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Abstract

This deliverable presents the results of several collaboration activities initiated by WP1 partners. Mainly, cooperation with JRA3 from GÉANT2 and IDC from Internet2/DICE, and Phosphorus/Harmony partners' contribution to standardization and other bodies such as the Open Grid Forum and the GLIF community are described. Finally, collaboration with HSVO/SAVOIR project initiatives from the United States is presented, where the Harmony system has been enabled to inter-work with the health systems from HSVO organisations.

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0 Executive Summary

This deliverable describes the collaboration between Harmony and other related projects (external to PHOSPHORUS consortium) on service inter-operability. Thus, the first section presents the collaborations opened between Harmony and other network resource brokers: GÉANT2 JRA3 AutoBAHN [1] and IDC [7] from Internet2. The inter-operability models developed are depicted and the tests and results obtained are also presented.

Moreover, the work done under the Harmony Service Interfaces has contributed to some standardization working groups. In this sense, the manuscript presents the contributions done to the OGF Network Service Interface (OGF-NSI) [3] working group, which aims to build a standard Network Service Interface. Additionally, next section presents the contributions done to the Generic Network Interface (GNI) [4], which is being developed under the GLIF community.

Finally, it presents another collaboration activity with another project which aims to use Harmony as a tool. The Health Services Virtual Organization (HSVO) is presented. The section also describes the inter-connection of the test-beds and the workflow used for demonstrating the systems collaboration, where HSVO uses Harmony in order to establish a transatlantic path and send 3D anatomical rendered data through the light path.

1 Harmony Interoperability with Third Party Bandwidth Broker

The interoperability between different bandwidth brokers is, among other issues, subject of distinct working groups. Namely the OGF NSI [3] and GLIF [4] initiatives are working on recommendations for a generic network service interface that can be called by a network external entity such as end users, middleware, and other network service providers. As a consequence of a lack of standards and the aim to interconnect existing bandwidth broker implementations, a decision had to be taken for an external interface. This chapter gives a brief overview of developments made for the planned third party bandwidth broker interoperability. Many architectural design choices were adopted by the already implemented G^2MPLS interconnection that was described in Deliverable D1.7.

1.1 The IDC/OSCARS protocol

The considered external projects that were taken into account for interoperability tests were Internet2 IDC [2], GÉANT2 AutoBAHN [1], G-Lambda project [5], or Enlightened Computing [6]. Since GÉANT2 JRA3 has chosen to support the OSCARS protocol in the AutoBAHN system in order to be interoperable with the Internet2 IDC developments, a bidirectional IDC/OSCARS translator module was implemented within Harmony to allow both, to communicate with Internet2 and AutoBAHN.

1.1.1 Implementation details

The translator module is using version 0.5 of the OSCARS Web Service specification [12]. **Figure 1.1** depicts the chosen architecture of the implemented translator, whereby orange boxes represent WP1 and green boxes Internet2 developments. While the Harmony to IDC/OSCARS translation was demonstrated on distinct conferences and other occasions, the other way around is already implemented but not tested in real world environments (those tests requires external parties support and resources)

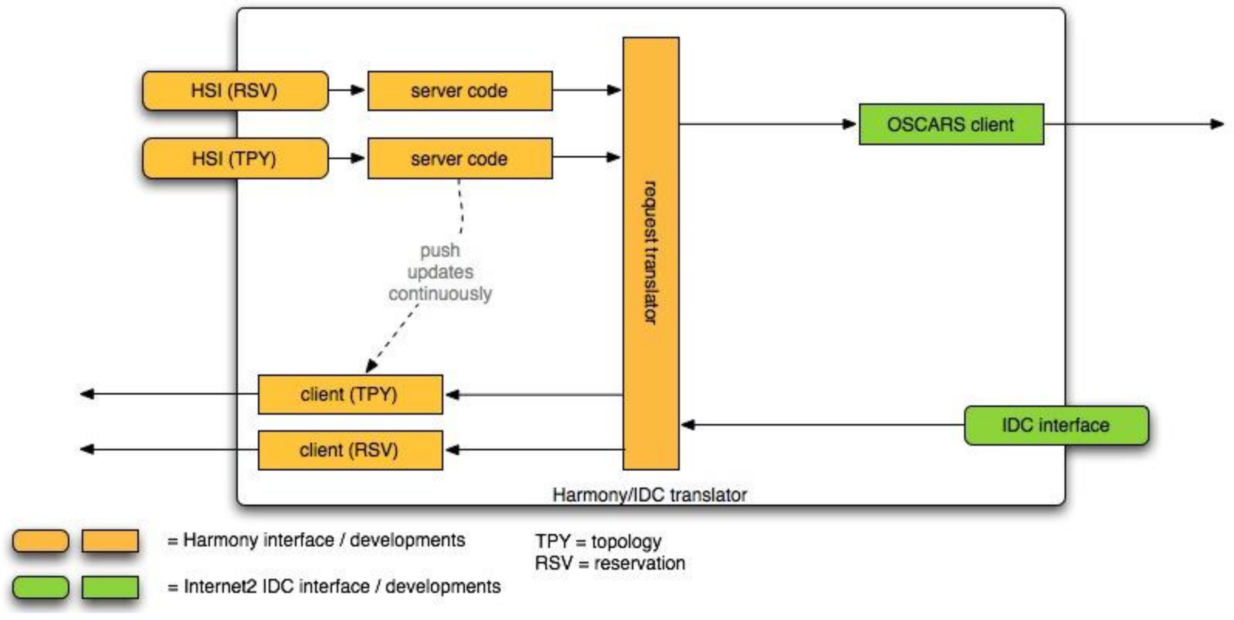

Figure 1.1: Abstract overview of the implemented translator

Mainly five main tasks can be identified that are handled by the translator:

- Security: based on Apache Rampart and exchanged certificates
- Signalling request translation: Harmony to IDC and vice versa
- Topology exchange translation: Harmony to IDC and vice versa
- ID mapping: mainly Harmony local vs. IDC global reservation ID
- Embedding: e.g. continuous topology updates within the Harmony domain

1.1.2 Implemented request translation

Since both protocol specifications aim the same goal to enable inter-domain network path provisioning, almost all basic operations could be mapped one-to-one. As shown in

Table 1.1**,** some operations can be simulated by invoking others. Some other requests were not translated.

Table 1.1: Overview of the Harmony/IDC operation translation

Description	Harmony	IDC
Create a reservation (incl. automatic activation)	createReservation	createReservation/createPath
Cancel a reservation	cancelReservation	cancelReservation/teardownPath
Query for available resources	isAvailable	listReservations
Query the status of a reservation	getStatus	queryReservation
Query a list of reservations	getReservations	listReservations
Query details for a reservation	getReservation	listReservations
Exchange topology information	addOrEditDomain	getNetworkTopology
Setup a path for a reservation	Activate	NOT TRANSLATED
Bind appl. and NRPS endpoint	bind	NOT TRANSLATED
Cancel a job workflow	cancelJob	NOT TRANSLATED
Submit a job workflow	completeJob	NOT TRANSLATED
Exchange topology information	NOT TRANSLATED	initiateTopologyPull
Modify a reservation	NOT TRANSLATED	modifyReservation
Keep a reservation alive	NOT TRANSLATED	refreshPath
Forward a signalling message	NOT TRANSLATED	forward

1.2 Collaboration with Internet2

Together with Internet2 it was possible to test the above described translation module on the below described test-bed.

1.2.1 Test-bed setup

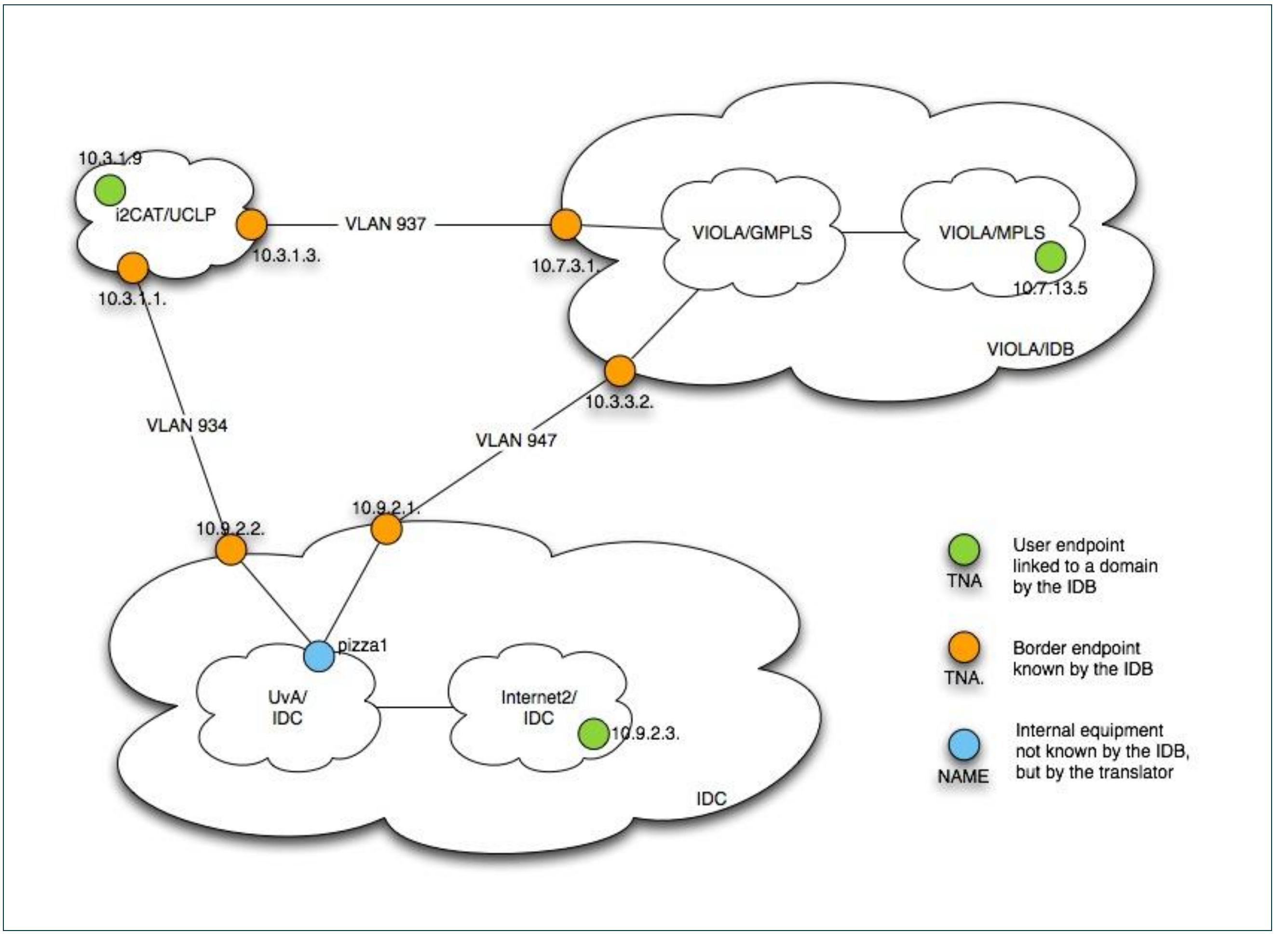

Figure 1.2: Abstract overview of the IDC/Harmony test-bed

As shown in **Figure 1.2** the test-bed was composed of three interconnected domains. The inter-domain endpoints were configured in the according systems and the Harmony IDB was used to signal the inter-domain path setup.

1.3 Collaboration with GÉANT2 AutoBAHN

After the successful deployment of the Internet2 IDC translator the next step was to interoperate with the GÉANT2 AutoBAHN system. Based on the same translator libraries the below depicted test-bed were setup.

1.3.1 Test-bed setup

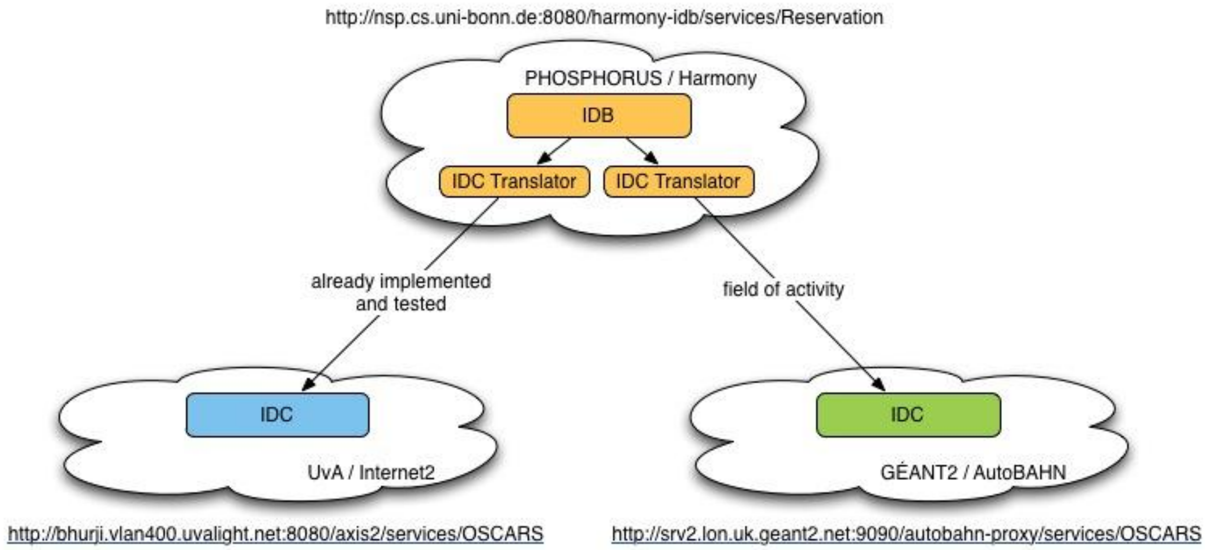

Figure 1.3: Abstract overview of the AutoBAHN/Harmony test-bed

At the time of writing this deliverable, the translator module was deployed and integrated into the Harmony domain but open configuration issues at the GÉANT2 AutoBAHN IDC had to be solved, however, GN2 resources were not available at that time.

2 Harmony in other International Collaboration Initiatives

2.1 Harmony at the Open Grid Forum (OGF)

2.1.1 The Network Service Interface working group (NSI-wg)

The following description was extracted from [3].

2.1.1.1 *Group Information*

- Group Type: Working Group
- Group Chair(s): Guy Roberts (DANTE, UK), Tomohiro Kudoh (AIST, JP), Inder Monga (Nortel Networks, USA)
- Active Contributors: DANTE (UK), AIST (JP), Nortel Networks (USA), Internet2 (USA), University of Essex (UK), University of Amsterdam (NL), i2CAT Foundation (ES), NCSU (USA), ICAIR (USA), Nordunet (NO), SURFnet (NL), ESnet (USA).

2.1.1.2 *Group Description*

High performance networks offer advanced network services to end users with differing requirements. The user/application/middleware may request network services from one or more network service providers through a network service interface (NSI). The network service setup then requires configuration, monitoring and orchestration of network resources under particular agreements and policies. Provisioning mechanisms support allocating, configuring, and maintaining network internal resources.

The Network Service Interface (NSI) Working Group (WG) will provide the recommendation for a generic network service interface that can be called by a network external entity such as end users, middleware, and other network service providers. The recommendation will define the information exchange, the required messages and protocols, operational environment, and other relevant aspects.

The scope of the NSI-wg includes, in particular, the interface between Grid middleware and the network infrastructure as well as the interface between network domains in order to provide interoperability in a heterogeneous multi-domain environment. The working group will consider user authentication/authorization, service negotiation agreements, and information exchange to describe advanced network services.

2.1.1.3 *Group Focus and Scope*

The main purpose of the NSI-wg is to facilitate interoperation between Grid users, applications and network infrastructures spanning different service domains, via the development of abstract messaging and protocols.

The NSI-wg provides a general and open definition independent of implementation of provisioning systems (e.g., Grid and network). It should be sufficiently flexible, modular and scalable to facilitate future enhancements. The NSI-wg recommendation will allow any user and network service to interoperate by using a common naming and message definition.

The NSI-wg will also focus on identifying existing standardization activities/documents, understand their relevance and specify the relationships with regards to NSI (e.g., OGF (NM-wg, NML-wg) IETF, OIF).

2.1.2 The Harmony Service Interface and the NSI

By the time of writing this document, one Phosphorus WP1 representative, who is tightly involved in design and implementation of the Harmony system, is actively contributing to the NSI-wg at OGF for more than a year.

Within the scope of Phosphorus WP1, a valuable work on NRPSs and control plane interfaces for multi-domain purposes has been done. This work is of interest for the NSI working group in OGF since Harmony and its HSI have been created for fully system-independent operation mode. That is, a simple Harmony adapter implementing the HSI can be created for adding a new domain in the network and enabling it for multi-domain capabilities basing on a minimum set of requirements.

Further more, Harmony implements the so-called Network Service Plane. (NSP) The NSP allows to provision network services to the Grid Middleware or any kind of application by letting them implement Harmony's simple HSI client API. This API is of special interest in the NSI-wg since it compiles a basic set of network attributes and web service calls to enable

Grid application workflows being interactive with the network provisioning and path management (modify, delete) phases.

Current topics being contributed by WP1 representatives on the NSI-wg are:

- Topology abstraction techniques.
- Topology sharing issues and their effects on the interface.
- Resource reservation workflow and definition of the minimal set of attributes and calls for setting up a connection/service requests.
- Time management and constraints for network service provisioning.
- Multi-domain path finding and their influence on the network service interface.
- Use cases for the NSI from the Phosphorus vision and Grid world.

2.2 Harmony and the GLIF community

2.2.1 The Generic Network Interface task force (GNI-tf)

The following description was extracted from [4].

2.2.1.1 *Group Information*

- Group Type: Task Force
- Group Leader(s): Evangelos Chaniotakis (ESnet, USA).
- Active Participants: ESnet (USA), NCSU (USA), TU-BS (DE), Inocybe (CA), AIST (JP).

2.2.1.2 *Group Background*

This task force was formed out of the common desire from implementers of virtual circuit provisioning systems to allow these systems to interoperate eachother, and due to a lack of a standard for such interoperability. After a study, the task force decided that these systems have very similar APIs that can be made to work together with some ad hoc translation, and undertook the task of developing a specification for a common API and a software implementation of the various translations. This task is underway, and has already produced some initial results.

2.2.1.3 *Group Focus and Scope*

Generic Network Interface task force (GNI-tf) aims to develop a GNI specification, using existing interfaces to capture the minimum set of calls and parameters required for a given set of applications identified. By the time of writing this document, GNI-tf is led by Evangelos Chaniotakis from ESnet (United States of America).

The GNI-tf will be creating an ad hoc common API specification which will be the lowest common denominator of existing APIs for virtual circuit provisioning systems. This specification is not meant to be a standard, but will hopefully provide some useful lessons to groups on a standards track, like the OGF NSI-wg.

The GNI-tf will also produce a translation framework software project to facilitate translation from this ad hoc API to the specific APIs of the various virtual circuit provisioning systems. This is meant as a stopgap measure to enable interoperability until a standard is in fact produced and implemented.

2.2.2 Technical details about GNI implementation

Fenius is a Java framework utilizing Maven, CXF, JWS and Jetty to build an extendable, many-to-one-to-many translation agent. Its main components are:

- A common internal Java API and supporting classes specification. This will be identical to the common external GNI API.
- Any number of external APIs. One is the common external GNI API, but others can be easily plugged in, as long as they implement the translation to the common internal API.
- Any number of translator components. A translator component must be able to translate requests from the common internal Java API to its native requests (i.e. to Harmony). Only one translator will be active for each Fenius instance.
- A container object to bundle together the above, do the wiring between them, and expose them as web services through an embedded Jetty instance.

2.2.3 Harmony system and the GNI

Harmony's contribution to the GNI task force in the GLIF community was concentrated on the first days of the task force. The contribution consisted in the edition of the comparison document [7] of the several existing initiatives all around the world. Systems compared were: IDC protocol[2], G-Lambda[5], Phosphorus/Harmony[11], Argia[8], Phosphorus/G^2MPLS[8], Argon[10], and AutoBAHN[1].

The comparison document showed differences between the systems in terms of:

- System requirements
- Supported standards (web services)
- Operation analysis
- Data structures
- Reservation processes and workflows

2.3 Harmony-HSVO and Harmony-SAVOIR collaborations

2.3.1 HSVO Overview

The HSVO project is funded by Canarie's Network Enabled Platforms (NEP) program. The Health Services Virtual Organization (HSVO) aims to create a sustainable research platform for experimental development of shared ICT-based health services. This includes support for patient treatment planning as well as team and individual preparedness in the operating room, emergency room, general practice clinics, and patients' bedsides. In the context of the Network-Enabled Platforms program, the project seeks to offer such support to distributed communities of learners and health-care practitioners. Achieving these goals entails the development of tools for simultaneous access to the following training and collaboration resources: remote viewing of surgical procedures (or cadaver dissections), virtual patient simulation involving medical mannequins and software simulators, access to 3D anatomical visualization resources, and integration of these services with the SAVOIR [13] [14] middleware along with the Argia network resource management software.

2.3.1.1 *HSVO Use cases*

Cadaveric dissection

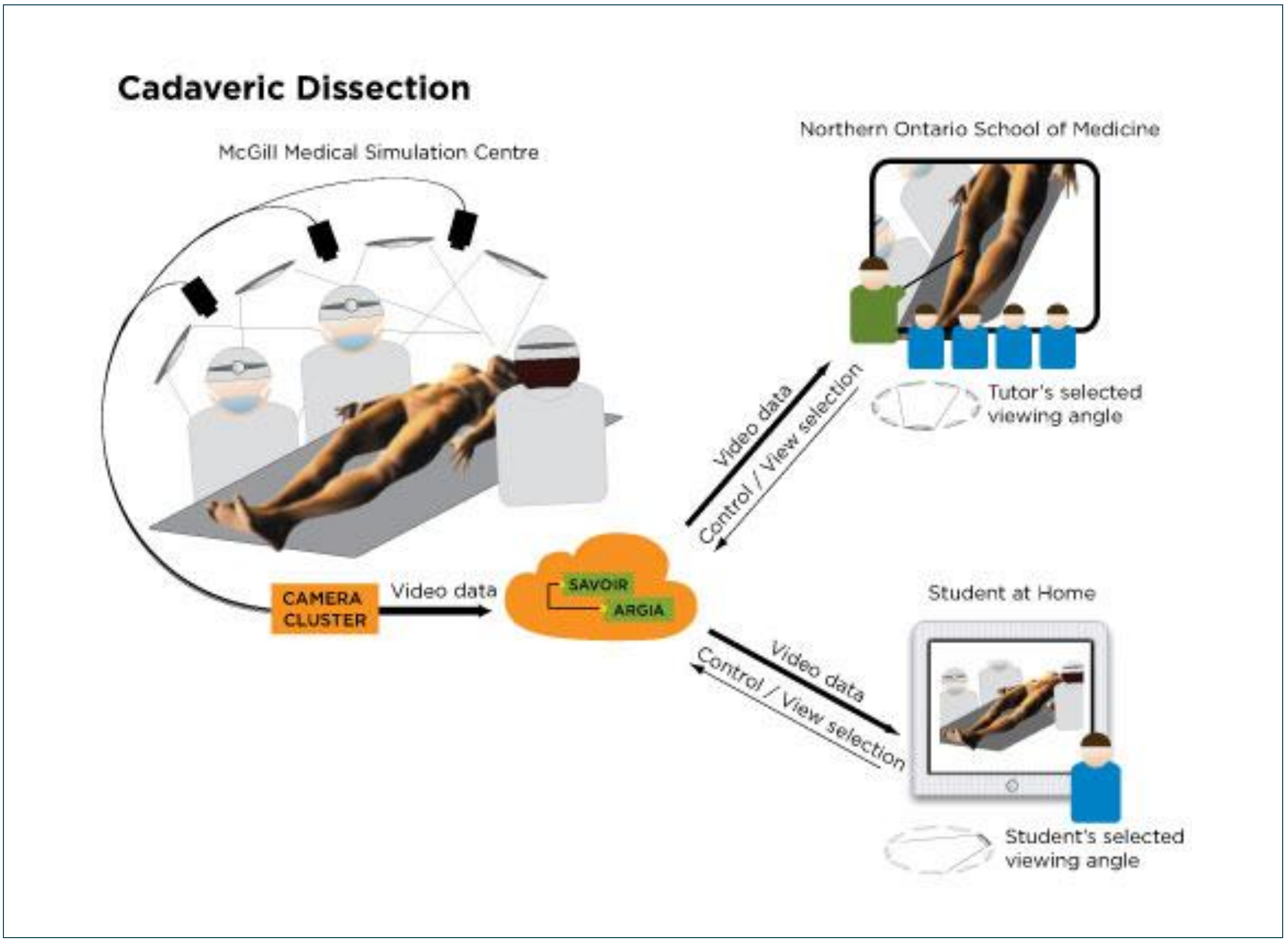

Figure 2.1: Cadaveric dissection

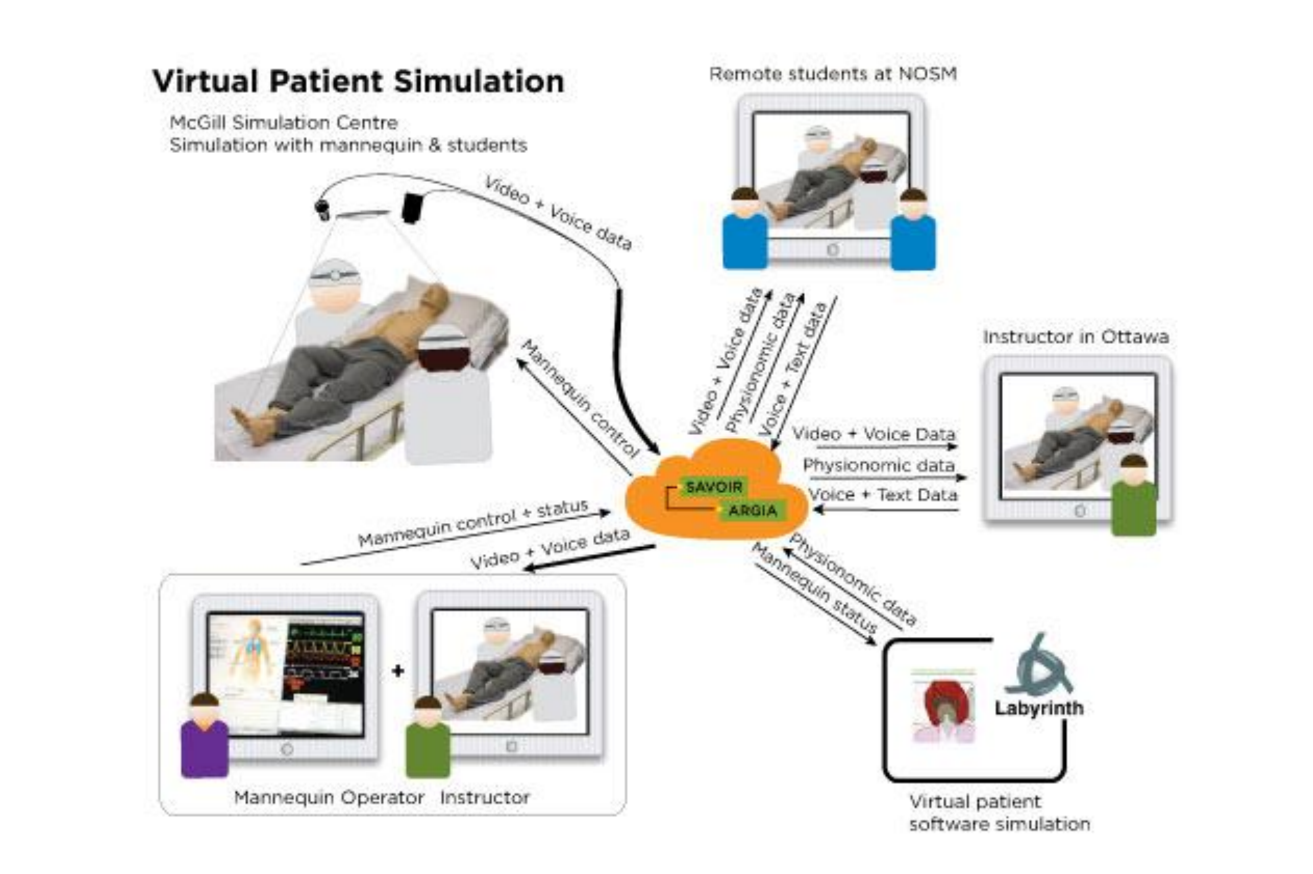

Figure 2.2: Virtual patient simulation

Anatomical Visualization

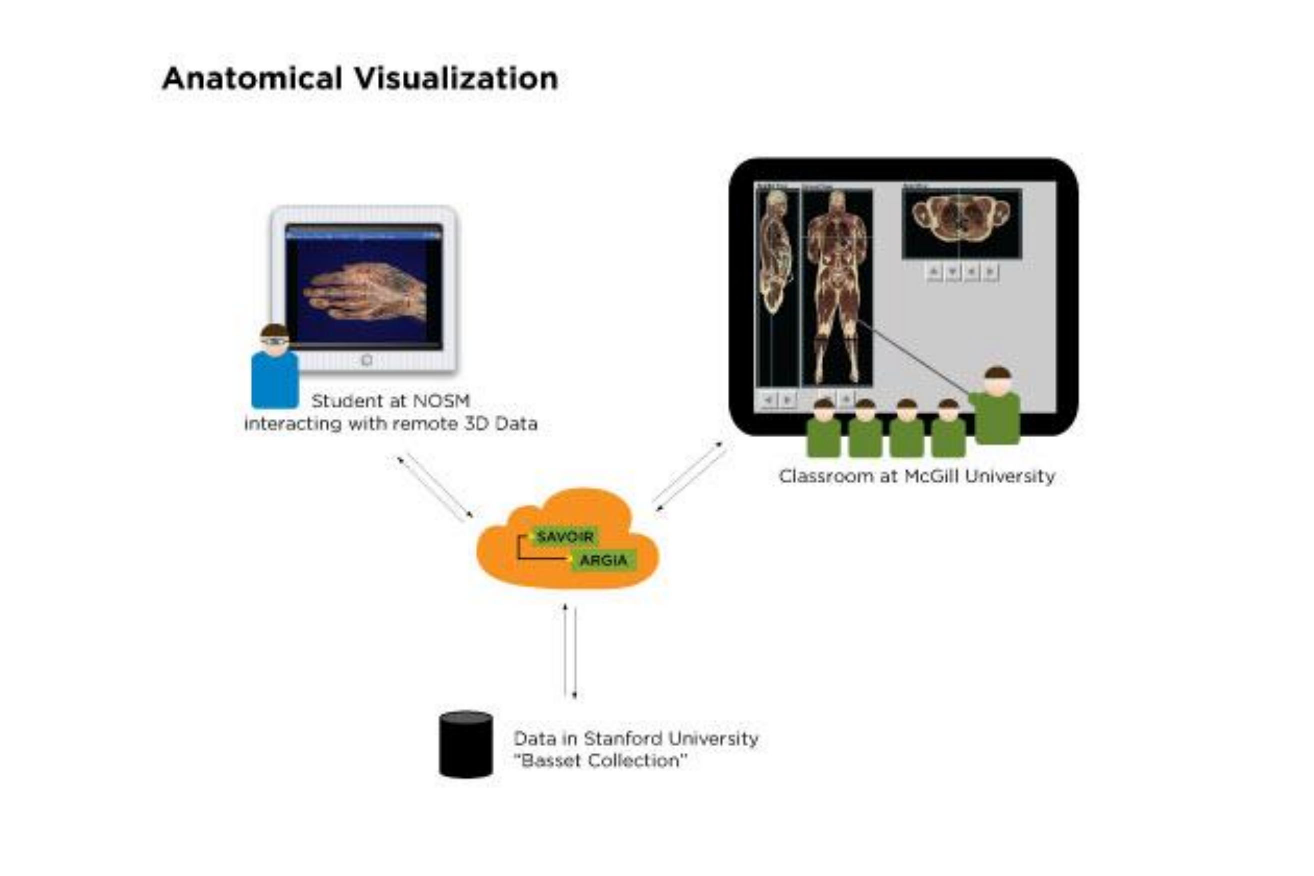

Figure 2.3: Anatomical visualization

2.3.2 Test-bed set up

2.3.2.1 *HSVO Test-bed*

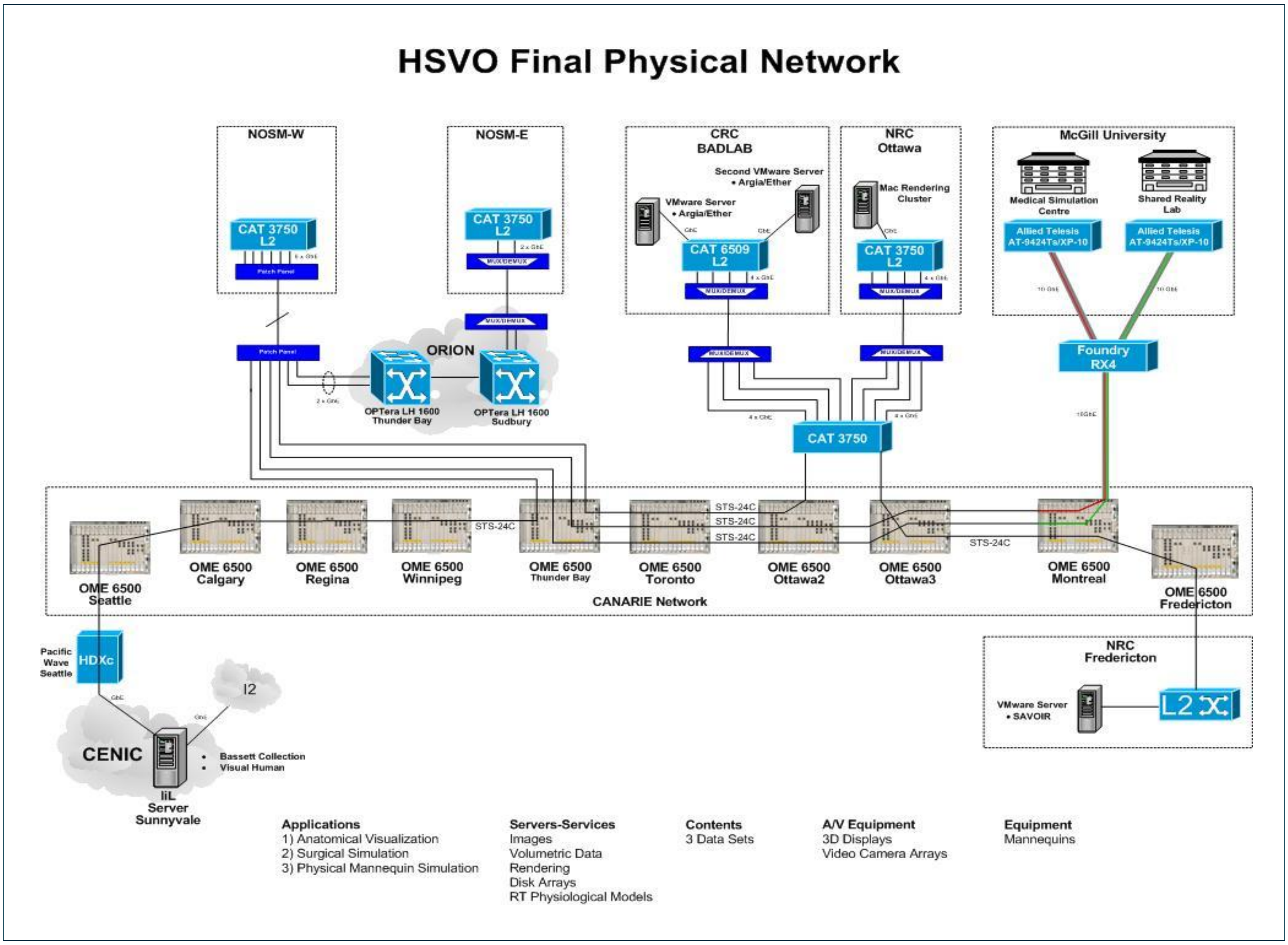

Figure 2.4: HSVO test-bed: Physical view

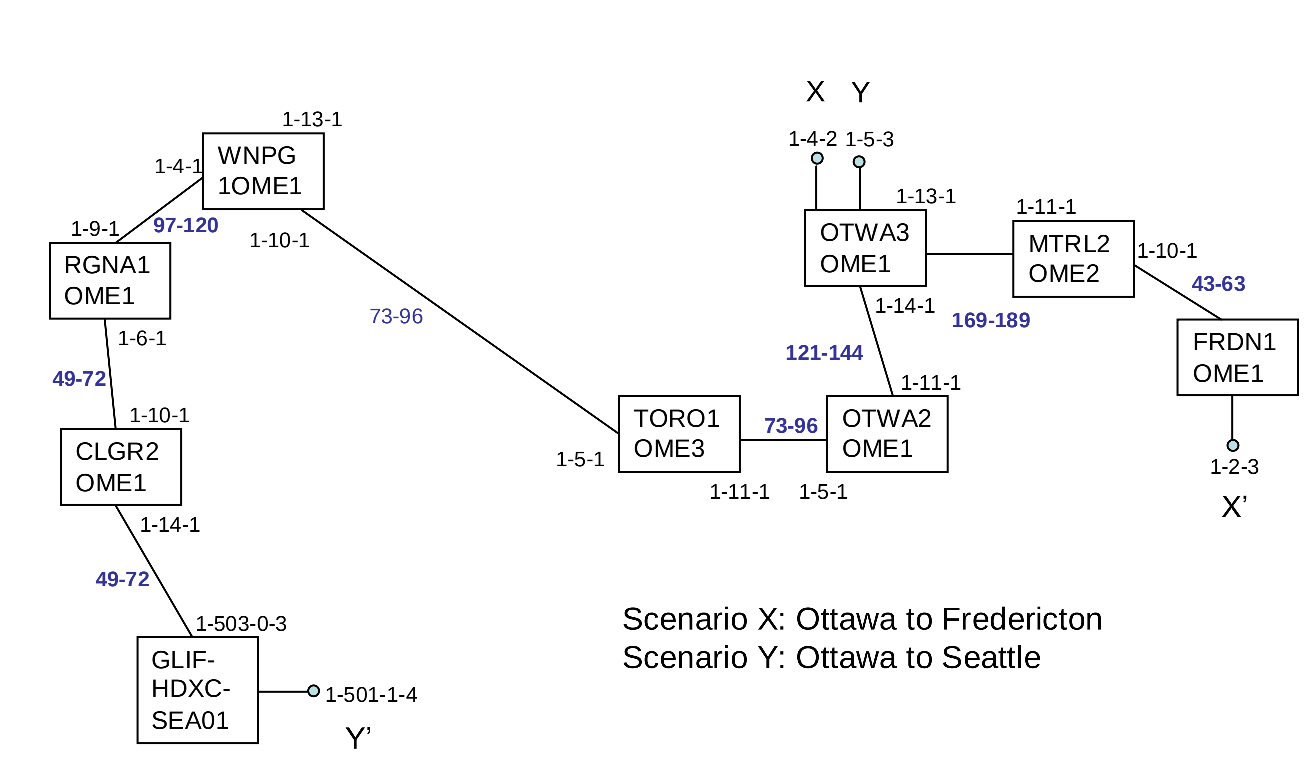

Figure 2.5: HSVO test-bed: Logical view

The HSVO test-bed consists of two connections over the CANARIE transport network: one VCATed STS21c connection from Ottawa to Fredericton (X to X'), and one STS24c connection from Ottawa to Seattle (Y to Y'). The Ottawa to Seattle connection will become the final 'leg' in the Harmony-HSVO test-bed, where Y is a border endpoint, and Y' is a user endpoint in the new HSVO domain.

2.3.2.2 *Harmony Test-bed*

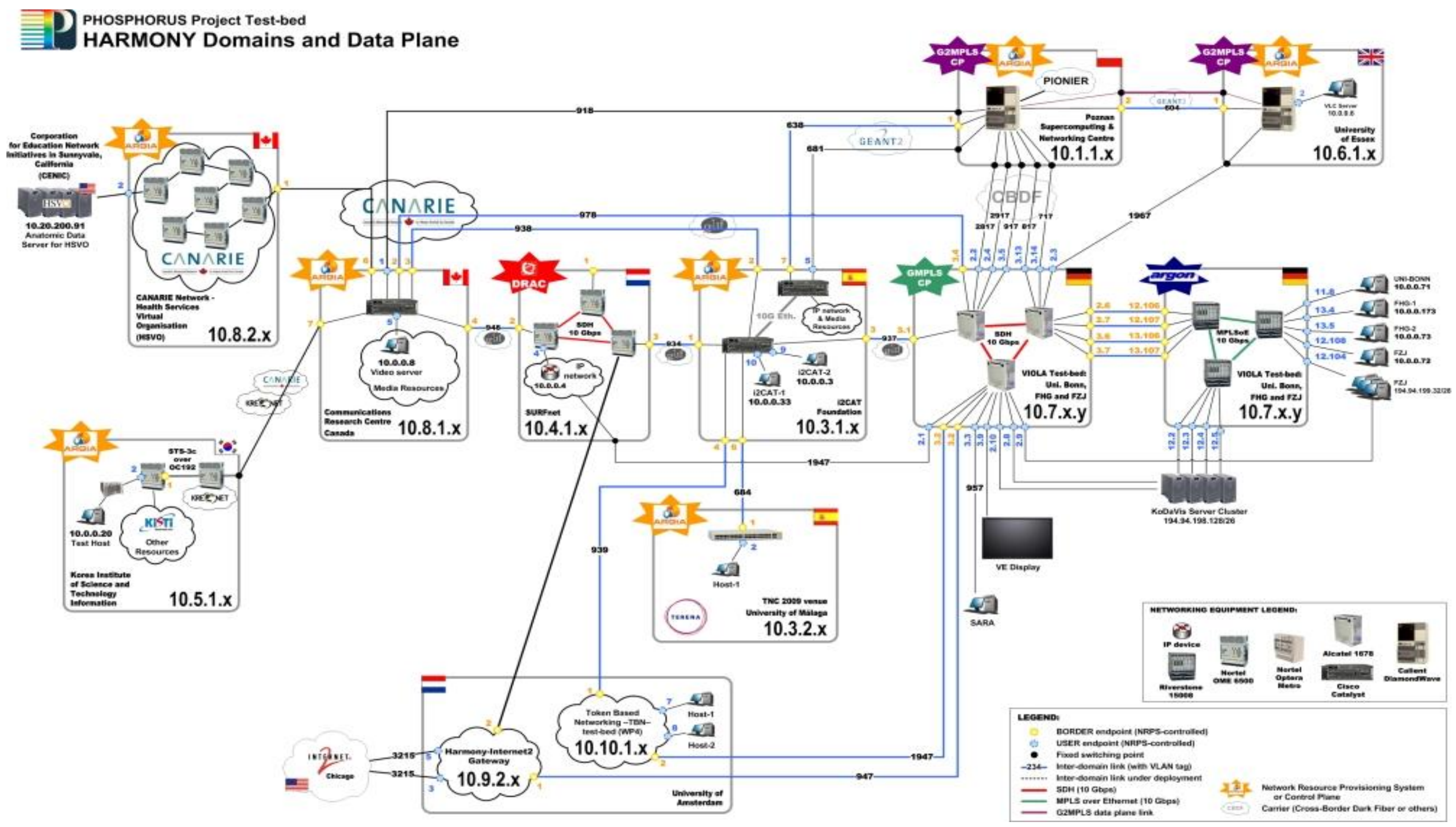

Figure 2.6: Harmony test-bed

The test-bed is composed of several heterogeneous domains. Each independent domain has its own transport network, which is represented by its own TNA space scheme and is controlled by the corresponding NRPS. These domains are inter-connected both on data plane and on control/provisioning plane. The data plane connections are based on dedicated light-paths from several providers. Most of these connections use the GEANT2 infrastructure, but also Global Lambda Infrastructure Facility (GLIF) provides some transatlantic light-paths and CANARIE provides the circuits over Canada and the US. The control plane connections go through a VPN between all the domains involved. There is several manufacturers' equipment supported in each domain: Cisco Catalyst 3750 and 6509; Nortel OME 6500 and HDXc; Calient DiamondWave FiberConnect; Alcatel-Lucent 1678, 1850 and 7750 and Riverstone 15008. Figure 2.6 depicts concretely the Harmony test-bed.

2.3.2.3 *Harmony – HSVO test-bed*

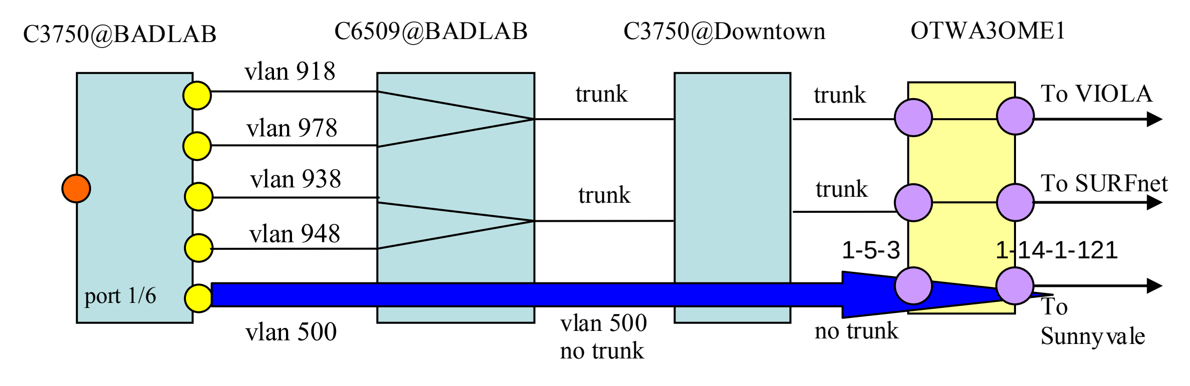

Figure 2.7: Segment of inter-connection of both, Harmony and HSVO, test-beds

The interconnection from the Harmony test-bed to the HSVO test-bed is achieved as shown in Figure 2.7. Port 1/6 on the Catalyst 3750 switch at CRC has been connected to the Catalyst 6509 switch at CRC using VLAN ID 500. Since port 1-5-3 on the OTWA3OME1 optical switch located at downtown Ottawa is also connected to the CRC Catalyst 6509 switch using VLAN 500, this setup, in effect, connects port 1/6 on the CRC Catalyst 3750 switch to port 1-5-3 on the OTWA3OME1 switch, which is 'Y' in Figure 2.5.

From the control plane perspective, port 1/6 on the CRC Catalyst 3750 switch has been added to the current CRC NRPS adapter as a border endpoint. A new adapter runs at CRC to facilitate the control of the HSVO network. In this new HSVO adapter, port Y in Figure 2.5 is defined as a border endpoint, and port Y' in Figure 2.5 is a user endpoint. The simplified logical topology of the Harmony-HSVO test-bed is shown in Figure 2.8. The Harmony-HSVO joint test-bed will consist of four Harmony adapters each controlling one domain: i2CAT adapter (no change needed from the current setup), VIOLA adapter (no change needed from current setup), CRC adapter (border endpoint 10.8.1.6 added), and a new HSVO adapter.

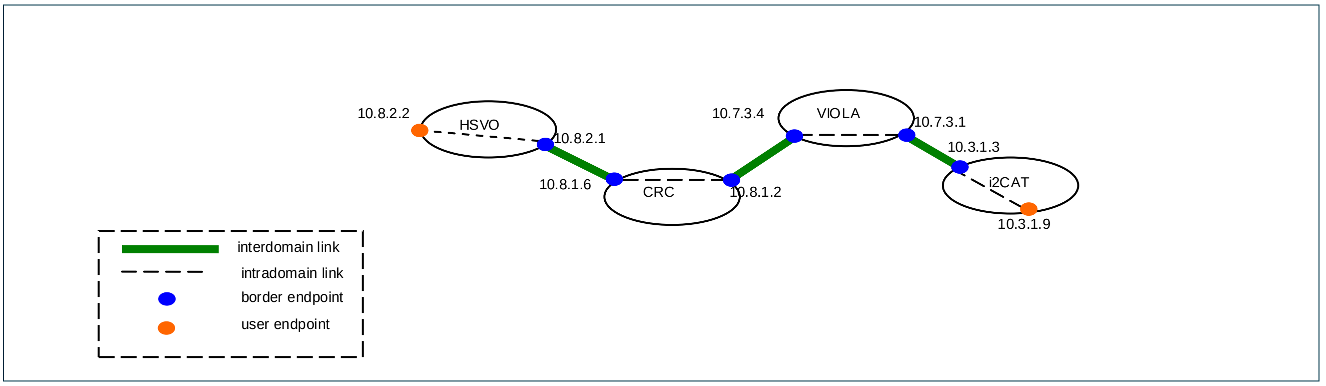

Figure 2.8: Logical topology of the Harmony-HSVO joint test-bed

From the Network Service Plane point of view, the HSVO domain will be one sub-domain of the main Inter-Domain Broker, located at Germany. Thus, the HSVO domain joins the Harmony test-bed enabling any other domain to create one reservation with source at California and target in its domain in order to visualize the anatomical data sent over the path set up by Harmony.

2.3.3 Achievements and Future work

The goal of this collaboration is to show how external applications, such as HSVO, can achieve the inter-operability with Harmony. The SAVOIR middleware coordinates the infrastructure and resources associated with the HSVO facilities. These resources are associated with the Use Cases presented in previous section. This collaboration has been demonstrated in one local event in Barcelona: “Internet del Futur. Jornada de Recerca: Projecte TRILOGY”. In the demonstration, SAVOIR middleware called the Harmony Inter-domain Broker, through its Harmony Service Interfaces (HSI), in order to establish a path from HSVO to i2CAT. The user in the conference venue was able to view rendered 3D data sets based on the Basset Collection.

Moreover, this collaboration will be demonstrated in the TERENA Networking Conference (June 09), which will take place in Málaga, Spain. The test-bed will be extended with one new domain located in the conference venue and directly connected to the i2CAT local test-bed. This new test-bed will be composed of one Allied Tellesys controlled by Argia NRPS. This deployment will allow the client to establish a path between Sunnyvale and Málaga (going through Canada and Barcelona) using the Harmony system and visualize anatomical 3D rendered data.

Finally, the demonstration of the inter-operability between Harmony and HSVO will also be demonstrated locally in Barcelona, where i2CAT will perform one special demonstration to the e-Health community of the city, including as well some medical employees, in order to show the commercial benefits of this collaboration.

Figure 2.9: SAVOIR Dashboard

Next figures show examples of the anatomical data streamed from the HSVO server to the requesting client.

Figure 2.10: Various hands views using the HSVO software

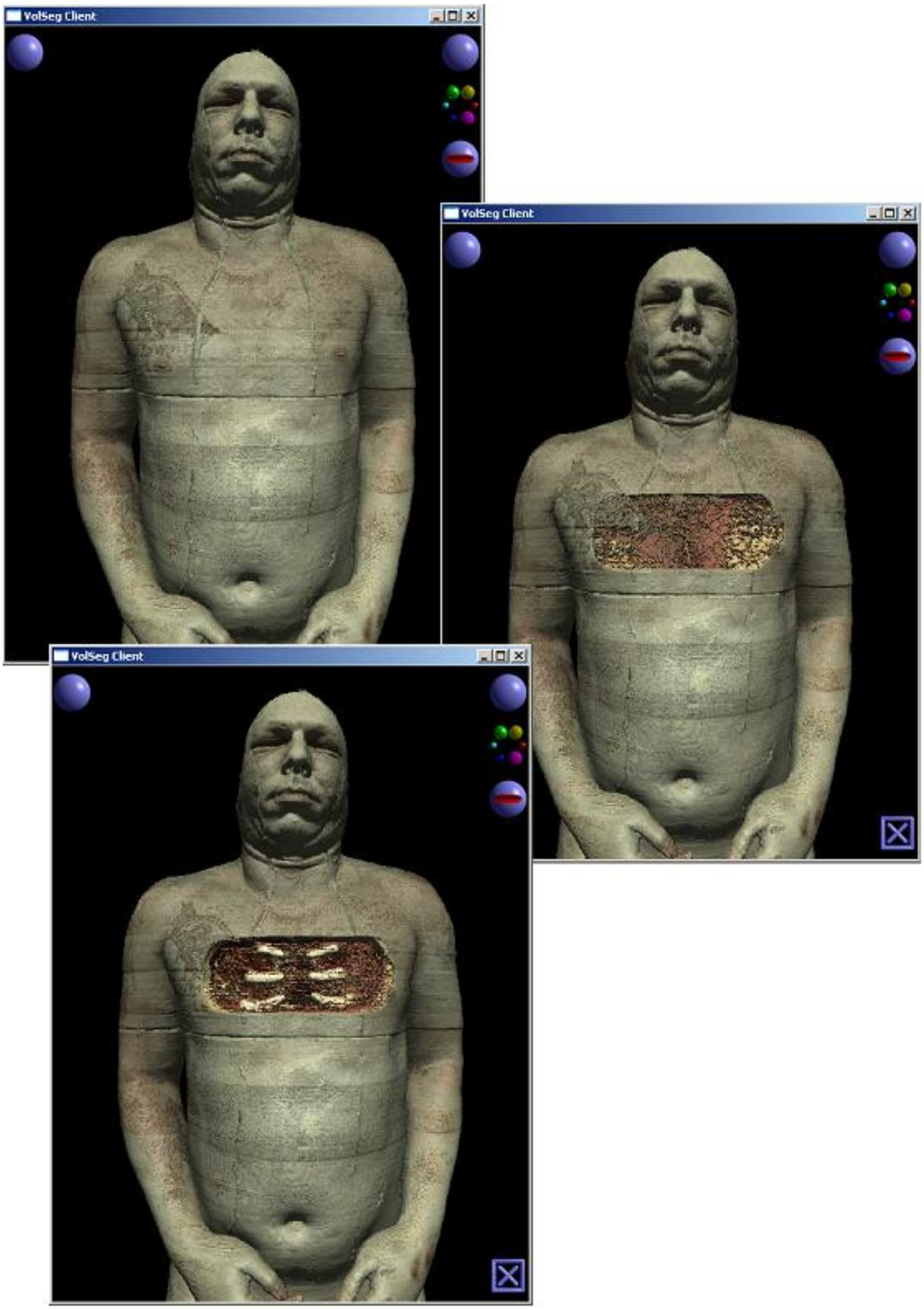

Figure 2.11: Various cadaver views using the HSVO software

3 Conclusions

This deliverable depicted the collaboration achievements between Harmony and Internet2, AutoBAHN, OGF, GLIF, HSVO, and SAVOIR. The Phosphorus WP1 developments are able to communicate with Internet2 and the GÉANT2 AutoBAHN system by using the OSCARS protocol and prototypes have shown the feasibility. Furthermore, the experience gained within this project was incorporated in the OGF NSI-wg and the GLIF GNI-tf. Finally, the developments were demonstrated on the TERENA Networking Conference this year by integrating Harmony in the SAVOIR middleware and using HSVO as an external application.

As a result of the strong collaboration with other projects, the OGF and the GLIF community it was possible to exert influence on further standard network service interface specifications. Also the cooperation with HSVO and SAVOIR allowed demonstrating the Harmony system to a wider audience.

Now the next short-term objective is to bring the current developments to a clean close and they should be accessible to other interested third parties. As a long-term objective the depicted developments should have an impact on the design of a standard network service interface.

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5 Acronyms

API	Application Programming Interface
ARGON	Allocation and Reservation in Grid-enabled Optical Networks
DRAC	Dynamic Resource Allocation Controller
GLIF	Global Lambda Integrated Facility
GNI	Generic Network Interface
GUSI	GLIF's Universal Service Interface
HNA	Harmony NRPS Adapter
HSI	Harmony Service Interface
HSVO	Health Services Virtual Organisation
IDB	Inter-Domain Broker
IDC	Inter-Domain Controller
NRPS	Network Resource Provisioning System
NSI	Network Service Interface
NSP	Network Service Plane
OGF	Open Grid Forum
SAVOIR	Service-oriented Architecture Virtual Organization Infrastructure and Resources