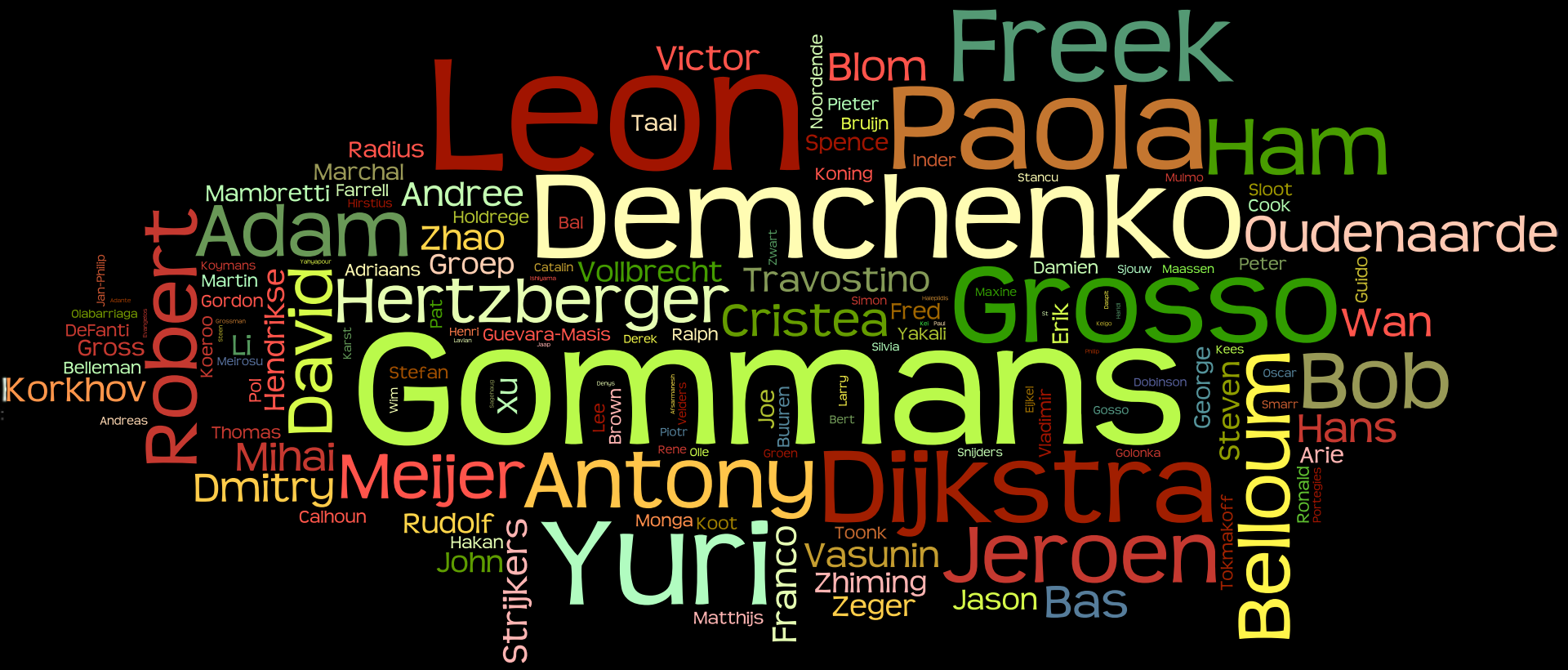
Smart Cyber Infrastructure for Big Data Processing

Cees de Laat & Paola Grosso



Science Faculty @ UvA

Informatics Institute

- AMLAB: Machine Learning (Prof. dr. M. Welling)
- FCN: Federated Collaborative Networks (Prof. dr. H. Afsarmanesh)
- ILPS: Information and Language Processing Systems (Prof. dr. M. de Rijke)
- ISIS: Intelligent Sensory Information Systems (Prof. dr. ir. A.W.M. Smeulders)
- CSL: Computational Science Laboratory (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)

SNE - Mission

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*
  - *Policy, Trust, Anonymity, Privacy, Integrity*
- *Sustainability*
  - *Greening infrastructure, Awareness*
- *Resilience*
  - *Failures, Disasters, Systems under attack*

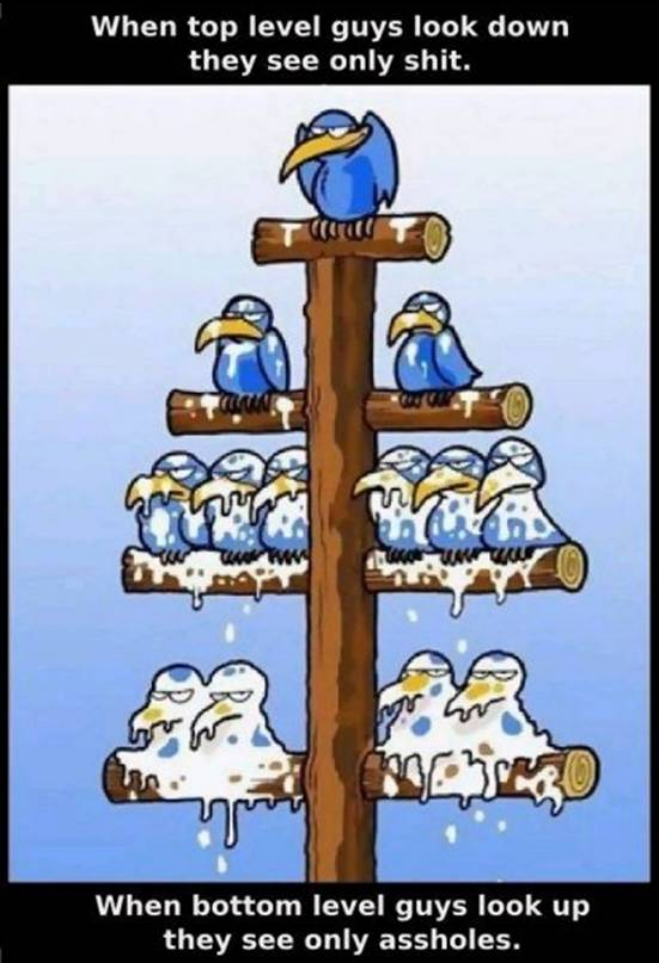
SNE - Staffing

Group leader: ***prof. C. de Laat***

Deputy group leaders: ***dr. Andy Pimentel, dr. Paola Grosso***

- 1 full prof (CdL)
- 2 part time professors
- 2 endowed professors
- *2 senior researchers*
- 1 associate prof (AP)
- 4 assistant professors (inc PG)
- ~12 postdoc's
- *About 15 phd students*
- ~10 guests

- *Yearly turnover ~ 3,5 MEuro*



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What Happens in an **Internet Minute?**

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

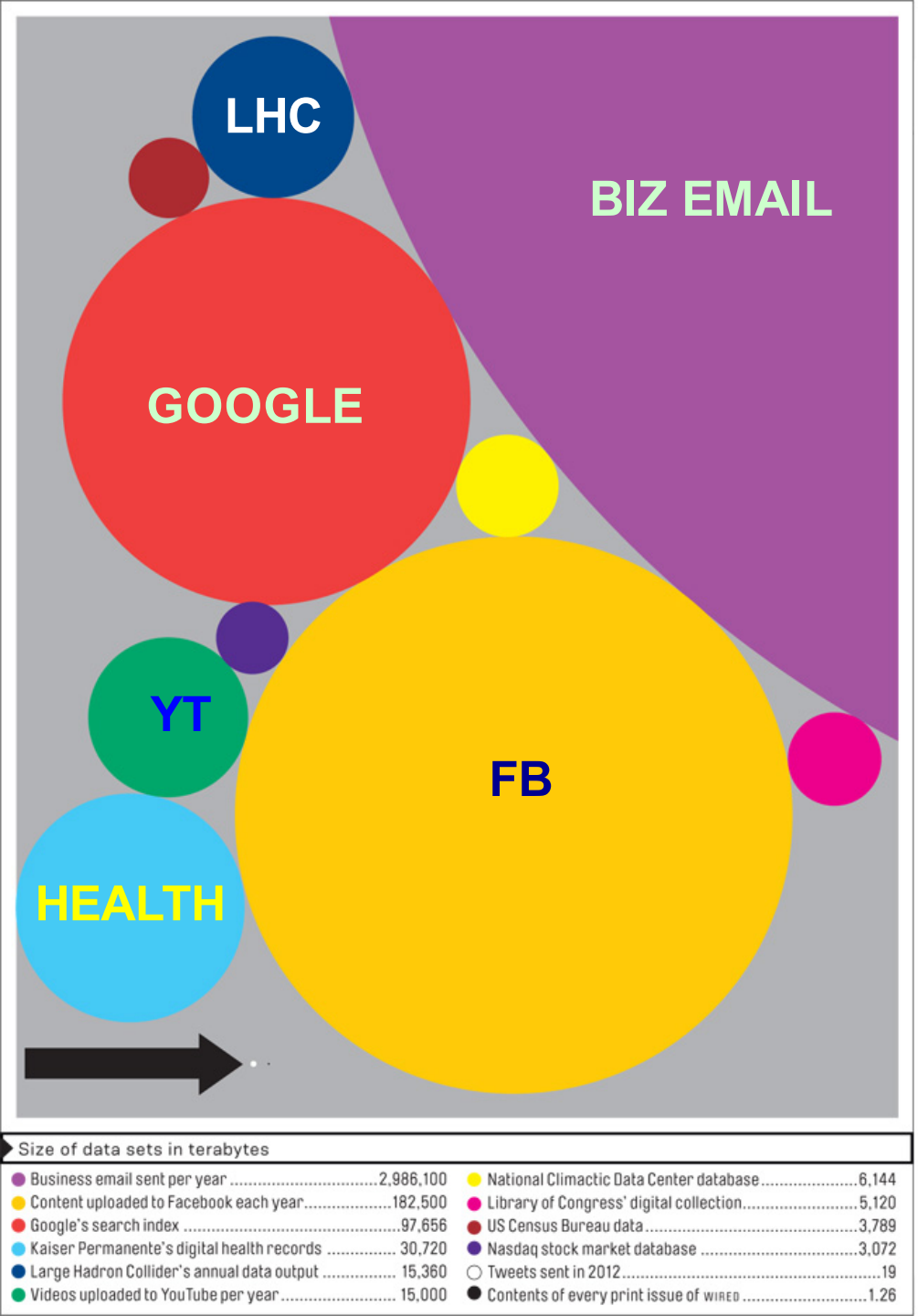
Today, the number of networked devices = the global population

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**

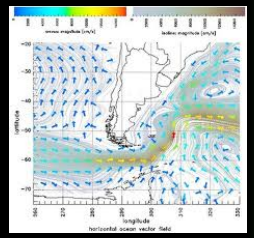
intel

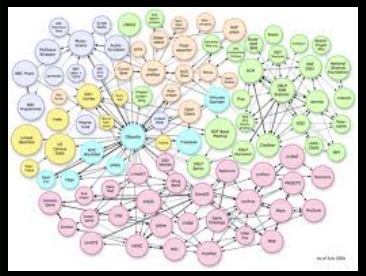


There
is
always
a
bigger
fish

Internet developments

... more data!





... more realtime!

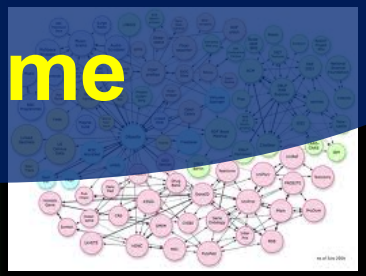
... more users!

Internet developments

... more data!

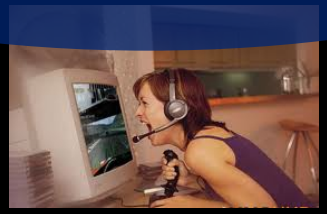
Speed

Volume



Deterministic

Real-time

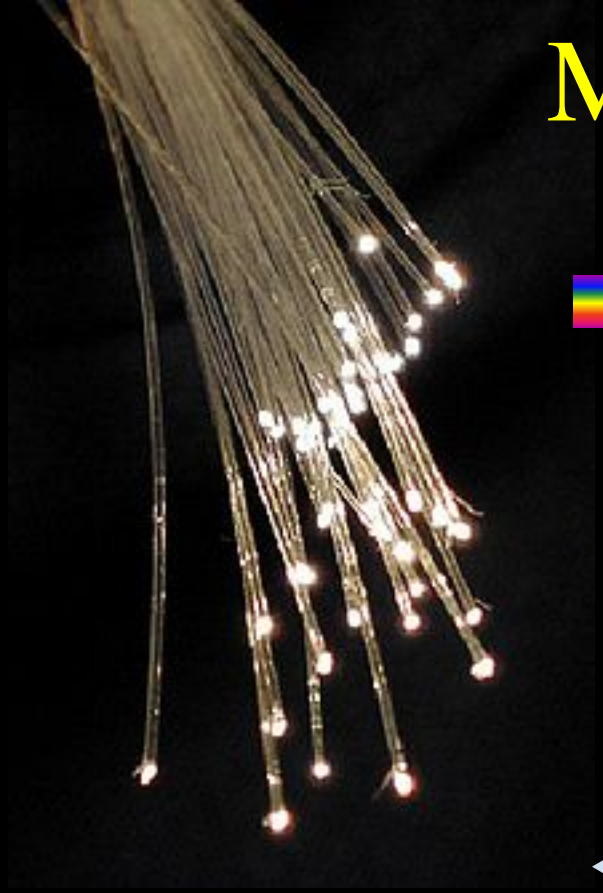


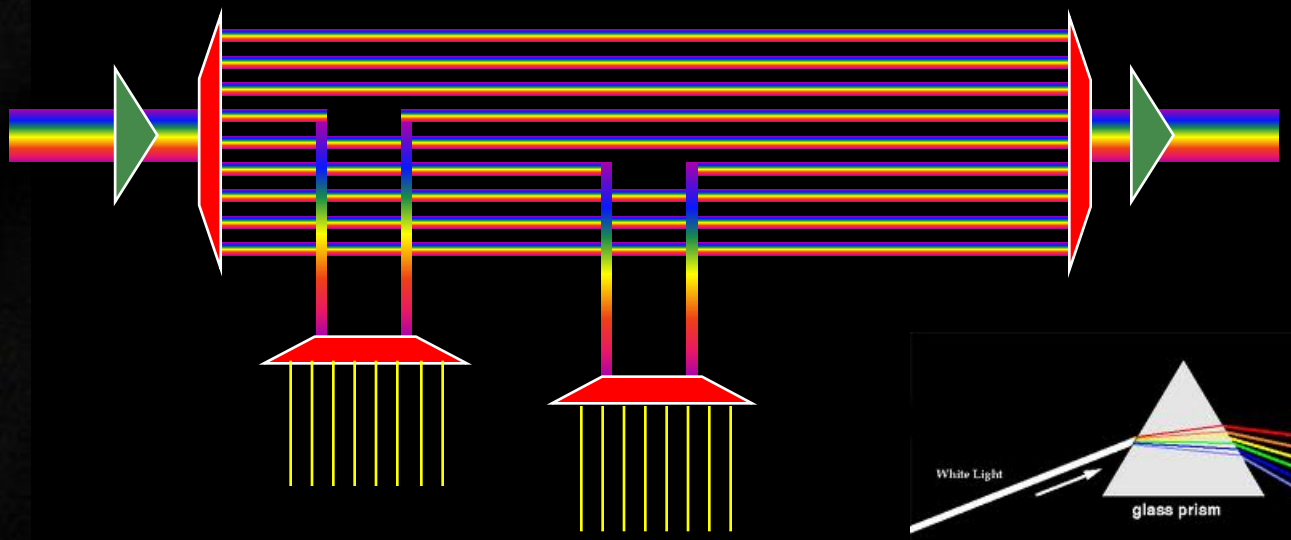
Scalable

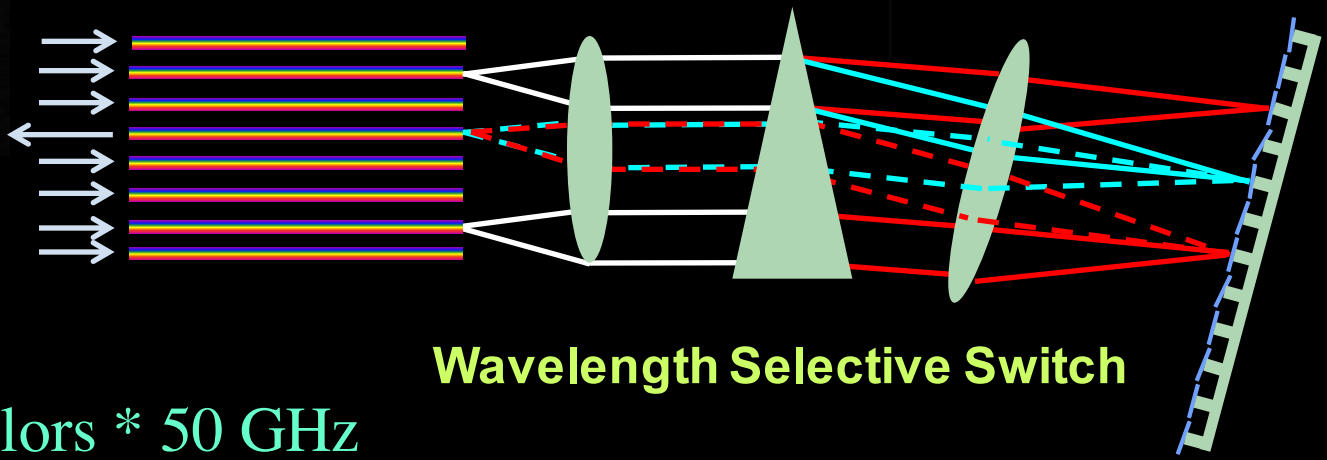
Secure

... more users!

Multiple colors / Fiber







Wavelength Selective Switch

Per fiber: ~ 80-100 colors * 50 GHz

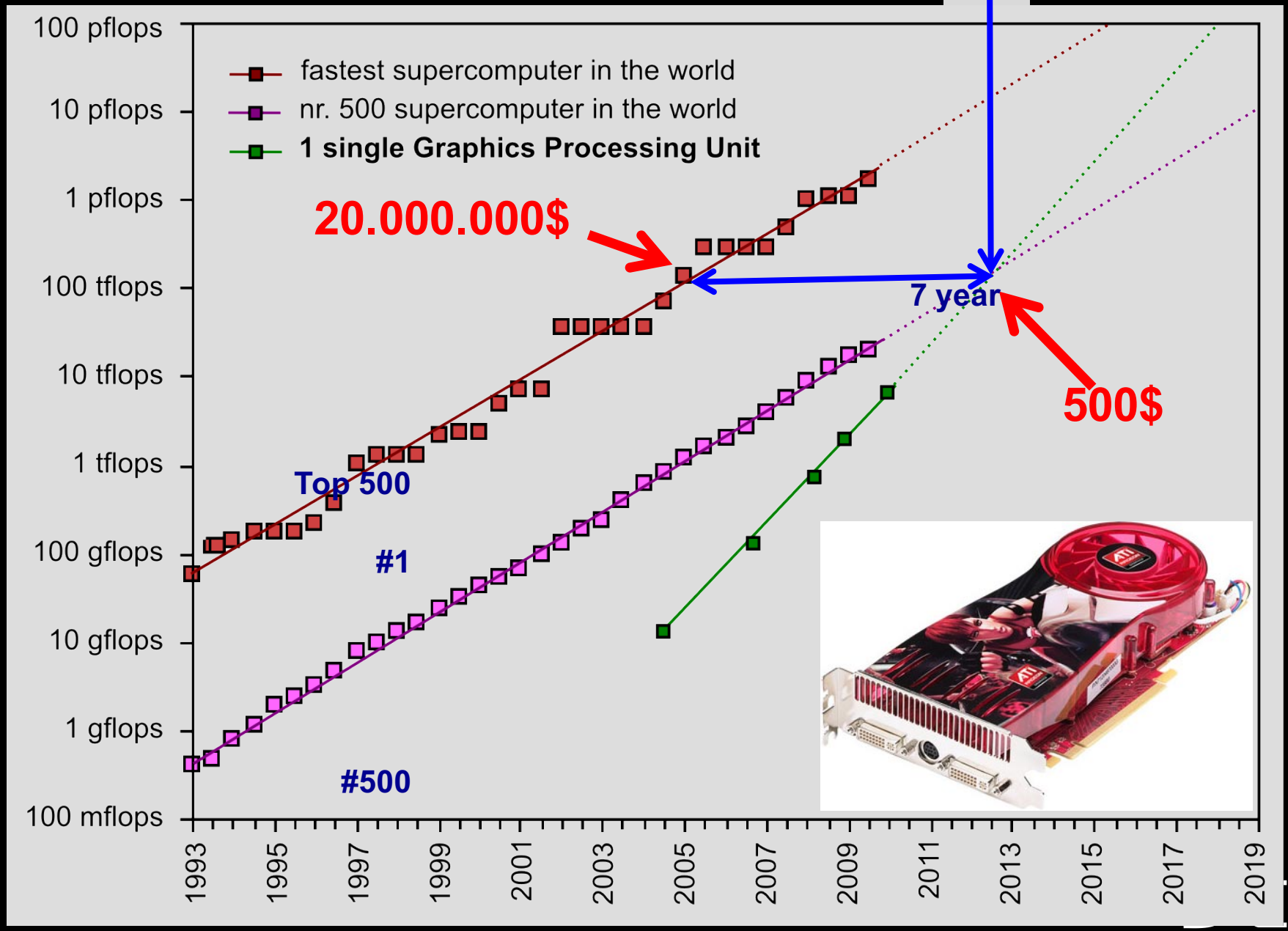
Per color: 10 – 40 – 100 Gbit/s

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

New: Hollow Fiber!

➔ less RTT!

GPU cards are distruptive!

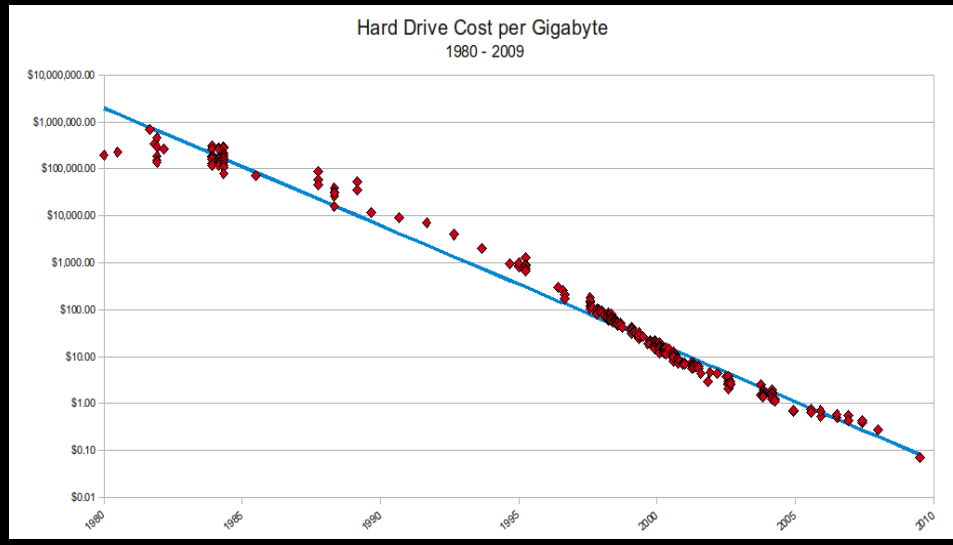


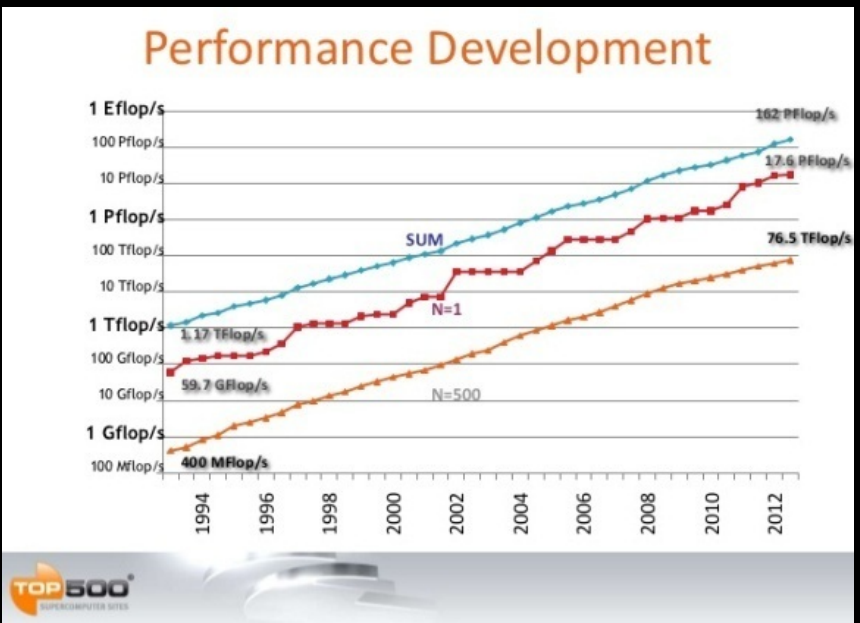
Reliable and Safe!

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 around the world.

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.



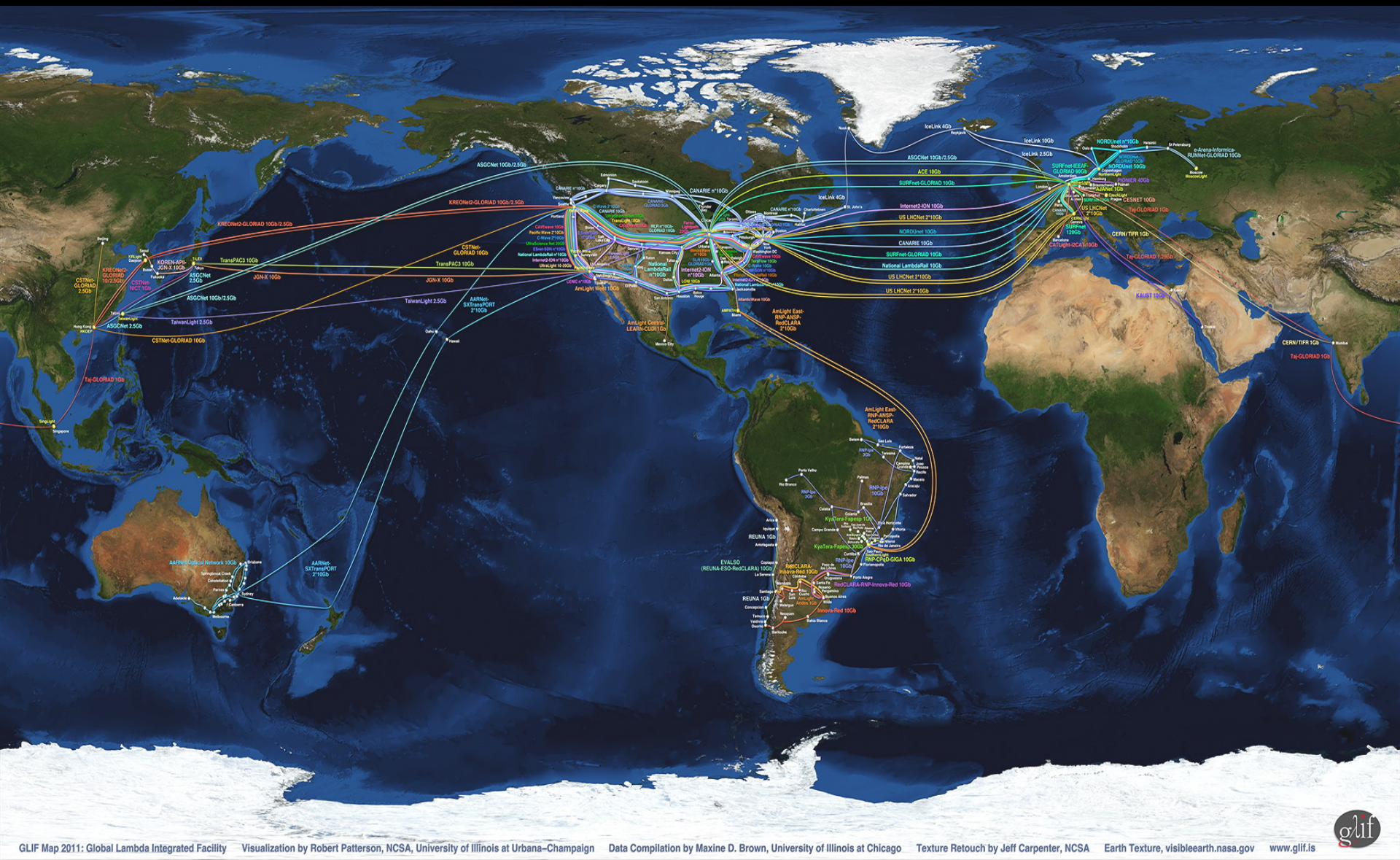


We will soon reach the limits of what is currently feasible and controllable.

https://www.knaw.nl/shared/resources/actueel/publicaties/pdf/20111029.pdf

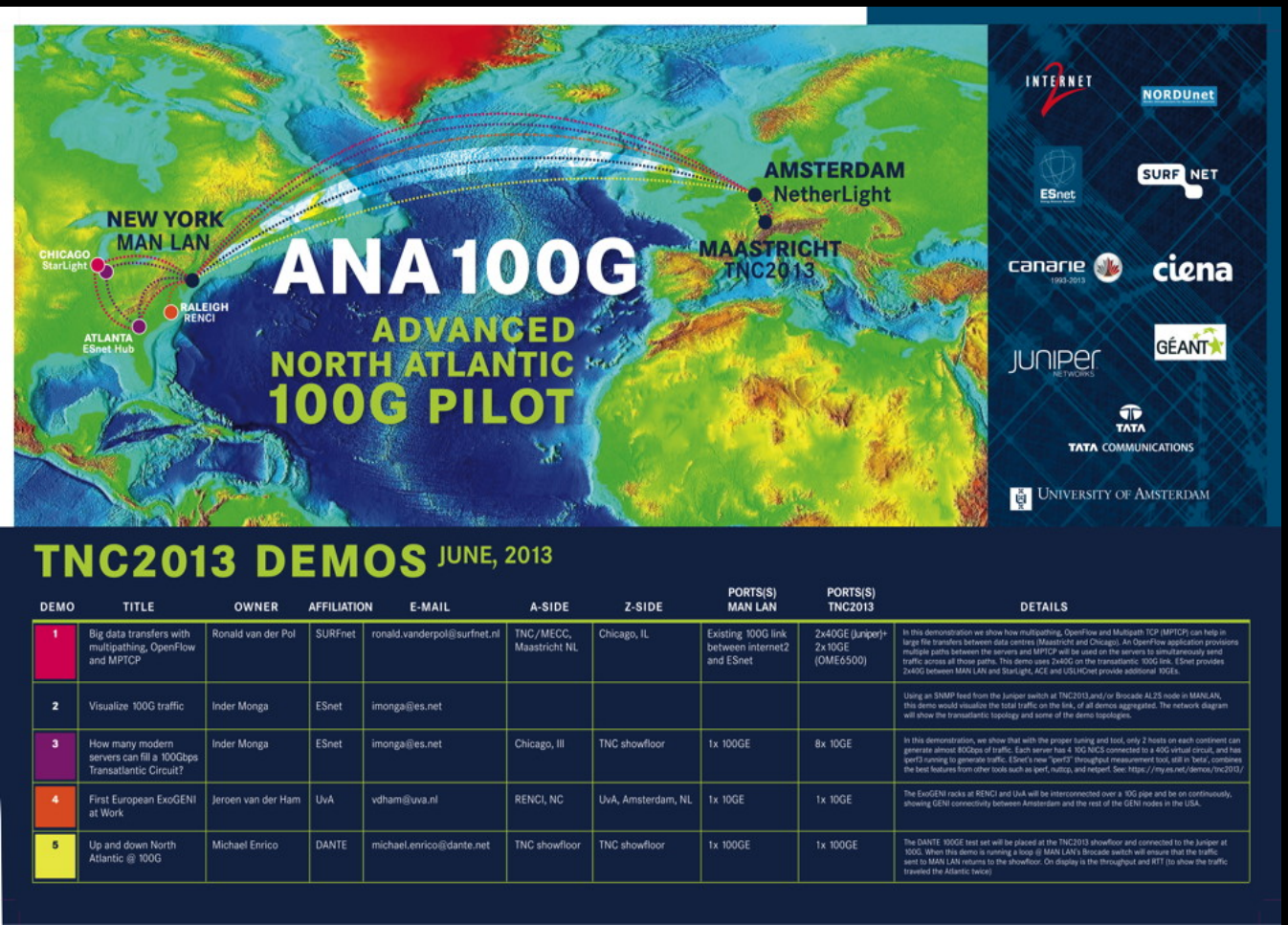
The GLIF – LightPaths around the World

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.



ExoGeni @ OpenLab - UvA

Installed and up June 3th 2013



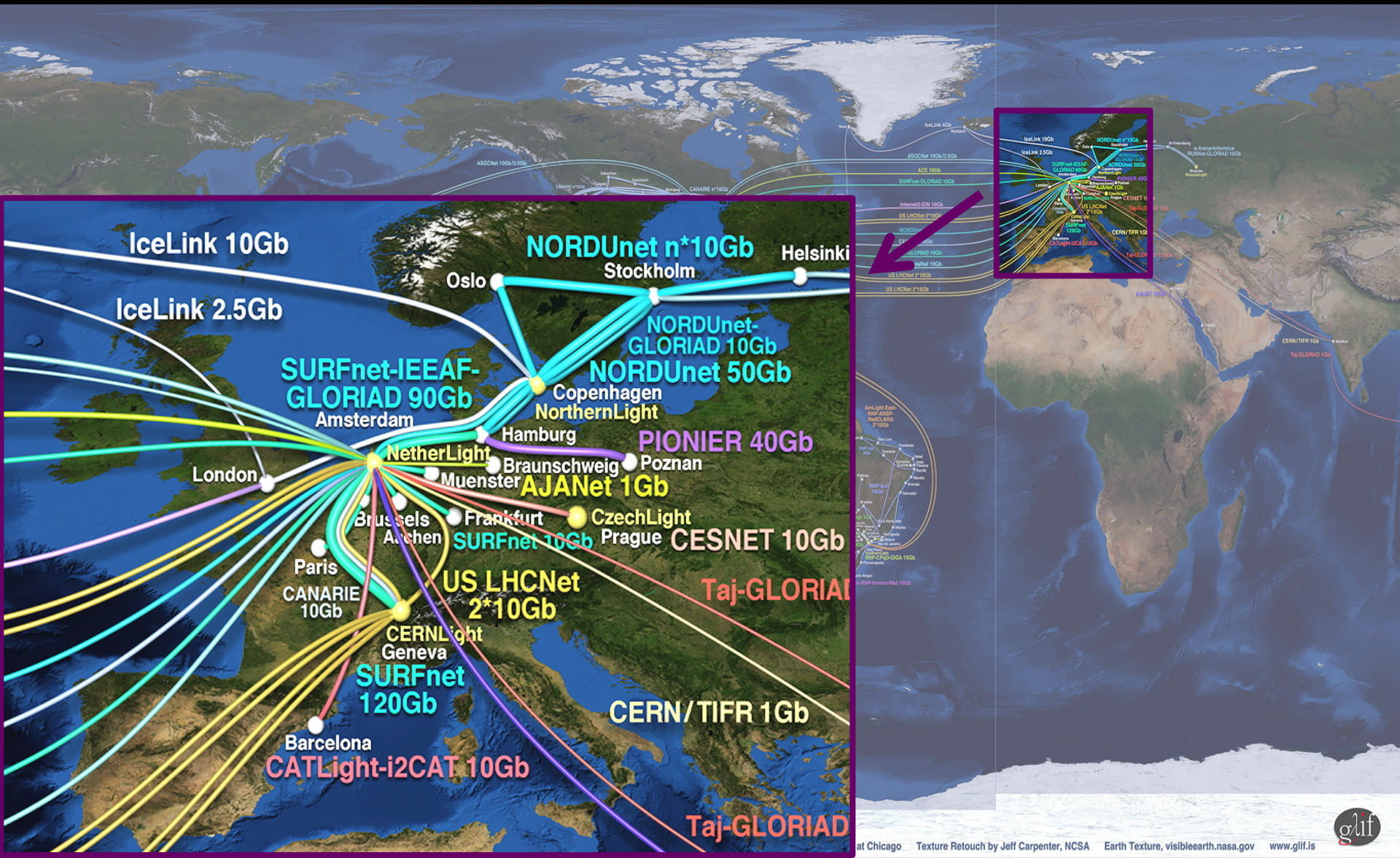
TNC2013 DEMOS JUNE, 2013

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)+ 2x 10GE (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

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.



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SARNET: Security Autonomous Response with programmable NETworks

Cees de Laat
Leon Gommans, Rodney Wilson, Rob Meijer
Tom van Engers, Marc Lyonais, Paola Grosso, Frans Franken,
Ameneh Deljoo, Ralph Koning, Ben de Graaff, Stojan Trajanovski

UNIVERSITY OF AMSTERDAM

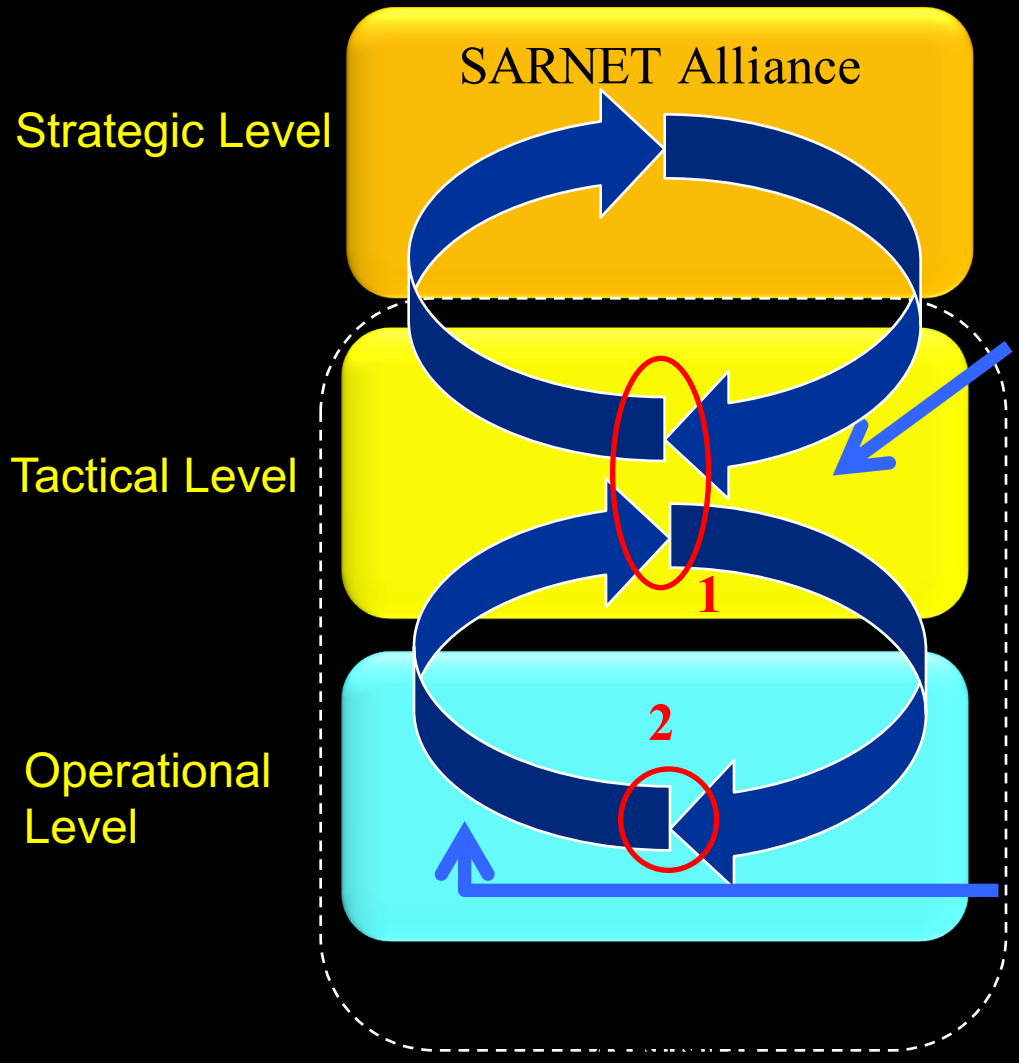
Cyber security program

- Research goal is to obtain the knowledge to create ICT systems that:
  - model their state (situation)
  - discover by observations and reasoning if and how an attack is developing and calculate the associated risks
  - have the knowledge to calculate the effect of counter measures on states and their risks
  - choose and execute one.

  In short, we research the concept of networked computer infrastructures exhibiting SAR: Security Autonomous Response.

Context & Goal

Security Autonomous Response NETwork Research

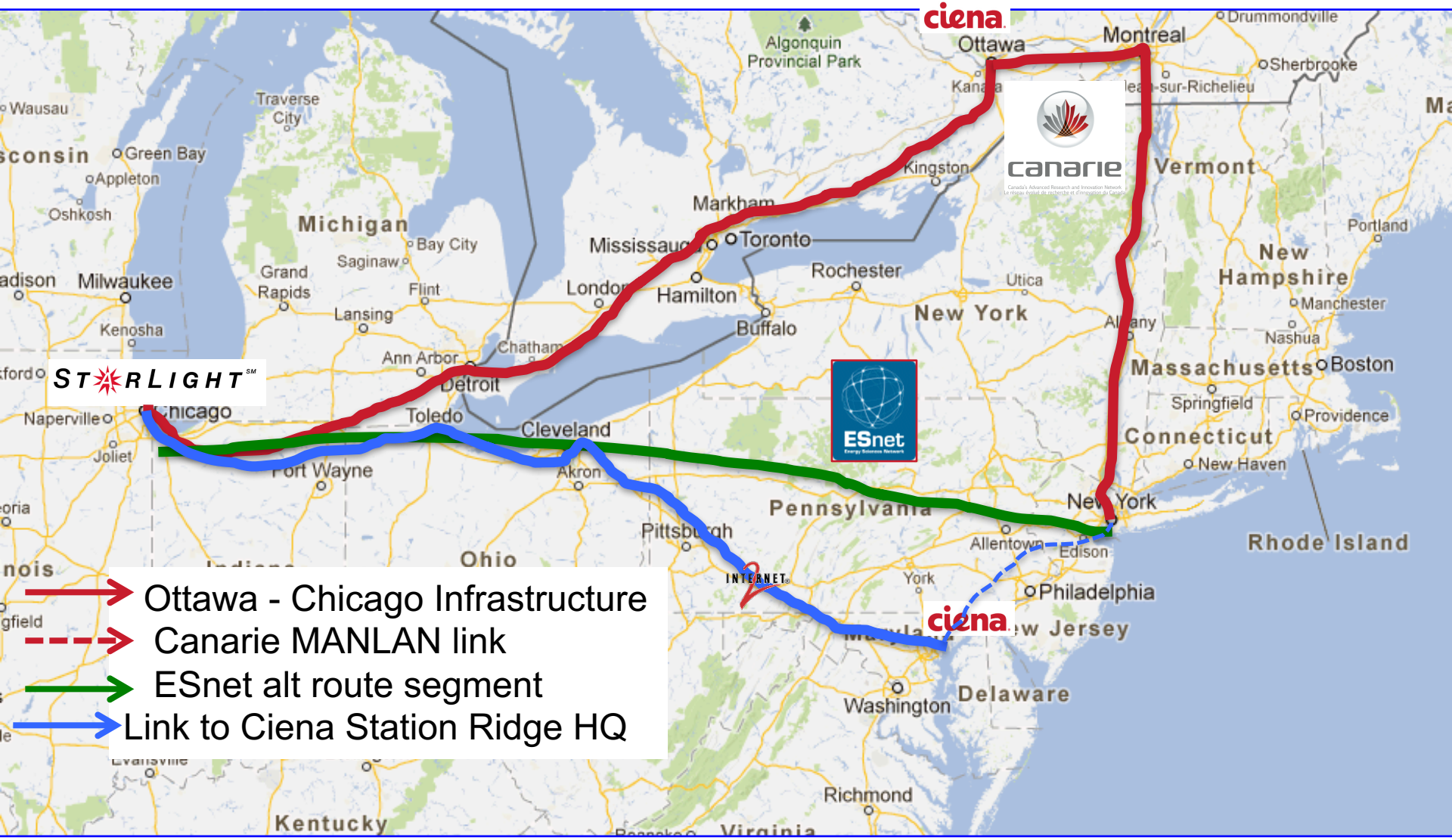


Ameneh Deljoo (PhD):
Why create SARNET Alliances?
Model autonomous SARNET behaviors to identify risk and benefits for SARNET stakeholders

Stojan Trajanovski (PD):
Determine best defense scenario against cyberattacks deploying SARNET functions (1) based on security state and KPI information (2).

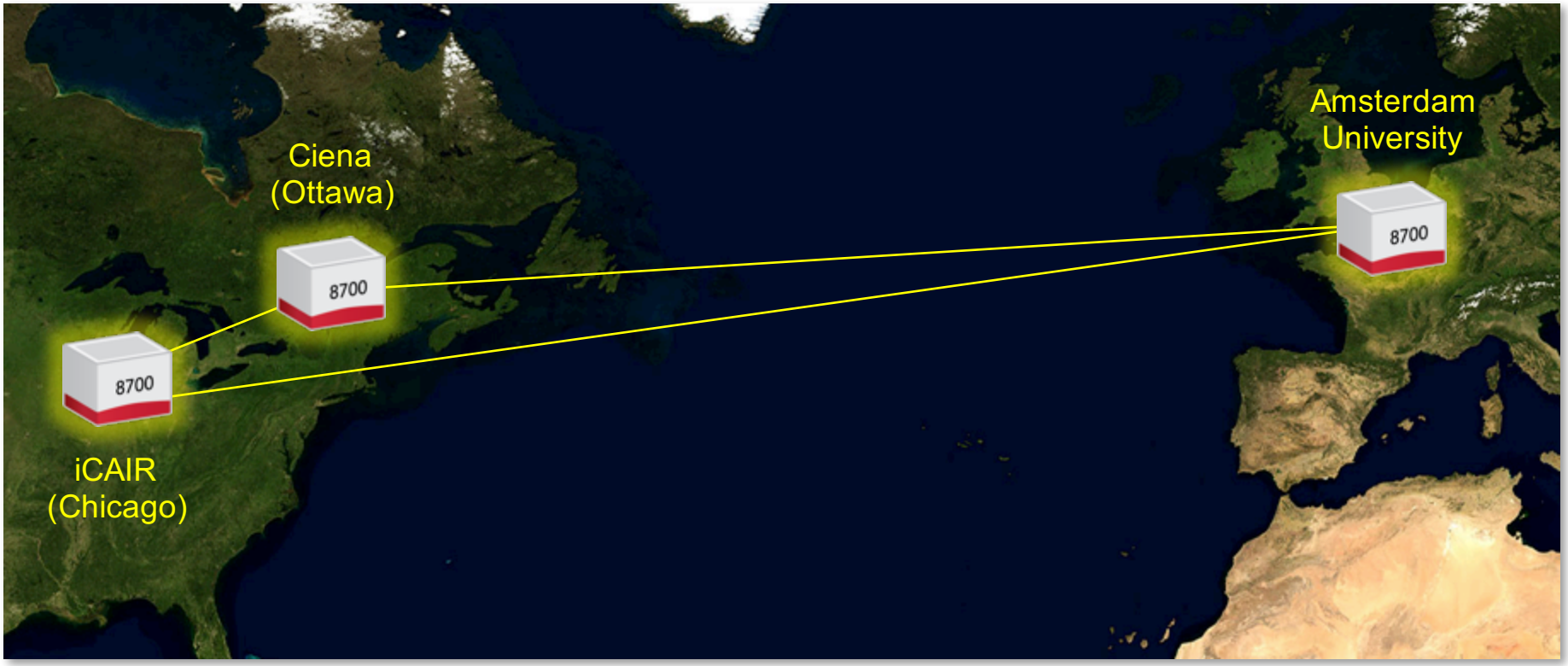
Ralph Koning (PhD)
Ben de Graaff (SP):
1. Design functionalities needed to operate a SARNET using SDN/NFV
2: deliver security state and KPI information (e.g cost)

Ciena's CENI topology



CENI, International extension to University of Amsterdam

Research Triangle Project. Operation Spring of 2015



National Science Foundations ExoGENI racks, installed at UvA (Amsterdam), Northwestern University (Chicago) and Ciena's labs (Ottawa), are connected via a high performance 100G research network and trans-Atlantic network facilities using the Ciena 8700 Packetwave platform. This equipment configuration is used to create a computational and storage test bed used in collaborative demonstrations.

Position of demo @ SC15

Objective

- To get a better understanding for cyber attack complexity by visually defend a network suffering from basic volumetric attacks.
- To find a way to visualize future research in automated response.

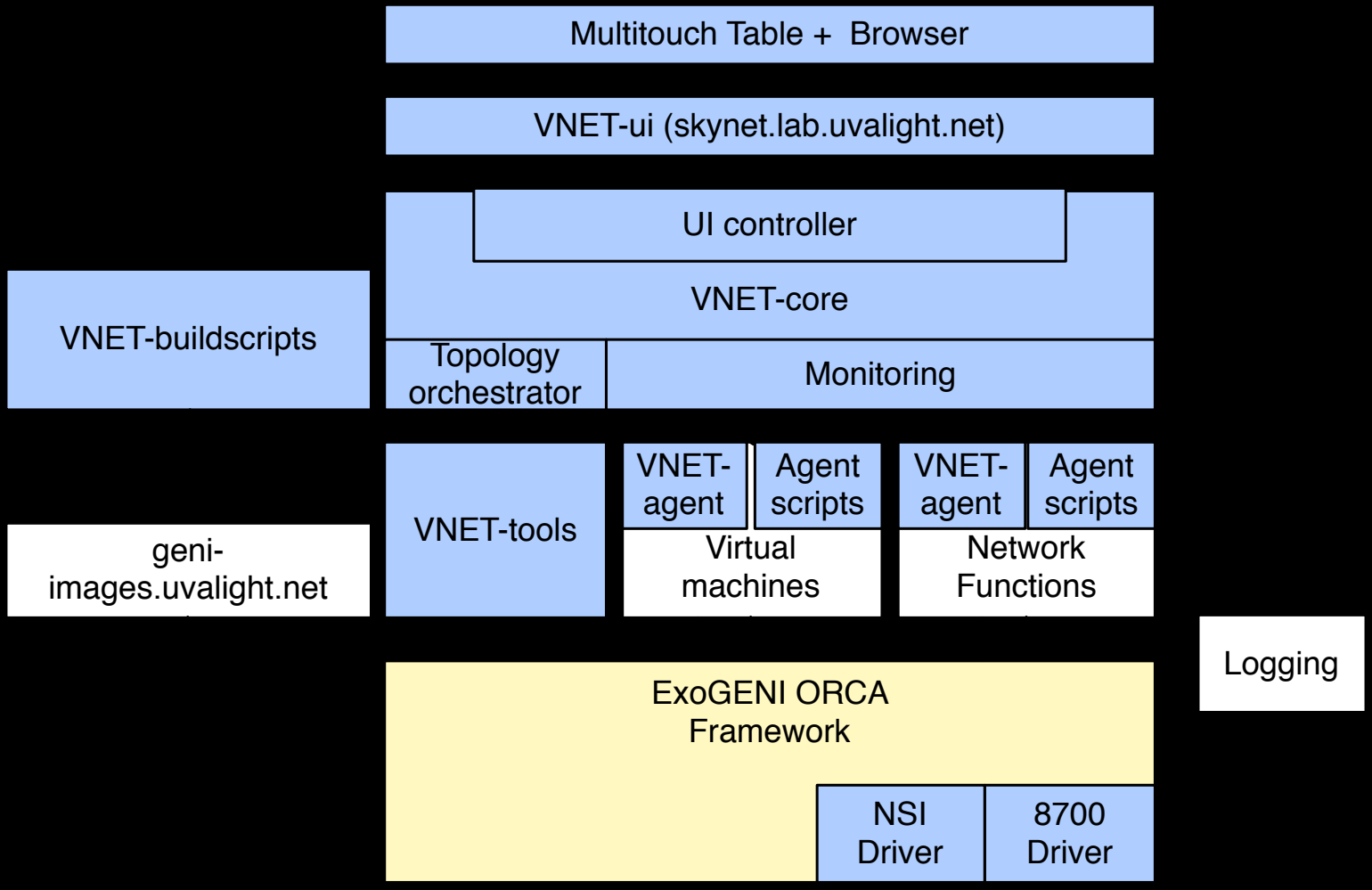
Demo highlights

- Pre-programmed attack scenarios that are able to show defense functions.
- Virtual sales + income from web services
- Defense cost

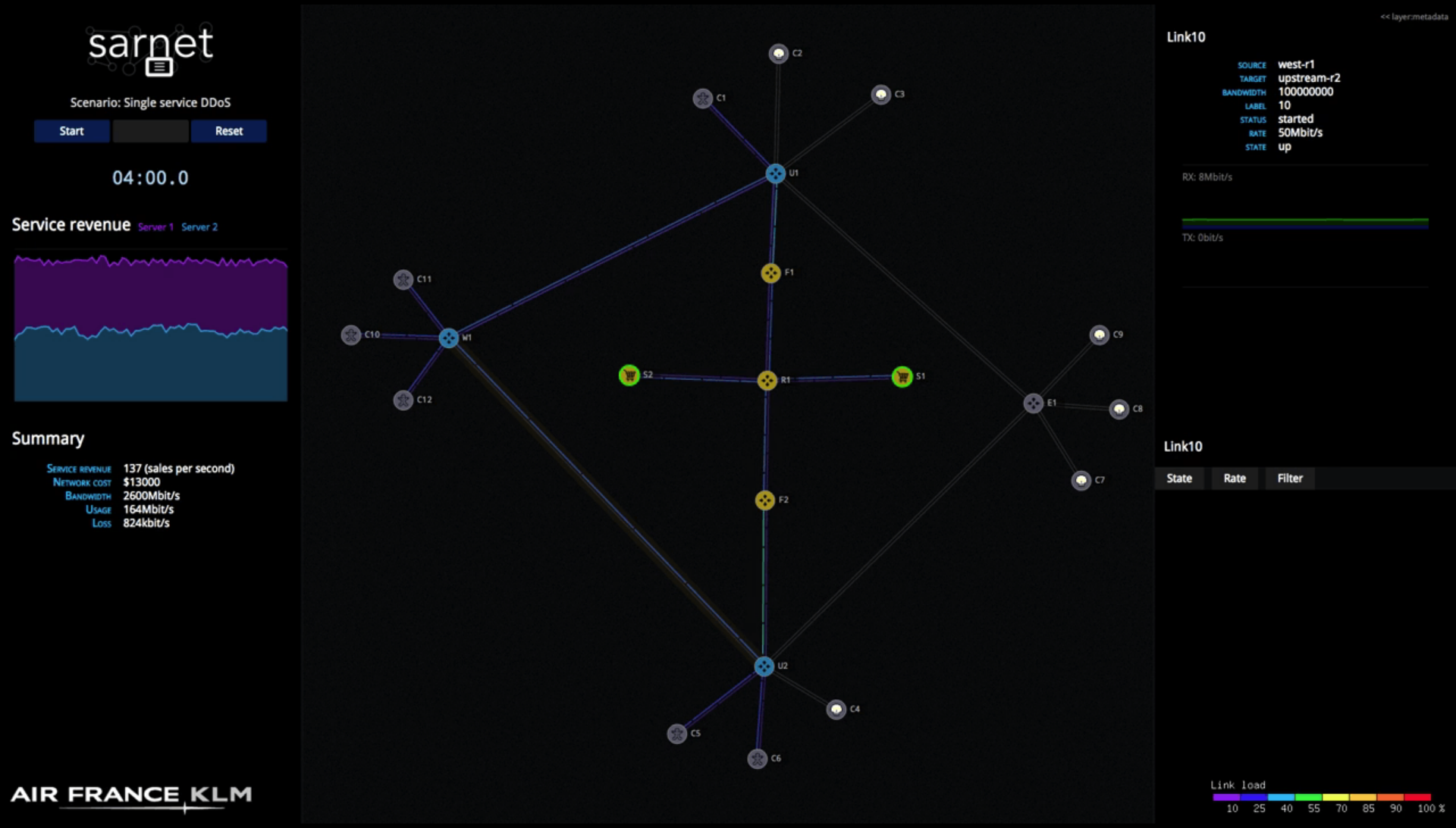
DDoS Defence functions.

- Filtering
- Blocking
- Resource Scaling

Demo stack


Multitouch Table + Browser
VNET-ui (skynet.lab.uvalight.net)
UI controller
VNET-core
VNET-buildscripts
Topology orchestrator
Monitoring
VNET-tools
VNET-agent
Agent scripts
VNET-agent
Agent scripts
geni-images.uvalight.net
Virtual machines
Network Functions
Logging
ExoGENI ORCA Framework
NSI Driver
8700 Driver
Developped by UvA
Developed by RENCI

Demo



AIR FRANCE KLM

University of Amsterdam

Service Provider Group framework

A Service Provider Group (SPG) is an organisation structure providing a defined service only available if its members collaborate.

Examples:

Internet2 NET+

SKYTEAM

geni
Exploring Networks of the Future

glif

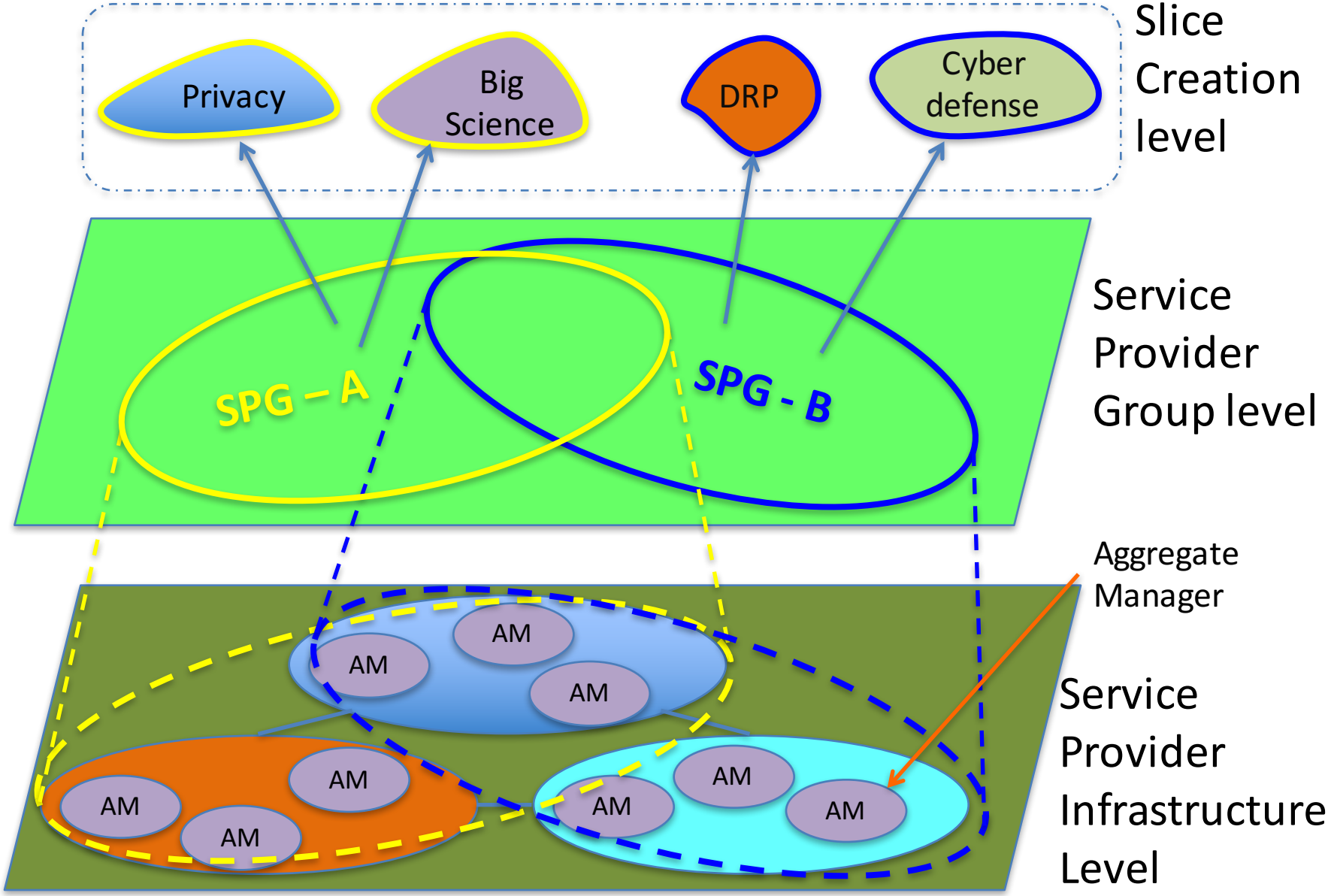
eduroam

MasterCard

Service Provider Group Characteristics

- Autonomous members acting together on a decision to provide a service none could provide on its own
- Appears as a single provider to a customer
- Appears as a collaborative group to members with standards, rules and policies that are defined, administered, enforced and judged by the group.
- Autonomy in the group: every member signs an agreement declaring compliance with common rules, unless local law determines otherwise.
- Membership rules organizes trust amongst members and manage group reputation and viability.

Envisioned role of the SPG: define slice archetypes?



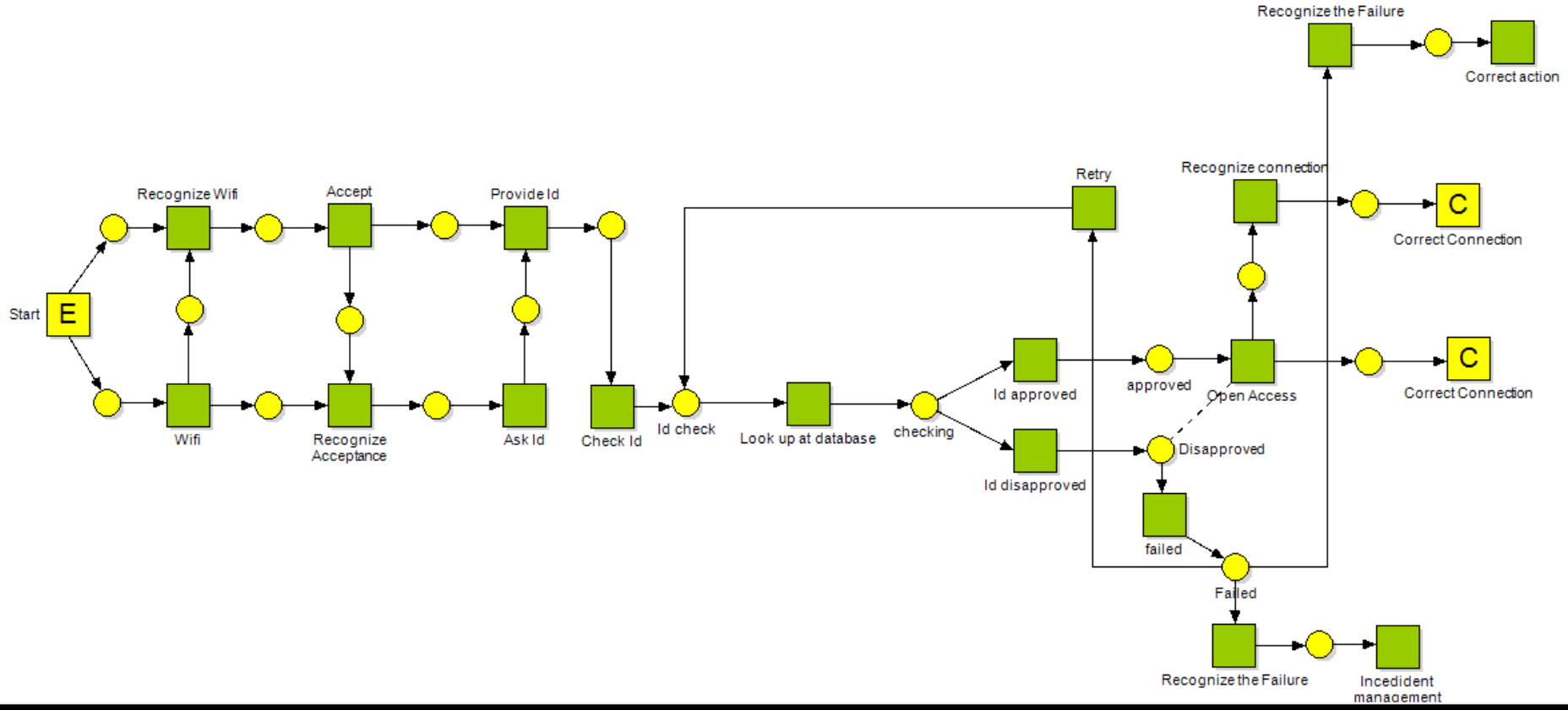
Agent Based Modelling Framework

	Main component
Signal layer	Message / Act
Action layer	Action / Activity
Intentional layer	Intention
Motivational layer	Motive

In our model, we refer to four layers of components:

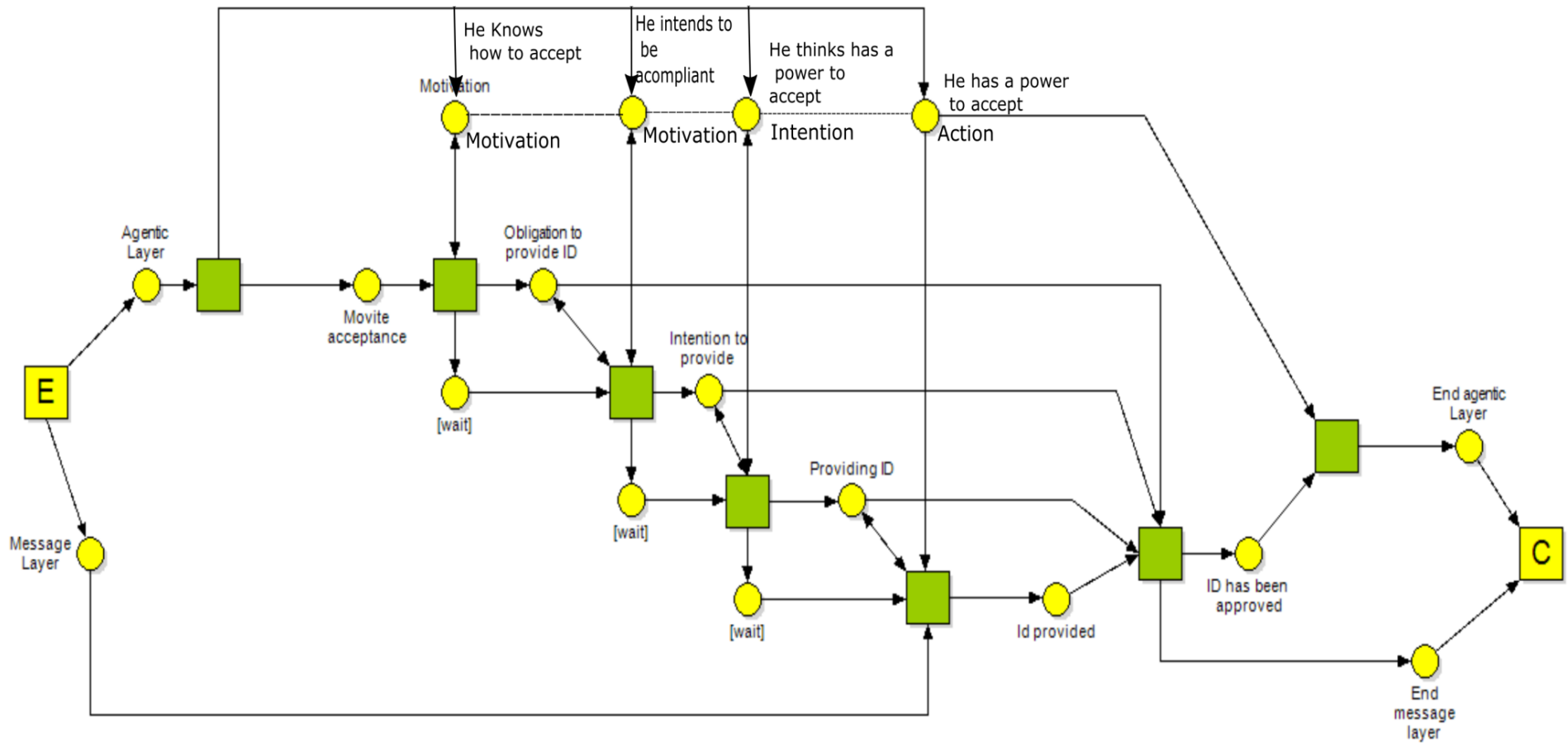
- the signal layer— describes acts, side-effects and failures showing outcomes of actions in a topology.
- the action layer—actions: performances that bring a certain result,
- the intentional layer—intentions: commitments to actions, or to build up intentions,
- the motivational layer—motives: events triggering the creation of intentions.

Simplified Eduroam case at signalling layer



Petri net of EduRoam Case
(first step)

Describing Intentions, Motivations and Actions



Petri net of EduRoam Case

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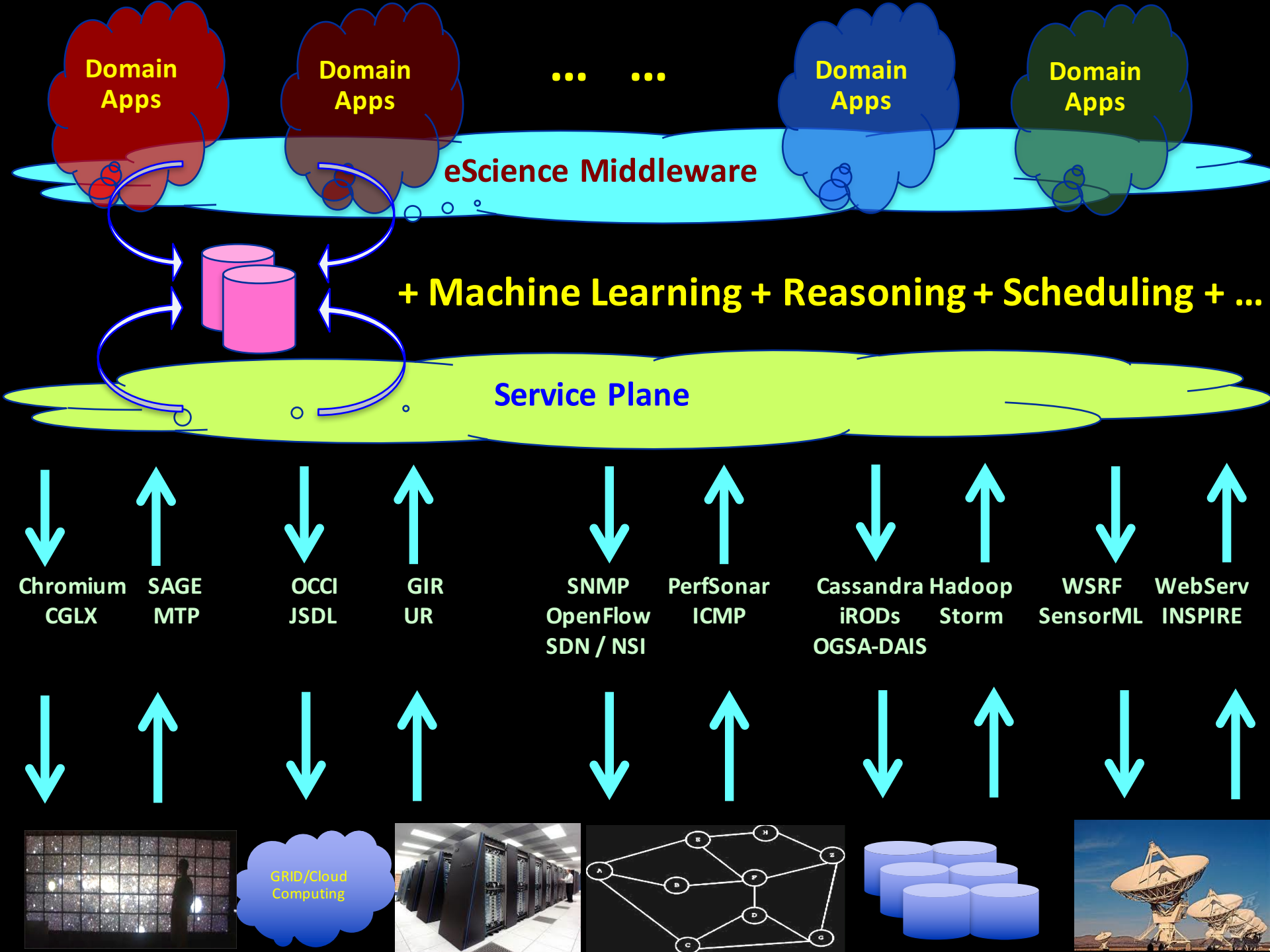
I want to

"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!


Domain Apps
Domain Apps
... ...
Domain Apps
Domain Apps
eScience Middleware
+ Machine Learning + Reasoning + Scheduling + ...
Service Plane
Chromium CGLX
SAGE MTP
OCCI JSDL
GIR UR
SNMP OpenFlow SDN / NSI
PerfSonar ICMP
Cassandra iRODs OGSA-DAIS
Hadoop Storm
WSRF SensorML
WebServ INSPIRE
GRID/Cloud Computing

The Big Data Challenge

Doing Science

Wis dom

Knowledge to act

Information

Data

a.o. from ESFRI's

ICT to enable Science

e-IRG

Workflows Schedulers to act

OWL

XML, RDF, rSpec, SNMP, Java based, etc.

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MAGIC DATA CARPET

curation - description - trust - security - policy – integrity

The Big Data Challenge

Doing Science

ICT to enable Science

Scientists live here!

Science App Store?

Wis dom

Knowledge

Information

Data

a.o. from ESFRI's

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Workflows Schedulers

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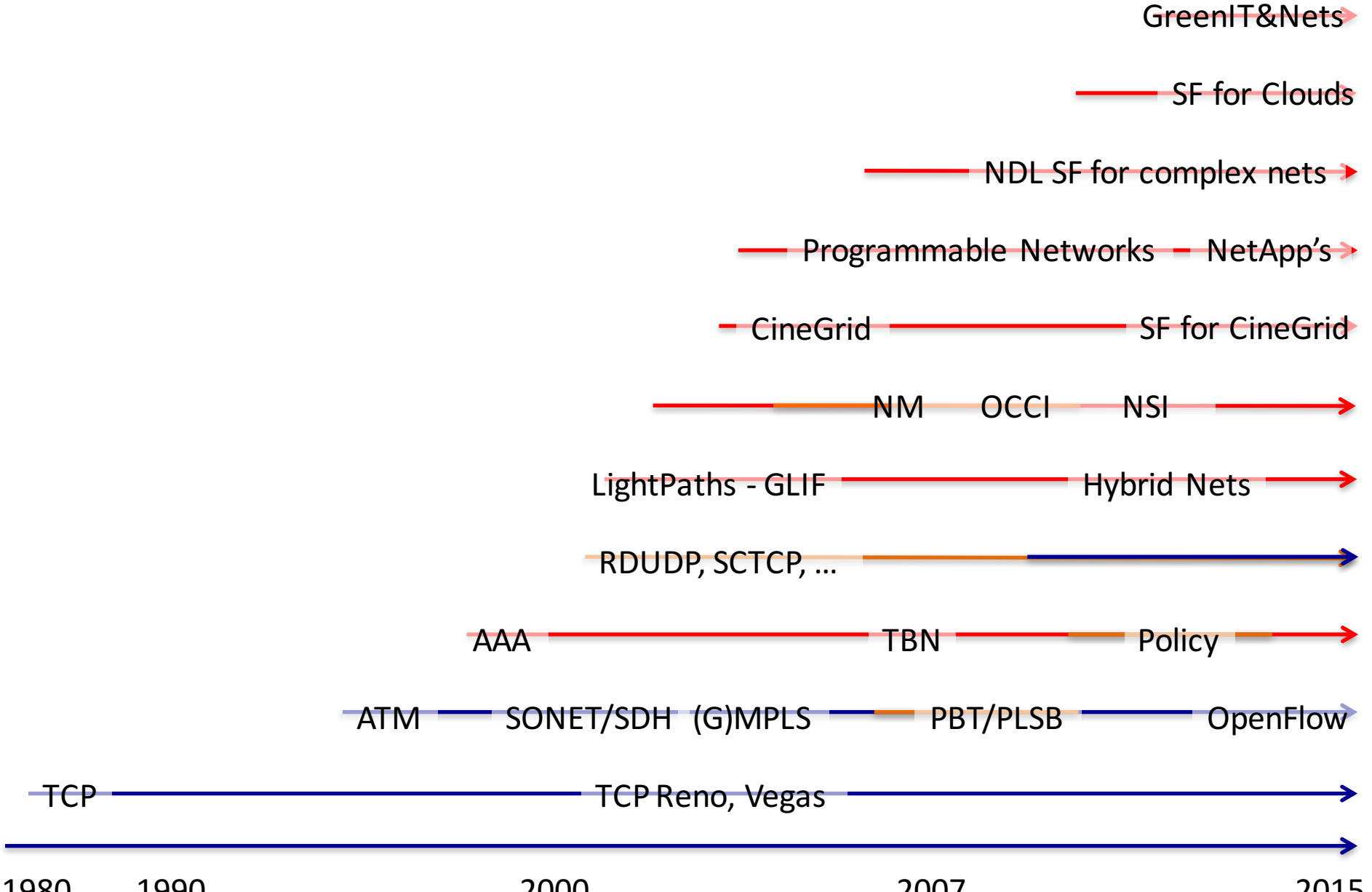
XML, RDF, rSpec, SNMP, Java based, etc.

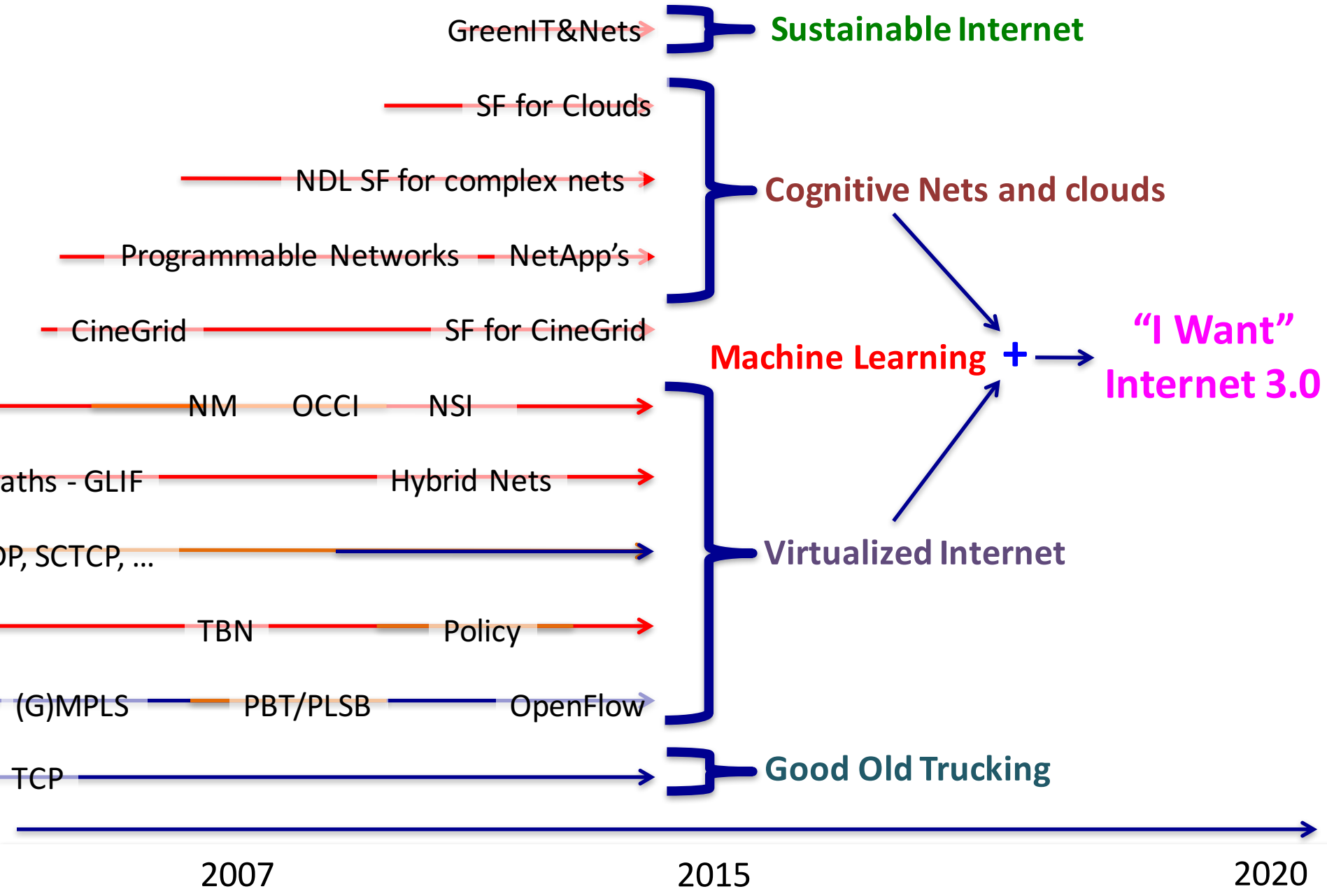
MAGIC DATA CARPET

curation - description - trust - security - policy – integrity

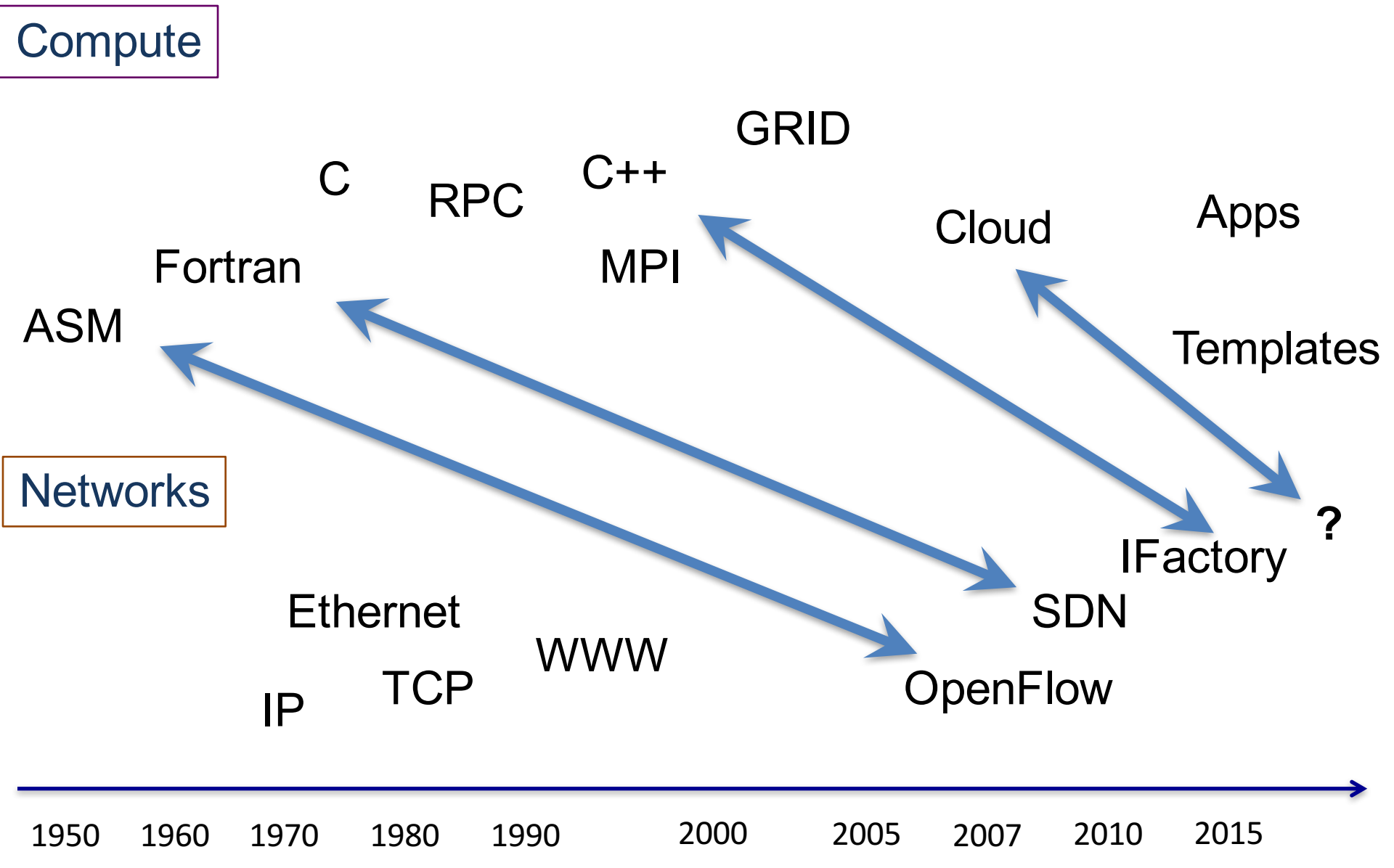
TimeLine


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
2007
2015

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
OP, SCTCP, ...
Virtualized Internet
TBN
Policy
(G)MPLS
PBT/PLSB
OpenFlow
TCP
Good Old Trucking
2007
2015
2020

TimeLine


Compute
GRID
C
RPC
C++
Cloud
Apps
Fortran
MPI
ASM
Templates
Networks
?
IFactory
SDN
Ethernet
WWW
TCP
IP
OpenFlow
1950
1960
1970
1980
1990
2000
2005
2007
2010
2015

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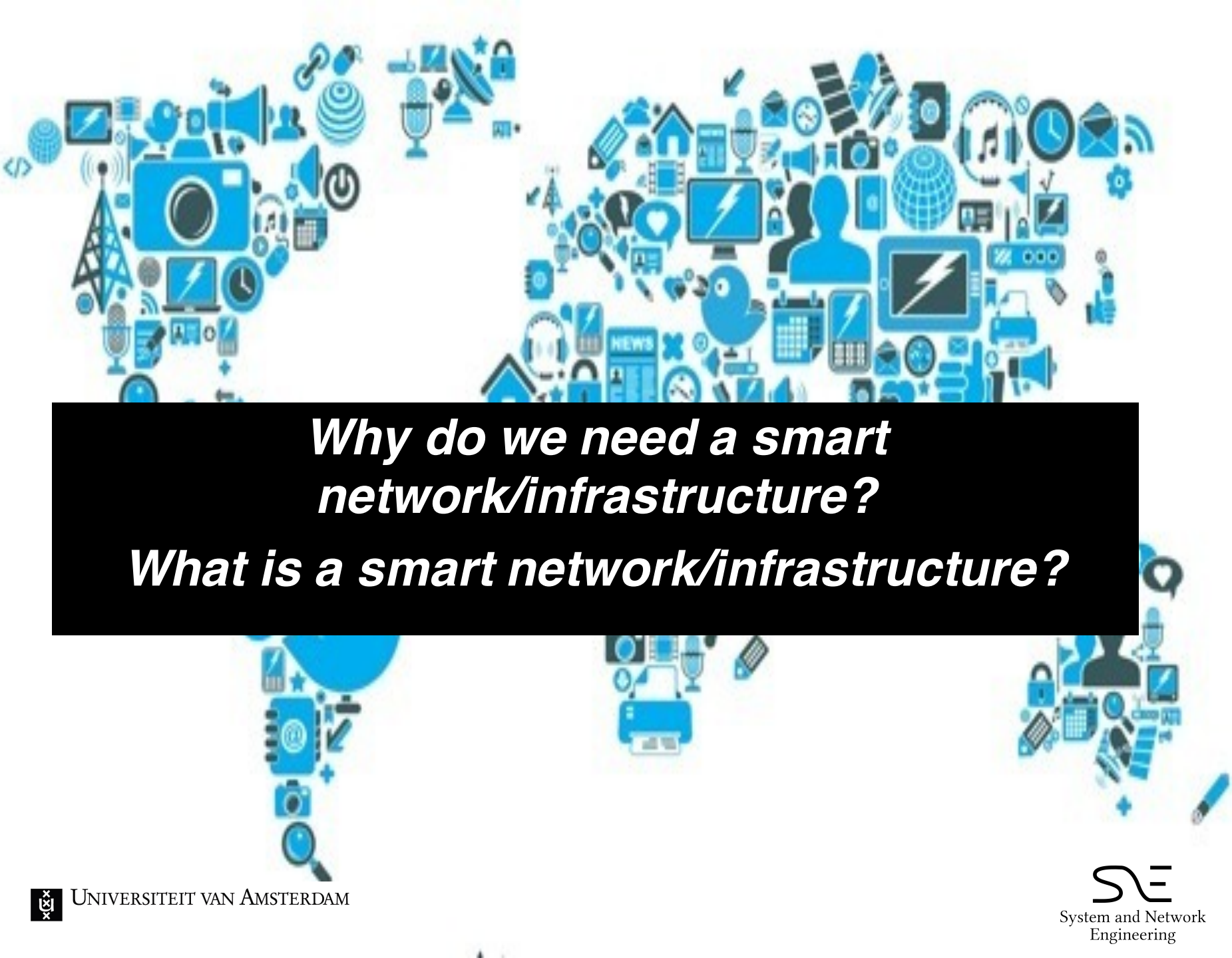
The smart network, the smart infrastructure

Dr. Paola Grosso
System and Network Engineering (SNE) research group
UvA
Email: p.grosso@uva.nl



Why do we need a smart network/infrastructure?

What is a smart network/infrastructure?

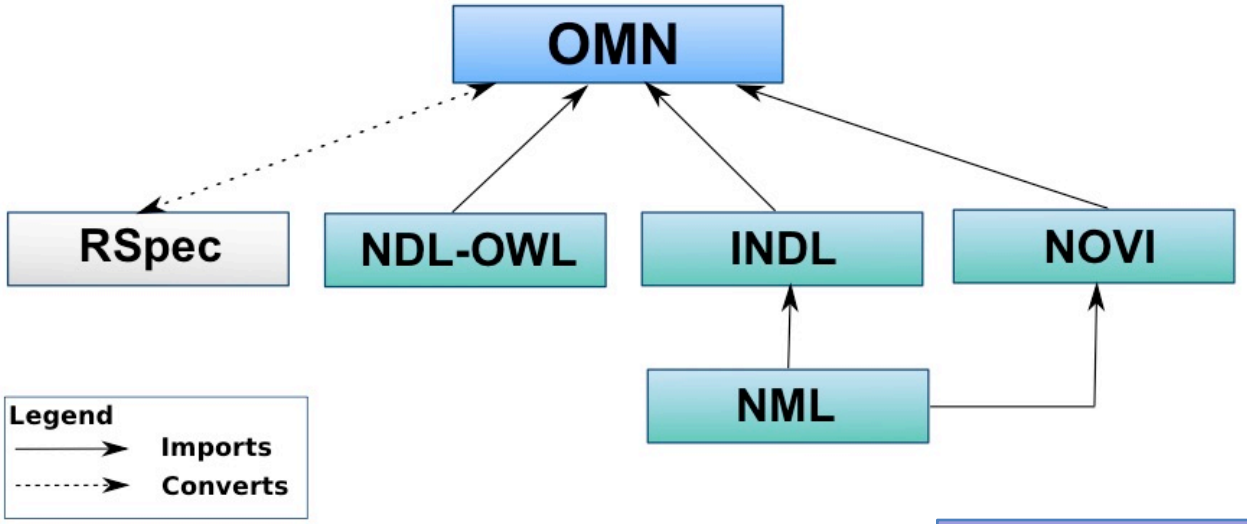
We exploit **richer network and infrastructure descriptions** to *deliver federated network and clouds services.*

We leverage the **SDN paradigm** to *align network behavior closer and applications needs*.

We get:

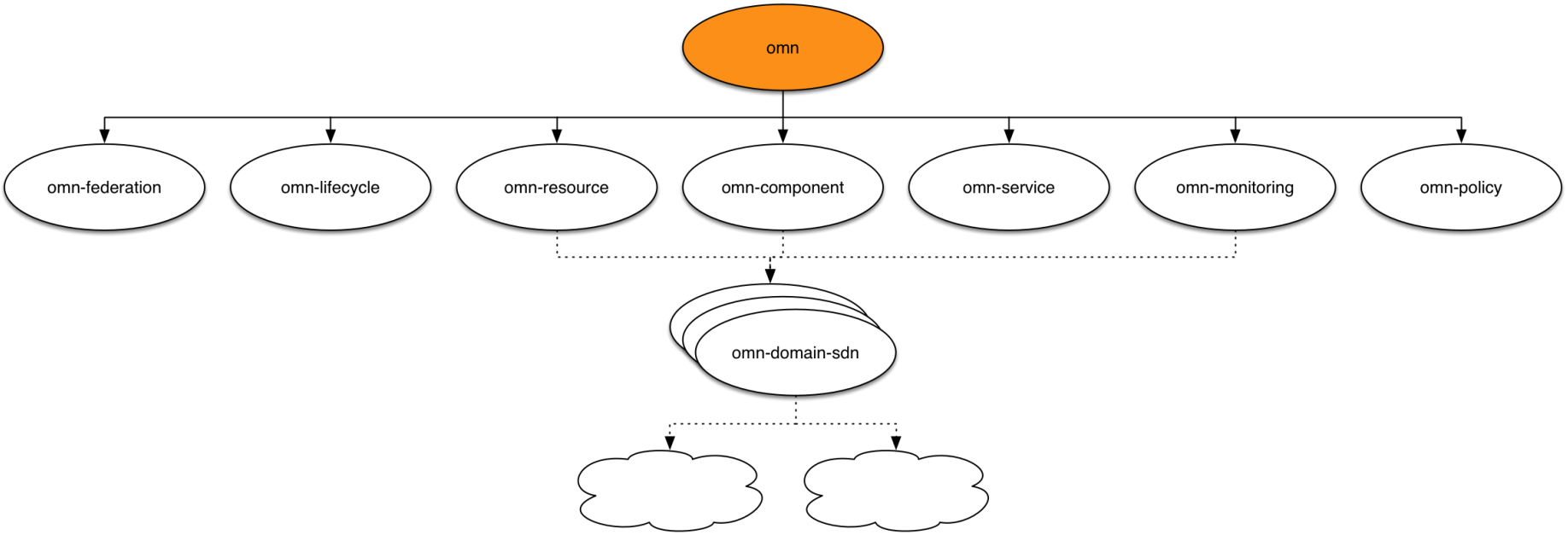
- more energy-efficient,
- more secure,
- more adaptable networks

Ontology families



M. Ghijsen, , J. v/d Ham, P. Grosso, C. Dumitru, H. Zhu, Z. Zhao, C. De Laat
"A Semantic-Web Approach for Modeling Computing Infrastructures," Computers and Electrical Engineering, vol. 39 (8), pp. 2553–2565, 2013

OMN – Open Multinet



https://github.com/open-multinet
https://github.com/open-multinet/playground-rspecs-ontology/tree/master/omnlib/ontologies

A. Willner, C. Papagianni, M. Giatili, P. Grosso, M. Morsey, Al-Hazmi Y., I. Baldin
The Open-Multinet Upper Ontology - Towards the Semantic-based Management of Federated Infrastructures
The 10th International Conference on Testbeds and Research Infrastructures for the Development of Networks & Communities (TRIDENTCOM 2015)

Transitioning from OpenNaas to SemNaaS

Developed a semantic enabled Network-as-a-Service (NaaS) system

Applied NML2/OMN on that system.

M Morsey, H Zhu, I Canyameres, P Grosso
SemNaaS: Add Semantic Dimension to the Network as a Service
The Semantic Web: ESWC 2015 conference

UNIVERSITEIT VAN AMSTERDAM

SemNaaS: Add Semantic Dimension to the Network as a Service

Mohamed Morsey, Hao Zhu, Isart Canyameres, Paola Grosso
Informatics Institute, University of Amsterdam
i2CAT Foundation, Barcelona

Objectives

- Applying Semantic Web on Network as a Service (NaaS).
- Utilizing Network Markup Language (NML) ontology to support NaaS operation.
- Developing a Semantic Web based system called SemNaaS, which applies Semantic Web technologies on NaaS.

Introduction

- The underlying network connecting (cloud) data center or within a single site is still less malleable and programmable than the other parts of the infrastructure.
- New frameworks are emerging to define and create such dynamic network services;these frameworks in essence support Network as a Service (NaaS) operations.
- The emerging NaaS software systems require powerful and rich vocabularies, such as the ones that can be provided by Semantic Web ontologies.
- OWL ontologies have several advantages as models for NaaS; i.e. they are easy to extend, they allow for automatic validation of both requests and provisioned services, and they enhance network resource discovery.

Network Markup Language

- Network Markup Language (NML) ontology constitutes the information model for describing and defining computer networks.
- NML is revised, i.e. more classes and properties are devised, and enhanced the existing ones.

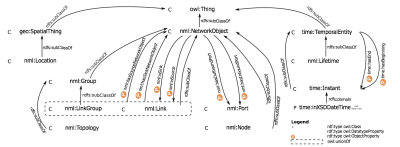


Fig. 1: NML ontology visualization

SemNaaS Architecture

- SemNaaS consists of four components:
  1. request validation and connectivity checking component;
  2. OpenNaaS component, which is a pluggable component, that supports the network resources provisioning;
  3. monitoring component;
  4. report generation component.

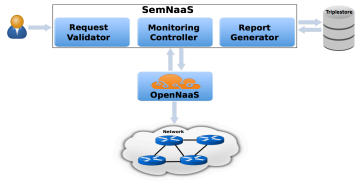


Fig. 2: SemNaaS system architecture.

SemNaaS Components

- Request Generation and Validation Component.
  - → SemNaaS performs two levels of validation, namely request validation, and connectivity check.
  - → It uses SPARQL to detect unreachability among various nodes.
- Monitoring Component.
  - → A network resource may experience failure conditions as well, e.g. network connectivity failure.
  - → Whenever a change occurs in the resource status, SemNaaS tracks that change.
- Report Generation Component.
  - → SemNaaS supports generating reports about the whole resource reservation process.
  - → Reports enable system administrator to identify the problematic resources of OpenNaaS.

Interconnection of Distributed NaaS Instances

- OpenNaaS faced the problem of maintaining the uniqueness of the IDs assigned to the various network components.
- SemNaaS utilizes URIs to identify various components, e.g. `http://ivi.fnwi.uva.nl/sne/resource/host1`, and `http://www.i2cat.net/resource/host1`.

Use Case

- The Virtual Routing Function use case aims to implement inter-domain routing through OpenNaaS over an OpenFlow infrastructure.

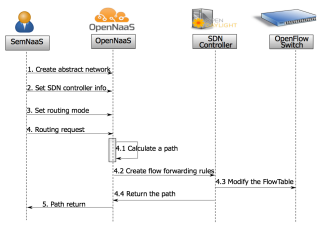


Fig. 3: Sequence diagram for Virtual Routing Function (VRF).

Conclusion and Future Work

- SemNaaS fuses Semantic Web with NaaS to develop an intelligent NaaS system.
- SemNaaS resources can be interlinked to LOD cloud.
- OpenMultinet initiative leverages ontologies for interlinking heterogeneous networks, thus SemNaaS can control heterogeneous networks, `http://open-multinet.info`.

Contact Information

- Web: https://ivi.fnwi.uva.nl/sne
- Email: m.morsey@uva.nl
- Phone: +31 20 525 7590

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`http://ivi.fnwi.uva.nl/sne`
`http://www.commit-nl.nl`

COMMIT/ GÉANT

SWSDI 2016 Workshop

The First International Workshop on Semantic Web for Federated Software Defined Infrastructures (SWSDI2016) Co-located with ESWC 2016, Anissaras, Crete, Greece. May, 2016

Contents [hide]

Workshop Objectives

The main objective of SWSDI 2016 is to study the applicability and maturity of Semantic Web based methodologies for modelling the newly emerging software-defined (computing and networking) infrastructures, particularly federated infrastructures and federated Clouds. Furthermore, SWSDI 2016 aims to identify how the Semantic Web surpasses other approaches, such as the exchange of simple XML or JSON serialized tree data structures.

Workshop organizers
Jorge Cardoso, University of Coimbra, Portugal
Paola Grosso, University of Amsterdam, The Netherlands
Mohamed Morsey, University of Amsterdam, The Netherlands
Alexander Willner, TU Berlin, Germany

Deadlines
Paper submission : Friday March 4th, 2016.
Notification of acceptance: Friday April 1st, 2016.

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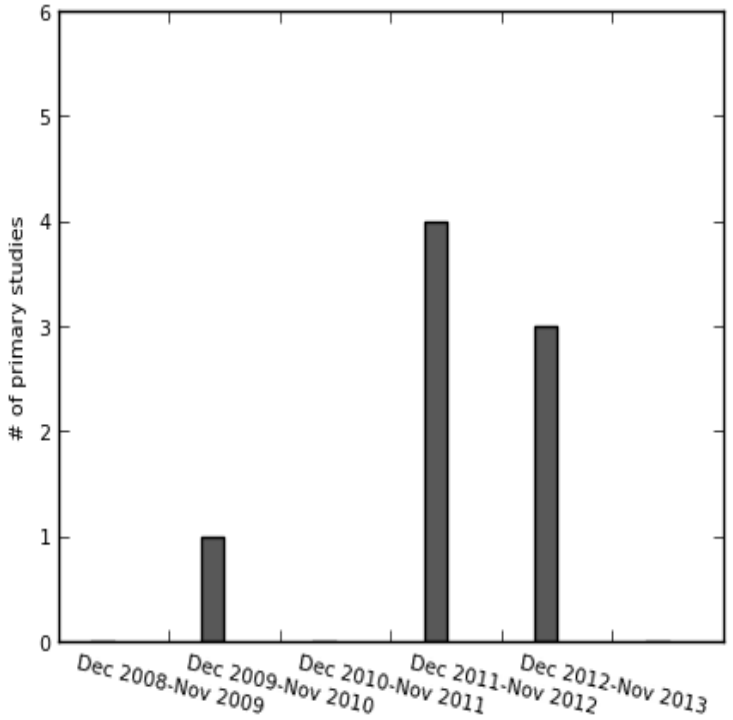
System and Network Engineering

Emerging interest in SDN for energy efficiency

- Emerging studies improve on the energy consumption of servers by the VM migration.
- Some change the OpenFlow protocol to be energy-aware.
- All of them are implemented in intra-data center scale.
- All have a fixed initial traffic matrix.

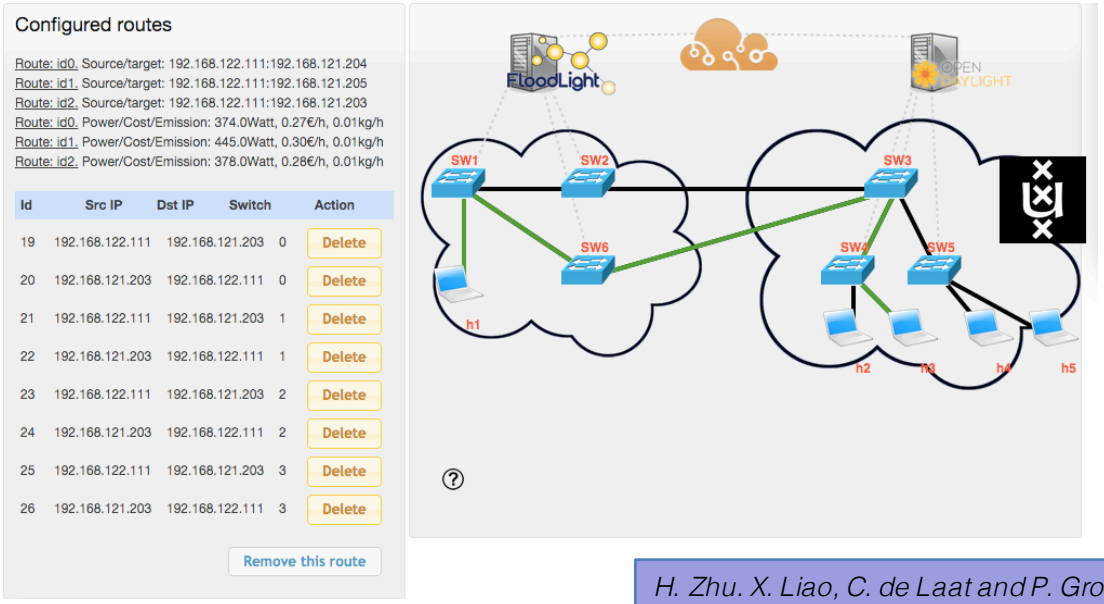


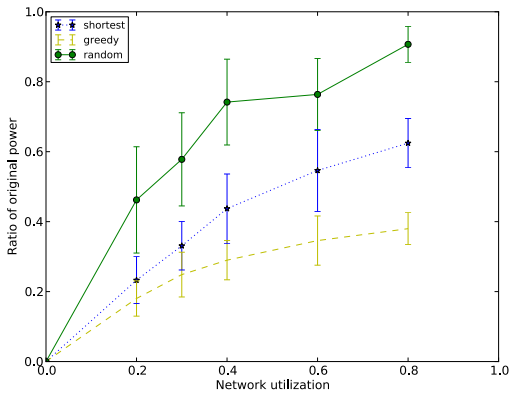
Yearly distribution of the OpenFlow technique adoption by decision frameworks from December 2008 to November 2013

Moghaddam, F. A., Lago, P., & Grosso, P. Energy-Efficient Networking Solutions in Cloud-Based Environments: A Systematic Literature Review. ACM Computing Surveys (CSUR), 47(4), 64. (2015)

Green routing with SDN

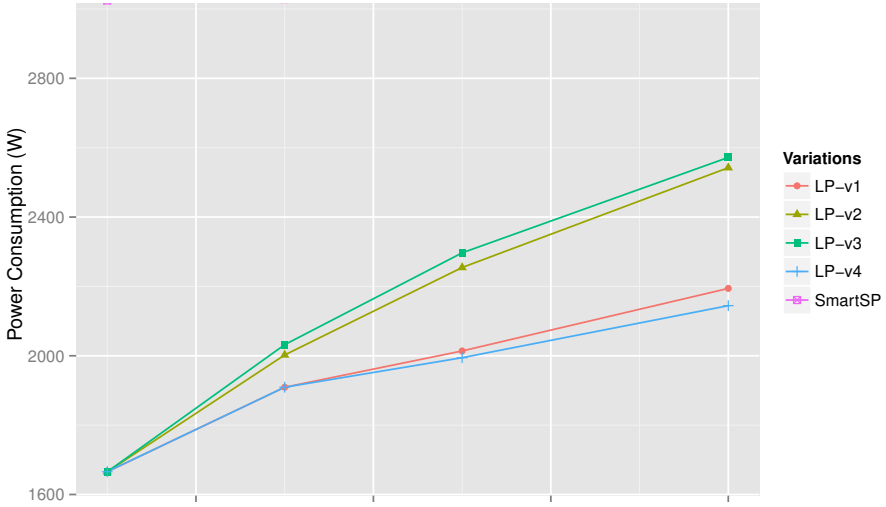
Make a routing decision to aggregate traffic over a subset of links and devices in over-provision networks and switch off unused network components





H. Zhu. X. Liao, C. de Laat and P. Grosso. (2015)
Joint flow routing-scheduling for energy efficient software defined data center networks
(to appear in Elsevier Journal of Network and Computer Applications)

How much savings?



We adopt linear programming to determine how to program flows in the network.

We show that in FatTree networks, where switches can save up to 60% of power in sleeping mode, we can achieve 15% minimum improvement assuming a one-to-one traffic scenario.
Two of our algorithm variations privilege performance over power saving and still provide around 45% of the maximum achievable savings.

F. A.. Moghaddam and P. Grosso. (2016)
Linear Programming Approaches for Power Savings in Software-defined Networks
(Under review at the NetSoft conference 2016)

4th International Conference on ICT for Sustainability (ICT4S)

Aug 30 - Sep 2, 2016 - Amsterdam, The Netherlands

Home | Calls & Dates | Program | Team | ict4s.org | Venue | Search

General chair
Anwar Osseyran, SURFsara & University of Amsterdam, The Netherlands

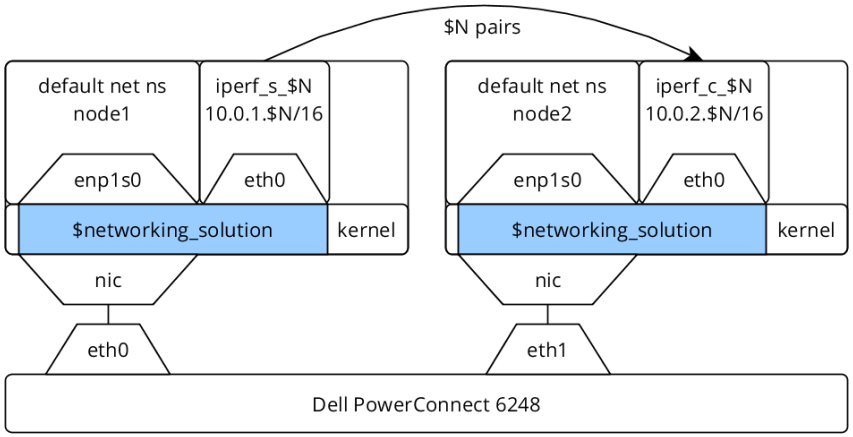
Program chairs
Paola Grosso, University of Amsterdam, The Netherlands
Patricia Lago, VU University Amsterdam, The Netherlands

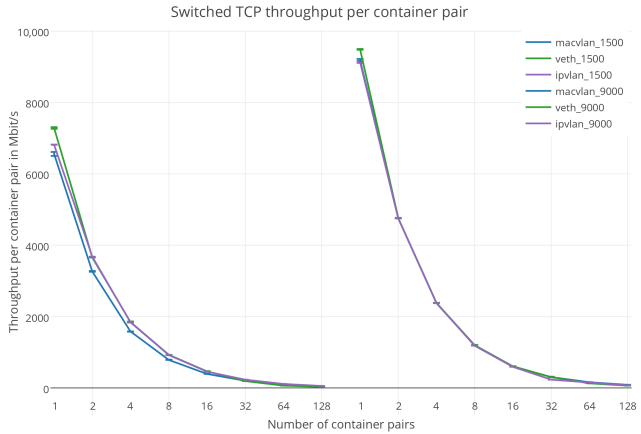
Deadlines
Paper submission : Monday April 11th, 2016.
Notification of acceptance: Tuesday May 31st, 2016.

Universiteit van Amsterdam

System and Network Engineering

Container networking





We benchmarked three kernel modules: **veth**, **macvlan** and **ipvlan**, to quantify their respective raw TCP and UDP performance and scalability.

Our results show that the macvlan kernel module outperforms all other solutions in raw performance. All kernel modules seem to provide sufficient scalability to be deployed effectively in multi- containers environments.

J. Claassen, R. Koning and P. Grosso. (2016)
Linux containers networking: performance and scalability of kernel modules
Accepted at NOMS 2016

Open research directions

- Can we create Semantic NaaS in federated environments?
- How can software services exploit SDN for energy efficiency of the applications?
- Are containers and (SDN) overlays the solution for secure networks?

The constant factor in our field is Change!

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

Assembler, Fortran, COBOL, VM, RSX11, Unix, c, Pascal, SmallTalk, DECnet, VMS, TCP/IP, c++, Internet, WWW, ATM, Semantic Web, Photonic networks, Google, Grid, Phyton, FaceBook, Twitter, Cloud, SDN, Data^3, App's

to:

DDOS attacks destroying Banks and BitCoins!

Conclusion:

Need for Safe, Smart, Resilient Sustainable Infrastructure.

Questions?

http://delaat.net

http://sne.science.uva.nl

http://www.os3.nl/

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

http://pire.opensciencedatacloud.org

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

https://rd-alliance.org

http://envri.eu