

## GENIOUS revisited

(Generalised Environment for tera-scale Network  
Innovations enabled by Optical Underlying  
Systems)

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- ❑ Hybrid networking is here to stay; beyond hybrid networking!
- ❑ Handle the big Science's extreme requirements
- ❑ keep things simple at users end
- ❑ Engineer CBDF into an testbed for network R&D
- ❑ Energy consumption of the Internet
- ❑ terabit to the multicore chip (end-system)
- ❑ network style&behavior programmability
- ❑ network infrastructure integrity and security

- ❑ hybrid applications
- ❑ massive transport capacity increase
- ❑ keep same or smaller energy footprint while increasing transport capacity
- ❑ programmable networks
- ❑ buffer-less high speed transport on high rtt
- ❑ semantic reasoning about networks and infrastructure
- ❑ from many small flows in sensor grids to teraflows
- ❑ optical/photonic cross border dark fiber peering and alien light transport
- ❑ dynamic photonic layer
- ❑ simulation of scaling infrastructure to Internet size

### □ Tera-scaling in link capacity, network elements, IT devices and number of users

- Terabit edge to edge capacity: Several Tb/s logical flows in the network
  - High performance LANs,
  - Optical interconnects,
  - 100 GE LAN and carrier grade technologies,
  - Optical peering solutions (>160 Gbps)
  - Terabit interfaces towards the end users
- Models for Tera-scale Applications:
  - TFlops                    ->        MPI / Globus
  - TBytes                   ->        OGSA/DAIS, DEISA
  - TPixels                  ->        SAGE
  - TSensors                ->        LOFAR, LHC, LOOKING, CineGrid, ...
  - Tbit/s                    ->        ?
- Billions of users
  - Consumer grids
  - Rapid growth of the popularity of video on demand services
  - Residential users able to access new giga/tera-scale services

### □ Programmability

- The implementation and validation of a network substrate, consisting of programmable layer 1/2 switches, routers and gateways
- Different applications are allowed to implement different network functions, which are driven by the application logic (this may be achieved through reprogrammable hardware implementations directly on network elements or advanced virtualisation software with associated programming environment)

# 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

```
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

Internal links: {192.168.2.3}

## Transaction on shortest path with tokens

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

```
Print["Path: ", nodePath];
```

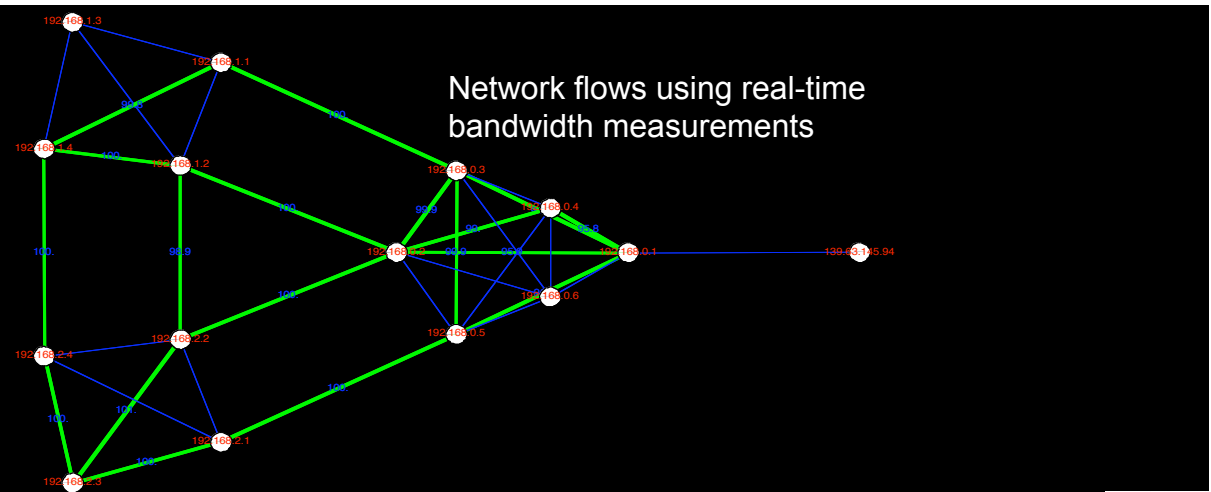
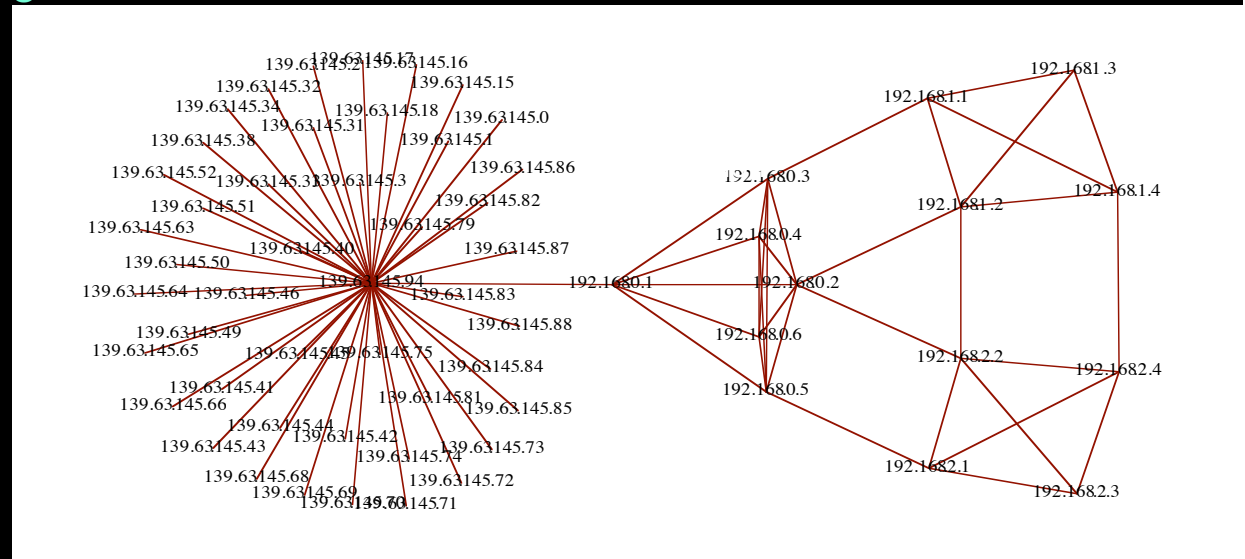
```
If[NetworkTokenTransaction[nodePath, "green"]==True,
Print["Committed"], Print["Transaction failed"]];
```

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.

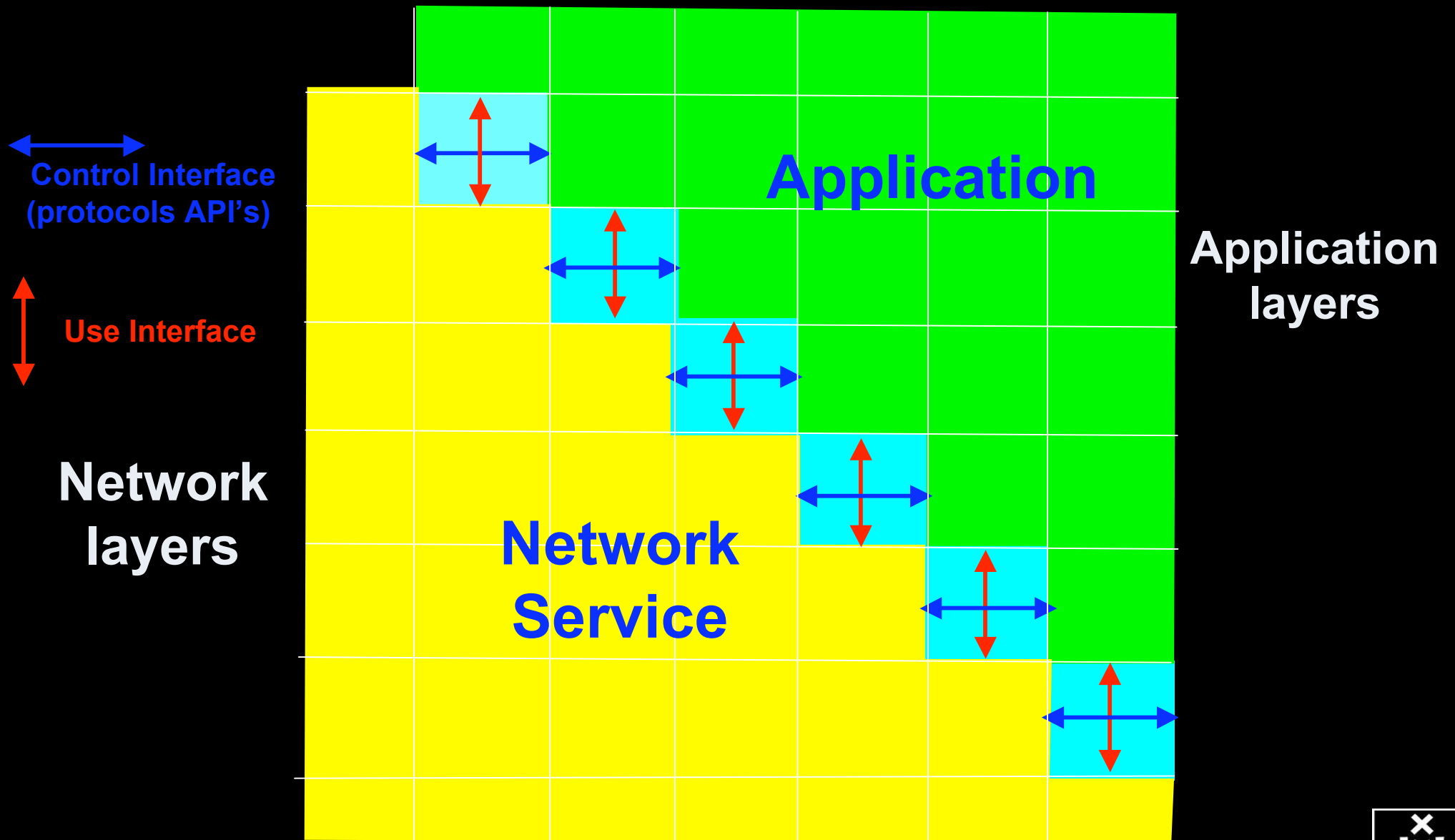


- **Create an architectural framework to represent the envisaged Tera-Internet**
  - Key features of the architecture:
    - Support **scaling** in terms of:
      - **link and network capacity** (Tbits/sec or even Petabits/sec)
      - **IT facilities** (TFlops, TBytes, TPixels, TSensors)
      - **number of users** (few to millions)
      - **styles of networks** (transport, aggregation, distribution, etc.)
    - Enable both, the application and providers to **create, shape, use** and **manage** the **network**
    - **Network services** running in **parallel** at a **very large scale**

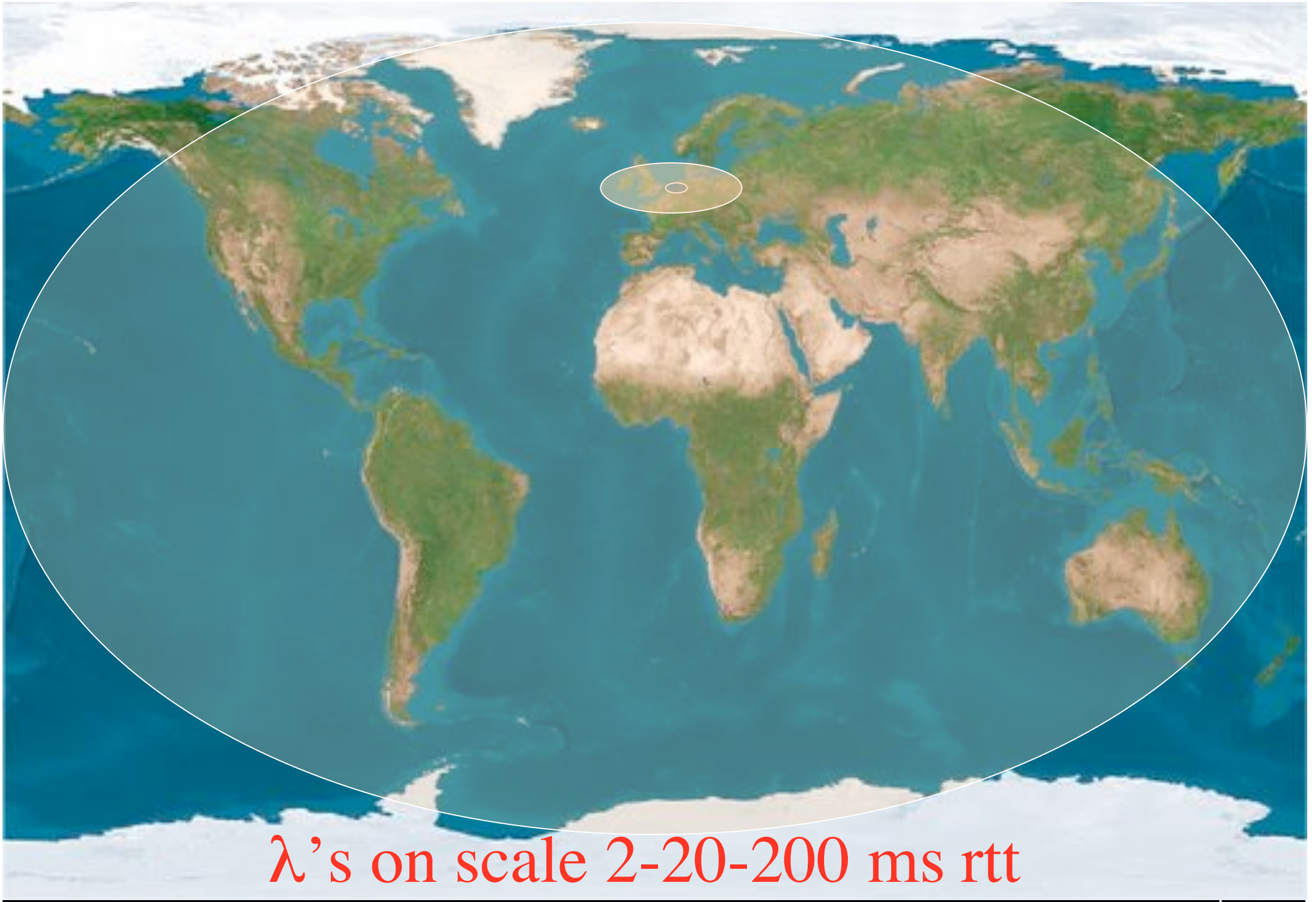
## Measurable outcomes

- Develop and validate the GENIOUS architecture based on collective requirements arising from applications, users, business and technology drivers

# Multi Layer Service Architecture







$\lambda$ 's on scale 2-20-200 ms rtt

# Towards Hybrid Networking!

- **Costs of optical equipment 10% of switching 10 % of full routing for same throughput**
  - 10G routerblade -> 50-300 k\$, 10G switch port -> 7-15 k\$, MEMS port -> 1 k\$
  - DWDM lasers for long reach expensive, 10-50 k\$
  - power consumption -> 250, 15, 1
- **Bottom line: look for a hybrid architecture which serves all classes in a cost effective way ==>**
  - map A -> L3 , B -> L2 , C -> L1
- **Give each packet in the network the service it needs, but no more !**

L1  $\approx$  1 k\$/port



L2  $\approx$  5-10 k\$/port



L3  $\approx$  75+ k\$/port



# Services

SCALE CLASS	2 Metro	20 National/ regional	200 World
<b>A</b>	Switching/ routing	Routing	<b>ROUTER\$</b>
<b>B</b>	Switches + E-WANPHY VPN's	Switches + E-WANPHY (G)MPLS	<b>ROUTER\$</b>
<b>C</b>	dark fiber DWDM MEMS switch	DWDM, TDM / SONET Lambda switching	Lambdas, VLAN's SONET Ethernet



### □ Network Adaptations

- GENIOUS will demonstrate how different styles of networks can be adapted seamlessly to offer application/user controlled hybrid networking
- In addition to offering IP to cater for legacy protocols and applications, the network layer will also offer access to layer 1 and 2 switching operations offered for example by OCS (Optical Circuit Switching) and OBS (Optical Burst Switching)
- The “clean slate” design philosophy behind GENIOUS will permit the functionality presently provided by layers 3 and 4 to be re-thought, while providing support for applications requiring legacy IP or offering ways to migrate without disruptions.

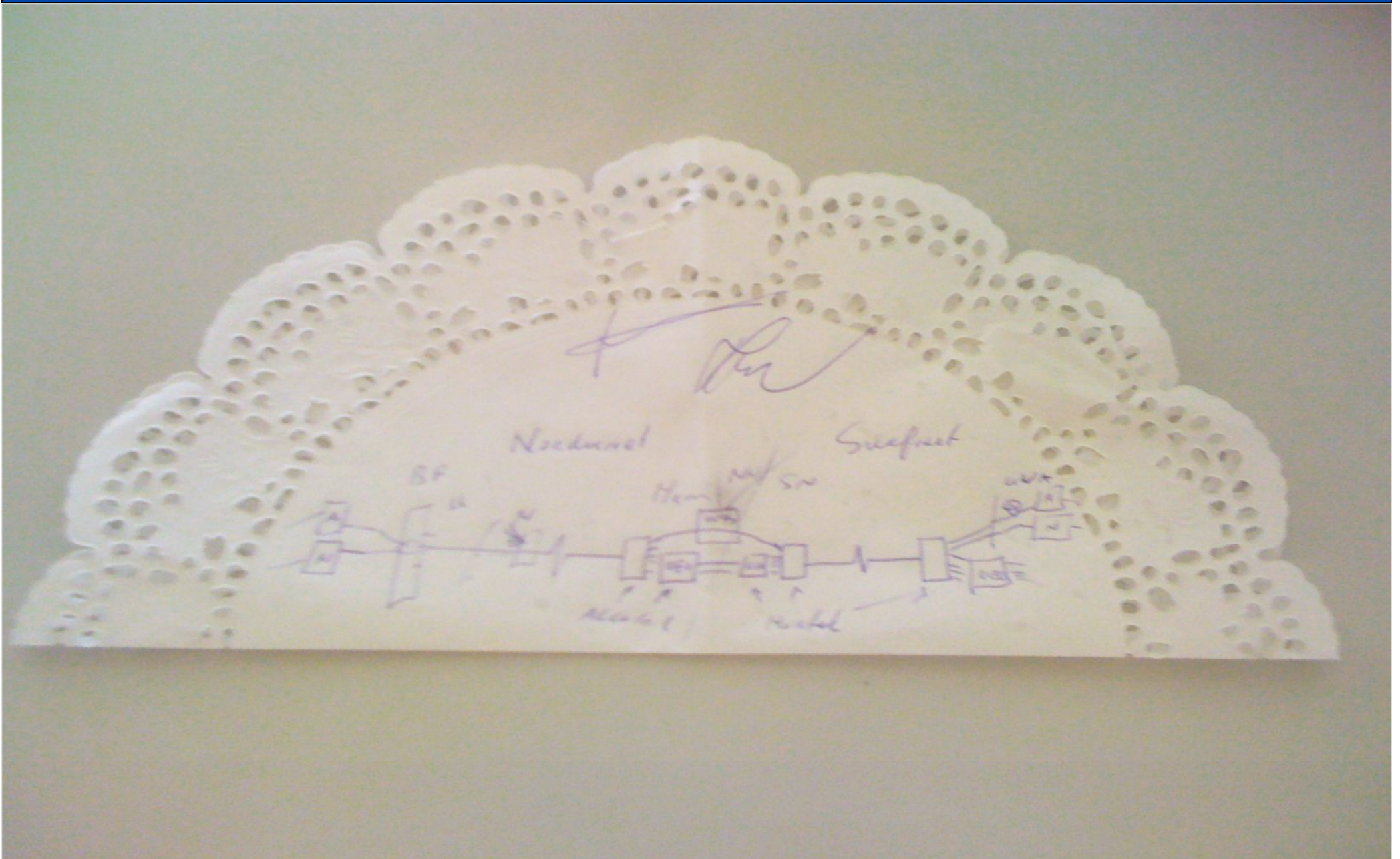
**FIRE at will**

at TNC2008: We ate the cookies



# FIRE at will

And then agreed on an experiment



# FIRE at will

## Questions