SARNET: Secure Autonomous Response Networks

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Marc Lyonnais, Gauravdeep Shami, Cees de Laat

System & Network Engineering
University of Amsterdam

Supported by NWO and C2D grants
SARNET, DL4LD and NWA VWDATA.

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UNIVERSITY OF AMSTERDAM

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

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

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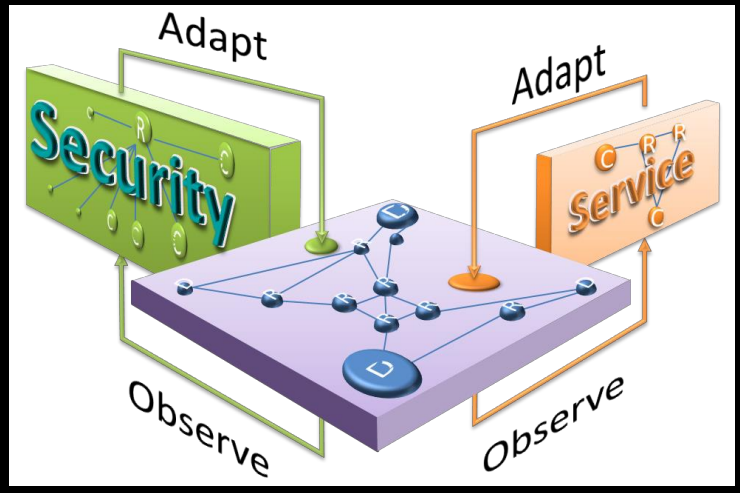
Cyber security program SARNET



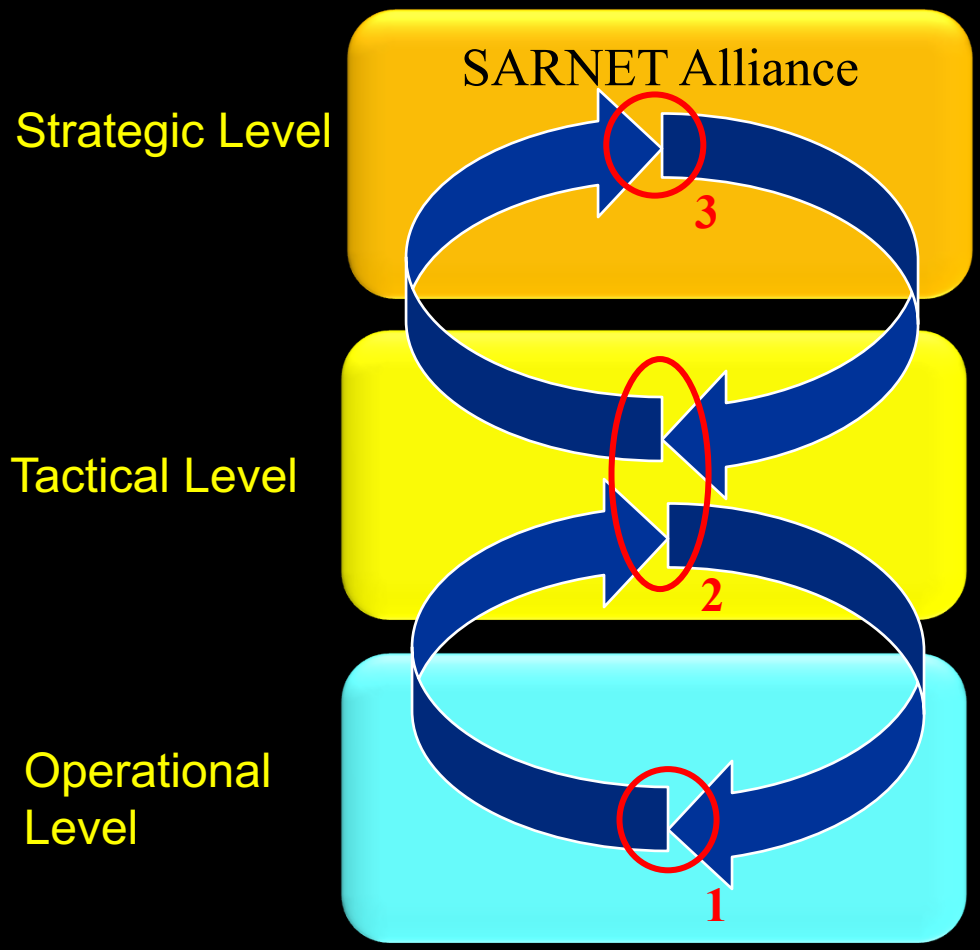
Research goal is to obtain the knowledge to create ICT systems that:

- 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

Laboratory: ExoGeni & PRP
Fieldlab with KLM & CIENA
OSA-Optical Forum Conference paper [1]

CoreFlow
Berkeley Internship 2016/2017
SC16 INDIS workshop paper [2]
TNC short paper [4]

IEEE NetSoft paper [5]

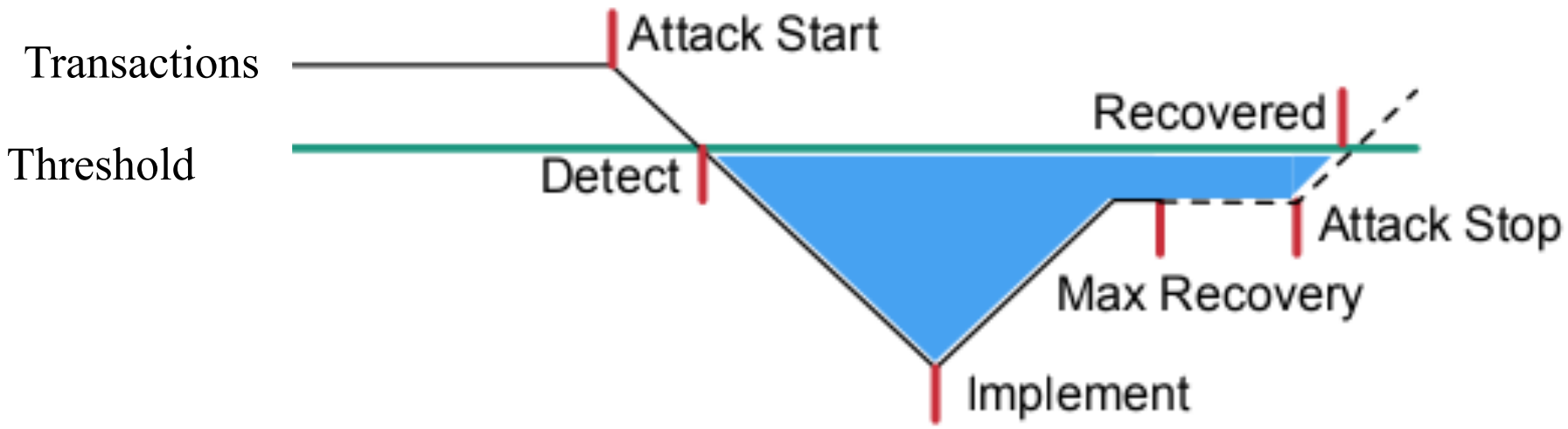
SC15 demo/poster <delaat.net/sc16>
Austin (TX)
Sec-Virtnet paper [3]

SC16 demo/poster <delaat.net/sc16>
Salt Lake City (UT)
IEEE Sec-Virtnet 2016 paper [3]

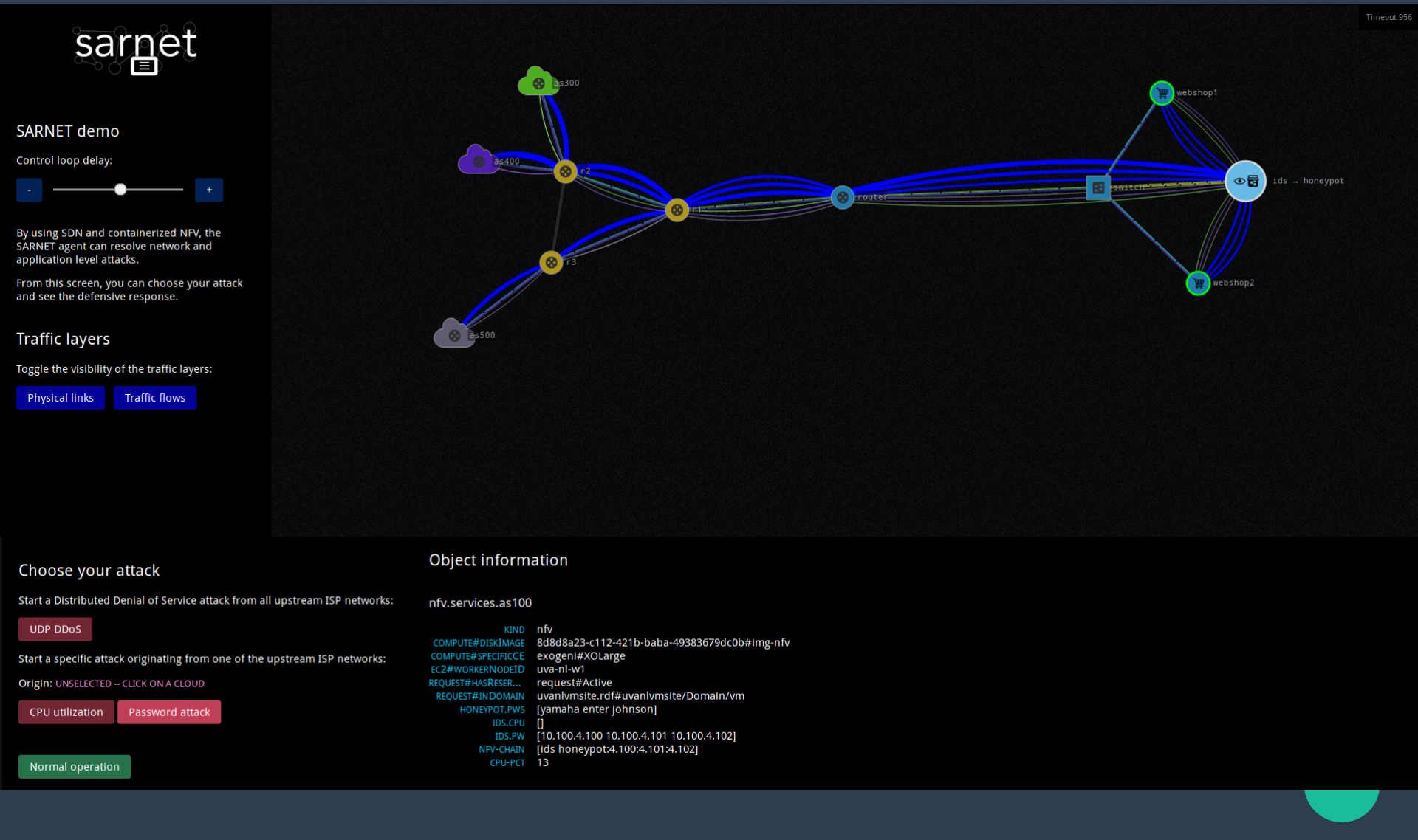
SC16 demo/poster <delaat.net/sc16>
Salt Lake City (UT)

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

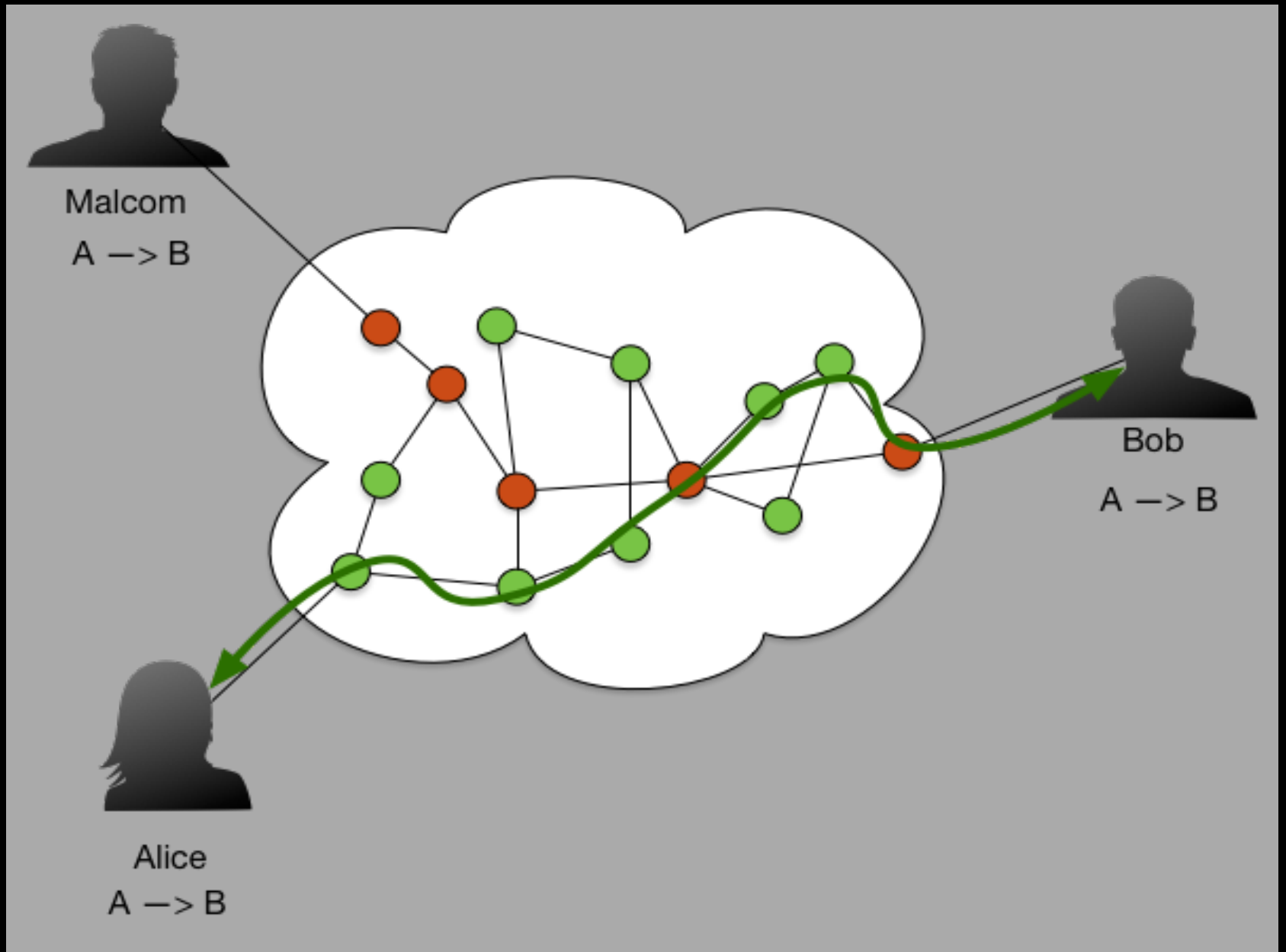


• Scenario


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

Example application: Spoofed Network Traffic



Analyse part: CoreFlow motivation

To effectively block attacks, the information from an IDS is not always sufficient

When an event triggers, the security team has to **manually collect** additional **data from different sources** to enrich the event to **create context and understanding** of the event.

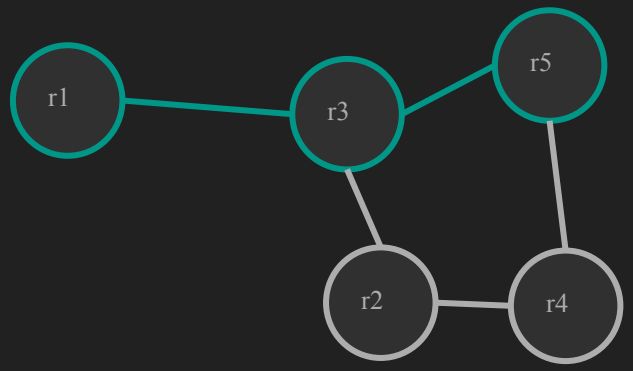
CoreFlow can auto this process by automatically correlating the security events to available data sources and provide this context.

In this prototype we focus on the following sources:

- **Bro** - Generates the events
- **NetFlow** - To add network traffic information
- **Route Explorer** - To assist in determining paths

CoreFlow Route estimation algorithm

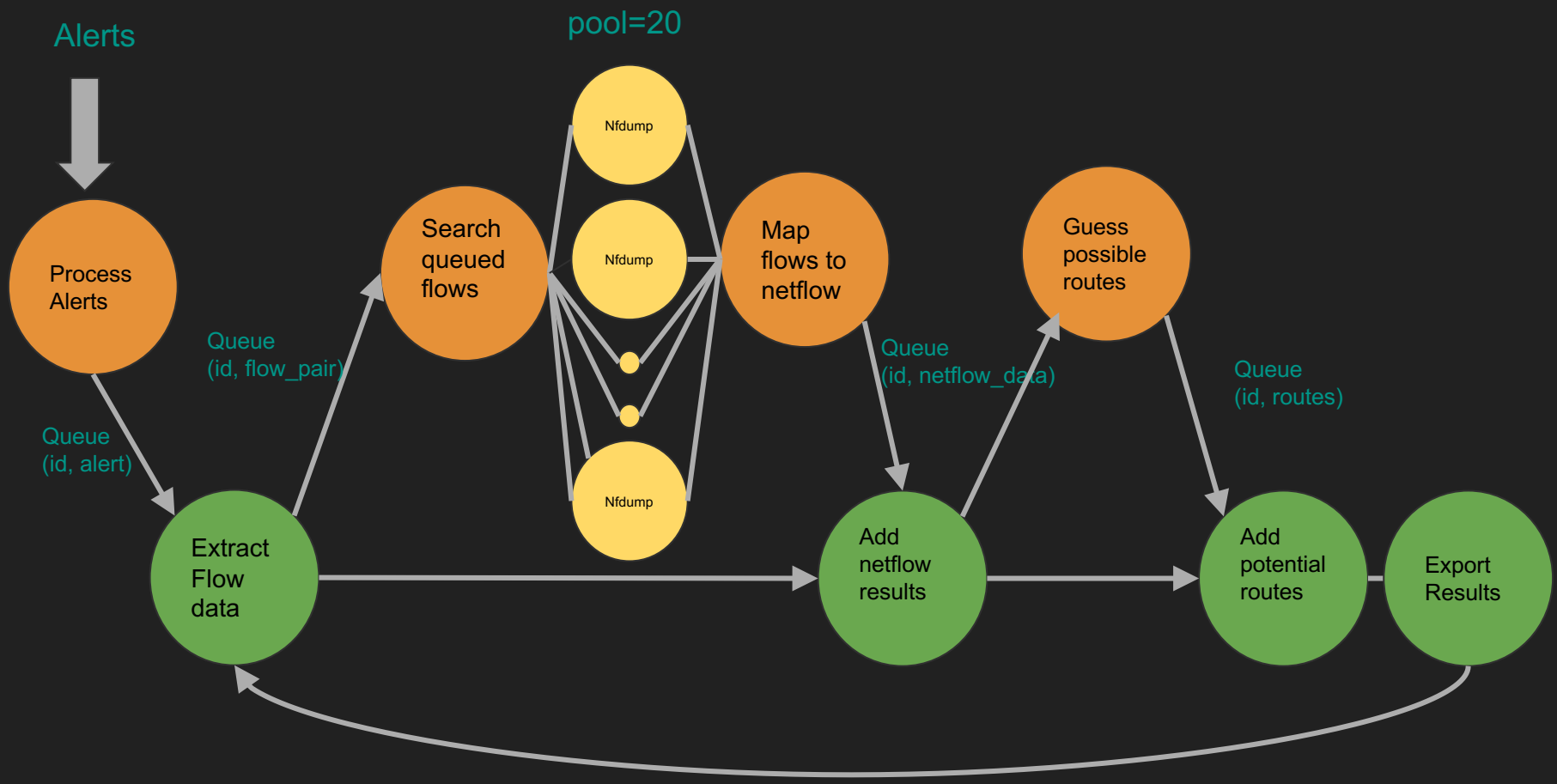
- It's able to fill in missing routers
- Flow traverse a router multiple times (loops)
- Finds potential 'shortest paths'



- 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	r1, r3	r1, r3, r1	r1, r3, r5
	r3, r5	r5, r3	r1, r3, r5	r5, r3, r1
	r3, r2	r2, r3	r1, r3, r2	
	r3, r5, r4	r4, r2, r3	r1, r3, r2, r4	
	r3, r2, r4	r4, r5, r3	r1, r3, r5, r4	
			…	

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.

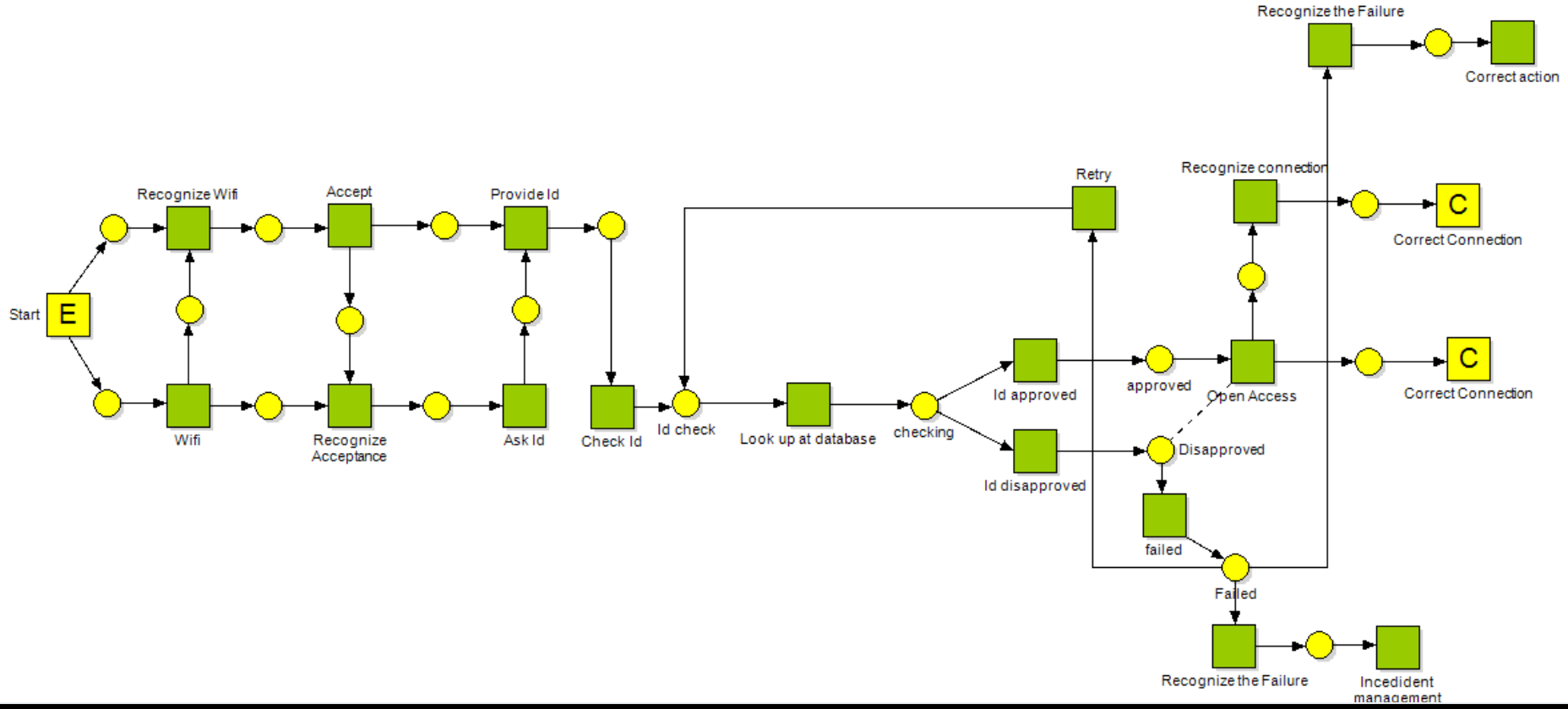
Agent Based Modelling Framework

	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:

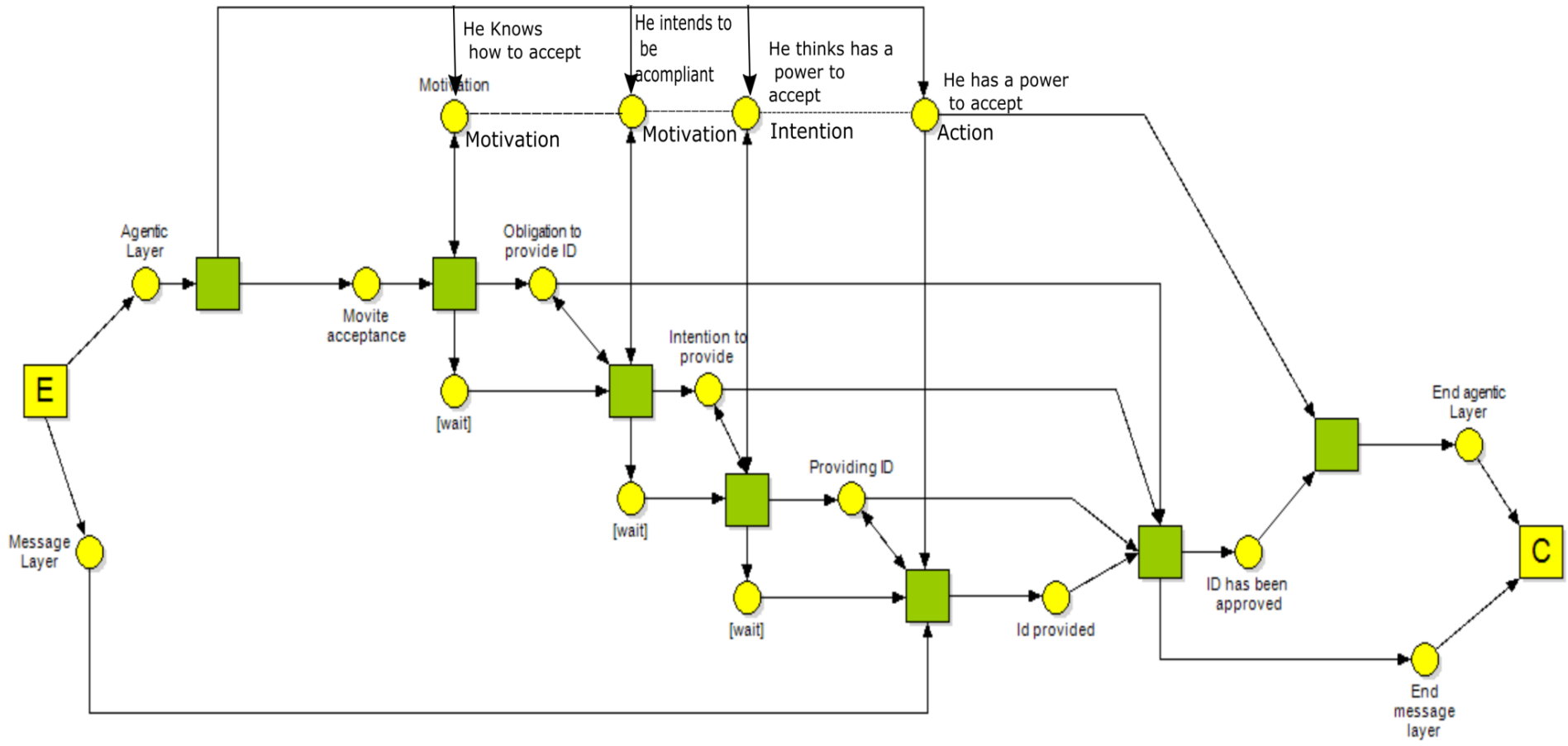
- the signal layer— describes acts, side-effects and failures showing outcomes of actions in a topology.
- the action layer—actions: performances that bring a certain result,
- the intentional layer—intentions: commitments to actions, or to build up intentions,
- the motivational layer—motives: events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

Simplified Eduroam case at signalling layer



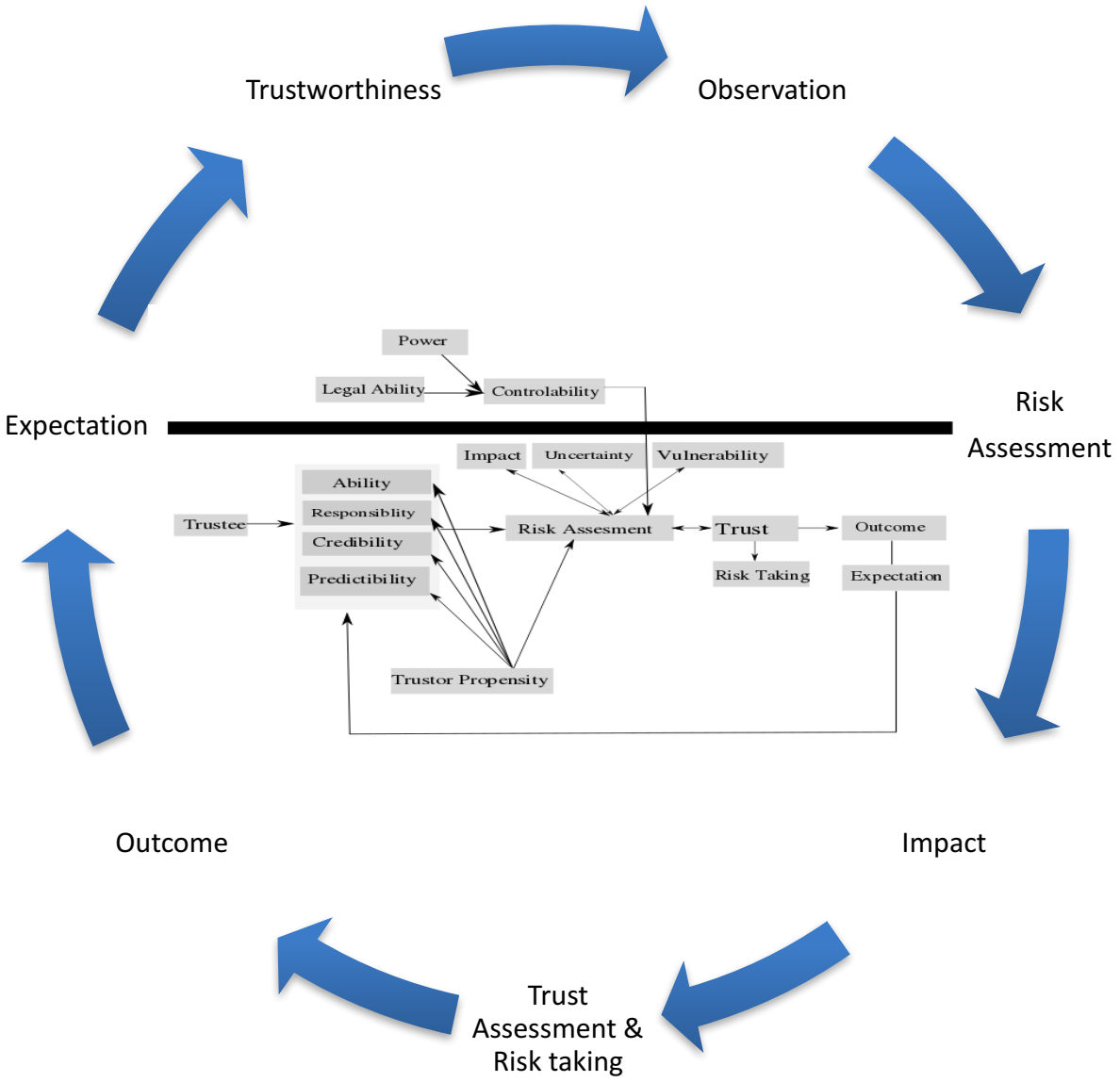
Petri net of EduRoam Case
(first step)

Describing Intentions, Motivations and Actions

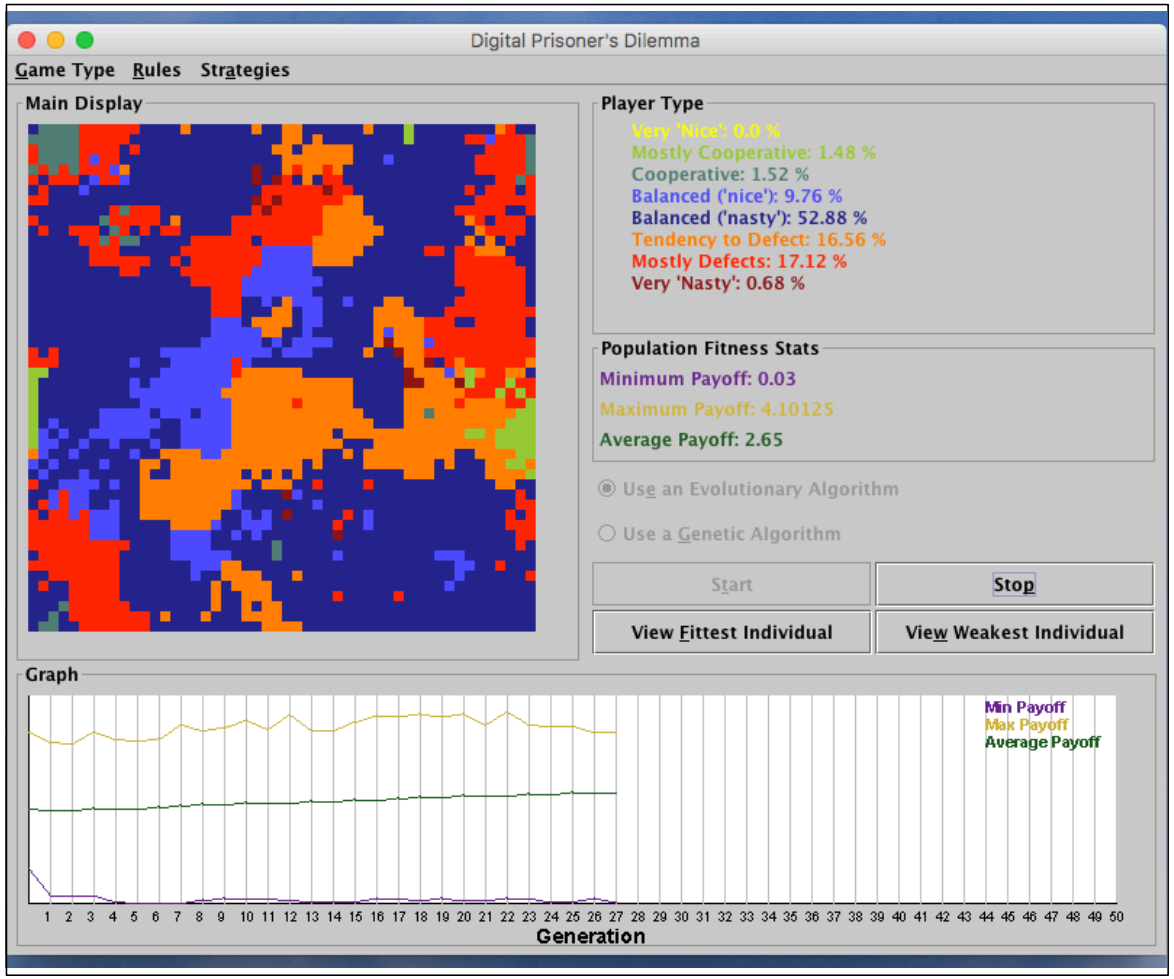


Petri net of EduRoam Case

Agent Model evaluating Trust



First step: Evolutionary Prisoners Dilemma using ABM Simulation



Agents choose from different strategies:

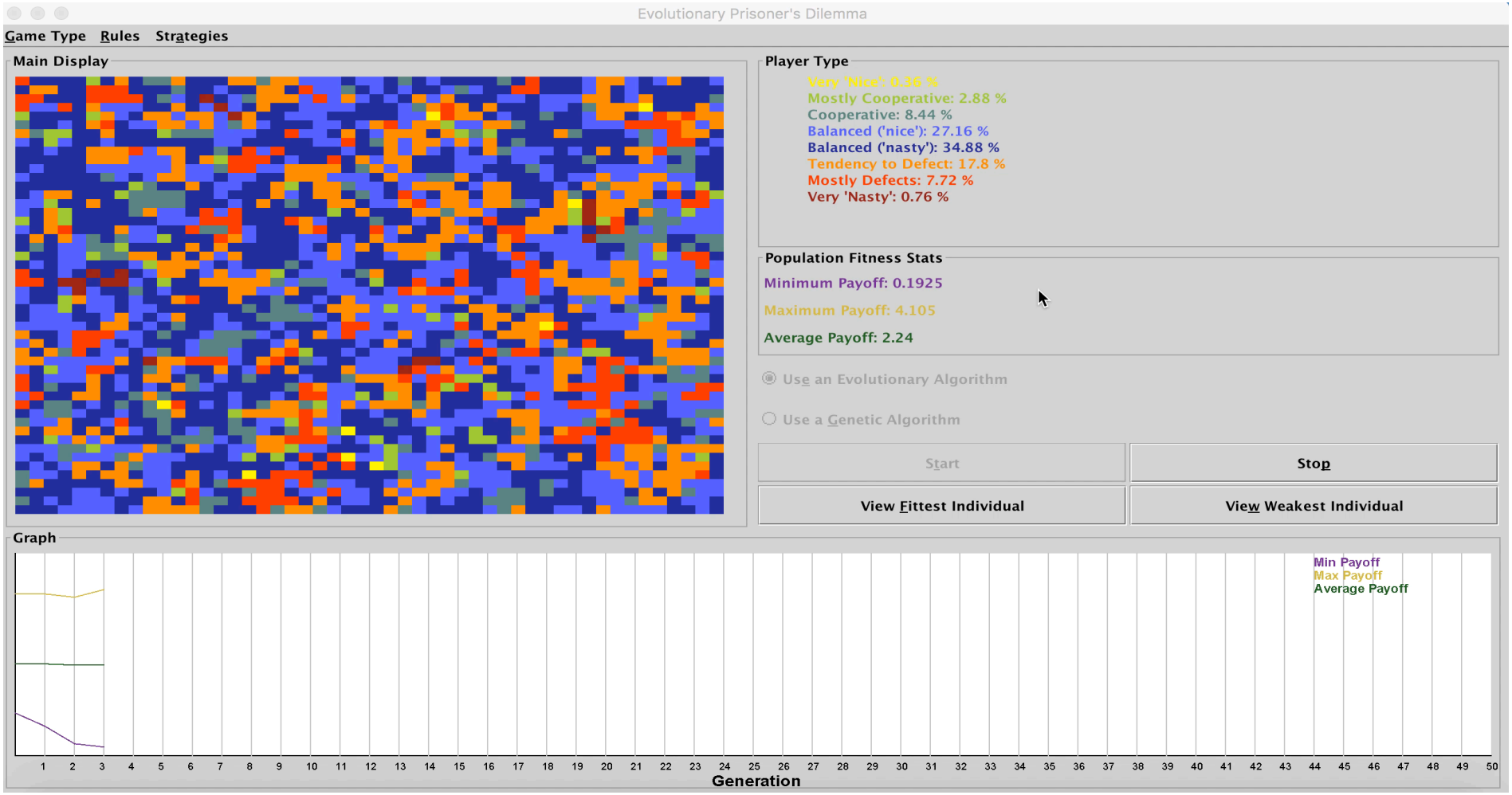
- Collaborate
- Defect
- During simulation: Agents predict next behavior of neighboring agents learned from observing past behavior.

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.

ABM Simulation



Ameneh Deljoo, Tom van Engers, Leon Gommans and Cees de Laat, "What is Going on: Utility-based Plan Selection in BDI Agents", KnowProS 2017 workshop, AAAI-17, San Francisco feb 5, 2017.

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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

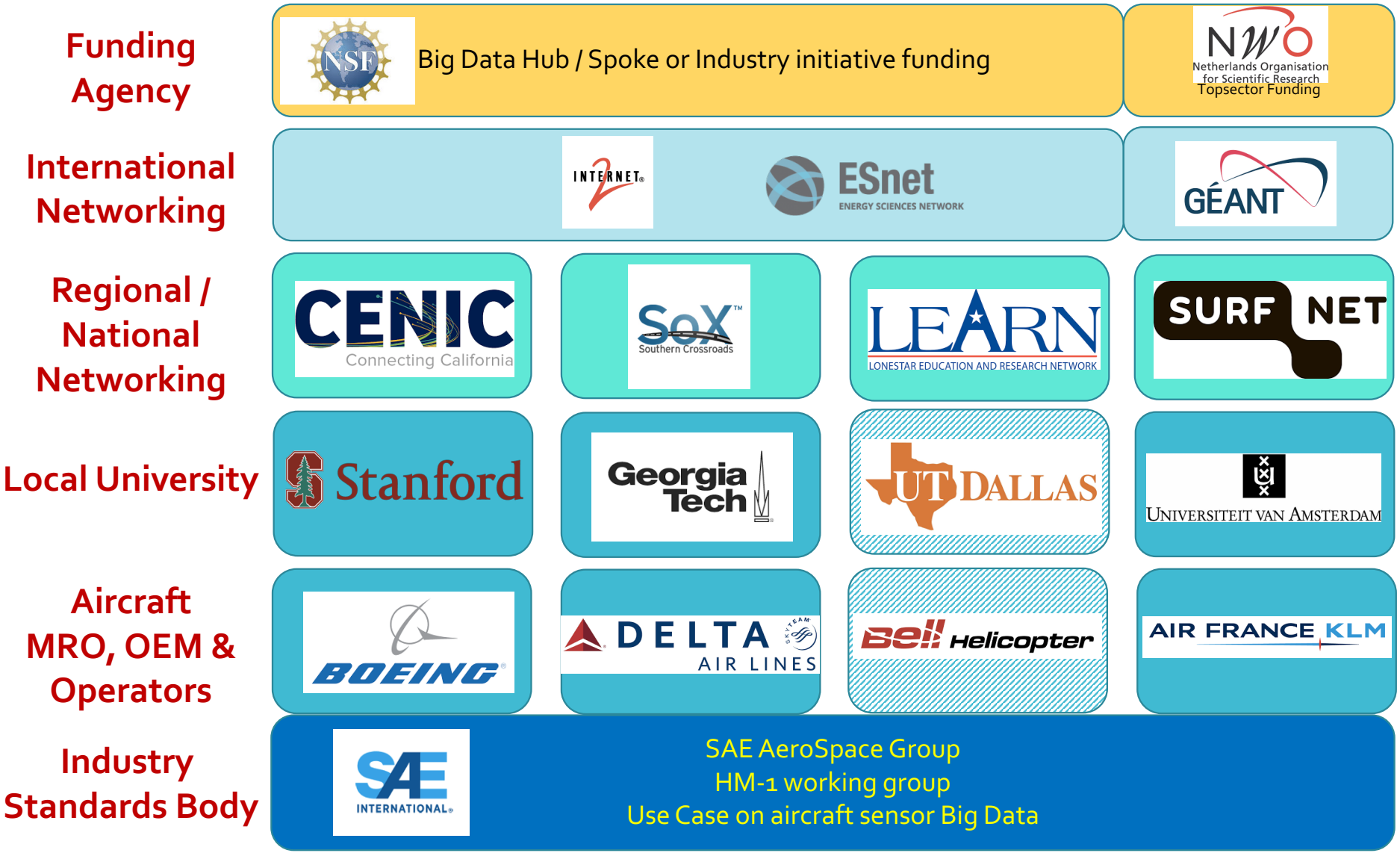
Cargo Logistics Data
(C1) DaL4LoD
(C2) Secure scalable policy-enforced distributed data Processing
(using blockchain)

NLIP iShare project

iSHARE
powered by NLIP

Cybersecurity Big Data
NWO COMMIT/
SARNET project
3.5 FTE

SAE Use Case envisaged research collaboration



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 + PEP technology

The VM Turntable Demonstrator

hitless remote rendering

Seattle

Toronto

Chicago

Starlight

Dynamic Lightpaths

Amsterdam

Netherlight

NYC

Grid05

VMs

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*

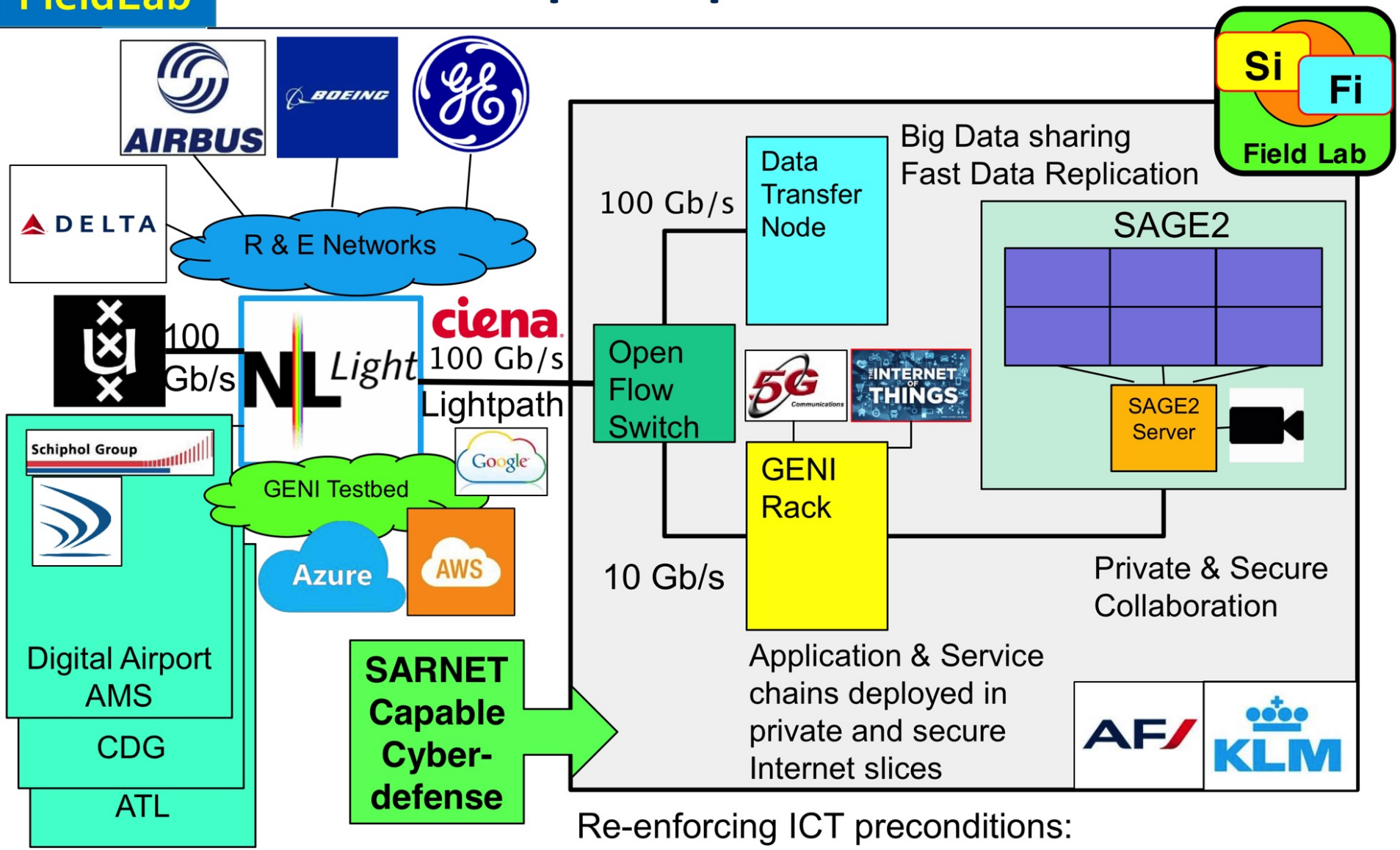
VM + Lightpaths across MAN/WAN are deemed a powerful and general alternative to RPC, GRAM approaches

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.

AF/KLM FieldLab

Ambition to put capabilities into fieldlab



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

AIRFRANCE KLM

AF/KLM FieldLab

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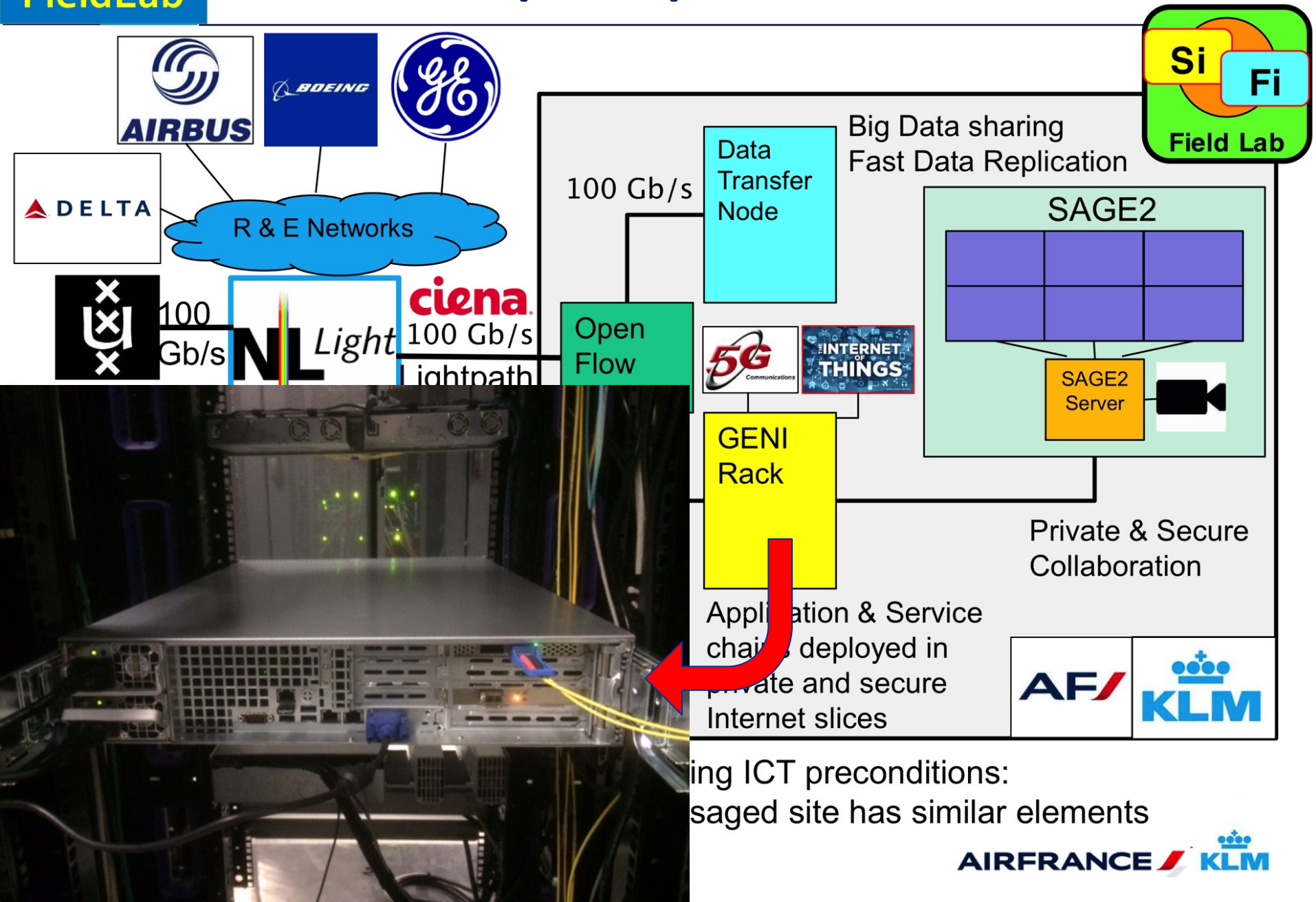
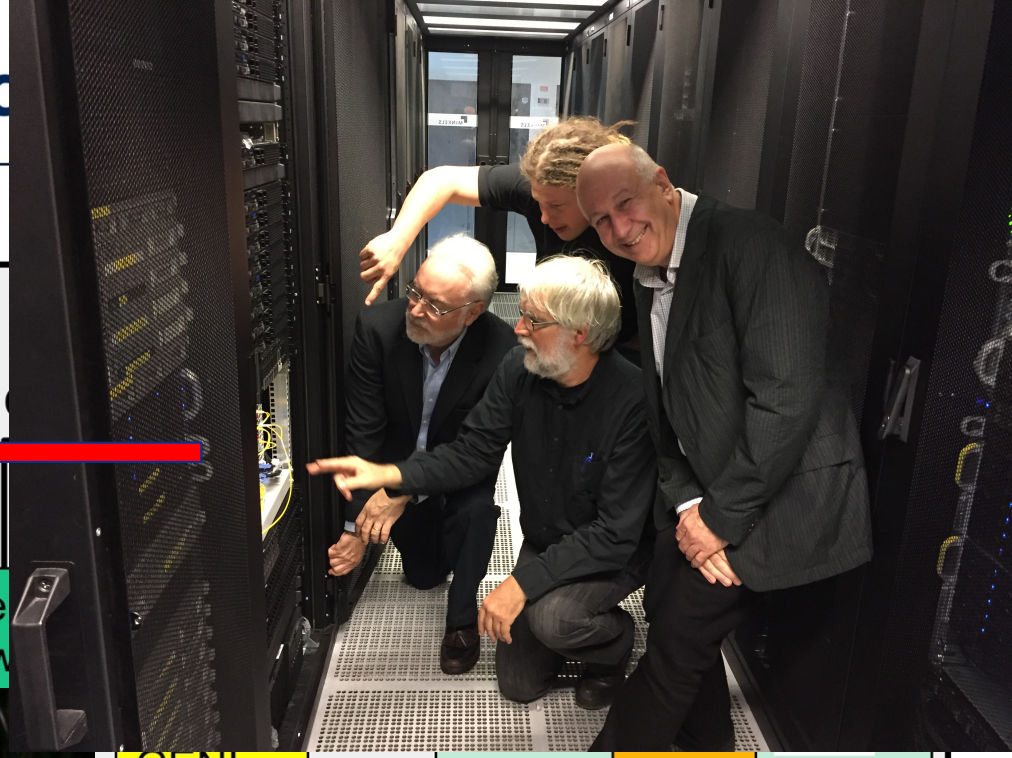


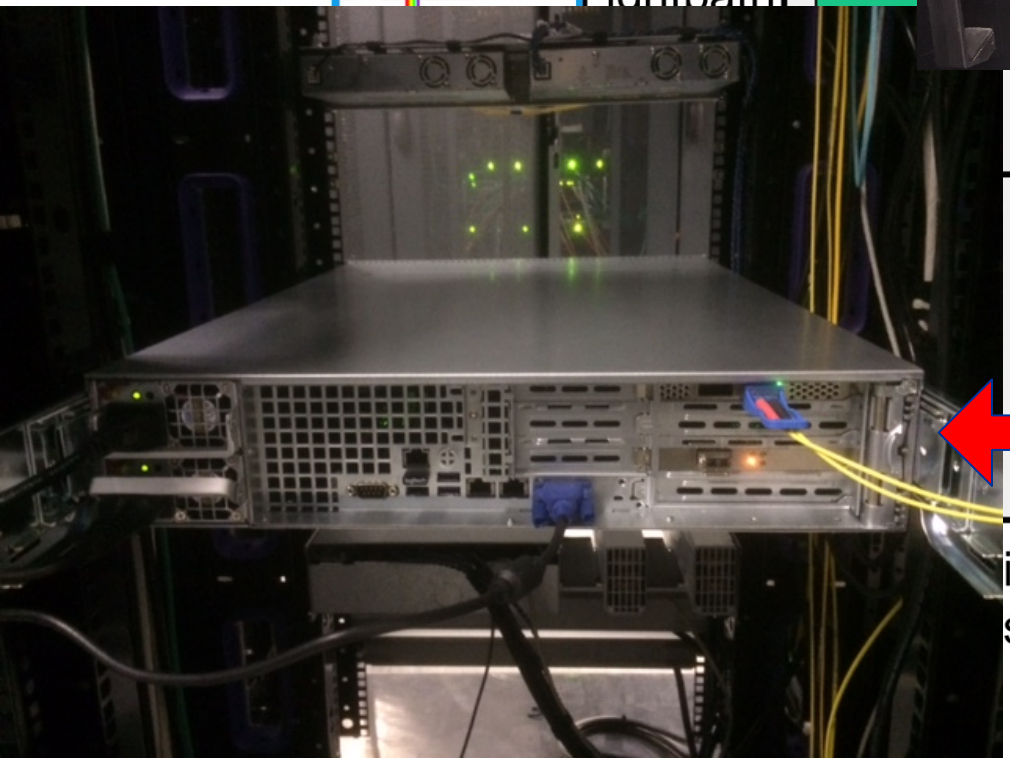
ing ICT preconditions:
saged site has similar elements

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

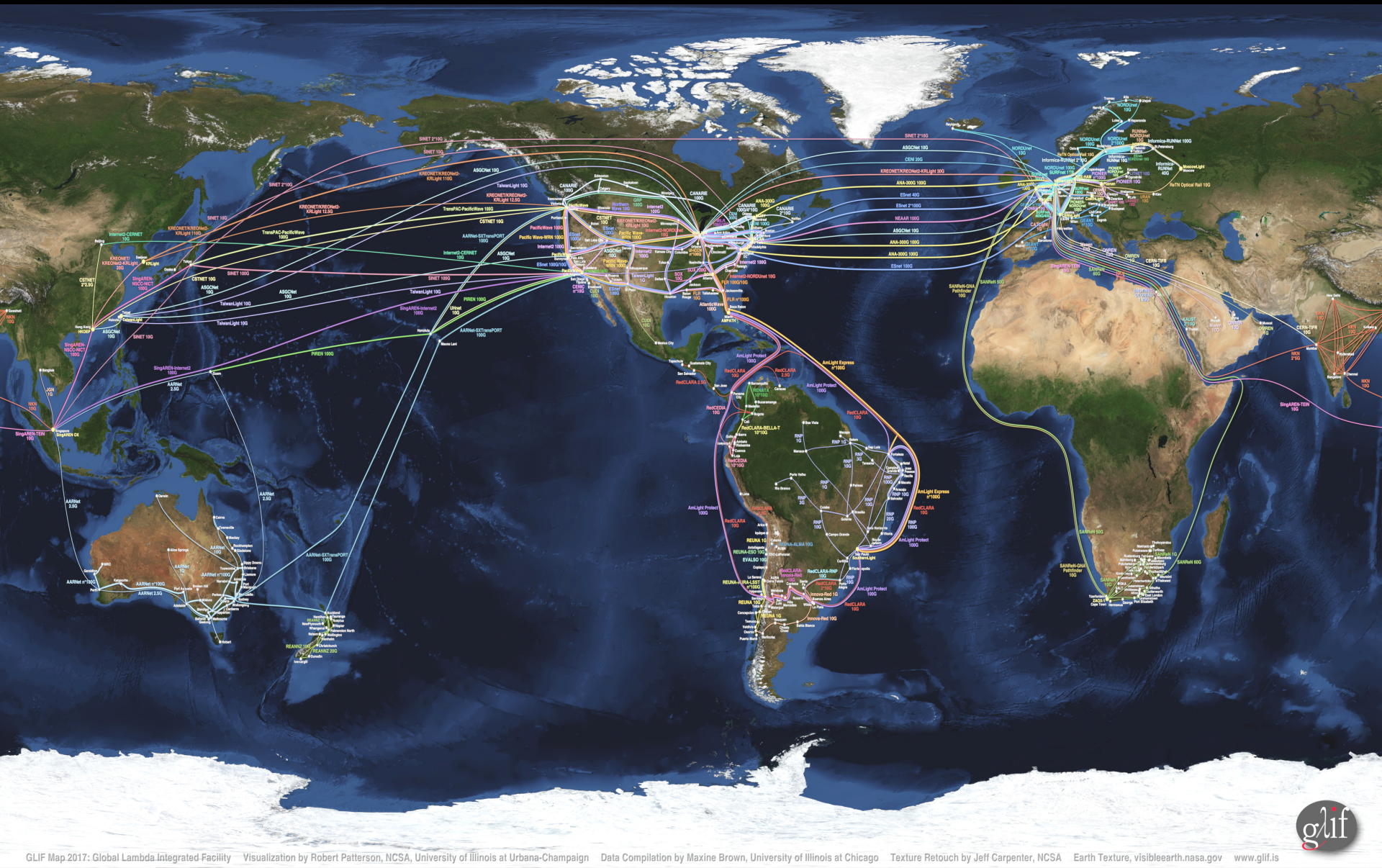
AF KLM

ing ICT preconditions:
saged site has similar elements

AIRFRANCE KLM

The GLIF – LightPaths around the World

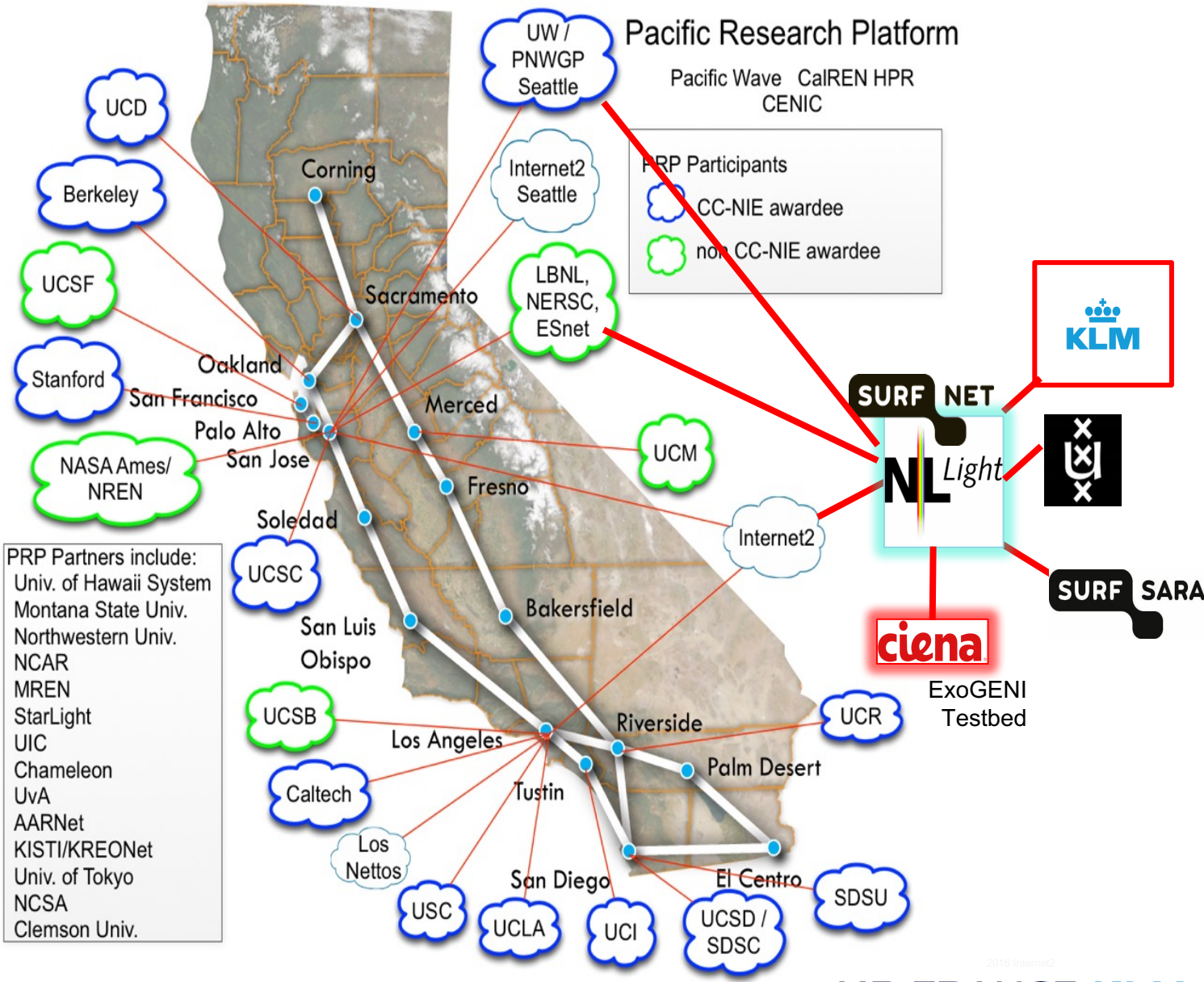
F Dijkstra, J van der Ham, P Grosso, C de Laat, "A path finding implementation for multi-layer networks", Future Generation Computer Systems 25 (2), 142-146.



GLIF Map 2017: Global Lambda Integrated Facility Visualization by Robert Patterson, NCSA, University of Illinois at Urbana-Champaign Data Compilation by Maxine Brown, University of Illinois at Chicago Texture Retouch by Jeff Carpenter, NCSA Earth Texture, visibleearth.nasa.gov www.glif.is

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

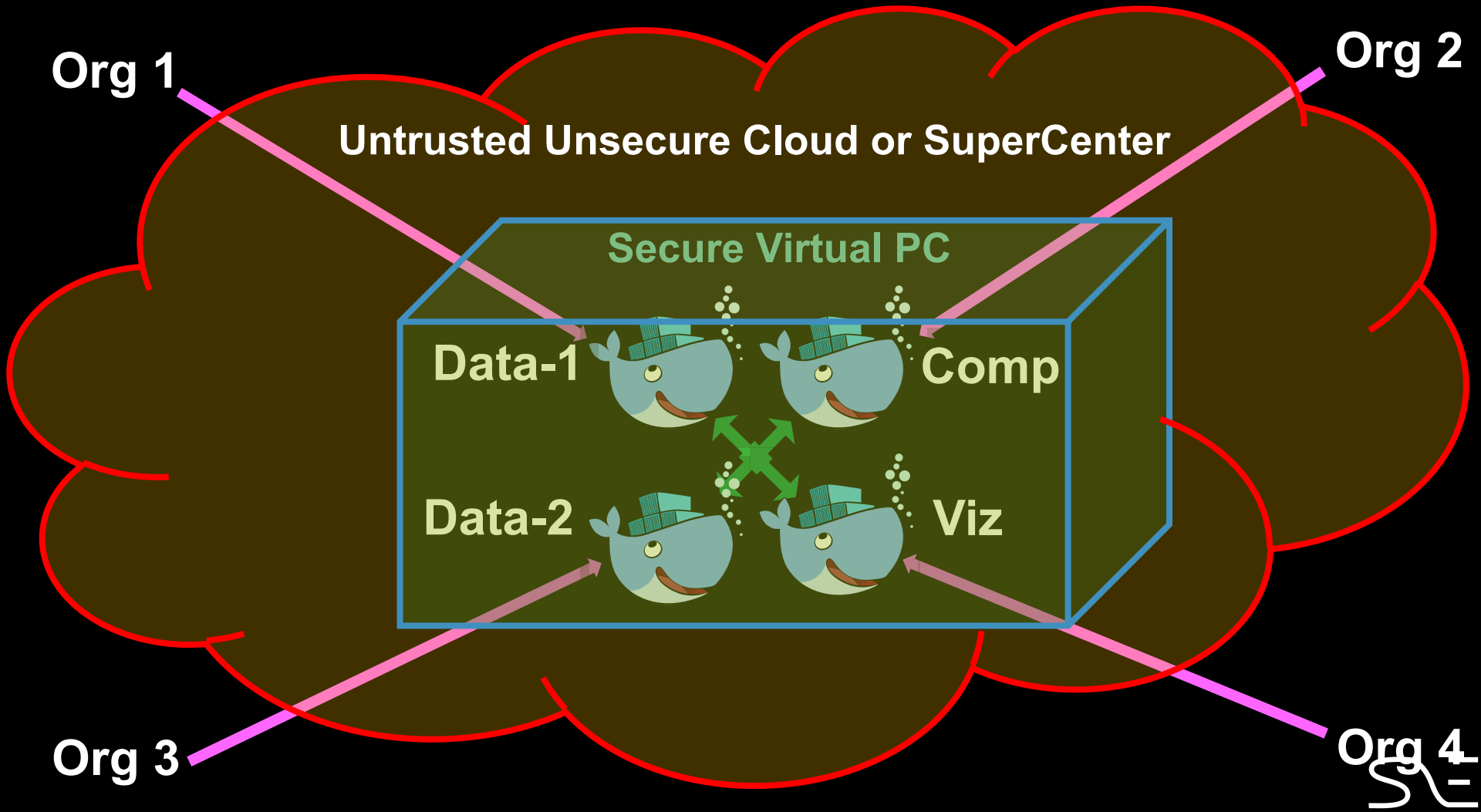
Note: this diagram represents a subset of sites and connections.

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 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)

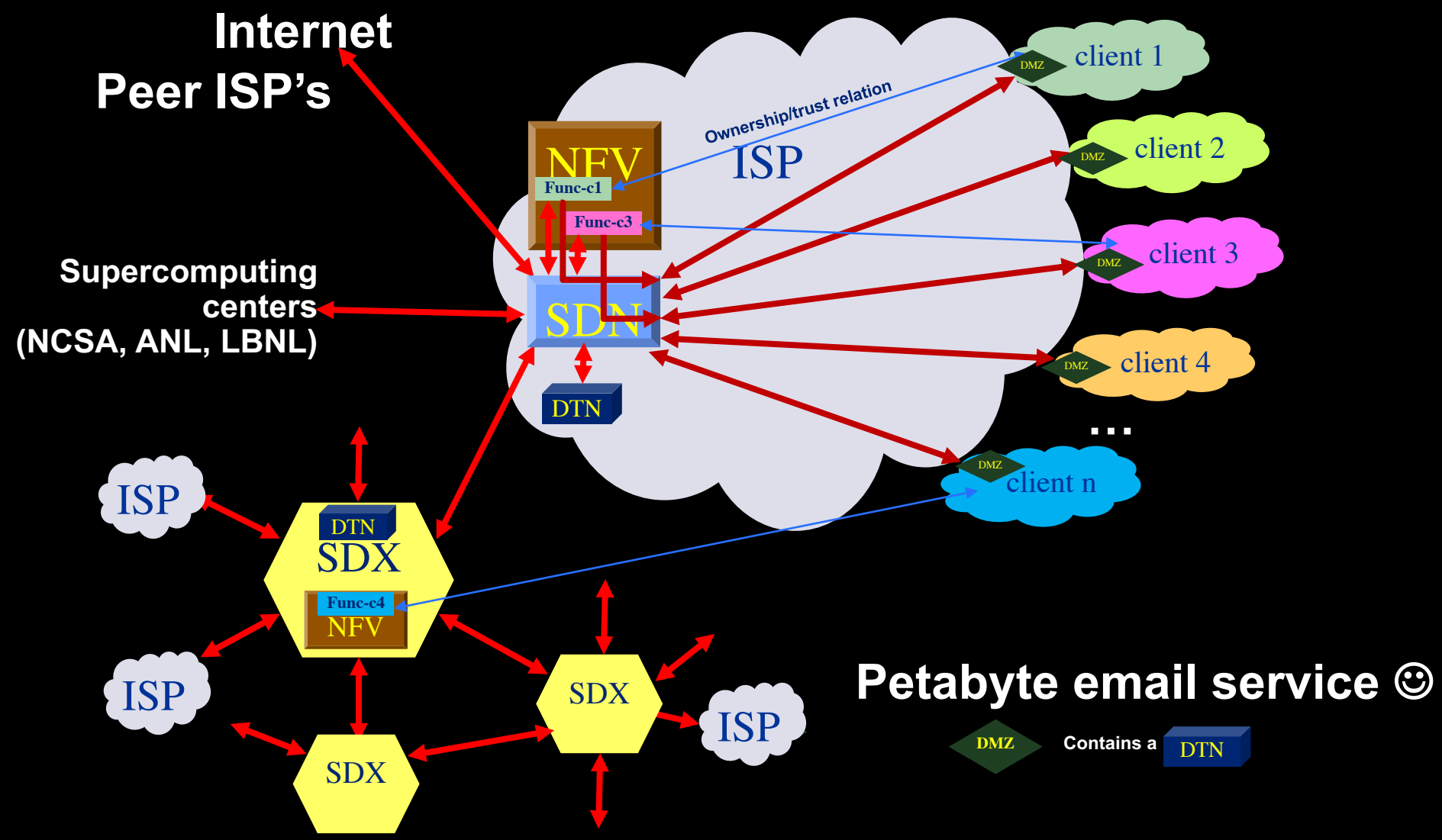


Q&A

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

BACKUP SLIDES FOLLOWING

Networks of ScienceDMZ's & SDX's



dutch digital delta

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

Validation Fieldlab and Dissemination

UVA - OpenLab

KLM
NetherLight
GENI
Fed4Fire
Cloud
SURFSARA
…

amsix
amsterdam internet exchange

NL Light

DataHub DTN

DataHub DTN

DataHub DTN

DataHub DTN

TNO - Intrepid

Smart Data
Factory
Innovations
Smart Rail
To-Grip
…

C2D – Big DataHubs

Arena
KAVE
AZURE
Use Cases
…

- Experimental facilities from day one!
- Proof of concepts demonstrating secure data sharing
- Blueprint, roadmap and standards where applicable
- Model for FAIR EOSC Infrastructure