

Globally Distributed Secure Data Exchange Fabrics

Cees de Laat

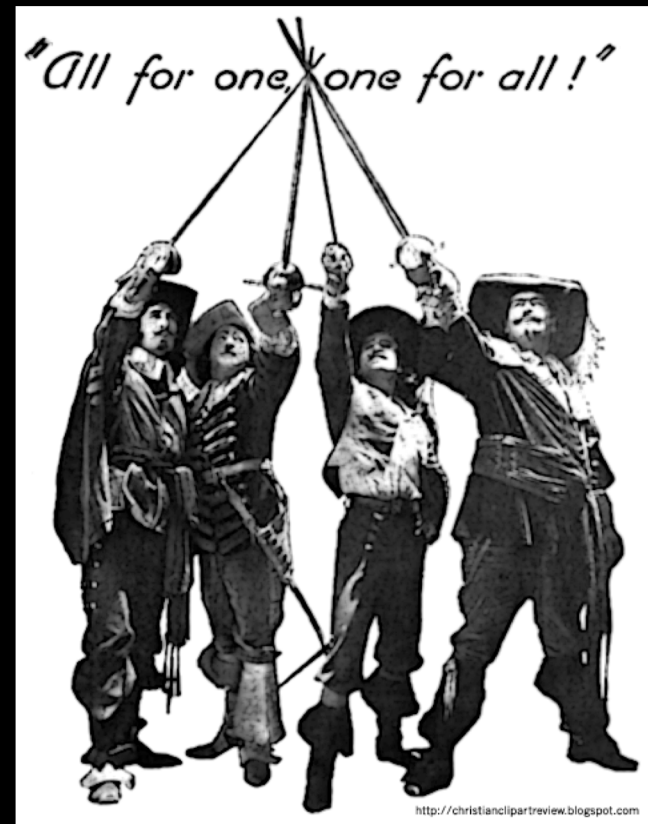
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Contributions from:

Leon Gommans, Paola Grosso, Wouter Los, Yuri Demchenko, Lydia Meijer, Tom van Engers, Sander Klous, Rodney Wilson, Marc Lyonais, Inder Monga, Reggie Cushing, Ameneh Deljoo, Sara Shakeri, Lu Zhang, Joseph Hill, Lukasz Makowski, Ralph Koning, Gleb Polevoy, Tim van Zalingen, and many others!



All for one and one for all



- All for one
 - Many infrastructures centered around compute and workflows
- One for all
 - Now we need to get a fluid data layer that frees data to be shared and used by (unforeseen) applications
- Efforts as FAIR and ScienceDMZ / DTN fabrics pave the way to solve the data problem that is also encountered by industry.

Harvard Business Review



Harvard Business Review

ECONOMY

Managing Our Hub Economy


by Marco Iansiti and Karim R. Lakhani

FROM THE SEPTEMBER–OCTOBER 2017 ISSUE

WHAT TO READ NEXT

The IT Transformation Health Care Needs

SUMMARY SAVE SHARE COMMENT 3 TEXT SIZE PRINT \$8.95 BUY COPIES



THOMAS M. SCHEER/EYEEM/GETTY IMAGES

I. The Problem

The global economy is coalescing around a few digital superpowers. We see unmistakable evidence that a winner-take-all world is emerging in which a small number of “hub firms”—including Alibaba, Alphabet/Google, Amazon, Apple, Baidu, Facebook, Microsoft, and Tencent—occupy central positions. While creating real value for users, these companies are also capturing a disproportionate and expanding share of the value, and that’s shaping our collective economic future. The very same technologies that promised to democratize business are now threatening to make it more monopolistic.

Data value creation
monopolies



Create an equal
playing field



Sound Market
principles

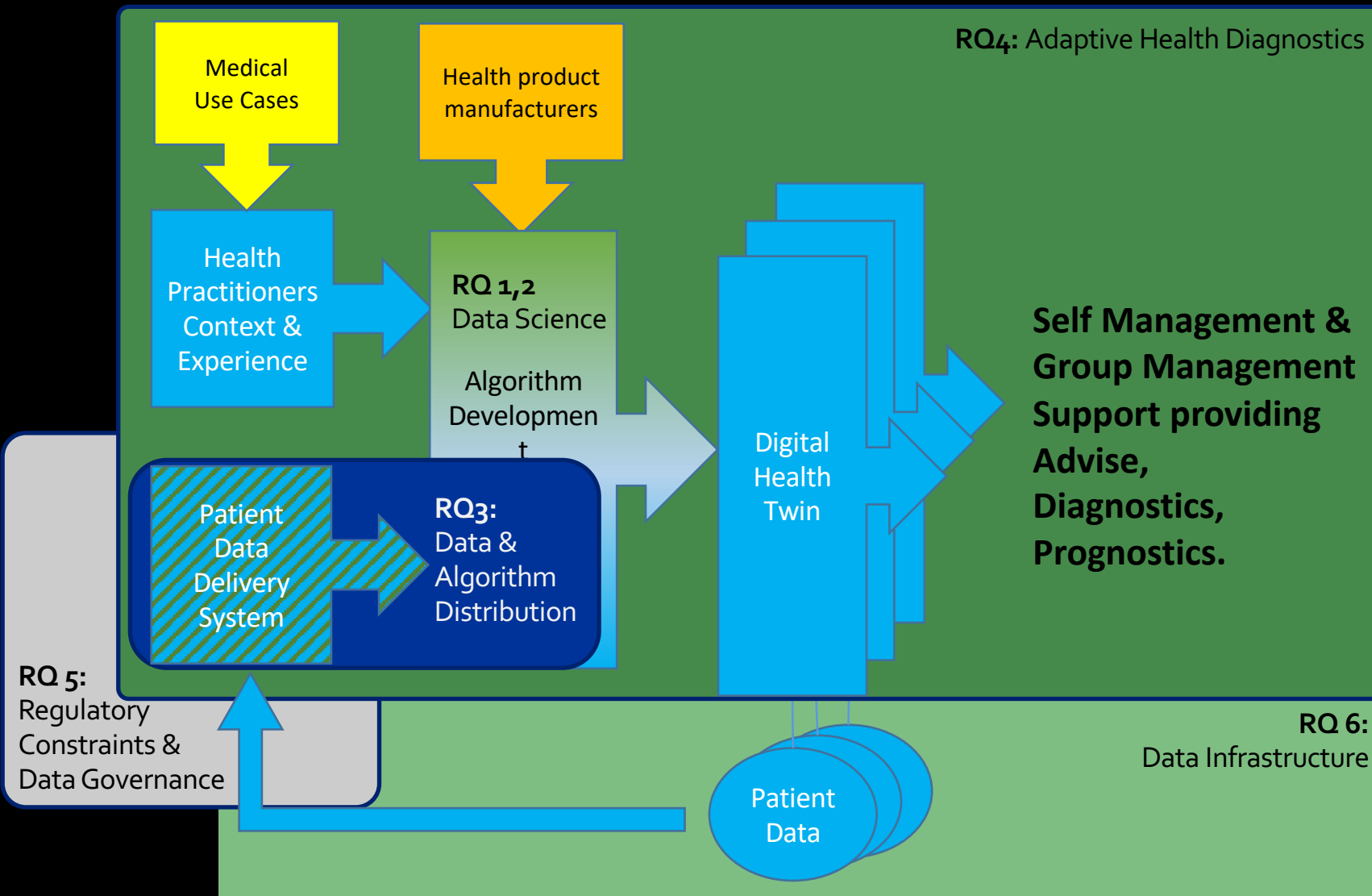
<https://hbr.org/2017/09/managing-our-hub-economy>

Main problem statement

- There is lots of data out there that is not shared (99%)
- FAIR is typically not fair ;-), but limited by policy and/or law
 - the A in FAIR is about access, trust is hard to implement across domains
- Organizations that normally compete have to bring data together to achieve a common goal/benefit!
- The shared data may be used for that goal but not for any other!
- Expected use is fine but unexpected use/mission creep...
- Data processed by alien algorithms in foreign data centers... Hmmm...
 - How to organize data processing alliances?
 - How to enforce policy using modern Cyber Infrastructure?
 - How to translate law policy from strategic via tactical to operational level?
 - What are the different fundamental data infrastructure models to consider?

Health Use Case

Enabling Personal Interventions



The overall aim of this project is to explore the use and effectiveness of data driven development of scientific algorithms, supporting personalized self- and joint management during medical interventions / treatments.

The key objective is to use data science promoting health practically with data from various sources to formulate lifestyle advice, prevention, diagnostics, and treatment tailored to the individual and to provide personalized effective real-time feedback via a concept referred in this proposal as a digital health twin.

Big Data Sharing use cases placed in airline context



Global Scale



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

National Scale



Cargo Logistics Data
(C1) DL4LD
(C2) **Secure scalable policy-enforced distributed data Processing**
(using blockchain)



Cybersecurity Big Data
NWO COMMIT/
SARNET project
3.5 FTE

City / regional Scale

Campus / Enterprise Scale

NLIP iShare project



iSHARE
powered by NLIP

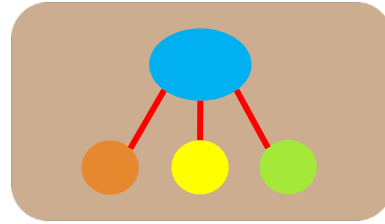
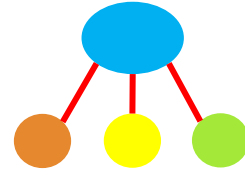
<https://delaat.net/dl4ld>

RESEARCH WORKING ALONGSIDE IT INDUSTRY

NETWORK RESEARCH INFRASTRUCTURES

COMMERCIAL DATACENTER INFRASTRUCTURE AS NEUTRAL GROUND

Data Sharing Infrastructure Model
Research using Future Internet capabilities

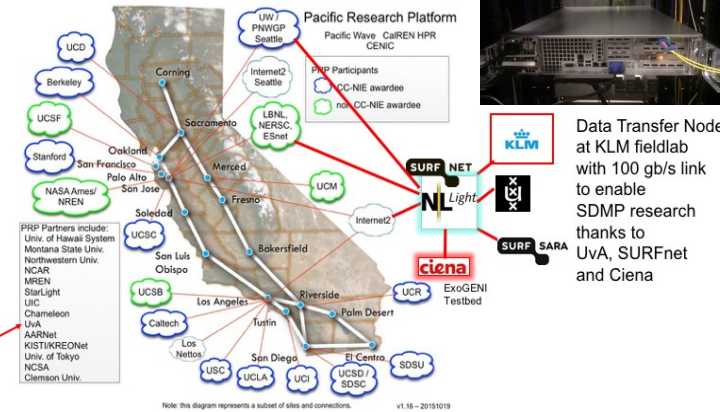


Goal: How to create a Digital Marketplace Ecosystem



prp.ucsd.edu

As foundation of the National Research Platform

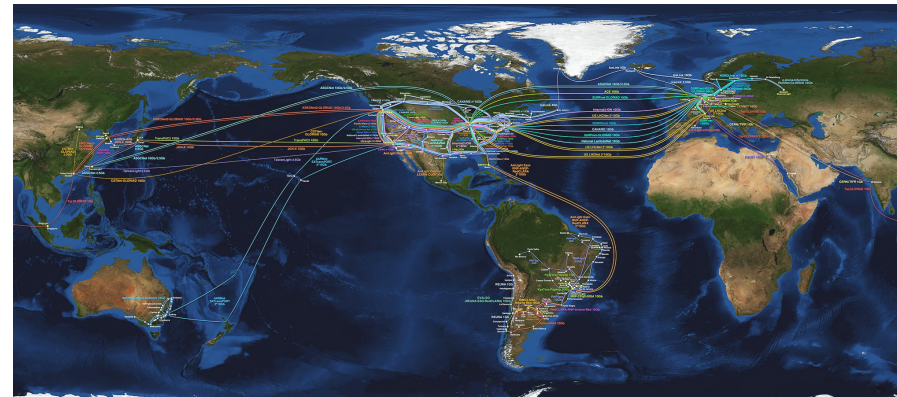


AM3 and AM4 Datacenters Science Park Amsterdam

SV10 Datacenter Silicon Valley



Global Lambda Integrated Facility →



SAE Use Case envisaged research collaboration



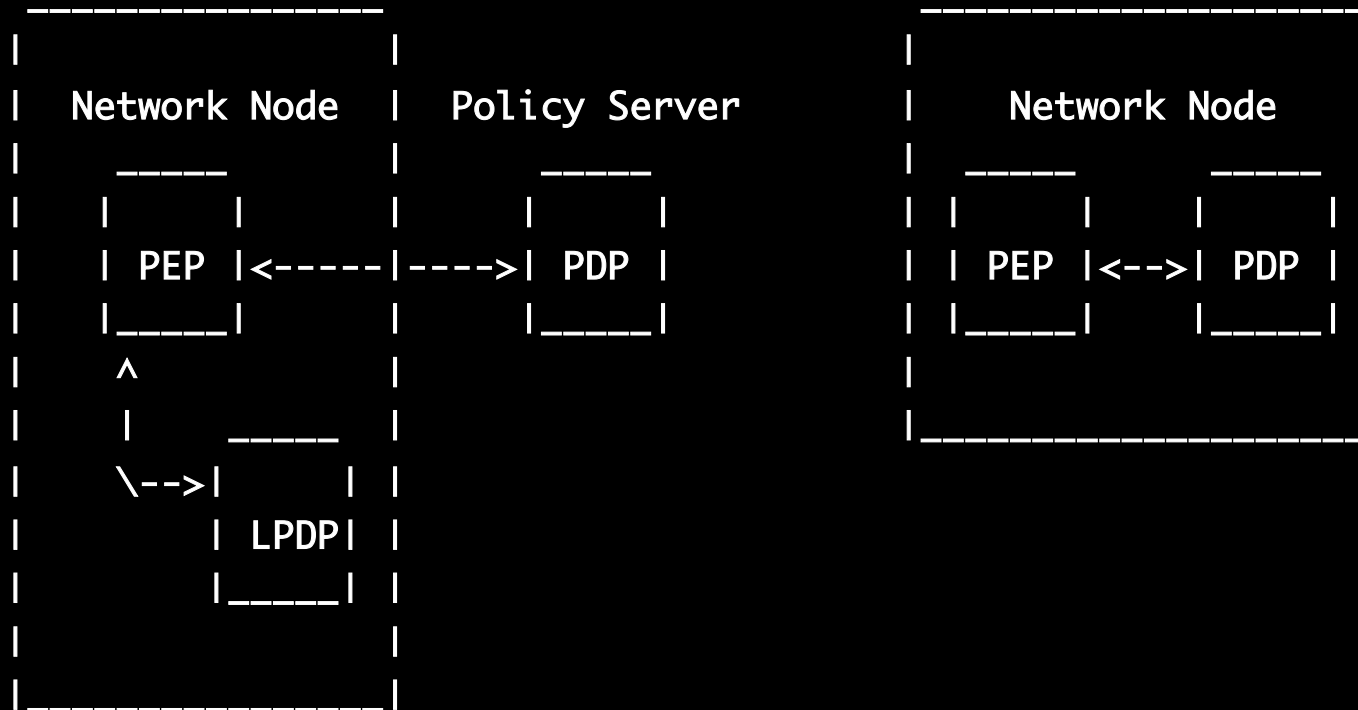
Approach

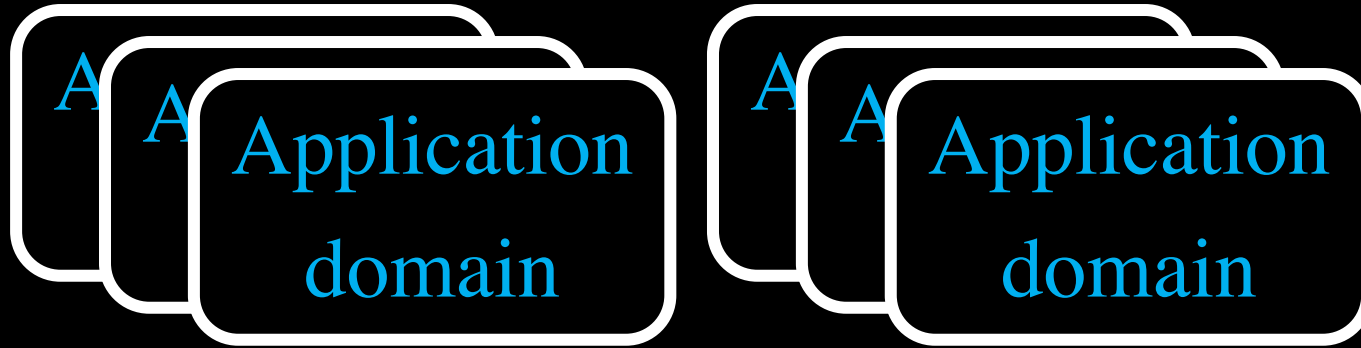
- Strategic:
 - Translate legislation into machine readable policy
 - Define data use policy
 - Trust evaluation models & metrics
- Tactical:
 - Map app given rules & policy & data and resources
 - Bring computing and data to (un)trusted third party
 - Resilience
- Operational:
 - TPM & Encryption schemes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



IETF: Common Open Policy Service (COPS)

- Rfc 2748, 2753, 4261





AmDex

Data objects & methods
Data & Algorithms service

FAIR / USE

AmsIX

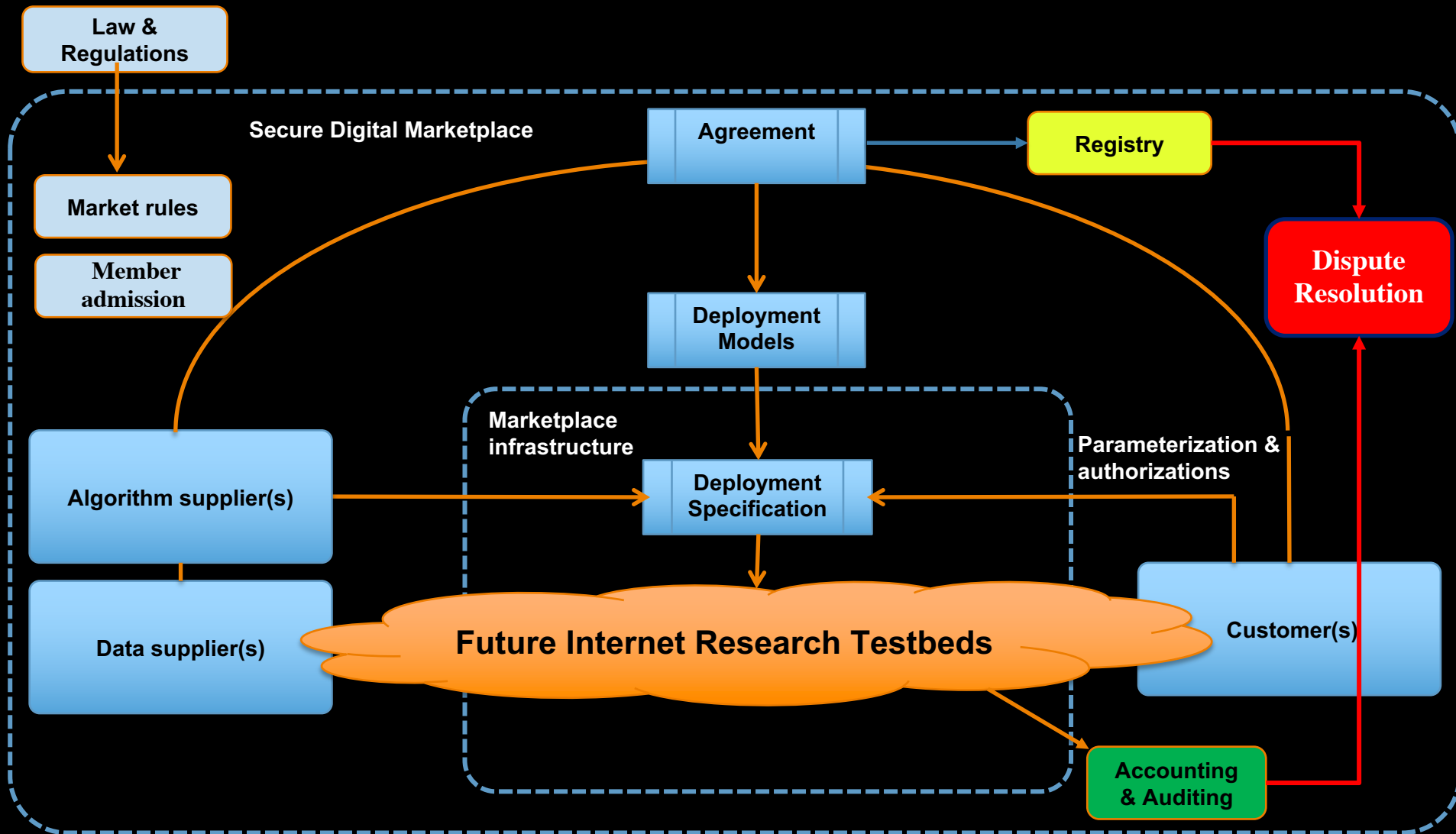
Routers - Internet – ISP's - Cloud
IP packet service

IP / BGP

Layer 2 exchange service
Ethernet frames

ETH / ST

Secure Digital Market Place Research



What have we been doing?

- Studying and defining draft Policy
- Working out model & defining Archetypes
- Implementing a proof of concept using several distributed DTN's and dockers on kubernetes.
- Demo at SC18 in Dallas TX, on data harbours.
- Tactical operation of Digital Data Markets
- Modeling and Matching Digital Data Marketplace Policies
- Optimization of degrees of freedom == value

SC16 Demo

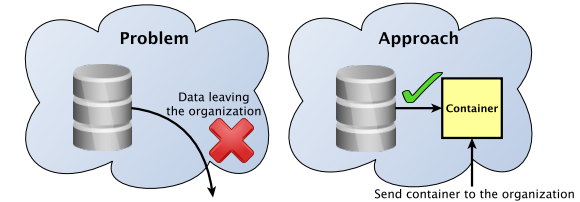
DockerMon Sending docker containers with search algorithms to databases all over the world.

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

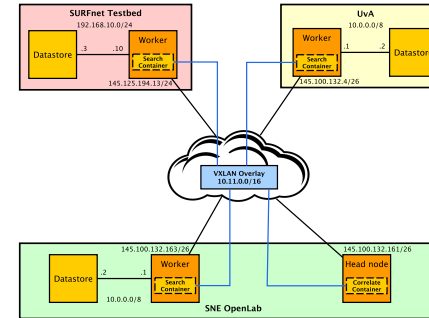
Container-based remote data processing

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

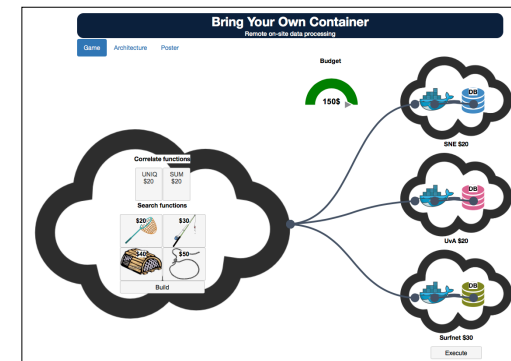
Our SC16 demo is a gamification of the remote dataset processing architecture.

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?



SC17 Posters and proof of concepts & demo's

<http://sc.delaat.net/sc17>

Unlocking the Data Economy via Digital Marketplaces

Researching governance and infrastructure patterns in airline context

Use Case: Sharing Aircraft Data to develop a Maintenance Credit System



- A **Digital Twin** estimates time before maintenance is needed after data is received from a corresponding aircraft system.
- Algorithm quality increases when data, owned by different airline operators, can be shared during its development.
- **Sharing data assets carries risk** (e.g. non-compliance).
- **Research Question:** "Can Digital Marketplace concepts organize trust amongst its stakeholders to enable common benefits no single organization can achieve, whilst observing economic principles?"

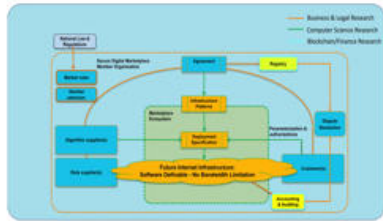
Digital Marketplace as a means to organize trusted data asset sharing

A Digital Marketplace is a membership organization identified by a common goal: *Share data to enable development of a Maintenance Credit System.*

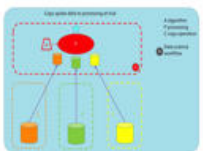
Membership organization is institutionalized to create, implement and enforce membership rules.

Market members create **digital agreements**.

Agreements are translated into different software defined infrastructures using **infrastructure patterns** offered by a **Digital Marketplace Ecosystem**.



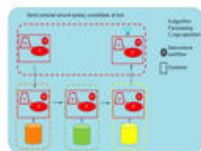
Examples of infrastructure patterns offered by a Digital Marketplace



Public cloud model



Container model



Turntable model

DEMONSTRATION: LIGHT PATHS AND DATA TRANSFER NODES FOR AIRCRAFT MAINTENANCE

Air France-KLM uses a 100 Gbit/s link, connected to Netherlight, to research an aircraft maintenance industry use case. Via this open exchange, Data Transfer Nodes (DTNs) of Air France-KLM in the Netherlands and iCAIR - present in Chicago at StarLight - connect to each other using light paths over their links. In this demonstration, users at SC17 in Denver will experience the difference in file transfer rates with and without using DTNs.

USE CASE: AIRCRAFT MAINTENANCE

Besides people and luggage, aircrafts transport data they generate, like flight information, technical statistics and sensor readings. These data tell pilots and engineers if the aircraft's critical systems are doing their job safely. When data are transferred and analyzed rapidly, defects can be solved more quickly, possibly even while the aircraft is waiting at the gate. When receiving the data within minutes, expert engineers in a remote airport can readily verify with the home base engineers if an engine vibration warning was caused by the engine or by a falling sensor.

INTERNET VS LIGHT PATH

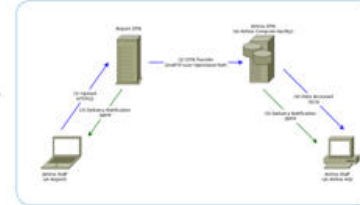
Air France-KLM uses a 100 Gbit/s light path and researches its benefits. Using light paths, you can transport huge amounts of data at high speed and with a guaranteed bandwidth between 2 points. When using high volumes of data, the current Air France-KLM's internet connections are not private or fast enough to transfer the data within the requested time frame. Transferring a terabyte of engine data via the current internet connections would take around 30 hours, with a 100 Gbit/s light path this could take less than 2 minutes.

AIR FRANCE-KLM CONNECTED TO NETHERLIGHT

Ciena and SURF facilitate the connection from Air France-KLM at Schiphol to NetherLight. SURF's European hub for international light paths in Amsterdam, SURF provides the 100 Gbit/s light path from Air France-KLM via NetherLight to the aircraft's destination. For this demonstration, the location is StarLight in Chicago, a hub similar to NetherLight.

DATA TRANSFER NODES

Data Transfer Nodes are high-performance systems that are optimized to transfer huge amounts of data. The interconnects between these systems exist of high-capacity dedicated bandwidth, removing network bottlenecks within the mesh of global DTNs. To date, DTNs are present on a small scale, e.g. a couple per continent. By copying a file from an end user system directly into the nearest DTN, the global DTN system sends the file to the DTN nearest to the final file destination, optimizing the process of high-latency international transfers.



LIVE DEMONSTRATION

In this demonstration, there are two end user systems, one in Amsterdam and one in Chicago. Neither system will be optimized for long range transfers, however each will have access to a nearby Data Transfer Node. Visitors are allowed to transfer pre-prepared datasets between the systems via the DTNs with graphs showing various performance metrics. As a comparison, the performance of a direct connection between the two systems - without using DTNs - will also be shown. The intention is to show that systems not optimized for long distance transfers can benefit from using nearby DTNs to facilitate the transfer and decreasing file transfer time.

RESEARCH IN OTHER INDUSTRIES

In addition to the aircraft research, high bandwidth, low latency light paths offer possibilities for research in other industries as well. For example, fundamental research on data transfer protocols suitable for these bandwidths can also help excel diagnosis by doctors when they can have access to terabytes of patient and other related research data within minutes, instead of days or weeks. Imagine what this would enable other research disciplines to do too. Possibilities are almost infinite!

More information: www.surf.nl/en/100-G-Air-France-KLM



Data Transfer Node (DTN) Workflows

Joseph Hill, Gerben van Malenstein, Cees de Laat, Paola Grosso, Leon Gommans

Why Data Transfer Nodes (DTNs)

- DTNs can act as an interface to a high performance link
- Configured to maximize performance for a given workflow
- Simplifies configuration of client systems
- Multiple clients may share a DTN
- DTNs strategically placed to best benefit clients
- DTNs can be compared to specialized high speed transport systems of the past

Pneumatic Tube Messaging System, 1943



United States Library of Congress's Press and Photograph Division (Digital ID 55a-82108-1)

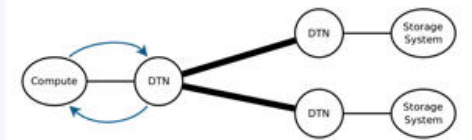
Example: Entry Point for High Speed Transport

A typical use case for DTNs is as a high speed file transfer service. A computer system's configuration may allow for the utilization of all available bandwidth in a LAN environment. However, it is often the case that in a WAN environment with high latency or packet loss the same system performs poorly. A DTN could be tuned to maximize performance on a high latency path. It could also use specialized transfer protocols to mitigate high packet loss. The DTN may also have access to an optimized path such as a light path. Files destined for a distant receiver would be first sent to a DTN located on the same LAN as the sender. That DTN would then forward it to at high speed to a DTN near the receiver. That DTN would then forward it to the final destination.



Example: Storage Access Point

Another possible use case for DTNs is to be used to access distributed data from remote locations. In this scenario a system located at a compute facility requests the data from the local DTN as it is required. That DTN would then transparently retrieve the data from multiple remote sites as needed. In contrast to the first example here block level access is provided by the DTNs. To the system performing the computations the nearby DTN appears to be the actual and only storage system. This hides both the remote and distributed nature of the data. While the compute side DTN may perform some caching, there need not be permanent storage of data at the compute facility.

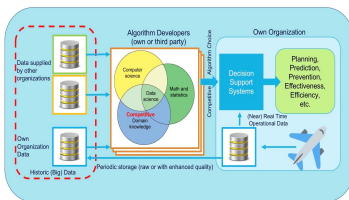


SC18 – Dallas TX

Training AI/ML models using Digital Data Marketplaces

Creating value and competition by enabling access to additional big data owned by multiple organizations in a trusted, fair and economic way

The more data - the better: an aircraft maintenance use-case



- AI/ML algorithm based Decision Support Systems create business value by supporting real-time complex decision taking such as **predicting the need for aircraft maintenance**.
- Algorithm quality increases with the availability of aircraft data.
- Multiple airlines operate the same type of aircraft.
- **Research Question:** "How can AI/ML algorithm developers be enabled to access additional data from multiple airlines?"
- **Approach:** Applying Digital Data Marketplace concepts to facilitate trusted big data sharing for a particular purpose.

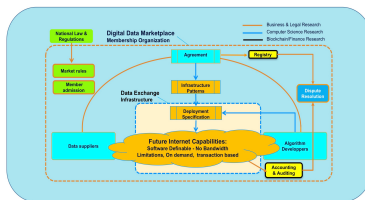
Digital Data Marketplace enabling data sharing and competition

A **Digital Data Marketplace** is a membership organization supporting a common goal: e.g. enable data sharing to increase value and competitiveness of AI/ML algorithms.

Membership organization is institutionalized to create, implement and enforce membership rules organizing **trust**.

Market members arrange **digital agreements** to exchange data for a **particular purpose** under specific conditions.

Agreements subsequently drive data science transactions creating processing infrastructures using infrastructure patterns offered by a Data Exchange as **Exchange Patterns**.

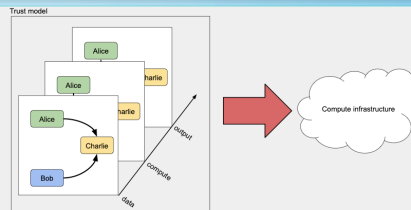


Dataharbours: computing archetypes for digital marketplaces

Reginald Cushing, Lu Zhang, Paola Grosso, Tim van Zalingen, Joseph Hill, Leon Gommans, Cees de Laat, Vijaay Doraiswamy, Purvish Purohit, Kaladhar Voruganti, Craig Waldrop, Rodney Wilson, Marc Lyonnais

The problem

How can competing parties share compute and data? The architecture of a digital marketplace is an active research field and has many components to it. Here we investigate a federated computing platform which is molded into different **archetypes** based on **trust** relationships between organizations.



The components

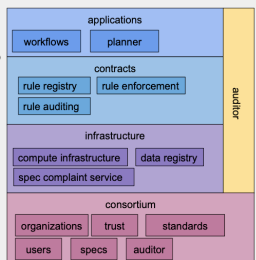
Consortium: is an initial document which brings together organizations that wish to collaborate. It defines static information such as keys to identify parties.

Infrastructure: A single domain organization infrastructure that securely hosts data, compute containers and, optionally, compute infrastructure. We dub this infrastructure a **data harbour**. A harbour implements a set of protocols that allows it to interact with other harbours.

Contracts: Are a set of rules that are shared amongst participating harbours which describe how objects (data, compute) can be traded between harbours and who can process data. In its simplest form is a 7-tuple which binds a user, data object, compute container, contract, consortium, harbour, and expiry date.

An application: Is a distributed pipeline which can make use of several contracts. The combination of application and contract defines the archetype of the computation i.e. how data and compute are moved to effect computation.

Auditor: A trusted entity that collects audit trails for use in litigation of policy violations.

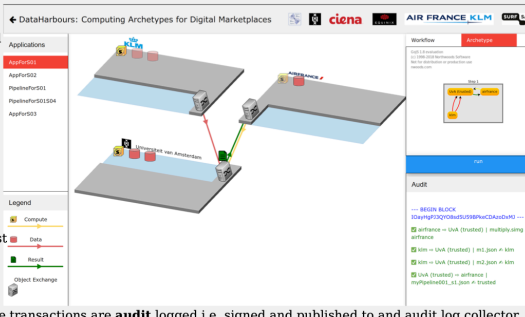


In action

Federated computing on 3 distributed data harbours. Here we illustrate one archetype where KLM and Airfrance do not trust each other and employ a trusted 3rd party to send the data and compute for processing.

For the scenario to succeed the different harbours need to effect several transactions which are governed by contractual rules.

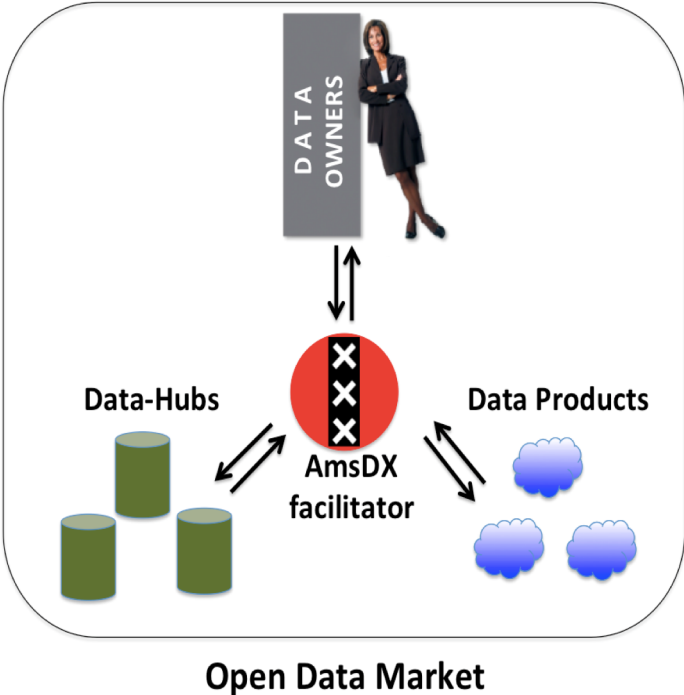
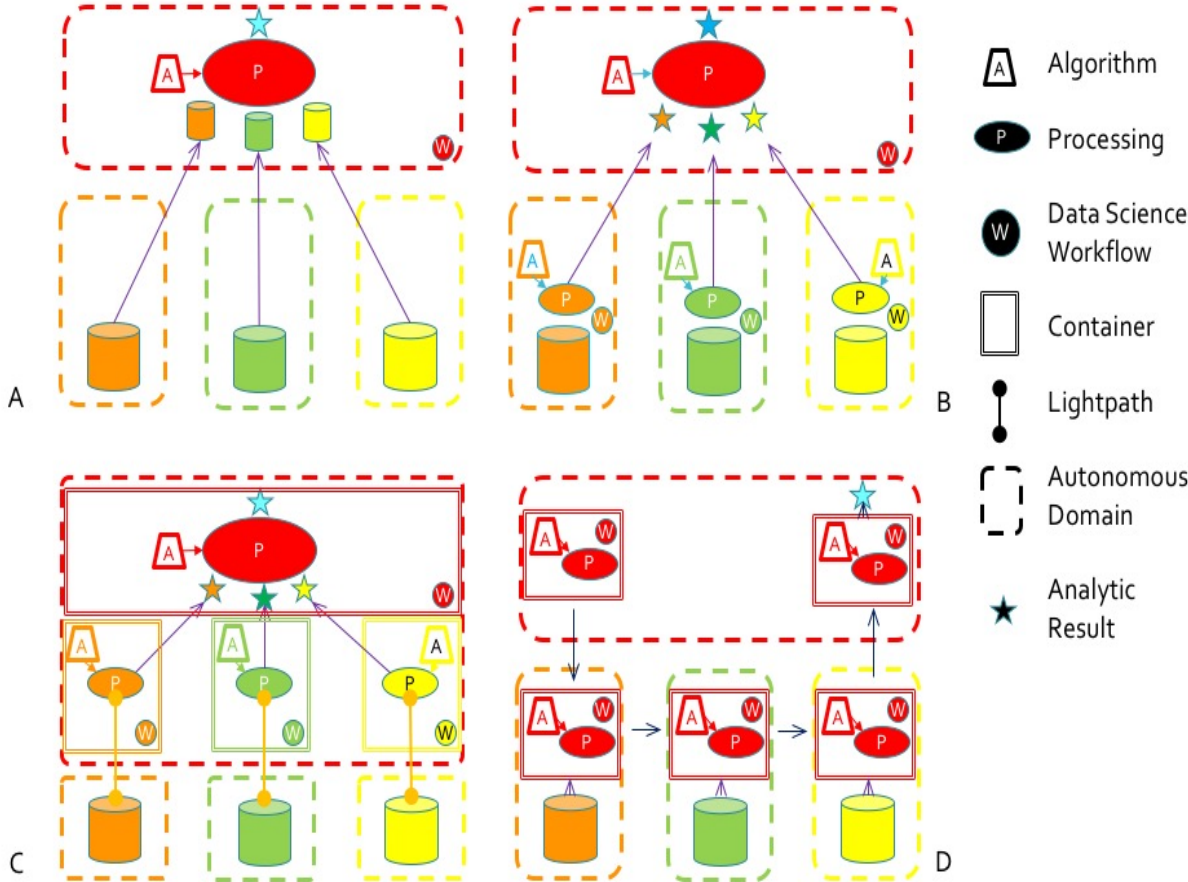
The transaction **protocol** involves first identifying both parties are who they say they are through pub/priv key challenges and secondly, that at least a **contract rule** is matched to allow the transaction. Important steps of the transactions are **audit** logged i.e. signed and published to and audit log collector.



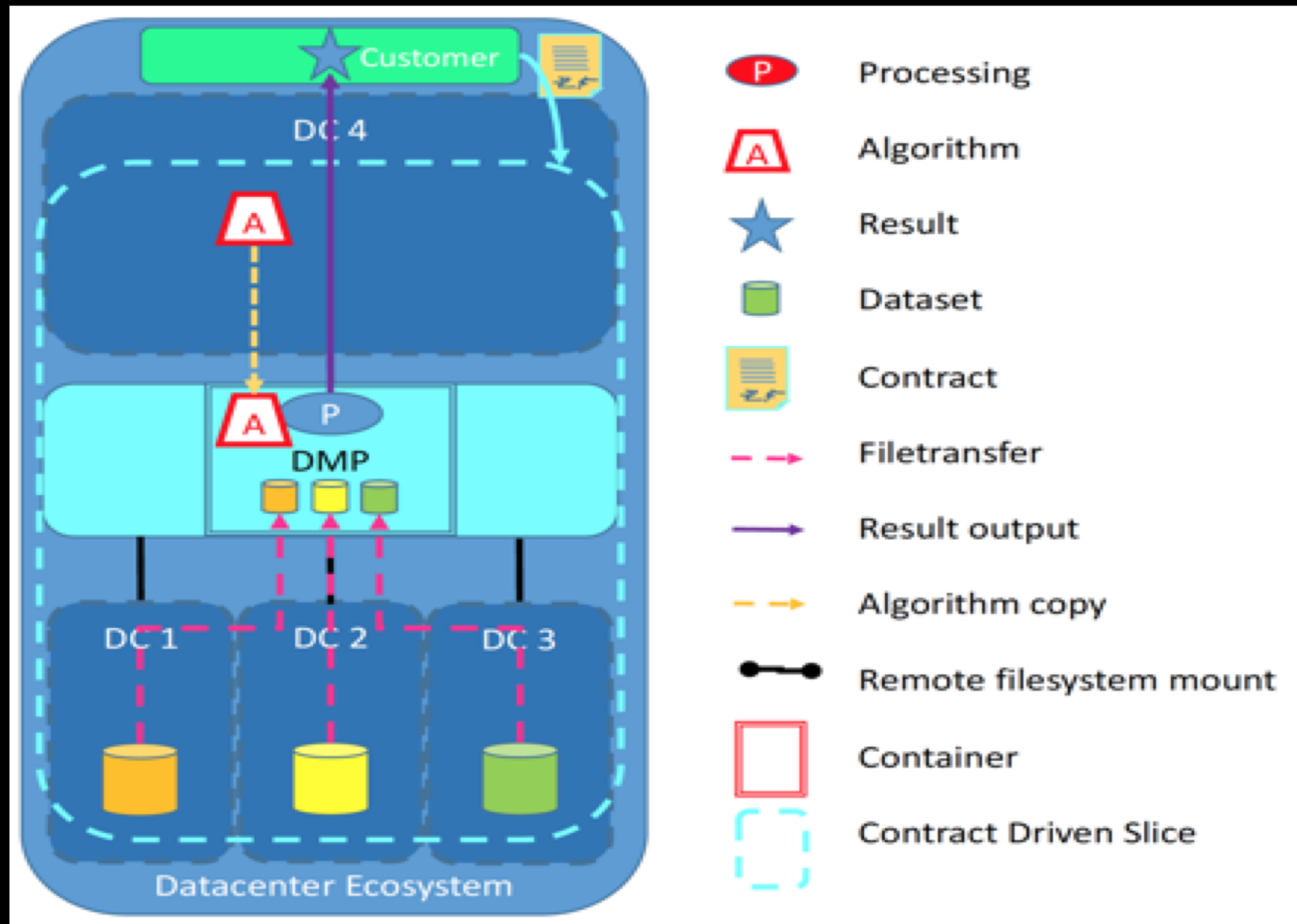
The screenshot shows the SC18 Dallas TX website. At the top, it lists the dates 'Nov 11-16, Dallas (TX)' and the booth number '2847 SURF booth 2041'. Below this, there are logos for various sponsors like AIR FRANCE KLM, TRANSFIDES, evofenedex, ciena, THALES, and SCinet. The main content area features several presentation slides, including 'Data Harbours: A compute infrastructure for data marketplaces', 'Building User-friendly Data Transfer Nodes', and 'Dynamic infrastructure planning and provisioning for time critical applications in clouds'. There is also a photo of the SC18 network staff and a group photo of the SC18 booth crew.

INFRASTRUCTURE PATTERN EXAMPLES

OFFERED BY A DATA EXCHANGE TO MARKETPLACES TO CHOOSE FROM



DMP archetypes and their representation

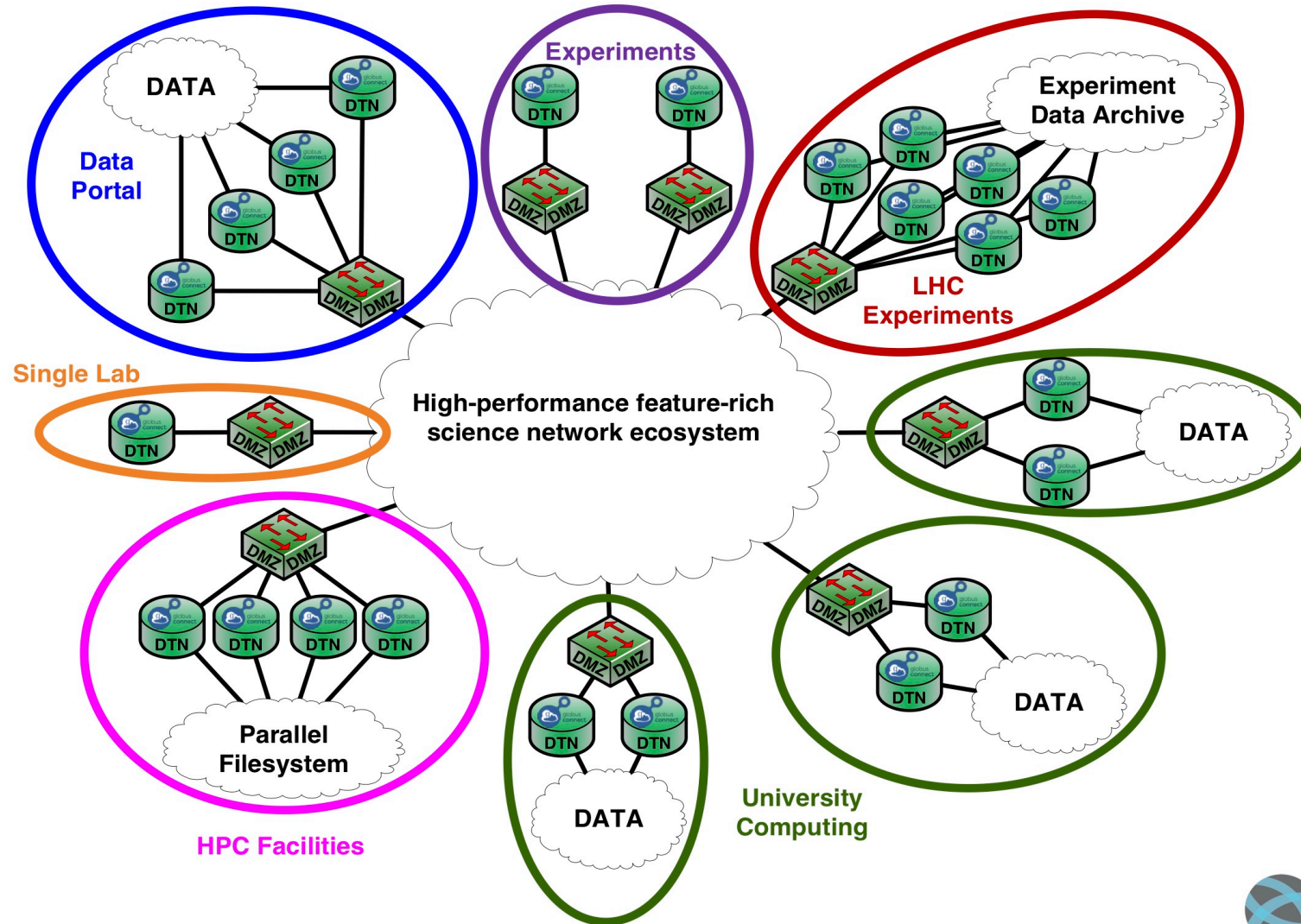


On the left one of the many collaboration models within a DMP. We call this archetype. One DMP can support multiple archetypes depending on the contracts between partners.

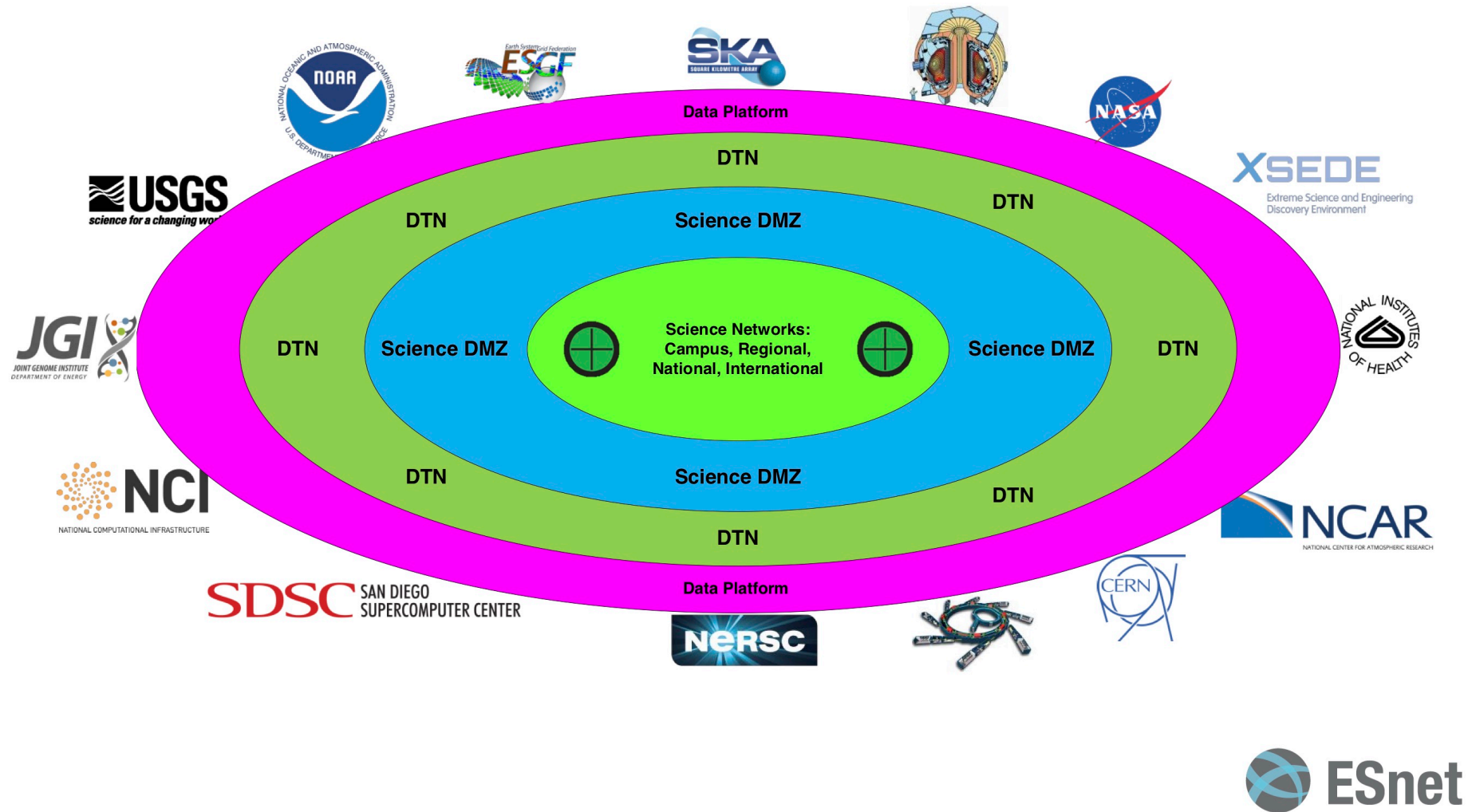
To match application/user requests to the archetype we need to model the archetype on the left in generic ways.

To be presented next week at eScience conference.

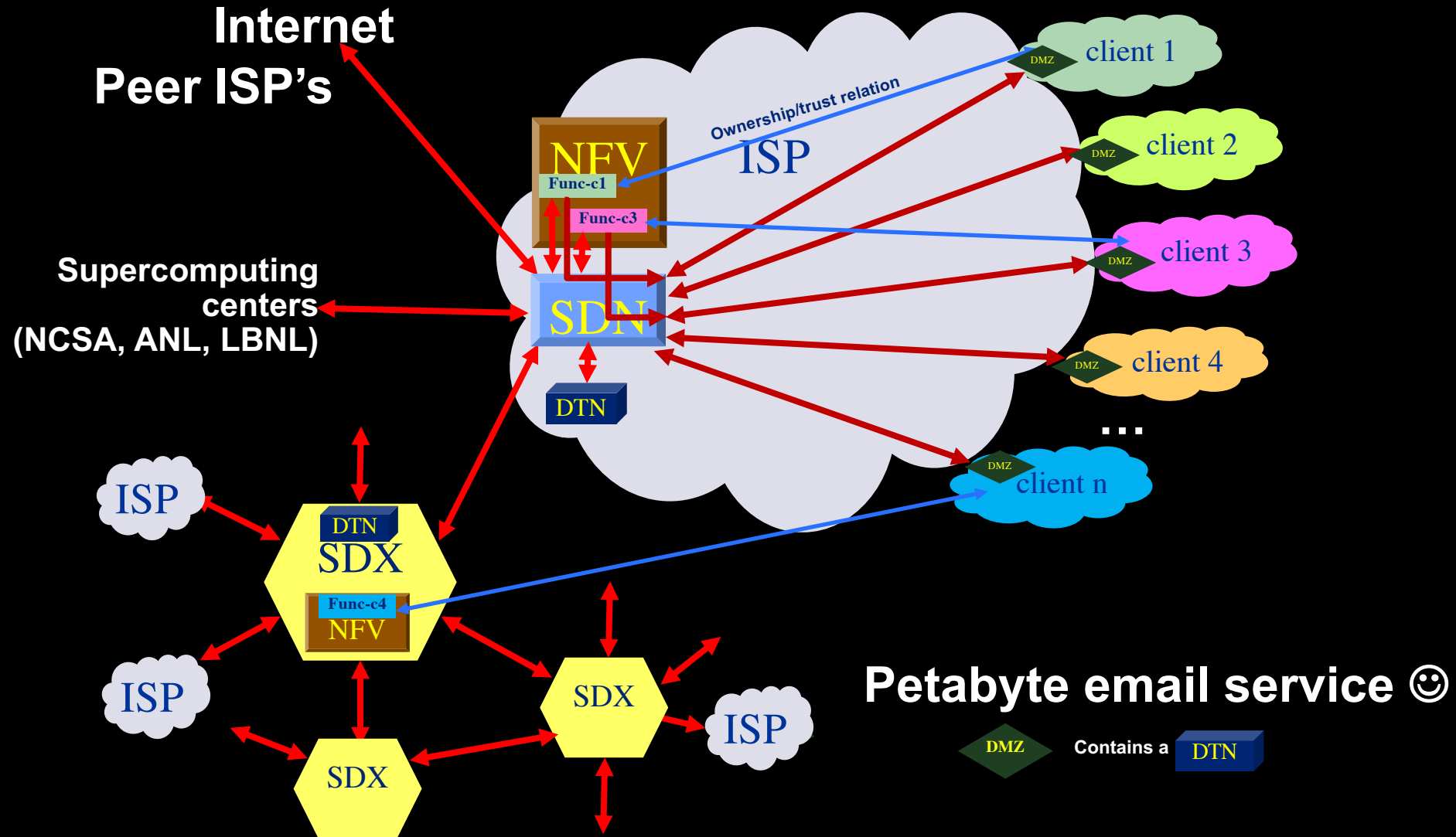
Science DMZs for Science Applications



Data Ecosystem – Concentric View



Networks of ScienceDMZ's & SDX's



The Big Data Challenge

Doing Science

ICT to enable Science

Wisdom

Scientists live here!

AI

Interdisciplinary Science App Store

Knowledge to act

Analytics library / Github / etc

Analytics Decision Support

MAGIC DATA CARPET

curation - description - trust - security - policy - integrity

Information

Web/OWL

Data

a.o. from ESFRI's

Docker, VM, XML, RDF, rSpec, SNMP



The Big Data Challenge

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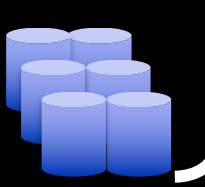
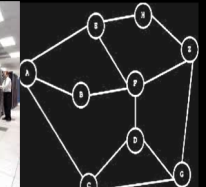
Docker, VM,

XML, RDF, rSpec, SNMP

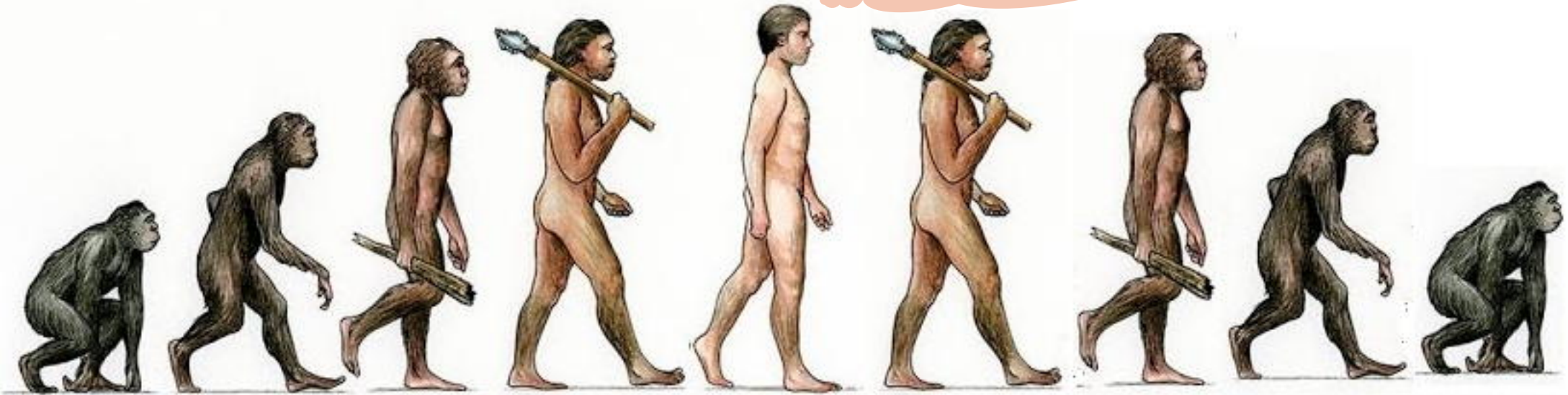
DSC
eScience

RDM/
DANS

ICT/
SURF



AI forking off



Artificial Intelligence

NOW

Conclusions, Info, Acknowledgements, Q&A

- Data hindered by risk of unexpected use, lack of trust
- Using market principles, enforcement and determining incentives and value in the data life cycle to make data flow
- More information:
 - <http://delaat.net/dl4ld> <http://delaat.net/epi>
 - <https://www.esciencecenter.nl/project/seconnet>
 - <https://towardsamdex.org>

