Lambda-Grids
TNC2006 Panel “circuit vs packet?”

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A. Lightweight users, browsing, mailing, home use
   Need full Internet routing, one to many

B. Business/grid applications, multicast, streaming, VO’s, mostly LAN
   Need VPN services and full Internet routing, several to several + uplink

C. E-Science applications, distributed data processing, all sorts of grids
   Need very fat pipes, limited multiple Virtual Organizations, few to few

For the Netherlands 2005
\[ \Sigma A = \Sigma B = \Sigma C \approx 100 \text{ Gb/s} \]

However:
- A -> all connects
- B -> on several
- C -> just a few (SP, LHC, LOFAR)
Towards Hybrid Networking!

- Costs of photonic equipment 10% of switching 10% of full routing
  - for same throughput!
  - Photonic vs Optical (optical used for SONET, etc, 10-50 k$/port)
  - DWDM lasers for long reach expensive, 10-50 k$
- 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 ≈ 0.5-1.5 k$/port  
L2 ≈ 5-8 k$/port  
L3 ≈ 75+ k$/port
Scale of Infrastructure

- **Global scale (200 ms)**
  - Trans oceanic lambda’s
  - Few Lambda’s usually SONET framed

- **Regional scale (20 ms)**
  - Continent or big country wide network
  - Either dark fiber of many Lambda’s on someone’s infrastructure

- **Metro scale (2 ms)**
  - Dark fiber network
  - Photonic devices

- **Degrees of Freedom**
  - $L > R > M$

\[ \# \lambda \approx \frac{200 \times e^{(t-2002)}}{rtt} \]
## Services

<table>
<thead>
<tr>
<th>CLASS</th>
<th>SCALE</th>
<th>2 Metro</th>
<th>20 Regional</th>
<th>200 World</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td>Switching/Routing</td>
<td>Routers</td>
<td>ROUTER$</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td>Switches VPN’s E-WANPHY</td>
<td>Routing Switches (G)MPLS E-WANPHY</td>
<td>ROUTER$</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td>dark fiber DWDM WSS Photonic switch</td>
<td>DWDM, TDM / SONET Lambda switching</td>
<td>VLAN’s TDM SONET Ethernet</td>
</tr>
</tbody>
</table>
Optical Exchange as Black Box

Optical Exchange

Switch
TDM
Store & Forward
DWDM mux/demux

Optical Cross Connect

Ref: gridnets paper by Freek Dijkstra, Cees de Laat
Cases for circuits

- where a single application needs interface speeds
- currently LHC and ASTRO (eVLBI)
- e-Health and e-Bioscience around the corner
- it depends on scale of network and time factors of the application what kind of circuit technology and CP is optimal
- inside a country “copy” customer interfaces to a central routing place.
- on circuits the transport protocols can switch off the congestion control which usually ruins throughput
- The NREN’s of today are the Telco’s of tomorrow! Universities, you know what to do!
Let’s panel!