Optical/Photonic Exchanges

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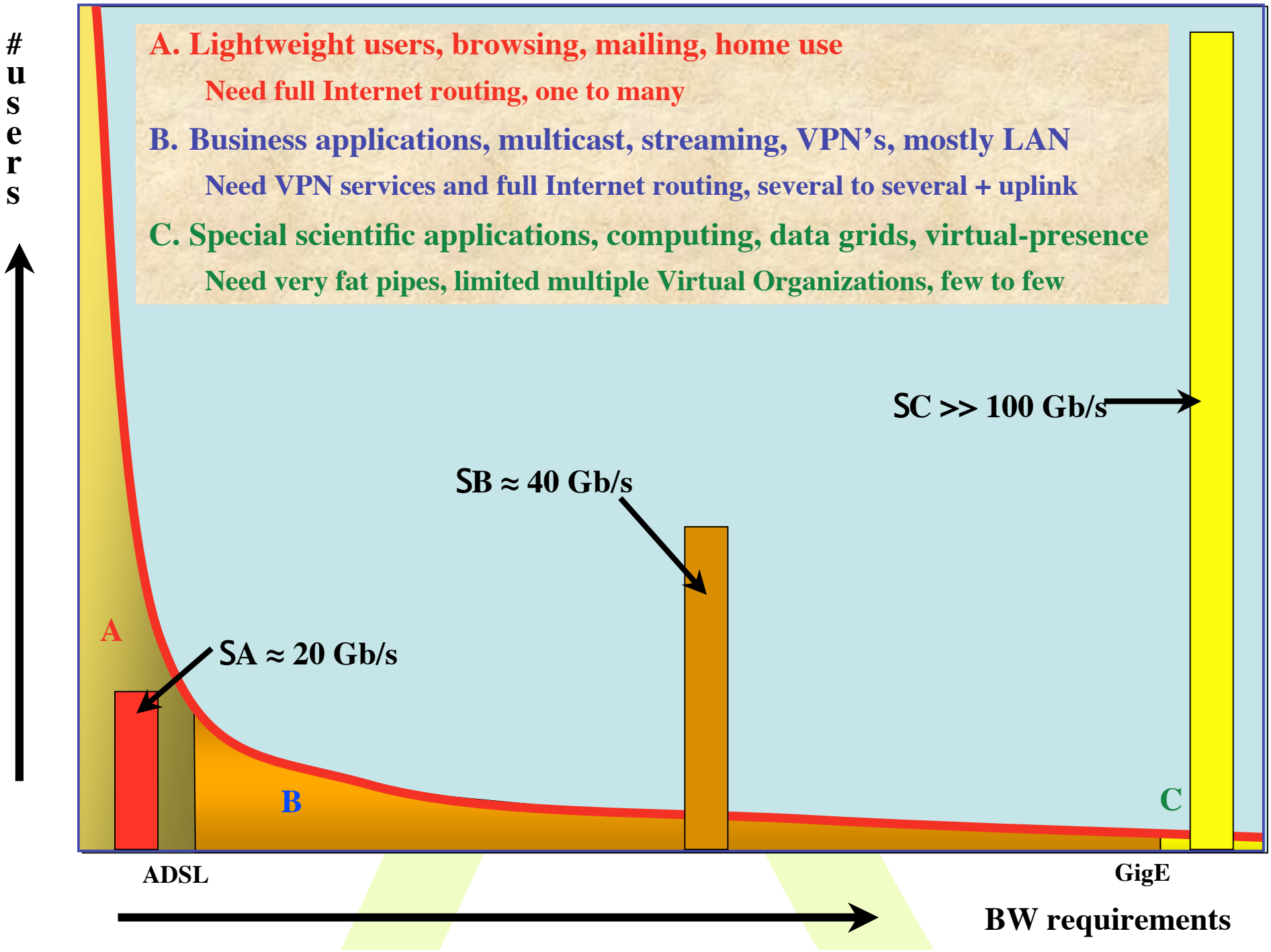
http://www.science.uva.nl/~delaat/articles/2004-2-opt-ex.pdf

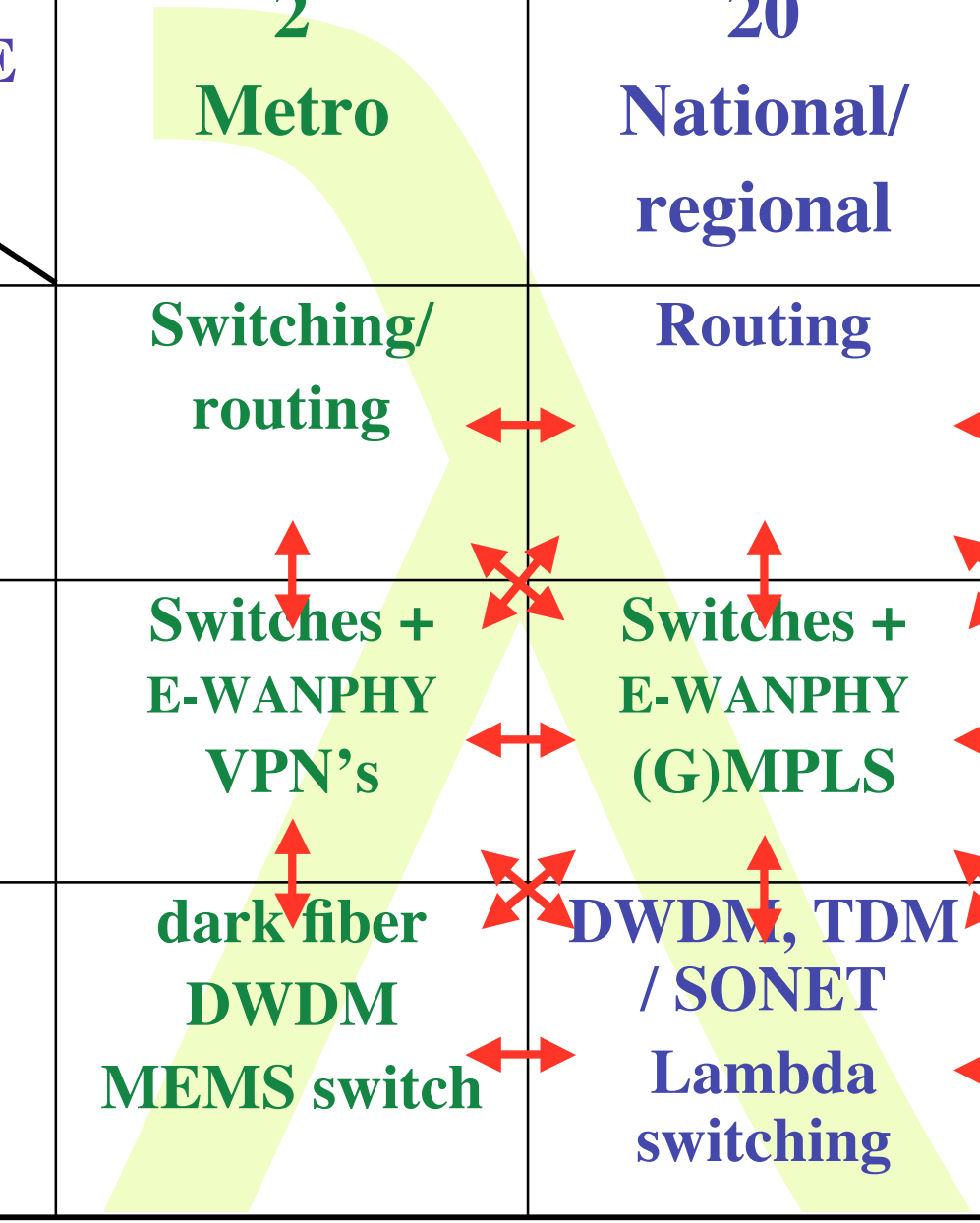
Exchanges

- Just fibers
  - Each provider has fibers to the other providers [n*(n-1)]
- ATM based
  - Through one connection ATM pvc's to all peers [n*(n-1)] constrained
  - StarTap
- Ethernet based
  - Ethernet switch as packet peering point (extended) [n] differently flexibly constrained
  - AMS-IX
- Lambda based
  - MEMS, DWDM, SONET (pseudo optical;-), Ethernet, etc. mix
  - NetherLight++, StarLight++


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. Special scientific applications, computing, data grids, virtual-presence
Need very fat pipes, limited multiple Virtual Organizations, few to few
users
SC >> 100 Gb/s
SB ≈ 40 Gb/s
SA ≈ 20 Gb/s
A
B
C
ADSL
GigE
BW requirements

Services

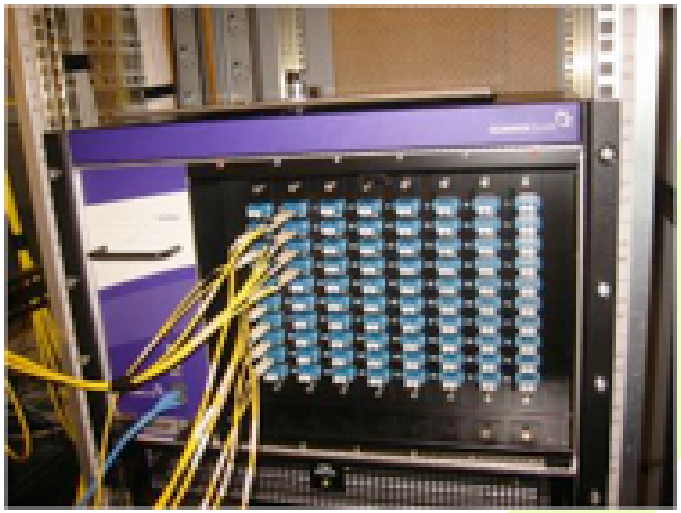
SCALE / CLASS	2 Metro	20 National/ regional	200 World
A	Switching/ routing	Routing	ROUTER$
B	Switches + E-WANPHY VPN's	Switches + E-WANPHY (G)MPLS	ROUTER$
C	dark fiber DWDM MEMS switch	DWDM, TDM / SONET Lambda switching	Lambdas, VLAN's SONET Ethernet



So what?

- **Costs of optical equipment 10% of switching 10 % of full routing equipment for same throughput**
  - **10G routerblade -> 100-300 k$, 10G switch port -> 10-20 k$, MEMS port -> 0.7 k$**
  - **DWDM lasers for long reach expensive, 10-50k$ (???)**
- **Bottom line: look for a hybrid architecture which serves all classes in a cost effective way (A -> L3 , B -> L2 , C -> L1)**
- **Give each packet in the network the service it needs, but no more**

L1 - 0.7 k$/port



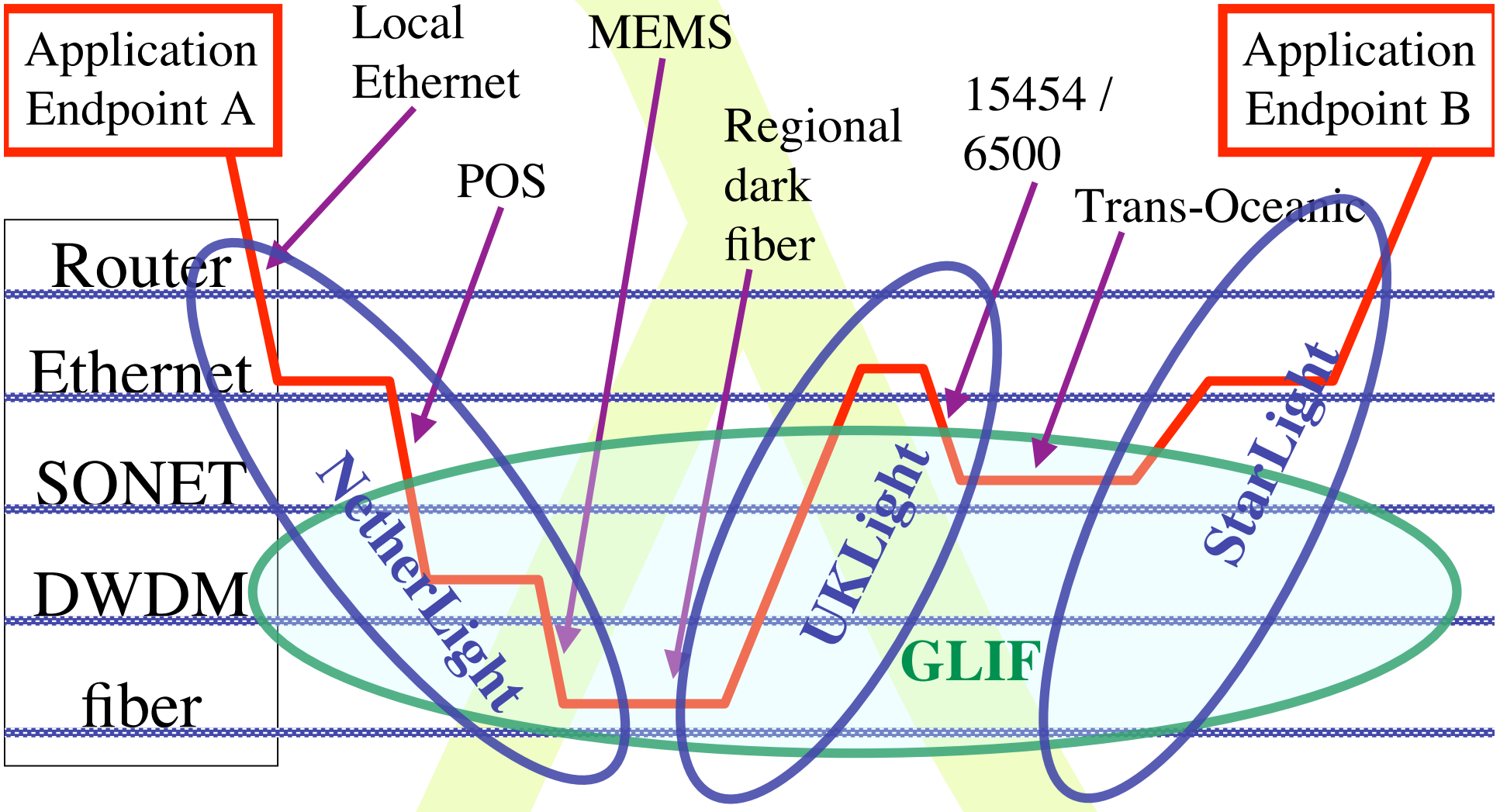
L2 - 10-20 k$/port

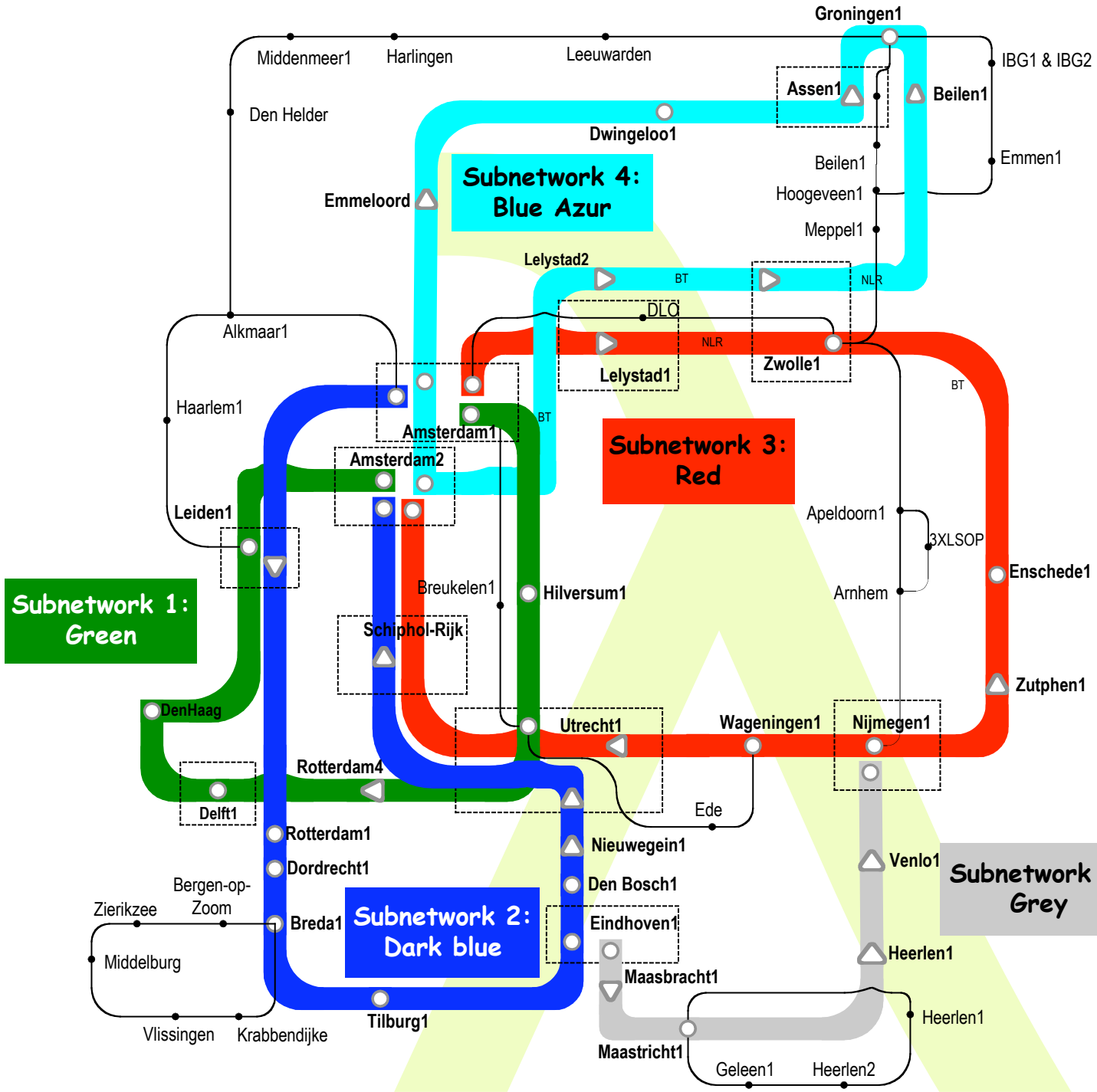
L3 - 100-300 k$/port

UVA/EVL's
64*64
Optical Switch
@ NetherLight
in SURFnet POP @
SARA

Costs 1/100th of a similar throughput router or 1/10th of an Ethernet switch but with specific services!

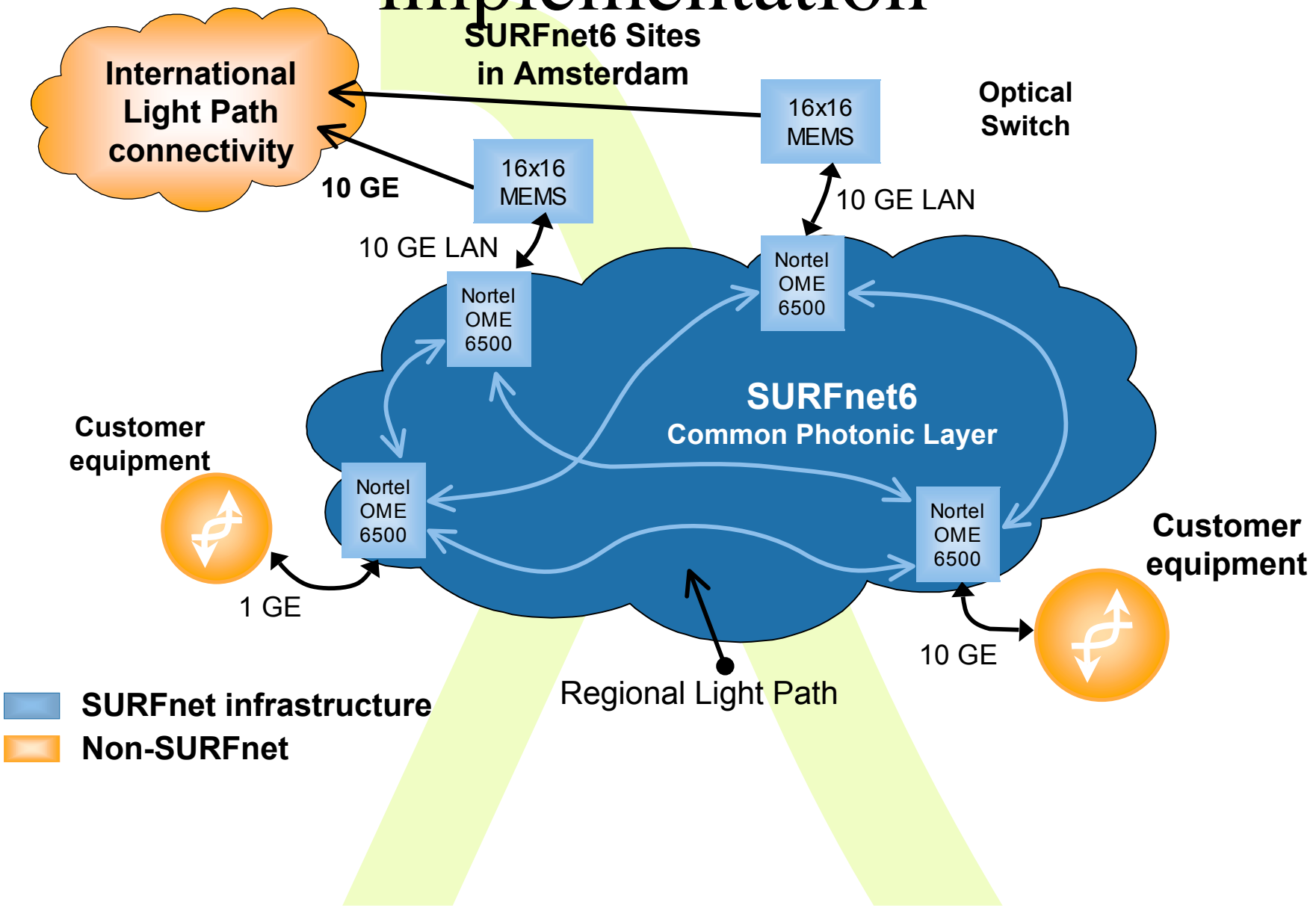
How low can you go?



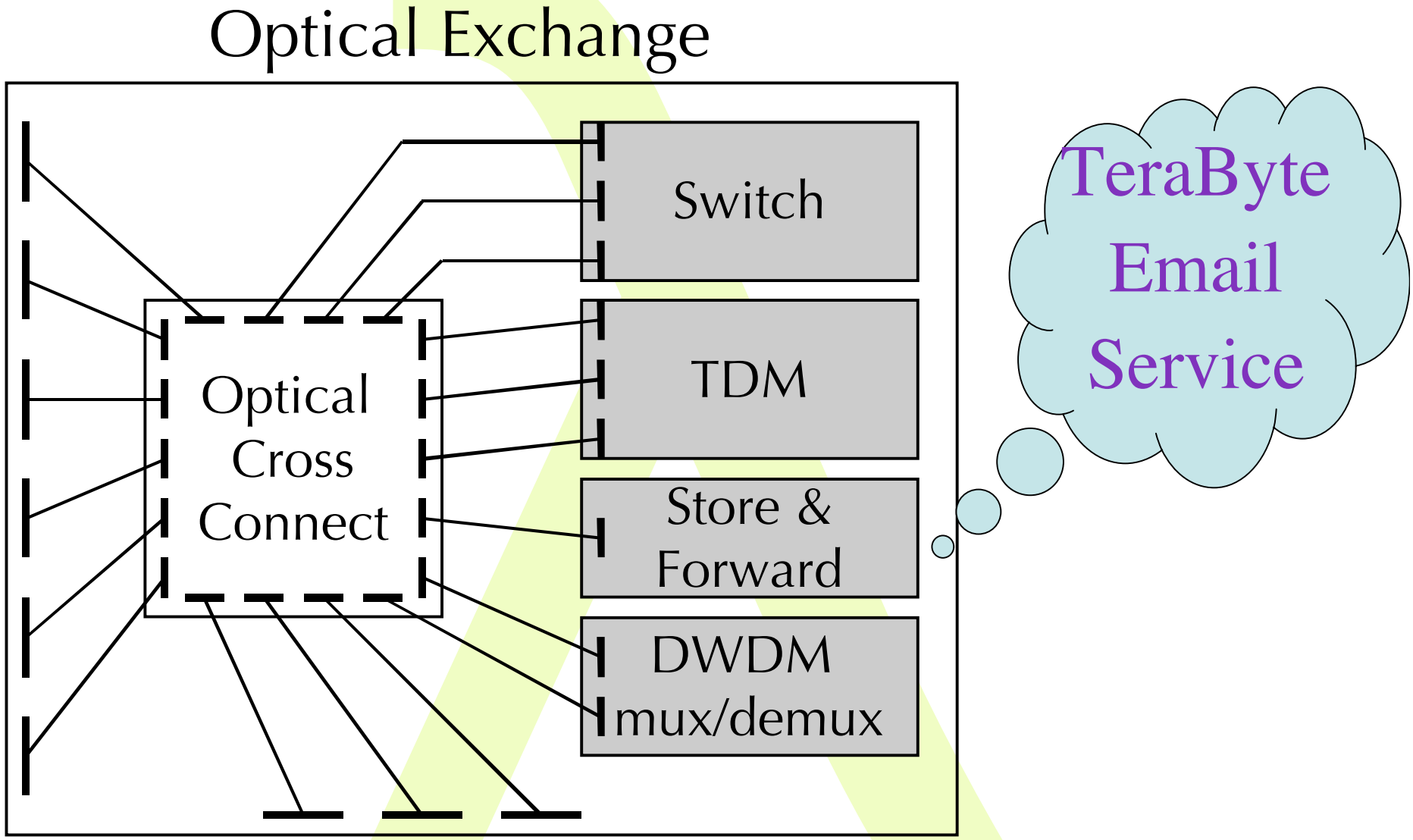


Common Photonic Layer (CPL) in SURFnet6

Light Paths provisioning implementation



Optical Exchange as Black Box



Service Matrix

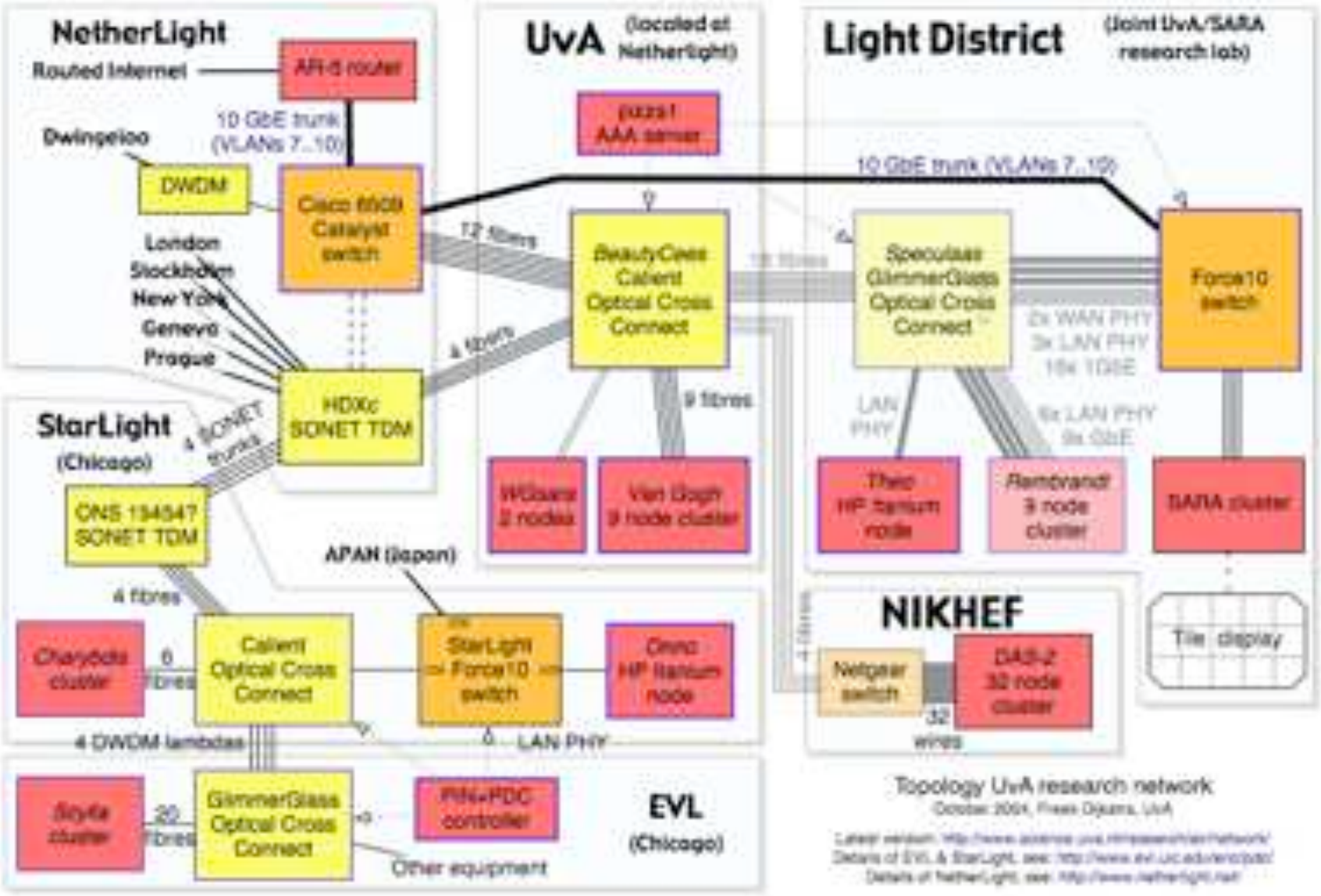
To / From	WDM (multiple λ)	Single λ, any bitstream	SONET/ SDH	1 Gb/s Ethernet	LAN PHY Ethernet	WAN PHY Ethernet	VLAN tagged Ethernet	IP over Ethernet
WDM (multiple λ)	cross-connect multicast, regenerate, multicast	WDM demux	WDM demux*	WDM demux *	WDM demux *	WDM demux *	WDM demux *	WDM demux *
Single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

Control Plane AAA

The grid approach:

- **Observe ownership, allow owner to set up the usage policy and delegation of control**
- **Ownership/AAA per port, line, service**
- **Services must be exposed at web-services (WSRF)**
- **Brokers will combine multiple web-services (multiple optical exchanges, and even other type of services like storage)**
- **Users will set up an end-to-end lightpath by contacting a broker, who checks the users rights and contacts the individual optical exchanges and Lambda owners to do the provisioning**

LightHouse



NetherLight
Routed Internet
AFI-6 router
10 GbE trunk (VLANs 7..10)
Dwingeloo
DWDM
Cisco 6509 Catalyst switch
London
Stockholm
New York
Geneva
Prague
HDXc SONET TDM
12 fibers
4 fibers
UvA
(located at NetherLight)
AAA server
BeautyCees Calient Optical Cross Connect
9 fibres
WGsara 2 nodes
Van Gogh 9 node cluster
Light District
(Joint UvA/SARA research lab)
10 GbE trunk (VLANs 7..10)
Speculaas GlimmerGlass Optical Cross Connect
Force10 switch
2x WAN PHY
3x LAN PHY
16x 1GbE
LAN PHY
6x LAN PHY
9x GbE
Theo HP Itanium node
Rembrandt 9 node cluster
SARA cluster
Tile display
StarLight
(Chicago)
4 SONET trunks
ONS 134547 SONET TDM
4 fibres
APAN (Japan)
Charybdis cluster
6 fibres
Calient Optical Cross Connect
StarLight Force10 switch
Omni HP Itanium node
4 DWDM lambdas
LAN PHY
NIKHEF
Netgear switch
DAS-2 32 node cluster
32 wires
Scylla cluster
20 fibres
GlimmerGlass Optical Cross Connect
PIN+PDC controller
Other equipment
EVL
(Chicago)
Topology UvA research network

Not quite The END

Thanks to
SURFnet: Kees Neggers,UIC&iCAIR: Tom DeFanti, Joel Mambretti, CANARIE: Bill St. Arnaud
Freek Dijkstra, Hans Blom, Leon Gommans, Bas van oudenaarde, Arie Taal, Pieter de Boer, Bert Andree, Martijn de Munnik, Antony Antony, Rob Meijer, VL-team.

Partially complete list:

Caas
Chase
Cess
Kess
Case

The END

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SURFnet

sara
Computing & Networking Services