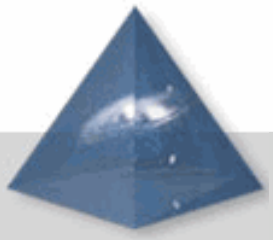
Optical Networking

www.science.uva.nl/~delaat

Cees de Laat



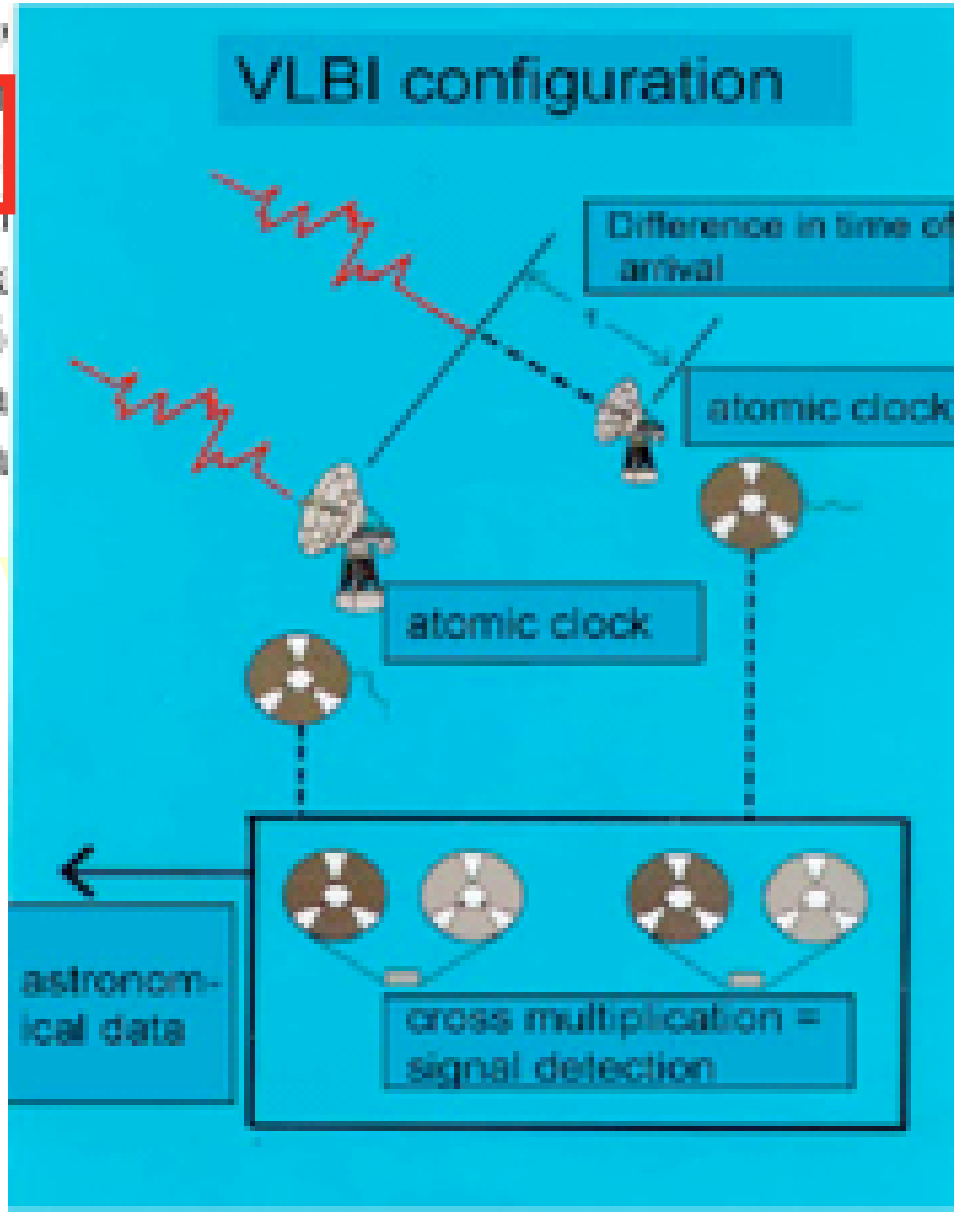
Faculty of Science

eVLBI

VLBI

ger term VLBI is easily capable of generating many Gb of data per
The sensitivity of the VLBI array scales v
(data-rate) and there is a strong push to
. Rates of 8Gb/s or more are entirely feasibl
ider development. It is expected that paral
orrelator will remain the most efficient approa
s distributed processing may have an appli
lti-gigabit data streams will aggregate into la
or and the capacity of the final link to the da
tor.

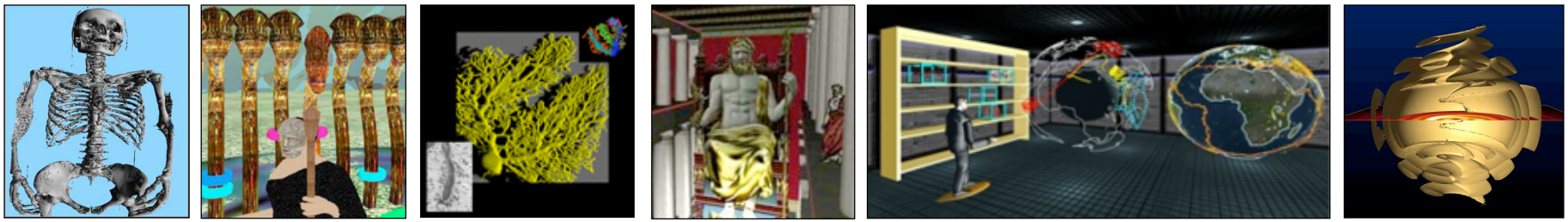
Westerbork Synthesis Radio Telescope - Netherlands



iGrid 2002

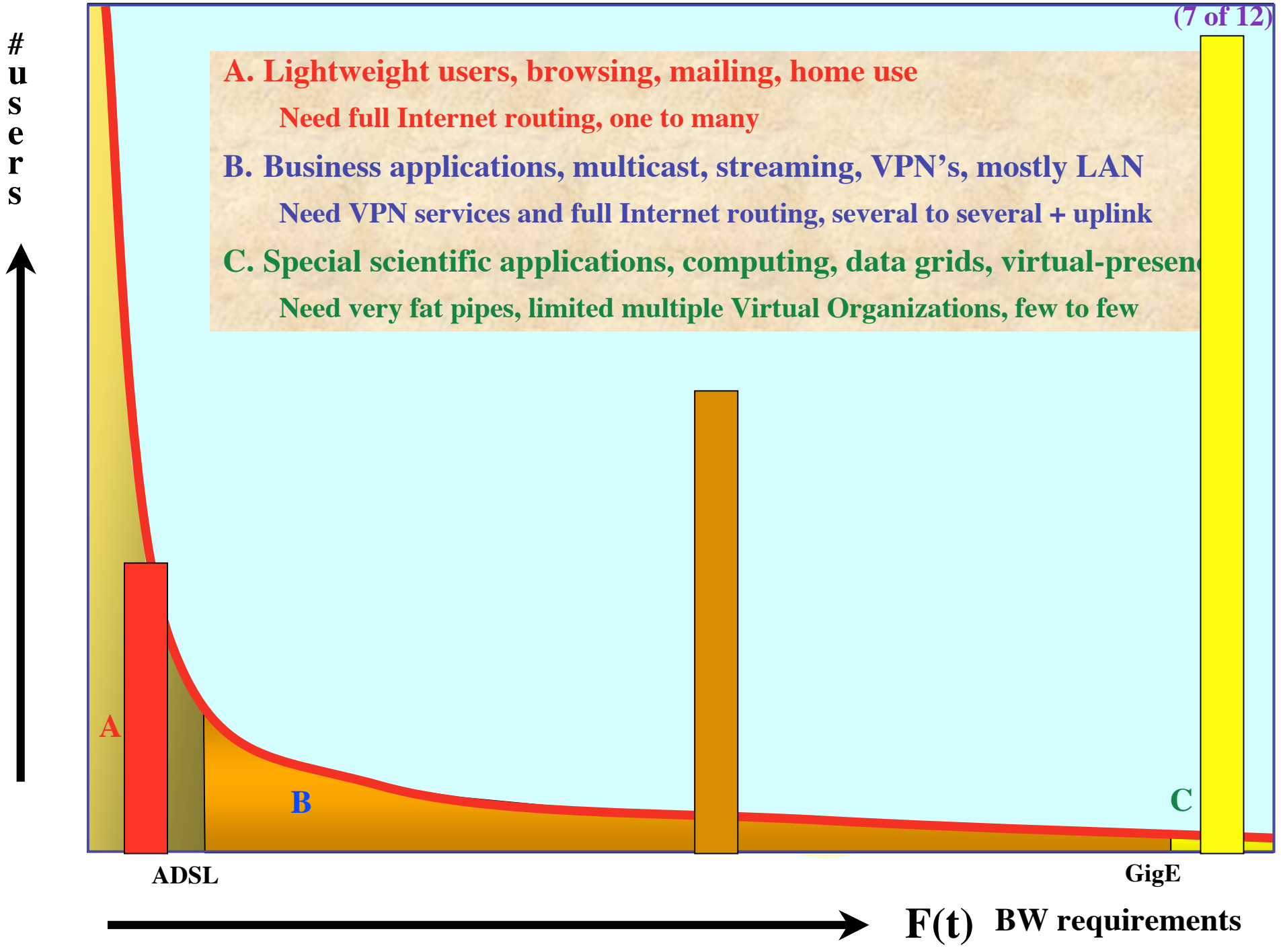
September 24-26, 2002, Amsterdam, The Netherlands

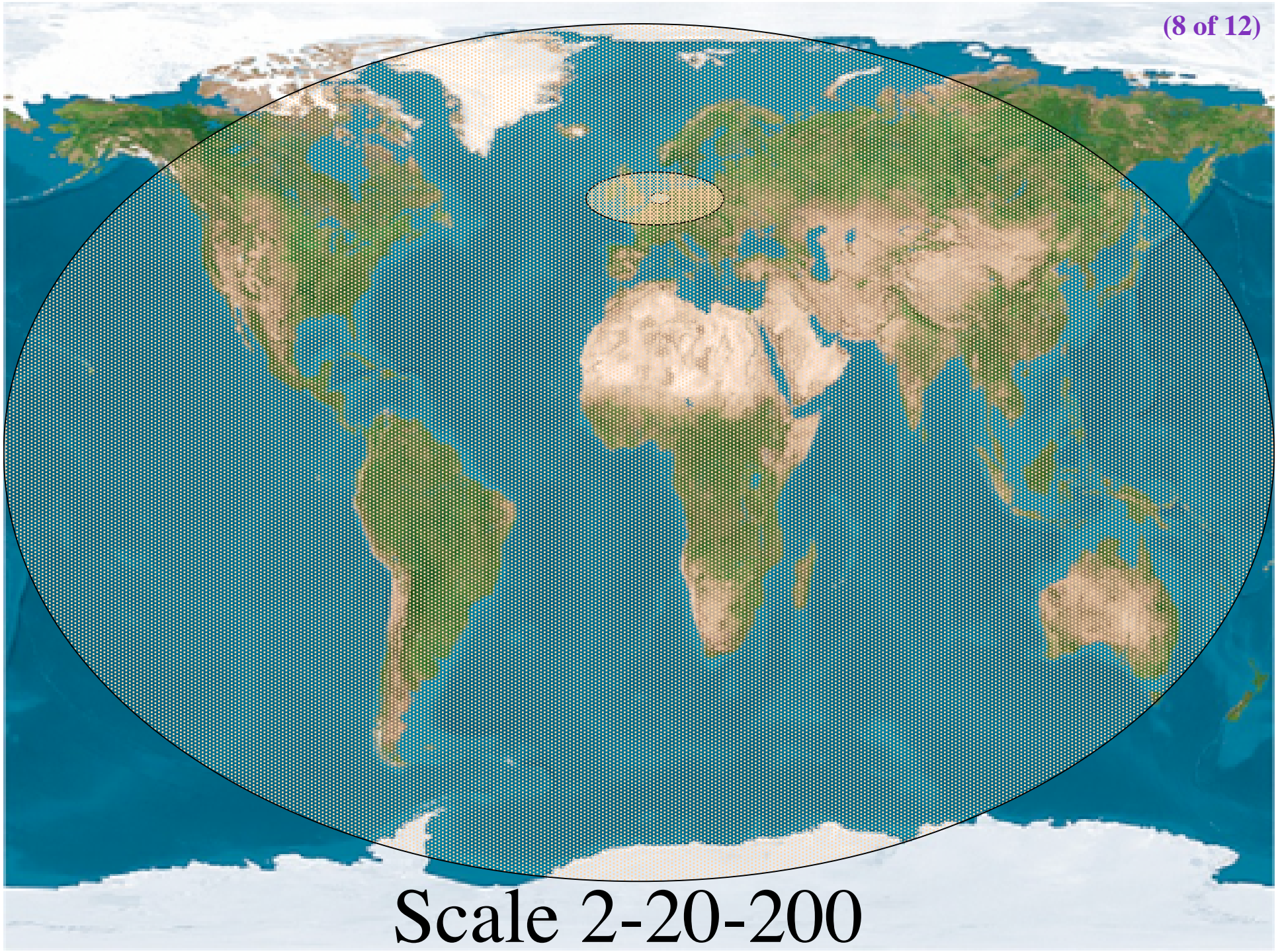
- 28 demonstrations from 16 countries: Australia, Canada, CERN, France, Finland, Germany, Greece, Italy, Japan, The Netherlands, Singapore, Spain, Sweden, Taiwan, United Kingdom, United States
- Applications demonstrated: art, bioinformatics, chemistry, cosmology, cultural heritage, education, high-definition media streaming, manufacturing, medicine, neuroscience, physics, tele-science



- Grid technologies demonstrated: Major emphasis on grid middleware, data management grids, data replication grids, visualization grids, data/visualization grids, computational grids, access grids, grid portals
- 25Gb transatlantic bandwidth (100Mb/attendee, 250x iGrid2000!)

www.igrid2002.org


#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. Special scientific applications, computing, data grids, virtual-presen
Need very fat pipes, limited multiple Virtual Organizations, few to few
A
B
C
ADSL
GigE
F(t) BW requirements



Scale 2-20-200

The only formula's

$$\#\,\lambda(rtt) \approx \frac{200 * e^{(t-2002)}}{rtt}$$

Now, having been a High Energy Physicist we set

c = 1

e = 1

$\bar{h}$ = 1

and the formula reduces to: $\#\,\lambda(rtt) \approx \frac{200 * e^{(t-2002)}}{rtt}$

Services

SCALE / CLASS	2 Metro	20 National/ regional	200 World
A	Switching/ routing	Routing	ROUTER$
B	VPN's, (G)MPLS	VPN's Routing	ROUTER$
C $\#\lambda(rtt) \approx \frac{200 * e^{(t-2002)}}{rtt}$	dark fiber Optical switching	Lambda switching	Sub-lambdas, ethernet-sdh

So what are the facts

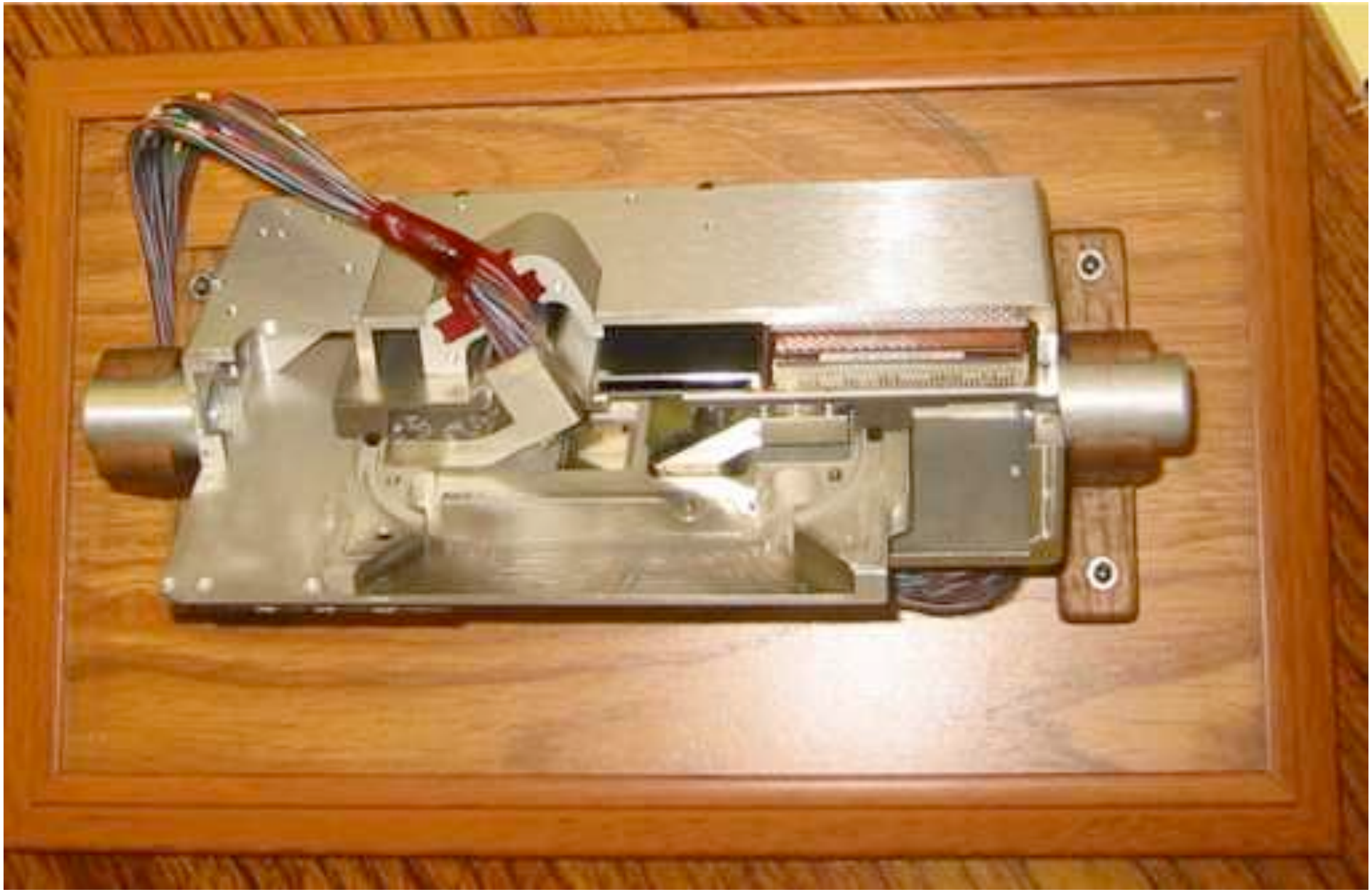
- Costs of fat pipes (fibers) are one/third of cost of equipment to light them up
  - Is what Lambda salesmen tell me
- Costs of optical equipment 10% of switching 10 % of full routing equipment for same throughput
  - 100 Byte packet @ 40 Gb/s -> 20 ns to look up in 140 kEntries routing table (light speed from me to you!)
- Big sciences need fat pipes
- Bottom line: look for a hybrid architecture which serves all users in a cost effective way

(Intermezzo)

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

Costs 1/100th of a similar throughput router but with specific services!

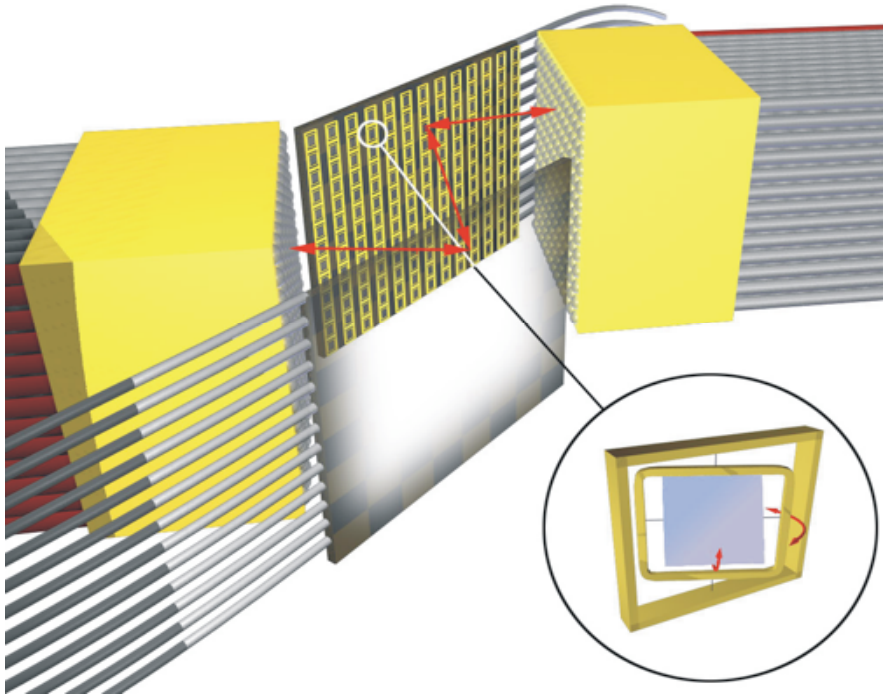
MEMS switch

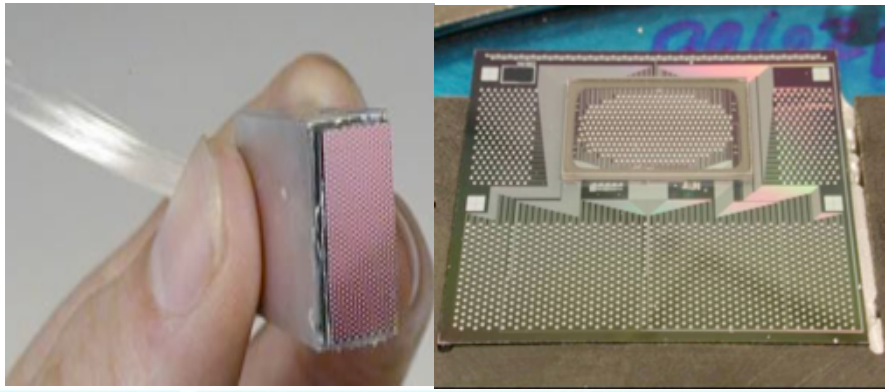


Core Switch Technology

(Intermezzo-3)

Calient NETWORKS





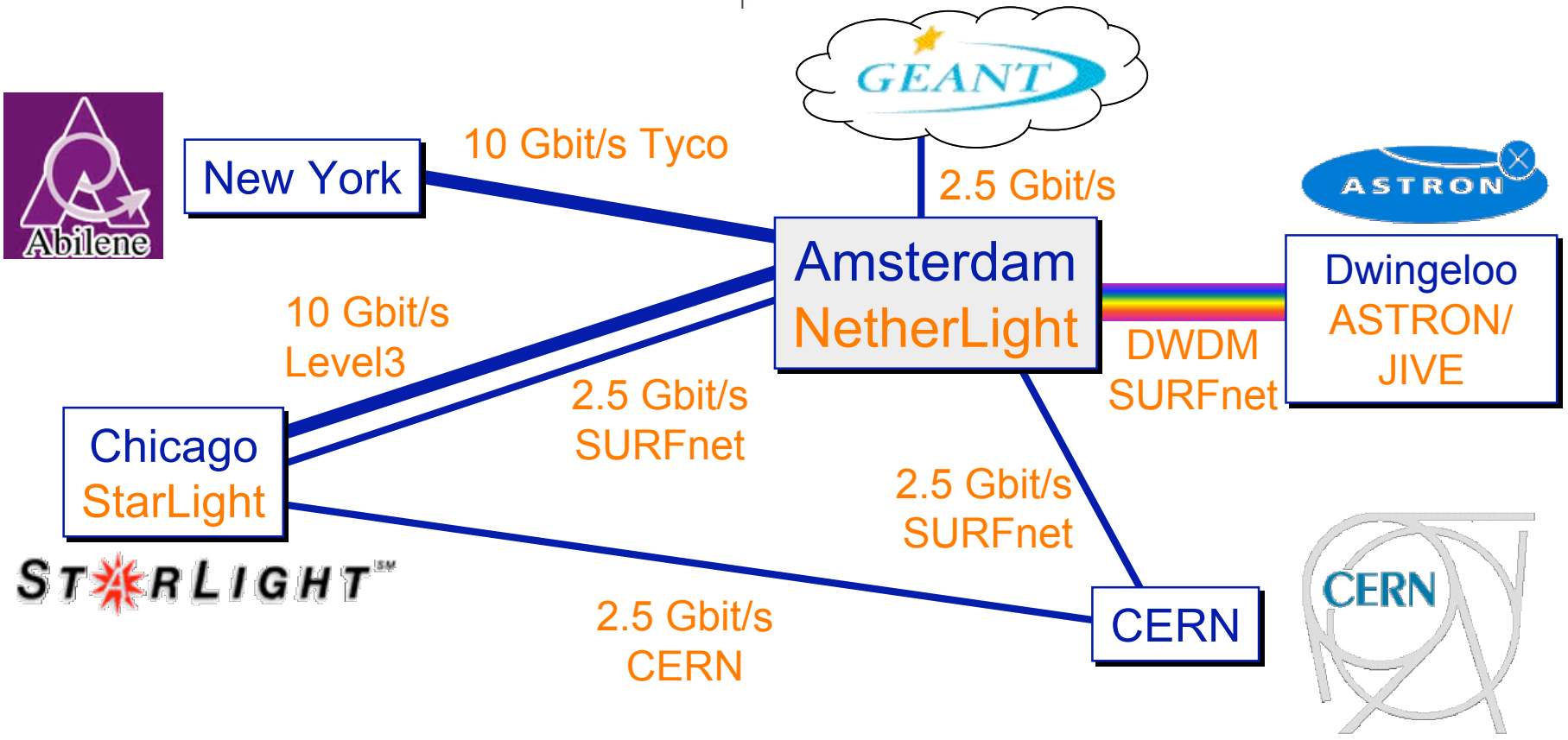
- **3D MEMS structure**
  - Bulk MEMS – High Density Chips
  - Electrostatic actuation
  - Short path length (~4cm)
  - <1.5 dB median loss
- **Completely Non-blocking**
  - Single-stage up to 1Kx1K
  - 10 ms switching time
- **Excellent Transparency**
  - Polarization
  - Bit rate
  - Wavelength

International networking in full operation

GigaPort

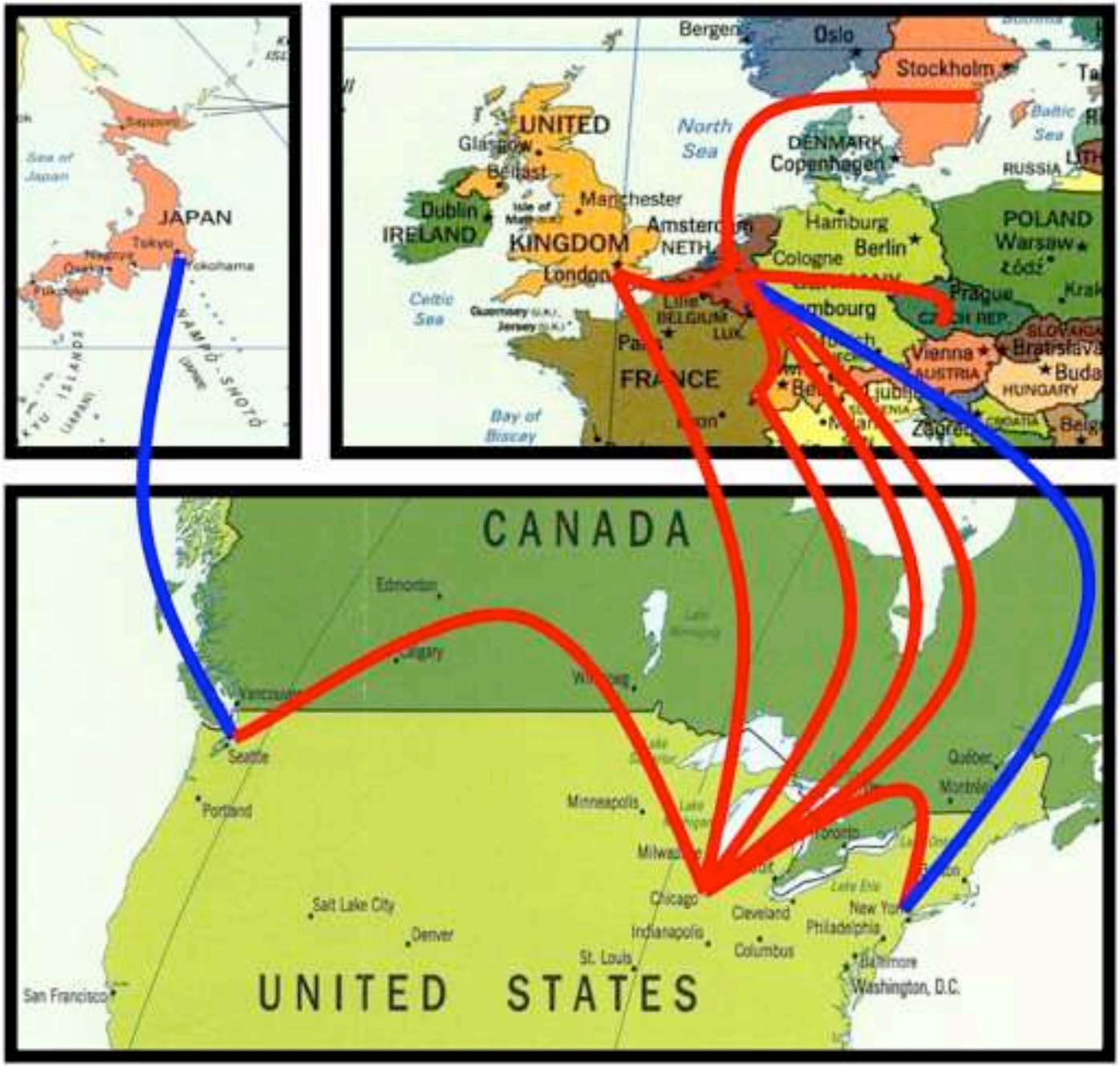
The network for

iGrid2002
The International Virtual Laboratory
www.igrid2002.org
www.startap.net/igrid2002



SURFnet

Real Lambda's



TransLight Lambdas

European lambdas to US
–6 GigEs Amsterdam—Chicago
–2 GigEs CERN—Chicago
–8 GigEs London—Chicago

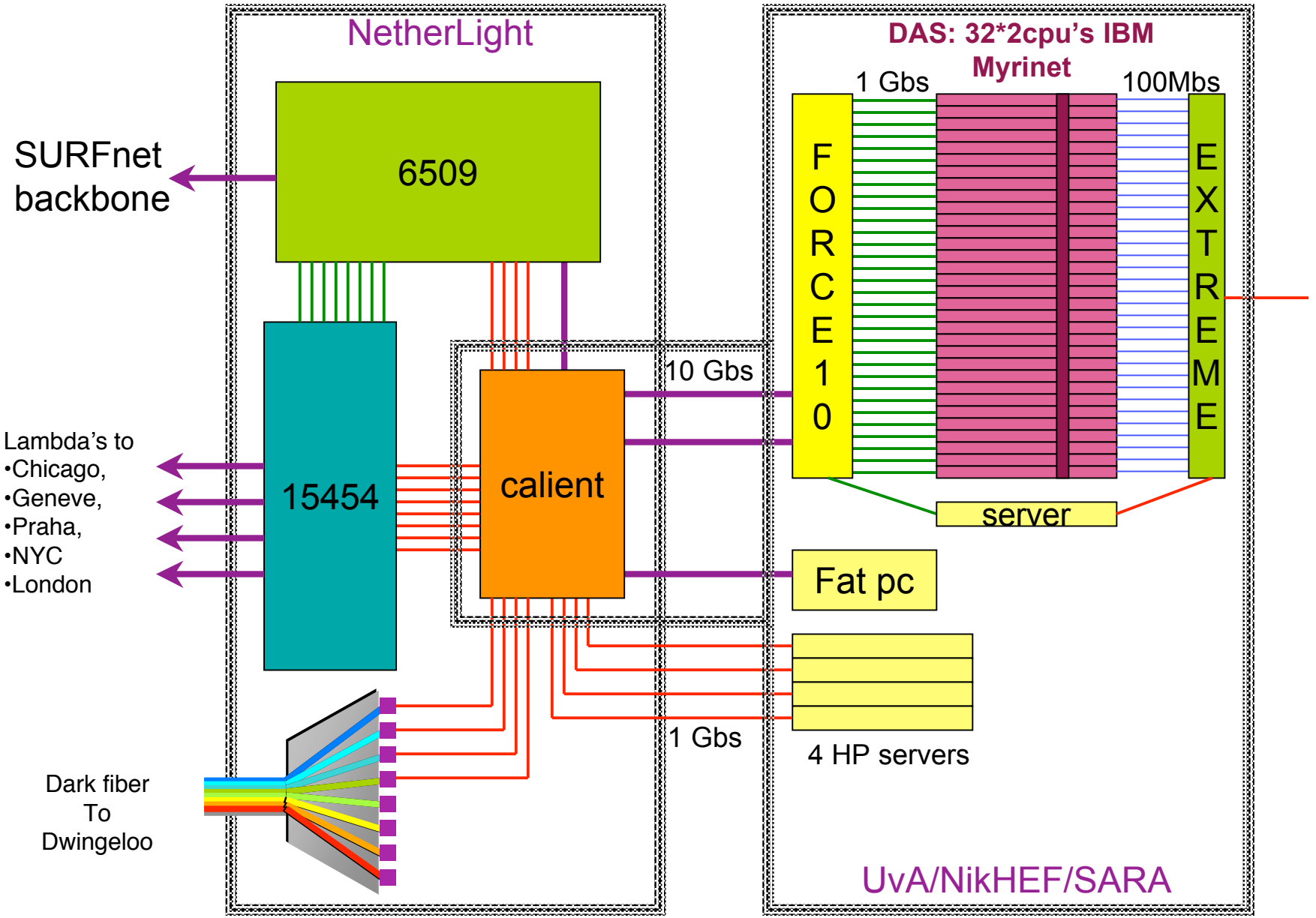
Canadian lambdas to US
–8 GigEs Chicago—Canada—NYC

–8 GigEs
Chicago—Canada—Seattle

US lambdas to Europe
–4 GigEs Chicago—Amsterdam
–2 GigEs Chicago—CERN

European lambdas
–8 GigEs Amsterdam—CERN
–2 GigEs Prague—Amsterdam
–2 GigEs
Stockholm—Amsterdam
–8 GigEs London—Amsterdam

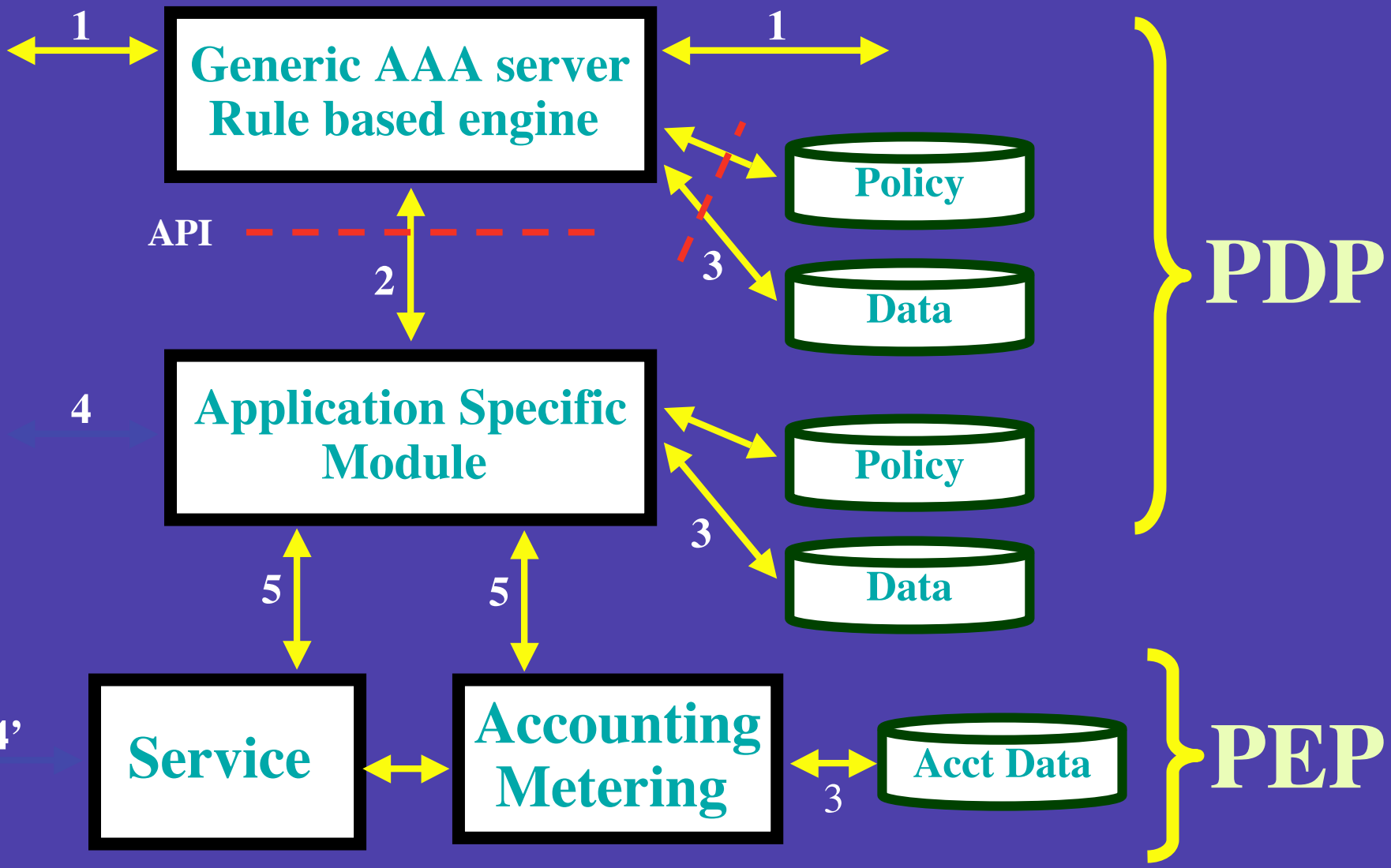
IEEAF lambdas (blue)
–8 GigEs Seattle—Tokyo
–8 GigEs NYC—Amsterdam


NetherLight
DAS: 32*2cpu's IBM
Myrinet
1 Gbs
100Mbs
SURFnet
backbone
6509
FORCE10
EXTREME
10 Gbs
Lambda's to
•Chicago,
•Geneve,
•Praha,
•NYC
•London
15454
calient
server
Fat pc
1 Gbs
4 HP servers
Dark fiber
To
Dwingeloo
UvA/NikHEF/SARA

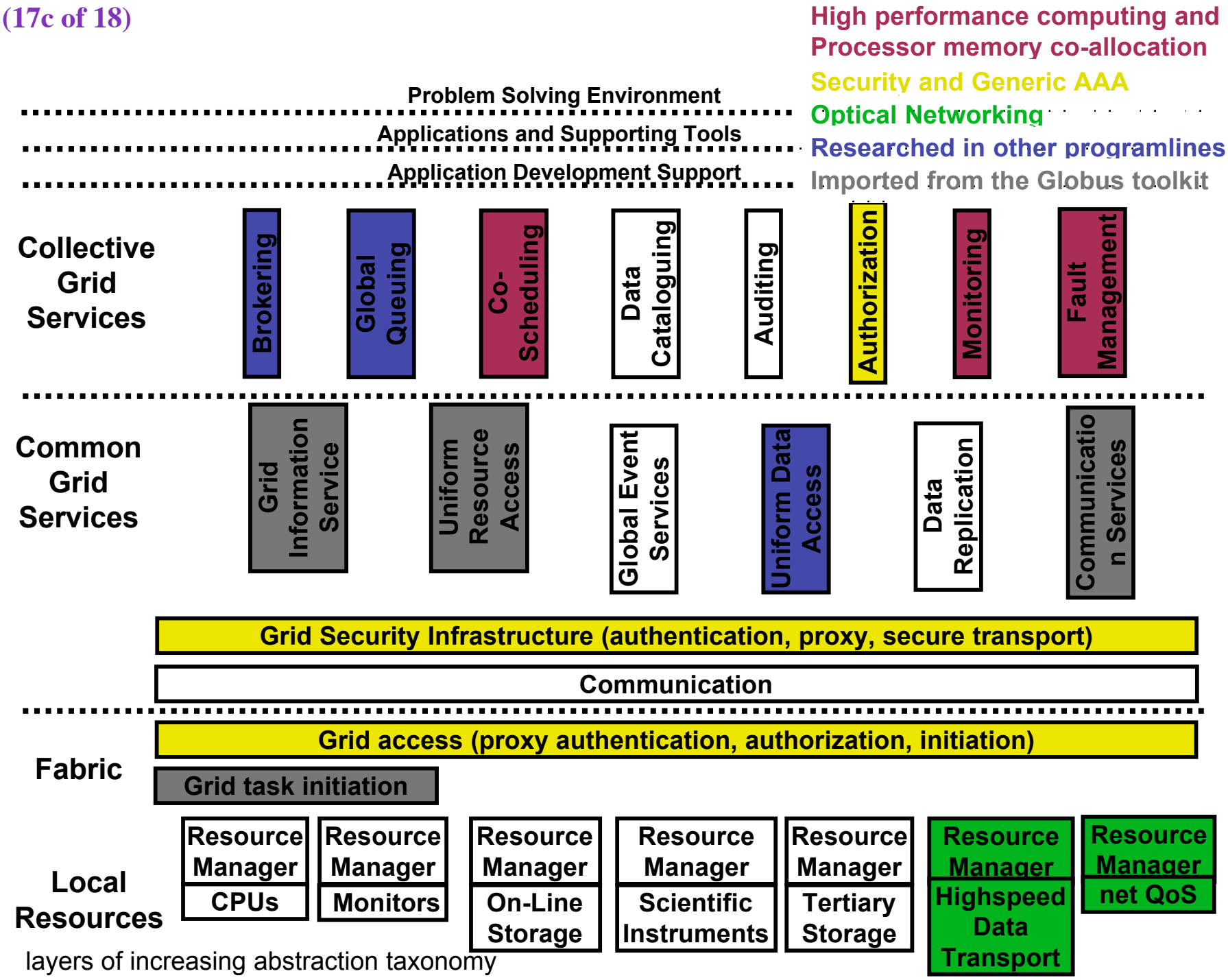
Conclusions

- www.igrid2002.org
- Even more bandwidth now at NetherLight
- SuperComputing 2002
- TransLight project
- Providing solutions for e-Science projects
- Rich networking research area
- 22 papers published in FGCS June 2003 issue

Starting point

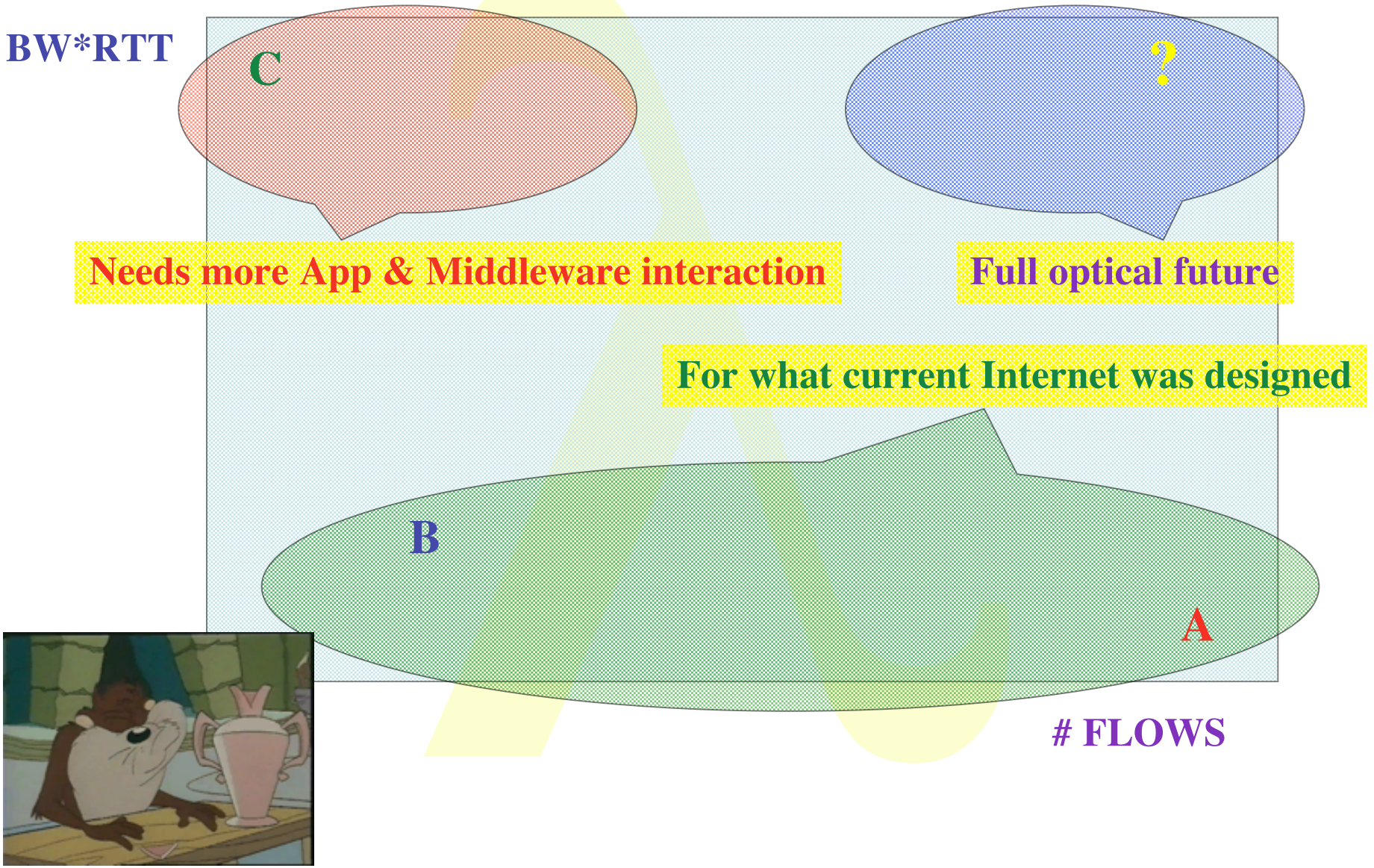


RFC 2903 - 2906 , 3334 , policy draft



layers of increasing abstraction taxonomy

Transport in the corners



The END

Thanks to

SURFnet: Kees Neggers,UIC&iCAIR: Tom DeFanti, Joel Mambretti, CANARIE: Bill St. Arnaud

This work is supported by:SURFnet, EU-IST project DATATAG, SARA