UNIVERSITEIT VAN AMSTERDAM

System and Network Engineering

Sustainable e-Infrastructures

Dr. Paola Grosso
System and Network Engineering research group
University of Amsterdam

Who am I?

- Assistant Professor in the SNE group
- Italian
  - Graduated at the University of Turin (Italy)

- … but leaving outside Italy since 14 years
  - Stanford Linear Accelerator Center (USA)
  - University of Amsterdam (NL)

Want to know more?

- p.grosso@uva.nl
- http://staff.science.uva.nl/~grosso/

- …a chat over dinner or in the breaks.

SNE

System and Network Engineering

- Lead by prof. Cees de Laat
- ~30 researchers working in the group
- Strong tie to education with own master program
- Many national and international projects

More information at the website:
http://sne.science.uva.nl/

SNE main research question

- quality of service and on-demand creation of virtual infrastructure including the underlying network

- managing sustainability and privacy in a distributed, heterogenous infrastructure

Projects

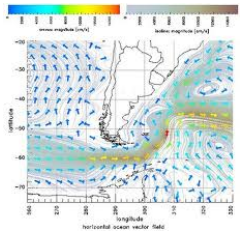
COMMIT/

GigaPort

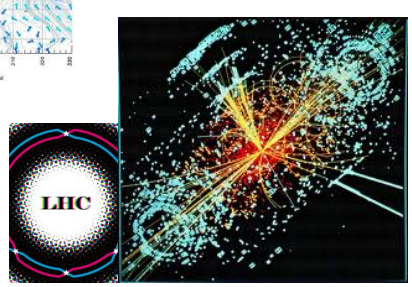
GreenClouds

e-Infrastructures

... more data!



Google



... more realtime!

LinkedIn

Hyves

... more users!

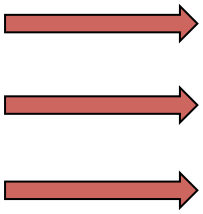
More data, more users, more realtime…

… gives you:

- Scalability
  - *How can serve all these users?*
- Robustness
  - *How can we provide QoS/QoE and reliable services?*
- Sustainability
  - *Can we exploit the above to also create greener services?*

This talk

- Scalability
- Robustness
- Sustainability



- Modeling
- e-Services
- Green ICT and green networks

e-Infrastructures

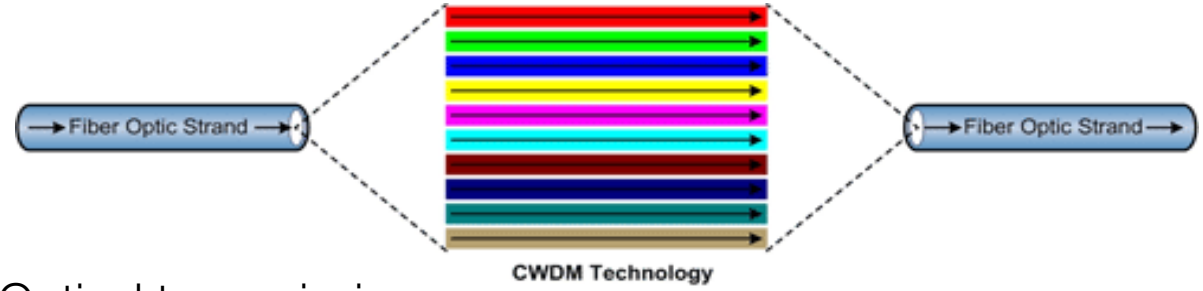
- Network
- Computing
- Storage

and….

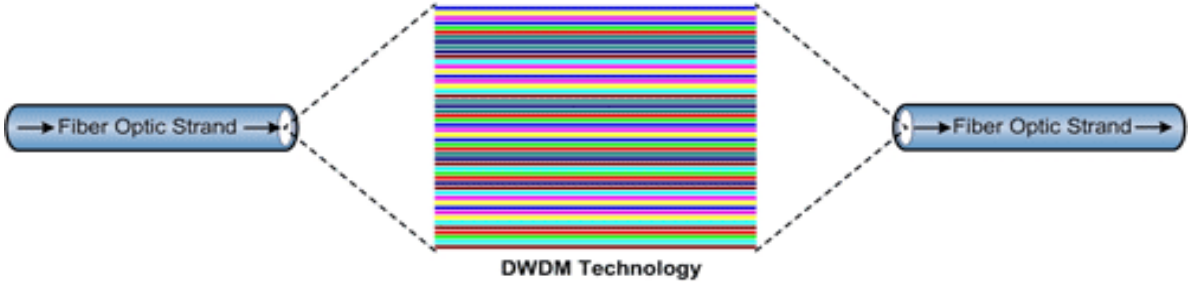
- Data (Big Data)

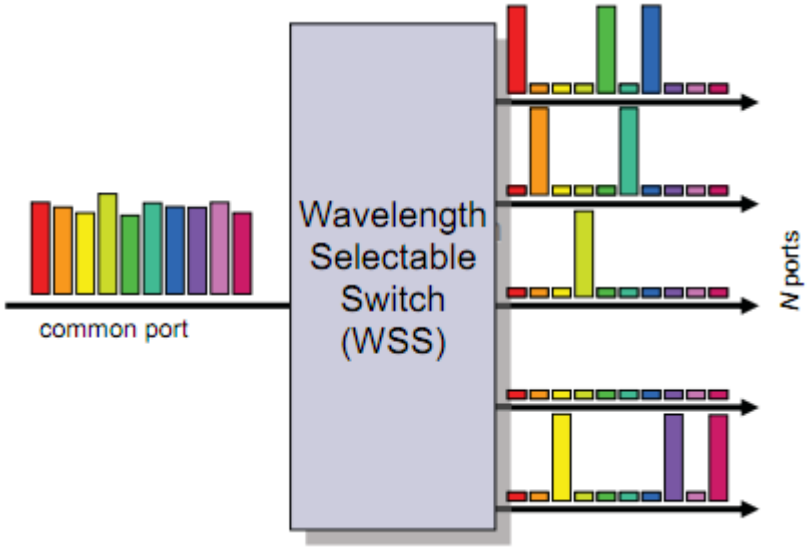
Putting it all together:
e-Infrastructures

Development In Networks



Optical transmission

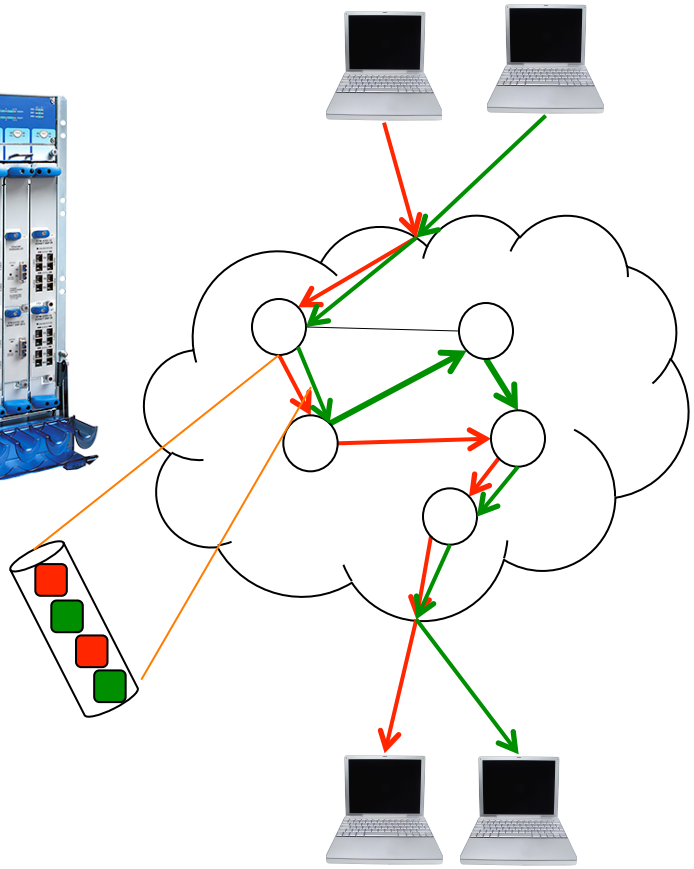




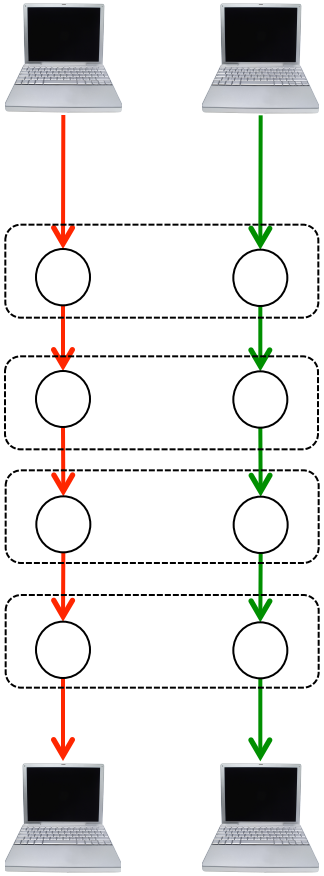
Virtualization

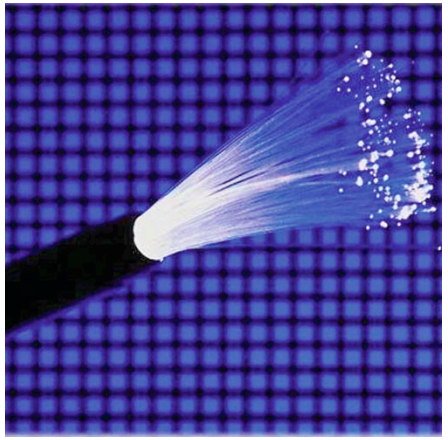
Hybrid networks

Packet switching

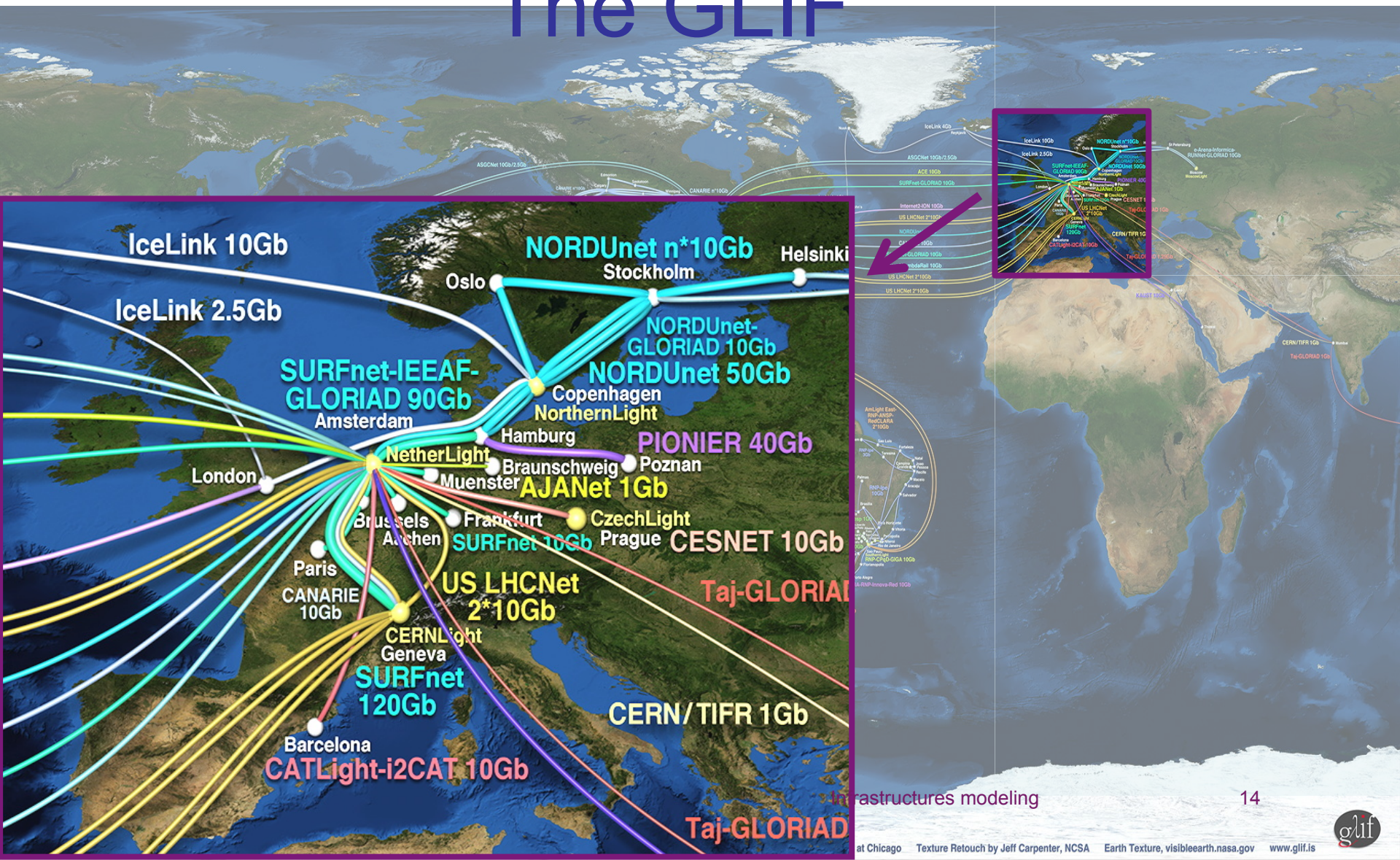


Circuit switching

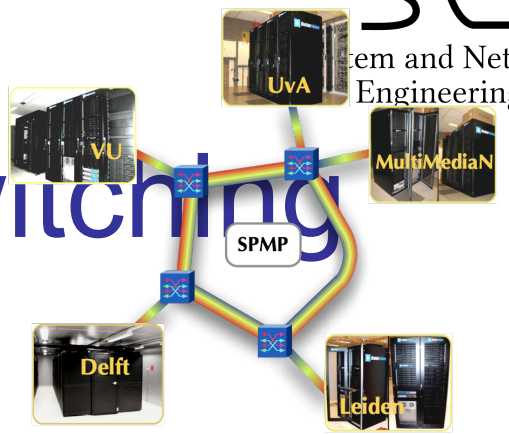




The GLIF



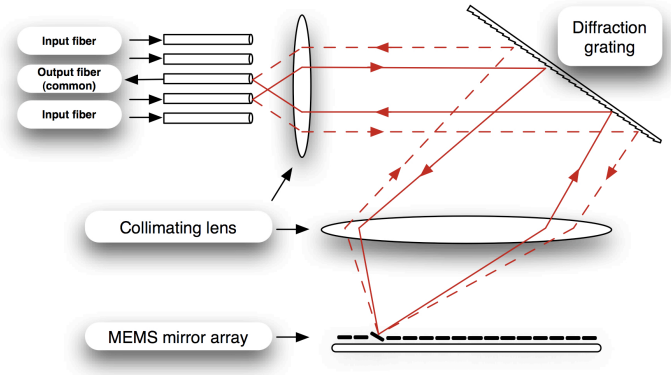
Dynamic lightpath switching

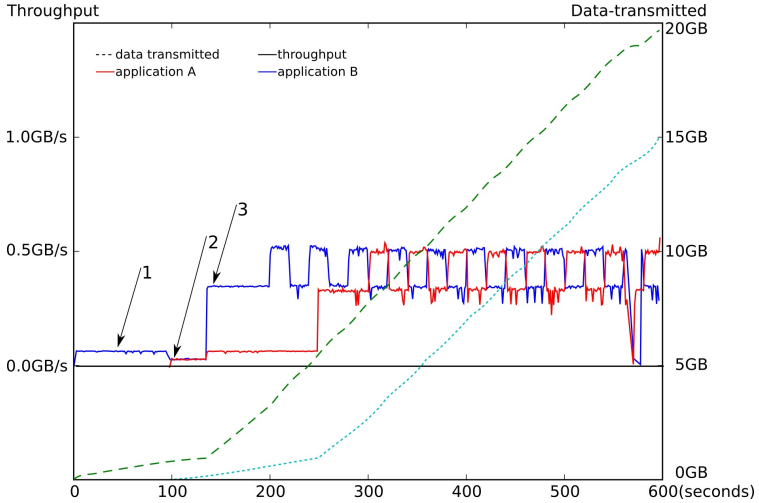


DAS-3+StarPlane

- How do we move from static to dynamic lightpaths?
- How do we achieve fast switching times?

WSS- Wavelength-Selective Switches





P. Grosso, D. Marchal, J.Maassen, E. Bernier, L. Xu and C.de Laat
Dynamic photonic lightpaths in the StarPlane network
In: Future Generation Computer Systems, Volume 25, Issue 2, 2009, Pages 132-136

P. Grosso , L. Xu, JP Velders, C. de Laat
StarPlane - A National Dynamic Photonic Network Controlled by Grid Applications
In: Emerald Journal of Internet Research, Vol.17, Issue 5, 2007, Page: 546 - 553

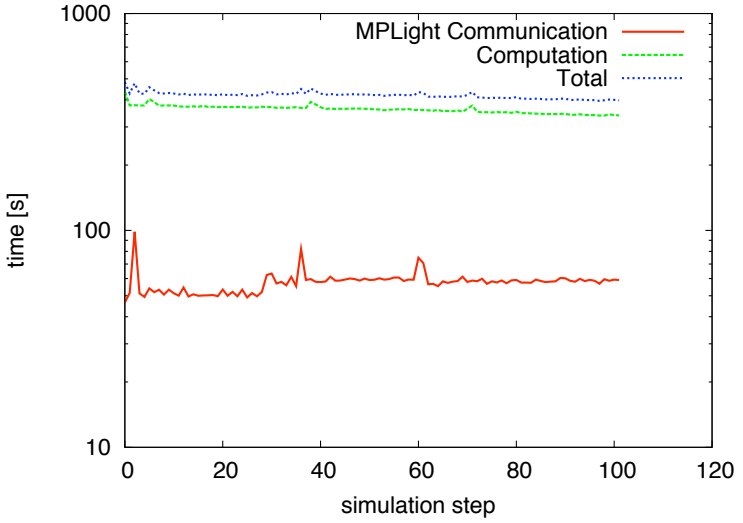
e-Science application of lightpaths - CosmoGrid

CosmoGrid

Many scientific application have a distributed nature:
•Data are collected from many places, see radio-astronomy eVLBI/SCARIe.

•Data are sent to multiple location for computation, see cosmological simulation – CosmoGrid.

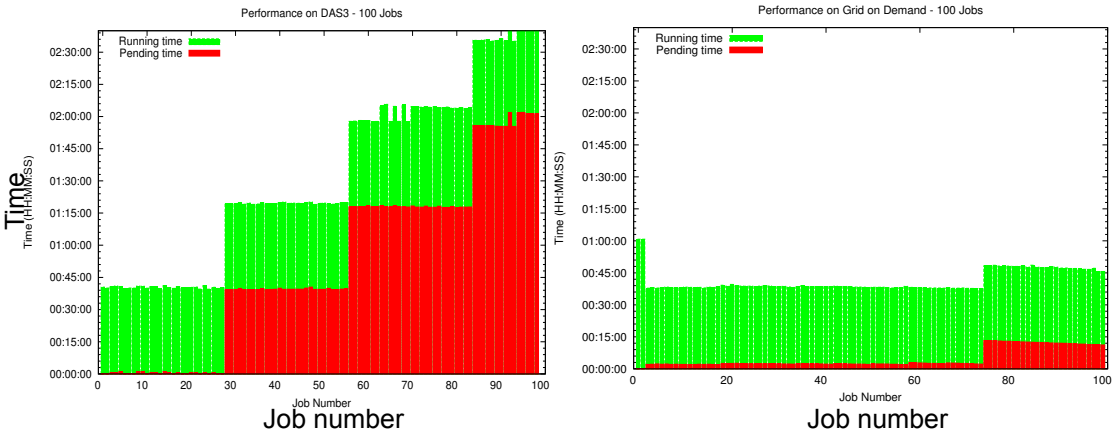
Dynamic lightpaths have proven to support this type of applications.



D.Groen, S.Rieder, P.Grosso, C.de Laat, S.Portegies Zwart
A light-weight communication library for distributed computing
In: IOP journal Computational Science & Discovery 3 (2010) 015002 (14pp)

Grid on demands

- If computing is ‘infinite’ and movable, then workflows and applications can program the network.



R.Strijkers, W.Toorop, A.van Hoof, P .Grosso, A.Belloum, D.Vasuining, C. de Laat, R. Meijer
AMOS: Using the Cloud for On-Demand Execution of e-Science Applications
In: Proc. eScience2010 conf, Dec. 2010

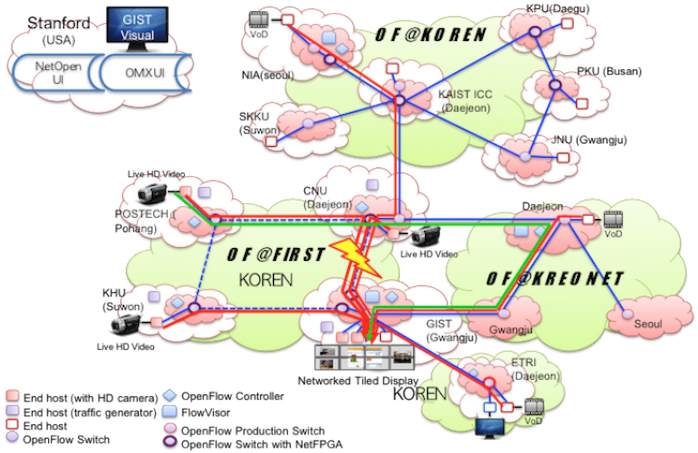
User programmable networks

Open Flow

- Move the intelligence out of the network hardware: application/ software programmable networks.

http://www.internet2.edu/network/ose/

http://fif.kr/wg/testbed/wiki.php/FrontPage



http://www.fp7-ofelia.eu/

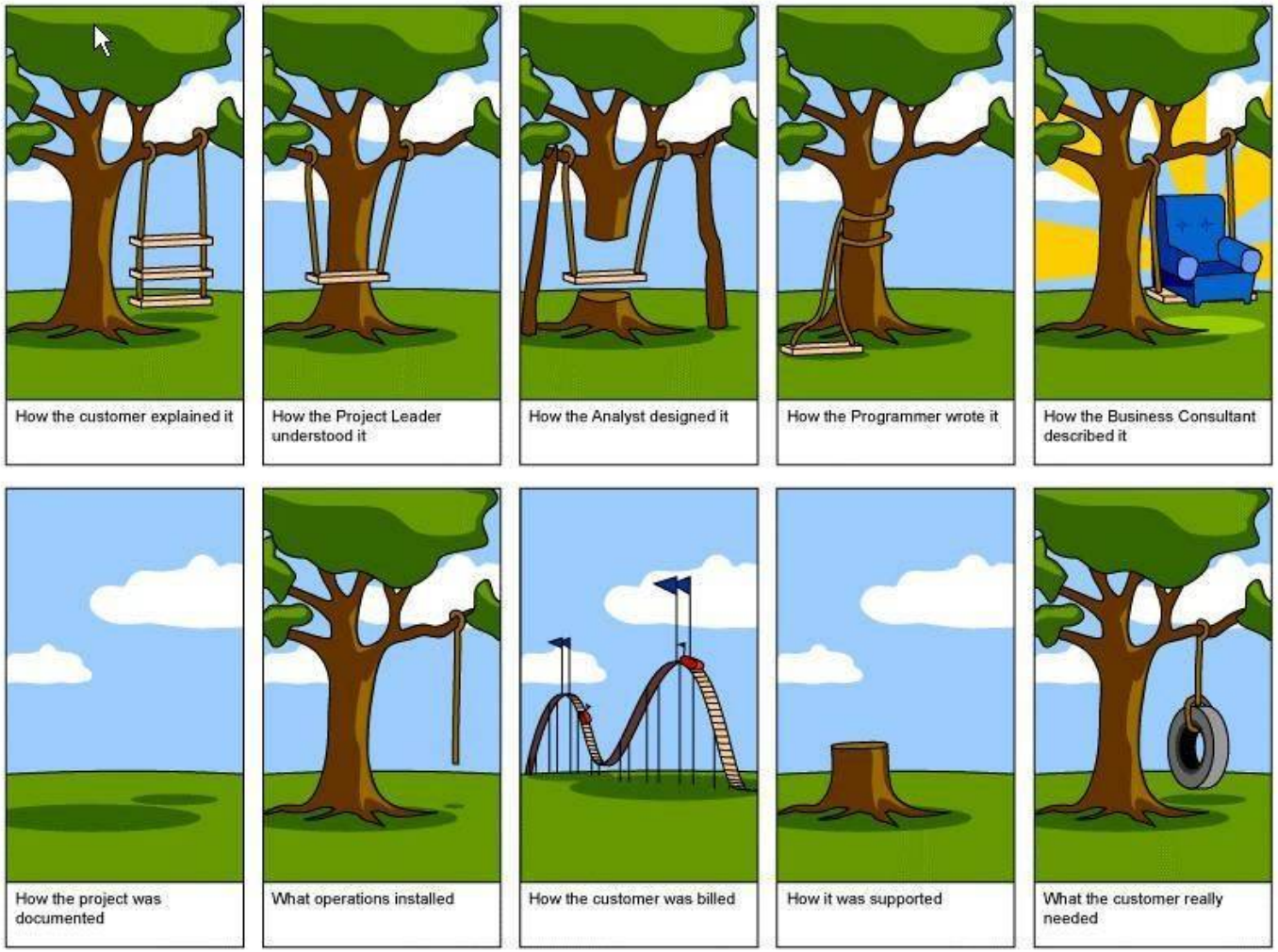
OFELIA
OpenFlow in Europe
Linking Infrastructure and Applications

What next?

- If users and applications can program the network, what kind of (network) services can we create?
- What are the challenges for providing these services across domains?

Modeling

How do you describe the underlying (network) infrastructure if you want to create a multi-domain path?


How the customer explained it
How the Project Leader understood it
How the Analyst designed it
How the Programmer wrote it
How the Business Consultant described it
How the project was documented
What operations installed
How the customer was billed
How it was supported
What the customer really needed

Finding a common language

- **Information model**
  - An information model describes resources at a conceptual layer.
- **Data model**
  - A data model describes protocols and implementation details, based on the representation of concepts and their relations provided by the information model.

The Semantic Web

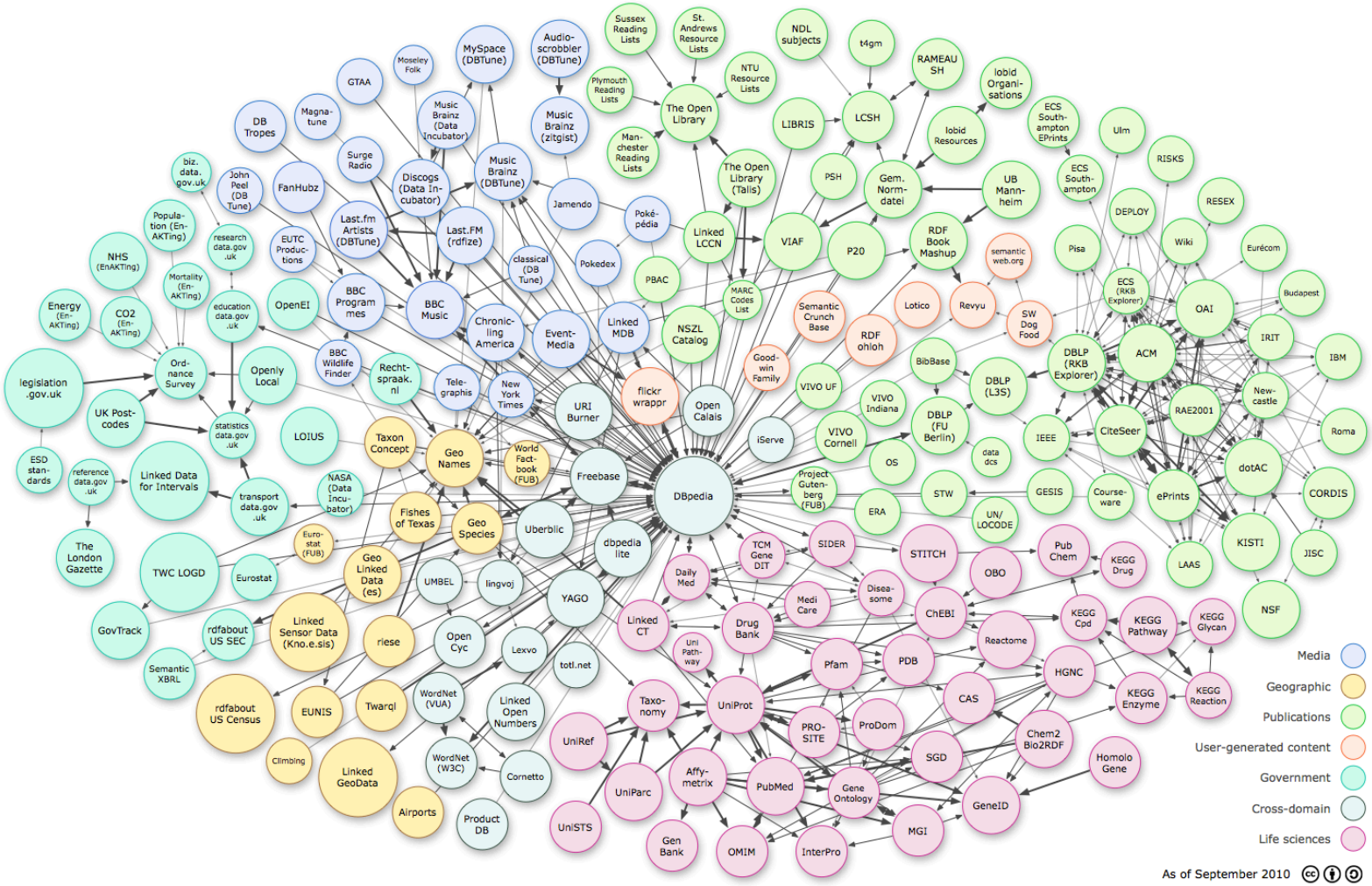
- RDF - Resource Description Framework - provides a way to categorize information:
  - resources are described by URIs;
  - triples define the relations between resources:

- OWL – Web Ontology Language - has stronger support for classes, attributes and constraints
  - Operations (unions, intersections, complements, cardinality constraints)

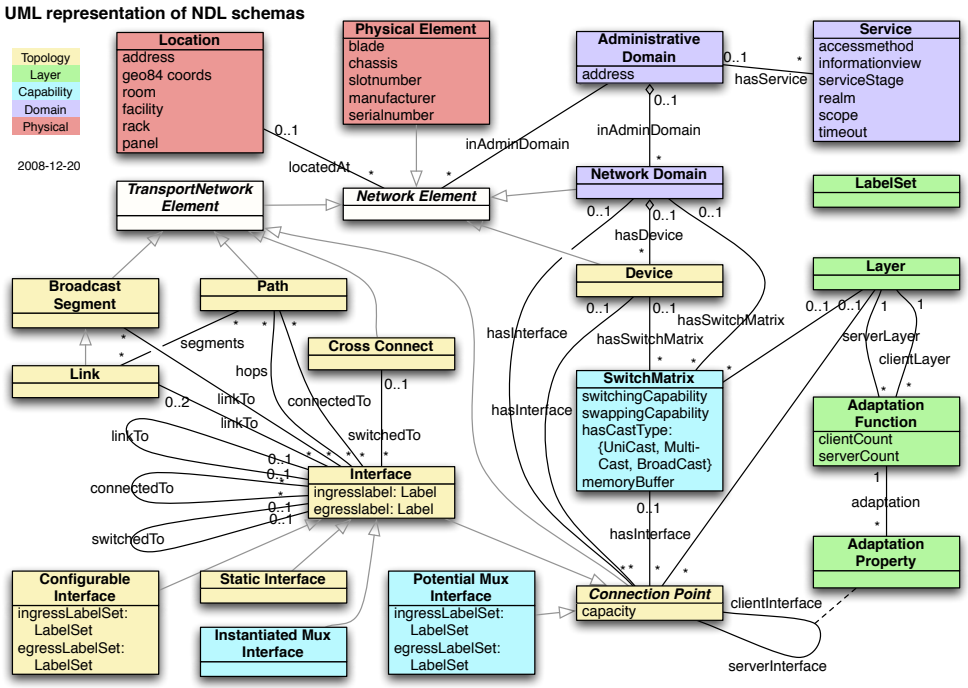
Terminologies

- An ontology is a formal representation of a set of concepts within a domain and the relationships between those concepts.
  - It is used to reason about the properties of that domain, and may be used to define the domain
- An Information Model describes resources at a conceptual level.
- A Data Model describes protocols and implementation details, based on the representation of concepts and their relations provided by the information model.

Open Linked Data



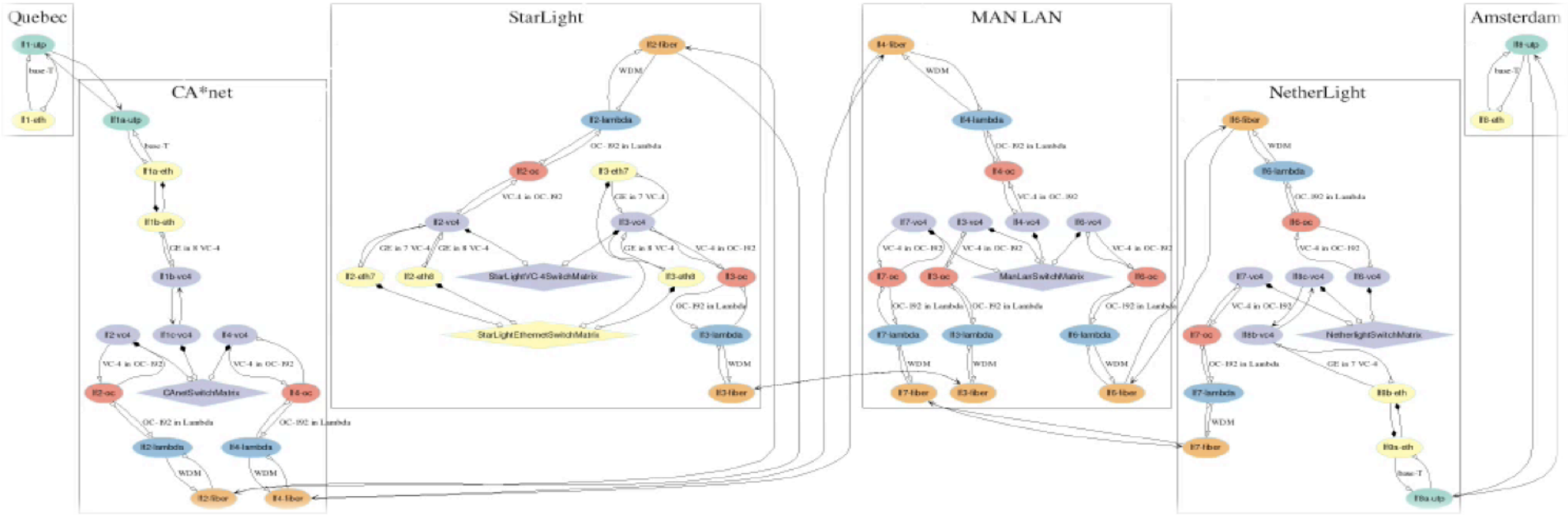
NDL



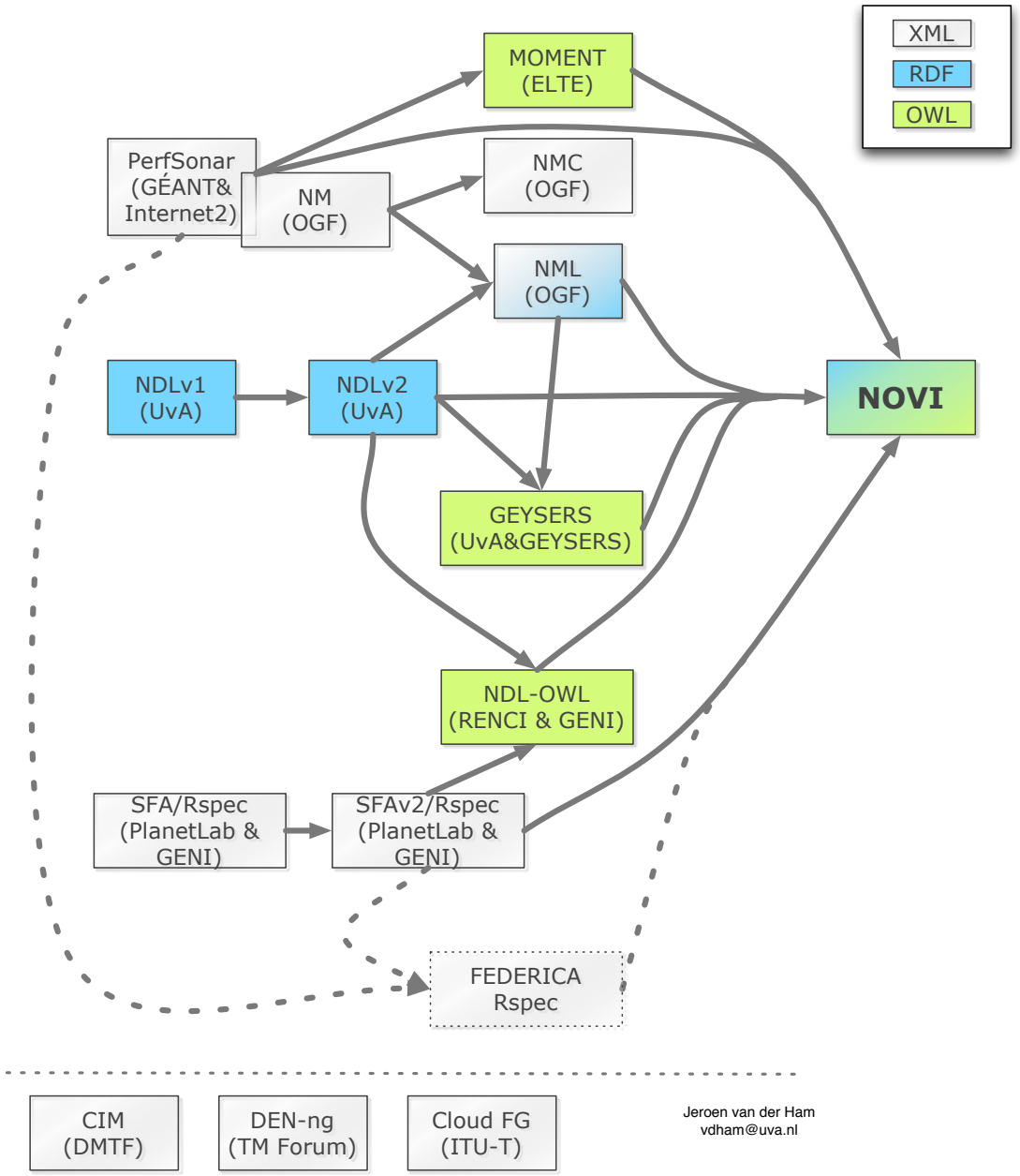
J. van der Ham, F. Dijkstra, P. Grosso, R. van der Pol, A. Toonk, C. de Laat
A distributed topology information system for optical networks based on the semantic web,
In: Elsevier Journal on Optical Switching and Networking, Volume 5, Issues 2-3, June 2008, Pages 85-93

Path finding in multi-layer multi-domain networks

F. Dijkstra, J. van der Ham, P. Grosso and C. de Laat.
A path finding implementation for multi-layer networks, In: Future Generation Computer Systems, Vol.25, Issue 2, Feb. 2009, pp.142-146

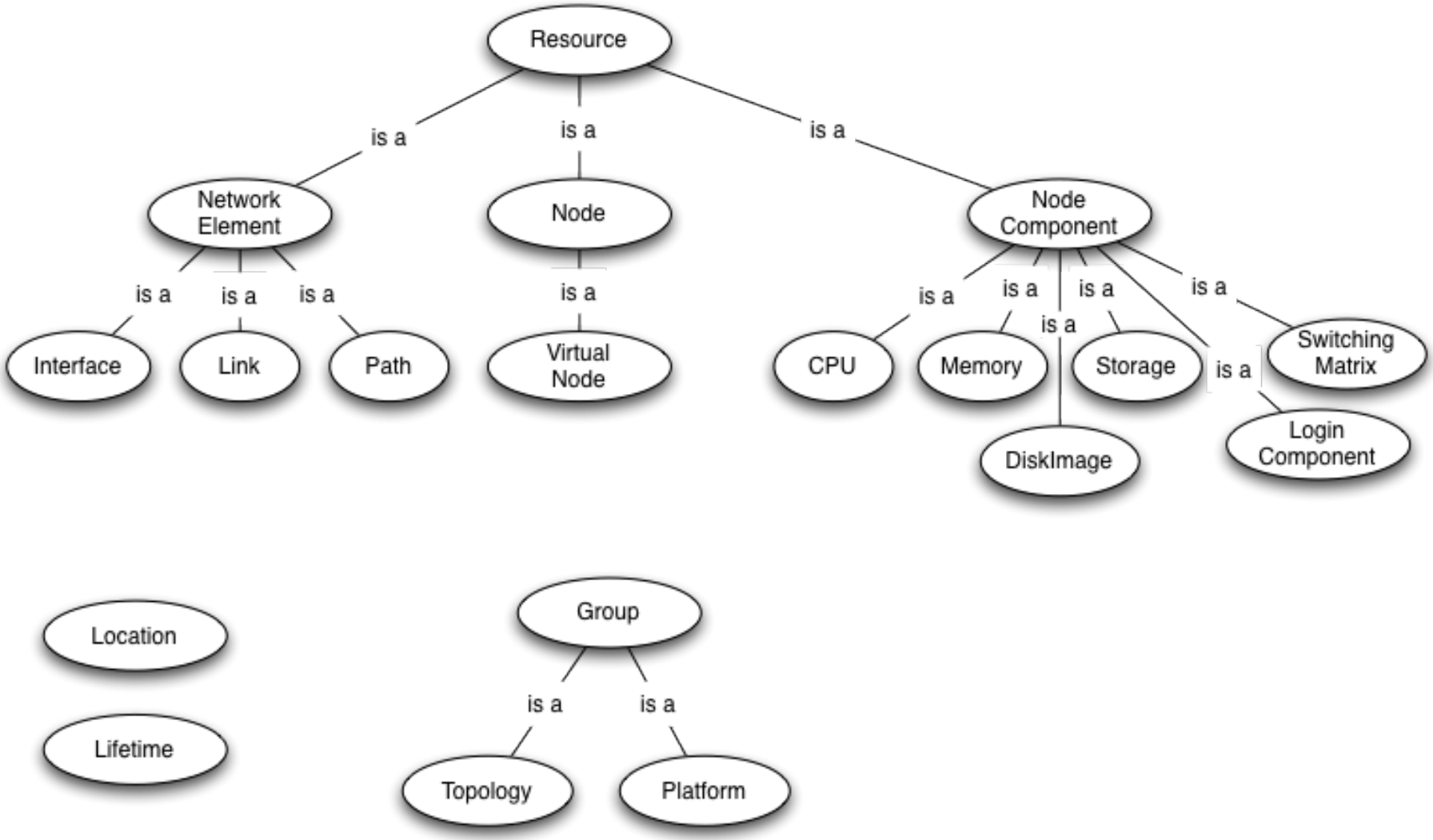


A. Taal, P. Grosso, J. van der Ham and C de Laat
Path finding strategies for multi-domain multi-domain network architectures
In: Proceedings of the Cracow Grid workshop 2010

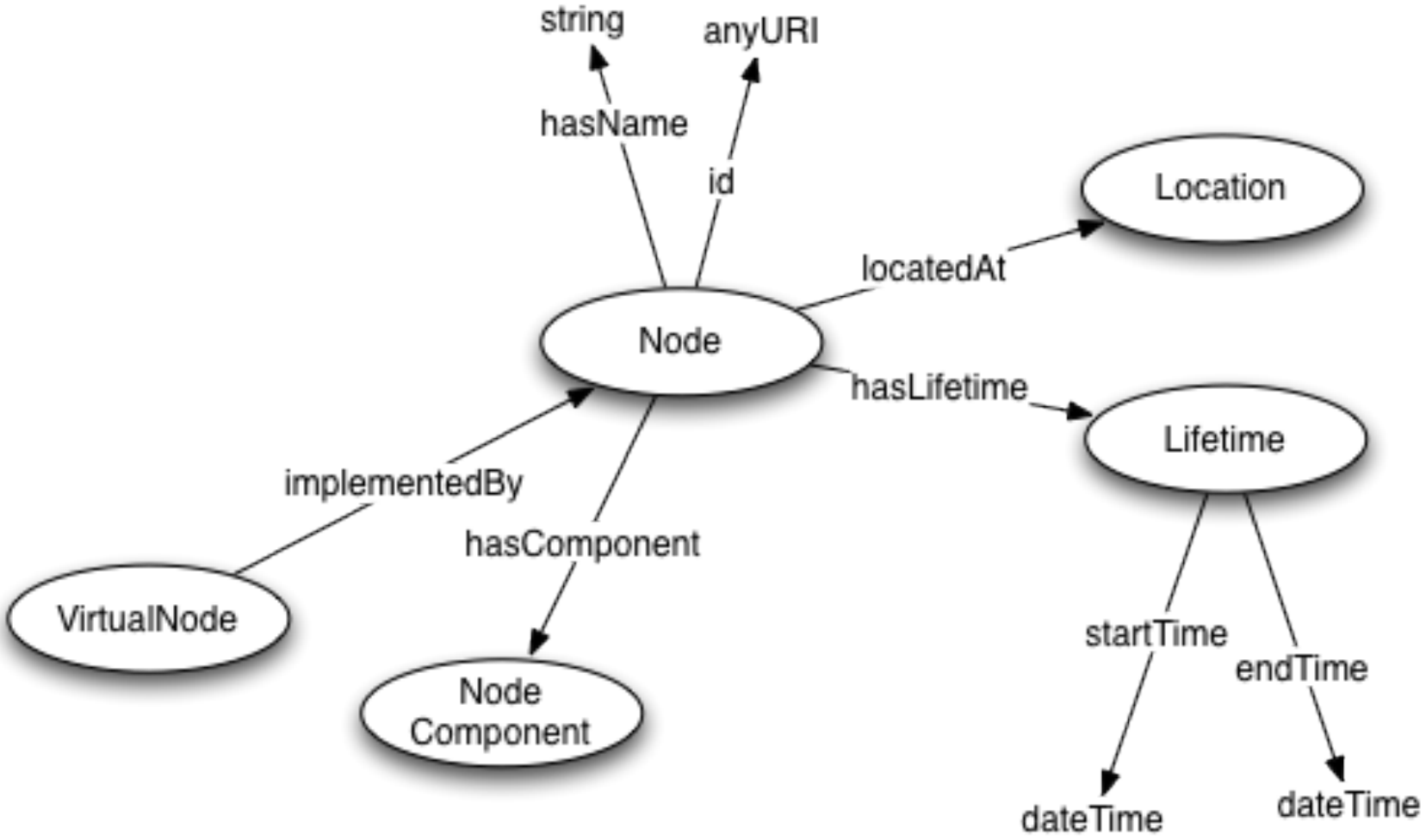


Jeroen van der Ham
vdham@uva.nl

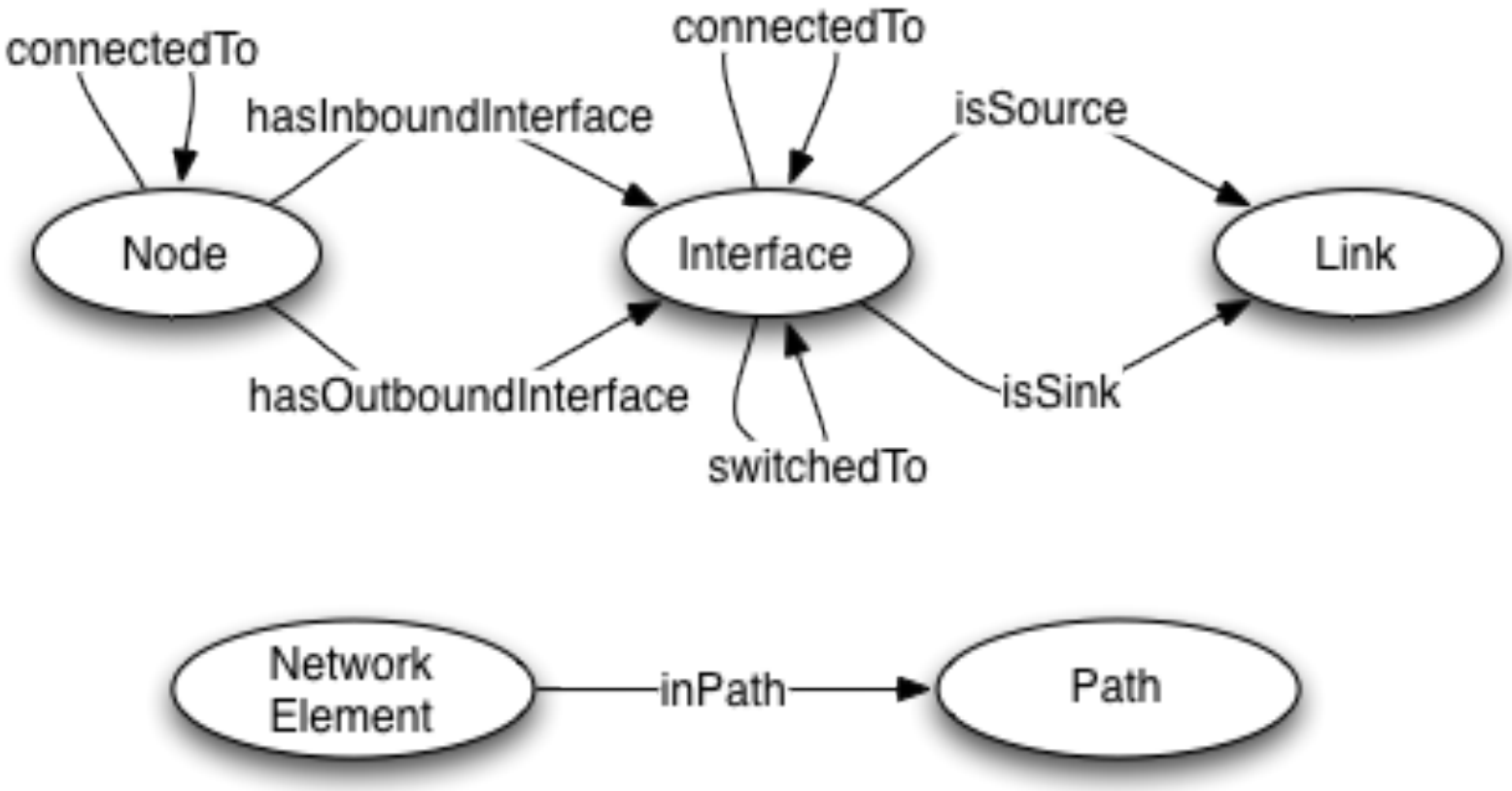
Resource ontology: base classes



Resource ontology: object relations

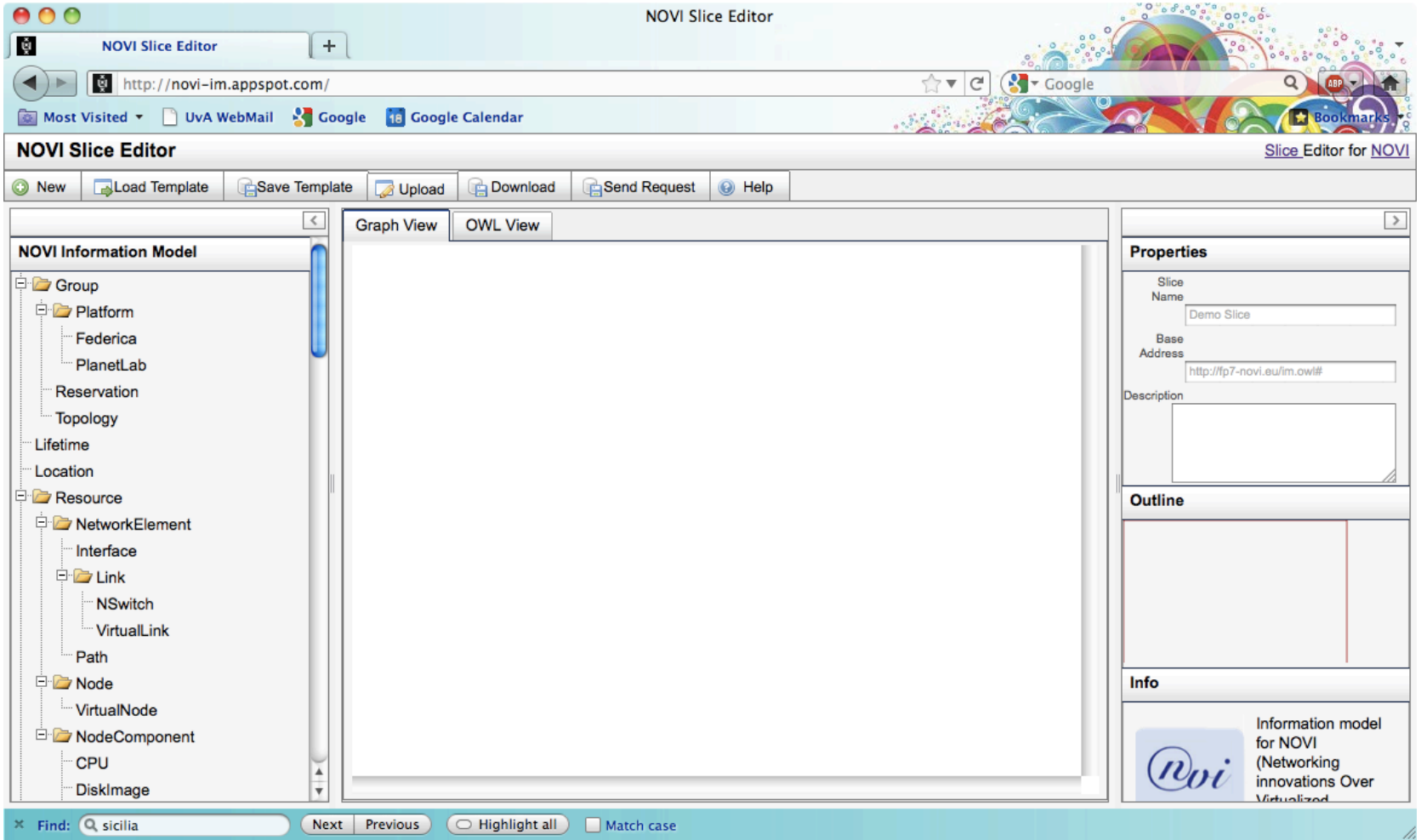


Resource ontology: network connectivity



Ontology editor

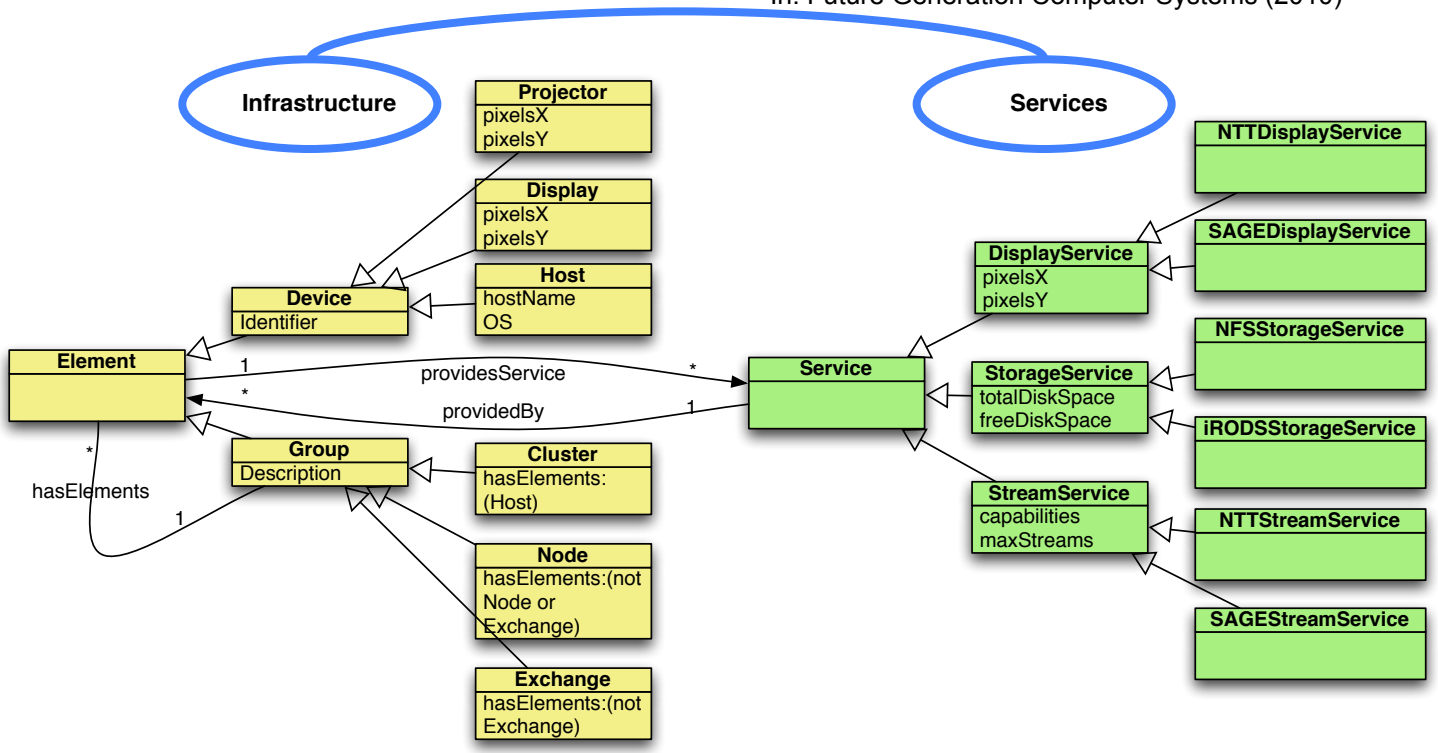
W. Adianto, R.Koning, P. Grosso, A. Belloum, M. Bubak and C.de Laat,
OIntEd: online ontology instance editor enabling a new approach to ontology development
In: Journal of "Software: Practice and Experience" 2012



e-Services

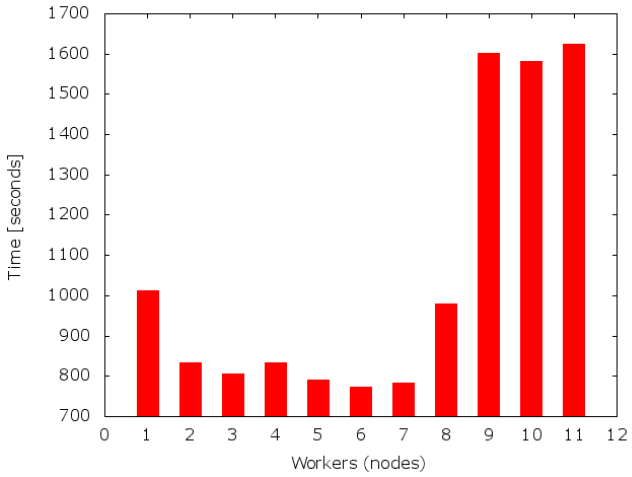
From infrastructure to services

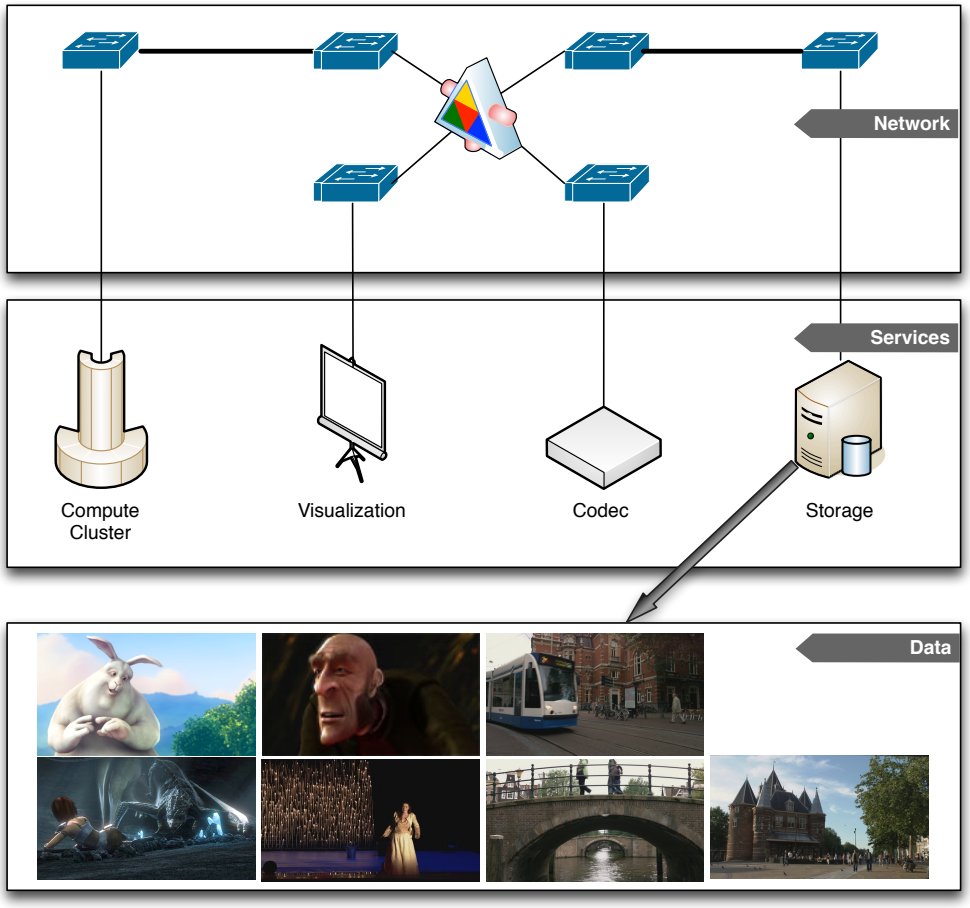
R.Koning, P.Grosso and C.de Laat
Using ontologies for resource description in the CineGrid Exchange
In: Future Generation Computer Systems (2010)



CineGrid

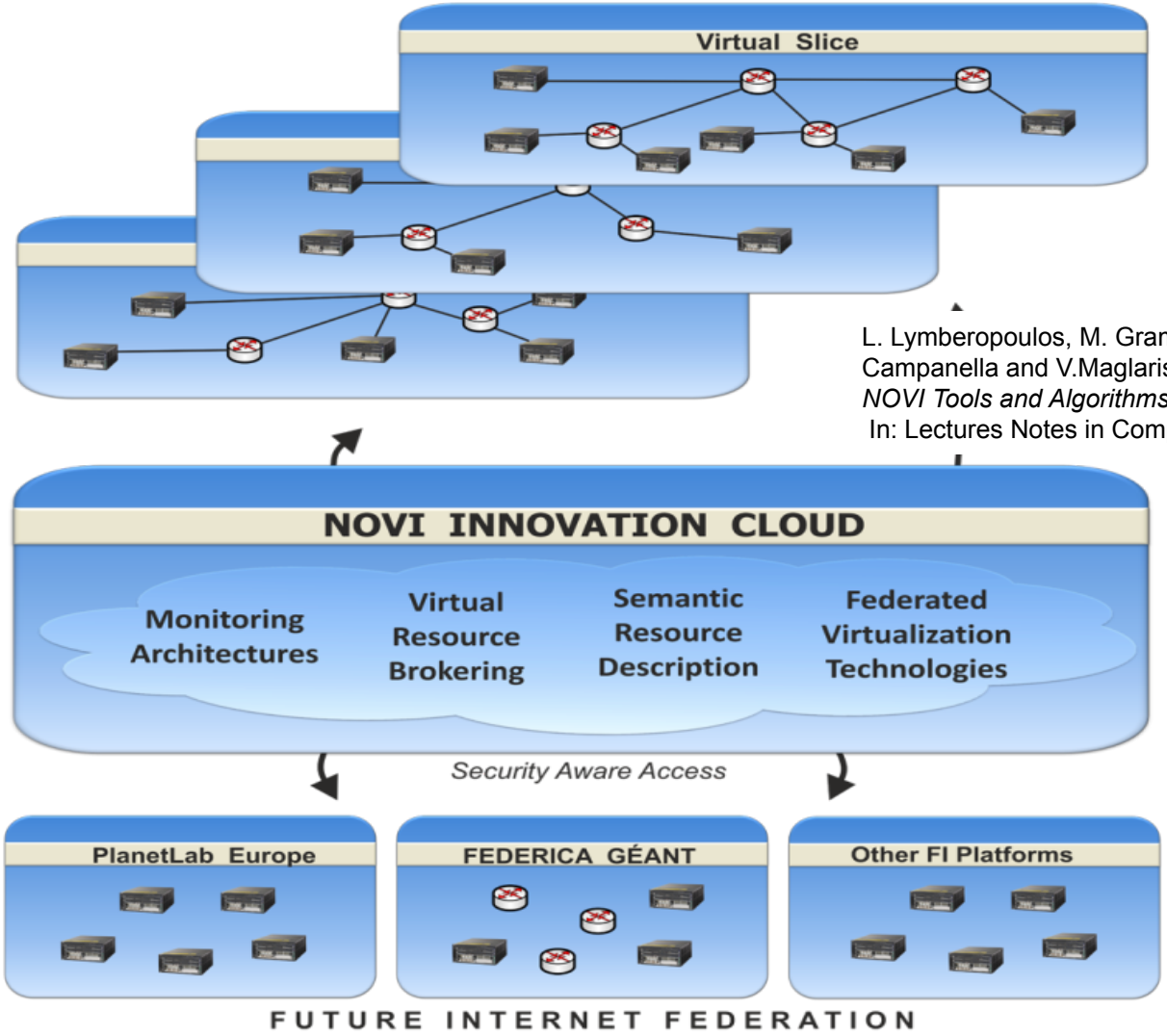
- http://www.cinegrid.org
- http://cgdev.uvalight.nl/home/





C. Dumitru, Z. Zhao, P. Grosso and C. de Laat
HybridFlow: Towards Intelligent Video Delivery and Processing Over Hybrid Infrastructures
(Under review)

NOVI innovation cloud



L. Lymberopoulos, M. Grammatikou, M.Potts, P. Grosso, A.Fekete, B. Belter, M. Campanella and V.Maglaris
NOVI Tools and Algorithms for Federating Virtualized Infrastructures
In: Lectures Notes in Computer Science, Vol: 7281/2012

Current NOVI platforms

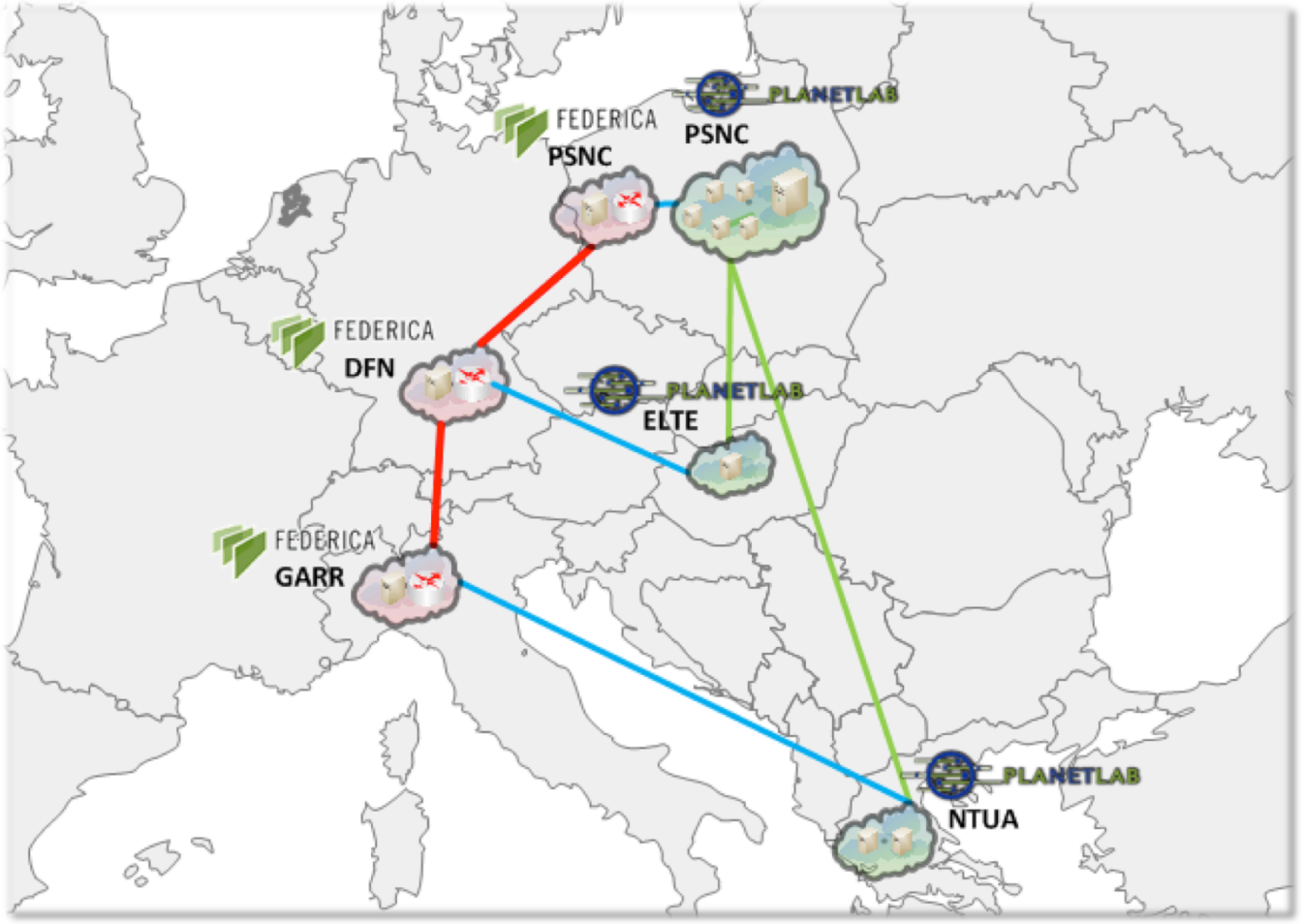
Provides virtualized computing resources:

- Virtual machines

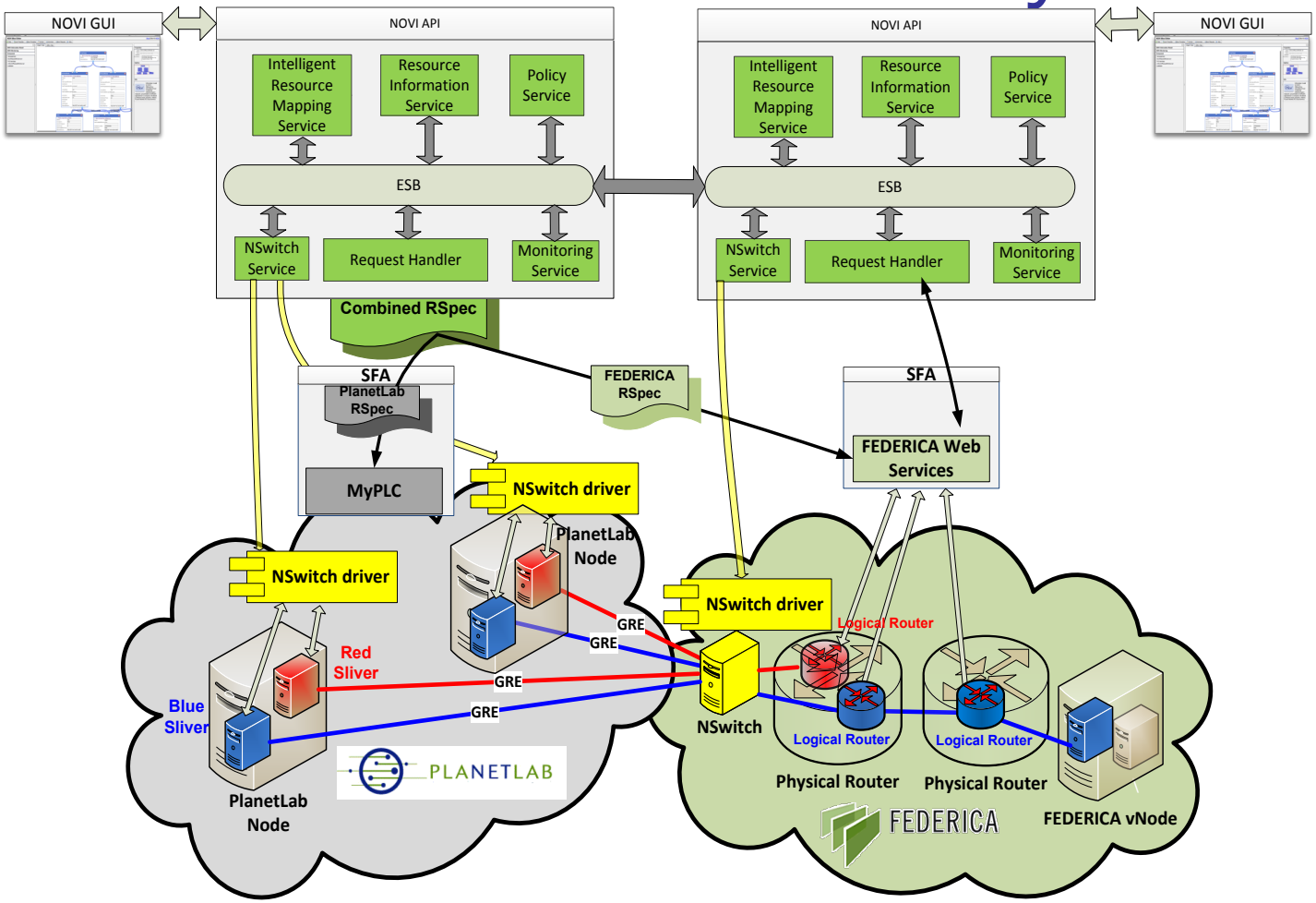
Provides virtualized networking resources:

- Logical routers

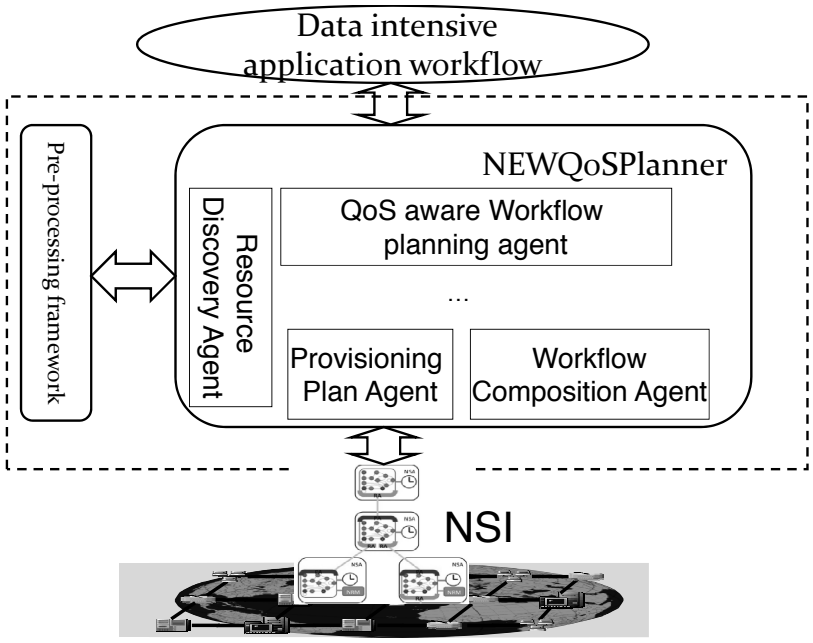
Experimentation environment

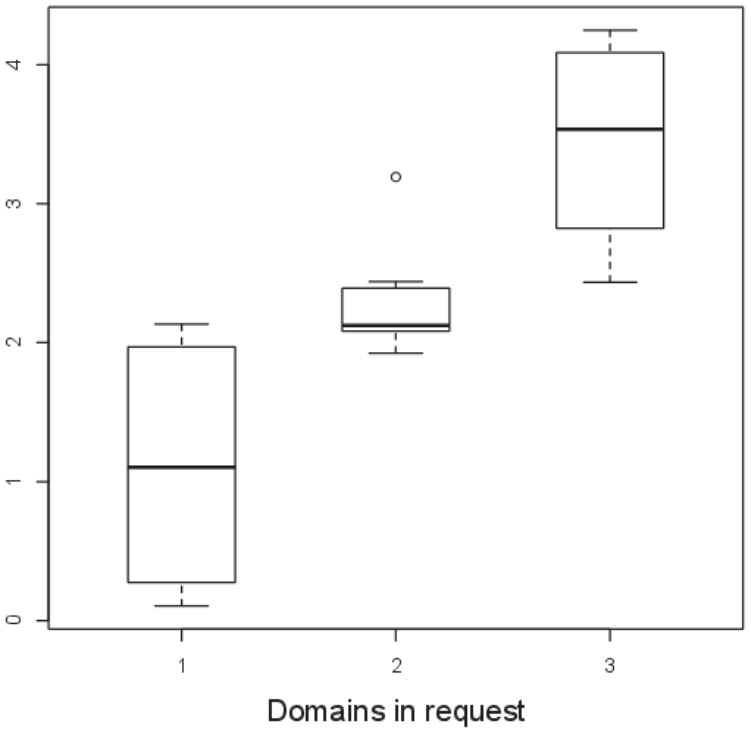


NOVI Service Layer



NewQOSPlanner





Z. Zhao, J. v/d Ham, A. Taal, R. Koning, P. Grosso and C. de Laat
Planning data intensive workflows on inter-domain resources using the Network Service Interface (NSI)
In:

What next?

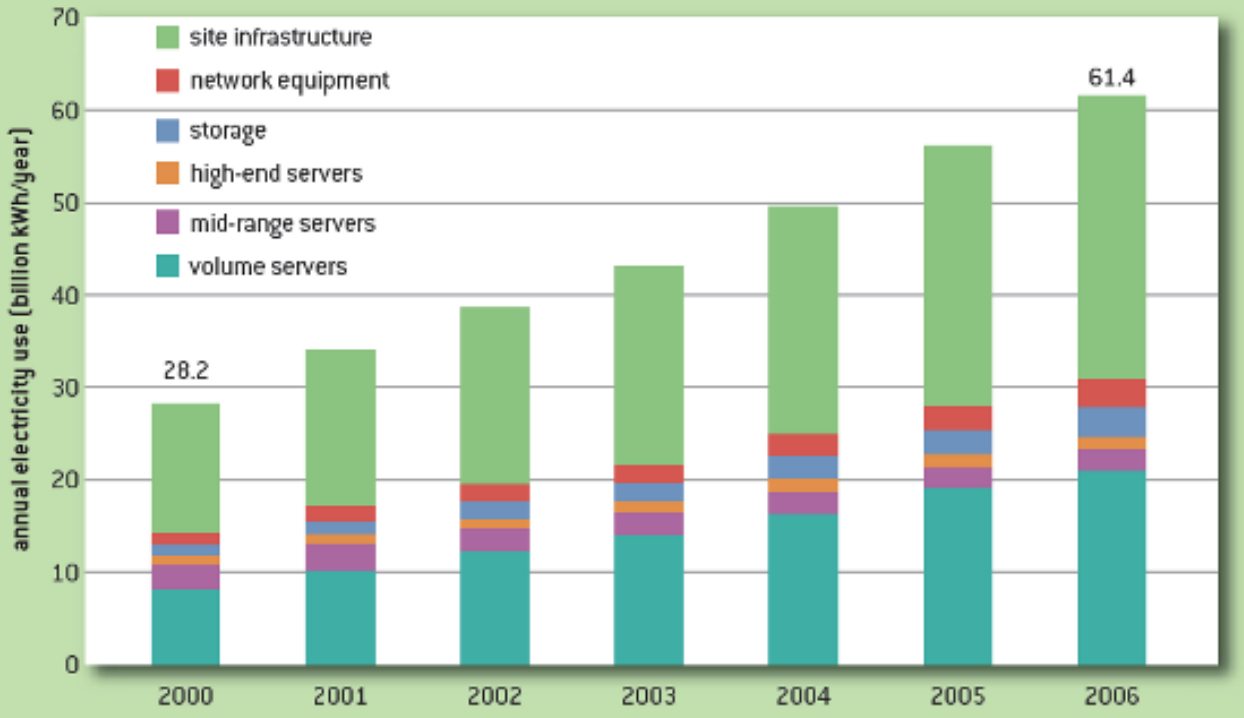
Network and services across domains are becoming a reality.

- Can we have **green** services?

Green e-Infrastructures

FIGURE 1

Electricity Use by End-Use Component, 2000 to 2006



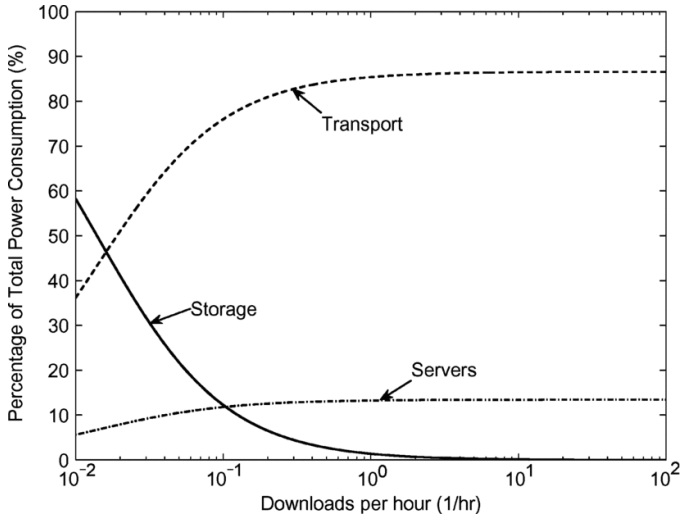
Source: EPA Report to Congress on Server and Data Center Energy Efficiency[5]

D. Brown and C. Reams
Towards energy-efficient computing
Communications of the ACM Volume 53 Issue 3, March 2010 Pages 50-58

Clouds: green or gray?

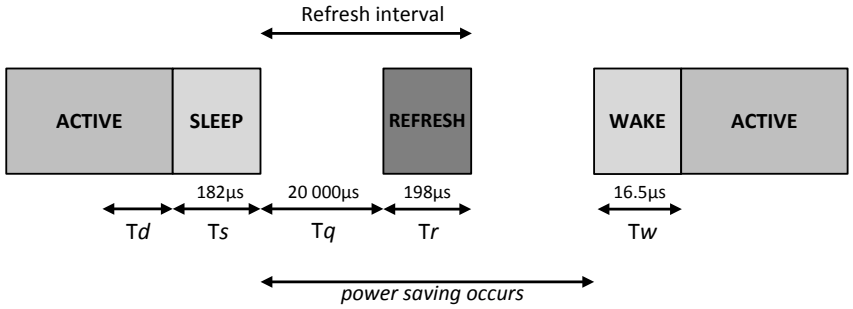
Complex question.

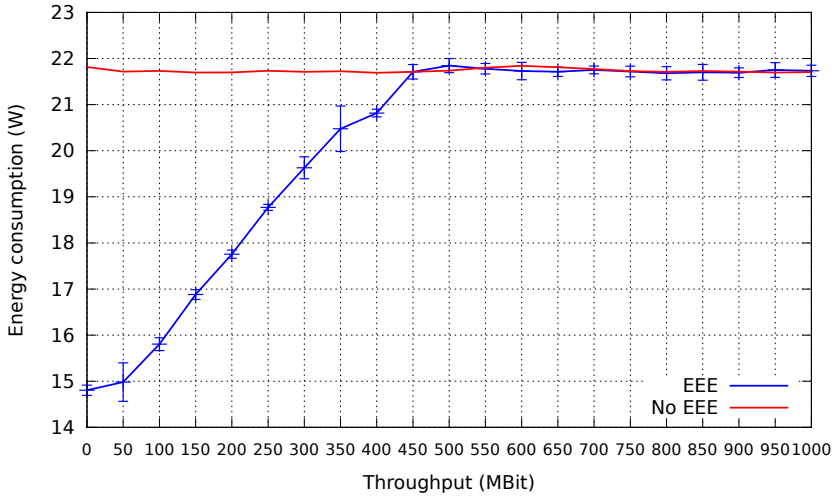
- Need knowledge of the carbon footprint
- Need knowledge of all contributing components, also of the network contribution between clouds, between user and cloud center

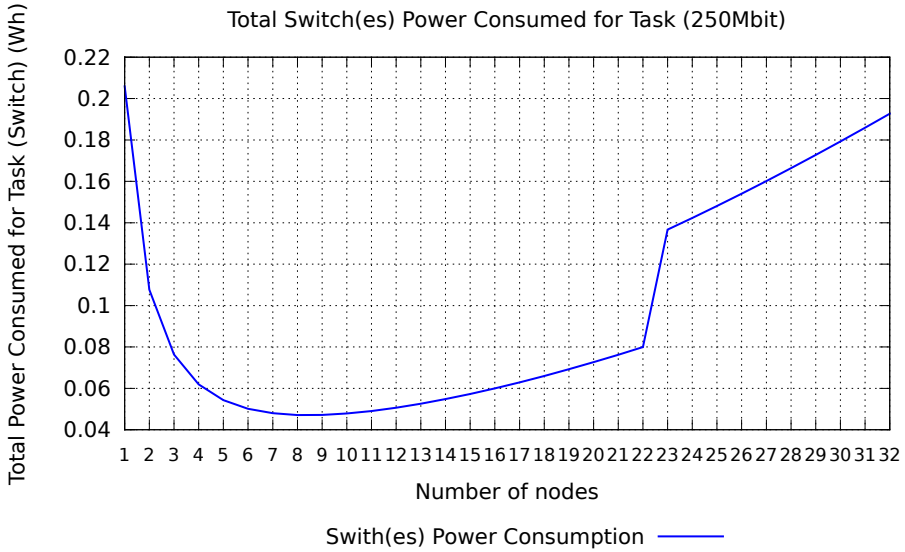


Baliga, J.; Ayre, R.W.A.; Hinton, K.; Tucker, R.S.
Green Cloud Computing:
Balancing Energy in Processing, Storage, and Transport
Proceedings of the IEEE , vol.99, no.1, pp.149-167, Jan. 2011

802.3az

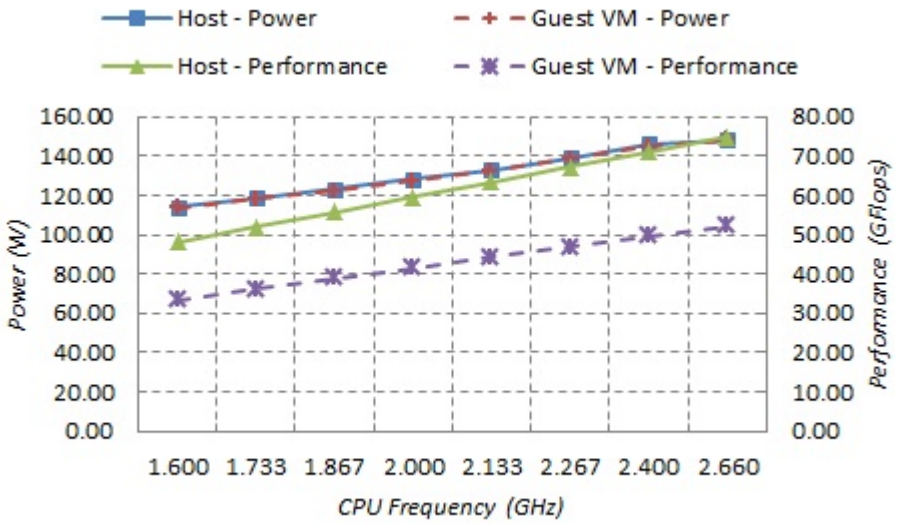




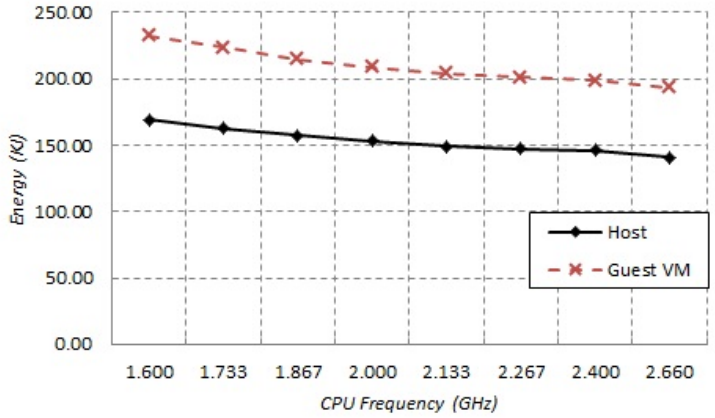


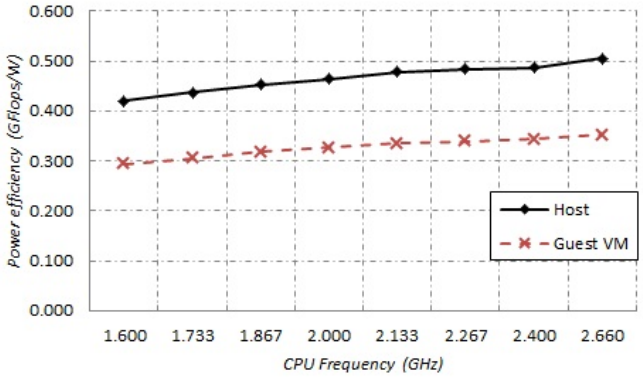
D. Pavlov and J. Soert and P. Grosso and Z. Zhao and K. van der Veldt and H. Zhu and C.de Laat
Towards energy efficient data intensive computing using IEEE 802.3az
In: DISCS 2012 workshop - Nov 2012

Profiling

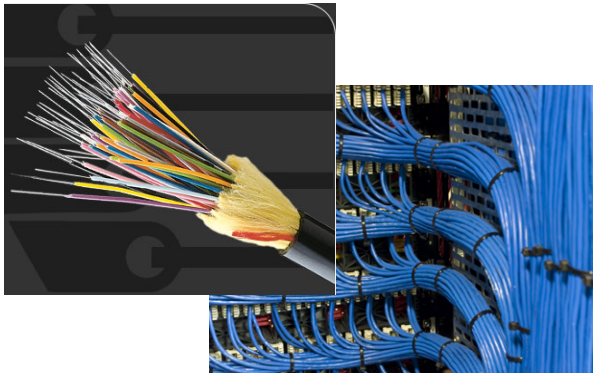


Q. Chen, P. Grosso, K. van der Veldt, C. de Laat, R. Hofman and H.Bal.
Profiling energy consumption of VMs for green cloud computing
In: International Conference on Cloud and Green Computing (CGC2011), Sydney December 2011

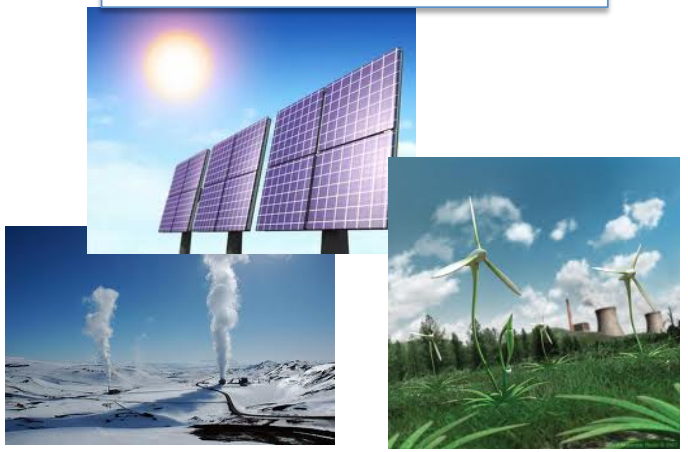




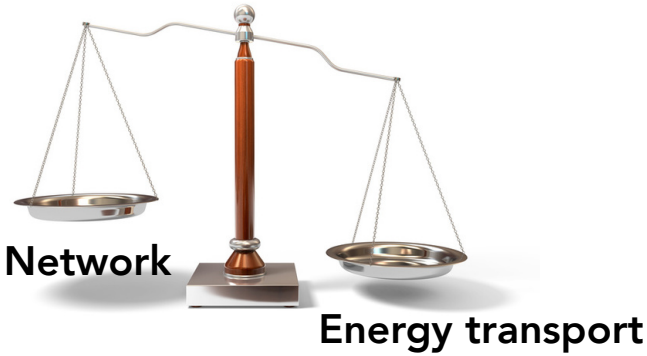
Network infrastructures



Green energy sources

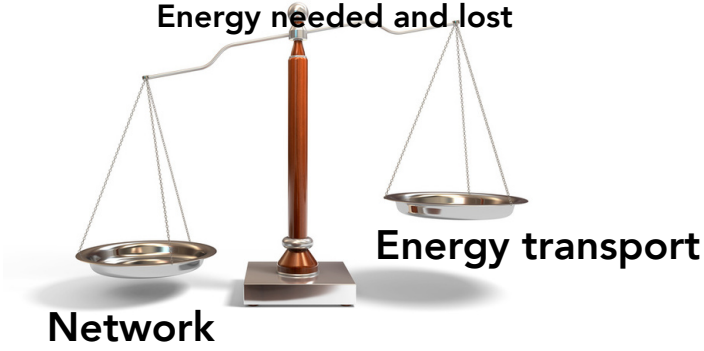


CO_2 footprint;
Energy needed and lost



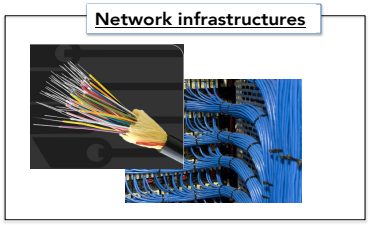
Bits to energy!

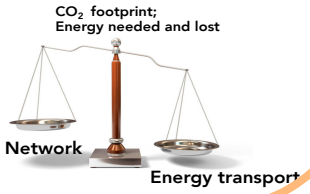
CO_2 footprint;
Energy needed and lost



Energy to bits!

Decision matrix



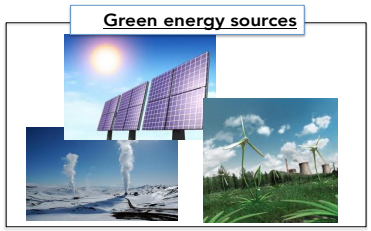


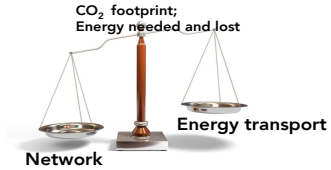
Bits to energy!

Identify realistic scenarios

Identify the variables relevant to each scenarios

Determine the cost of:
transport of bits
transport of energy





Energy to bits!

Scenario	Variables 1	Variable2	Variable 3	…	….
Scenario1					
Scenario2					
Scenario3					

Bits-to-nets	Energy-to-bits

Bits to Energy or Energy to Bits

Choose a service scenario

PUE of source and destination data center

Src: Dest:

Transport network between source and destination data center

Energy production X [gr CO_2/kWh]

source datacenter

X:

location energy production:

dest. datacenter

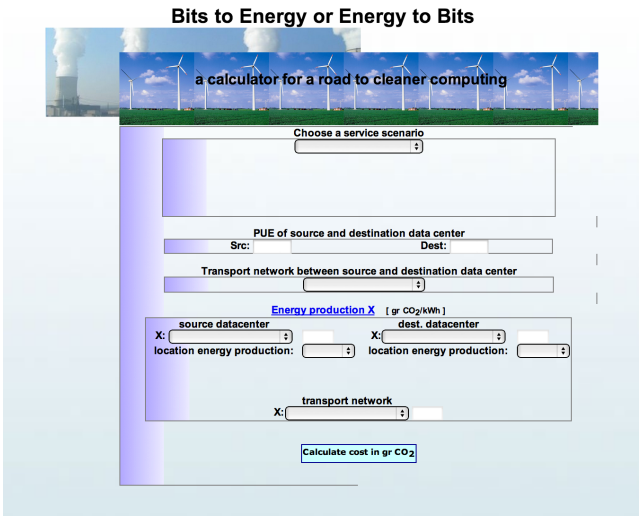
X:

location energy production:

transport network

X:

Calculate cost in gr CO_2



Efficiency vs. sustainability

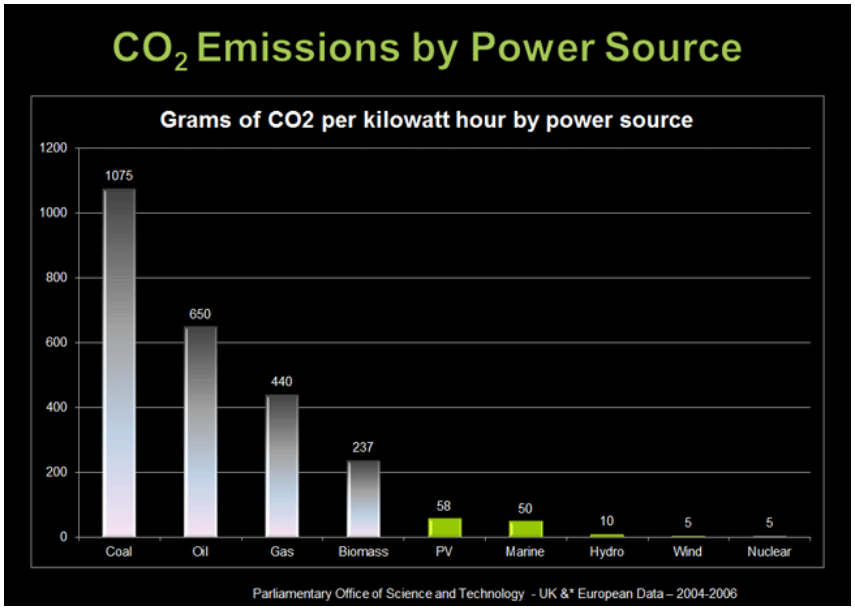
- Energy efficiency:

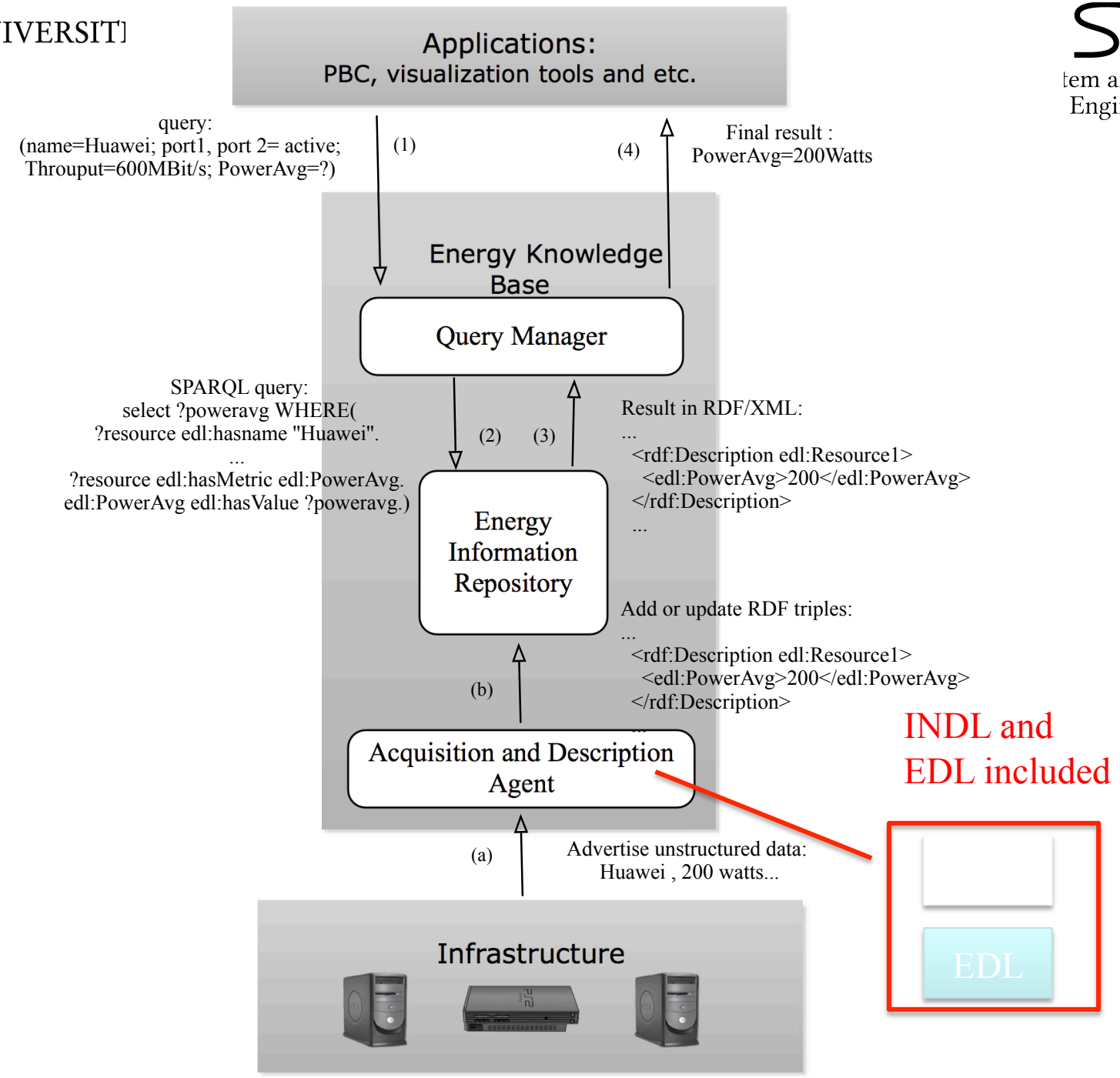
Reduce the amount of energy used to provide services, power devices

- Sustainability:

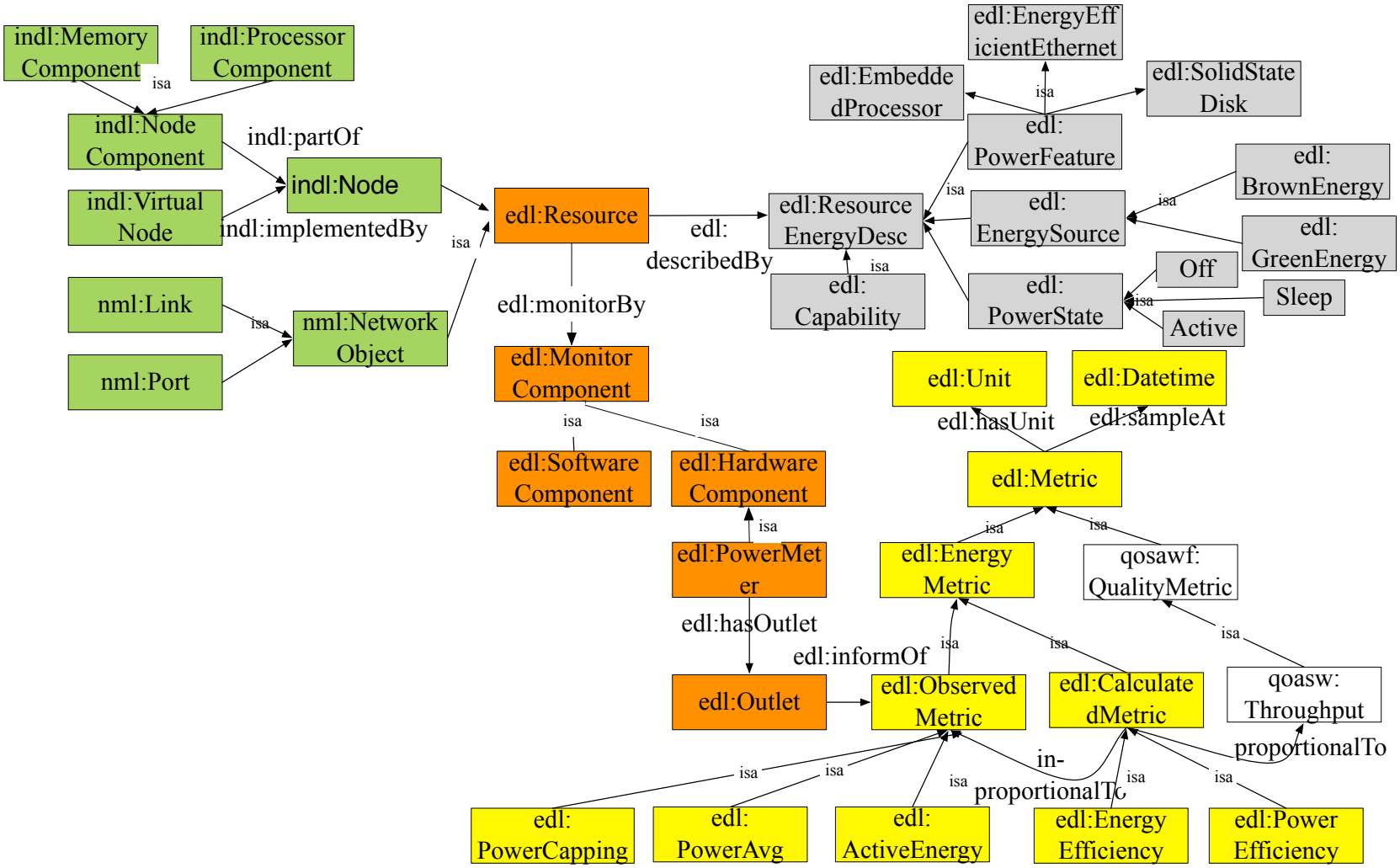
Use of renewables energy sources and reduction of carbon footprint.

Jevon's paradox!




Applications:
PBC, visualization tools and etc.
query:
(name=Huawei; port1, port 2= active;
Throuput=600MBit/s; PowerAvg=?)
(1)
(4)
Final result :
PowerAvg=200Watts
Energy Knowledge Base
Query Manager
SPARQL query:
select ?poweravg WHERE(
?resource edl:hasname "Huawei".
...
?resource edl:hasMetric edl:PowerAvg.
edl:PowerAvg edl:hasValue ?poweravg.)
(2)
(3)
Result in RDF/XML:
...
<rdf:Description edl:Resource1>
<edl:PowerAvg>200</edl:PowerAvg>
</rdf:Description>
...
Energy Information Repository
Add or update RDF triples:
...
<rdf:Description edl:Resource1>
<edl:PowerAvg>200</edl:PowerAvg>
</rdf:Description>
...
(b)
Acquisition and Description Agent
INDL and EDL included
EDL
(a)
Advertise unstructured data:
Huawei , 200 watts...
Infrastructure

Energy Description Language - EDL



Conclusions

- Scalability ⟹ Modeling
- Robustness ⟹ e-Services
- Sustainability ⟹ Green ICT and green networks

⟹
- INDL
- CDL
- EDL