

# Optical/Photonic Exchanges

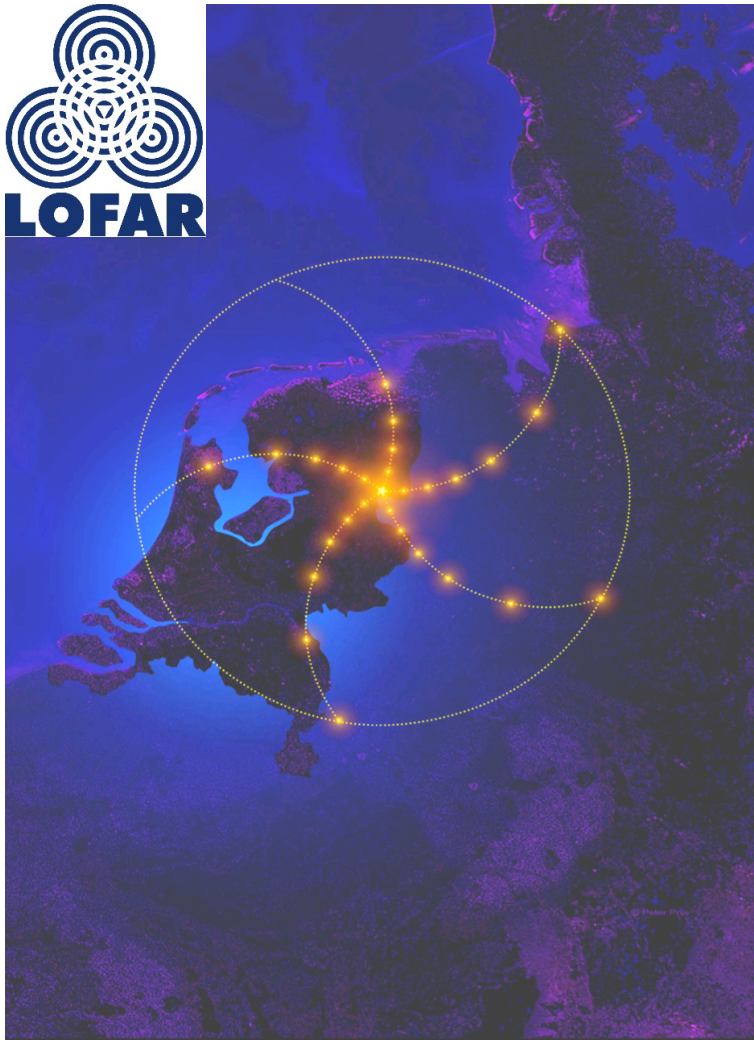
[www.science.uva.nl/~delaat](http://www.science.uva.nl/~delaat)

## Cees de Laat

University of Amsterdam



# Sensor Grids



~ 40 Tbit/s  
[www.lofar.org](http://www.lofar.org)

## eVLBI

longer term VLBI is easily capable of generating  
The sensitivity of the VLBI array scales with  
width (=data-rate) and there is a strong push to mo  
widths. Rates of 8Gb/s or more are entirely feasible.  
under development. It is expected that parallel  
ed correlator will remain the most efficient approach  
olves dist  
, multi-gig  
relator and  
g factor.

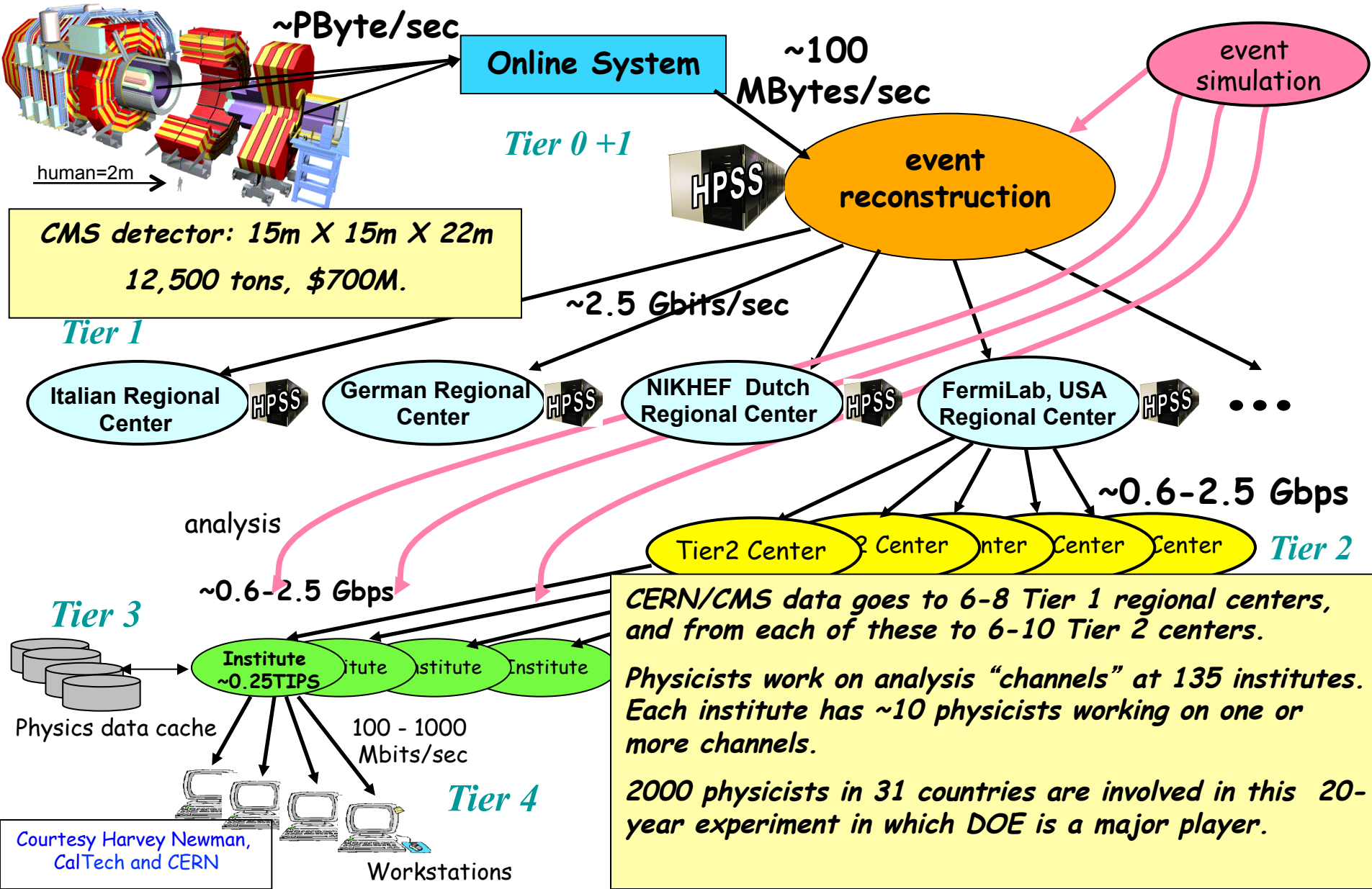
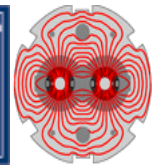


*Westerbork Synthesis Radio Telescope -  
Netherlands*



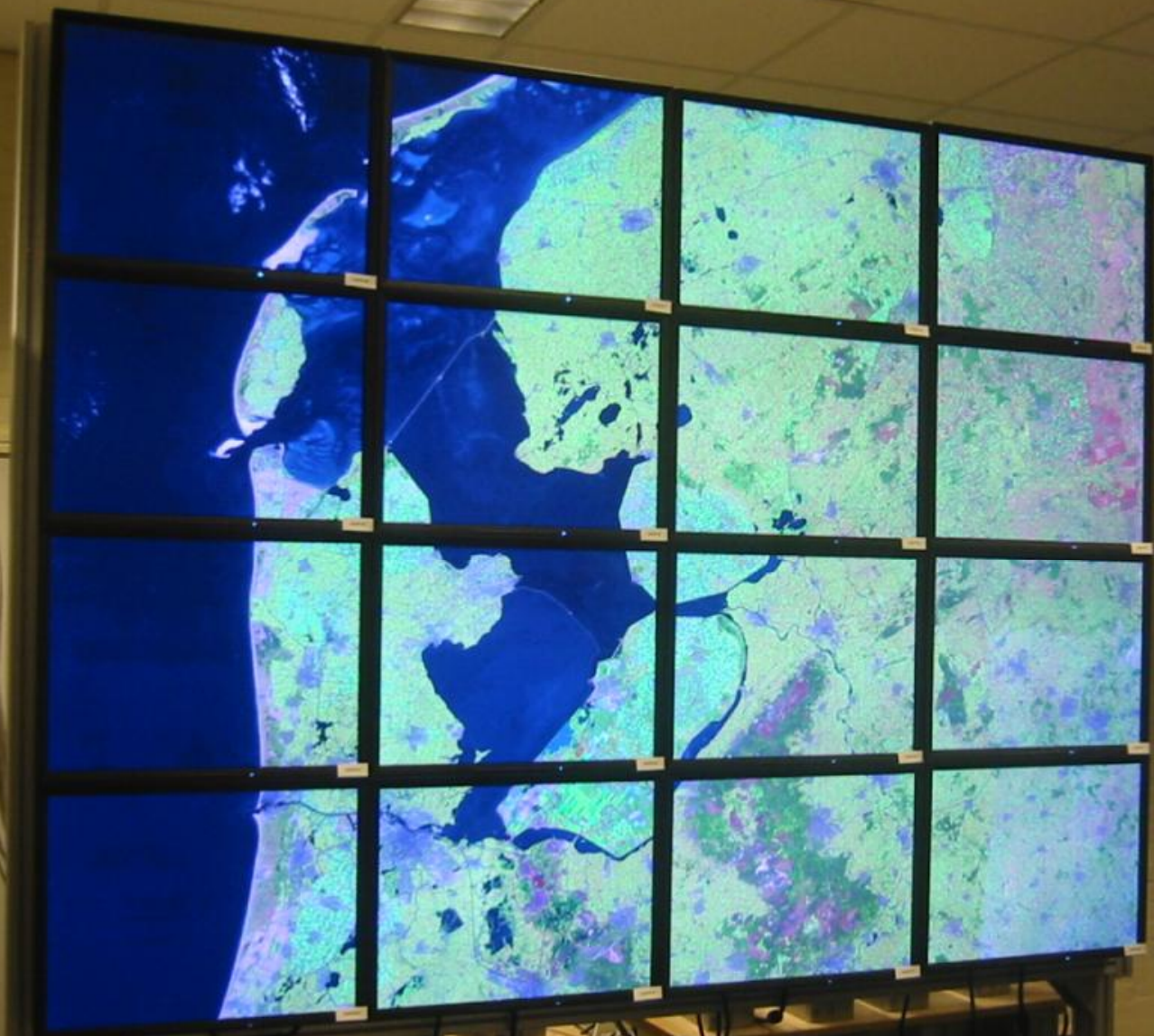
# LHC Data Grid Hierarchy

CMS as example, Atlas is similar



Courtesy Harvey Newman, CalTech and CERN





# users



**A. Lightweight users, browsing, mailing, home use**

**Need full Internet routing, one to many**

**B. Business applications, multicast, streaming, VPN's, mostly LAN**

**Need VPN services and full Internet routing, several to several + uplink**

**C. Scientific applications, distributed data processing, all sorts of grids**

**Need very fat pipes, limited multiple Virtual Organizations, few to few, p2p**

$\Sigma C \gg 100 \text{ Gb/s}$  →

$\Sigma B \approx 30 \text{ Gb/s}$

A →  $\Sigma A \approx 40 \text{ Gb/s}$

A

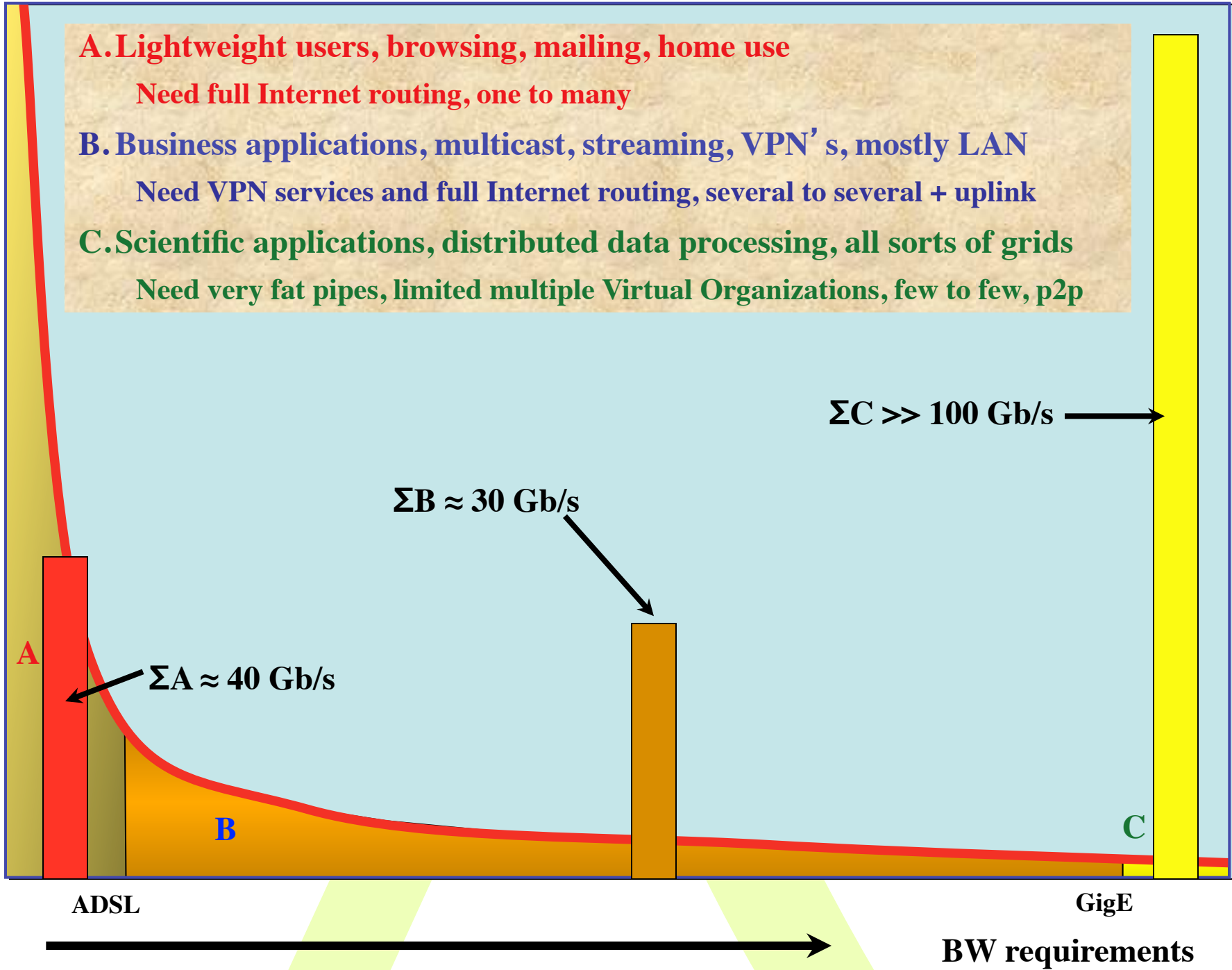
B

C

ADSL

GigE

→ BW requirements





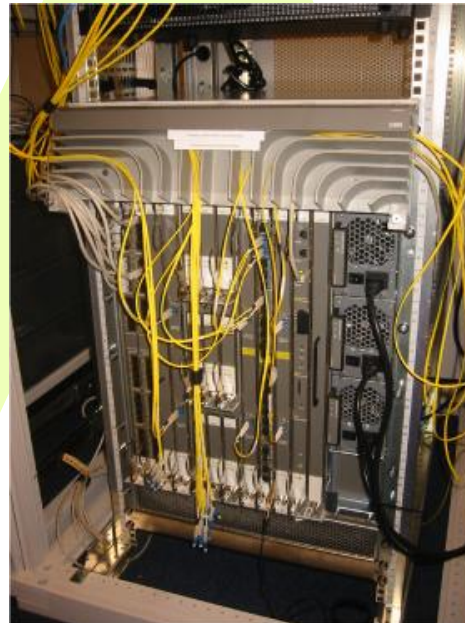
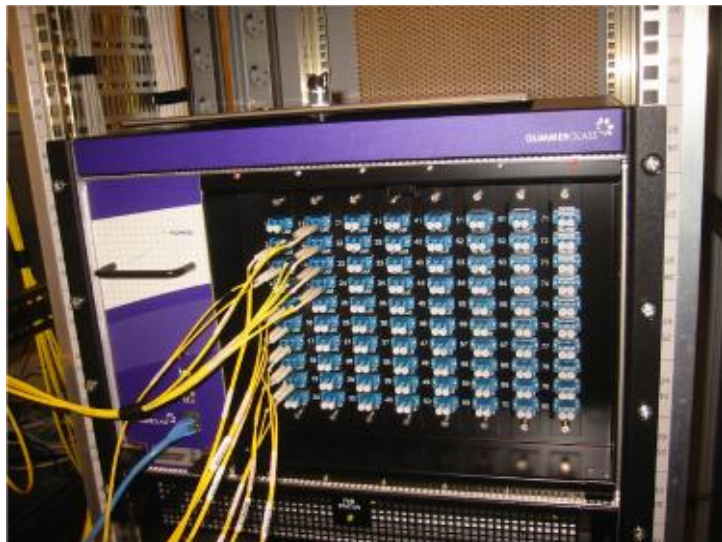
# Towards Hybrid Networking!

- Costs of optical equipment 10% of switching 10 % of full routing equipment for same throughput
  - 10G routerblade -> 75-300 k\$, 10G switch port -> 7-15 k\$, MEMS port -> 1 k\$
  - DWDM lasers for long reach expensive, 10-50 k\$
- Bottom line: look for a hybrid architecture which serves all classes in a cost effective way ==> map A -> L3 , B -> L2 , C -> L1
- Give each packet in the network the service it needs, but no more !

L1  $\approx$  1 k\$/port

L2  $\approx$  5-10 k\$/port

L3  $\approx$  75+ k\$/port



UVA's

64\*64

Optical Switch

@ LightHouse

**Costs 1/100th of  
a similar  
throughput router**

or

**1/10th of**

**a similar**

**throughput**

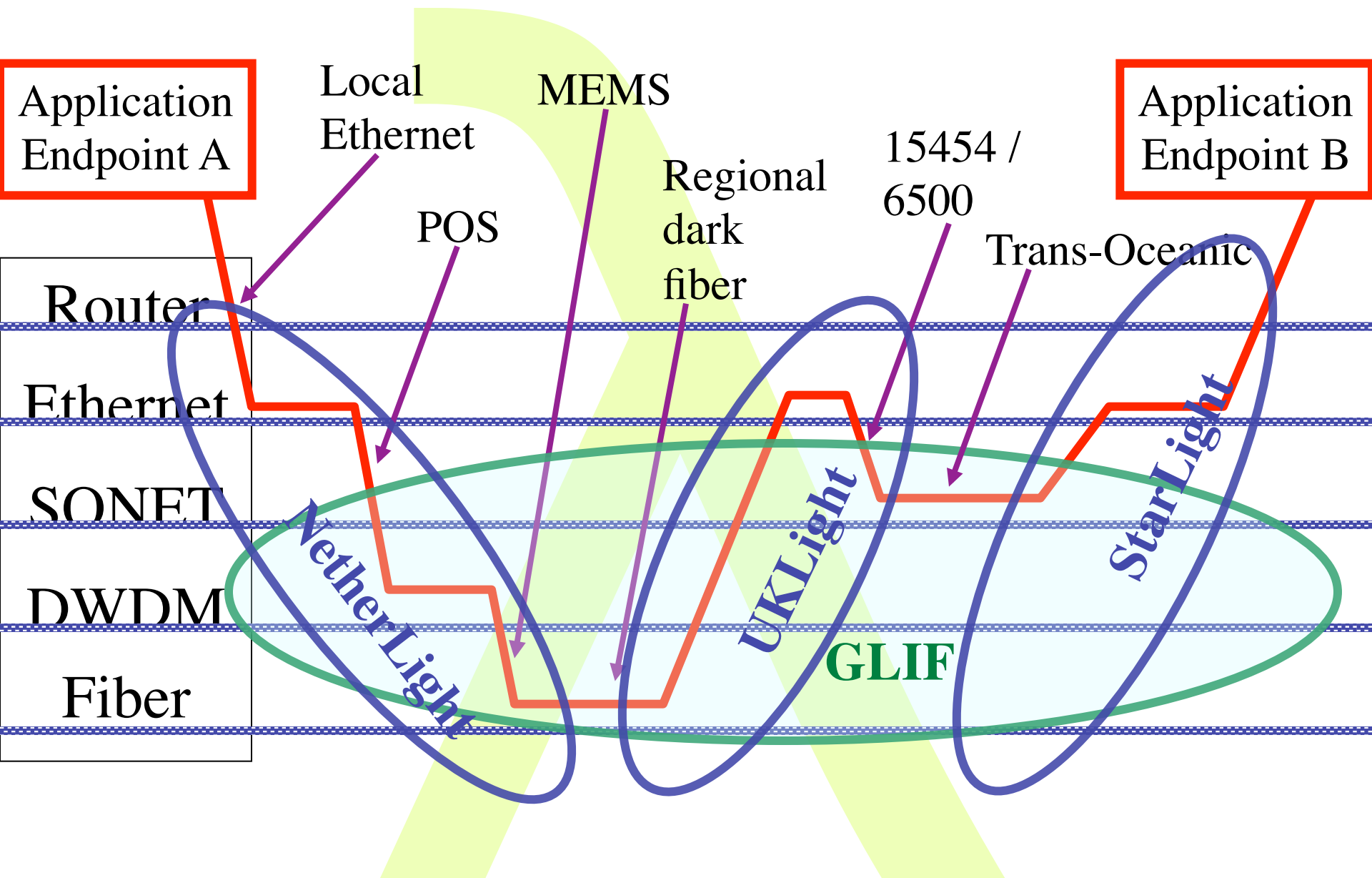
**Ethernet switch**

but has only

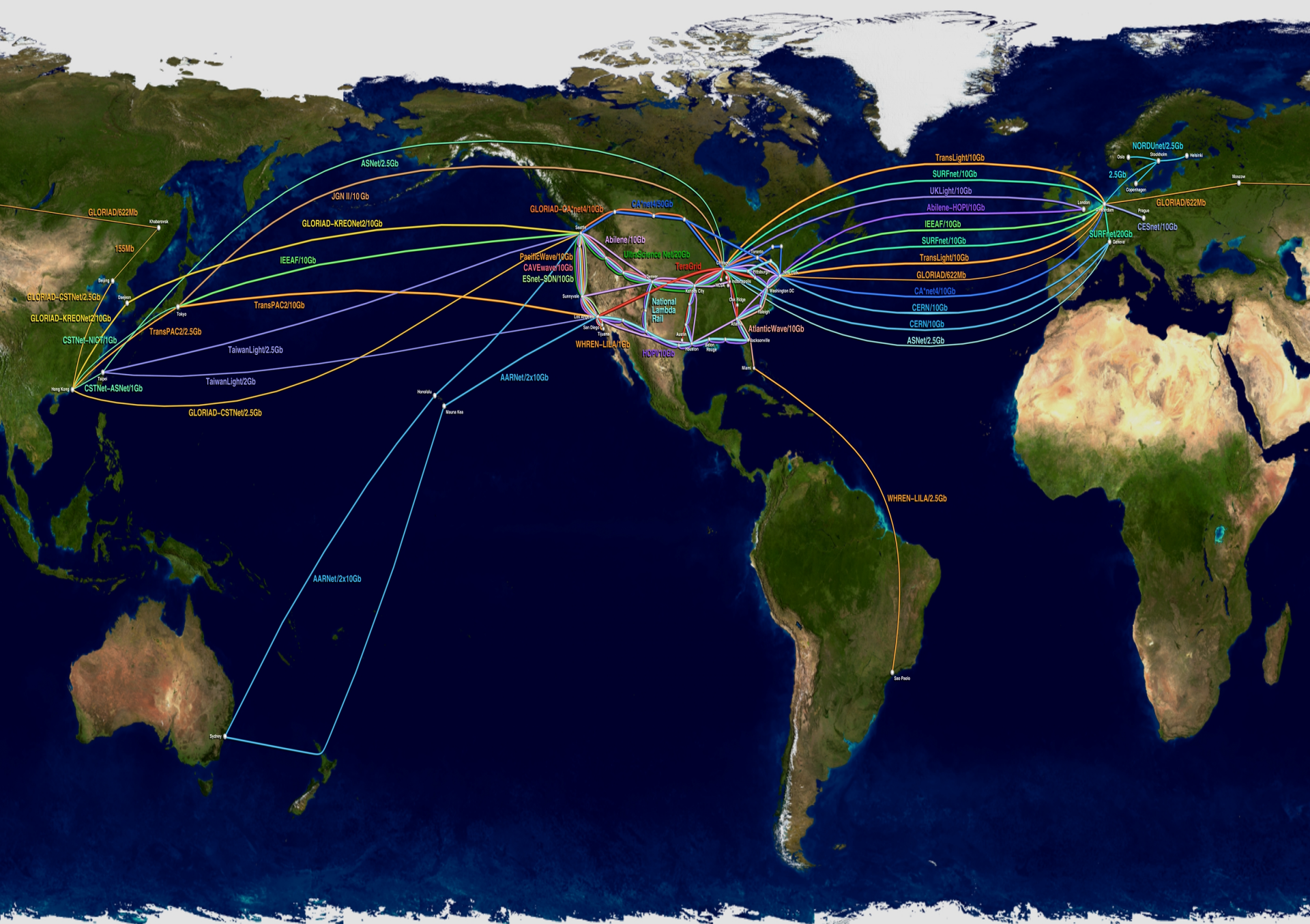
specific services!



# How low can you go?





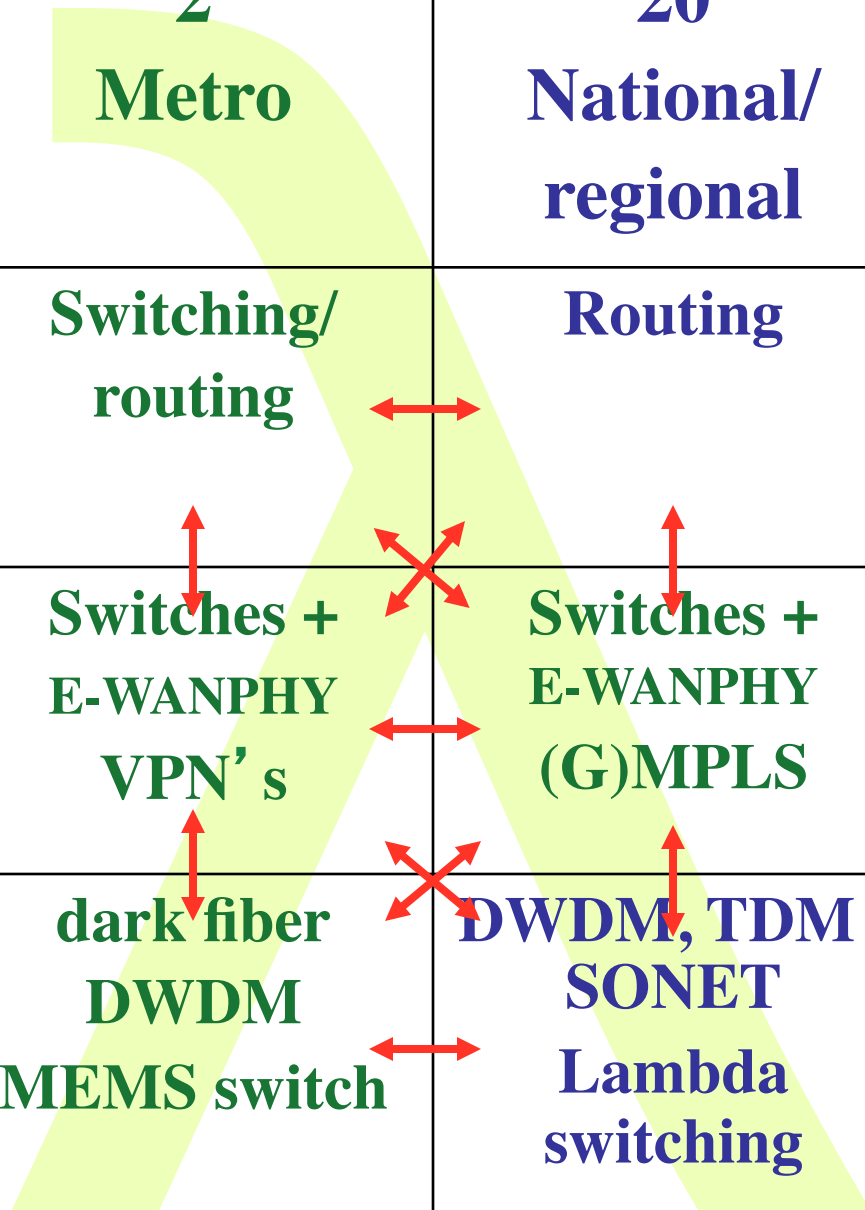


GLIF Q3 2005

Visualization courtesy of Bob Patterson, NCSA  
Data collection by Maxine Brown.

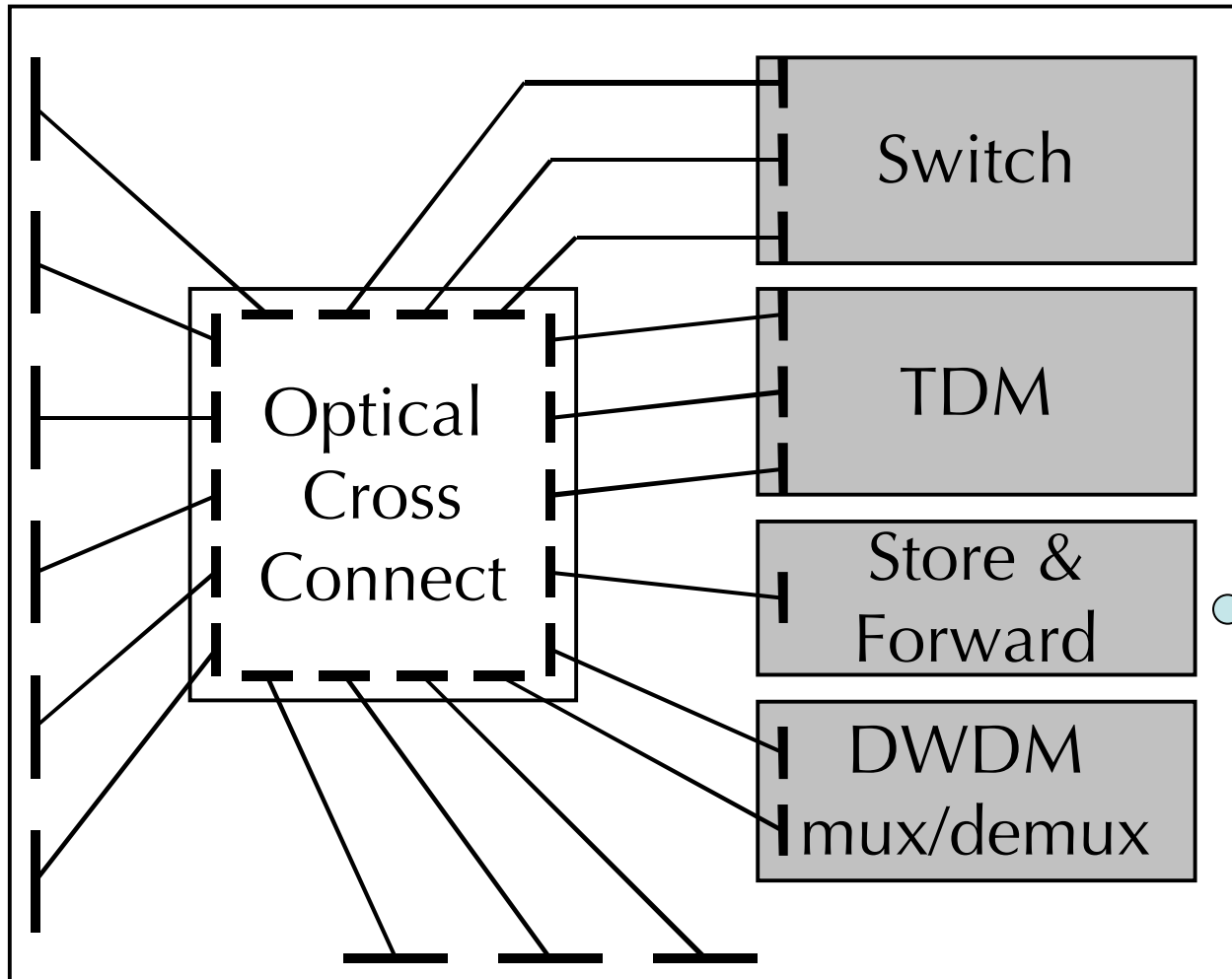
# Services

<div style="text-align: right;"><b>SCALE</b></div> <div style="text-align: left;"><b>CLASS</b></div>	<b>2</b> <b>Metro</b>	<b>20</b> <b>National/ regional</b>	<b>200</b> <b>World</b>
<b>A</b>	<b>Switching/ routing</b>	<b>Routing</b>	<b>ROUTER\$</b>
<b>B</b>	<b>Switches + E-WANPHY VPN's</b>	<b>Switches + E-WANPHY (G)MPLS</b>	<b>ROUTER\$</b>
<b>C</b>	<b>dark fiber DWDM MEMS switch</b>	<b>DWDM, TDM / SONET Lambda switching</b>	<b>Lambdas, VLAN's SONET Ethernet</b>



# Optical Exchange as Black Box

## Optical Exchange

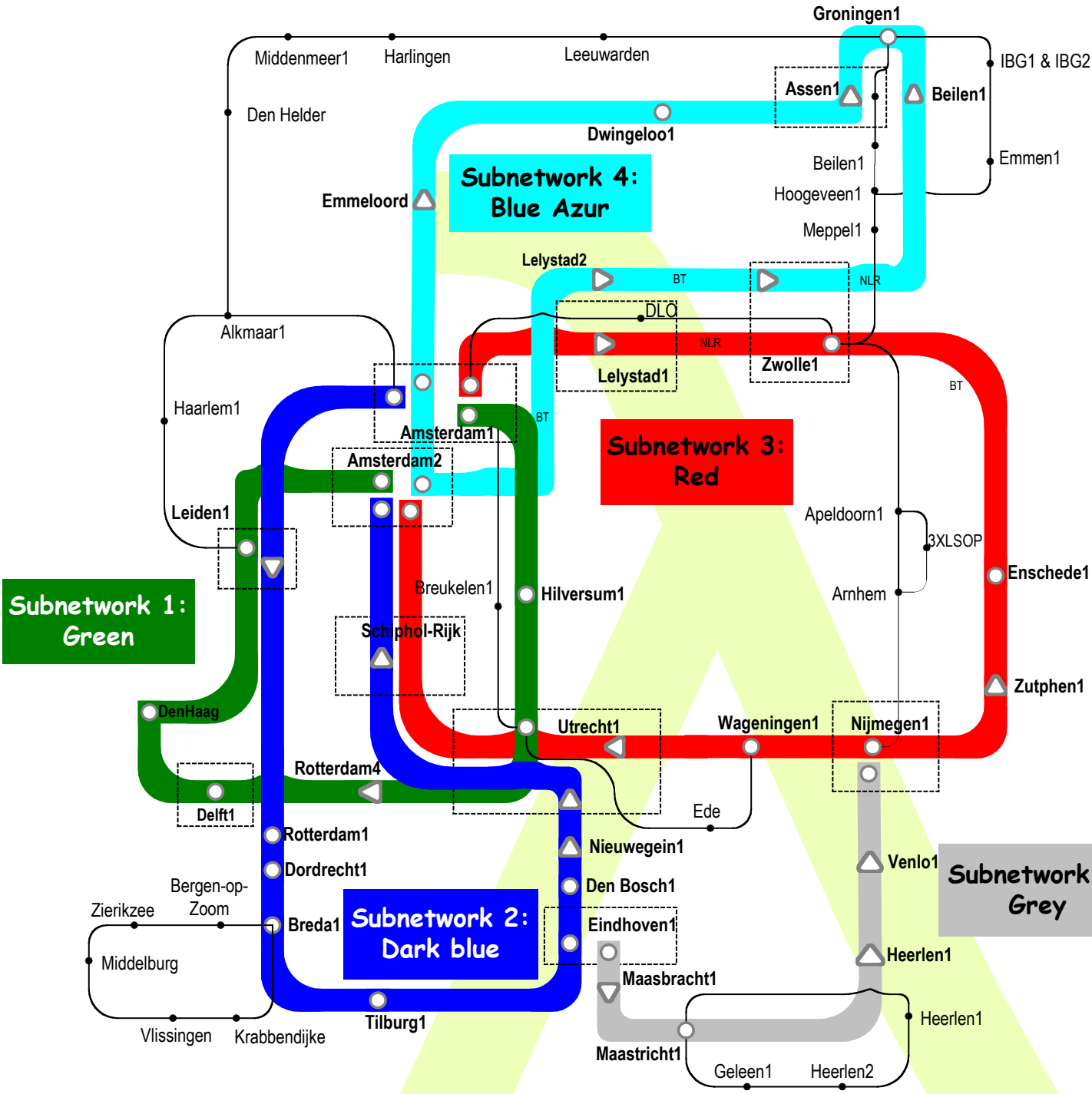


TeraByte  
Email  
Service

# Service Matrix

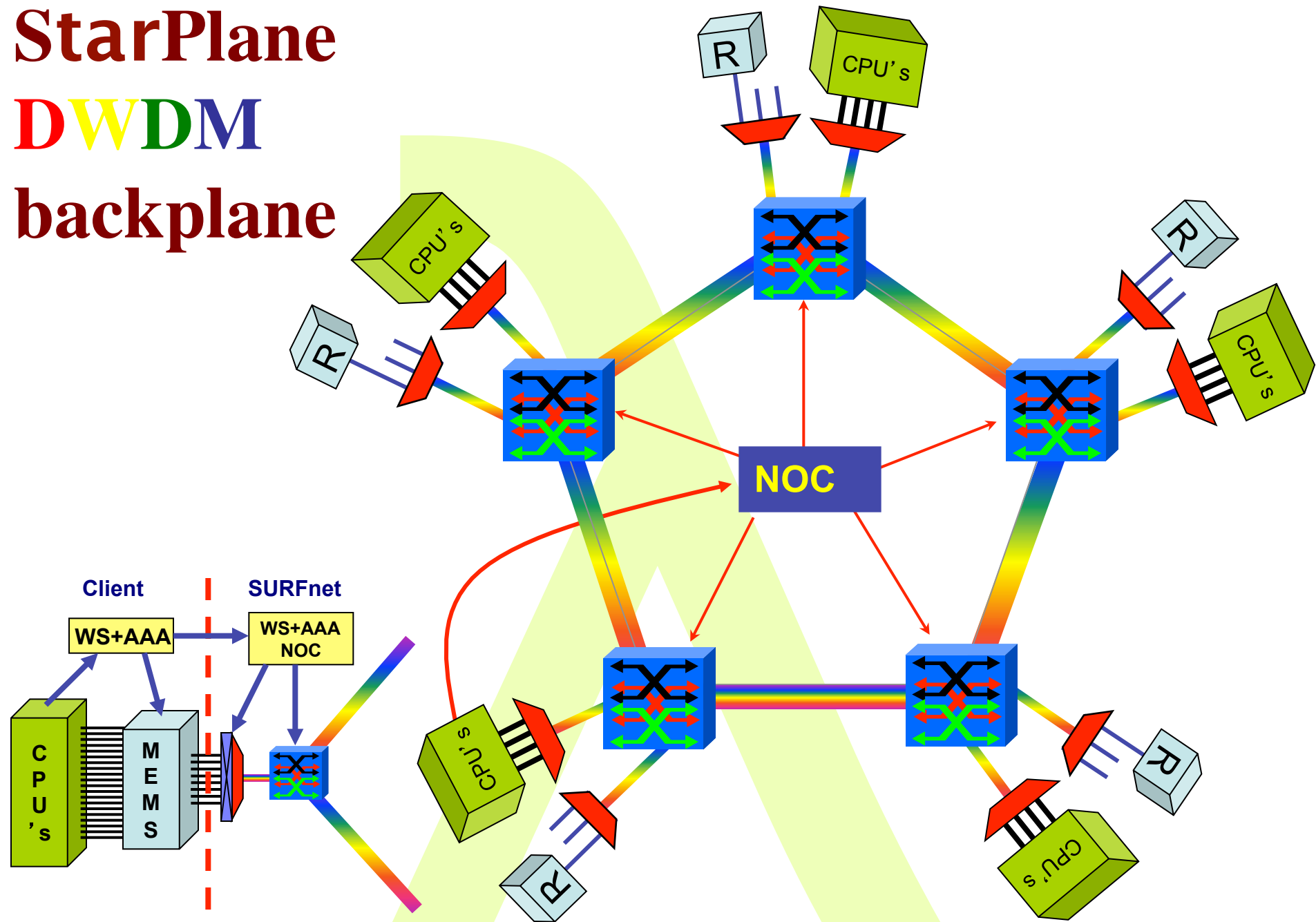
<b>From</b>	<b>To</b>	<b>WDM (multiple <math>\lambda</math>)</b>	<b>Single <math>\lambda</math>, any bitstream</b>	<b>SONET/ SDH</b>	<b>1 Gb/s Ethernet</b>	<b>LAN PHY Ethernet</b>	<b>WAN PHY Ethernet</b>	<b>VLAN tagged Ethernet</b>	<b>IP over Ethernet</b>
<b>WDM (multiple <math>\lambda</math>)</b>	cross-connect multicast, regenerate, multicast	WDM demux	WDM demux*	WDM demux*	WDM demux*	WDM demux*	WDM demux*	WDM demux*	WDM demux*
<b>Single <math>\lambda</math>, any bitstream</b>	WDM mux	cross-connect multicast, regenerate, multicast	N/A *	N/A *	N/A *	N/A *	N/A *	N/A *	N/A *
<b>SONET/SDH</b>	WDM mux	N/A *	SONET switch, +	TDM demux*	TDM demux <sup>6</sup>	SONET switch	TDM demux*	TDM demux*	
<b>1 Gb/s Ethernet</b>	WDM mux	N/A *	TDM mux	aggregate, Ethernet conversion +	aggregate, eth. convert	aggregate, Ethernet conversion	aggregate, VLAN encap	L3 entry *	
<b>LAN PHY Ethernet</b>	WDM mux	N/A*	TDM mux <sup>6</sup>	aggregate, Ethernet conversion	aggregate, Ethernet conversion +	Ethernet conversion	aggregate, VLAN encap	L3 entry *	
<b>WAN PHY Ethernet</b>	WDM mux	N/A *	SONET switch	aggregate, Ethernet conversion	Ethernet conversion	aggregate, Ethernet conversion +	aggregate, VLAN encap	L3 entry *	
<b>VLAN tagged Ethernet</b>	WDM mux	N/A *	TDM mux	aggregate, VLAN decap	aggregate, VLAN decap	aggregate, VLAN decap	Aggregate, VLAN decap & encap +	N/A	
<b>IP over Ethernet</b>	WDM mux	N/A *	TDM mux	L3 exit *	L3 exit *	L3 exit *	N/A	Store & forward, L3 entry/exit+	





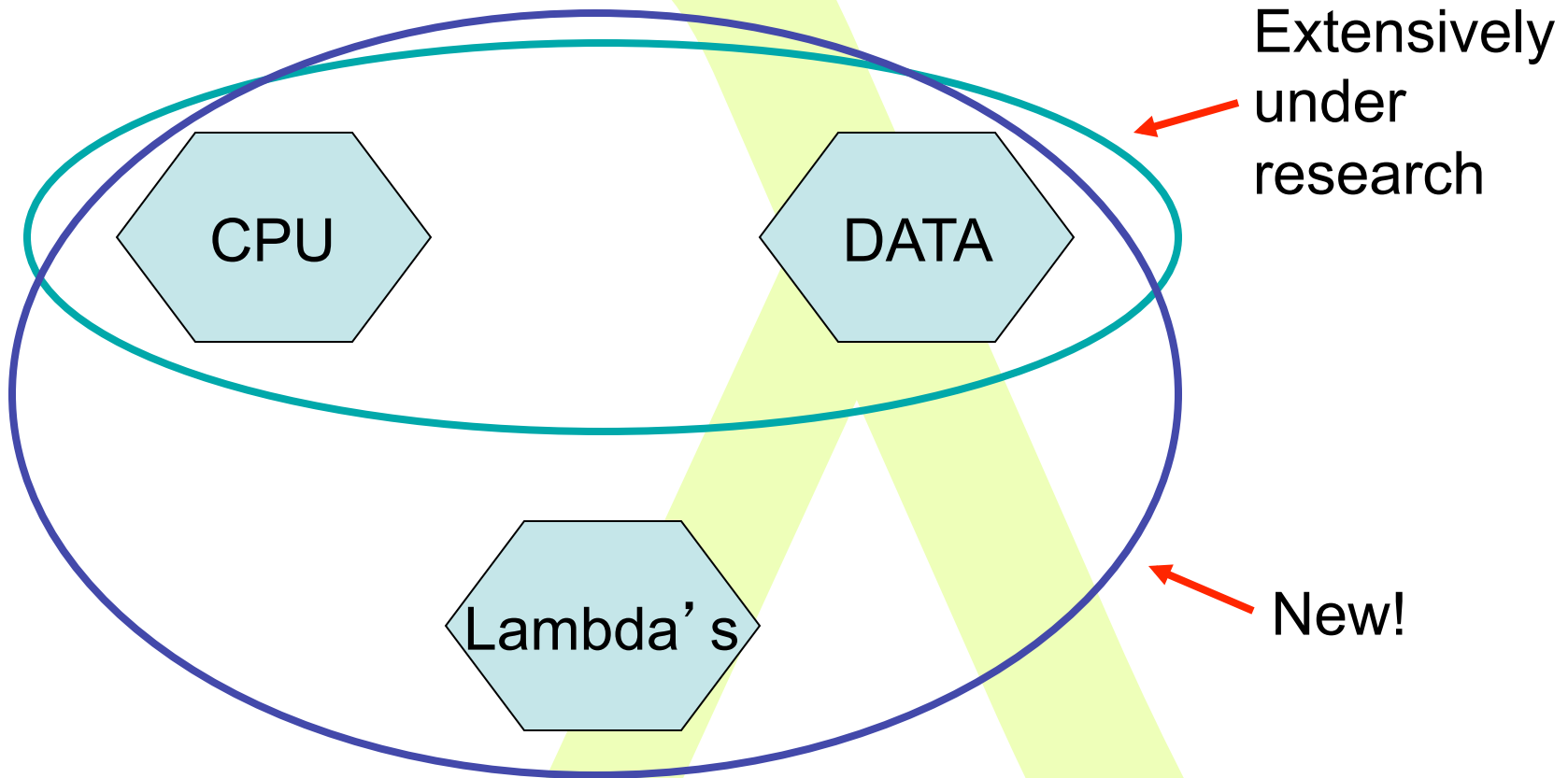
# Common Photonic Layer (CPL) in SURFnet6

# StarPlane DWDM backplane



Disclaimer: final architecture and choice of equipment will be different, this is a schematic picture!

# GRID-Colocation problem space



# Transport of flows

