Mastering Complex Cyber Infrastructure

Cees de Laat

EU

COMMIT

UvA

NWO

PID/EFRO

SURFnet

TNO

NCF

Science Faculty @ UvA

Informatics Institute

- CSA: Computer Systems Architecture (dr. A.D. Pimentel)
- FCN: Federated Collaborative Networks (Prof. dr. H. Afsarmanesh)
- IAS: Intelligent Autonomous Systems (Prof. dr. ir. F.C.A. Groen)
- ILPS: Information and Language Processing Systems (Prof. dr. M. de Rijke)
- ISIS: Intelligent Sensory Information Systems (Prof. dr. ir. A.W.M. Smeulders)
- SCS: Section Computational Science (Prof. dr. P.M.A. Sloot)
- SNE: System and Network Engineering (Prof. dr. ir. C.T.A.M. de Laat)
- TCS: Theory of Computer Science (Prof. dr. J.A. Bergstra)

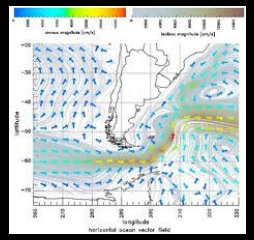
Mission

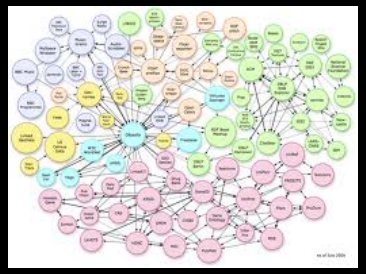
The System and Network Engineering research group (SNE) focuses its research on the complexity of emerging hybrid System and Network architectures and the associated models, protocols and system approaches for data processing in science.

The group builds tools and proof of concept applications that promote optimal use of high speed networks. Security of the required mechanisms, infrastructure, middleware, applications and the privacy of data in distributed processing environments is an essential aspect of the research.

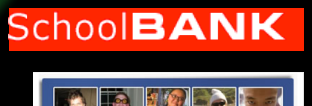
Internet developments

... more data!





... more realtime!



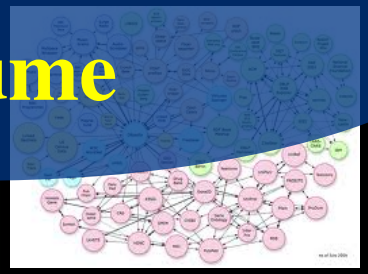
... more users!

Internet developments

... more data!

Speed

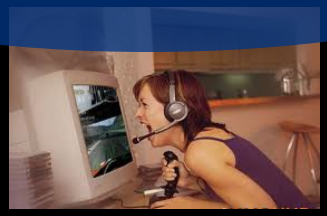
Volume



Deterministic

Real-time

more realtime!

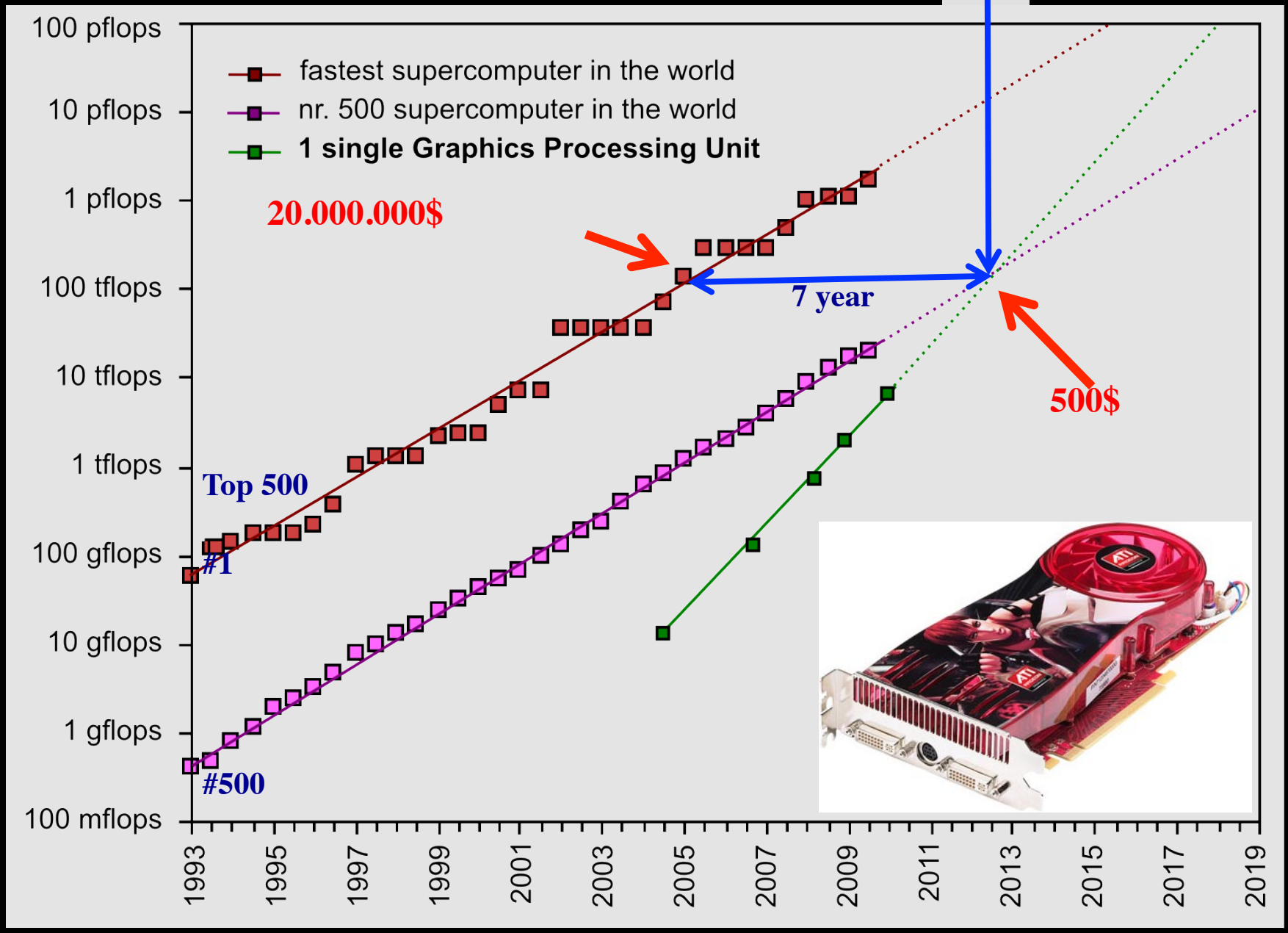


Scalable

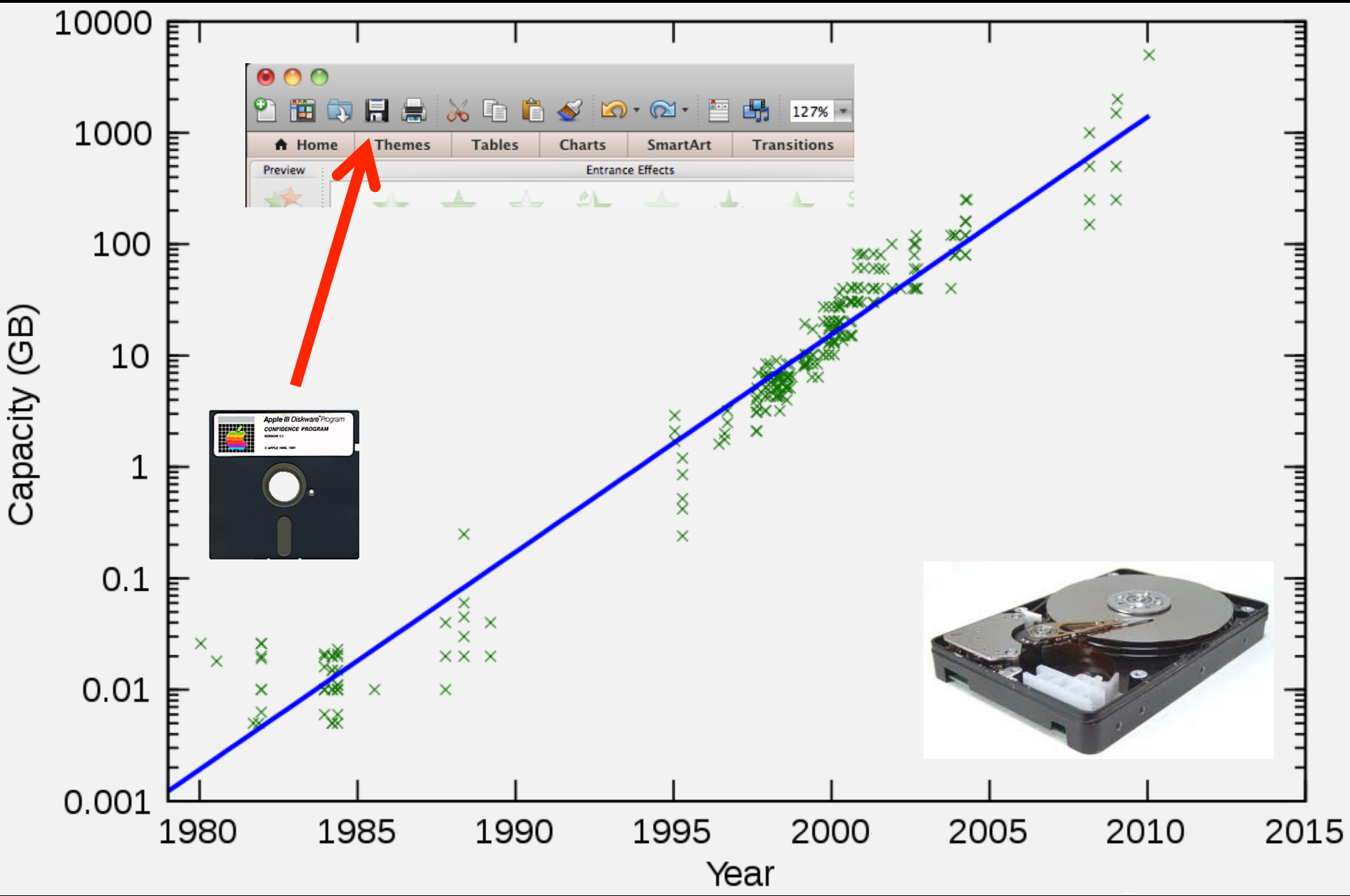
Secure

... more users!

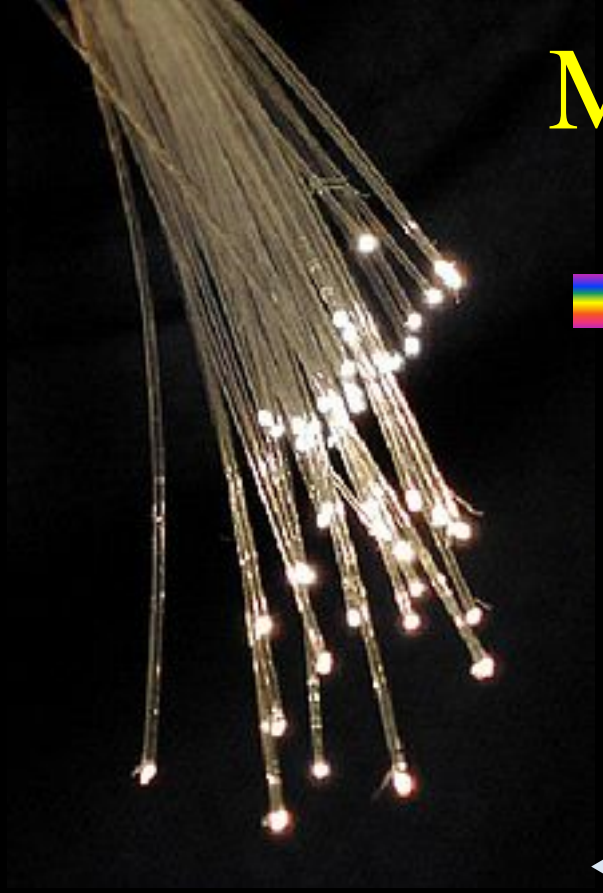
GPU cards are distruptive!

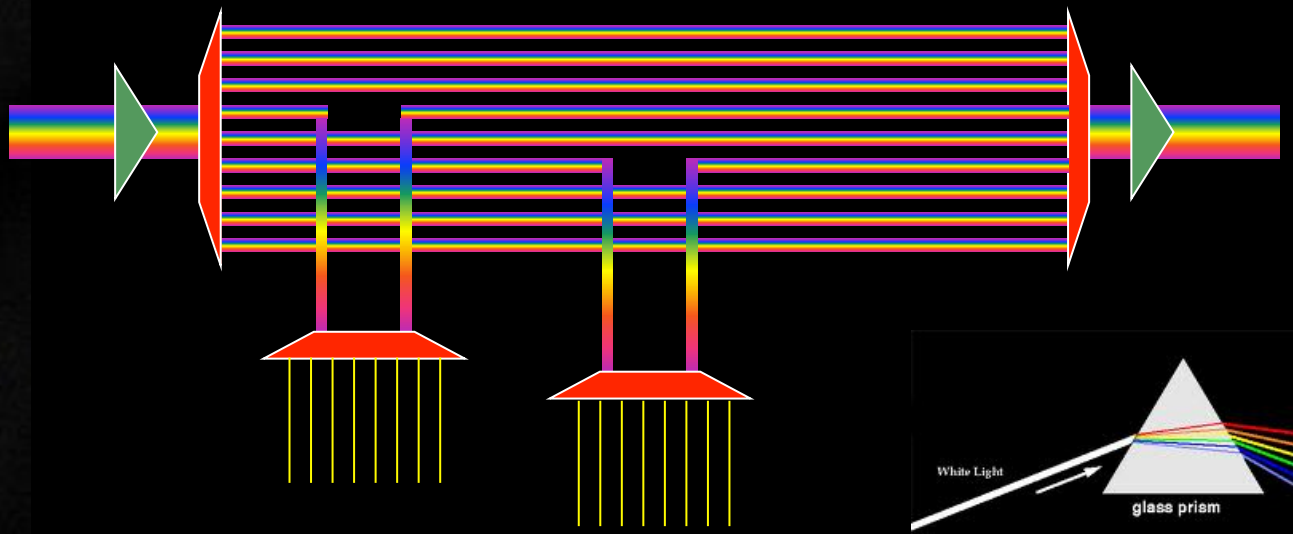


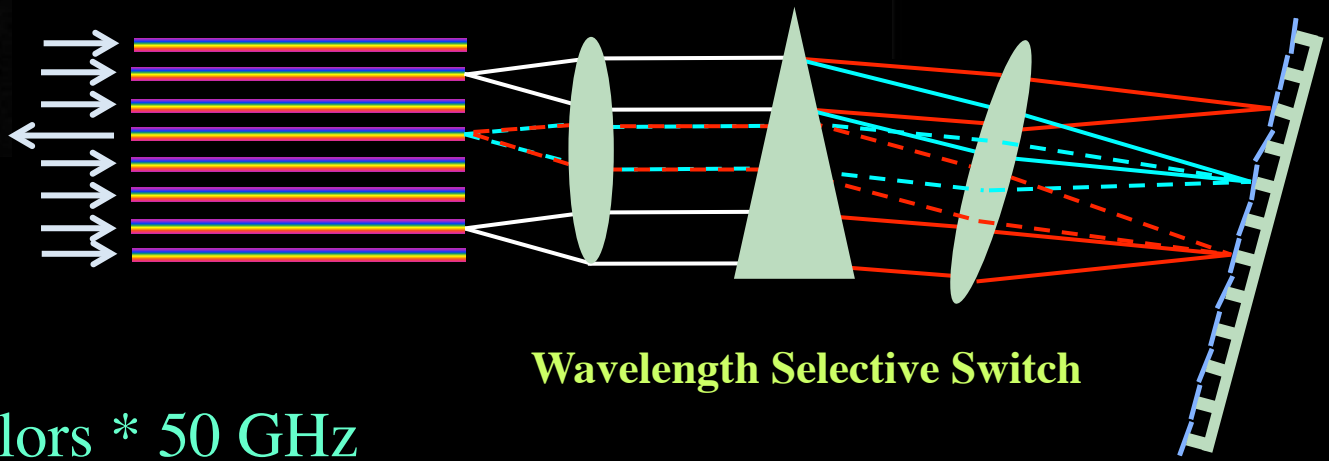
Data storage: doubling every 1.5 year!



Multiple colors / Fiber







Wavelength Selective Switch

Per fiber: ~ 80-100 colors * 50 GHz

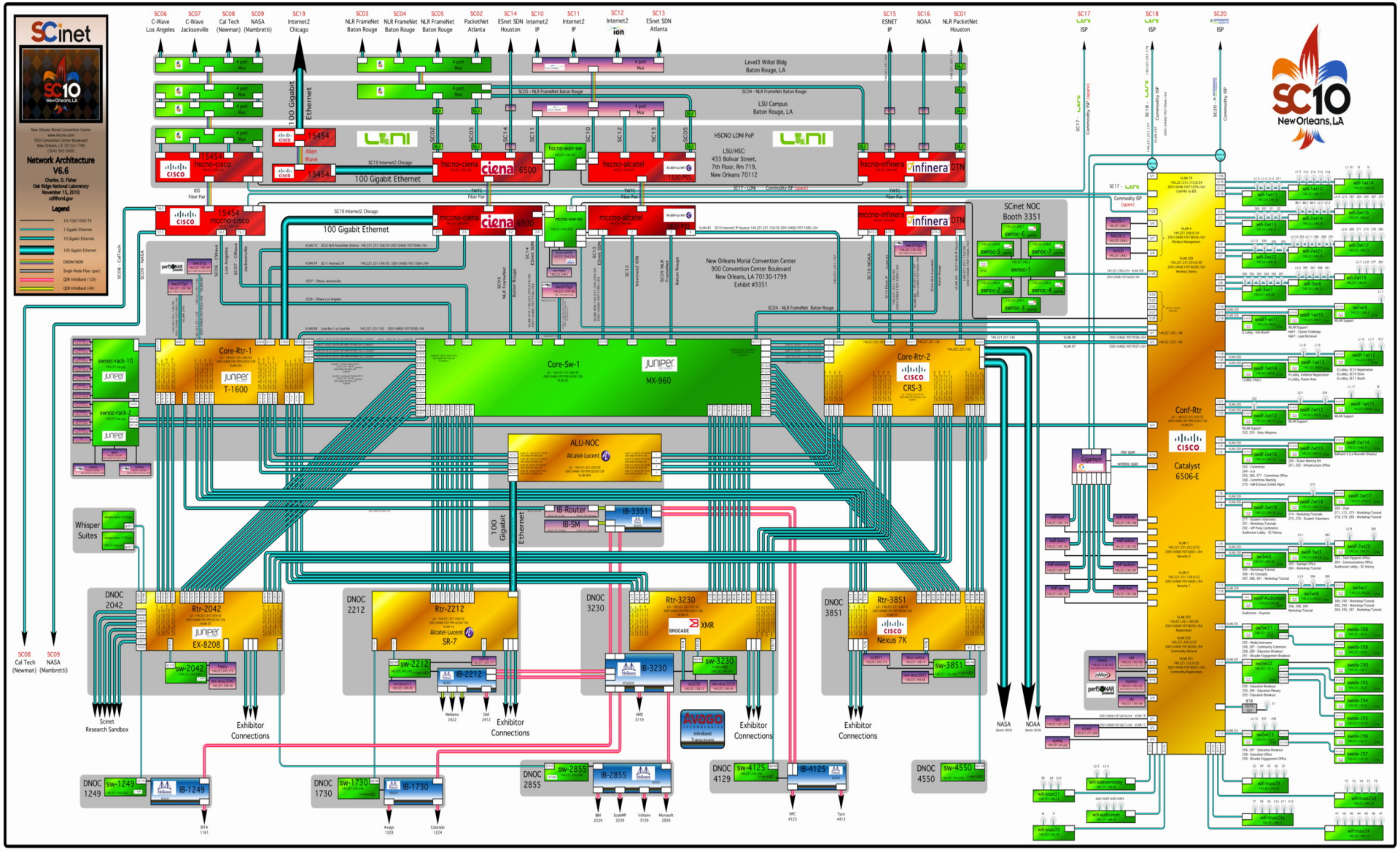
Per color: 10 – 40 – 100 Gbit/s

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

New: Hollow Fiber!

➔ less RTT!

Complex e-Infrastructure!



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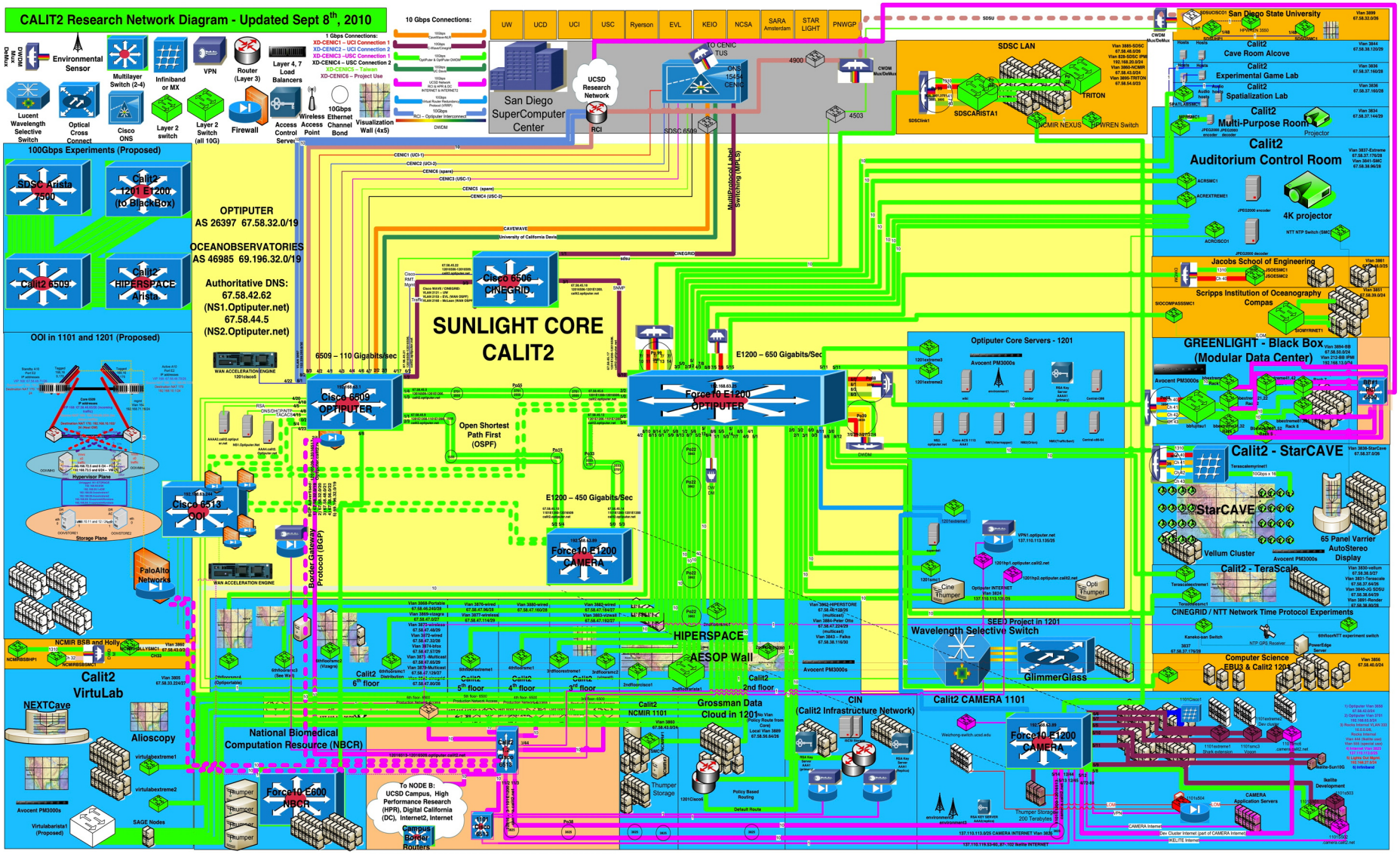
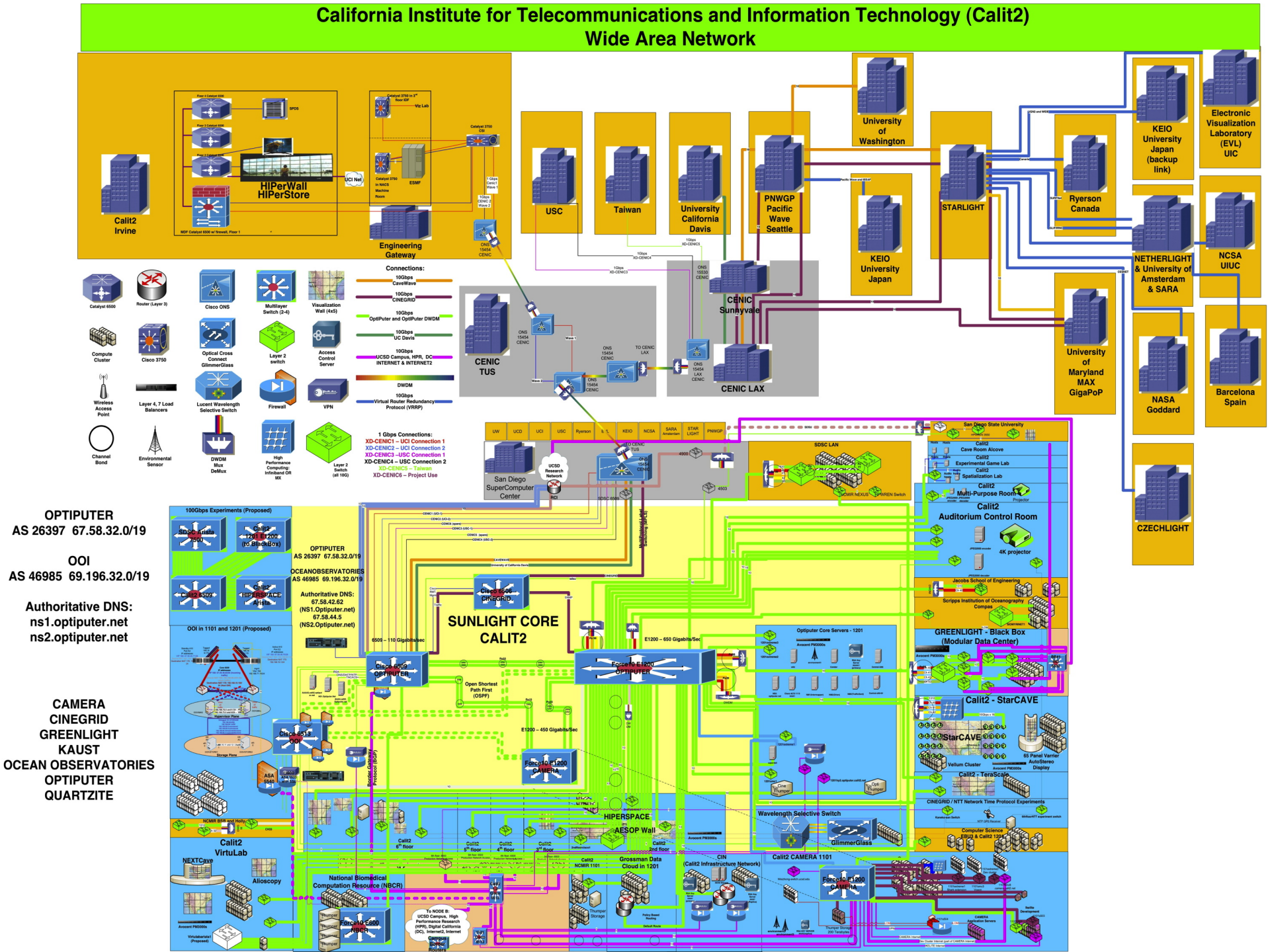


California Institute for Telecommunications and Information Technology (Calit2)
Wide Area Network



Why?

I want to:

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

Why?

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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.

The Ten Problems with the Internet

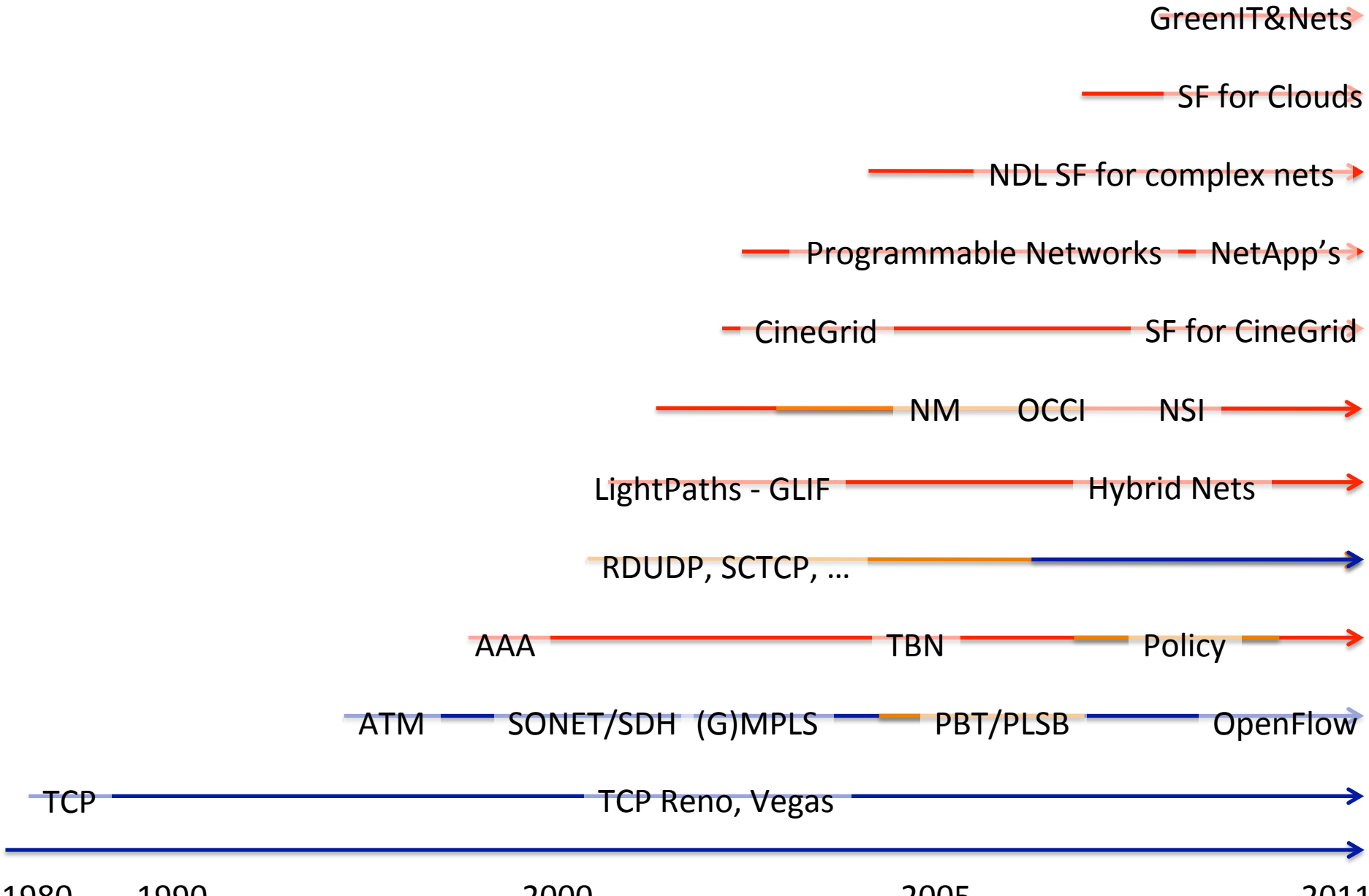
1. **Energy Efficient Communication**
2. Separation of Identity and Address
3. Location Awareness
4. **Explicit Support for Client-Server Traffic and Distributed Services**
5. Person-to-Person Communication
6. Security
7. **Control, Management, and Data Plane separation**
8. **Isolation**
9. Symmetric/Asymmetric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

Nice to have:

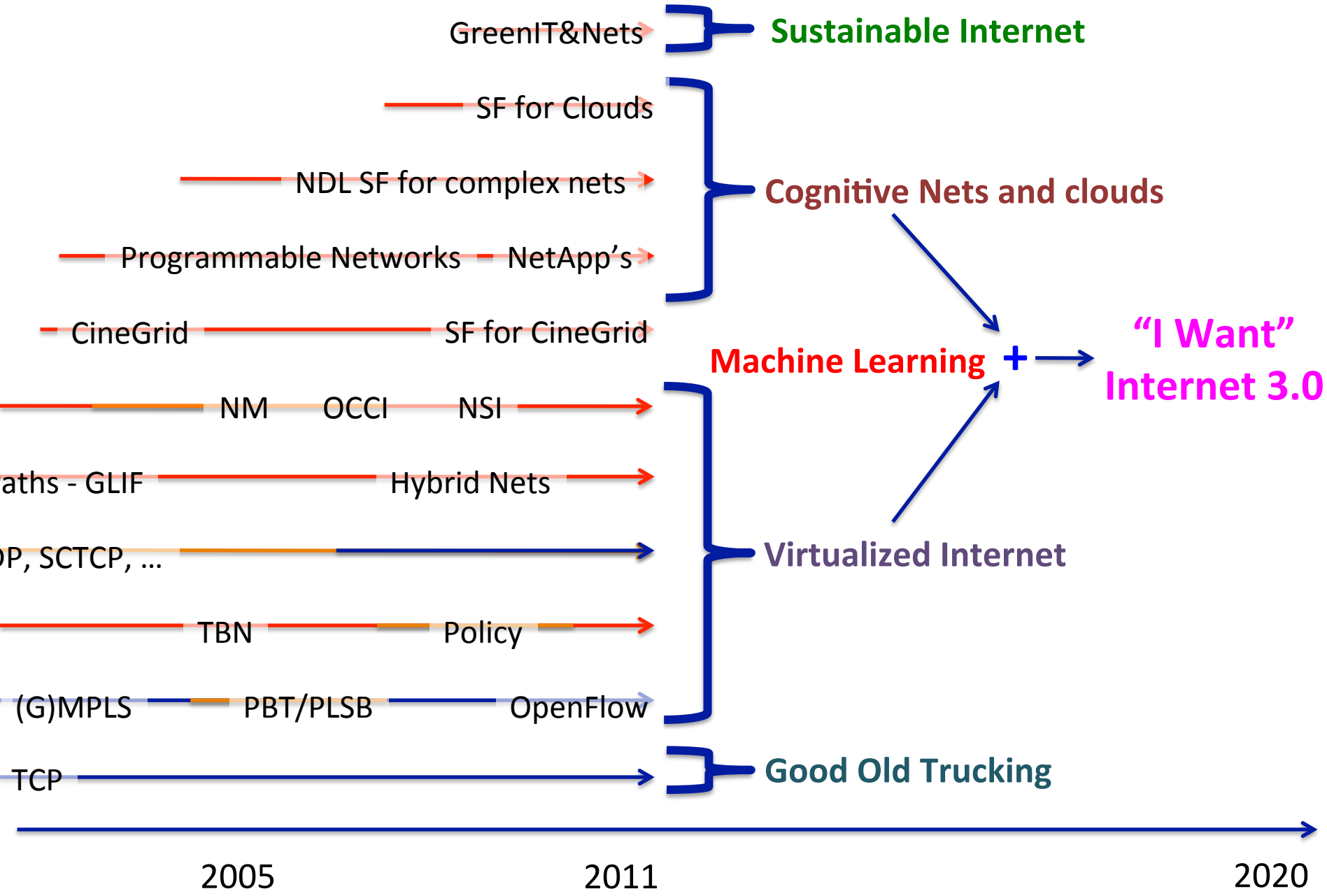
- Global Routing with Local Control of Naming and Addressing
- **Real Time Services**
- **Cross-Layer Communication**
- Manycast
- Receiver Control
- Support for Data Aggregation and Transformation
- **Support for Streaming Data**
- **Virtualization**

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

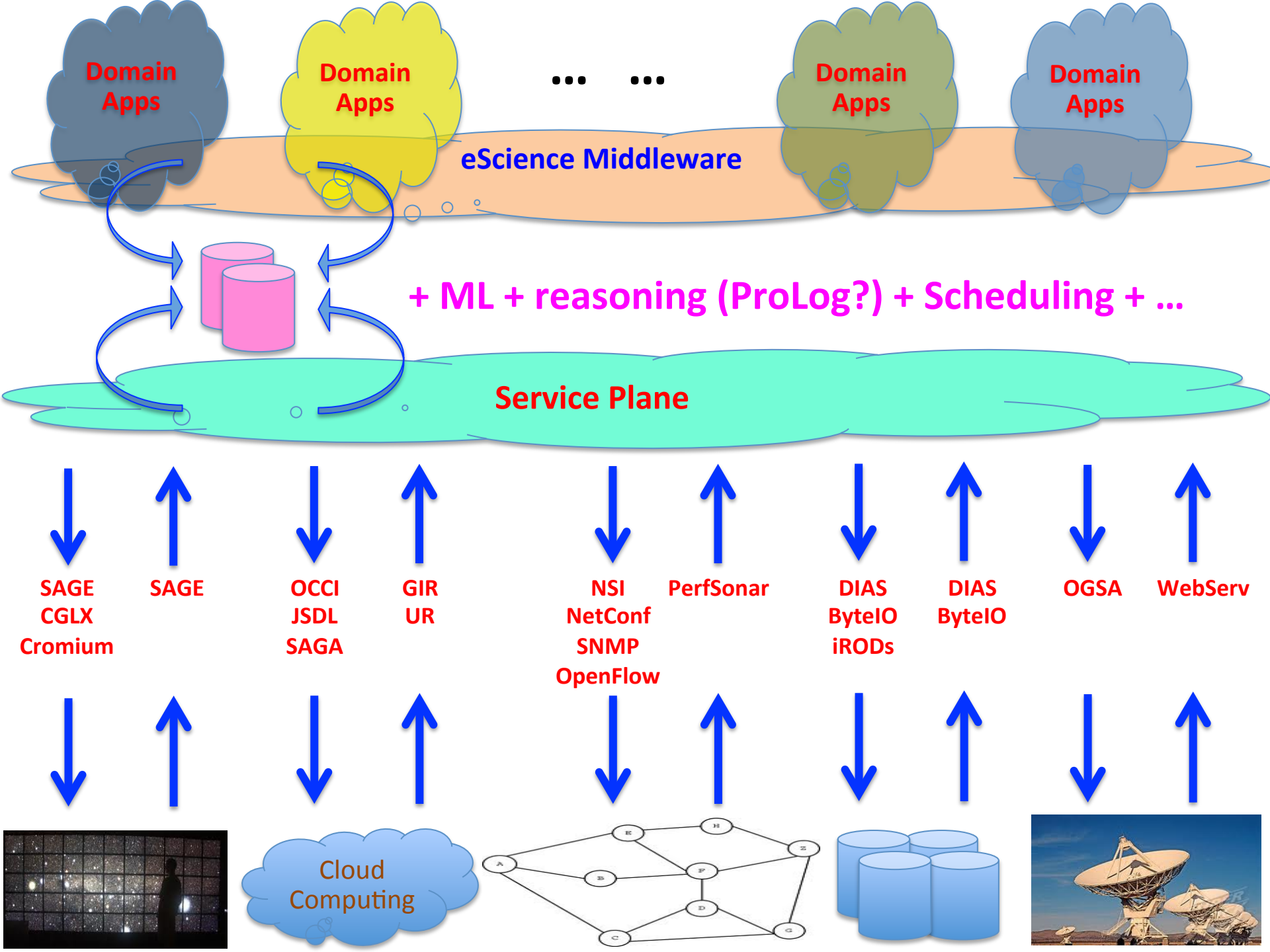
TimeLine

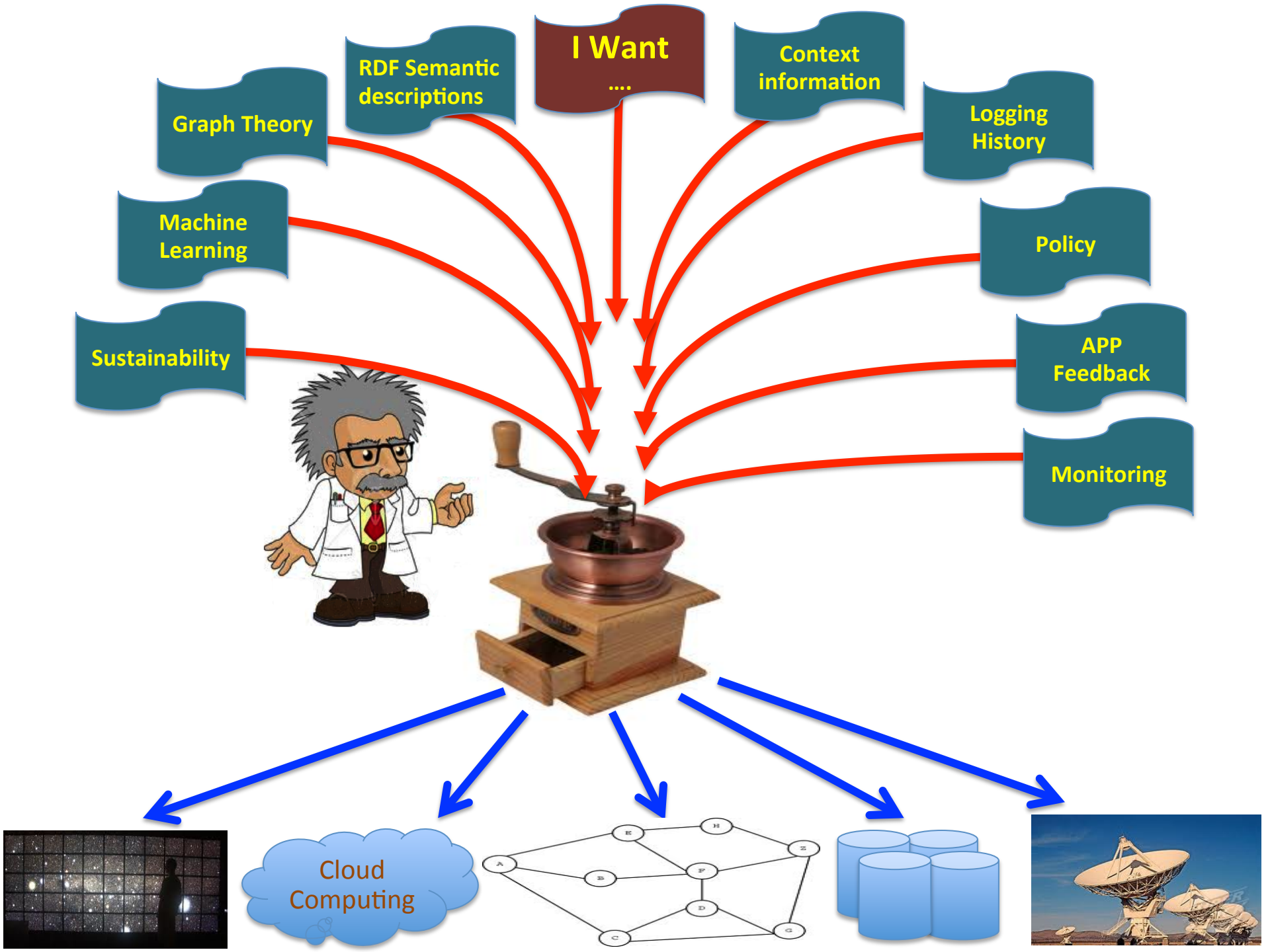
- Sustainable Internet
- Cognitive Nets and clouds
- Machine Learning + → "I Want" Internet 3.0
- Virtualized Internet
- Good Old Trucking

I retire

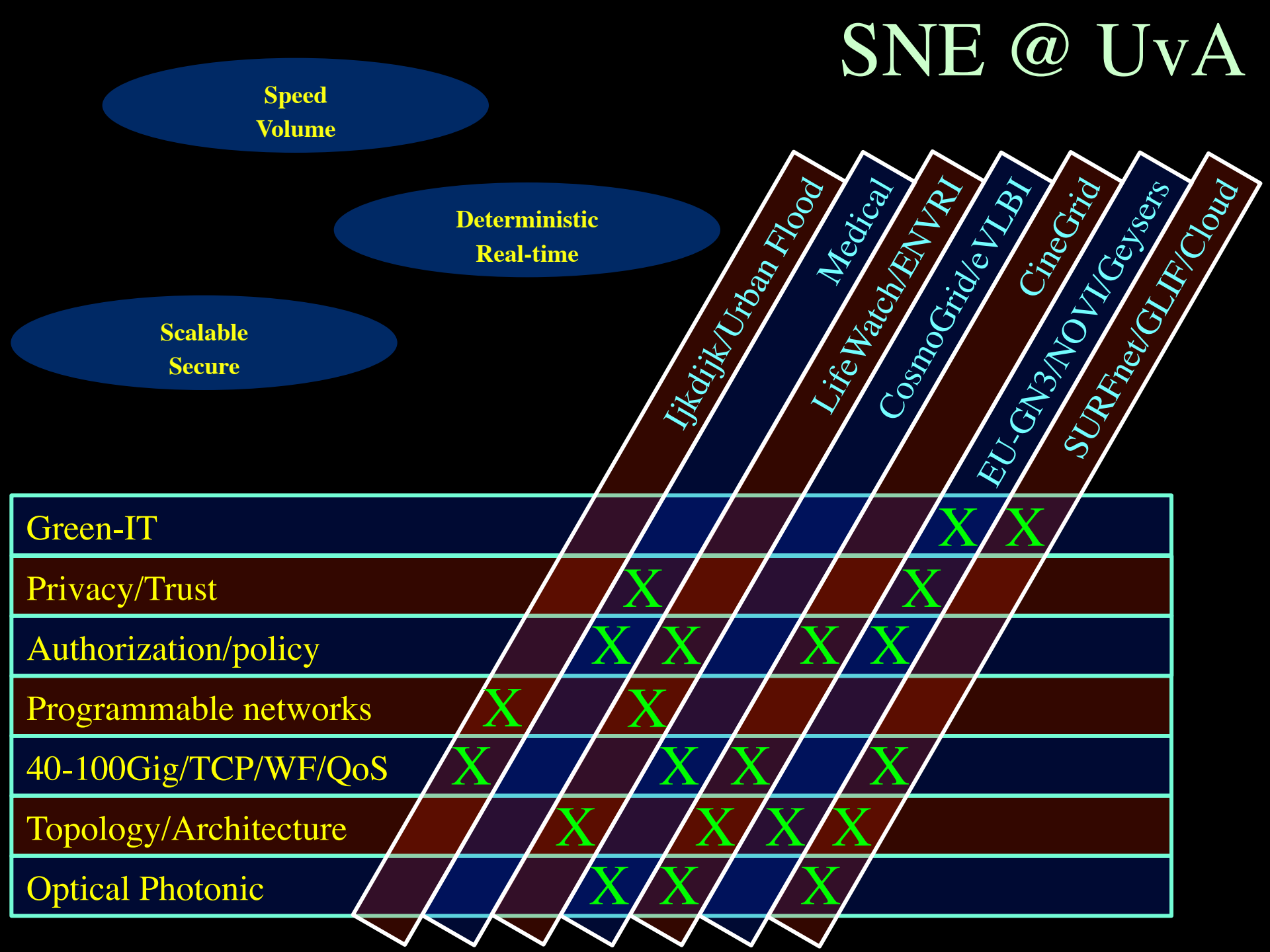
2020

2040

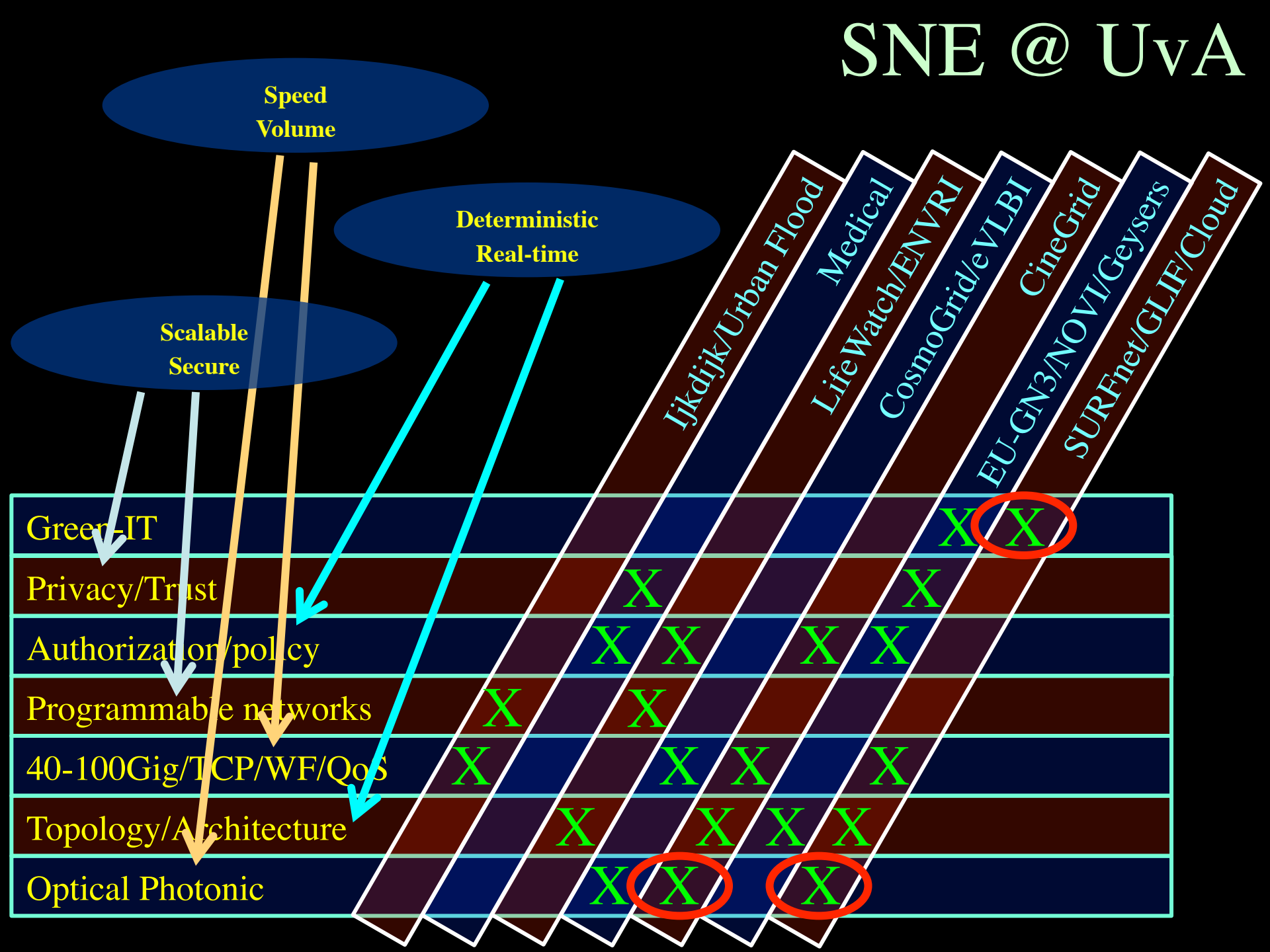

Domain Apps
Domain Apps
... ...
Domain Apps
Domain Apps
eScience Middleware
+ ML + reasoning (ProLog?) + Scheduling + …
Service Plane
SAGE
CGLX
Cromium
SAGE
OCCI
JSDL
SAGA
GIR
UR
NSI
NetConf
SNMP
OpenFlow
PerfSonar
DIAS
ByteIO
iRODs
DIAS
ByteIO
OGSA
WebServ
Cloud Computing


I Want
....
Graph Theory
RDF Semantic descriptions
Context information
Logging History
Machine Learning
Policy
Sustainability
APP Feedback
Monitoring
Cloud Computing

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
Privacy/Trust
Authorization/policy
Programmable networks
40-100Gig/TCP/WF/QoS
Topology/Architecture
Optical Photonic

SNE @ UvA


Speed
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SURFnet/GLIF/Cloud
Green-IT
Privacy/Trust
Authorization/policy
Programmable networks
40-100Gig/TCP/WF/QoS
Topology/Architecture
Optical Photonic

Organizational news: Grant e-Science Center

Henri Bal (VU) **Cees de Laat (UvA)**

Project title:

Generic e-Science initiative for the Netherlands e-Science Center

Grant: 500 k€ (3 y) -> total including matching 3 pd's + 1 AIO

Currently two subprojects:

1. **Big Data, Distributed Data Processing for LOFAR**
   Rob van Nieuwpoort (VU, ASTRON) - Paola Grosso (UvA), Ralph Wijers (UvA)
2. **Information Management**
   Frank van Harmelen (VU) – Pieter Adriaans (UvA)

Some other grants at IvI – System & Network Engineering research in the past year:
GigaPort3-2012 318 k€ (1y), EU-ENVRI (3y) 248 k€, SURF (1y) 240 k€
GigaPort3-2011 238 k€ (1y), COMMIT (5y) 1480 k€, NWO GreenClouds (4y) 205 k€

IJKDIJK

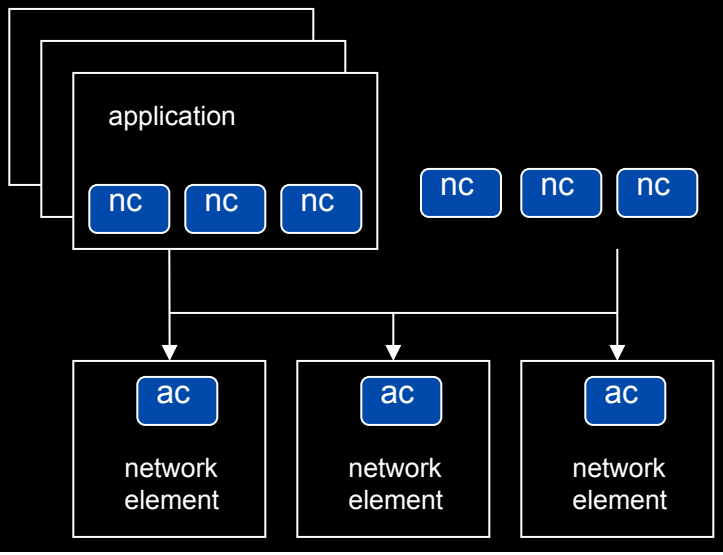
Sensors: 15000km* 800 bps/m ->12 Gbit/s to cover all Dutch dikes

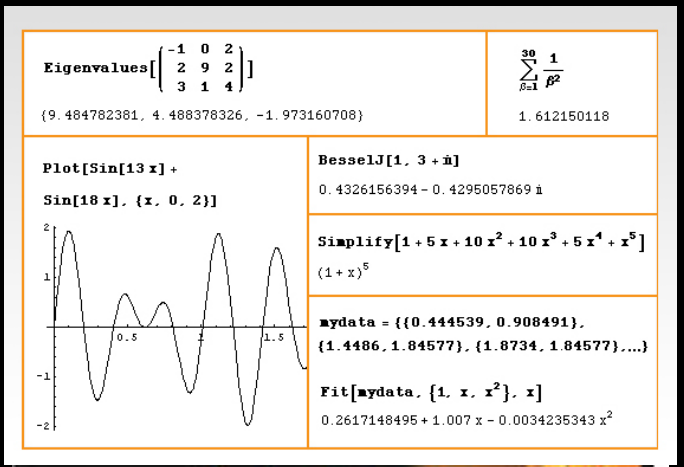
Sensor grid: instrument the dikes

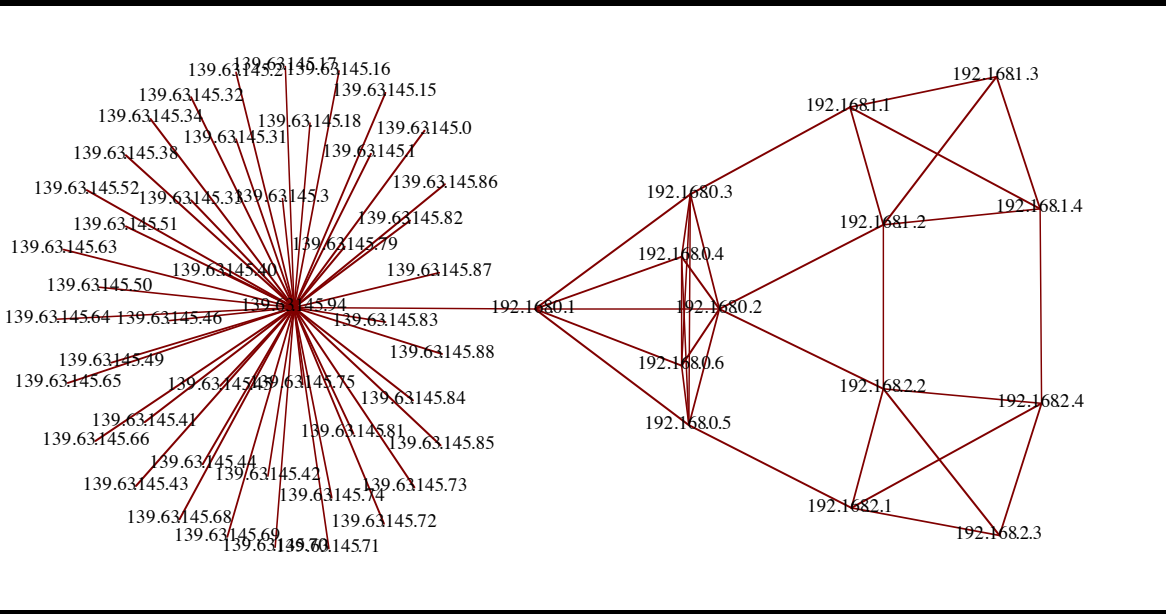
First controlled breach occurred on sept 27th ‘08:

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



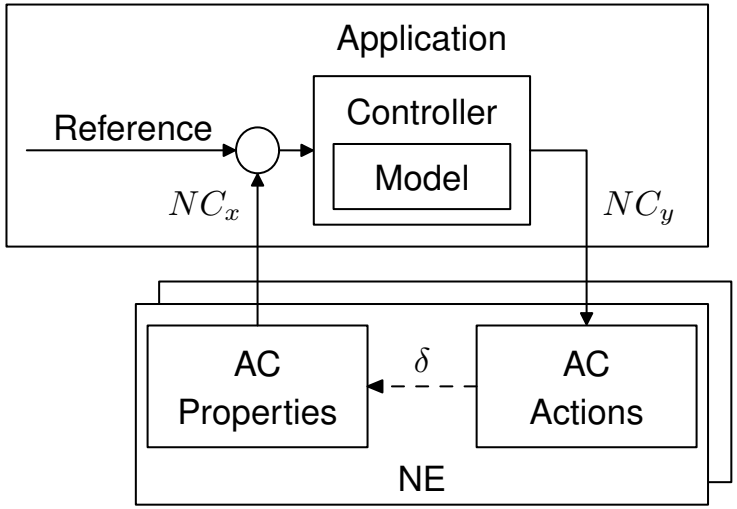




ref: Robert J. Meijer, Rudolf J. Strijkers, Leon Gommans, Cees de Laat, User Programmable Virtualiized Networks, accepted for publication to the IEEE e-Science 2006 conference Amsterdam.

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?

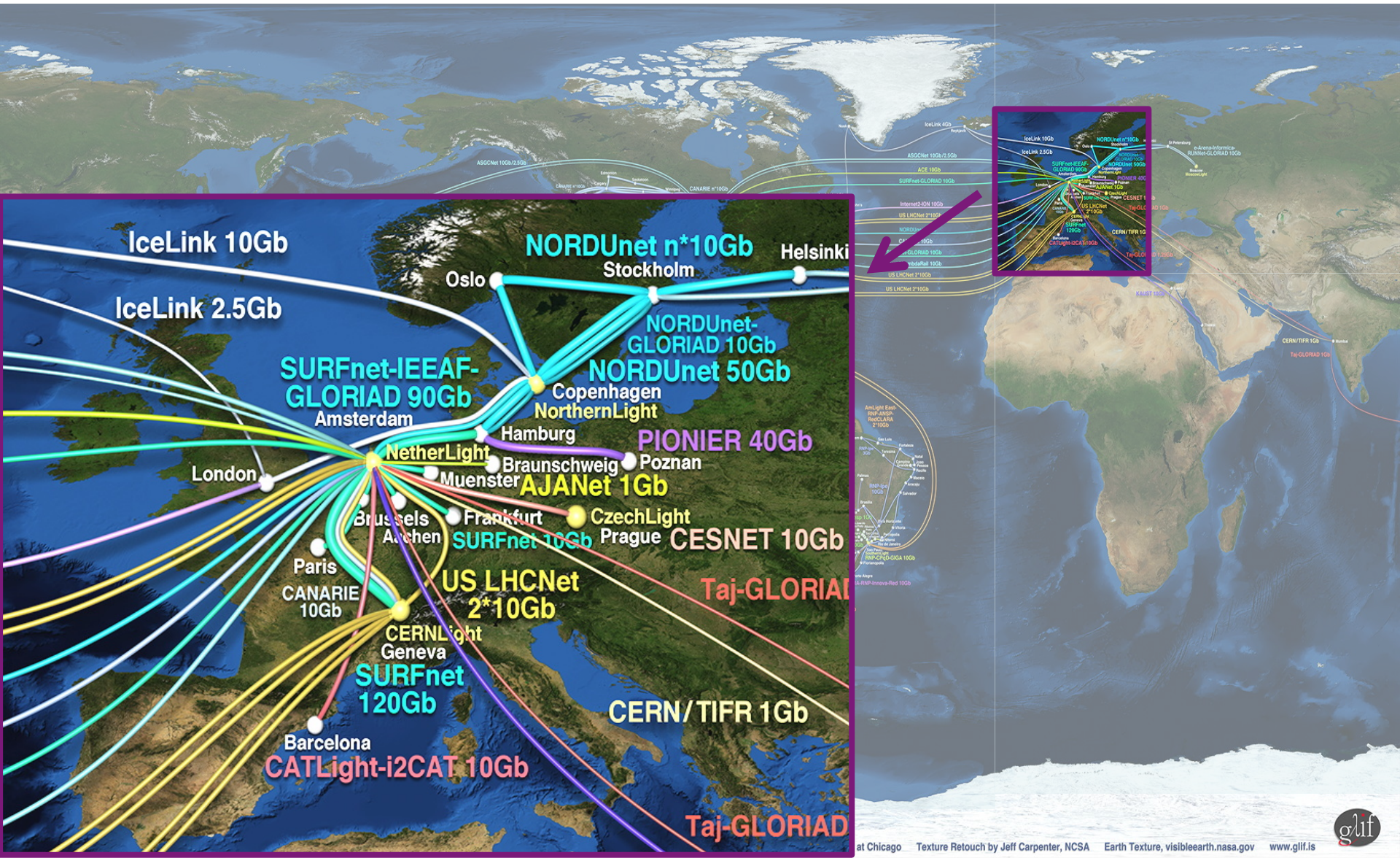


Interactive Networks

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

We investigate: for complex networks!

The GLIF – lightpaths around the world



Alien light From idea to realisation!

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

NCF

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.

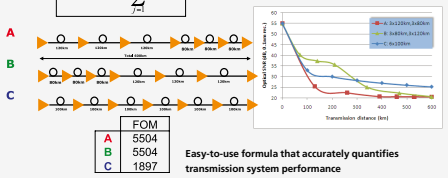
In this demonstration we will investigate the performance of a 40Gb/s PM-QPSK alien wavelength installed on a 10Gb/s DWDM infrastructure.

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

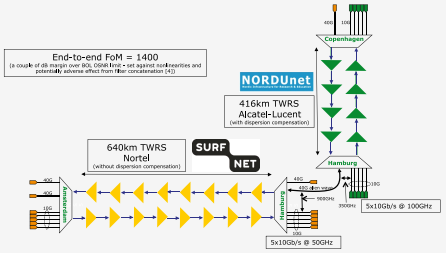


	FOM
A	5504
B	5504
C	1897

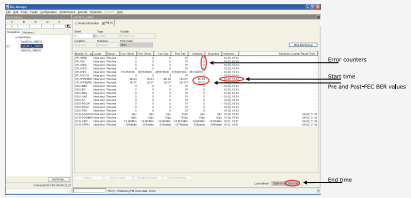
Easy-to-use formula that accurately quantifies transmission system performance

Transmission system setup

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



Test results



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

Conclusions

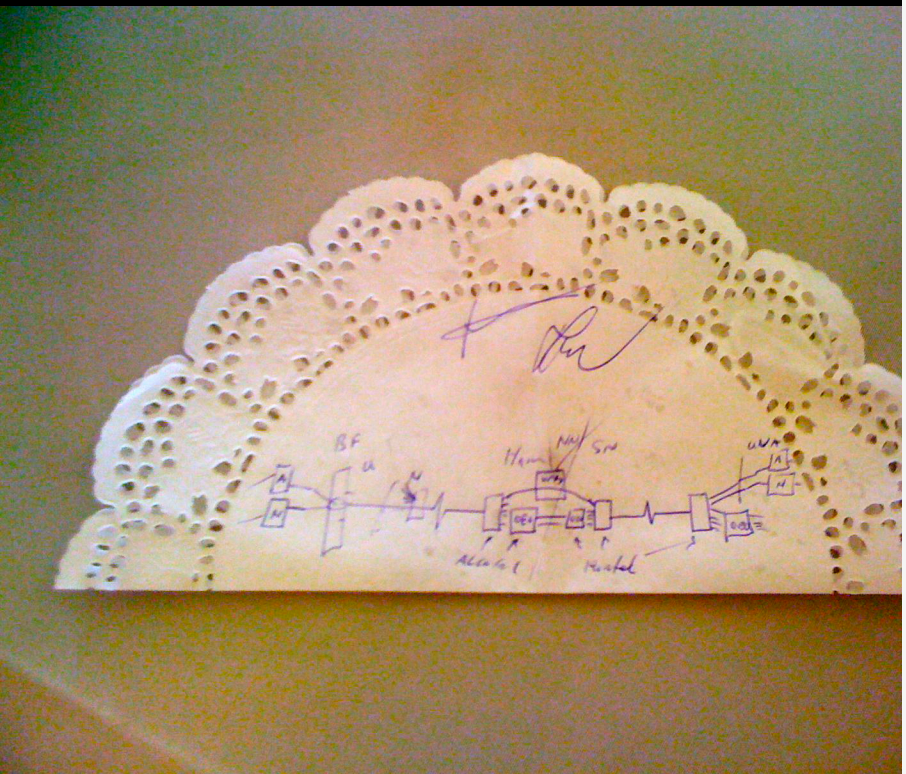
- We have investigated experimentally the all-optical transmission of a 40Gb/s PM-QPSK alien wavelength via a concatenated native and third party DWDM system that both were carrying live 10Gb/s wavelengths.
- The end-to-end transmission system consisted of 1056 km of TWRS (TrueWave Reduced Slope) transmission 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.

NORTEL NORDUnet telindus together with ISTY 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

Alien light From idea to realisation!



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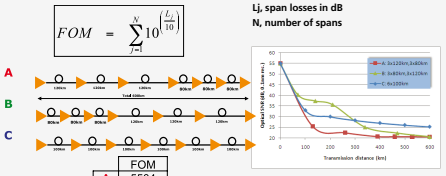

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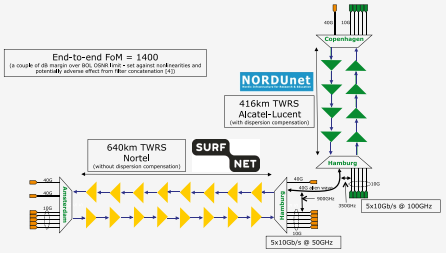

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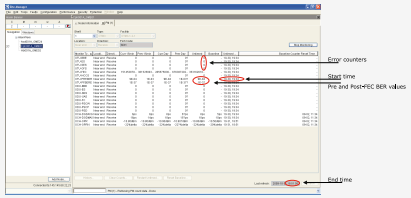

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ClearStream @ TNC2011

Setup codename:
FlightCees

UvA

iPerf
I7 3.2 GHz Q-core

iPerf
Amd Ph II 3.6 GHz HexC

Mellanox

40G E

Copenhagen

iPerf
2* dual 2.8 GHz Q-core

iPerf

Mellanox

CIENA
OME
6500

CERN

Hamburg

CIENA DWDM

Alcatel DWDM

CIENA
OME
6500

CIENA
OME
6500

17 ms RTT

27 ms RTT

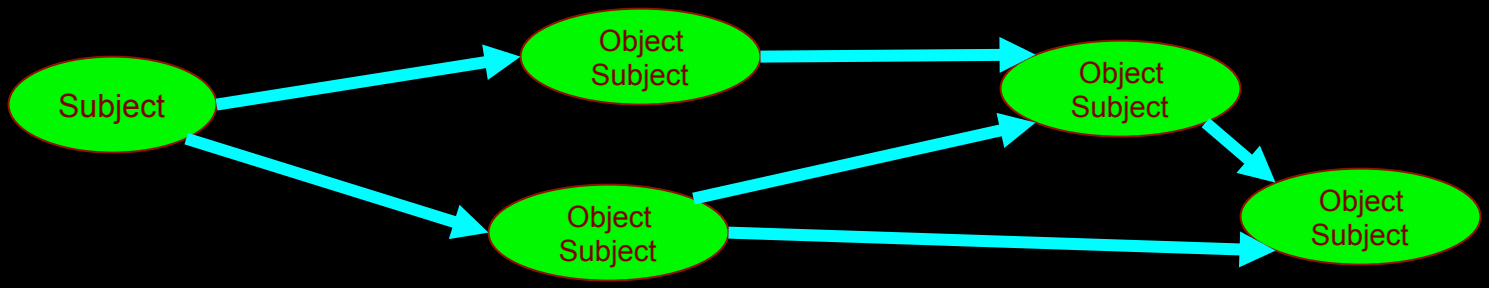
LH

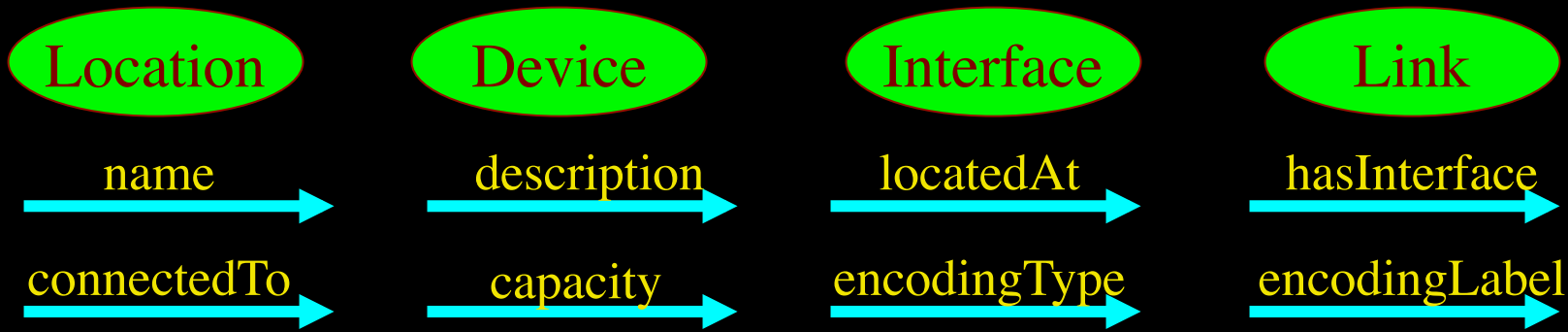
LH

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

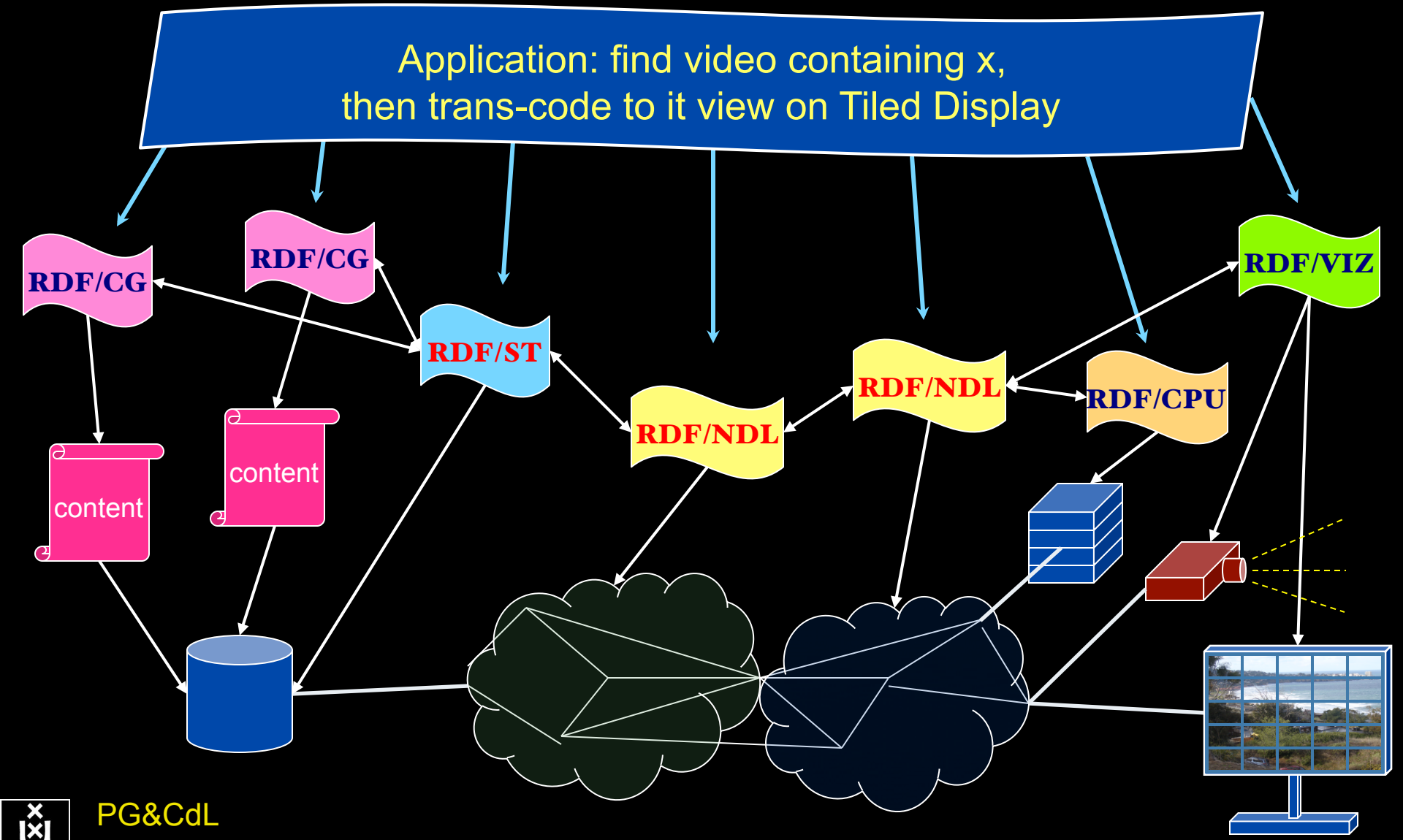
LinkedIN for Infrastructure

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



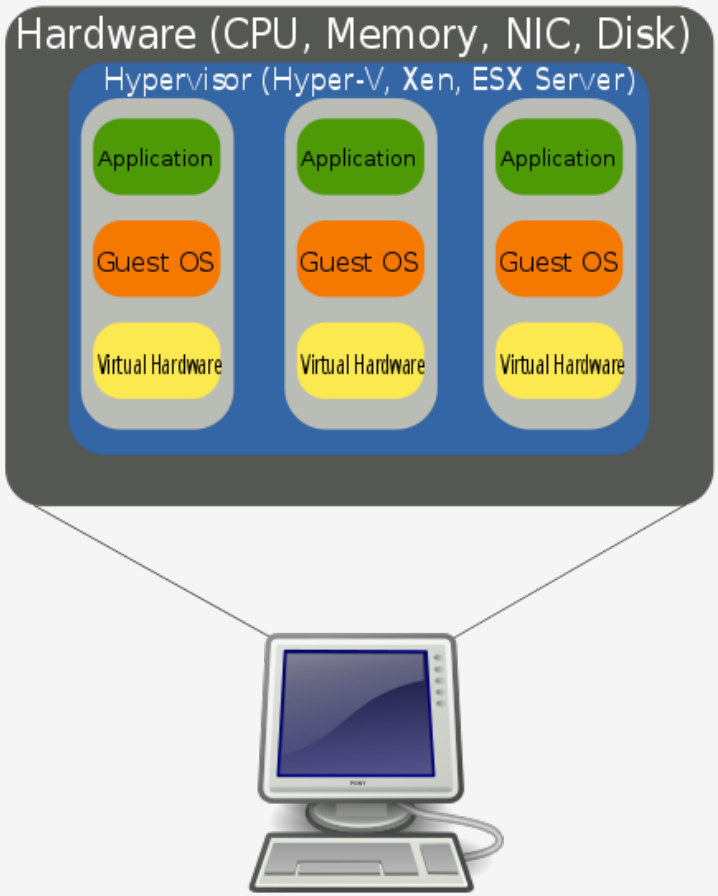


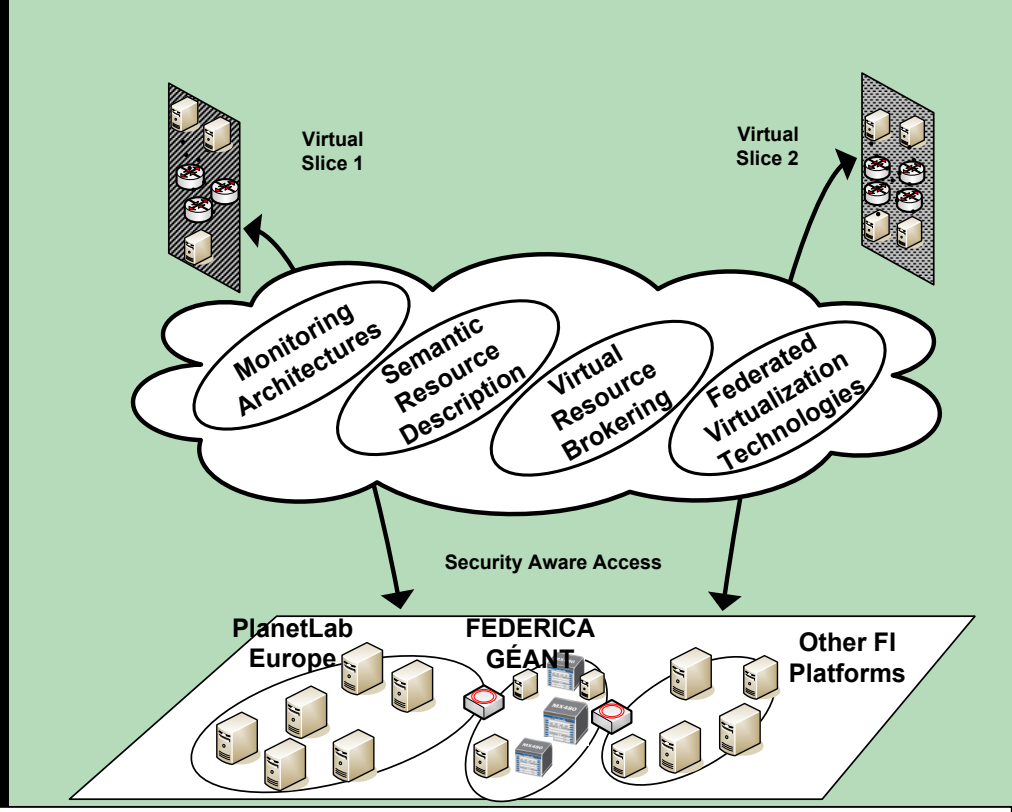
RDF describing Infrastructure

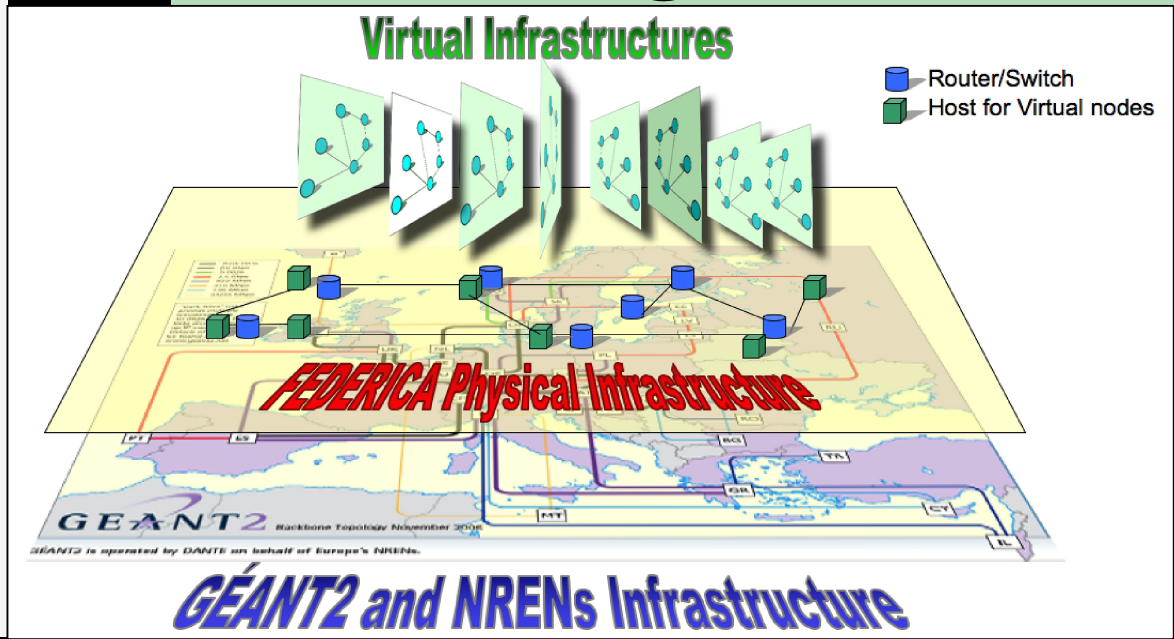


PG&CdL

Virtualisatie van infrastructuur & QoS







The laboratory of environmental research infrastructures

Deep Earth, land and sea, the atmosphere

Living and dead environments

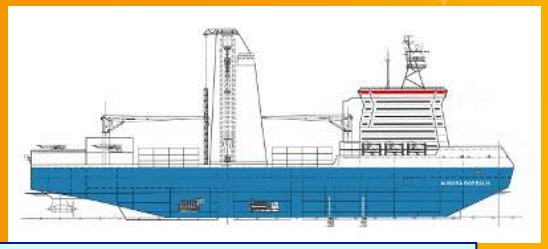
ESFRI Projects for Env. Sciences: status 2010

EURO-ARGO

SIOS

IAGOS-ERI

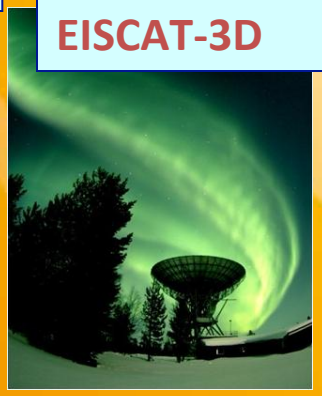
EUFAR-COPAL



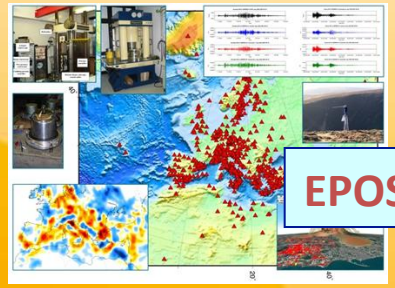
AURORA BOREALIS

LIFEWATCH

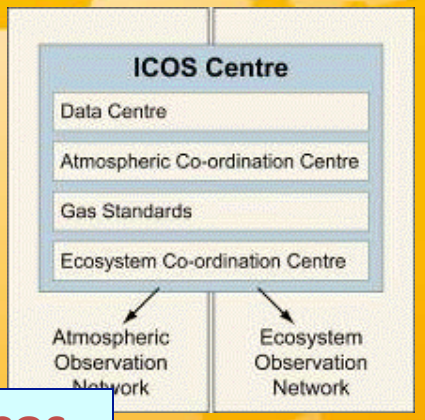
EISCAT-3D



EMSO

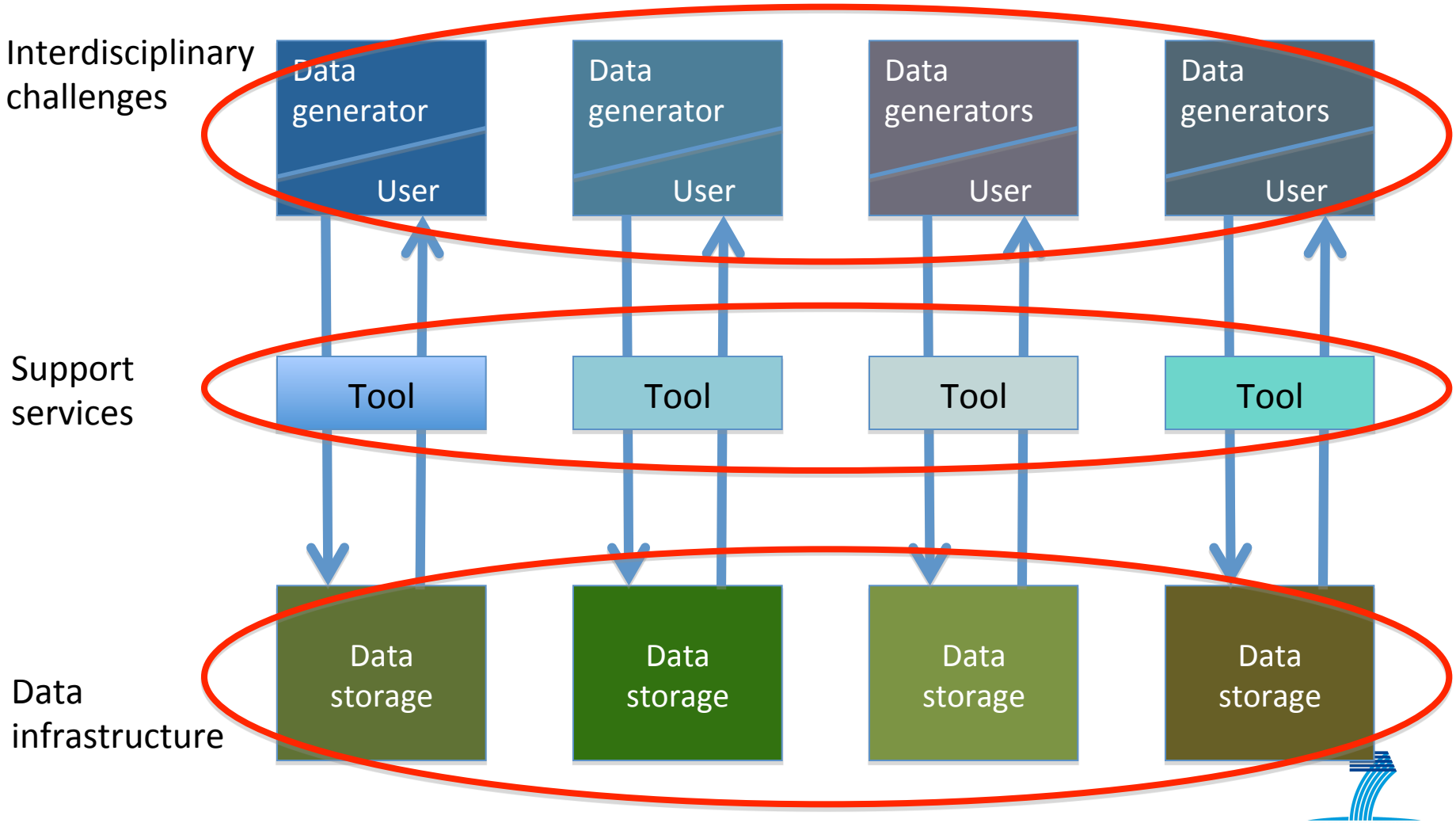


EPOS



ICOS

A cottage industry in the data desert



SEVENTH FRAMEWORK PROGRAMME

Data generators

Users

Community Support Services

Data Services
+ processed data and workflows

Data transfer
Fast data transmission
Operation at remote sites

User functionalities
Virtual Environments & Collaborative organisations
Security & Protection

Data discovery & Navigation
Data submission tools (meta) data tagging tools
Operational Semantic Interoperability

Workflow Generator
Knowledge management
Virtualisation

Persistant storage capacity
24/7 operation
Preservation & Sustainability (digital asset management)

Authenticity
Certification & Integrity
GUIDs

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 loosly coupled than totally unified integrated…

Hybrid Networking <-> Computing

Routers ⇐ ⇒ Supercomputers

Ethernet switches ⇐ ⇒ Grid & Cloud

Photonic transport ⇐ ⇒ GPU's

What matters:

- Energy consumption/multiplication
- Energy consumption/bit transported

ECO-Scheduling

Education- Master SNE

- Open Source approach

☺ He listens!
☺

- Based on open and non-discriminatory standards
- Privacy and Security
- Digital security & forensics
- Internet infrastructure
- Master closely related to researchgroup!

Q & A

http://ext.delaat.net/

Slides thanks to:

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