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Abstract

The Harmony system, after a first proof-of-concept stage, has evolved to a more stable system. In the last phase of the project, several enhancements have been done to the system. The first group of enhancements refers to the communication between Harmony and G^2MPLS. In the first prototype of the HG^2GW, it did not contain any security module. Consequently, the signaling between the two systems has been enhanced by means of integrating the security in its functionalities.

Moreover, the Harmony system has been further tested over emulated scenarios in order to study performance and scalability of the system in real-size scenarios. Thus, WP5 has developed a simulator which enables the system to be simulated in large scale scenarios. Additionally, the cooperation with the FEDERICA EU FP7 project has been started in order to use their facilities for deploying our system in an emulated mode and then continue with the performance and scalability tests.

Finally, the Harmony test-bed has undergone a big growth during this last phase of the project. Apart from the domains acting as gateways towards Internet2/IDC and G^2MPLS, there are three new domains integrated into the Harmony test-bed. These domains are controlled by the Argia/UCLP Network Resource Provisioning System (NRPS). The domains are Poznan Supercomputing and Networking Centre (PSNC), University of Essex (UESSEX), and Korea Institute of Science and Technology Information (KISTI).

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0 Executive Summary

This deliverable presents the report about the final enhancements done within WP1 software as well as the extensions of the test-bed. The first section presents the enhancements done in the HG2-GW. The new gateway enables a more stable communication between Harmony and G^2MPLS.

The second section, entitled Emulation and Performance Analysis of the Harmony system over a virtual network, presents all the executed tests over different infrastructures in order to evaluate performance and scalability of the Harmony system. The section is divided into three main parts. The first part, includes the collaboration established and maintained between Harmony and EU FP7 FEDERICA. The second part presents the collaboration between WP1 and WP5. Also, the simulator developed by WP5 and the simulation scenarios tested are presented. Finally, this section ends with a list of the publications relevant to the Harmony system and resulted from this work.

The third section, presents the extensions done to the Harmony test-bed in the last period of the project. These include extensions done in Poland (PSNC), United Kingdom (University of ESSEX), and Korea (KISTI). The local topology of each test-bed and the resources involved in the test-bed are depicted. The inter-domain connections done in order to add these new domains in the whole Harmony test-bed are also explained.

Finally, last section presents the conclusion of the document, taking into account all the previous sections.

1 Enhancements on the Harmony-to-G^{2}MPLS Signaling

Harmony-G^{2}MPLS interoperation has been further enhanced by integrating security support to its functionalities. These enhancements have been achieved by extending HG^{2}GW ([Phosphorus-D1.7], [Phosphorus-D2.9]) which translates requests from Harmony to G^{2}MPLs and vice versa. Moreover further tests for the preparation of the public demonstration performed in TNC09 have been carried out, helping to optimize the system for faster and more reliable performance.

1.1 Reservation operations

The transport of security parameters between Harmony and G^{2}MPLS is made within the reservation operations of the Reservation WS implemented in the HG^{2}GW. Two new security parameters have been added to some of the Reservation WS methods, the Global Reservation Identifier (GRI) and a security Token, as follows:

- createReservation/createReservationResponse
- getReservation
- getStatus
- cancelReservation

The GRI and Token parameters are parsed and forwarded to G^{2}MPLS where they are processed and validated. Since HG^{2}GW is carrying transparently this parameters from one domain to the other, details about the usage of the security operations within each system is out of scope for this deliverable.

HG^{2}GW has also been optimized for the interoperation between Harmony and G^{2}MPLS by removing from the Reservation WS the operations that were not supported by G^{2}MPLS and leaving the basic methods useful to establish and cancel connection reservations.

1.2 Topology/Routing operations

The topology/routing operations in both Harmony and G^2MPLS use different mechanisms to exchange topology information about their domains, as explained in Phosphorus-D1.7 and Phosphorus-D2.9. The Harmony-to-G^2MPLS exchange of topology information uses a two-step message protocol.

The method used by Harmony for topology exchange is the *addOrEditDomain* method. This operation contains all the information related to one domain (domain name, inter-domain links, endpoints). This is also the method which is used by the distinct peer domains in the Network Service Plane for exchanging their respective information.

The communication between Harmony and the HG^2-GW is done through one adapter under the control of the Harmony main Inter-domain broker. This adapter is responsible for forwarding the requests from Harmony towards the HG^2-GW.

1.3 Demonstration at TNC 09 and conclusions

The inter-operability between Harmony and G^2MPLS was demonstrated at TERENA Networking Conference 09[1]. The demonstration involved several domains controlled by its own provisioning system. Specifically, CRC and i2CAT domains used Argia (Harmony) and PSNC domain used G^2MPLS. The demonstration aimed to show the inter-operability of the developments done by WP1 and WP2, as well as show how both can deal with heterogeneous, multi-domain, and multi-vendor realistic scenarios. Next figure shows the test-bed map used for this demonstration.

[1] http://tnc2009.terena.org/schedule/meetings/index.php?event_id=1

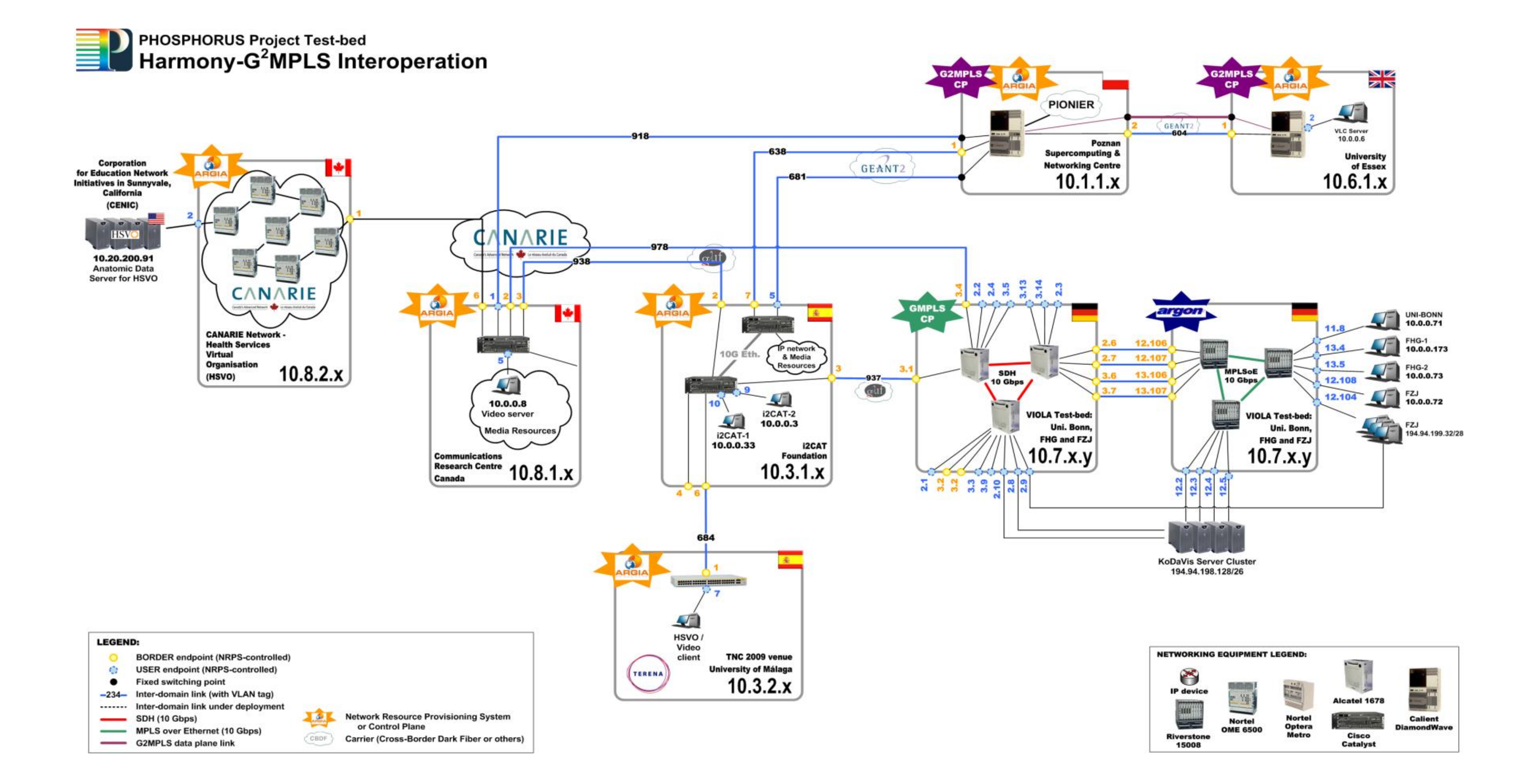
PHOSPHORUS Project Test-bed
Harmony-G2MPLS Interoperation
Corporation for Education Network Initiatives in Sunnyvale, California (CENIC)
10.20.200.91
Anatomic Data Server for HSVO
CANARIE
CANARIE Network - Health Services Virtual Organisation (HSVO)
10.8.2.x
10.0.0.8
Video server
Media Resources
Communications Research Centre Canada
10.8.1.x
10G Eth.
IP network & Media Resources
i2CAT-1
10.0.0.33
i2CAT-2
10.0.0.3
i2CAT Foundation
10.3.1.x
GEANT2
PIONIER
Poznan Supercomputing & Networking Centre
10.1.1.x
VLC Server
10.0.0.6
University of Essex
10.6.1.x
G2MPLS CP
ARGIA
GMPLS CP
argon
SDH 10 Gbps
MPLSoE 10 Gbps
VIOLA Test-bed: Uni. Bonn, FHG and FZJ
10.7.x.y
UNI-BONN
10.0.0.71
FHG-1
10.0.0.173
FHG-2
10.0.0.73
FZJ
10.0.0.72
FZJ
194.94.199.32/28
KoDaVis Server Cluster
194.94.198.128/26
HSVO / Video client
TNC 2009 venue University of Málaga
10.3.2.x
TERENA
LEGEND:
BORDER endpoint (NRPS-controlled)
USER endpoint (NRPS-controlled)
Fixed switching point
Inter-domain link (with VLAN tag)
Inter-domain link under deployment
SDH (10 Gbps)
MPLS over Ethernet (10 Gbps)
G2MPLS data plane link
Network Resource Provisioning System or Control Plane
Carrier (Cross-Border Dark Fiber or others)
NETWORKING EQUIPMENT LEGEND:
IP device
Riverstone 15008
Nortel OME 6500
Nortel Optera Metro
Alcatel 1678
Cisco Catalyst
Calient DiamondWave

Figure 1.1: WP1-WP2 joint demo test-bed map

2 Emulation and Performance Analysis of the Harmony System over a Virtual Network

This section of the deliverable, reports on the efforts done during the last phase of the project in order to further test the Harmony system. Due to the real test-bed constraints, in terms of physical equipment limitation and also availability of limited number of domains, the tendency for these tests has consisted of emulating or simulating the test-bed topologies. Thus, the first section presents the collaboration work done between WP1 and WP5. As a main output of this collaboration, we can mention the simulator environment developed by WP5 members with the inputs from WP1 members.

Next section presents the collaboration started between EU FP7 FEDERICA project and WP1. At the time of writing the document, the collaboration has not started. However, the memorandum of understanding between the two projects has been signed. Currently, we are waiting for an official notification of the FEDERICA User Policy Board. Finally, this chapter of the deliverable references the publications related to the Harmony system resulted from work in this last phase of the project. These publications also include some performance and scalability analysis done over a virtual test-bed.

2.1 Harmony-WP5 Collaboration

WP5 is responsible for the supporting studies to the other WP's in the Phosphorus project. The main purpose of the activities in WP5 consists of the design and evaluation of innovative architectures and algorithms to efficiently manage optical Grid infrastructures. This work is essential because it allows to effectively test interesting alternatives with short turn-around times. The Harmony – WP5 collaboration can be situated within these supporting studies activities.

The main objective of the collaboration between WP1 and WP5 is to build a simulation environment to evaluate the different architectural approaches of the Network Service Plane in Harmony. Thus, the results of the simulations executed by WP5 aim to assess the performance and scalability of the service plane as well as to determine which architecture performs optimally under different scenarios.

As the prototype and test-bed infrastructure is quite limited for extensive evaluation of the Harmony service plane, WP5 has built a simulation environment that is able to simulate much larger topologies to allow performance evaluation under realistic circumstances. Also, simulation allows a wide range of service and control algorithms to be rapidly tested under various network and traffic conditions. As such, the main purpose of this collaboration is to provide feedback to the Harmony designers and developers about the high-level and large-scale behavior of their software stack through simulation analysis.

2.1.1 Simulator

The simulator was built using the Python programming language. As our aim was to use discrete event simulation (DES), we selected the SimPy library that offers an object-oriented and process-based DES language. The fundamental entity of the simulator is the Resource object provided by the SimPy package, which simulates a queuing system and corresponds to an IDB in the Harmony system.

Furthermore, to incorporate features for the creation, manipulation and study of complex networks, we required an additional Python library. For this, we selected the NetworkX package for its advanced support in network generation capabilities and various network algorithms such as routing and topology evaluation. In particular, the NetworkX package was used for random graph generation using the Barabasi-Albert preferential attachment model. Also routing functions and extraction of various topology parameters were extensively used.

The simulator itself makes a distinction between the three basic architectural approaches, more specifically:

- Centralized: a single IDB functions as point of entry, and has a direct connection to all HNAs.

- Hierarchical: multiple levels of IDBs are assembled in a tree structure. Each IDB can function as point of entry, but only the leaf nodes in the tree can directly control the HNAs. Thus, when a connection request arrives at a point of entry that is not in direct or indirect control of the relevant HNAs, the request is propagated upwards in the tree until an IDB is found that has indirect control of all HNAs that are part of the connection request. Refer to D1.4 for the full description on how the hierarchical approach functions.

- Distributed: Each HNA has a single IDB that it controls directly; while the IDB network is assumed to be a full mesh (other scenarios are studies in D5.5 addendum).

Further explanation is required for the hierarchical approach, as it is not directly obvious how to construct the tree structure on top of the HNA network. For this, we chose an easily implementable technique for which we cannot prove any optimality properties. On the contrary, our results indicate that the technique can be easily parameterized and this may lead to large variations in the behavior of the system, ultimately implying that the construction of such an IDB hierarchy corresponds to an optimization problem. Our proposed algorithm is based on the grouping degree, which indicates how many lower level entities will be controlled by an upper level IDB. More specifically, we start from the HNA network, and introduce IDB's with each IDB controlling the exact number of HNA nodes that correspond to the grouping degree. Any HNA's that remain are then controlled by an additional IDB. We repeat this process for the IDB that were introduced, and create new IDB's on higher levels until a single root IDB is created.

For more details with regard to the design and implementation of this simulation environment, refer to Deliverable D5.9 Extended Simulation Environment, and the addendum to Deliverable D5.5 Recommendations for Control Plane Design.

2.1.2 Simulated scenarios

In this deliverable, we will only show results from a single scenario to demonstrate the validity of our simulation environment, and sketch some preliminary conclusions with respect to the scalability behavior of various approaches. More specifically, we will discuss how the average duration of a connection request effects different Harmony architectures.

Analysis of a working Harmony IDB controller implementation has shown that the processing time for a forwarded request is 20 ms, while a request that must be processed (leading to individual HNA reservations) has a duration of 25 ms. Likewise, the response time of a HNA controller is 7 ms.

We generated a random 100 node HNA network, using the Barabasi-Albert preferential attachment model. The Barabasi-Albert parameter, which corresponds to the number of edges that are attached from a new node to an existing node, was configured to 3. This led to an average degree of 5.58 for the HNA network (other degrees of meshedness are studied in D5.5 addendum).

The arrival process is the typical Poisson process, i.e. with exponentially distributed inter-arrival times. The point of entry IDB is chosen random leading to a uniform traffic pattern. All processing queues in the IDB's and HNA's have a first-come first-serve policy,

Furthermore, the grouping degree in the hierarchical approach was varied to study its influence on the scalability properties. For the given network size of 100 nodes, we chose grouping degrees of 2, 5, 10, 25 and 50.

2.1.3 Preliminary results

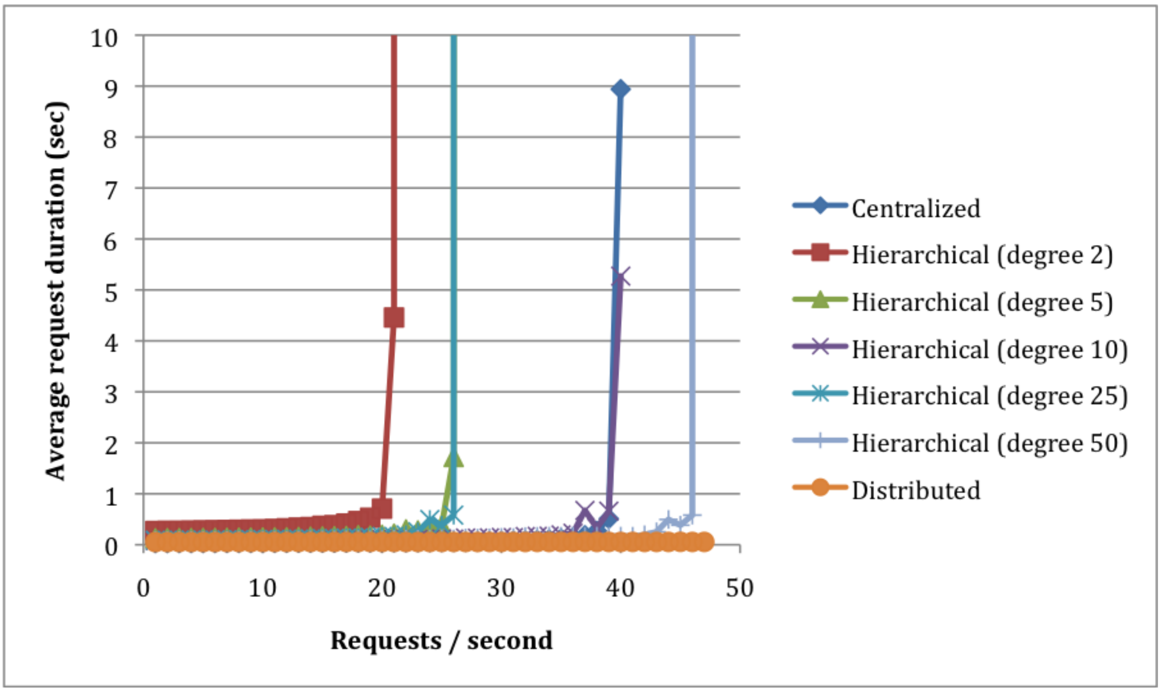

Figure 2.1: Scalability of average request duration for different Harmony architectures

Figure 2.1 shows the average request duration for various Harmony architectures. A number of interesting conclusions can be drawn from this figure. First, every architecture has a certain arrival rate (requests per second) at which the average duration increases very quickly. This is the point where the system becomes unstable as more arrivals are generated than the system can process. Obviously, this should be avoided at all cost, and this point is highly dependent on the arrival pattern (care must be taken for non-uniform loads as this may overload only certain parts of the system), the architecture, the processing speed of the IDB/HNAs (more efficient implementation can improve scalability), and other parameters.

It is also clear that the hierarchical system only performs better than the centralized under certain circumstances (i.e. grouping degrees 10 and 50 lead to similar or better performance, the other grouping degrees lead to much worse behaviour). This implies that the proposed algorithm for building the hierarchy of IDB's can be further improved. As such, this problem will be further studied in the future and will lead to a more intensive collaboration with Harmony's designers.

Finally, it can also be observed that the distributed system does not show an apparent instable point. However, this is mainly for clarity reasons, as we have seen (and we can also predict) that the distributed scenario becomes overloaded for an arrival rate over 220 requests per second: more than 5 times most other architectures can handle.

For more details we refer to the addendum to the Deliverable D5.5, which was released at the end of the Phosphorus project by WP5 partners.

2.1.4 Conclusion

In this section, we described our simulation environment that was created to study scalability issues of the Harmony service plane solution. More specifically, we implemented a simulator that incorporates the different architectural approaches: centralized, hierarchical and distributed. We demonstrated some results related to the average process duration of a connectivity request, and showed the existence of large variations in the behavior of the various architectures.

2.2 Harmony-FEDERICA Collaboration

As a result from the Harmony-WP5 collaboration efforts, the need for further and wider performance validation of the Harmony system arose. Phosphorus-WP1 has had very few hardware resources for simulations and stress/performance evaluation of the Harmony system, rather than those committed by Phosphorus-WP1 and Phosphorus-WP5 partners. It was considered that a Phosphorus-FEDERICA collaboration initiative would be an excellent framework for achieving both projects' goals.

On the one hand, Phosphorus-WP1 will be provided the computing facilities needed for running stress tests and performance analysis of the Harmony system over a wide scenario, with a high amount of IDB, HNA and NRPS entities inter-working each other, following the several models studied in WP1. This testing scenario can be provided in a FEDERICA slice, as a set of computing resources (virtual machines, from now on VM) and a normal IP connectivity among them.

On the other hand, FEDERICA project will get a real user that is interested in using its virtualization capabilities. This way, FEDERICA project will be able to test both its administrative procedures for giving a virtualized slice of its test-bed to users and, at the same time, test the stability and performance of its appliances, both software and hardware.

In the date of writing of this document, collaboration has not started yet, since the responsible members of the User Policy Board in Federica project have not yet given a formal acceptance of the Phosphorus project as a Federica User, although non-formal notification has been received.

2.3 Related Publications

There have been four publications in different conferences that presented the Harmony system and its capabilities to the community. Two of these publications aim to make a performance and scalability analysis respectively of the brokering system. Moreover, once the tests over FEDERICA test-bed finish, there is the possibility of writing a joint publication between WP1 members (S. Figuerola, J. A. García-Espín, J. Ferrer, and A. Willner) and WP5 members (M. de Leenheer). This joint publication will introduce the tests done over FEDERICA infrastructure, the simulator developed, and the comparison of the results obtained as well as the comparison with the results already obtained in the analysis done by WP1 members.

[1] S. Figuerola, J. A. Garcia-Espin, J. Ferrer, and A. Willner. Scalability analysis and evaluation of the multi-domain, optical network service plane in Harmony. In Published on the 35th European Conference and Exhibition on Optical Communication, Austria Center Vienna, Austria, 9 2009.

[2] S. Figuerola, J. A. Garcia-Espin, J. Ferrer, and A. Willner. Performance analysis of harmony: An optical, multi-domain network resource broker. In to be published on the 11th International Conference on Transparent Optical Networks, June 2009.

[3] A. Willner, C. Barz, J. Garcia Espin, J. Ferrer, S. Figuerola, and P. Martini. Harmony: Advance reservations in heterogeneous multi-domain environments. In Proceedings of the 8th IFIP Networking conference, Springer's LNCS, 5 2009.

[4] S. Figuerola, J.A. García-Espín, J. Ferrer, H. Zhang, and M. Savoie: Enabling Network Resources in the Grid: Functionalities and Services in Harmony. Invited paper. GridNets 2009. To be published.

3 Extension of the Harmony test-bed to Korea, Poland and United Kingdom

During the last phase of the PHOSPHORUS project, the Harmony test-bed has grown by integrating new domains. These new domains in the Harmony test-bed contribute in demonstrating the multi-technology, multi-vendor capabilities of the Harmony system, since each involved domain composed of different physical equipments. The domains added are Poznan Supercomputing and Networking Centre (PSNC), University of Essex (UESSEX), and Korea Institute of Science and Technology Information (KISTI).

3.1 Harmony in PSNC (Poland)

The Harmony/Argia domain was installed in PSNC at the end of 2008 in order to interconnect Uessex Harmony/Argia domain with I2cat Harmony/Argia domain. The Argia system and Argia-to-Harmony adapter was deployed using two OS systems running within PSNC VMware ESXi virtualization platform.

3.1.1 Local test-bed

In PSNC, the Harmony system with Argia was installed to manage the Calient DiamondWave FiberConnect fiber switch device. The Calient DiamondWave FiberConnect was divided to four independent sections to establish four virtual FSC switches as presented on **Figure 3.1**. The three of them were used for G^2MPLS purposes (Calient1, Calient2, Calient4). The Calient3 virtual switch was managed by Argia system. The Argia was managing only two Calient ports:

- Port 2.1.1 towards i2CAT domain via VLAN 638 over GÉANT2 network,
- Port 2.1.2 towards UESSEX domain via VLAN 604 over GÉANT2 network.

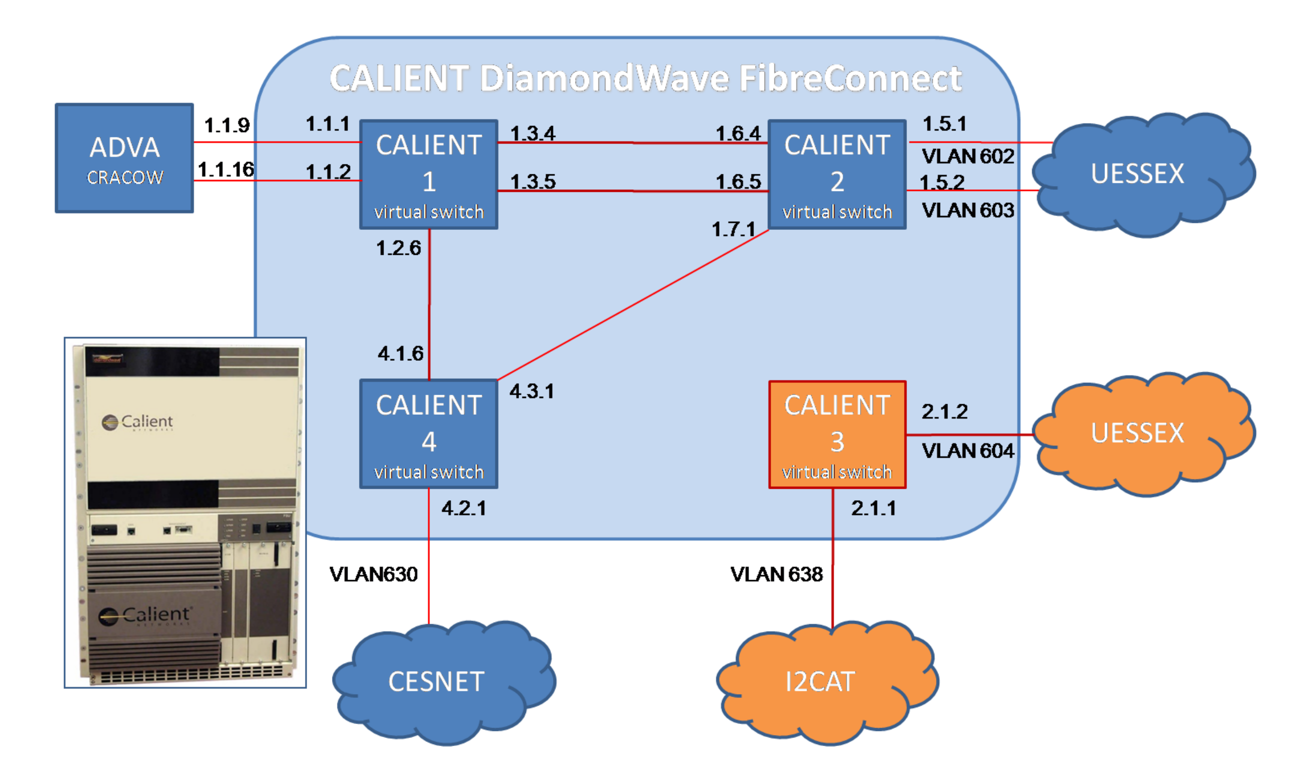

Figure 3.1: Configuration and Transport Plane connectivity of PSNC Calient fiber switch device

Very simple PSNC Argia domain topology perspective is shown on **Figure 3.2**. It is composed only of two border endpoints (belong to PSNC 10.1.1.x endpoints space):

- 10.1.1.1 towards i2CAT domain,
- 10.1.1.2 towards UESSEX domain.

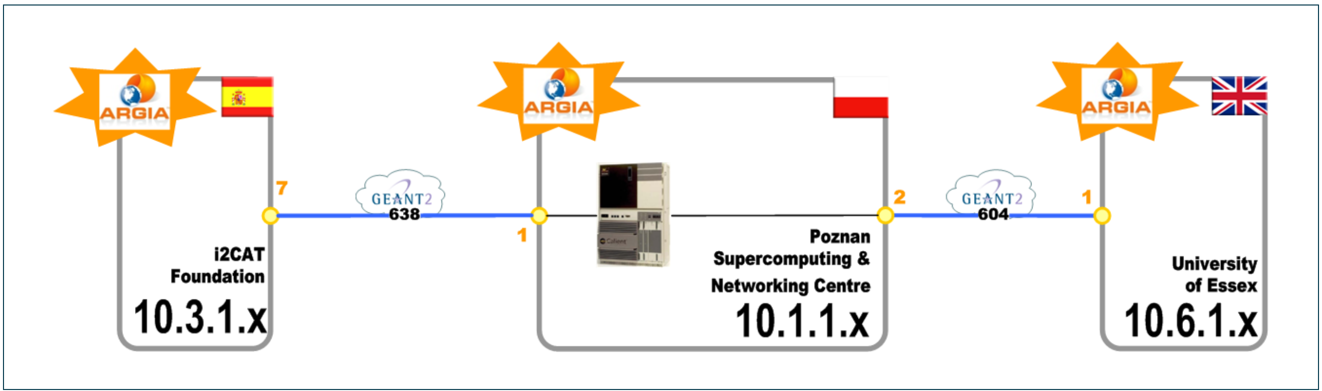

Figure 3.2: Harmony configuration for PSNC Argia domain

There are no user endpoints in PSNC Argia domain thus the Harmony system can establish/destroy only one particular cross-connection.

3.1.2 Harmony configuration

The Harmony adapter configuration is presented in **Code** . The configuration contains the descriptions of PSNC domain (name, reservation interface, parent domain reservation and topology interfaces, and domain TNA prefix) and inter-domain data-links with other domains (peer domain names, number of links, link name and endpoint identifier).

```
# set this to "none" to disable:
domain.parentDomainTopologyEPR = none
domain.name = psnc
domain.description = Poznan Supercomputing and Networking Center HNA Argia Domain
domain.reservationEPR = http://10.1.1.100:8080/harmony-adapter-uclp/services/Reservation

domain.numTNAPrefixes = 1
domain.TNAPrefix0 = 10.1.1.0/24

########################################
### parent domain information (optional)

parent.reservationEPR = http://10.1.7.1:8080/harmony-idb/services/Reservation
parent.topologyEPR = http://10.1.7.1:8080/harmony-idb/services/Topology

# for peer-to-peer topology exchange (with topologyEPR defined)
# and for interdomain link data for hierarchical architecture (without topologyEPR defined)

numPeers = 2

peer0.name = i2CAT
peer0.numLinks = 1
peer0.link0.name = VLAN638
peer0.link0.srcEP = 10.1.1.1

peer1.name = Uessex
peer1.numLinks = 1
peer1.link0.name = VLAN604
peer1.link0.srcEP = 10.1.1.2
```

Code 3.1: PSNC Harmony configuration file.

3.2 Harmony in the University of Essex (United Kingdom)

The Argia domain at University of Essex was deployed to provide interoperability within the Harmony multi-domain system. The connection uses JANET light-path to connect to PSNC domain in Poland (Poznan) and from there it has access to i2CAT in Spain (Barcelona). Since G^2MPLS is also installed in UEssex test-bed, the deployment of Argia proved the feasibility of partitioning efficiently the transport network and its control using different provisioning systems.

3.2.1 Local test-bed

In University of Essex, the local test-bed is similar to the one in PSNC. The Harmony system controls a partition of the Calient DiamondWave FiberConnect fiber switch device. The Calient DiamondWave FiberConnect is used to connect the incoming VLAN 604 from PSNC to a VLC server used for tests and demonstrations. As shown in Figure 3.3, port 2.1.4 is connected towards PSNC domain via VLAN 604 over the GÉANT2 network. On the other hand, port 1.1.4 is connected towards the VLC server.

Regarding the logical topology, there are two TNAs configured:

- 10.6.1.1 towards PSNC domain (border endpoint),
- 10.6.1.2 towards VLC server (user endpoint).

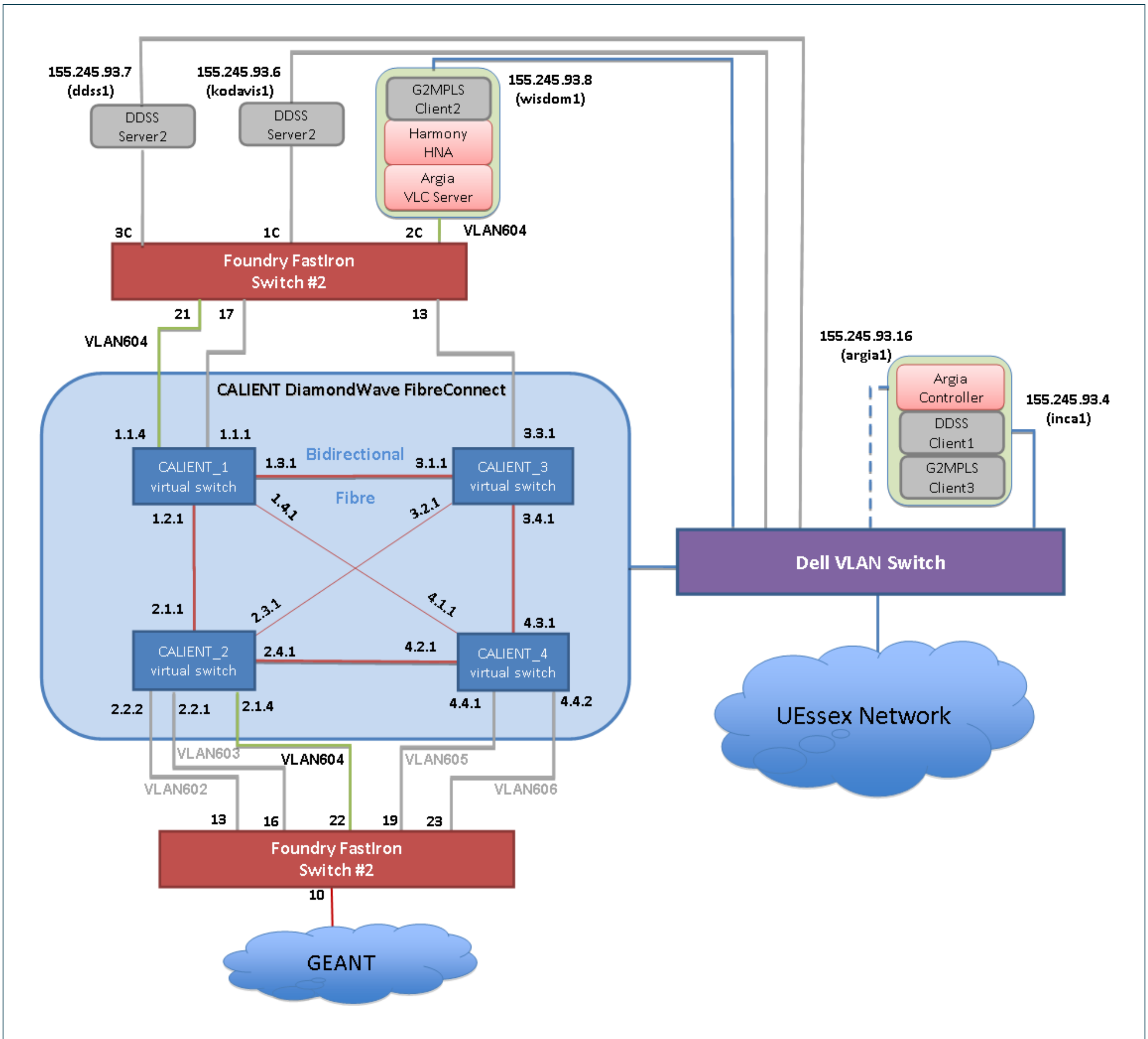

Figure 3.3: Configuration and Transport Plane connectivity of UEssex Calient fiber switch device

3.2.2 Harmony configuration

The Harmony adapter configuration is presented in Code 4.3.3. The configuration contains the descriptions of UESSEX domain (name, reservation interface, parent domain reservation and topology interfaces, and domain TNA prefix) and inter-domain data-links with other domains (peer domain names, number of links, link name and endpoint identifier).This file is used by the adapter in order to register the domain in the main Inter-domain Broker, located in Germany.

```
# set this to "none" to disable:
domain.parentDomainTopologyEPR = none

domain.name = uessex
domain.description = University of ESSEX HNA domain
domain.reservationEPR = http://10.1.6.1:8081/harmony-adapter-uclp/services/Reservation
#domain.topologyEPR = http://10.1.3.201:8080/harmony-adapter-uclp/services/Topology
#domain.notificationEPR = http://10.1.3.201:8080/harmony-adapter-uclp/services/Notification

domain.numTNAPrefixes = 1
domain.TNAPrefix0 = 10.6.1.0/24

########################################
### parent domain information (optional)


parent.reservationEPR = http://10.1.7.1:8080/harmony-idb/services/Reservation
parent.topologyEPR = http://10.1.7.1:8080/harmony-idb/services/Topology

# for peer-to-peer topology exchange (with topologyEPR defined)
# and for interdomain link data for hierarchical architecture (without topologyEPR defined)

numPeers = 1

#peer0.name = i2CAT

#peer0.numLinks = 1

#peer0.link0.name = VLAN638
#peer0.link0.srcEP = 10.1.1.1

peer0.name = psnc
peer0.numLinks = 1

peer0.link0.name = VLAN604
peer0.link0.srcEP = 10.6.1.1
```

Code 3.2: UESSEX Harmony configuration file

3.3 Harmony in KISTI (Korea)

The Argia domain in KISTI was deployed as a result of a common interest between KISTI and the Phosphorus project. In 2006, KISTI had their early experimentation with a prototype of the UCLP software, for controlling their Cisco ONS15400 series devices. Argia, being the successor of UCLP, was chosen for deploying the new dynamic switching domain at KISTI, that in turn make KISTI network fully compatible with the Harmony system. Nowadays, KISTI is using Nortel's OME 6500 platform, which is also supported by Argia NRPS.

3.3.1 International data link

Data link from the Phosphorus test-bed to KISTI has been provisioned using self-funded resources from both KISTI and CRC. This is due to the fact that the most feasible interconnection path between KISTI's local test-bed and the Phosphorus test-bed is via the PacificWave and Starlight networks, to which KREONET2 (for KISTI) and CANARIE (for CRC) networks are connected. The whole path is limited to 155 Mbps of maximum bandwidth due to the limit existing in the STS3c-1v path available for this collaboration from KISTI to CRC. The following image depicts the whole path from KISTI premises to I2CAT premises, passing through CRC premises.

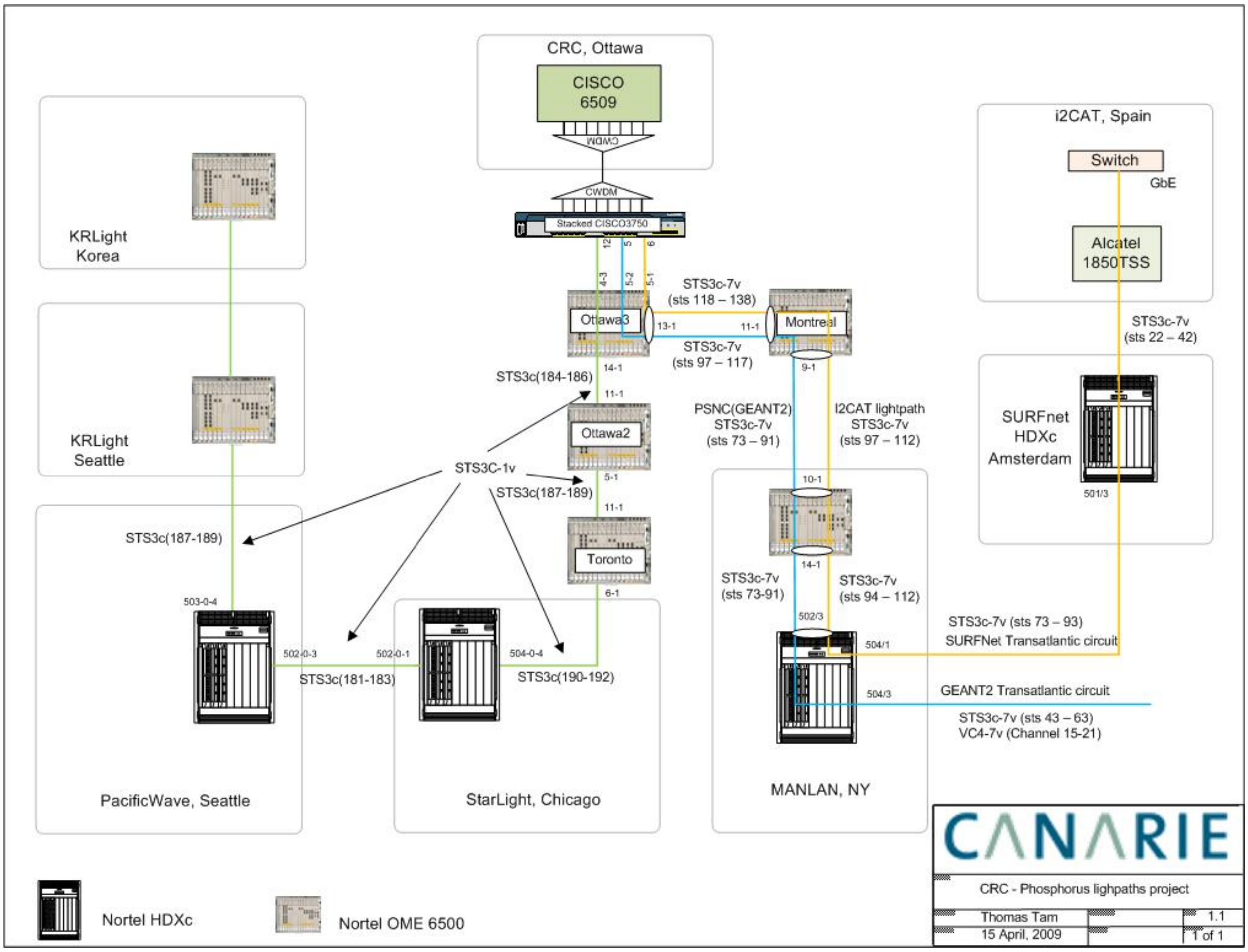

Figure 3.4: Whole data path between KISTI premises and i2CAT premises, passing through CRC premises.

The following image depicts the several options considered for interconnecting i2CAT local network for the Phosphorus project and KISTI premises. As can be seen with the two dotted lines, direct and indirect connection was considered. Indirect connection was designed to go across Canarie network and end in CRC premises. As far as CRC premises are directly connected to i2CAT ones, this solution (red dotted line + violet line) was a good alternative to the direct interconnection (green dotted line), which was discarded due to a lack of interfaces available along the path.

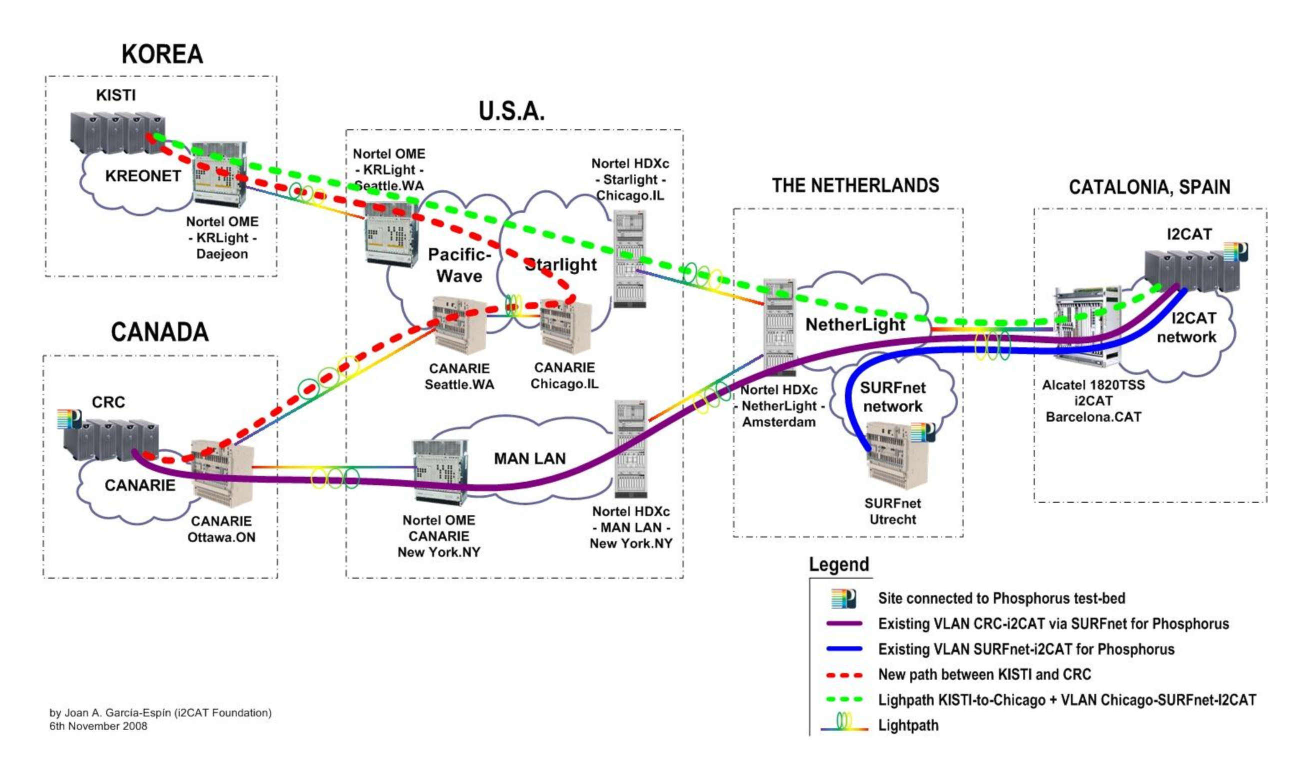

Figure 3.5: Initial proposal and available options for i2CAT to KISTI data plane interconnection

3.3.2 Local test-bed

The local test-bed of KISTI domain controlled by Argia/HNA software is composed by one Nortel OME, as depicted in next figure. From the Harmony point of view, the domain contains two endpoints: one border endpoint which connects the domain with CRC domain; and one user endpoint, where there is a test PC used to stream video towards the other domains.

The TNA space configured for this domain is 10.5.1.0/24, while the endpoints TNA are 10.5.1.1 for the border endpoint and 10.5.1.2 for the user endpoint.

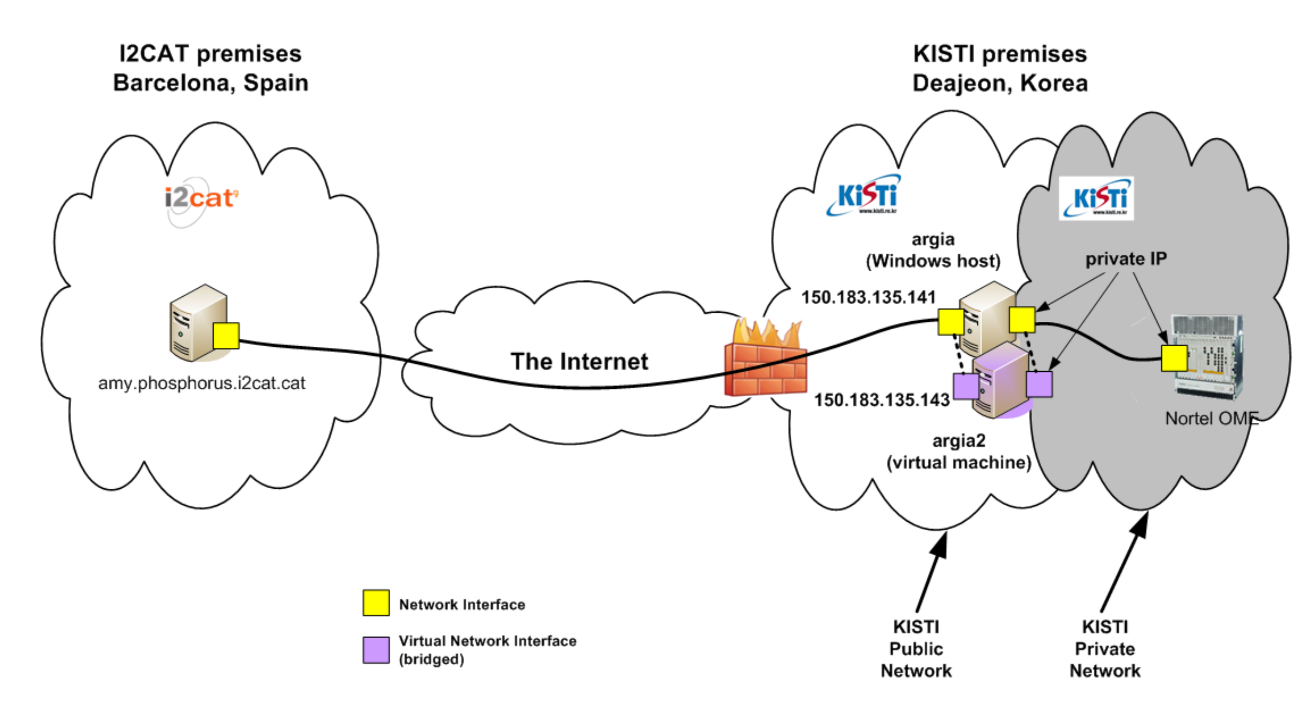

Figure 3.6: Configuration of the remote management of the Argia and HNA software in KISTI, from i2CAT premises.

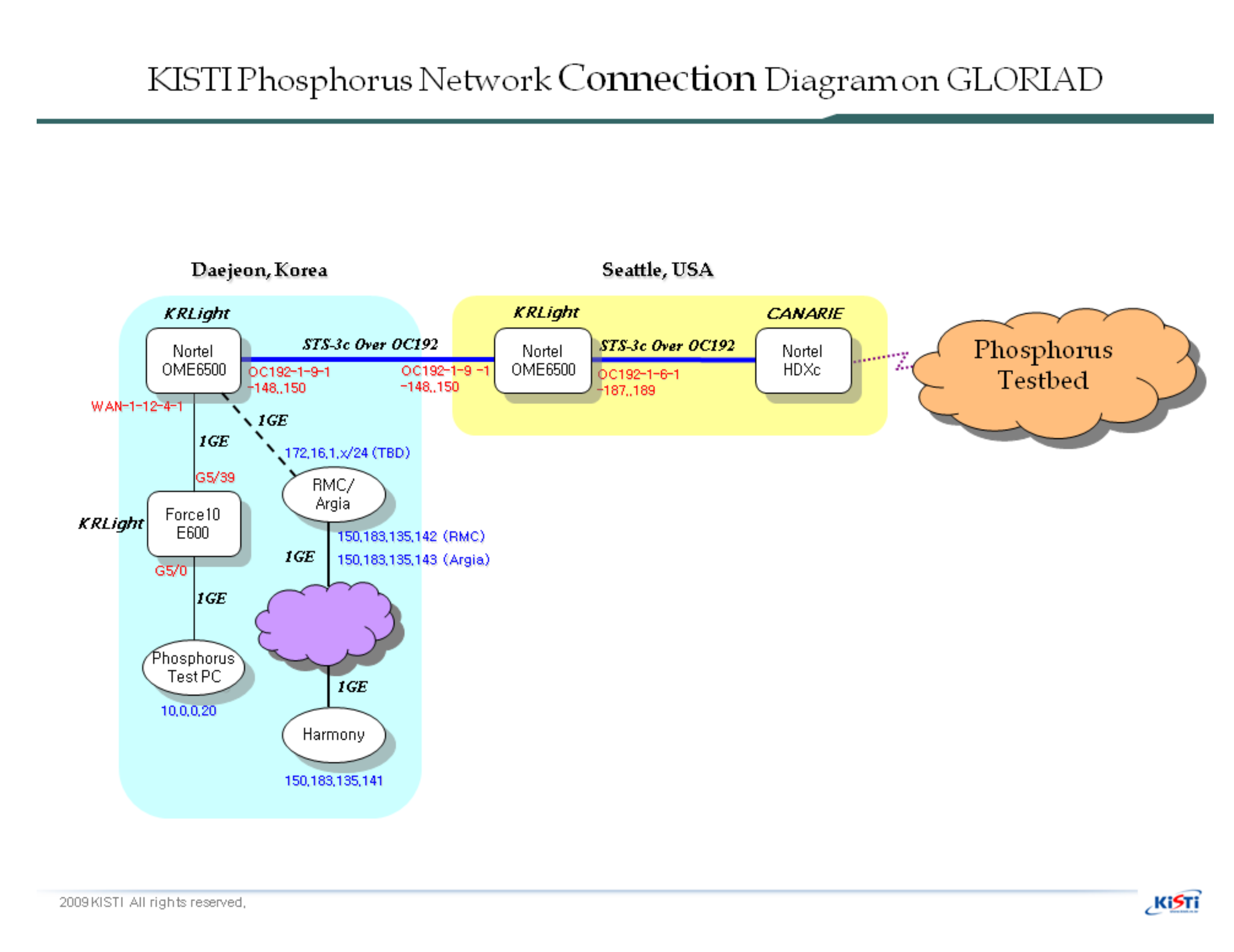

Figure 3.7: Configuration of the remote management of the Argia and HNA software in KISTI, from i2CAT premises, showing also the data plane details for the Korean part of the path.

3.3.3 Harmony configuration

The Harmony adapter configuration is presented in Code 4.4.4. The configuration contains the descriptions of KISTI domain (name, reservation interface, parent domain reservation and topology interfaces, and domain TNA prefix) and inter-domain data-links with other domains (peer domain names, number of links, link name and endpoint identifier).This file is used by the adapter in order to register the domain in the main Inter-domain Broker, located in Germany.

```
# set this to "none" to disable:
domain.parentDomainTopologyEPR = none


domain.name = kisti
```

```
domain.description = Korean Institute for Science and Technology Information HNA Argia Domain
domain.reservationEPR = http://10.1.5.100:8080/harmony-adapter-uclp/services/Reservation
domain.topologyEPR = http://10.1.5.100:8080/harmony-adapter-uclp/services/Topology
#domain.notificationEPR = http://10.1.3.201:8080/harmony-adapter-uclp/services/Notification

domain.numTNAPrefixes = 1
domain.TNAPrefix0 = 10.5.1.0/24

########################################
### parent domain information (optional)


parent.reservationEPR = http://10.1.7.1:8080/harmony-idb/services/Reservation
parent.topologyEPR = http://10.1.7.1:8080/harmony-idb/services/Topology

# for peer-to-peer topology exchange (with topologyEPR defined)
# and for interdomain link data for hierarchical architecture (without topologyEPR defined)

numPeers = 1

peer0.name = crc

peer0.numLinks = 1

peer0.link0.name = dae_sea_KISTI_CRC_STS3c
peer0.link0.srcEP = 10.5.1.1
```

Code 3.3: KISTI Harmony configuration file.

4 Conclusions

We have presented the final enhancements done in the Harmony system. First, we have presented the enhancements done in the Harmony-to-G^2MPLS signaling. These enhancements mainly include the integration of the security module within the gateway, enabling both systems to inter-communicate in a secure way. The result of this integration enables a user connecting to Harmony, to book in advance a path involving both Harmony controlled domains or domains controlled by G^2MPLS. The inter-operability between the developments of WP1 was demonstrated during the TERENA Networking Conference held in Malaga.

Additionally, we have presented the performance and scalability analysis of the Network Service Plane over emulated networks. to this extend, we have started a cooperation line with another EU funded project, the FEDERICA project. Harmony system is going to be further tested over the FEDERICA facilities. Due to the limitations of the test-bed, in terms of limited equipment and limited number of domains, the FEDERICA infrastructure provides the resources in order to perform the new set of tests over very large scale scenarios, trying to emulate realistic situations. Also, in order to compare the results obtained in the tests, we have collaborated pro-actively with WP5 in order to build a simulator of the NSP. This simulator, generates several architectures of the Network Service Plane and evaluates its performance by simulating distinct request arrival load. Moreover, we have presented the related publications as a main outcome of all the performed tests.

Finally, we have presented our test-bed growth in the last period of the project. Three new domains have been integrated in the whole test-bed, demonstrating with this integration the potential of Harmony as well as its capabilities to control heterogeneous independent administrative domains.

5 References

[Phosphorus D1.7] ”Network Service Plane Interfaces to G^{2}MPLS”. European IST project Phosphorus.

[Phosphorus D2.9] “Design of Grid-GMPLS interworking with NRPS”. European IST project Phosphorus.

[Phosphorus D1.4] “Definition and development of the Network Service Plane and Northbound Interfaces development”. European IST project Phosphorus.

[Phosphorus D5.5] “Recommendations for control plane design”. European IST project Phosphorus.

6 Acronyms

API	Application Programming Interface
ARGON	Allocation and Reservation in Grid-enabled Optical Networks
DRAC	Dynamic Resource Allocation Controller
IDC	Inter-Domain Controller
IDB	Inter-Domain Broker
NRPS	Network Resource Provisioning System
NSP	Network Service Plane
Glif	Global Lambda Integrated Facility
OGF	Open Grid Forum
GNI	Generic Network Interface
GUSI	Glif's Universal Service Interface
NSI	Network Service Interface
NSP	Network Service Plane
HNA	Harmony NRPS Adapter
HSI	Harmony Service Interface
SAVOIR	Service-oriented Architecture Virtual Organization Infrastructure and Resources
HSVO	Health Services Virtual Organization
KISTI	Korea Institute of Science and Technology Information
UESSEX	University of Essex
PSNC	Poznan Supercomputing and Networking Centre
VM	Virtual Machine
MoU	Memorandum of Understanding
UPB	User Policy Board (cf. Federica project)

Appendix A Phosphorus and the Federica User Policy Board (UPB)

A.1 The User Policy Board in Federica

The target users of the infrastructure are the researchers and the activities engaged in research “on” networking, using networks not just as the “tool” but primarily as the “subject’ of their work. User groups will include EC projects, research groups in universities or research centres, equipment manufacturers and telecommunications research labs or even individuals (e.g. PhD students). Users of the FEDERICA infrastructure will be distinguished between 'contributors' (i.e. being able to modify -in a controlled way- their allocated virtual slice properties, configuration, software) and 'consumers' (i.e. those who are simply using a FEDERICA slice or layer to do higher layer or application layer testing).

The FEDERICA project is dedicated to research on the "Internet of the future". Compliance to this objective is the main criteria for the prioritization of a proposal. On the other hand, the scientific merit of a proposal is not normally explicitly included in the evaluation criteria.

In general, the infrastructure will be available to both the academic and private sector, but due to its own status within FP7, research projects under the FIRE initiative will be preferred.

As a general rule, the evaluation process should not prevent proposals to be accepted when a minimal set of requirements are met and resources for the requested timeframe are available. However, the UPB reserves the right to reassess a proposal and possibly reallocate resources during the lifetime of a project.

The FEDERICA infrastructure can be exploited by selected users in their future internet R&D activity. Accessing the infrastructure requires that the project staff receive additional information from candidate users, and a simple application procedure.

- Research groups or individuals interested in using the infrastructure can apply by sending their request to the e-mail address fed-upb@fp7-federica.eu, attaching the relevant forms.

- The request is submitted to the FEDERICA User Policy Board, whose goal is to examine and prioritize requests for the use of the infrastructure, according to the resource availability and the proposed technical work plan of the applicant.

- During the evaluation process, a responsible UPB member will interact with the user.

- After the acceptance of the proposed project, the UPB will transfer the documentation to the technical activity for implementation.

- At the end of their use of the infrastructure, users are requested to submit a short report about the use of the resources, the communication with the project and also achieved results (if publicly available).

A.2 Documentation

The documentation needed for getting an application to Federica’s UPB approved is the following:

- D1: Letter of Introduction
- D2: Basic User Information
- D3: Access Rules for Users
- D4: Acceptable Use Policy
- D5: Resource Description
- D6: Memorandum of Understanding
- D7: Project Plan
- D8: User Feedback

Files D2 to D5, both included, are informational documents, whereas D1, D6, D7 and D8 are file templates to be filled by users and conform the formality of the application. In this case, Phosphorus has already sent D6 and D7, being D1 unnecessary and D8 is not produced up to the end of the collaboration.

Appendix B Phosphorus-Federica Memorandum of Understanding (MoU) – UPB-D6

B.1 Text Transcription

Memorandum of Understanding (MoU)

between

FEDERICA and PHOSPHORUS
(20th May 2009)

1. Purpose

The purpose of this MOU is to formalise the access and use of the FEDERICA infrastructure by PHOSPHORUS, named USER in the following. It briefly outlines the access policies, the timeframe and any associated conditions.

It represents one of the three key documents that describe the collaboration, namely:

The Memorandum of Understanding: this document, formalising the collaboration, the timeframe and listing the mandatory information to be exchanged

The Acceptable Use Policy: The rules defining the responsibilities of each party, the type of traffic that can be carried, the nature of acceptable experiments, respect of private and confidential information from FEDERICA and/or parallel experiments and taking due care not to intentionally disrupt the infrastructure;

The Project Plan: The technical description of the planned use of the FEDERICA infrastructure by USER. It details the resource request in form of a “slice”, the resources needed and connectivity requested by the FEDERICA infrastructure, what experiments will be performed.

Feedback of the use of the infrastructure will be requested.

By signing this MoU the USER agrees to conditions hereby stated and in particular to the AUP and the other documents part of the “user kit”.

2. FEDERICA

FEDERICA is a project of the 7th Framework Program of the European Commission, grant no. RI-213107, which duration, at the time of writing, is from January the 1st, 2008 to June the 30th, 2010.

The project has the goal to set up an infrastructure made of virtual resources (circuits, nodes and network equipment) which researchers may request for their experiments.

Resources are offered in an isolated, dedicated environment named a “slice”. The researchers receive control on the assigned resources and the possibility to access them from general Internet through a gateway.

The up-to-date information on the infrastructure topology and request and access guidelines is available on the web site www.fp7-federica.eu and on the information kit provided at the time of registration.

3. PHOSPHORUS

The PHOSPHORUS project focuses on delivering advanced network services to Grid users and applications interconnected by heterogeneous network infrastructures. The project is addressing some of the key technical challenges to enable on-demand end-to-end network services across multiple domains. The PHOSPHORUS network concept and test-bed makes applications aware of their complete Grid resources (computational and networking) environment and capabilities, and enables dynamic, adaptive and optimized use of heterogeneous network infrastructures connecting various high-end resources.

The main innovation introduced by PHOSPHORUS is a network Service and Control Plane concept where the network (light-path) and Grid (computational, storage) resources are provisioned in a single step: network and Grid-specific resources are controlled and set-up at the same time and with the same priority, with a set of seamlessly integrated procedures. From a user’s perspective, this results in a real, node-to-node deployment of on-demand Grid services.

PHOSPHORUS will enhance and demonstrate solutions that facilitate communication among applications middleware, existing Network Resource Provisioning Systems, and the proposed Grid-GMPLS Control Plane. The main technical objectives are: 1) enhancements of the GMPLS Control Plane (G^2MPLS) to provide optical network resources as first-class Grid resource, 2) implementation of interfaces between different NRPS to allow multi-domain interoperability with

PHOSPHORUS's resource reservation system (Harmony System), 3) middleware extensions and APIs to expose network and Grid resources and make reservations of those resources.

To disseminate ideas and developments the PHOSPHORUS consortium will strongly interact with other relevant programmes, research activities and initiatives at the European and international level. Various network-oriented R&D projects are encouraged to share results and exchange ideas with PHOSPHORUS project.

4. The use of the infrastructure

4.1 Technical details

The technical details of the agreed use of infrastructure are explained in the document "FEDERICA Project Plan".

4.2 Timeline

The timeline for the collaboration is shown below:

2009												2010					
1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
					X	X	X	X									

4.3 USER Obligations

USER agrees:

To provide feedback on the use of the infrastructure, using the provided template

To share the results of any experiments performed on both their equipment and FEDERICA, to the extent that the information is anonymous and non-confidential. This may be done, for example, through a workshop, or by giving access to the relevant deliverable or publication in journals. The results - and the methodology for sharing them with FEDERICA - will be described in the *User Feedback* document acknowledging the use of FEDERICA in any publication or presentation

4.4 Data privacy

FEDERICA partners agree by default to a non-disclosure agreement on USER data, experiment details and results and it will ensure to its best such privacy.

5. Partnership

Nothing in this MOU implies any partnership between the parties.

6. Financing

Each party is responsible for financing its own participation in this collaboration.

No charge is made by FEDERICA for the services and resources (bandwidth, equipment, processing resources and personal support) it provides in accordance with its commitments to the EC and the separate *Project Plan* between the parties.

In case the agreement requires specific expenses, they will be quoted here with the financial agreement between FEDERICA and USER

7. Term and Termination

This MOU shall become effective upon signature by both party and shall remain in force initially until 30th September 2009. Either party may cancel the MoU by notifying the other party in writing with one week's notice. The MoU may be extended by mutual agreement.

8. Signatures

Two originals to be signed; one for each party.

FEDERICA	PHOSPHORUS	
Co-ordinator Mauro Campanella	Co-ordinator Artur Binczewski	WP1 Leader Sergi Figuerola
Signature:	Signature:	Signature:
Date:	Dates:	

Appendix C Phosphorus-Federica Project Collaboration Plan – UPB-D7

C.1 Text Transcription

1 FP6-Phosphorus: Lambda User Controlled Infrastructure for European Research

The Phosphorus project focuses on delivering advanced network services to Grid users and applications interconnected by heterogeneous infrastructures. The project is addressing some of the key technical challenges to enable on-demand end-to-end network services across multiple domains. The Phosphorus network concept and test-bed make applications aware of their complete Grid resources environment (computational and networking) and its capabilities. Phosphorus enables and tests dynamic, adaptive and optimised use of heterogeneous network infrastructures interconnecting various high-end resources.

1.1 Phosphorus objectives

The Phosphorus main goal is broken down into the following, measurable objectives:

- Demonstrate on demand service delivery across access-independent multi-domain/multi-vendor research network test-beds on a European worldwide scale. The test-bed will include EU NRENs and national test-beds connected with GN2, Cross Border Dark Fibre (GN2/JRA4) infrastructure and GLIF virtual facility. A set of highly demanding applications will be adapted to prove the concept.

- Develop integration between application middleware and transport networks, based on three planes: Service plane, Network Resource Provisioning plane and Control plane.

- Conduct accompanying studies to investigate and evaluate further the technological implications of the project outcomes.

- Disseminate the project experience and outcomes to the targeted actors: NRENs and research users

- Communicate and collaborate with other National, European and Global Grid and Networking projects in order to understand and possibly integrate relevant developments.

1.2 Participating institutions

Organization			Country
	PSNC	Poznan Supercomputing and Networking Centre	Poland
	ADVA	ADVA AG Optical Networking	Germany
	CESNET	CESNET, Zajmove Sdruzeni Pravnickych Osob	Czech Republic
	NXW	Netxworks s.r.l	Italy
	FHG	Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V.	Germany
	i2CAT	Fundació i2CAT, Internet i Innovació digital a Catalunya	Spain
	FZJ	Forschungszentrum Jülich GMBH	Germany
	HEL	HITACHI Europe SAS	France
	IBBT	Interdisciplinair Instituut voor Breedbandtechnologie VZW	Belgium
	CTI	Research Academic Computer Technology Institute	Greece
	AIT	Research and Education Society in Information Technologies	Greece
	SARA	Stichting Academisch Rekencentrum Amsterdam (SARA) Computing and Networking Services	Netherlands
	SURFnet	SURFnet b.v.	Netherlands

	UniBonn	Rheinische Friedrich-Wilhelms-Universität Bonn	Germany
	UvA	University van Amsterdam	Netherlands
	UESSEX	University of Essex	United Kingdom
	ULEEDS	University of Leeds	United Kingdom
	NORTEL	NORTEL Networks B.V.	Netherlands
	CRC	Communications Research Centre	Canada

Table 1.1: Participating institutions

1.3 Harmony within Phosphorus

Harmony is the brand name adopted by the software developed within the Phosphorus Work Package 1. The Harmony system is a multi-domain, multi-vendor network resource brokering system. Harmony defines an architecture for a network service layer between the Grid middleware and applications and the Network Resource Provisioning Systems (NRPS).

Harmony was born with two main assumptions: the system had to be multi-domain and had to be capable of creating end-to-end optical and allow layer 2 paths in a seamless environment for the scientific personnel at the end points. These conditions were set because PHOSPHORUS aims to make existing provisioning systems (NRPS) interoperable and fill the gap between these hardware-coupled software pieces and the Grid application middleware. The NRPSs compatible with Harmony at the current implementation stage are:

- ARGIA/UCLP: stands for the User Controlled Light-Paths initiative, developed by CRC, Inocybe Technologies (both from Canada) and i2CAT Foundation (Catalonia, Spain). It provides a network virtualization framework upon which communities of users can build their own services or applications. Articulated Private Network (APNs) are presented as the first services. APNs can be considered as a next generation Virtual Private Network where a user can create a complex, multi-domain network topology by binding together network resources, time slices, switching nodes and virtual or real routing services.

- ARGON: stands for the Allocation and Reservation in Grid-enabled Optic Networks. It was developed to manage resources of advanced network equipment, as it is present in the German VIOLA test-bed. The advance reservation service of ARGON is able to operate on the GMPLS as well as on the MPLS level. It guarantees the requested level of QoS for applications for the requested time interval. This feature enables a Meta-Scheduling Service to seamlessly integrate the network resources into a Grid environment.

- DRAC: stands for the Dynamic Resource Allocation Controller initiative. It is the world's first commercial-grade network abstraction and mediation middleware platform, acting as an agent for network clients to negotiate and reserve appropriate network resources on their behalf. DRAC user client's QoS requirements and pre-defined policies to negotiate end-to-end connectivity across heterogeneous domains in support of just-in-time or scheduled computing workflows.

Moreover, Harmony has developed a *Thin NRPS* entity which is able to communicate with the Optical User to Network Interface (OUNI) of a Generalized-MPLS Control Plane (GMPLS-CP) – although it is not considered an NRPS itself– and perform signalling operations and path management

The integration between application middleware and optical transport networks pretended by Harmony has been successfully achieved based on an architecture with three planes: the Service plane, the Network Resource Provisioning plane and the Control plane. This architecture is built over a SOA model and its compliant with the Web Service Resource Framework version 1.2. The figure 1.1 depicts the architecture of the system and shows the above mentioned layers and their components.

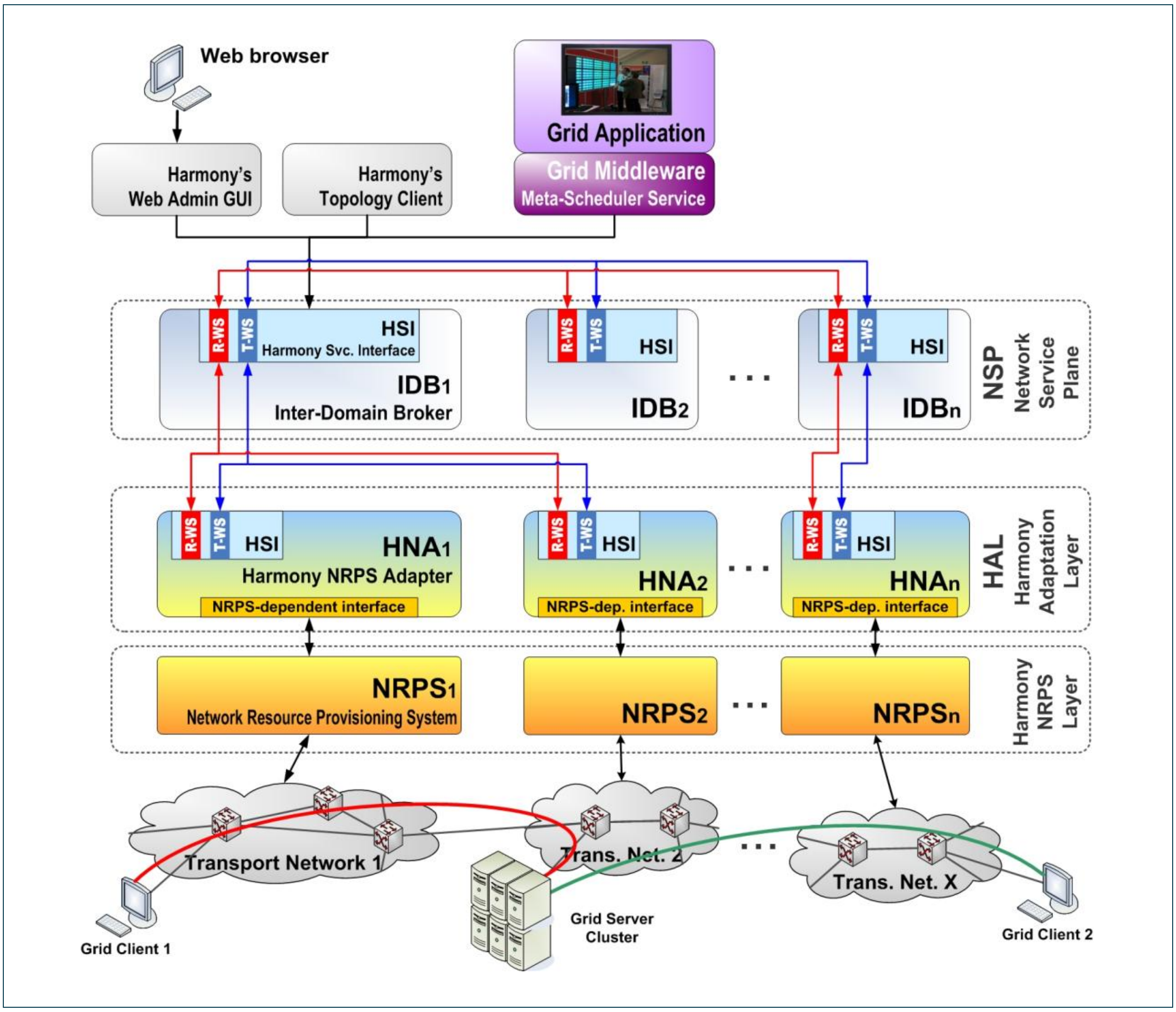

Figure 1.1: Harmony architecture

1.4 Federica typical usage scenario

The following figure depicts what will be the typical usage of a FP7-Federica slice. The slice is composed by several VMs, where the Harmony entities will be deployed. These VMs, located within a private IP Network, have connectivity to any other VM inside the private network. Moreover, there is an access point to the slice. This access point is a VM with one extra NIC with public IPv4 address. Further explanations and requirements are presented in next sections.

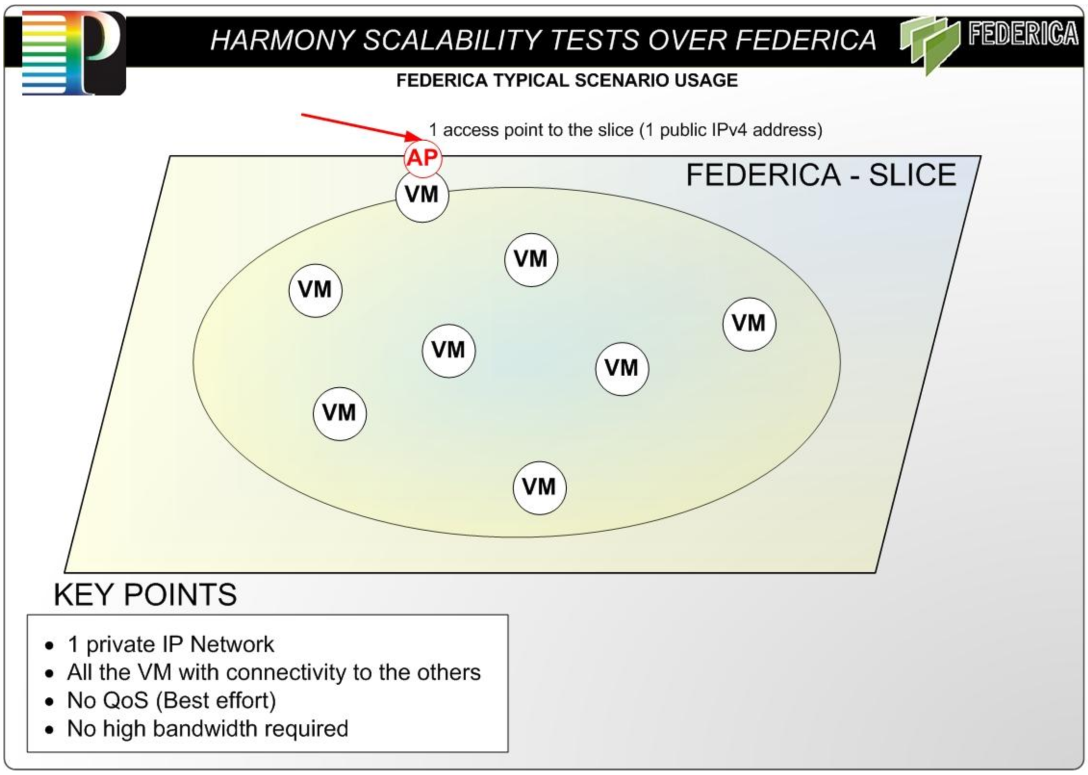

Figure 1.2: Federica typical usage scenario.

2 Harmony scalability overview

Harmony architecture has evolved from a centralized Network Service Plane (NSP) model to a distributed NSP model, passing through a mid stage, the multi-level, hierarchical NSP model. The NSP is composed of several entities: Inter-Domain Brokers (IDBs), which are responsible of managing and brokering network resources inter-domain, and Harmony Network Resource Provisioning Systems Adapters (HNA), which are in charge of translating unified Harmony signalling into Network Resource Provisioning System (NRPS) specific signalling.

In the early prototypes of WP1 in Phosphorus, one IDB controlling several HNAs composed the service plane (centralised model). Figure 2.1.a depicts this approach. This first attempt was deployed over a test-bed with five underlying administrative domains. That attempt became a good proof of concept but lacked of scalability when dealing with a high number of HNAs due to signalling load. In order to solve this problem, a hierarchical model approach was implemented, letting IDB being stacked, so that on IDB could control HNAs and other IDBs seamlessly. This second approach is depicted in Figure 2.1.b. In this solution, one or more children IDBs could be controlled as simple domains by another IDB. Child IDB abstracts all domains under its control to a single composed domain. This second version solved scalability deficiency of the original approach, but the performance of Harmony's NSP was not still good as the number of domains increased, due to signalling bottlenecks appearing in large hierarchies.

Finally, the third approach prototyped in WP1 consists of a distributed NSP model (Figure 2.1.c); that is, several IDBs populating the NSP and sharing the topology information via a reduced, OSPF-like flooding protocol [Phos-D1.8]. This solution has been deployed over a virtual test-bed (where NRPS work in a virtual mode, emulating physical equipment) and preliminary results showed an improvement of performance and scalability in Harmony.

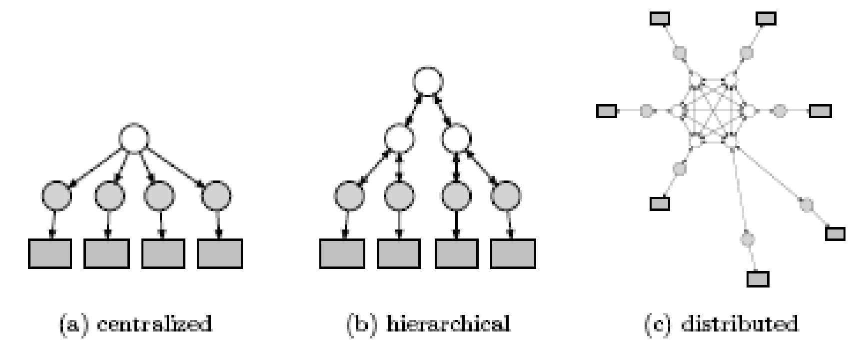

Figure 2.1: Architectures in Harmony

Tests executed in Phosphorus WP1 and analyses of their results have proved some expectations in NSP behaviour depending on the model deployed results, i.e. the distributed approach can handle more requests than the centralized approach. However, all tests performed over real and virtual test-bed are not enough concluding in order to state that the best solution for large topologies (production environment) due to limitations existing in the emulation environment when creating middle/large-size NSP topologies.

The infrastructure of FP7-Federica can provide a large set of virtual hosts with good connectivity for carrying out a set of extensive and intensive testing in Phosphorus WP1 prototypes. Therefore, large Harmony NSP emulated topologies can be built and tested over these hosts. Next section present the distinct test cases and the requirements needed for executing each test case.

3 Test cases

3.2 Considerations

The motivation of having different test cases comes from the three architecture models commented in the previous section. In this sense, each test case represents one service plane model of the system (centralized, hierarchical and distributed). The parameters which will be measured in each test case are:

1. Number of requests per second supported by the system
2. Average rate of successful reservations requests
3. Duration of each successful reservation request
4. Duration of all successful reservation requests

Parameters 1 and 2 are used to measure the response of the system under stress situations (capability of processing a high number of requests per second and capability of processing them successfully) and provide an estimation of the saturation point of the system itself. Meanwhile, parameters 3 and 4 measure the response of the system by means of the time response under stress conditions.

The tests will be performed using dummy Harmony NRPS; that is, there will be neither real NRPS deployed nor any physical equipment. Instead, Phosphorus WP1 has created a prototype for a special HNA emulating a dummy NRPS below. Thus, responses from dummy-HNAs will be generated automatically inside the HNA and forwarded to the IDB.

3.3 Centralized architecture

The first test case considers a centralized architecture with one IDB controlling 30 different administrative domains. Each administrative domain is emulated with one dummy-HNA. This test case is depicted in Figure 3.1.

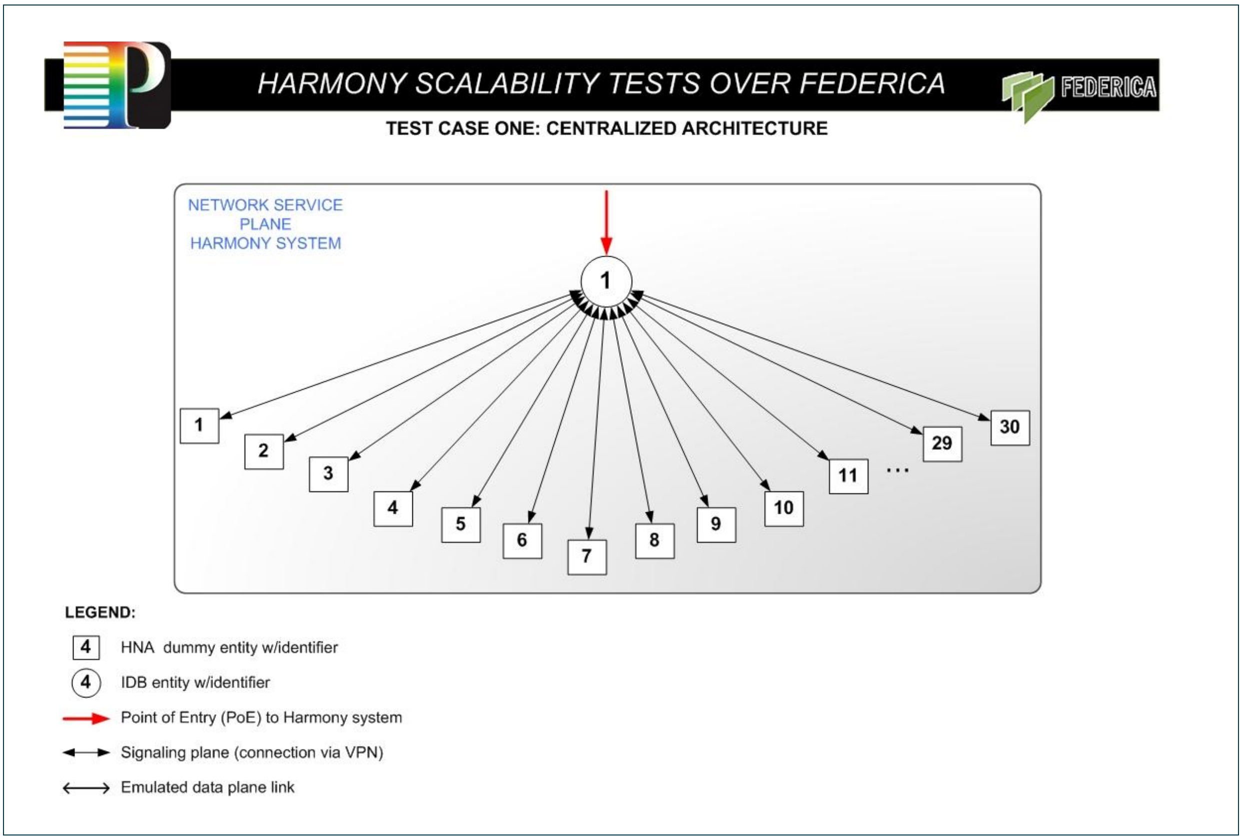

Figure 3.1: Test case one: centralized NSP model.

As there is only one IDB in the service plane, the system only has one point of entry (red arrow pointing circle 1); what means that all the requests will get into the system via this IDB and that all inter-domain network resources requested will be controlled by this main IDB.

Requirements

NSP Item	Constraints	Computing Requirements per VM	Networking Requirements per VM
1 IDB	1 VM	1 GB RAM – 10 GB HDD	1x NIC with public IP address 1x NIC with private IP address (LAN)
30 HNA	1 VM per 4 HNA	1 GB RAM – 10 GB HDD	1x NIC with private IP address (LAN)
TOTAL	9 VM		Interconnection between VMs is only needed for signalling purposes. No high performance/

			BW links needed.

Table 3.1: Requirements for test case one (centralized NSP model).

3.4 Hierarchical architecture

The second test case considers a hierarchical architecture with three levels of IDBs. Figure 3.2 depicts the situation for this test case. This NSP topology should be expanded, increasing the number of stacked IDBs.

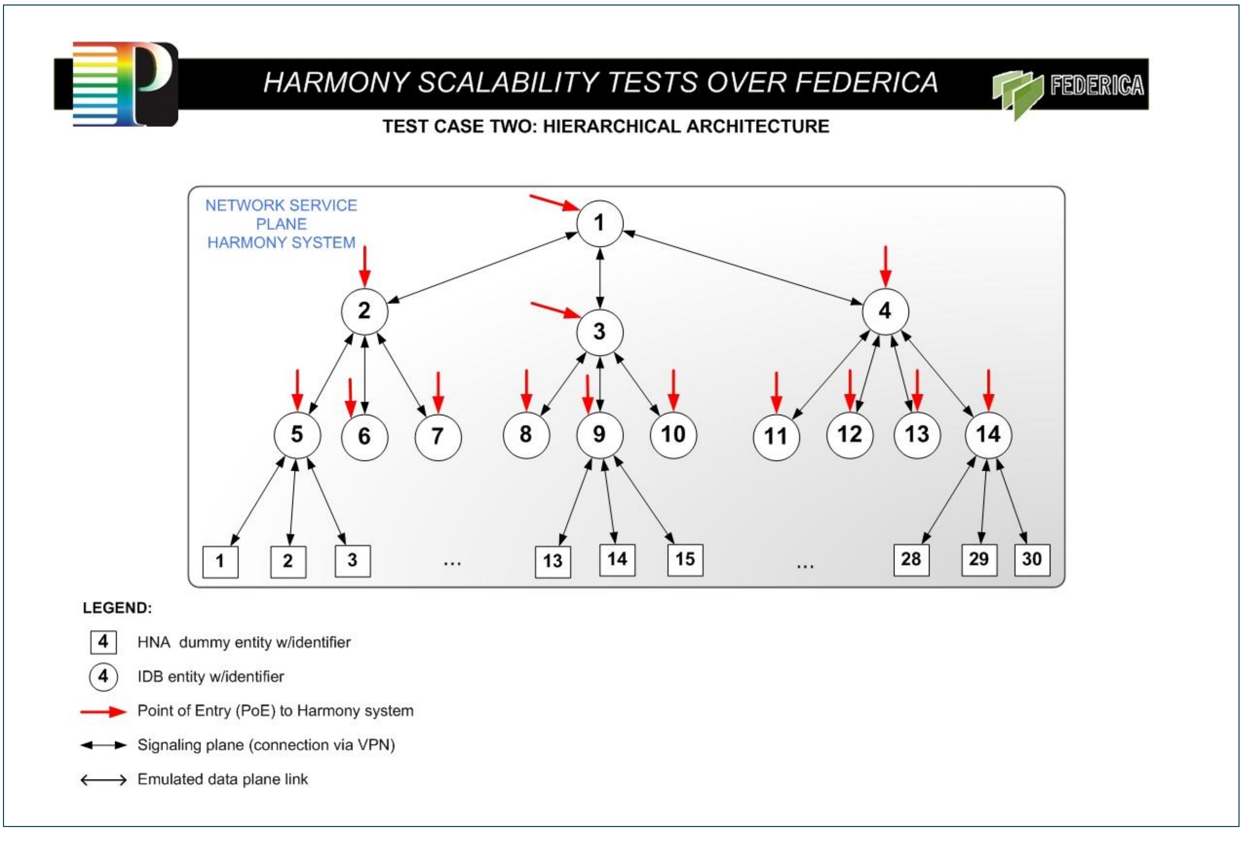

Figure 3.2: Test case two: hierarchical NSP architecture.

In this test case, there are several points of entry to the system, since there are 14 IDBs populating the service plane. The complexity in this test case appears lies on the distribution of request arrivals over the several points of entry. IDBs in the bottom level of the hierarchy have not knowledge about the overall topology, since there is no topology flooding between IDB levels. Consequently, the request can arrive to the correct IDB or not; that is, the resources requested can be under the control of the IDB or not. In the second case, the request should be forwarded to the upper level, where again the resources requested can be under control of the IDB or not. So the request forwarding depends directly from the number of levels in the topology. The aim in this test is to evaluate how performance is affected when increasing the number of IDBs stacked.

These are only some factors to take into account. In order to approximate the tests to a real behaviour when the system is deployed in a real environment, some formal definitions and considerations must be taken into account (i.e. the probability of reserving a resource in the correct IDB or the probability of not having to forward the request to the upper hierarchy level).

Requirements

NSP Item	Constraints	Computing Requirements per VM	Networking Requirements per VM
14 IDB	1 VM – 3 IDB	1 GB RAM – 10 GB HDD	1x VM with public IP address 1x NIC with private IP address per VM (LAN)
30 HNA	1 VM per 4 HNA	1 GB RAM – 10 GB HDD	1x NIC with private IP address (LAN)
TOTAL	13 VM		Interconnection between VMs is only needed for signalling purposes. No high performance /BW links needed.

Table 3.2: Requirements for test case two (hierarchical NSP model).

3.5 Distributed architecture

The third test case aims to emulate the distributed NSP model, which is initially planned to be composed of 20 IDBs sharing inter-domain topology information via flooding protocol implemented for this operating mode in Harmony. Each IDB controls one administrative domain emulated using dummy-HNA. Figure 3.3 depicts this situation.

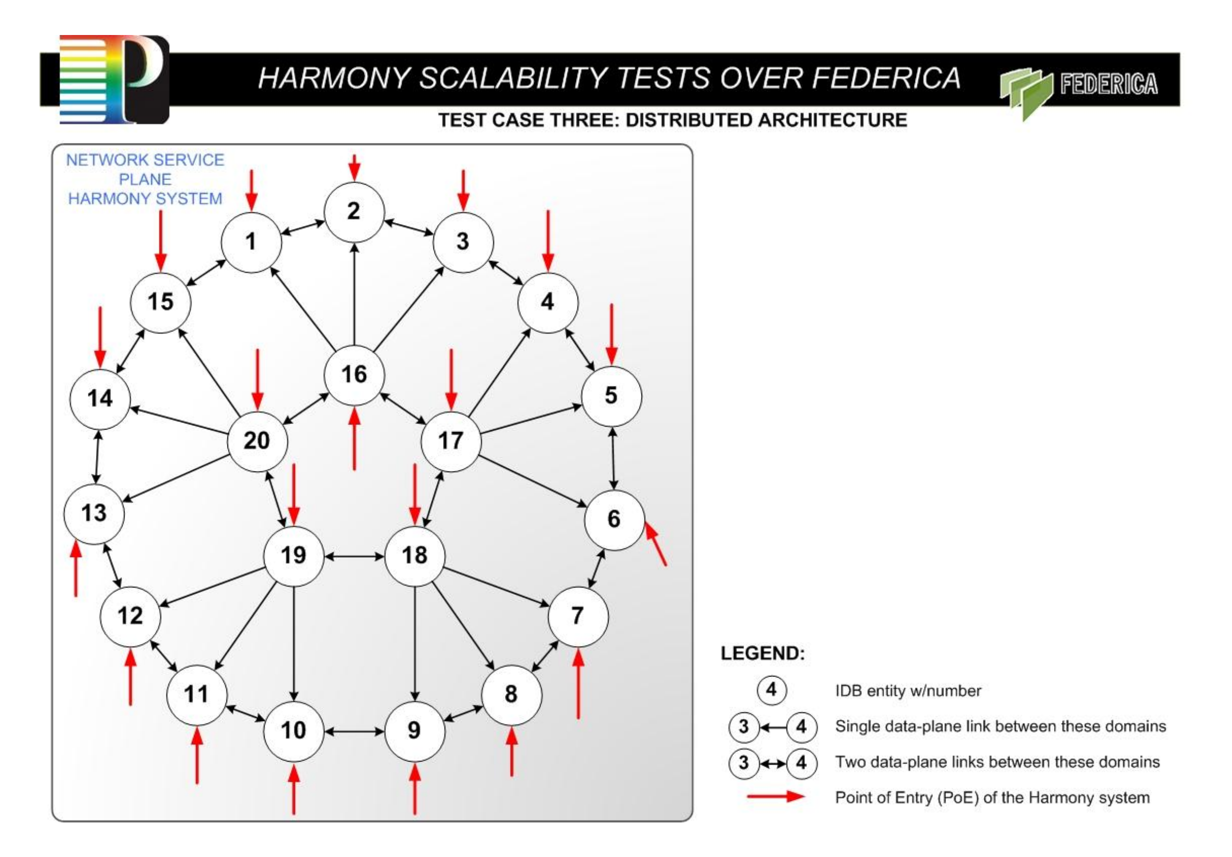

Figure 3.3: Test case three: distributed architecture.

In this test case, there are also several points of entry to the NSP. However, in this test case, the modelling of the tests is different, since each IDB has information about the whole topology. In this sense, when a request is received in one IDB and the resources requested are not under the control of such IDB, the broker only has to look in its database and forward the request to the peer in charge of them.

Requirements

NSP Item	Constraints	Computing Requirements per VM	Networking Requirements per VM
20 IDB	1 VM – 3 IDB	1 GB RAM – 10 GB HDD	1x VM with public IP address 1x NIC with private IP address per VM (LAN)
20 HNA	1 VM per 4 HNA	1 GB RAM – 10 GB HDD	1x NIC with private IP address (LAN)
TOTAL	13 VM		Interconnection between VMs is only

			needed for signalling purposes. No high performance/BW links needed.

Table 3.3: Requirements for test case three (distributed NSP model).

3.6 Summary and software requirements

The following table shows a summary of computing and networking resources needed in the three tests cases. Software requirements will be in charge of Phosphorus staff.

Virtual Machine Resources	
Number	15 VM
Storage capacity	Minimum: 150 GB in total (at least 10 GB per VM)
RAM (per VM)	Minimum: 1 GB per VM Desired: 2 GB per VM
Networking	Public IP addresses are needed for at least 1 VM Private LAN is needed for interconnecting VMs () No high performance networking needed.
OS to be installed by Phosphorus WP1	Debian [Deb] GNU/Linux release 5.0
Software to be used by Phosphorus WP1	Apache-tomcat.6.x or later [Atomcat] MySQL Server 5.0 or later [MySql] Java 6 or later [Java] Apache-ant-1.7.0* [Aant] Sun JAXB 2.0.5* or later (used within the HSI module) [Jaxb] Apache Muse 2.2.0* or later (used within the HSI module) [Amuse]

Table 3.4: Software and hardware requirements for each VM.

3.7 Federica-service-related requirements

Category	Parameter	Requirement
Research on network layers / Transparency	Layer 2	Research on layer 4+
	Layer 3	
	Layer 4+	
Time of usage	Short (hours)	Long (4 months estimated)
	Mid (days)	
	Long (months)	
Response / Provisioning time	Provisioned	Provisioned
	Scheduled	
	On-demand	
Level of control	Off-line reports	Interactive debug
	Interactive debug	
Scalability	Number and size of the network slices	1 slice composed of several VMs
Reliability / Availability	R/A of the network slices	High
Security / Authentication	Internal risks	Some VMs may be publicly reachable (SSH connection)
	External threats	

Table 3.5: Federica-service-related requirements

3.8 Federica network-related requirements

Category	Parameter	Requirement
Traffic matrix / Connection topology	Point-to-point	Multi point-to-multi point (all VMs must be able to communicate with each other)
	Point-to-multi point	
	Multi point-to-multi point	
Bandwidth	High ap. / Narrowband	Narrowband (signalling)
QoS level	Best effort	Best effort

	Quality of service	
Delay		--
Jitter		--
Loss rate		--
Fairness		--
Type of IP Network	Close network	Close network - LAN
	Open Network	(public access to at least one VM is needed)
Network management	Fault	Not needed.
	Performance	Topology is fully meshed
	Topology	(LAN)
Traffic management	Bandwidth	
	CAC	--
	Policing	
Accounting		--
Cost		--

Table 3.6: Federica-network-related requirements

4 References

[Aant] http://ant.apache.org

[Amuse] http://ws.apache.org/muse

[Atomcat] http://tomcat.apache.org

[Fede-01] http://fp7-federica.eu

[GAAA-tk] http://staff.science.uva.nl/~demch/projects/aaauthreach/index.html

[Java] http://java.sun.com

[Jaxb] https://jaxb.dev.java.net/

[MySql] http://www.mysql.com

[Phos-D1.8] Phosphorus Deliverable 1.8: "Network Service Plane enhancements".

[PHOS] Figuerola, S., Ciulli, N., de Leenheer, M., Demchemko, Y., Ziegler, W., Binczewski, A., et al: PHOSPHORUS: single-step on-demand services across multi-domain networks for e-science. In: Network Architectures, Management, and Applications.

5 Acronyms

CAC	Call Admission Control
HAL	Harmony Adaptation Layer
HDD	High Density Disk
HNA	Harmony NRPS Adapter
HSI	Harmony Service Interface
IDB	Inter-domain broker
NRPS	Network Resource Provisioning System
NSP	Network Service Plane
OSPF	Open Shortest Path First
PoE	Point of Entry
VM	Virtual Machine
WP1	Work Package 1 (refers to the PHOSPHORUS project)

Appendix.D Phosphorus-Federica Project Collaboration Plan – UPB-D7

D.1 Phosphorus-KISTI Memorandum of Understanding (MoU)

Text Transcription

Cooperation Agreement

between

The PHOSPHORUS project consortium and
the Korea Institute of Science and Technology Information (KISTI)

Purpose

The purpose of the present CA is to:

- Explore the possibility to share the experience and technical knowledge between PHOSPHORUS and the Korea Institute of Science and Technology (from now on, KISTI) during the series of workshops foreseen within the scope of PHOSPHORUS, organized by PHOSPHORUS project or KISTI for the research community.
- Define the required effort for KISTI to join the PHOSPHORUS test-bed and participate in the tests of new technologies and services.
- Define the required effort for KISTI to deploy a Network Resource Provisioning System and the Harmony System created in PHOSPHORUS project for allowing service plane interoperability.
- Formalize the dissemination and promotion of the PHOSPHORUS results in research community.

Background

PHOSPHORUS
http://www.ist-phosphorus.eu/

The PHOSPHORUS project focuses on delivering advanced network services to Grid users and applications interconnected by heterogeneous network infrastructures. The project is addressing some of the key technical challenges to enable on-demand end-to-end network services across multiple domains. The PHOSPHORUS network concept and test-bed makes applications aware of their complete Grid resources (computational and networking) environment and capabilities, and enables dynamic, adaptive and optimized use of heterogeneous network infrastructures connecting various high-end resources.

The main innovation introduced by PHOSPHORUS is a network Service and Control Plane concept where the network (light-path) and Grid (computational, storage) resources are provisioned in a single step: network and Grid-specific resources are controlled and set-up at the same time and with the same priority, with a set of seamlessly integrated procedures. From a user's perspective, this results in a real, node-to-node deployment of on-demand Grid services.

PHOSPHORUS will enhance and demonstrate solutions that facilitate communication among applications middleware, existing Network Resource Provisioning Systems, and the proposed Grid-GMPLS Control Plane. The main technical objectives are: 1) enhancements of the GMPLS Control Plane (G^2MPLS) to provide optical network resources as first-class Grid resource, 2) implementation of interfaces between different NRPS to allow multi-domain interoperability with PHOSPHORUS's resource reservation system (Harmony System), 3) middleware extensions and APIs to expose network and Grid resources and make reservations of those resources.

To disseminate ideas and developments the PHOSPHORUS consortium will strongly interact with other relevant programmes, research activities and initiatives at the European and international level. Various network-oriented R&D projects are encouraged to share results and exchange ideas with PHOSPHORUS project.

KOREA INSTITUTE OF SCIENCE AND TECHNOLOGY INFORMATION
http://www.kisti.re.kr/english/

KISTI (Korea Institute of Science and Technology Information) is playing a crucial role in Korea as a national core institute for supporting researchers in various R&D areas. To do well-support, KISTI is the largest provider of supercomputing resources and high performance research networks, KREONET, in Korea. Over the last decades, KISTI has grown to provide high-end technologies in supercomputing and networking along with active support and services, to the various groups of research communities of academia, research institutes, and governmental and scientific organizations.

KISTI will implement and provided the Cyber R&D infrastructure based on the high performance computing resources, high performance network resources, and intelligent information services.

Timeframe

The collaboration is foreseen to be performed until the end of the PHOSPHORUS project.

Main Participants

The work will be carried out by PHOSPHORUS partners in co-operation with the KISTI organization and associated institutions.

Financial Conditions

No transfer of funds between the PHOSPHORUS project and KISTI is anticipated.

However, partners may decide to transfer some of their existing resources into one or more of the co-operation activities mentioned above.

Signed:

Il-Sun Hwang (on behalf of the Korea Institute of Science and Technology Information)	Artur Binczewski (on behalf of the PHOSPHORUS Consortium)

D.2 Scanned Document

Page 1 out of 3

Cooperation Agreement

between

The PHOSPHORUS project consortium and
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Purpose

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- Explore the possibility to share the experience and technical knowledge between PHOSPHORUS and the Korea Institute of Science and Technology (from now on, KISTI) during the series of workshops foreseen within the scope of PHOSPHORUS, organized by PHOSPHORUS project or KISTI for the research community.
- Define the required effort for KISTI to join the PHOSPHORUS testbed and participate in the tests of new technologies and services.
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Background

PHOSPHORUS
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1

adaptive and optimized use of heterogeneous network infrastructures connecting various high-end resources.

The main innovation introduced by PHOSPHORUS is a network Service and Control Plane concept where the network (lightpath) and Grid (computational, storage) resources are provisioned in a single step: network and Grid-specific resources are controlled and set-up at the same time and with the same priority, with a set of seamlessly integrated procedures. From a user's perspective, this results in a real, node-to-node deployment of on-demand Grid services.

PHOSPHORUS will enhance and demonstrate solutions that facilitate communication among applications middleware, existing Network Resource Provisioning Systems, and the proposed Grid-GMPLS Control Plane. The main technical objectives are: 1) enhancements of the GMPLS Control Plane (G^2MPLS) to provide optical network resources as first-class Grid resource, 2) implementation of interfaces between different NRPS to allow multi-domain interoperability with PHOSPHORUS's resource reservation system (Harmony System), 3) middleware extensions and APIs to expose network and Grid resources and make reservations of those resources.

To disseminate ideas and developments the PHOSPHORUS consortium will strongly interact with other relevant programmes, research activities and initiatives at the European and international level. Various network-oriented R&D projects are encouraged to share results and exchange ideas with PHOSPHORUS project.

KOREA INSTITUTE OF SCIENCE AND TECHNOLOGY INFORMATION
http://www.kisti.re.kr/english/

KISTI (Korea Institute of Science and Technology Information) is playing a crucial role in Korea as a national core institute for supporting researchers in various R&D areas. To do well-support, KISTI is the largest provider of supercomputing resources and high performance research networks, KREONET, in Korea. Over the last decades, KISTI has grown to provide high-end technologies in supercomputing and networking along with active support and services, to the various groups of research communities of academia, research institutes, and governmental and scientific organizations.

KISTI will implement and provided the Cyber R&D infrastructure based on the high performance computing resources, high performance network resources, and intelligent information services.

2

Timeframe

The collaboration is foreseen to be performed until the end of the PHOSPHORUS project.

Main Participants

The work will be carried out by PHOSPHORUS partners in co-operation with the KISTI organization and associated institutions.

Financial Conditions

No transfer of funds between the PHOSPHORUS project and KISTI is anticipated.

However, partners may decide to transfer some of their existing resources into one or more of the co-operation activities mentioned above.

Signed:

Kierownik Działu
Sieci Miejskiej
mgr inż. A. Binczewski

Il-Sun Hwang
(on behalf of the Korea Institute of Science and Technology Information)

Artur Binczewski
(on behalf of the PHOSPHORUS Consortium)

Appendix E Phosphorus-KISTI Project Plan

E.1 Foreword

The project plan between Phosphorus and KISTI is divided into two main documents:

- The Collaboration Plan, and
- The Effort Allocation Plan.

In the first one, all details on the collaboration efforts are given, including task details, estimated time frames, responsible people and outcomes to be achieved, whereas in the second one, a detailed estimation on the effort to be allocated by each of the parts in the agreement is given.

E.2 Text Transcription of the Collaboration Plan

1 The Harmony system

The Harmony system is a multi-domain, multi-vendor network resource brokering system. Harmony, developed under the European Union co-funded project PHOSPHORUS [PHOS], defines an architecture for a service layer between the Grid middleware and applications and the Network Resource Provisioning Systems (NRPS).

Harmony was born with two main assumptions: the system had to be multi-domain and had to be capable of creating end-to-end optical and layer 2 paths in a seamless environment for the scientific personnel at the end points. These conditions were set because PHOSPHORUS aims to make existing provisioning systems (NRPS) interoperable and fill the gap between these hardware-coupled software pieces and the Grid application middleware. The NRPSs compatible with Harmony at the current implementation stage are:

- ARGIA/UCLP: stands for the User Controlled Light-Paths initiative, developed by CRC, Inocybe Technologies (both from Canada) and i2CAT Foundation (Catalonia, Spain).

- ARGON: stands for the Allocation and Reservation in Grid-enabled Optic Networks, an initiative deployed in the VIOLA test-bed in Germany.

- DRAC: stands for the Dynamic Resource Allocation Controller initiative, implemented and commercialized by Nortel Networks (Canada) and deployed in SURFnet (The Netherelands' NREN).

Moreover, Harmony has developed a *Thin NRPS* entity which is able to communicate with the Optical User to Network Interface (OUNI) of a Generalized-MPLS Control Plane (GMPLS-CP) –although it is not considered an NRPS itself– and perform signaling operations and path management

1.1 Basics about the architecture of Harmony

Harmony is a web-service based tool which is compliant with the Web Service Resource Framework 1.2. Harmony creates a Service Layer which exposes network services of the different NRPSs to the applications or the Grid middleware.

As seen on figure 1.1, Harmony is composed of a Network Service Plane (NSP) and a Harmony Adaptation Layer (HAL). These layers are populated with Inter-Domain Brokers (IDB) and Harmony NRPS Adapters (HNA), respectively. Once an NRPS is deployed (for example, Argia), Harmony sets up an HNA on top of it which is able to communicate with the NRPS using its native interface (in this example, Argia's WS interface). Harmony defines three different HNA, one for Argia/UCLP, another for Argon and another for DRAC. Currently, all these three NRPSs have WS interfaces, but are not compatible with each other.

As seen on figure 1.1, the following interface operations must be distinguished in Harmony (letters in the following list correspond to letters in the arrows of the image):

A. Interface between an IDB entity within the NSP and a user administration application or a Grid middleware which perform as clients (a.k.a. Northbound Interface). The actors are the clients and the server is the IDB.

   – Arrow **a1** symbolizes resource reservation/scheduling requests from either the Grid application middleware or Harmony's administration web GUI.

- Arrow **a2** symbolizes the topology operations between either Harmony's topology administration GUI or other IDBs topology flooding.

Please note that c1 and c2 join a1 and a2 respectively. This will be explained in C of this list.

B. Interface between an IDB entity within the NSP and another IDB entity or an HNA entity (a.k.a. East/West Interface) where the actor is an IDB entity and the server is another IDB or an HNA. Arrows mean:

   - Arrow **b1** symbolizes the resource reservation requests from an IDB to an HNA.

   - Arrow **b2** symbolizes the topology requests from an IDB to another IDB for topology flooding.

   - Arrow **b3** symbolizes the resource reservation requests from an IDB to another IDB for configuring requesting resource reservation to other IDBs within the NSP.

C. This is also the interface between and IDB and an HNA (East/West Interface, see B). However, in this case the actor is an HNA and the server is its parent IDB. That is, the HNA will send requests only to the IDB where it is attached/registered. In this case, the HNA acts as a client performing the operations depicted in arrows c1 and c2:

   - Arrow **c1** symbolizes the topology operations between an HNA and its parent IDB. Main operation here is the *AddOrEditDomain()* call, where the HNA registers itself on the IDB automatically or refreshes its information registered on its parent IDB.

   - Arrow **c2** symbolizes the ability of the HNA to forward resource reservation requests to its parent IDB. This operation is barely used, as it is not part of any use case in the Phosphorus project.

D. Interface between an HNA and the NRPS underlying (a.k.a. Southbound Interface). Only one NRPS per HNA can be set.

E. Interface between an NRPS and its underlying transport network. This interface is out of Phosphorus's scope. In case that the underlying transport network is a GMPLS control plane, this interface is also named Southbound Interface (as the interface described in D) and is considered in scope of the Phosphorus project.

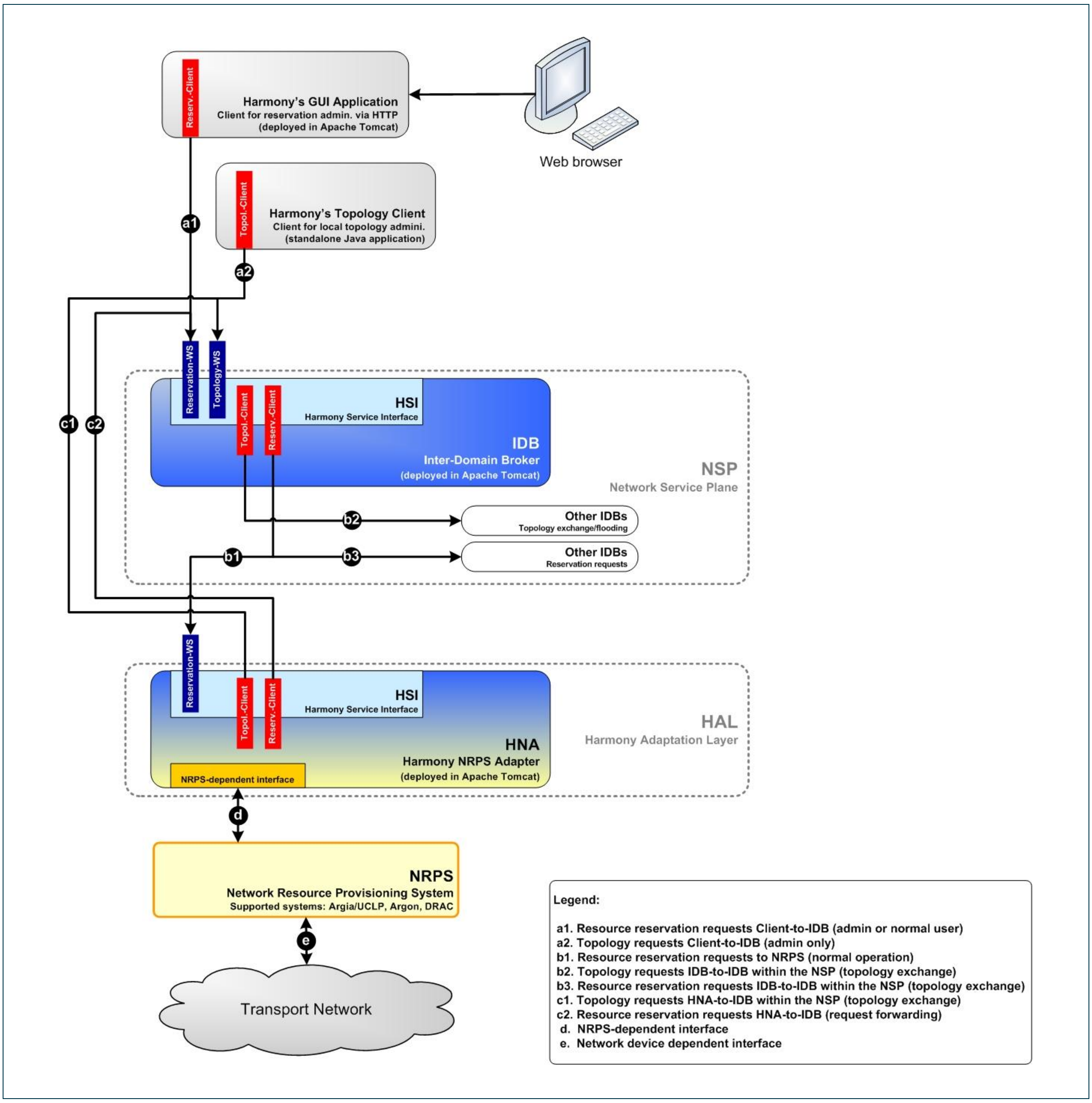

Figure 1.1: Harmony architecture and main operations in the different services of the interfaces across the Network Service Layer and the Adaptation Layer defined in Harmony.

2 Goals, Schedule and Milestones

2.2 Goals

1. Interconnect the data plane of KISTI's dedicated network to the data plane of the test-bed used by Harmony in the Phosphorus project.

2. Deploy Argia as a Network Resource Provisioning System at KISTI's dedicated network.

3. Set up a Harmony NRPS Adapter for Argia at KISTI and let it join the Network Service Plane of Harmony in the Phosphorus project.

4. Perform joint demonstrations of Harmony and demanding media content streaming between Korea and any endpoint in Harmony's test-bed. For example, Korea-Spain, Korea-Canada or Korea-Germany can be performed, among others. In this case, trusted third parties will be involved in the demonstration, providing its media contents.

2.3 Schedule and Milestones

This section contains both a table summarising the activities to develop and milestones to achieve and a Gantt diagram of this scheduling.

Activity or Milestone No.	Description	Start Date	Due Date	Responsible(s)
A0[2]	Define the MM (person/month) resources needed to achieve goals 1, 2, 3 and 4 detailed above.	27-10-2008	29-10-2008	I2CAT/KISTI
A1.1	Send network map of KISTI where the network	27-10-2008	29-10-2008	KISTI

[2] Detailed information about effort allocation for extra activities can be found on Appendix A.

	devices to be controlled by Argia are depicted.			
A1.2	Set up international path between KISTI and Harmony test-bed	03-02-2009	15-02-2009	KISTI/I2CAT
A1.3	Test international path between KISTI and Harmony test-bed	15-02-2009	24-02-2009	KISTI/I2CAT
M1	**International path up & running.**		**25-02-2009**	**All**
A2.1	Set up hardware needed for Argia and Harmony NRPS Adapter	29-10-2008	04-11-2008	KISTI
A2.2	Set up Argia at KISTI	04-11-2008	01-02-2009	KISTI/I2CAT
A2.3	Set up HNA at KISTI and VPN client to join Harmony's signaling VPN.	15-01-2009	05-02-2009	KISTI/I2CAT
M2.1	**Argia @ KISTI up & running.**		**01-2-2009**	**All**
M2.2	**HNA @ KISTI up & running.**		**05-2-2008**	**All**
A3.1	Test Argia locally at KISTI domain	01-01-2009	20-02-2009	KISTI
A3.2	Test HNA locally at KISTI domain	10-01-2009	25-02-2009	KISTI
M3	**KISTI domain joins the Harmony system in Phosphorus and data plane is interconnected.**		**25-02-2009**	**All**

Table 2.1: Main schedule of activities and milestones for cooperation.

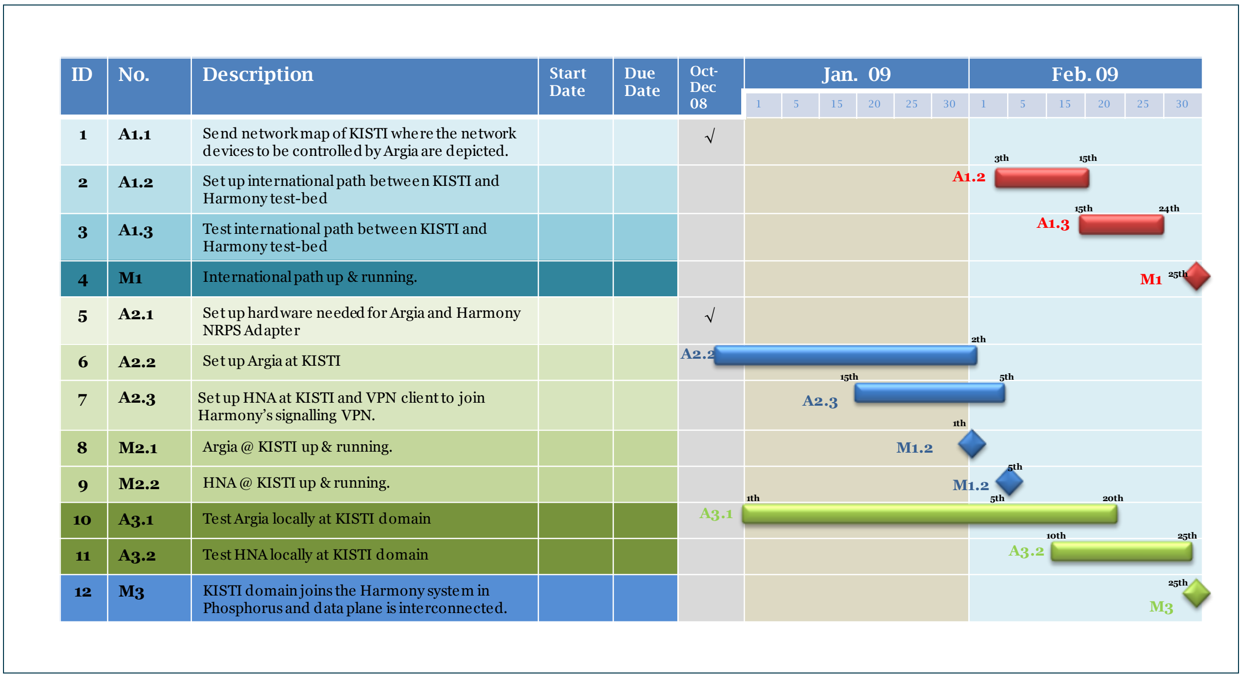

Figure 2.1: Gantt diagram of the activities and milestones.

3 Test-bed setup

There are several options to interconnect KISTI and the Harmony test-bed data planes. However, only two options seem to be the most feasible and are described in this section.

3.2 Scenario

KISTI

KISTI uses KREONet2 network in Korea [KRN2N]. Its core nodes are located at Daejeon (Korea).

There is a 10 Gbps link from KREONet2 to GLORIAD (Global Ring Network for Advanced Applications Development) [Gloriad] that crosses CANARIE [CANARIE] network from Seattle (USA) to Chicago (USA). This link already has a 1 Gbps path provisioned which transits CANARIE network but its use is restricted to IP traffic only.

Phosphorus partners involved in Harmony

Phosphorus partners involved in Harmony activities have several connections to both the Global Lambda Infrastructure Facility [Glif] and the Géant2 network [GN2]. Most of the Glif connections are concentrated at Netherlight [NLightN].

The Communication Research Centre (CRC) in Canada is directly connected to the CANARIE network.

I2CAT Foundation (Barcelona, Catalonia, Spain), University of Bonn (Bonn, Germany), SURFnet (Amsterdam, The Netherlands) and the University of Amsterdam (Amsterdam, The Netherlands) have connections to Glif and Géant2 networks via Netherlight (most used) and Dark Fiber (not commonly used).

I2CAT Foundation has a 10 Gbps link from Barcelona (Catalonia, Spain) to Netherlight (Amsterdam, The Netherlands). Currently, Phosphorus project has a dedicated path on this link with a bandwidth of 1 Gbps which hosts three VLANs: i2CAT-SURFnet, i2CAT-CRC and i2CAT-University of Bonn.

3.3 Options for interconnection

As commented before, there are two options for interconnecting KISTI's test-bed and Harmony test-bed:

1. **Interconnect KISTI with CRC at Canada via Starlight (Chicago) and CANARIE.**

CRC could cross connect itself in Chicago into the existing light-path from StarLight to CRC. This light-path is currently provisioned as an STS-3 (155 Mbps) circuit for the Phosphorus test-bed. Thus, a limitation on the available bandwidth would exist.

Important update (24-10-2008): this connection is not feasible because CRC is currently using all its ports to the CANARIE for the Phosphorus project and the HDPMnet initiative for SuperComputing 2008 event.

2. Interconnect KISTI with I2CAT at Catalonia (Spain) via Starlight and Netherlight.

I2CAT Foundation could request a new link from Netherlight to StarLight crossing SURFnet. This new link can be provisioned by Netherlight through the existing 10 Gbps interconnection between i2CAT and SURFnet.

3.4 International path between KISTI and i2CAT

The current scenario and the options considered lead to the proposal of the provisioning of the following link:

i2CAT (Barcelona.CAT) <–> **SURFnet** (Amsterdam.NL) <–> **Netherlight** (Amsterdam.NL) <–>

<–> **Starlight** (Chicago.USA) <->**PacificWave** (Seattle .USA) <-> **KRlight** (Seattle .USA) <->**KRlight** (Daejeon.KR)<–> **KREOnet2** (Daejeon.KR) <–> **KISTI** (Daejeon.KR)

4 Hardware and Software Requirements

4.1 Hardware

- Argia is normally installed as a standalone O.S. in a host. Phosphorus partners have successfully installed it as a Virtual Machine.

- Argia requires a resolvable network name. E.g.: public IP address registered as a name in the DNS service.

- HNA can be installed in any existing host or virtual machine.

4.2 Software

Argia is provided as a standalone Linux distribution with all the needed packages included. The initial configuration of the network in Argia is done with Argia's Remote Management Centre (RMC).

The HNA is provided as a WAR file to be deployed in Apache Tomcat.

However, some requirements must be met:

- Hosts must have date and time synchronised with NTP.

- HNA requires a VPN client using TINC software [tinc-vpn] to communicate with Harmony's NSP and port 655 UDP open.

- HNA requires a Java 6 virtual machine.

- HNA requires Apache Tomcat 6 to be deployed and port 8080 TCP open for accepting HTTP requests.

5 Documentation

Work Package 1 (where Harmony is developed) within Phosphorus has already produced the necessary documentation for other partners or third parties to deploy Argia and its associated HNA in their test-beds.

The existing documentation which can be provided by WP1 is briefly described below:

- **Argia 1.4 Installation and Setup for the Harmony Environment.**

This document is a guide for installing, setting up and configuring Argia in your network.

- **Harmony's HNA Deployment for Argia.**

This document describes how to deploy the WAR file containing Harmony's NRPS Adapter (HNA) for Argia. Moreover, the needed configuration steps are explained.

- **TINC-VPN Set-up and Configuration for Signalling in Harmony**

This document describes how to set up and configure the VPN network for signalling used in Harmony by means of the open source software named TINC. All configuration stages are explained.

6 References

[Argia]	http://www.inocybe.ca/19
[CANARIE]	http://www.canarie.ca/about/index.html
[EU-IST-FP6]	http://ec.europa.eu/research/fp6/index_en.cfm
[Glif]	http://www.glif.is
[Gloriad]	http://www.gloriad.org/gloriad/index.html
[GN2]	http://www.geant2.net
[KRN2N]	http://noc.kreonet2.net
[NLightN]	http://noc.netherlight.net
[PHOS]	http://www.ist-phosphorus.eu
[tinc-vpn]	http://www.tinc-vpn.org
[tomcat]	http://tomcat.apache.org

7 Acronyms

ARGON	Allocation and Reservation in Grid-enabled Optic Networks
CA	Cooperation Agreement
DRAC	Dynamic Resource Allocation Controller
EU	European Union
FP6	6th Framework Programme
HNA	Harmony NRPS Adapter
IDB	Inter-Domain Broker
IST	Information Society Technologies
NRPS	Network Resource Provisioning System
WSRF	Web Service Resource Framework

8 Extra activities

The Cooperation Agreement (from now on, CA) signed between KISTI and the Phosphorus project consortium is the framework for all efforts to be allocated by KISTI and I2CAT (or other Phosphorus partners). Nevertheless, extra activities may appear for strengthening and improving the outcomes for research, innovation and cooperation between the above cited institutions. These activities may require further effort allocation, apart from the activities and milestones defined in the previous pages.

8.1 Activities defined within this document

On the one hand, after following the work plan described in this document, and basing on the CA as framework for cooperation, KISTI will have its own Argia Network Resource Provisioning System. I2CAT will provide it to KISTI and the needed documentation, software and support to normally deploy it. These activities will follow the same guidelines which apply to the same tasks defined within the Phosphorus project. Thus, KISTI will have total control over its Argia NRPS as either an end-user or an administrator user. Argia will be provided as an installable Operating System with all needed packages included.

On the other hand, again in line with the current procedures inside Phosphorus to deploy Argia and Harmony over new domains, KISTI will have its own Harmony NRPS Adapter deployed locally, for controlling Argia NRPS deployed at their premises. I2CAT will also provide the needed support, under Phosphorus and CA guidelines.

8.2 Extra activities out of the CA

It must be noted that the normal procedures for deploying Argia NRPS and its related Harmony adapter do not include extra activities such described below. These activities are out of the scope of the current CA between Phosphorus consortium and KISTI. Extra activities may require additional efforts to be allocated by any of the co-operators and which implies the transference of funds between them. Currently, resources within the Phosphorus project to perform these extra activities are not available. Thus, extra activities to be carried out and its associated fund transference will have to be agreed by co-operators (KISTI and I2CAT, in the current stage).

Some extra activities identified are:

1. In-site/remote training about part or all of Harmony / Argia internals.

2. Delivery of part or all of the Harmony code.

3. In-site/remote training about part or all of Harmony / Argia code.

4. Deployment of other applications not described in this document, such as the Harmony's Inter-Domain Broker or Harmony's administration tools (such as Harmony's web administration GUI or Harmony's topology client).

5. In-site/remote training about other applications not described in this document, such as the Harmony's Inter-Domain Broker or Harmony's administration tools (such as Harmony's web administration GUI or Harmony's topology client).

6. All other activities not scoped in this document.

E.3 Text Transcription of the Effort Allocation Plan

1 Executive Summary and Considerations

This document describes the tasks to be completed in order to deploy Argia and Harmony over the KISTI infrastructure. The achievement of these tasks will represent the successful integration of KISTI local test-bed into the whole Phosphorus-WP1 international test-bed. The distribution of the document consists of a set of tasks regarding Argia deployment and another set of tasks regarding Harmony NRPS Adapter (HNA). Finally, another set of tasks for testing Argia and HNA together and check that the KISTI local test-bed is correctly integrated within the whole Phosphorus-WP1 test-bed.

A special notice must be done on common working time slots between Canada (Ottawa), Europe (Barcelona) and Korea (Daejeon). Time differences between these three locations are as follow:

Ottawa (CA)	**Barcelona (ES)**	**Daejeon (KR)**
GMT–5 (EST)	GMT+1	GMT+9 (KST)
← 6 hours →	← 8 hours →	

Therefore, the suitable working-hour time slots for i2CAT-KISTI cooperation could be:

Barcelona (ES) GMT+1	**Daejeon (KR)** GMT+9 (KST)
8:00 a.m. to 12:00 a.m.	4:00 p.m. to 8:00 p.m.

And regarding a triple party collaboration, CRC-i2CAT-KISTI, there is no common working-hour time slot. The only option is out of working-hours in two of the three locations:

Ottawa (CA) GMT–5 (EST)	**Barcelona (ES)** GMT+1	**Daejeon (KR)** GMT+9 (KST)
7:00 a.m. to 8:00 a.m.	1:00 p.m. to 2:00 p.m.	9:00 p.m. to 10:00 p.m.

However, this triple-party situation can be avoided by letting i2CAT work separately with CRC and KISTI. In case of unavoidable need, CRC, i2CAT and KISTI could choose to use this common time slot.

2 VMware Installation

- **Task 0 – VMware server installation**

- Task 0.0 – Download and install **VMware server** for your operating system (30min).
  - **ATTENTION**: Current activities in Phosphorus use and recommend VMware Server version 1.6.
- Task 0.1 – Create a Virtual Machine (from now on: VM) for later deployment of HNA software (1h) and install GNU Linux operating system (Debian 4 Linux recommended).
  - Requirements: RAM > 512 MB, hard disk space for Linux: > 4 GB.
  - **ATTENTION**: Argia is distributed as a VMware disk image. It is **not** necessary to create a VM for it at this step (→Task 1).

Estimated effort: 1h 30min

Involved team(s): KISTI

3 Argia deployment

- **Task 1 – Argia environment installation**

  - Task 1.1 – Argia VM installation (1h). Please refer to the Argia Installation Guide to install Argia's VM.
  - Task 1.3 – Resource Management Centre (RMC) installation (30 min)
  - Task 1.4 – CHRONOS installation (1h)

  Estimated effort: 2h 30min

  Involved team(s): KISTI, i2CAT

- **Task 2 – RMC User account setup**

  - Task 2.1 - Create users (2h)

  Estimated effort: 2h

  Involved team(s): KISTI, i2CAT

- **Task 3 – Create the physical Network and add the equipment**

- Task 3.1 – Create physical network (30 min)
- Task 3.2 – Add network elements (1h 30min)
- Task 3.3 – Create topology (2h)

Estimated effort: 4h

Involved team(s): KISTI, i2CAT

- **Task 4 – Create partitions of the physical network and assign them to the reservation service**
  - Task 4.1 – Create partitions of the physical network (4h)
  - Task 4.2 – Assign resources to the reservation service (30min)

Estimated effort: 4h 30min

Involved team(s): KISTI, i2CAT

- **Task 5 – Test your set-up creating reservations with CHRONOS**
  - Task 5.1 - Test the set-up using CHRONOS (1h)

Estimated effort: 1h

Involved team(s): KISTI, i2CAT

4 HNA deployment

- **Task 6 – Install HNA environment**
  - Task 6.1 – Install tinc (2h)
  - Task 6.2 – Install Apache Tomcat 6.0 or later versions (30min)

Estimated effort: 2h 30min

Involved team(s): KISTI, i2CAT

- **Task 7 – Deploy HNA**

  - Task 7.1 - Create the .war file of the HNA for Argia (1h)
  - Task 7.2 - Deploy the HNA in Tomcat (30min)
  - Task 7.3 - Check communication between HNA and Argia (2h)
  - Task 7.4 - Check communication between HNA and IDB (2h)

  Estimated effort: 5h 30min

  Involved team(s): KISTI, i2CAT

5 Validation

- **Task 8 – Create reservation involving KISTI resources**

  - Task 8.1 – Create reservations involving KISTI resources (1h)

  Estimated effort: 1h

  Involved team(s): KISTI, i2CAT

- **Task 9 – Check link deployment (i2CAT–CRC–KISTI)**

  - Task 9.1 – Check link status in all segments (2h)
  - Task 9.2 – Check connectivity end-to-end (4h)

  Estimated effort: 6h

  Involved team(s): KISTI, i2CAT, CRC

6 Effort Summary for software deployment

- **Total estimated effort: 30h 30min (aprox. 0.2 person/month)**

This effort must be allocated by KISTI and by i2CAT. Therefore, both partners must allocate 0.2 p/m for a successful work. CRC would only cooperate occasionally and no effort allocation has been assigned to them.

- **Involved people:**
  - KISTI: Minki Noh
  - i2CAT: Joan Antoni García-Espín, Jordi Ferrer, Sergi Figuerola
  - CRC: Michel Savoie, Hanxi Zhang, Bobby Ho

- **Detailed effort estimation per task:**
  - T0: 1h 30min (5%)
  - T1: 2h 30min (8%)
  - T2: 2h (7%)
  - T3: 4h (13%)
  - T4: 4h 30min (15%)
  - T5: 1h (3%)
  - T6: 2h 30min (8%)
  - T7: 5h 30min (18%)
  - T8: 1h (3%)
  - T9: 6h (20%)