Smart Cyber Infrastructure for Big Data Processing

Cees de Laat
Mission

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

- Capacity
- Capability
- Security
- Sustainability
- Resilience
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  - Bandwidth on demand, QoS, architectures, photonics, performance

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- **Sustainability**
  - Greening infrastructure, awareness

- **Resilience**
  - Systems under attack, failures, disasters
What Happens in an Internet Minute?

- 639,800 GB of global IP data transferred
- 20 New victims of identity theft
- 204 million Emails sent
- 20 million Photo views
- 47,000 App downloads
- 61,141 Hours of music
- $83,000 In sales
- 20 million Photo uploads
- 320+ New Twitter accounts
- 135 Botnet infections
- 6 New Wikipedia articles published
- 1,300 New mobile users
- 100+ New Linkedin accounts
- 277,000 Logins
- 6 million Facebook views
- 2+ million Search queries
- In 2015, it would take you 5 years to view all video crossing IP networks each second

And Future Growth is Staggering
There is always a bigger fish
GPU cards are disruptive!

- 500 supercomputers
- #500 at 7 years
- 20,000,000$ (top 500)
- 500$ (single Graphics Processing Unit)

Graph showing the progression of supercomputers with time, indicating a significant increase in performance and cost over 7 years.
Reliable and Safe!

This omnipresence of IT makes us not only strong but also vulnerable.

- A virus, a hacker, or a system failure can instantly send digital shockwaves around the world.

The hardware and software that allow all our systems to operate is becoming bigger and more complex all the time, and the capacity of networks and data storage is increasing by leaps and bounds.

We will soon reach the limits of what is currently feasible and controllable.

The GLIF – LightPaths around the World

ExoGeni @ OpenLab - UvA

Installed and up June 3th 2013

Connected via the new 100 Gb/s transatlantic
To US-GENI
Amsterdam is a major hub in The GLIF

Alien light
From idea to realisation!

40Gb/s alien wavelength transmission via a multi-vendor 10Gb/s DWDM infrastructure

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.

\[
FOM = \sum_{i=1}^{n} l_i
\]

- \(l_i\) : span losses in dB
- \(n\) : number of spans

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.

Test results
Error-free transmission for 23 hours, 17 minutes → BER < 3.0 \times 10^{-15}

REFERENCES
[2] "40G OPTICAL TRANSPORT NETWORKS", RABBANI, DITTL, OCTOBER.
[3] "ERRORS FROM ALL-OPTICAL CORE NETWORKS", ABRAMOWITZ, COSSO, ET AL, OCTOBER.

ACKNOWLEDGMENTS
We are grateful to NORDUnet for providing us with bandwidth on their DWDM links for this experiment and also for their support and assistance during the experiments. We also acknowledge TELEFIS and NORTHEL for their integration work and simulation support.
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REFERENCES
[1] "OPERATIONAL SOLUTIONS FOR AN OPTICAL NETWORK", O. GERSTE et al., OCT'99
[4] WE ARE GRATEFUL TO NORDU-TEST FOR PROVIDING US WITH BASEWAVE ON TWIN REDUCED FOR THIS EXPERIMENT AND ALSO FOR THEIR SUPPORT AND ASSISTANCE DURING THE EXPERIMENTS. WE ALSO ACKNOWLEDGE TELEFIS AND NORTTEL FOR THEIR INTEGRATION WORK AND SIMULATION SUPPORT

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ClearStream @ TNC2011

Setup codename: FlightCees

UvA
- iPerf
  - I7 3.2 GHz Q-core
- Amd Ph II 3.6 GHz HexC
  - 40G E

Copenhagen
- iPerf
  - 2* dual 2.8 GHz Q-core

CIENA DWDM
- CIENA OME 6500
- 17 ms RTT

Alcatel DWDM
- Copenhagen
- 27 ms RTT

Amsterdam – Geneva (CERN) – Copenhagen – 4400 km (2700 km alien light)
Server Architecture

DELL R815
4 x AMD Opteron 6100

Supermicro X8DTT-HIBQF
2 x Intel Xeon
We used `numactl` to bind `iperf` to cores.
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We investigate: for complex networks!
LinkedIN for Infrastructure

- From semantic Web / Resource Description Framework.
- The RDF uses XML as an interchange syntax.
- Data is described by triplets (Friend of a Friend):

Diagram:

- Subject
- Predicate
- Object

- Location
  - name
  - connectedTo

- Device
  - description
  - capacity

- Interface
  - locatedAt
  - encodingType

- Link
  - hasInterface
  - encodingLabel
Choice of RDF instead of XML syntax
Grounded modeling based on G0805 description:

Multi-layer descriptions in NDL

- IP layer
- Ethernet layer
- STS layer
- OC-192 layer
- SONET switch with Ethernet intf.
- End host

Université du Quebec
Universiteit van Amsterdam
CA Net Canada
StarLight Chicago
MAN LAN New York
NetherLight Amsterdam
End host

Chicago
Canada
New York
Amsterdam

Multi-layer network diagram showing various network layers and connectivity points.
NML

OGF spec
Network topology research supporting automatic network provisioning

- Inter-domain networks
- Multiple technologies
- Based on incomplete information
- Possibly linked to other resources

http://redmine.ogf.org/projects/nml-wg
http://redmine.ogf.org/projects/nsi-wg
http://sne.science.uva.nl/ndl
GLIF 2013 in NML
Information Modeling

Define a common information model for *infrastructures* and *services*. Base it on Semantic Web.

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*, Elsevier Journal on Optical Switching and Networking, Volume 5, Issues 2-3, June 2008, Pages 85-93

R.Koning, P.Grosso and C.de Laat
*Using ontologies for resource description in the CineGrid Exchange*
Applications and Networks become aware of each other!
Our connecting models

- geysers.owl
- novi.owl
- cdl.owl
- indl.owl
- edl.owl
- nml.owl
- qosawf.owl
- qosawf_map.png.owl

Full import vs Selective import
NewQOSPlanner

The NSI – Network Service Interface – creates on the fly connections between domains.

Pre-processing framework

Data intensive application workflow

NEWQoSPlanner

Resource Discovery Agent

QoS aware Workflow planning agent

Provisioning Plan Agent

Workflow Composition Agent

NSI

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: WORKS 2012
Encoding times improve as the end nodes are connected via dynamic lightpaths.
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I want to

“Show Big Bug Bunny in 4K on my Tiled Display using green Infrastructure”

• Big Bugs Bunny can be on multiple servers on the Internet.
• Movie may need processing / recoding to get to 4K for Tiled Display.
• Needs deterministic Green infrastructure for Quality of Experience.
• Consumer / Scientist does not want to know the underlying details.

➤ His refrigerator also just works!
TCP	
  
  Reno, Vegas

RDUDP, SCTCP, …

(G)MPLS

SONET/SDH

ATM

LightPaths - GLIF

AAA

TBN

Policy

NDL	
  
  SF	
  
  for	
  
  complex	
  
  nets

GreenIT&Nets

SF for Clouds

PBT/PLSB

OpenFlow

NetApp’s

Programmable Networks

CineGrid

SF for CineGrid

Hybrid Nets

NM	
  
  OCCI	
  
  NSI

we started this

we use

we strongly participated
Timeline

- GreenIT&Nets
- Sustainable Internet
- SF for Clouds
- Cognitive Nets and clouds
- NDL SF for complex nets
- Programmable Networks, NetApp’s
- CineGrid
- SF for CineGrid
- NM, OCCI, NSI
- Op, SCTCP, ...
- Hybrid Nets
- TBN, Policy
- (G)MPLS, PBT/PLSB, OpenFlow
- TCP

“i Want” Internet 3.0

Virtualized Internet

Machine Learning

Good Old Trucking

2005 2012 2020
Layers

- Wisdom
- Knowledge to act
- Information

- Schedulers to act
- OWL
- XML, RDF, rSpec, text, Java based, etc.
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Need for GreenIT
Greening the Processing System

Positive proof of global warming.

ECO-Scheduling
Green scheduling

Network infrastructures

CO₂ footprint; Energy needed and lost

Network

Energy transport

Bits to energy

Green energy sources

CO₂ footprint; Energy needed and lost

Network

Energy transport

Energy to bits
Energy saving in clouds

Quantifying the energy performance of VMs is the first step toward energy-aware job scheduling.

Profiling energy consumption of VMs for green cloud computing
In: International Conference on Cloud and Green Computing (CGC2011), Sydney December 2011
Energy Efficient Ethernet (802.3az)

Power savings techniques in hardware can be leveraged in architecturing communication patterns in data centres.

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
Networks and CO2

- Take a network (Esnet, working on using SURFnet data)
- Define the traffic model running on it
- Use the energy monitoring information and energy costs data
- Compare path selection strategies: shortest, cheapest and greenest

“A motivation for carbon aware path provisioning for NRENs” (submitted to eEnergy2014)
Why?
Because we can!
Questions?

http://delaat.net
http://sne.science.uva.nl
http://www.os3.nl/
http://i4dw.nl/
http://dsrc.nl/
http://sne.science.uva.nl/openlab/
http://pire.opensciencedatacloud.org
http://staff.science.uva.nl/~delaat/pire/
https://rd-alliance.org
http://envri.eu

Trip supported by: