

Virtualization frameworks and a service plane for multi-domain provisioning

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Outline

Today's presentation topics

- **Core Network Virtualization**
- **Infrastructure as a Service**
- **Industrial Impact**
- **Environmental Impact**
- **The IaaS Framework**
- **Reference to Projects**

Core Network Virtualization

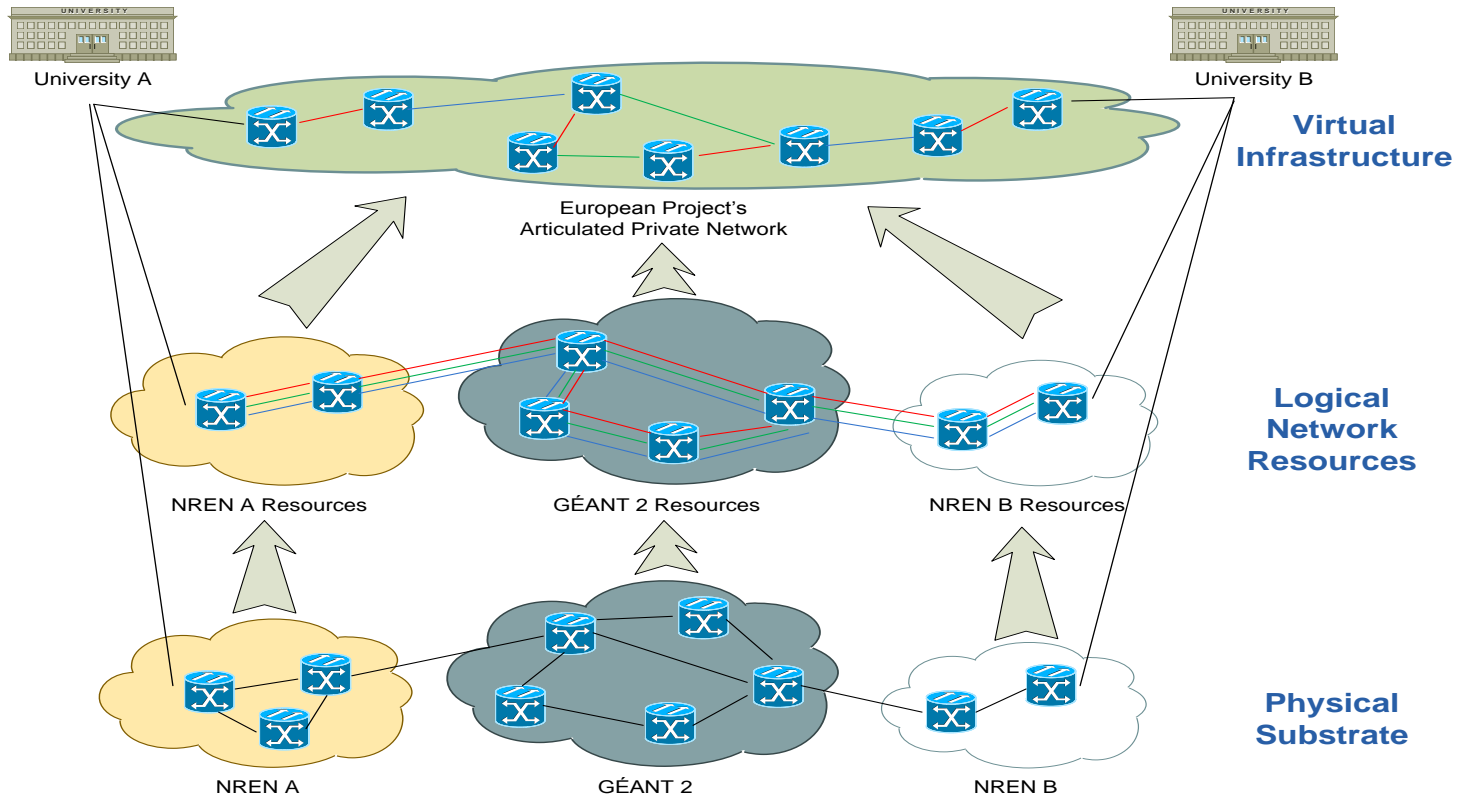
Types of Virtualization

- **Emulation**
 - A device's functionality is replicated in software only
 - Examples: Asterix PBX, Zebra (Router), Vyatta (Router)
- **Native/ParaVirtualization**
 - OS level virtualization where some functionalities are provided by software while others are sent directly to the hardware.
 - Examples: VRF, Virtual Router, Controller Agents
- **Hardware Partitioning**
 - Dedicated hardware resources are allocated for virtual devices on a shared physical substrate.
 - Examples: Logical Router (LR), L1VPNs
- **Datapath**
 - Provides isolation and resource allocation on shared hardware
 - Examples: L2-VPNs, L3-VPNs and other Overlays

Network virtualization

Goal: Federated Resources

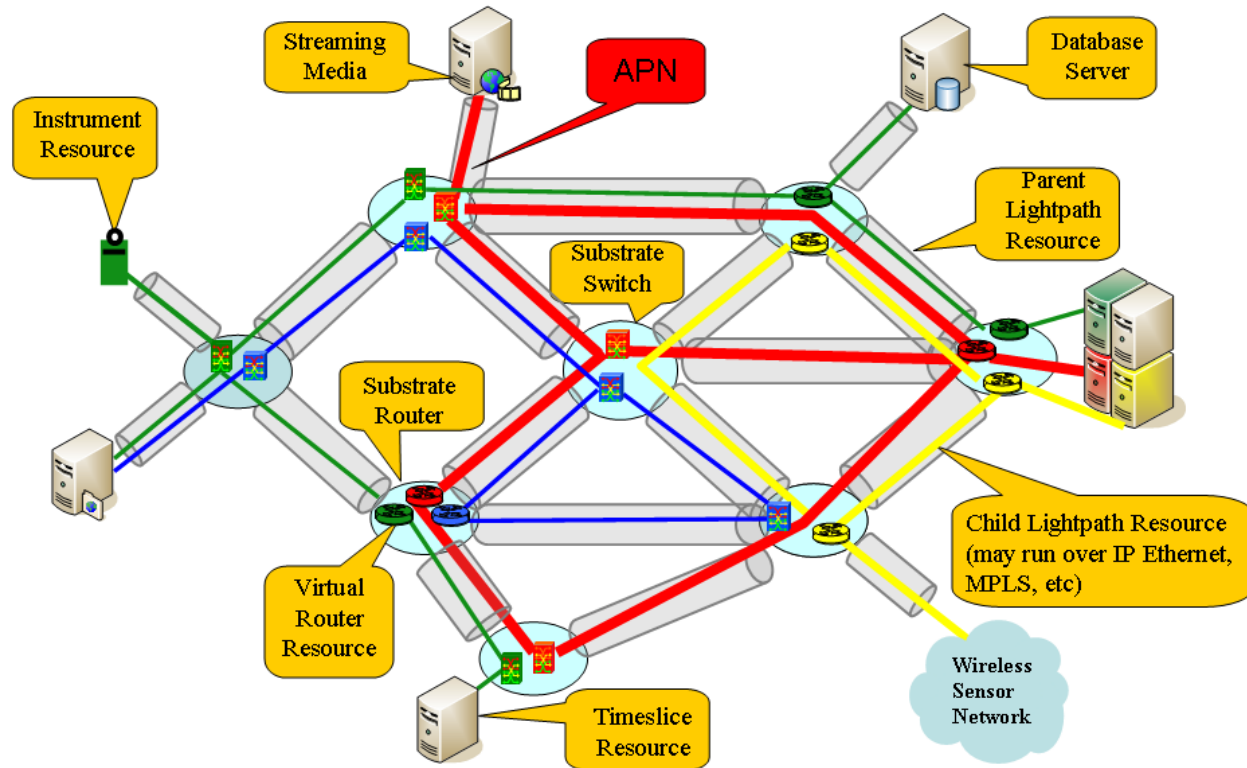
- Using resources coming from a single substrate it is possible to have a unified network that crosses multiple domains.



Network Capable Platforms

Create network segments for different purposes

- A set of dedicated resources (Network, Instruments, Sensors) that can be manipulated through a web services interface
- Create several parallel application specific networks from a single physical network



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- **Projects**

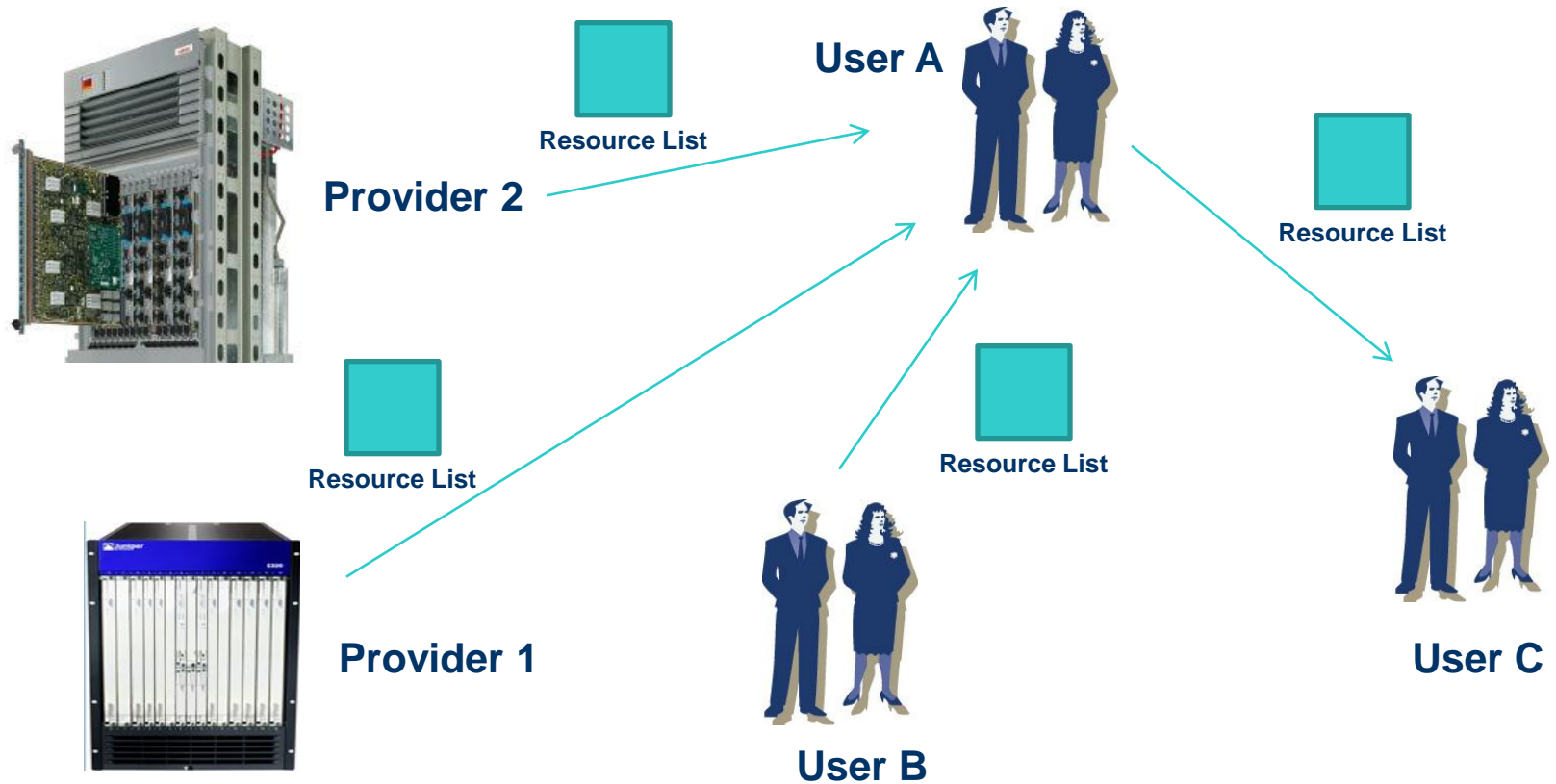
Infrastructure as a Service

IaaS and virtualization.

- **Virtualization consists of representing a physical device/substrate/datapath as a Software entity (P2V)**
 - Initially started with PC virtualization (VMWare, Virtuallron, VirtualPC)
 - Provides Isolation.
- **IaaS is equivalent of SaaS for hardware devices**
 - Amazon and BlueLock pioneer the IaaS service by renting hardware using proprietary solutions
 - Users pay to use shared infrastructures
 - Monthly fees or Pay per use
 - Long term exchanged compared to on-demand services
 - Users control/own the infrastructure

The IaaS Framework

Resource Trading (I): Direct Exchange



The IaaS Framework

Resource Trading (II): Brokering

The screenshot shows the vInfrastructures website in a Mozilla Firefox browser window. The browser's address bar displays the URL <http://www.vinfrastructures.com/>. The website's header features the vInfrastructures logo and navigation links for NEWS, FORUMS, and BLOGS. Below the header is a menu with buttons for BUY, SELL, TRADE, WANT, MY VININFRASTRUCTURE, and HELP. A login section includes fields for USERNAME and PASSWORD, along with a SIGN IN • REGISTER link. On the left, a 'BROWSE BY CATEGORIES' box lists Networks (189), Labs (46), and Computers (309). A 'Welcome' message states: 'vInfrastructures will be a brokering website used to exchange, manage, and configure resources using middleware built upon the [IaaS Framework](#) architecture. This site can be used to , buy, sell and trade resources between different organisations. The site is currently under construction please [send us](#) any potential feedback/ideas.' The 'FEATURED RESOURCES' section lists three items: 1) ARGIA OC-48 Lightpath from Montréal (OME-MON01) to Toronto (OME-TORO 1) with Location: TBD; 2) GRM Grid Resources for Research and Education, Optical Virtual Laboratory, Location: École de Technologies Supérieure (ÉTS); 3) ARGIA Private Network Resources and ARGIA Gigabit Ethernet Interface on (OME-MON01). The footer contains the copyright notice: 'Copyright © 2007 vInfrastructures. All Rights Reserved. Use of this Web site constitutes acceptance of the Auction-Warehouse User Agreement and Privacy Policy.'

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Infrastructure as a Service

Become Infrastructure Providers

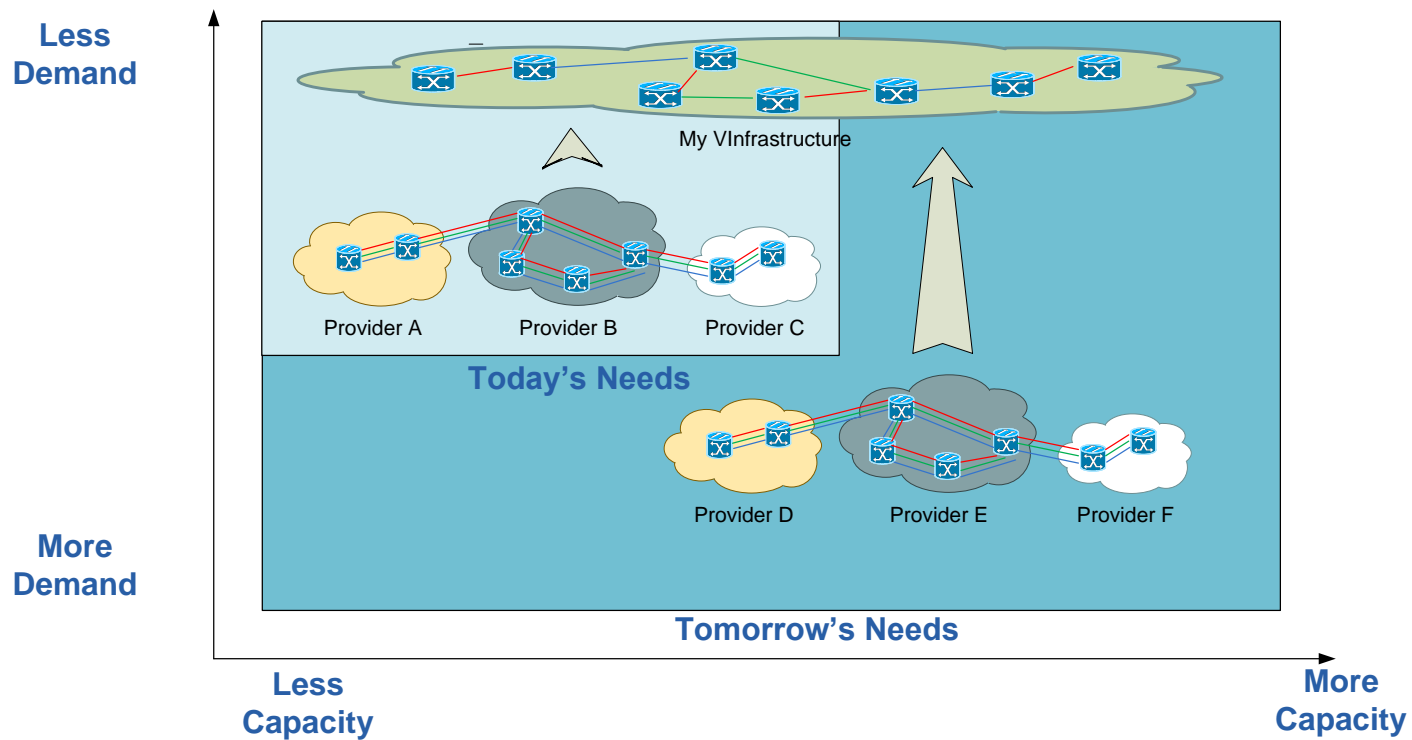
- **Why go back to Infrastructure while Services are higher in Value Chain?**
 - Google, Inuk Networks, and others are now offering free services
 - High churn rate on the services for the providers
 - Bandwidth demand increases but end users don't want to pay more.

	Service Providers	Infrastructure Providers
Liability (Different level of SLA)	Provider's liability (SLA)	User responsibility
Financial Impact (Reduce Opex)	ROI hard to achieve for infrastructure when selling services only.	User pays for both infrastructure + service.
User Satisfaction (User Empowerment)	Users locked in service contracts and have no control over network.	Users feel empowered to perform required changes on the network at will as if they owned all of it.
Operation Expenses (Efficient Use of Technical Resources)	NOC must perform all changes no time left to plan ahead/monitor.	Users do the simple changes, NOC does network planning.

Infrastructure as a Service

Scale infrastructure on demand

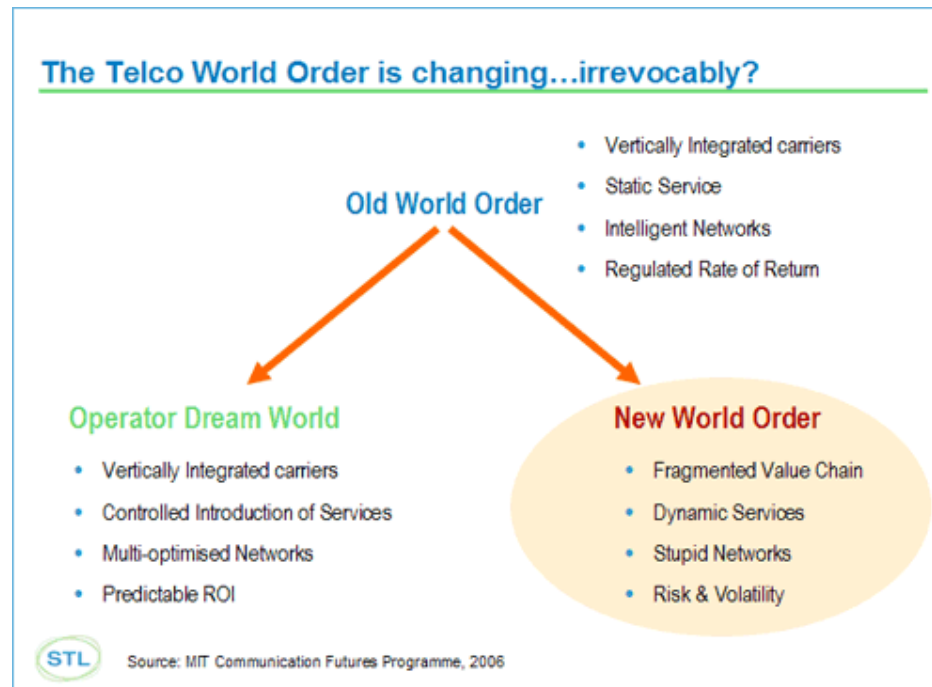
- Your infrastructure follows your business need. You can change your infrastructure based on the demand within hours or less.



Infrastructure as a Service

A need for a new Telco model

- The fragmented value chain gives two options to Telcos as their vertical nature can't compete with Agile software companies:
 - Break the Network Neutrality paradigm
 - Go back to offering infrastructure



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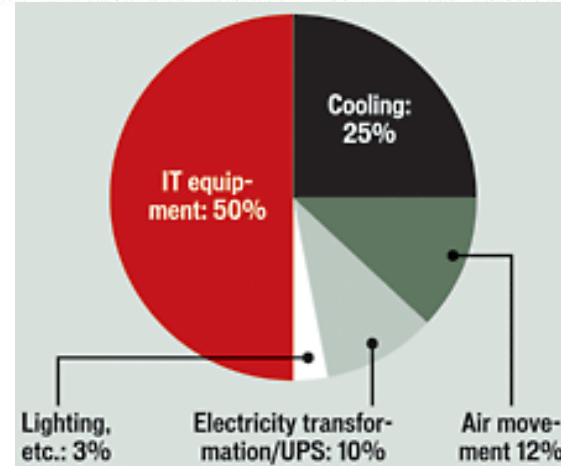
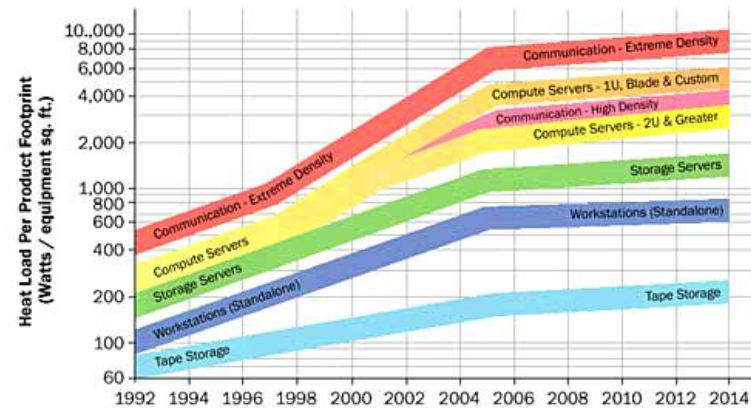
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Environmental Impact

Virtualization's Environmental Impact

- Energy is wasted because infrastructures are underutilized.
- Virtualization has a direct impact of environment and CO2 emissions:
 - Partitioned networks are simpler to operate and the equipment energy needs are less.
 - Maximizing resource usage by sharing a common infrastructure.
 - Organizations who bought equipment to control can now rent existing infrastructure and have the same control.
 - Having less devices in data centers reduces cooling requirements.

Gartner Says « Data Centres Account for 23 Per Cent of Global ICT CO2 Emissions »

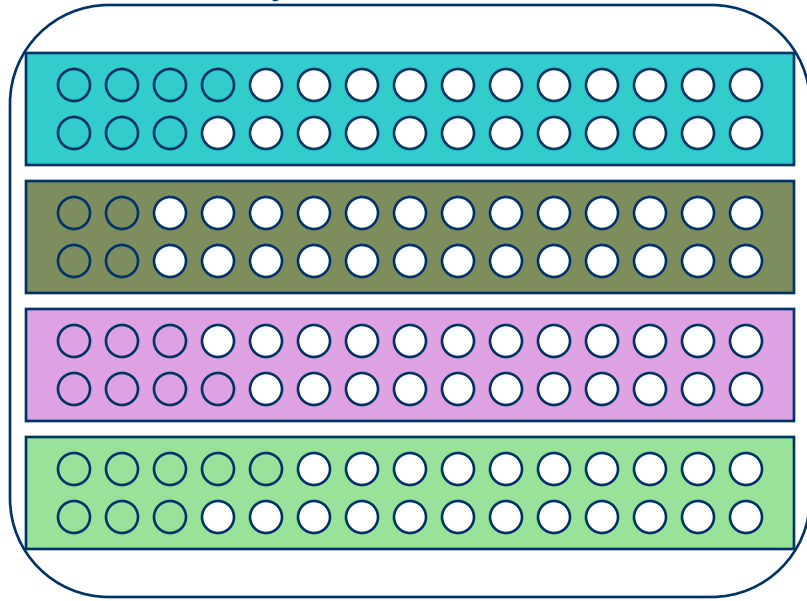


Source: Hewlett-Packard (2006)

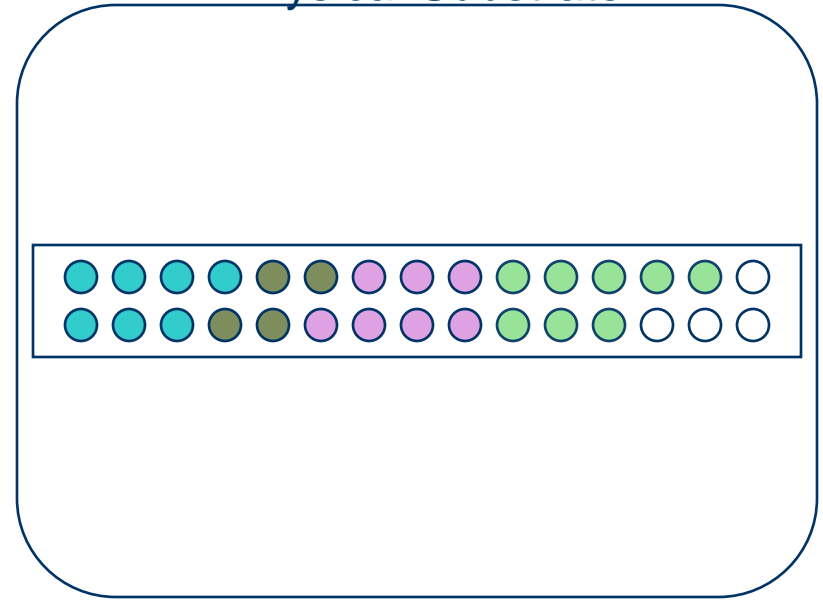
Environmental Impact

Virtualization's Environmental Impact

Traditional Infrastructure
Physical Substrate



Virtualized Infrastructure
Physical Substrate



Power Requirements

- $4 \times P_{\text{chassis}}$
- $26 \times P_{\text{port}}$
- P_{cooling}



Power Requirements

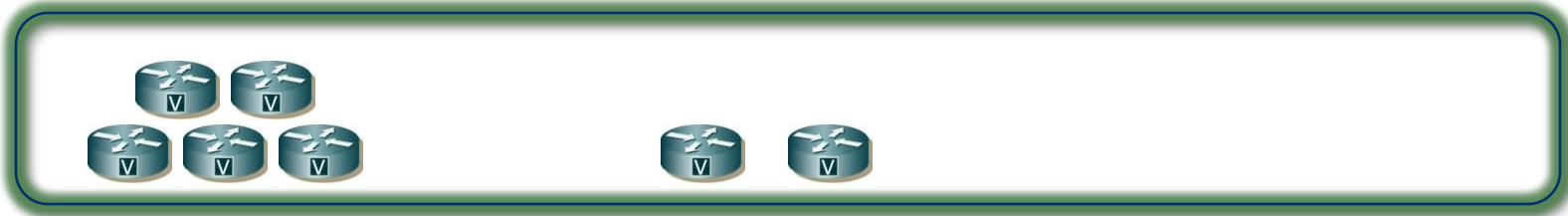
- $1 \times P_{\text{chassis}}$
- $26 \times P_{\text{port}}$
- Fraction of P_{cooling}

Environmental Impact (St. Arnaud)

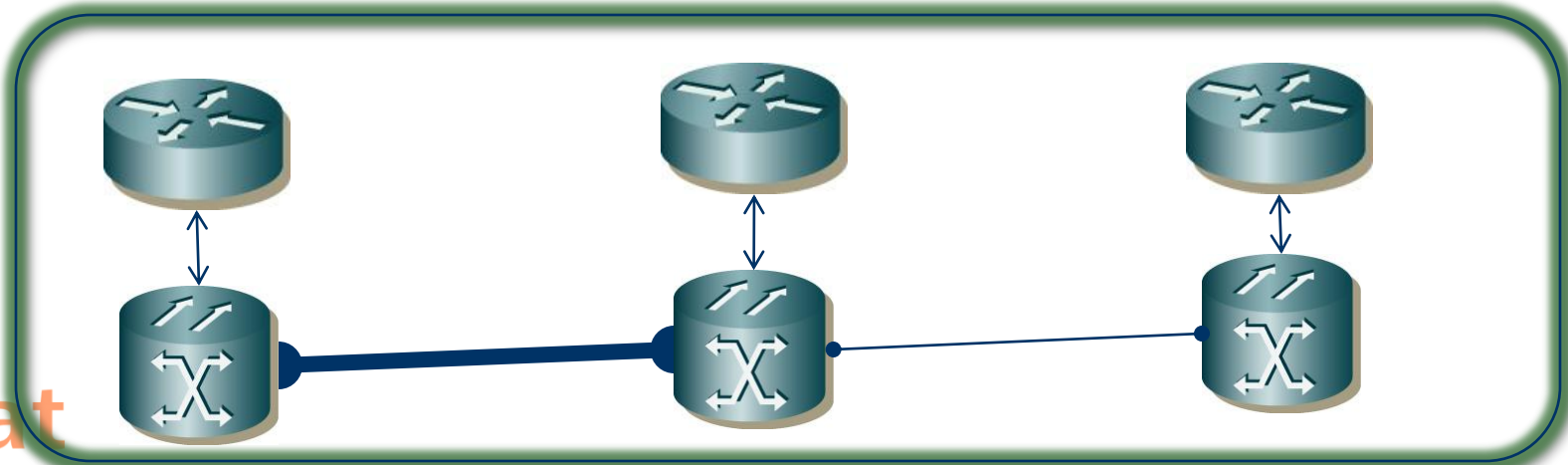
Solar powered IT - Follow the sun example



Virtual Network



Physical Network

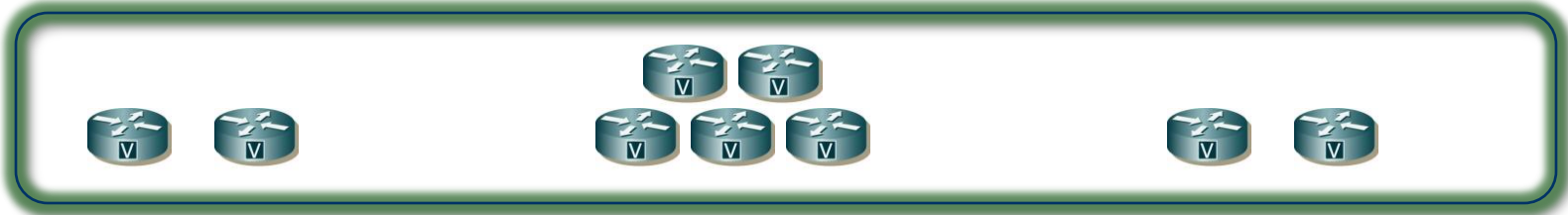


Environmental Impact

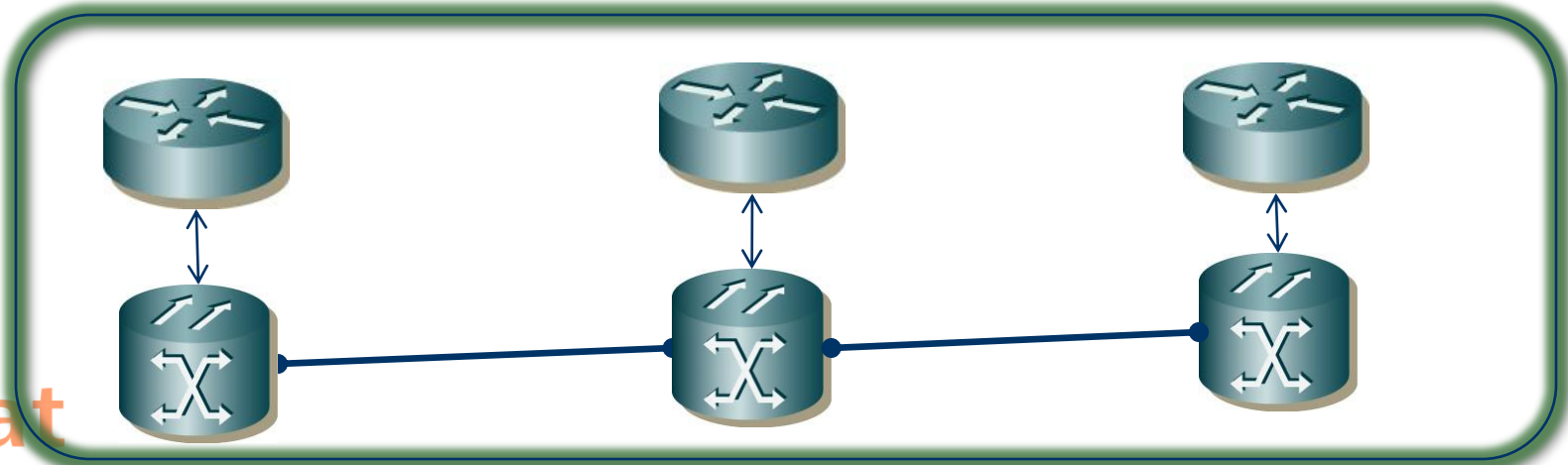
Solar powered IT - Follow the sun example



Virtual Network



Physical Network

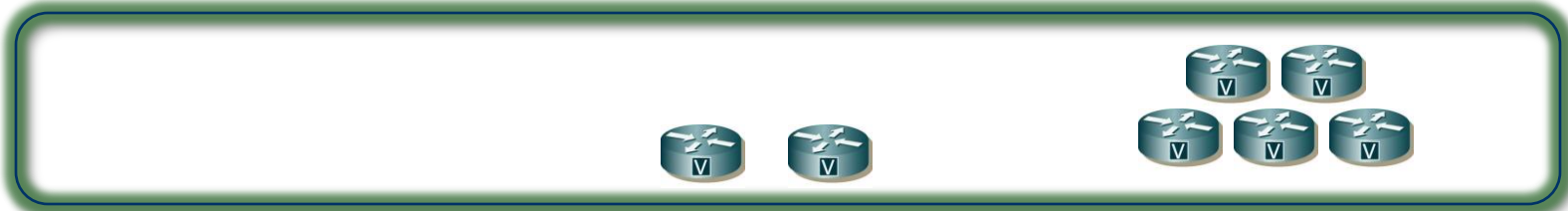


Environmental Impact

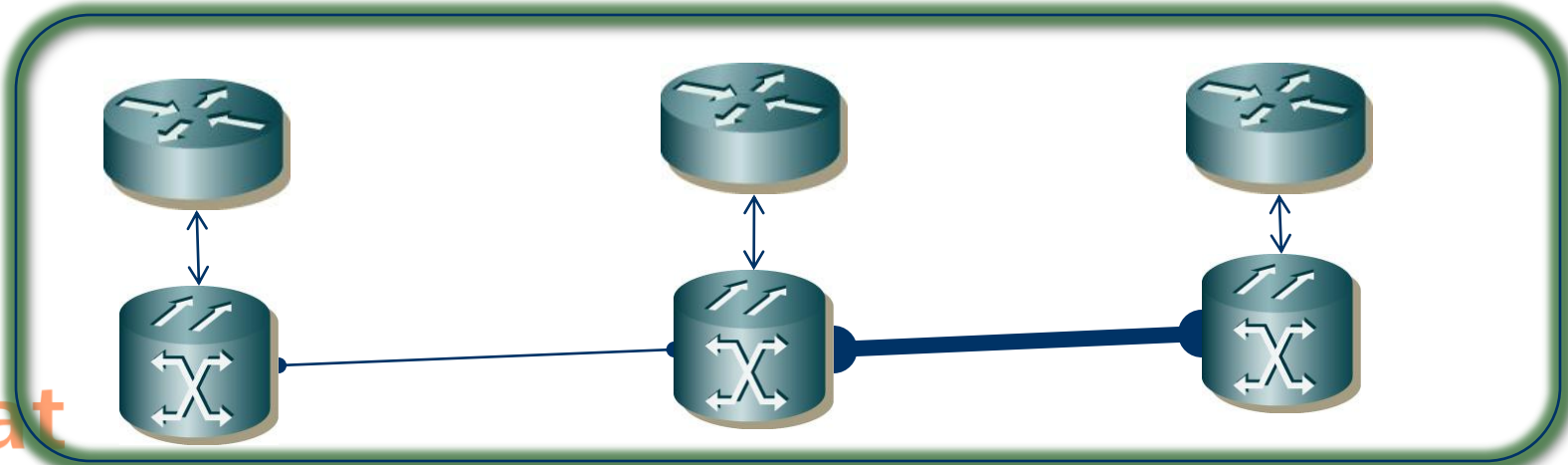
Solar powered IT - Follow the sun example



Virtual Network



Physical Network



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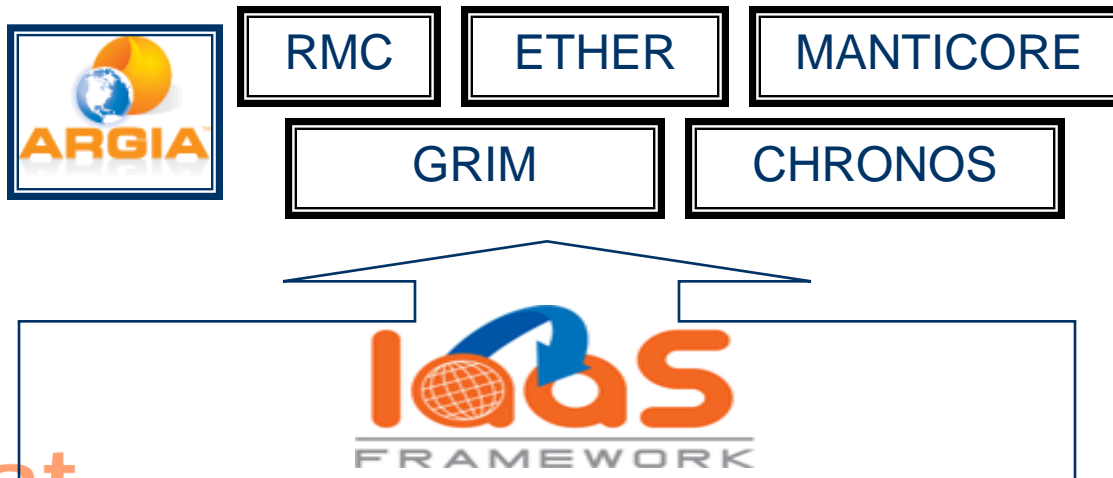
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The IaaS Framework

The Framework's Origins



- Two UCLP research programs were put in place by CANARIE to provide a user empowered solution for optical networks starting in 2001
 - UCLP initial goal was to provide end to end paths across domains (DataPath Virtualization)
 - UCLPv2 goals were to create reusable and configurable network blocks (Hardware Partitioning Virtualization)



IaaS Framework

What is the IaaS Framework



- **The Infrastructure as a Service (IaaS Framework), available (by the 4Q of 2008) at <http://www.iaasframework.com> is:**
 - Open Source for building IaaS solutions
 - A generalized architecture to the outcome of years of research under the UCLP Research programs funded by CANARIE
 - A set of software resources used to administer a domain from user workspaces, physical infrastructure services, to resource exchanges
 - A set of capabilities that can be used to quickly provide functionalities like permissions/security, reservation, lifetime management
 - Libraries and tools to manage persistence or communication with the hardware devices (IaaS Engine -> Driver Architecture)
 - A basic RMC GUI extensible with plugins
 - The enabling technology for upcoming products and R&D initiatives

IaaS Framework

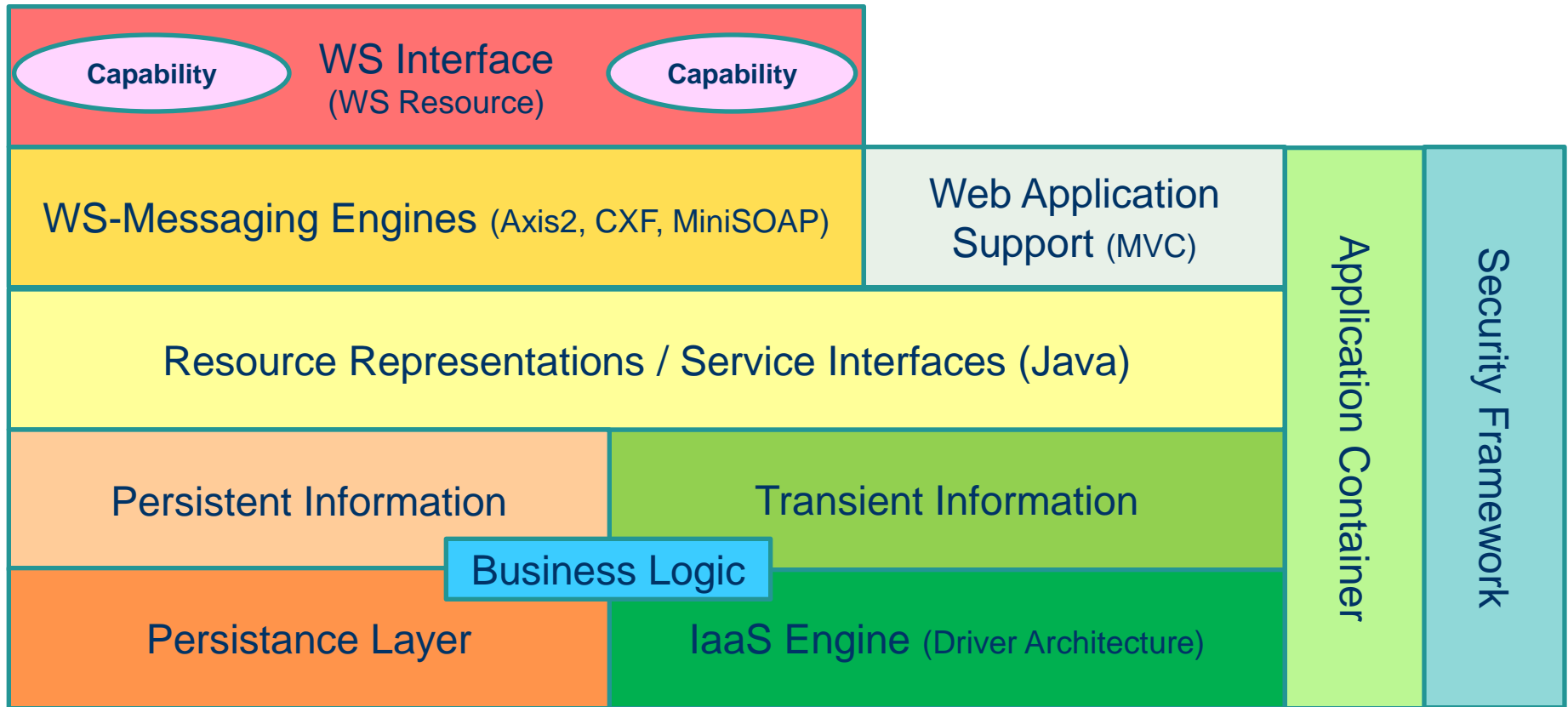
More on the IaaS Framework



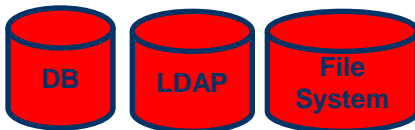
- **What benefits are provided by the framework**
 - Quickly develop new Virtualization solutions
 - Integrate directly in the Resource Management Center by creating a plugin
 - Leverage years of experience in virtualization best practices
 - Virtual Resources are compatible with third party resources and services
 - Benefit from an active community of developers
 - Resources using the framework can be exchanged by brokers sites like the upcoming (expected end 2008) <http://www.vinfrastructures.com/>
- **What the framework is not**
 - The framework is not a standard and doesn't aim to become one
 - The framework is not an application or middleware-solution on its own
 - The framework is not a proprietary product it is licensed under Apache Software License version 2 and may be used by third parties to create commercial products

The IaaS Framework

Software Resource Architecture



Data Sources



Physical Devices

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- **The IaaS Framework**
- **Projects**
 - ARGIA, MANTICORE, FEDERICA & PHOSPHORUS

The IaaS Framework project

More Info:

Inocybe Technologies Inc. <http://www.inocybe.ca>

IaaS Framework website: <http://www.iaasframework.com>



Unless specified otherwise the development is being performed in partnership by i2CAT, CRC and Inocybe Technologies.

WS

WS

WS

WS

WS

Framework (Open Source)

Argia™ (Product) (Optical Networks)

Ether™ (Product) (Ethernet Networks)

MANTICORE (i2CAT) (IP Research Project)

GRIM (CRC & Inocybe) (Virtual Instruments Research)

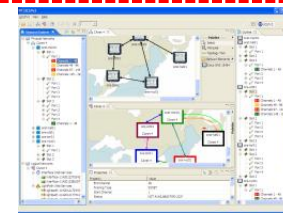
Application Services

Scenarios Resources

Physical Network Resources

Resource List Resources

Resource Management Centre and User Web Portal.



RCP



WEB (Development)

Network Virtualization Services

Connections Resources

VLAN Resources

IP Network Resources

Instrument Resources

Device Controller Services

Optical Switch Resources

Ethernet Switch Resources

Router Resources

GRIM Resources

Device Virtualization Services

Ethernet Port Resources

TDM Timeslot Resources

Lambda Resources

Support Services

User Workspace Resources

Appliance Resources

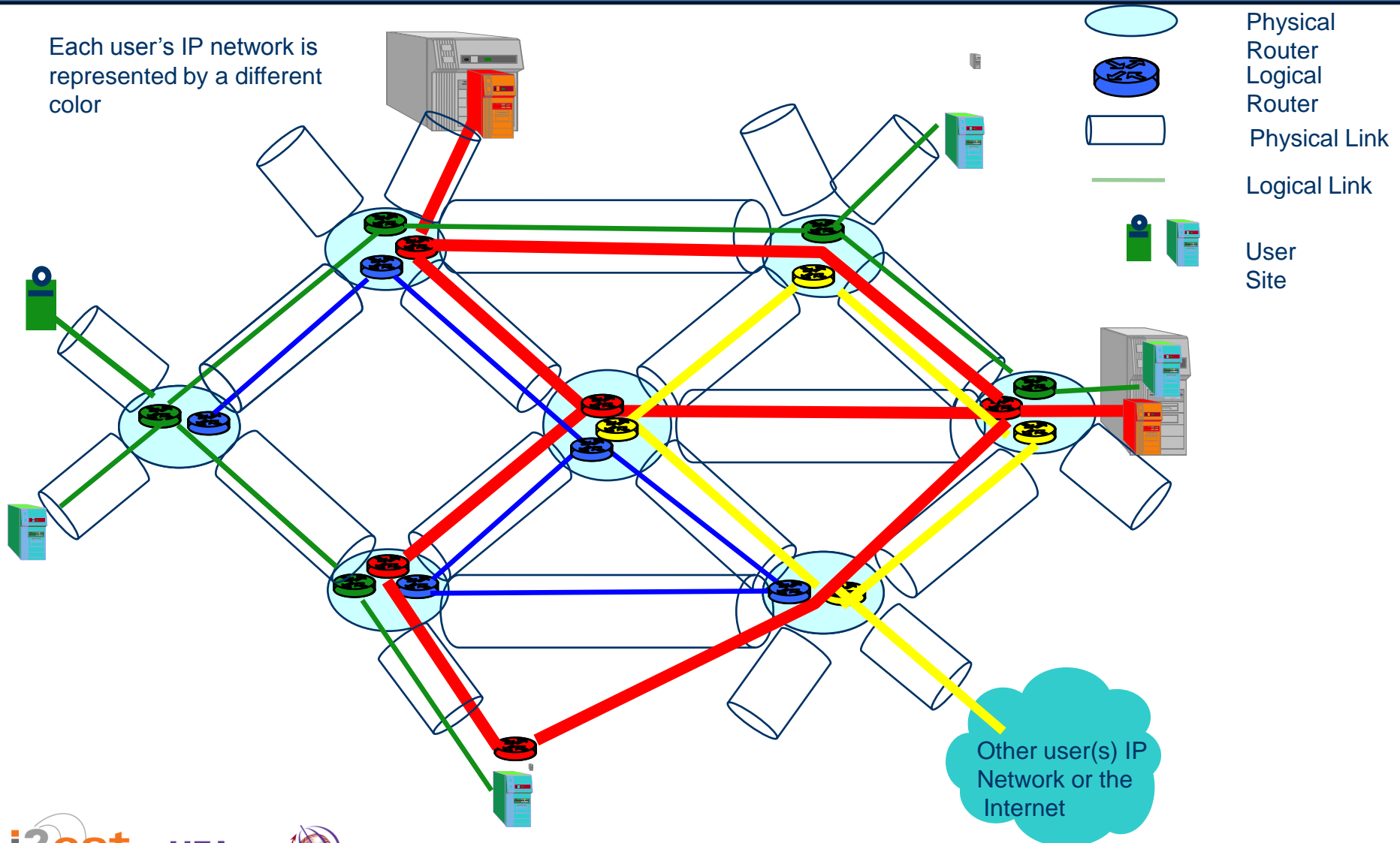


MANTICORE: Beyond connectivity services

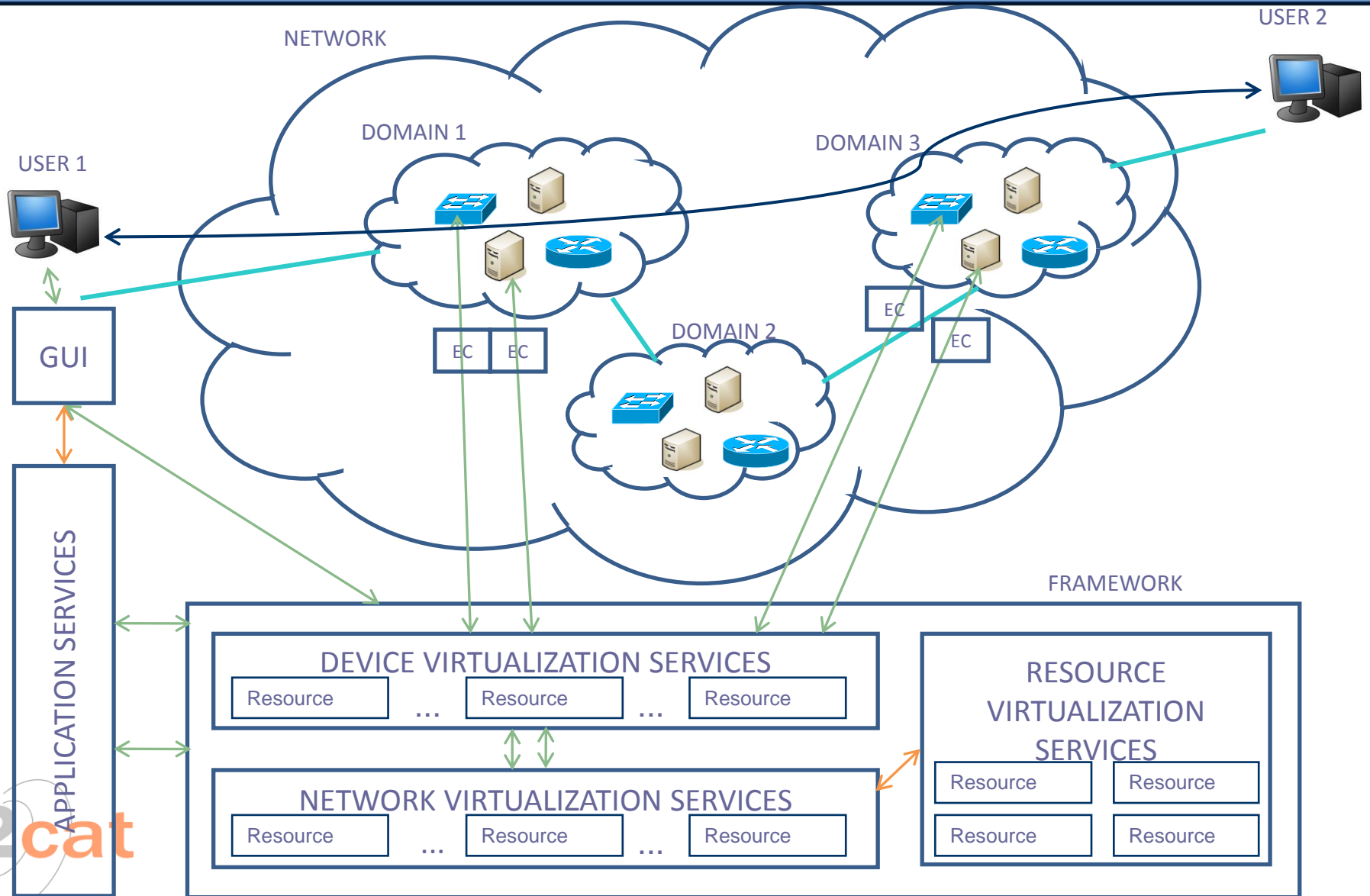
- The main goal: Create an innovative web service based system that provides the User (NOC and/or the end user) with the ability to define and configure of its own physical and/or logical IP network
- **IP Network Service Functionalities:**
 - General configuration of the router interfaces (IP address, netmask, status, ...)
 - Add/Delete static route
 - Configure an IGP on a interface or the whole network (OSPF)
 - Configure an EGP on an interface or the whole network (BGP).
 - Federation of user-defined autonomous systems (ASs): Users can create their own IP domains and choose to what other IP domains they want to peer with.

The MANTICORE vision

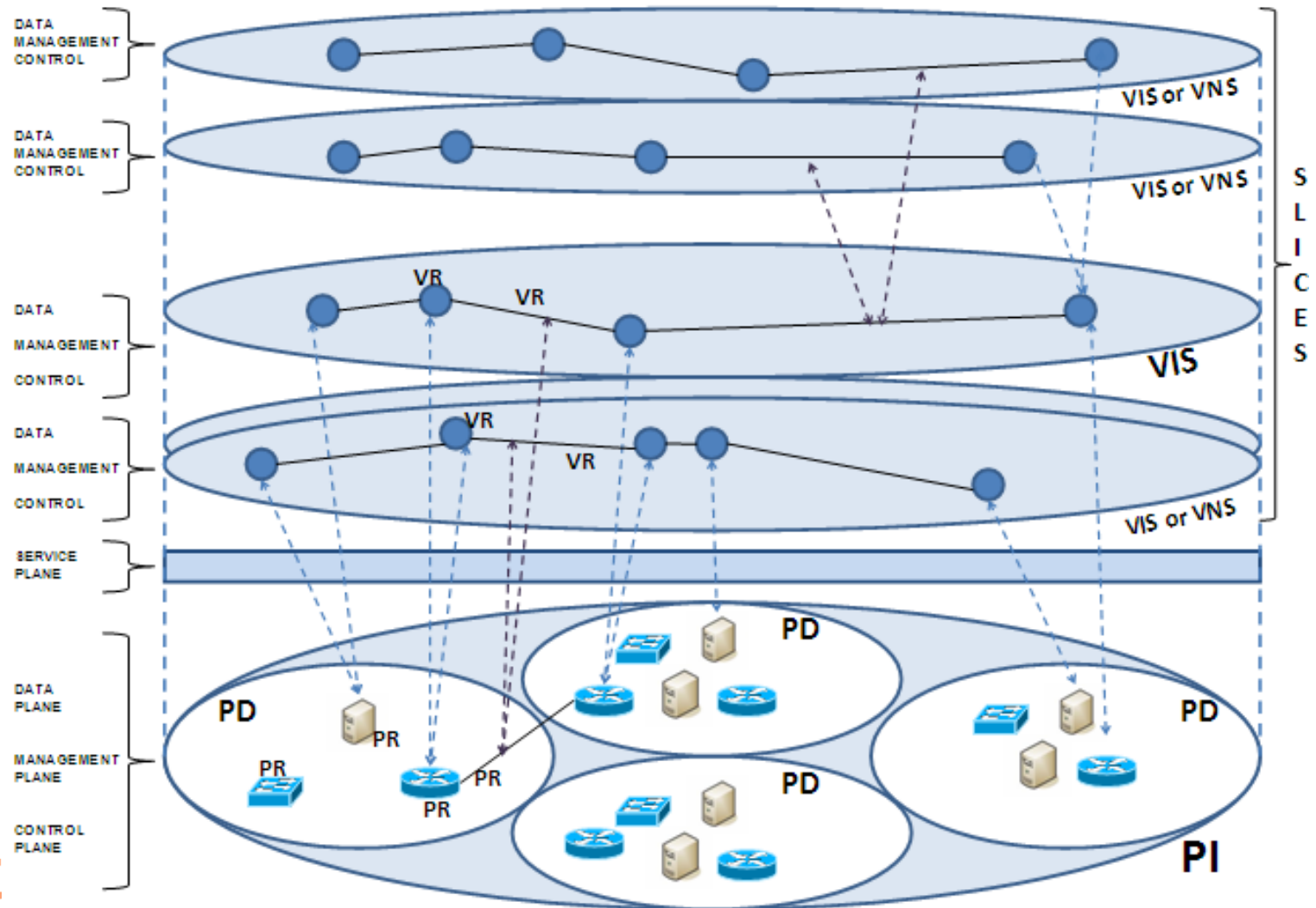
Each user's IP network is represented by a different color



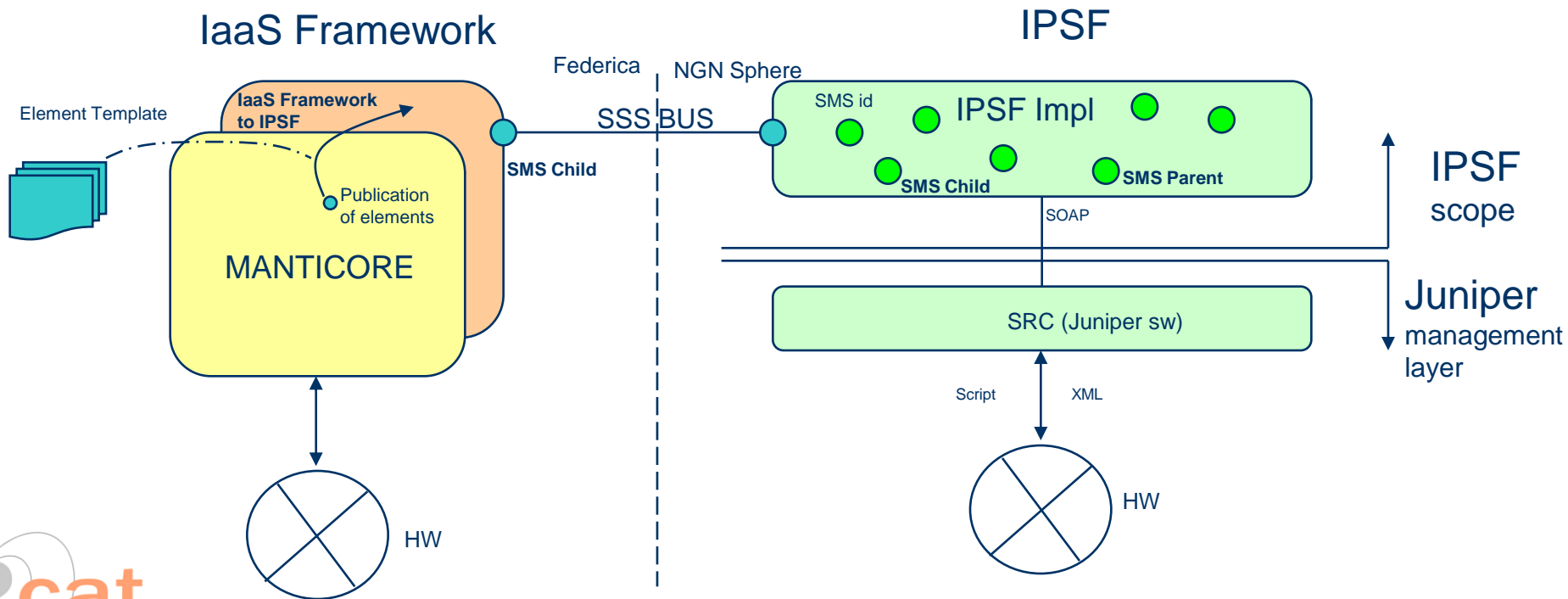
FEDERICA NETWORK



Federica Slice Architecture



- **Objective: establishment of a technical collaboration framework between IaaS Framework and IPSphere Framework within the FEDERICA scope.**



The Phosphorus NSP (WP1)

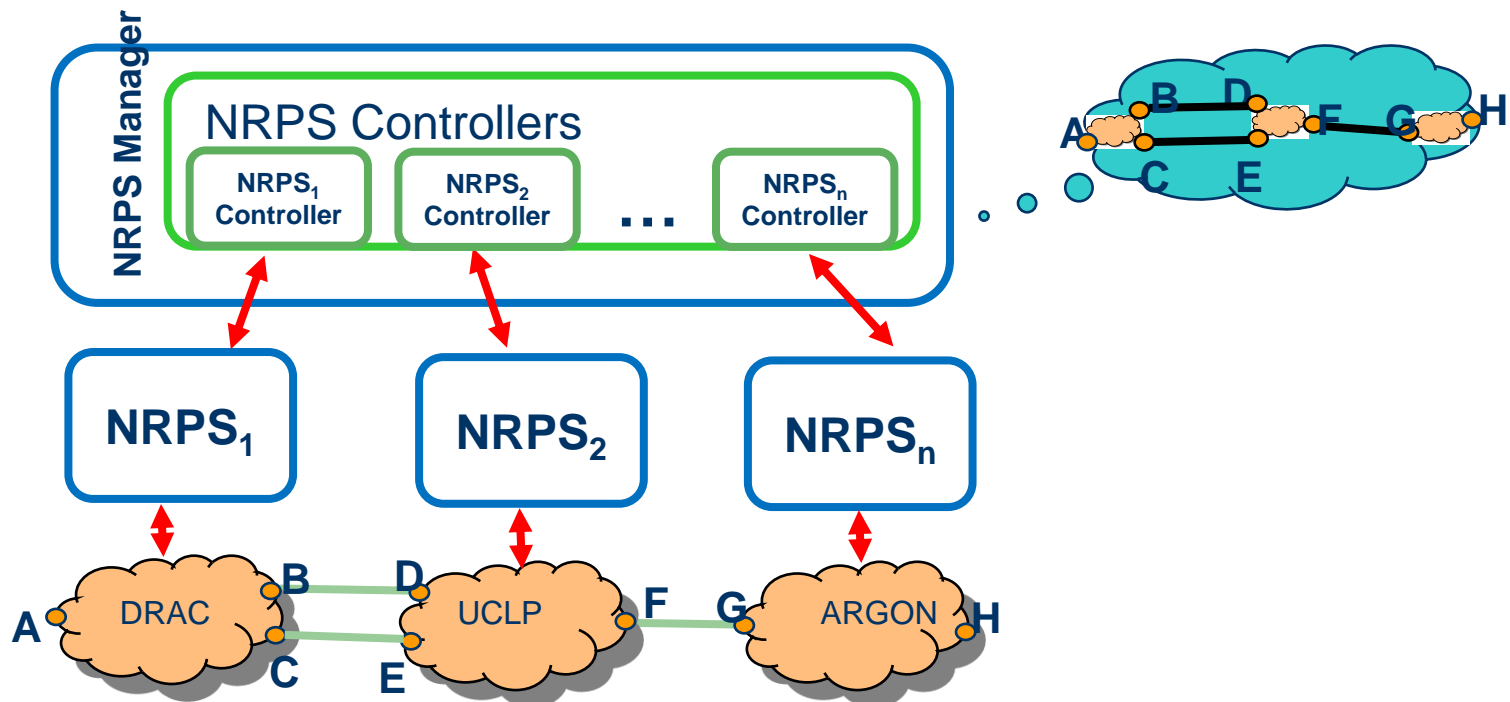


- **WP1 GOAL:**
 - *To allow Grid applications provide a single-step inter-domain provisioning of dedicated end-to-end paths with specific BW, duration, delay parameters and AR capabilities in a multi-technology approach.*
- **Key Points:**
 - Ability to create point-to-point connections using resources from several domains (DRAC, ARGON, UCLP)
 - AAA mechanism for global authentication
 - Advance reservations: users and Grid applications can program fixed or malleable resource reservations with one or more connections
 - Northbound interface to grid applications and est/west interfaces to other projectes/initiatives.

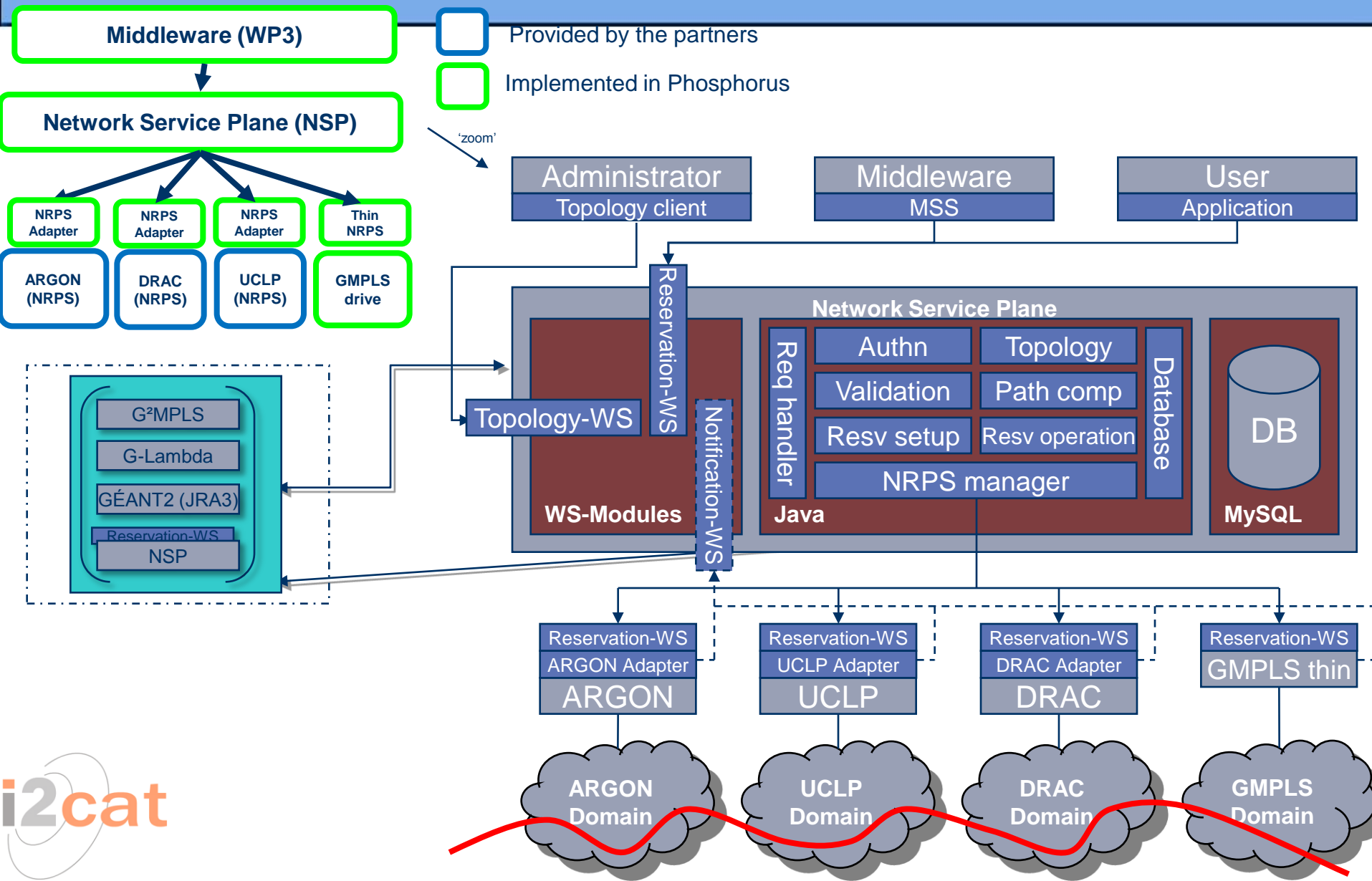
The NRPS Manager



- Module inside the NSP in charge of direct communications with NRPSs, by means of their endpoints
- Coordinate calls from the NSP to the NRPSs adapters and returns the replies
- The requests to the NRPSs adapters are launched at the same time to let the NRPSs work in parallel in order to shorten the request processing time.





NSP Global architecture

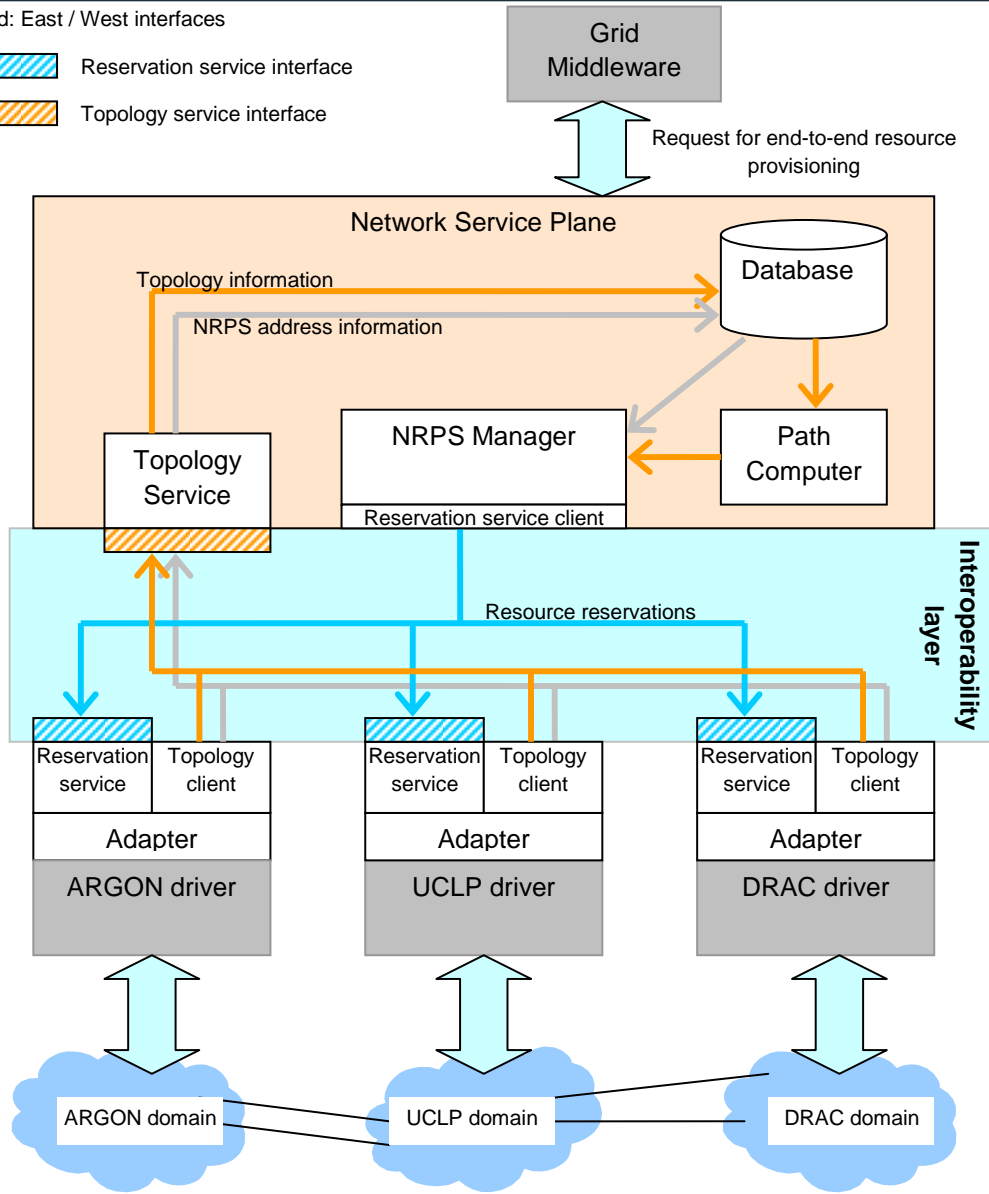


NRPS & NSP interoperability (high level view)

Legend: East / West interfaces

 Reservation service interface

 Topology service interface



Current NRPS Adapter functionalities

Reservation WS:

- Availability Request
- Reservation Request
- Cancel Reservation
- Status Request
- Retrieve Features
- Retrieve Endpoints

Topology WS:

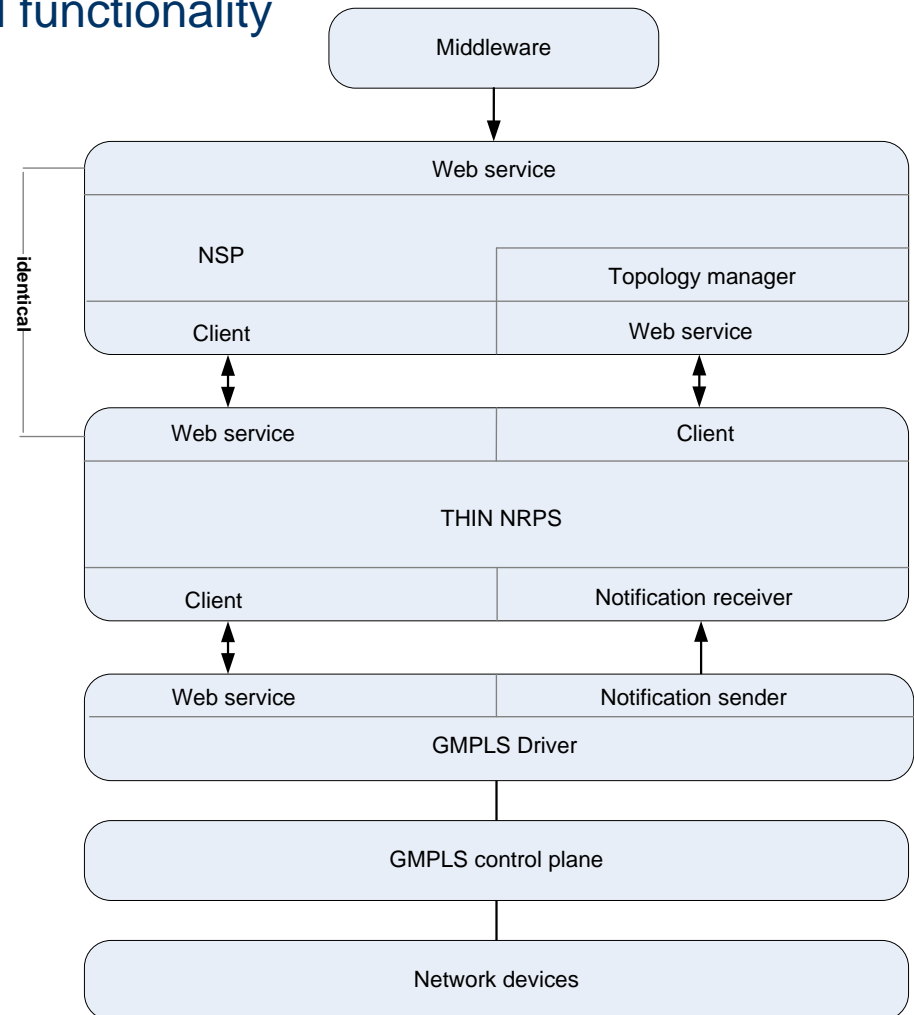
- Add domain
- Delete domain
- Edit domain
- Retrieve domain
- Add Endpoints
- Delete Endpoint
- Edit Endpoints
- Retrieve Endpoints
- Add Link
- Delete Link
- Edit Link
- Retrieve Link

Thin NRPS for GMPLS CP



Thin NRPS: is a network resource provisioning system for domains with a GMPLS control plane. It is a NRPS with restricted functionality

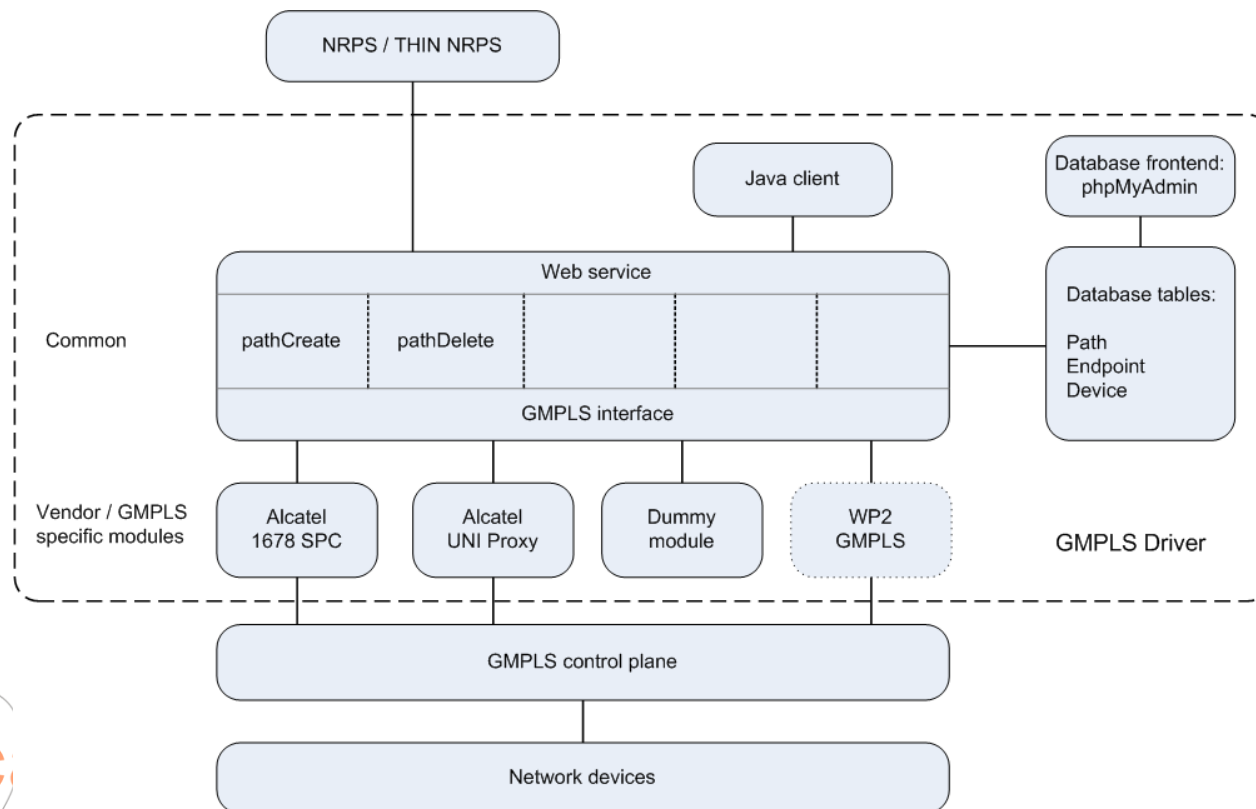
- Provides a reservation web service to reserve, create and delete network connections via the GMPLS driver
- Provides advance reservation services (checking end points availability and possible overlapping reservations)
- Provides notifications receiver interface
- Acts as a client of the Topology manager WS of the NSP
- Acts as a client of the GMPLS driver
- Domain registering
- Handles reservation request from NSP



The GMPLS Driver



GMPLS driver: an interface between NRPS and the GMPLS CP. It is a general WS to create, delete and monitor paths for different GMPLS implementations, provides a WEB interface for testing the WEB service, Internal data base containing topology, path and status information, modules for accessing vendor specific GMPLS control planes (e.g. Alcatel-Lucent or Nortel and G⁽²⁾MPLS, dummy interface to GMPLS



GMPLS driver services:

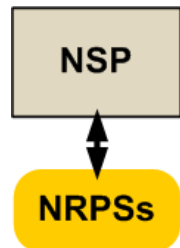
- Path creation
- Path termination
- Path monitoring
- Path discovery
- Endpoint discovery
- Registration service
- Path delete notification
- EndPoint update notification

Overall Implementation Strategy – Enhanced NSP

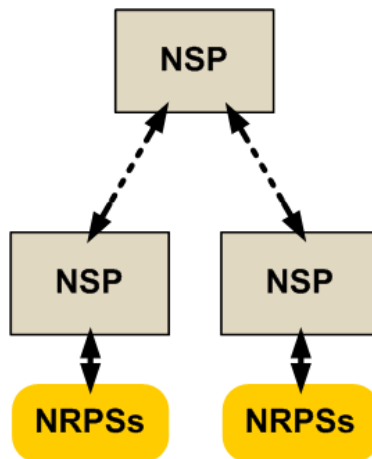


- Flat (Past)
- In the phase I, a flat architecture has been implemented
- Hierarchical (Present)
- The first approach for the phase II is a distributed hierarchical architecture
- Distributed (Future)
- The next step is to implement a fully distributed version of the NSP

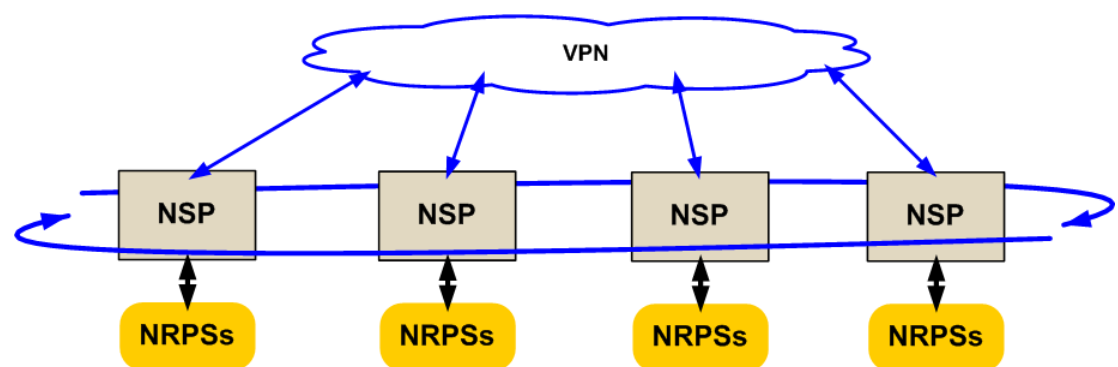
PAST



PRESENT



FUTURE



Overall Implementation Strategy – Enhanced NSP



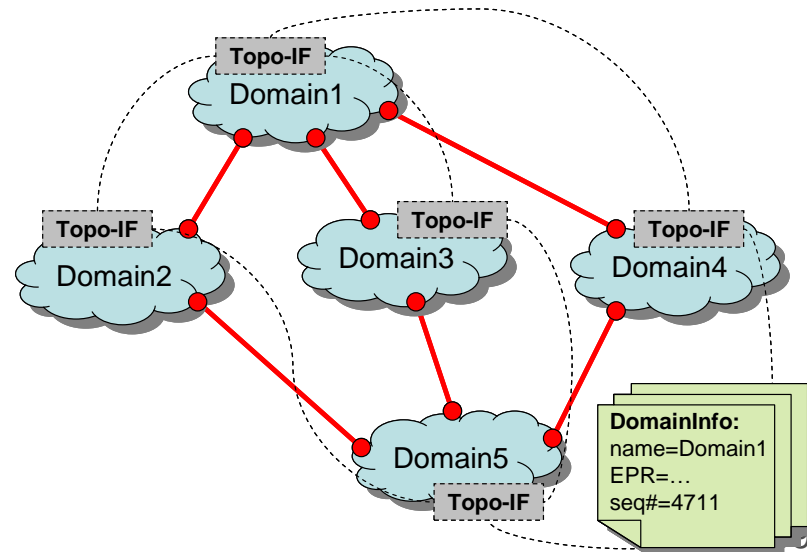
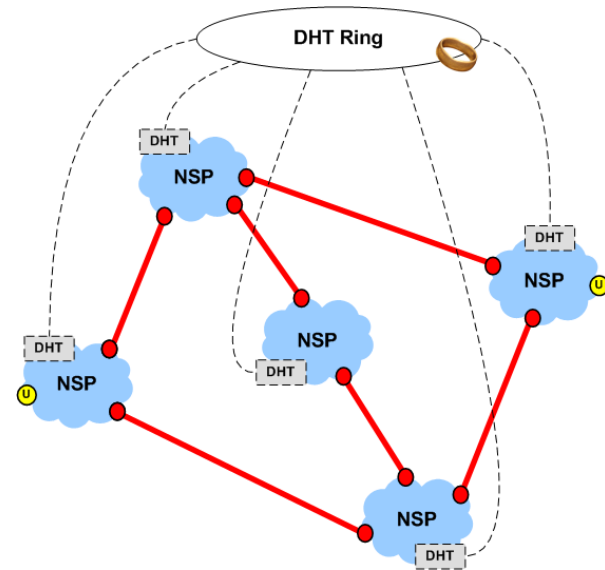
- **Alternatives studied**

- DHT

- Distribution of information from the application point of view using DHT
 - Innovative approach
 - Information sharing through the DHT ring

- Flooding

- Distribution of information in the “classical” way: Tell your neighbours all you know about the world.
 - Simple mechanisms to age information (sequence numbers).



Overall Implementation Strategy – Enhanced NSP



- **Decision taken: FLOODING**

- + Simple and traditional approach
- - The protocol has to be defined
- - Flood all information every time
- - Takes time in big networks
- Safe option

- **DHT rejected**

- + Simple integration and use
- - Too risky since there is not previous work available
- - High cost in path computing and information retrieval

G²MPLS Implementation Strategy



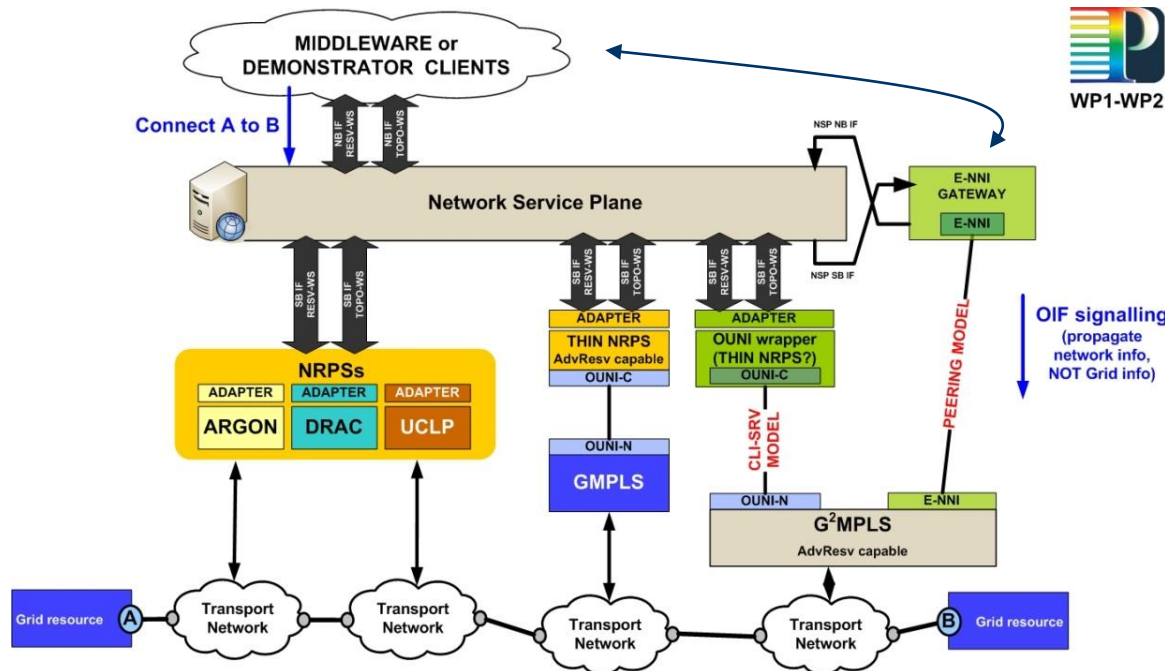
2 integration options :

Client-server model:

- Consists on reproducing GMPLS as it is right now but for G²MPLS (Thin NRPS for G²MPLS)
- NSP is a mere client not GRID-enabled, it can only request connections to G²MPLS

Peering model:

- Implement a common interface for NSP and E-NNI gateway
- Inline with the peering model
- G²MPLS can only request Network Services to the NSP, as the NSP is not Grid-enabled. G²MPLS must support advance reservations to deal with the NSP.



WP1-WP2

MANY THANKS

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