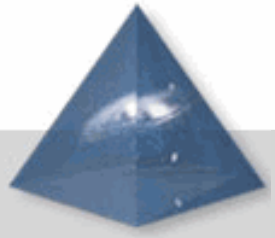
Optical Networking / Experiences @ iGrid2002

www.science.uva.nl/~delaat

Cees de Laat



Faculty of Science

Optical Networking / Experiences@ iGrid2002

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Cees de Laat

EU

SURFnet

University of Amsterdam

SARA

NIKHEF

canarie

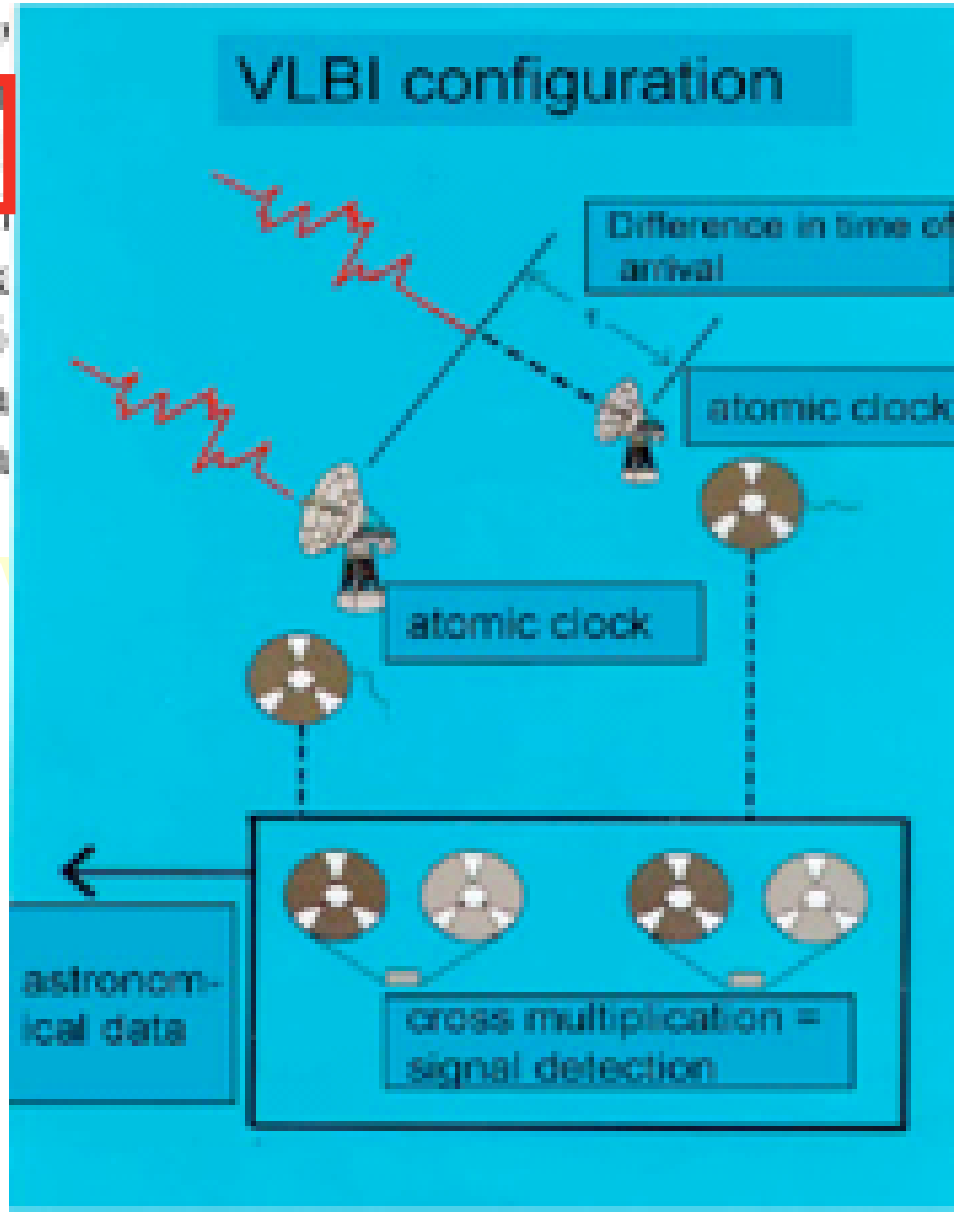
What is this buzz about optical networking

- **What does the remark "bring us your Lambda's" mean?**
- **Networks are already optical for ages**
- **Almost all current projects are about SONET circuits and Ethernet (old wine in new bags?)**
- **Are we going back to the telecom world, do NRN's want to become telco's**
- **Does it scale / integrate**
- **Is it all about speed (swimming pool argument)**

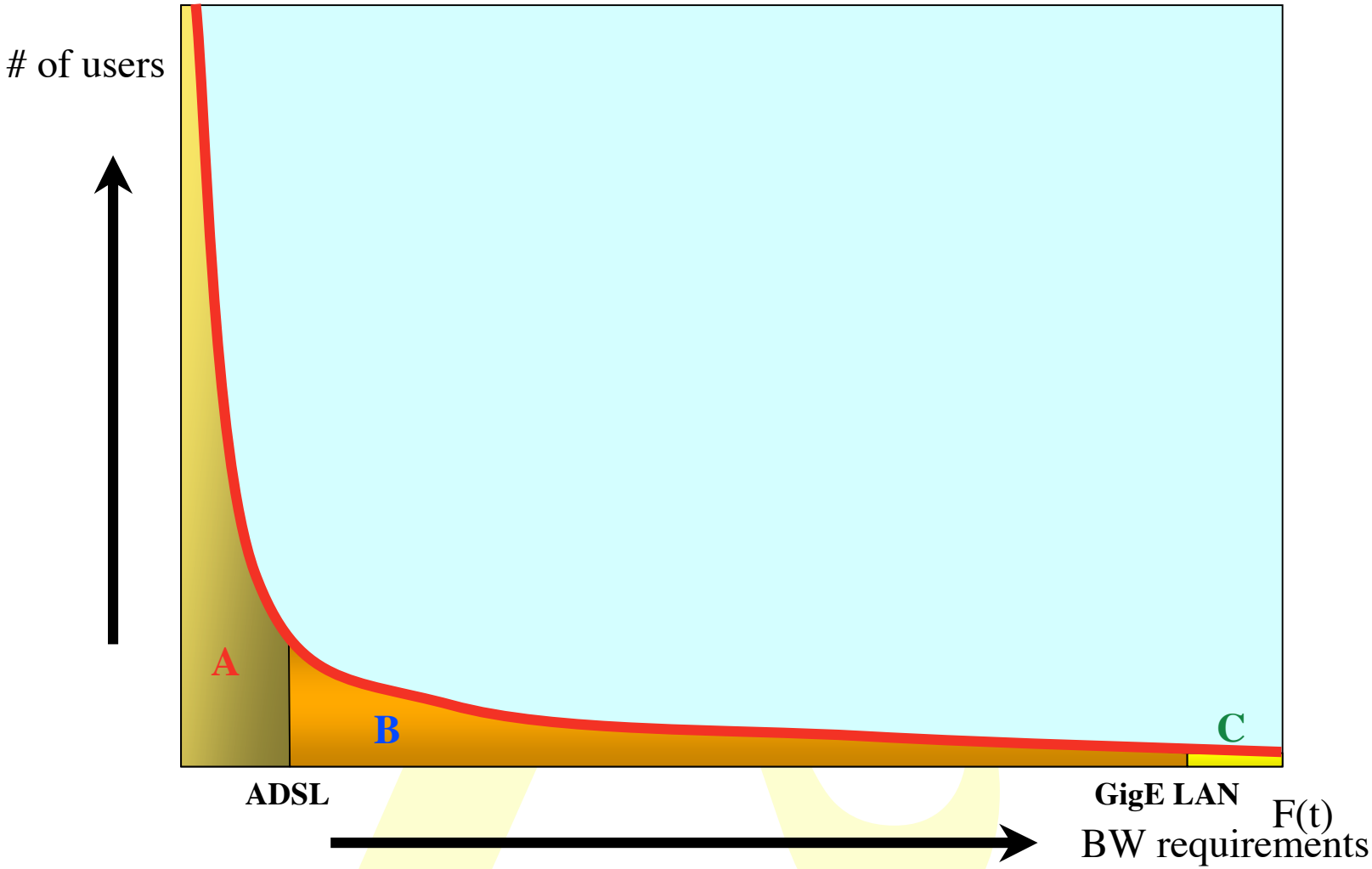
VLBI

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



Know the user

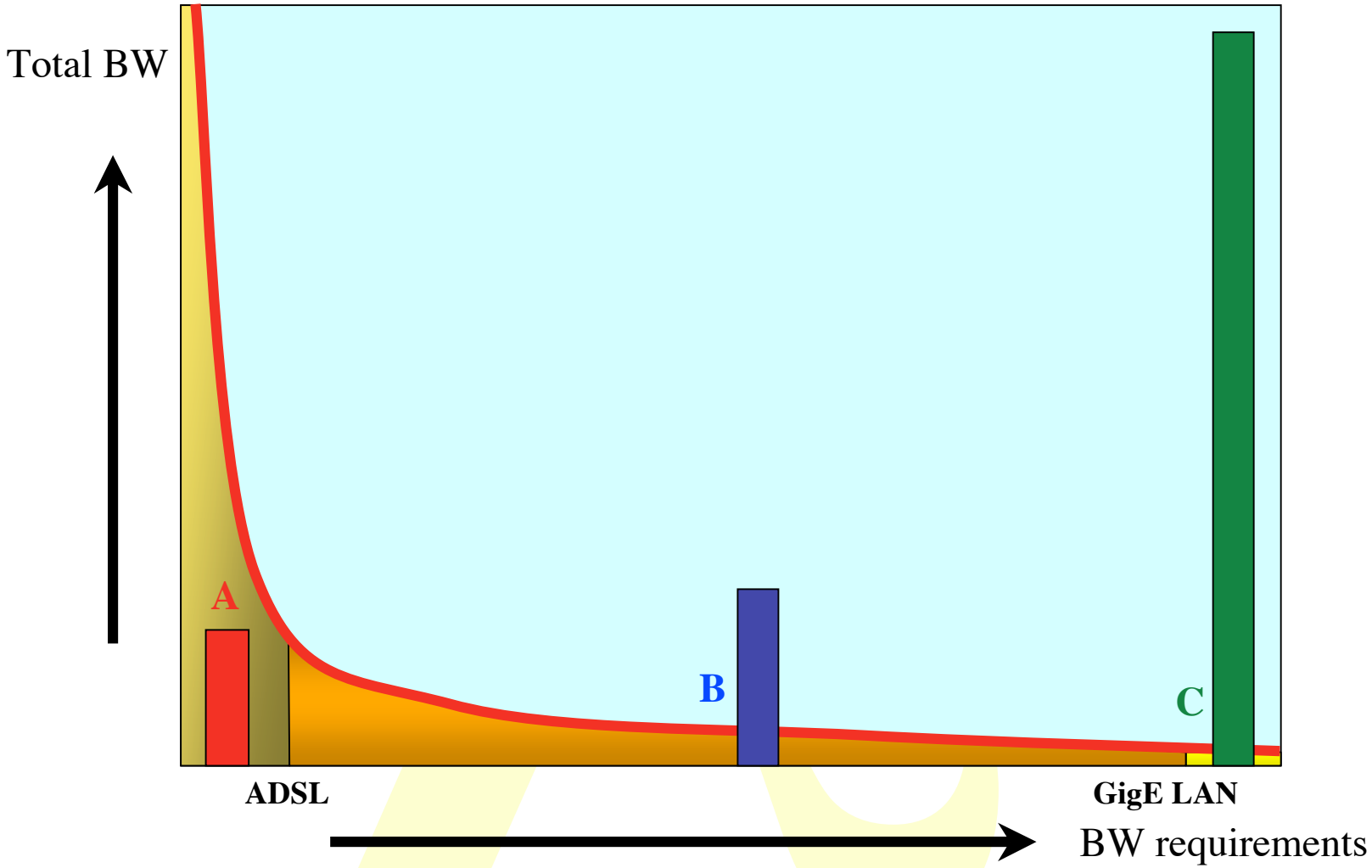


A -> Lightweight users, browsing, mailing, home use

B -> Business applications, multicast, streaming, VPN's, mostly LAN

C -> Special scientific applications, computing, data grids, virtual-presence

What the user



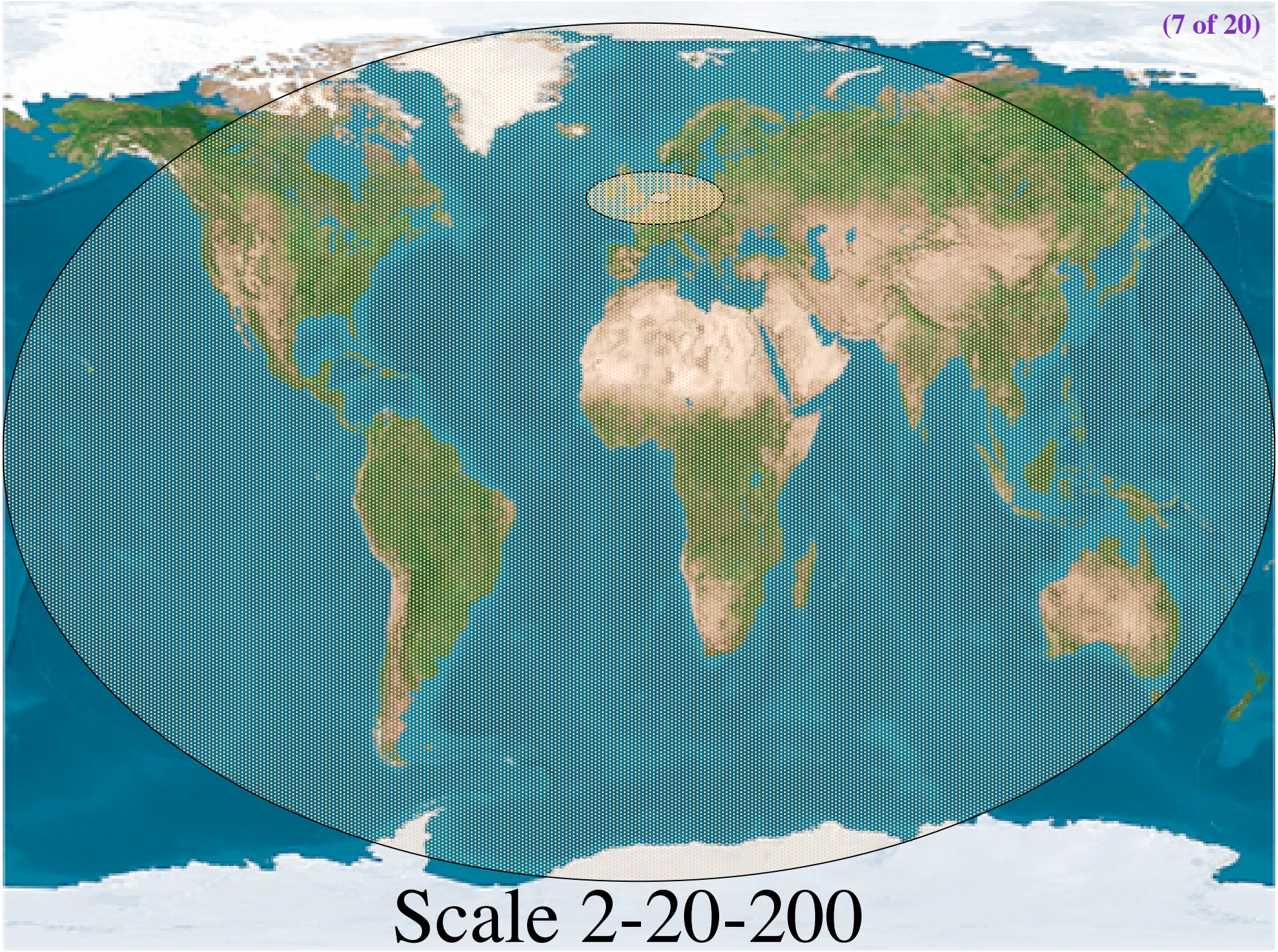
A -> Need full Internet routing, one to many

B -> Need VPN services on/and full Internet routing, several to several

C -> Need very fat pipes, limited multiple Virtual Organizations, few to few

So what are the facts

- Costs of fat pipes (fibers) are one/third 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 @ 10 Gb/s -> 80 ns to look up in 100 Mbyte routing table (light speed from me to you on the back row!)
- Big sciences need fat pipes
- Bottom line: create a hybrid architecture which serves all users in one consistent cost effective way



Scale 2-20-200

The only formula's

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

Now, as having been a High Energy Physicist we set

c = 1

e = 1

ħ = 1

and the formula reduces to:

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

Services

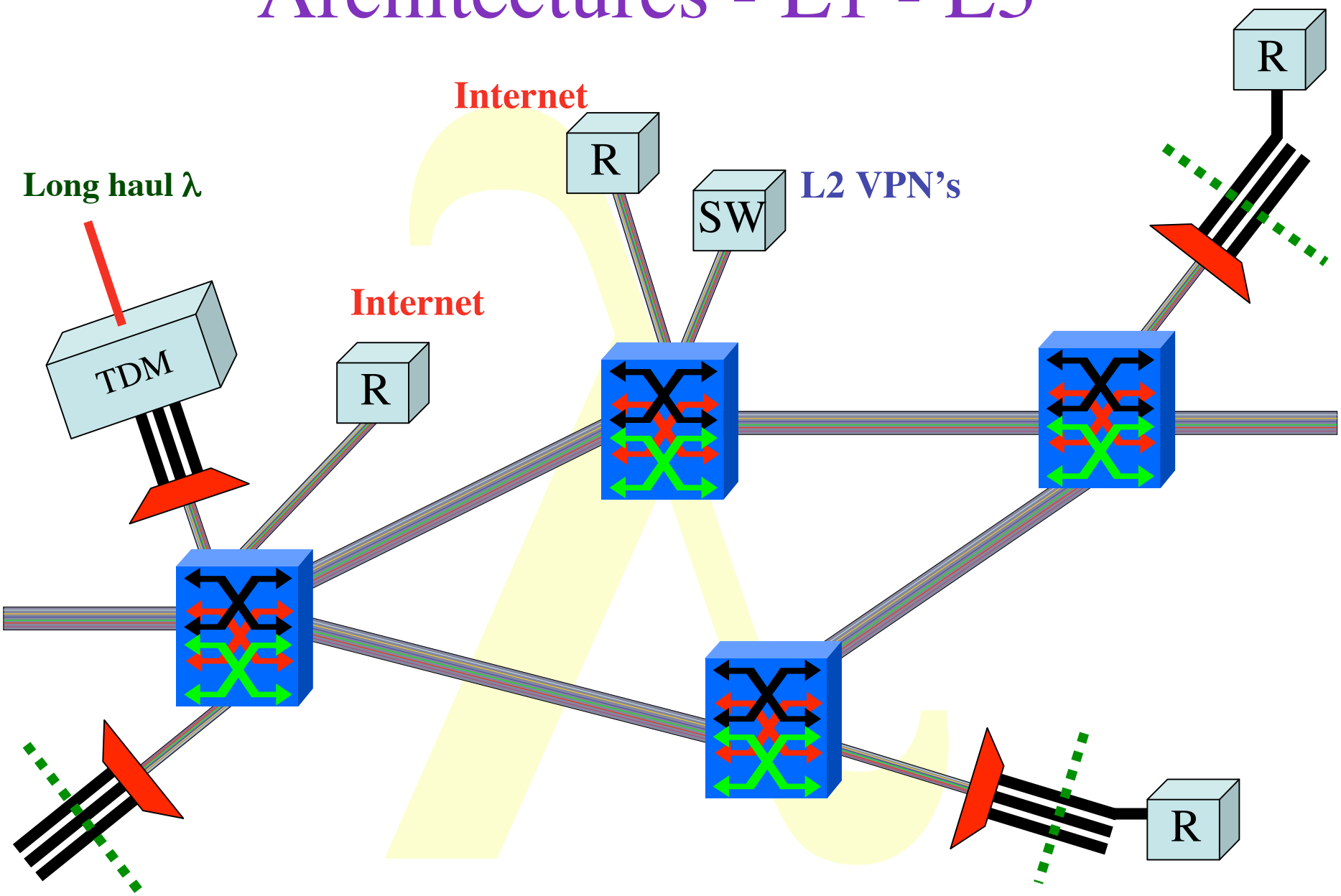
	2 Metro	20 National/ regional	200 World
A	Switching/ routing	Routing	ROUTER$
B	VPN's, (G)MPLS	VPN's Routing	Routing
C $\#\lambda \approx \frac{200 * e^{(t-2002)}}{rtt}$	dark fiber Optical switching	Lambda switching	Sub- lambdas, ethernet- sdh

Current technology + (re)definition

- Current (to me) available technology consists of SONET/SDH switches
- Changing very soon!, optical switch on the way!
- DWDM+switching coming up
- Starlight uses for the time being VLAN's on Ethernet switches to connect [exactly two] ports (but also routing)
- So redefine a λ as:

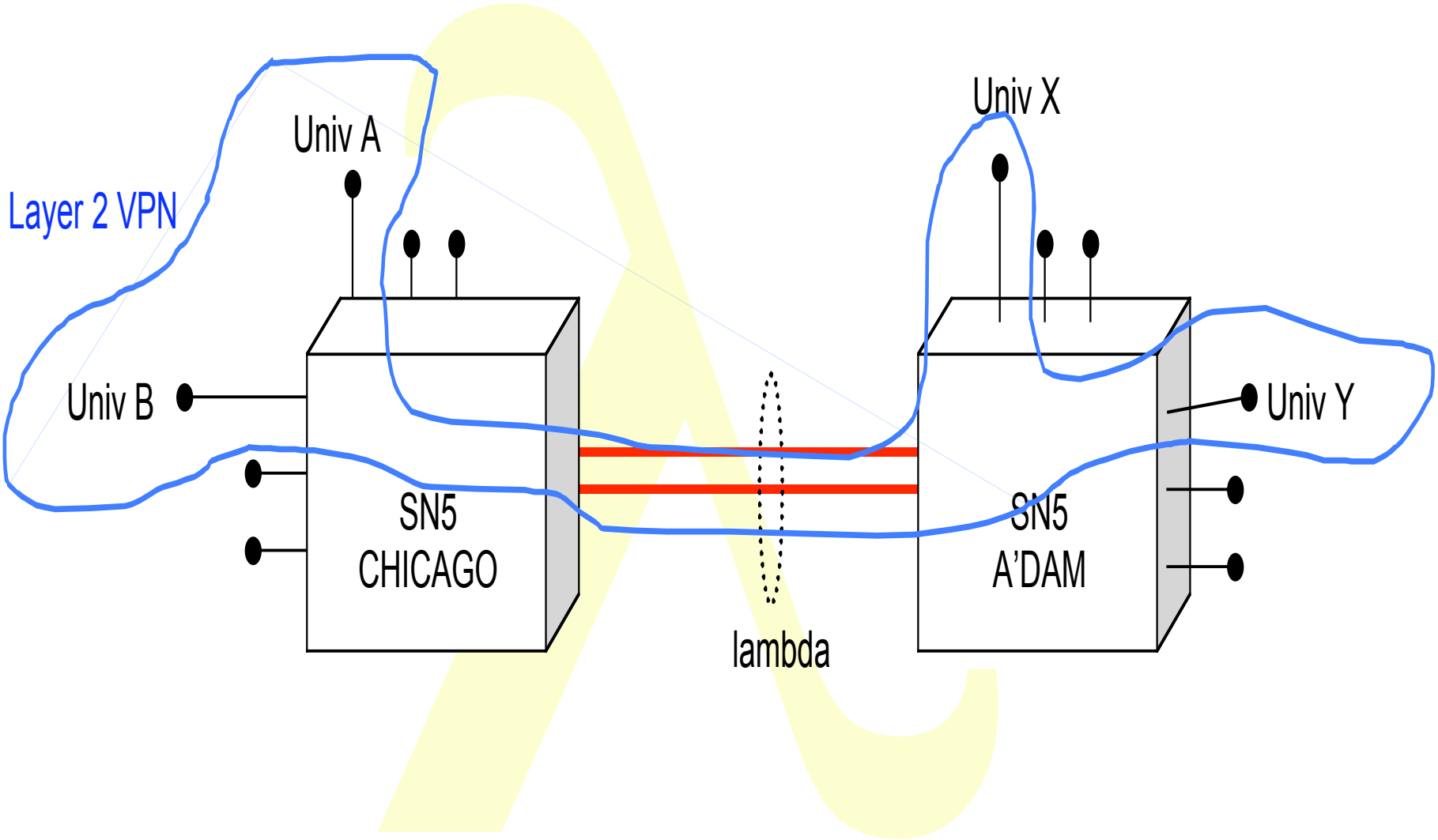
"a λ is a pipe where you can inspect packets as they enter and when they exit, but principally not when in transit. In transit one only deals with the parameters of the pipe: number, color, bandwidth"

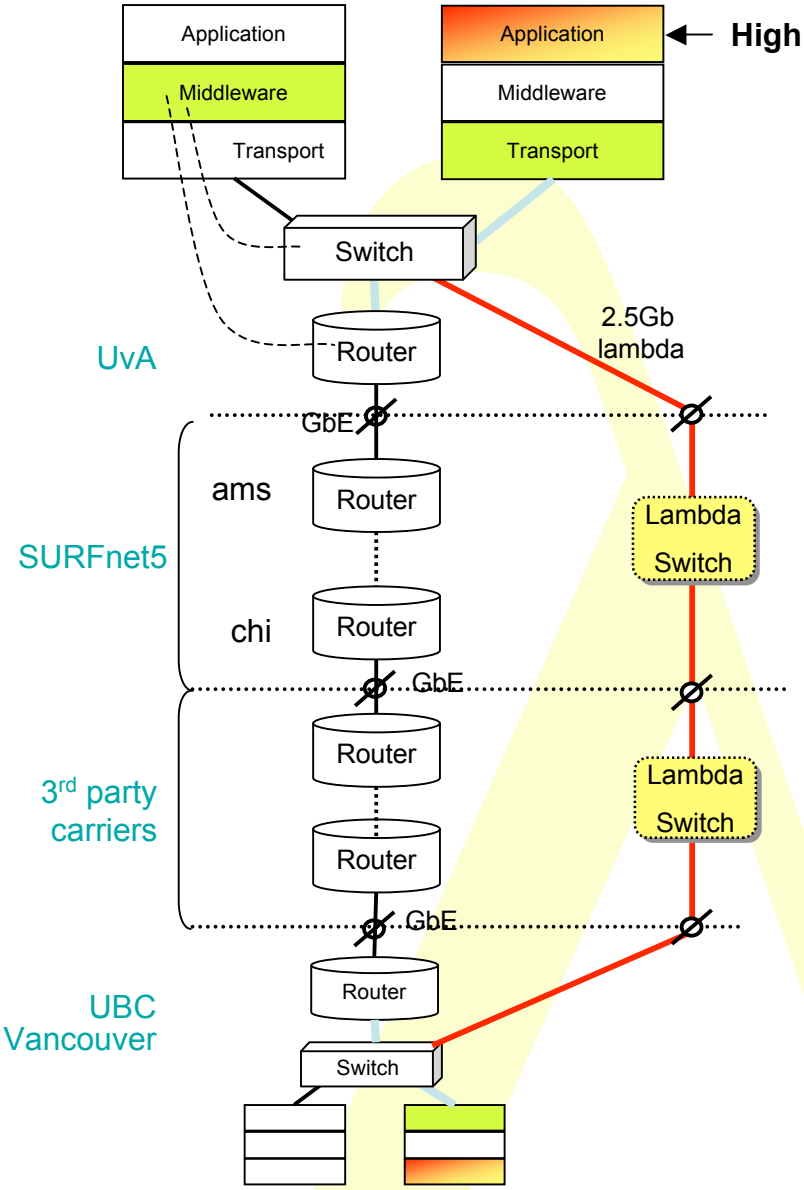
Architectures - L1 - L3



Bring plumbing to the users, not just create sinks in the middle of nowhere

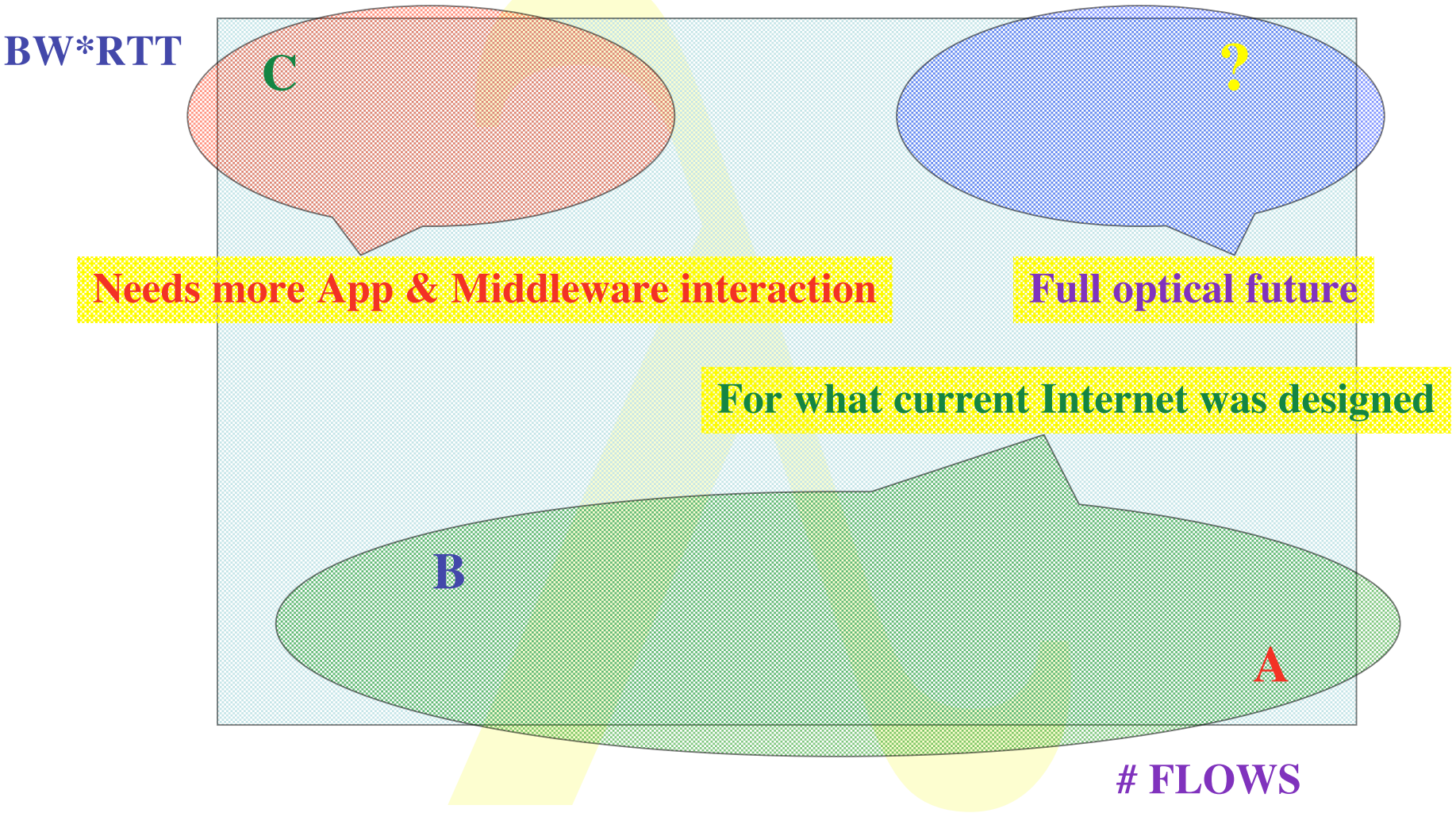
Distributed L2





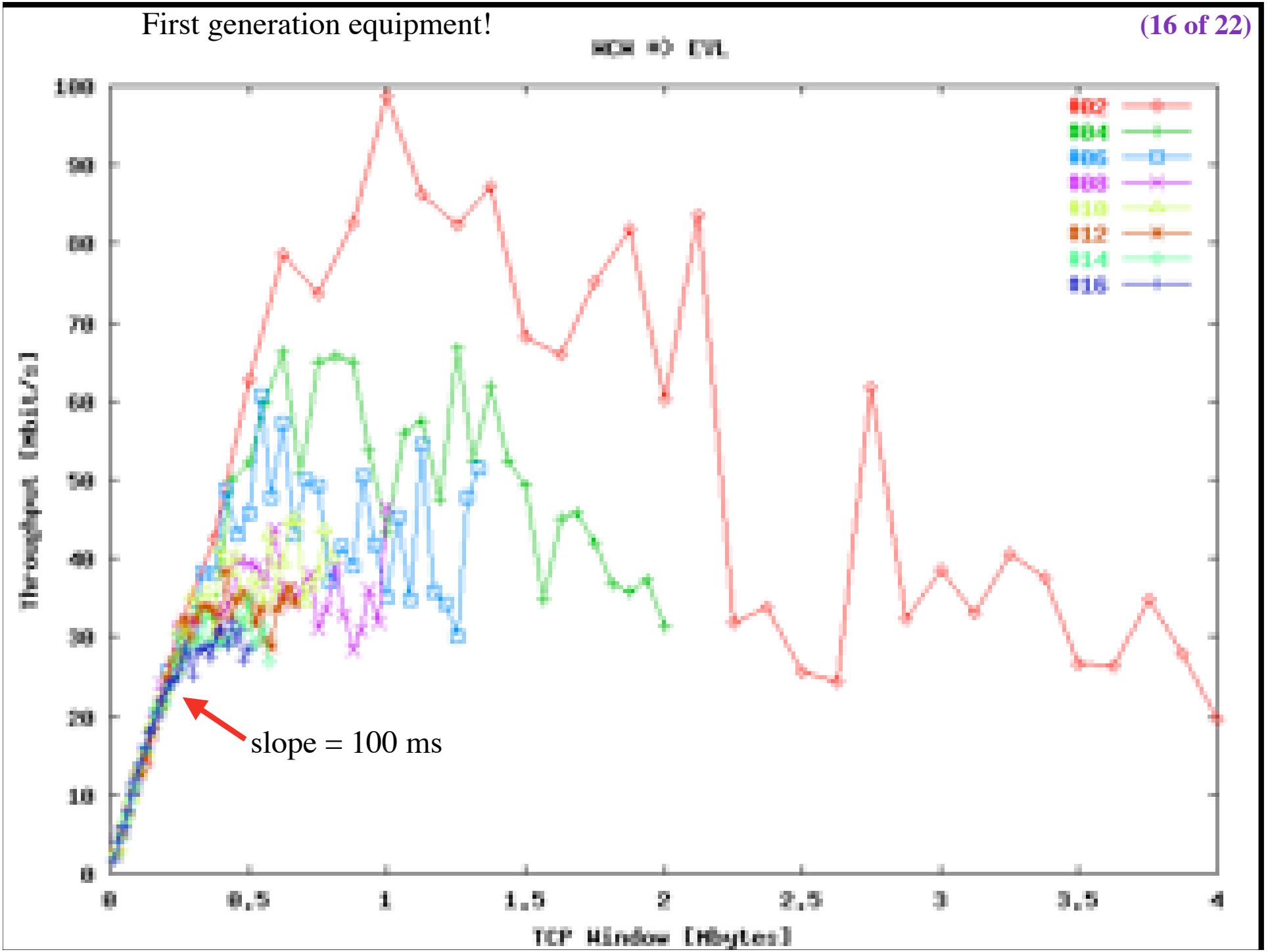
- lambda for high bandwidth applications
  - Bypass of production network
  - Middleware may request (optical) pipe
- RATIONALE:
  - Lower the cost of transport per packet

Transport in the corners



Early Lambda/LightPath usage experiences

First generation equipment!



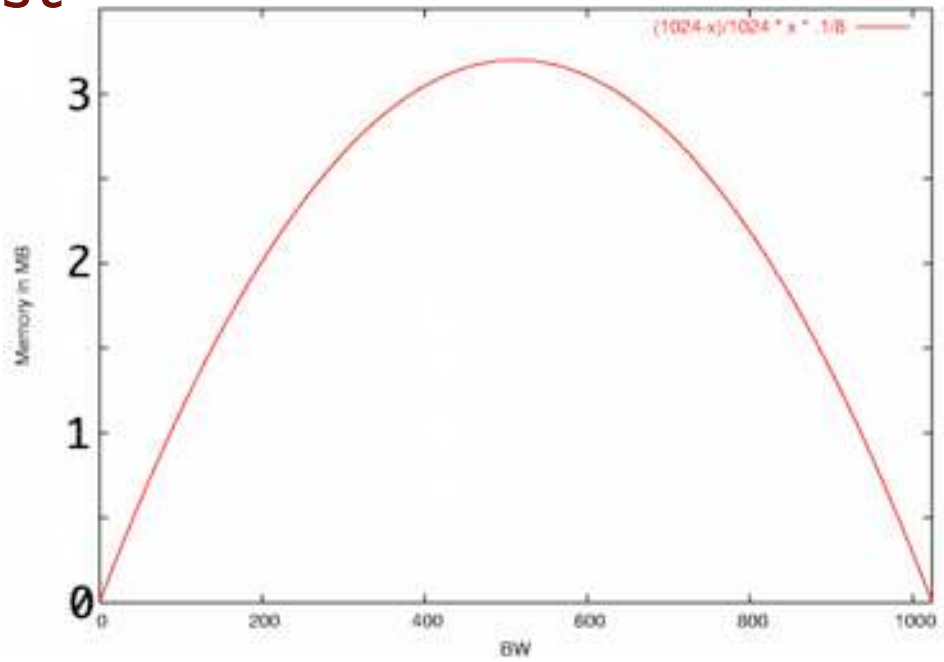
Layer - 2 requirements from 3/4

TCP is bursty due to sliding window protocol and slow start algorithm.

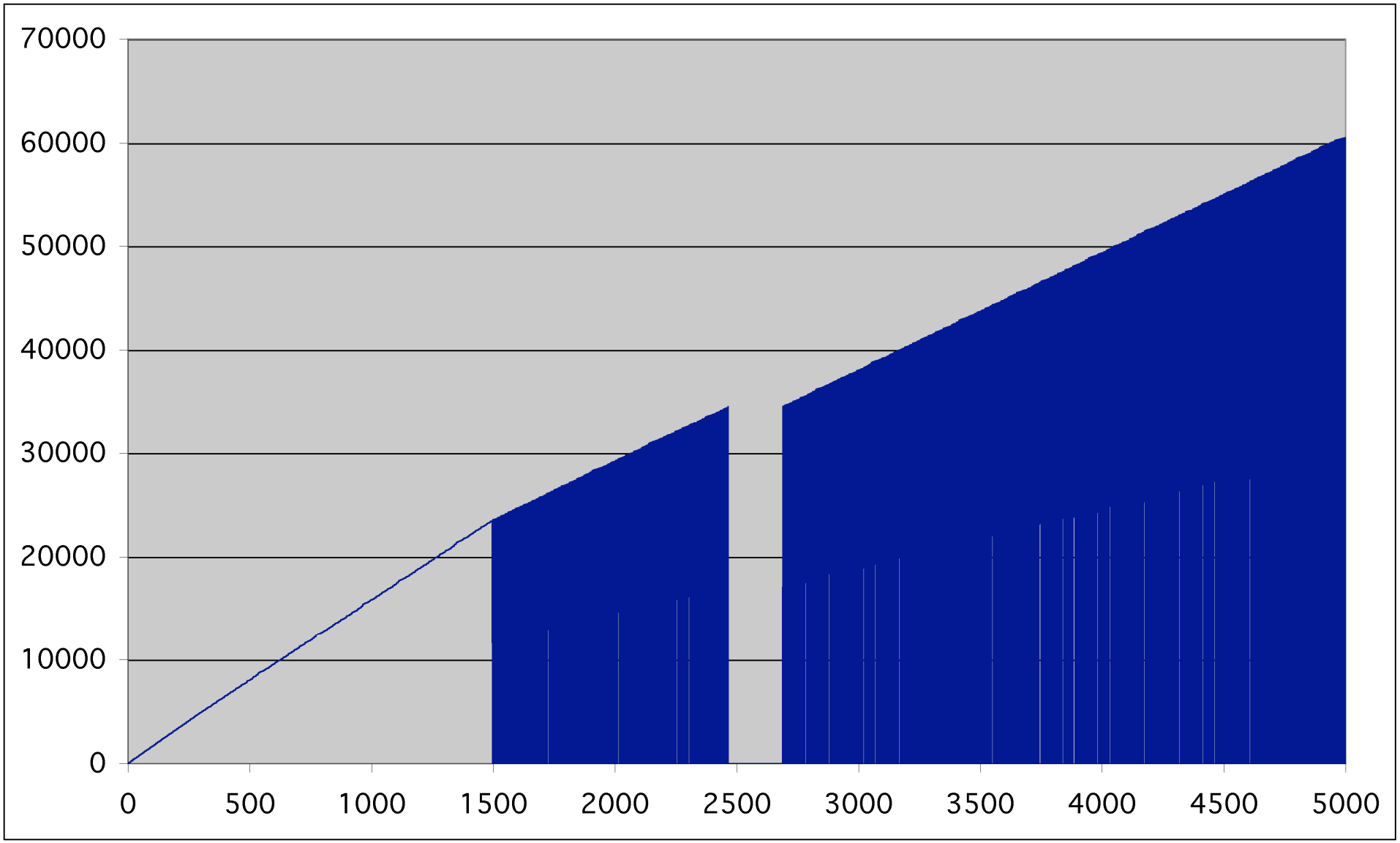
```
Window = BandWidth * RTT     &    BW == slow

                                fast - slow
Memory-at-bottleneck = ------------ * slow * RTT
                                  fast
```

So pick from menu:

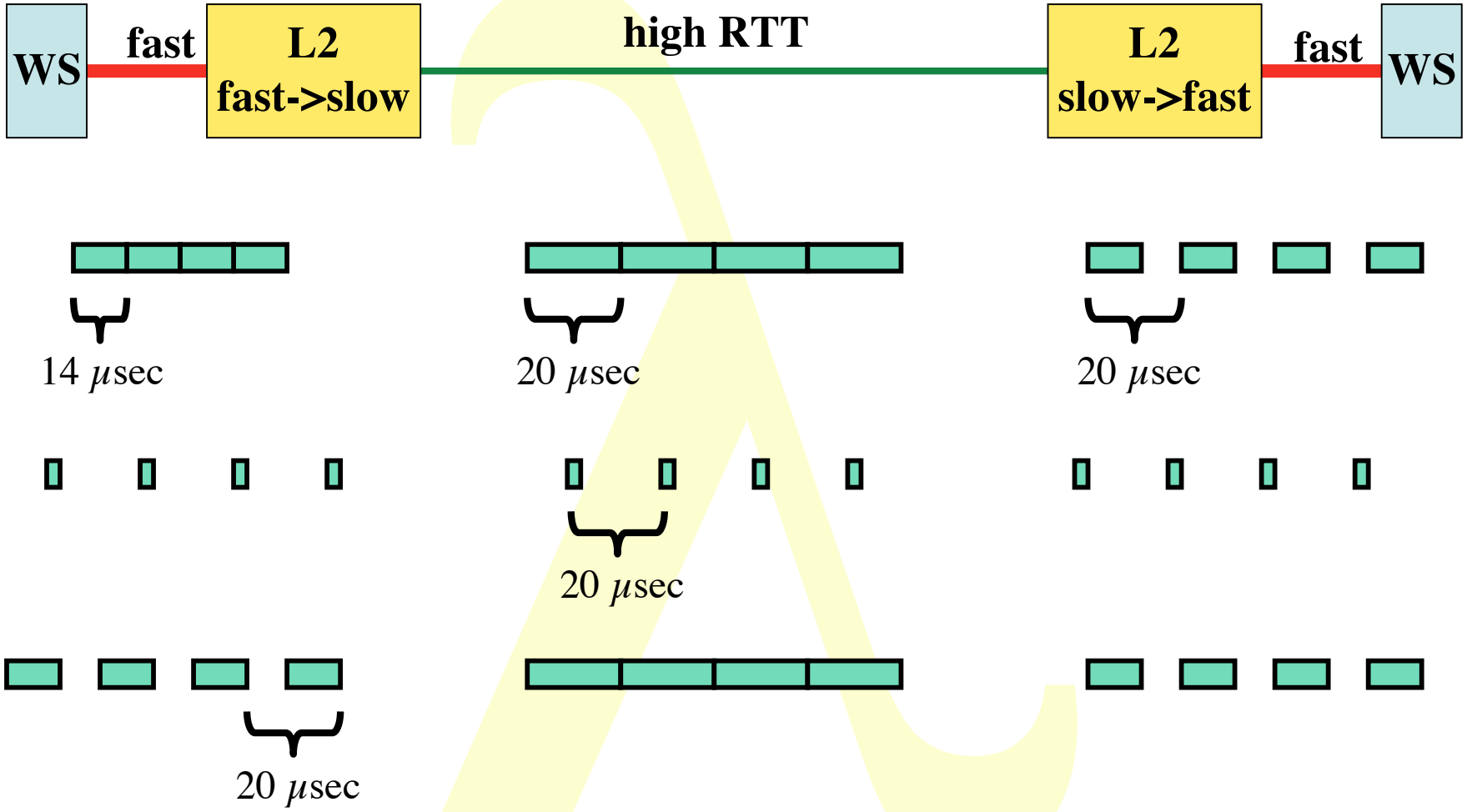
- *Flow control*
- *Traffic Shaping*
- *RED (Random Early Discard)*
- *Self clocking in TCP*
- *Deep memory*



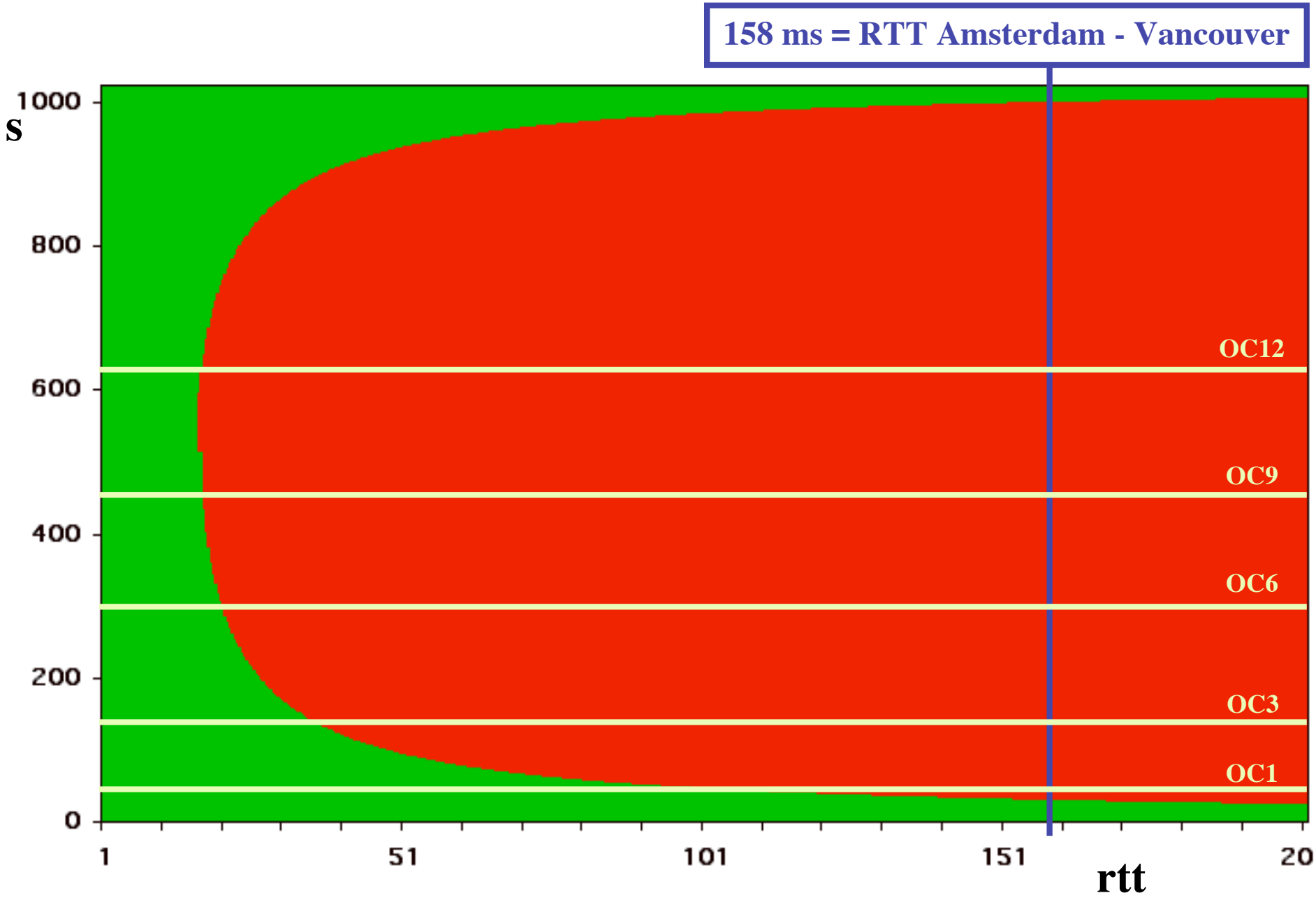
5000 1 kByte UDP packets



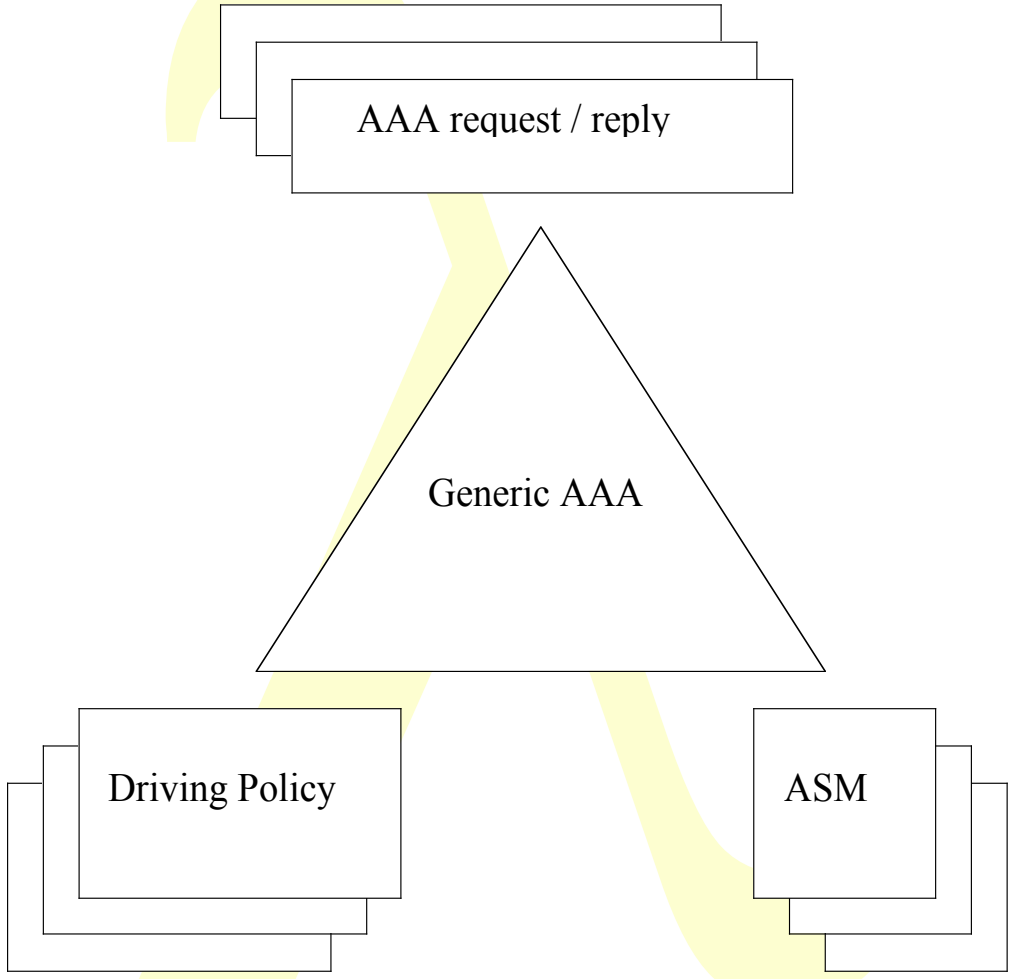
Self-clocking of TCP



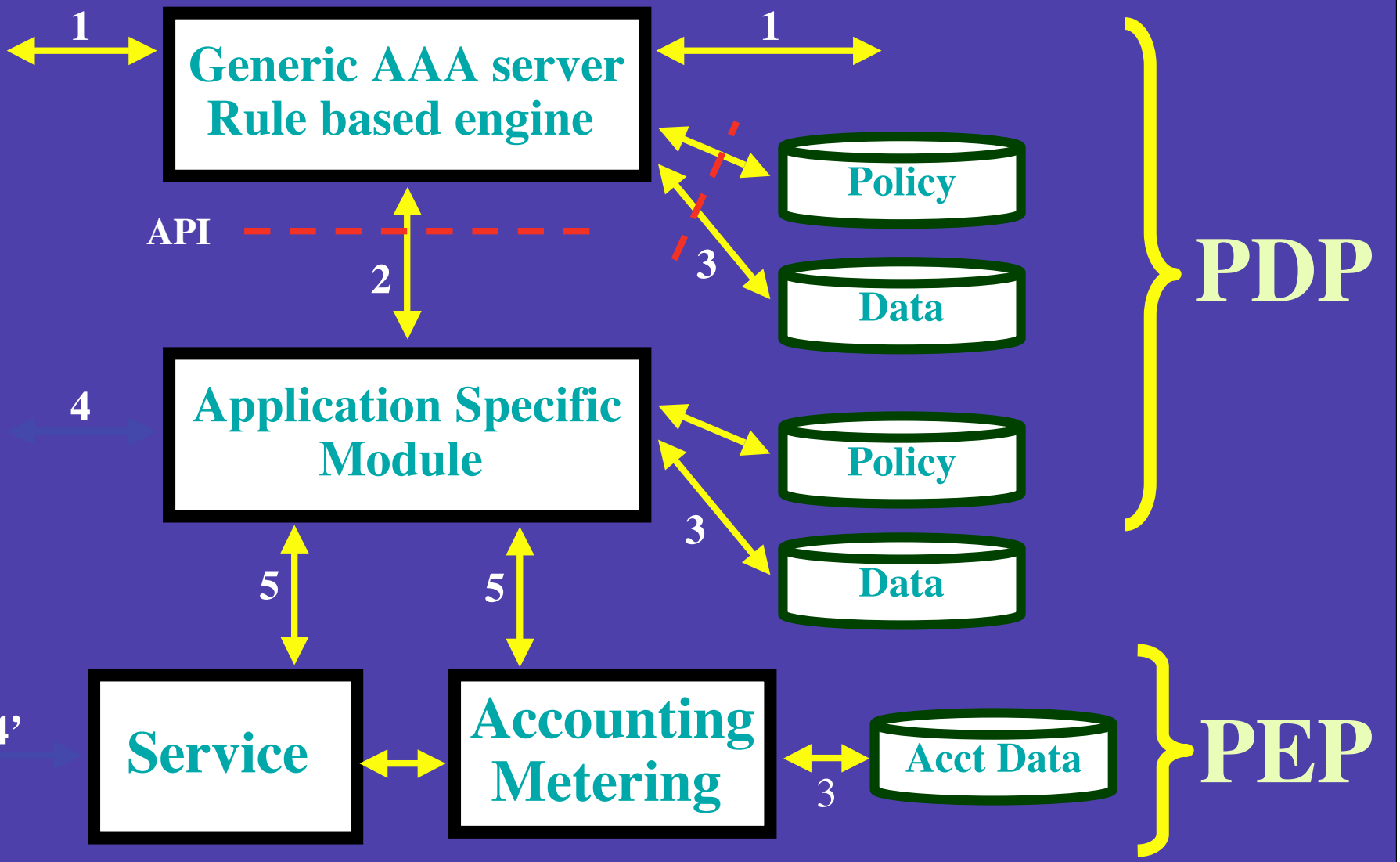
Forbidden area, solutions for s when f = 1 Gb/s, M = 0.5 Mbyte AND NOT USING FLOWCONTROL



Daisy Chain control model of administrative domains

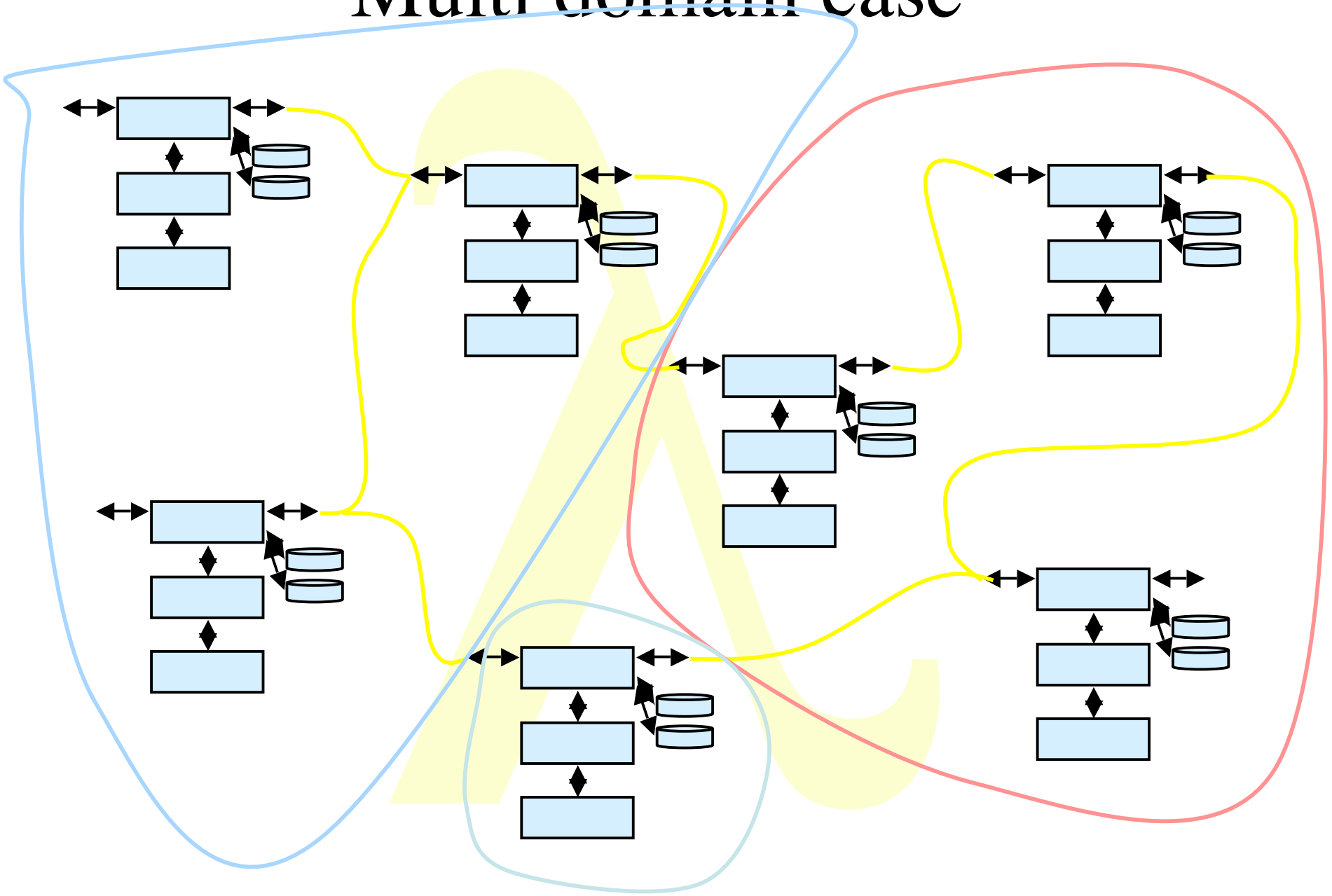


Starting point



RFC 2903 - 2906 , 3334 , policy draft

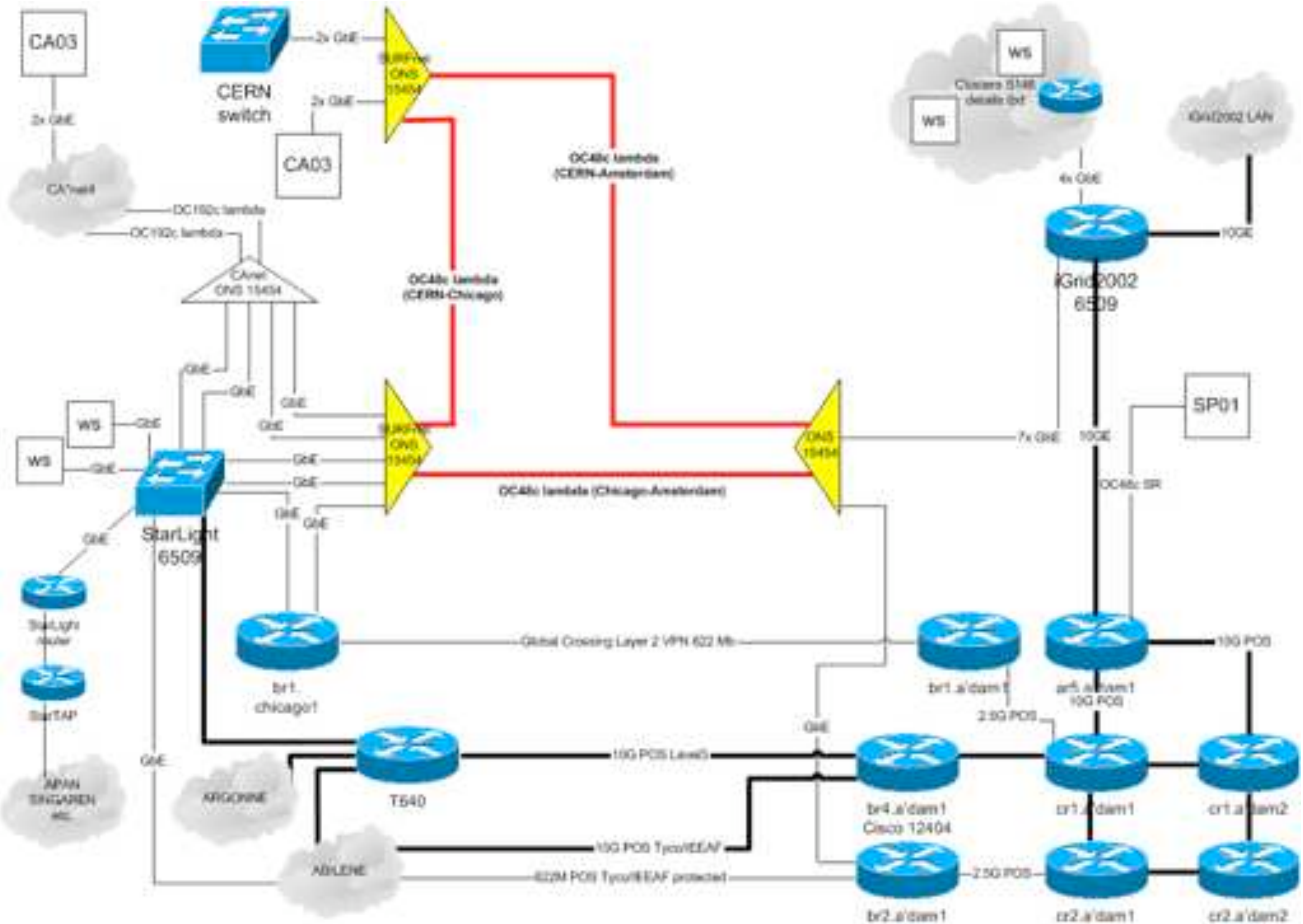
Multi domain case



iGrid2002

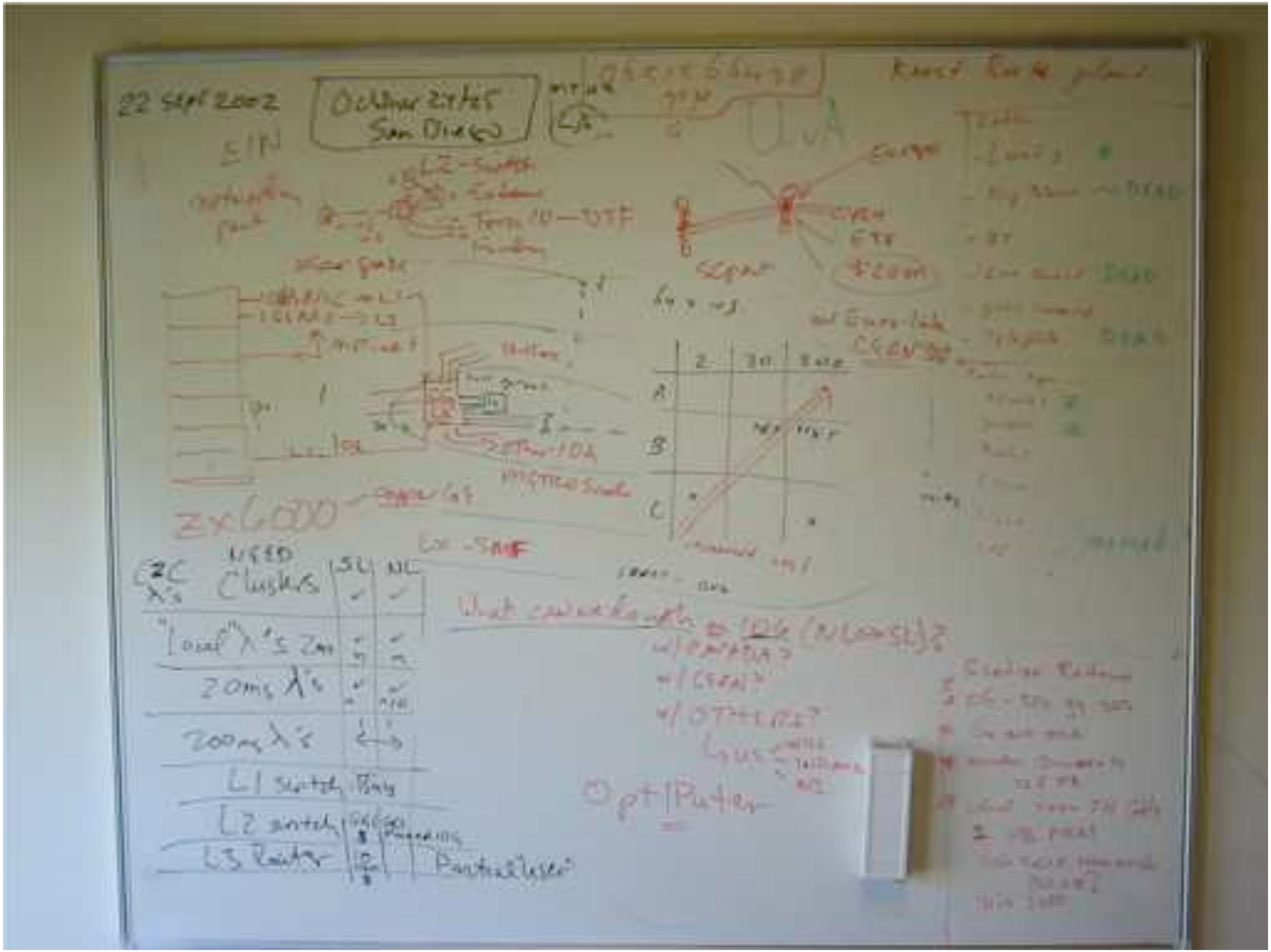
- www.igrid2002.org
- 25 demonstrations
- 16 countries (at least)
- Level3, Tyco, IEEAF Lambda's
- CISCO, Hp equipment sponsoring
- Shipping nightmare, debugging literally
- ~30 Gbit/s International connectivity
- Huge networking collaboration
- Smelly NOC in the iGrid preparation weekend

NOC


CA03
CERN switch
CA03
OC48c lambda (CERN-Amsterdam)
OC48c lambda (CERN-Chicago)
OC48c lambda (Chicago-Amsterdam)
iGrid2002 LAN
iGrid2002 6509
SP01
StarLight 6509
br1 chicago1
T640
br1.a'dam1
br4.a'dam1 Cisco 12404
br2.a'dam1
cr1.a'dam1
cr2.a'dam1
cr1.a'dam2
cr2.a'dam2
ARGONNE
ABILENE
StarTAP
10G POS Level3
10G POS Tyco/IEEAF
2.5G POS
10G POS
10GE
7x GbE
4x GbE
2x GbE
GbE
WS

GridFTP testcluster

Real Lambda's


22 Sept 2002
October 21st-25
San Diego
ZX6000
NEED
Clusters
SL
NL
20ms λ's
200ms λ's
L1 switch
L2 switch
L3 Router
Partial use
OptIPuter

American tourist in Amsterdam

Lessons learned

- Most applications could not cope with the network!!!
- No bottleneck whatsoever in the network
- Many got about 50 - 100 mbit/s singlestream tcp
- On Sunday evening my laptop had the highest single stream to Chicago (~ 340 Mbit/s)
- NIC's, Linux implementation and timing problem
- Gridftp severely hit
- ~ 22 papers to be published

Revisiting the truck of tapes

Consider one fiber

- **Current technology allows 320 λ in one of the frequency bands**
- **Each λ has a bandwidth of 40 Gbit/s**
- **Transport: 320 * 40*10^9 / 8 = 1600 GByte/sec**

- **Take a 10 metric ton truck**
  - **One tape contains 50 Gbyte, weights 100 gr**
  - **Truck contains (10000 / 0.1) * 50 Gbyte = 5 PByte**

- **Truck / fiber = 5 PByte / 1600 GByte/sec = 3125 s ≈ one hour**
- **For distances further away than a truck drives in one hour (50 km) minus loading and handling 100000 tapes the fiber wins!!!**

The END

Thanks to
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CANARIE: Bill St. Arnaud
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EU-IST project DATATAG