From Optical Transceivers to integrated optics market

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Optical connectivity Market trends highlights

- **Clouds service and content providers driving the next generation Ethernet optical connectivity requirements and market**
  - **High Demand of 100G optical transceivers (CWDM4, PSM4 and SR4) for intra DC**
  - **Next Generation 200G/400G sampling in 2018 but ramp up not before 2019-2021**
    - **400G fragmented module form factor QSFP-DD, OSFP, COBO**
    - **400G an infinity of IEEE and MSAs specifications**
  - **Next generation 100G DR for optical link to the server NIC**
  - **High Demand of 100G Coherent optical modem for Data Center Interconnect**
    - **81% of market is non-pluggable in 2017, 15% DCO, 4%ACO**
    - **2017 is the year of the change in strategy, open group standardizing 400G pluggable**
  - **Next generation 400G coherent pluggable DCO specification started by OIF, IEEE will follow**
- **Future demand of integrated optics**

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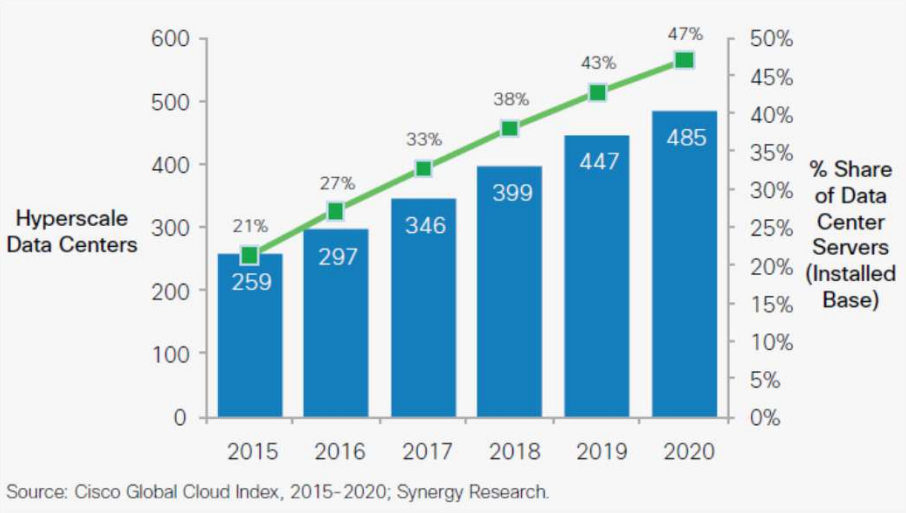
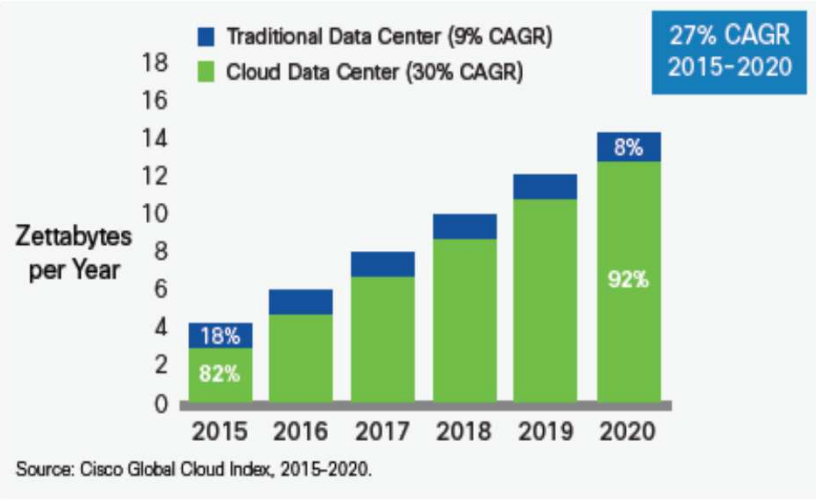
Hyper Scale DATA CENTER Growth
CLOUDS TRAFFIC Explosion



Source: Cisco Global Cloud Index, 2015-2020; Synergy Research.

- + 140 new Hyper Scale DC by 2020
- 47% of all servers installed in Hyper Scale DC by 2020



Source: Cisco Global Cloud Index, 2015-2020.

- Majority of DC traffic is Cloud traffic
  - Clouds Traffic 30% CAGR (2015-2020)

77% of the DC traffic it is within DC

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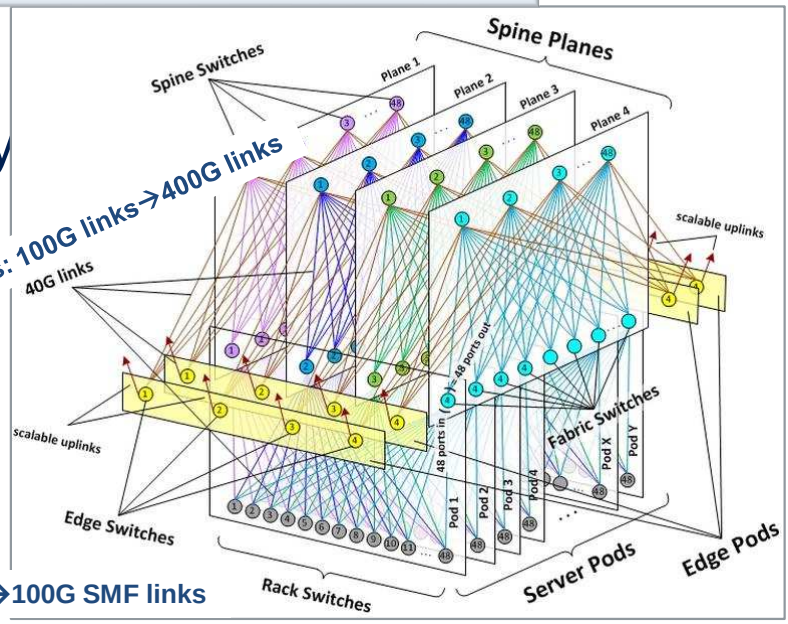
Next Generation High speed intra DC connectivity

With 100G per lane the **Single Mode Fiber** will enter into the RACK

- Rack switches to Fabric switches connectivity
  - pluggable **100G QSFP28**➔pluggable **400G QSFP-DD** (Cisco) 400G OSFP (Arista)
- Rack switches to server NIC connectivity
  - **100G DAC breakout** to 4x25G and 2x50G ➔ **400G DR4 AOC breakout** to 100G DR



Schematic of Facebook data center fabric network topology

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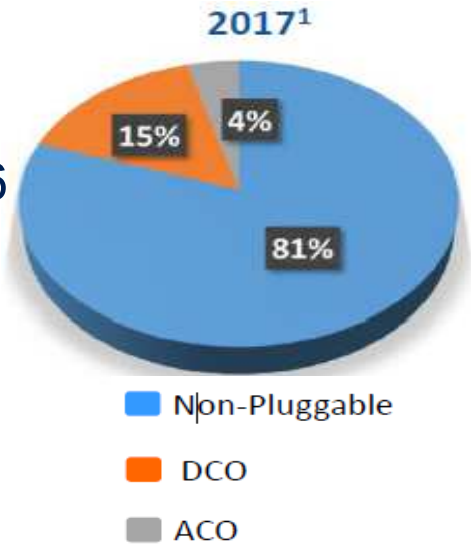
Metro DCI Coherent Transceiver Market: a path towards pluggable

- Majority of the market today is non pluggable: 81%
- DCI revenue segment projected to grow at a 20.6% CAGR 2016 to 2021 (source ACG research) mainly due to Clouds
- Metro DCI expected to be >500ku in 2020, half of it pluggable,
  - Clouds prefer DWDM system equipped with pluggable transponders
  - Clouds promoting open optical DWDM platforms



1:Source Acacia public pres.

- Towards 400G:
  - OIF 400ZR Interop Project for pluggable digital coherent (DCO) modules <15W, operating as a 400G GbE PMD compatible with 400G-AUI
  - IEEE started study group for 50G/200G/400G beyond 10km optical PHY

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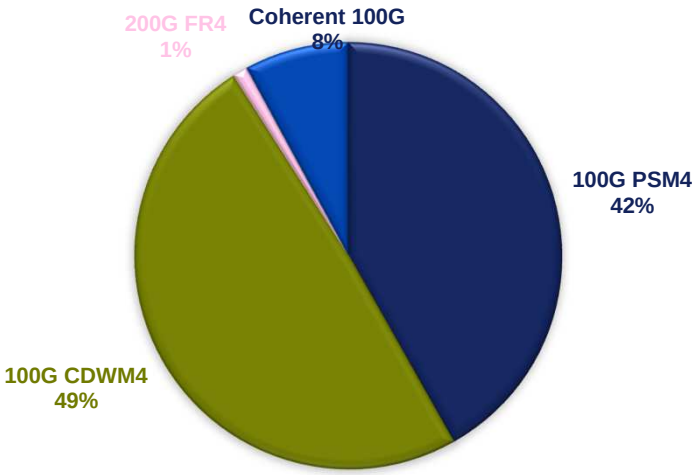
High speed Ethernet SMF Transceivers TAM

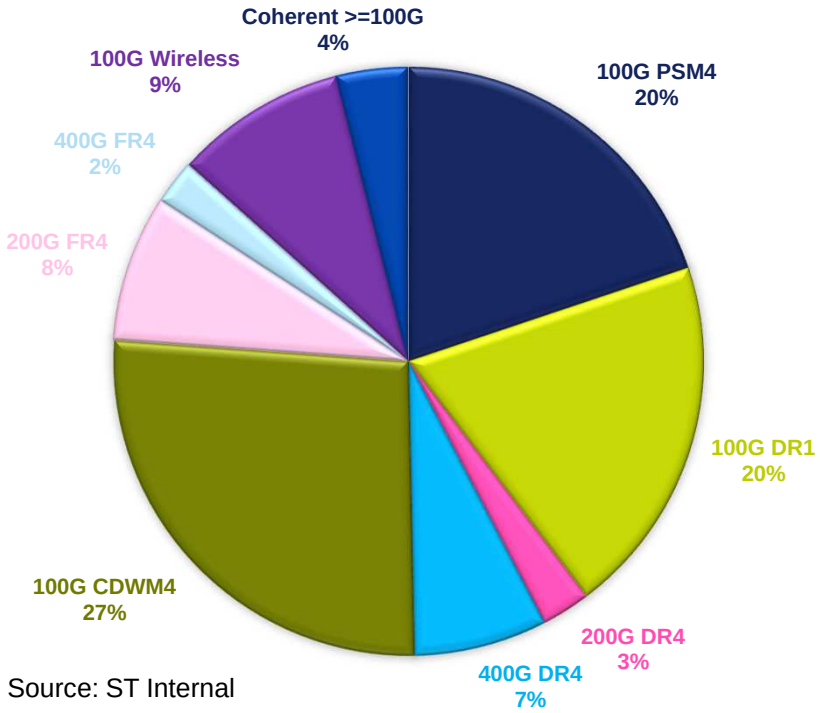
All transceivers addressable by Silicon Photonics ICs

TAM 2018
Total Units: 4.2Mu



Source: ST Internal

TAM 2021
Total Units: 15.9Mu



Source: ST Internal

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DC market vision

100 of new Hyper-scale datacenters for cloud and web2

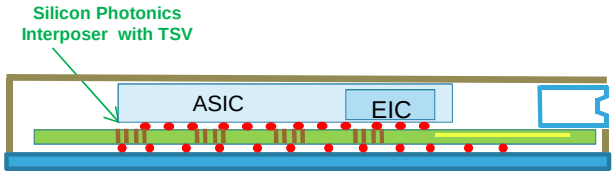
- **Millions** of **low cost 100Gbps pluggable transceiver** for optical link up to **2km distance**

Exponential growing of bandwidth requirements for Datacenter, High Performance Computing (HPC)

- **high port density**, **400 pluggable, 800Gbps On-Board Optics**

Integrated Optics for Terabit Communication

- **very low power servers (few Tbps) and switches with very high density I/O (up to 25Tbps)** through **Optical Interposer**

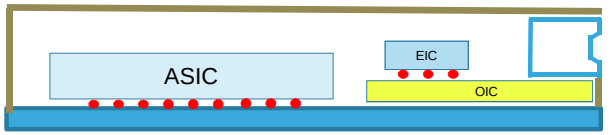


Optical Interposer with TSV and Photonic Control IP embedded into ASIC

NOW — 2-3 Years — 4-5 Years

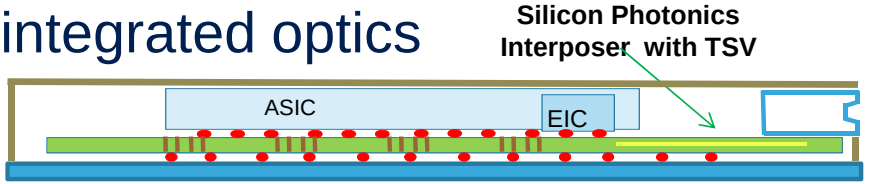
Optics Integration: beyond on board optics

- >112Gbps the electrical link is no longer effective wrt to optical links (due to the re-timers needs)
  - 112Gbps PAM4 USR (<10mm, <3dB@28Ghz) for MCM
  - Parallel I/Os from Core die to serdes within ASIC 3D stack over silicon photonics interposer
    - Serdes directly coupled with Photonics via a very short interface in 3D stack SiP
    -



Optics integrated into a MCM

- From 2-3$/Gbps to 0.10$/Gbps thanks to integrated optics



Photonic Drivers and detector IP embedded into ASIC

- Several challenges to overcome
  - Co-Packaging: SMF fibers passive alignment, reflow capability, laser attach/integration
  - Low size modulators needed, much smaller than MZM

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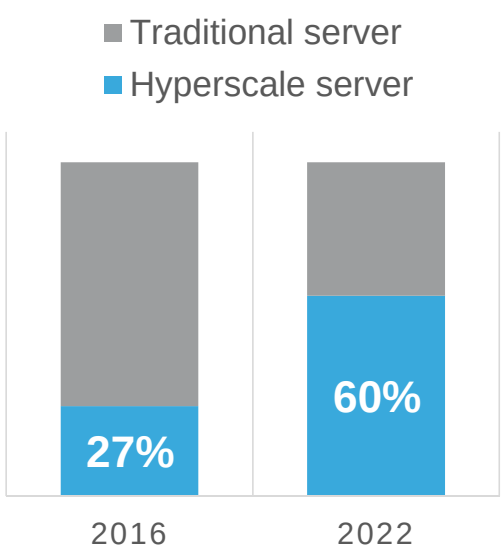
Servers based on photonics interposer market

250kunit servers addressable by Silicon Photonics Interposer

>120%

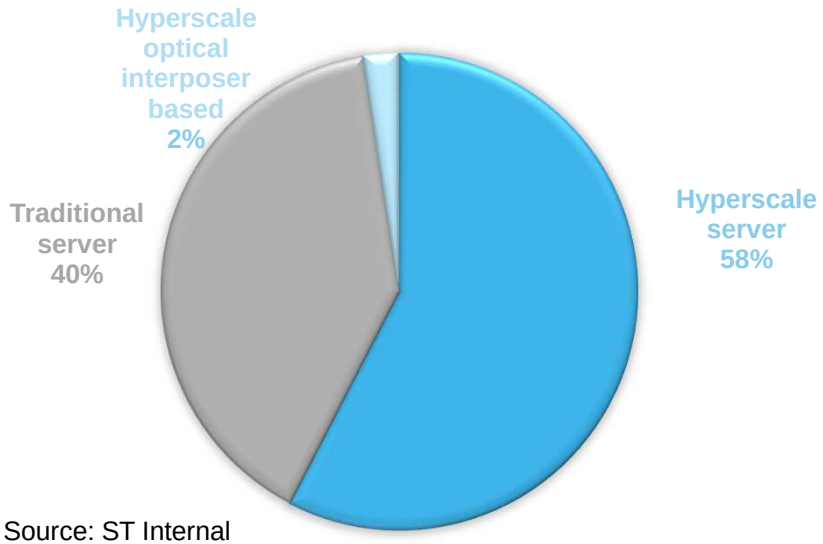
GROW IN HYPERSCALE SERVER SHIPMENTS



Source: ST Internal

2%

Server based on optical interposer 2022



Source: ST Internal

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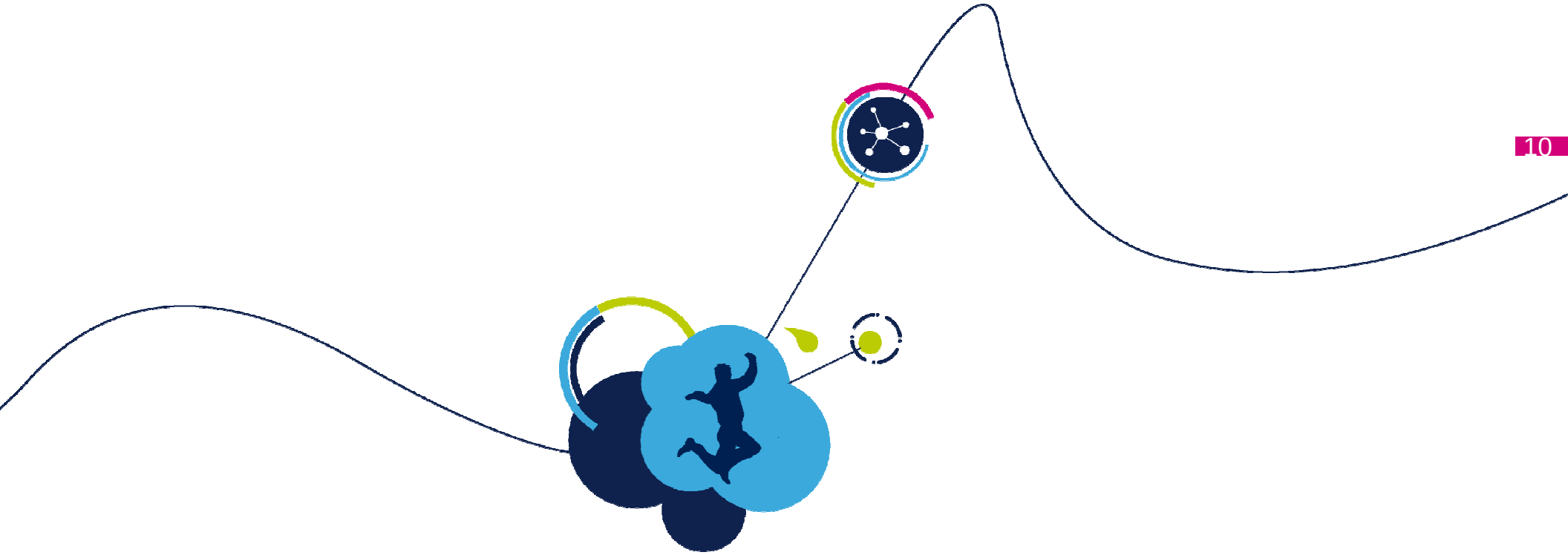

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