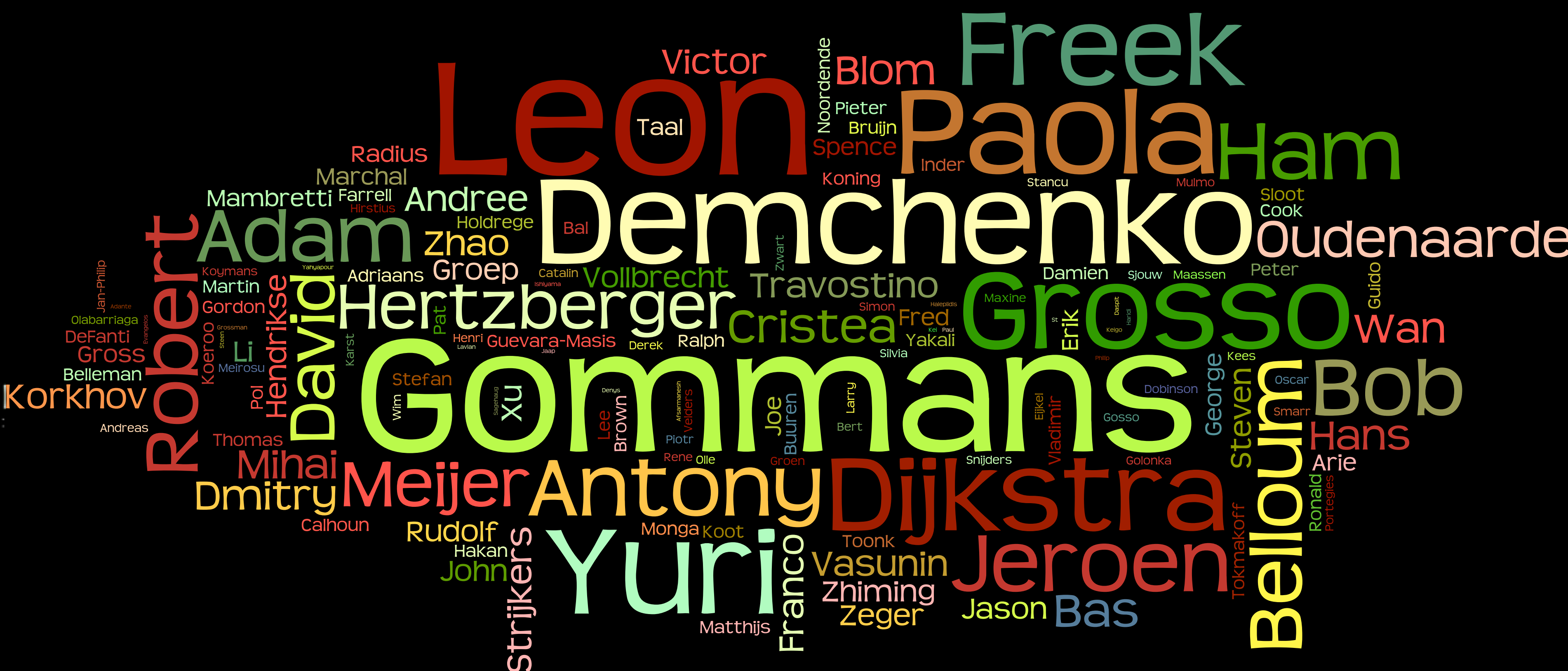
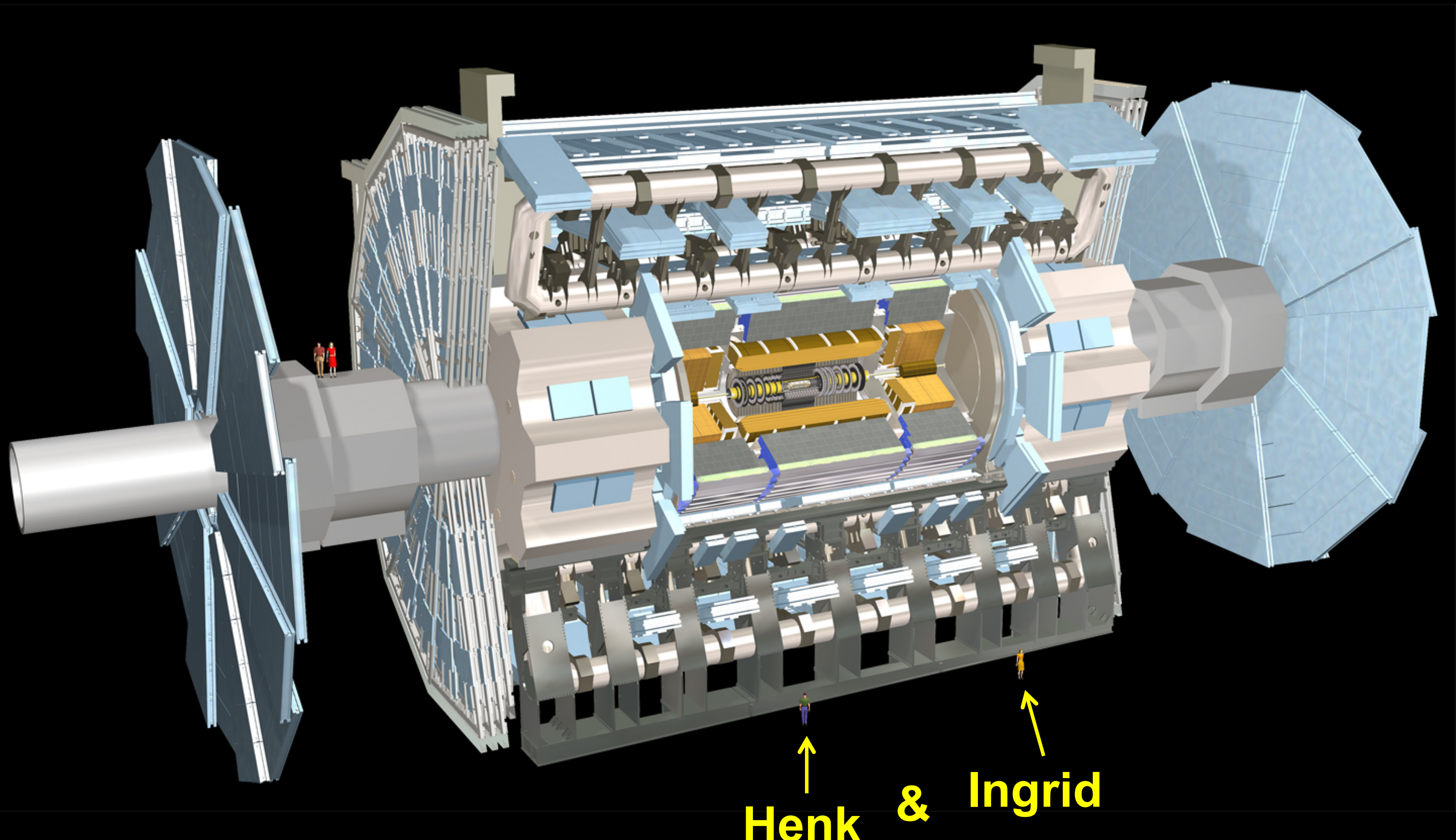
Smart Cyber Infrastructure for Big Data Processing

Cees de Laat

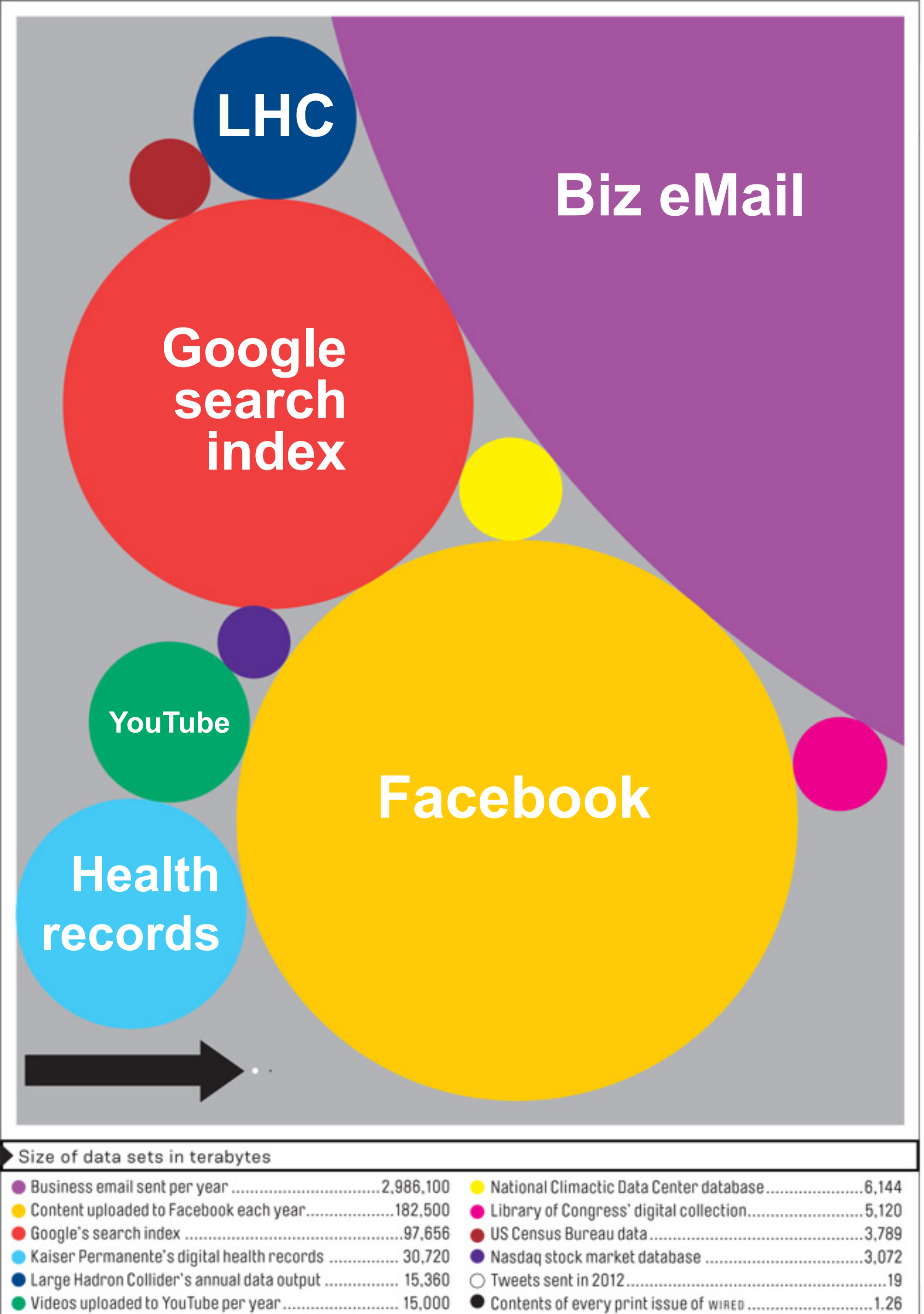


ATLAS detector @ CERN Geneve



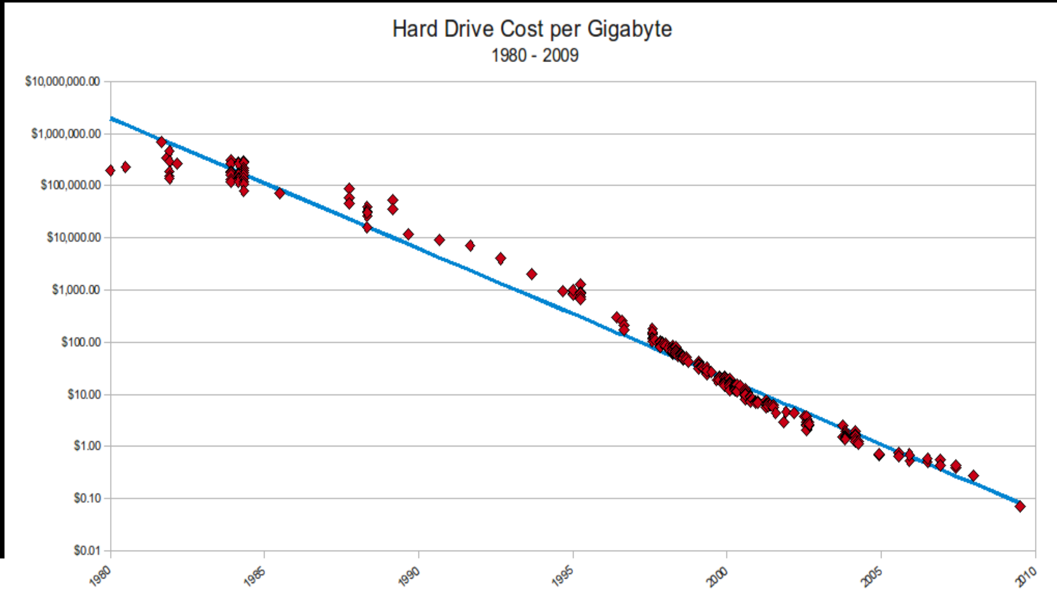
15 Pbyte/year

What Happens in an **Internet Minute?**

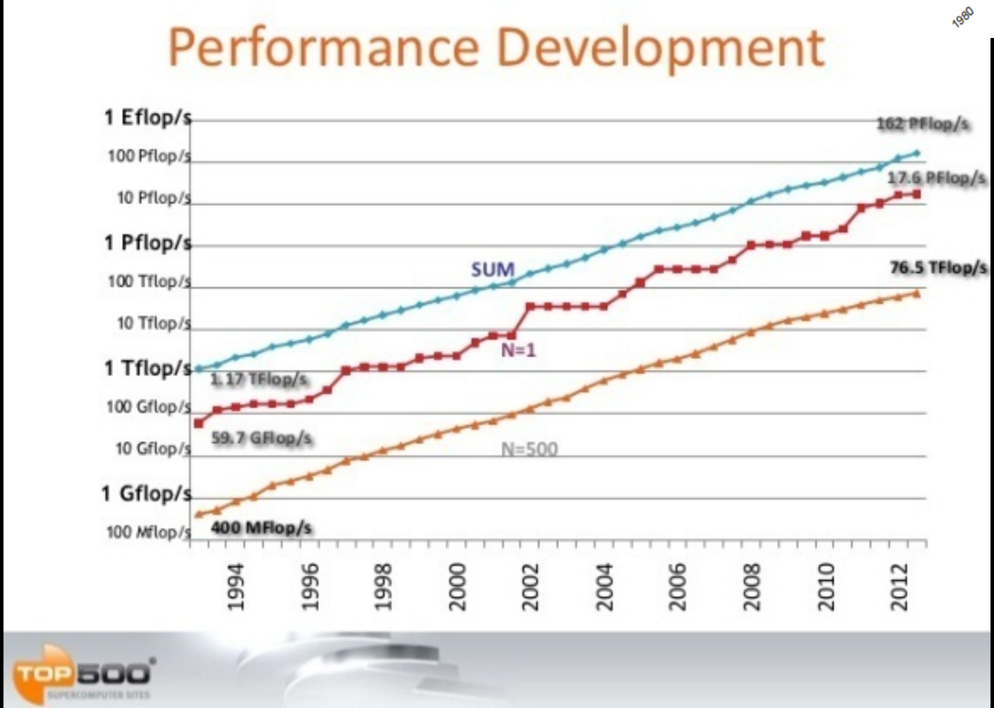


There is always a bigger fish

Computing vs Data



Computing per unit cost has doubled roughly every 18 months.

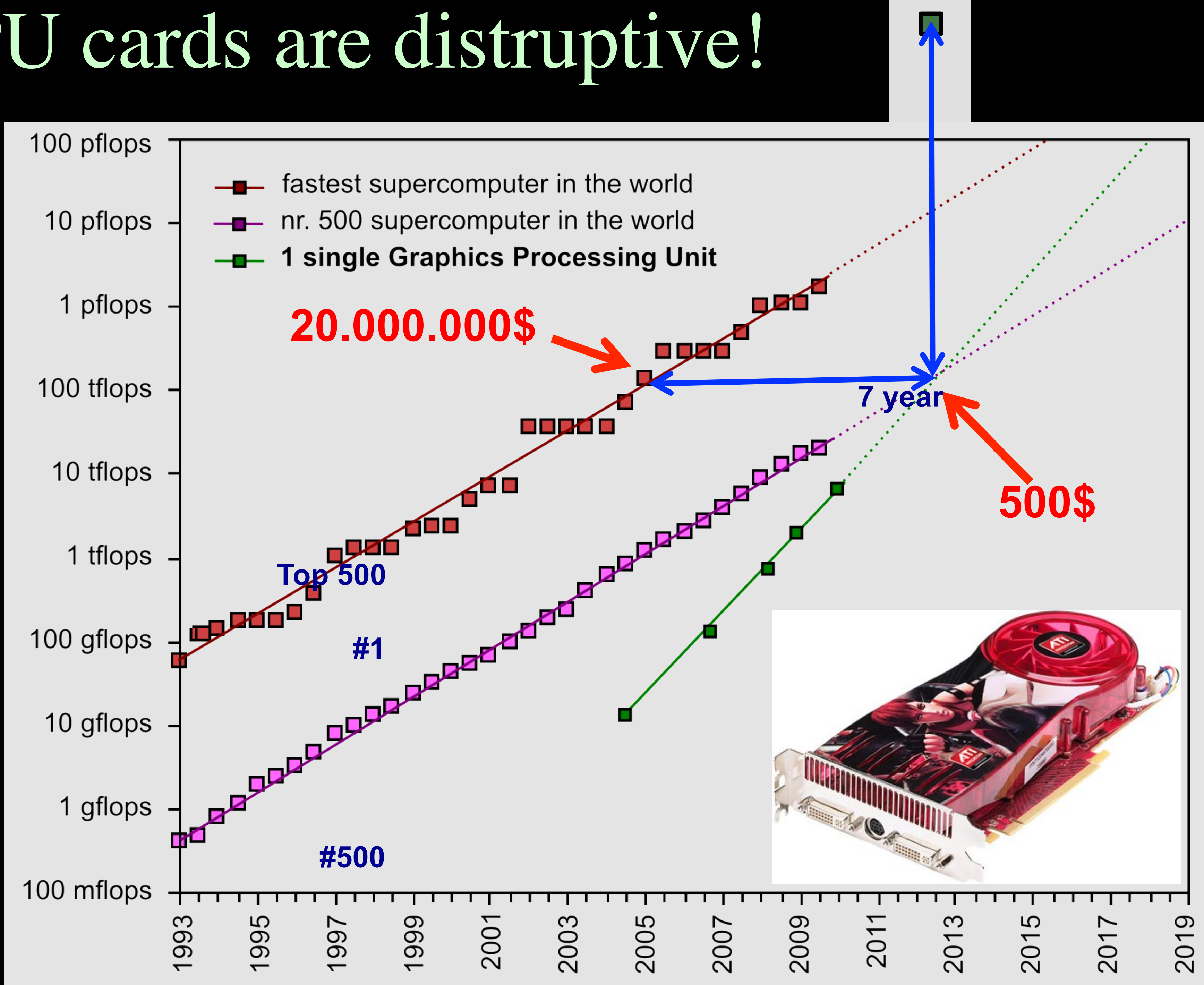


Space per unit cost has doubled roughly every 14 months.

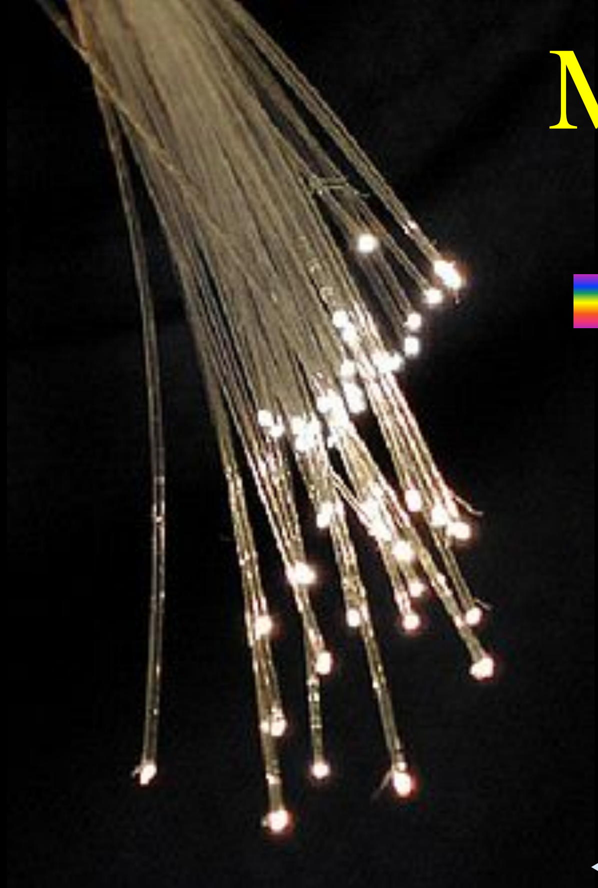
So: data becomes exponentially uncomputable.

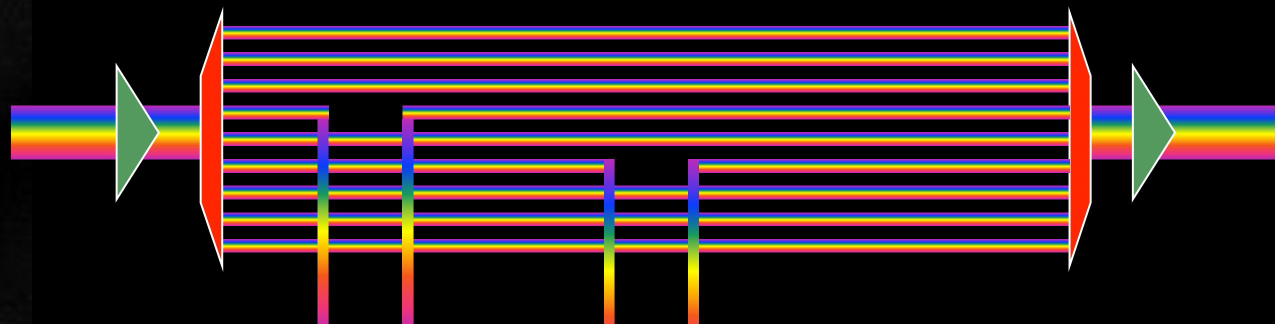
http://www.mkomo.com/cost-per-gigabyte

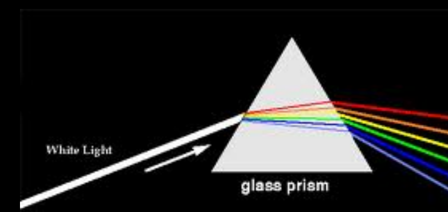
GPU cards are distruptive!

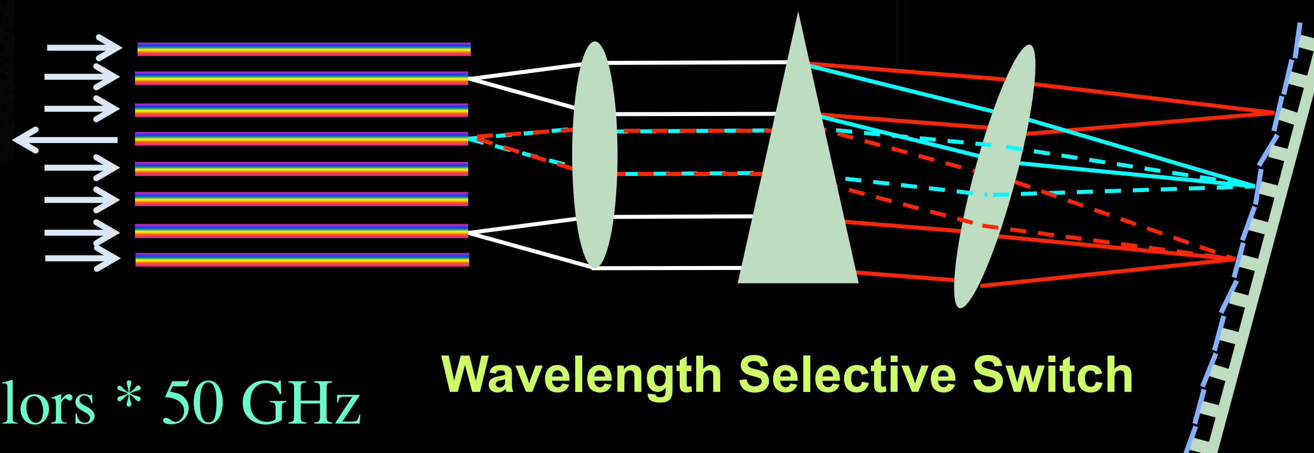


Multiple colors / Fiber









Wavelength Selective Switch

Per fiber: ~ 80-100 colors * 50 GHz

Per color: 10 – 40 – 100 Gbit/s

About 10 Tbit/s per fiber long dist.

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

New: Hollow Fiber!

→ less RTT!

Mission

Can we create smart and safe data processing systems that can be tailored to diverse application needs?

- *Capacity*
- *Capability*
- *Security*
- *Sustainability*
- *Resilience*

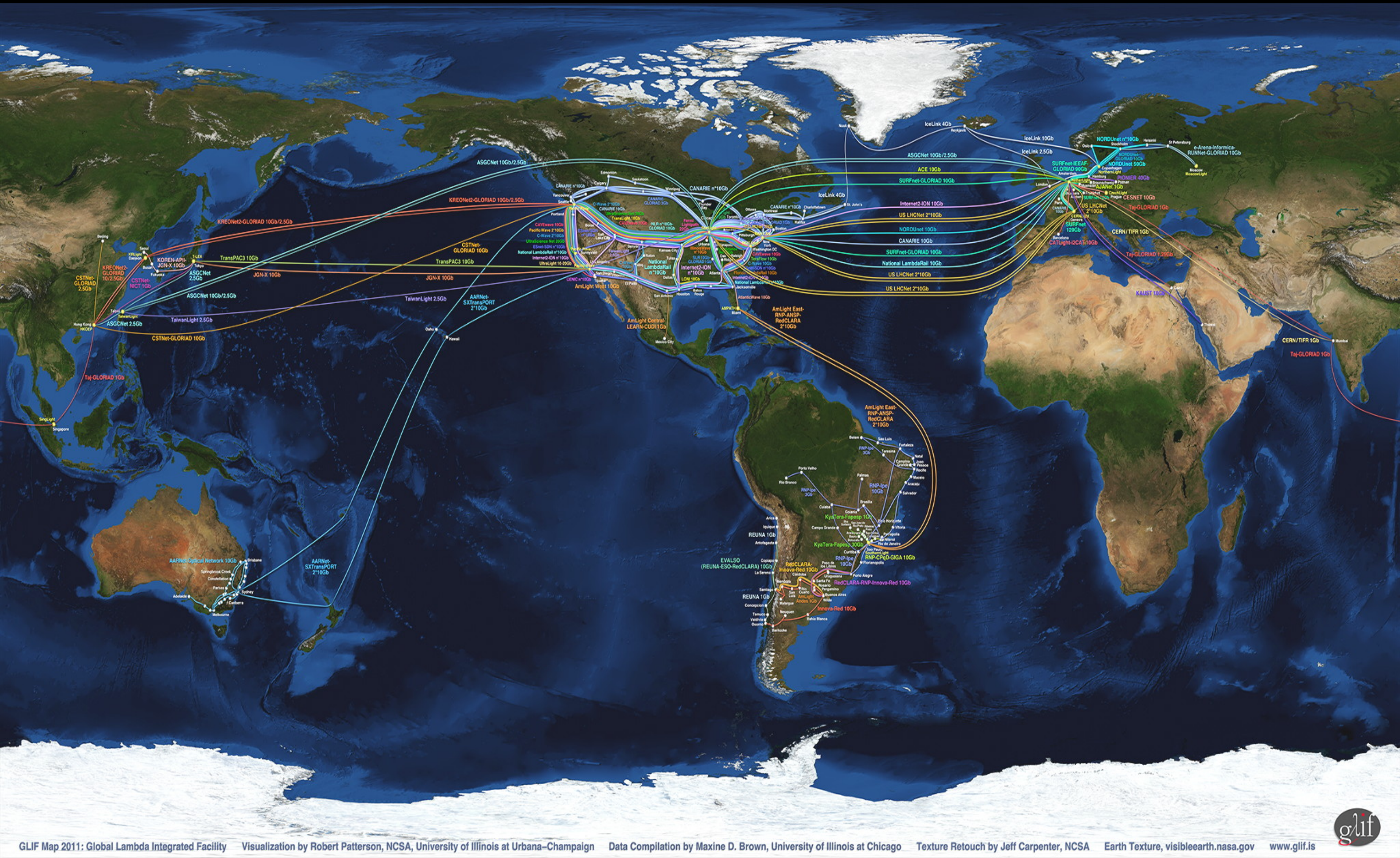
Mission

Can we create smart and safe data processing systems that can be tailored to diverse application needs?

- *Capacity*
  - *Bandwidth on demand, QoS, architectures, photonics, GPU, performance*
- *Capability*
  - *Programmability, virtualization, complexity, semantics, workflows*
- *Security*
  - *Anonymity, integrity of data in distributed data processing*
- *Sustainability*
  - *Greening infrastructure, awareness*
- *Resilience*
  - *Systems under attack, failures, disasters*

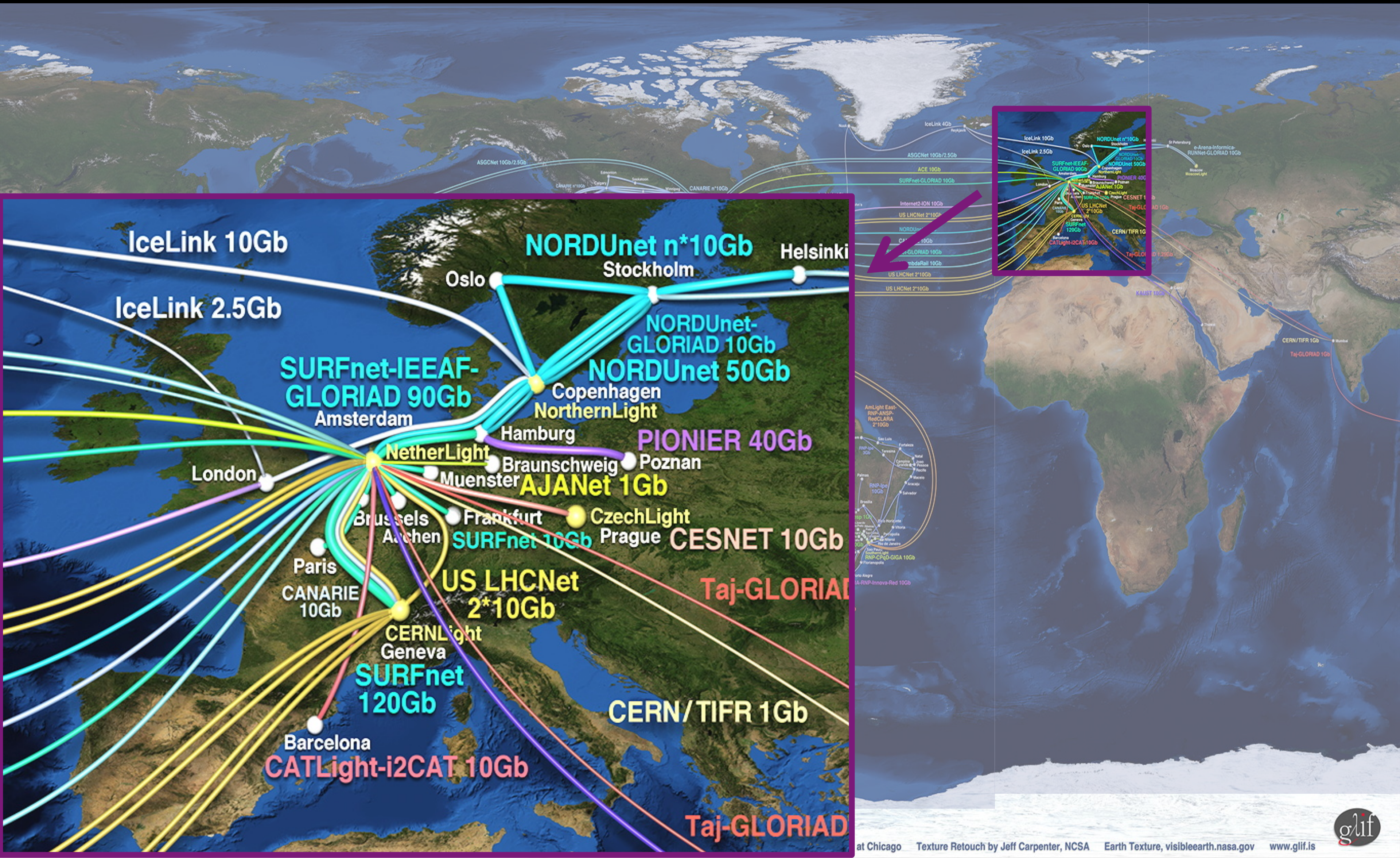
The GLIF – LightPaths around the World

F Dijkstra, J van der Ham, P Grosso, C de Laat, “A path finding implementation for multi-layer networks”, Future Generation Computer Systems 25 (2), 142-146.



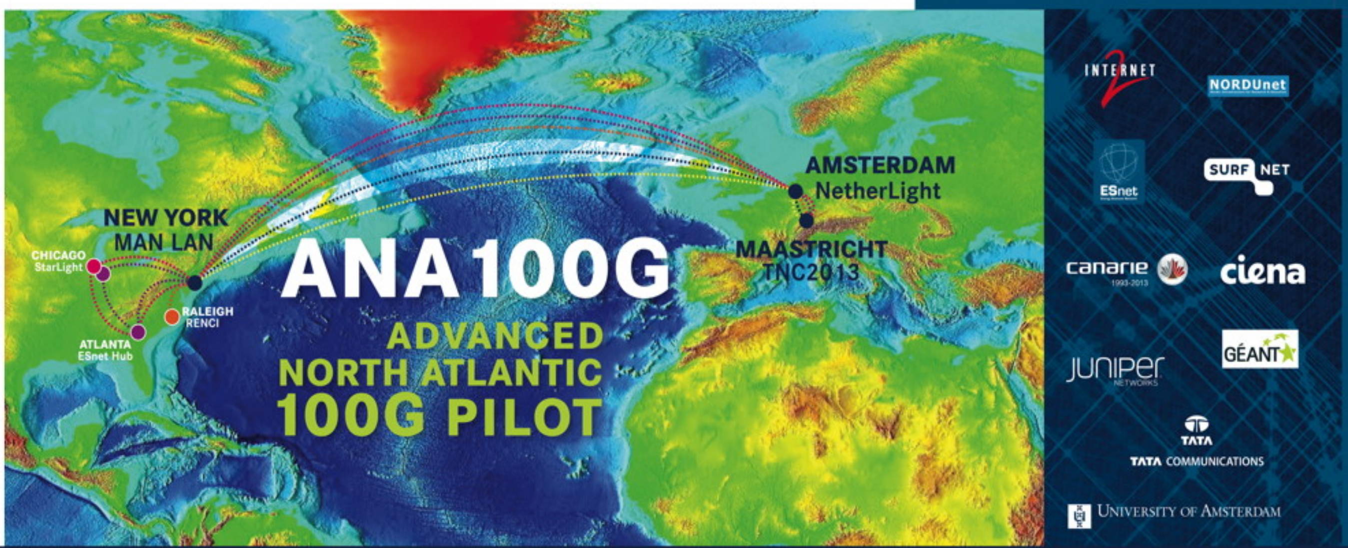
Amsterdam is a major hub in The GLIF

F Dijkstra, J van der Ham, P Grosso, C de Laat, “A path finding implementation for multi-layer networks”, Future Generation Computer Systems 25 (2), 142-146.



ExoGeni @ OpenLab – UvA
http://sne.science.uva.nl/openlab/

Installed and up June 3th 2013



TNC2013 DEMOS JUNE, 2013

DEMO	TITLE	OWNER	AFFILIATION	E-MAIL	A-SIDE	Z-SIDE	PORTS(S) MAN LAN	PORTS(S) TNC2013	DETAILS
1	Big data transfers with multipathing, OpenFlow and MPTCP	Ronald van der Pol	SURFnet	ronald.vanderpol@surfnet.nl	TNC/MECC, Maastricht NL	Chicago, IL	Existing 100G link between internet2 and ESnet	2x40GE (Juniper)+ 2x10GE (OME6500)	In this demonstration we show how multipathing, OpenFlow and Multipath TCP (MPTCP) can help in large file transfers between data centres (Maastricht and Chicago). An OpenFlow application provisions multiple paths between the servers and MPTCP will be used on the servers to simultaneously send traffic across all those paths. This demo uses 2x40G on the transatlantic 100G link. ESnet provides 2x40G between MAN LAN and StarLight, ACE and USLHCnet provide additional 10GEs.
2	Visualize 100G traffic	Inder Monga	ESnet	imonga@es.net					Using an SNMP feed from the Juniper switch at TNC2013,and/or Brocade AL2S node in MANLAN, this demo would visualize the total traffic on the link, of all demos aggregated. The network diagram will show the transatlantic topology and some of the demo topologies.
3	How many modern servers can fill a 100Gbps Transatlantic Circuit?	Inder Monga	ESnet	imonga@es.net	Chicago, Ill	TNC showfloor	1x 100GE	8x 10GE	In this demonstration, we show that with the proper tuning and tool, only 2 hosts on each continent can generate almost 80Gbps of traffic. Each server has 4 10G NICS connected to a 40G virtual circuit, and has iperf3 running to generate traffic. ESnet's new "iperf3" throughput measurement tool, still in 'beta', combines the best features from other tools such as iperf, nuttcp, and netperf. See: https://my.es.net/demos/tnc2013/
4	First European ExoGENI at Work	Jeroen van der Ham	UvA	vdham@uva.nl	RENCI, NC	UvA, Amsterdam, NL	1x 10GE	1x 10GE	The ExoGENI racks at RENCI and UvA will be interconnected over a 10G pipe and be on continuously, showing GENI connectivity between Amsterdam and the rest of the GENI nodes in the USA.
5	Up and down North Atlantic @ 100G	Michael Enrico	DANTE	michael.enrico@dante.net	TNC showfloor	TNC showfloor	1x 100GE	1x 100GE	The DANTE 100GE test set will be placed at the TNC2013 showfloor and connected to the Juniper at 100G. When this demo is running a loop @ MAN LAN's Brocade switch will ensure that the traffic sent to MAN LAN returns to the showfloor. On display is the throughput and RTT (to show the traffic traveled the Atlantic twice)

Connected via the new 100 Gb/s transatlantic To US-GENI

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.

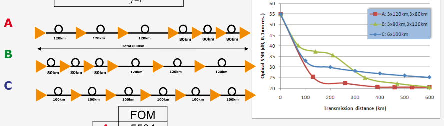
In this demonstration we will investigate the performance of a 40Gb/s PM-QPSK alien wavelength installed on a 10Gb/s DWDM infrastructure.

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

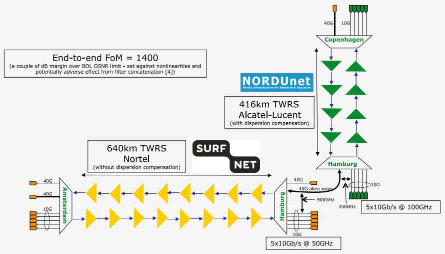


	FOM
A	5504
B	5504
C	1897

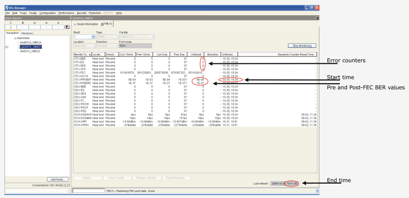
Easy-to-use formula that accurately quantifies transmission system performance

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

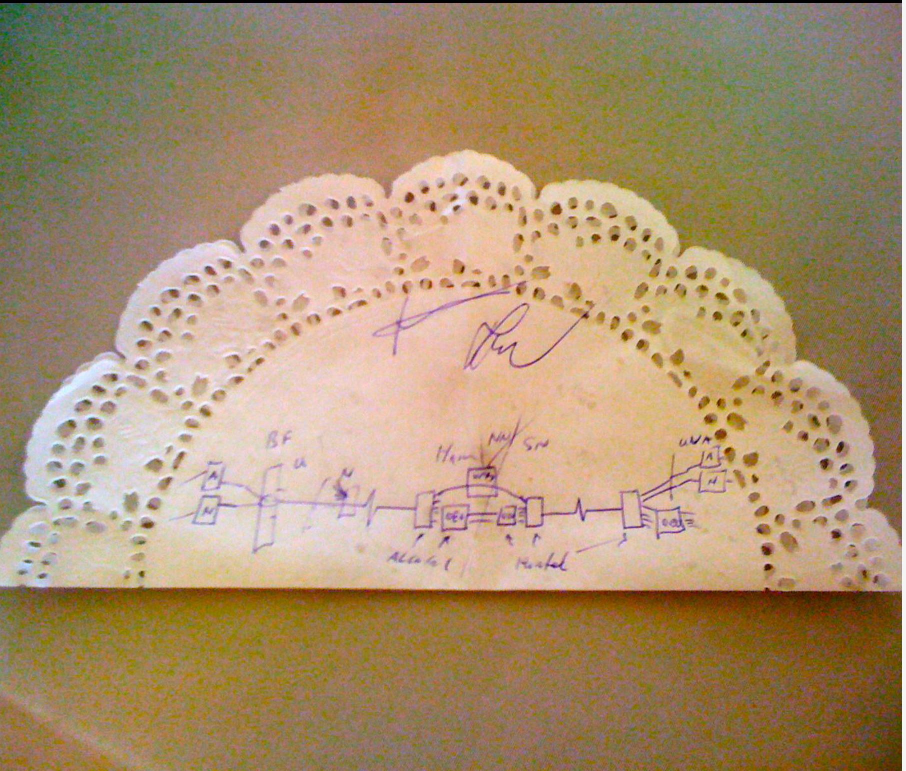
- We have investigated experimentally the all-optical transmission of a 40Gb/s PM-QPSK alien wavelength via a concatenated native and third party DWDM system that both were carrying live 10Gb/s wavelengths.
- The end-to-end transmission system consisted of 1056 km of TWRS (TrueWave Reduced Slope) transmission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

Alien light
From idea to realisation!



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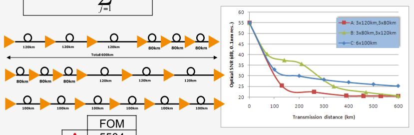

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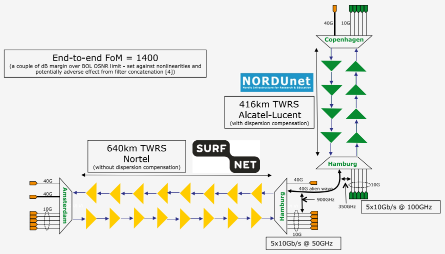

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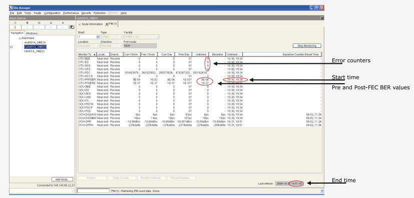

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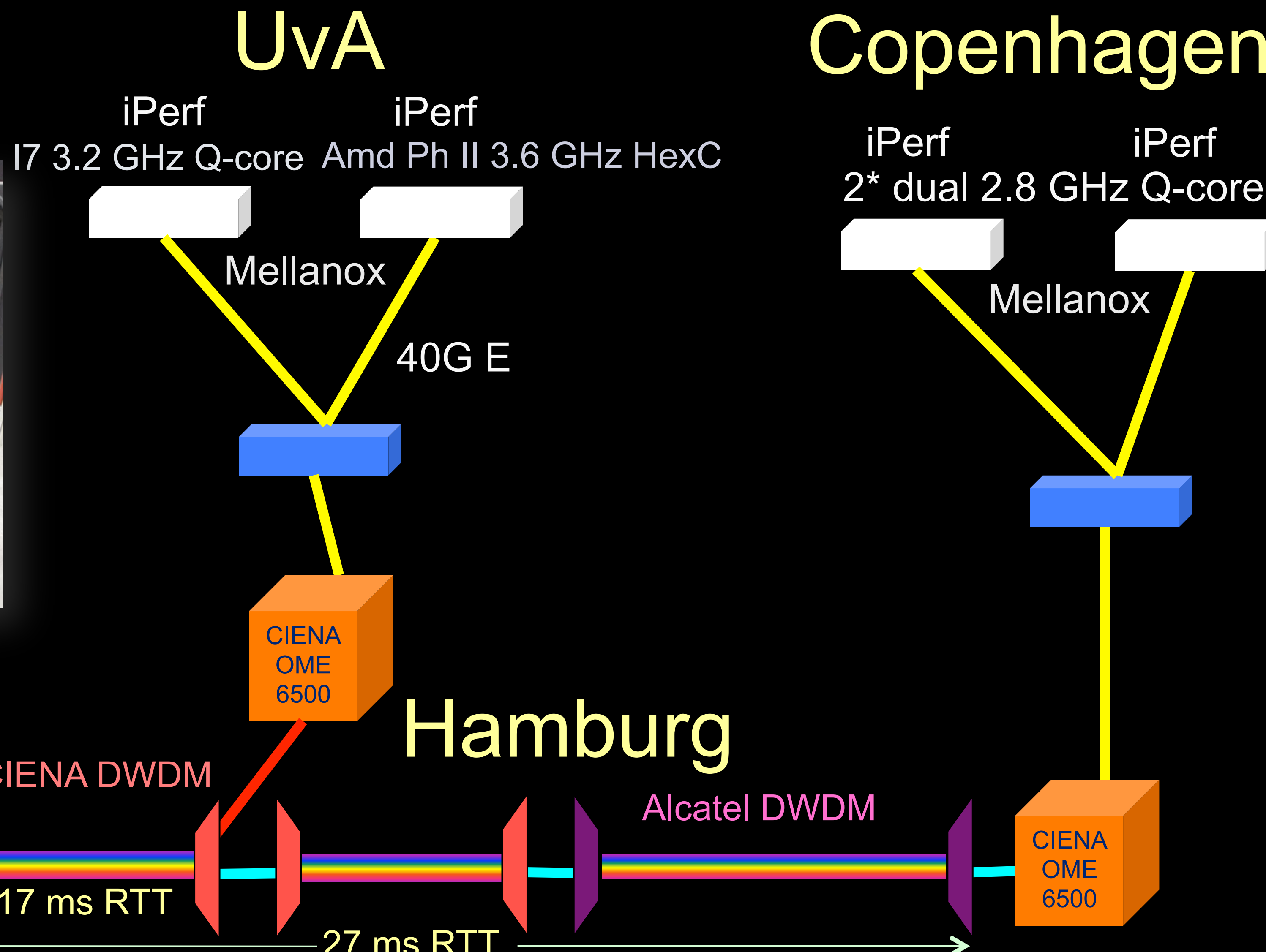
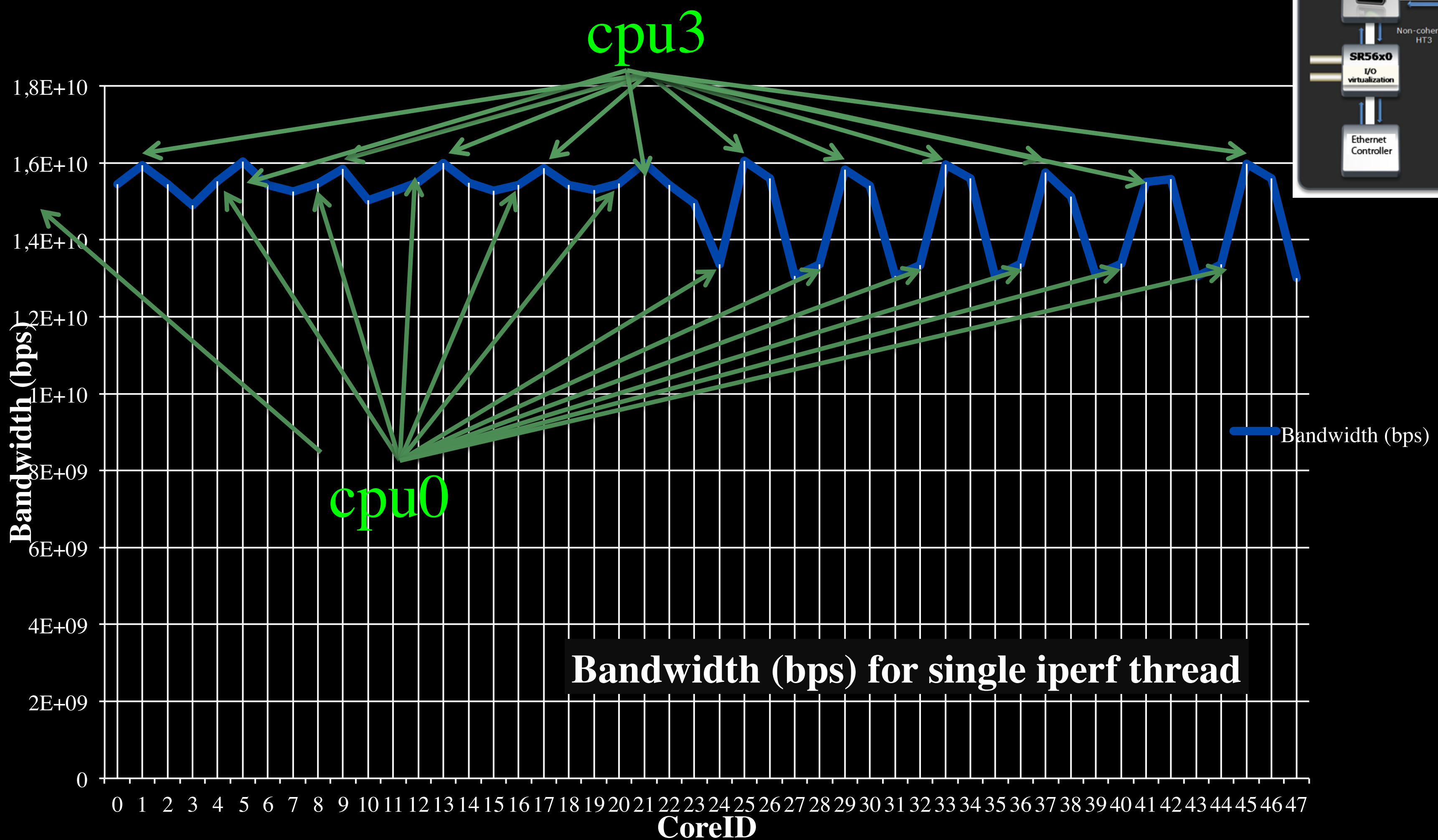
ClearStream @ TNC2011

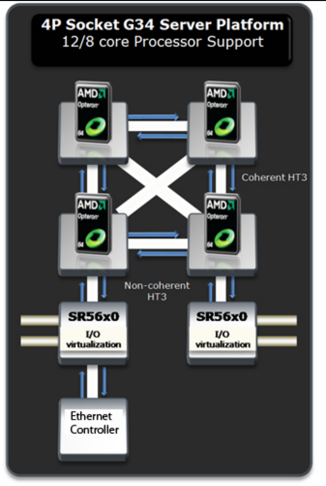
Setup codename: FlightCees



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

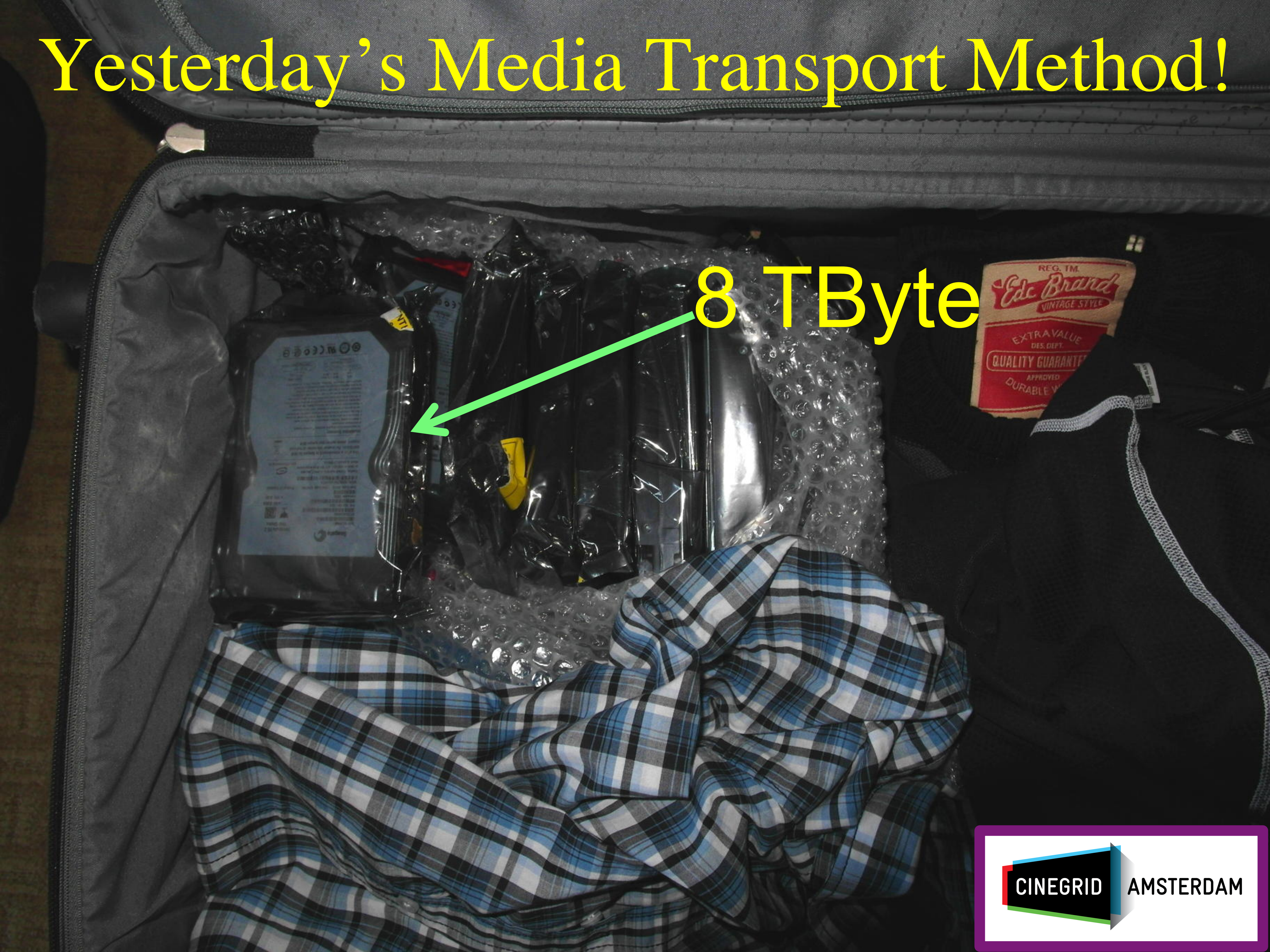
CPU Topology benchmark





We used numactl to bind iperf to cores

Yesterday's Media Transport Method!



CINEGRID AMSTERDAM

Moving Cinegrid Objects Globally

- **Digital Motion Picture for Audio Post-Production**
  - 1 TV Episode Dubbing Reference ~ 1 GB
  - 1 Theatrical 5.1 Final Mix ~ 8 GB
  - 1 Theatrical Feature Dubbing reference ~ 30 GB
- **Digital Motion Picture Acquisition**
  - 4K RGB x 24 FPS x 10bit color: ~ 48MB/Frame uncompressed *(ideal)*
  - 6:1 ~ 20:1 shooting ratios => 48TB ~ 160TB digital camera originals
- **Digital Dailies**
  - HD compressed MPEG-2 @ 25 ~ 50 Mb/s
- **Digital Post-production and Visual Effects**
  - Gigabytes - Terabytes to Select Sites Depending on Project
- **Digital Motion Picture Distribution**
  - Film Printing in Regions
    - Features ~ 8TB
    - Trailers ~ 200GB
  - Digital Cinema Package to Theatres
    - Features ~ 100 - 300GB per DCP
    - Trailers ~ 2 - 4GB per DCP

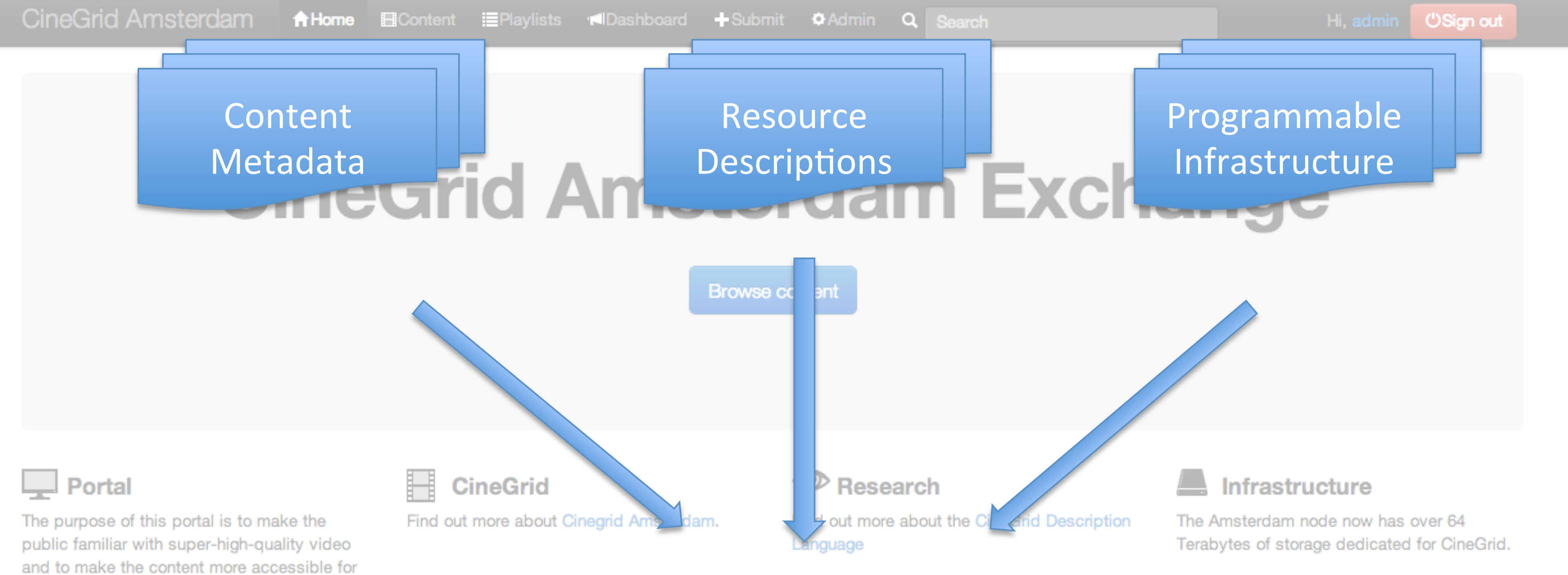
UHDTV(4K)

3840

2160

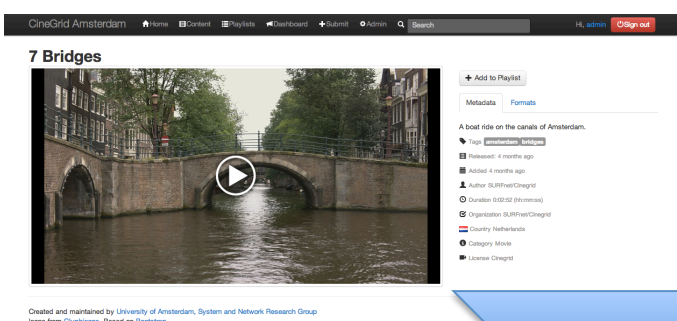
CineGrid

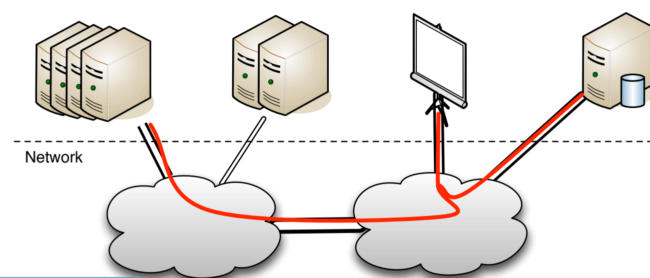
CINEGRID AMSTERDAM



CineGrid Portal

Unified orchestration of distributed CineGrid resources

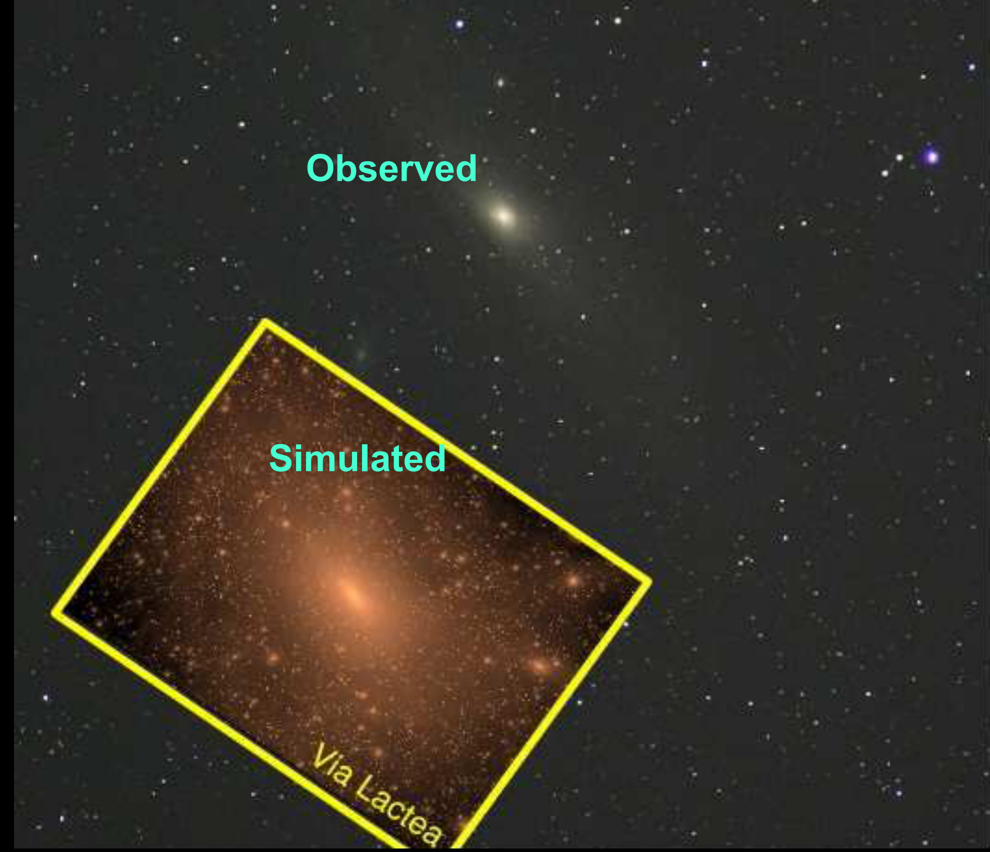


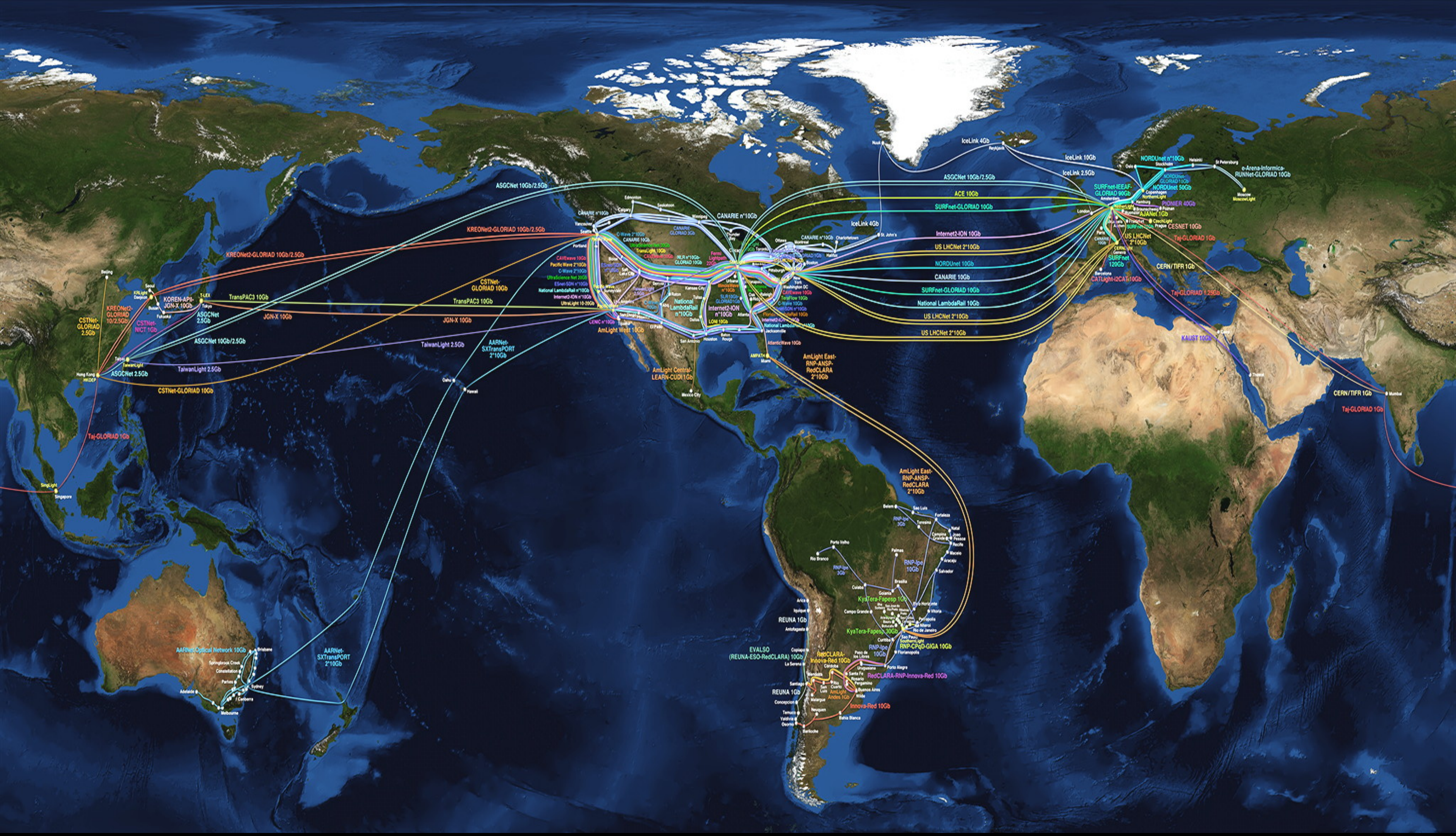


CosmoGrid

Simon Portegies Zwart et al.

- Motivation:
  - **previous simulations found >100 times more substructure than is observed!**
- Simulate large structure formation in the Universe
- Method: Cosmological *N*-body code
- Computation: Intercontinental SuperComputer Grid
- Current (2013) problem:
  - 2 PByte data in Oak Ridge!

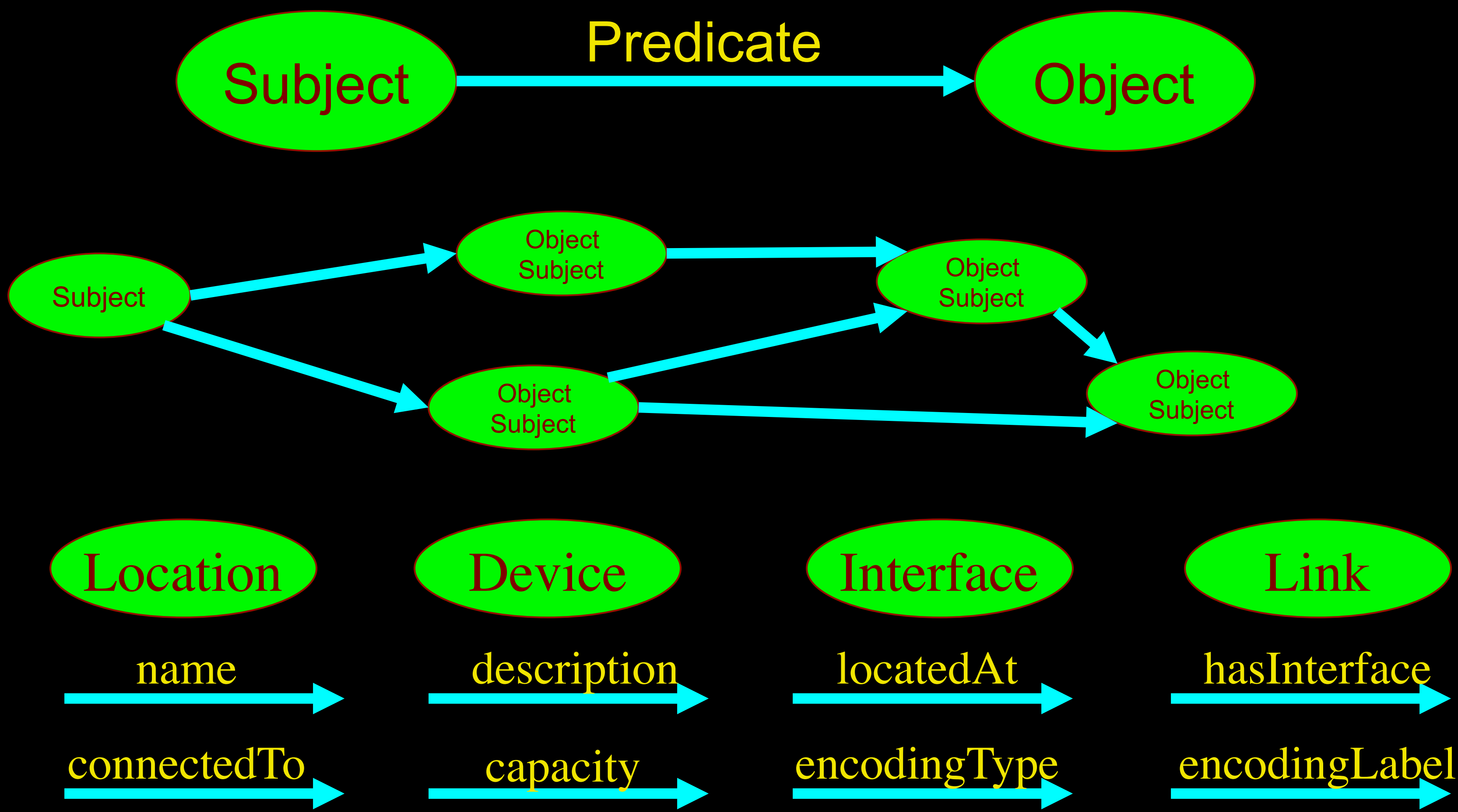




We investigate: TOMTOM for complex networks!

LinkedIN for Infrastructure

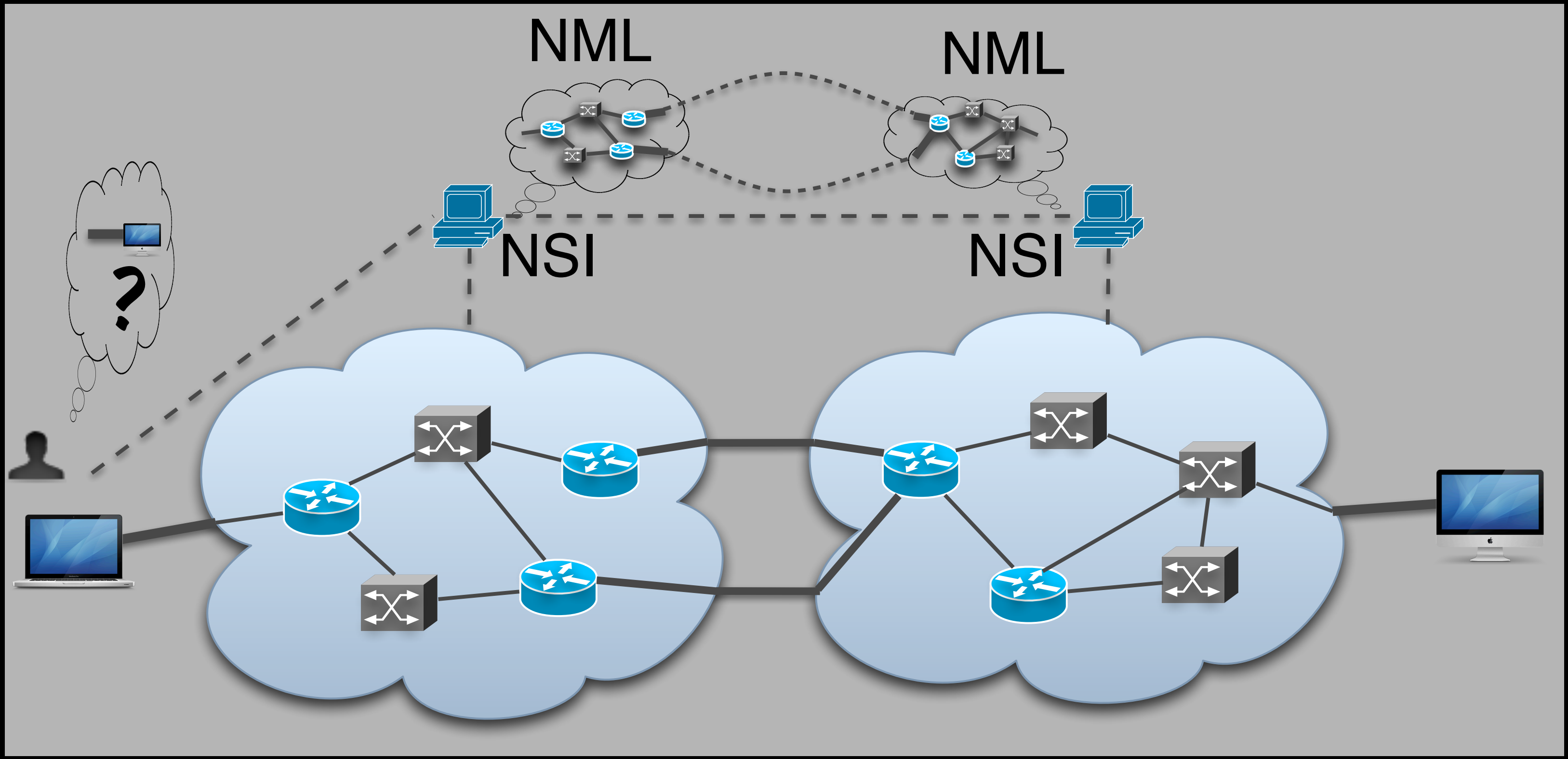
- From semantic Web / Resource Description Framework.
- The RDF uses XML as an interchange syntax.
- Data is described by triplets (Friend of a Friend):



Network Topology Description

Network topology research supporting automatic network provisioning

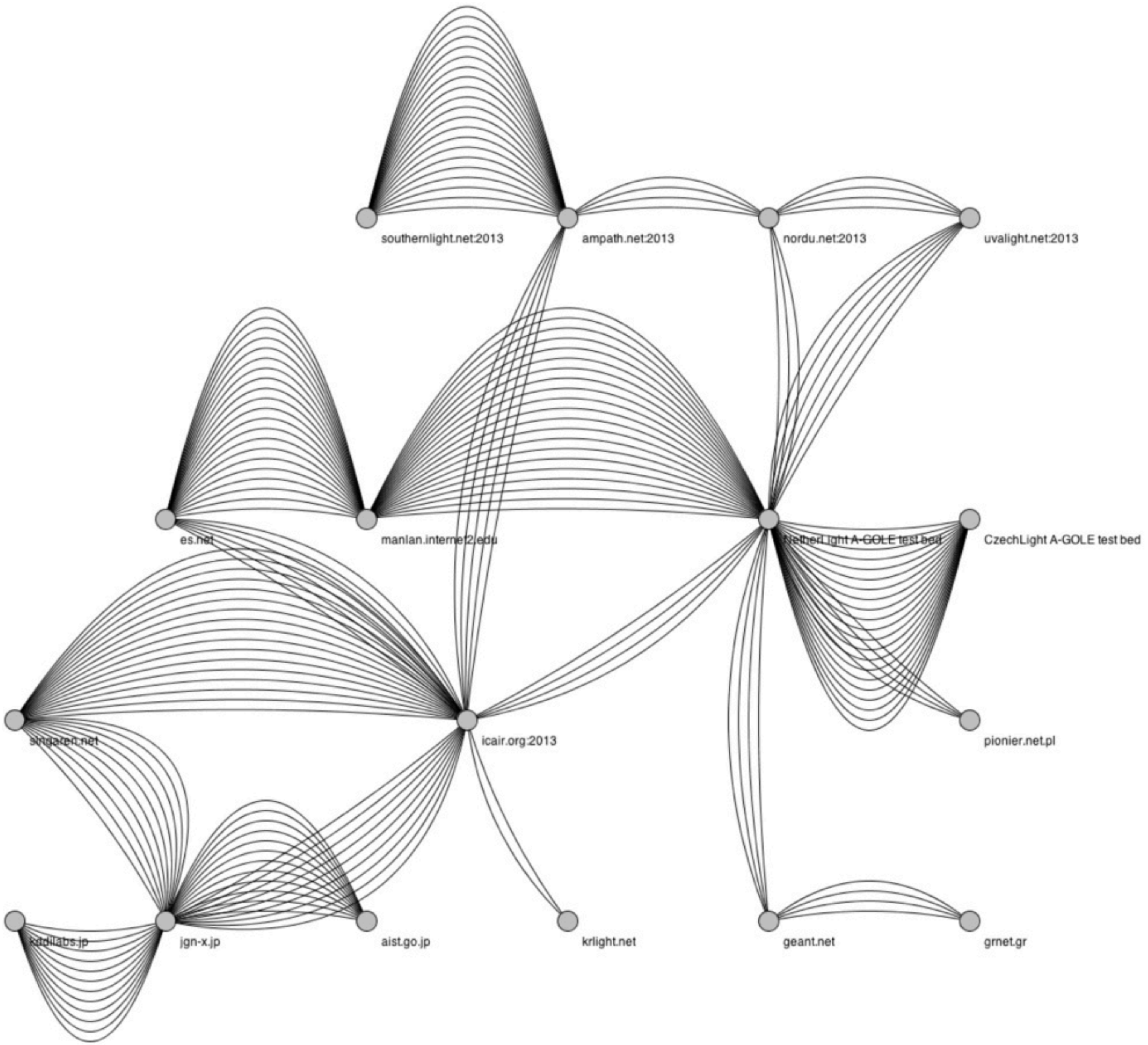
- Inter-domain networks
- Multiple technologies
- Generalized to ExoGeni & FED4FIRE



http://redmine.ogf.org/projects/nml-wg
http://redmine.ogf.org/projects/nsi-wg

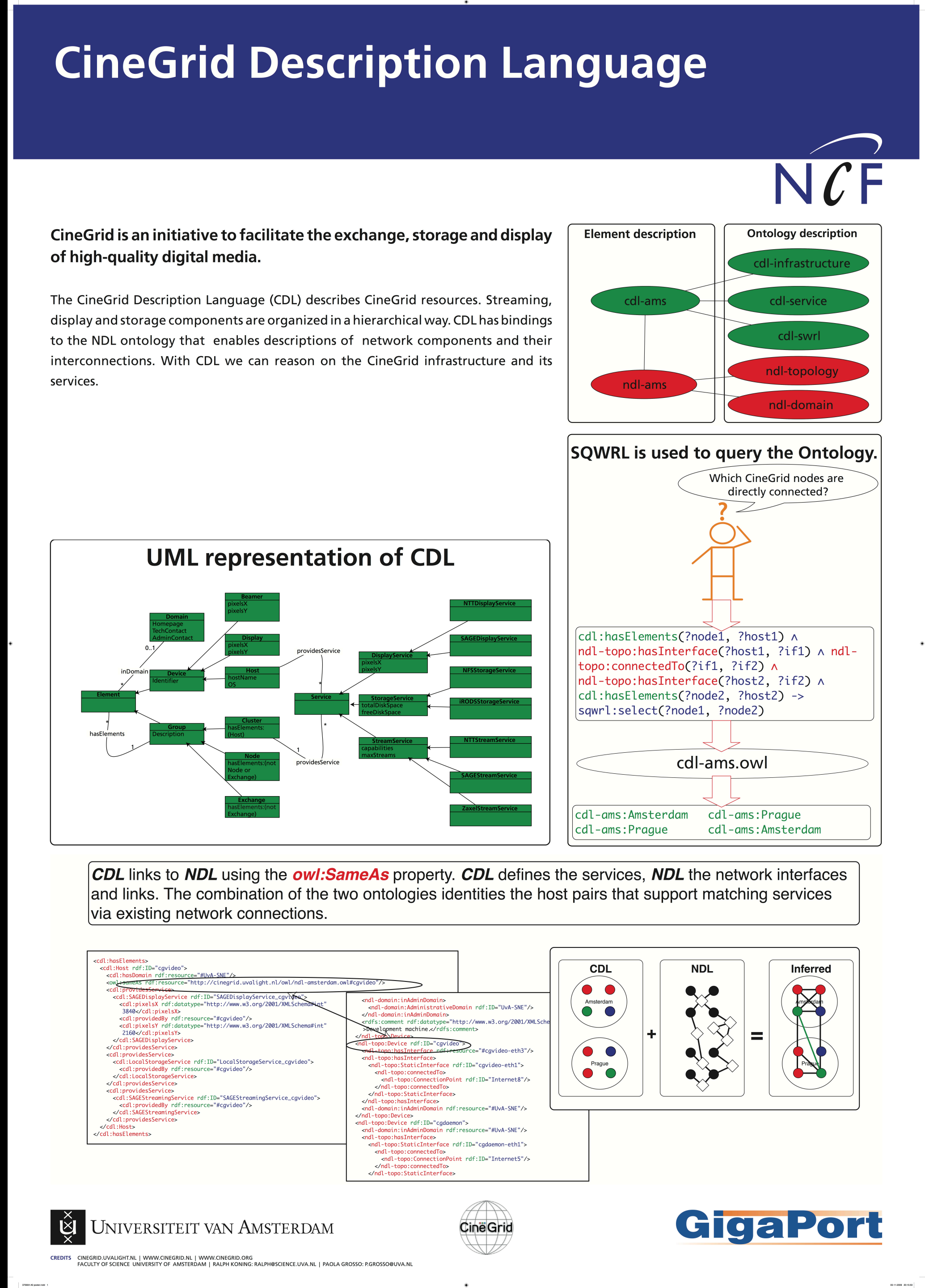
http://sne.science.uva.nl/ndl

GLIF NSI 2013 in NML



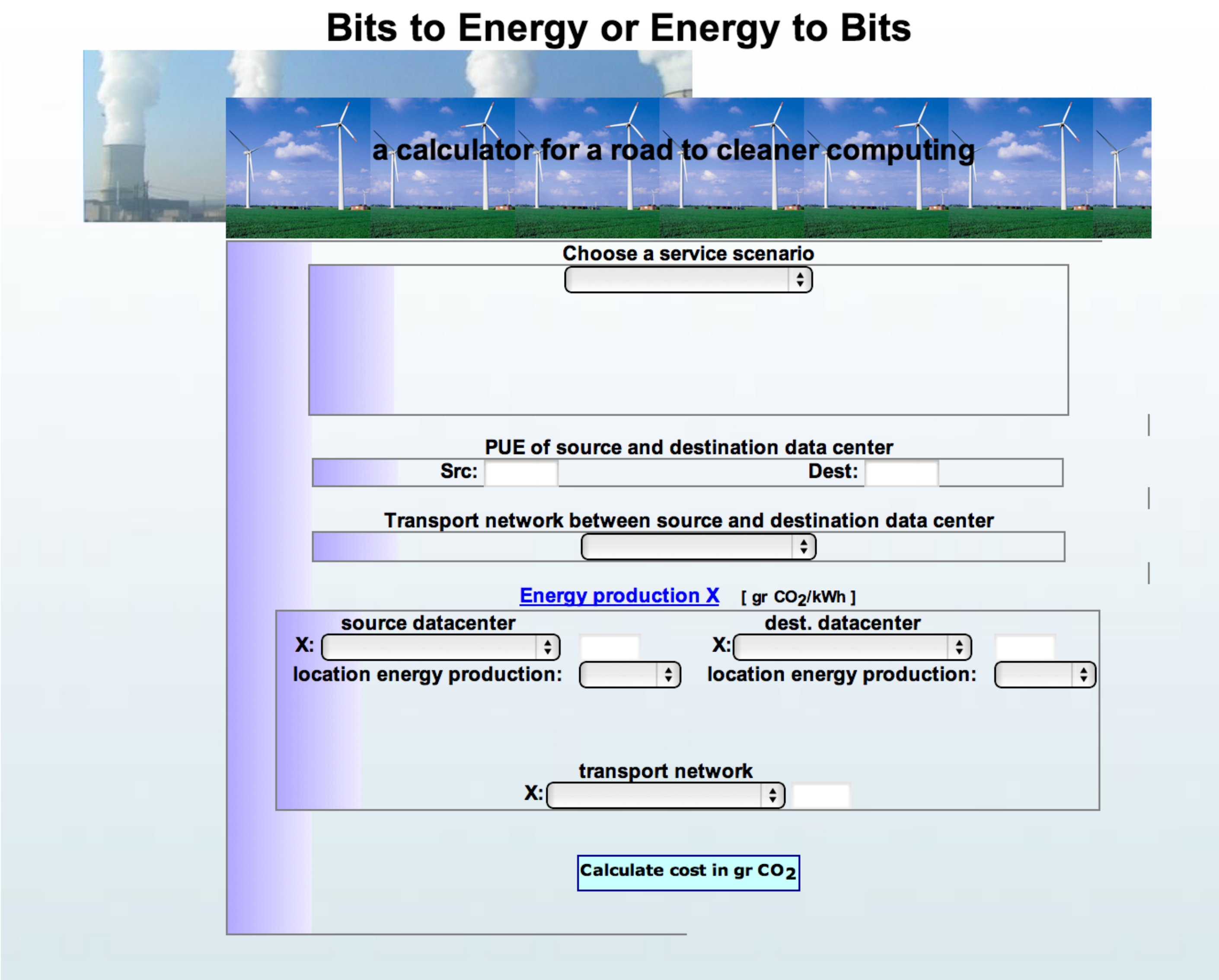
CdL
☺

Applications, Data and Networks become aware of each other!



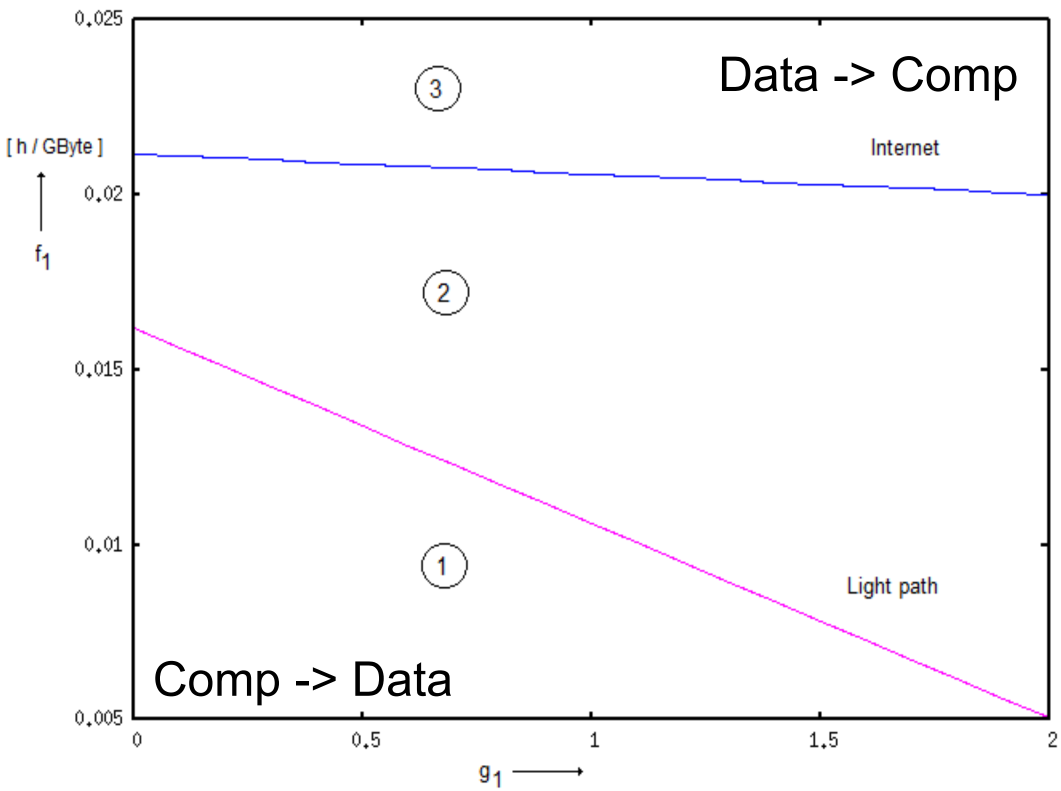
Bits-Nets-Energy

http://sne.science.uva.nl/bits2energy/

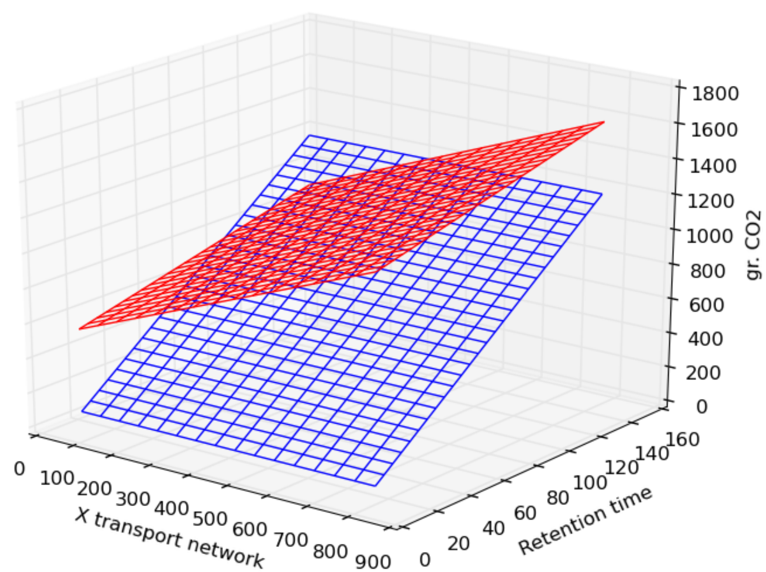


Taal & Grosso

"Data to Computing or vice versa?"



Storage to energy: when should you move hot or cold data to a green remote data centra for storage?

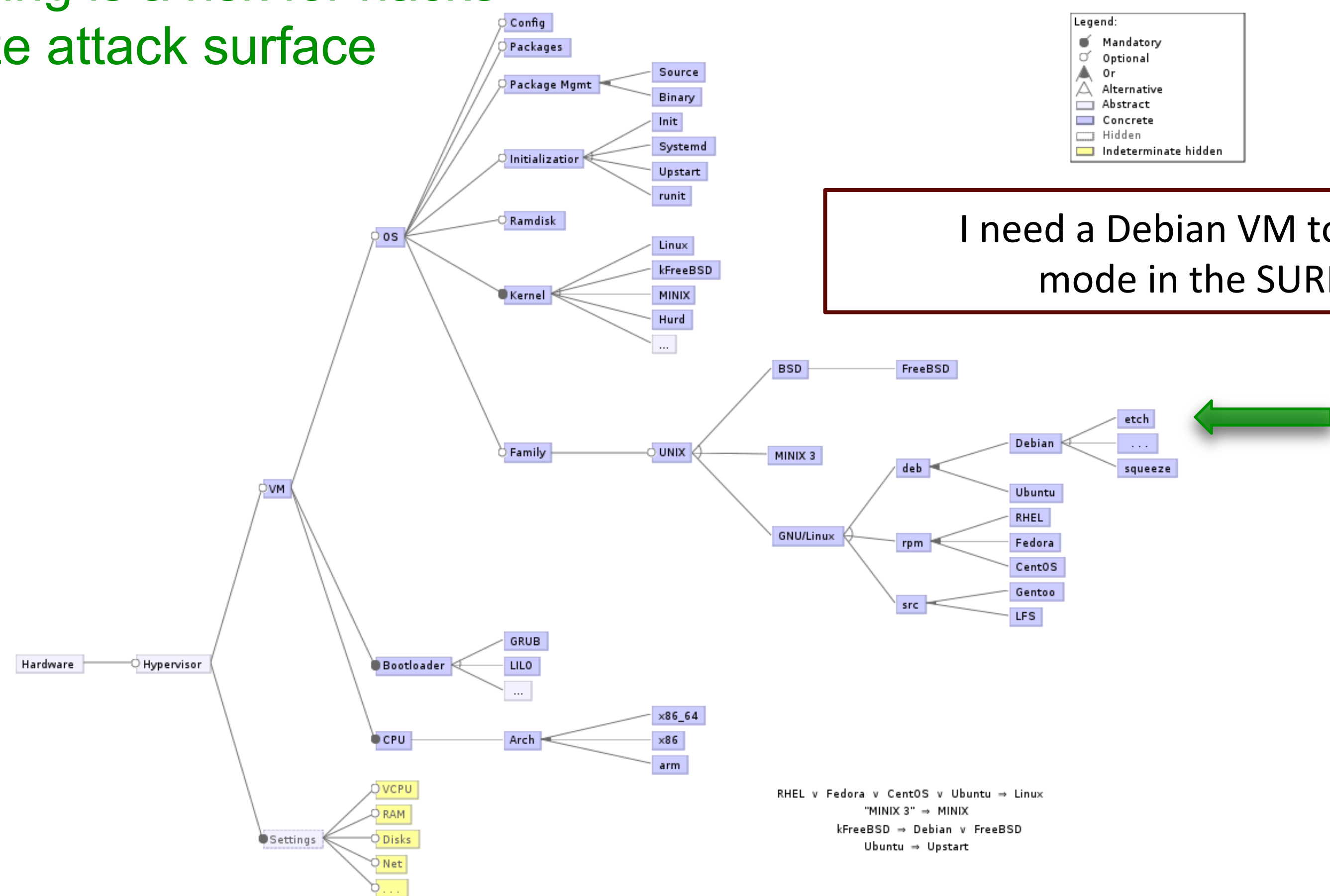


Given different network paths what are the decision boundaries as function of the task complexity.

Naod Duga Jebessa, Guido van 't Noordende, Cees de Laat

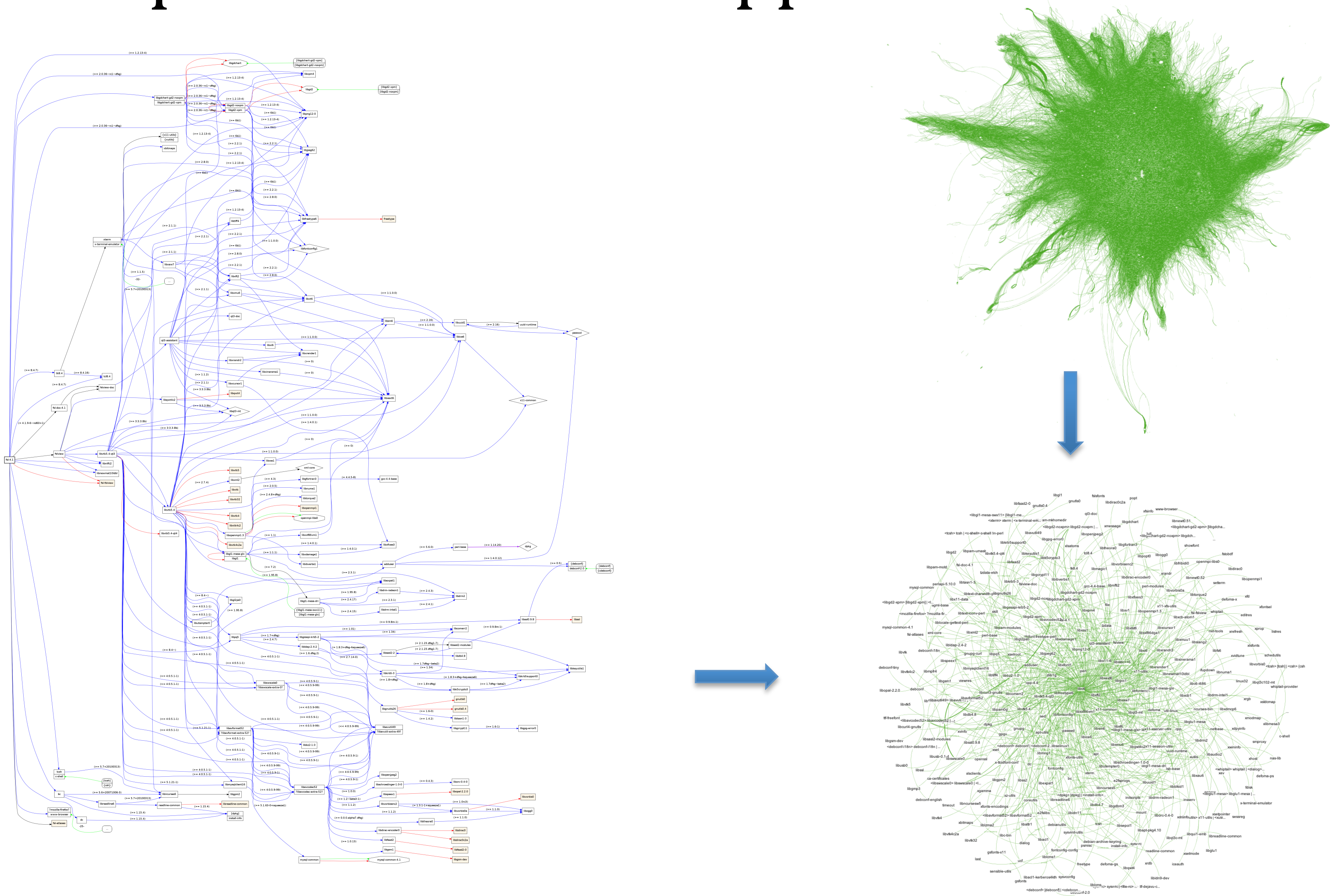
Security of Data in Purpose-Driven Virtual Machines

⇒ Cloud VM's contain lots of lib's and features not needed by application
⇒ Everything is a risk for hacks
⇒ Minimize attack surface



I need a Debian VM to run `fsl` in text mode in the SURFsara HPC Cloud.

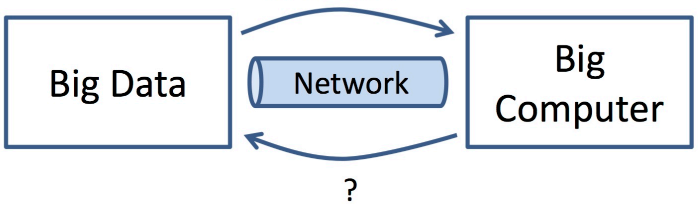
Dependencies of an application

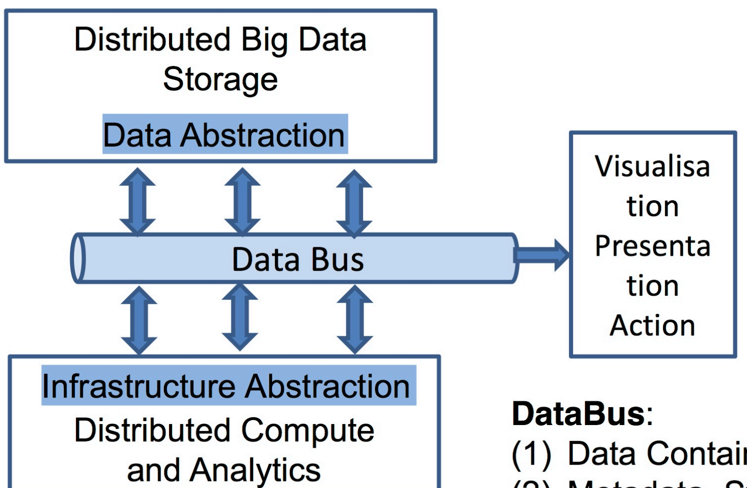


The application is `fsl-4.1`. LEFT: before dependency resolution, with all dependency constraints shown and RIGHT: resolved dependencies in a particular setup, `libc` is the center node

Yuri Demchenko, Marcel Worring, Wouter Los, Cees de Laat

Big Data Paradigm Change: Moving to Data-Centric Models





DataBus:
(1) Data Container
(2) Metadata, State
(3) Data Transfer
Protocol

Current IT and communication technologies are host based or host centric (service/message centric)

- Any communication or processing are bound to host/computer that runs software
- For security: all security models are host/client based

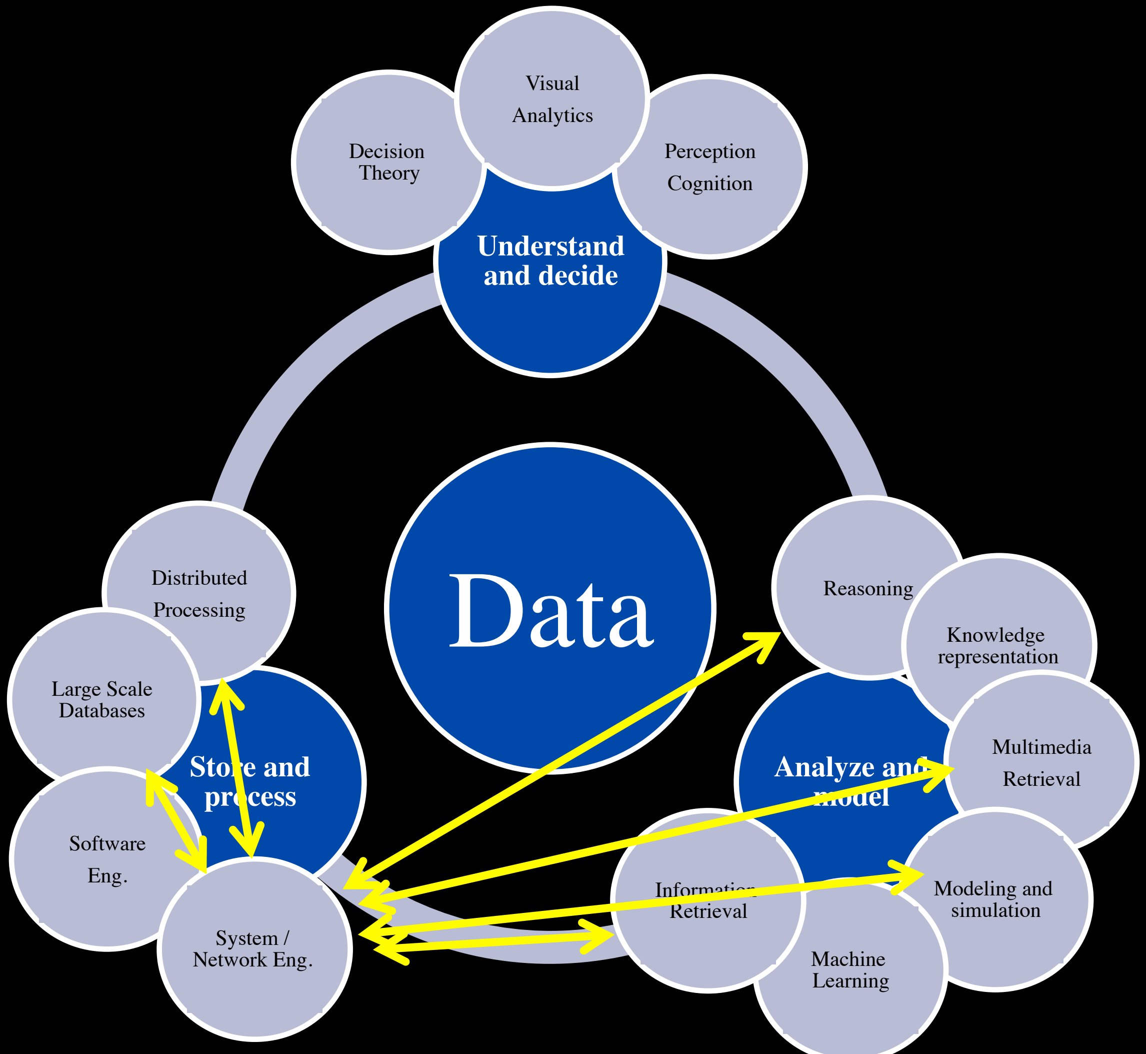
Big Data requires new data-centric models

- Data location, replication, search, access
- Data lifecycle, transformation, variability
- Data integrity, identification, ownership
- Data centric security and access control

Paradigm changing factors

- **Big Data properties: 5+1 V's**
- **Data aggregation:** multi-domain, multi-format, variability, linkage, referral integrity
- **Policy granularity:** variety and complex structure, for their access control processing
- **Virtualization:** Can improve security of data processing environment but cannot solve data security "in rest"
- **Mobility** of the different components of the typical data infrastructure: data, sensors or data source, data consumer

SNE in Data Science



Research direction

- Information on Infrastructure
- Control & programmability of Infrastructure
- Virtualization
- Networked data processing
- Sustainability & Complexity

Events on the horizon

- I4DW & DSRC
  - Launch Nov 13
- PIRE & OpenScienceDataCloud.org
  - Workshop June 2014 @ UvA
- Research Data Alliance
  - Conference in Amsterdam Sept 2014

Announcement June 2014
PIRE Workshop Amsterdam

- OpenScienceDataCloud.org
- PIRE Fellowship Application (+/- 15)
- The OSDC PIRE Program is six to eight week fully funded fellowship for US graduate student researchers with an information technology background.
- Format:
  - 1 week tutorials and hands on training
  - 2 months research at a participating institute
  - Results in science/tools and papers/posters/

NSF Partnerships for International Research and Education
OSDC OPEN SCIENCE DATA CLOUD
cisa
CIARA Center for Internet Augmented Research & Assessment research • collaboration • scholarship
AMPATH PATHWAY OF THE AMERICAS
FIU FLORIDA INTERNATIONAL UNIVERSITY
OCC OPEN CLOUD CONSORTIUM
THE UNIVERSITY OF CHICAGO
COMMIT/
sicsa* The Scottish Informatics & Computer Science Alliance
edinburgh data-intensive research
UNIVERSITY OF AMSTERDAM

PIRE - OpenScienceDataCloud.org

1000 Genomes Project
Human sequence data from populations around the world with the goal of cataloging human genetic variation.
Total Size: 383.5TB   Categories: genomics, biology

ASTER
ASTER Level-1B Registered Radiance at the Sensor
Total Size: 12.7TB   Categories: earth science

Complete Genomics Public Data
Whole human genome sequence data sets provided by Complete Genomics, containing 69 standard, non-diseased samples as well as two matched tumor and normal sample pairs.
Total Size: 47.1TB   Categories: genomics, biology

Earth Observing-1 Mission
Data gathered by the Advanced Land Imager (ALI) Hyperspectral Imager (Hyperion) instruments on NASA's Earth Observing-1 Mission (EO-1) satellite.
Total Size: 45.2TB   Categories: earth science, satellite imagery

City of Chicago Public Datasets
Data set from the City of Chicago Data Portal in JSON format for tabular data and the raw files for "blob" data.
Total Size: 9.7GB   Categories: social science

EMDataBank
Unified Data Resource for 3-Dimensional Electron Microscopy
Total Size: 91.3GB   Categories: biology

Enron Emails
Data sets based on the original Enron emails released to the public by the Federal Energy Regulatory Commission as part of their investigation.
Total Size: 155.9GB   Categories: social science

FlyBase
FlyBase is the leading database and web portal for genetic and genomic information on the fruit fly Drosophila melanogaster and related fly species.
Total Size: 614.8GB   Categories: biology, genomics

OSDC OPEN SCIENCE DATA CLOUD

ENVRI

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Research Data Alliance

- https://rd-alliance.org
- The Research Data Alliance implements the technology, practice, and connections that make Data Work across barriers.
- The Research Data Alliance aims to accelerate and facilitate research data sharing and exchange.
  - Working groups and interest groups
  - Joining groups and attendance at the twice-yearly plenary meetings is open.
- Plenary Sep 2014 hosted by the Netherlands - Amsterdam
  - Conference Management Team (CMT) Chair: Peter Doorn (DANS)
  - Program Committee (PC): chair Cees de Laat (UvA)
  - Satellite Events Committee (SEC): Jeroen Rombouts (TUD)

Program week, very very preliminary!

22-sep		23-sep		24-sep		25-sep		26-sep	
morning	afternoon	morning	afternoon	morning	afternoon	morning	afternoon	morning	afternoon
RDA 4P	RDA 4P	RDA 4P	RDA 4P	RDA 4P	EUDAT	EUDAT	EUDAT	EUDAT	EUDAT
						BioDiversity	BioDiversity	BioDiversity	BioDiversity
					Dutch Dataprize	DataCite	DataCite		
						ASTRON	ASTRON		
						DSRC-A'dam	DSRC-A'dam	DSRC/UvA-Bits	DSRC/UvA-Bits
						DSA workshop	DSA workshop		

Program RDA, very very preliminary!

	Day 1	Day 2	Day 3
08:00	Registration	Registration	Registration
08:30			
09:00			
09:30	Welcome & Keynotes	Keynotes	Parallel 7
10:00			
10:30	Coffee	Coffee	Coffee
11:00			
11:30	Parallel 1	Parallel 4	Keynote/Wrap up
12:00			
12:30	Lunch	Lunch	Lunch
13:00			
13:30			
14:00	Parallel 2	Parallel 5	
14:30			
15:00	Tea	Tea	
15:30			
16:00	Parallel 3	Parallel 6	
16:30			
17:00			
17:30	Posters + reception	Posters + reception	
18:00			
18:30			
19:00			
19:30			
20:00	Social Event?	Social Event & Conference Dinner	
20:30			
21:00			
21:30			
22:00			

2 – 3 Keynotes
9 sessions parallel

- **56 RG/WG**
- **7 PC**

Committee's

- **Conference Management Team (CMT):**
  - Chair: Peter Doorn (DANS)
  - Ingrid Dillo (DANS)
  - Elly Dijk (DANS)
  - Cees de Laat (chair PC)
  - Jeroen Rombouts (chair SEC)
  - Herman Stehouwer: as liaison RDA
  - Andrew Treloar: as consultant
- **Program Committee (PC):**

– Cees de Laat (Chair)	UvA
– Wouter Los (Co-Chair)	UvA
– Herman Stehouwer	MPI
– Patrick Aerts	NL – eScience
– Tony Hey	USA, Microsoft
– Sander Klous	KPMG
– Satoshi Sekiguchi	AIST - Japan
– Leif Laaksonen	RDA Europe
– Liu Chuang	Chinese partnership
– Dinesh Katre	India
– Wim Hugo	South Africa
– Andrew Treloar	Australia

  - **Satellite Events Committee (SEC):**
  - Chair: Jeroen Rombouts (TUD)
  - Jacco Konijn (UvA)

D S
R C

Questions?

Arie Taal
Paola Grosso
Ana Oprescu
Cees de Laat
Marc Makkes
Ralph Koning
Bas Terwijn
Leon Gommans
Fahimeh Alizadeh
Pieter Adriaans
Cosmin Dumitru
Karst Koymans
Yuri Demchenko
Rob Meijer
Karel van der Veldt
Reggie Cushing
Rudolf Strijkers
Miroslav Zivkovic
Jan Sipke van der Veen
Naod Duga Jebessa
Spiros Koulouzis
Hao Zhu
Sander Klous
Jaap van Ginkel
Guido van 't Noordende
Jeroen van der Ham
Mikolaj Baranowski
Steven de Rooij
Ngo Tong Canh
Souley Madougou
Paul Klint
Adianto Wibisono
Magiel Bruntink
Zhiming Zhao
Anna Varbanescu
Marijke Kaat
Niels Sijm
Hans Dijkman
Gerben de Vries
Adam Belloum
Arno Bakker
Marian Bubak
Daniel Romao
Erik-Jan Bos
Peter Bloem

http://sne.science.uva.nl

http://delaat.net

http://www.os3.nl/

http://i4dw.nl/

http://dsrc.nl/

http://sne.science.uva.nl/openlab/

http://pire.opensciencedatacloud.org

http://staff.science.uva.nl/~delaat/pire/

https://rd-alliance.org

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