Secure Cyber Infrastructure for Valuable Big Data Processing!

The Global Big Data Hub infrastructure inspired by PRP

Cees de Laat

Systems & Network Laboratory
University of Amsterdam

Supported by NWO, TKI-Dinalog and C2D grants
SARNET, DL4LD and NWA.

Science Faculty @ UvA

Informatics Institute

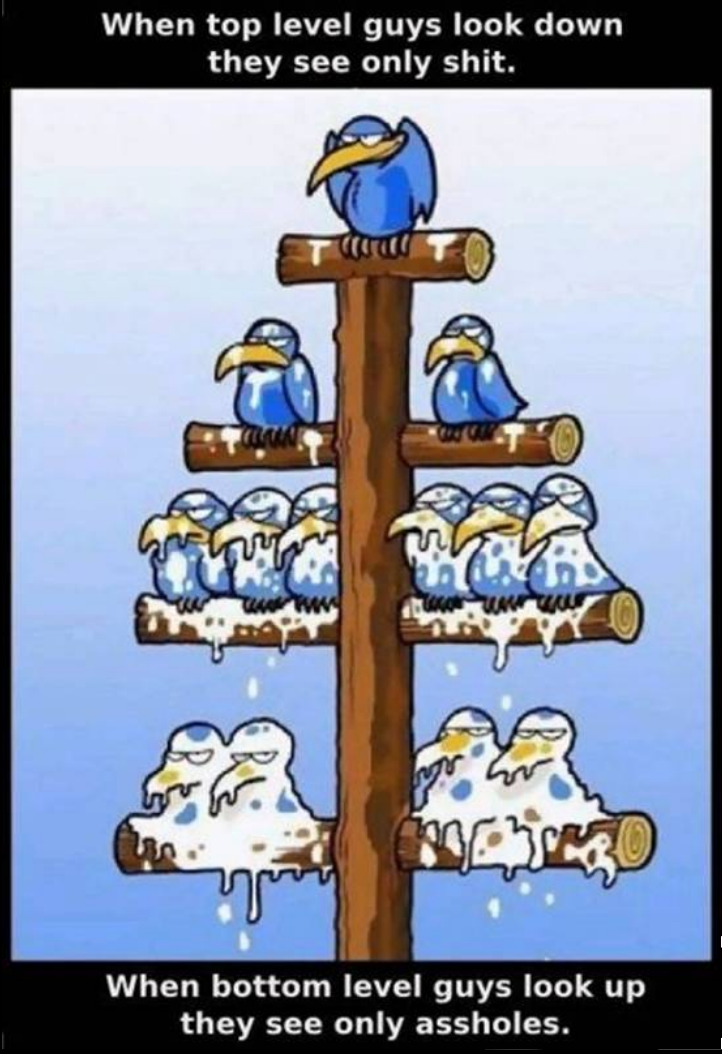
- AMLAB: Machine Learning (Welling)
- FCN: Federated Collaborative Networks (Afsarmanesh)
- ILPS: Information and Language Processing Systems (de Rijke)
- ISIS: Intelligent Sensory Information Systems (Snoek/Smeulders)
- CSL: Computational Science Laboratory (Hoekstra/Sloot)
- SNL: Systems and Network Laboratory (Gosso/Pimentel/de Laat)
- TCS: Theory of Computer Science (Ponse/Bergstra)

SNL - Staffing

Group leader: prof.dr.ir. C. de Laat

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

- 1 full prof (me)
- 2 part time professors
- 2 endowed professors
- 2 associate professors
- 4 assistant professors
- *2 senior researchers*
- ~12 postdoc's
- *About 15 phd students*
- ~10 guests
  - a.o. dr. Leon Gommans
- *Yearly turnover ~ 3 MEuro*



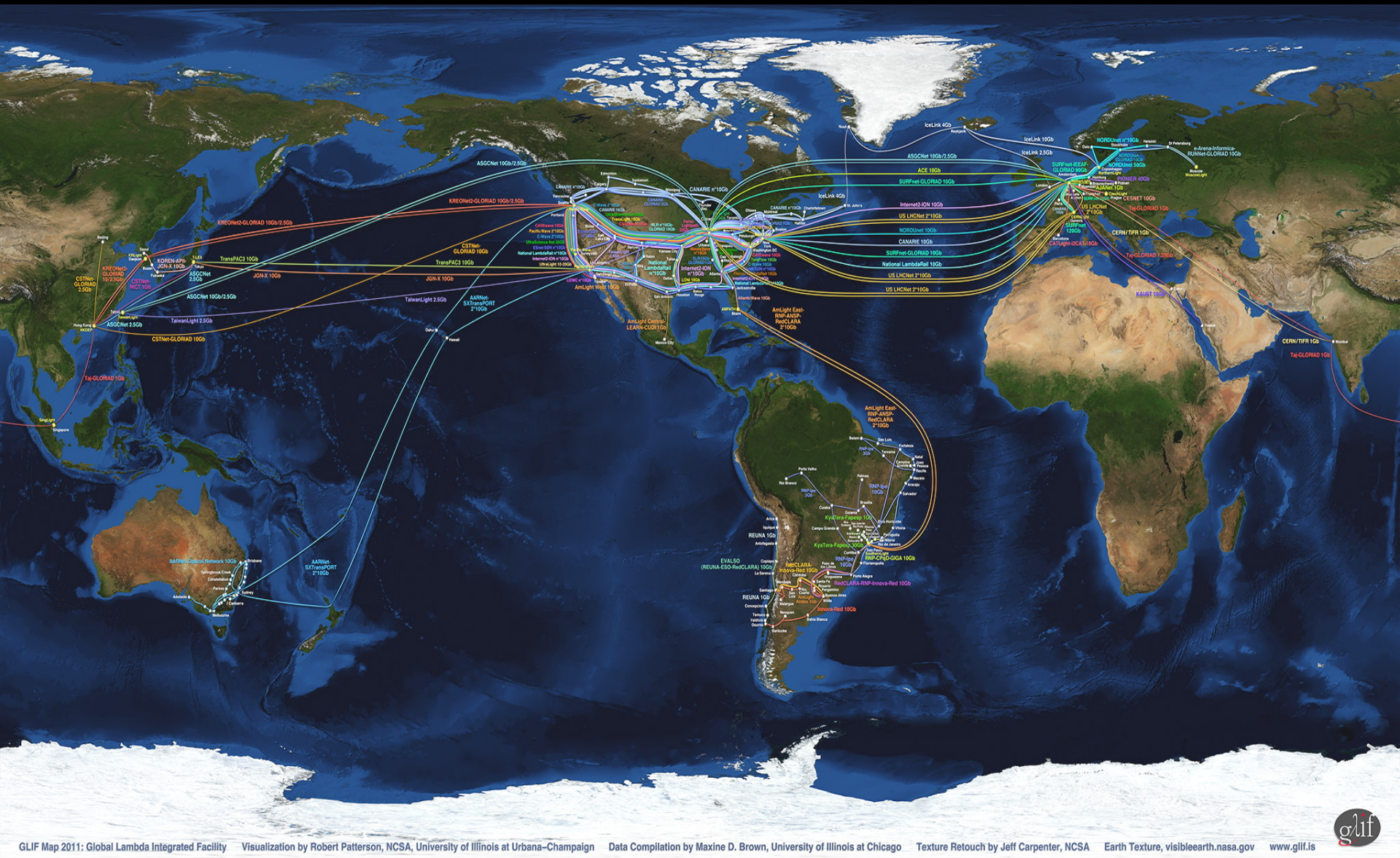
Mission

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

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

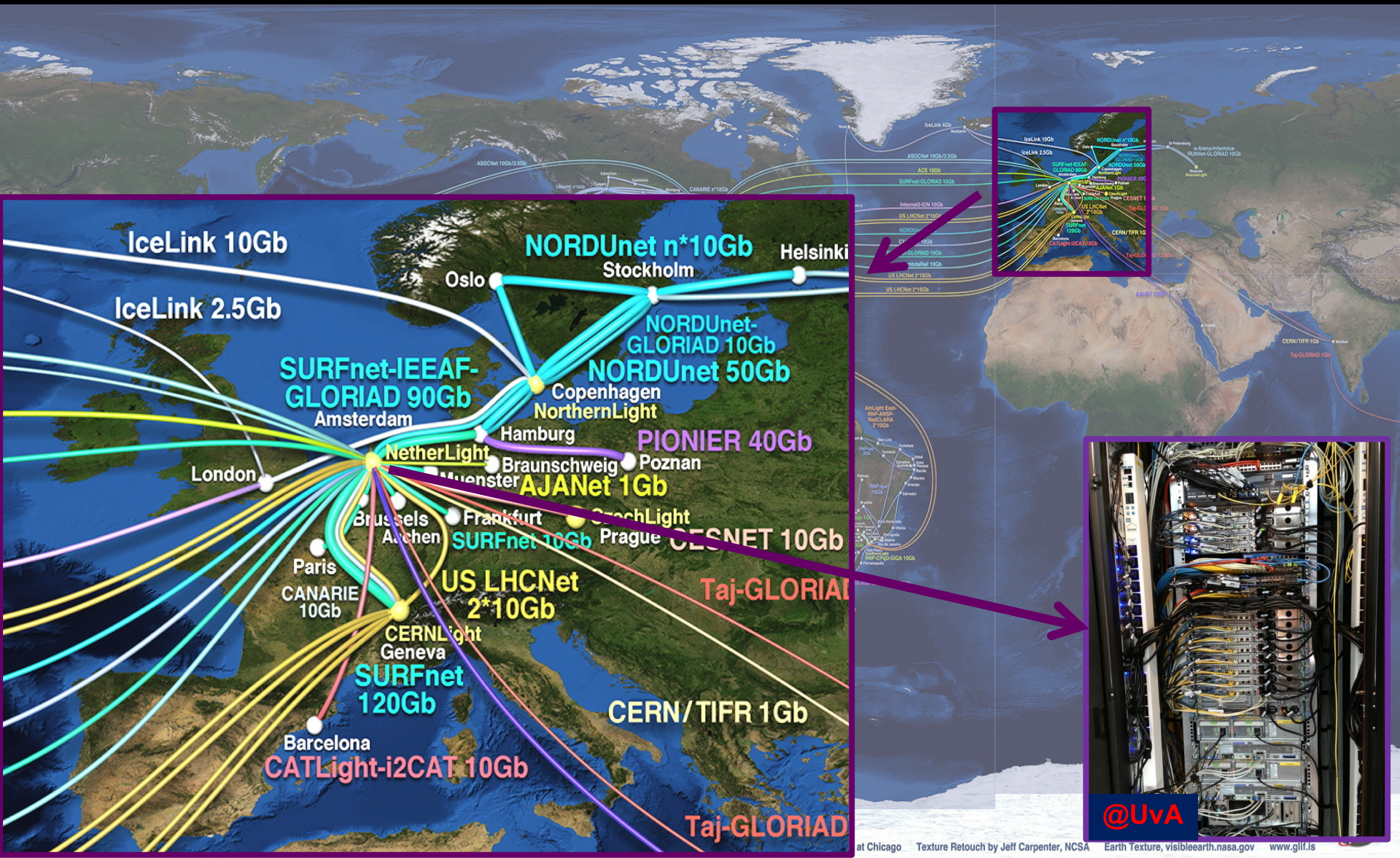
The GLIF – LightPaths around the World

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.



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.

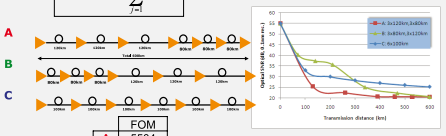
In this demonstration we will investigate the performance of a 40Gb/s PM-QPSK alien wavelength installed on a 10Gb/s DWDM infrastructure.

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

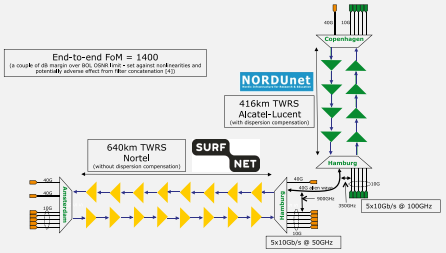


	FOM
A	5504
B	5504
C	1897

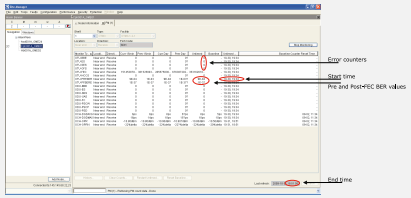
Easy-to-use formula that accurately quantifies transmission system performance

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

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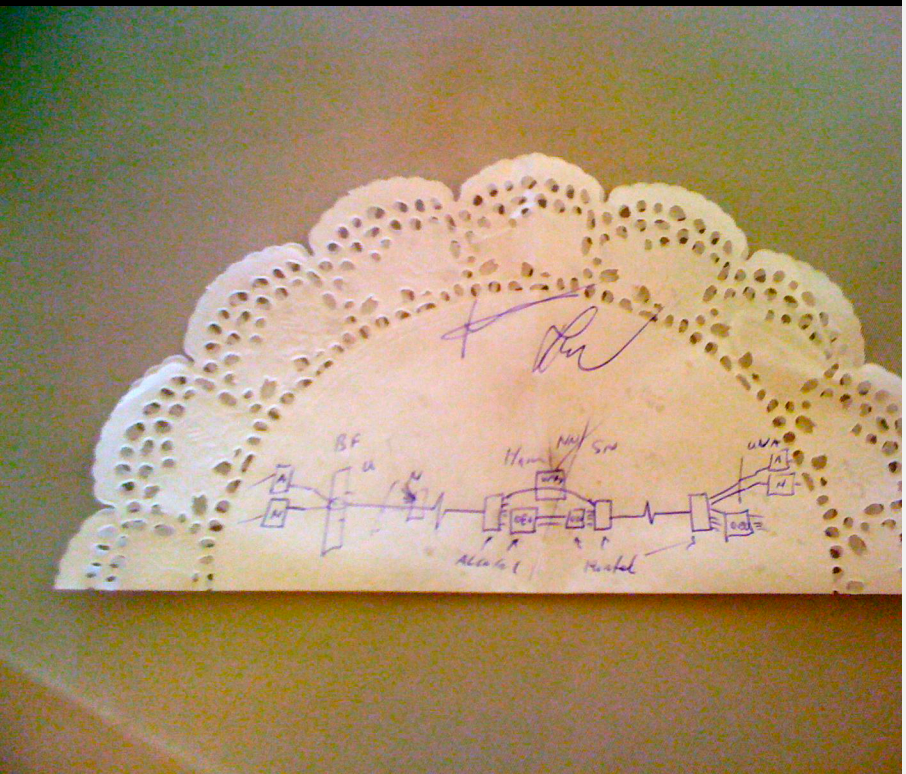

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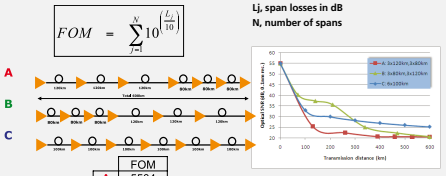

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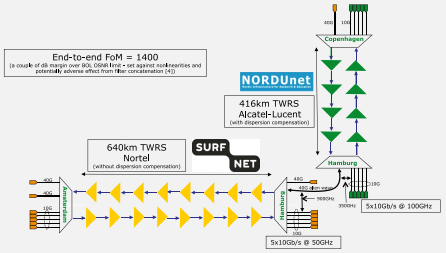

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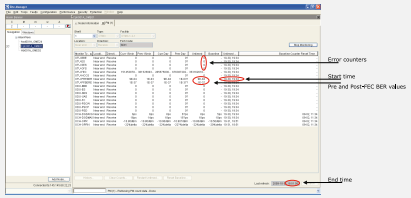

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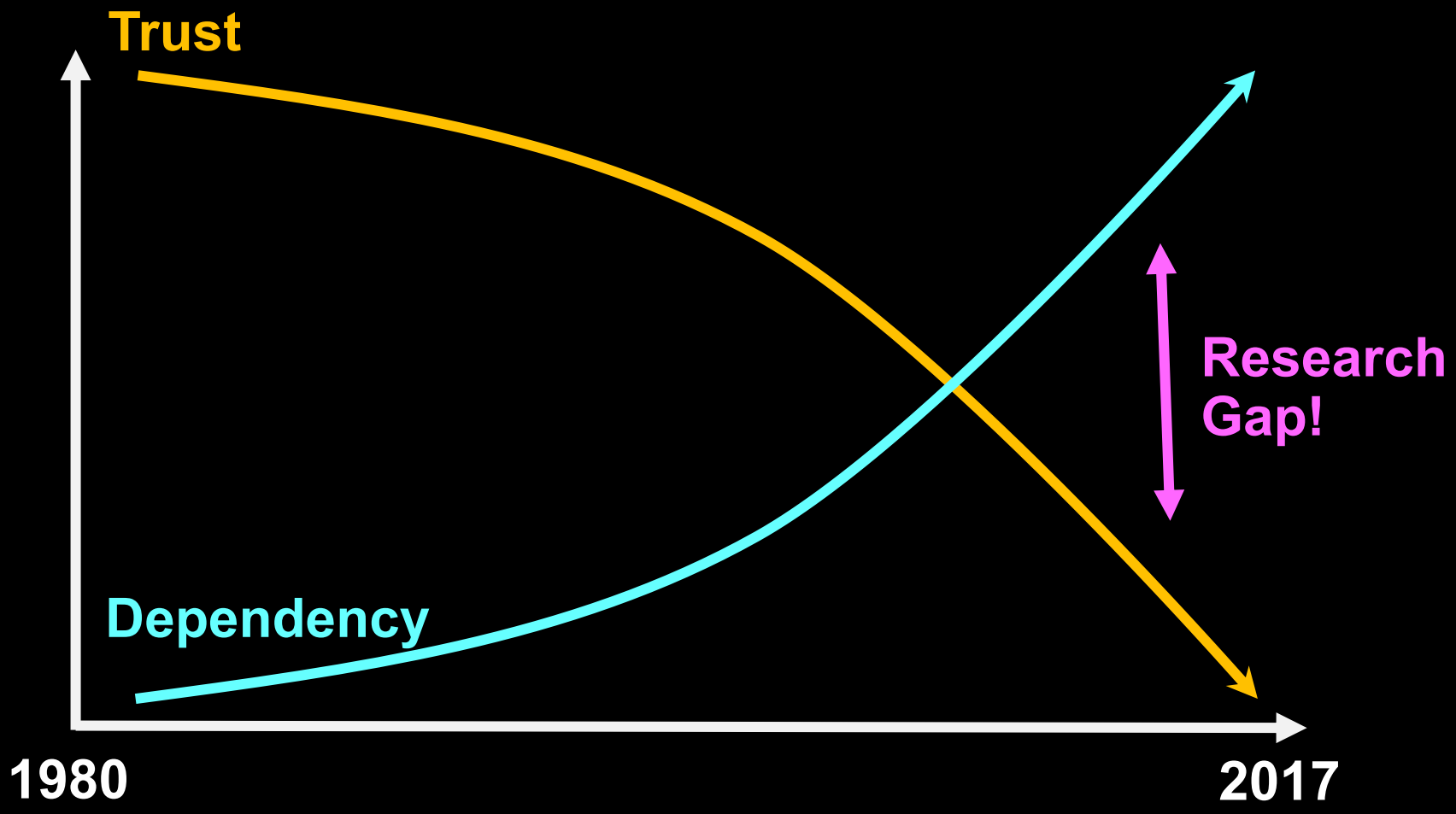
Fading Trust in Internet



SARNET: Security Autonomous Response with programmable NETworks

Marc Lyonnais, Leon Gommans, Rodney Wilson, Rob Meijer,
Frank Fransen Tom van Engers, Paola Grosso, Gauravdeep Shami, Cees de Laat,
Ameneh Deljoo, Ralph Koning, Ben de Graaff, Gleb Polevoy, Stojan Travanovski.

UNIVERSITY OF AMSTERDAM

Big Data: real time ICT for logistics
Data Logistics 4 Logistics Data (dl4ld)

Robert Meijer, TNO, Co-PI, Cees de Laat, UvA, Co-PI, Leon Gommans, KLM

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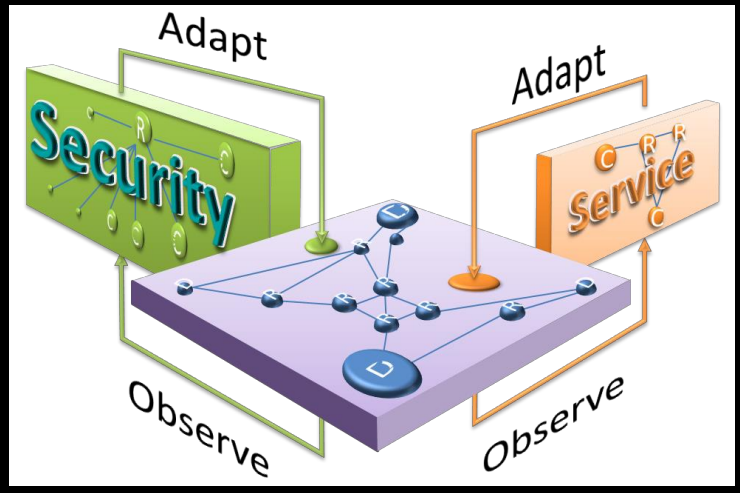
Cyber security program SARNET



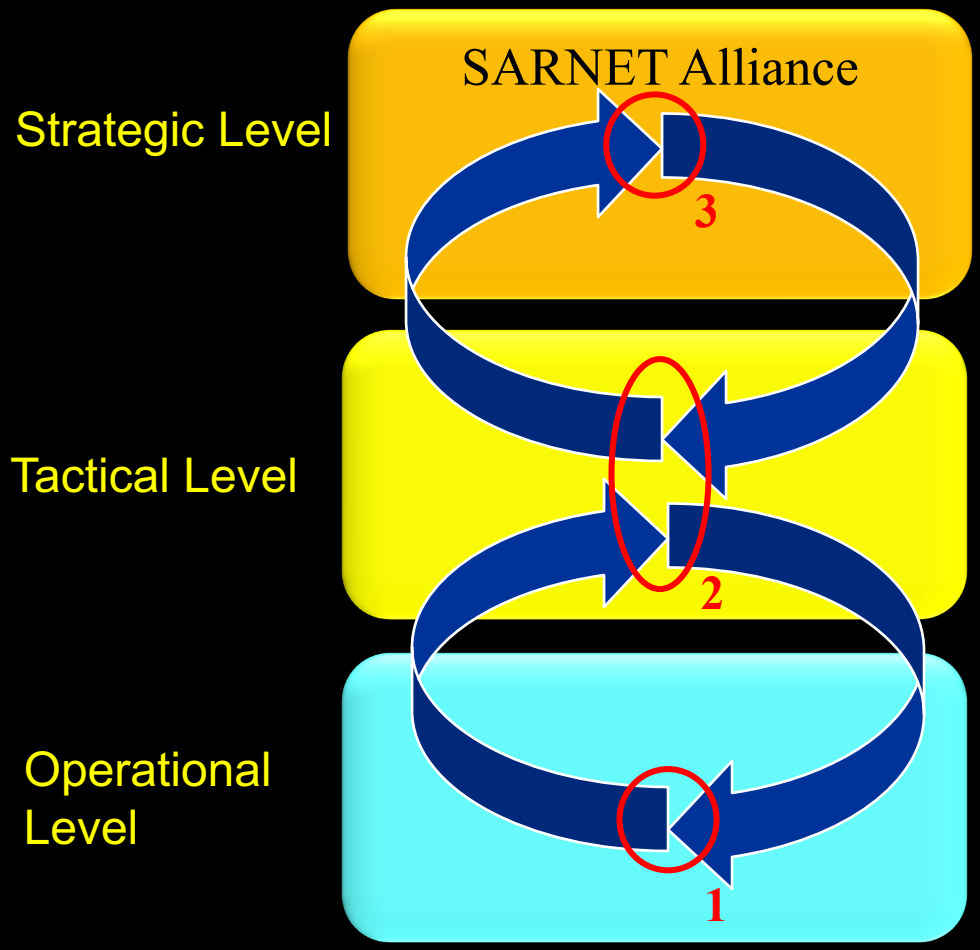
Research goal is to obtain the knowledge to create ICT systems that:

- 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

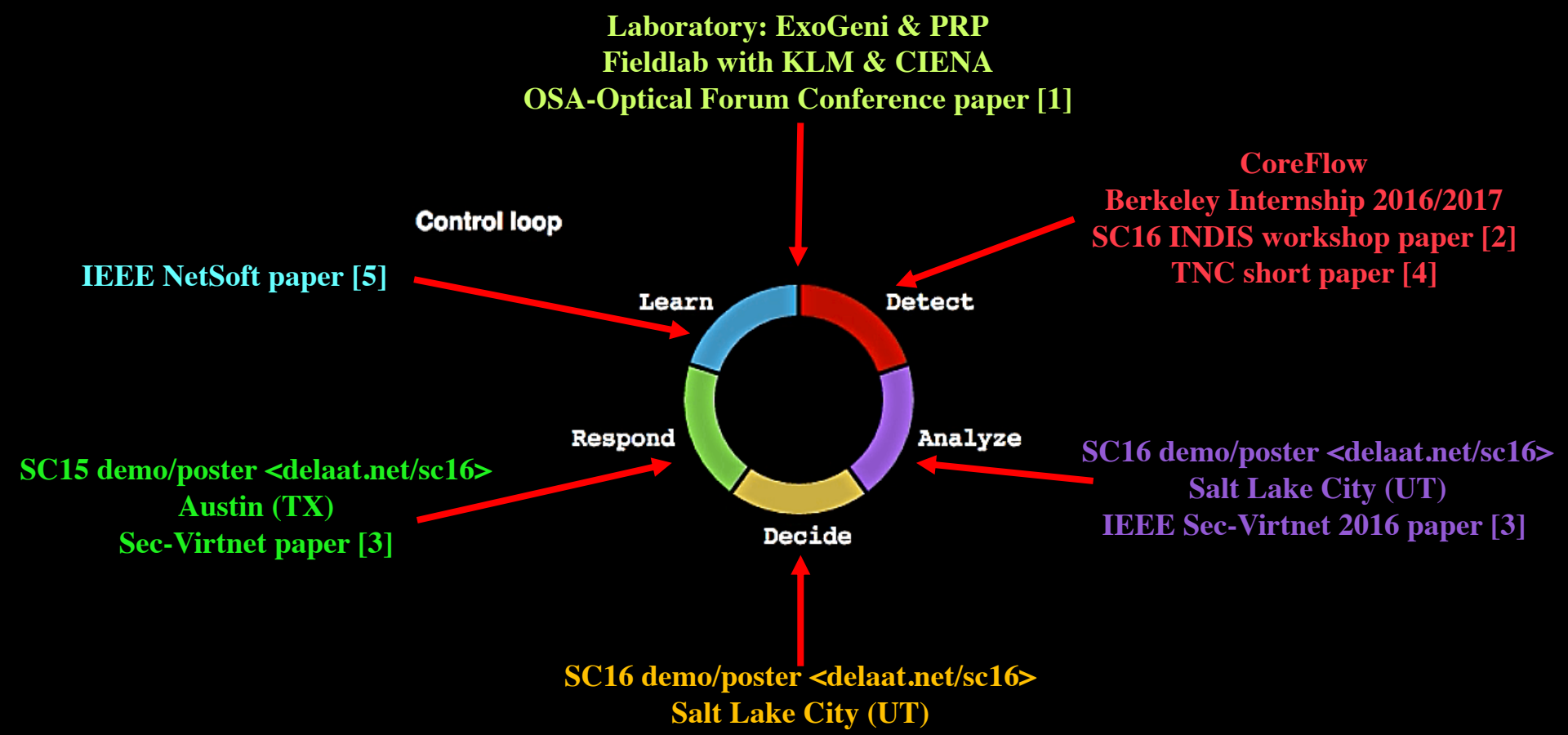


Ameneh Deljoo (PhD):
Why create SARNET Alliances? Model autonomous SARNET behaviors to identify risk and benefits for SARNET stakeholders (3)

Gleb Polevoy (PD):
Determine best defense scenario against cyberattacks deploying SARNET functions (1) based on security state, KPI information (2) keeping in mind strategic motifs (3).

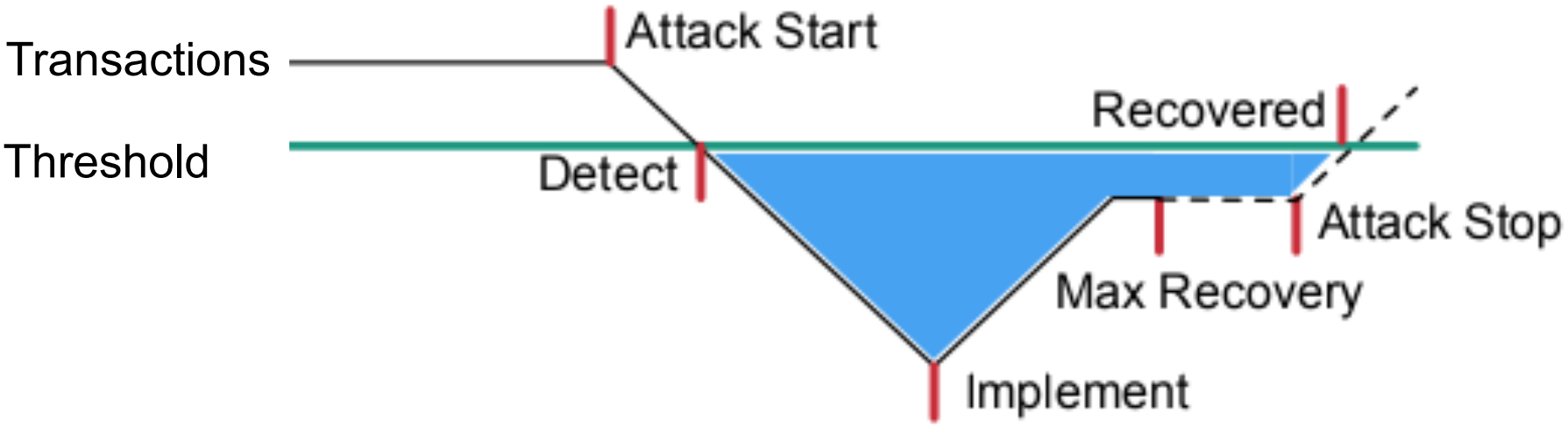
Ralph Koning (PhD)
Ben de Graaff (SP):
1. Design functionalities needed to operate a SARNET using SDN/NFV
2: deliver security state and KPI information (e.g cost)

Status SARNET Operational Level

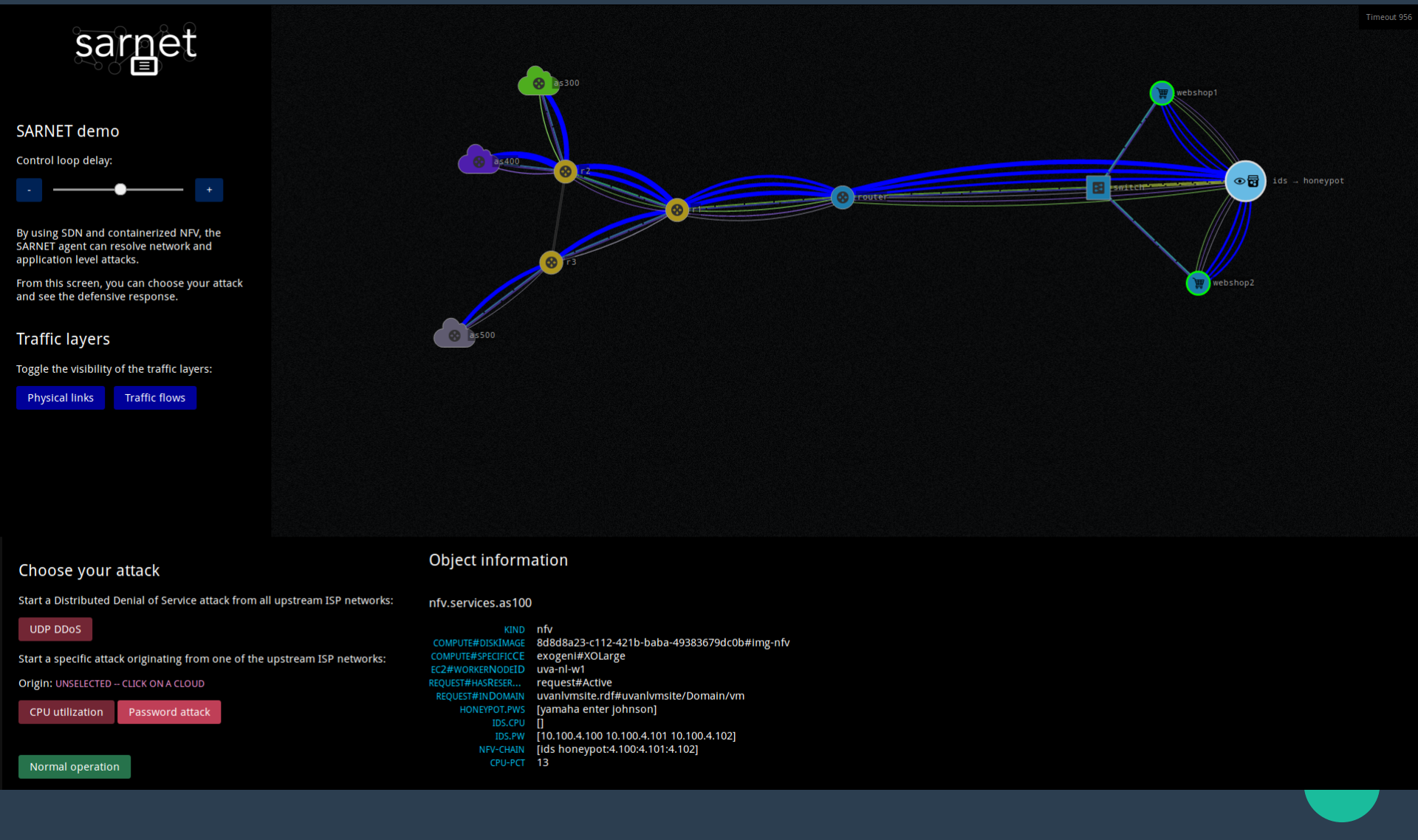


1. Paper: R. Koning, A. Deljoo, S. Trajanovski, B. de Graaff, P. Grosso, L. Gommans, T. van Engers, F. Fransen, R. Meijer, R. Wilson, and C. de Laat, "Enabling E-Science Applications with Dynamic Optical Networks: Secure Autonomous Response Networks ", OSA Optical Fiber Communication Conference and Exposition, 19-23 March 2017, Los Angeles, California.
2. Paper: Ralph Koning, Nick Buraglio, Cees de Laat, Paola Grosso, "CoreFlow: Enriching Bro security events using network traffic monitoring data.", Special section on high-performance networking for distributed data-intensive science, SC16", Future Generation Computer Systems, <accepted for publication>
3. Paper: Ralph Koning, Ben de Graaff, Cees de Laat, Robert Meijer, Paola Grosso, "Analysis of Software Defined Networking defenses against Distributed Denial of Service attacks", The IEEE International Workshop on Security in Virtualized Networks (Sec-VirtNet 2016) at the 2nd IEEE International Conference on Network Softwarization (NetSoft 2016), Seoul Korea, June 10, 2016.
4. Short paper: Nick Buraglio, Ralph Koning, Cees de Laat, Paola Grosso, "Enriching network and security events for event detection", Conference proceedings TNC2017, https://tnc17.geant.org/core/presentation/30.
5. Paper: Ralph Koning, Ben de Graaff, Robert Meijer, Cees de Laat, Paola Grosso, "Measuring the effectiveness of SDN mitigations against cyber attacks", IEEE Conference on Network Softwarization (Netsoft 2017 - SNS 2017), Bologna, Italy, July 3-7, 2017.

Effectiveness and Impact

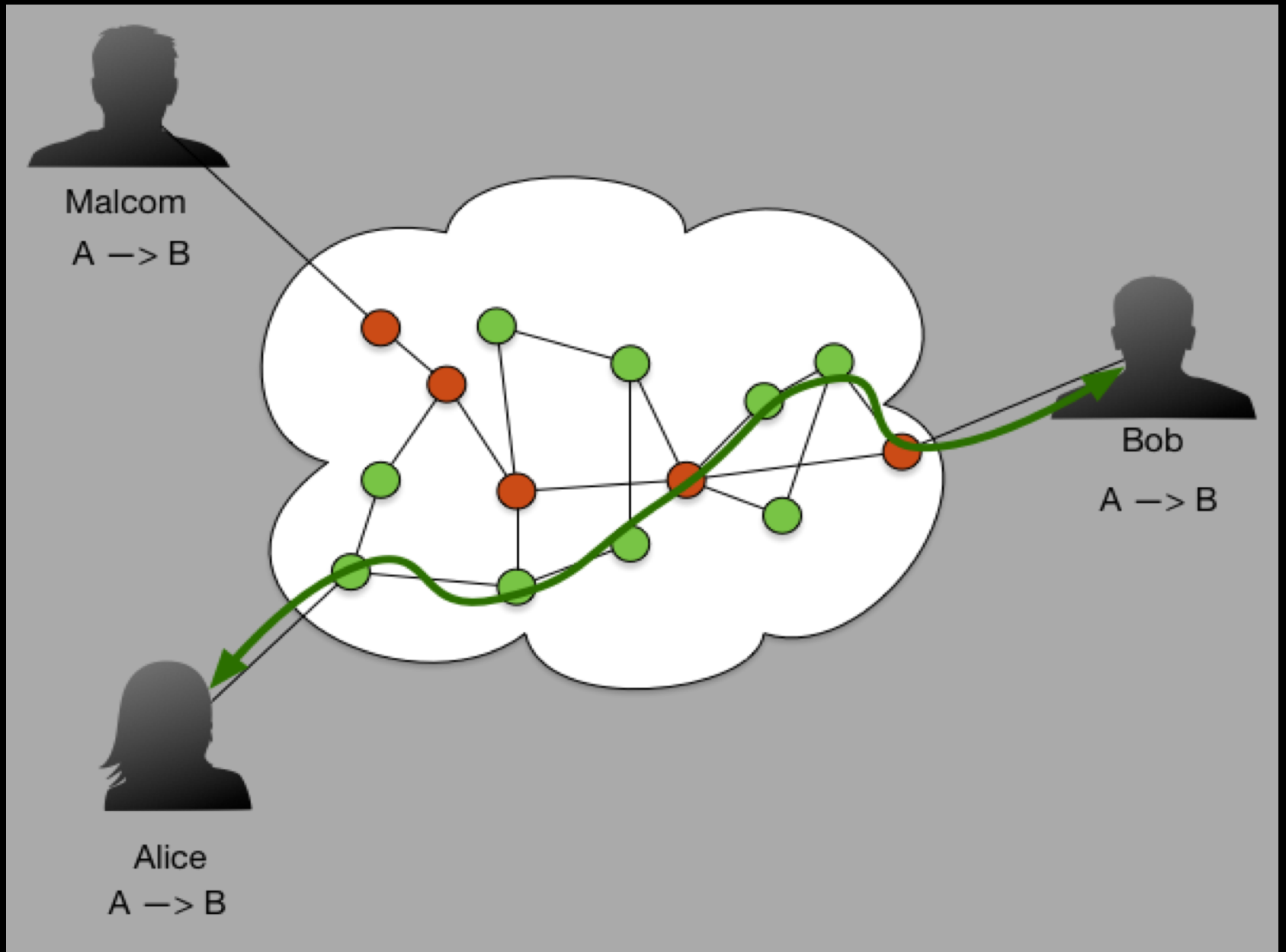


Scenario


sarnet
SARNET demo
Control loop delay:
-
+
By using SDN and containerized NFV, the SARNET agent can resolve network and application level attacks.
From this screen, you can choose your attack and see the defensive response.
Traffic layers
Toggle the visibility of the traffic layers:
Physical links
Traffic flows
Timeout 956
as300
as400
as500
r1
r2
r3
router
switch
webshop1
webshop2
ids → honeypot
Choose your attack
Start a Distributed Denial of Service attack from all upstream ISP networks:
UDP DDoS
Start a specific attack originating from one of the upstream ISP networks:
Origin: UNSELECTED -- CLICK ON A CLOUD
CPU utilization
Password attack
Normal operation
Object information
nfv.services.as100
KIND nfv
COMPUTE#DISKIMAGE 8d8d8a23-c112-421b-baba-49383679dc0b#img-nfv
COMPUTE#SPECIFICCE exogeni#XOLarge
EC2#WORKERNODEID uva-nl-w1
REQUEST#HASRESER... request#Active
REQUEST#INDOMAIN uvanlvmsite.rdf#uvanlvmsite/Domain/vm
HONEYPOT.PWS [yamaha enter johnson]
IDS.CPU []
IDS.PW [10.100.4.100 10.100.4.101 10.100.4.102]
NFV-CHAIN [ids honeypot:4.100:4.101:4.102]
CPU-PCT 13

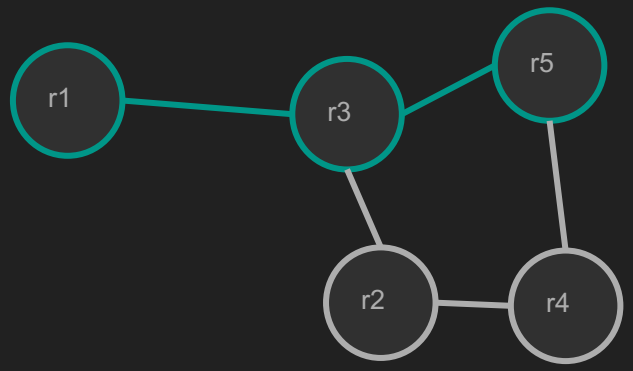
SC16 DEMO SARNET Operational Level

CoreFlow application: Spoofed Network Traffic



CoreFlow Route estimation algorithm

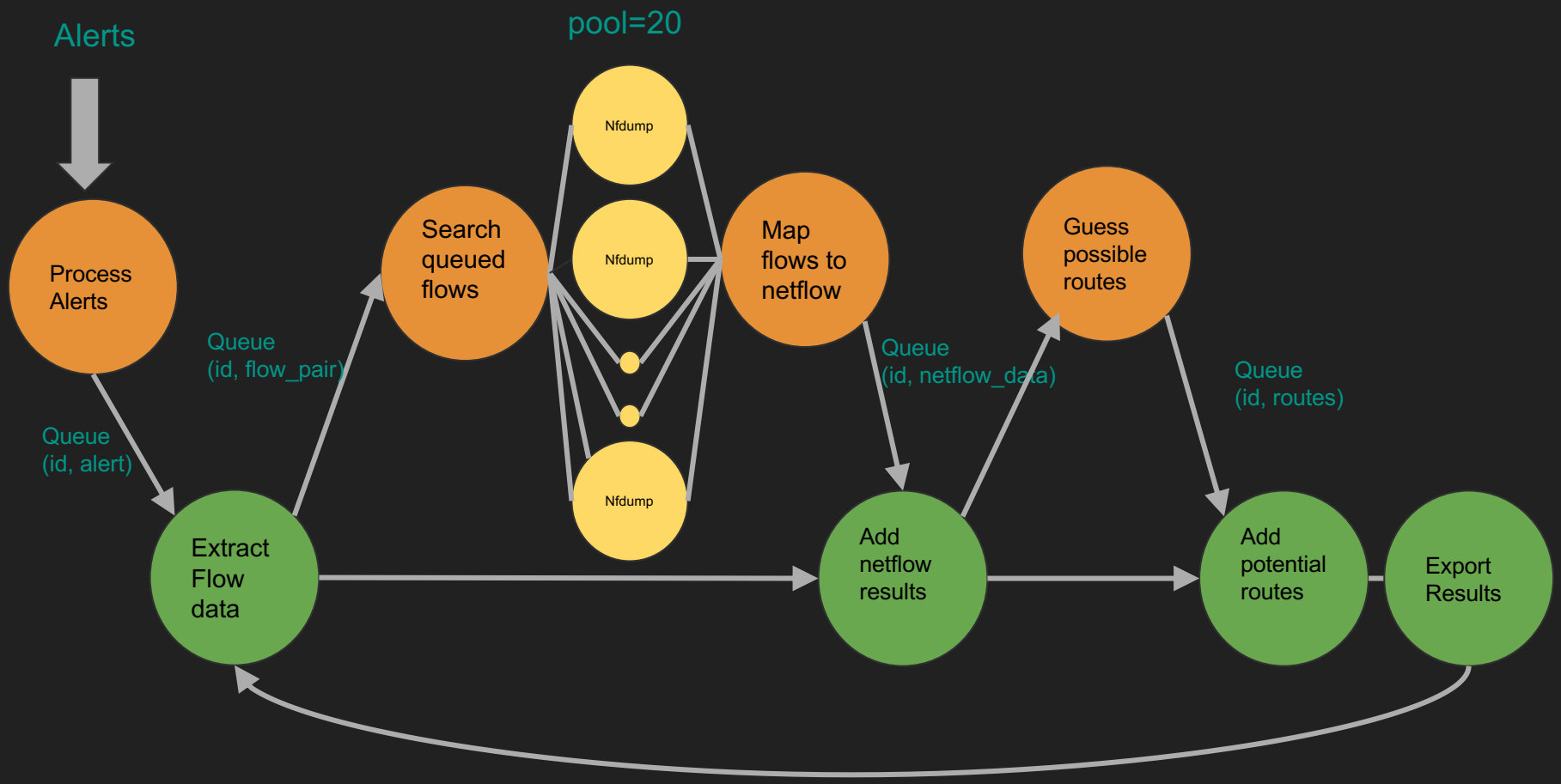
- It's able to fill in missing routers
- Flow traverse a router multiple times (loops)
- Finds potential 'shortest paths'



- Topology information from OSCARS
- Based on latest topology
- Does not account for policies or metrics

Unordered route:	Get possible routes from r3:	Reverse	Concat	Shortest
r3, r1, r5	r3, r1 r3, r5 r3, r2 r3, r5, r4 r3, r2, r4	r1, r3 r5, r3 r2, r3 r4, r2, r3 r4, r5, r3	r1, r3, r1 r1, r3, r5 r1, r3, r2 r1, r3, r2, r4 r1, r3, r5, r4 ...	r1, r3, r5 r5, r3, r1

Current workflow



Ralph Koning, Nick Buraglio, Cees de Laat, Paola Grosso, "CoreFlow: Enriching Bro security events using network traffic monitoring data.", Special section on high-performance networking for distributed data-intensive science, SC16", Future Generation Computer Systems.

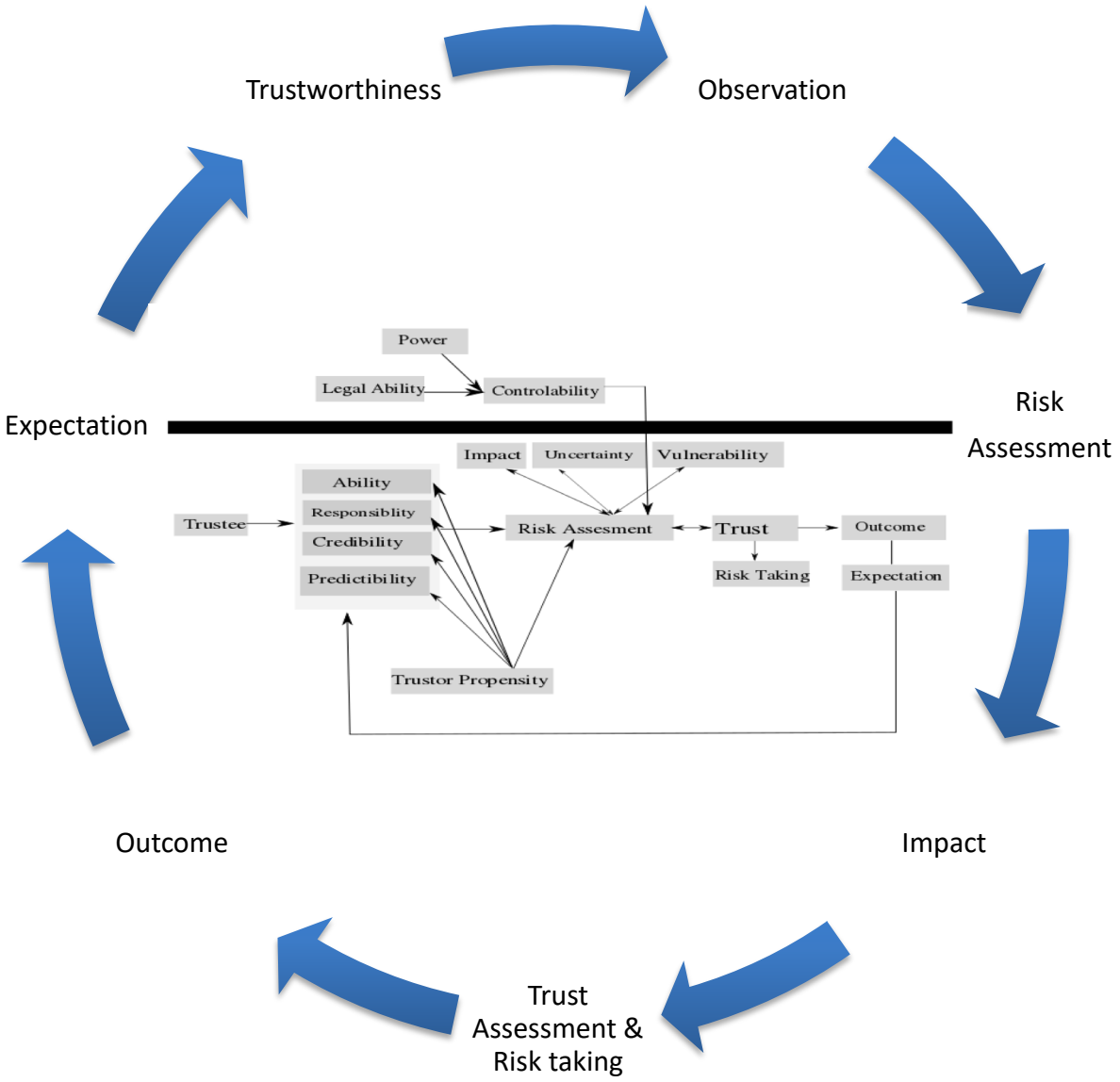
Agent Based Modelling Framework

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

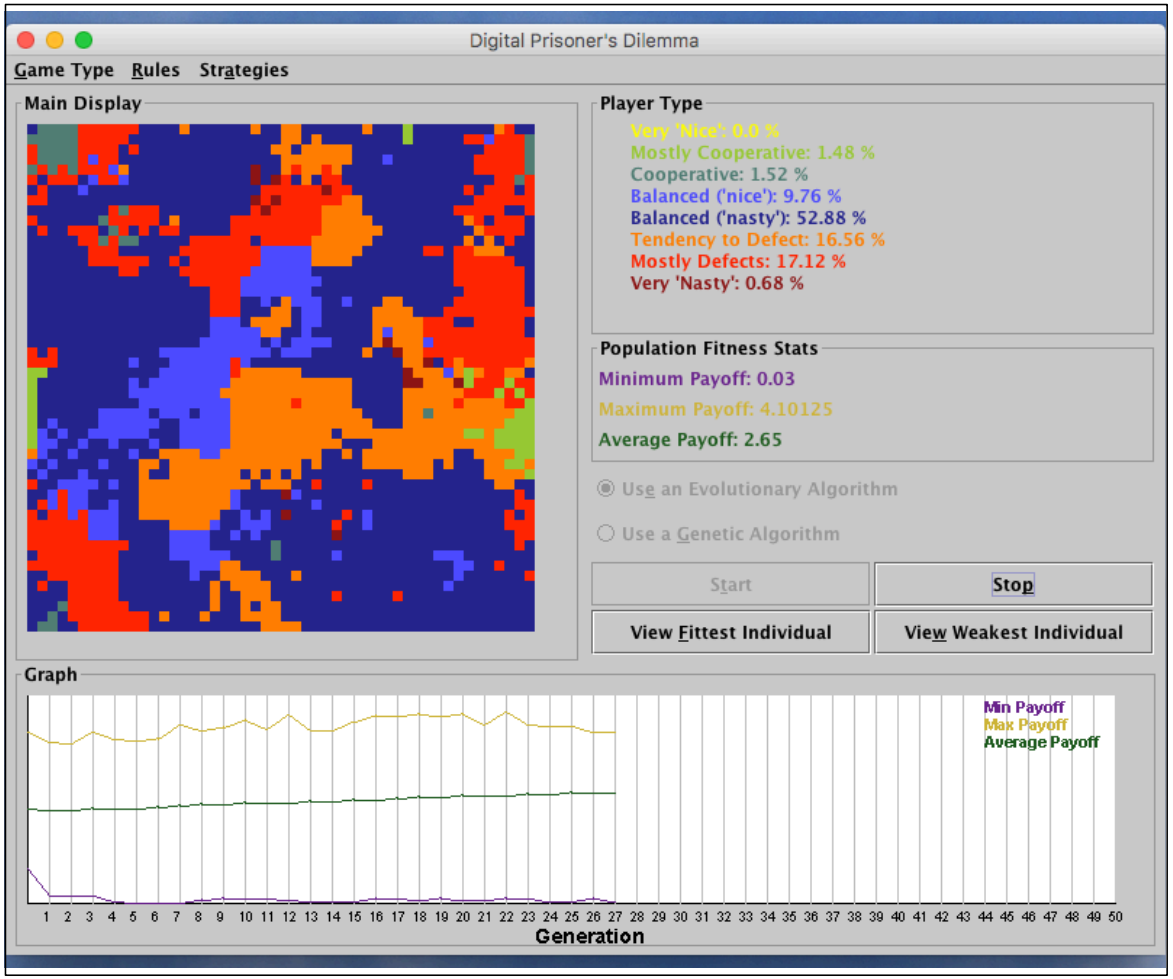
In our model, we refer to four layers of components:

- 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.

Agent Model evaluating Trust



First step: Evolutionary Prisoners Dilemma using ABM Simulation



Agents choose from different strategies:

- Collaborate
- Defect
- During simulation: Agents predict next behavior of neighboring agents learned from observing past behavior.

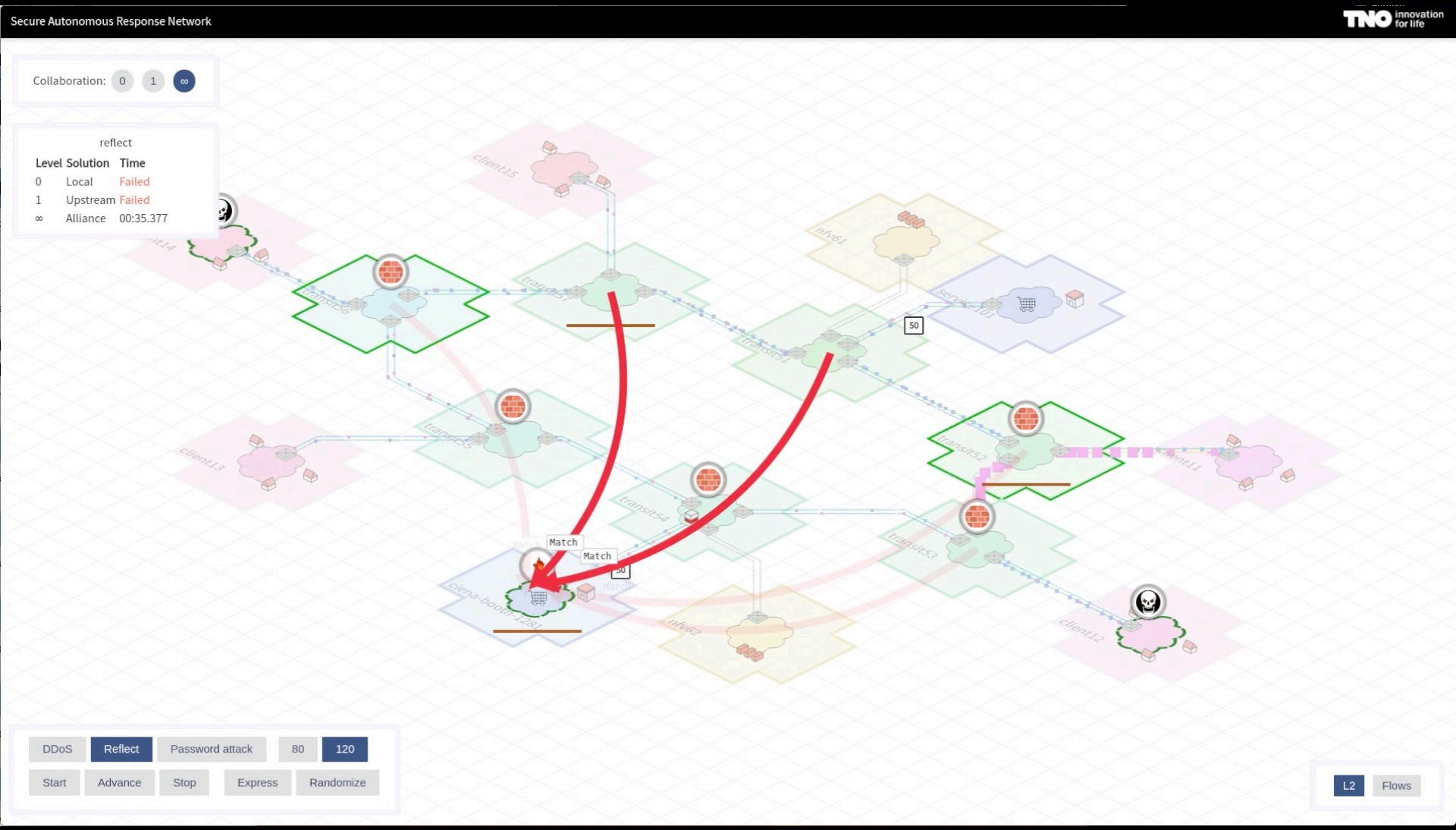
Simulation observes tendency to maximize individual welfare instead of helping the group.

This type of simulation will be base to simulate more complex collaborations of autonomous organizations.

Research performed by Ameneh Deljoo, PhD candidate University of Amsterdam.

Ameneh Deljoo, Tom van Engers, Robert van Doesburg, Leon Gommans and Cees de Laat, "A Normative Agent-based Model for Sharing Data in Secure Trustworthy Digital Market Places.", Proceedings of 10th conference on Agents and Artificial Intelligence, ICAART 2018, http://www.icaart.org/Home.aspx

SC17 DEMO Operational Level Multi Domain



SC17 DEMO Operational Level Multi Domain

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Big Data: real time ICT for logistics
Data Logistics 4 Logistics Data (dl4ld)

Robert Meijer, TNO, Co-PI, Cees de Laat, UvA, Co-PI, Leon Gommans, KLM

Main problem statement

- Organizations that normally compete have to bring data together to achieve a common goal!
- The shared data may be used for that goal but not for any other!
- Data may have to be processed in untrusted data centers.
  - How to enforce that using modern Cyber Infrastructure?
  - How to organize such alliances?
  - How to translate from strategic via tactical to operational level?
  - What are the different fundamental data infrastructure models to consider?

Big Data Sharing use cases placed in airline context

Global Scale

National Scale

City / regional Scale

Campus / Enterprise Scale

Aircraft Component Health Monitoring (Big) Data
NWO **CIMPLO project**
4.5 FTE

Cargo Logistics Data
(C1) DaL4LoD
(C2) Secure scalable policy-enforced distributed data Processing
(using blockchain)

NLIP iShare project

iSHARE
powered by NLIP

Cybersecurity Big Data
NWO COMMIT/
SARNET project
3.5 FTE

B2B DATA SHARING MODELS

AS RECOGNIZED BY EU BASED ON ANALYSIS CURRENT SITUATION

Case studies

Approaches to B2B data sharing

European Commission

everis an NTT DATA Company

Five different approaches to B2B data sharing

1 DATA MONETISATION

2 DATA MARKETPLACES

3 INDUSTRIAL DATA PLATFORMS

4 TECHNICAL ENABLERS

5 OPEN DATA

INDUSTRIAL DATA PLATFORMS

- ✓ Strategic and collaborative partnerships
- ✓ Mutual benefits for all parties
- ✓ Data shared (for free) in a closed, exclusive and secure environment
- ✓ Develop new or improved products and/or services
- ✓ Enhance internal performance

AIRBUS MAN

AIRFRANCE KLM

B2B DATA SHARING MODEL: COMBINE 2&3

DESIRED SITUATION BY AIRLINE OPERATORS SUCH AS AIR FRANCE - KLM

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Independent Marketplace data platform operated by Industry membership organization

INDUSTRIAL DATA PLATFORMS

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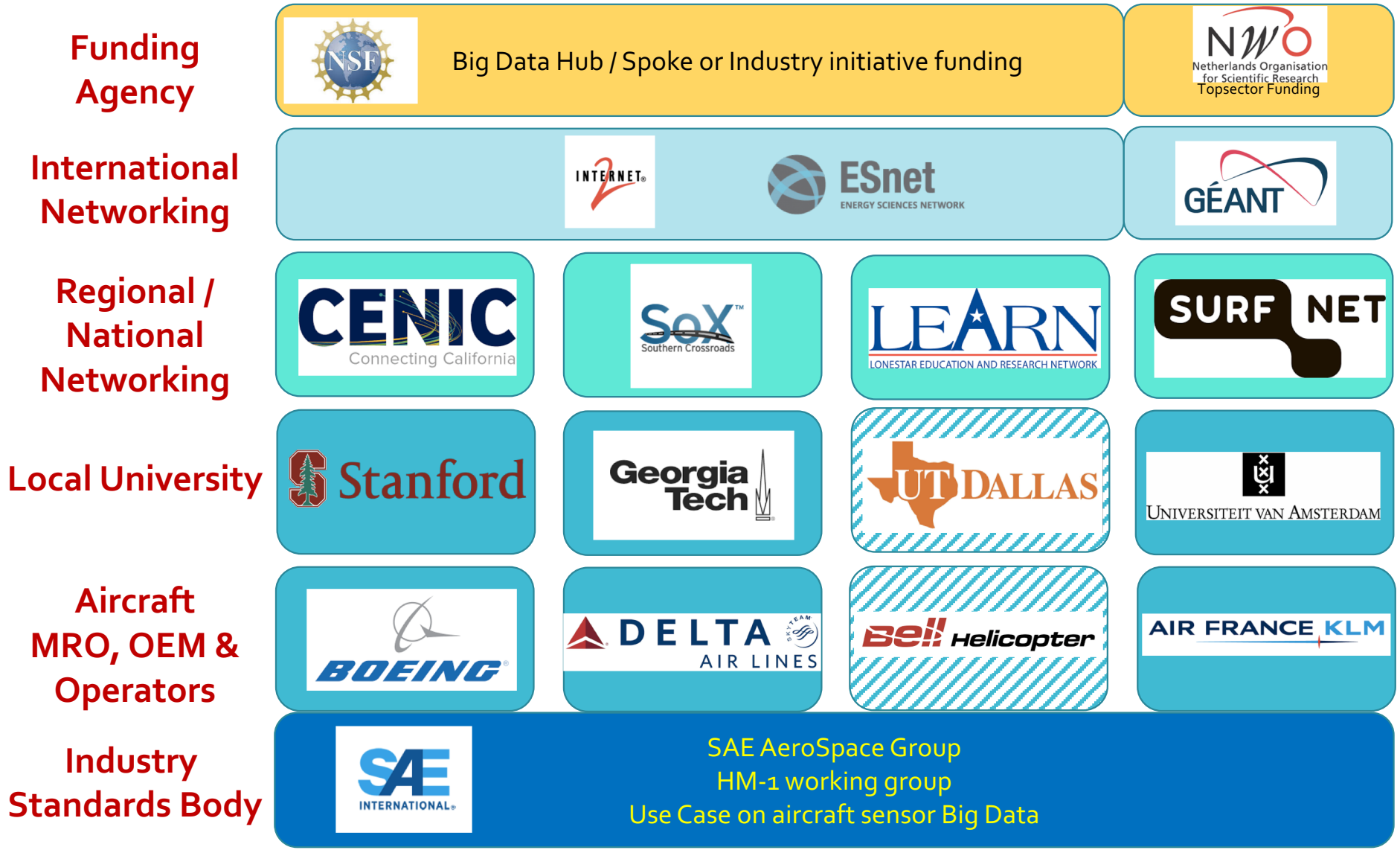
- ✓ [illegible] improved products

[illegible] performance

MAN

AIRFRANCE KLM

SAE Use Case envisaged research collaboration



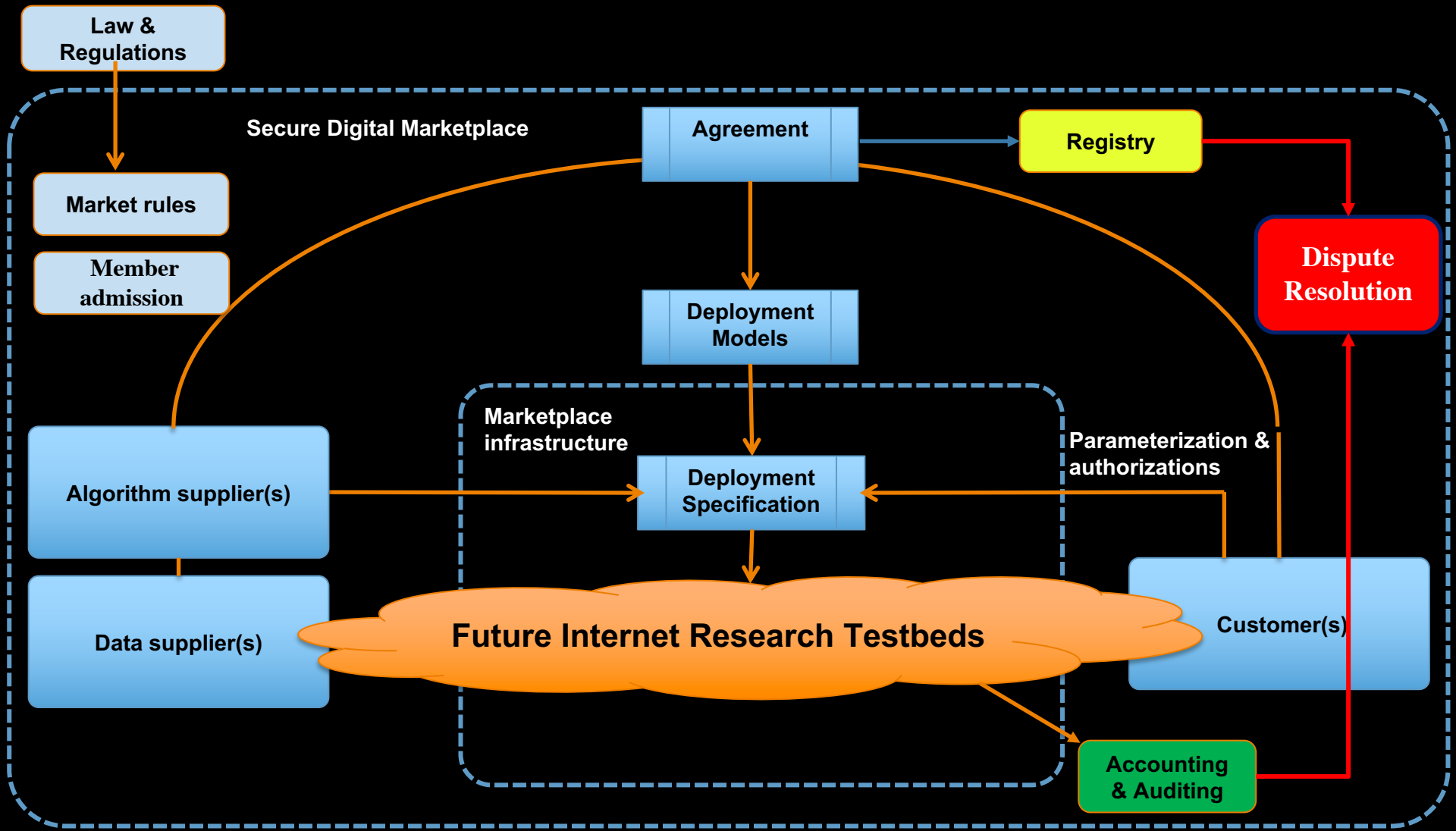
SE System and Network Engineering

AIR FRANCE KLM

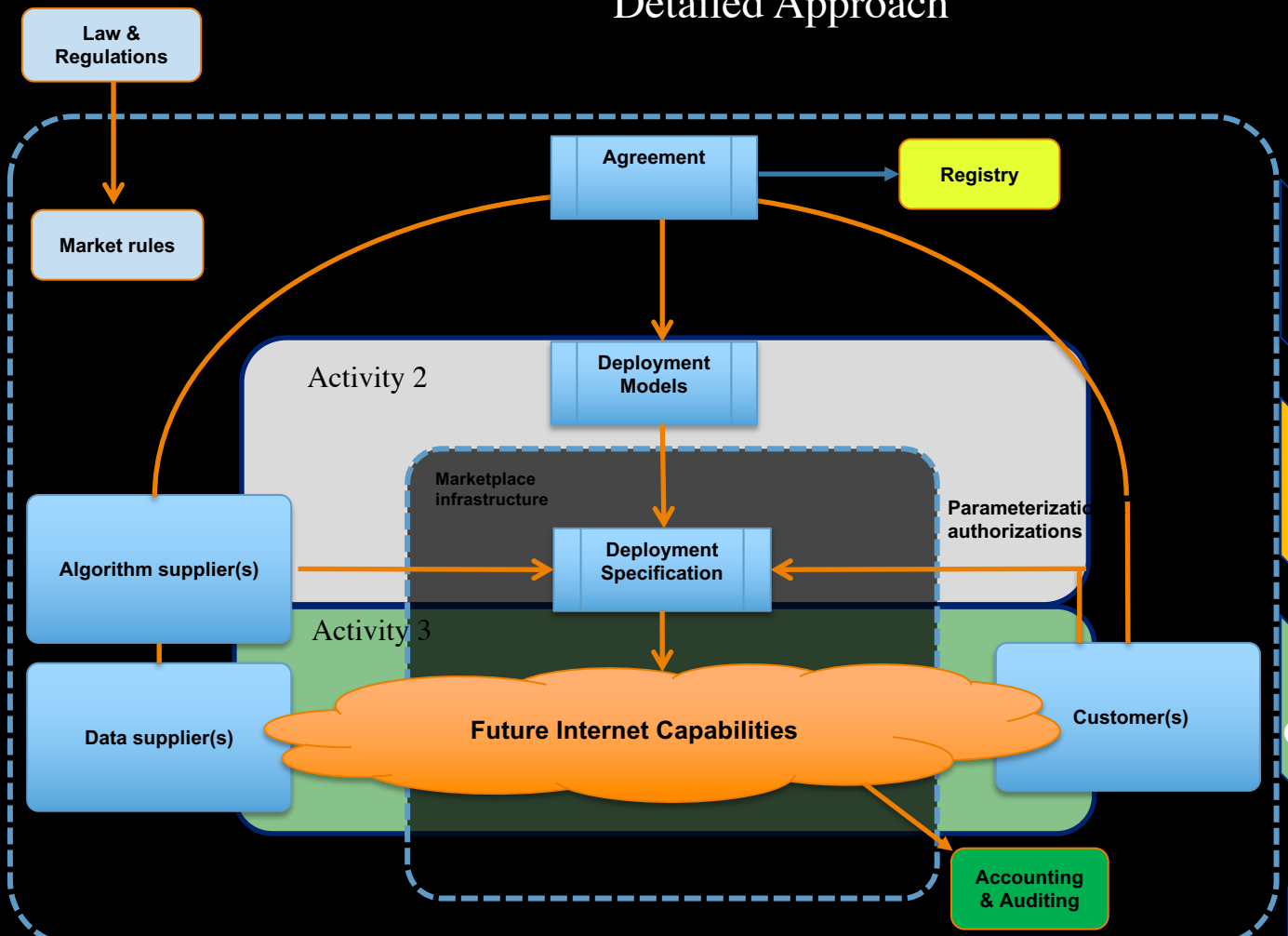
Approach

- Strategic:
  - Translate legislation into machine readable policy
  - Define data use policy
  - Trust evaluation models & metrics
- Tactical:
  - Map app given rules & policy & data and resources
  - Bring computing and data to (un)trusted third party
  - Resilience
- Operational:
  - TPM & Encryption schemes to protect & sign
  - Policy evaluation & docker implementations
  - Use VM and SDI/SDN technology to enforce
  - Block chain to record what happened (after the fact!)

Secure Digital Market Place Research



Detailed Approach



Why & What

Strategic

- Digital business agreement negotiation & trust organized by member organization
- Architecture driven deployment of trusted system functions needed by business
- Creating Inter-organizational solutions

How

Tactical

- Digital realization & implementation of trust
- Creating archetypes of deployment models.
- Semantic composition of services
- Incorporating forward looking infrastructure architectures

With what

Operational

- Inter-organization service quality & consistency in practice
- Multidomain aspects (identity, AAA)
- Infrastructure programmability
- Programmable component deployment

National & International Academic Fieldlabs

WP4 Knowledge Exchange

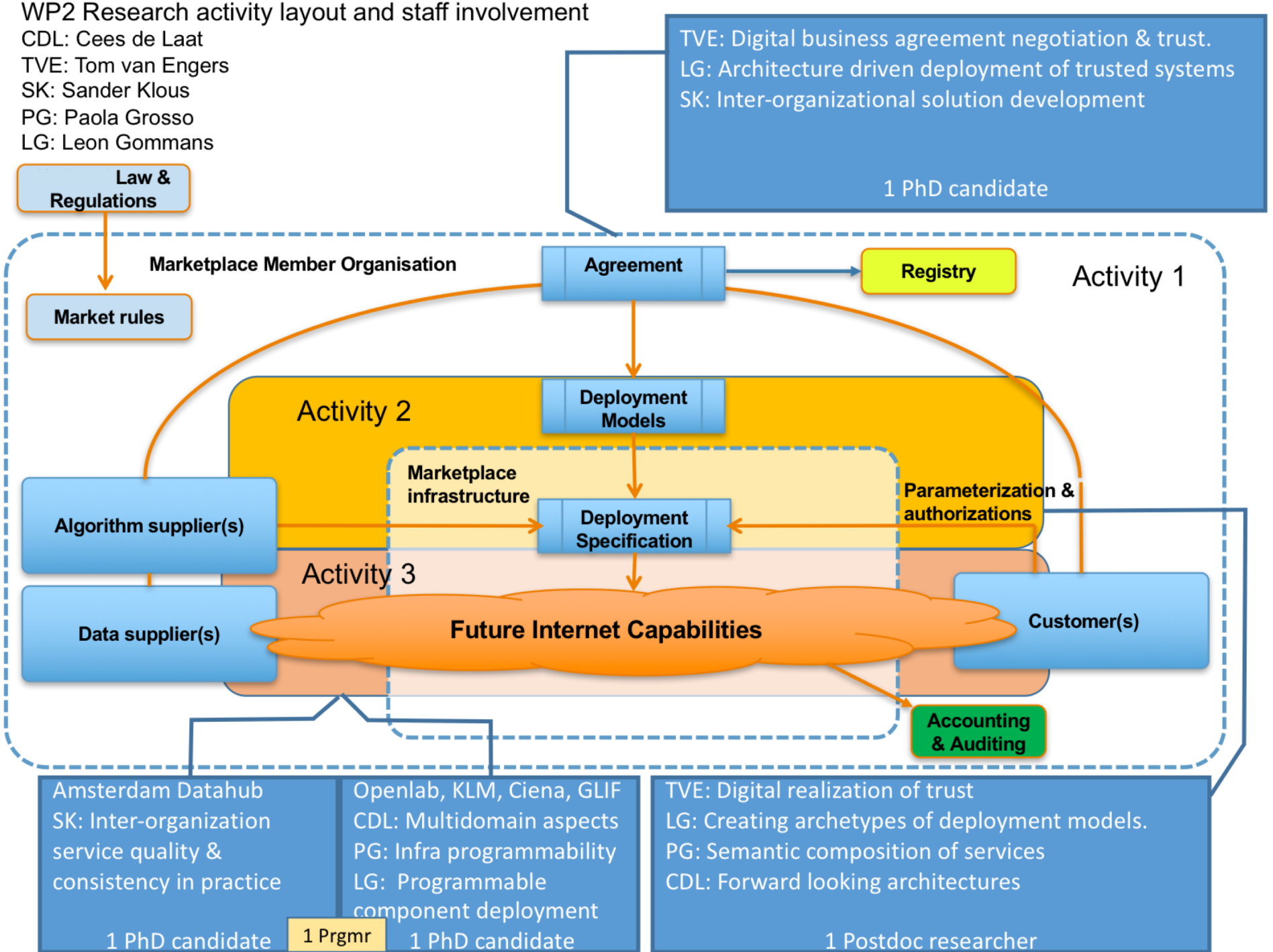
WP3 Sector Requirements

Topsector Fieldlabs (Logistics, Smart Industry, Health, AgriFood, ..)

WP3 Blue print

WP2 Research activity layout and staff involvement

CDL: Cees de Laat
TVE: Tom van Engers
SK: Sander Klous
PG: Paola Grosso
LG: Leon Gommans



Data Processing models

- Bring data to computing
- Bring computing to data
- Bring computing and data to (un)trusted third party
- A mix of all of the above
- Block chain to record what happened
- Block chain for data integrity
- Bring the owner of Data in control!
- Data owner policy + enforcement technology

Yesterday's Media Transport Method on the KL601 AMS-LAX-SAN!

Trucks of Tapes

WSJ Nov 30, 2016

THE WALL STREET JOURNAL.

Amazon Uses Trucks to Drive Data Faster

PERSONAL TECHNOLOGY

The Cable-Cutting Dream Is Kind ...

Altice Plans Fiber Upgrade That Could Leave Rivals in the Dust

Netflix Now Lets You Download, But Many Top Shows Are Off Limits

TECH

Amazon Uses Trucks to Drive Data Faster

Cloud-computing unit, Amazon Web Services, unveils new offerings at annual conference in Las Vegas

Amazon unveiled the 'Snowmobile' service on Wednesday in Las Vegas. *PHOTO: AMAZON WEB SERVICE*

The tractor-trailer hauls a massive storage device, dubbed Snowmobile, in the form of a 45-foot shipping container that holds 100 petabytes of data. A petabyte is about 1 million gigabytes.

1 fiber does about 16 Tbit/s
= 2 Tbyte/s
⇒ 500000 s/ExaByte
⇒ One week/ExaByte

The company, however, isn't promising lightning speed. Ten Snowmobiles would reduce the time it takes to move an exabyte from on-premises storage to Amazon's cloud to a little less than six months, from about 26 years using a high-speed internet connection, by the company's calculations.

By JAY GREENE By LAURA STEVENS
Updated Nov. 30, 2016 7:19 p.m. ET

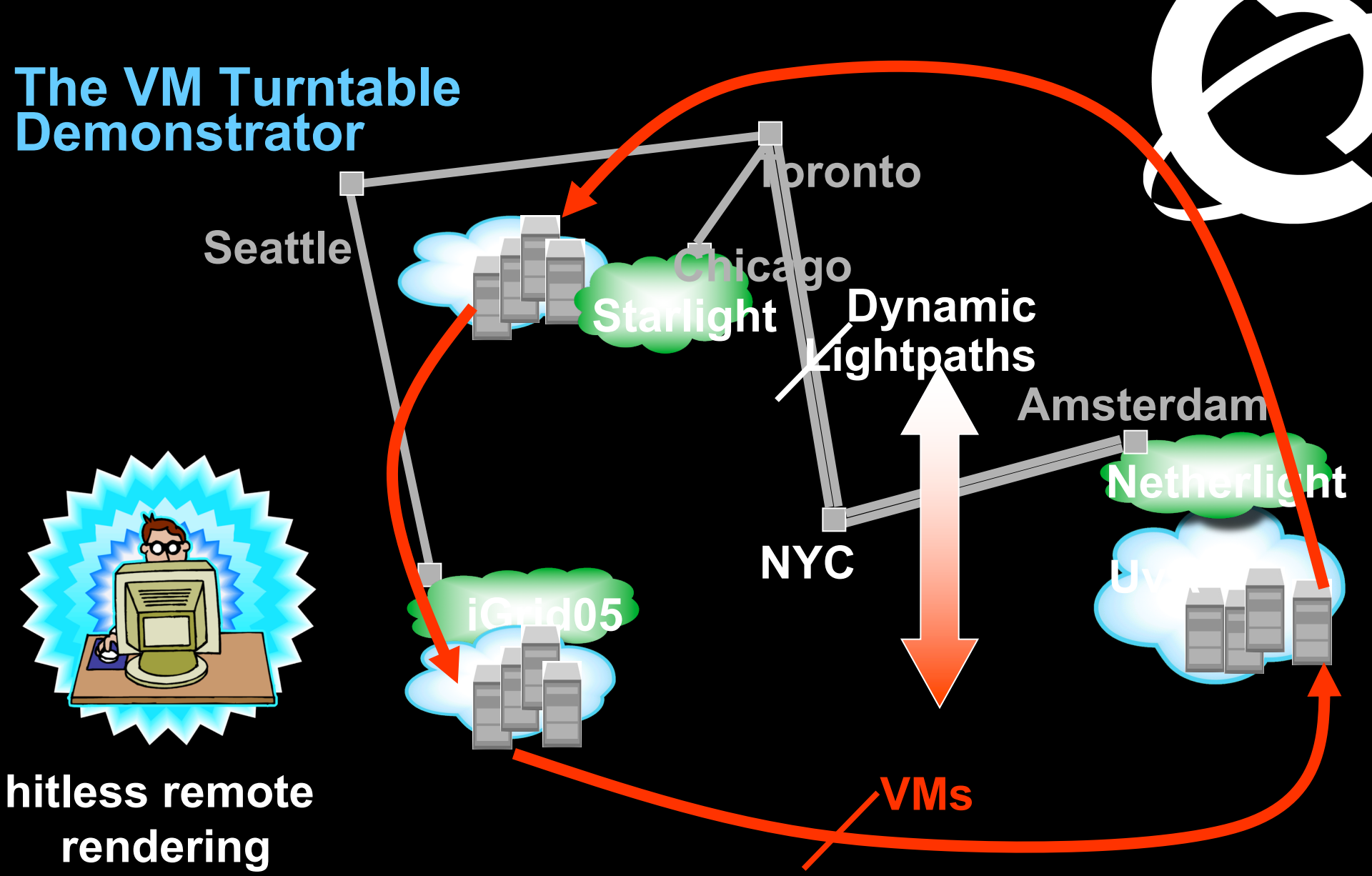
LAS VEGAS—In Amazon Web Services, Amazon.com Inc. has built one of the most powerful computing networks in the world, on pace to post more than $12 billion in revenue this year.

But the retail giant on Wednesday proposed a surprising way to move data from large corporate customers' data centers to its public cloud-computing operation: by truck.

Networks can move massive amounts of data only so fast. Trucks, it turns out, can move it faster.

1 fiber does
100 Petabytes
in one day,
if you can fill it!

The VM Turntable Demonstrator



hitless remote rendering

The VMs that are live-migrated run an iterative search-refine-search workflow against data stored in different databases at the various locations. A user in San Diego gets hitless rendering of search progress as VMs spin around

Experiment outcomes
Note, this was in 2005 at SC and igrid2005!

We have demonstrated seamless, live migration of VMs over WAN

For this, we have realized a network service that

- Exhibits predictable behavior; tracks endpoints
- Flex bandwidth upon request by credited applications
- Doesn't require peak provisioning of network resources

Pipelining bounds the downtime in spite of high RTTs

- San Diego – Amsterdam, 1GE, RTT = 200 msec, downtime <= 1 sec
- Back to back, 1GE, RTT = 0.2-0.5 msec, downtime = ~0.2 sec*
- **Clark et al. NSDI 05 paper. Different workloads*

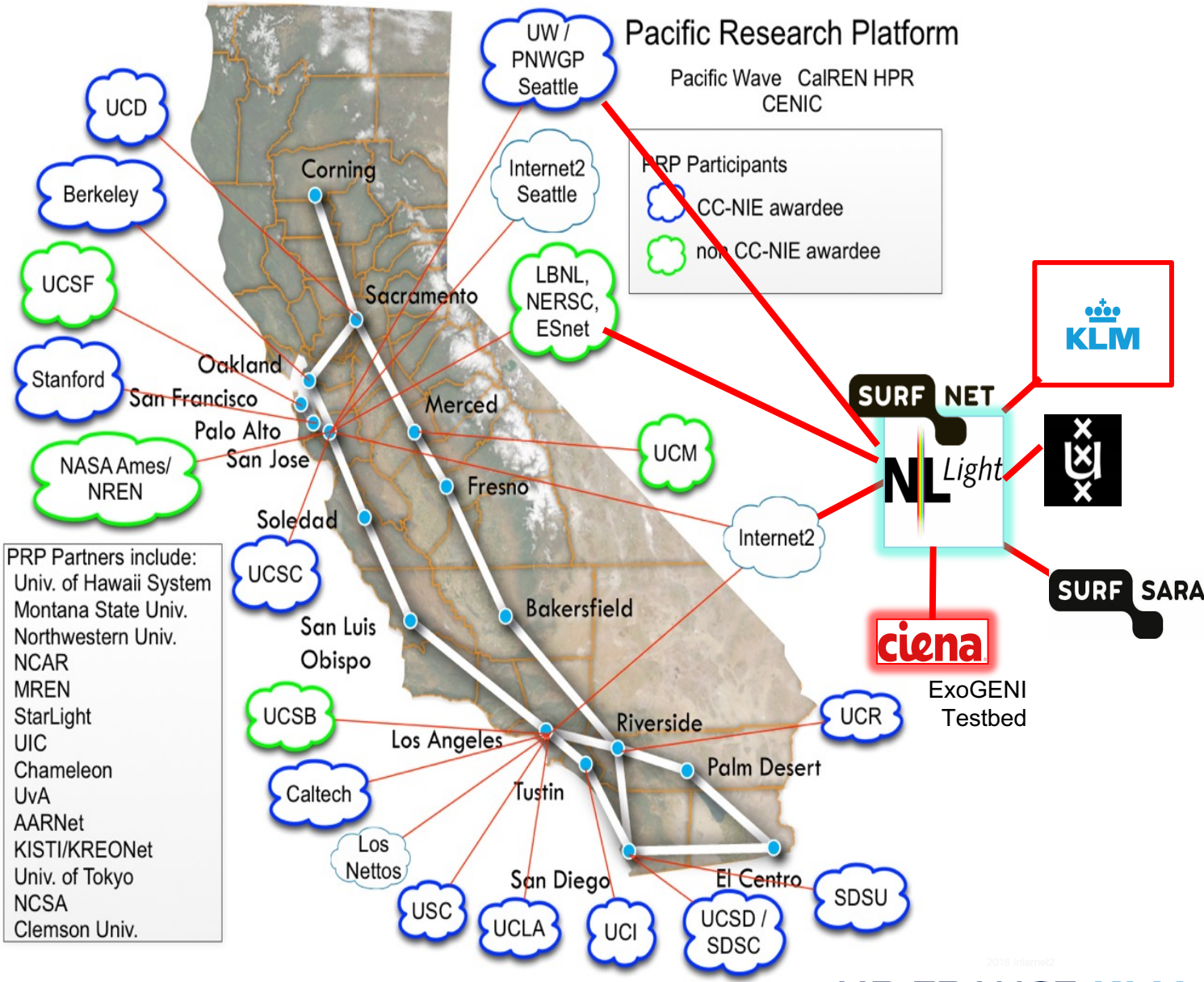
VM + Lightpaths across MAN/WAN are deemed a powerful and general alternative to RPC, GRAM approaches

We believe it's a representative instance of active cpu+data+net orchestration

F. Travostino, P. Daspit, L. Gommans, C. Jog, C.T.A.M. de Laat, J. Mambretti, I. Monga, B. van Oudenaarde, S. Raghunath and P.Y. Wang, "Seamless Live Migration of Virtual Machines over the MAN/WAN", Future Generation Computer Systems, Volume 22, Issue 8, October 2006, Pages 901-907.

Pacific Research Platform testbed involvement

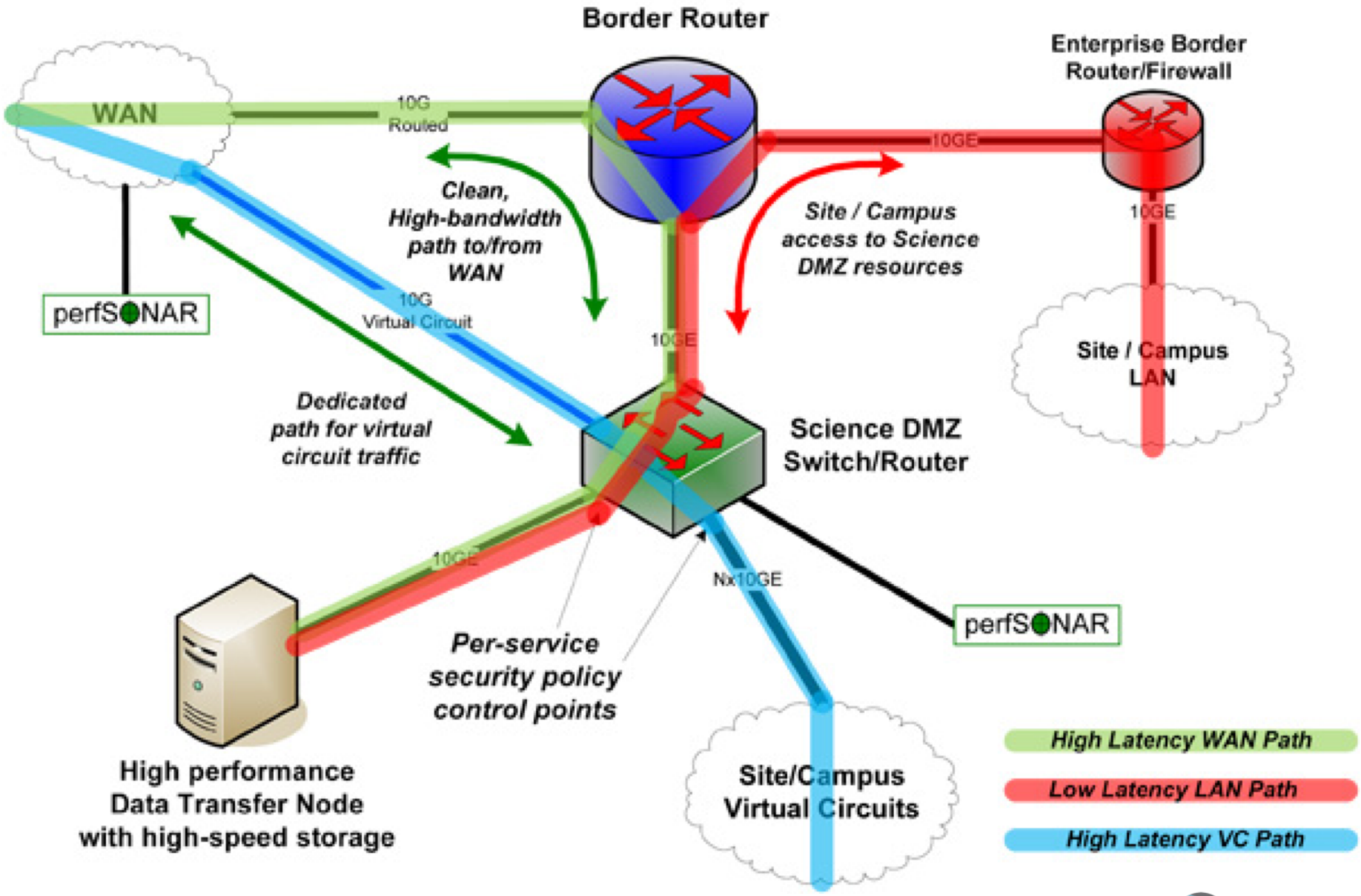
Research goal: Explore value of academic network research capabilities that enable innovative ways & models to share big data assets



PACIFIC RESEARCH PLATFORM

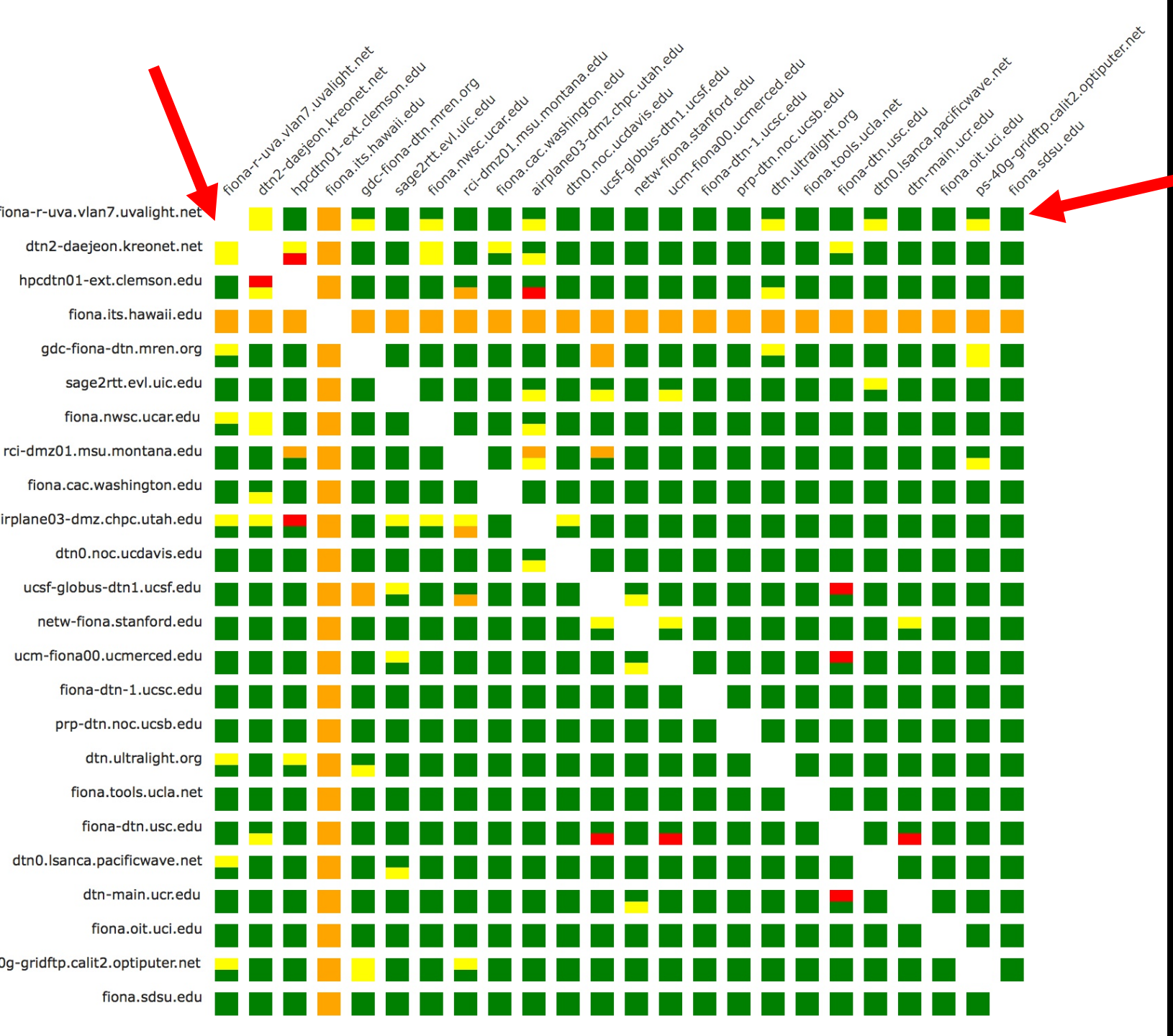
Note: this diagram represents a subset of sites and connections.

Science-DMZ



CENIC

ESnet


fiona-r-uva.vlan7.uvalight.net
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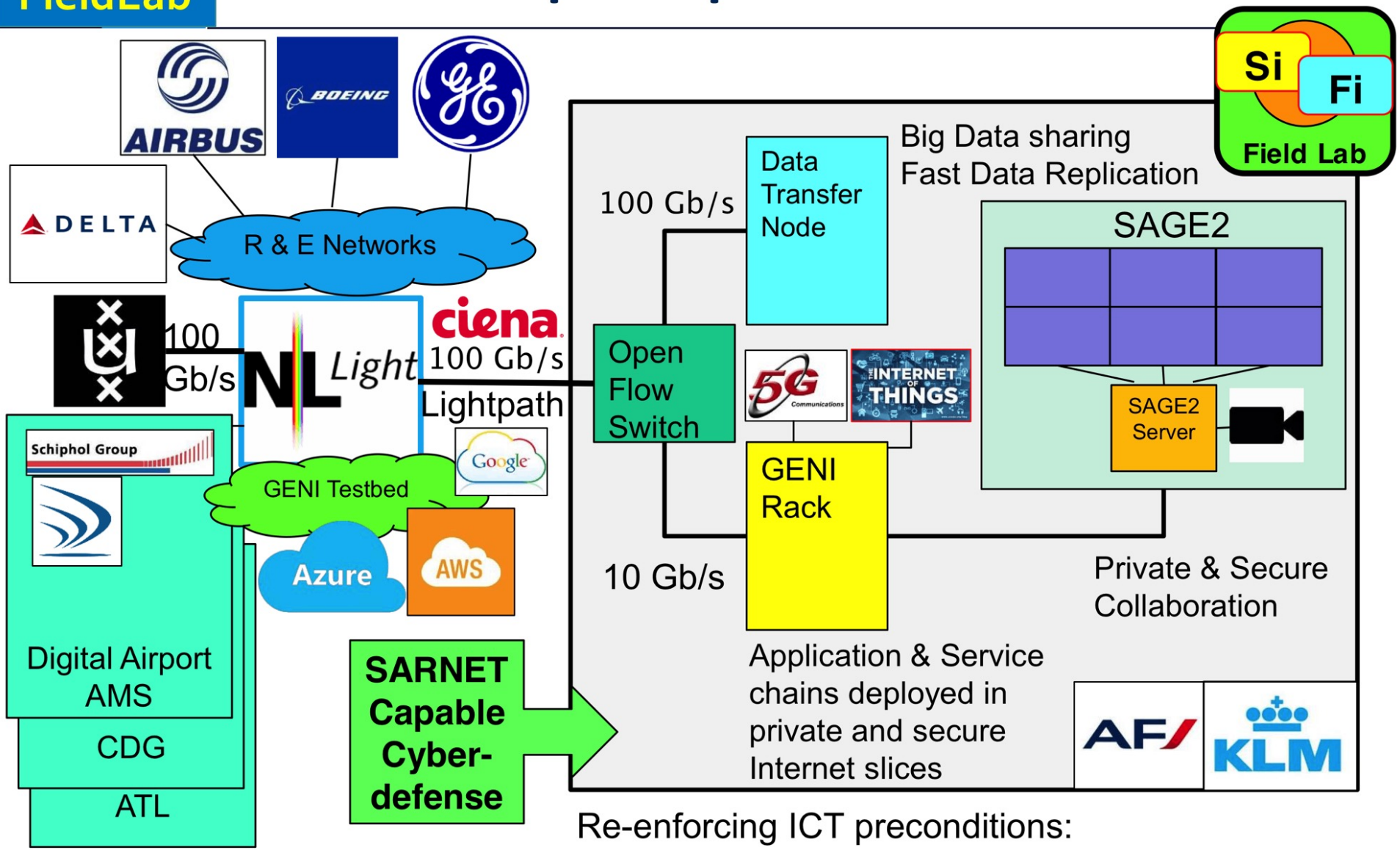
hpcdtn01-ext.clemson.edu
fiona.its.hawaii.edu
gdc-fiona-dtn.mren.org
sage2rtt.evl.uic.edu
fiona.nwsc.ucar.edu
rci-dmz01.msu.montana.edu
fiona.cac.washington.edu
airplane03-dmz.chpc.utah.edu
dtn0.noc.ucdavis.edu
ucsf-globus-dtn1.ucsf.edu
netw-fiona.stanford.edu
ucm-fiona00.ucmerced.edu
fiona-dtn-1.ucsc.edu
prp-dtn.noc.ucsb.edu
dtn.ultralight.org
fiona.tools.ucla.net
fiona-dtn.usc.edu
dtn0.lsanca.pacificwave.net
dtn-main.ucr.edu
fiona.oit.uci.edu
ps-40g-gridftp.calit2.optiputer.net
fiona.sdsu.edu

PRP -> NRP -> GRP

AF/KLM FieldLab

Ambition to put capabilities into fieldlab

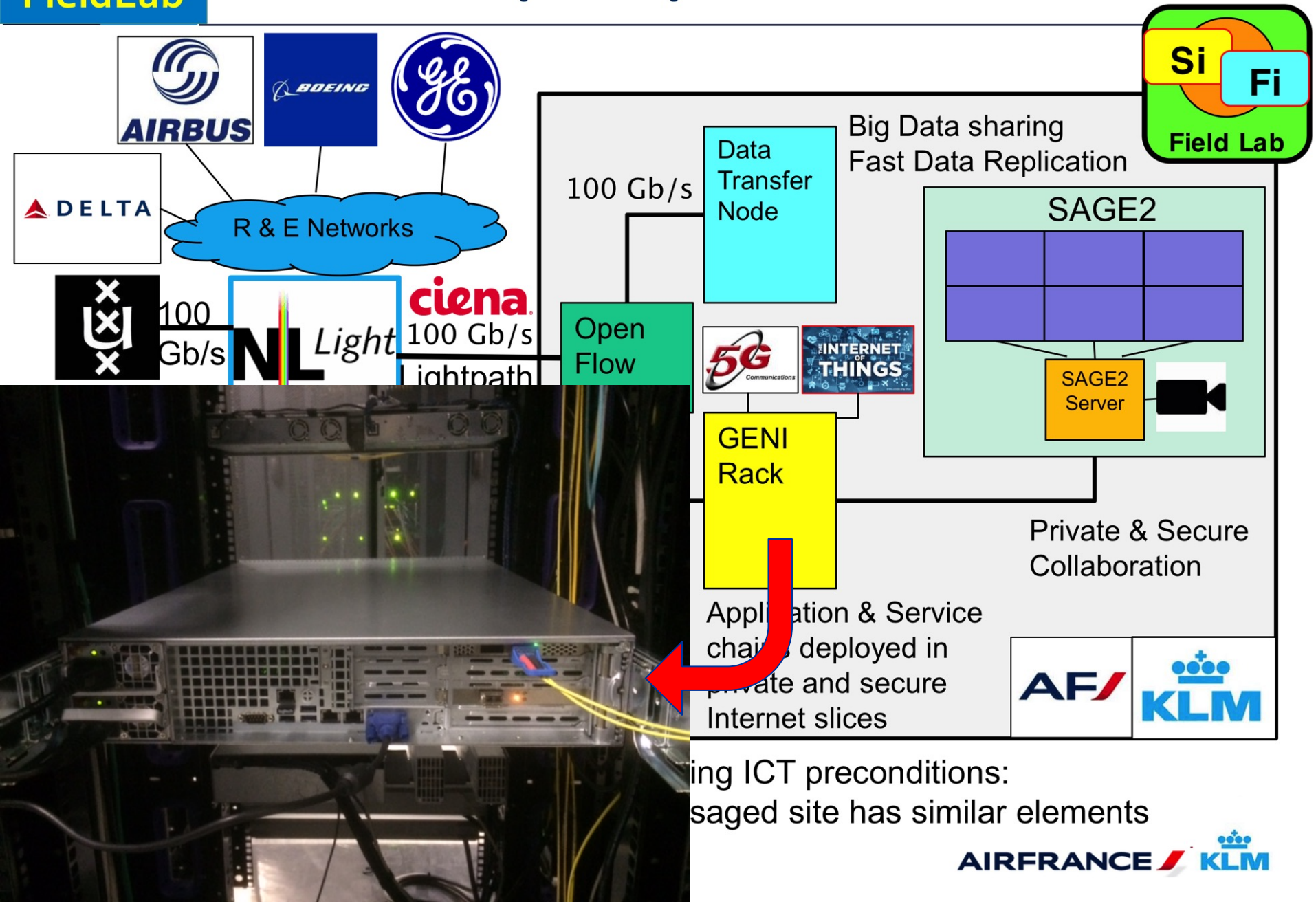


Re-enforcing ICT preconditions:
Each envisaged site has similar elements

AIRFRANCE KLM

AF/KLM FieldLab

Ambition to put capabilities into fieldlab

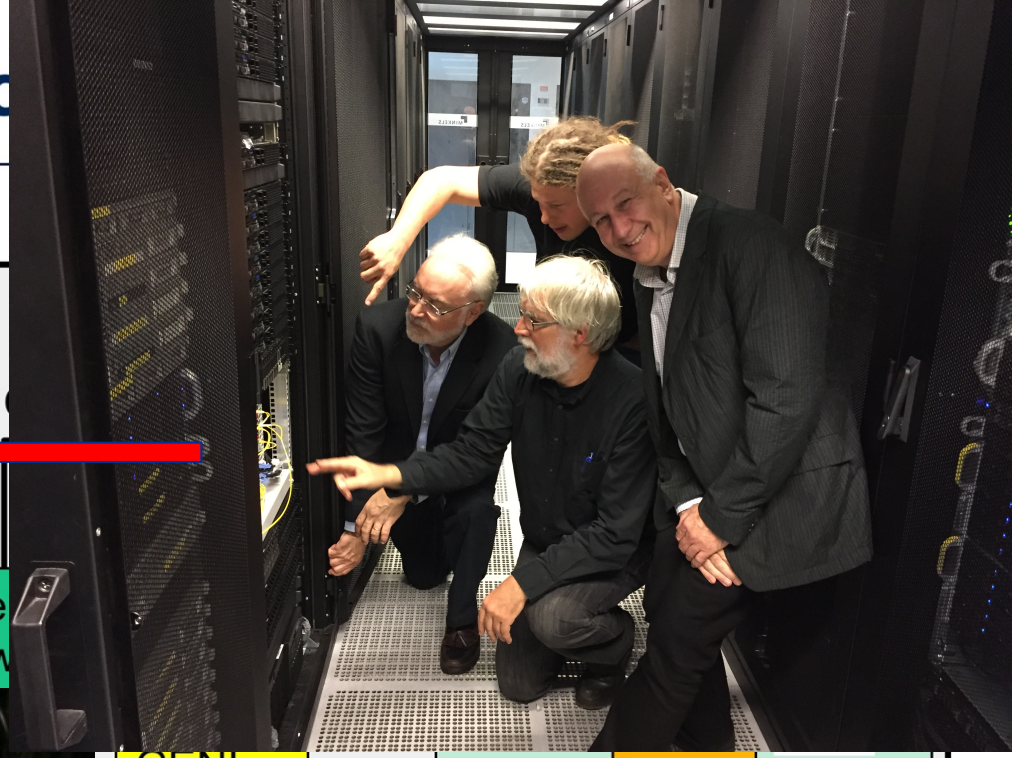


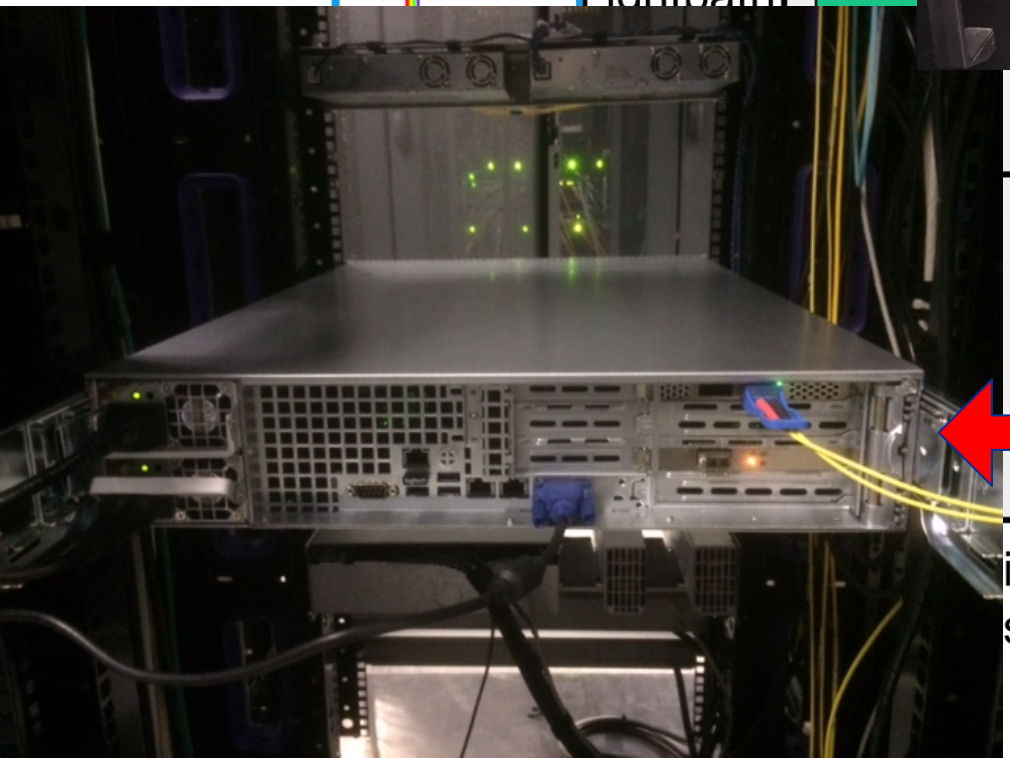
ing ICT preconditions:
saged site has similar elements

AIRFRANCE KLM

AF/KLM FieldLab

Ambition to put c





GENI Rack

Private & Secure Collaboration

Appli ation & Service chai deployed in vate and secure Internet slices

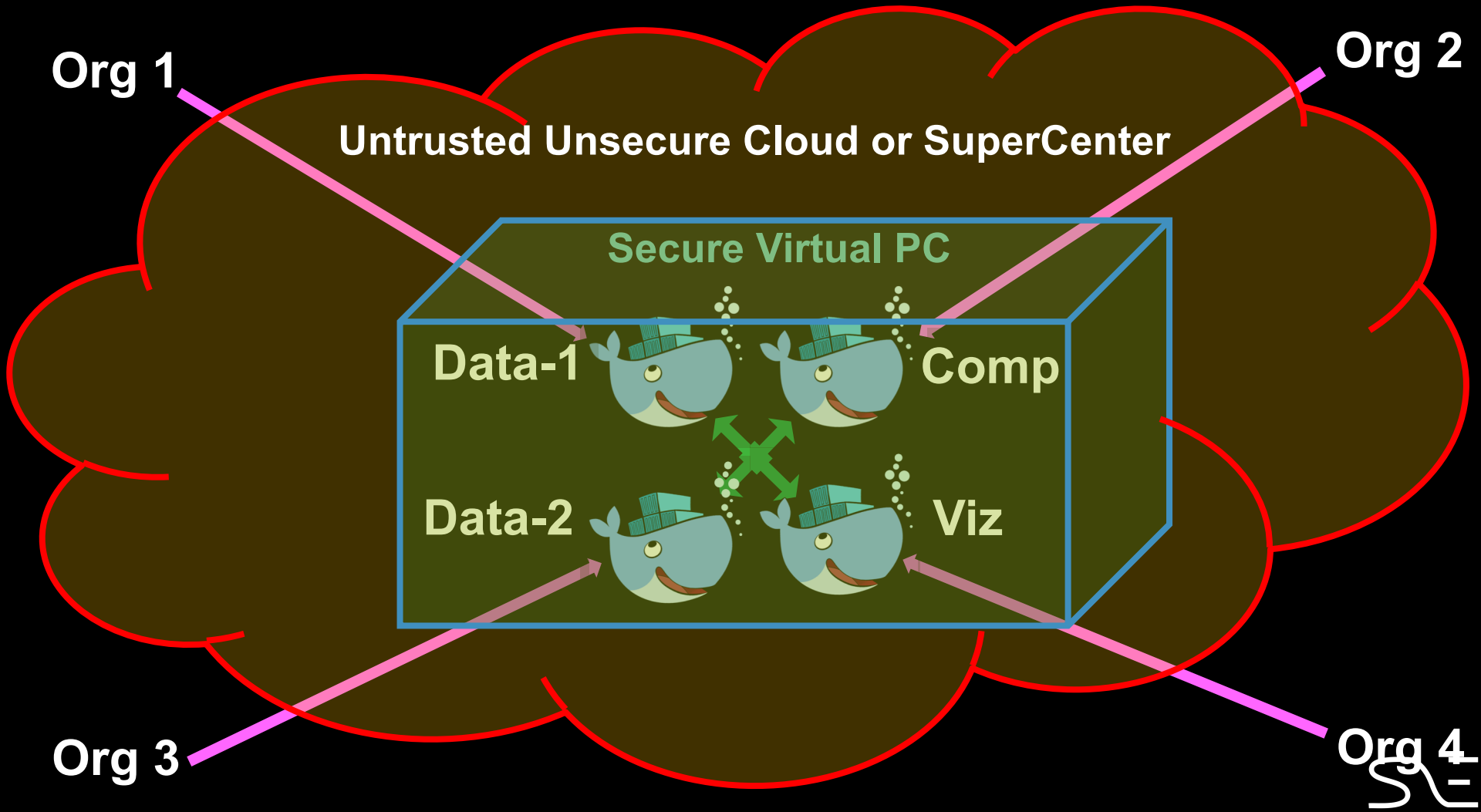
AF KLM

ing ICT preconditions:
saged site has similar elements

AIRFRANCE KLM

Secure Policy Enforced Data Processing

- Bringing data and processing software from competing organisations together for common goal
- Docker with encryption, policy engine, certs/keys, blockchain and secure networking
- Data Docker (virtual encryped hard drive)
- Compute Docker (protected application, signed algorithms)
- Visualization Docker (to visualize output)



SC16 Demo

DockerMon

Sending docker containers with search algorithms to databases all over the world.

http://sc.delaat.net/sc16/index.html#5

Container-based remote data processing

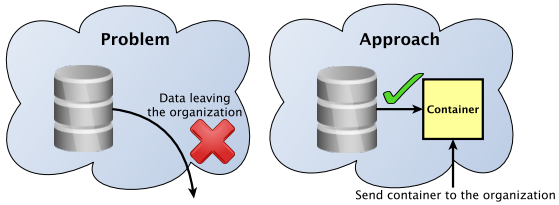
Universiteit van Amsterdam

Łukasz Makowski, Daniel Romão, Cees de Laat, Paola Grosso
System and Networking Research Group, University of Amsterdam

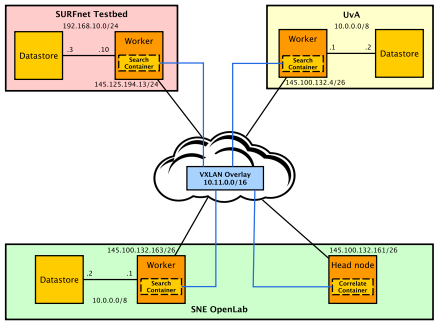
System and Network Engineering

Problem Description

- Scientific datasets are usually made publicly available
  ….but data cannot always leave the organization premises
- On-site data processing can be challenging because of incompatibility of systems or lack of manpower
- Can a container-based system perform remote on-site data processing efficiently?
- What are the networking issues to solve?



Underlay and Overlay



Main features:

- Networked containers
- VXLAN overlay
- Containers that perform data retrieval and computation
- Containers built on-demand
- On-site data processing
- Distributed data source
- Multiple sites with datasets

The Game

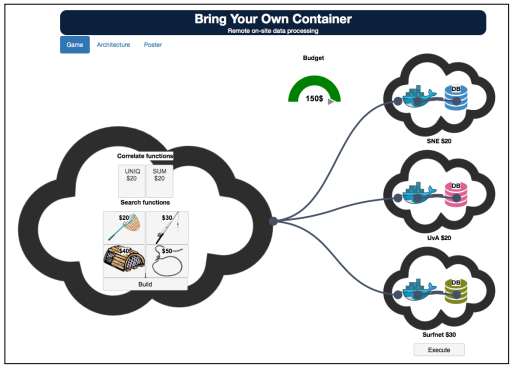
Our SC16 demo is a gamification of the remote dataset processing architecture.

How many different animal species can you find?
You have a fixed budget and each function and processing will cost you money!

In our game you will:

- Select a correlate function to combine the results of the different sites.
- Pick different search functions, represented as tools, to find animals in the remote datasets.
- Build containers with the search and correlate functions.
- Execute the containers on the sites of your choice.

Will you have the best score?

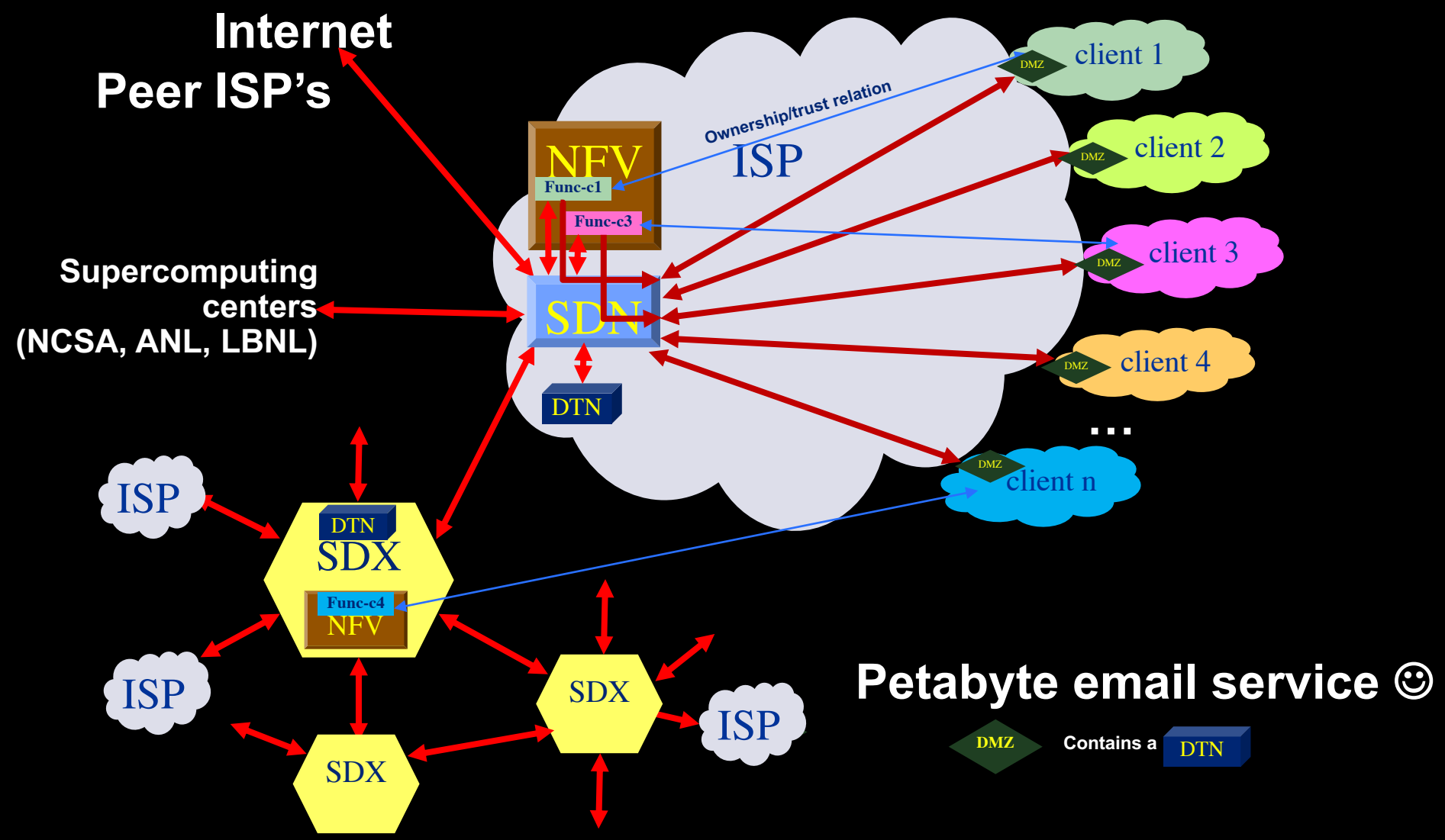


More information:

- http://byoc.lab.uvalight.net/info
- http://sne.science.uva.nl/sne/gigaport3
- http://delaat.net/sc

SURFNET

Networks of ScienceDMZ's & SDX's



Data Hub System Applicability

Industry

- Cross Cutting Field lab
- Innovation with SURF

Science

- European Open Science Cloud
- FAIR model
  - Findable – Accessible – Interpretable - Reusable

Society

- Smart Cities & Arena
- Streaming Data Decision Support

Q&A

- More information:
  - http://delaat.net/sarnet
  - http://delaat.net/dl4ld