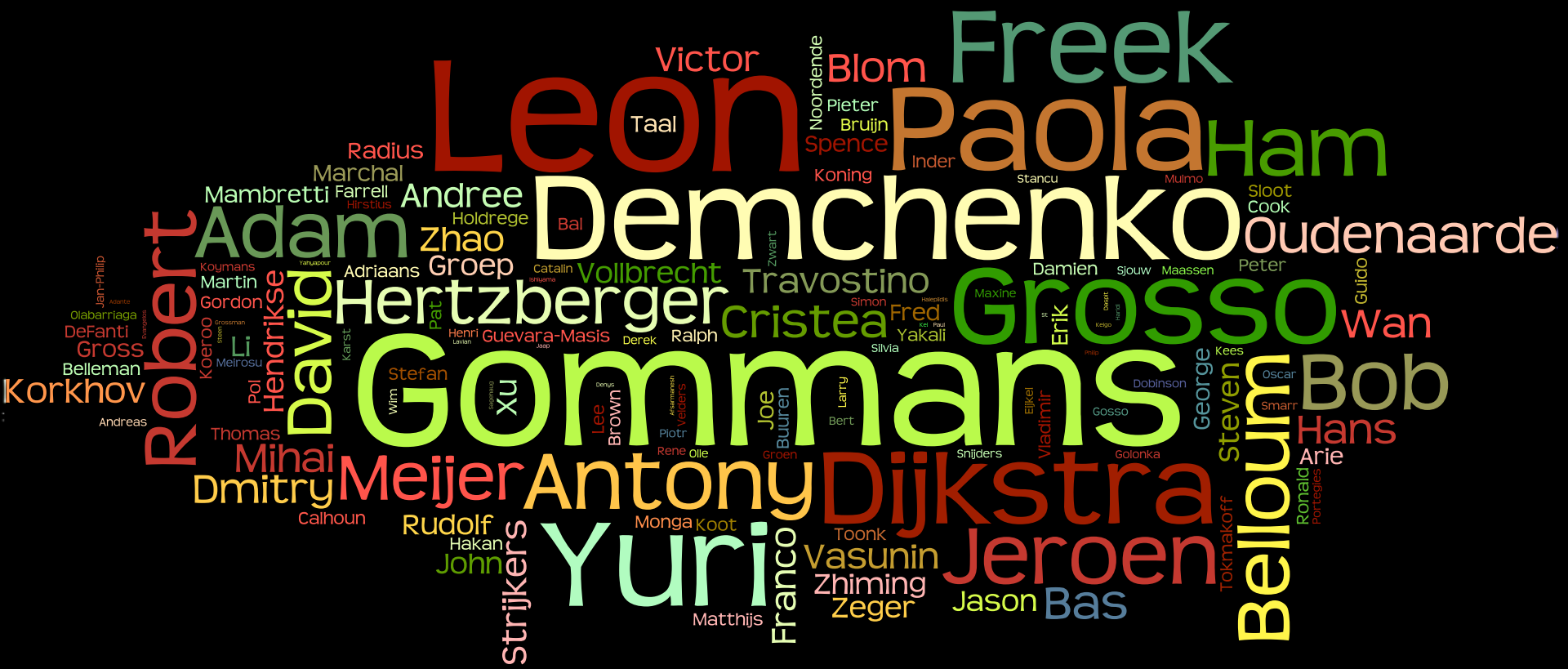
System and Network Engineering Research for Big Data Sciences

Cees de Laat

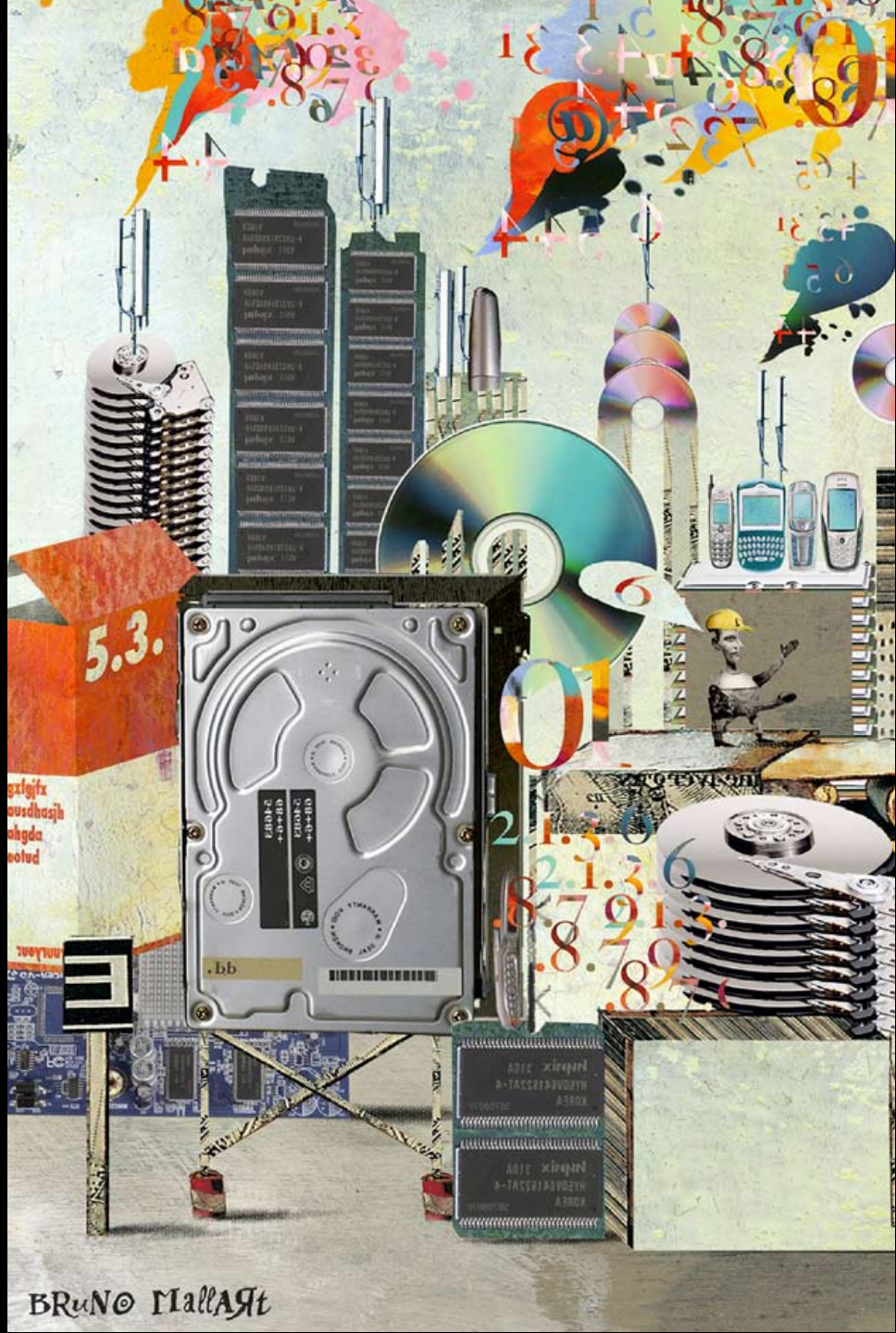


From King's Dutch Academy of Sciences

The Dutch Research Agenda

•"Information technology (IT) now permeates all aspects of public, commercial, social, and personal life. bank cards, satnav, and weather radar... IT has become completely indispensable."

•"But to guarantee the reliability and quality of constantly bigger and more complicated IT, we will need to find **answers to some** fundamental questions!"



•https://www.knaw.nl/nl/actueel/publicaties/the-dutch-research-agenda/@@download/pdf_file/20111029.pdf

Reduction of Complexity by Integration

•By combining services such as telephony, television, data, and computing capacity within a single network, we can cut down on complexity, energy consumption and maintenance.

- How can we describe and analyze complex information systems effectively?
- How can we specify and measure the quality and reliability of a system?
- How can we combine various different systems?
- How can we design systems in which separate processors can co-operate efficiently via mutual network connections within a much larger whole?
- Can we design information systems that can diagnose their own malfunctions and perhaps even repair them?
- How can we specify, predict, and measure system performance as effectively as possible?

•SNE addresses a.o. the **highlighted** questions!

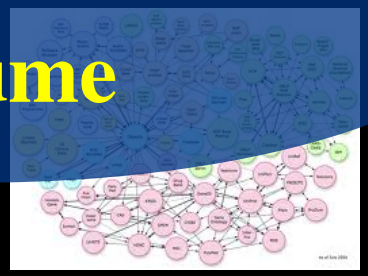
•http://www.knaw.nl/Content/Internet_KNAW/publicaties/pdf/20111029.pdf

Internet developments

... more data!

Speed

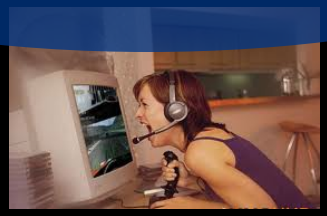
Volume



Deterministic

Real-time

more realtime!



Scalable

Secure

... more users!

Mission SNE

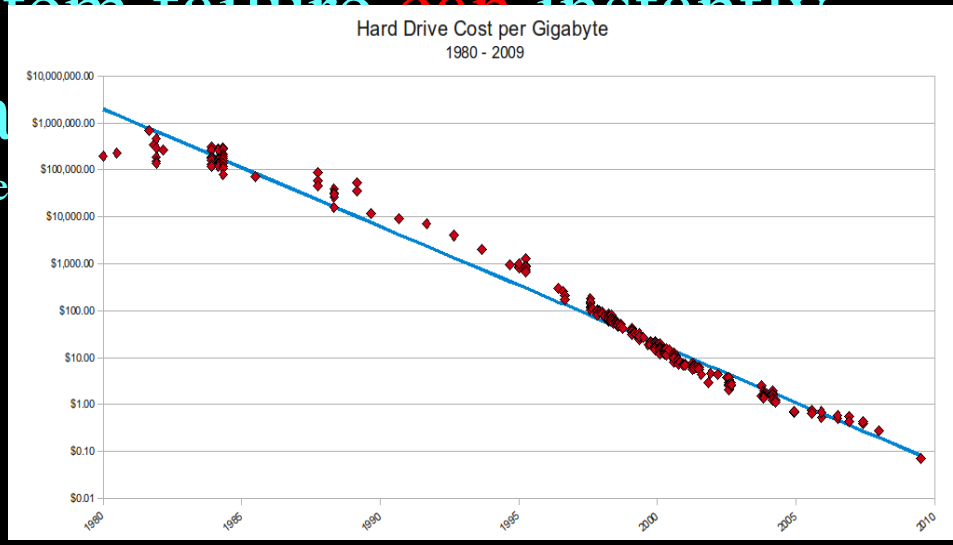
Can we create smart and safe data processing infrastructures that can be tailored to diverse application needs?

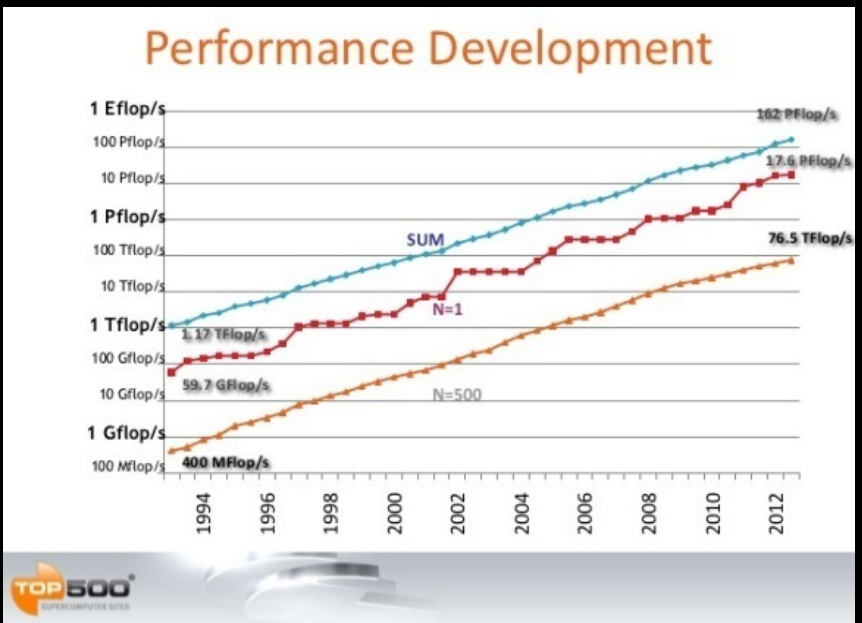
- *Capacity*
  - *Bandwidth on demand, QoS, architectures, photonics, performance*
- *Capability*
  - *Programmability, virtualization, complexity, semantics, workflows*
- *Security*
  - *Authorization, Anonymity, integrity of data in distributed data processing*
- *Sustainability*
  - *Greening infrastructure,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

Reliable and Safe!

- This omnipresence of IT makes us not only strong but also vulnerable.
- A virus, a hacker, or a system failure can instantly send digital shockwaves a

- The hardware and software that allow all our systems to operate is becoming bigger and more complex all the time, and the capacity of networks and data storage is increasing by leaps and bounds.

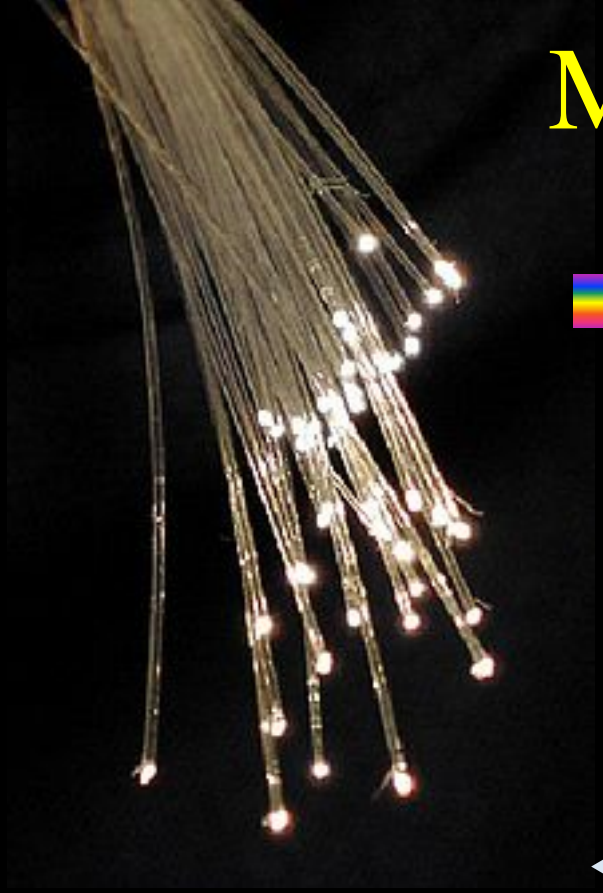


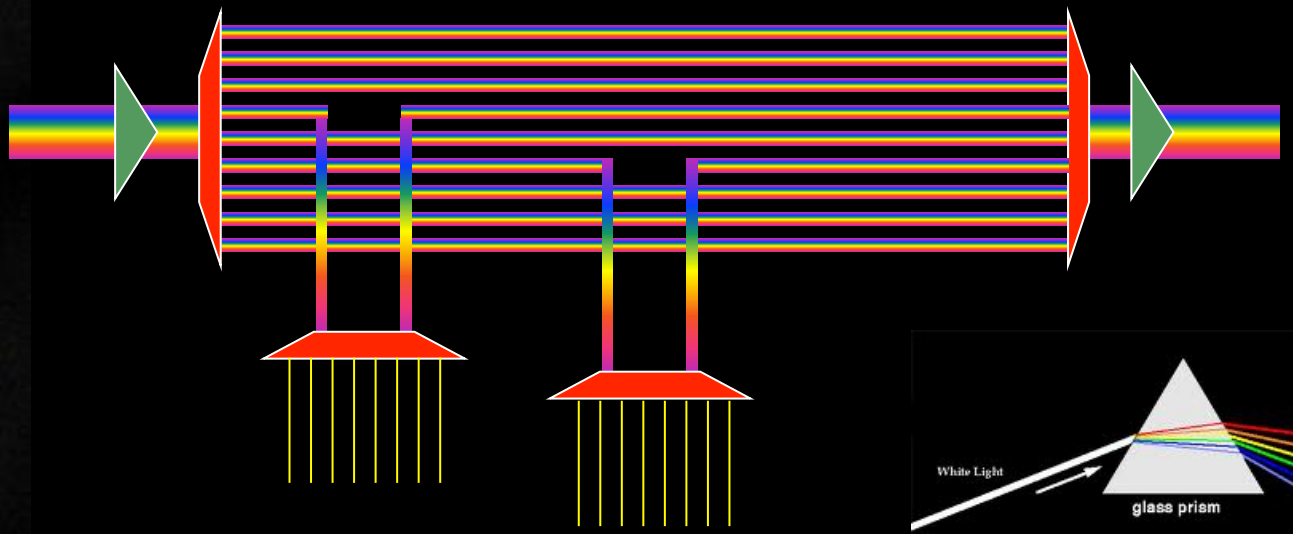


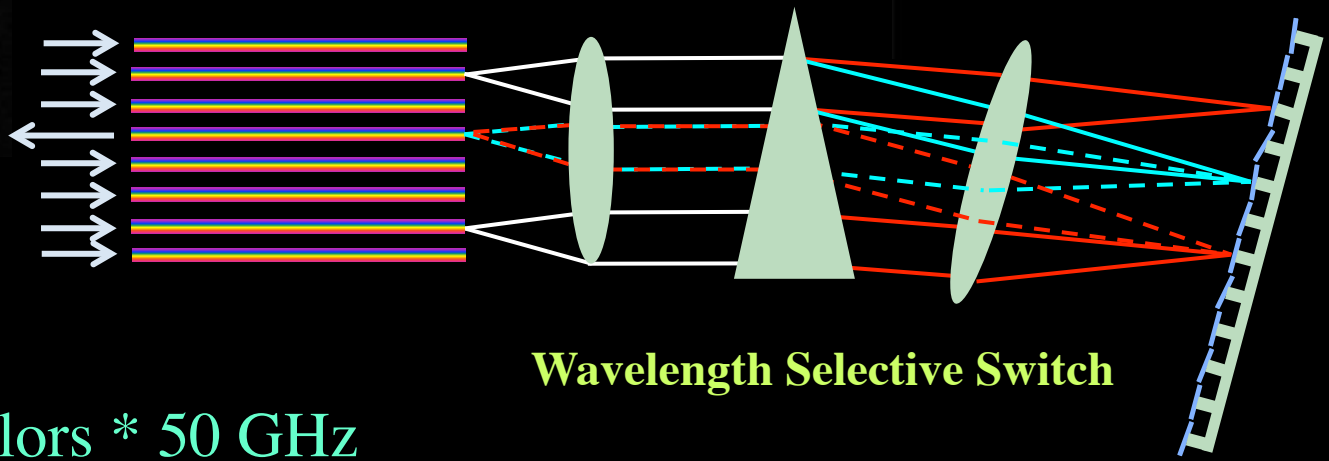
- We will soon reach the limits of what is currently feasible and controllable.

- http://www.knaw.nl/Content/Internet_KNAW/publicaties/pdf/20111029.pdf

Multiple colors / Fiber







Wavelength Selective Switch

Per fiber: ~ 80-100 colors * 50 GHz

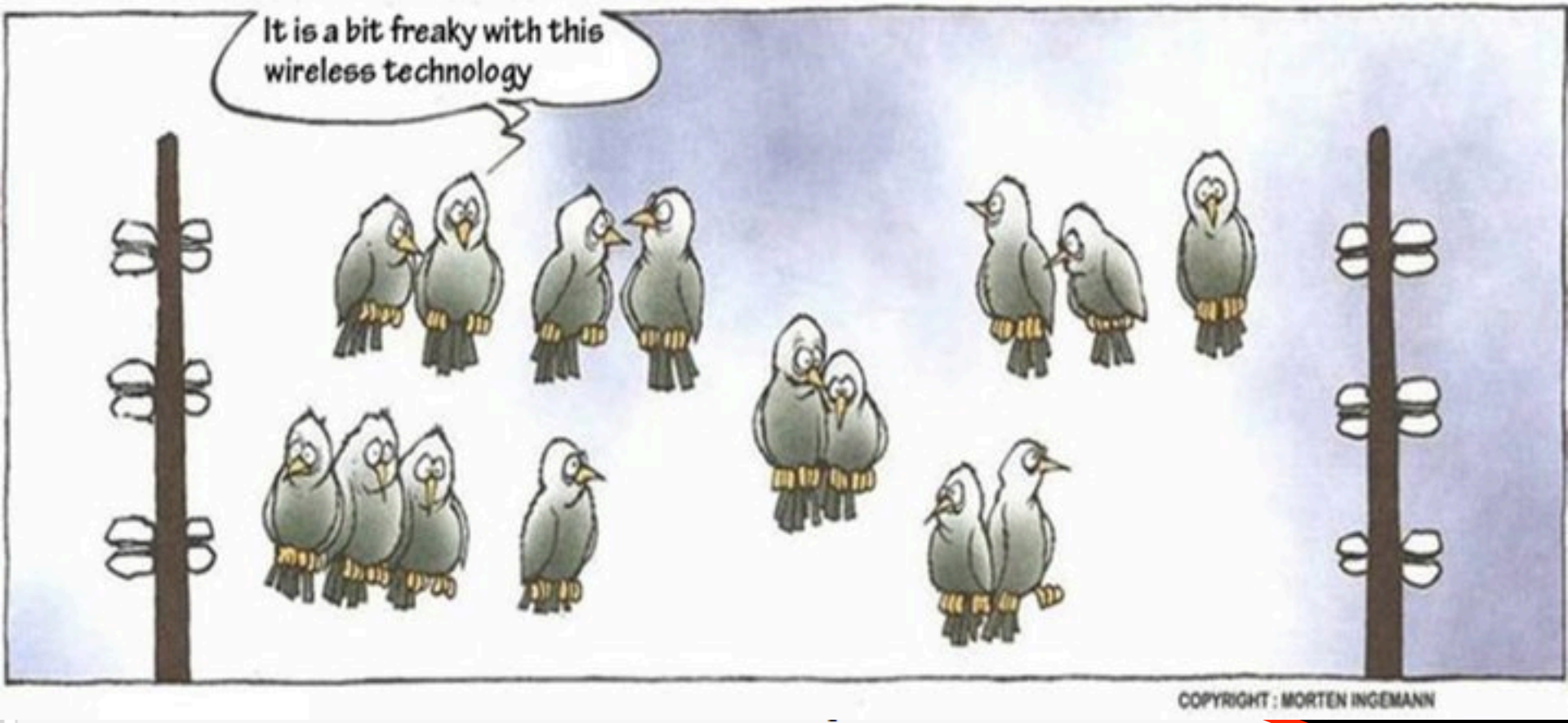
Per color: 10 – 40 – 100 Gbit/s

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

New: Hollow Fiber!

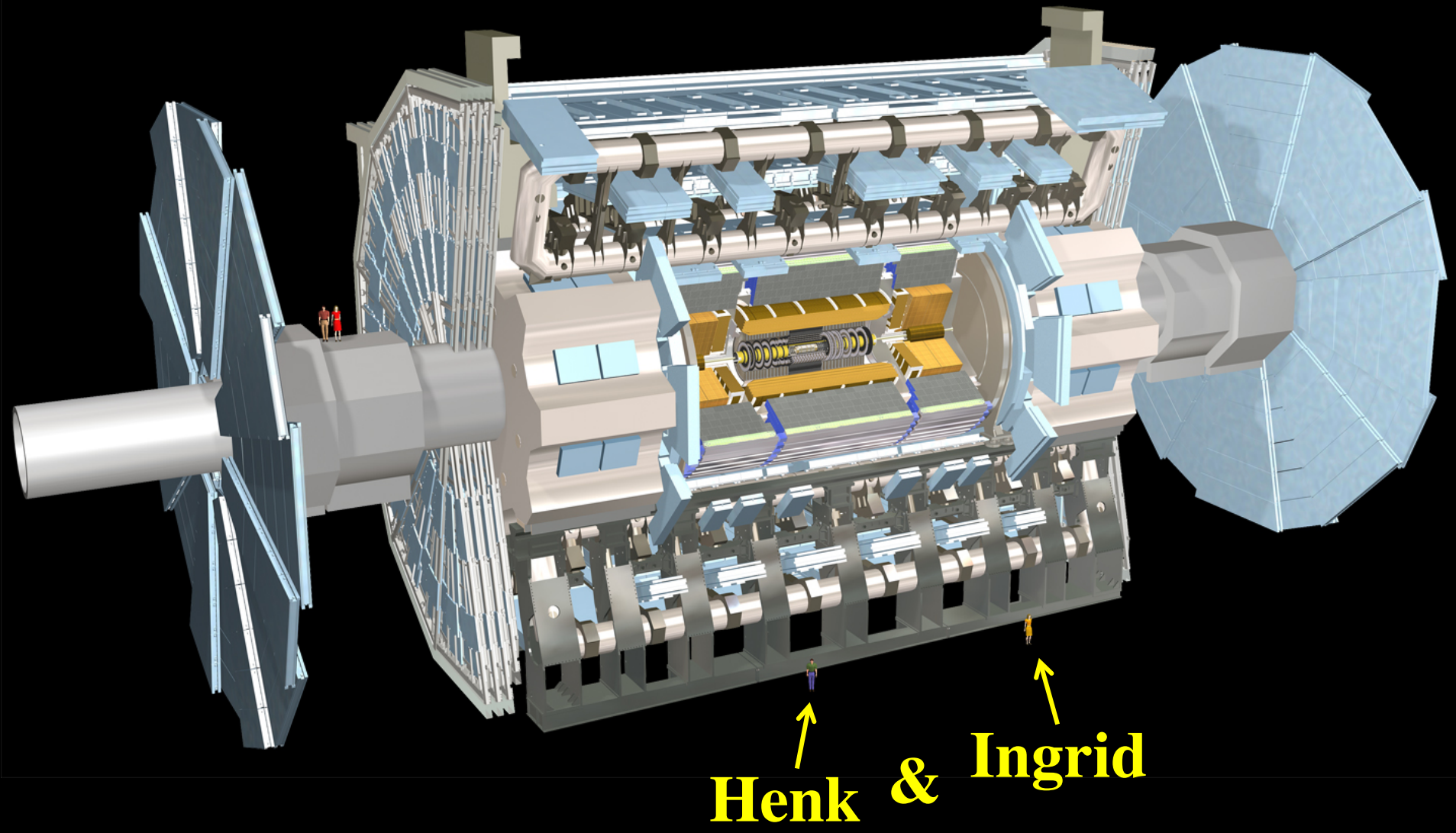
➔ less RTT!

Wireless Networks



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.

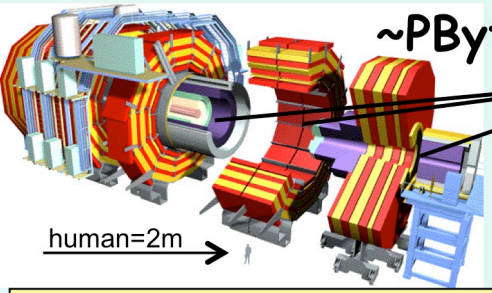
ATLAS detector @ CERN Geneve



ATLAS detector @ CERN Geneve

LHC Data Grid Hierarchy

CMS as example, Atlas is similar



~PByte/sec

Online System

~100 MBytes/sec

100000 flops/byte

10 Pflops/s

event simulation

Tier 0 +1

HPSS

event reconstruction

CMS detector: 15m X 15m X 22m

12,500 tons, $700M.

~2.5 Gbits/sec

Status 2002!

Tier 1

Italian Regional Center

German Regional Center

NIKHEF Dutch Regional Center

FermiLab, USA Regional Center

...

~0.6-2.5 Gbps

analysis

Tier2 Center

Tier 2

~0.6-2.5 Gbps

Tier 3

Institute ~0.25TIPS

Physics data cache

100 - 1000 Mbits/sec

Tier 4

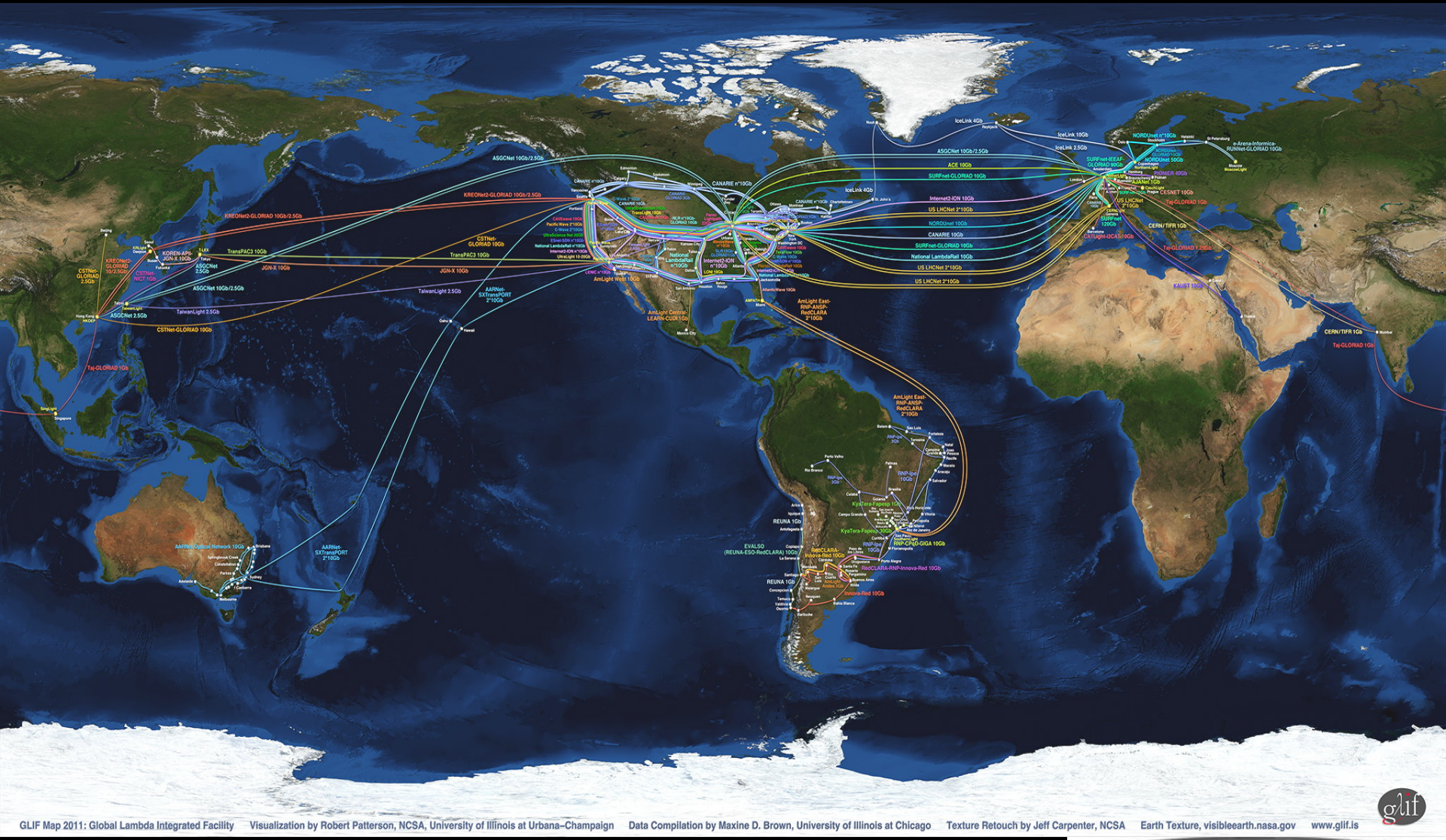
Workstations

Courtesy Harvey Newman, CalTech and CERN

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

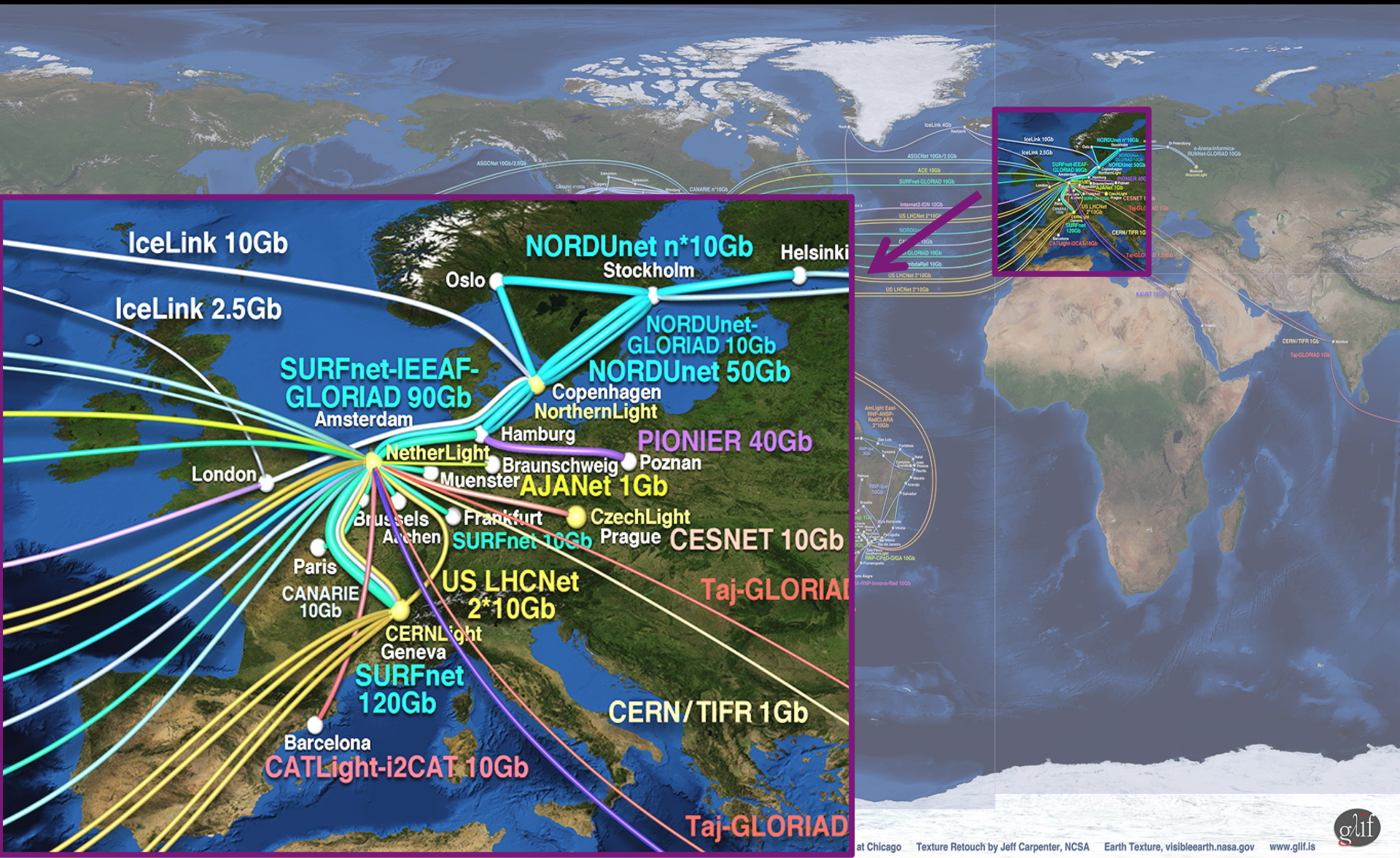
Physicists work on analysis "channels" at 135 institutes. Each institute has ~10 physicists working on one or more channels.

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



We investigate: TOMTOM for complex networks!

- 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.



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.

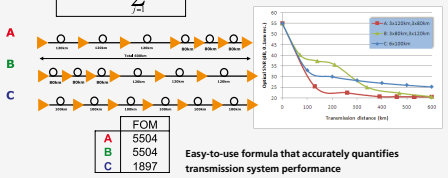
In this demonstration we will investigate the performance of a 40Gb/s PM-QPSK alien wavelength installed on a 10Gb/s DWDM infrastructure.

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

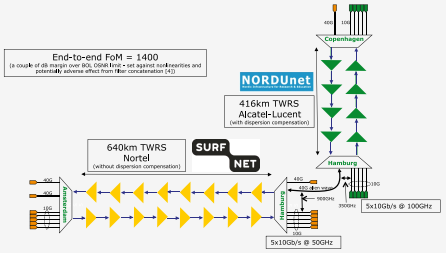


	FOM
A	5504
B	5504
C	1897

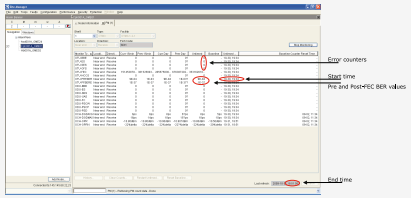
Easy-to-use formula that accurately quantifies transmission system performance

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

What Happens in an **Internet Minute?**

And **Future Growth** is **Staggering**

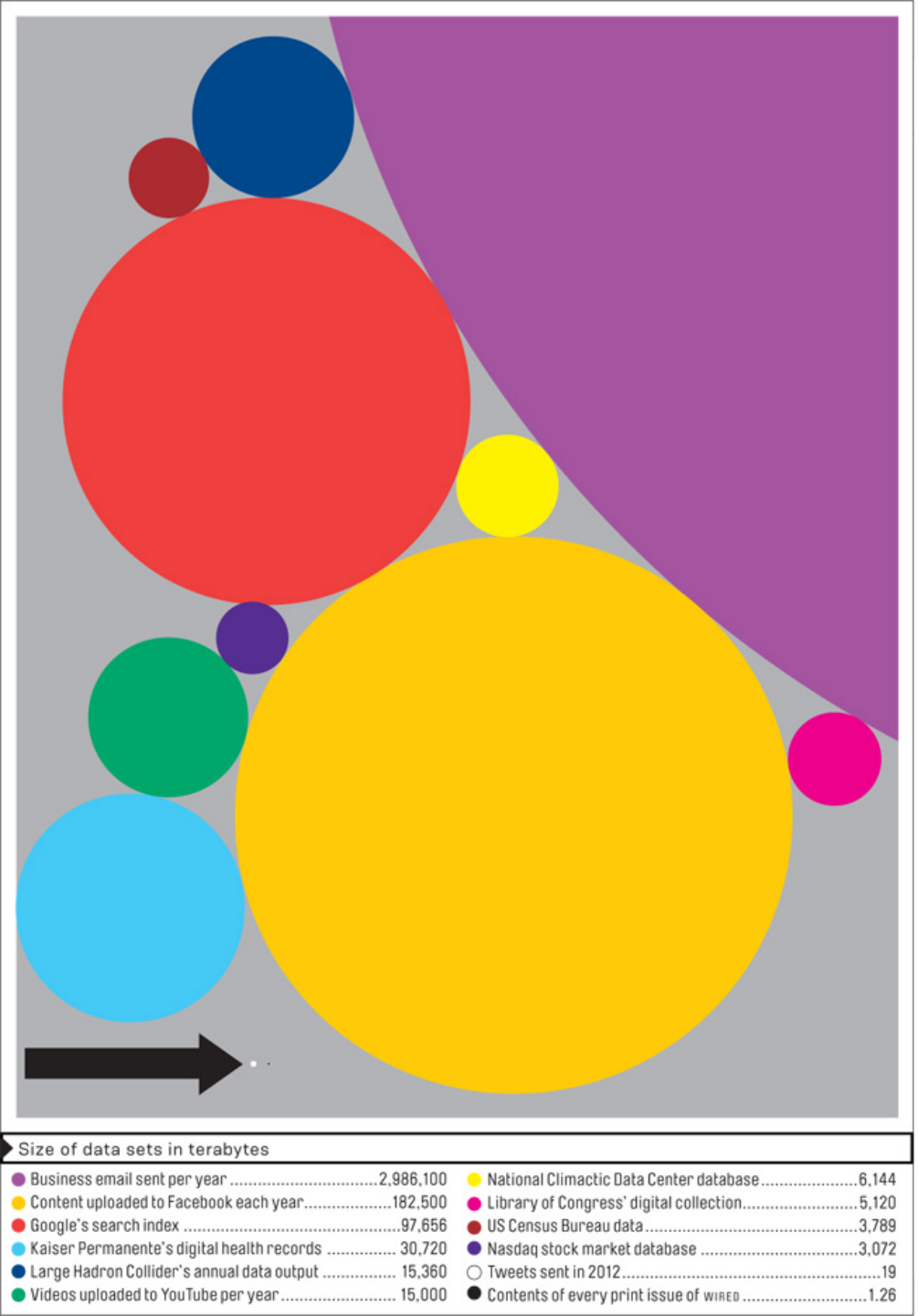
Today, the number of networked devices = the global population

By **2015**, the number of networked devices = 2x the global population

In **2015**, it would take you **5 years**

to view all video crossing IP networks each **second**

intel



There is always a bigger fish

The constant factor in our field is Change!

The 50 years it took Physicists to find one particle, the Higgs, we came from:

"Fortran goto", Unix, c, SmallTalk, DECnet, TCP/IP, c++, Internet, WWW, Semantic Web, Photonic networks, Google, grid, cloud, Data^3, App

to:

DDOS attacks destroying Banks and Bitcoins.

Conclusion:

Need for Safe, Smart, Resilient Sustainable Infrastructure.

SNE-Master

- RP's
  - 2005-21 Beveiliging banktransacties.
  - 2005-30 SURFnet Intrusion Detection System (IDS).
  - 2006-22 Beveiliging grote overheids organisatie: CERT procedures.
  - 2006-24 Beveiliging grote overheids organisatie: Vertrouwd Toegangspad.
  - 2007-23 CERT noodnet.
  - 2007-41 Onderzoek naar de beveiliging van de wegwerp OV ritten kaart.
  - 2008-18 Security and Reliability of Automated Waste Registration in The Netherlands.
  - 2008-33 Slimme meters.
  - 2008-41 Security en privacy in het Landelijk Schakelpunt.
  - 2009-02 Online Banking: Attacks & Defences.
  - 2009-07 Browser Security.
  - 2009-41 The DFRWS 2009 Challenge.
  - 2010-07 Modern Age Burglars.
  - 2010-15 Horse-ID.
  - 2010-34 GPU-based password cracking.
  - 2011-43 Passive LAN information gathering.
  - 2011-08 PersLink Security.
  - 2012-53 Secure Internet Banking on Insecure Hosts
  - 2013-59 BGP origin validation (RPKI).

CHANGE!