

400ZR: Revolutionizing Networking

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What is 400ZR?

- Coherent optical technology
 - Single wavelength
 - Long distance
 - Requires a sophisticated digital signal processor (DSP)
- Running at 400Gbps
- In a client form-factor module
 - QSFP-DD (mostly) or OSFP
- Originally defined by the OIF
 - Interoperable

400ZR: Perfect Serendipity

- For the first time, pluggable coherent for outside the datacenter and rates inside the datacenter match up (400GbE)
- 400ZR is designed to work in routers without limiting front panel space (QSFP-DD / OSFP)
- 400ZR is an industry standard, so interoperability is at least theoretically possible
- 400ZR is compatible with the way networks outside the datacenter are built
- **400ZR has changed the way network operators design networks**

400ZRx Standards, MSAs, and more

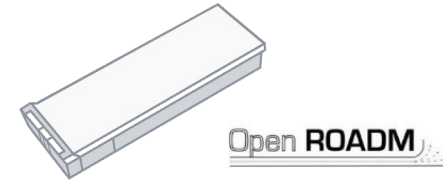
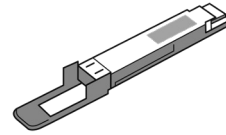
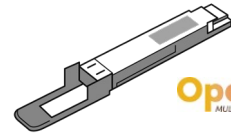
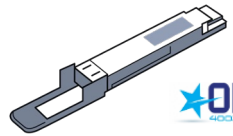
		Primary Application	Client Protocols	Reach	Form Factor	Vendors
Standards-Based	400ZR	Short reach data center interconnect	400GbE	80-100km	QSFP-DD / OSFP	Cisco Ciena Huawei Marvell
	IEEE 802.3ct/cw (100ZR)	Short reach data center and metro interconnect	100/400GbE	80km	QSFP-DD / OSFP	NEL
Industry Coalition	OpenZR+	Metro Ethernet and data center interconnect	100/200/400GbE	~600km	QSFP-DD / OSFP	Cisco Ciena Huawei Marvell
	OpenROADM	Incumbent telco metro networks, multi-haul	100/200/400GbE & OTN	~600km	CFP2	NEL
Proprietary	Regional/Long Haul	Longer reach optical network	Multiple	>600km	CFP2	Many
	Subcarrier	Point to Point & Access networks	Multiple	TBD	QSFP QSFP-DD	Infinera

- No one is building a DSP with just OIF 400ZR support
- OpenZR+ and OpenROADM have some of the variations “standardized”
- 0dBm, proprietary FEC, subcarrier, and more options being developed

400ZR Fragmentation and Expansion

Same DSP, Multiple markets

Expanded Market



400ZR

- Datacenter Interconnect
- Ethernet client only
- 400G rate only
- Generic FEC
- Low launch power

400ZR+

- IP-over-DWDM
- Ethernet client only
- 100G-400G multi-rate
- Improved / proprietary FEC
- Low launch power

0dBm

- Expanded range / ROADMs
- Ethernet client only
- 100-400G multirate
- Improved/proprietary FEC
- High launch power

OpenROADM

- Carrier Applications
- Ethernet+OTN client support
- 100G-400G multi-rate
- Improved / proprietary FEC
- High launch power
- Tunable TX filter
- Improved dispersion comp
- Encryption

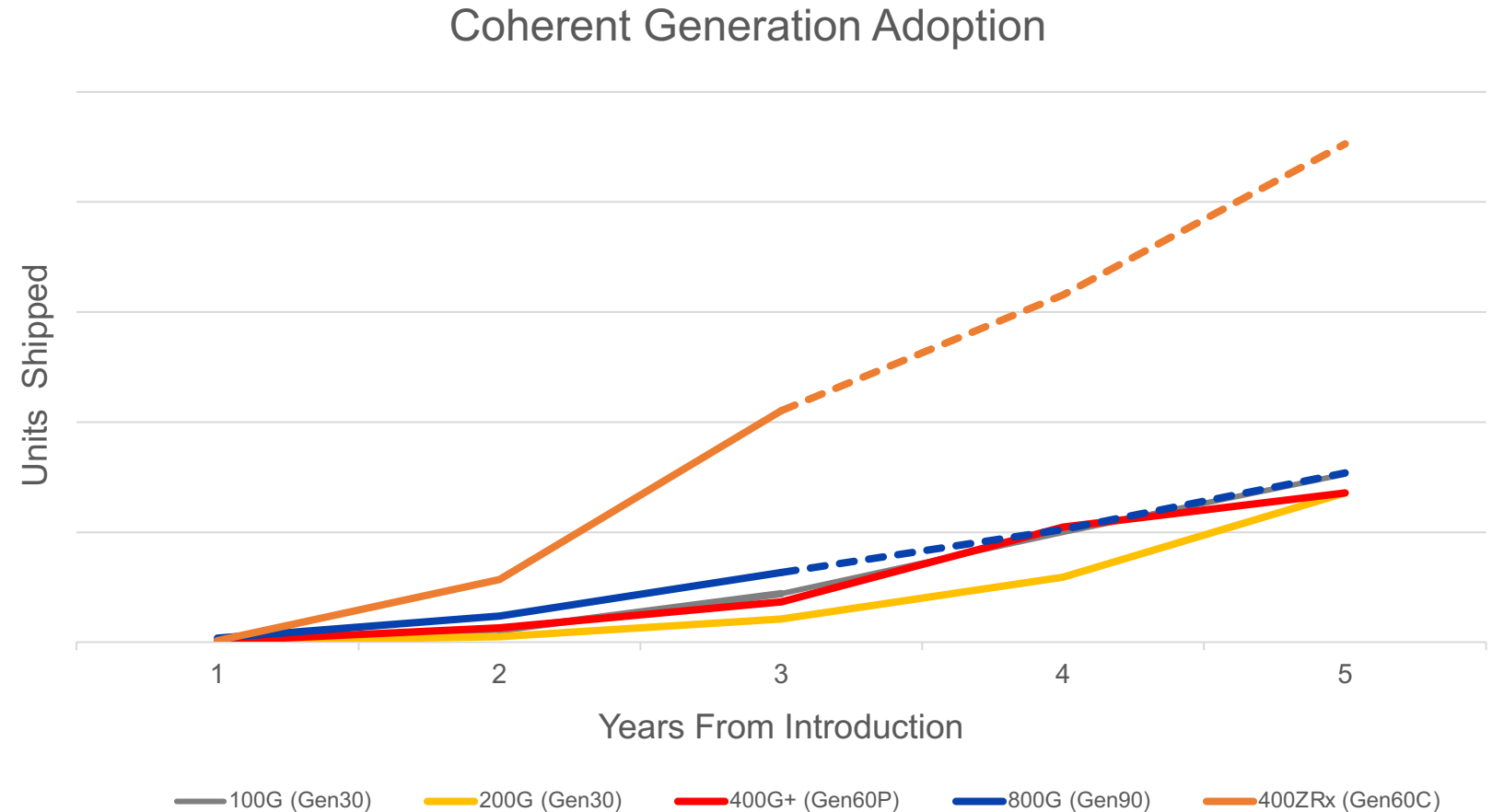
Functional Superset

Functional Superset

Functional Superset

400ZR(x): The most successful coherent generation ever

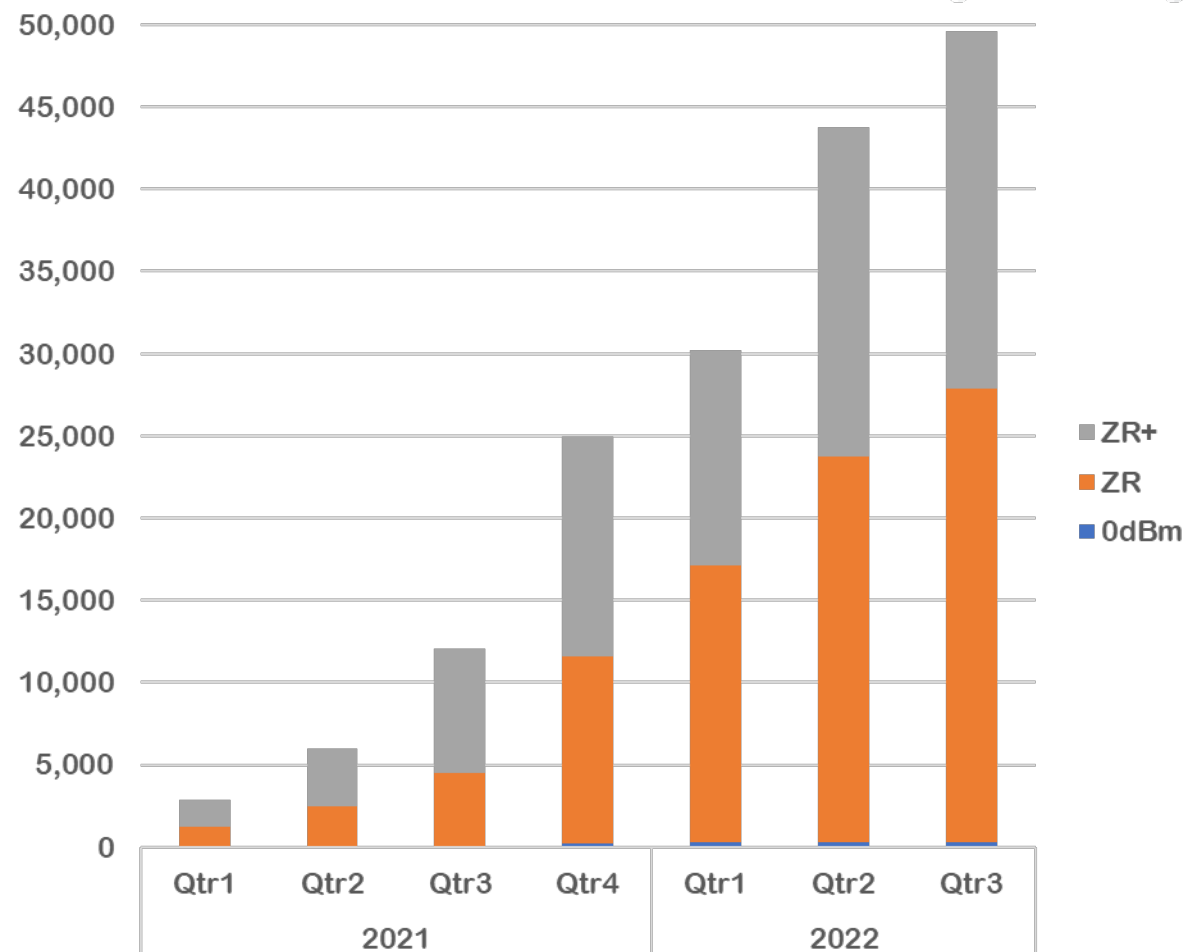
- Most deployments are in switches & routers
- Growing at datacenter rates, not telecom rates



400ZRx: Current Market

- 4 DSP suppliers shipping now
- 9 DSP suppliers expected by the end of 2023
- Almost 50k units shipped in Q3
- More than 30% of all optical bandwidth outside of the datacenter in 2023 will be 400ZRx

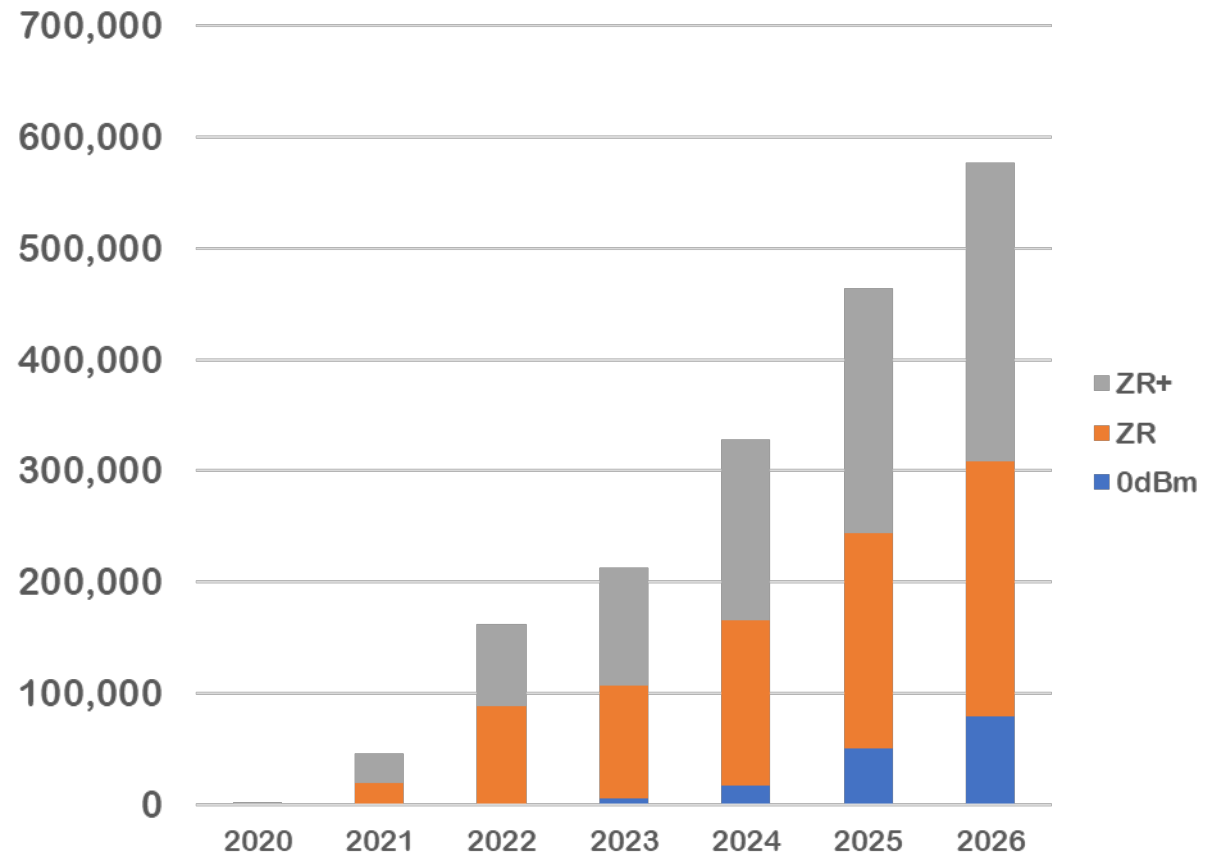
QSFP-DD/OSFP Units Shipped



400ZRx Forecast: Long Tail

- 400ZRx will have a very long lifetime
- 9 DSP vendors means innovation and new applications
 - 100ZR
 - ZR/ZR+ collapse
 - Multi-wavelength solutions
- Commodity = lower price

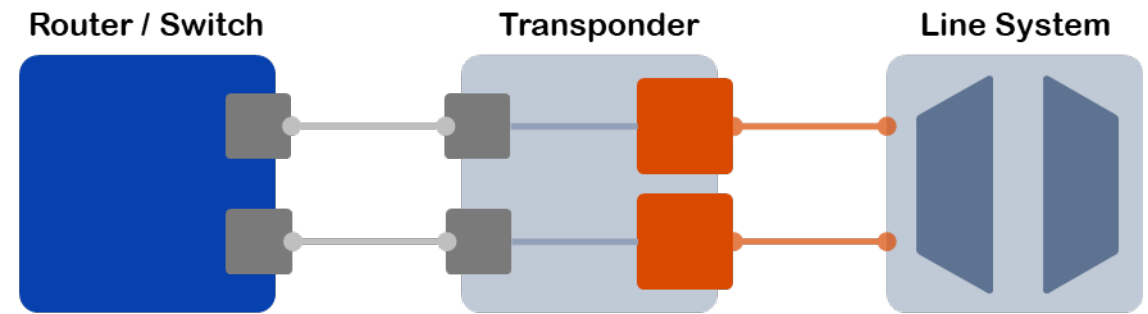
QSFP-DD/OSFP Units Shipped per Year



IP-over-DWDM: This time is different

- It's timely: 400G inside matches 400G outside
- Form factor parity
- Multi-vendor ecosystem
- It works in the fastest growing network segment – datacenter interconnect

Traditional Model



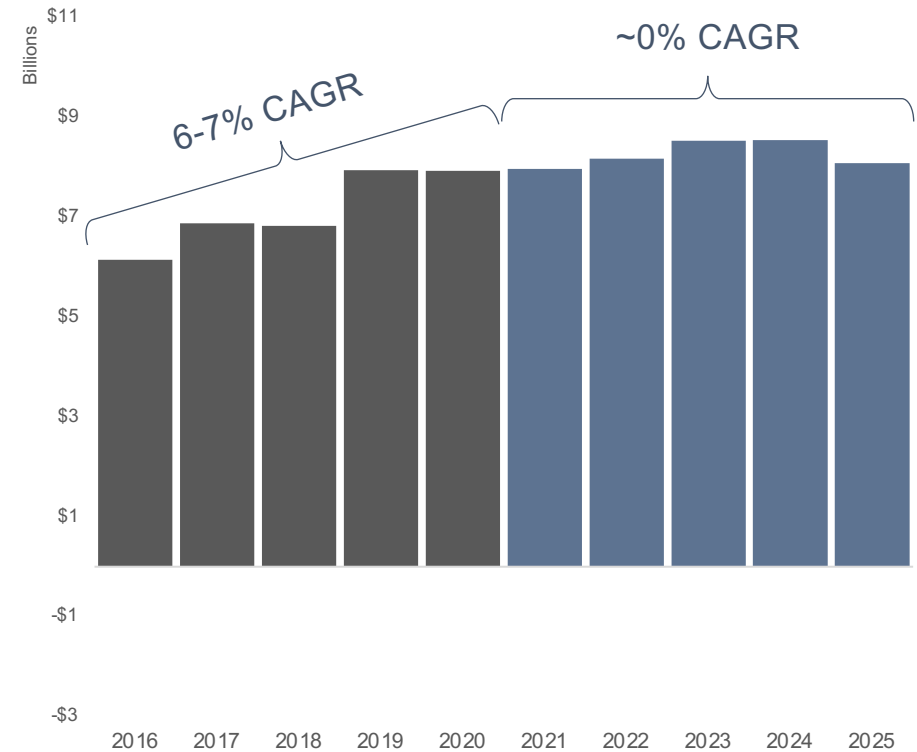
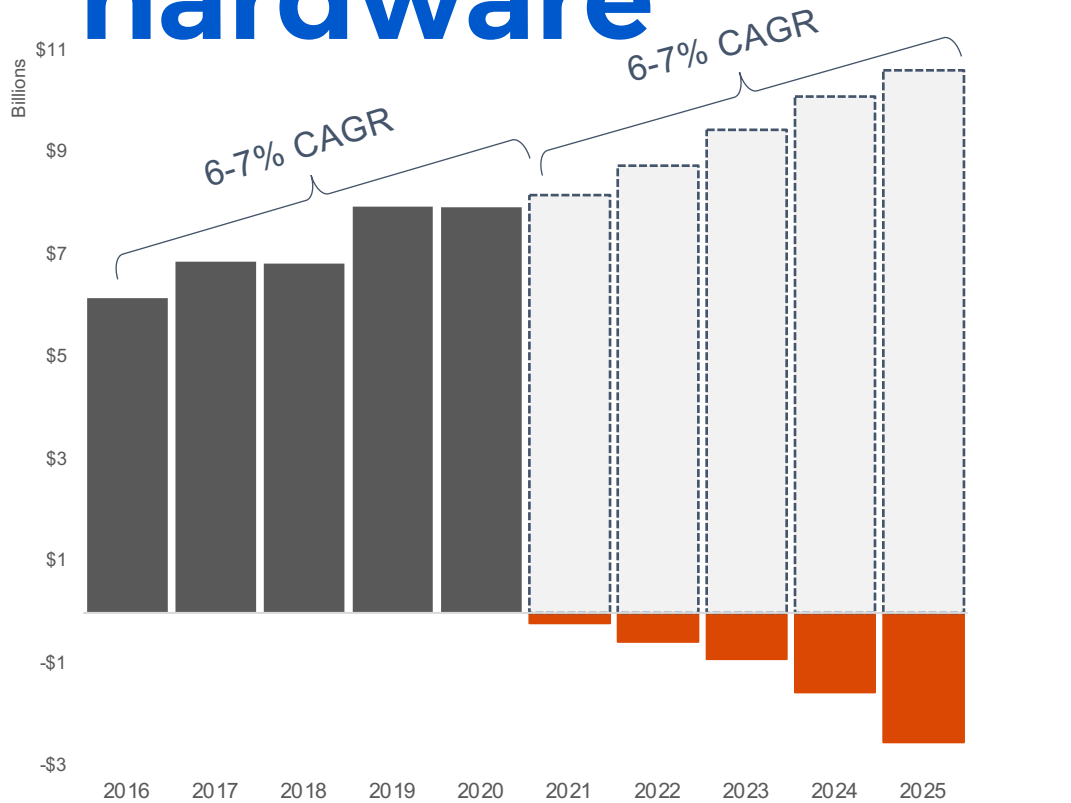
Router-based DCO (IP-over-DWDM)



400ZRx: Changing the way networks are built

- IP-over-DWDM finally works
 - DCI optics directly in the router, eliminate transponder layer
 - Routers integrating optical layer management / pass-through
- New networks that could not be built before
 - E.g., Microsoft et. al.'s distributed datacenters
- Expansion into new areas
 - Just put in a switch, much less real estate and power
- Causing network operators of all types to re-evaluate networking plans

Impact on traditional optical hardware



Historical Optical Systems Metro Sales
 Optical Systems reduction due to IPoWDM
 Optical Systems Metro forecast w/o IPoWDM (hypothetical)
 Optical Systems Metro forecast - IPoWDM



What's next?

- More vendors offering 400ZRx in more varieties
 - More functionality in QSFP-DD (migrating from CFP2)
 - QSFP-DD adoption in more optical systems
 - Huge uptake in China for long-haul 200G operations
- 800ZR (project underway by the OIF standards body)
 - Can also work as very long-haul 400G
 - Lines up with 800GbE (coming very soon)
 - Won't be as popular as 400ZRx or ramp as quickly

What's next?

- 100ZR
 - Bringing coherent to the edge – reduce fiber count, eliminate Nx10G LAG, close 100G rings
 - Two options – QSFP28 (new DSP required) or QSFP-DD (higher power)
- Coherent inside the datacenter
 - Not economical at 400G or 800G
 - May make sense at 1.6T (2x800G)



Thank you

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