WP1: The Harmony System

Phosphorus Work Package 1 focuses on **delivering advanced network services to Grid users and applications interconnected by heterogeneous network infrastructures**. This WP addresses some of the key technical challenges to enable on-demand, end-to-end network service provisioning across multiple domains. Moreover, WP1 overcomes the service constraints dictated by the Grid, such as network resource reservation in advance, and enables flexible and easy integration with Grid meta-scheduling engines.

Harmony is the network resource brokering system developed under Phosphorus WP1. **Harmony** provides co-allocation of heterogeneous network resources in multi-domain and multi-technology environments with advance reservation capabilities for the Grid. **Harmony's Network Service Plane** architecture has evolved from a first proof-of-concept, **centralized** model to a **distributed** one, passing through a mid-term, multi-level **hierarchical** model. Due to the modularity **Harmony** has been provided and its branding flexibility, it even allows complex service plane configurations such as **daisy chain** (control plane-like) or **hybrid** deployments (mixing any model).

Objectives

The main objective of the **Harmony** system is provide to the Users or Grids application with the ability to **create point-to-point** or **point-to-multipoint connections** using resources from several domains in a transparent way. The solution proposed in this WP speeds up the creation of complex connections with advance reservation features involving several Network Resource Provisioning Systems (NRPS) or GMPLS control plane by making them **interoperable**. Moreover, Harmony introduces the **advance reservation** concept, which enables users or Grid applications to program **fixed**, **deferrable** or **malleable** reservations with one or more connections each. **Harmony** also drives **AAI** management as another hot topic for the prototype: once the user is authenticated and authorised, he or she can use any of the services offered by **Harmony NSP**. Moreover, his credentials are automatically translated to the local credentials of the systems involved in the service and authorized session control is implemented by pilot tokens.

Another objective of **Harmony**, but not less important, is to achieve **interoperation** with other international projects, such as AutoBAHN from GÉANT2 JRA3, IDC protocol from Internet2, EnLIGHTened or G-Lambda. International cooperation has been treated as first class task inside WP1, allowing also to contributed to standardization initiatives as the Network Service Interface working group at the Open Grid Forum.

Developments

Phosphorus WP1 has implemented **Harmony** service architecture with the set of interfaces for interoperability in a seamless environment between different NRPS and the standard GMPLS towards the Grid Middleware, and novel G^{2}MPLS control plane of the Phosphorus project. Moreover, **Harmony** test-bed has been extended to the Korea Institute of Science and Technology Information (KISTI), the Poznan Supercomputing and Networking Centre and the University of Essex, apart of the signature of a memorandum of understating with EU FP7 FEDERICA project.

Key achievements of Harmony: NSP implementation with flexible operating modes, Inter-Domain Brokers and path computing for optical network resources, advance reservations for Grid, Grid middleware integration, topology sharing, easy client integration in third party applications, public API for both reservation and topology services, AAI integration, WSDL interface description (WSRF 1.2 compliant), automatic domain registration/update process, automatic and synchronized activation of reservation, and a long etcetera.

Demonstrations and Use Cases

PHOSPHORUS Project Test-bed
HARMONY Domains and Data Plane
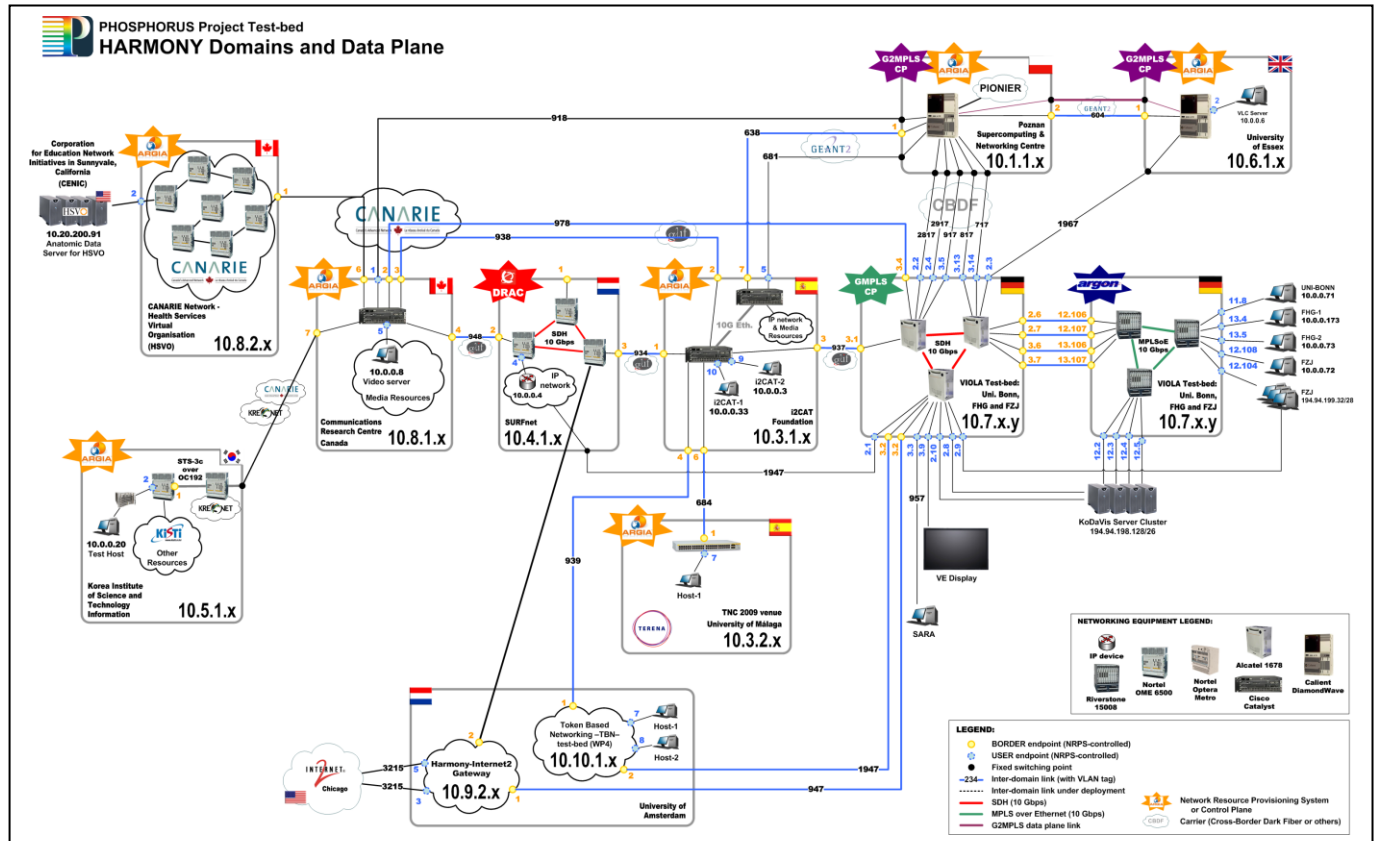
Harmony test-bed is composed of heterogeneous, independent administrative domains. Data plane inter-connections within the test-bed use dedicated light-paths from GÉANT2, GLIF, CANARIE and KREONET. The switching equipment at each local test-bed is composed among others by the following devices: Alcatel-Lucent 1678, 1850 TSS, and 7750; Calient DiamondWave FiberConnect; Cisco Catalyst 6509, 3750, Nortel Optera Metro 5200, OME 6500, and HDXc; and Riverstone 15008. Moreover, a new Harmony domain has been set up for the conference using low cost switching equipment from Allied Telesis (AT-8000S). Connection to the Phosphorus test-bed is provided by RedIRIS.

As demonstration use case, an external application named Health Services Virtual Organization (HSVO), a Canadian initiative, which aims to send anatomical data for construction high resolution images remotely, will use the Harmony system in order to provide a transatlantic light-path. HSVO client, located at the conference venue, will communicate with Harmony Inter-Domain Broker in order to schedule and provision the path. Once it has been created, HSVO server, located at Sunnyvale (California, US) will send the data through all the domains involved to the client. The anatomical data will then be displayed in the conference venue after international, multi-domain, high bandwidth path has been provisioned with a single mouse click in the end-user application.

This demonstration shows, on the one hand, the feasibility of integrating Harmony with e-Science applications in a successfully way, by the means of using the public API of the Harmony Service Interface (HSI); and on the other hand, it shows how Harmony capabilities can be used by the Grid Middleware for multi-domain path provisioning. Apart from HSVO application, HD video can be streamed from Korea (KISTI) towards the conference venue.