



Optics for the Cloud

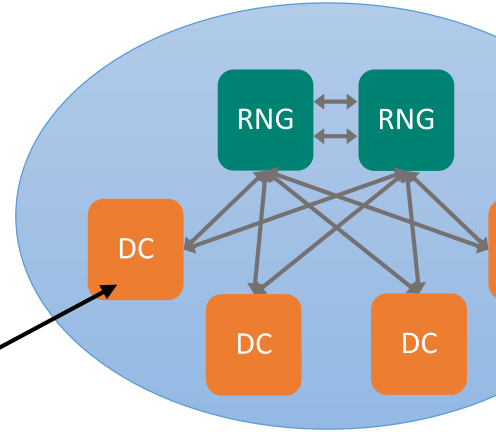
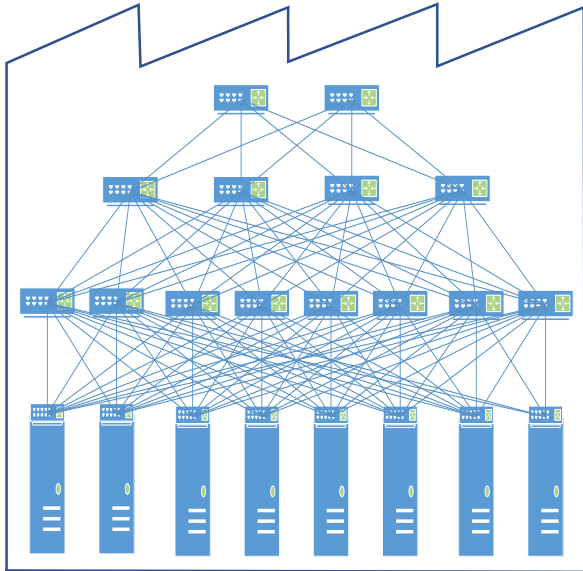
Benn Thomsen

Microsoft Research

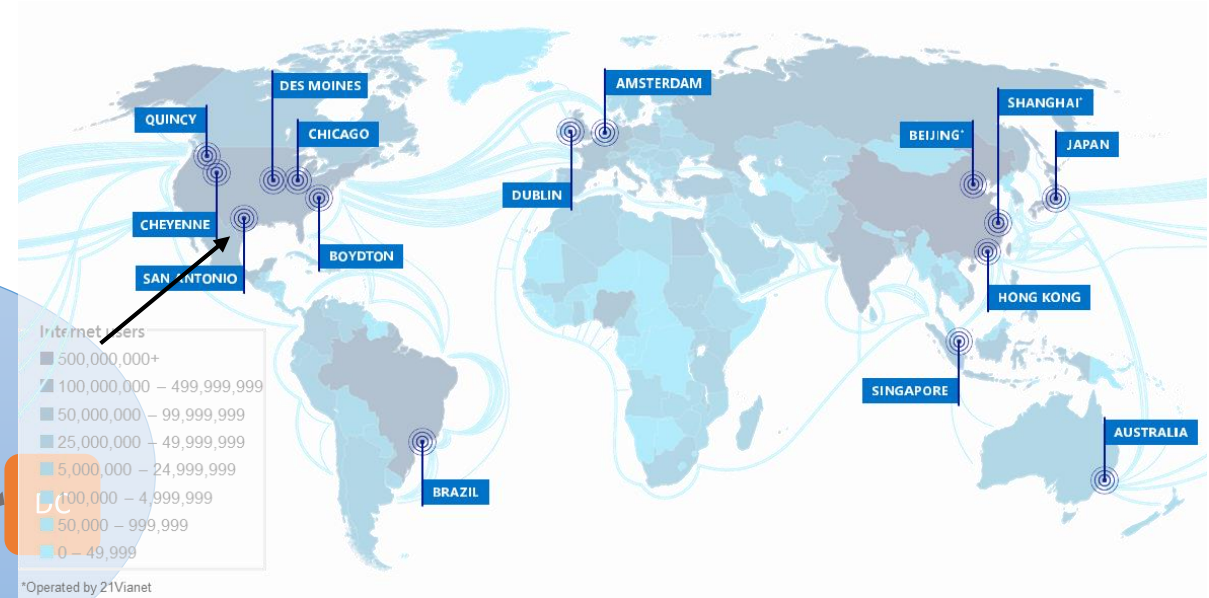


Operating Optics at scale

Data Center
1 km radius
150,000 servers
120,000 100G optical transceivers

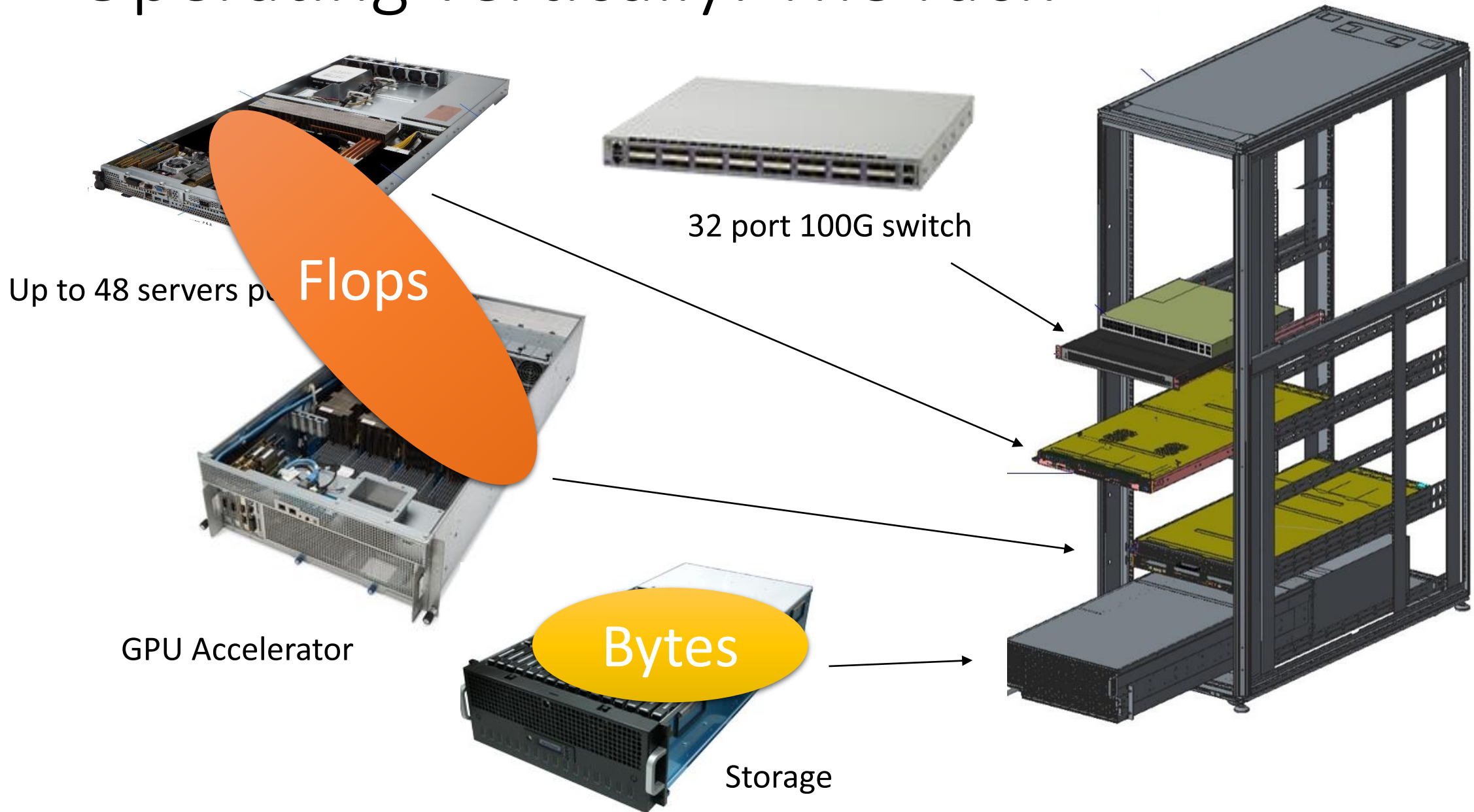


Regional Network
70km radius
512 fibre pairs
2Pb/s

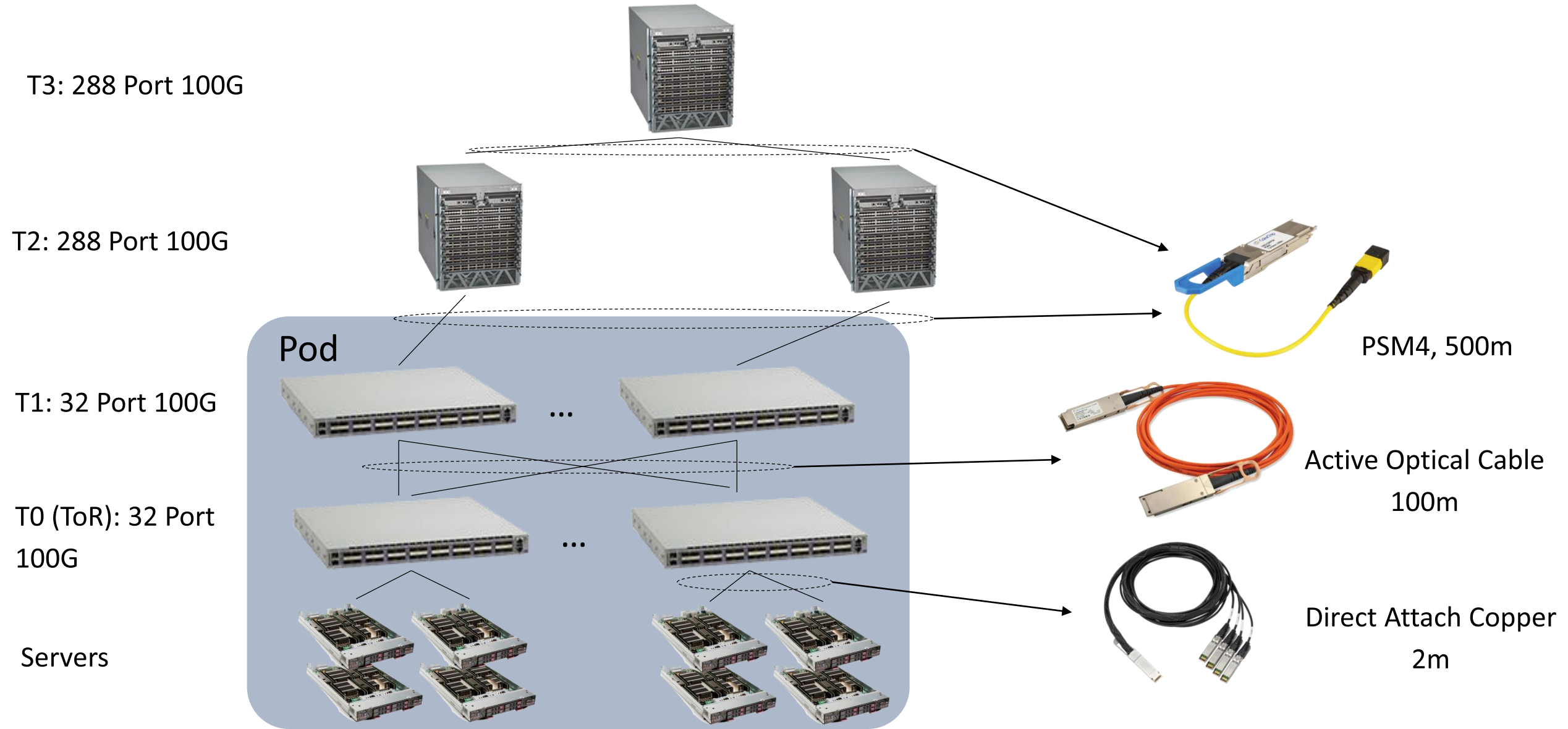


WAN
Data centers in 50+ regions
More than 70,000km of fibre

Operating vertically: The rack



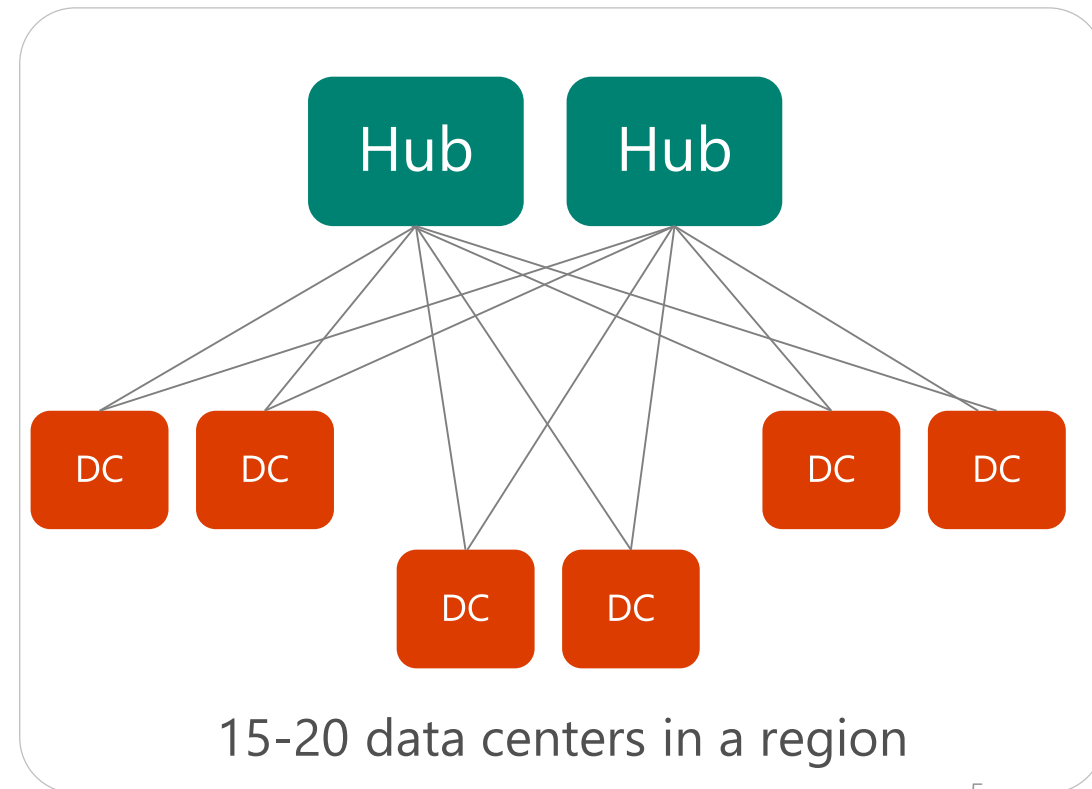
Operating vertically: DC Network



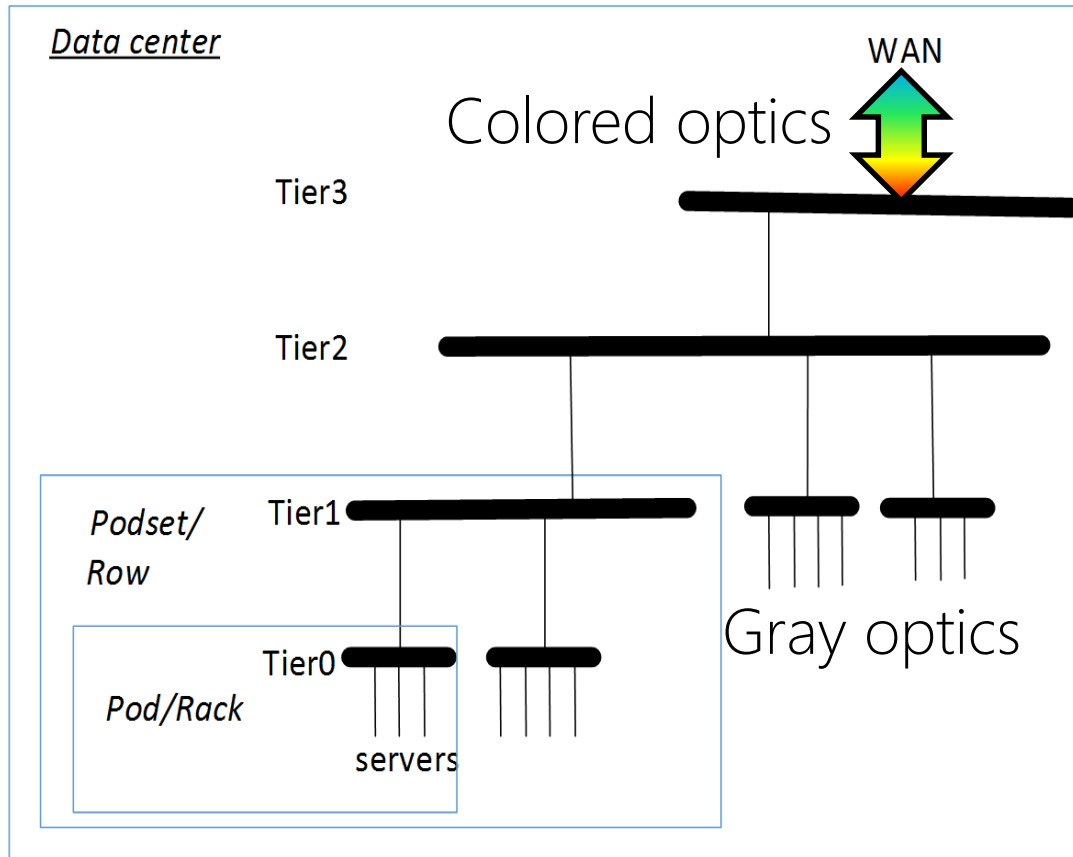
Innovating vertically: Regional Architecture

Distributed data centers across an 80Km region to keep pace with cloud growth

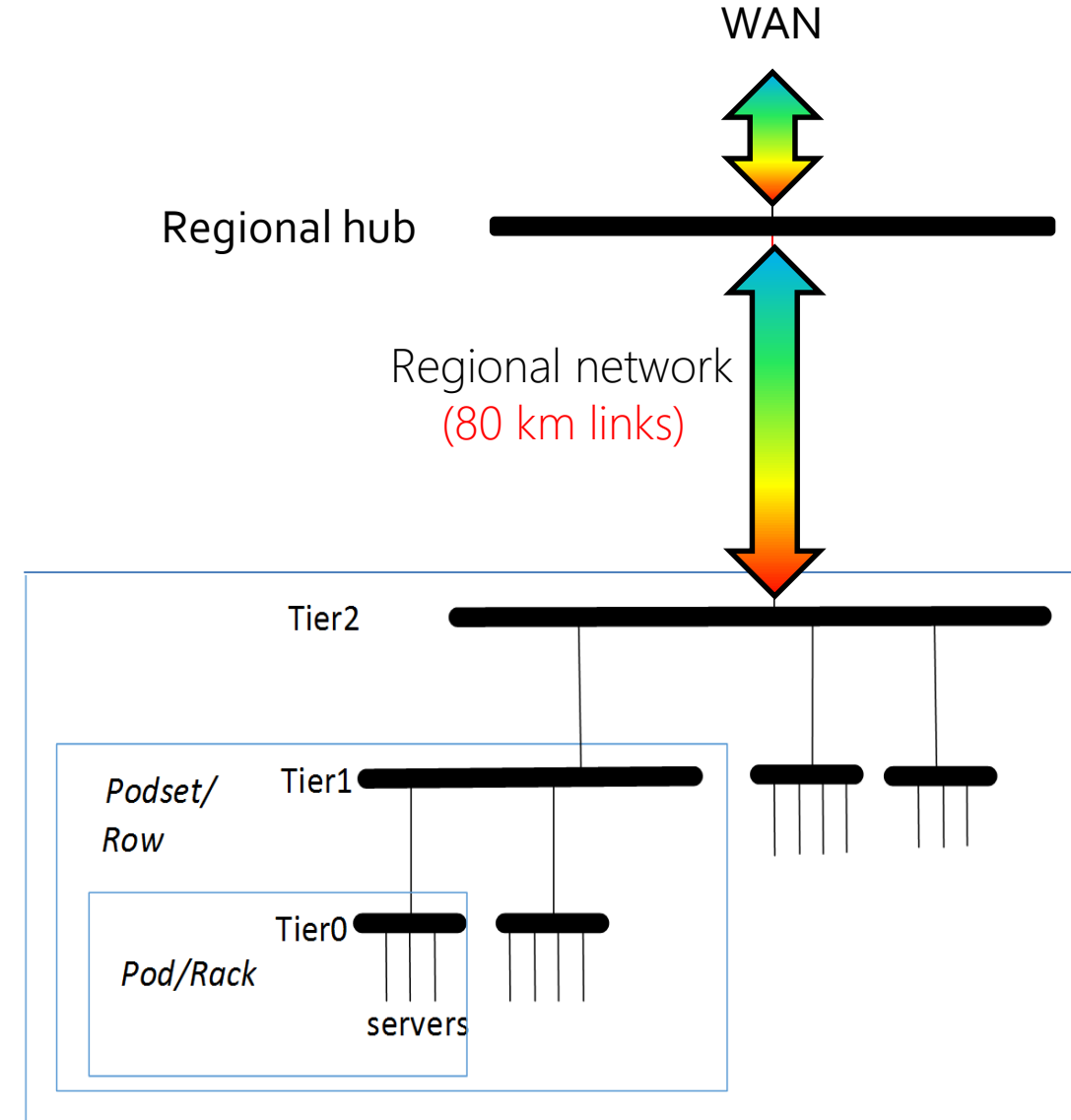
Mega Data Center



Innovating in optics



Mega data center



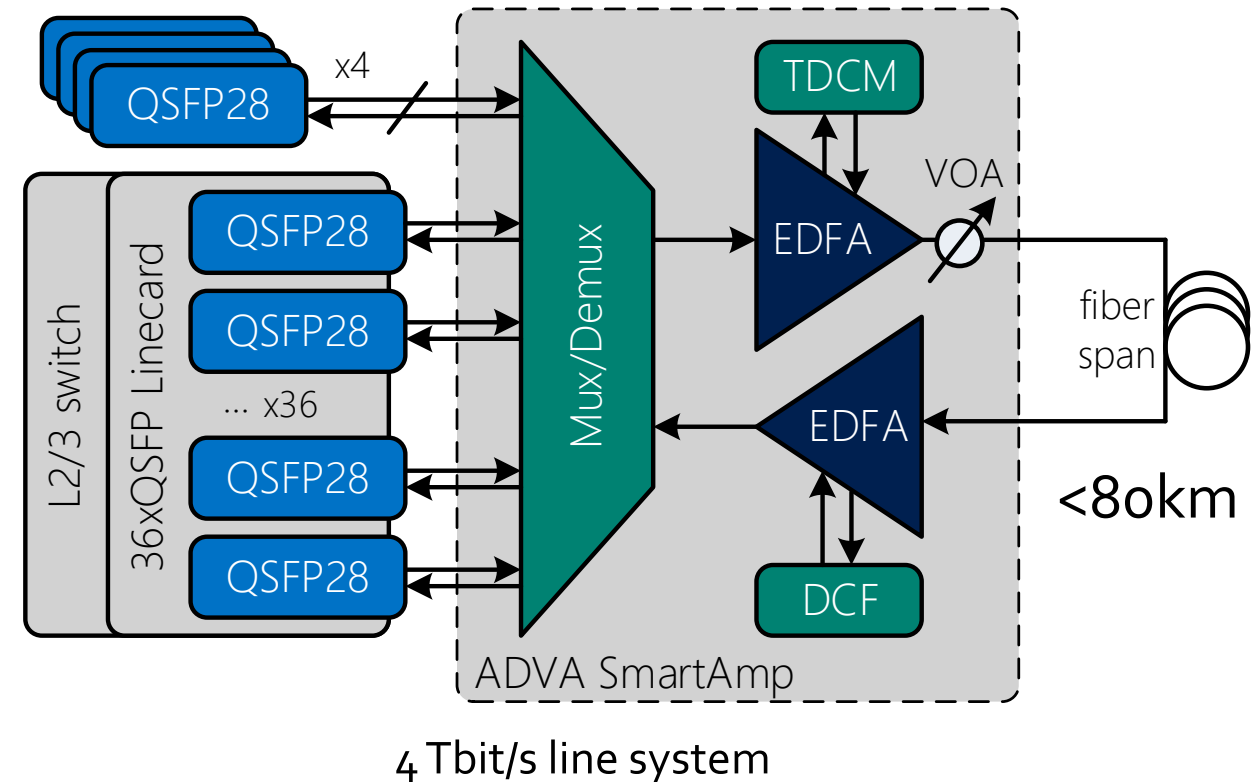
Regional architecture ₆

Regional architecture: PAM4 QSFP28 DWDM transceiver

- Inphi 100G QSFP28 switch-pluggable module
 - » Dual- λ , 28 Gbaud PAM4
 - » < 4.5 W per module
- Integrated Si Photonics optics
- PAM₄ ASIC with integrated DSP and FEC
- Inphi PAM₄ modules – 40x100G
- ADVA 100GHz grid open line system
 - » Variable gain/tilt EDFAs
 - » Automatic Tunable CD compensation

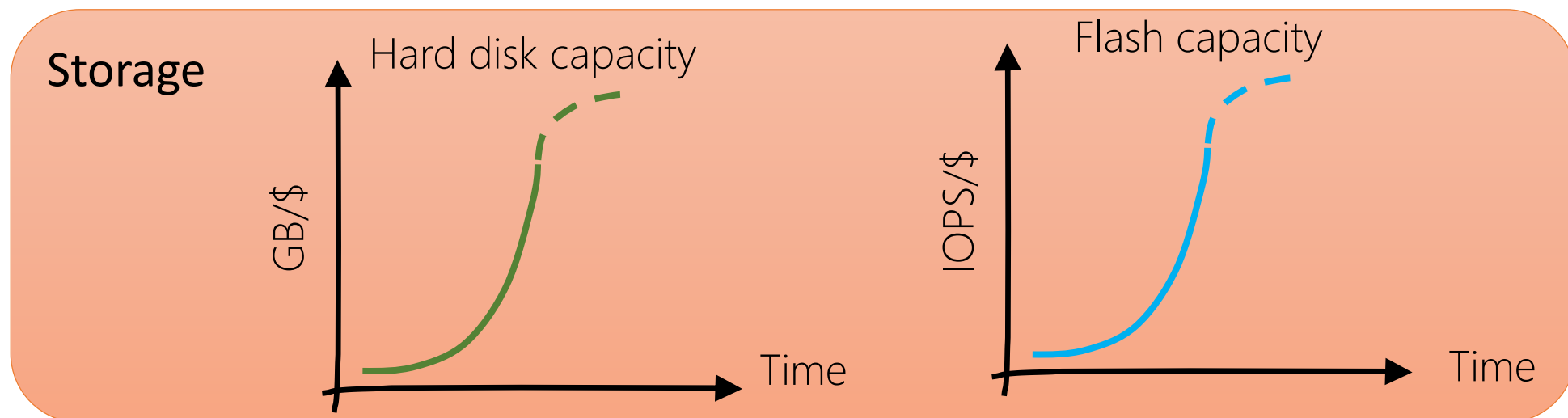
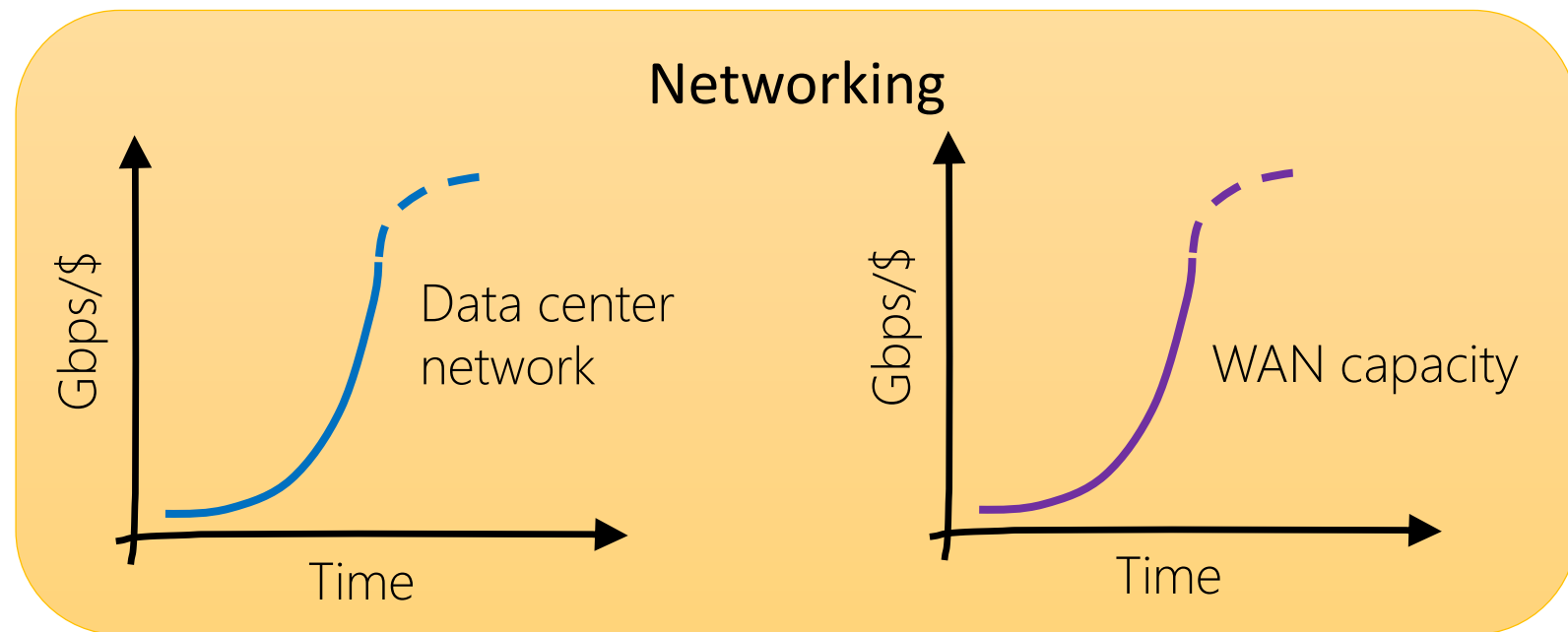
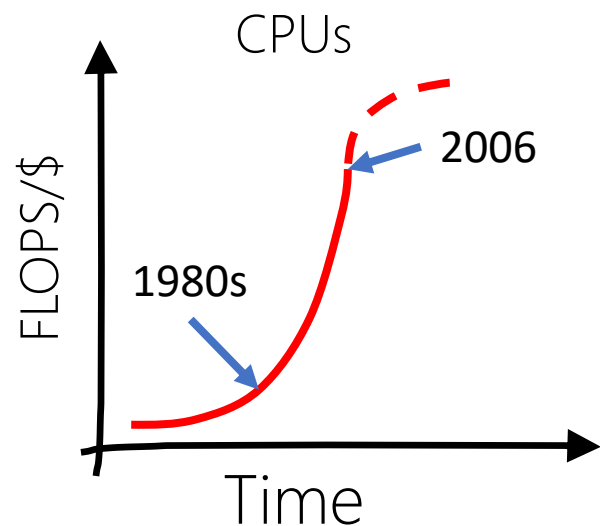


ColorZ: Inphi 100G QSFP28

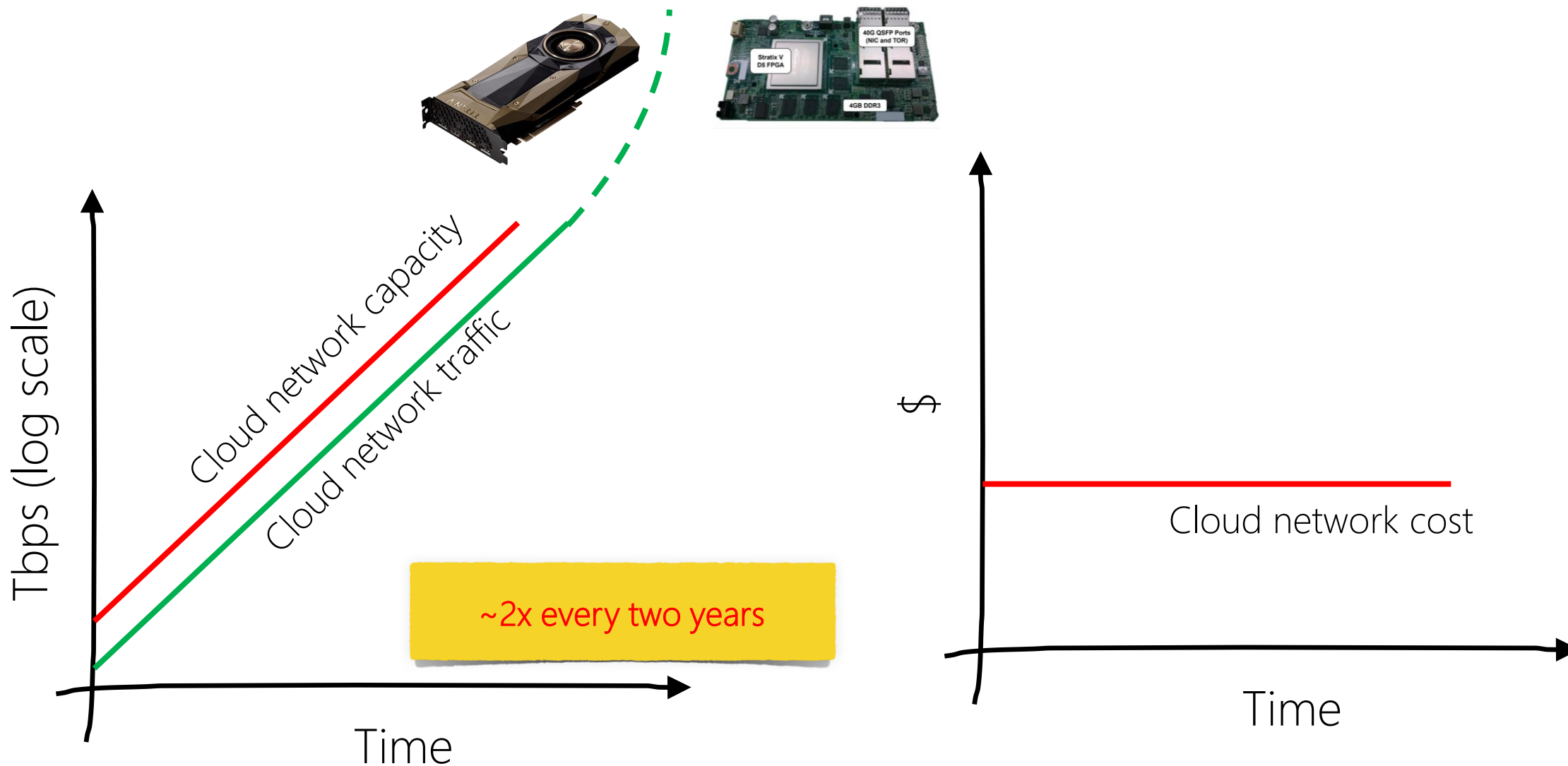


Optimised for 80km

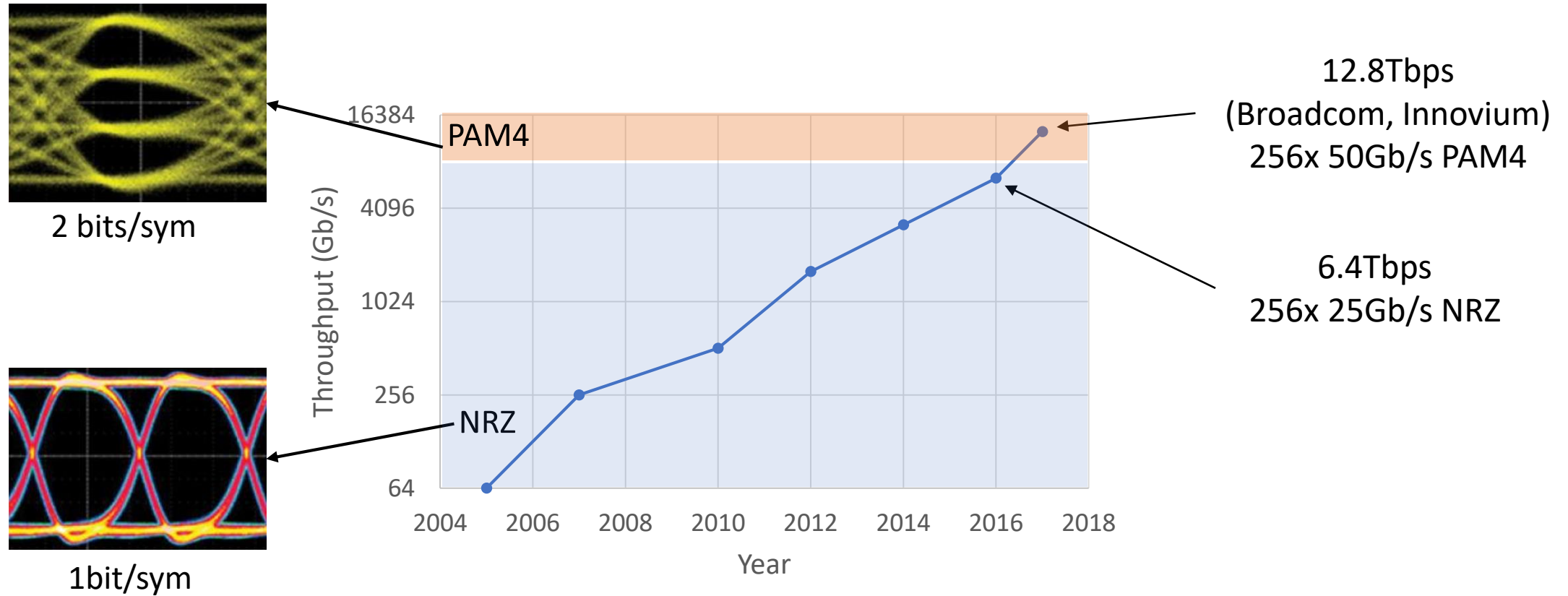
Disruption across the board



Moore's Law for Networking

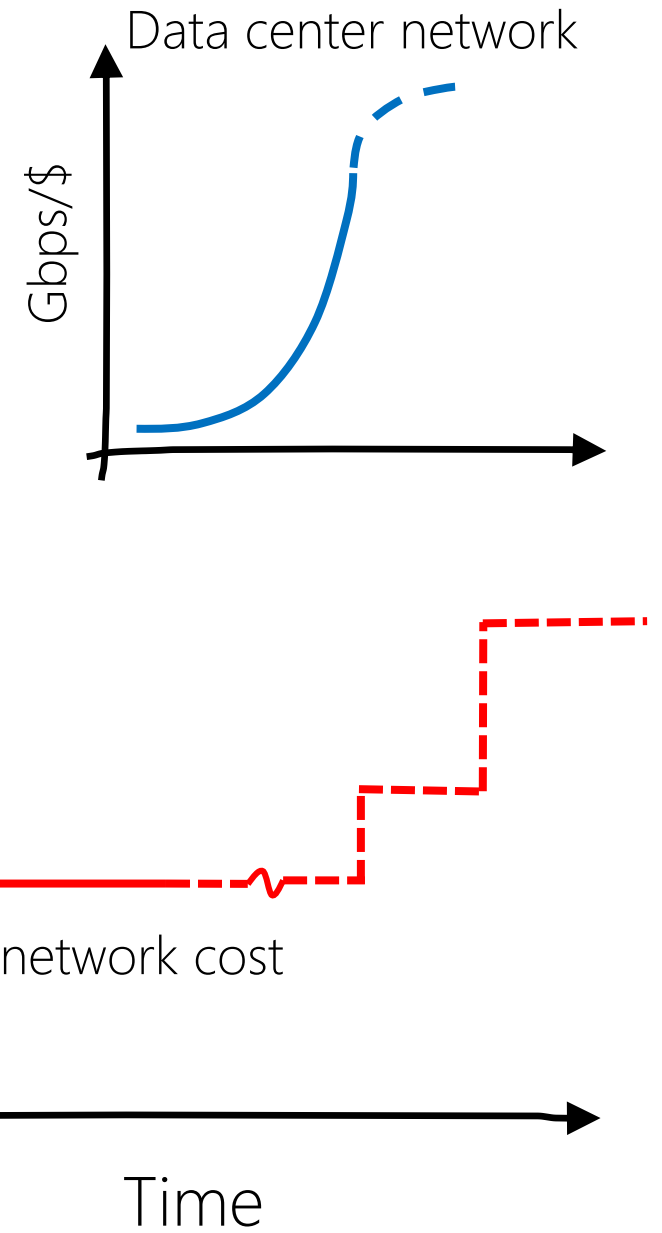
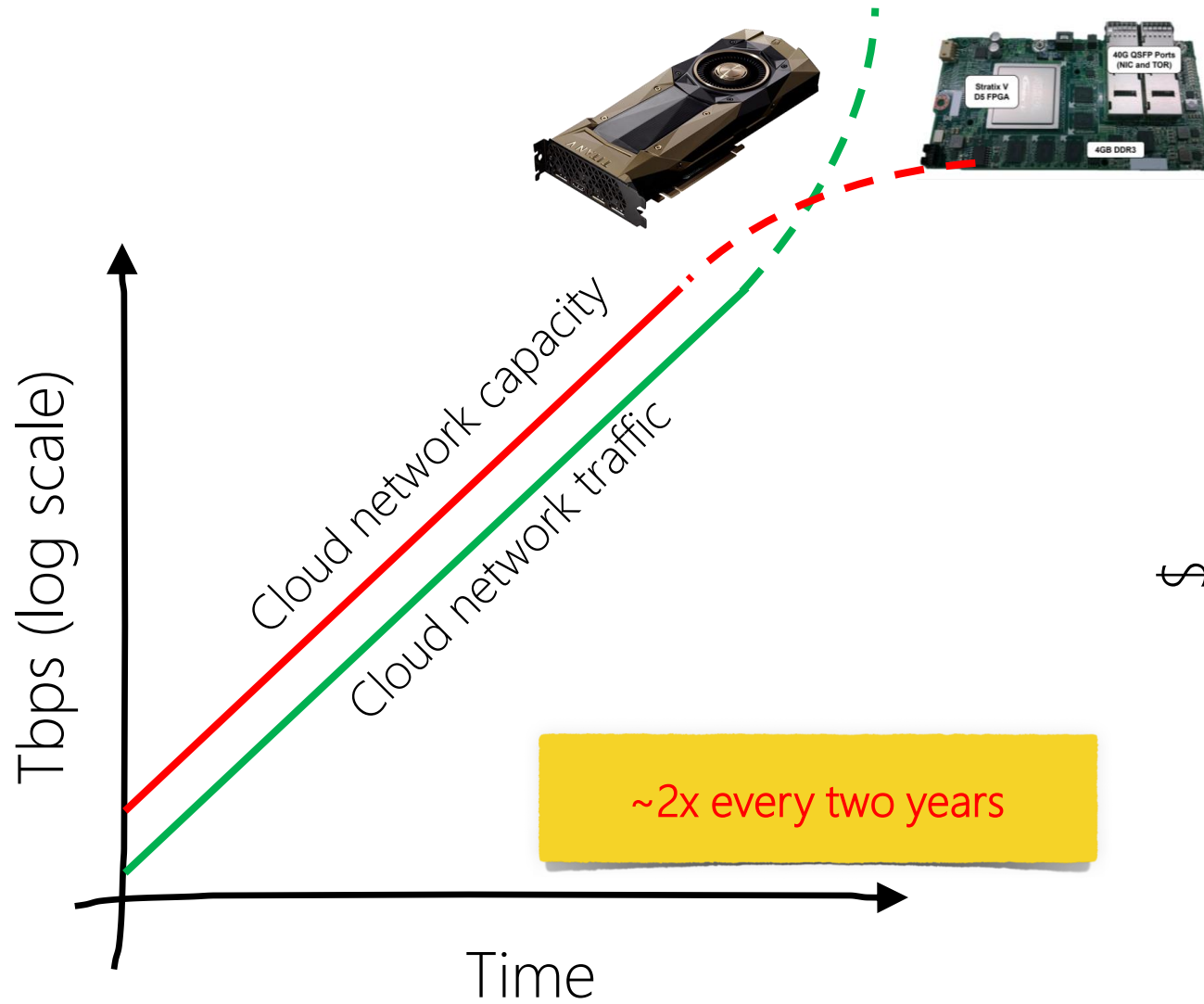


Will free scaling continue?

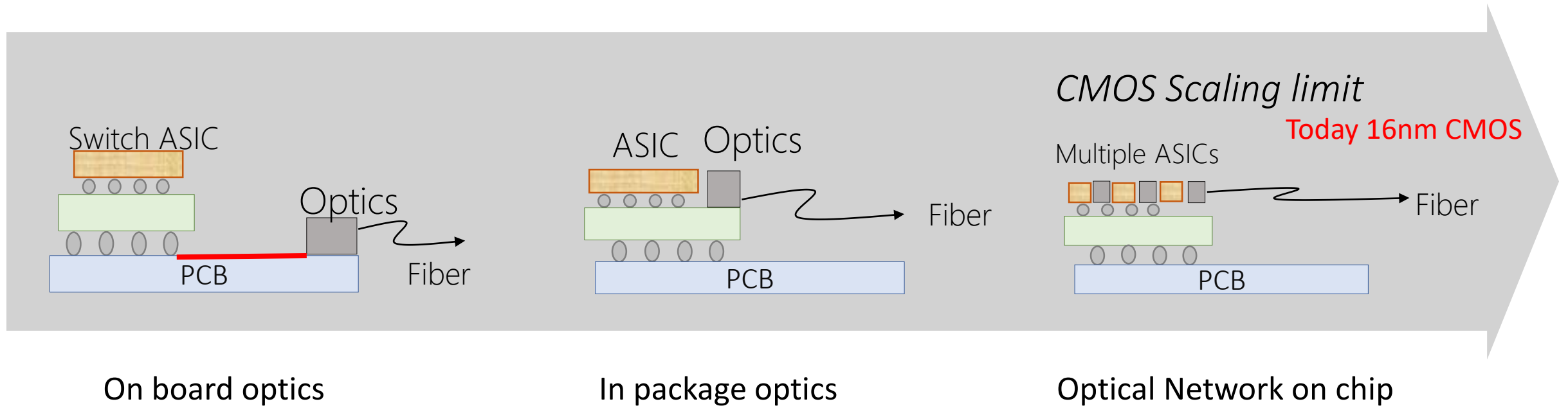


Switches are becoming edge bandwidth limited

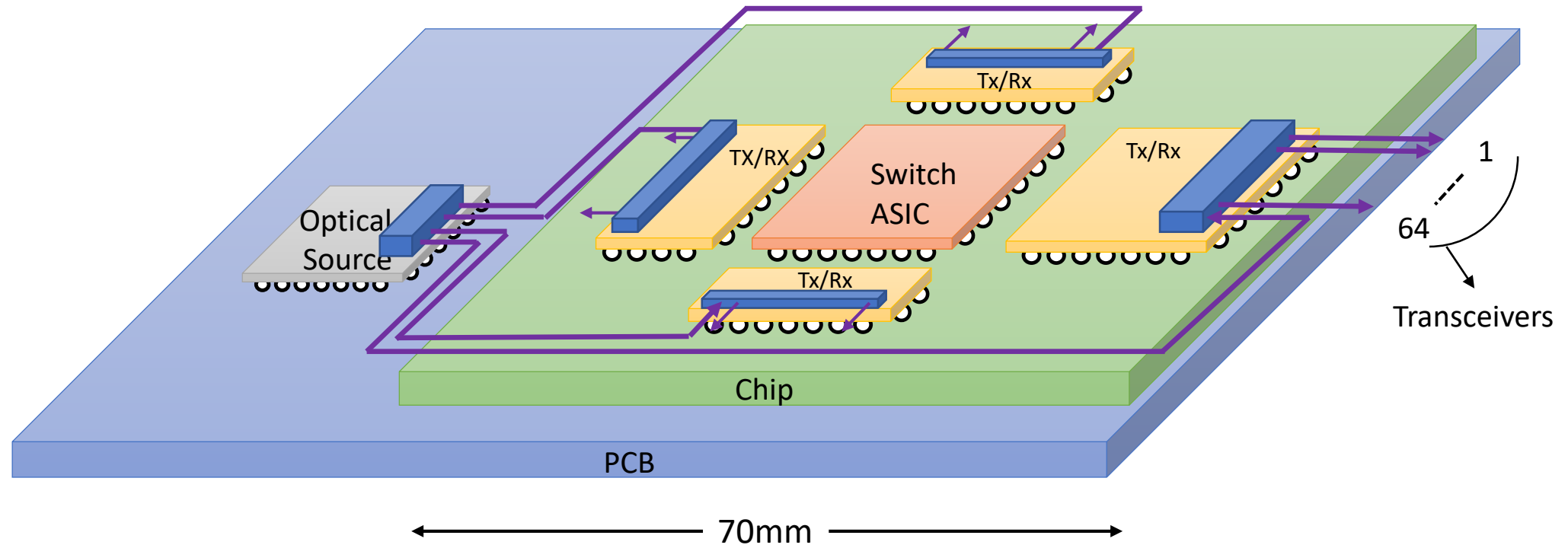
Moore's Law for Networking



Opportunity for photonics (shorter-term)



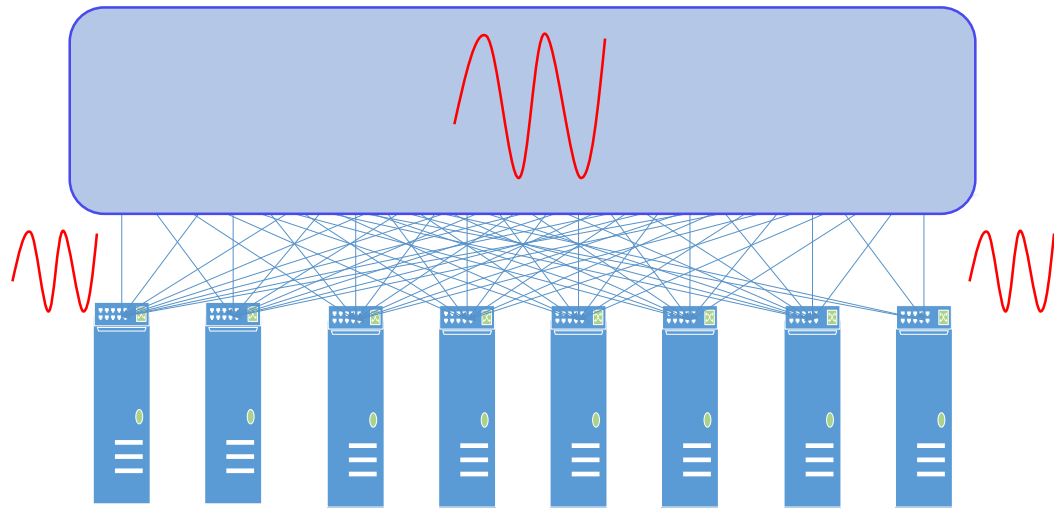
In-package optics (IPO)



- Challenges

- Material: Silicon, InP
- Approach: Direct modulation, MZM, Ring modulator, Coherent??
- Real estate, yield, operating environment
- Fibre attach

Opportunity for photonics (long-term)



 Optical packet switch

- ✗ Fundamental challenges
- All optical header processing
 - Optical buffers

 Optical circuit/burst switch

- ✓ More developed technology
- Higher- radix enables a flat network

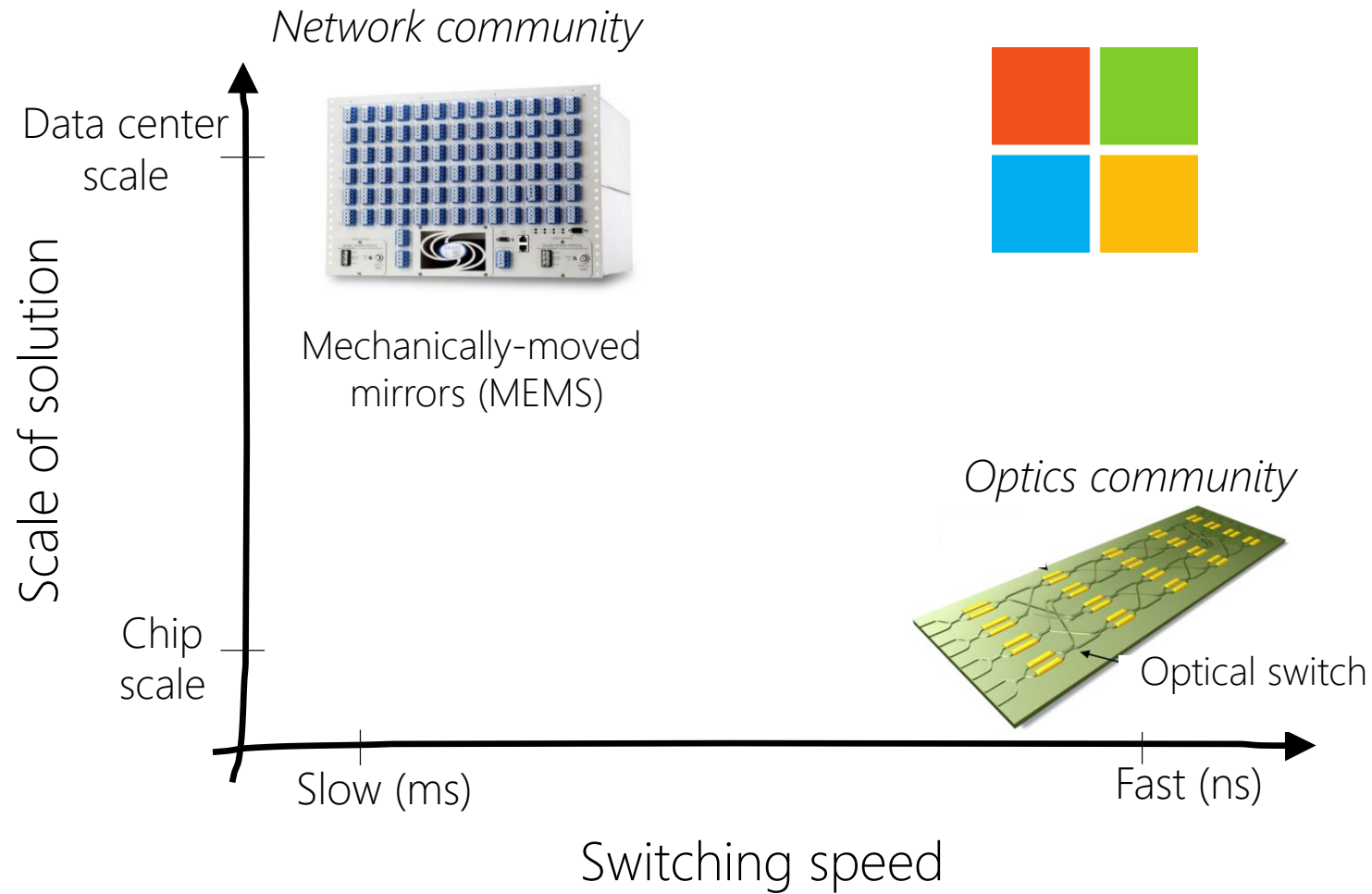
An old idea made new

New goalpost

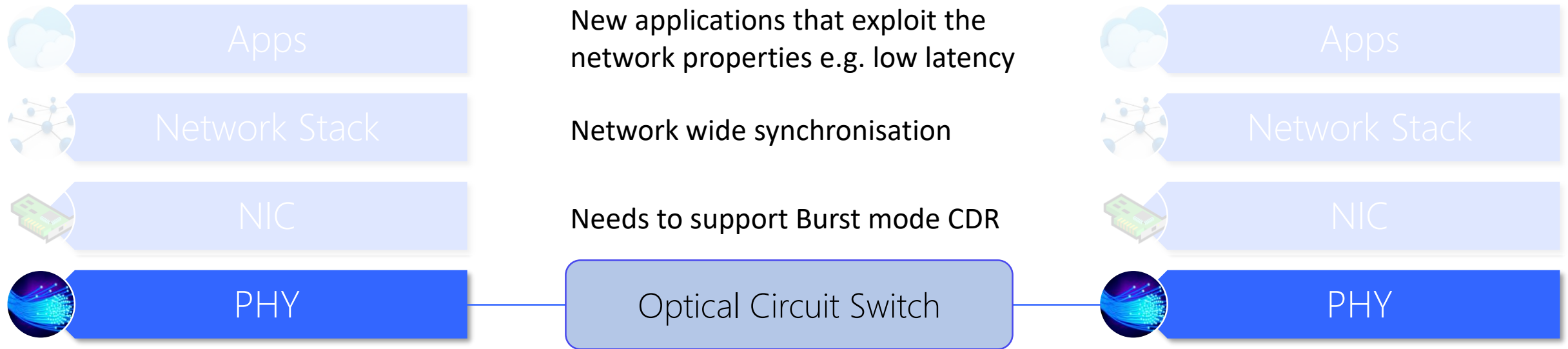
Large Scale
data-center-wide

&

Fast switching
Sub nano-second

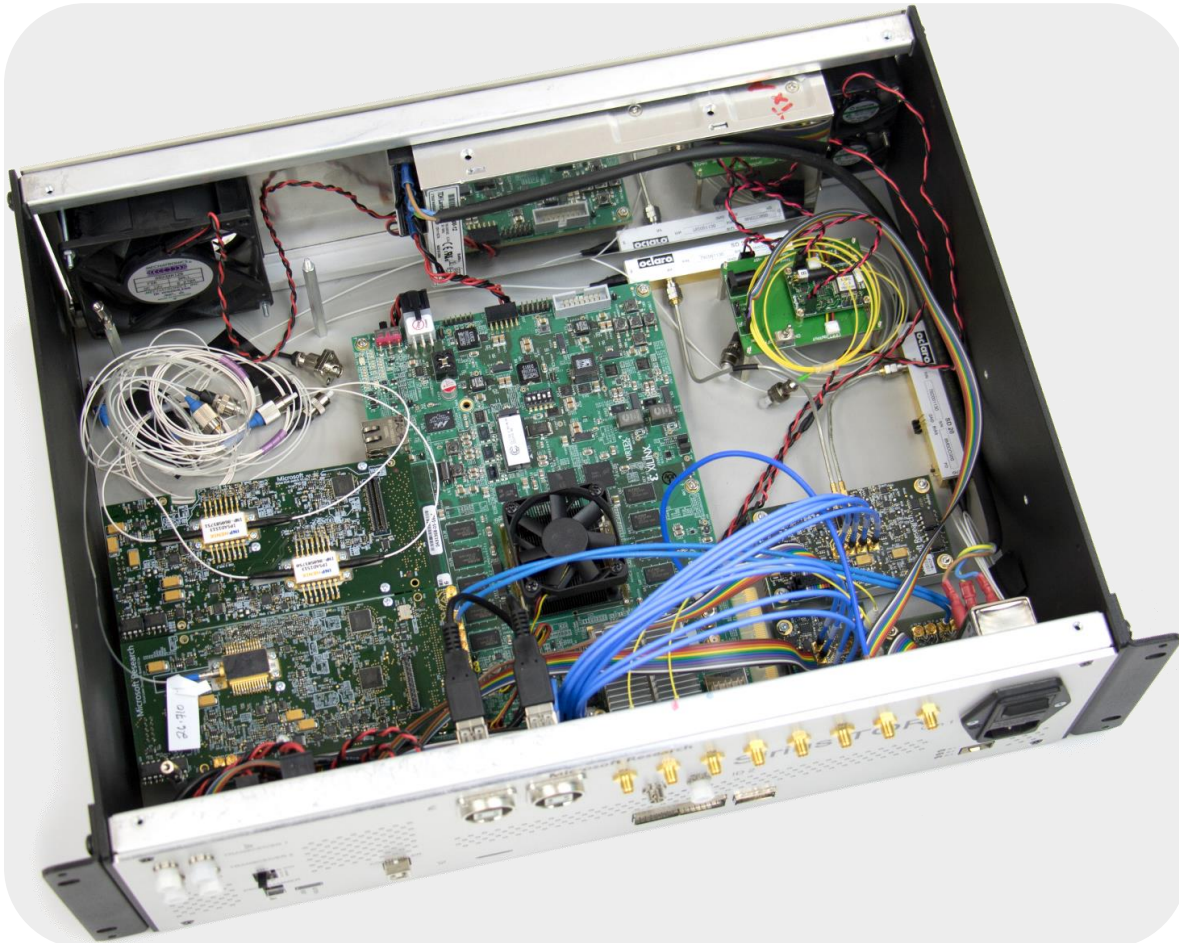


Bridging the last mile



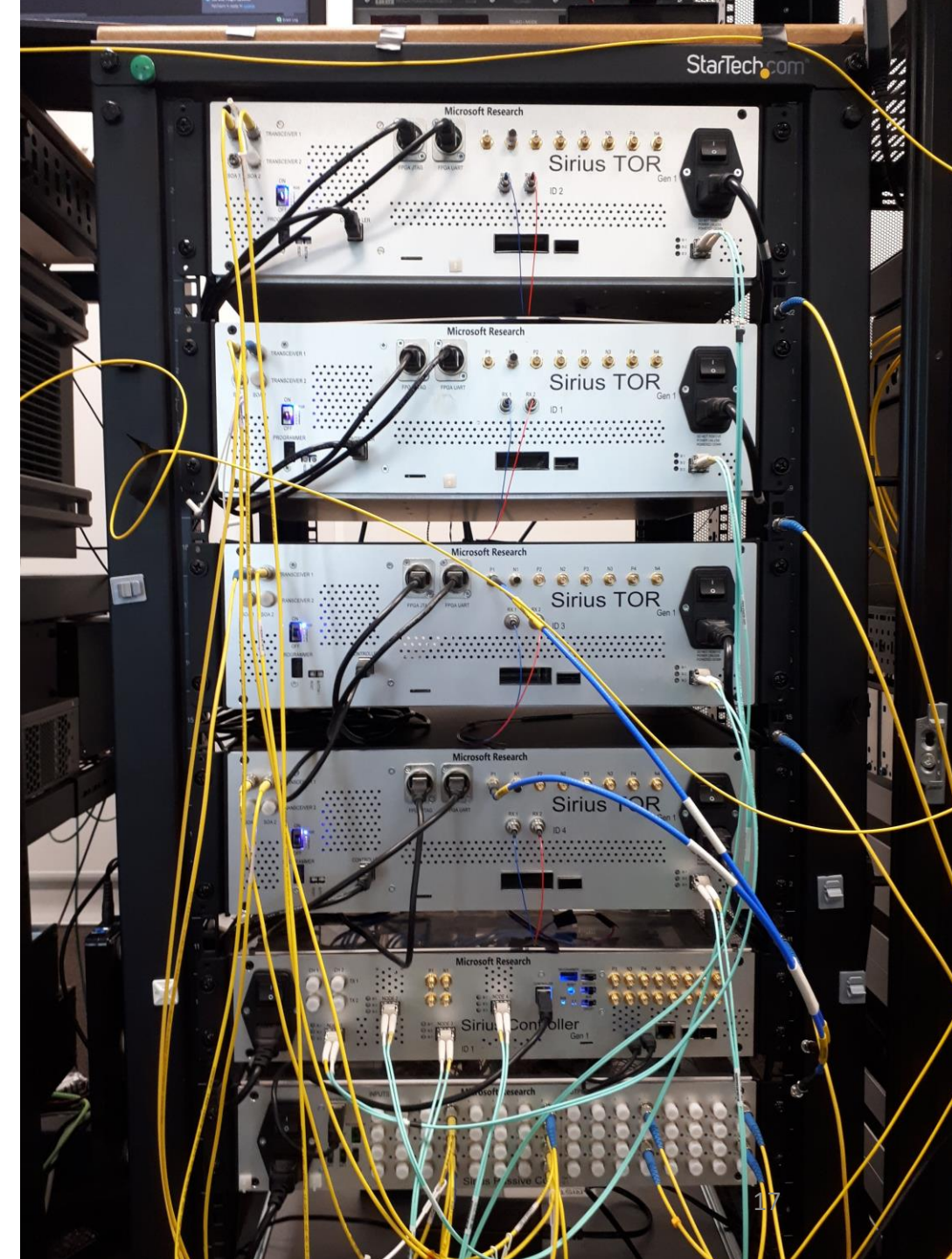
We need to consider the implications for the whole system

Optical Network Prototype

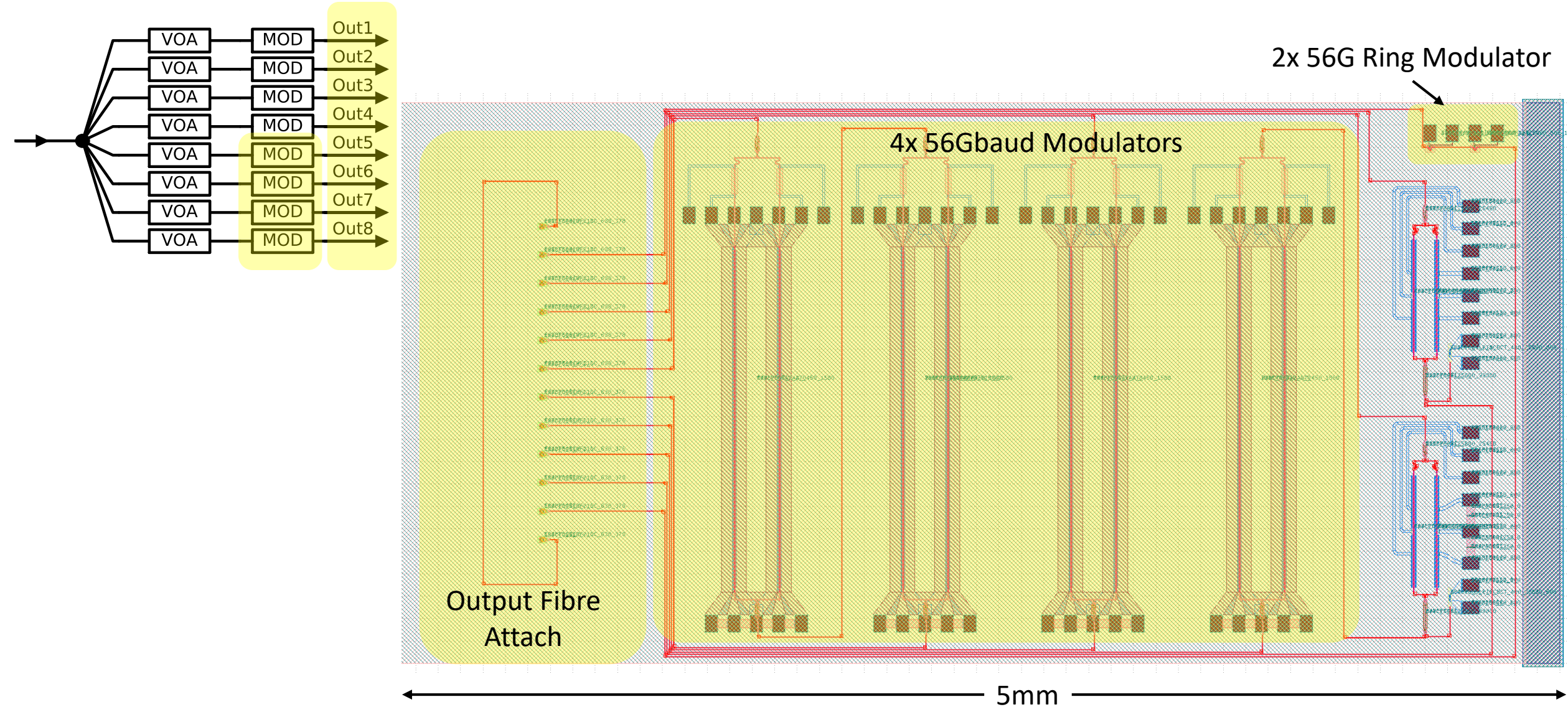


Nanosecond-granularity switching

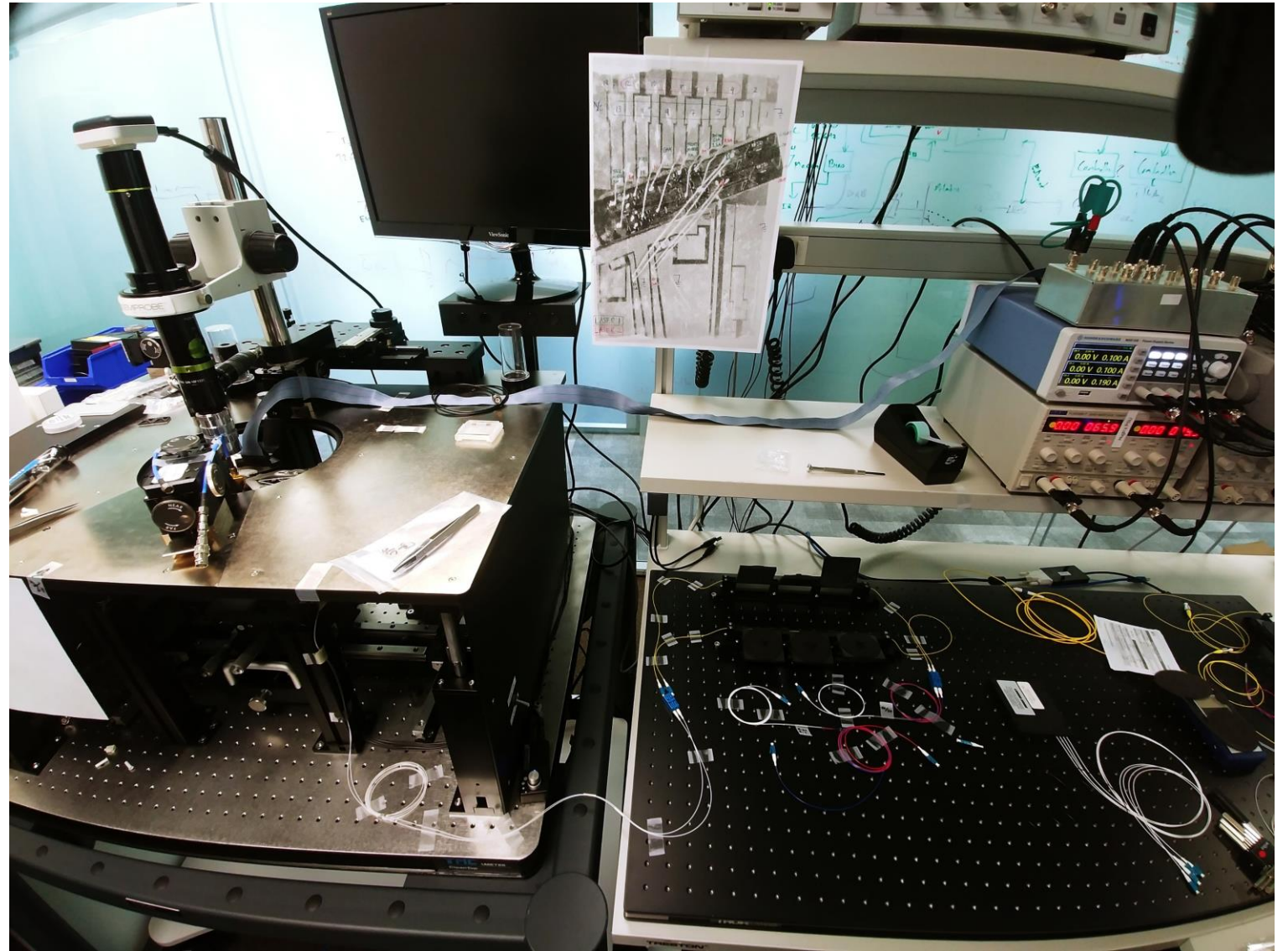
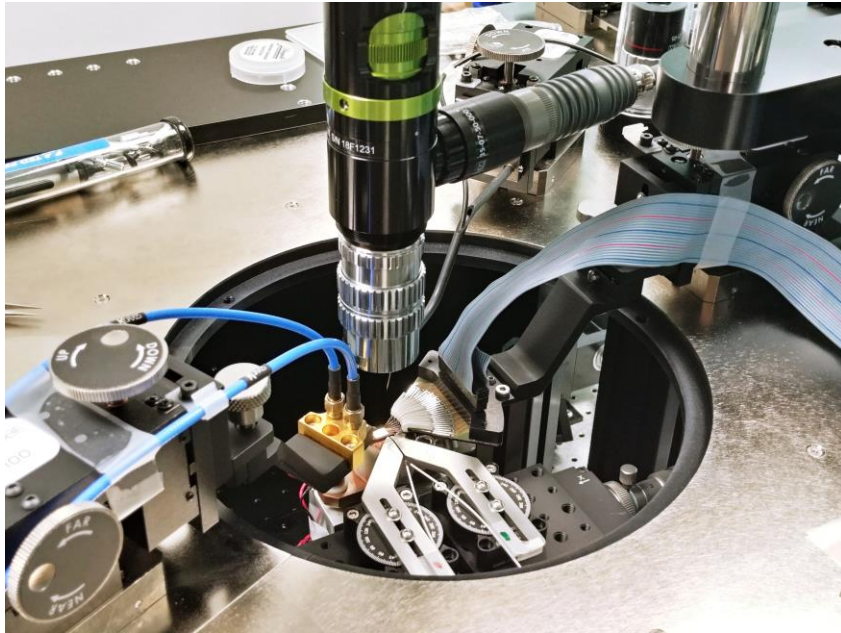
Long, long way to go!



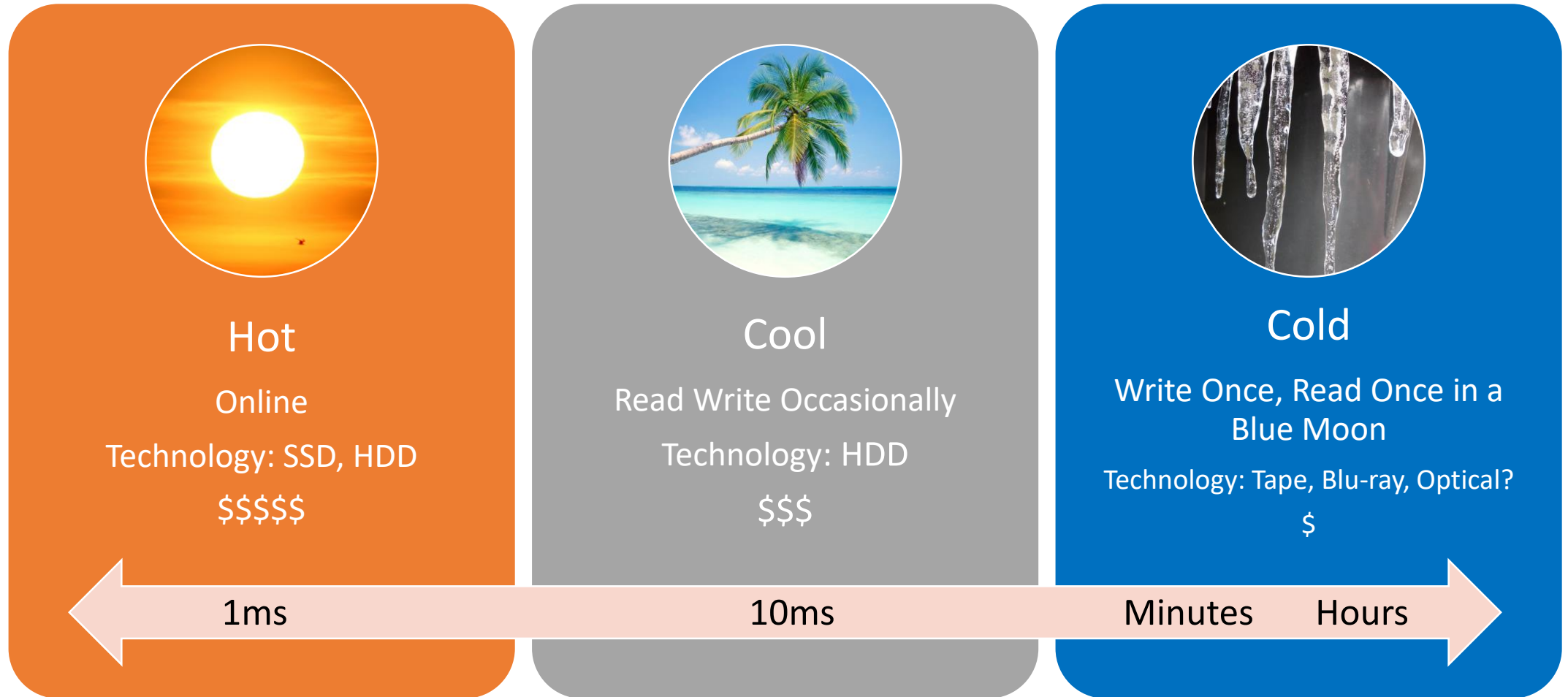
Integrated Photonics: 56 Gbaud Modulator Array



Chip testing

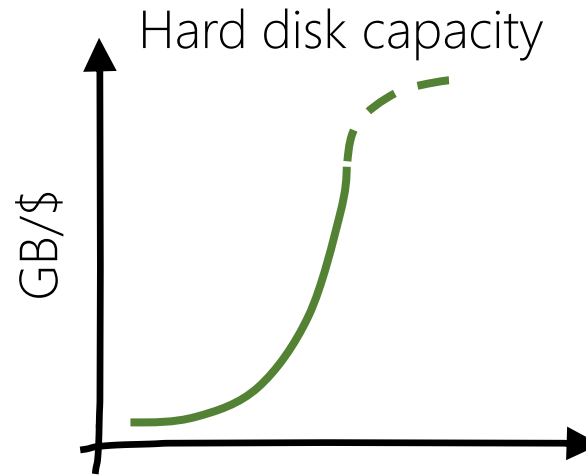


Storage



Today's cold storage

Hard disk drive



Tape



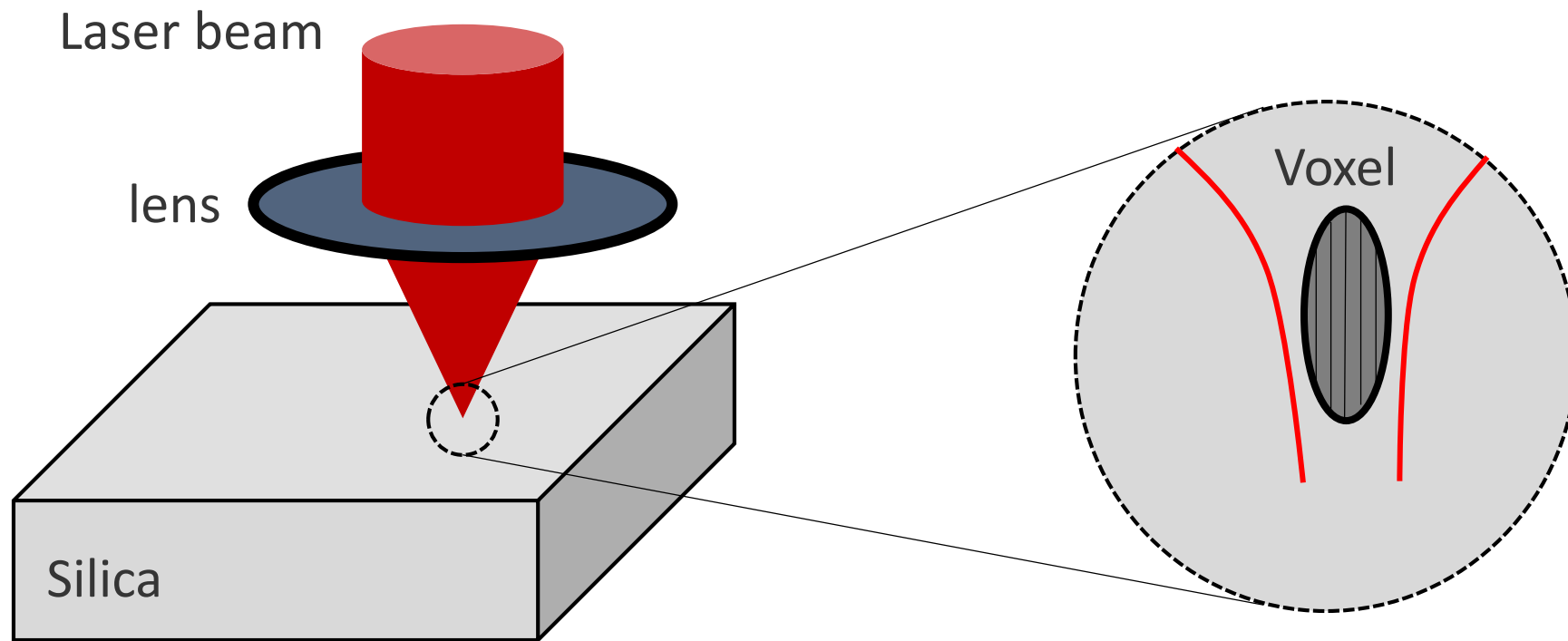
Credit: stock.adobe.com



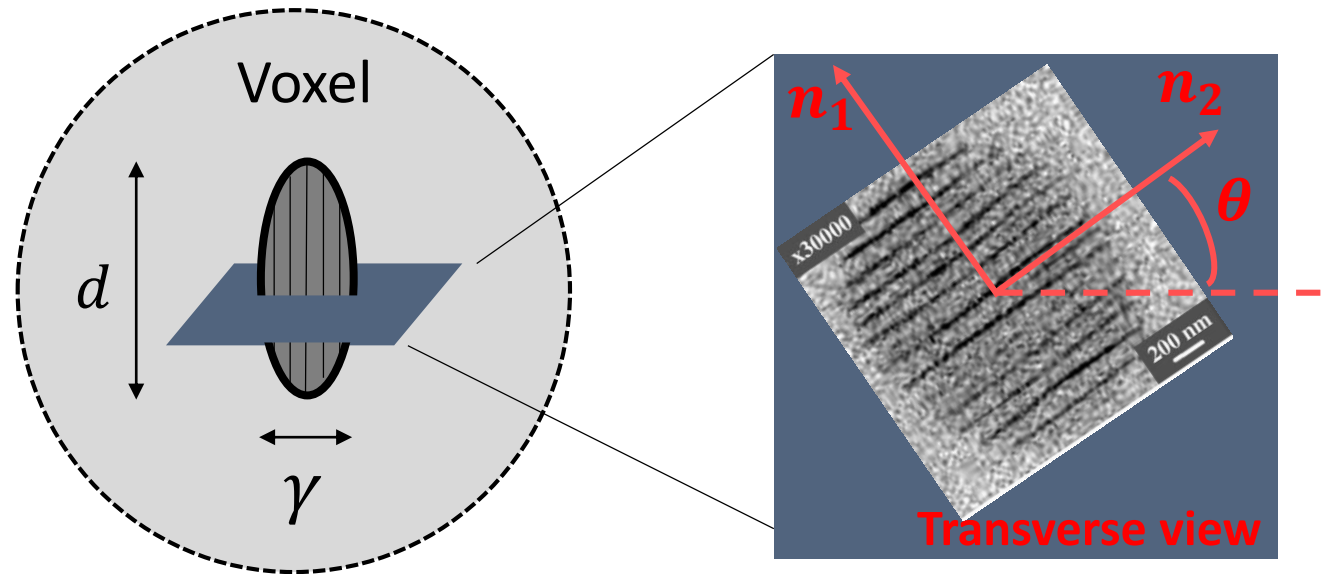
New storage media: Silica

Writing in Silica glass

100-300fs, 1 μ m pulses, 1-50nJ



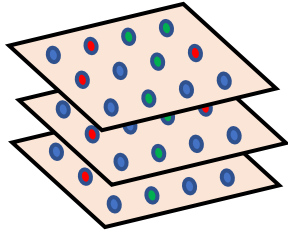
Voxel structure



- Approx. ellipsoidal shape, $\gamma \sim 1\mu m$, $d \sim 5\mu m$
- Volumetric nanograting
- Exhibits form birefringence
- Multi-level encoding using ***Ret*** and θ to store multiple bits per voxel

Voxel Writing

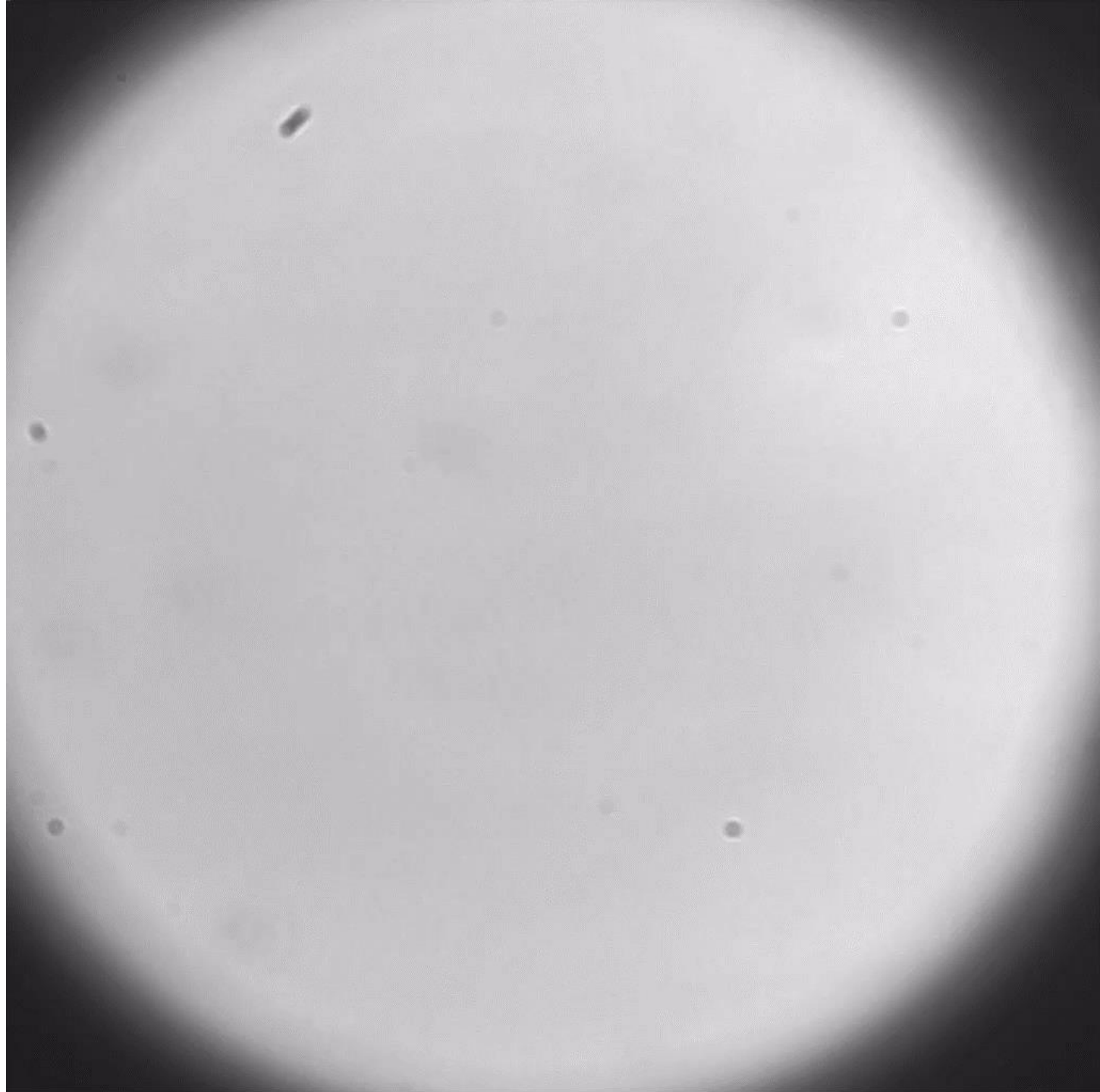
**Arrays
of voxels**



Information encoded by modulating
the intensity and polarisation of the
laser pulses

Challenge: Scaling write speed

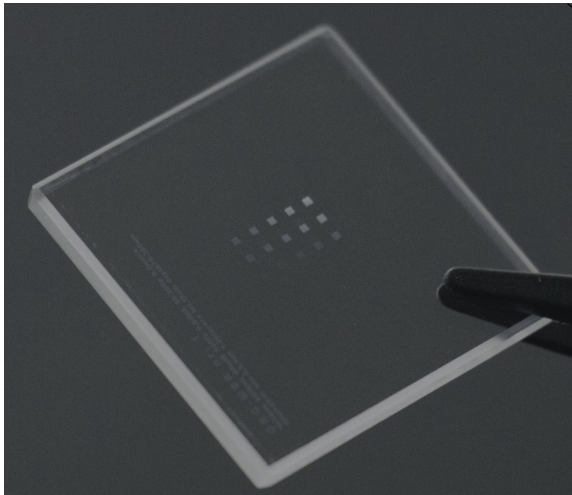
- Modulator bandwidth
- Parallelism



Reading from Silica glass

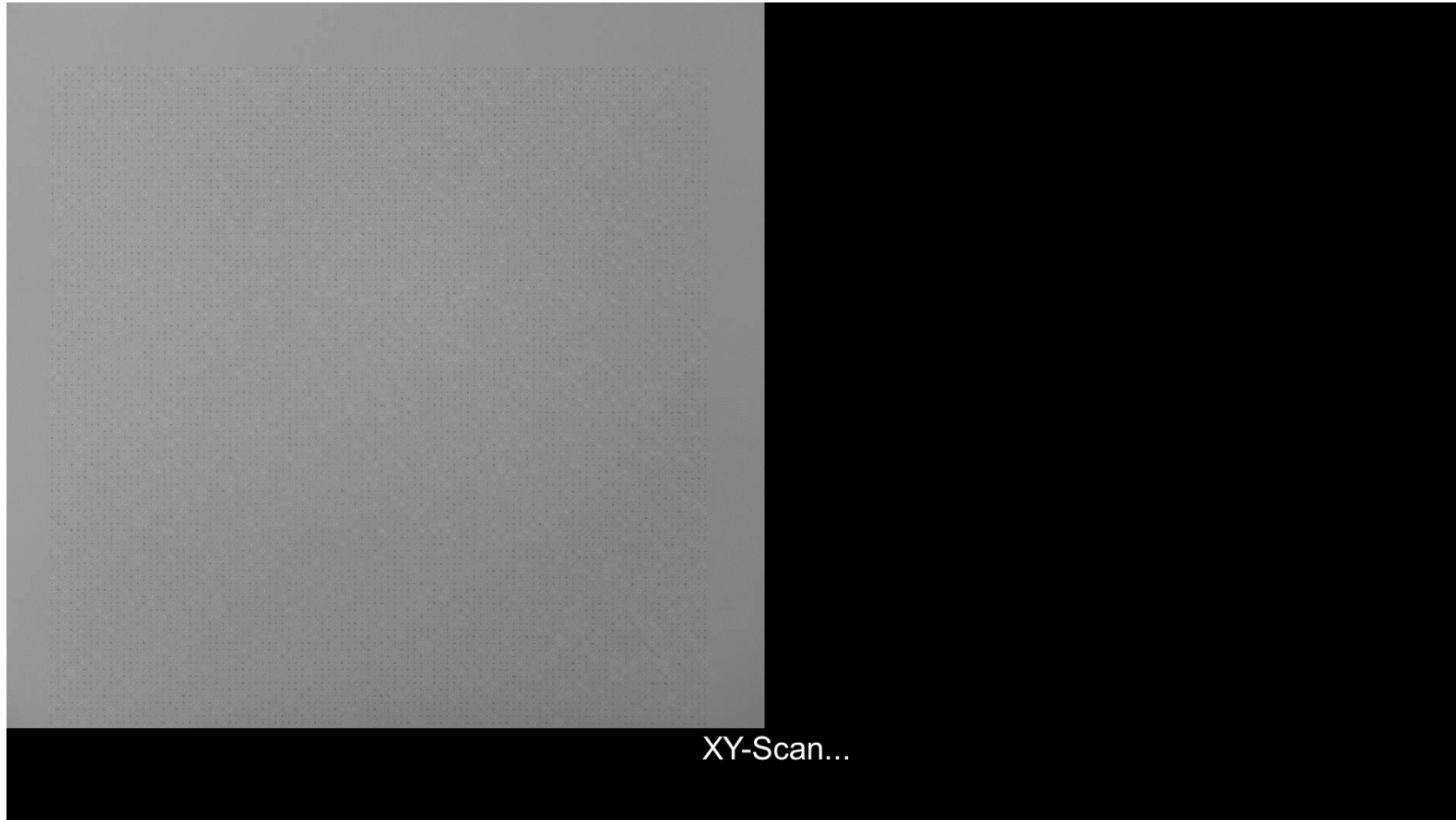
Optical microscopy:

Sample

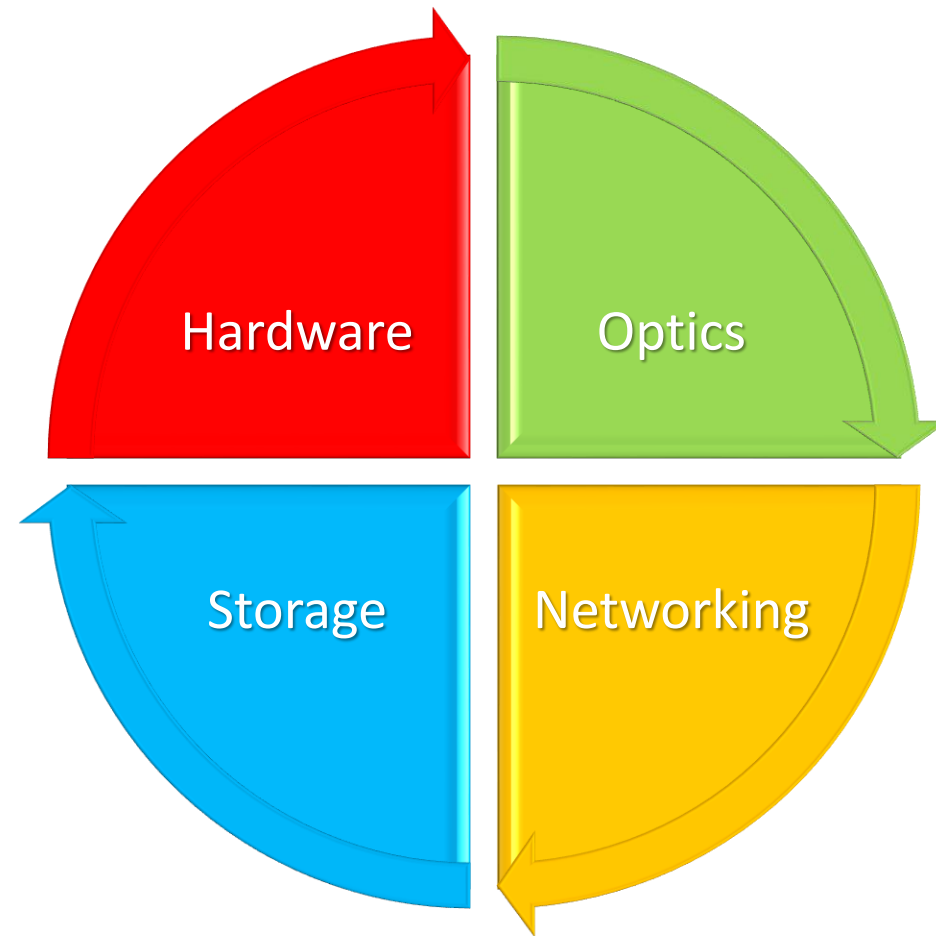


Exploit developments in
consumer cameras
e.g. Sony 16MPixel 1000fps

Voxel Reading Read demo



A big opportunity – cross-disciplinary approach



Optics for the Cloud

Application

New scenarios

Network

New
hardware/software

Storage

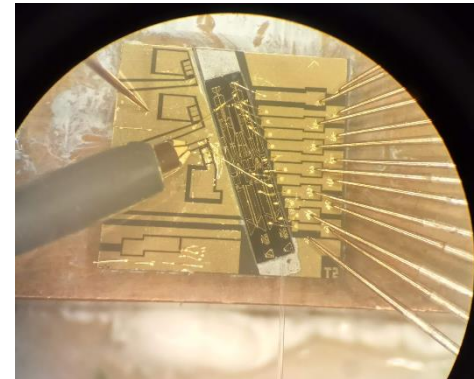
New Media

Physical

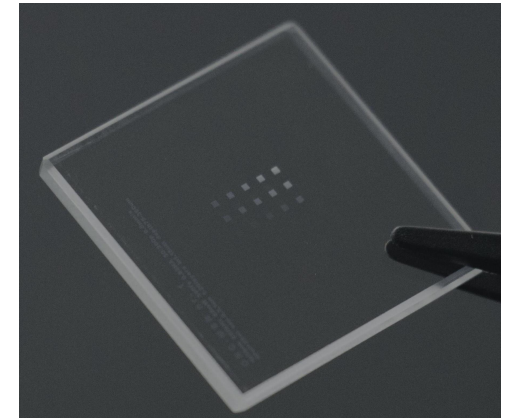
New optics



Prototype switch



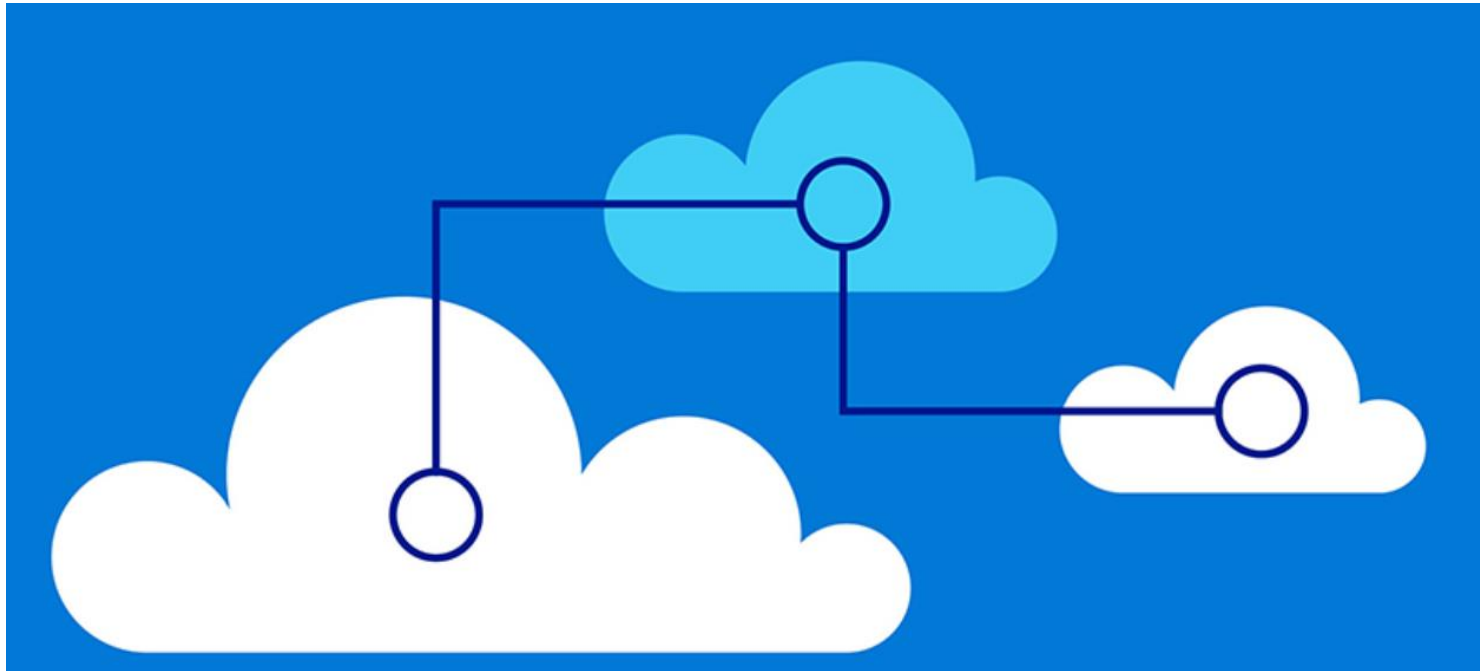
Custom PIC



Silica

Innovation across the cloud stack
At Microsoft and with collaborators

Want to know more



www.opticsforthecloud.com