Internet Innovation to support Science & Education.

Cees de Laat

EU

COMMIT

UvA

NWO

PID/EFRO

SURFnet

NLESC

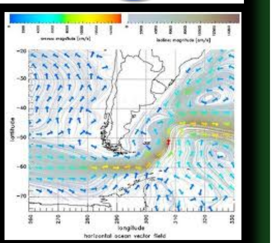
TNO

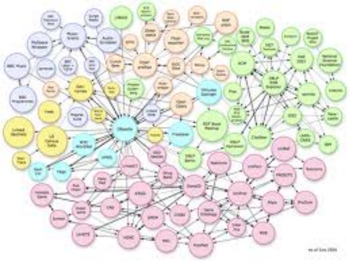
NWO/ncf

Internet developments

... more data!

Google





... more realtime!

YouTube

twitter

myspace
a place for freedom

SchoolBANK

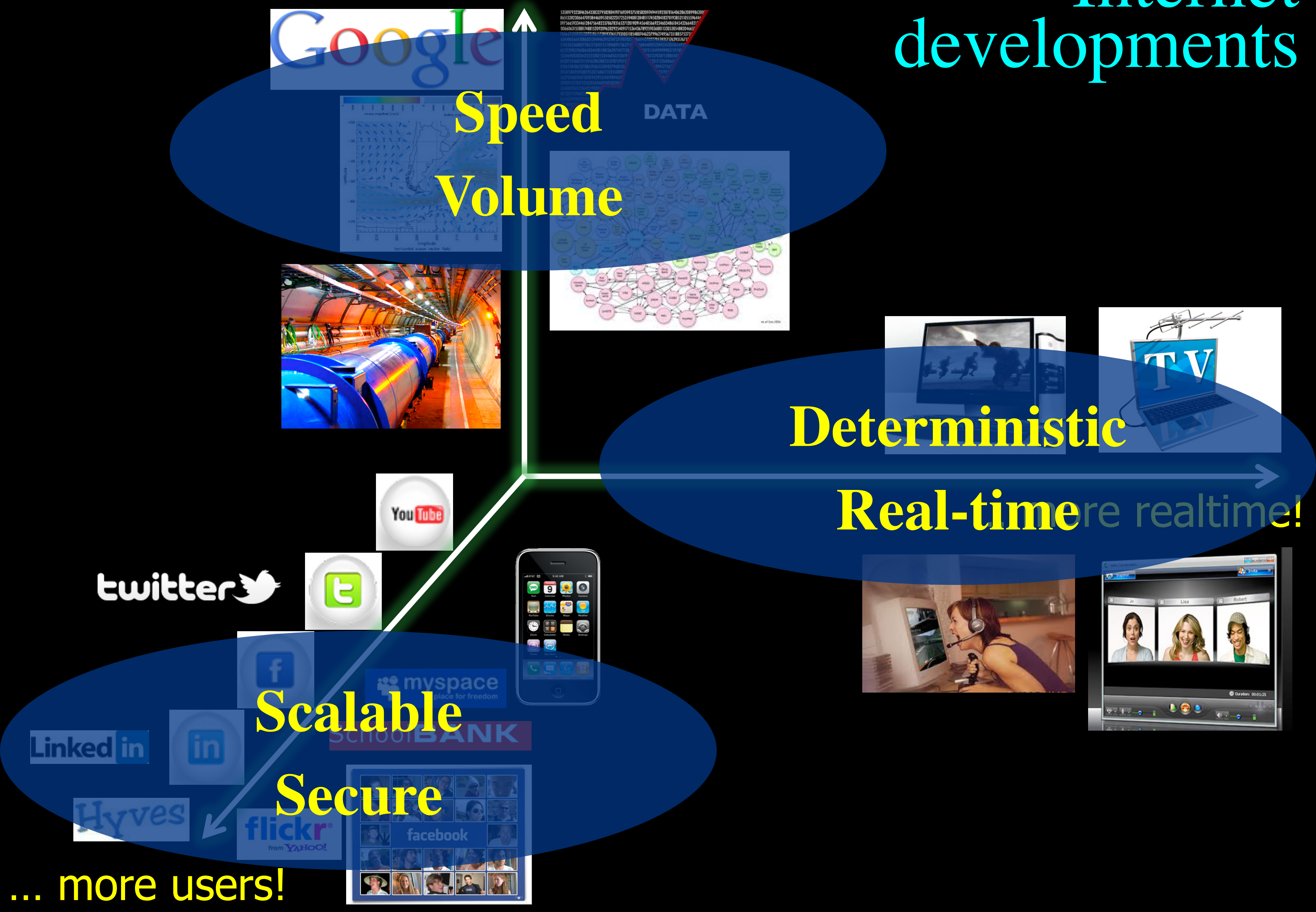
Linked in

Hyves

flickr
from YAHOO!

... more users!

Internet developments



... more data!

Speed

Volume

Deterministic

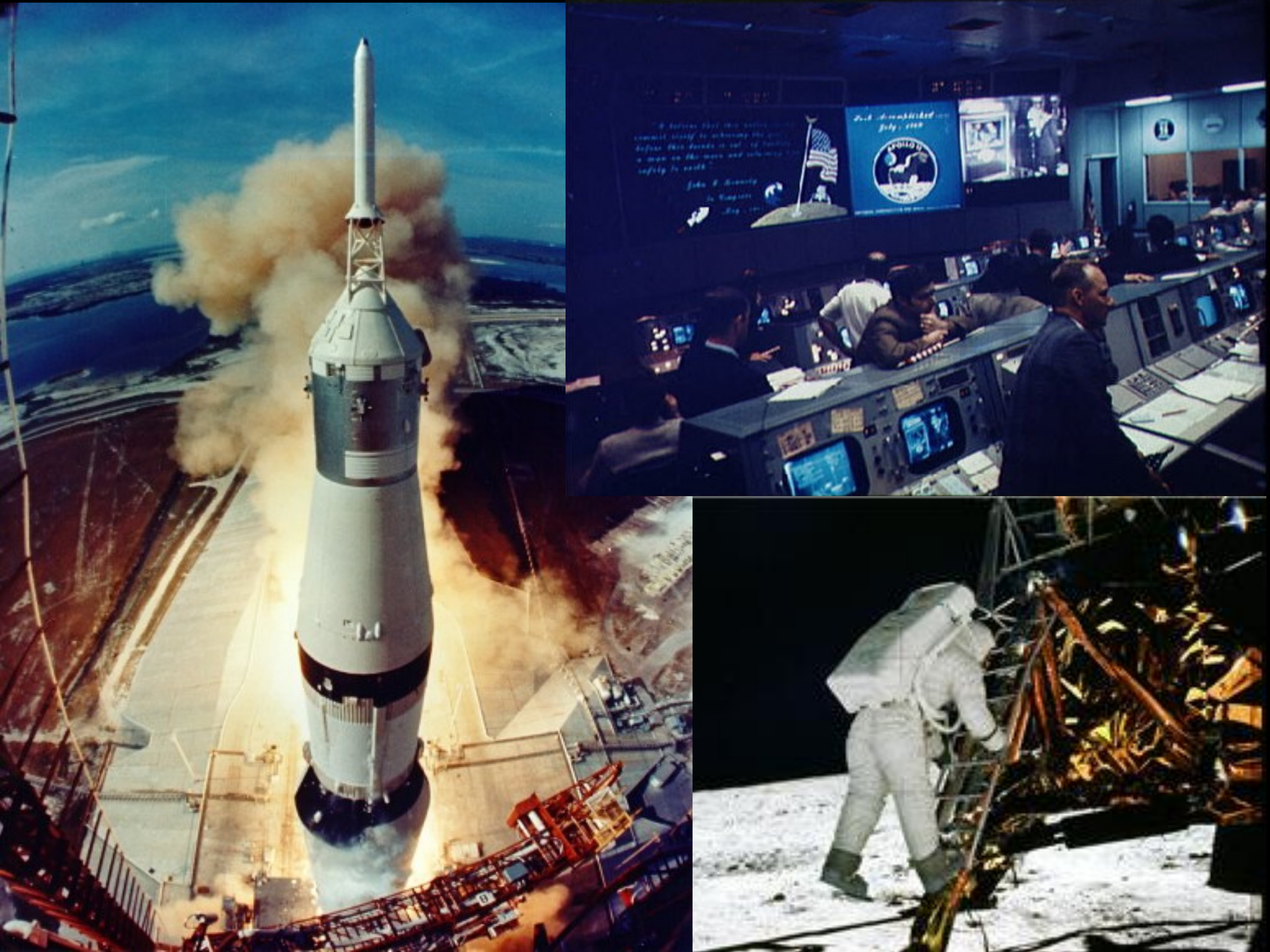
Real-time

... more realtime!

Scalable

Secure

... more users!



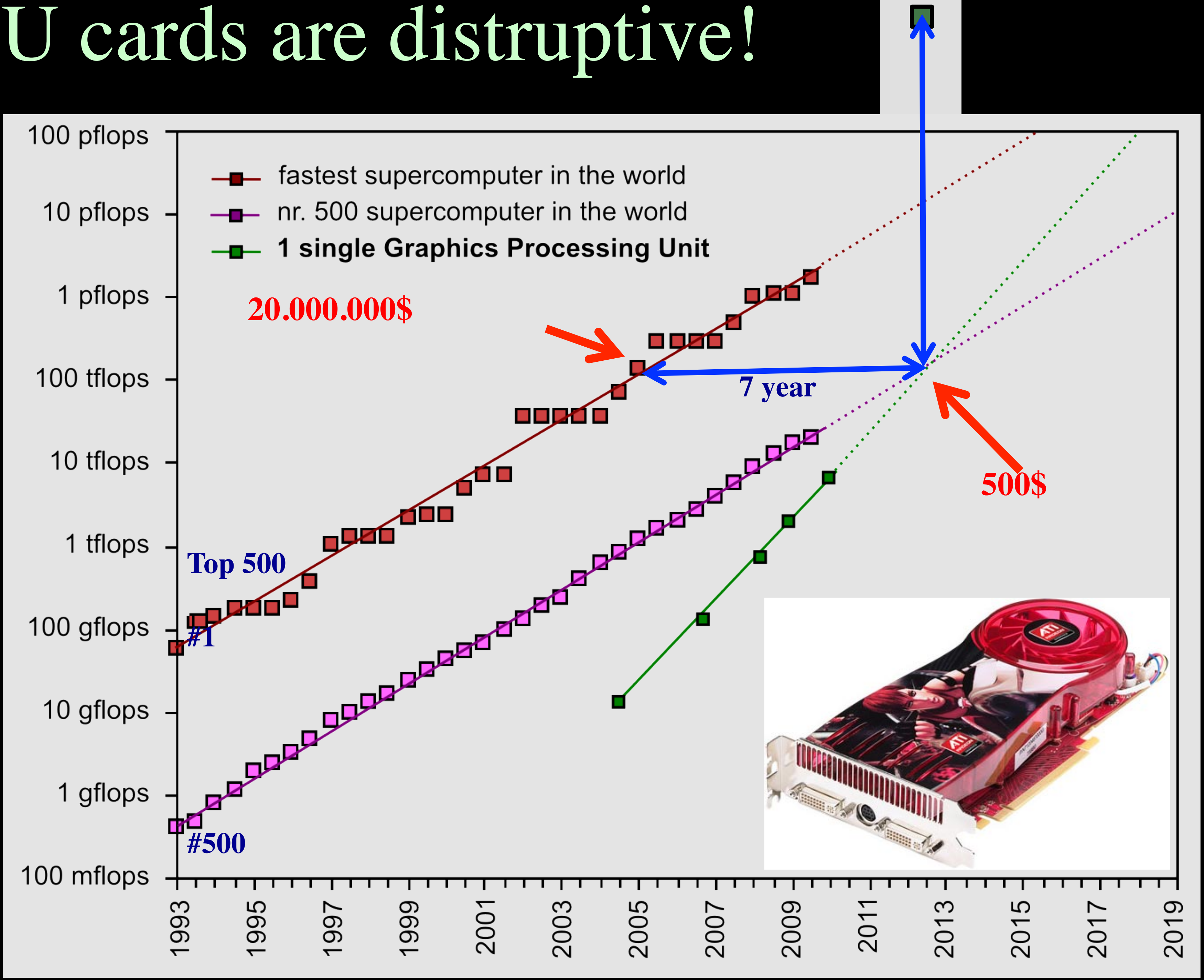
APOLLO 11

OFF
TEMP
GIMBAL LOCK
PROG
RESTART
TRACKER
VERB
NOUN
+
7
8
9
−
4
5
6
0
1
2
CSM/LM FINAL SEP-2

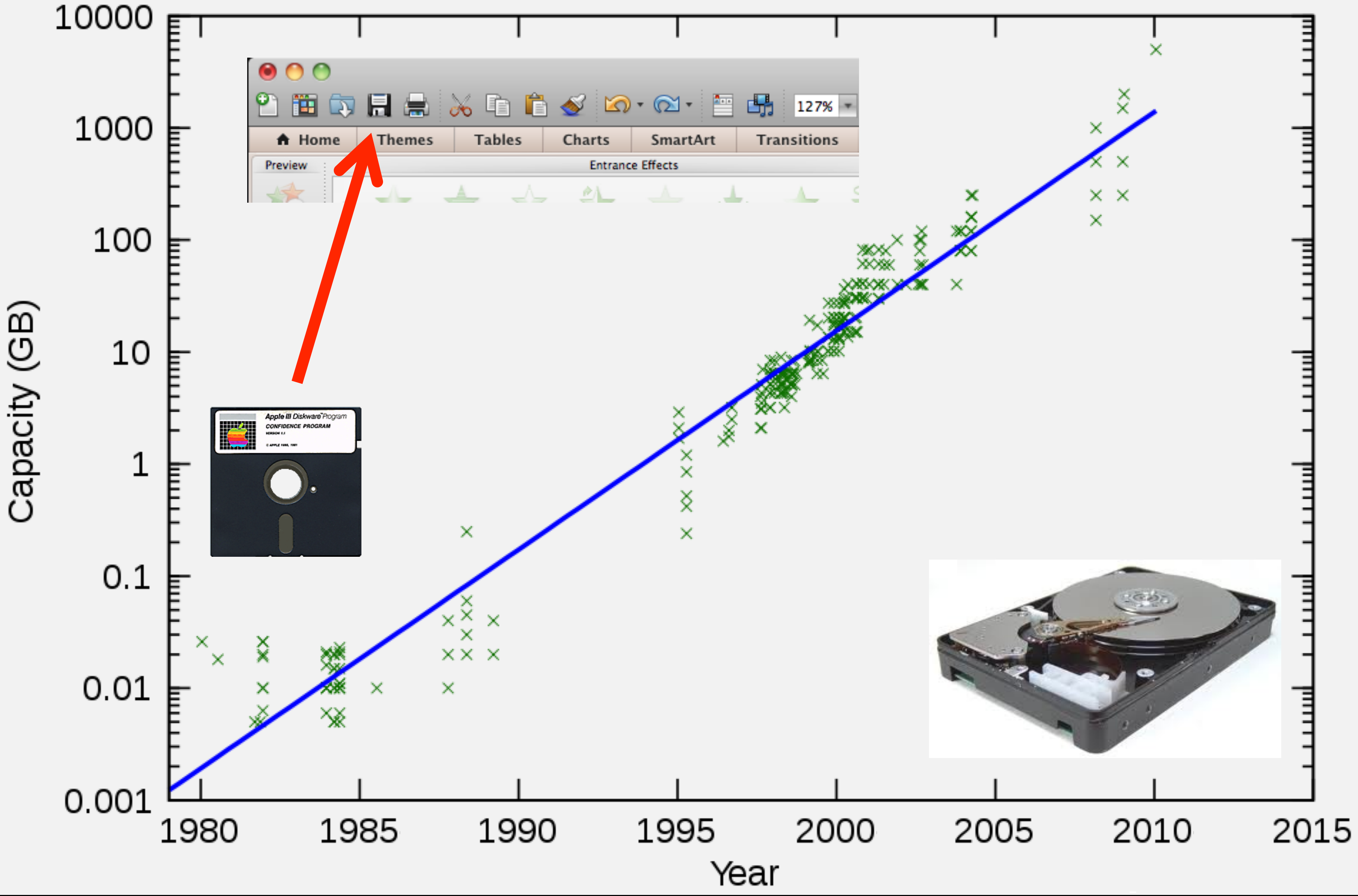
UPLINK ACTY
TEMP
AUTO
GIMBAL LOCK
HOLD
PROG
FREE
RESTART
NO ATT
TRACKER
STBY
ALT
KEY REL
OPR ERR
COMP ACTY
PROG
VERB
NOUN
+
7
8
9
CLR
−
4
5
6
STBY
ENTR
1
2
3
KEY REL
RSET

AT&T
3G
9:42 AM
Tuesday
9
Text
Calendar
Photos
Camera
YouTube
Stocks
280
Maps
73°
Weather
Clock
Calculator
Notes
Settings
iTunes
App Store
Phone
Mail
Safari
iPod
UPLINK ACTY
TEMP
AUTO
GIMBAL LOCK
PROG
RESTART
NO ATT
TRACKER
STBY
ALT
KEY REL
OPR ERR
COMP ACTY
PROG
VERB
NOUN
VERB
NOUN
CLR
ENTR
STBY
RSET
KEY REL

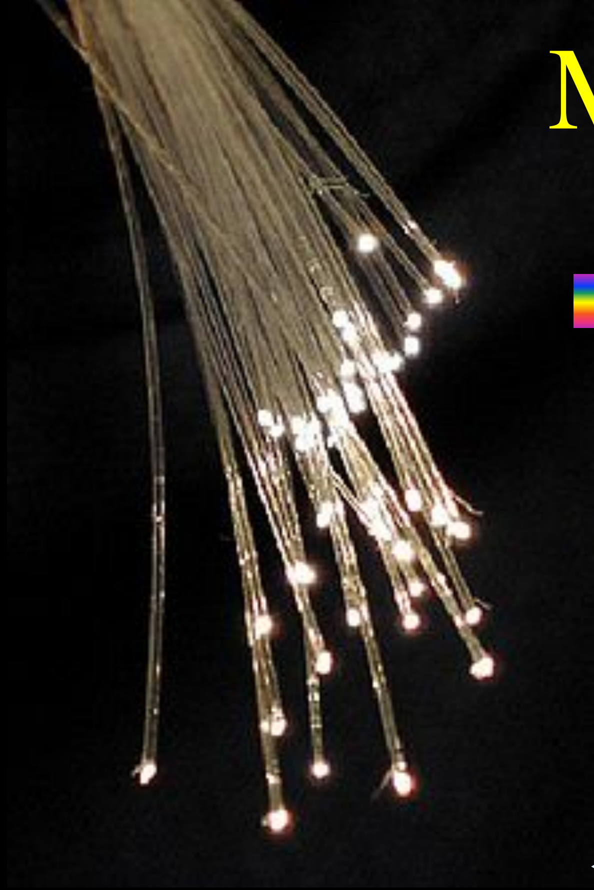
GPU cards are distruptive!

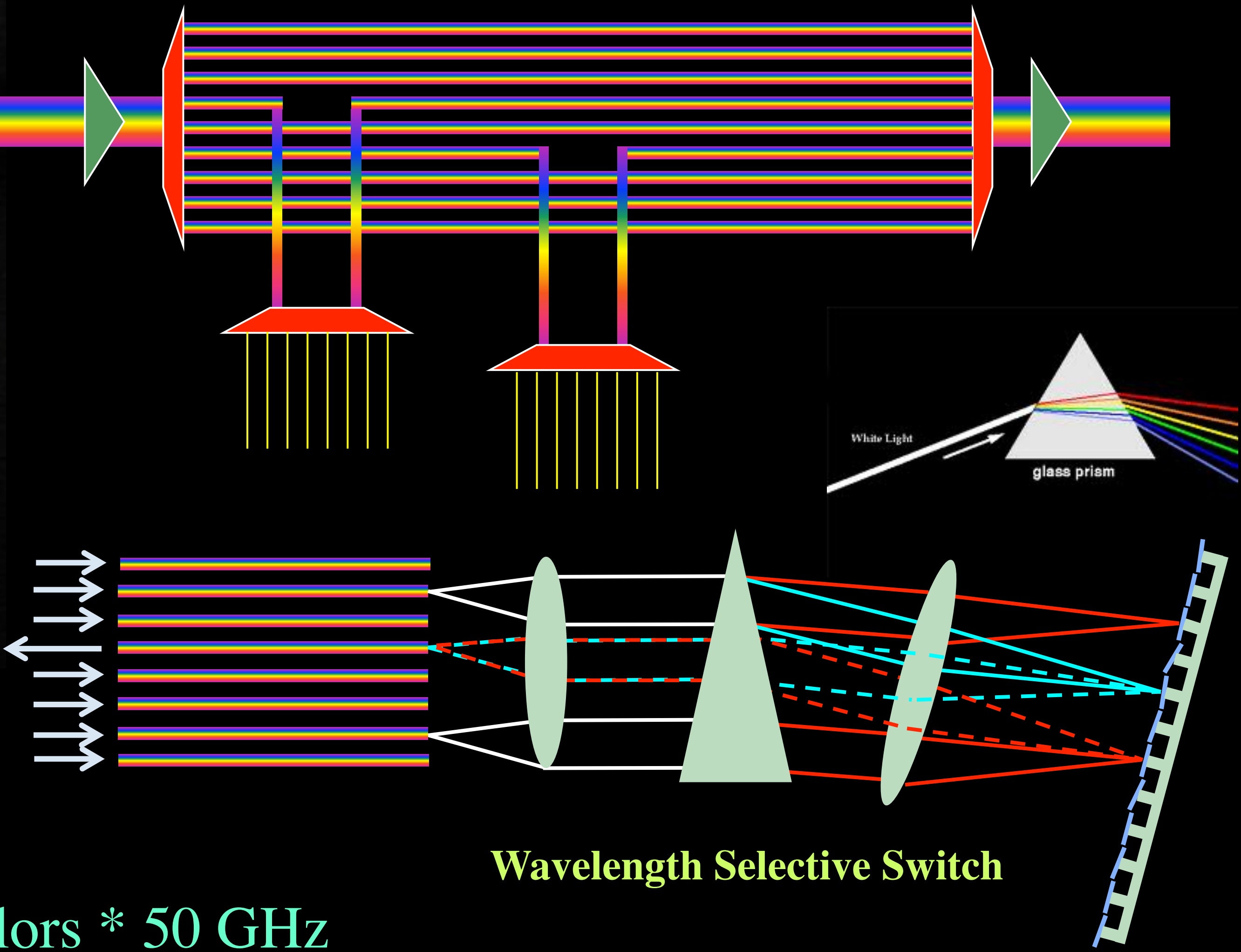


Data storage: doubling every 1.5 year!



Multiple colors / Fiber





Wavelength Selective Switch

Per fiber: ~ 80-100 colors * 50 GHz

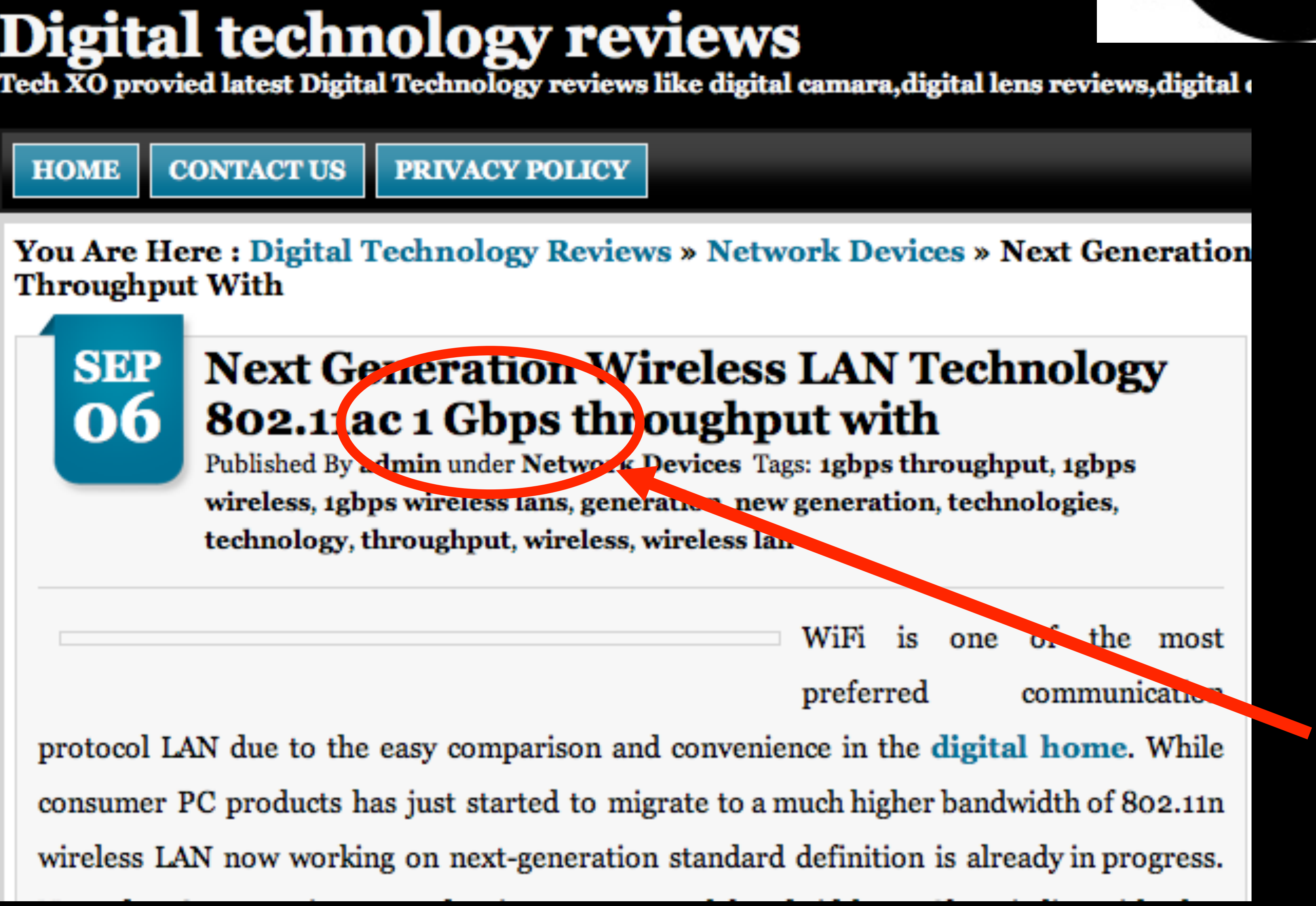
Per color: 10 – 40 – 100 Gbit/s

BW * Distance ~ $2*10^{17}$ bm/s

New: Hollow Fiber!

➔ less RTT!

Wireless Networks



Digital technology reviews

Tech XO provied latest Digital Technology reviews like digital camara,digital lens reviews,digital

You Are Here : Digital Technology Reviews » Network Devices » Next Generation Throughput With

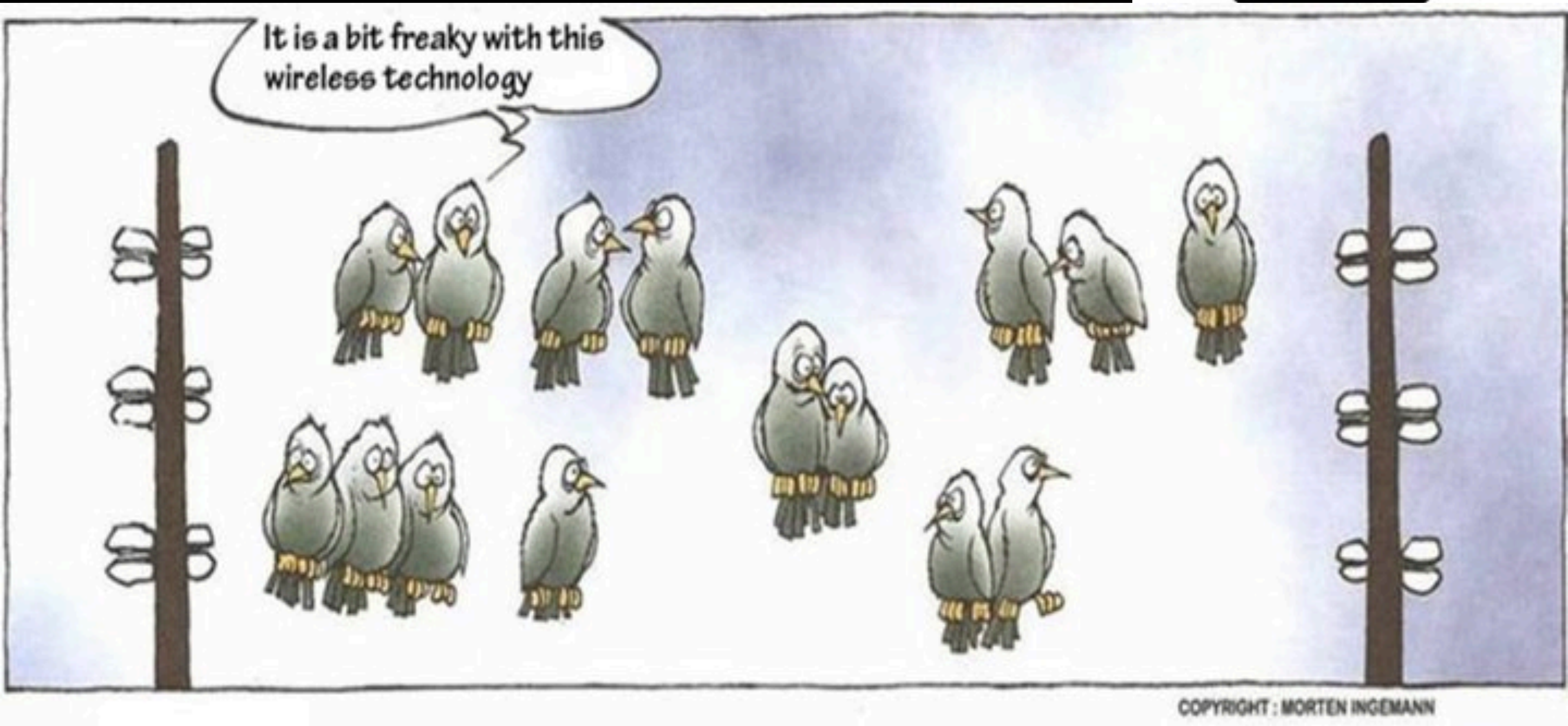
SEP 06

Next Generation Wireless LAN Technology 802.11ac 1 Gbps throughput with

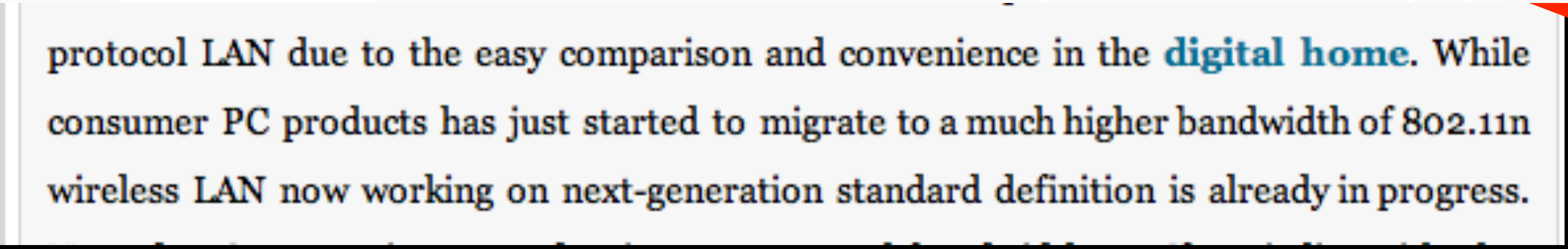
Published By admin under Network Devices Tags: 1gbps throughput, 1gbps wireless, 1gbps wireless lans, generation, new generation, technologies, technology, throughput, wireless, wireless lan

WiFi is one of the most preferred communication protocol LAN due to the easy comparison and convenience in the digital home. While consumer PC products has just started to migrate to a much higher bandwidth of 802.11n wireless LAN now working on next-generation standard definition is already in progress.

Wireless Networks



COPYRIGHT : MORTEN INGEMANN



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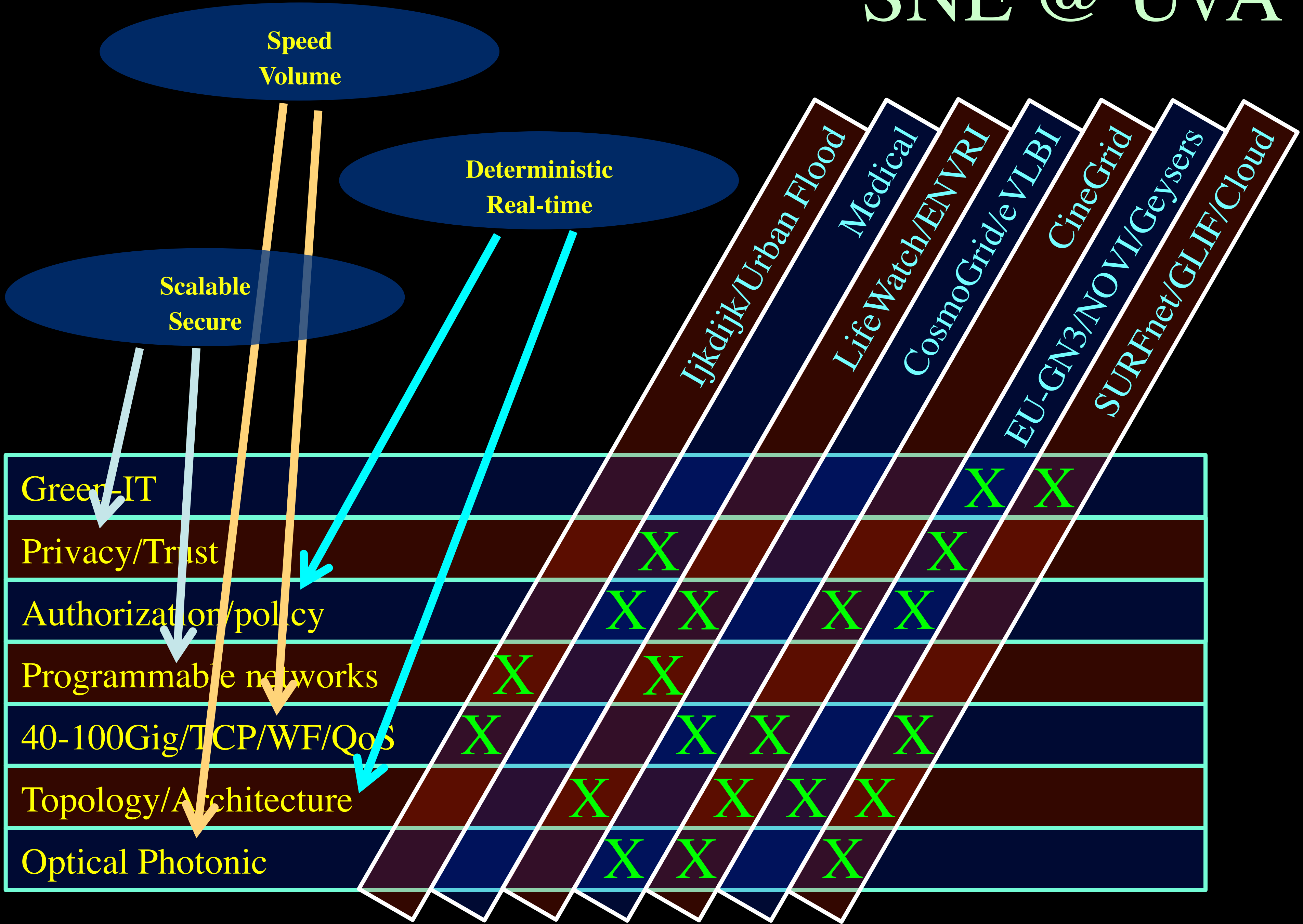
SNE @ UvA



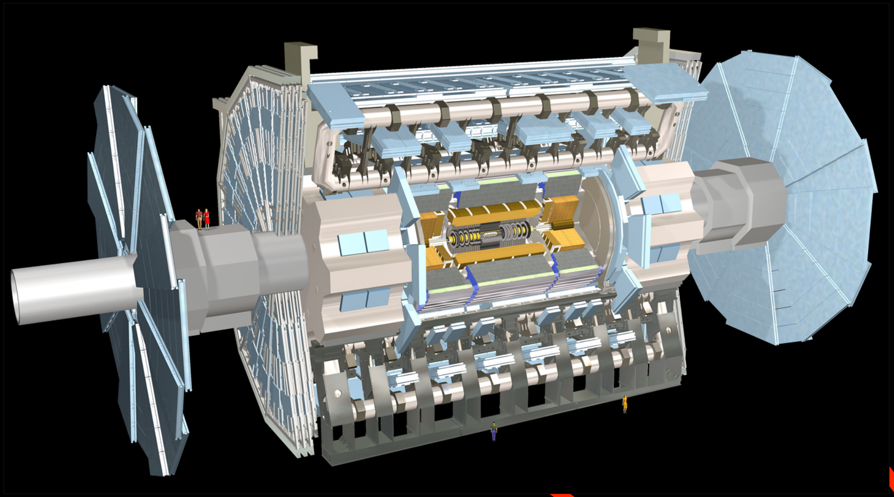
Speed
Volume

Deterministic
Real-time

Scalable
Secure

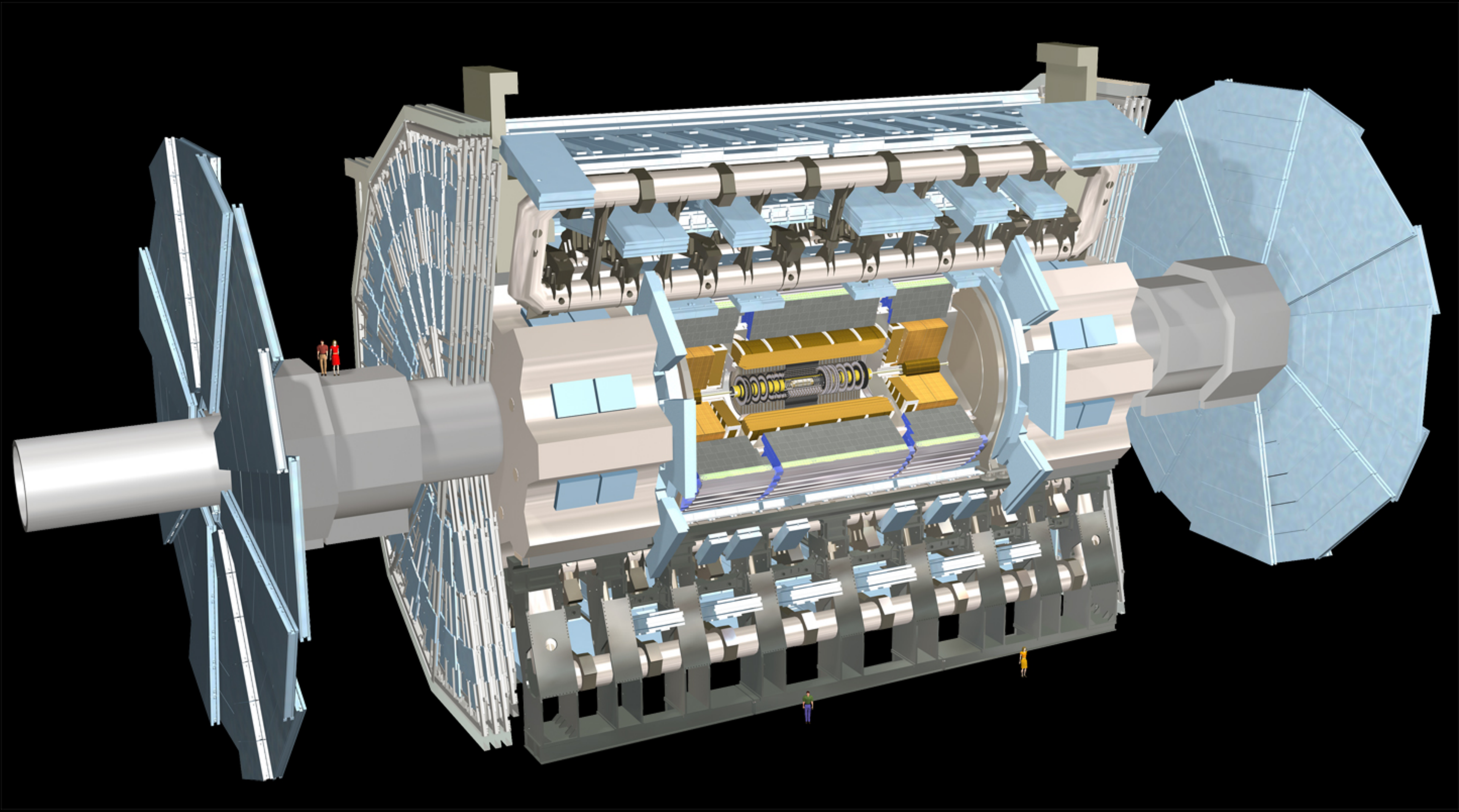
	Ijkdijk/Urban Flood	Medical	LifeWatch/ENVRI	CosmoGrid/eVLBI	CineGrid	EU-GN3/NOVI/Geysers	SURFnet/GLIF/Cloud
Green-IT						X	X
Privacy/Trust		X				X	
Authorization/policy		X	X		X	X	
Programmable networks	X		X				
40-100Gig/TCP/WF/QoS	X			X	X		X
Topology/Architecture			X		X	X	X
Optical Photonic				X	X		X

SNE @ UvA



	Ijkdijk/Urban Flood	Medical	LifeWatch/ENVRI	CosmoGrid/eVLBI	CineGrid	EU-GN3/NOVI/Geysers	SURFnet/GLIF/Cloud
Green-IT						X	X
Privacy/Trust		X				X	
Authorization/policy		X	X		X	X	
Programmable networks	X		X				
40-100Gig/TCP/WF/QoS	X			X	X		X
Topology/Architecture			X		X	X	X
Optical Photonic				X	X		X

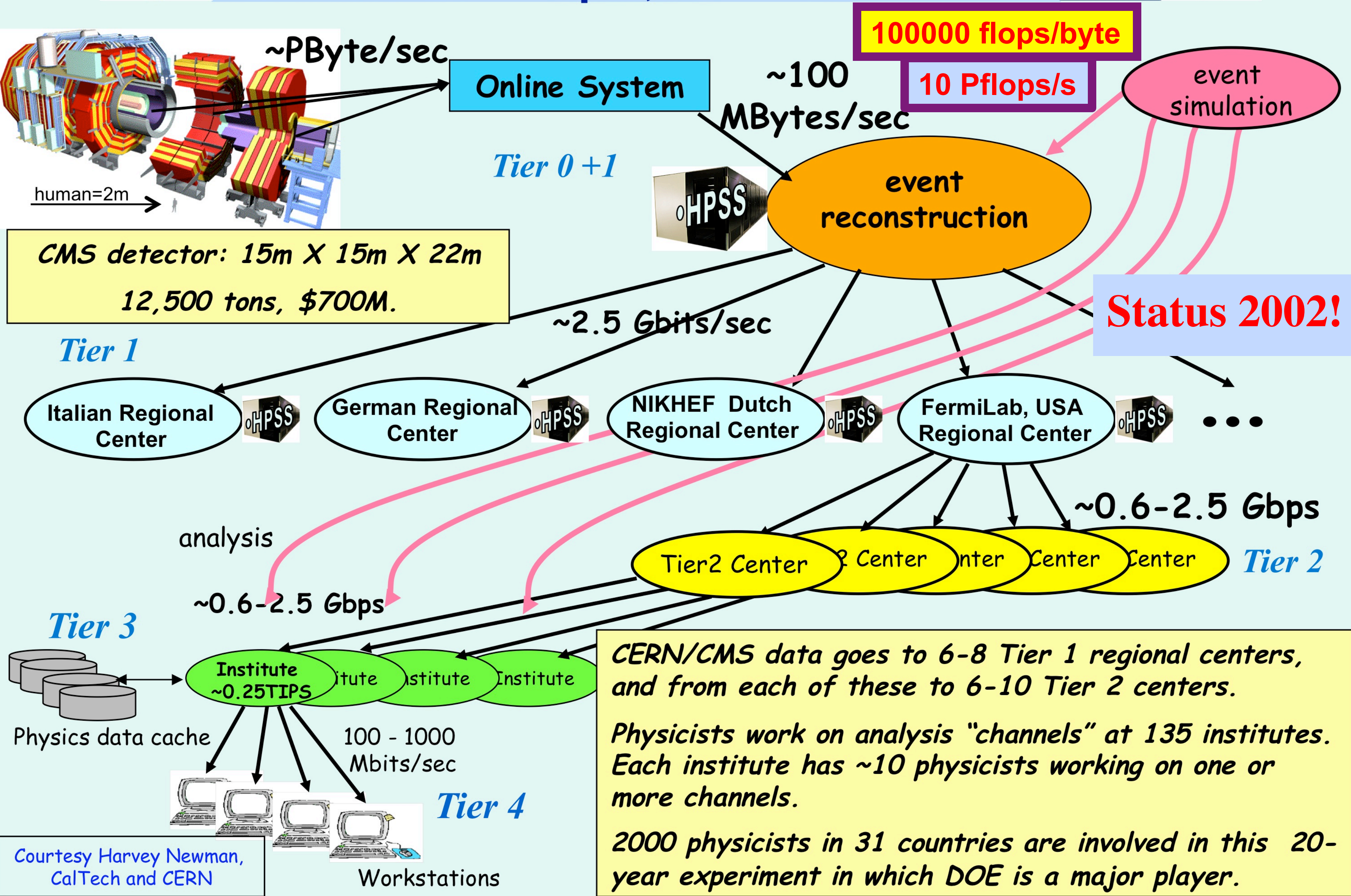
ATLAS detector @ CERN Geneve



ATLAS detector @ CERN Geneve

LHC Data Grid Hierarchy

CMS as example, Atlas is similar



CMS detector: 15m X 15m X 22m

12,500 tons, $700M.

Status 2002!

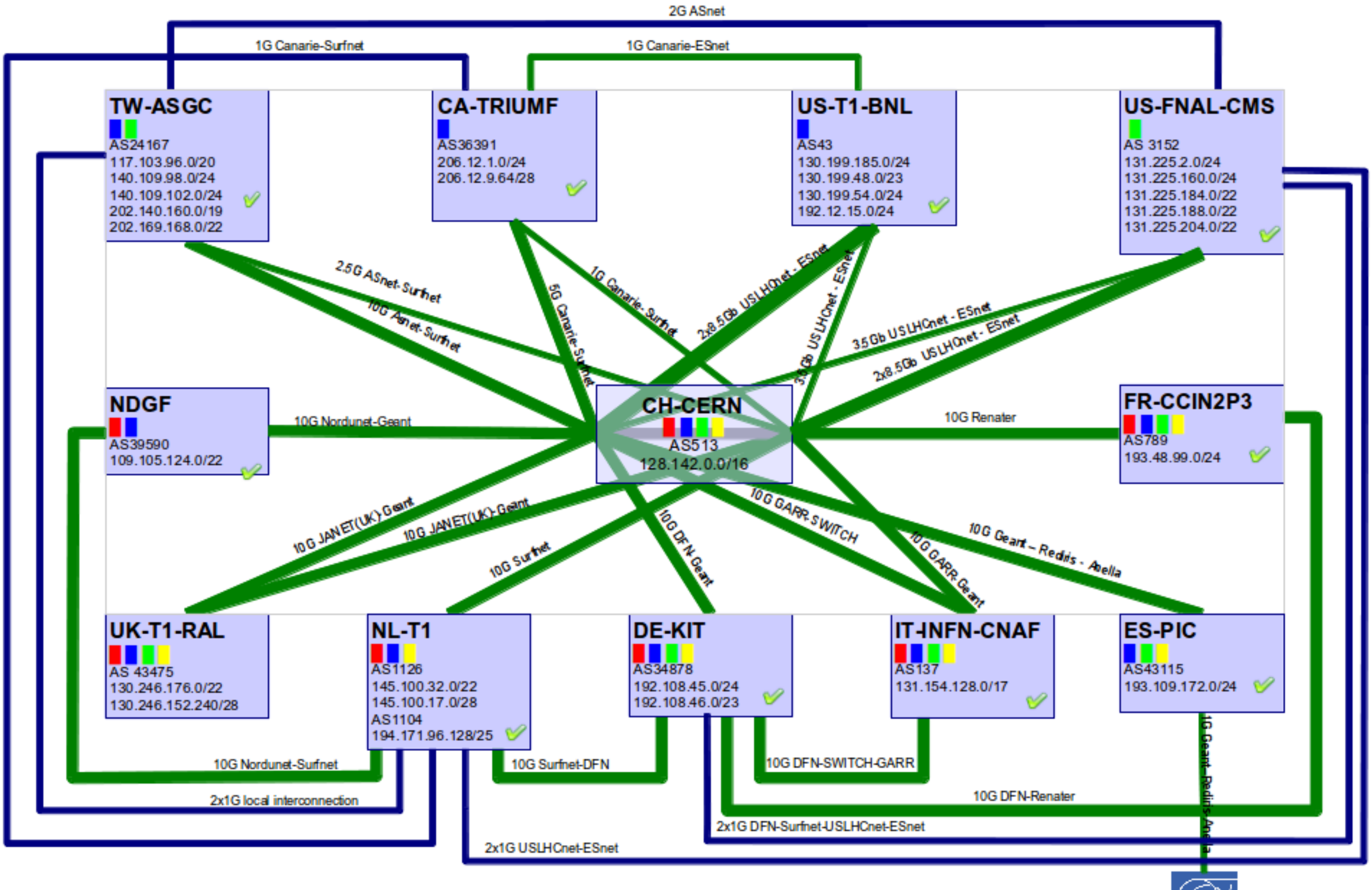
CERN/CMS data goes to 6-8 Tier 1 regional centers, and from each of these to 6-10 Tier 2 centers.

Physicists work on analysis "channels" at 135 institutes. Each institute has ~10 physicists working on one or more channels.

2000 physicists in 31 countries are involved in this 20-year experiment in which DOE is a major player.

Courtesy Harvey Newman, CalTech and CERN

LHCOPN



TW-ASGC
🟦🟩
AS24167
117.103.96.0/20
140.109.98.0/24
140.109.102.0/24
202.140.160.0/19
202.169.168.0/22
✓

CA-TRIUMF
🟦
AS36391
206.12.1.0/24
206.12.9.64/28
✓

US-T1-BNL
🟦
AS43
130.199.185.0/24
130.199.48.0/23
130.199.54.0/24
192.12.15.0/24
✓

US-FNAL-CMS
🟩
AS 3152
131.225.2.0/24
131.225.160.0/24
131.225.184.0/22
131.225.188.0/22
131.225.204.0/22
✓

NDGF
🟥🟦
AS39590
109.105.124.0/22
✓

CH-CERN
🟥🟦🟩🟨
AS513
128.142.0.0/16

FR-CCIN2P3
🟥🟦🟩🟨
AS789
193.48.99.0/24
✓

UK-T1-RAL
🟥🟦🟩🟨
AS 43475
130.246.176.0/22
130.246.152.240/28

NL-T1
🟥🟦🟨
AS1126
145.100.32.0/22
145.100.17.0/28
AS1104
194.171.96.128/25
✓

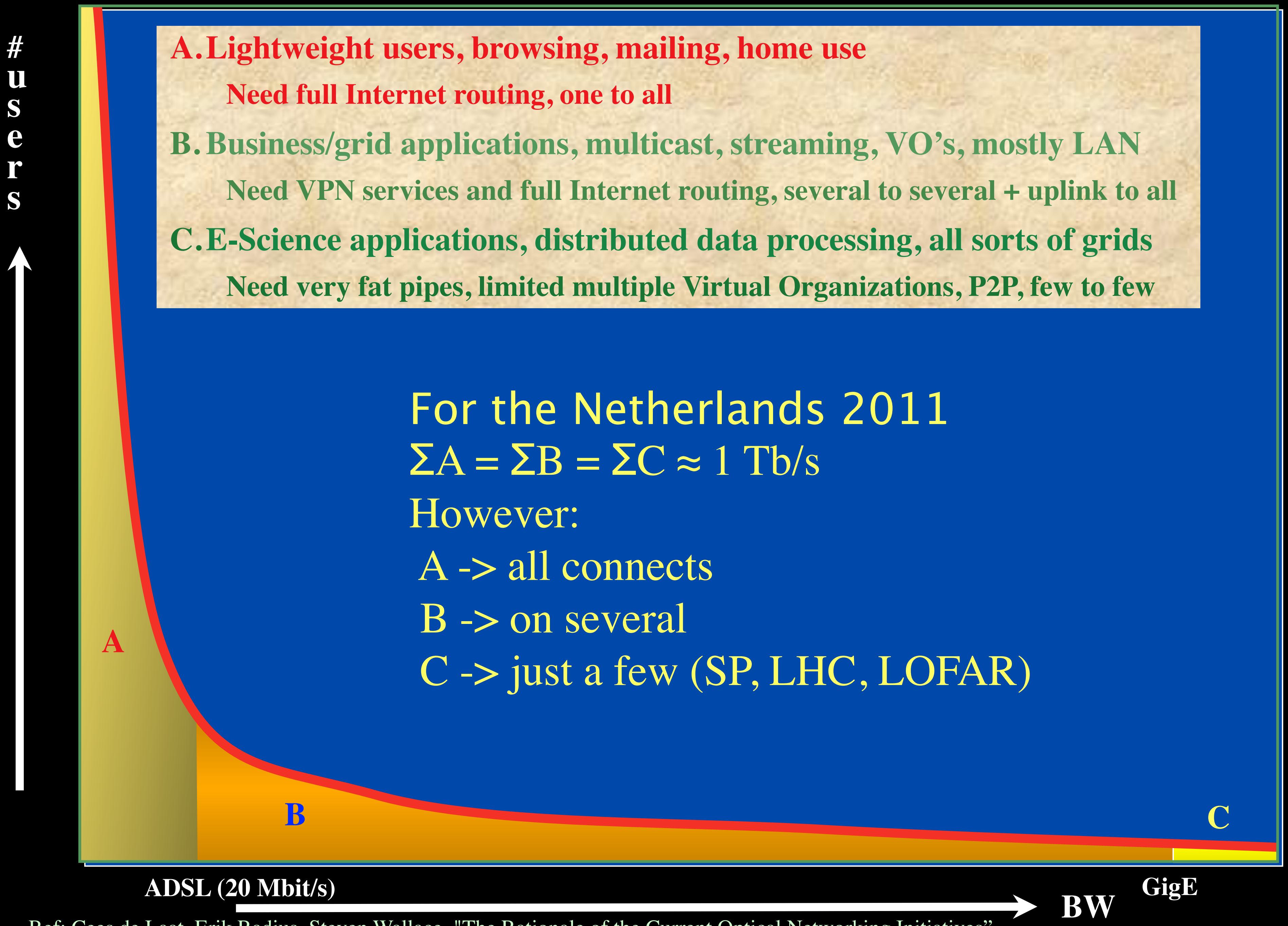
DE-KIT
🟥🟦🟩🟨
AS34878
192.108.45.0/24
192.108.46.0/23
✓

IT-INFN-CNAF
🟥🟦🟩🟨
AS137
131.154.128.0/17
✓

ES-PIC
🟦🟩🟨
AS43115
193.109.172.0/24
✓

▬ T0-T1 and T1-T1 traffic
▬ T1-T1 traffic only
▬ ▬ ▬ Not deployed yet
▬ (thick) >= 10Gbps
▬ (thin) <10Gbps

🟥 = Alice 🟦 = Atlas
🟩 = CMS 🟨 = LHCb
✓ = internet backup available
p2p prefix: 192.16.166.0/24



A. Lightweight users, browsing, mailing, home use

Need full Internet routing, one to all

B. Business/grid applications, multicast, streaming, VO's, mostly LAN

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

C. E-Science applications, distributed data processing, all sorts of grids

Need very fat pipes, limited multiple Virtual Organizations, P2P, few to few

For the Netherlands 2011

$\Sigma A = \Sigma B = \Sigma C \approx 1$ Tb/s

However:

A -> all connects

B -> on several

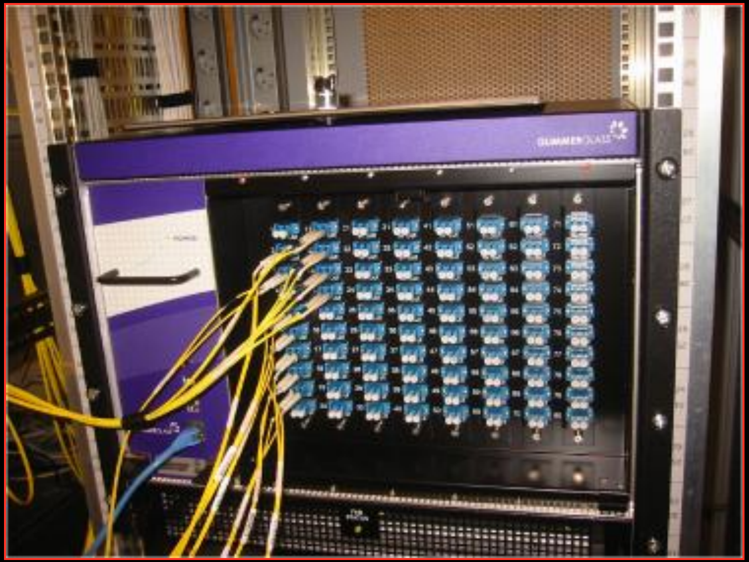
C -> just a few (SP, LHC, LOFAR)

Ref: Cees de Laat, Erik Radius, Steven Wallace, "The Rationale of the Current Optical Networking Initiatives"
iGrid2002 special issue, Future Generation Computer Systems, volume 19 issue 6 (2003)

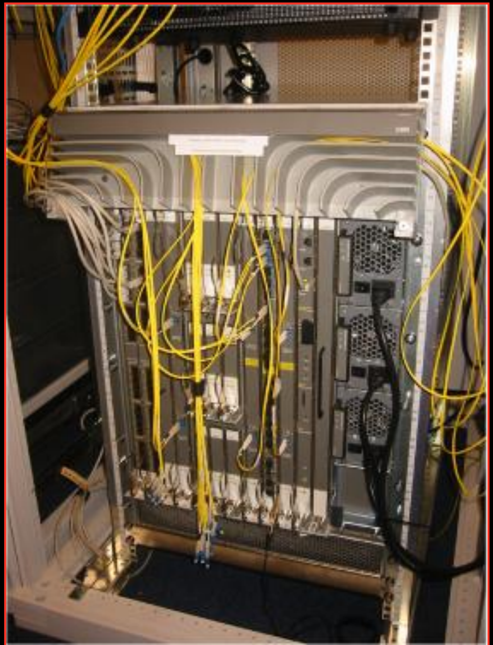
Towards Hybrid Networking!

- 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 and L2
- Give each packet in the network the service it needs, but no more !

L1 ≈ 2-3 k$/port

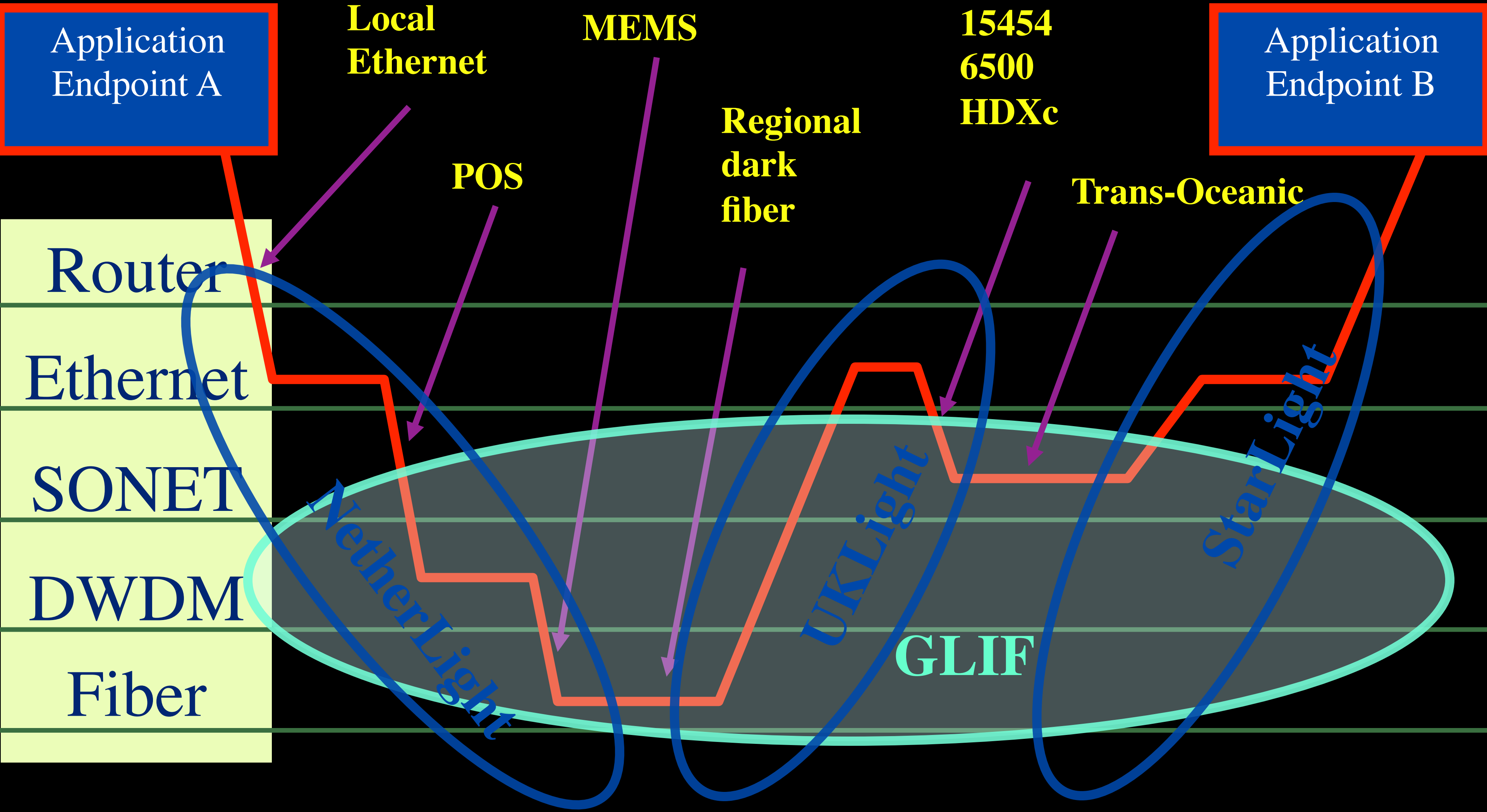


L2 ≈ 5-8 k$/port

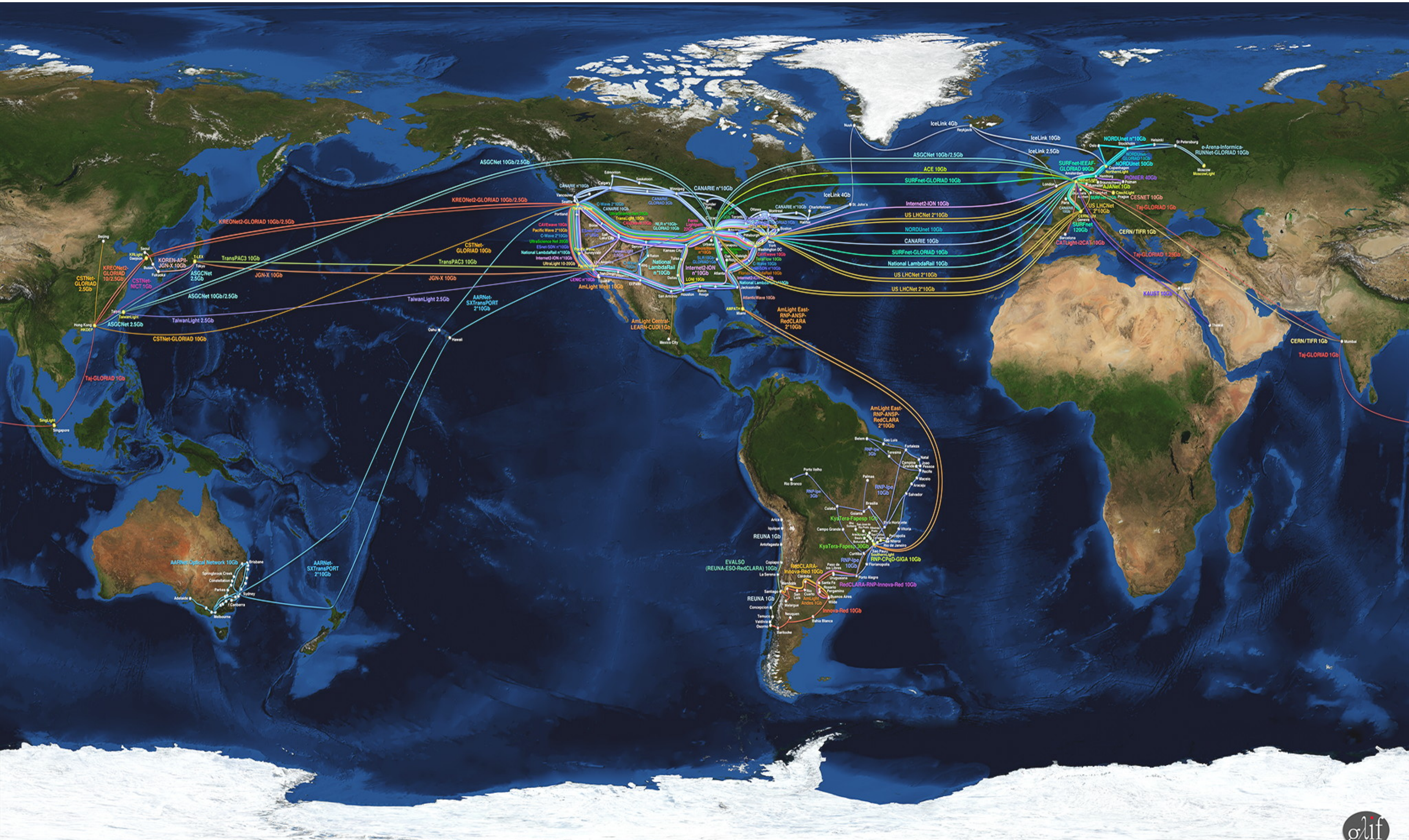


L3 ≈ 75+ k$/port

How low can you go?

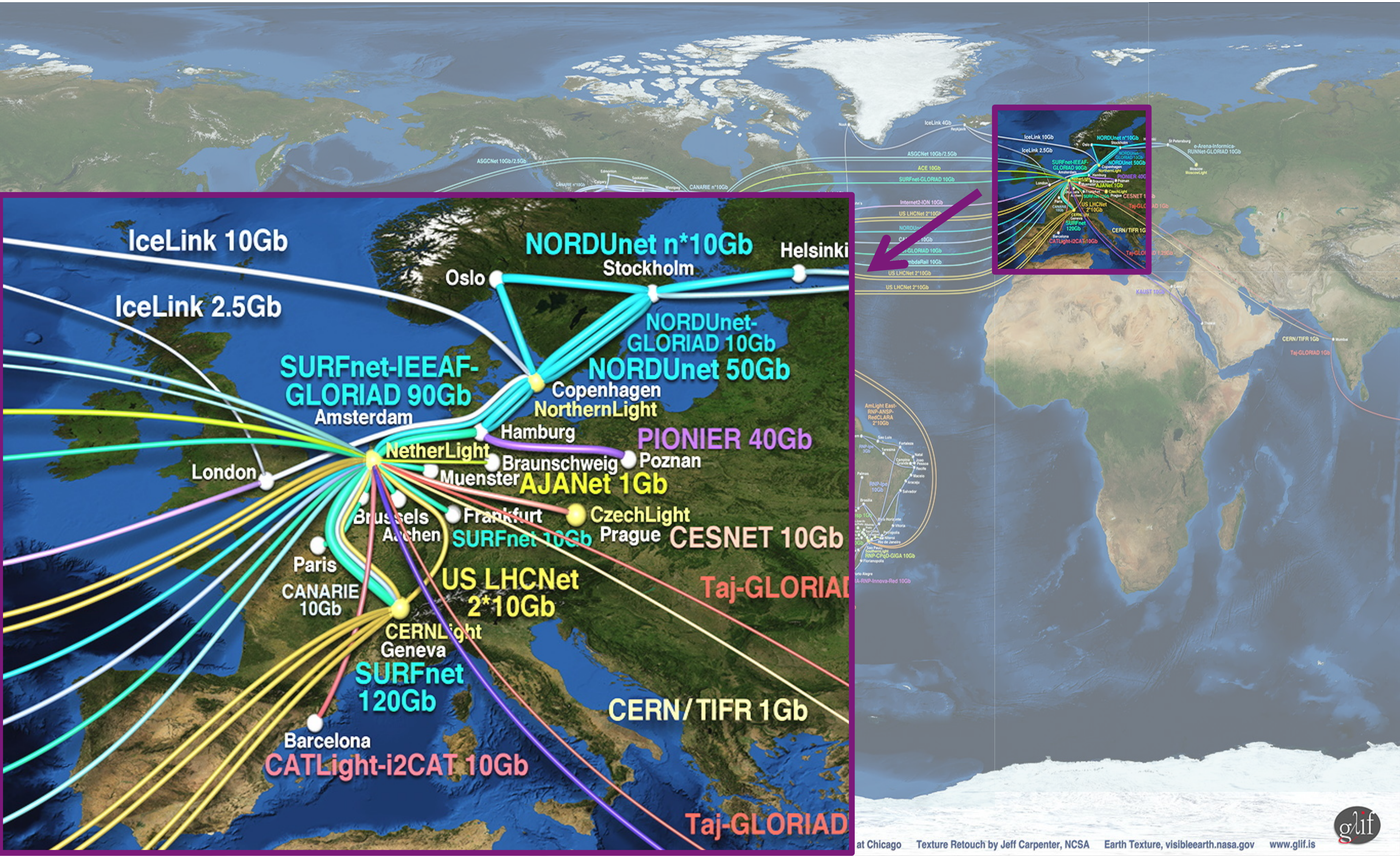


The GLIF – lightpaths around the world

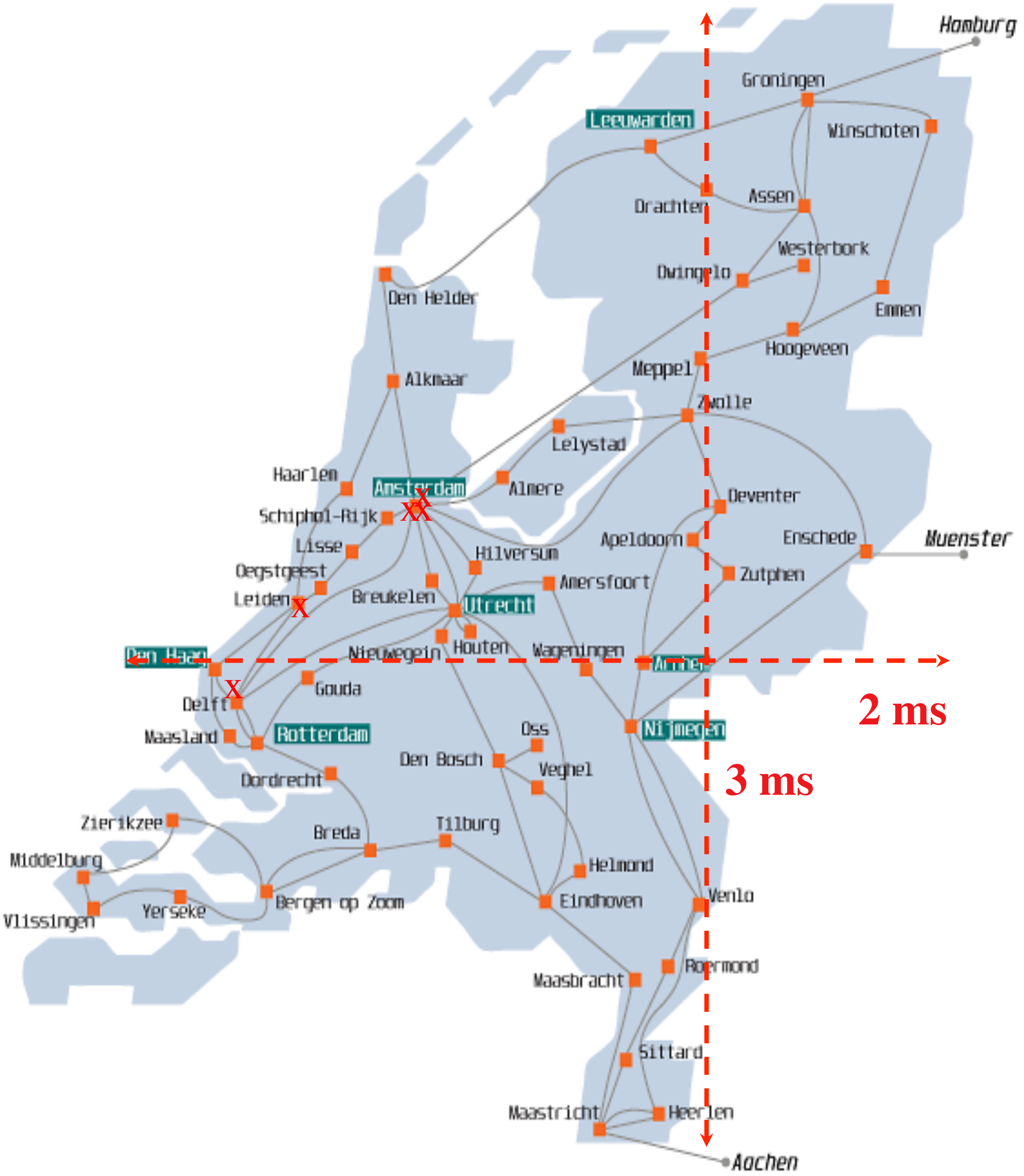


GLIF Map 2011: Global Lambda Integrated Facility   Visualization by Robert Patterson, NCSA, University of Illinois at Urbana–Champaign   Data Compilation by Maxine D. Brown, University of Illinois at Chicago   Texture Retouch by Jeff Carpenter, NCSA   Earth Texture, visibleearth.nasa.gov   www.glif.is

The GLIF – lightpaths around the world



at Chicago Texture Retouch by Jeff Carpenter, NCSA Earth Texture, visibleearth.nasa.gov www.glif.is



In The Netherlands SURFnet connects between 180:

- universities;
- academic hospitals;
- most polytechnics;
- research centers.

with an indirect ~750K user base

~ 8860 km

scale comparable to railway system

Alien light
From idea to realisation!

40Gb/s alien wavelength transmission via a multi-vendor 10Gb/s DWDM infrastructure

Alien wavelength advantages

- Direct connection of customer equipment[1] → cost savings
- Avoid OEO regeneration → power savings
- Faster time to service[2] → time savings
- Support of different modulation formats[3] → extend network lifetime

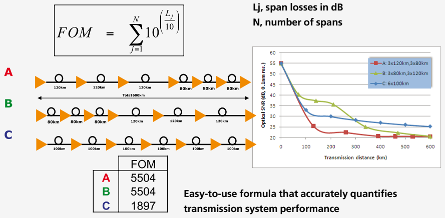
Alien wavelength challenges

- Complex end-to-end optical path engineering in terms of linear (i.e. OSNR, dispersion) and non-linear (FWM, SPM, XPM, Raman) transmission effects for different modulation formats.
- Complex interoperability testing.
- End-to-end monitoring, fault isolation and resolution.
- End-to-end service activation.

In this demonstration we will investigate the performance of a 40Gb/s PM-QPSK alien wavelength installed on a 10Gb/s DWDM infrastructure.

New method to present fiber link quality, FoM (Figure of Merit)

In order to quantify optical link grade, we propose a new method of representing system quality: the FOM (Figure of Merit) for concatenated fiber spans.



$$FOM = \sum_{j=1}^{N} 10^{\left(\frac{L_j}{10}\right)}$$

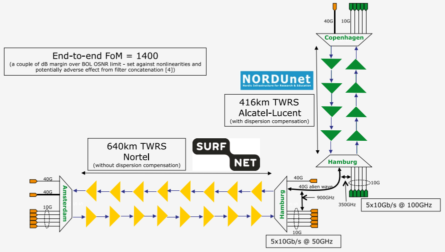
Lj, span losses in dB
N, number of spans

	FOM
A	5504
B	5504
C	1897

Easy-to-use formula that accurately quantifies transmission system performance

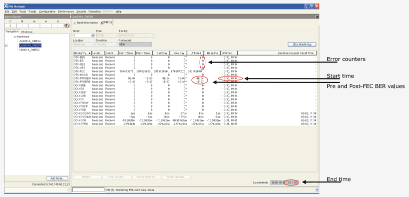
Transmission system setup

JOINT SURFnet/NORDUnet 40Gb/s PM-QPSK alien wavelength DEMONSTRATION.



End-to-end FoM = 1400
(a couple of dB margin over BOL OSNR limit - set against nonlinearities and potentially adverse effect from filter concatenation [4])

Test results



Shelf: 1 Type: OTM3 Facility: OTM3-1-2-1
Location: Near end Direction: Receive Port mode: SDH

Monitor Ty...	Locati...	Directi...	Curr 15min	Prev 15min	Curr Day	Prev Day	Untimed	Baseline	Untimed ...	Baseline Counter Reset Time
OTU-BBE	Near end	Receive	0	0	0	0?	0	-	10-30, 19:34	
OTU-ES	Near end	Receive	0	0	0	0?	0	-	10-30, 19:34	
OTU-SES	Near end	Receive	0	0	0	0?	0	-	10-30, 19:34	
OTU-OFS	Near end	Receive	0	0	0	0?	0	-	10-30, 19:34	
OTU-FEC	Near end	Receive	151453879...	381525803...	285575836...	676387202...	353162610...	-	10-30, 19:34	
OTU-HCCS	Near end	Receive	0	0	0	0?	0	-	10-30, 19:34	
OTU-PRFBER	Near end	Receive	9E-04	1E-03	9E-04	1E-03?	9E-04	-	10-30, 19:34	
OTU-PFBERE	Near end	Receive	1E-37	1E-37	1E-37	1E-37?	1E-37	-	10-30, 19:34	
ODU-BBE	Near end	Receive	0	0	0	0?	0	-	10-30, 19:34	
ODU-ES	Near end	Receive	0	0	0	0?	0	-	10-30, 19:34	
ODU-SES	Near end	Receive	0	0	0	0?	0	-	10-30, 19:34	
ODU-UAS	Near end	Receive	0	0	0	0?	0	-	10-30, 19:34	
ODU-FC	Near end	Receive	0	0	0	0?	0	-	10-30, 19:34	
ODU-PSCW	Near end	Receive	0	0	0	0?	0	-	10-30, 19:34	
ODU-PSCP	Near end	Receive	0	0	0	0?	0	-	10-30, 19:34	
ODU-PSD	Near end	Receive	0	0	0	0?	0	-	10-30, 19:34	
OCH-DGDAVG	Near end	Receive	6ps	6ps	6ps	6?ps	6ps	5ps	10-30, 19:34	09-02, 11:34
OCH-DGDMAX	Near end	Receive	16ps	14ps	18ps	15?ps	18ps	10ps	10-30, 19:34	09-02, 11:34
OCH-OPR	Near end	Receive	-10.80dBm	-10.80dBm	-10.90dBm	-10.80?dBm	-10.80dBm	-10.50dBm	10-31, 18:51	09-02, 11:34
OCH-OPRN	Near end	Receive	-22%delta	-22%delta	-22%delta	-22?%delta	-22%delta	-20%delta	10-31, 18:51	09-02, 11:34

Connected to:145.145.68.22,23
Last refresh: 2009-10-3 10:51:05
PM (1) - Retrieving PM count data...Done

Error-free transmission for 23 hours, 17 minutes → BER < 3.0 10^{-16}

Conclusions

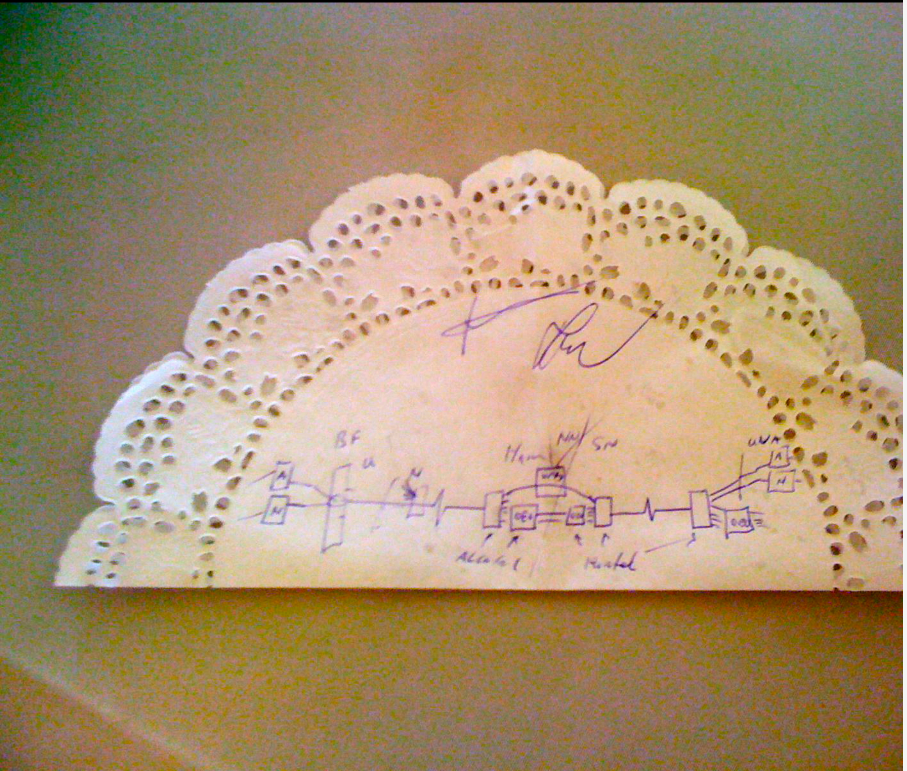
- We have investigated experimentally the all-optical transmission of a 40Gb/s PM-QPSK alien wavelength via a concatenated native and third party DWDM system that both were carrying live 10Gb/s wavelengths.
- The end-to-end transmission system consisted of 1056 km of TWRS (TrueWave Reduced Slope) transmission fiber.
- We demonstrated error-free transmission (i.e. BER below 10-15) during a 23 hour period.
- More detailed system performance analysis will be presented in an upcoming paper.

together with

REFERENCES [1] "OPERATIONAL SOLUTIONS FOR AN OPEN DWDM LAYER", O. GERSTEL ET AL, OFC'2009 | [2] "AT&T OPTICAL TRANSPORT SERVICES", BARBARA E. SMITH, OFC'09
[3] "OPEX SAVINGS OF ALL-OPTICAL CORE NETWORKS", ANDREW LORD AND CARL ENGINEER, ECOC2009 | [4] NORTEL/SURFNET INTERNAL COMMUNICATION

ACKNOWLEDGEMENTS WE ARE GRATEFUL TO NORDUNET FOR PROVIDING US WITH BANDWIDTH ON THEIR DWDM LINK FOR THIS EXPERIMENT AND ALSO FOR THEIR SUPPORT AND ASSISTANCE DURING THE EXPERIMENTS. WE ALSO ACKNOWLEDGE TELINDUS AND NORTEL FOR THEIR INTEGRATION WORK AND SIMULATION SUPPORT

Alien light From idea to realisation!



40Gb/s alien wavelength transmission via a multi-vendor 10Gb/s DWDM infrastructure

NCF

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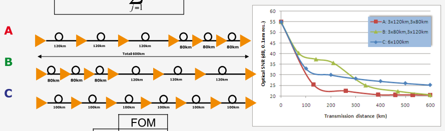

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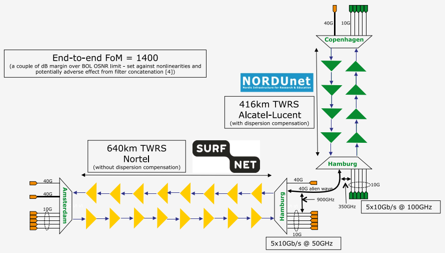

End-to-end FoM = 1400
(a couple of dB margin over BOL OSNR limit - set against nonlinearities and potentially adverse effect from filter concatenation [4])

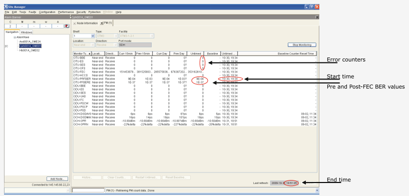
416km TWRS
Alcatel-Lucent
(with dispersion compensation)

640km TWRS
Nortel
(without dispersion compensation)

5x10Gb/s @ 100GHz

5x10Gb/s @ 50GHz

Test results



Connected to:145.145.68.22:23

PM (1) - Retrieving PM count data...Done

Monitor Ty...	Locati...	Directi...	Curr 15min	Prev 15min	Curr Day	Prev Day	Untimed	Baseline	Untimed ...	Baseline Counter Reset Time
OTU-BBE	Near end	Receive	0	0	0	0?	0	-	10-30, 19:34	-
OTU-ES	Near end	Receive	0	0	0	0?	0	-	10-30, 19:34	-
OTU-SES	Near end	Receive	0	0	0	0?	0	-	10-30, 19:34	-
OTU-OFS	Near end	Receive	0	0	0	0?	0	-	10-30, 19:34	-
OTU-FEC	Near end	Receive	151453879...	381525803...	295575636...	676387202...	353162610...	-	10-30, 19:34	-
OTU-HCCS	Near end	Receive	0	0	0	0	0	-	10-30, 19:34	-
OTU-PRFBER	Near end	Receive	9E-04	1E-03	9E-04	1E-03?	9E-04	-	10-30, 19:34	-
OTU-PFBERE	Near end	Receive	1E-37	1E-37	1E-37	1E-37?	1E-37	-	10-30, 19:34	-
ODU-BBE	Near end	Receive	0	0	0	0?	0	-	10-30, 19:34	-
ODU-ES	Near end	Receive	0	0	0	0?	0	-	10-30, 19:34	-
ODU-SES	Near end	Receive	0	0	0	0?	0	-	10-30, 19:34	-
ODU-UAS	Near end	Receive	0	0	0	0?	0	-	10-30, 19:34	-
ODU-FC	Near end	Receive	0	0	0	0?	0	-	10-30, 19:34	-
ODU-PSCW	Near end	Receive	0	0	0	0?	0	-	10-30, 19:34	-
ODU-PSCP	Near end	Receive	0	0	0	0?	0	-	10-30, 19:34	-
ODU-PSD	Near end	Receive	0	0	0	0?	0	-	10-30, 19:34	-
OCH-DGDAVG	Near end	Receive	6ps	6ps	6ps	6?ps	6ps	5ps	10-30, 19:34	09-02, 11:34
OCH-DGDMAX	Near end	Receive	16ps	14ps	18ps	15?ps	18ps	10ps	10-30, 19:34	09-02, 11:34
OCH-OPR	Near end	Receive	-10.80dBm	-10.80dBm	-10.90dBm	-10.80?dBm	-10.80dBm	-10.50dBm	10-31, 18:51	09-02, 11:34
OCH-OPRN	Near end	Receive	-22%delta	-22%delta	-22%delta	-22?%delta	-22%delta	-20%delta	10-31, 18:51	09-02, 11:34

Last refresh: 2009-10-3[illegible] 18:51:05

Error-free transmission for 23 hours, 17 minutes → BER $< 3.0 \cdot 10^{-16}$

Conclusions

- We have investigated experimentally the all-optical transmission of a 40Gb/s PM-QPSK alien wavelength via a concatenated native and third party DWDM system that both were carrying live 10Gb/s wavelengths.
- The end-to-end transmission system consisted of 1056 km of TWRS (TrueWave Reduced Slope) transmission fiber.
- We demonstrated error-free transmission (i.e. BER below 10-15) during a 23 hour period.
- More detailed system performance analysis will be presented in an upcoming paper.

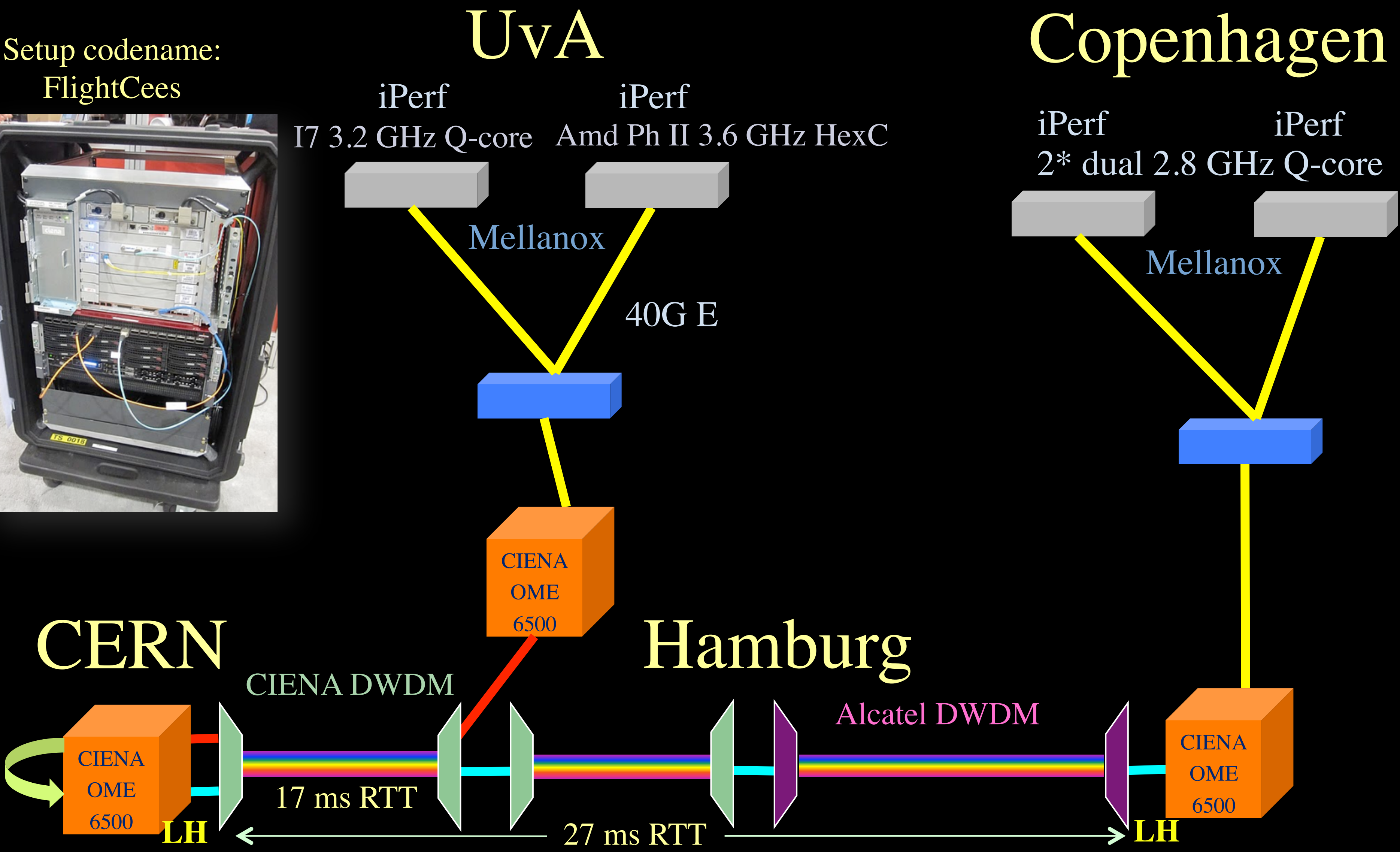
NORTEL NORDUnet Nordic Infrastructure for Research & Education telindus belgacom ICT together with ISIT THE STORAGE COMPANY SURF NET

REFERENCES
[1] "OPERATIONAL SOLUTIONS FOR AN OPEN DWDM LAYER", O. GERSTEL ET AL, OFC'2009 | [2] "AT&T OPTICAL TRANSPORT SERVICES", BARBARA E. SMITH, OFC'09
[3] "OPEX SAVINGS OF ALL-OPTICAL CORE NETWORKS", ANDREW LORD AND CARL ENGINEER, ECOC2009 | [4] NORTEL/SURFNET INTERNAL COMMUNICATION

ACKNOWLEDGEMENTS
WE ARE GRATEFUL TO NORDUNET FOR PROVIDING US WITH BANDWIDTH ON THEIR DWDM LINK FOR THIS EXPERIMENT AND ALSO FOR THEIR SUPPORT AND ASSISTANCE DURING THE EXPERIMENTS. WE ALSO ACKNOWLEDGE TELINDUS AND NORTEL FOR THEIR INTEGRATION WORK AND SIMULATION SUPPORT

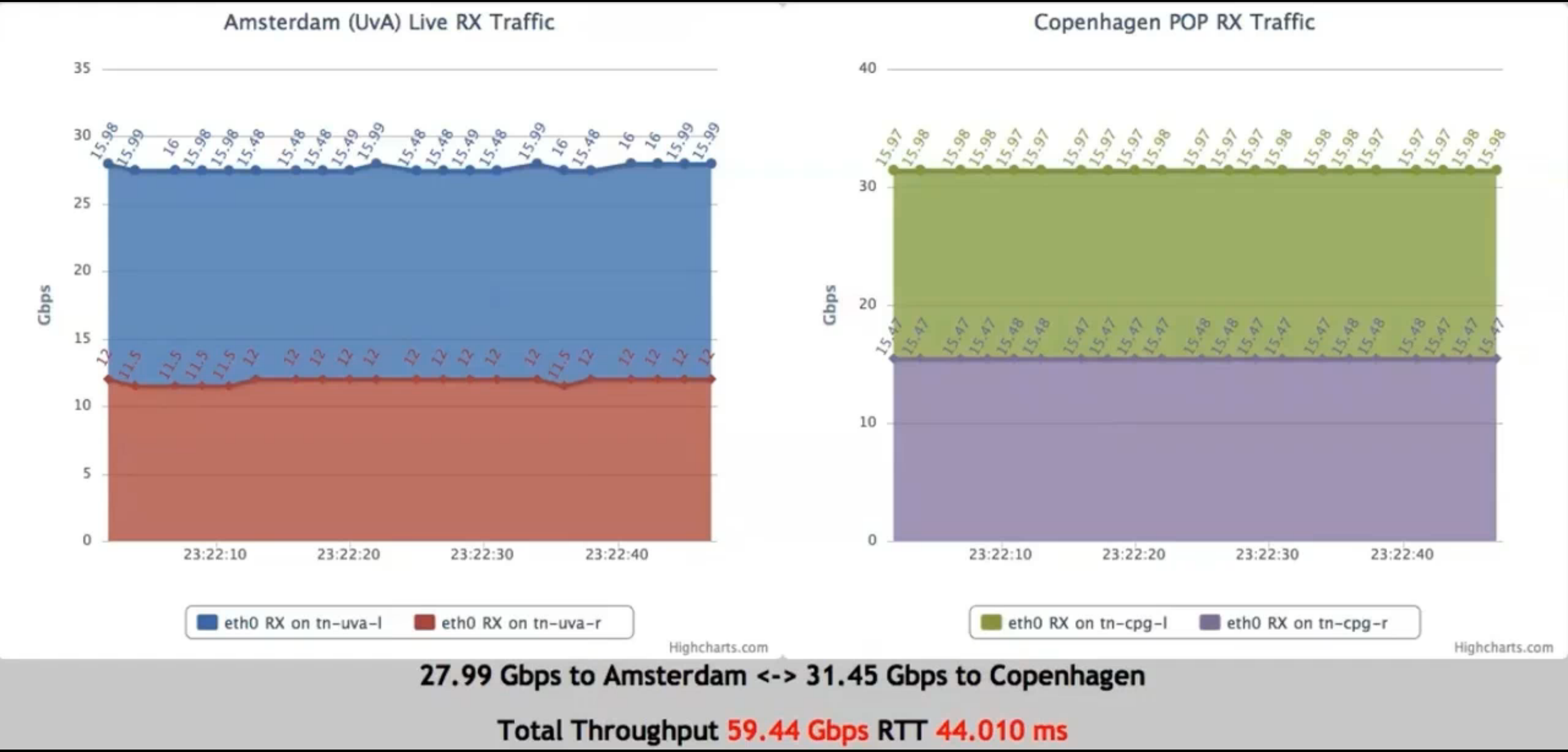
ClearStream @ TNC2011

Setup codename:
FlightCees



Amsterdam – Geneva (CERN) – Copenhagen – 4400 km (2700 km alien light)

http://tnc11.delaat.net



27.99 Gbps to Amsterdam <-> 31.45 Gbps to Copenhagen

Total Throughput 59.44 Gbps RTT 44.010 ms

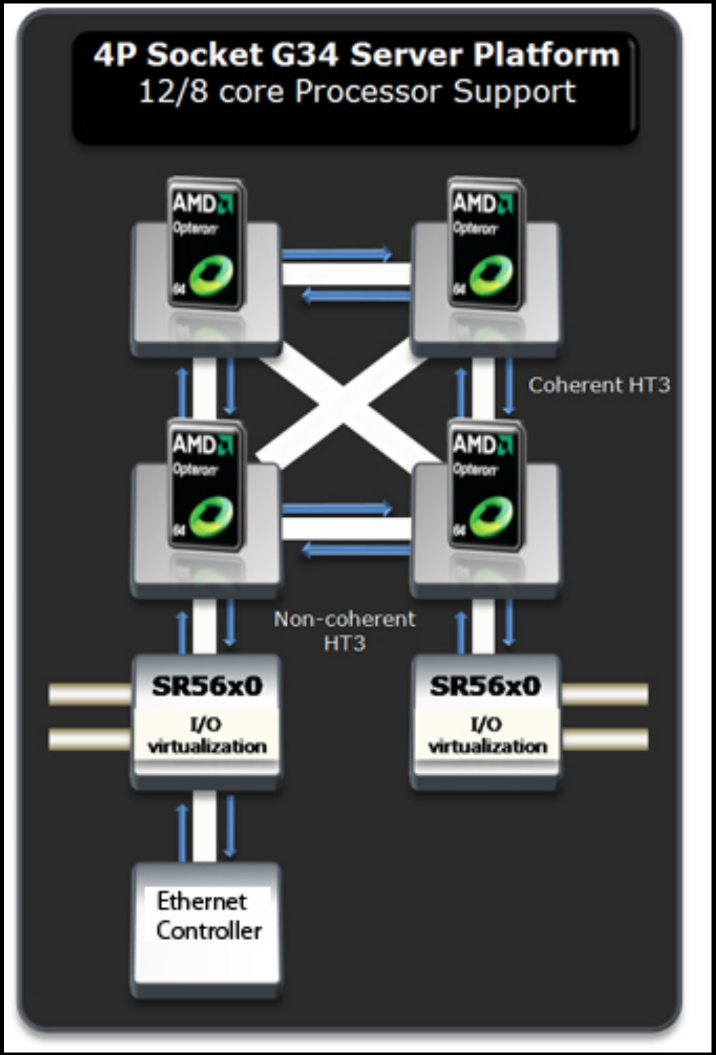
Results (rtt = 17 ms)

- Single flow iPerf 1 core -> 21 Gbps
- Single flow iPerf 1 core <> -> 15+15 Gbps
- Multi flow iPerf 2 cores -> 25 Gbps
- Multi flow iPerf 2 cores <> -> 23+23 Gbps
- DiViNe <> -> 11 Gbps
- Multi flow iPerf + DiVine -> 35 Gbps
- Multi flow iPerf + DiVine <> -> 35 + 35 Gbps

Performance Explained

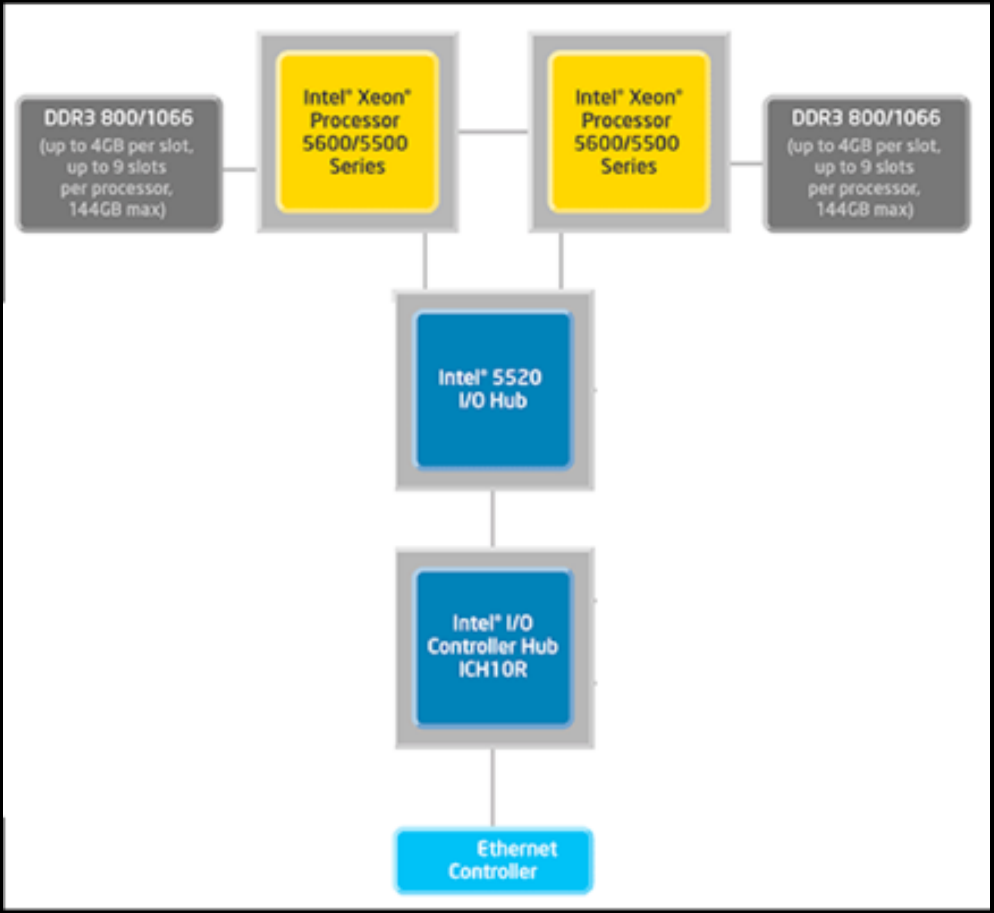
- Mellanox 40GE card is PCI-E 2.0 8x (5GT/s)
- 40Gbit/s raw throughput but ….
- PCI-E is a network-like protocol
  - 8/10 bit encoding -> 25% overhead -> 32Gbit/s maximum data throughput
  - Routing information
- Extra overhead from IP/Ethernet framing
- Server architecture matters!
  - 4P system performed worse in multithreaded iperf

Server Architecture


4P Socket G34 Server Platform
12/8 core Processor Support
AMD Opteron
AMD Opteron
AMD Opteron
AMD Opteron
Coherent HT3
Non-coherent HT3
SR56x0 I/O virtualization
SR56x0 I/O virtualization
Ethernet Controller

DELL R815

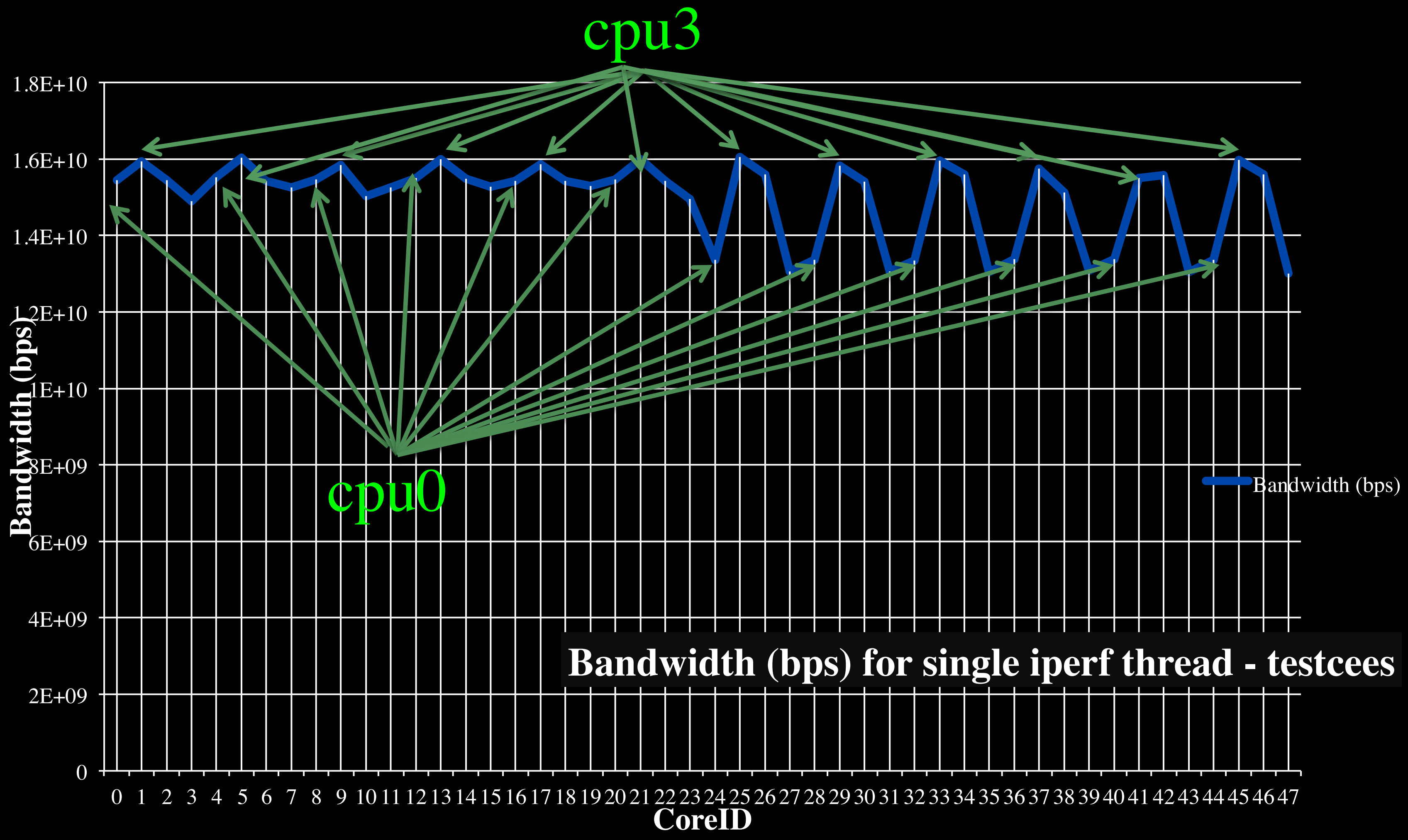
4 x AMD Opteron 6100


DDR3 800/1066 (up to 4GB per slot, up to 9 slots per processor, 144GB max)
Intel® Xeon® Processor 5600/5500 Series
Intel® Xeon® Processor 5600/5500 Series
DDR3 800/1066 (up to 4GB per slot, up to 9 slots per processor, 144GB max)
Intel® 5520 I/O Hub
Intel® I/O Controller Hub ICH10R
Ethernet Controller

Supermicro X8DTT-HIBQF

2 x Intel Xeon

CPU Topology benchmark



We used numactl to bind iperf to cores

SNE @ UvA

Where when will it happen?

	Ijkdijk/Urban Flood	Medical	LifeWatch/ENVRI	CosmoGrid/eVLBI	CineGrid	EU-GN3/NOVI/Geysers	SURFnet/GLIF/Cloud
Green-IT						X	X
Privacy/Trust		X				X	
Authorization/policy		X	X		X	X	
Programmable networks	X		X				
40-100Gig/TCP/WF/QoS	X			X	X		X
Topology/Architecture			X		X	X	X
Optical Photonic				X	X		X

IJKDIJK

Sensors: 15000km* 800 bps/m ->12 Gbit/s to cover all Dutch dikes

Sensor grid: instrument the dikes

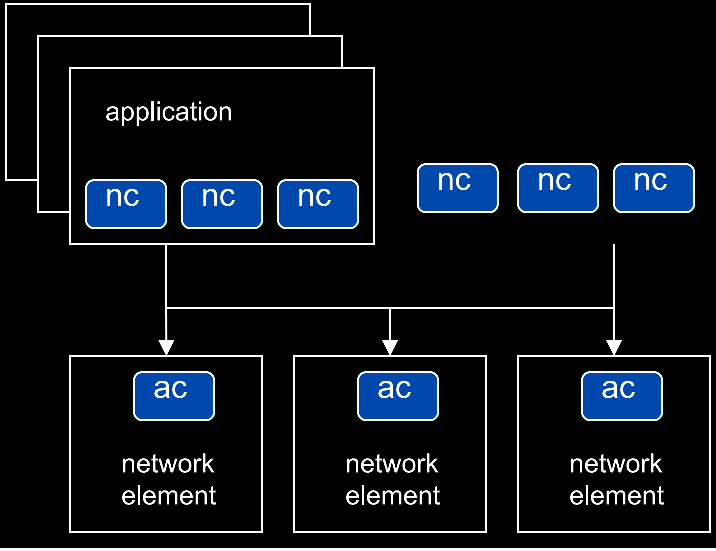
First controlled breach occurred on sept 27th ‘08:

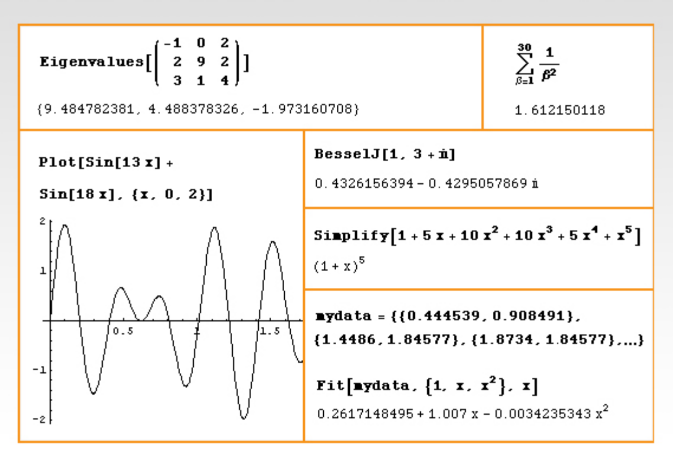
Many Pflops/s

Many small flows -> 12 Gb/s

User Programmable Virtualized Networks.

- The network is virtualized as a collection of resources
- UPVNs enable network resources to be programmed as part of the application
- Mathematica interacts with virtualized networks using UPVNs and optimize network + computation





```
Eigenvalues[( -1  0  2
               2  9  2
               3  1  4 )]
{9.484782381, 4.488378326, -1.973160708}
```

$$\sum_{\beta=1}^{30} \frac{1}{\beta^2}$$

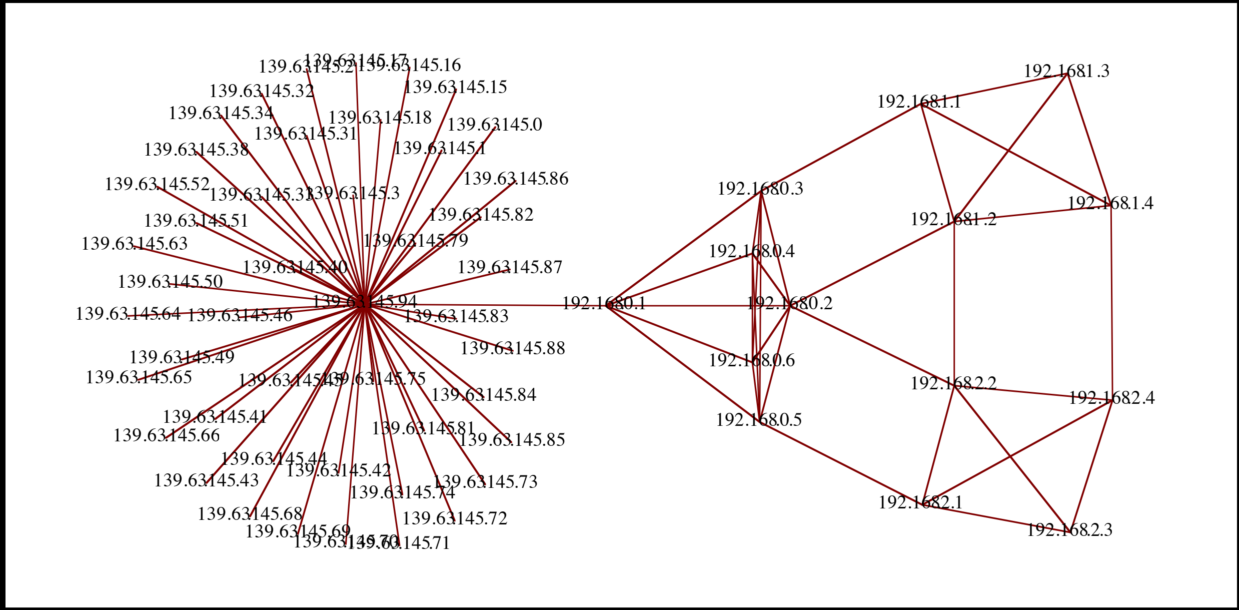
```
1.612150118
```

```
Plot[Sin[13 x] +
Sin[18 x], {x, 0, 2}]
```

```
BesselJ[1, 3 + ⅈ]
0.4326156394 - 0.4295057869 ⅈ
```

```
Simplify[1 + 5 x + 10 x^2 + 10 x^3 + 5 x^4 + x^5]
(1 + x)^5
```

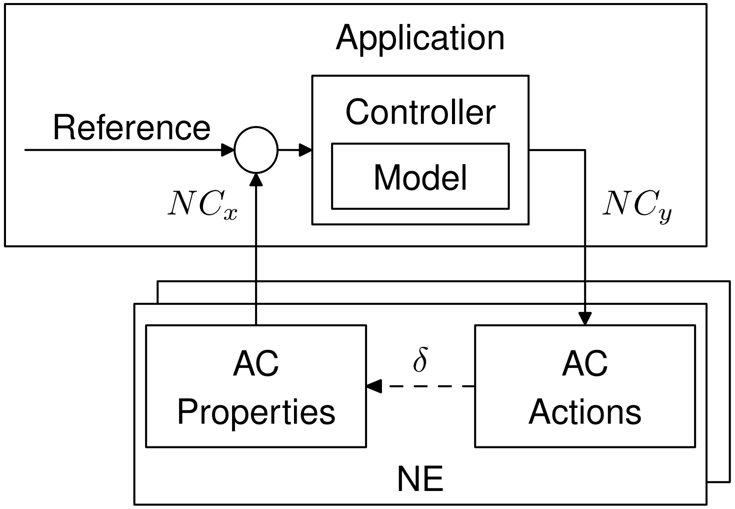
```
mydata = {{0.444539, 0.908491},
{1.4486, 1.84577}, {1.8734, 1.84577},...}

Fit[mydata, {1, x, x^2}, x]
0.2617148495 + 1.007 x - 0.0034235343 x^2
```



ref: Robert J. Meijer, Rudolf J. Strijkers, Leon Gommans, Cees de Laat, User Programmable Virtualiized Networks, accepted for publication to the IEEE e-Science 2006 conference Amsterdam.

In the Intercloud virtual servers and networks become software

- Virtual Internets adapt to the environment, grow to demand, iterate to specific designs
- Network support for application specific interconnections are merely opitimizations: Openflow, active networks, cisco distributed switch
- But how to control the control loop?

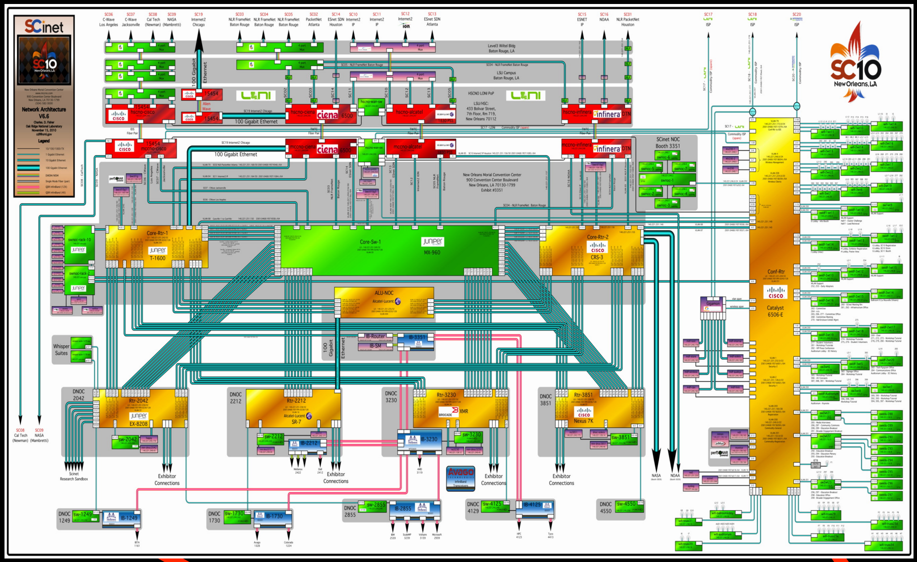


Interactive Networks

Rudolf Strijkers [1,2]
Marc X. Makkes [1,2]
Mihai Christea 1
Laurence Muller [1]
Robert Belleman [1]
Cees de Laat [1]
Robert Meijer[1,2]
[1] University of Amsterdam, Amsterdam The Netherlands
[2] TNO Information and Communication Technology, Groningen, The Netherlands

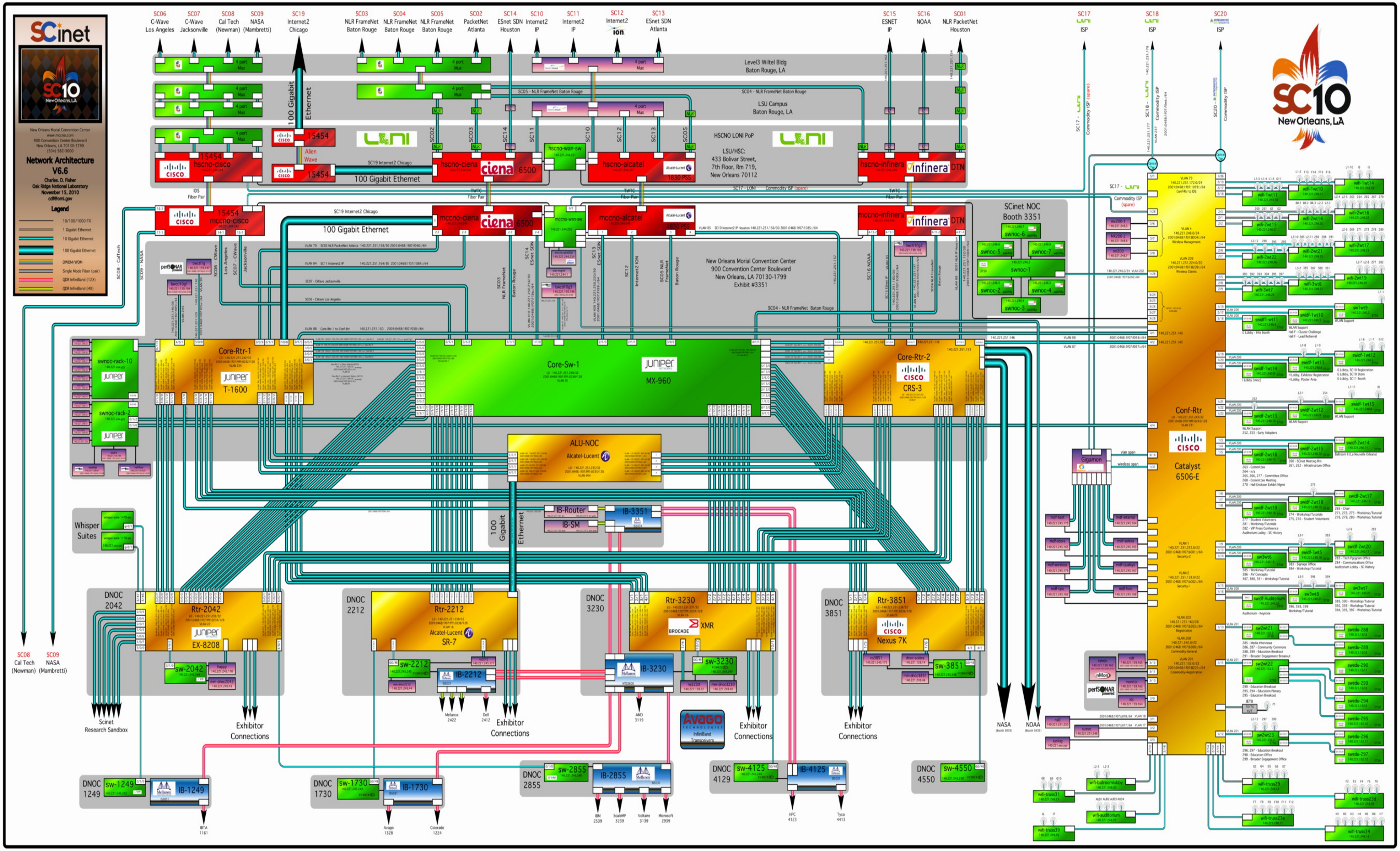
SNE @ UvA

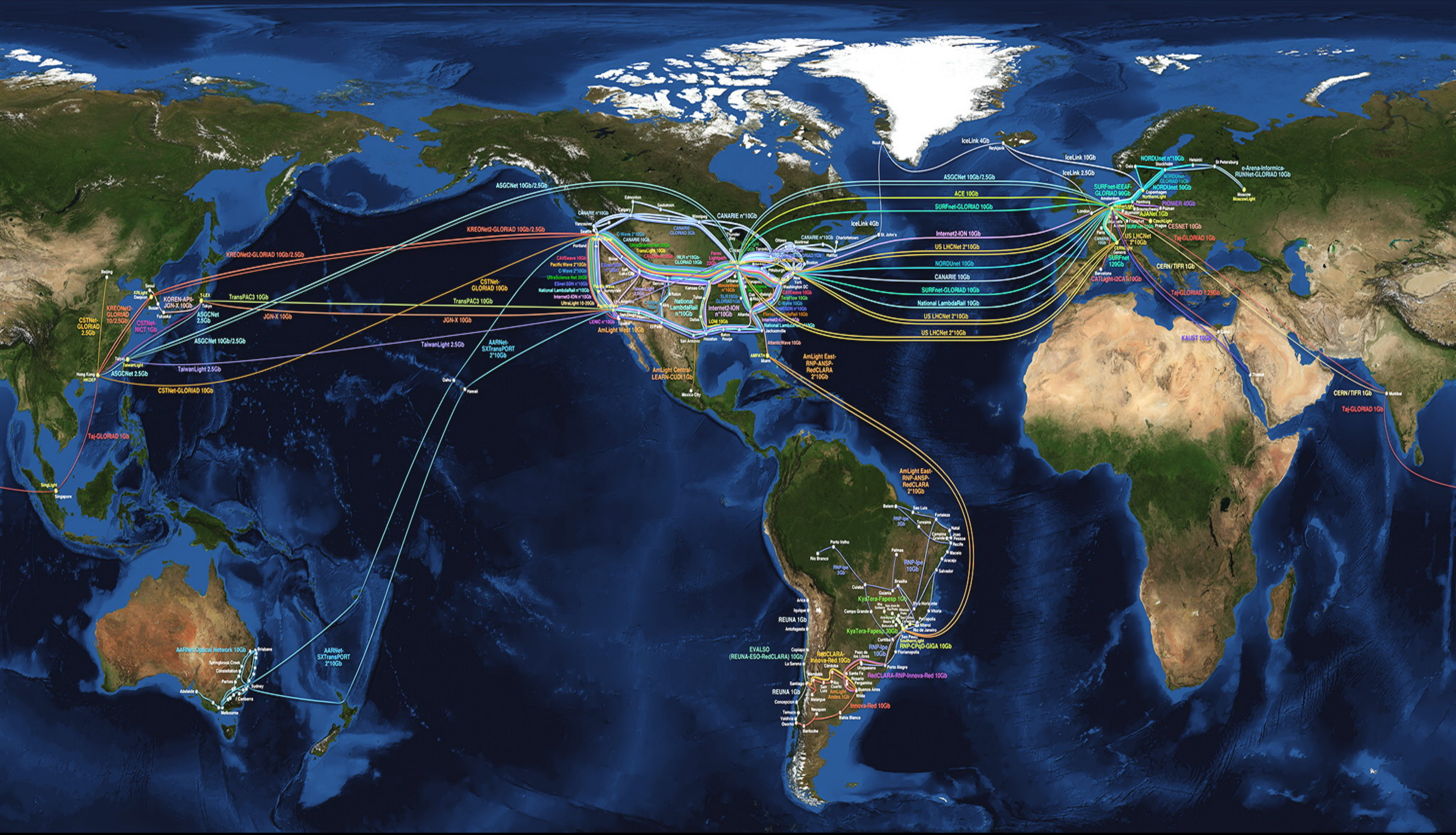
Mastering Complexity



	Ijkdijk/Urban Flood	Medical	LifeWatch/ENVRI	CosmoGrid/eVLBI	CineGrid	EU-GN3/NOVI/Geysers	SURFnet/GLIF/Cloud
Green-IT						X	X
Privacy/Trust		X				X	
Authorization/policy		X	X		X	X	
Programmable networks	X		X				
40-100Gig/TCP/WF/QoS	X			X	X		X
Topology/Architecture			X		X	X	X
Optical Photonic				X	X		X

Complex eInfrastructure @ SC10

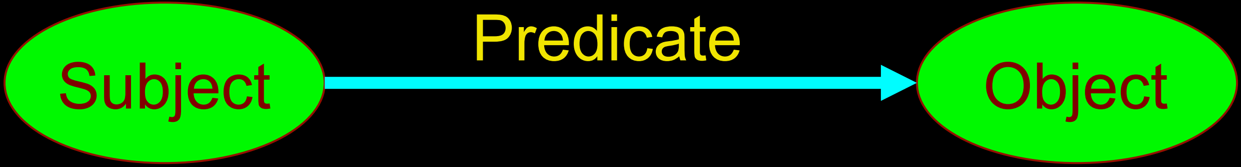


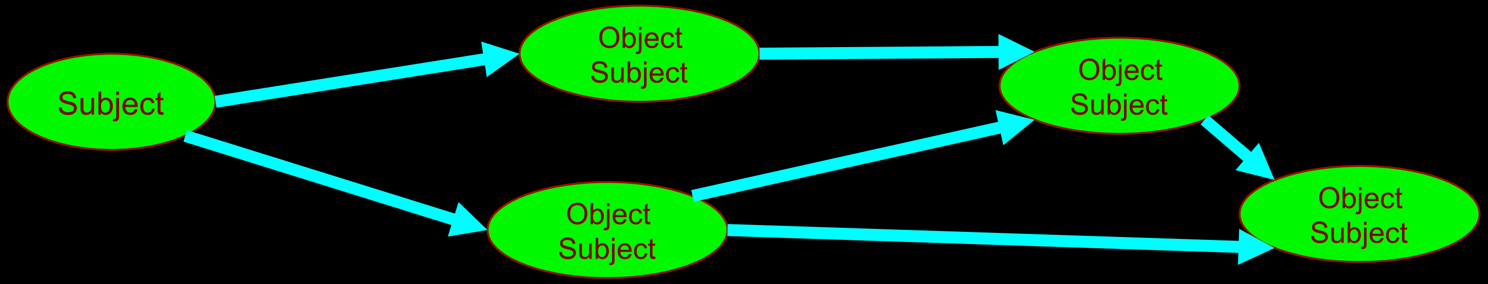


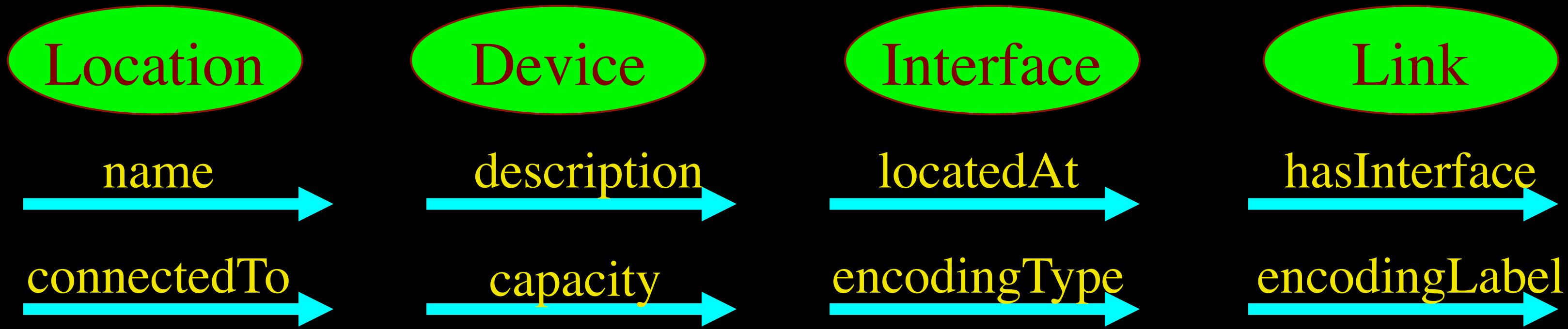
We investigate: TOMTOM for complex networks!

LinkedIN for Infrastructure

- From semantic Web / Resource Description Framework.
- The RDF uses XML as an interchange syntax.
- Data is described by triplets (Friend of a Friend):





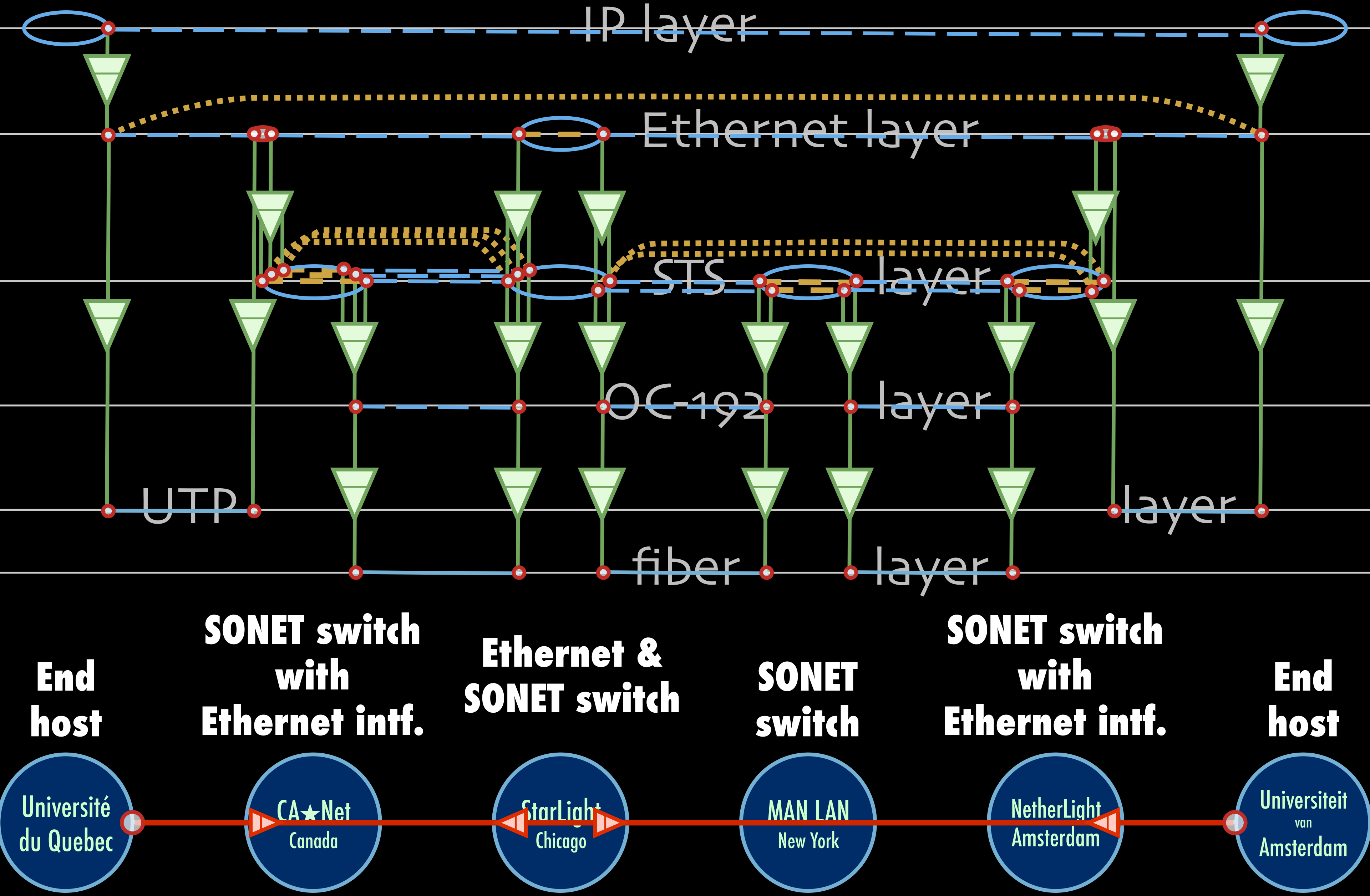


NetherLight in RDF

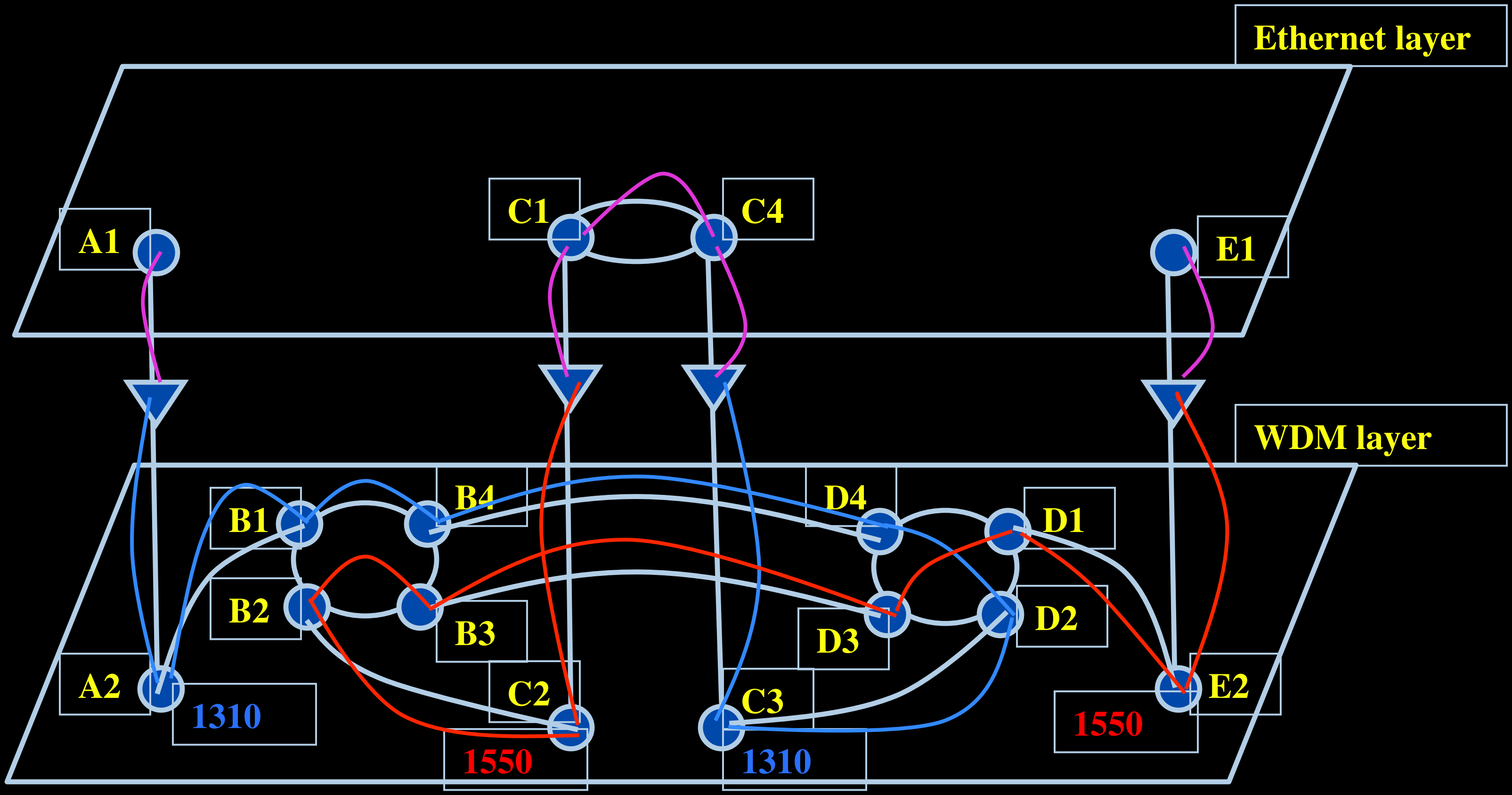
```
<?xml version="1.0" encoding="UTF-8"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
        xmlns:ndl="http://www.science.uva.nl/research/air/ndl#">
<!-- Description of Netherlight -->
<ndl:Location rdf:about="#Netherlight">
        <ndl:name>Netherlight Optical Exchange</ndl:name>
</ndl:Location>
<!-- TDM3.amsterdam1.netherlight.net -->
<ndl:Device rdf:about="#tdm3.amsterdam1.netherlight.net">
        <ndl:name>tdm3.amsterdam1.netherlight.net</ndl:name>
        <ndl:locatedAt rdf:resource="#amsterdam1.netherlight.net"/>
        <ndl:hasInterface rdf:resource="#tdm3.amsterdam1.netherlight.net:501/1"/>
        <ndl:hasInterface rdf:resource="#tdm3.amsterdam1.netherlight.net:501/3"/>
        <ndl:hasInterface rdf:resource="#tdm3.amsterdam1.netherlight.net:501/4"/>
        <ndl:hasInterface rdf:resource="#tdm3.amsterdam1.netherlight.net:503/1"/>
        <ndl:hasInterface rdf:resourc
        <ndl:hasInterface rdf:resourc
        <ndl:hasInterface rdf:resourc
        <ndl:hasInterface rdf:resourc
        <ndl:hasInterface rdf:resourc
        <ndl:hasInterface rdf:resourc
        <ndl:hasInterface rdf:resourc
        <ndl:hasInterface rdf:resourc
```

```
<!-- all the interfaces of TDM3.amsterdam1.netherlight.net -->

<ndl:Interface rdf:about="#tdm3.amsterdam1.netherlight.net:501/1">
                <ndl:name>tdm3.amsterdam1.netherlight.net:POS501/1</ndl:name>
                <ndl:connectedTo rdf:resource="#tdm4.amsterdam1.netherlight.net:5/1"/>
</ndl:Interface>
<ndl:Interface rdf:about="#tdm3.amsterdam1.netherlight.net:501/2">
                <ndl:name>tdm3.amsterdam1.netherlight.net:POS501/2</ndl:name>
                <ndl:connectedTo rdf:resource="#tdm1.amsterdam1.netherlight.net:12/1"/>
</ndl:Interface>
```

Multi-layer descriptions in NDL



Multi-layer Network PathFinding



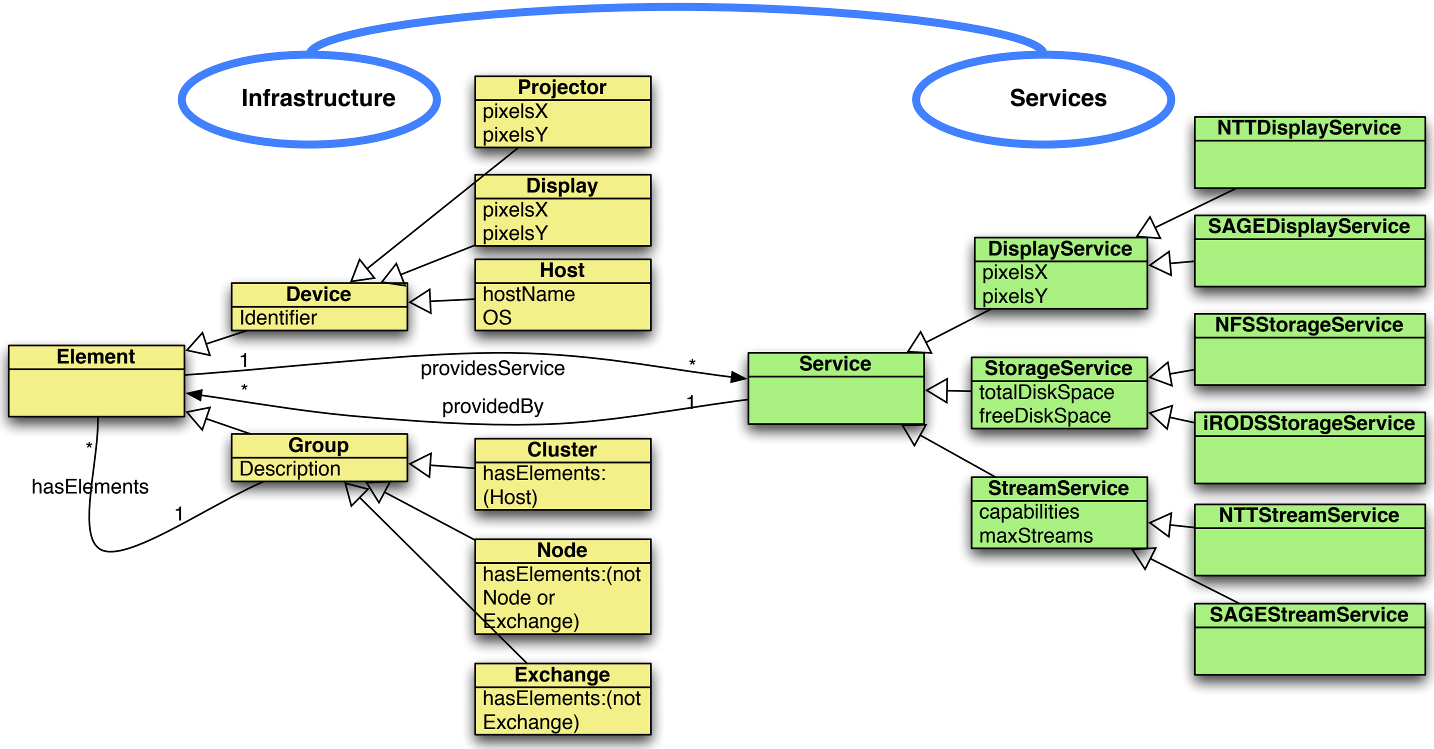
Path between interfaces A1 and E1:

A1-A2-B1-B4-D4-D2-C3-C4-C1-C2-B2-B3-D3-D1-E2-E1

Scaling: Combinatorial problem

Information Modeling

Define a common information model for ***infrastructures*** and ***services***.
Base it on Semantic Web.



J. van der Ham, F. Dijkstra, P. Grosso, R. van der Pol, A. Toonk, C. de Laat
A distributed topology information system for optical networks based on the semantic web,
In: Elsevier Journal on Optical Switching and Networking, Volume 5, Issues 2-3, June 2008, Pages 85-93

R.Koning, P.Grosso and C.de Laat
Using ontologies for resource description in the CineGrid Exchange
In: Future Generation Computer Systems (2010)

Why?

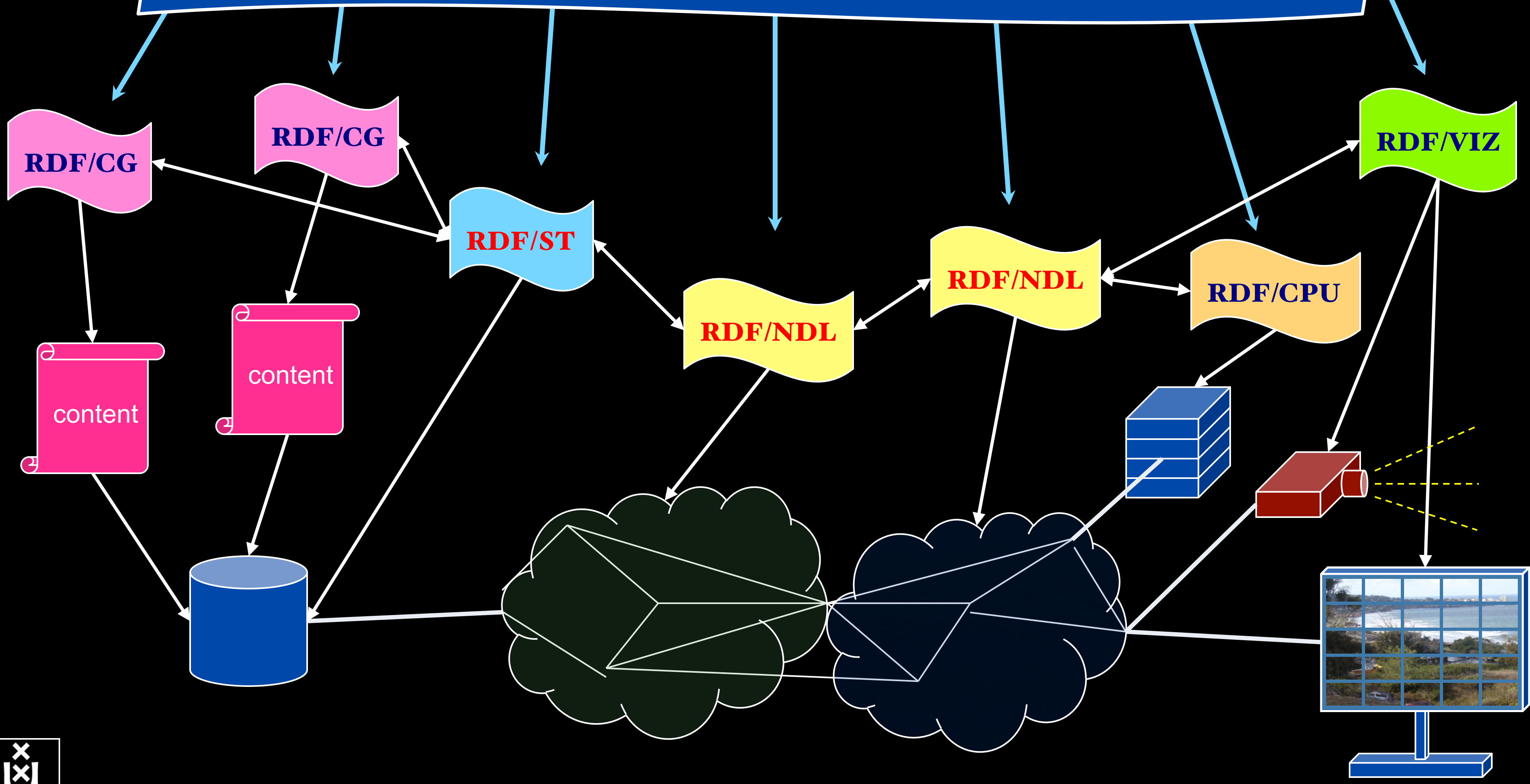
I want to:

"Show Big Bug Bunny in 4K on my Tiled Display using green Infrastructure"

- Big Bugs Bunny can be on multiple servers on the Internet.
- Movie may need processing / recoding to get to 4K for Tiled Display.
- Needs deterministic Green infrastructure for Quality of Experience.
- Consumer / Scientist does not want to know the underlying details.
  ➔ His refrigerator also just works.

RDF describing Infrastructure
“I want”

Application: find video containing x,
then trans-code to it view on Tiled Display



The Ten Problems with the Internet

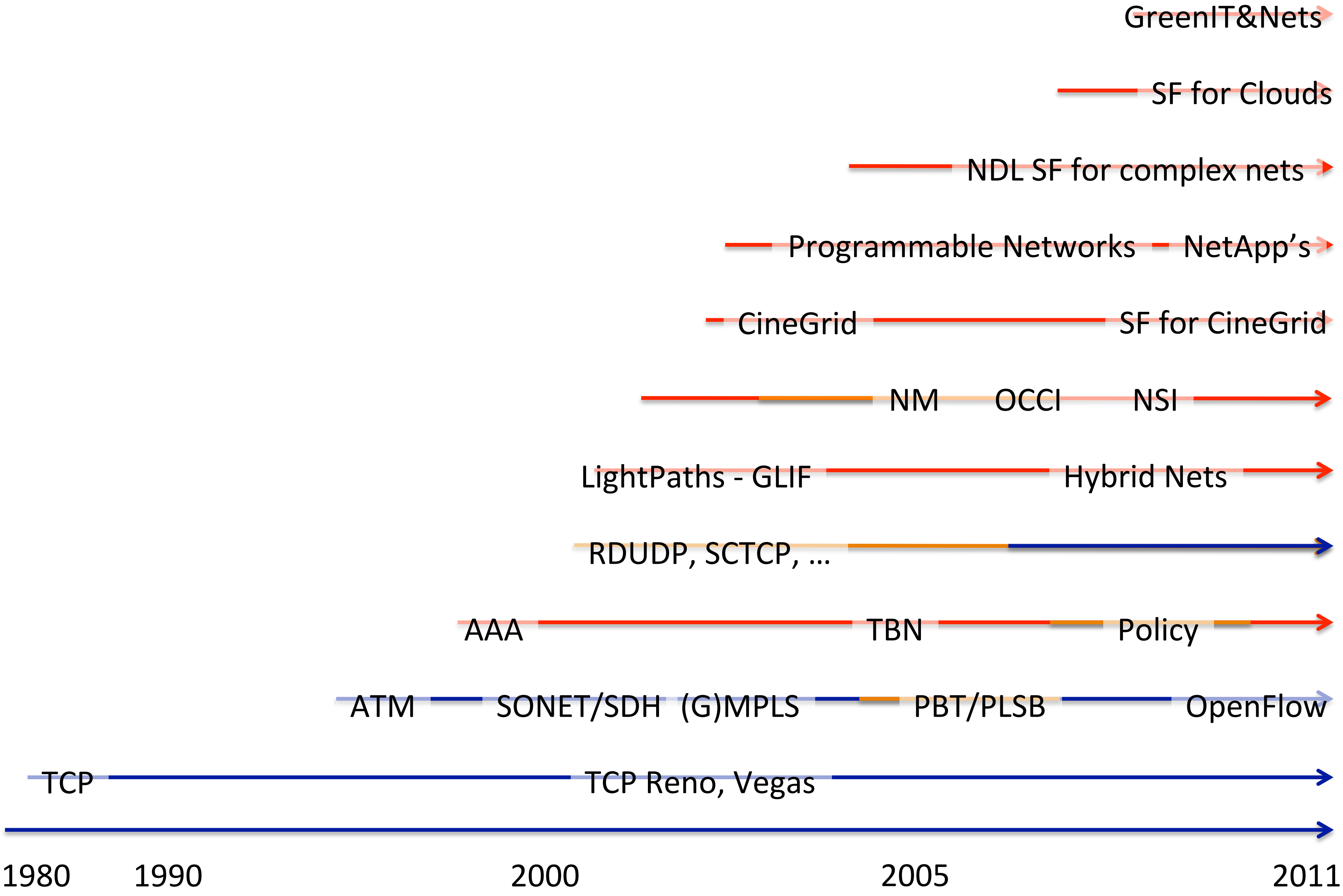
1. **Energy Efficient Communication**
2. Separation of Identity and Address
3. Location Awareness
4. **Explicit Support for Client-Server Traffic and Distributed Services**
5. Person-to-Person Communication
6. Security
7. **Control, Management, and Data Plane separation**
8. **Isolation**
9. Symmetric/Asymmetric Protocols
10. **Quality of Service**

Nice to have:

- Global Routing with Local Control of Naming and Addressing
- **Real Time Services**
- **Cross-Layer Communication**
- Manycast
- Receiver Control
- Support for Data Aggregation and Transformation
- **Support for Streaming Data**
- **Virtualization**

ref: Raj Jain, "Internet 3.0: Ten Problems with Current Internet Architecture and Solutions for the Next Generation", Military Communications Conference, 2006. MILCOM 2006. IEEE

TimeLine



GreenIT&Nets

SF for Clouds

NDL SF for complex nets

Programmable Networks NetApp's

CineGrid SF for CineGrid

NM OCCI NSI

LightPaths - GLIF Hybrid Nets

RDUDP, SCTCP, …

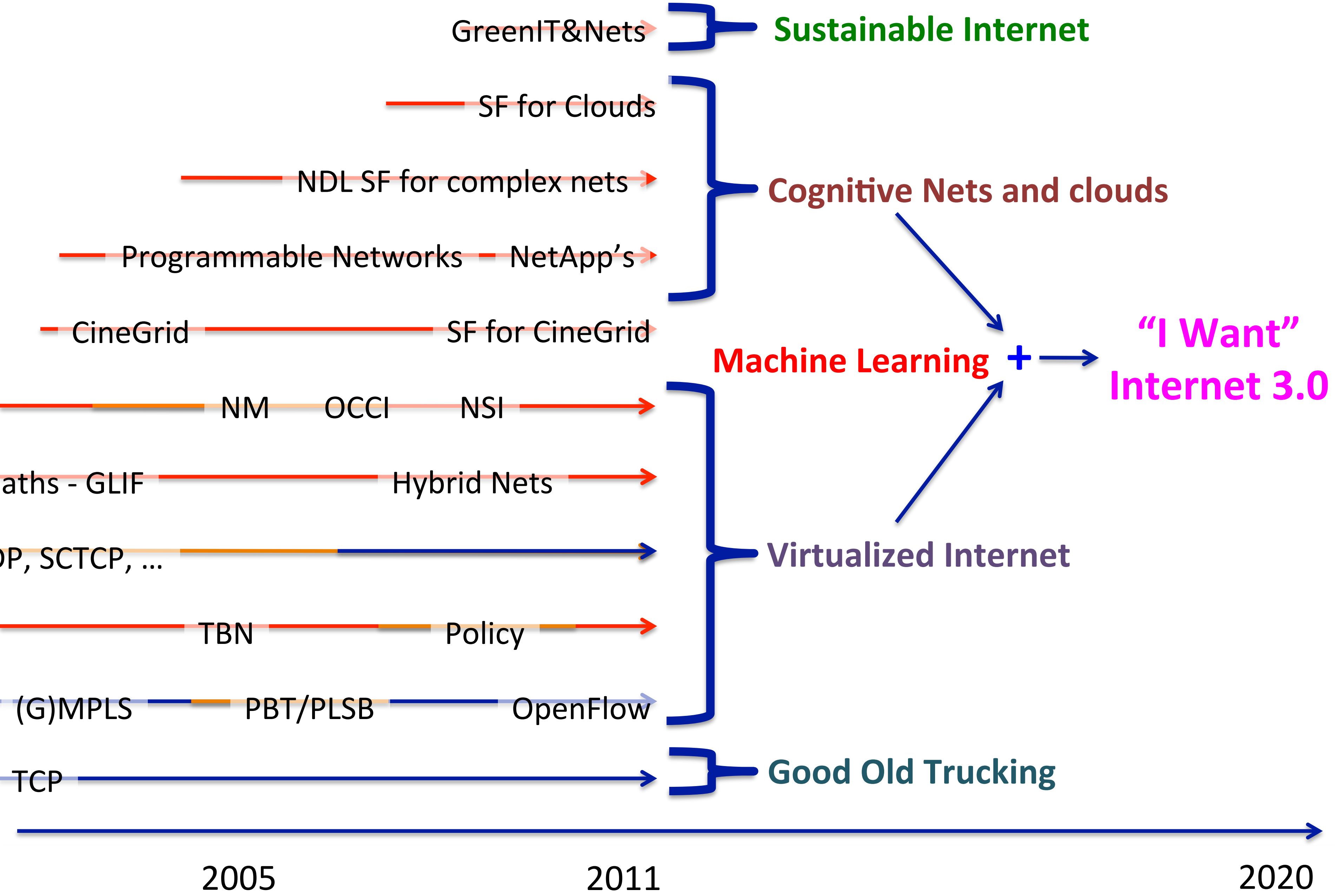
AAA TBN Policy

ATM SONET/SDH (G)MPLS PBT/PLSB OpenFlow

TCP TCP Reno, Vegas

1980 1990 2000 2005 2011

TimeLine



GreenIT&Nets

Sustainable Internet

SF for Clouds

NDL SF for complex nets

Programmable Networks NetApp's

Cognitive Nets and clouds

CineGrid SF for CineGrid

Machine Learning +

"I Want" Internet 3.0

NM OCCI NSI

aths - GLIF Hybrid Nets

P, SCTCP, …

Virtualized Internet

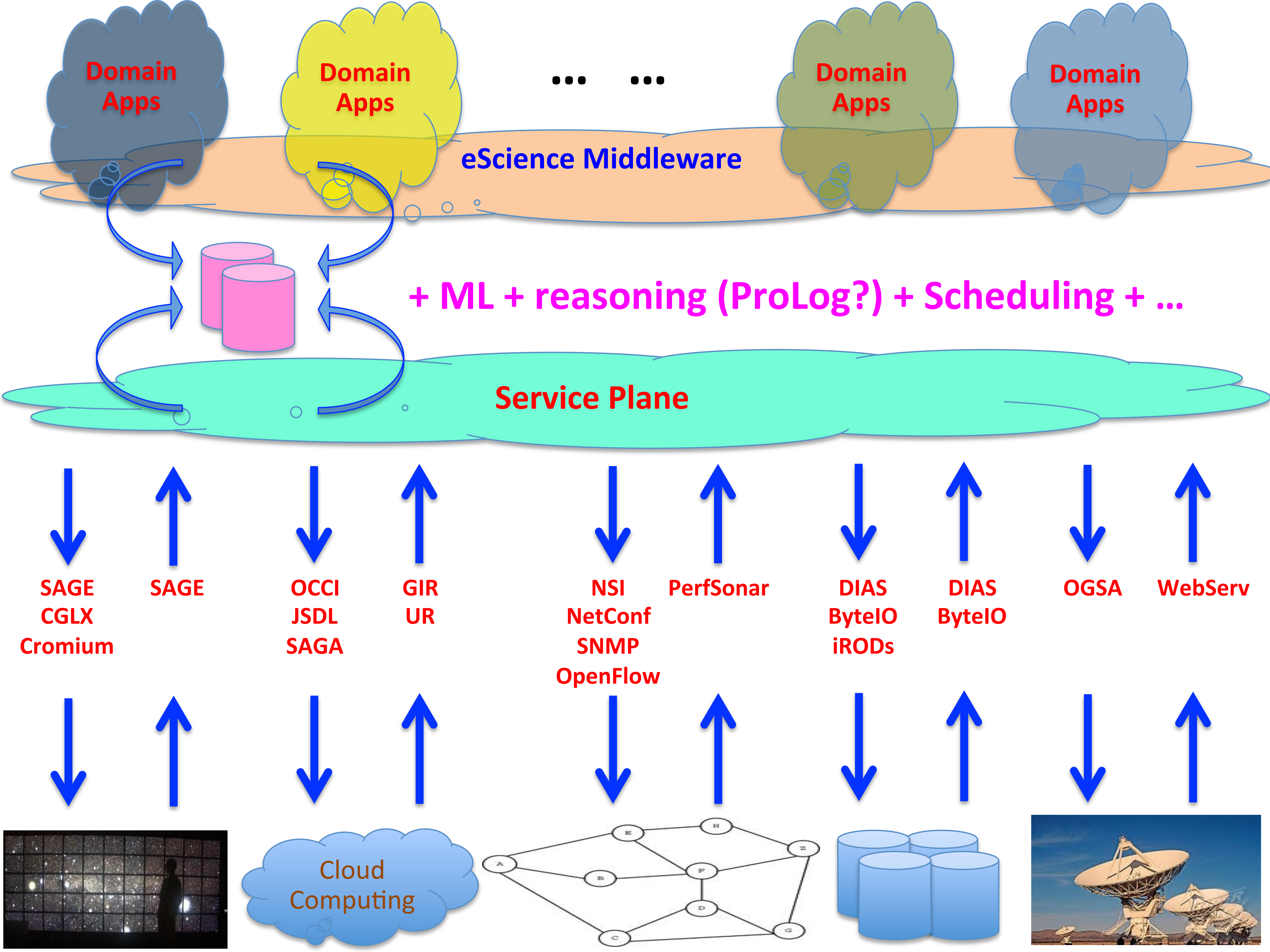
TBN Policy

(G)MPLS PBT/PLSB OpenFlow

TCP

Good Old Trucking

2005 2011 2020



Domain Apps

Domain Apps

… …

Domain Apps

Domain Apps

eScience Middleware

+ ML + reasoning (ProLog?) + Scheduling + …

Service Plane

SAGE
CGLX
Cromium

SAGE

OCCI
JSDL
SAGA

GIR
UR

NSI
NetConf
SNMP
OpenFlow

PerfSonar

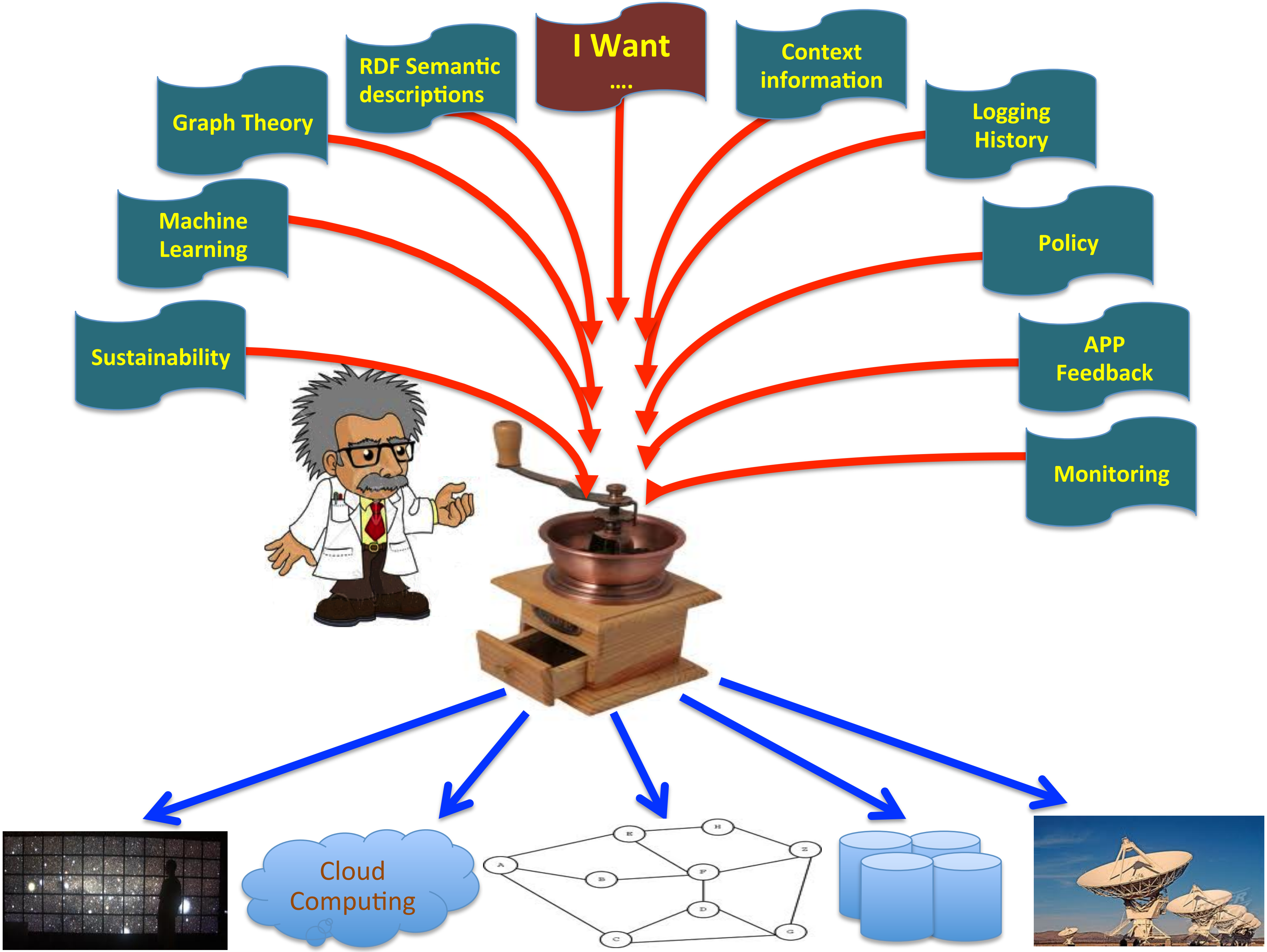
DIAS
ByteIO
iRODs

DIAS
ByteIO

OGSA

WebServ

Cloud Computing



I Want ….

RDF Semantic descriptions

Context information

Graph Theory

Logging History

Machine Learning

Policy

Sustainability

APP Feedback

Monitoring

Cloud Computing

Challenges

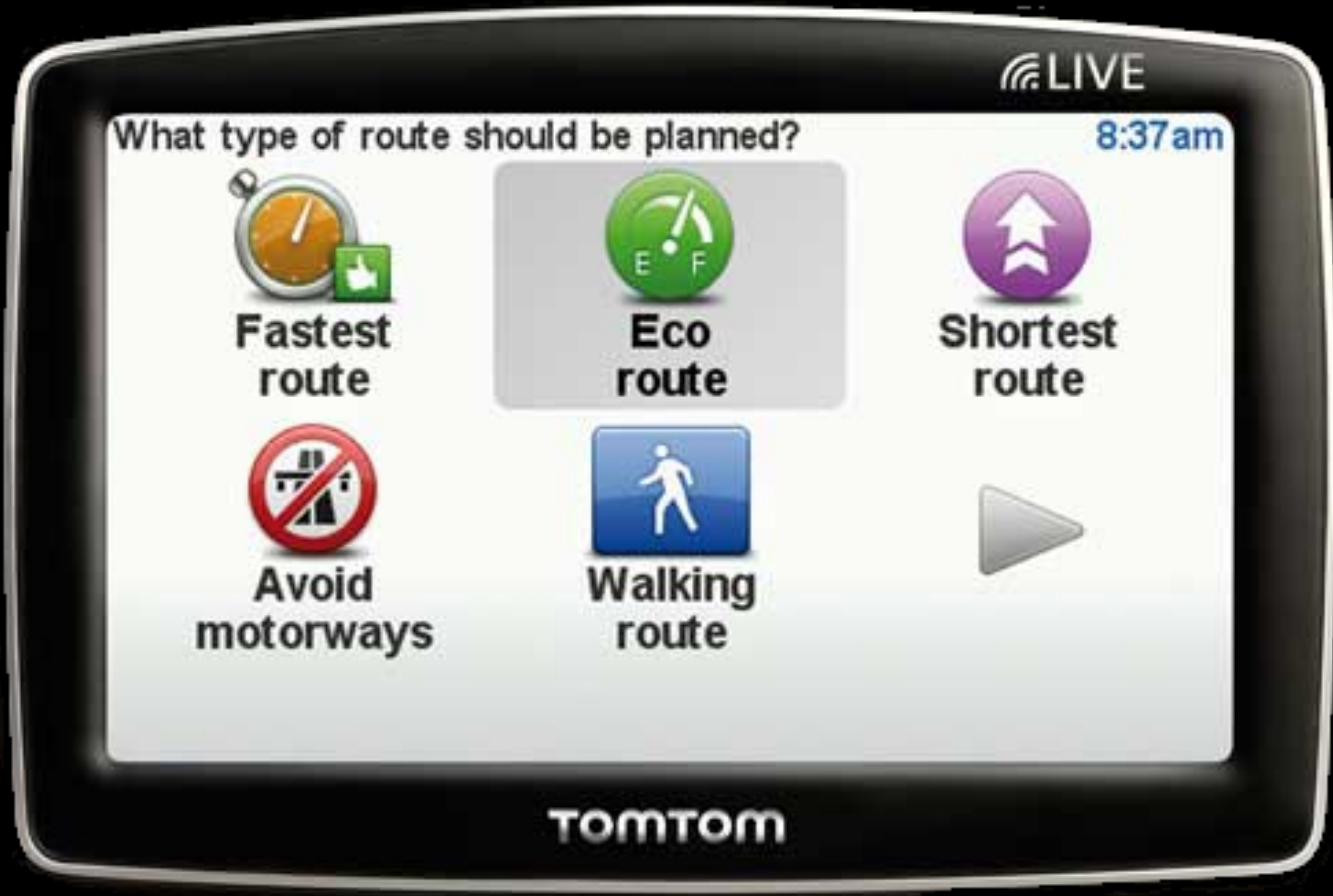
- Data – Data – Data
  - Archiving, publication, searchable, transport, self-describing, DB innovations needed, multi disciplinary use
- Virtualisation
  - Another layer of indeterminism

- Greening the Infrastructure
  - e.g. Department Of Less Energy: http://www.ecrinitiative.org/pdfs/ECR_3_0_1.pdf
- Disruptive developments
  - BufferBloath, Revisiting TCP, influence of SSD’s & GPU’s
  - Multi layer Glif Open Exchange model
  - Invariants in LightPaths (been there done that ☺)
    - X25, ATM, SONET/SDH, Lambda’s, MPLS-TE, VLAN’s, PBT, OpenFlow, ….
  - Authorization & Trust & Security and Privacy

The Way Forward!

- Nowadays scientific computing and data is dwarfed by commercial & cloud, there is also no scientific water, scientific power.
  - Understand how to work with elastic clouds
  - Trust & Policy & Firewalling on VM/Cloud level
- Technology cycles are 3 – 5 year
  - Do not try to unify but prepare for diversity
  - Hybrid computing & networking
  - Compete on implementation & agree on interfaces and protocols
- Limitation on natural resources and disruptive events
  - Energy becomes big issue
  - Follow the sun
  - Avoid single points of failure (aka Amazon, Blackberry, …)
  - Better very loosely coupled than totally unified integrated…

ECO-Scheduling



What type of route should be planned?

8:37am

Q & A

http://ext.delaat.net/

Slides thanks to:

- Paola Grosso
- Sponsors see slide 1. ☺
- SNE Team & friends, see below

I did not talk about:

- CineGrid, digital Cinema on CI
- Knowlegde complexity
- Security & privacy
- AAA
- …