# Mastering Complex Cyber Infrastructure

**Cees de Laat**

EU

COMMIT

UvA

NWO

PID/EFRO

SURFnet

TNO

NCF

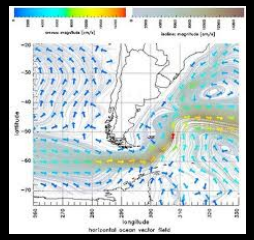
# Science Faculty @ UvA

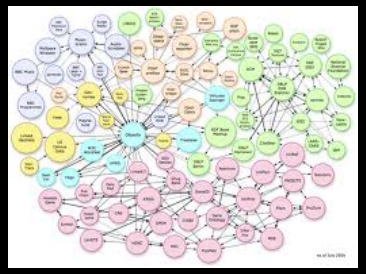
## Informatics Institute

- 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)

# Internet developments

... more data!

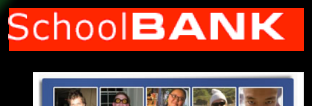




... more realtime!











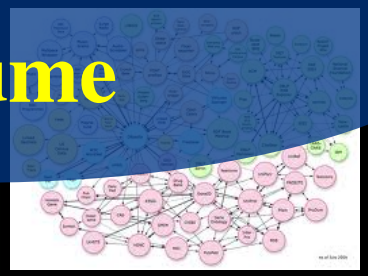
... more users!

# Internet developments

... more data!

**Speed**

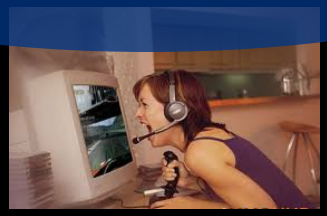
**Volume**



**Deterministic**

**Real-time**

more realtime!

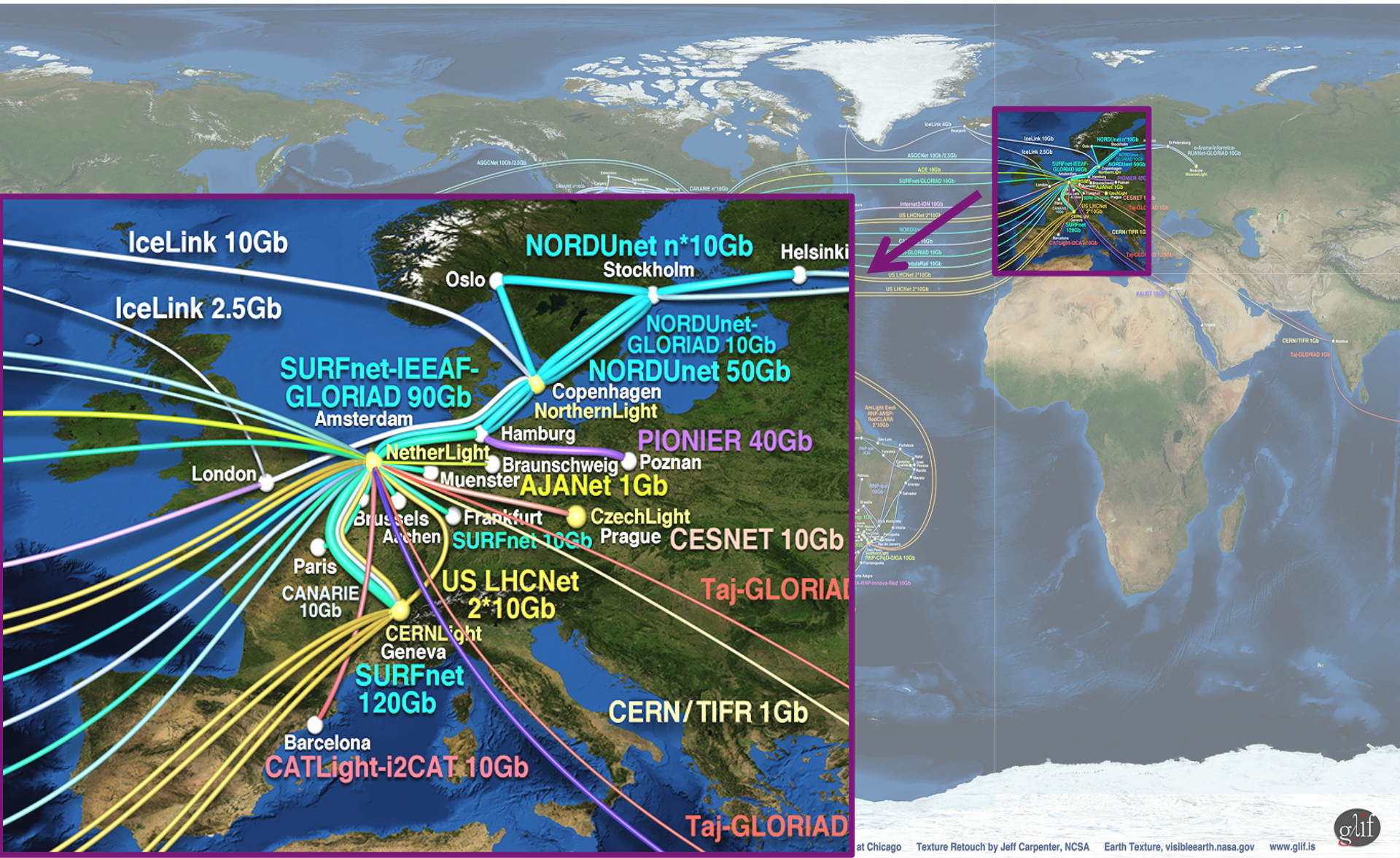
**Scalable**

**Secure**


... more users!

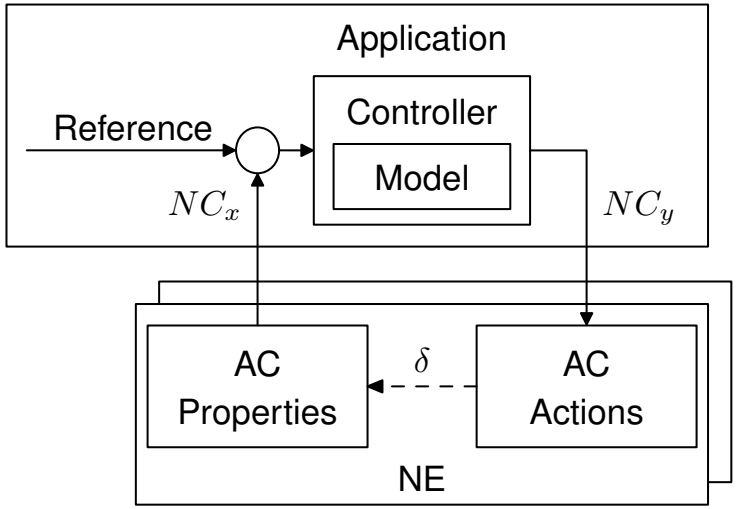
We investigate: for complex networks!

# The GLIF – lightpaths around the world



# In the Intercloud virtual servers and networks become software

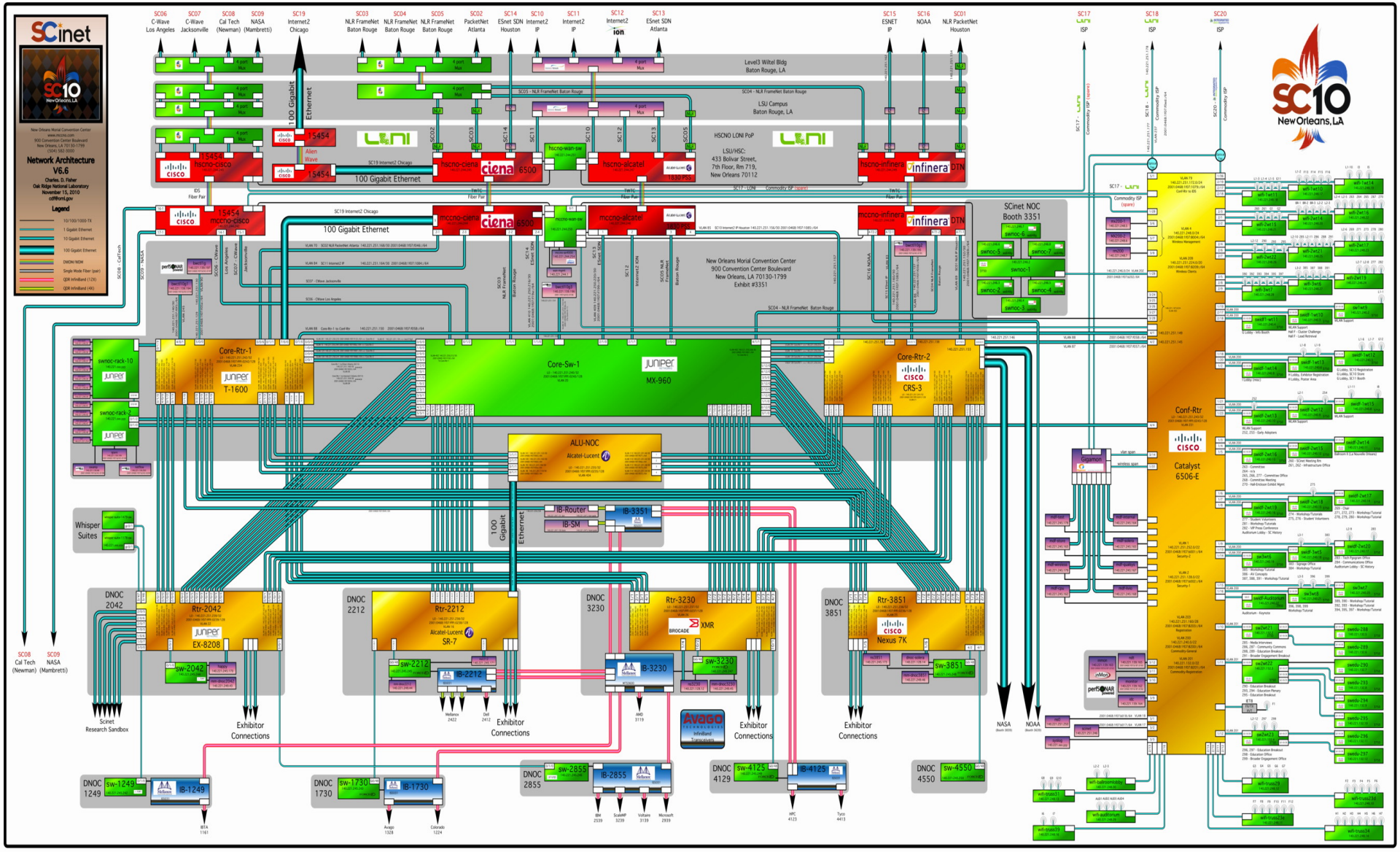
- Virtual Internets adapt to the environment, grow to demand, iterate to specific designs
- Network support for application specific interconnections are merely opitimizations: Openflow, active networks, cisco distributed switch
- But how to control the control loop?



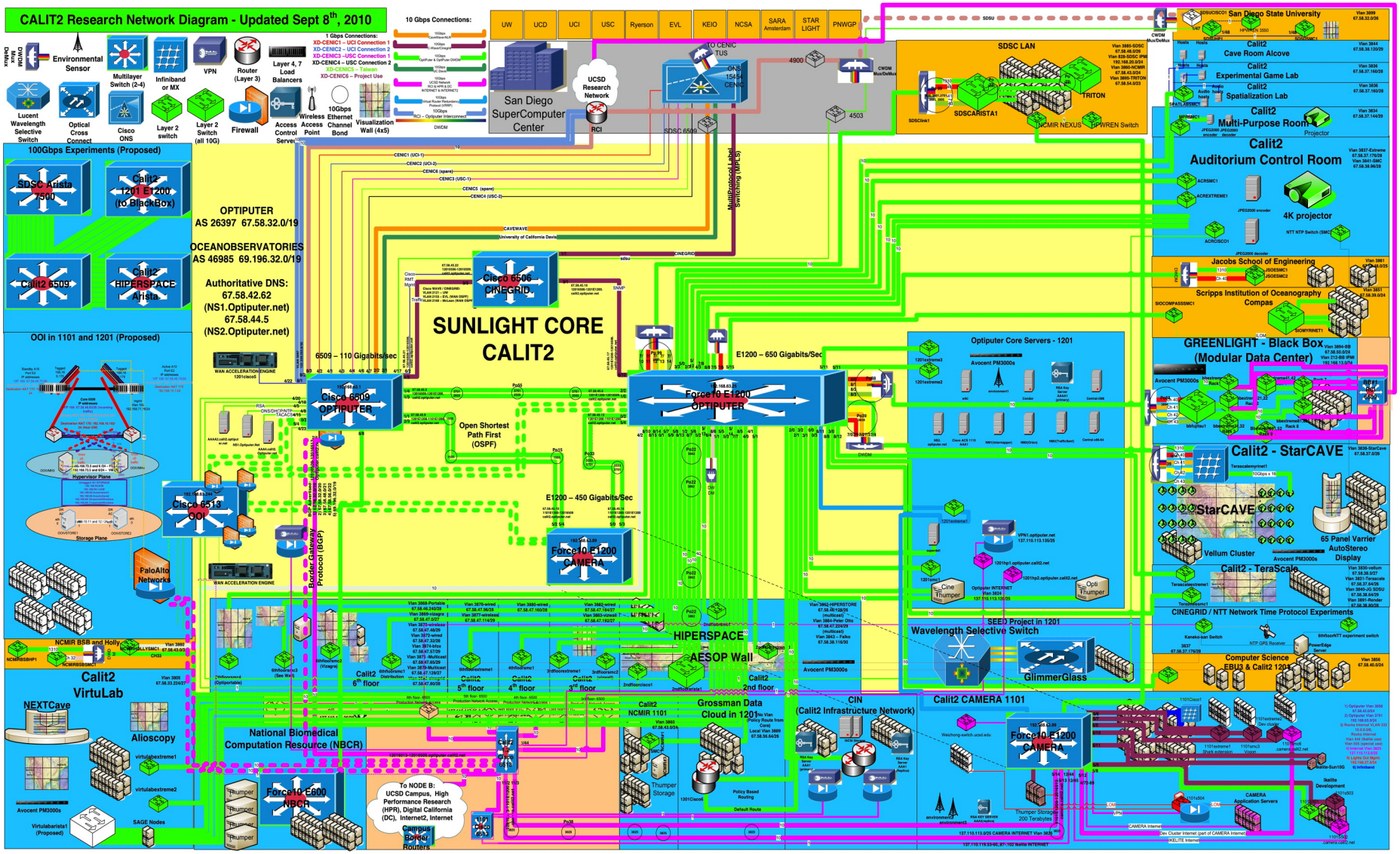

# Interactive Networks

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

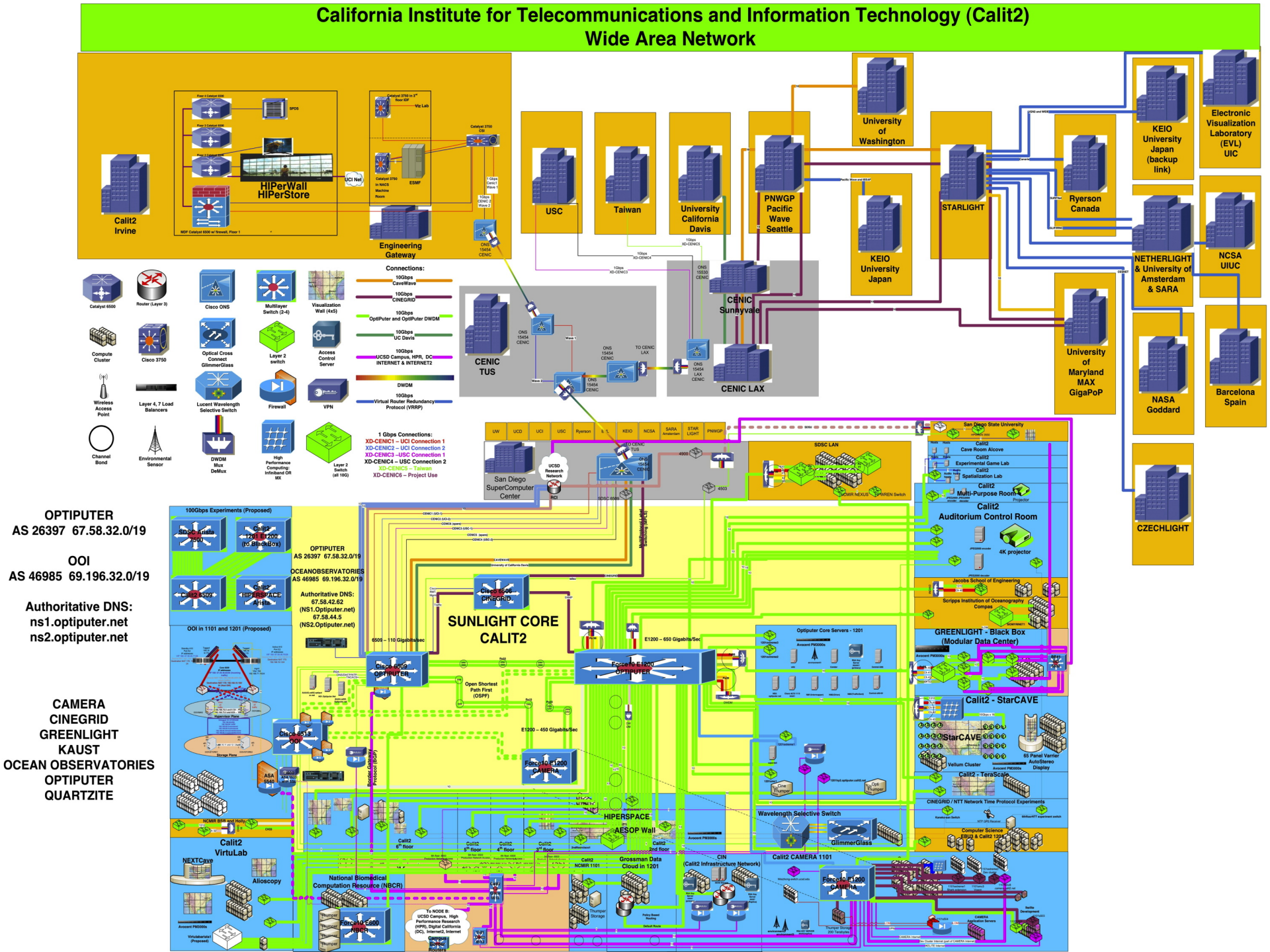
# Complex e-Infrastructure!



# Complex e-Infrastructure!



# 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?

I want to:

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

# 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

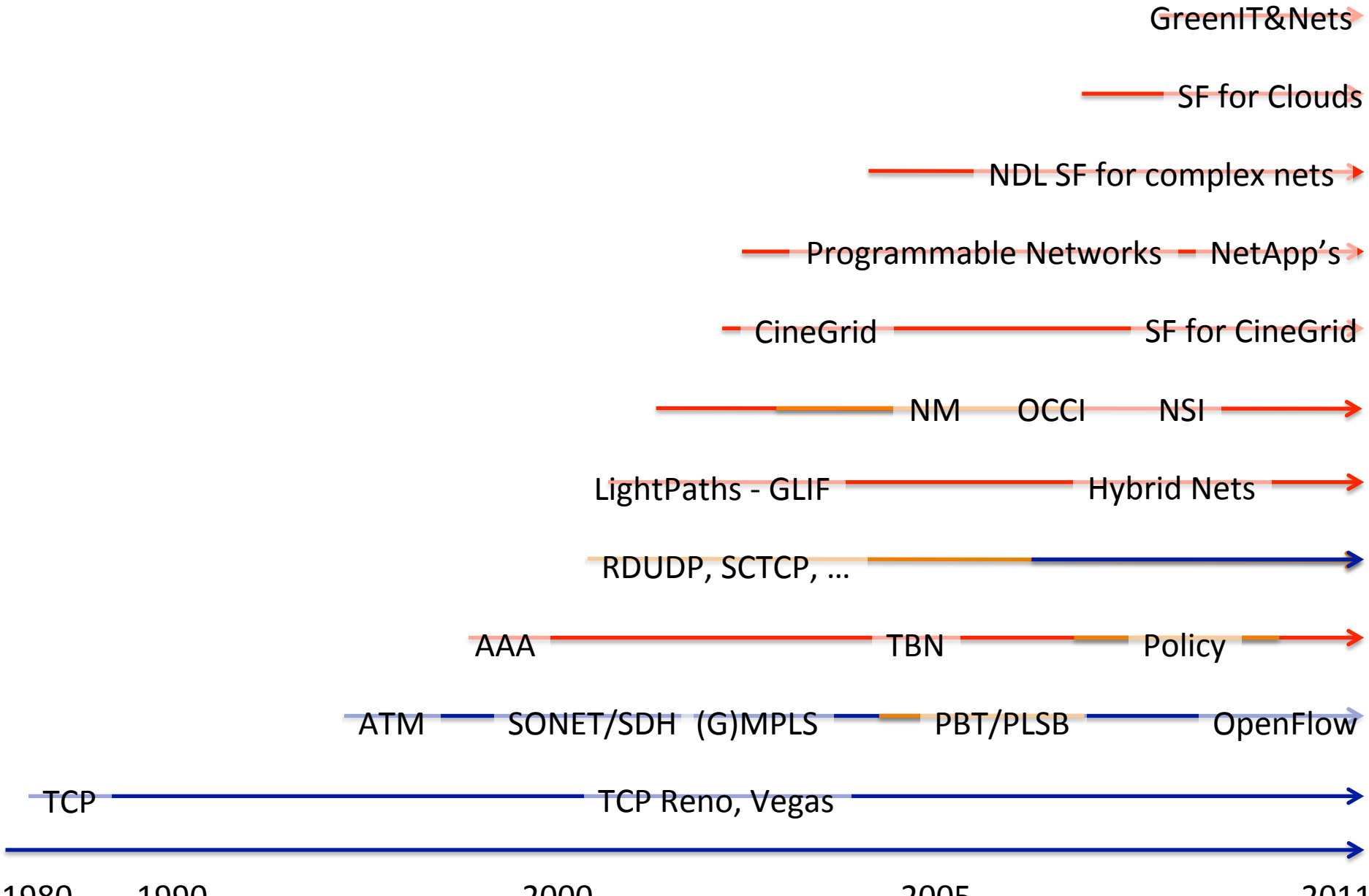
1. **Energy Efficient Communication**
2. Separation of Identity and Address
3. Location Awareness
4. **Explicit Support for Client-Server Traffic and Distributed Services**
5. Person-to-Person Communication
6. Security
7. **Control, Management, and Data Plane separation**
8. **Isolation**
9. Symmetric/Asymmetric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

*Nice to have:*

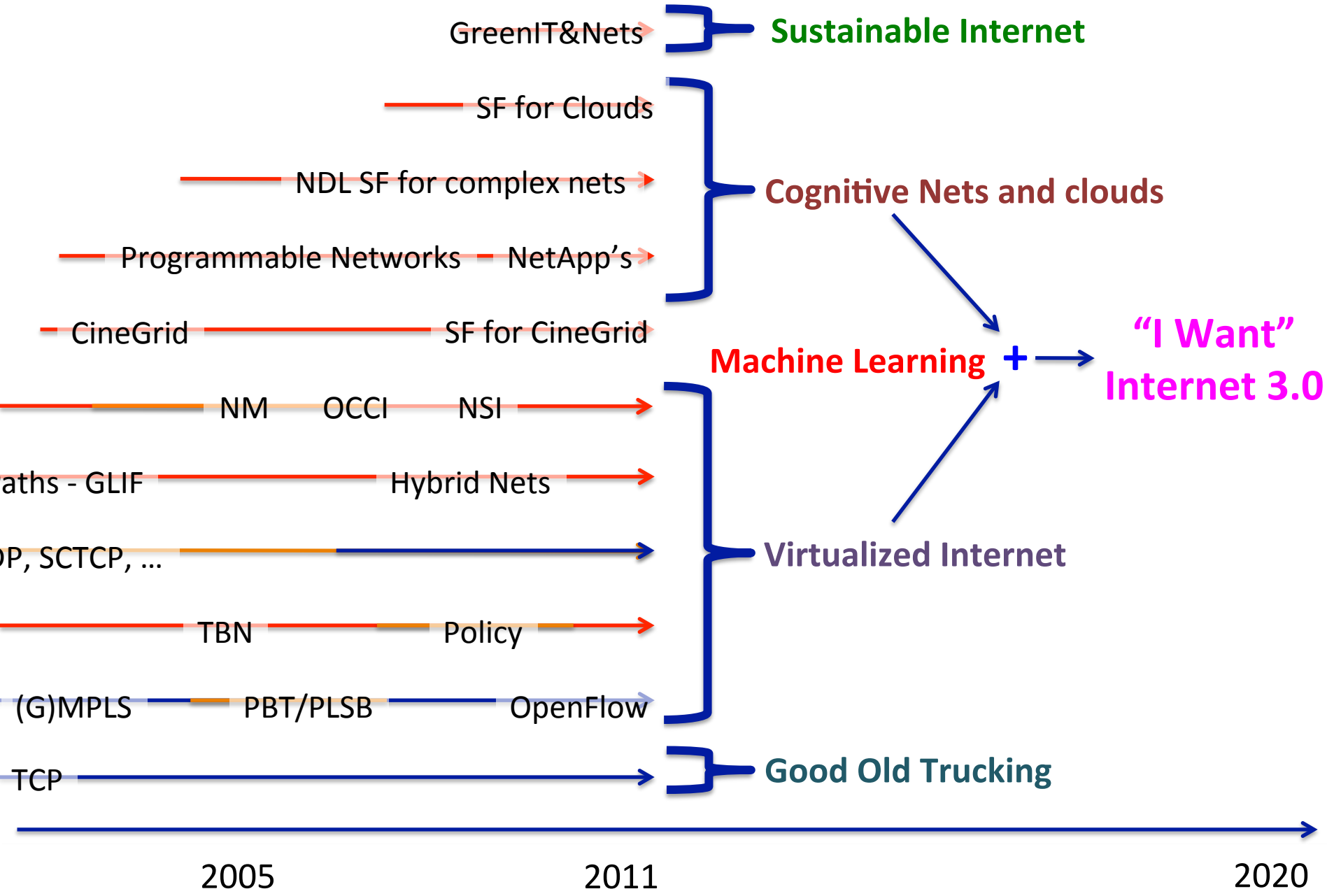
- Global Routing with Local Control of Naming and Addressing
- **Real Time Services**
- **Cross-Layer Communication**
- Manycast
- Receiver Control
- Support for Data Aggregation and Transformation
- **Support for Streaming Data**
- **Virtualization**

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

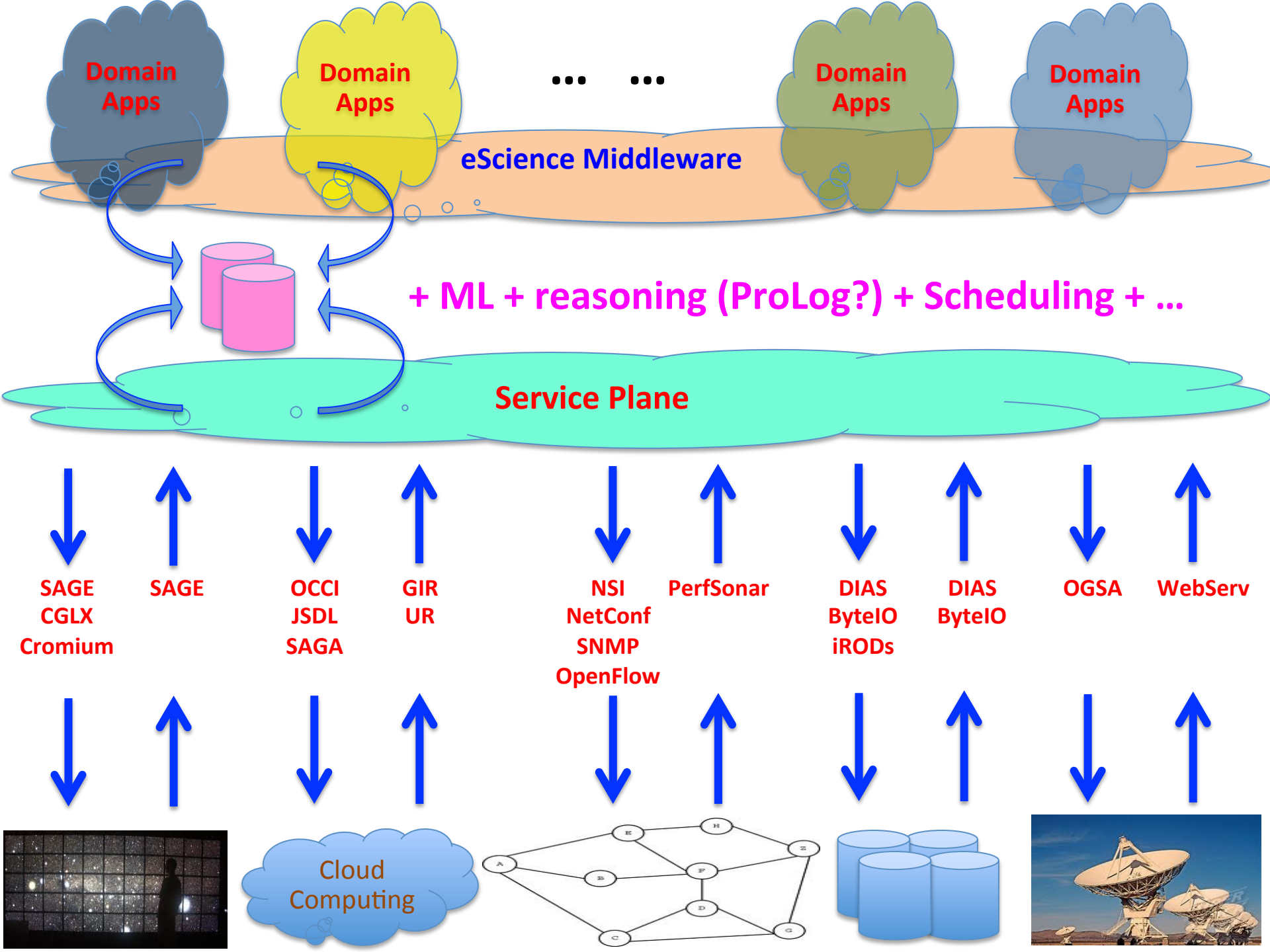
# TimeLine

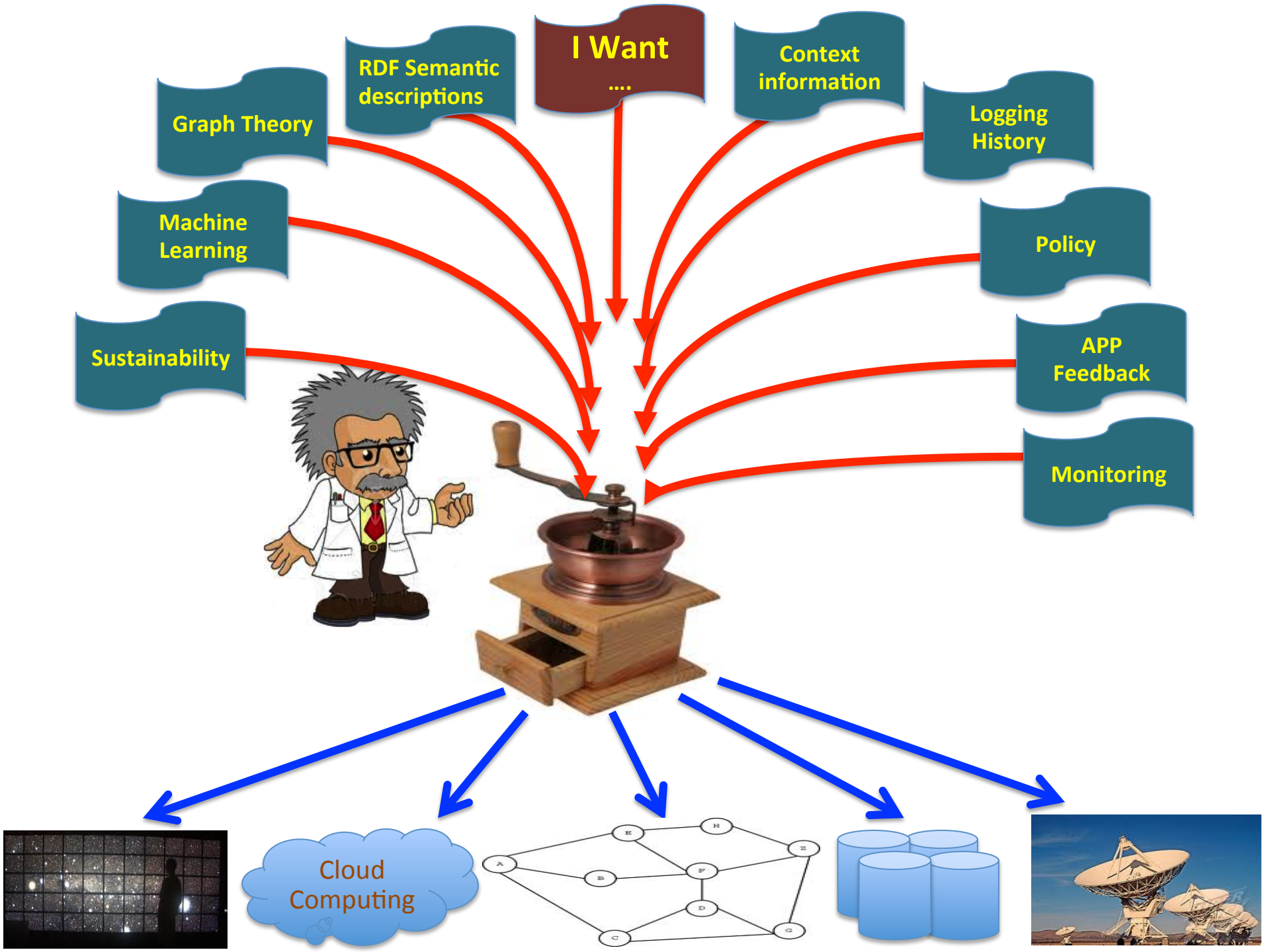
- Sustainable Internet
- Cognitive Nets and clouds
- Machine Learning + → "I Want" Internet 3.0
- Virtualized Internet
- Good Old Trucking

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

# Hybrid Networking <-> Computing

Routers ⇐ ⇒ Supercomputers

Ethernet switches ⇐ ⇒ Grid & Cloud

Photonic transport ⇐ ⇒ GPU's

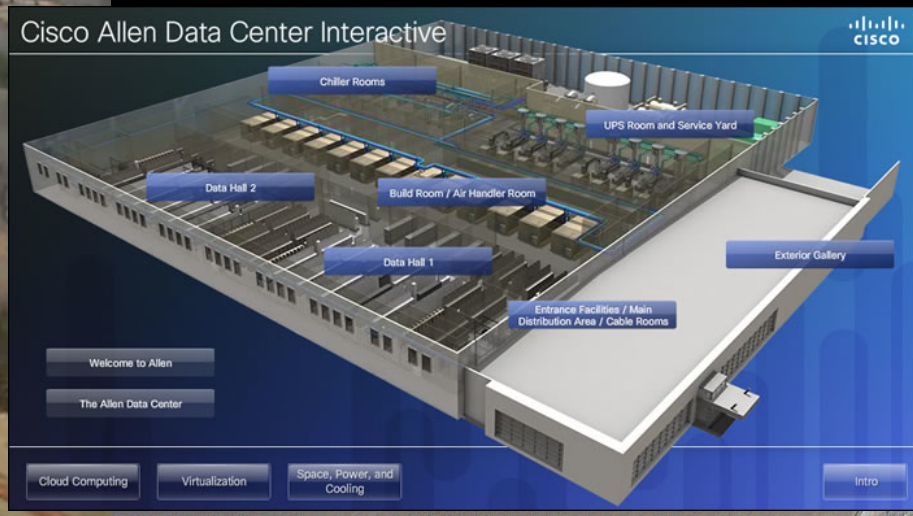
What matters:

- Energy consumption/multiplication
- Energy consumption/bit transported

# 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

# Data Centers




# 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…

# ECO-Scheduling

# Q & A

http://ext.delaat.net/

Slides thanks to:

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