GreenSonar

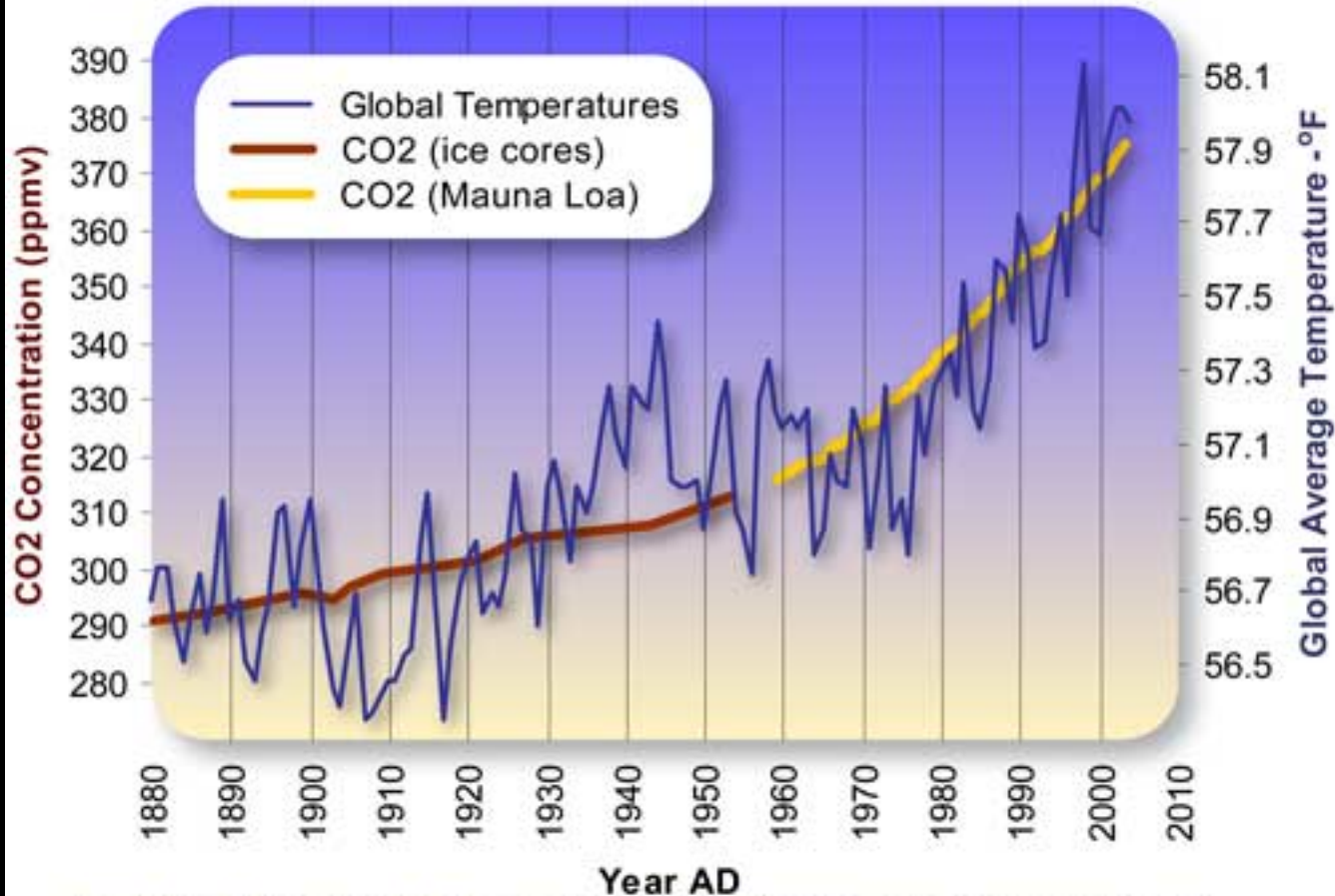**Cees de Laat** **&** **Paola Grosso** **&** **Inder Monga**

EU
COMMIT
UvA

DoE
LBNL

NWO
PID/EFRO
SURFnet
NLESC
TNO
NWO/ncf

Need for GreenIT

Global Average Temperature and Carbon Dioxide Concentrations, 1880 - 2004

Turn Green Tech into Greenbacks
IT Certifications for Jobs That Make a Difference

ENERGY STAR

green tech

Uptime Institute Accredited Tier Designer

The Uptime Institute has long been a proponent for green data center design and implementation. Its certification course on data center design embeds green principles into the curriculum.
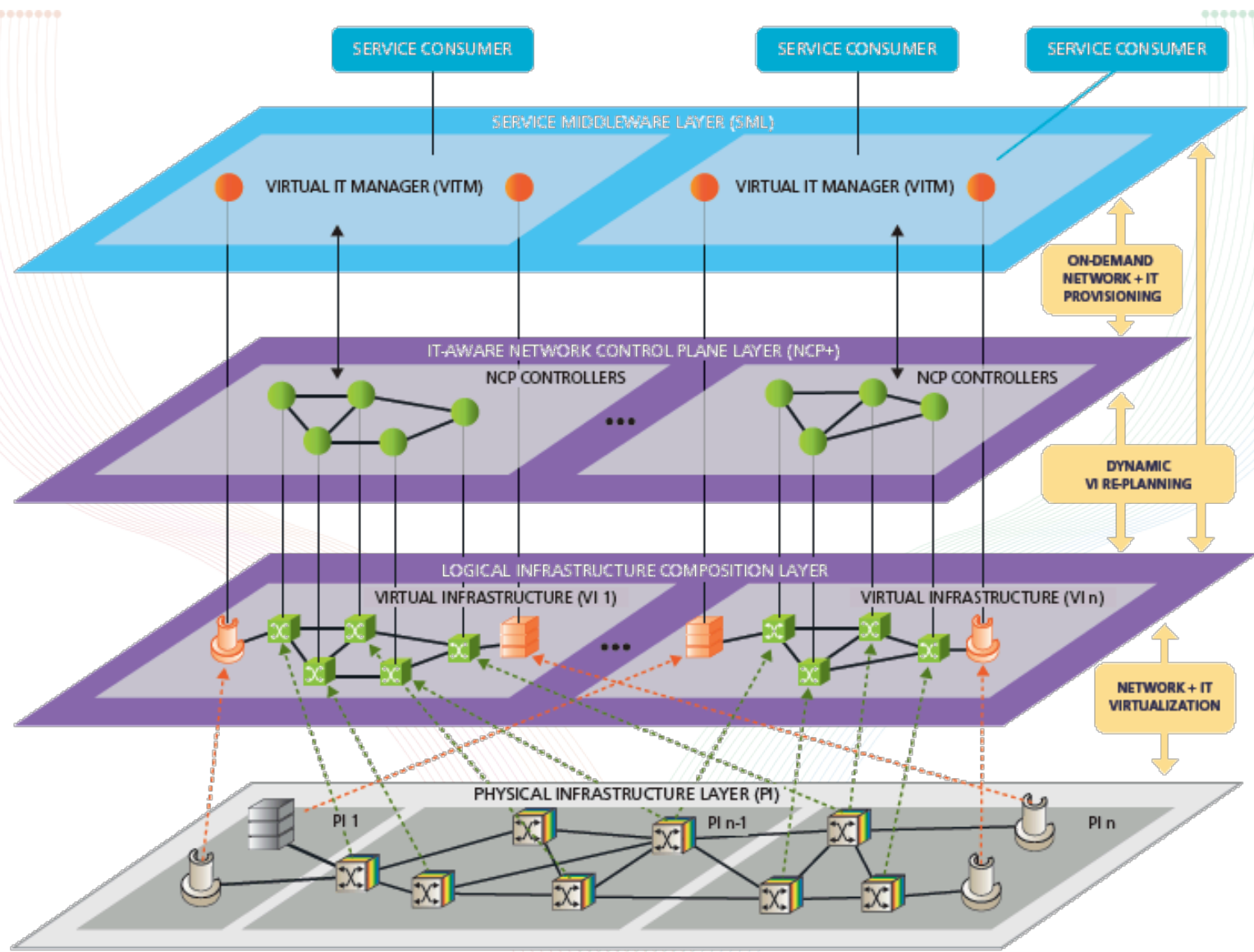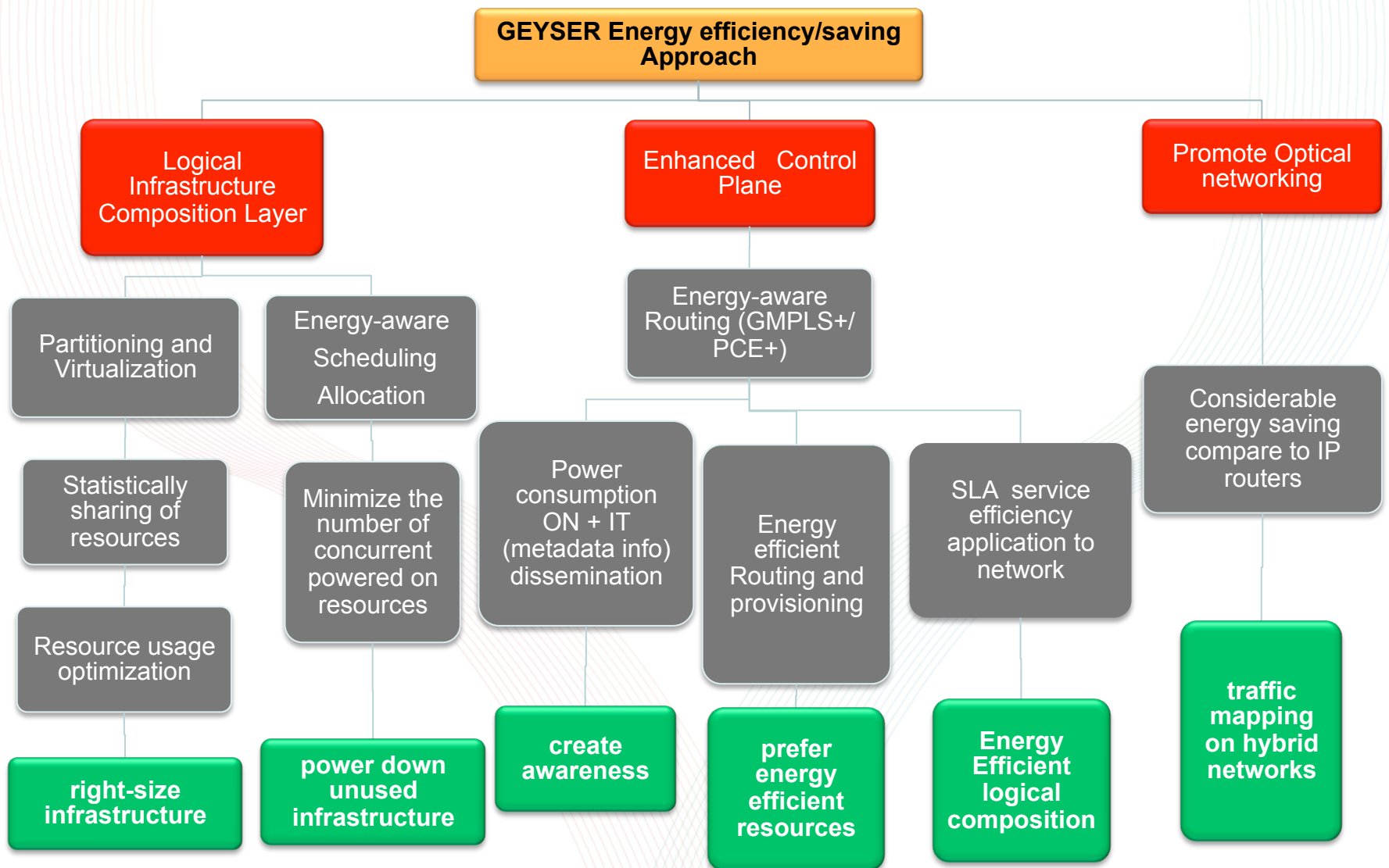
CERTIFIED GREEN COMPUTING USER SPECIALIST

GCI
Green Computing Initiative

SUSTAINABILITY
Your Career

Greening the Processing System

GEYSER Energy efficiency/saving Approach

Logical Infrastructure Composition Layer

Enhanced Control Plane

Promote Optical networking

Partitioning and Virtualization

Energy-aware Scheduling Allocation

Energy-aware Routing (GMPLS+/ PCE+)

Considerable energy saving compare to IP routers

Statistically sharing of resources

Minimize the number of concurrent powered on resources

Power consumption ON + IT (metadata info) dissemination

Energy efficient Routing and provisioning

SLA service efficiency application to network

Resource usage optimization

right-size infrastructure

power down unused infrastructure

create awareness

prefer energy efficient resources

Energy Efficient logical composition

traffic mapping on hybrid networks

ECO-Scheduling

The Ten Problems with the Internet

1. **Energy Efficient Communication**
2. Separation of Identity and Address
3. Location Awareness
4. Explicit Support for Client-Server Traffic and Distributed Services
5. Person-to-Person Communication
6. Security
7. Control, Management, and Data Plane separation
8. Isolation
9. Symmetric/Asymmetric Protocols
10. Quality of Service

Nice to have:
- Global Routing with Local Control of Naming and Addressing
- Real Time Services
- Cross-Layer Communication
- Manycast
- Receiver Control
- Support for Data Aggregation and Transformation
- Support for Streaming Data
- Virtualization

ref: Raj Jain, "Internet 3.0: Ten Problems with Current Internet Architecture and Solutions for the Next Generation", Military Communications Conference, 2006. MILCOM 2006. IEEE

GreenSonar

- Sustainability requires Green-IT in all kinds of resources, compute, network, storage, sensor, …
  - > System wide approch!
- Measure to know; information needed for smart infrastructure.
- Basic idea: been there done that in Networking!
- Why not apply iNDL/NML & PerfSonar methods to provide Green & Energy information?
- Need also application information.
- Big hurdle: energy metrics on heterogeneous resources
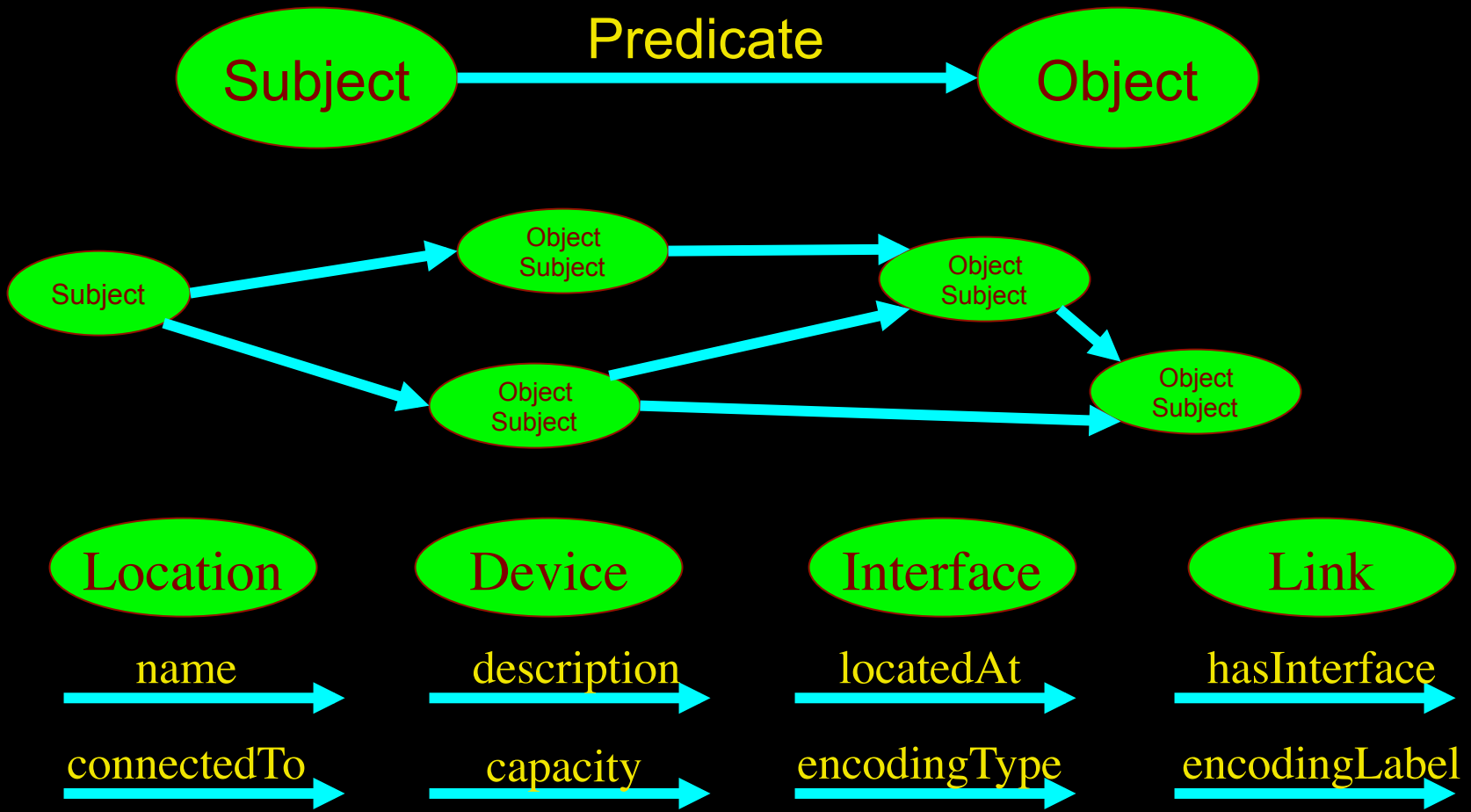- OGF BOF/Charter meeting at OGF36, Chicago.

Approach

- Define metrics
- Extend xDL with GreenDL
- GreenSonar
- Measure & publish
- Build data base -> information base
- Machine Learn good/bad practices
- Reason & Select & Schedule

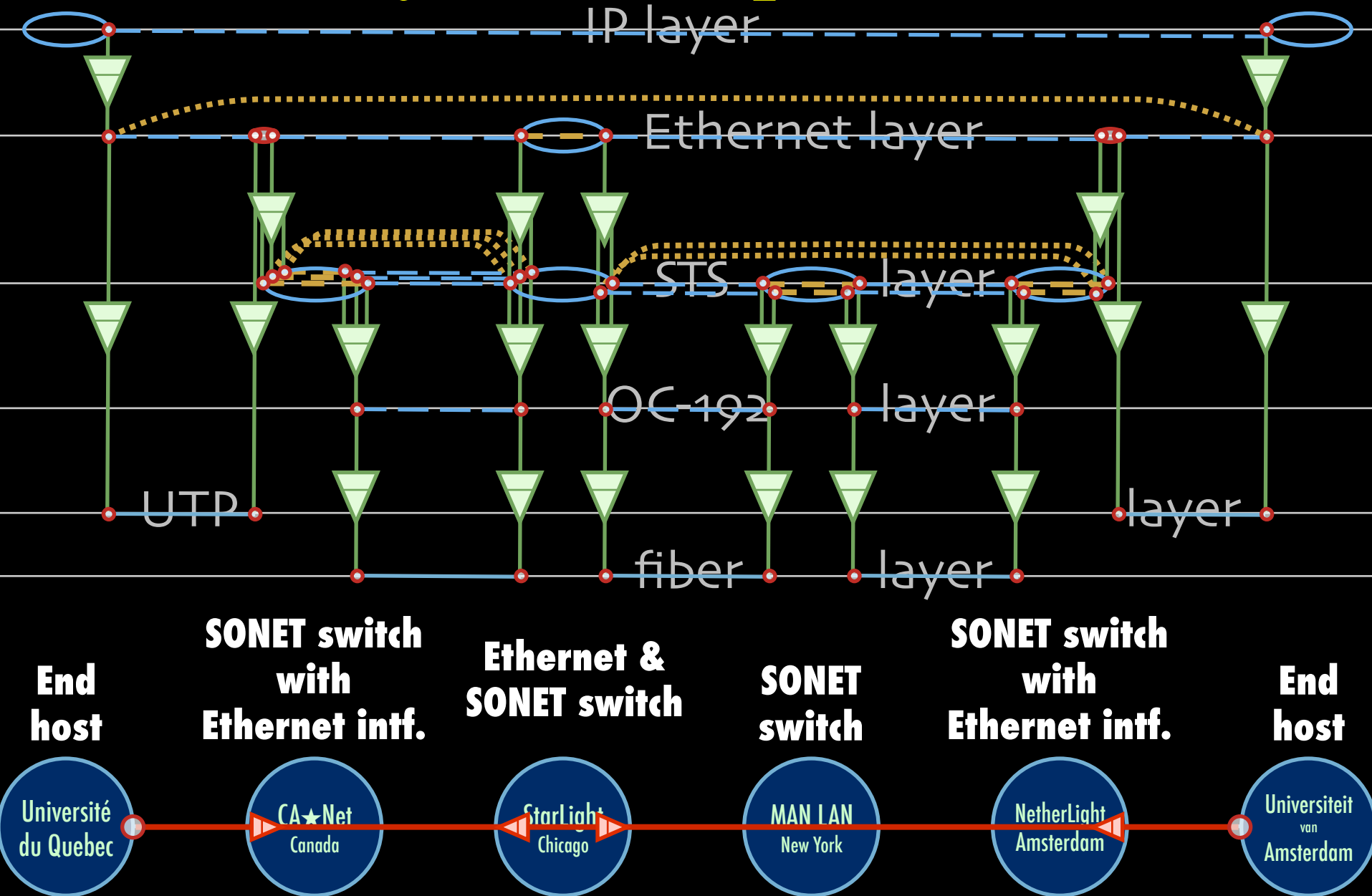We investigate: TomTom for complex networks!

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):

Subject — Predicate → **Object**

Subject → Object Subject → Object Subject → Object Subject

Subject → Object Subject → Object Subject → Object Subject

Location **Device** **Interface** **Link**

name → description → locatedAt → hasInterface →

connectedTo → capacity → encodingType → encodingLabel →

Multi-layer descriptions in NDL

IP layer

Ethernet layer

STS layer

OC-192 layer

UTP layer

fiber layer

End host

SONET switch with Ethernet intf.

Ethernet & SONET switch

SONET switch

SONET switch with Ethernet intf.

End host

Université du Quebec

CA★Net Canada

StarLight Chicago

MAN LAN New York

NetherLight Amsterdam

Universiteit van Amsterdam

CdL

Applications and Networks become aware of each other!
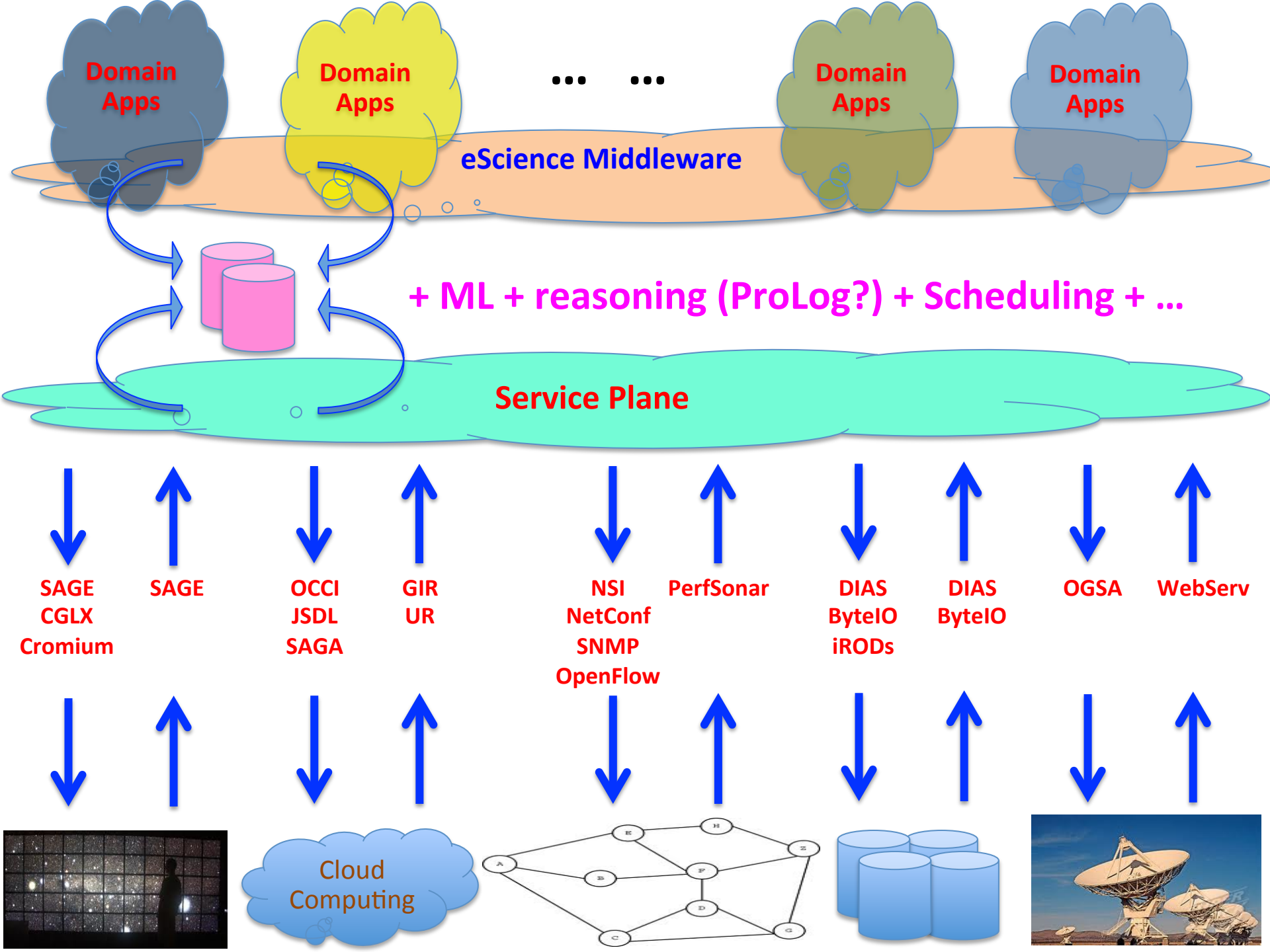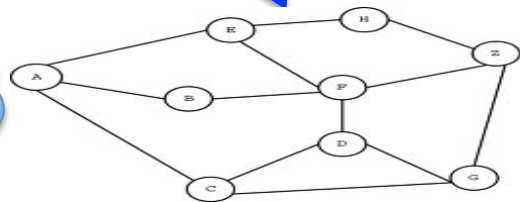
EdL (have already CdL)

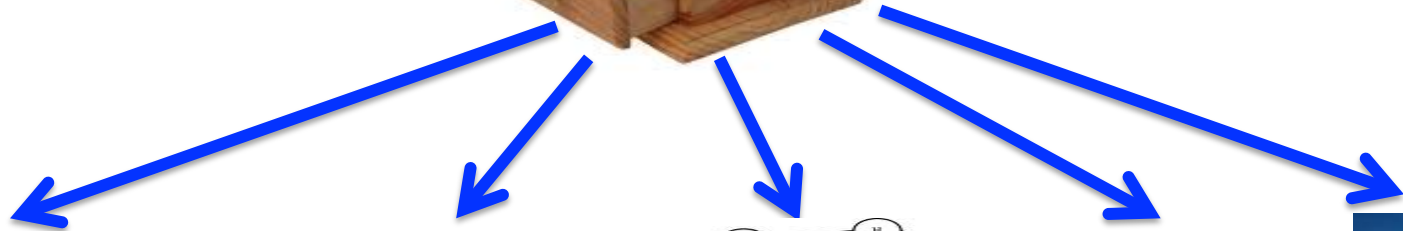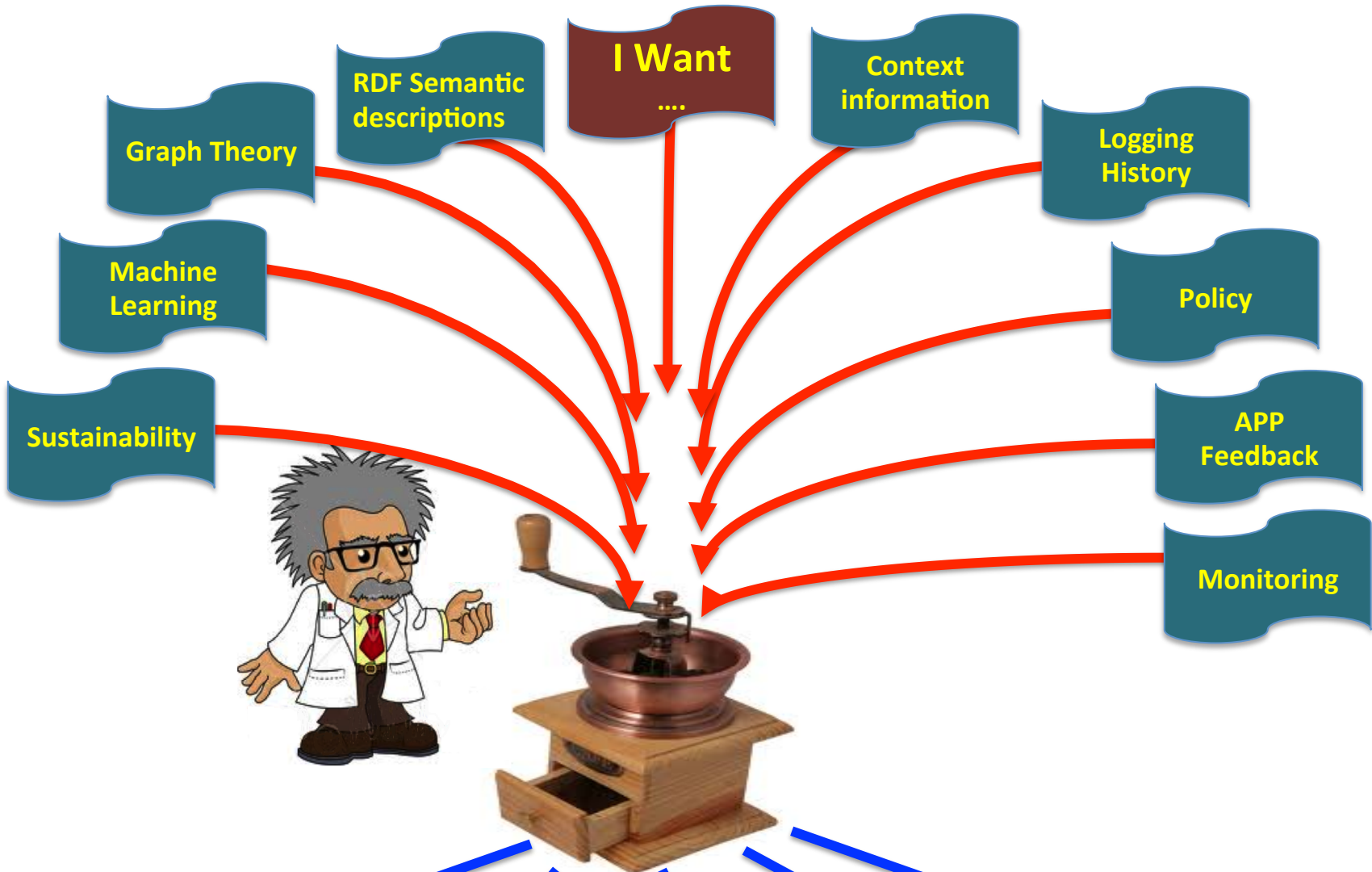I want to

"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.

Domain Apps   Domain Apps   …   …   Domain Apps   Domain Apps

eScience Middleware

+ ML + reasoning (ProLog?) + Scheduling + …

Service Plane

SAGE
CGLX
Cromium

SAGE

OCCI
JSDL
SAGA

GIR
UR

NSI
NetConf
SNMP
OpenFlow

PerfSonar

DIAS
ByteIO
iRODs

DIAS
ByteIO

OGSA

WebServ

Cloud Computing

Graph Theory

RDF Semantic descriptions

I Want ....

Context information

Logging History

Machine Learning

Policy

Sustainability

APP Feedback

Monitoring

Cloud Computing

Why GreenSONAR?

- ICT today is responsible for ~2% of the global carbon emissions, and is expected to overtake the airline industry in the near future.

- There is no systematic approach to measuring where that energy is spent, what type of energy is spent, or if it is spent well.

- Analyzing the data may lead to better scheduling and routing algorithms geared towards increasing system-wide energy efficiency.

What is GreenSONAR?

- Proposed architecture to monitor and give insight into the energy efficiency of ICT infrastructure.

- Holistic approach.

- Requires monitoring both power consumption and performance.

- Potentially appealing to researchers, networking engineers, system administrators, maybe even CEOs, politicians.

  - Potential to save money, chart impact of ICT on environment, help make decisions on where and how to apply green energy to ICT.

What is PerfSONAR?

- Service-oriented architecture to monitor performance of networking infrastructure.

- Specifically meant to make life easier for networking engineers.

- Is the PerfSONAR architecture suitable for GreenSONAR?

Holistic approach

- Have to look at all aspects of ICT infrastructure, not only networking.
- How easily could each aspect be monitored with GreenSONAR/PerfSONAR?
  - Networking: Relatively straightforward.
  - Grids (and supercomputers): Difficult.
  - Virtualized environments: Not possible?

GreenSONAR vs Networking

- Relatively straightforward for the following reasons:

  - Networking elements have a single well-defined purpose.

  - Performance metrics are always the same.

  - Means correlating performance and power metrics is straightforward.

GreenSONAR vs Grids

- Want to measure energy efficiency of a given job running on a grid, as well the grid as a whole.

- This is difficult, because:

  - Requires provenance on many characteristics: How to identify an application between job runs? On which node was it running? When did the job start and finish? etc...

  - How to systematically gather performance statistics on a job? Which metrics?

  - Heterogeneous hardware adds more parameters to be tracked.

GreenSONAR vs Grids

– All in all lots of meta-data needs to be tracked and stored, just to know what you are monitoring.

– Practical problems: Grid engines may not maintain all the required information.

GreenSONAR vs Virtualization

- Want to monitor VMs and clouds in the same way as grids.

- Currently not possible, because:
  – VMs are black boxes, the cloud system has no knowledge of what goes on inside them, so you cannot take meaningful measurements.

GreenSONAR vs Virtualization

- Fundamentally there is a paradox in monitoring a system that is designed to be opaque.

- May require a new kind of cloud architecture or platform in which the system knows what is happening *inside* a VM.

On metrics

- There are many ways to measure energy efficiency, including but not limited to: joule/bit, GFLOPs/Watt, PUE, DCiE, TEEER, and so on.

- Essentially they all represent the same thing: the amount of energy dissipated per unit of work done, but they are not comparable.

- Is there a better metric?

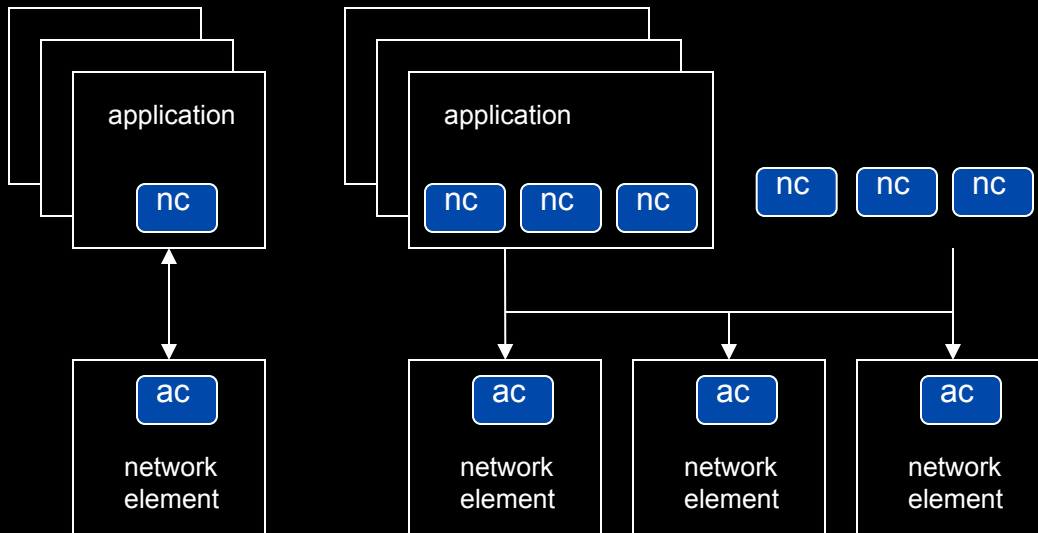# Food for Thought

Or

Thoughts for after Food.

TeraThinking

- What constitutes a Tb/s network?

- CALIT2 has 8000 Gigabit drops ?->? Terabit Lan?

- look at 80 core Intel processor
    - cut it in two, left and right communicate 8 TB/s

- think back to teraflop computing!
    - MPI turns a room full of pc's in a teraflop machine

- massive parallel channels in hosts, NIC's

- TeraApps programming model supported by
    - TFlops   ->   MPI / Globus
    - TBytes   ->   OGSA/DAIS
    - TPixels   ->   SAGE
    - TSensors   ->   LOFAR, LHC, LOOKING, CineGrid, ...
    - Tbit/s   ->   ?

User Programmable 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

```
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 neigbours of: 139.63.145.94
Internal links: {192.168.0.1, 139.63.145.94}
(...)
Getting neigbours of:192.168.2.3
```
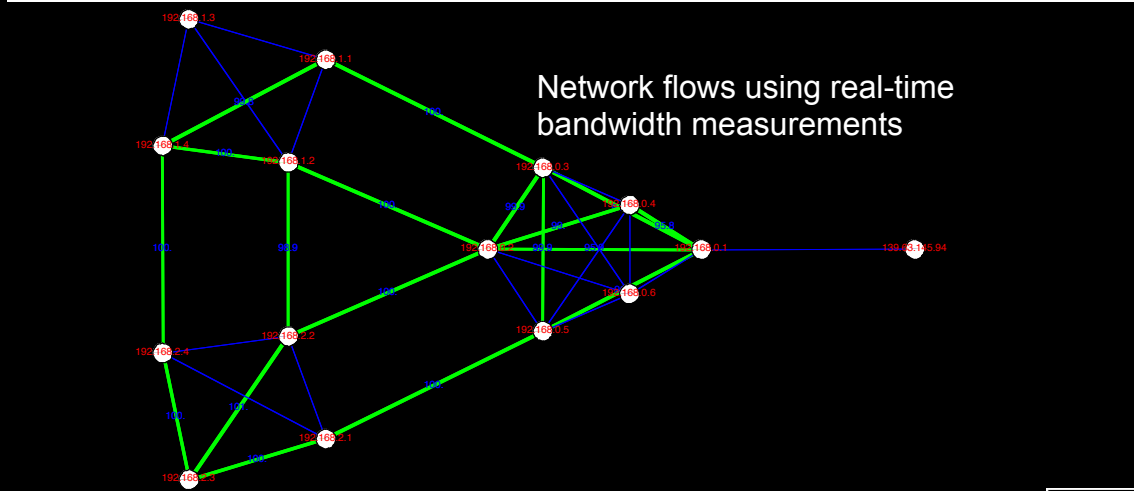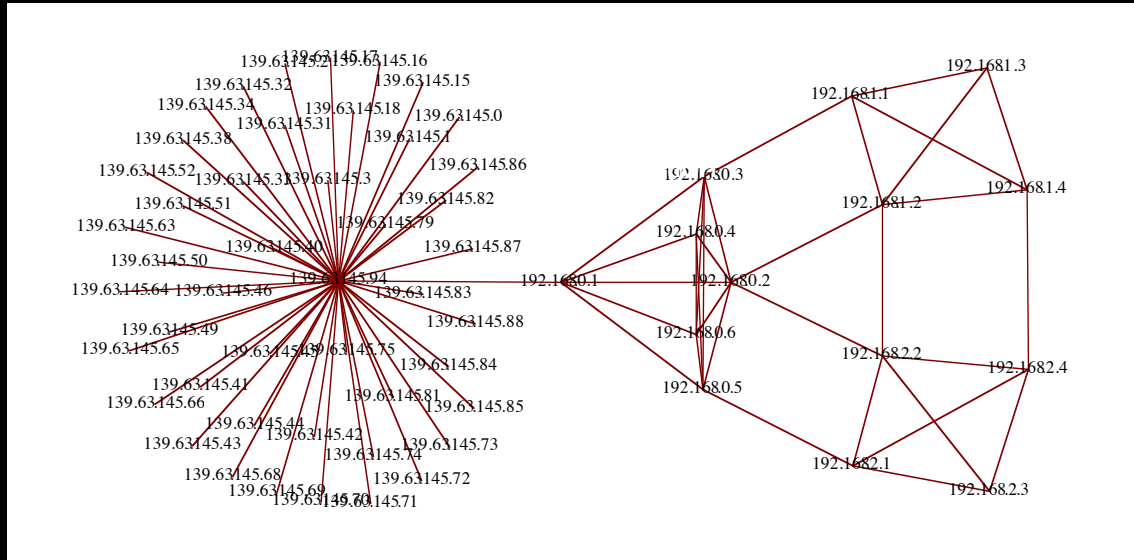
Transaction on shortest path with tokens
Internal links: {192.168.2.3}

```
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
```
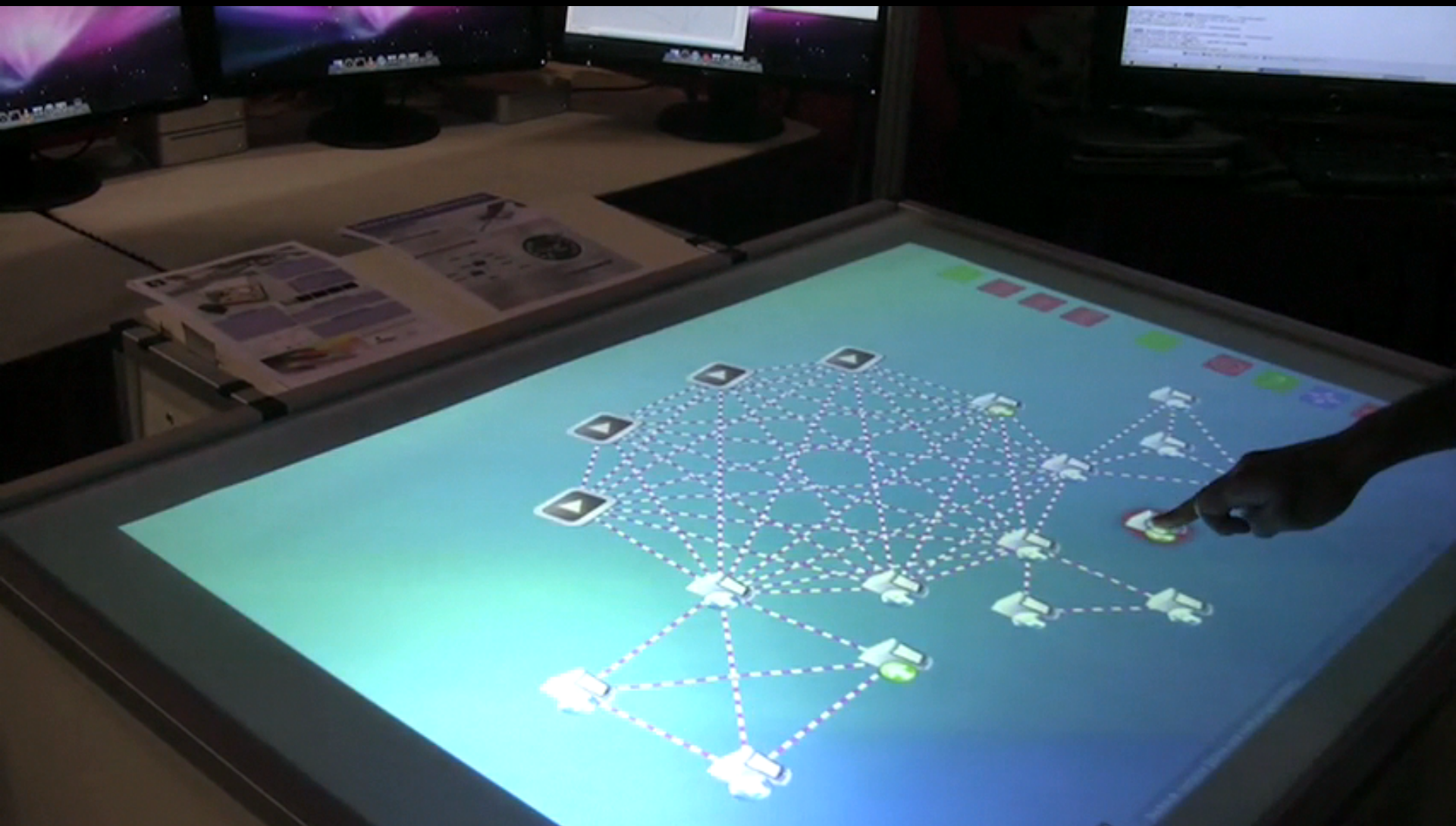
Network flows using real-time bandwidth measurements

ref: Robert J. Meijer, Rudolf J. Strijkers, Leon Gommans, Cees de Laat, User Programmable Virtualiized Networks, accepted for publication to the IEEE e-Science 2006 conference Amsterdam.

StarPlane

TouchTable Demonstration @ SC08

Conclusions

- PerfSONAR architecture is a good starting point for GreenSONAR, but may not be sufficient.

- Need provenance in grid and virtualized (computing) environments.

- Not clear which metrics are most useful to monitor.

Links

- http://ext.delaat.net/

- http://ext.delaat.net/smartgreen/index.html

- http://ext.delaat.net/news/2012-03-23/index.html

- http://wiki.cs.vu.nl/greenclouds/index.php/Main_Page

- Thanks:
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  - Lutz Engels

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SURF NET   GEYSERS