SNE Research

Cees de Laat

EU

SURFnet

BSIK

NWO

University of Amsterdam
LHC Data Grid Hierarchy

CMS as example, Atlas is similar

Tier 0 +1

- Online System
  - ~100 MBytes/sec
  - ~PByte/sec
  - event simulation

CMS detector: 15m x 15m x 22m
12,500 tons, $700M.

Tier 1

- Italian Regional Center
- German Regional Center
- NIKHEF Dutch Regional Center
- Fermilab, USA Regional Center

Tier 2

- Tier2 Center
- Tier2 Center
- Tier2 Center
- Tier2 Center
- Tier2 Center

Tier 3

- Institute
- Institute
- Institute

Tier 4

- Physics data cache
- 100 - 1000 Mbits/sec
- Workstations

CERN/CMS data goes to 6-8 Tier 1 regional centers, and from each of these to 6-10 Tier 2 centers.

Physicists work on analysis "channels” at 135 institutes. Each institute has ~10 physicists working on one or more channels.

2000 physicists in 31 countries are involved in this 20-year experiment in which DOE is a major player.
The SCARLe project

**SCARLe**: a research project to create a Software Correlator for e-VLBI.

**VLBI Correlation**: signal processing technique to get high precision image from spatially distributed radio-telescope.

To equal the hardware correlator we need:

- 16 streams of 1Gbps
- $16 \times 1\text{Gbps}$ of data
- 2 Tflops CPU power
- $2 \text{Tflop} / 16 \text{Gbps} = \frac{2}{16} \text{Tflops} / \text{byte} = 1000 \text{flops/byte}$
  
  **THIS IS A DATA FLOW PROBLEM !!!**

**SCARLe**

**VLBI Correlation**

**Data Flow Problem**
LOFAR as a Sensor Network

- LOFAR is a large distributed research infrastructure:
  - Astronomy:
    - >100 phased array stations
    - Combined in aperture synthesis array
    - 13,000 small “LF” antennas
    - 13,000 small “HF” tiles
  - Geophysics:
    - 18 vibration sensors per station
    - Infrasound detector per station
    - >20 Tbit/s generated digitally
    - >40 Tflop/s supercomputer
  - Innovative software systems
    - new calibration approaches
    - full distributed control
    - VO and Grid integration
    - datamining and visualisation

20 flops/byte
2 Tflops/s
US and International OptIPortal Sites

- SIO
- NCMIR
- USGS EDC
- NCSA & TRECC
- SARA
- KISTI
- AIST
- RINCON & Nortel
- TAMU
- UCI
- UIC
- CALIT2

Real time, multiple 10 Gb/s
The “Dead Cat” demo

SC2004, Pittsburgh, Nov. 6 to 12, 2004
iGrid2005, San Diego, sept. 2005

Many thanks to:
AMC
SARA
GigaPort
UvA/AIR
Silicon Graphics, Inc.
Zoölogisch Museum

IJKDIJK

300000 * 60 kb/s * 2 sensors (microphones) to cover all Dutch dikes
Sensor grid: instrument the dikes

First controlled breach occurred on sept 27th ‘08:

Many small flows $\rightarrow$ 36 Gb/s
CosmoGrid

- Motivation:
  previous simulations found >100 times more substructure than is observed!

- Simulate large structure formation in the Universe
  - Dark Energy (cosmological constant)
  - Dark Matter (particles)

- Method: Cosmological $N$-body code

- Computation: Intercontinental SuperComputer Grid
The hardware setup

- 2 supercomputers:
  - 1 in Amsterdam (60Tflops Power6 @ SARA)
  - 1 in Tokyo (30Tflops Cray XD0-4 @ CFCA)

- Both computers are connected via an intercontinental optical 10 Gbit/s network

10 Mflops/byte
1 Eflops/s

270 ms RTT
Auto-balancing Supers
Why is more resolution better?

1. More Resolution Allows Closer Viewing of Larger Image
2. Closer Viewing of Larger Image Increases Viewing Angle
3. Increased Viewing Angle Produces Stronger Emotional Response

Why is more resolution better?

1. More Resolution Allows Closer Viewing of Larger Image
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3. Increased Viewing Angle Produces Stronger Emotional Response

Yutaka TANAKA
SHARP CORPORATION
Advanced Image Research Laboratories
CineGrid portal

Welcome to the Amsterdam CineGrid distribution node. Below are the latest additions of super-high-quality video to our node.

For more information about CineGrid and our efforts look at the about section.

Latest Additions

- **Wypke**
  - Amsterdam animation
  - antonacc
  - duration: 1 hour and 8 minutes
  - created: 1 week, 2 days ago
  - author: Wypke
  - categories:

- **Prague Train**
  - Steam locomotive in Prague
  - duration: 27 hours and 46 minutes
  - created: 1 week, 2 days ago
  - author: CineGrid
  - categories: delta-99 prague train

- **VLC: Big Buck Bunny**
  - CGI copyright Blender Foundation
  - http://www.bigbuckbunny.org
  - duration: 1 hour and 0 minutes
  - created: 1 month, 1 week ago
  - author: Blender Foundation
  - categories: animation blender bunny CGI
Amsterdam CineGrid S/F node

“COCE”

DAS-3 @ UvA

DP AMD processor nodes

comp node

head node

bridge node

bridge node

bridge node

bridge node

bridge node

bridge node

bridge node

storage node

100 TByte

10 Gbit/s

NORTEL 8600 L2/3 switch

F10 L2/3 switch

GlimmerGlass photonic switch

NetherLight, StarPlane the cp testbeds and beyond

Rembrandt Cluster
total 22 TByte disk space
@ LightHouse

Opteron 64 bit nodes

head node

comp node

comp node

comp node

comp node

comp node

comp node

comp node

streaming node

8 TByte

Node 41

suitcases & briefcases

10 Gbit/s
MicroStories (Handelingen)
A. Lightweight users, browsing, mailing, home use
   Need full Internet routing, one to all

B. Business/grid applications, multicast, streaming, VO’s, mostly LAN
   Need VPN services and full Internet routing, several to several + uplink to all

C. E-Science applications, distributed data processing, all sorts of grids
   Need very fat pipes, limited multiple Virtual Organizations, P2P, few to few

For the Netherlands 2007

\[ \Sigma A = \Sigma B = \Sigma C \]

However:

- A -> all connects
- B -> on several
- C -> just a few (SP, LHC, LOFAR)

Ref: Cees de Laat, Erik Radius, Steven Wallace, "The Rationale of the Current Optical Networking Initiatives"
Towards Hybrid Networking!

- Costs of photonic equipment 10% of switching 10% of full routing
  - for same throughput!
  - Photonic vs Optical (optical used for SONET, etc, 10-50 k$/port)
  - DWDM lasers for long reach expensive, 10-50 k$

- Bottom line: look for a hybrid architecture which serves all classes in a cost effective way
  - map A -> L3 , B -> L2 , C -> L1 and L2

- Give each packet in the network the service it needs, but no more!

L1 ≈ 2-3 k$/port
L2 ≈ 5-8 k$/port
L3 ≈ 75+ k$/port
How low can you go?

- Application Endpoint A
- Local Ethernet
- POS
- MEMS
- Regional dark fiber
- 15454 6500 HDXc
- Trans-Oceanic
- Application Endpoint B
- Router
- Ethernet
- SONET
- DWDM
- Fiber
- CERN
- NetherLight
- GLIF
- StarLight
Hybrid computing

Routers ↔ Supercomputers

Ethernet switches ↔ Grid & Cloud

Photonic transport ↔ GPU’s

What matters:

Energy consumption/multiplication
Energy consumption/bit transported
Visualization courtesy of Bob Patterson, NCSA
Data collection by Maxine Brown.
Management
Visualisation
Mining
Web2.0
Media
Backup
Security
NetherLight
Meta
CineGrid
Medical
TV
Gaming
Conference
Workflow
Clouds
Distributed
EventProcessing
Simulations
Predictions
StreamProcessing
Distributed Simulations
Predictions
In The Netherlands SURFnet connects between 180:
- universities;
- academic hospitals;
- most polytechnics;
- research centers.
with an indirect ~750K user base

~ 8860 km
scale comparable to railway system
Common Photonic Layer (CPL) in SURFnet6 supports up to 72 Lambda’s of 10 / 40 / 100 G
StarPlane
DWDM
backplane
DAS-3 Cluster Architecture

- 85 (40+45) compute nodes
- Fast interconnect
- Local interconnect
- 10 Gb/s Ethernet lanphy

**UvA-node**

- To local University
- 1 Gb/s Ethernet
- Local interconnect

**Nortel**

- 10 Gb/s Ethernet lanphy

**Myrinet**

- To SURFnet
- 10 Gb/s Ethernet lanphy
- 8 * 10 Gb/s from bridgenodes
The challenge for sub-second switching

- bringing up/down a $\lambda$ takes minutes
  - this was fast in the era of old time signaling (phone/fax)
  - $\lambda$ 2 $\lambda$ influence (Amplifiers, non linear effects)
  - however minutes is historically grown, 5 nines, up for years
  - working with Nortel CIENA to get setup time significantly down

- plan B:
The StarPlane vision is to give flexibility directly to the applications by allowing them to choose the logical topology in real time, ultimately with sub-second lambda switching times on part of the SURFnet6 infrastructure.
Overview Net Tests between DAS-3 Hosts

- Authorise here to store the current table settings in your cookies file.
- See the getting started introduction or the user guide for a description of the table below.
- See also the hosts documentation.
- Some observations about the package and the required bandwidth.

Select ping value: min, avg, max, all, list.
Select UDP value: min, list.

### DAS-3 Net Test Results

**Date:** 31/05/2007  
**Time:** 12:30:01

<table>
<thead>
<tr>
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<tbody>
<tr>
<td><strong>Load</strong></td>
<td>0</td>
<td>0</td>
<td>0.087</td>
<td>0</td>
<td>0.013</td>
<td>0.013</td>
<td>0.017</td>
<td>0.15</td>
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</tbody>
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<tr>
<td><strong>Ping Min (ms)</strong></td>
<td></td>
<td></td>
<td>1.380</td>
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<tbody>
<tr>
<td><strong>Throughput [Mbit/s]</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4684.22</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

MAY 31th 2007
Games and Model Checking

- Can solve entire Awari game on wide-area DAS-3 (889 B positions)
  - Needs 10G private optical network [CCGrid'08]
- Distributed model checking has very similar communication pattern
  - Search huge state spaces, random work distribution, bulk asynchronous transfers
- Can efficiently run DevinE model checker on wide-area DAS-3, use up to 1 TB memory [IPDPS'09]
Required wide-area bandwidth

![Graph showing the relationship between total number of cores and WAN throughput in Gigabits per second (Gbit/s) for different core configurations: 1 core per node, 2 cores per node, and 4 cores per node. The throughput increases as the total number of cores increases.]
Head node

64 bit multi-core nodes

+ GPU’s

Phase 1: SURFnet to other DAS sites

local network exp. equipment

≥10 Gb/s

≥10 Gb/s

Future Accelerators

10/40/100 Gb/s

WAN link switch

= phase 1

= phase 2

Photonic network SURFnet
Power is a big issue

- UvA cluster uses (max) 30 kWh
- 1 kWh ~ 0.1 €
- per year -> 26 k€/y
- add cooling 50% -> 39 k€/y
- Emergency power system -> 50 k€/y
- per rack 10 kWh is now normal

- **YOU BURN ABOUT HALF THE CLUSTER OVER ITS LIFETIME!**

- Terminating a 10 Gb/s wave costs about 200 W
- Entire loaded fiber -> 16 kW
- Wavelength Selective Switch : few W!
Alien light
From idea to realisation!
Diagram for SAGE video streaming to ATS

Lab 10, Nortel

SAGE Display
SAGE Servers
MERS

Netherlight
Canarie

1 Gbps

Internet
Content Choice

User
Regular Browser

UvA, Amsterdam

comp clusters

MERS

Traffic Generators

Content Portal
Streaming Server
100 TB Storage

Content Request

MERS

MERS

MERS

SAGE Servers

SAGE Display

User

Regular Browser

Internet

Content Choice

Content Request

1 Gbps

MERS

MERS
UvA Testbed

Congestion introduced in the network with multiple PBT paths carrying streamed SHD Content
Experimental Data

10 Second Traffic bursts with No PBT

10 Second Traffic bursts with PBT

PBT is **SIMPLE** and **EFFECTIVE** technology to build a shared Media-Ready Network
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...
Network Description Language

- From semantic Web / Resource Description Framework.
- The RDF uses XML as an interchange syntax.
- Data is described by triplets:
NetherLight in RDF

```xml
<?xml version="1.0" encoding="UTF-8"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
   xmlns:ndl="http://www.science.uva.nl/research/air/ndl#">
<!-- Description of Netherlight -->
<ndl:Location rdf:about="#Netherlight">
   <ndl:name>Netherlight Optical Exchange</ndl:name>
</ndl:Location>
<!-- TDM3.amsterdam1.netherlight.net -->
<ndl:Device rdf:about="#tdm3.amsterdam1.netherlight.net">
   <ndl:name>tdm3.amsterdam1.netherlight.net</ndl:name>
   <ndl:locatedAt rdf:resource="#amsterdam1.netherlight.net"/>
   <ndl:hasInterface rdf:resource="#tdm3.amsterdam1.netherlight.net:501/1"/>
   <ndl:hasInterface rdf:resource="#tdm3.amsterdam1.netherlight.net:501/3"/>
   <ndl:hasInterface rdf:resource="#tdm3.amsterdam1.netherlight.net:501/4"/>
   <ndl:hasInterface rdf:resource="#tdm3.amsterdam1.netherlight.net:503/1"/>
   <ndl:hasInterface rdf:resource="#tdm3.amsterdam1.netherlight.net:504/1"/>
   <ndl:hasInterface rdf:resource="#tdm3.amsterdam1.netherlight.net:504/2"/>
   <ndl:hasInterface rdf:resource="#tdm3.amsterdam1.netherlight.net:504/3"/>
   <ndl:hasInterface rdf:resource="#tdm3.amsterdam1.netherlight.net:504/4"/>
   <ndl:hasInterface rdf:resource="#tdm3.amsterdam1.netherlight.net:501/2"/>
</ndl:Device>
<!-- all the interfaces of TDM3.amsterdam1.netherlight.net -->
<ndl:Interface rdf:about="#tdm3.amsterdam1.netherlight.net:501/1">
   <ndl:name>tdm3.amsterdam1.netherlight.net:POS501/1</ndl:name>
   <ndl:connectedTo rdf:resource="#tdm4.amsterdam1.netherlight.net:5/1"/>
</ndl:Interface>
<ndl:Interface rdf:about="#tdm3.amsterdam1.netherlight.net:501/2">
   <ndl:name>tdm3.amsterdam1.netherlight.net:POS501/2</ndl:name>
   <ndl:connectedTo rdf:resource="#tdm1.amsterdam1.netherlight.net:12/1"/>
</ndl:Interface>
</rdf:RDF>
```
Multi-layer descriptions in NDL

End host
Université du Quebec

SONET switch with Ethernet intf.
CA Net Canada

Ethernet & SONET switch
StarLight Chicago

SONET switch
MAN LAN New York

SONET switch with Ethernet intf.
NetherLight Amsterdam

End host
Universiteit van Amsterdam
A weird example

Université du Québec

CA Net Canada

Can adapt GE in STS-24c

StarLight Chicago

Can adapt GE in STS-24c or STS-3c-7v

Man LAN New York

Can adapt GE in STS-24c

2x OC-192 (63 free)

2x OC-192 (87 free)

2x OC-192 (22 free)

OC-192 (38 free)

Gigabit Ethernet

Universiteit van Amsterdam

Can adapt GE in STS-3c-7v

GE

Thanks to Freek Dijkstra & team
The Problem

I want HC and AB
Success depends on the order
Wouldn’t it be nice if I could request [HC, AB, ...]
Another one 😊

I want AB and CD
Success does not even depend on the order!!!
NDL + PROLOG

Research Questions:
• order of requests
• complex requests
• usable leftovers

• Reason about graphs
• Find sub-graphs that comply with rules
Single layer networks: results

- Number of interfaces,
- given \(N\) nodes per domain \(D\)
- \(4(D-2) + D*4(N-2)\) for \(D > 2\)

**Prolog DFS**

- Prolog time to find first path shorter than Python time.
- We observe a quadratic dependence.
- Length of paths found comparable.
Multi-domain 2-layer networks

How do multi-domain 2-layer networks look like?

Guess: Projection algorithm (2-layer: Ethernet / WDM)

Steps:
1. Generate a multi-domain graph by BA-algorithm
2. Generate a graph for each domain by BA-algorithm
3. For each domain graph project random nodes onto WDM layer
4. Connect the domains at each layer according to the multi-domain graph
5. Assign random wavelengths to the adaptation links

Advantage:
• Number of adaptations determined by the degree of the projected nodes
• Multi-domain Ethernet-layer as well as the multi-domain WDM-layer graph are not necessarily connected.

Input parameters:
• Number domains, number of nodes(devices) per domain
• Ratio of Ethernet-devices over WDM-devices per domain
• Distribution of wavelength
Multi-domain 2-layer networks

Projection algorithm

BA-algorithm to generate a graph for each domain
Project random nodes onto WDM layer
Prolog rule:

linkedto( Intf1, Intf2, CurrWav ):-
    rdf_db: rdf( Intf1, ndl:'layer', Layer ),
    Layer == 'wdm#LambdaNetworkElement',
    rdf_db: rdf( Intf1, ndl:'linkedTo', Intf2 ),
    rdf_db: rdf( Intf2, wdm:'wavelength', W2 ),
    compatible_wavelengths( CurrWav, W2 ). %-- is there a link between Intf1 and Intf2 for wavelength CurrWav ?

%-- get layer of interface Intf1 \rightarrow Layer
%-- are we at the WDM-layer ?
%-- is Intf1 linked to Intf2 in the RDF file?
%-- get wavelength of Intf2 \rightarrow W2
%-- is CurrWav compatible with W2 ?

linkedto( B4, D4, CurrWav ) is true for any value of CurrWav
linkedto( D2, C3, CurrWav) is true if CurrWav == 1310
Path between interfaces A1 and E1:
A1-A2-B1-B4-D4-D2-C3-C1-C2-B2-B3-D3-D1-E2-E1

Scaling: Combinatorial problem
# Prolog pathfinding results

<table>
<thead>
<tr>
<th>#Domains (#Ether:#WDM) (&lt;#Intf&gt;)(&lt;#Adap&gt;)</th>
<th>Prolog time [ms] μ(σ)</th>
<th>Timeouts</th>
<th>Success %</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 (9:6)(55)(11)</td>
<td>20(4)</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>4 (48:32)(377)(73)</td>
<td>2620(8245)</td>
<td>74</td>
<td>92.6</td>
</tr>
<tr>
<td>4 (96:64)(771)(147)</td>
<td>6592(11802)</td>
<td>207</td>
<td>79.3</td>
</tr>
<tr>
<td>3 (9:6)(55)(11)</td>
<td>20(4)</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>4 (48:32)(377)(73)</td>
<td>1303(5052)</td>
<td>22</td>
<td>97.8</td>
</tr>
<tr>
<td>4 (96:64)(771)(147)</td>
<td>3910(10045)</td>
<td>51</td>
<td>94.9</td>
</tr>
<tr>
<td>3 (9:6)(55)(11)</td>
<td>20(4)</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>4 (48:32)(377)(73)</td>
<td>755(3210)</td>
<td>8</td>
<td>98.9</td>
</tr>
<tr>
<td>4 (96:64)(771)(147)</td>
<td>3240(9052)</td>
<td>38</td>
<td>96.1</td>
</tr>
</tbody>
</table>

**DFS path constraints:**

Number of different wavelength

No max #wav

#wav ≤3

#wav ≤2
# Prolog pathfinding results

**Parallel calls:** A->B and B->A

**Projection: A->B**

<table>
<thead>
<tr>
<th>#Domains (#Ether:#WDM) (&lt;#Intf&gt;) (&lt;#Adap&gt;)</th>
<th>Prolog time [ms] (\mu(\sigma))</th>
<th>Timeouts</th>
<th>Success %</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 (9:6)(55)(11)</td>
<td>20(4)</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>4 (48:32)(377)(73)</td>
<td>755(3210)</td>
<td>8</td>
<td>98.9*</td>
</tr>
<tr>
<td>4 (96:64)(771)(147)</td>
<td>3240(9052)</td>
<td>38</td>
<td>96.1*</td>
</tr>
</tbody>
</table>

**Projection: first of A->B and B->A**

<table>
<thead>
<tr>
<th>#Domains (#Ether:#WDM) (&lt;#Intf&gt;) (&lt;#Adap&gt;)</th>
<th>Prolog time [ms] (\mu(\sigma))</th>
<th>Timeouts</th>
<th>Success %</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 (9:6)(55)(11)</td>
<td>19(1)</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>4 (48:32)(377)(73)</td>
<td>144(486)</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>4 (96:64)(771)(147)</td>
<td>601(2722)</td>
<td>2</td>
<td>99.6*</td>
</tr>
</tbody>
</table>

*false negatives also taken into account
RDF describing Infrastructure

Application: find video containing x, then trans-code to it view on Tiled Display

RDF/CG

RDF/ST

RDF/NPL

RDF/CPU

RDF/VIZ

content

PG&CdL
Applications and Networks become aware of each other!
Workflow execution: mapping between resources
Quality tuning in scientific workflow

Abstract processes:
Refine application logic

Concrete workflow:
select optimal services, components

Storage, computing elements:
select high performance resources

Network:
network path selection.
Network for Workflow QoS planner (NEWQoSPlanner)

- A planner for expensive data movement related processes workflow system
  - Select network resources
  - Make provision plan
  - Generate network QoS aware sub workflow

NEWQoSPlanner
System architecture

- Network resource descriptions
- Resource Discovery
  - Agent (RDA)
- QoS aware Workflow Planner (QoSWP)
- Workflow engine
- Workflow
- Provision plan
- Resources
- User request
- Provisioning plan
- Network resource descriptions
- Resource Provision
  - Planner (RPP)
- Workflow
  - Composer
  - Agent (WCA)
- QoS Monitoring Agent (QMA)
- Provenance Service Agent (PSA)
- Multi agent system for QoS aware workflow management
User Programmmable Virtualized Networks allows the results of decades of computer science to handle the complexities of application specific networking.

- The network is virtualized as a collection of resources
- UPVNs enable network resources to be programmed as part of the application
- Mathematica, a powerful mathematical software system, can interact with real networks using UPVNs
Mathematica enables advanced graph queries, visualizations and real-time network manipulations on UPVNs

Topology matters can be dealt with algorithmically
Results can be persisted using a transaction service built in UPVN

Initialization and BFS discovery of NEs

```mathematica
Needs["WebServices"]
<<DiscreteMath'Combinatorica'
<<DiscreteMath'GraphPlot'
InitNetworkTopologyService["edge.ict.tno.nl"]

Available methods:

{DiscoverNetworkElements, GetLinkBandwidth, GetAllIpLinks, Remote, NetworkTokenTransaction}

Global`upvnverbose = True;

AbsoluteTiming[nes = BFSDiscover["139.63.145.94"];][[1]]

AbsoluteTiming[result = BFSDiscoverLinks["139.63.145.94", nes];][[1]]

Getting neighbours of: 139.63.145.94
Internal links: {192.168.0.1, 139.63.145.94}
...

Getting neighbours of: 192.168.2.3

Transaction on shortest path with tokens

Internal links: {192.168.2.3}

nodePath = ConvertIndicesToNodes[
  ShortestPath[
    g,
    Node2Index[nids,"192.168.3.4"],
    Node2Index[nids,"139.63.77.49"]
  ],
  nids]

Print["Path: ", nodePath];

If[NetworkTokenTransaction[nodePath, "green"] == True,
  Print["Committed"], Print["Transaction failed"]];

Path: {192.168.3.4,192.168.3.1,139.63.77.30,139.63.77.49}

Committed

ref: Robert J. Meijer, Rudolf J. Strijkers, Leon Gommans, Cees de Laat, User Programmable Virtualized Networks, accepted for publication to the IEEE e-Science 2006 conference Amsterdam.
TouchTable Demonstration @ SC08
Themes for next years

- 40 and 100 gbit/s
- Network modeling and simulation
- Cross domain Alien Light switching
- Green-Light
- Network and infrastructure descriptions & WEB2.0
- Reasoning about services
- Cloud Data – Computing - Virtualisation
- Web Services based Authorization
- Network Services Interface (N-S and E-W)
- e-Science integrated services
- Prototyping the Internet Exchange of the Future
CookReport
feb 2009 and feb-march 2010

November ’08

Interview with
Kees Neggers (SURFnet),
Cees de Laat (UvA)

and furthermore

on November ’09

Wim Liebrandt (SURF),
Bob Hertzberger (UvA) and
Hans Dijkman (UvA)

BSIK projects
GigaPort &
VL-e / e-Science

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I did not talk about:

- Token Based Networking
- Privacy & Security
- Authorization, Policy and Trust
- Sensor networks

Questions ?