Sustainable e-Infrastructures

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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

GigaPort

CINEGRID AMSTERDAM

GreenClouds

nvi

ENVRI
e-Infrastructures
... more users!

... more data!

... more realtime!
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
Hybrid networks

Packet switching

Circuit switching
The GLIF

Infrastructures modeling
Dynamic lightpath switching

• 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

P. Grosso , L. Xu, JP Velders, C. de Laat
StarPlane - A National Dynamic Photonic Network Controlled by Grid Applications
Many scientific applications have a distributed nature:

- Data are collected from many places, see radio-astronomy eVLBI/SCARLe.
- Data are sent to multiple locations 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)
• If computing is ‘infinite’ and movable, then workflows and applications can program the network.
User programmable networks
• Move the intelligence out of the network hardware: application/software programmable networks.

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

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

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?
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
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. 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
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
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
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
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
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 energy consumption of VMs for green cloud computing


*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

CO₂ footprint; Energy needed and lost

CO₂ footprint; Energy needed and lost

Bits to energy!

Energy to bits!
## Decision matrix

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Variables 1</th>
<th>Variable2</th>
<th>Variable 3</th>
<th>…</th>
<th>…</th>
<th>Bits-to-nets</th>
<th>Energy-to-bits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario1</td>
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<tr>
<td>Scenario2</td>
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<tr>
<td>Scenario3</td>
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</tbody>
</table>
Bits to Energy or Energy to Bits

a calculator for a road to cleaner computing

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 CO₂/kWh ]

source datacenter dest. datacenter
X: X:
location energy production: location energy production:

Calculate cost in gr CO₂
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=?)

**SPARQL query:**
```
select ?poweravg WHERE(
  ?resource edl:hasname "Huawei".
  ...
  ?resource edl:hasMetric edl:PowerAvg.
  edl:PowerAvg edl:hasValue ?poweravg.)
```

**Final result:**
PowerAvg=200Watts

**Result in RDF/XML:**
```
...<rdf:Description edl:Resource1>
<edl:PowerAvg>200</edl:PowerAvg>
</rdf:Description>
...```

**Add or update RDF triples:**
```
...<rdf:Description edl:Resource1>
<edl:PowerAvg>200</edl:PowerAvg>
</rdf:Description>
...```

**Advertise unstructured data:**
Huawei, 200 watts...

**INDL and EDL included**
Energy Description Language - EDL
Conclusions

- Scalability
- Robustness
- Sustainability
- Modeling
- e-Services
- Green ICT and green networks
- INDL
- CDL
- EDL