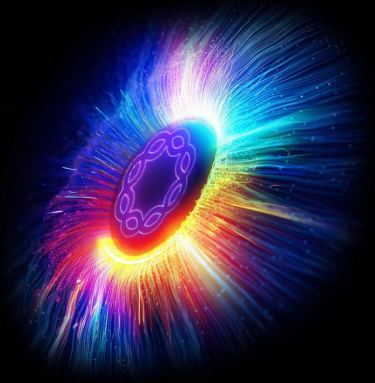
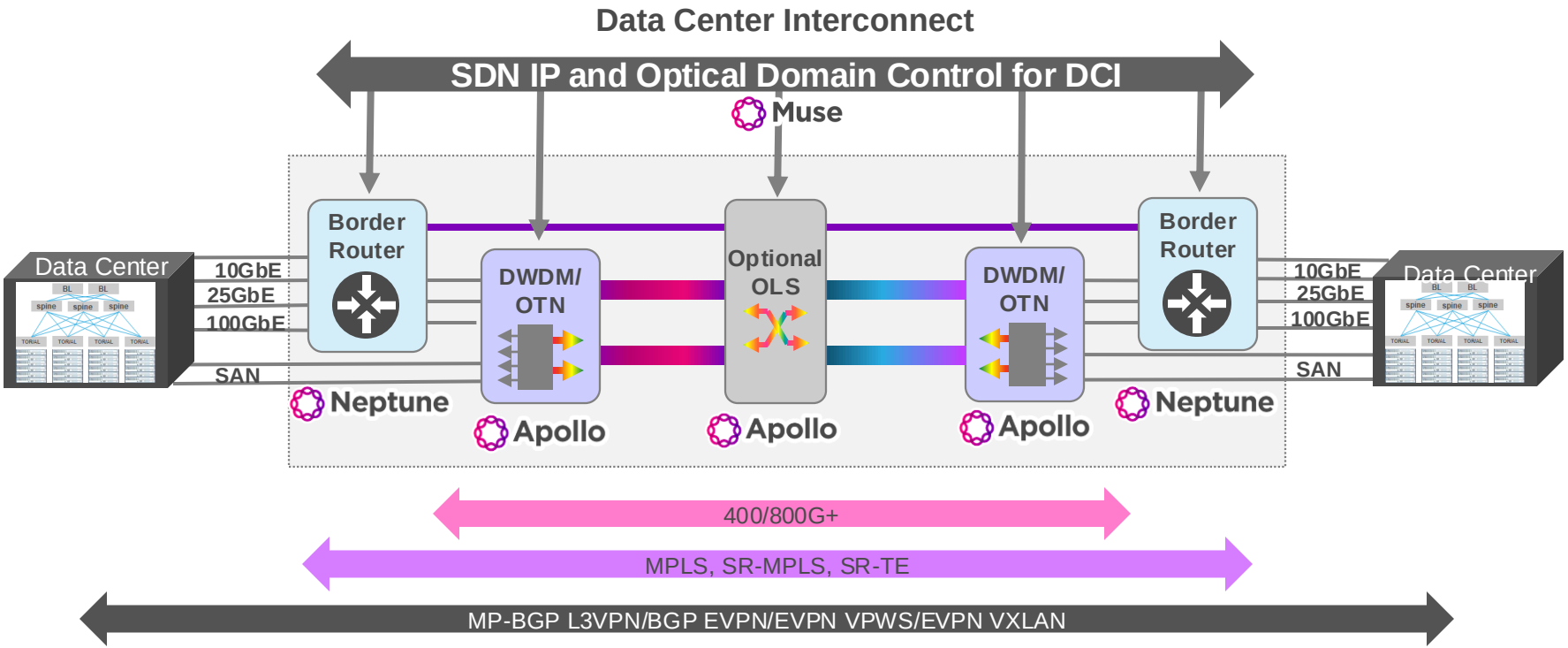


DCI Solution Framework



Which Ribbon Products?

Muse SDN Domain Controller with Low Code Automation

NPT 2714

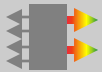
Border Router

- 14.4T capacity “pay as you grow”
- Ethernet interfaces - 1/10/100/400GE
- Front to Back air-flow
- L2/L3 VPN Services
- IPoDWDM

NPT 2400

- Compact 2RU form factor
- 4.8T switching capacity
- 30 traffic ports 10G/25G/100G/400G

Apollo 9408 High Density Platform



DWDM/ OTN

MPJ1200_2

MPQ_8

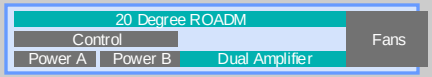
- 140Gbaud: 1200G, real 800G, unlimited 400G
- Ultra-dense metro 400

Apollo 9600 Series Modular Platform

- Multiservice clients – 1/10/100/400GE, FC, TDM, OTN
- OTN, Integrated OTDR
- Low power consumption of 0.15 W/G

Optional OLS

Apollo 9600 Series Modular Platform



Apollo 9603

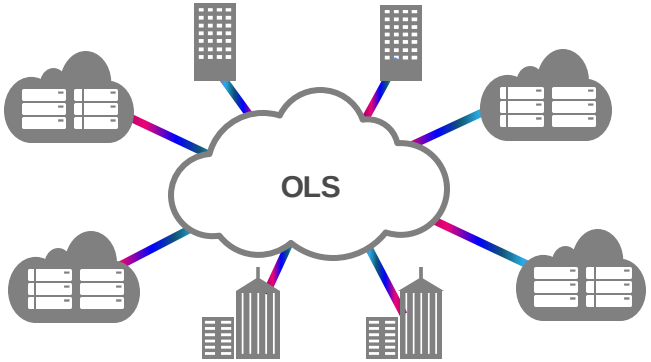
Single degree of an up to 20-degree ROADM, providing complete chassis independence against failures

Apollo OLS9458

- 4RU, 548mm deep
- Front to Back cooling
- Single Slot Integrated OADM/ 8 degrees per 4RU

Flexible Optical Line System

- Covers C+L Bands
- A rich menu of Erbium Doped Fiber Amplifiers (EDFAs), Raman, and Hybrid EDFA/Raman amplifiers.
- A range of 4-degree to 20-degree flex grid ROADMs, supporting a full set of colorless, directionless, and contentionless add/drop options.
- Fast Wavelength Switched Optical Networking(WSON) software delivers automated restoration.

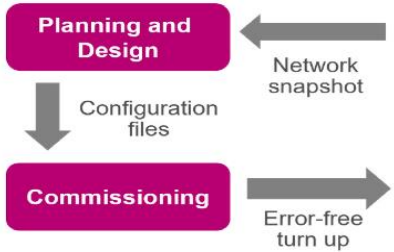


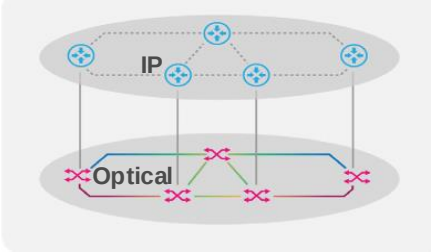
Ultra-compact 4-degree ROADMs with integrated amplifiers

Pluggable amplifiers and optical line protection

Muse – Advanced Software Wrapper

Muse

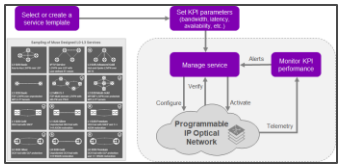




Multilayer Orchestration

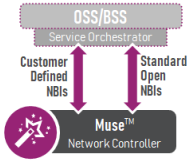
Network Automation

Workflow Engine

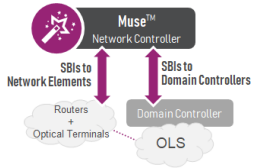


Closed Loop Automation

Multi-Vendor and OSS Integration



Flexible NBI



Flexible SBI

Advanced Analytics

Network Insights

Network Health

Cloud Native Architecture

Microservices Architecture

K8S Infrastructure

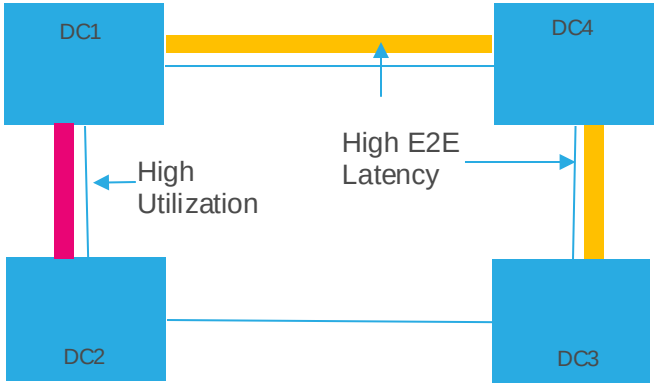
Automation & AIOpps Evolution

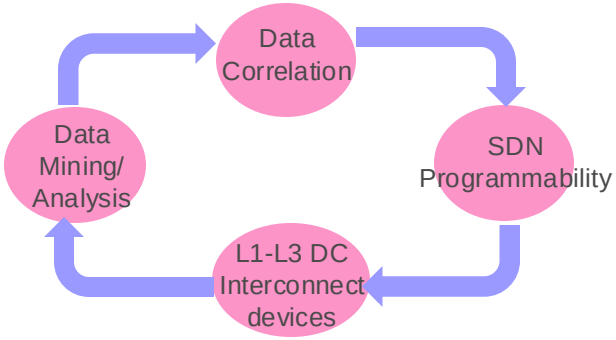
Data Center Traffic Engineering

- Compute/App communication inter/intra DC
  - Requires TE for dealing with network events
- Need for Automation of device and infrastructure
- Life Cycle Management of network infrastructure

Ribbon Tooling

- **Muse Orchestrator- Available Now**
  - SDN Programmability
  - Workflow Engine
- **AIOpps – Future Evolution**
  - Data Mining and Analysis
  - Custom Apps based on business/operations intent





DCI Bundles

- Facilitate selling Ribbon solutions for simple configurations
- Can be the whole solution (single part number) or the ***starting point*** for further discussions

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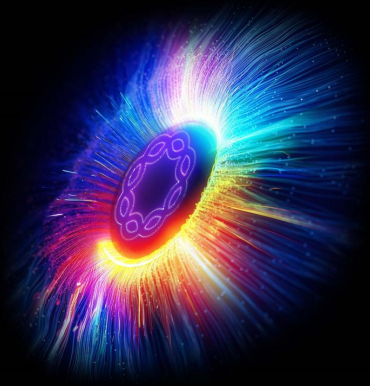


Bundles Comparison: Essential Elements

Bundle					Included Clients	Other Clients	Encryption
1-2	4 x 100GbE	9408 with **MPQ_8**	**400G** (800G ready) 40km/80km	9408 with **MPQ_8**	**4 x 100GbE**	400GbE	Optional
3-4	4 x 100GbE	9603 with **TM400_2**	**400G** 40km/80km	9603 with **TM400_2**	**4 x 100GbE**	400GbE	No
5-6	4 x 100GbE	9603 with **TM400ENB**	**400G** 40km/80km	9603 with **TM400ENB**	**4 x 100GbE**	10/25/400GbE FC 16/32/64	Optional
7	2 x 10GbE	9600CPE_E	**2 x 10G** 40km only	9600CPE_E	**2 x 10GbE**	STM64/OC192 (roadmap)	No
8	6 x 1GbE	9600CPE_M	**10G** 40km only	9600CPE_M	**6 x 1GbE**	FE STM1/4/16; OC3/12/48	No

These bundles cover popular basic configurations.
Please discuss tailored configurations with your Ribbon representative.

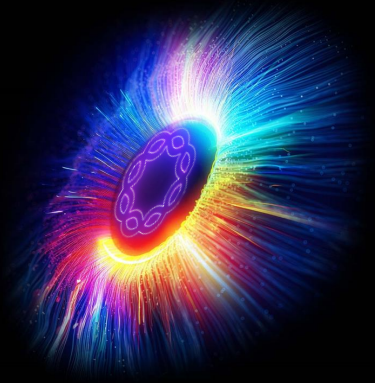
Apollo DCI Bundles - Compared

		Bundle 1 (40Km) Bundle 2 (80Km) 9408	Bundle 3 (40Km) Bundle 4 (80Km) 9603LC	Bundle 5 (40Km) Bundle 6 (80Km) 9603MSC	Bundle 7 9600CPE-E-40KM	Bundle 8 9600CPE-M-40KM
Included in bundle	Platform Type	2RU	2RU	2RU	1RU pizza box	1RU pizza box
	Airflow	Front to back	Side to side	Side to side	Fan-less design	Fan-less design
	Client Interfaces	4x100 GbE /400GE	4x100 GbE /400GE	4x100 GbE /400GE	2x10GE	6xFE/GE
	Line Rates	400G (800G ready)	400G	400G	10G	10G
	Amplification	Bundle 1 - No Bundle 2 - Pluggable EDFA	Bundle 1 - No Bundle 2 - EDFA	Bundle 1 - No Bundle 2 - EDFA	No	No
	Control and management	CLI, SNMP V1/V2/V3	CLI, SNMP V1/V2/V3	CLI, SNMP V1/V2/V3	Netconf/Yang	Netconf/Yang
Optional	Control and management	Encryption, WebUI LCT, NETCONF/YANG	Encryption, WebUI LCT, NETCONF/YANG	Encryption, WebUI LCT, NETCONF/YANG		

Note: Consult your sales prime in case of a need for additional items ordering.

Use Cases

ribbon
INSIGHTS



Ribbon DCI Use Cases

Telehouse (Cloud DC)

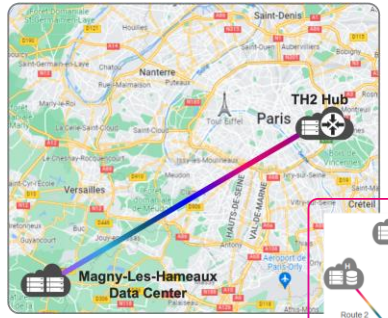
- Easy-to-provision high-performance transport for 100GbE and 400GbE clients while providing Redundancy

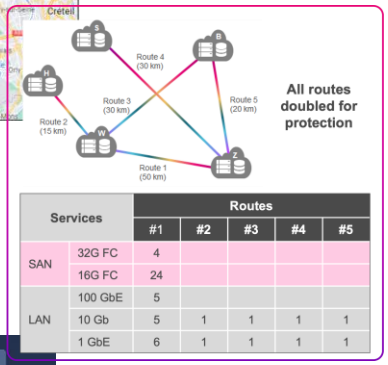
German Auto Manufacturer (Enterprise)

- Multiservice for 1/10/100 GbE & FC16/32 clients
- **Optical encryption** for Fibre Channel links and (OTDR) fiber path monitoring

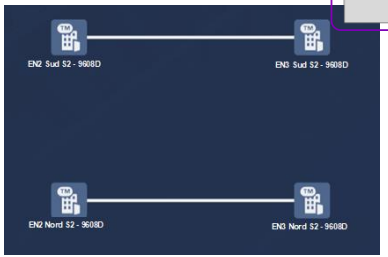
VA Telecom (Service Provider)

- Provided 400G connectivity with Fiber Channel between DC sites through fiber paths.





Services		Routes				
		#1	#2	#3	#4	#5
SAN	32G FC	4				
	16G FC	24				
LAN	100 GbE	5				
	10 Gb	5	1	1	1	1
	1 GbE	6	1	1	1	1



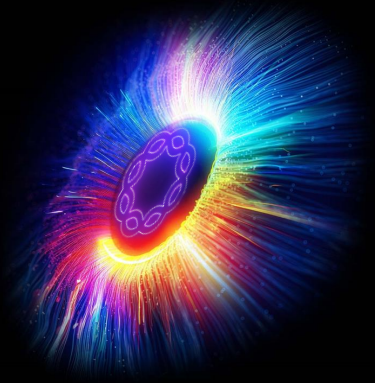
Why Ribbon

RIBBON MAKES DCI EASY

Complete Solution Set	Superior Technology	Preferred Partner
• MPLS, DWDM, OLS • Multilayer automation • Ecosystem integration • Get started bundles	• Unique 400GZR+ upgradeable to 800GZR+ • Wavelengths to 1.2T • Highest density • Lowest power	• Tailored configurations • White glove installation • Tiered field support

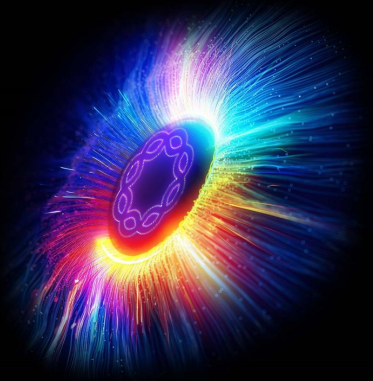
Thank You

ribbon
INSIGHTS



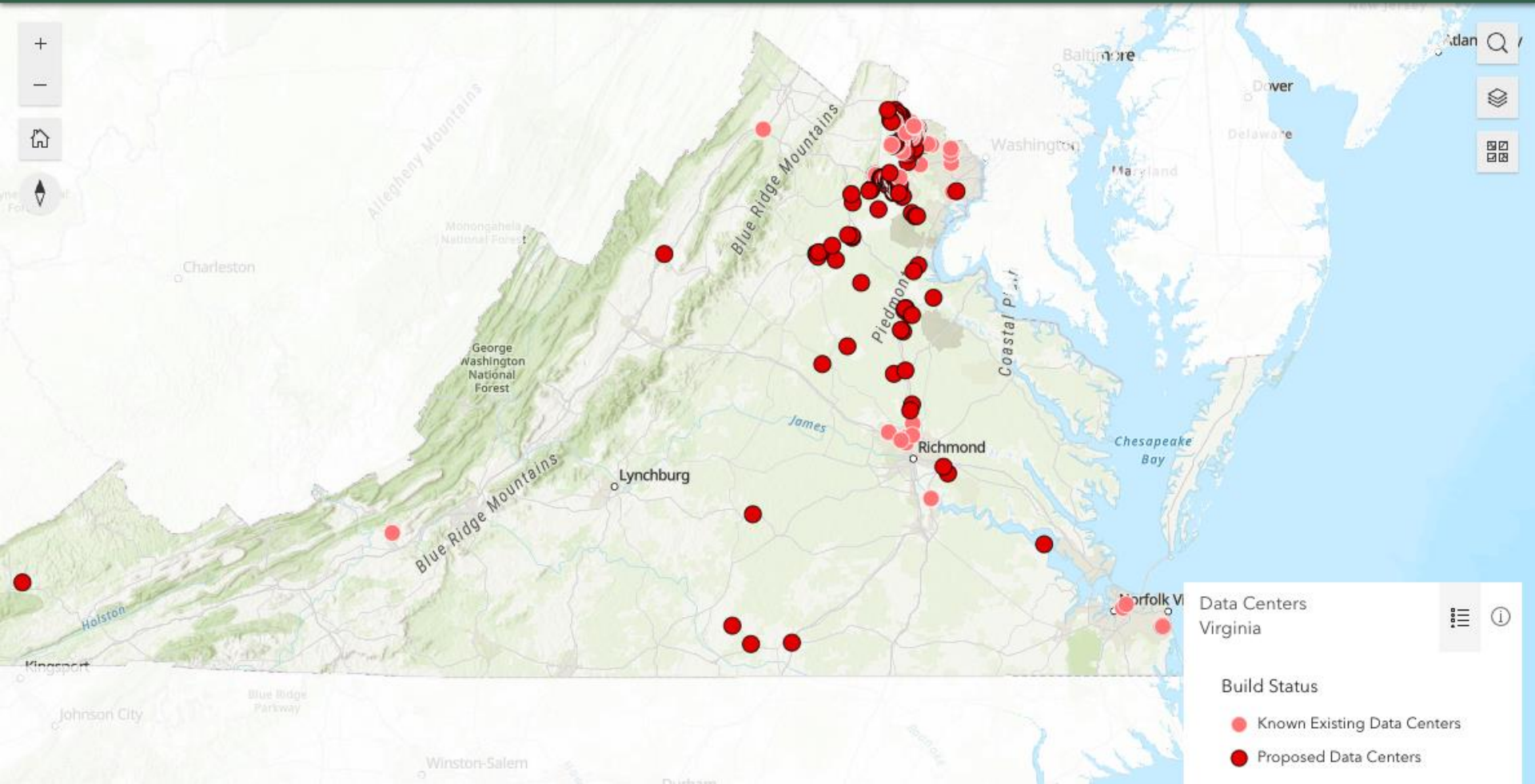
Backup

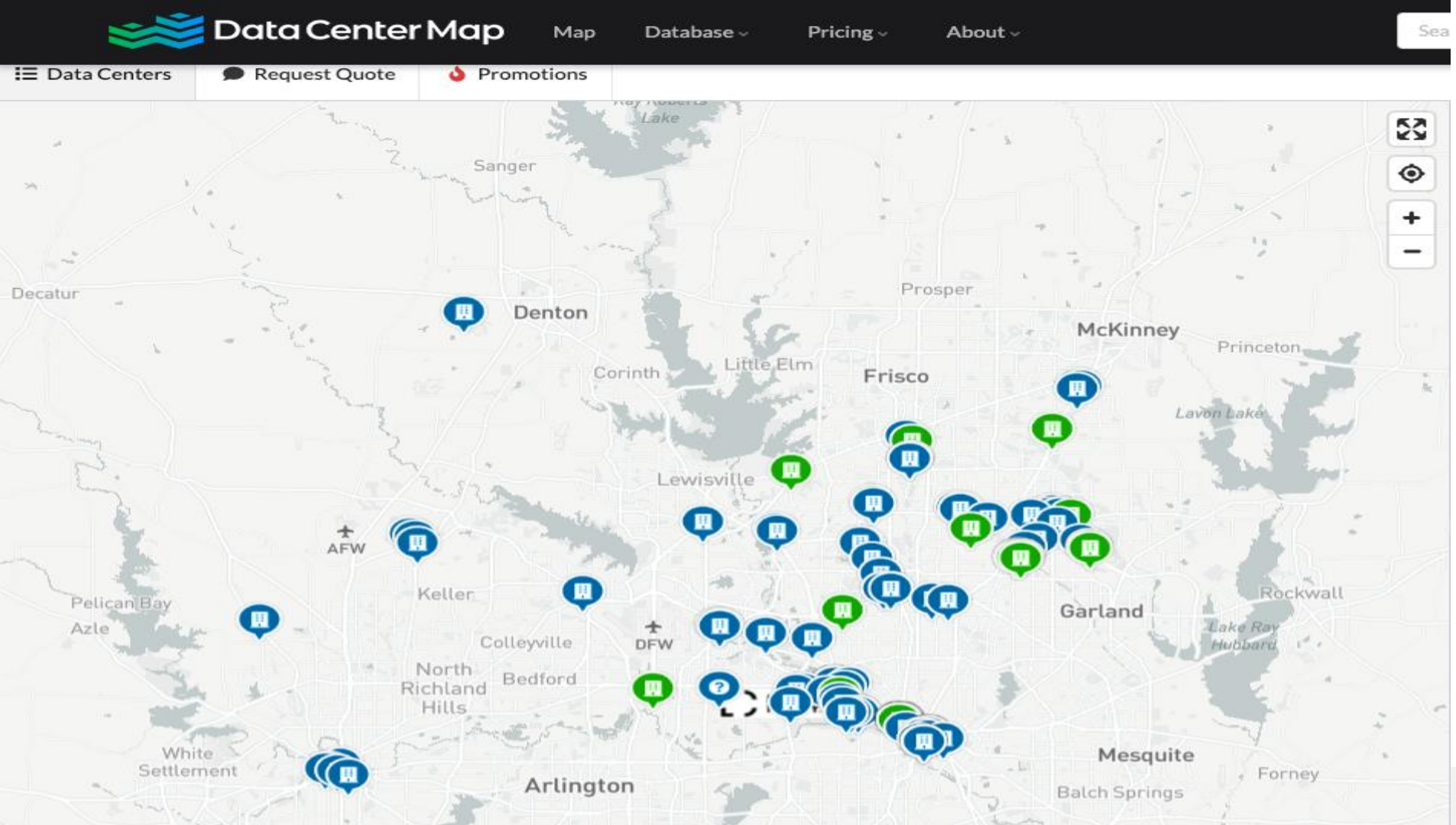
ribbon INSIGHTS



Piedmont Environmental Council

Existing and Proposed Data Centers - A Web Map

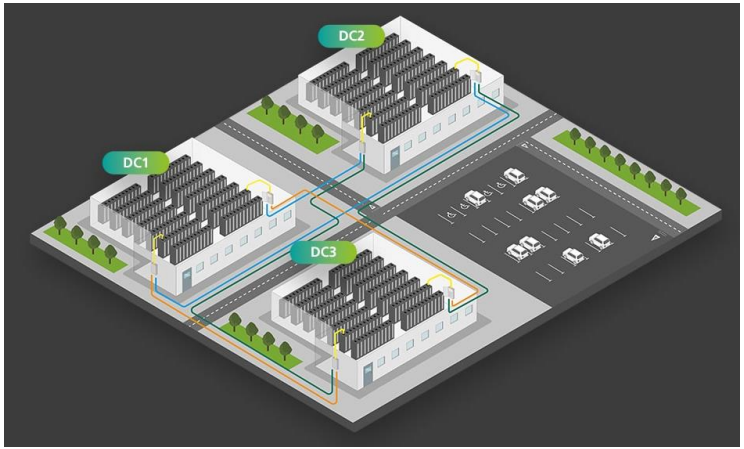



Data Center Map
Map
Database
Pricing
About
Sea
Data Centers
Request Quote
Promotions
Lake
Sanger
Decatur
Denton
Prosper
McKinney
Princeton
Corinth
Little Elm
Frisco
Lavon Lake
Lewisville
AFW
Keller
Pelican Bay
Azle
Colleyville
DFW
North Richland Hills
Bedford
Garland
Rockwall
Lake Ray Hubbard
White Settlement
Arlington
Mesquite
Forney
Balch Springs

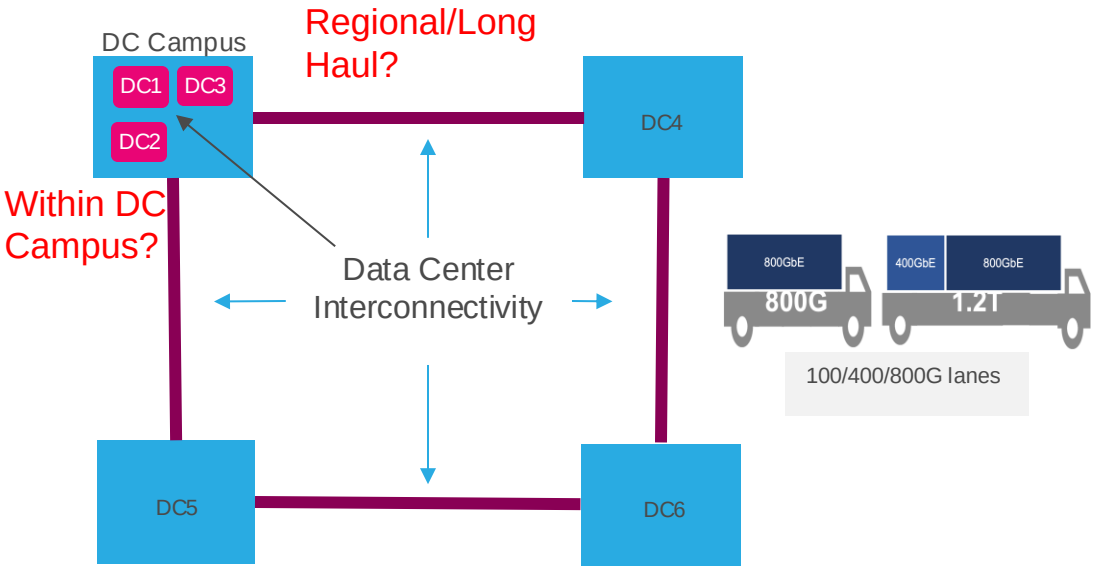
What is DCI

Data Center Interconnect (DCI):

- Represents a direct link between two or more data centers.
- Facilitate high-speed, secure, and reliable communication and data transfer between DC sites.



DC Campus



Pluggable Evolution driving DCI demarcation to the IP Router

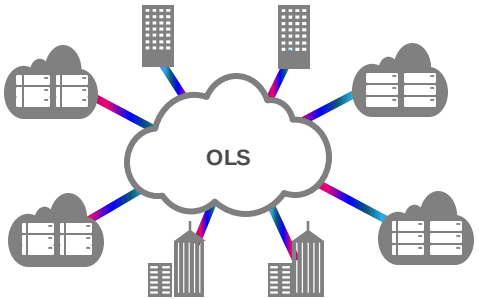
Pluggable Evolution:

"Photonic layer" DCI transport is tied to the pluggable/Coherent Transceiver.

- Focus on QSFP-DD/OSFP form factors
- 800ZR/ZR+
- Increased BaudRate to 120GBd+

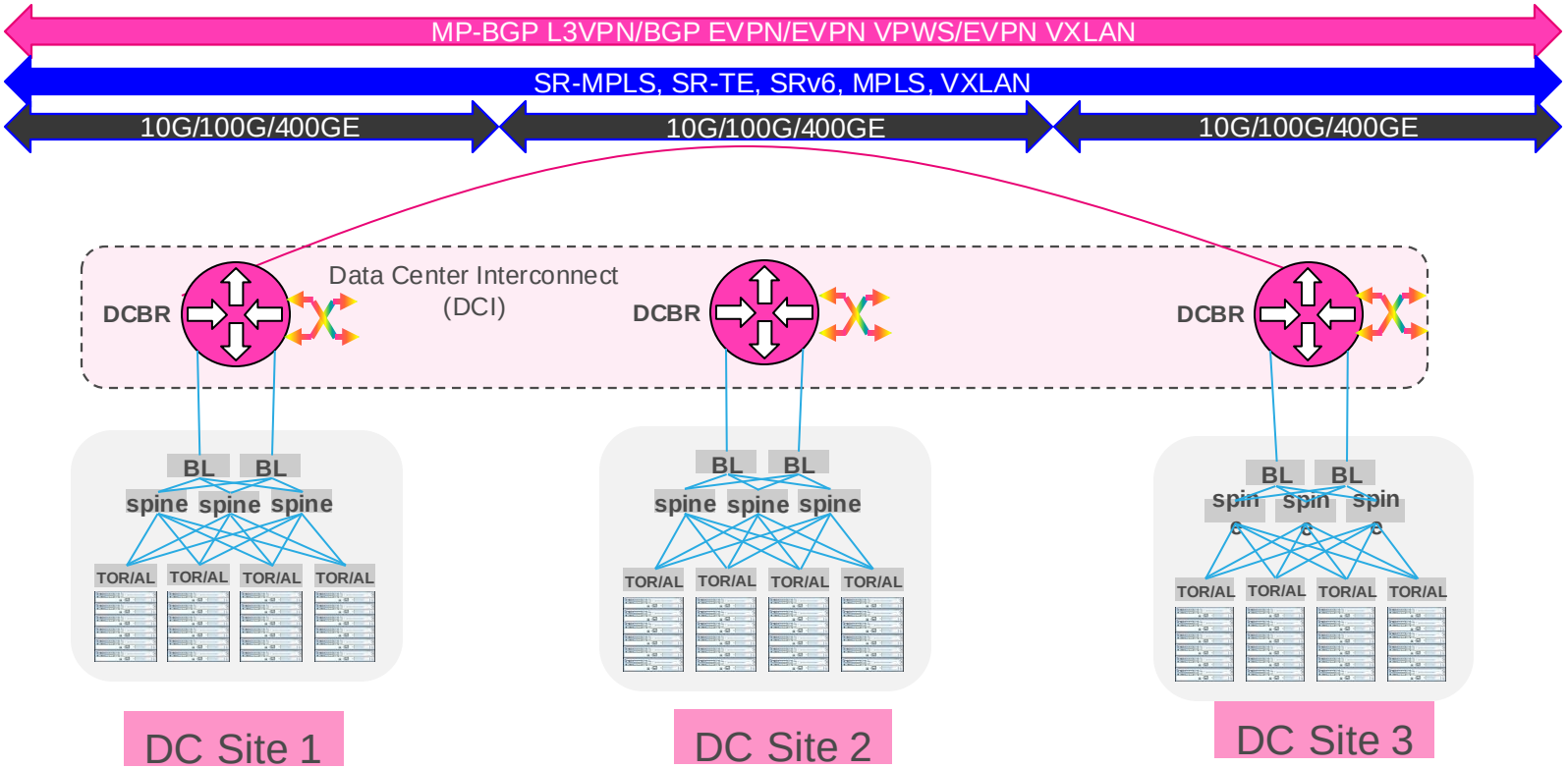
Continued Pluggable evolution:

- QSFP-DD OLS (preamp and booster amp, various channel breakouts to combine or separate)
- OSC and OTDR plugs for Channel and fiber monitoring
- OLP for line protection



Pluggable amplifiers and optical line protection

Data Center Infrastructure from a L3 standpoint



Piedmont Environmental Council

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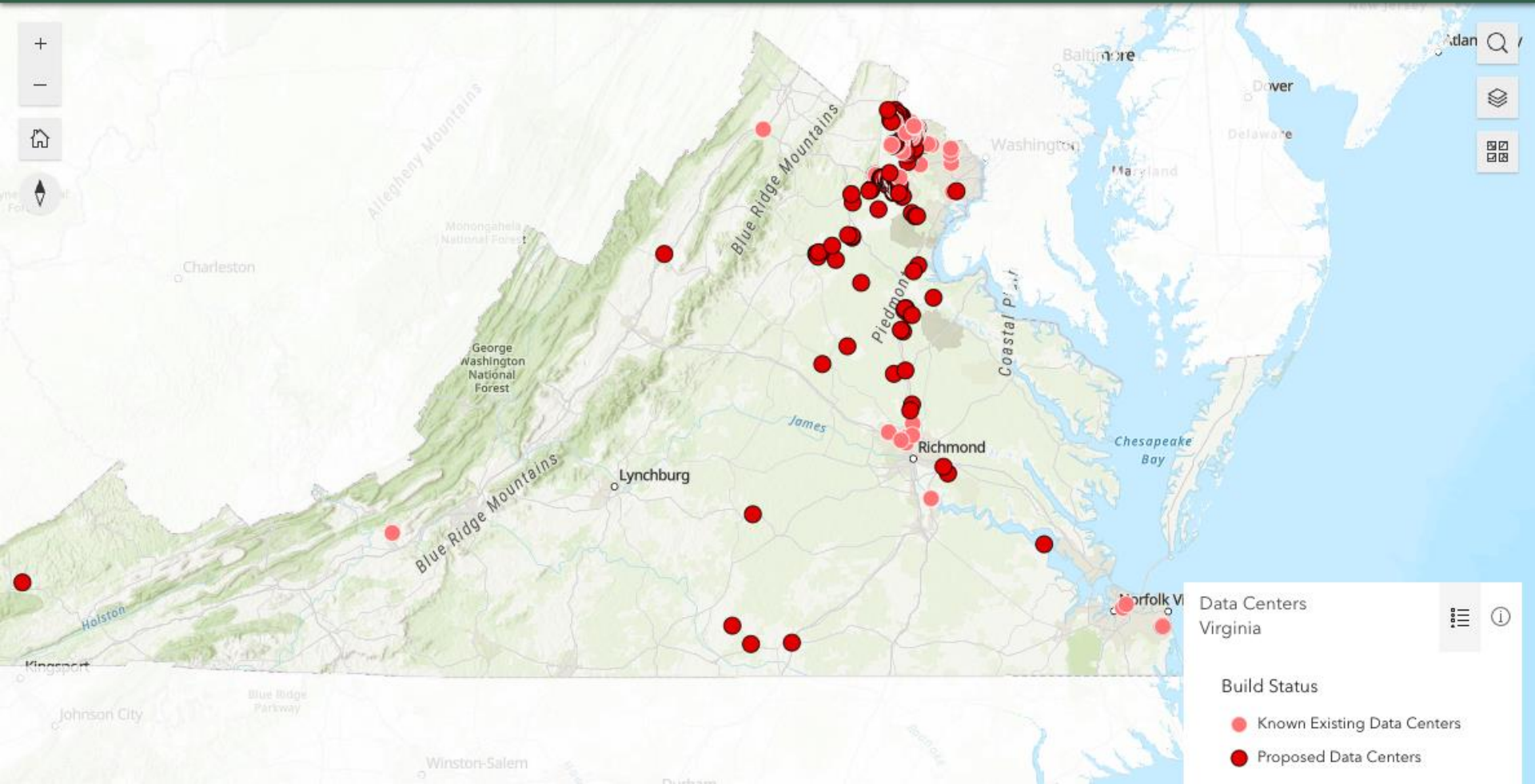


DIGITAL REALTY™

Digital Realty brings companies and data together in bold new ways in Texas

2323 Bryan Street (DFW10)
Digital Realty
2323 Bryan Street
75201 Dallas

8435 Stemmons Freeway (DFW36)
Digital Realty
8435 Stemmons Freeway
75247 Dallas

1232 Alma Road (DFW16)
Digital Realty
1232 Alma Road
75081 Richardson

Ribbon DCI Solutions

Muse SDN Domain Controller with Low Code Automation

DCBR (MPLS)

100GZR/ZR+ and 400GZR/ZR+

1RU
0.8T capacity

2RU
4.8T capacity

6RU
14.4T capacity
(2025)

Optical Transport (DWDM/OTN)

High Density 100GbE & 400GbE

Compact modular 2RU

Power-cost optimized
400GZR+ and 800GZR+

Capacity-reach optimized
- 1.2T/100km
- 800G/1200km
- 400G/3500km

Modular Applications: Ethernet, SAN, OLS

Multipurpose 2RU and 5RU (not shown)

Multi-service
- 1 x 400G
- Ethernet + SAN
- L1 Encryption

Ethernet
- 2 x 400G
- 100GbE & 400GbE

Other transport and OLS cards

Economical CPE

1RU

1GbE and 10GbE clients over 2 x 10G

Apollo DCI Platforms and Main Blades

	Apollo 9408 High Density Applications	Apollo 9600 Series Modular Applications
Platforms	 **Data Center** **600mm deep** **F2B airflow**	  **Telco** **300mm deep** **R2L airflow (9608D F2B airflow)**
Main solutions **Power-Cost Optimized Cards for up to 500Km**	 **MPQ_8** • 8 x 400G • 8 x 800G Ready **12.8T to 25.6T in 2RU!**	**TM400_2** 2 x 400G  **TM400ENB** 1 x 400G  Ethernet + SAN services Encryption
Capacity-Reach Optimized Cards for Long Haul or Maximum Short Haul ($$)	 **MPJ1200_2** 2 x 1.2T 100km 800G 1000km 400G 3000km	**TM800_2** 2 x  800G 1000km 400G 3000km

NPT DCI Solution (IPoDWDM)

		Height	Capacity	NPU	Ports / Slots	
NPT 2100		1RU	800G	Q2A	24x 10G/25G	2x 100G + 2x 400G
NPT 2300		3RU	3T	J2C	7-Slot Chassis All NPT-1300 Cards 1x 400G; 2x 100G Cards	Packet-Switch Card: - 2x 100/200/400 QSFP-DD - 4x 100G QSFP28 - 8x 1/10/25 SFP28
NPT 2400		2RU	4.8T	J2	24x 100G	6x 400G
NPT 2714		6RU	14.4T	J2C+	9 Slot Chassis 1.6T per card Red. Processor/ Fabric	F2B air-flow Multi-Speed Card MS w/ FlexE SFP/QSFP Card mix

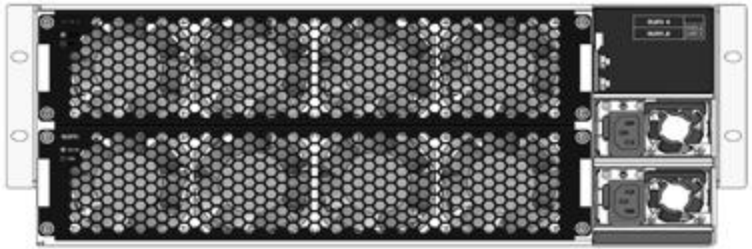
Services:
L2/L3 VPN
EVPN
6VPE
Underlay:
SR-MPLS
SR-TE
IGP/BGP
BGP-LU
Program:
PCEP
NETCONF
BGP-LS
TE
FlexAlgo

Apollo 9458 Ultra-dense Open Optical Line System

- **4RU, 548mm deep**
- Front to Back cooling
- Full redundancy 1+1 for shelf controller, fans and power modules
- MPO cables with fiber shuffle to simplify installation
- Up to 6 shelf cascading with single IP address
- Up to 32 degree ROADM with integrated amplifiers and high resolution channel monitoring
- Low insertion loss 12 x 20 colorless directionless add/drop
- 16 ports rotating OTDR
- Alien Wavelengths and Shared Spectrum support

- Single slot Integrated ROADM blade
- 8 degrees per 4RU platform

Rear view

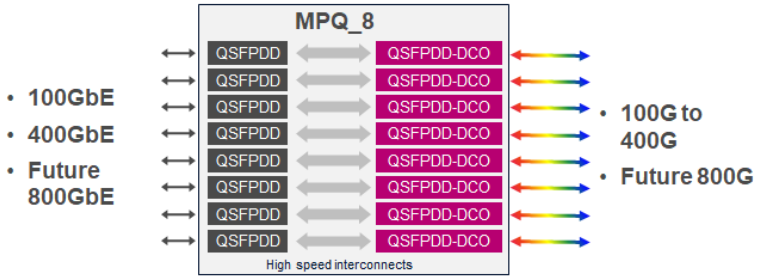


Apollo 9408 w/ MPQ_8
Highest Density and Lowest Power 100GbE/400GbE DCI

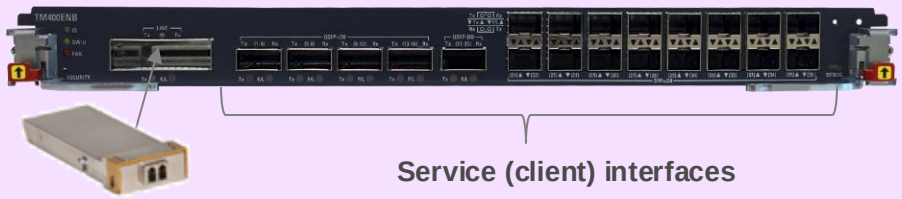
- **Unique "Investment Protection" Value Proposition:**
  400G today with upgradability to 800G on the same blade
- Highest 2RU density:
  - 400G 12.8T
  - 800G 25.6T
- Lowest power consumption
  - 400G 0.09W/G
  - 800G 0.07W/G

Competition Killer for High Density Cloud DCI

	ribbon	cisco	ciena	NOKIA	Infinera
800G Ready	Yes	No	No	No	No
2RU Density 400G	12.8T	12.8T	4.8T	3.2T	3.2T
2RU Density 800G	25.6T	N/A	N/A	N/A	N/A

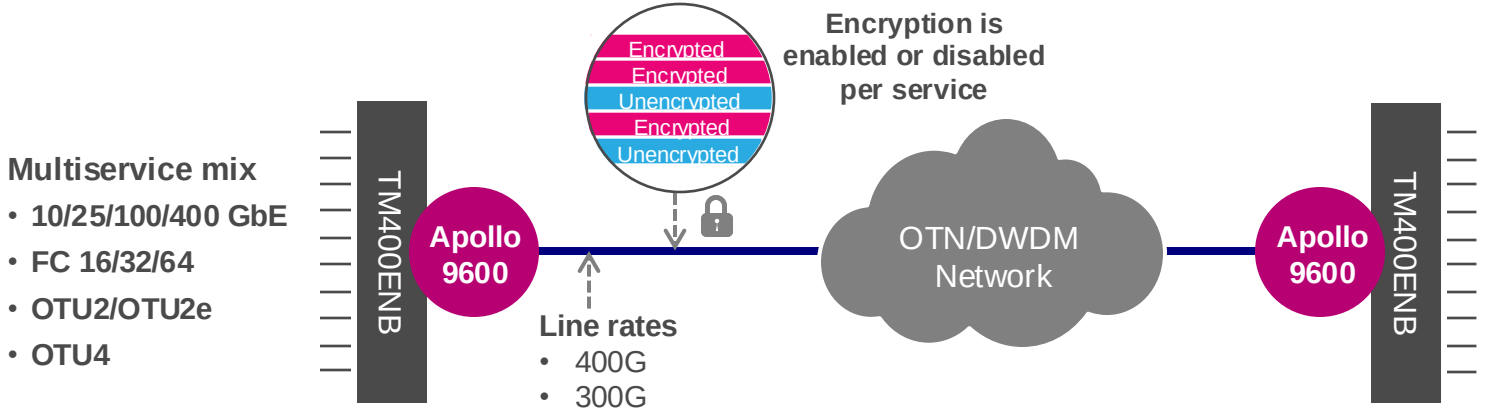


TM400ENB: 400G Multiservice Encryption Muxponder



400GZR+ CFP2-DCO

- Supports 400G capacity multiservice encryption within Apollo's Layer 1 Optical Encryption Solution Framework
  - Including Diffie-Hellman, QKD, and PQC (V13) key exchange options
- Provides FIPS 140-3 compliancy against physical tampering



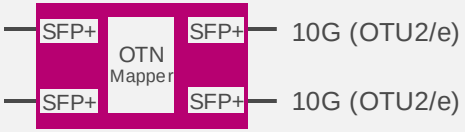
Apollo 9600CPE

Two compact **10G platforms** to extend OTN economically to customer premises

- 1RU for 19”/21”/23” rack, or wall/desktop installation
- Power consumption: ~27W,
- Temperature range: -5 to 50°C with fanless design
- Dual AC/(DC roadmap) power with 1+1 protection

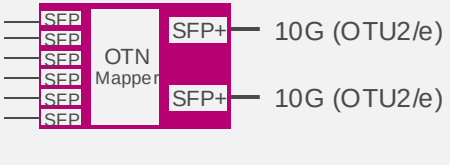
9600CPE_E
Dual 10G Transponder

Two clients:
- **10GbE**
- STM64 (roadmap)



9600CPE_M
Dual 10G Muxponder

Six clients:
- **FE, 1GbE**
- STM1/4
- STM16;OC3/12 /48 (roadmap)



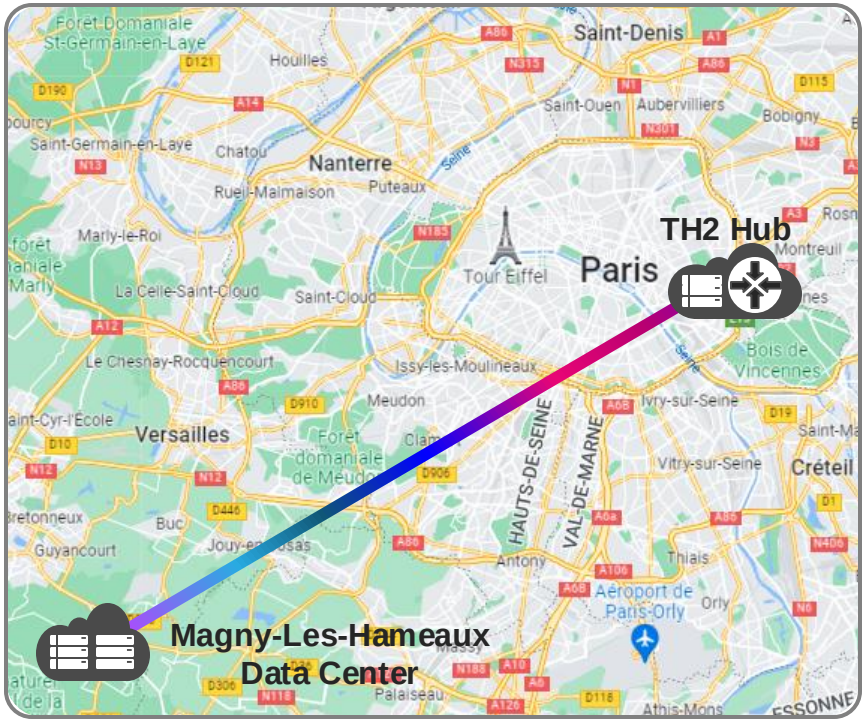
Telehouse
Cloud DCI

Customer Challenge

- Paris TH2 hub is one of the world's most connected data centers.
- Wanted to enable business customers to host IT infrastructures in its cost-effective suburban data center with high speed, reliable, low latency connectivity to TH2.

Why Ribbon

- Easy-to-provision high-performance transport for 100GbE and 400GbE clients
- Redundancy that enables Telehouse to guarantee its customers 99.999% service availability.
- Turnkey "white glove" solution and installation, tailored to Telehouse's needs.



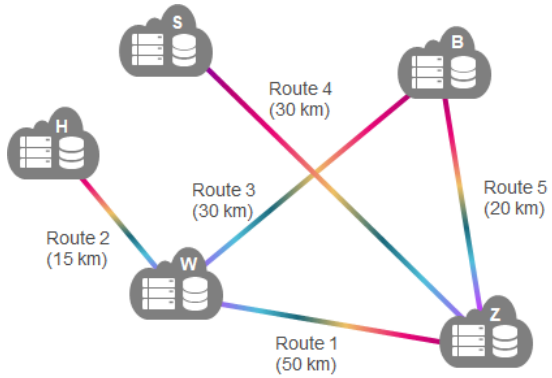
German Auto Manufacturer
Enterprise DCI Application

Customer and Challenge

- **Secure** and resilient data center storage networking over dark fibers
  - Low latency for synchronous data replication
  - Redundancy for protection against failures
- Multiservice (Ethernet, Fibre Channel)
- Economical

Why Ribbon

- Multiservice for 1/10/100 GbE & FC16/32 clients
- **Optical encryption** for Fibre Channel links
- Superior optical performance and fiber health (OTDR) monitoring
- Close cooperation with channel partner and SP who supplied dark fiber



All routes doubled for protection

Services		Routes				
		#1	#2	#3	#4	#5
SAN	32G FC	4				
	16G FC	24				
LAN	100 GbE	5				
	10 Gb	5	1	1	1	1
	1 GbE	6	1	1	1	1

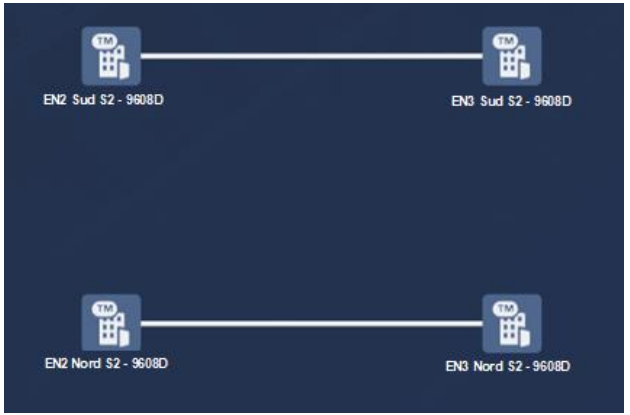
VA Telecom
SP Delivering Enterprise DCI

Customer and Challenge

- Provide 400G DCI for Ethernet and FC services to an Enterprise customer

Why Ribbon

- Provided 400G connectivity between two DC sites through two fiber paths.
- Our compact and flexible solution with all embedded services was considered superior to competitor solutions (Adtran, Ekinops)
- Strong customer relationship, working with customer from project start.



South path

9608D per site carrying :

- 1x100GbE, 2x40GbE, 5x10GbE
- 3xFC32, 3xFC16

North path

9608D per site carrying

- 3xFC32, 3xFC16

SURF
NREN Enterprise DCI

Customer and Challenge

- Serves over 190 Dutch education and research institutions over 11,000 km of dark fiber
- Needed flexible, high performance and high availability optical network for ICT innovation

Why Ribbon

- Technical and price merits on public tender, replacing incumbent Ciena
- Powerful flexible solution
  - National 200G backbone now upgrading to 400G
  - 2 x 400GbE link from Amsterdam to Geneva (25 hops with no regeneration)
    - – Demonstrated 800G single-wavelength capability
  - Colorless-directionless multi-degree ROADMs with WSON dynamic restoration