



034115

## PHOSPHORUS

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Integrated Project

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**Deliverable reference number: D.2.10**

## Final Grid-GMPLS Control Plane prototype

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## Final Grid-GMPLS Control Plane prototype

### Abstract

This document contains the release notes for the final G<sup>2</sup>MPLS Network Control Plane prototype. It consists of all the software modules designed, implemented and publicly demonstrated by the Phosphorus WP2. The prototype includes the PEPGW module for the integration with the WP4 AuthN/AuthZ framework, the gateway module between G<sup>2</sup>MPLS Control Plane and WP1-Harmony, plus some refinements and fixings to the previously released G<sup>2</sup>MPLS prototype (D2.5) that derived from the G<sup>2</sup>MPLS consolidation activity.

This deliverable constitutes the official and public release of G<sup>2</sup>MPLS Control Plane in the form of release notes and software package.

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## 0 Executive Summary

This document provides the release notes of the final G<sup>2</sup>MPLS Network Control Plane prototype delivered in the form of a XEN virtual machine.

In section 3 the contents and basics for operations of the G<sup>2</sup>MPLS prototypes are described for the different deployment cases: G<sup>2</sup>MPLS core controller, G<sup>2</sup>MPLS border controller (i.e. with G.E-NNI), G<sup>2</sup>MPLS edge controller (i.e. with G.UNI-N) and G<sup>2</sup>MPLS G.UNI client node (i.e. with guni-gw functionality towards the Grid middleware).

In section 4 the configuration process is detailed, in order to set a general reference for any users in his specific deployment scenario.

In Section 5 some details on the topology and configuration of the G<sup>2</sup>MPLS Control Plane in the multi-domain heterogeneous Phosphorus test-bed are provided. This Control and Transport Plane layouts have been used in the public G<sup>2</sup>MPLS demonstrations and experiments during Supercomputing 2008 (Austin-TX, USA on 16-21 November 2008) and the ICT'08 (Lyon-FR, EU, on 25-27 November 2008).

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# 1 Objectives and Scope

This document briefly describes the contents of the G<sup>2</sup>MPLS software package. The detailed architectural background and system design notes have been provided in the other WP2 deliverables, listed below:

- D2.1 “The Grid-GMPLS Control Plane architecture”,
- D2.2 “Routing and Signalling Extensions for the Grid-GMPLS Control Plane”
- D2.7 “Grid-GMPLS network interfaces specification”
- D2.3 “Grid-GMPLS high level system design”
- D2.6 “Deployment models and solutions of the Grid-GMPLS Control Plane”

Basic configuration hints and bootstrap procedures are the core of this document, in order to provide a general reference for any users willing to deploy G<sup>2</sup>MPLS in its own Transport Network with a specific SCN, addressing spaces and interconnections between equipments. Detailed explanations on the available configuration commands exposed by each software module can be retrieved during operation of the stack, by logging into the VTY interface and using the module help.

Most of the G<sup>2</sup>MPLS modules released in this prototype are based on the QUAGGA routing suite, and therefore the QUAGGA official documentation [QUAGGA-DOC] complements these notes.

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## 2 Terminology

No specific terminology is introduced by this document, which refers to Deliverable D2.1, D2.2, D2.6, D2.7 and D2.4 for any specific terms used.

A full list of the abbreviations used in this document is provided in Section 7.

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## 3 G<sup>2</sup>MPLS Control Plane final prototype

### 3.1 Package format

The final G<sup>2</sup>MPLS prototype is released in the form of a XEN virtual machine, configured with all the system packages (libraries and programs) needed for the correct operations of the G<sup>2</sup>MPLS software modules.

The G<sup>2</sup>MPLS virtual machine is a XEN Domain U (DomU) based on a Linux/Gentoo distribution for x86 32-bit platforms. It is built with XEN capabilities activated in its kernel 2.6.16. The hosting server from which it has been derived (XEN Domain 0 – Dom0) is a Linux/Ubuntu 7.04 with kernel 2.6.19 and XEN 3.0 installed.

The G<sup>2</sup>MPLS XEN VM consists of two disks

- g2mpls\_controller.sda1, containing the system root (“/”)
- g2mpls\_controller\_swap.sda2, representing the swap memory for that system

The XEN dom0 configuration which is needed to start the G<sup>2</sup>MPLS XEN VM is provided in the following excerpt to be added as independent file in `/etc/xen/seeds` directory.

```
kernel = "/mnt/xen/vmlinuz-2.6.16-xenU"
memory = 128
name = " g2mpls_controller "
disk = ['file:/mnt/xen/seeds/ g2mpls_controller.sda1,sda1,w', 'file:/mnt/xen/seeds/
g2mpls_controller_swap.sda2,sda2,w']
root = "/dev/sda1 ro"
vif = []
cpus = "0-1"
vcpus = 2
```

Code 3-1: G<sup>2</sup>MPLS XEN VM configuration file in dom0.

The G<sup>2</sup>MPLS VM boots with pre-configured hostname (`g2mpls-controller`) and IP address for its virtual network interface. Both can be overridden in `/etc/conf.d` according to the user's needs. The root user can be accessed with password “g2mpls”.

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## 3.2 Package contents

The G<sup>2</sup>MPLS prototype comes up with a preconfigured user (user01, password user01) and the main object codes of G<sup>2</sup>MPLS software modules, as listed in Figure 3-1. These components are contained in the directory `phosphorus-g2mpls` located in `/home/user01`. In details:

- `phosphorus-g2mpls/build` contains the protocols executables and the common libraries of the G<sup>2</sup>MPLS stack; specifically
  - `phosphorus-g2mpls/build/sbin` groups most of the G<sup>2</sup>MPLS protocols executables ([PH-WP2-D2.3], [PH-WP2-D2.9]);
  - `phosphorus-g2mpls/build/pyg2mpls` groups all the python components (NCC, CCC and framework tools) just described in [PH-WP2-D2.3];
  - `phosphorus-g2mpls/build/etc` contains the controllers run-scripts and some minimal example of configurations (more detailed configurations are provided in G<sup>2</sup>MPLS-DEMOS folder);
  - `phosphorus-g2mpls/build/pepgw` groups all the PEPGW components and the GAAATK released by WP4 for AAA integration [PH-WP2-D2.8]
- `phosphorus-g2mpls/G2MPLS-DEMOS` contains all the configurations of the G<sup>2</sup>MPLS controllers used during the G<sup>2</sup>MPLS demonstrations in SC'08 and ICT'08 conferences and exhibitions (ref. section 5 for a topology description).

The G<sup>2</sup>MPLS prototype is based on the Quagga v0.99.7 substrate [QUAGGA-DOC] from which it inherits the base OSPFv2 implementation and some common libraries and tools. Many other functionalities and protocols are implemented in the form of independent processes, also based on the QUAGGA framework. Therefore, most of the G<sup>2</sup>MPLS modules/processes expose a VTY interface for the inspection and configuration and it is similar to the command line interfaces of the other QUAGGA protocols.

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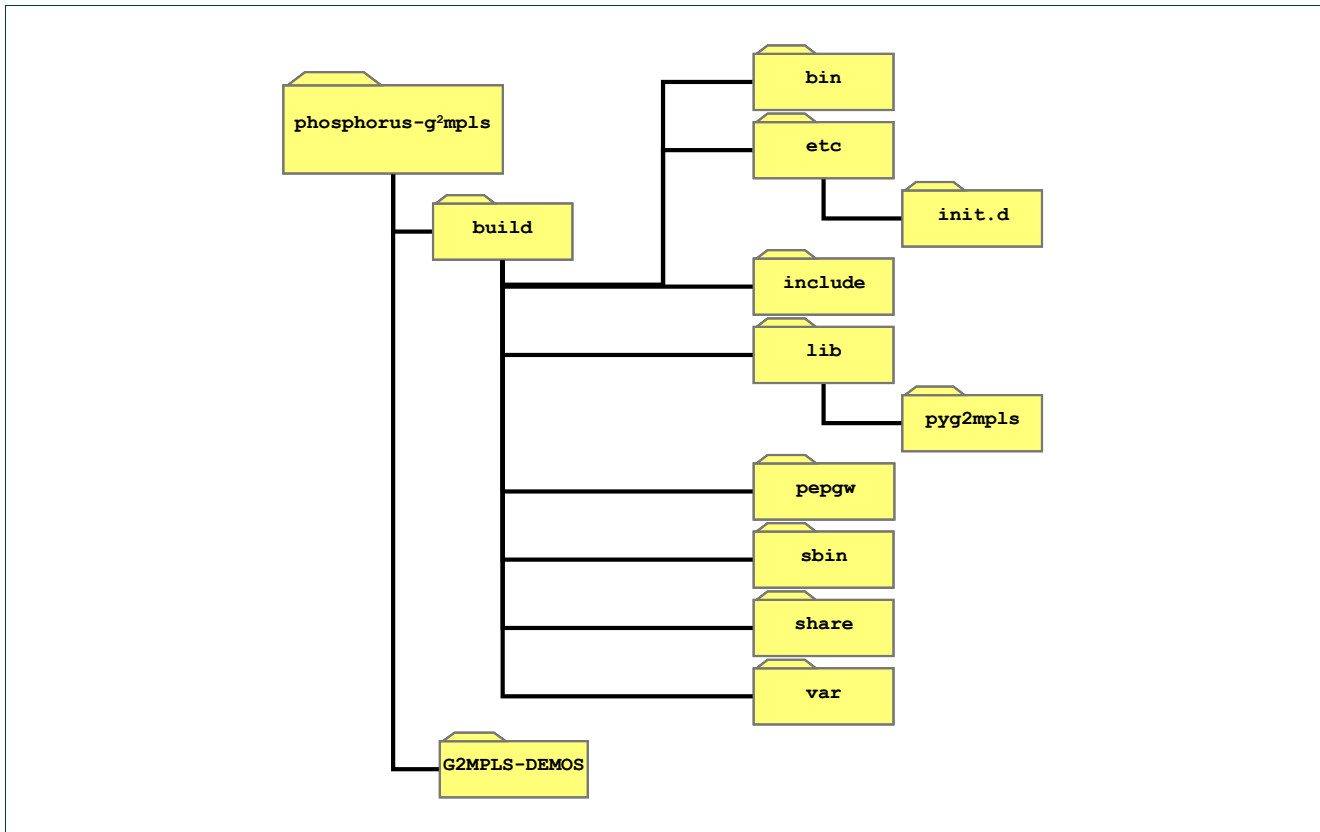


Figure 3-1: Phosphorus G<sup>2</sup>MPLS prototype build structure.

## 3.3 Start-up and shut-down procedures

### 3.3.1 Single protocols

NOTE. This procedure is deprecated for a full controller operation, since most of the protocols depend on the existence of other modules and open CORBA interfaces. These dependencies are preserved by the init scripts for the full G<sup>2</sup>MPLS controllers (core, border, edge, uni-client) described in sections

Each process in `./build/sbin` can be run with a set of options, briefly described below.

```
"Usage : PROGRAM-NAME [OPTION...]"
    "Daemon which manages PROGRAM-NAME module"

    "-d, --daemon           Runs in daemon mode"
    "-f, --config_file      Set configuration file name"
    "-i, --pid_file         Set process identifier file name"
    "-C, --dryrun           Check configuration and exit"
    "-o, --iors_dir         Set IORs directory"
```

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```
"-P, --vty_port    Set vty's port number"
"-u, --user        User to run as"
"-g, --group       Group to run as"
"-v, --version     Print program version"
"-h, --help       Display this help and exit"
```

#### Code 3-2: G<sup>2</sup>MPLS process run options.

Automated bash scripts have been provided in `build/etc/init.d` to start-up, shut-down and restart singularly most of these executables. They locate the configuration files, set some options and run/kill the G<sup>2</sup>MPLS modules.

Each G<sup>2</sup>MPLS daemon can be checked for its correct operation and possibly further configured through its VTU, which is a command line interface accessed via telnet to the `g2mpls-controller` at the ports specified below.

```
TNRCD_VTY_PORT      2613
LRMD_VTY_PORT       2610
SCNGWSD_VTY_PORT    2620
OSPF_VTY_PORT       2604
G2RSVPTED_VTY_PORT 2630
GENNI_G2RSVPTED_VTY_PORT 2631
GUNIN_G2RSVPTED_VTY_PORT 2632
GUNIC_G2RSVPTED_VTY_PORT 2633
G2PCERAD_VTY_PORT   2615
GUNIGWD_VTY_PORT    2614
HG2GWD_VTY_PORT     2625
NCCD_VTY_PORT       2616
```

#### Code 3-3: G<sup>2</sup>MPLS main VTU ports.

The configuration file specified as a run option of each daemon contains the VTU commands that are read at the bootstrap of the protocol. Therefore, a set of the available commands per protocol can be inferred by these files or retrieved exhaustively through the help of the VTU interface.

### 3.3.2 Python modules

**NOTE.** This procedure is deprecated for a full controller operation, since most of the protocols depend on the existence of other modules and open CORBA interfaces. These dependencies are preserved by the init scripts for the full G<sup>2</sup>MPLS controllers (`core`, `border`, `edge`, `uni-client`) described in sections

The binaries for NCC and CCC modules are located in `./build/lib/pyg2mpls`, which is linked by the python site-packages location on the VM (`/usr/lib/python.x.x/site-packages/`). The start-up/shut-down procedures for these modules are wrapped by a bash script:

```
`build/lib/tools/pyrun.sh build/lib/tools/pyg2` <action> <protocol>
<action>      := { start | stop | restart }
<protocol>    := { nccd | cccd | rcd }
```

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```
<instance_no> := number of protocol instances to be run on the same controller  
                (just for the single-module debugging purposes)
```

Code 3-4: G<sup>2</sup>MPLS Python objects run script.

NOTE. the execution of any xCC modules and of RCD generates persistency files (\*.pdb) that must be removed for a correct restart from scratch of the modules.

All the activities of these python modules depend on actions from G<sup>2</sup>MPLS protocols or CORBA interfaces. Therefore, the VTY interface they export is a stand-alone process, the nccd, and is mainly used for show commands and creation of Soft Permanent Connections (SPC).

### 3.3.3 G<sup>2</sup>MPLS Controllers

NOTE. In order to simplify all the operations, it is suggested to run the controllers described below from the root user. This is necessary for those G<sup>2</sup>MPLS protocols using the system sockets.

Reference init bundle scripts are

```
build/etc/init.d/g2mpls-core-ctrl  
  
build//etc/init.d/g2mpls-border-ctrl  
  
build//etc/init.d/g2mpls-edge-ctrl  
  
build//etc/init.d/g2mpls-uniclient-ctrl
```

#### 3.3.3.1 G<sup>2</sup>MPLS core controller

The modules needed by a G<sup>2</sup>MPLS core controller are:

- tnrcd, i.e. the process in charge of implementing the mediation between Control Plane and the Transport Plane equipment;
- lrmd, i.e. the process storing the Control Plane data model and the internal bindings between resources
- scngwsd, i.e. the process that bridges the set of SCN interfaces with the TE-Links and related Control Channels;
- g2rsvpted, i.e. the process implementing the G.I-NNI G2.RSVP-TE;
- ospfd, i.e. the process implementing the I-NNI G2.OSPF-TE;
- g2pcerad, i.e. the process implementing the routing algorithms on the G<sup>2</sup>MPLS multi-domain topologies.

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A G<sup>2</sup>MPLS core controller can be run with the init script `build/etc/init.d/g2mpls-core-ctrl` in which the correct launch sequence is preserved across different start/stop/restart events.

NOTE. In case of failure of any G<sup>2</sup>MPLS daemons a full restart of the controller must be done, due to the lack of process dependency tracking in this preliminary release.

#### 3.3.3.2 G<sup>2</sup>MPLS border controller

The modules needed by a G<sup>2</sup>MPLS border controller are:

- `tnrcd`;
- `lrmd`;
- `scngwsd`;
- `pepgw`
- the python `nccd` and `rcd`
- `g2rsvpted` implementing the G.I-NNI G2.RSVP-TE;
- `g2rsvpted` implementing the G.E-NNI G2.RSVP-TE;
- `ospfd`, i.e. the process implementing the I-NNI G2.OSPF-TE;
- `g2pcerad`, i.e. the process implementing the routing algorithms on the G<sup>2</sup>MPLS multi-domain topologies.
- `nccd`, i.e. the process implementing the VTY interface to the python xCCs modules

A G<sup>2</sup>MPLS border controller can be run with the init script `build/etc/init.d/g2mpls-border-ctrl` in which the correct launch sequence is preserved across different start/stop/restart events.

NOTE. In case of failure of any G<sup>2</sup>MPLS daemons a full restart of the controller must be done, due to the lack of process dependency tracking in this preliminary release.

#### 3.3.3.3 G<sup>2</sup>MPLS edge controller

The modules needed by a G<sup>2</sup>MPLS edge controller are:

- `tnrcd`;
- `lrmd`;
- `scngwsd`;
- `pepgw`
- the python `nccd` and `rcd`
- `g2rsvpted` implementing the G.I-NNI G2.RSVP-TE;
- `g2rsvpted` implementing the G.UNI-N G2.RSVP-TE;
- `ospfd`, i.e. the process implementing the I-NNI G2.OSPF-TE and the UNI flooding of Grid information;

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- g2pcerad, i.e. the process implementing the routing algorithms on the G<sup>2</sup>MPLS multi-domain topologies.
- nccd, i.e. the process implementing the VTY interface to the python xCCs modules

A G<sup>2</sup>MPLS edge controller can be run with the init script `build/etc/init.d/g2mpls-edge-ctrl` in which the correct launch sequence is preserved across different start/stop/restart events.

**NOTE.** In case of failure of any G<sup>2</sup>MPLS daemons a full restart of the controller must be done, due to the lack of process dependency tracking in this preliminary release.

#### 3.3.3.4 G<sup>2</sup>MPLS G.UNI CLIENT controller

The modules needed by a G<sup>2</sup>MPLS G.UNI CLIENT controller are:

- tnrcd, always using a simulator for the Transport Plane;
- lrmd;
- scngwsd;
- pepgw
- the python ccd
- g2rsvpted implementing the G.UNI-C G2.RSVP-TE;
- ospfd, i.e. the process implementing the UNI flooding of Grid information;
- gunigwd, i.e. the process implementing the gateway functionality between the G<sup>2</sup>MPLS protocols and the WS-Agreement interface towards the Grid Middleware.
- the python g2dialer, i.e. an additional module implementing a direct bridging between the application layer (in particular DDSS) and the G<sup>2</sup>MPLS protocols.

A G<sup>2</sup>MPLS G.UNI CLIENT controller can be run with the init script `build/etc/init.d/g2mpls-uniclient-ctrl` in which the correct launch sequence is preserved across different start/stop/restart events.

**NOTE.** In case of failure of any G<sup>2</sup>MPLS daemons a full restart of the controller must be done, due to the lack of process dependency tracking in this preliminary release.

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## 4 G<sup>2</sup>MPLS prototype configuration

The configuration files distributed with the G<sup>2</sup>MPLS prototype represent a simple and not exhaustive reference, released just to let the controller boot and start its operation. A user should customize those configurations and possibly extend them in order to fit his choices about address spaces, functionalities and Control Plane scenarios to implement.

Most of the Control Plane configurations are contained in the configuration files of tnrzd and lrmz. lrmz acts a hub element for all the protocols, in particular the ospfd and the g2rsvpted. For this reason, the launch sequence of the daemons is crucial and must follow the order:

1. tnrzd
2. lrmz
3. scngwd
4. pepgw (where needed, ref. [PH-WP2-D2.8] for detailed scenarios)
5. Python Object Codes
6. g2rsvpted
7. ospfd
8. g2pcerad
9. nccd

Only this order can guarantee the openness of the needed CORBA interfaces and the meaningfulness of the data model information, as explained in sections 3.3.3.1, 3.3.3.2, 3.3.3.3 and 3.3.3.4.

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## 4.1 Transport Plane resources

The Transport Plane data model is stored in TNRC. The `tnrcd.conf` file specifies the location of the equipment. This equipment could be a real Transport Plane equipment or a simulator. In the first case, the `tnrcd` automatically retrieves TN resources from the equipment, while in the latter case (simulator) ports and labels must be declared by the user. The simulator option can be very useful to run the G<sup>2</sup>MPLS Control Plane without connecting to real hardware, a feature that can help the training/learning or the pre-production phases.

Examples of `tnrcd` configuration files for the simulator are provided in the following:

```
!*****NODE 1 - EQUIPMENT CONFIGURATION FILE*****!  
!  
! Enter in TNRC_NODE  
tnrc  
!  
! EQUIPMENT 1  
  
eqpt id 1 addr 1.1.1.1 type simulator opstate up admstate enabled location XXX  
  
! BOARD 1  
board id 1 eqpt-id 1 sw-cap fsc enc-type fiber opstate up admstate enabled  
  
! PORT 0x1101  
port id 0x1101 board-id 1 eqpt-id 1 flags 0 rem-eq-addr 1.1.1.2 rem-portid 1 opstate  
up admstate enabled bw 0x4A99CE3D protection unprotected lambdas-base 0 lambdas-count  
0  
  
! PORT 0x1201  
port id 0x1201 board-id 1 eqpt-id 1 flags 0 rem-eq-addr 1.1.1.2 rem-portid 0x2101  
opstate up admstate enabled bw 0x4A99CE3D protection unprotected lambdas-base 0  
lambdas-count 0  
  
! PORT 0x1301  
port id 0x1301 board-id 1 eqpt-id 1 flags 0 rem-eq-addr 1.1.1.2 rem-portid 0x3101  
opstate up admstate enabled bw 0x4A99CE3D protection unprotected lambdas-base 0  
lambdas-count 0  
  
! PORT 0x1401  
port id 0x1401 board-id 1 eqpt-id 1 flags 0 rem-eq-addr 1.1.1.2 rem-portid 0x4101  
opstate up admstate enabled bw 0x4A99CE3D protection unprotected lambdas-base 0  
lambdas-count 0
```

Code 4-1: A sample `tnrcd` simulator file for Fiber Switching Capable equipments.

```
!*****NODE 1 - EQUIPMENT SIMULATOR CONFIGURATION FILE*****!  
!  
! Enter in TNRC_NODE  
tnrc  
!  
! EQUIPMENT 1  
  
eqpt id 1 addr 150.254.212.137 type simulator opstate up admstate enabled location XXX  
  
! BOARD 1
```

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```
board id 1 eqpt-id 1 sw-cap lsc enc-type lambda opstate up admstate enabled

! PORT 0x1108
port id 4360 board-id 1 eqpt-id 1 flags 0 rem-eq-addr 150.254.212.139 rem-portid 4365
opstate up admstate enabled bw 0x4A99CE3D protection unprotected lambdas-base
0x2900000b lambdas-count 40
resource id 0x24 port-id 4360 board-id 1 eqpt-id 1 type lsc tp-flags 0 opstate up
admstate enabled state free

! PORT 0x110D
port id 4365 board-id 1 eqpt-id 1 flags 0 rem-eq-addr 150.254.212.138 rem-portid 4360
opstate up admstate enabled bw 0x4A99CE3D protection unprotected lambdas-base
0x2900000b lambdas-count 40
resource id 0x24 port-id 4365 board-id 1 eqpt-id 1 type lsc tp-flags 0 opstate up
admstate enabled state free

! PORT 0x110E
port id 4366 board-id 1 eqpt-id 1 flags 0 rem-eq-addr 171.16.50.1 rem-portid 1 opstate
up admstate enabled bw 0x4A99CE3D protection unprotected lambdas-base 0x2900000b
lambdas-count 40
resource id 0x24 port-id 4366 board-id 1 eqpt-id 1 type lsc tp-flags 0 opstate up
admstate enabled state free
```

Code 4-2: A sample tnrcd simulator file for Lambda Switching Capable equipments.

## 4.2 Control Plane logical topology

The Control Plane resources are all maintained by the LRM. In `lrmd.conf` the Control Plane logical topology is detailed in terms of:

- router ID of the `g2mps_controller`
- SCN interfaces used to receive/transmit protocol packets
- Control Channels
- TE-links with their TE attributes (adjacency type, TE metric, colours, SRLGs, TNAs, etc.)
- Data-links (in 1:1 correspondence with those loaded by `tnrcd` and exported at the TNRC's CORBA interface)
- bindings of TE-links with Control Channels
- insertion of Data-links into TE-links.

This information is centralized and used by all the protocols for routing and signalling. Therefore, the `lrmd` configuration file is the larger than the configuration files of the upper protocols, which inherit most of the information from it.

An example of more complex LRM configuration is provided in the following excerpt.

```
!*****NODE 1 - LRM CONFIGURATION FILE*****!
!
!
```

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```

hostname ADVA1_lrmd
password zebra
enable password zebra

log file /home/user01/phosphorus-g2mpls/build/var/lrmd.log

!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
! User specific part (add your commands from here)
!
! starting LRM and entering its context
lrmd
!
router-id 192.168.100.137
router-uni-id 192.168.150.137
!
! INNI control interface
scn-if add ip 192.168.100.137
scn-if en ip 192.168.100.137
!
! UNI control interface
scn-if add ip 192.168.150.137
scn-if en ip 192.168.150.137
!
!
! Adva1 - Adva2
cc add ccid 0x12 scn-ip 192.168.100.137 scn-nbr 192.168.100.138
cc en ccid 0x12
cc up ccid 0x12
!
! Adva1 - Adva3
cc add ccid 0x13 scn-ip 192.168.100.137 scn-nbr 192.168.100.139
cc en ccid 0x13
cc up ccid 0x13
!
! Adva1 TNA
cc add ccid 0x1101 scn-ip 192.168.150.137 scn-nbr 192.168.150.115
cc en ccid 0x1101
cc up ccid 0x1101
!
!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!! TELink Adva1 - Adva2 !!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
te-link-inni add ipv4 1.2.1.1 pref-len 30 nbr-id 192.168.100.138 rem-telink-id 1.2.1.2
te-link bind ipv4 1.2.1.1 pref-len 30 ccid 0x12
te-link en ipv4 1.2.1.1 pref-len 30
!
!! DataLinks !!
data-link add id 0x04011108 nbr-id 0x0401110D
data-link en id 0x04011108
!
!
te-link push ipv4 1.2.1.1 pref-len 30 data-link-id 0x04011108
te-link set ipv4 1.2.1.1 pref-len 30 tem 100
te-link run ipv4 1.2.1.1 pref-len 30
!
!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!! TELink Adva1 - Adva3 !!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

```

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```
te-link-inni add ipv4 1.3.1.1 pref-len 30 nbr-id 192.168.100.139 rem-telink-id 1.3.1.2
te-link bind ipv4 1.3.1.1 pref-len 30 ccid 0x13
te-link en ipv4 1.3.1.1 pref-len 30
!
!! DataLinks !!
data-link add id 0x0401110D nbr-id 0x04011108
data-link en id 0x0401110D
!
te-link push ipv4 1.3.1.1 pref-len 30 data-link-id 0x0401110D
te-link set ipv4 1.3.1.1 pref-len 30 tem 100
te-link run ipv4 1.3.1.1 pref-len 30
!
!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!! TELink TNA !!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
te-link-uni add ipv4 1.101.1.1 pref-len 30 nbr-id 192.168.150.115 rem-telink-id
1.101.1.2
te-link set ipv4 1.101.1.1 pref-len 30 tna 10.10.10.1 pref-len 24
te-link bind ipv4 1.101.1.1 pref-len 30 ccid 0x1101
te-link en ipv4 1.101.1.1 pref-len 30
!
!! DataLink !!
data-link add id 0x0401110E nbr-id 0x04010001
data-link en id 0x0401110E
!
te-link push ipv4 1.101.1.1 pref-len 30 data-link-id 0x0401110E
te-link run ipv4 1.101.1.1 pref-len 30
```

Code 4-3: A sample Irmcd configuration file.

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## 5 Demonstrations of G<sup>2</sup>MPLS Control Plane

This chapter presents the multi-domain heterogeneous optical test-bed using the G<sup>2</sup>MPLS Control Plane that has been used in the public demonstrations and experiments during Supercomputing 2008 (Austin-TX, USA on 16-21 November 2008) and the ICT'08 (Lyon-FR, EU, on 25-27 November 2008).

The demonstrations have been focused on the DDSS application for remote anycast storage of data contents. This application built in the framework of Phosphorus WP3 has been interfaced to the G<sup>2</sup>MPLS Control Plane, and the Phosphorus Integrated model with anycasting has been successfully demonstrated (ref. [PH-WP2-D2.1]).

### 5.1 G<sup>2</sup>MPLS test-bed topology

The G<sup>2</sup>MPLS Control Plane has been run in two local test-beds, PSNC-PIONIER (Poland) and UESSEX (UK), interconnected through the GÉANT2 network (ref. Figure 5-1). Two types of switching capabilities have been demonstrated in the two administrative domains:

- the Fiber Switching Capability (FSC) in UESSEX test-bed, built around one Calient Diamond Wave Fiber Connect equipment partitioned into four independent fiber-switching sub-nodes for Control Plane purposes. Each sub-switch has been interconnected with bi-directional optical fibers to the other sub-switches to realize a fully meshed topology. Each sub-switch has been controlled by a G<sup>2</sup>MPLS controller running the appropriate instance of G<sup>2</sup>MPLS Control Plane (edge, core or border node). The four controllers have been connected through a dedicated 1GbE local area network, which constitutes the Signaling Control Network (SCN) for the G<sup>2</sup>MPLS Control Plane.
- the Lambda Switching Capability (LSC) in PSNC-PIONIER test-bed, based on an optical DWDM ring with three ADVA FSP 3000RE-II ROADMs. These equipments have been inter-connected with bi-directional optical fibers and the DWDM system configured to hold up to 40 wavelengths. Each ROADM has been controlled by a G<sup>2</sup>MPLS controller running the appropriate instance of G<sup>2</sup>MPLS Control Plane (edge, core or border node). These three controllers have been connected through a dedicated 1GbE local area network implementing the SCN.

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The two test-beds have been completed with the respective G.UNI clients towards the application/Grid layer equipments: one client in PSNC, another client and two servers in UESSEX.

The interconnection between the two test-beds has been implemented through VLAN switching on a GÉANT2 connection between PSNC and UESSEX laboratories (ref. WP6 topologies for details). Each inter-domain TE-link has been mapped into a specific VLAN, as well as the SCN which has been mapped into another VLAN. These configurations have been treated completely opaque at G<sup>2</sup>MPLS level and under the control of WP6 test-bed operators.

The final SCN topology resulting from this process is depicted in Figure 5-2.

## 5.2 Configurations of the G<sup>2</sup>MPLS controllers

Different types of G<sup>2</sup>MPLS controllers have been demonstrated in the Phosphorus testbed, according to the logical topology shown in Figure 5-3.

A dedicated folder in the released prototype (`/home/user01/phosphorus-g2mpls/G2MPLS-DEMOS`) contains all the configuration files of the G<sup>2</sup>MPLS modules run on each node. The purpose of this directory is to provide a reference for G<sup>2</sup>MPLS users about the commands needed to setup the G<sup>2</sup>MPLS Control Plane in this complex multi-domain scenario.

An executive description of the G<sup>2</sup>MPLS capabilities demonstrated in the Phosphorus testbed is provided in the form of a video clip on the Phosphorus website (<http://www.ist-phosphorus.eu/documents.php>).

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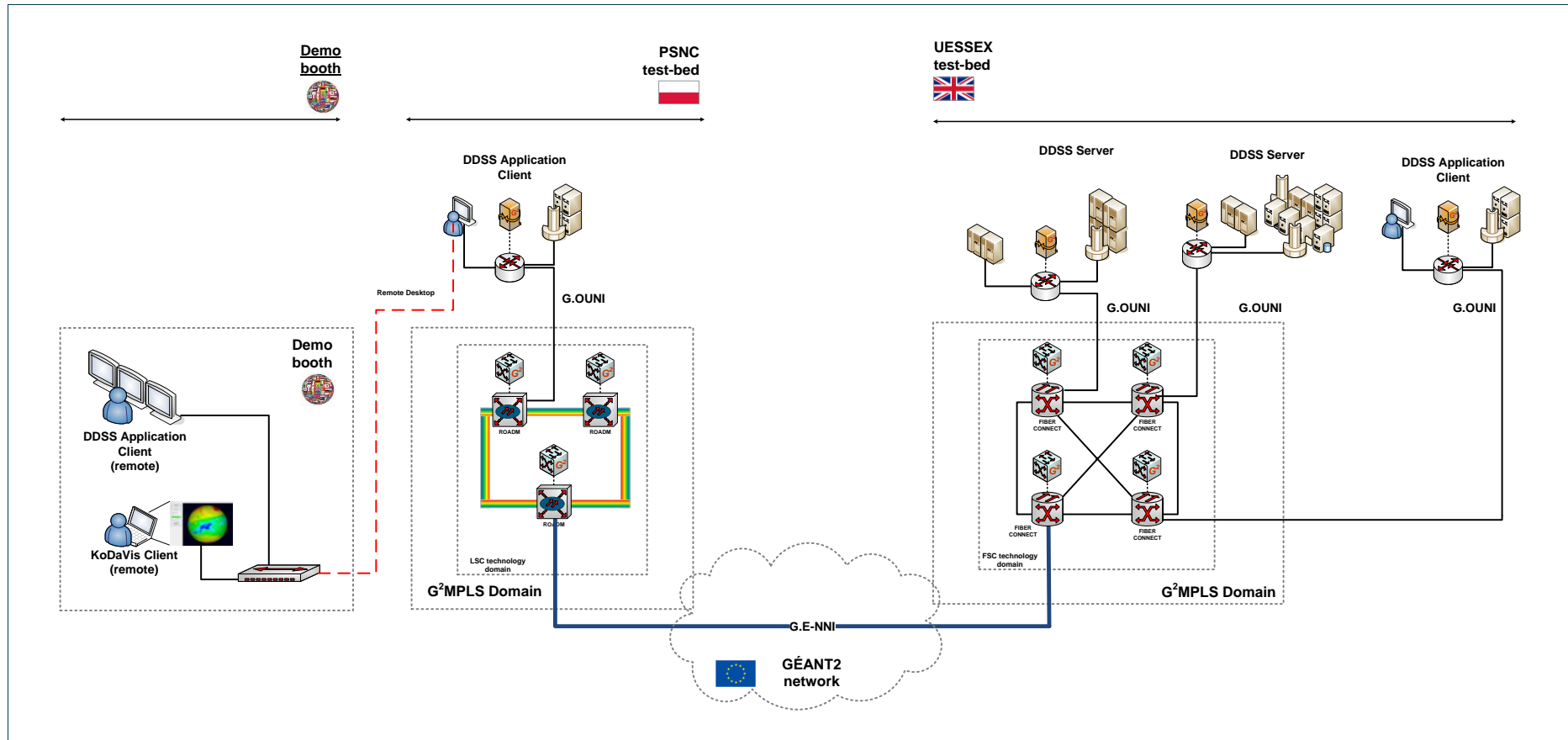


Figure 5-1: Phosphorus G<sup>2</sup>MPLS testbed: physical layout.

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Final Grid-GMPLS Control Plane prototype

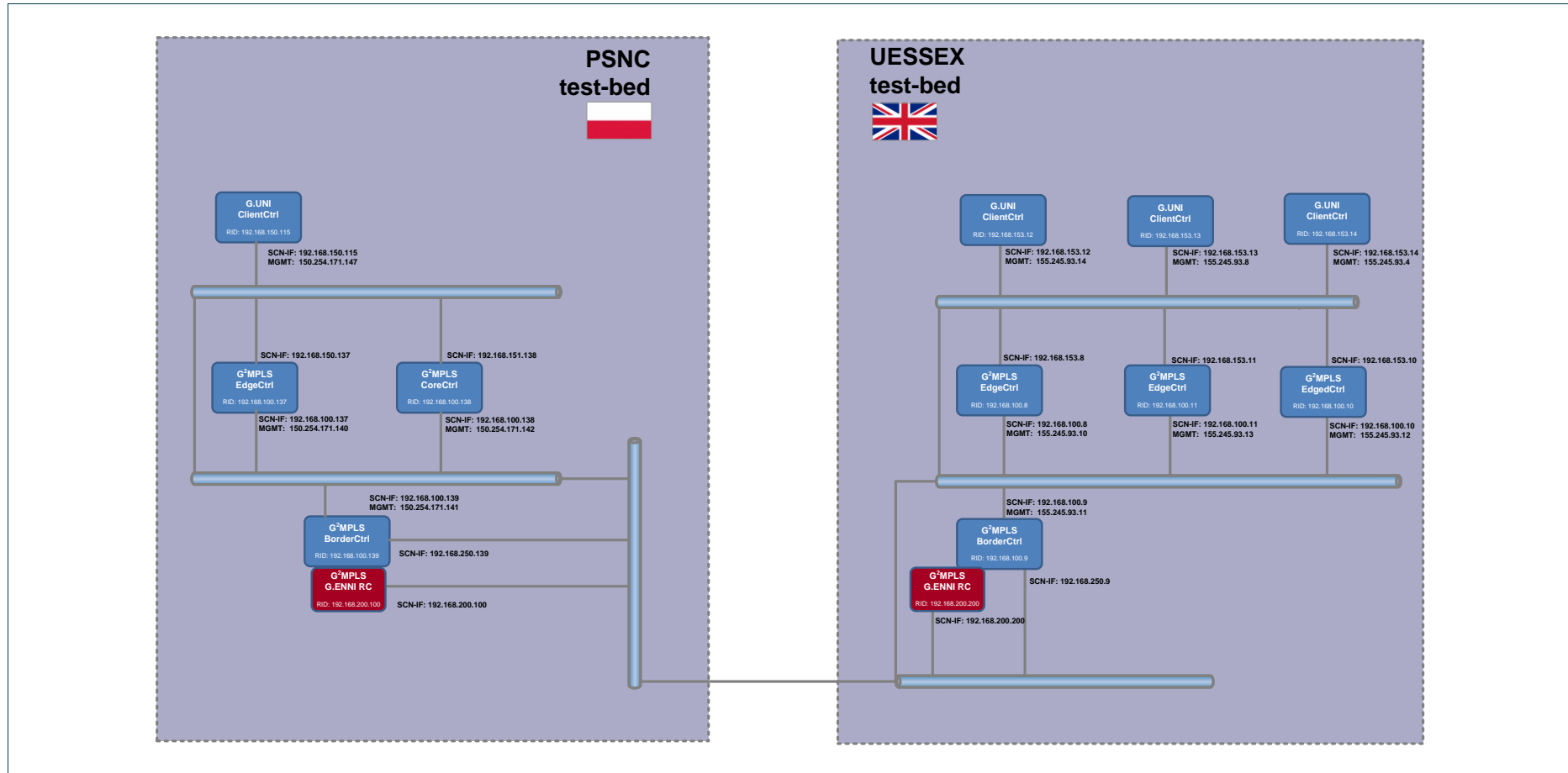


Figure 5-2: Phosphorus G<sup>2</sup>MPLS testbed: SCN topology.

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## 6 References

The references listed here are only those directly functional to this document. For a list of the references to standards appearing in this document, please point to D2.1, D2.2, D2.3, D2.4, D2.6 and D2.7.

<b>[PH-WP2-D2.1]</b>	Phosphorus deliverable D2.1, "The Grid-GMPLS Control Plane architecture".
<b>[PH-WP2-D2.2]</b>	Phosphorus deliverable D2.2, "Routing and Signalling Extensions for the Grid-GMPLS Control Plane".
<b>[PH-WP2-D2.3]</b>	Phosphorus deliverable D2.3, "Grid-GMPLS high level system design".
<b>[PH-WP2-D2.4]</b>	Phosphorus deliverable D2.4, "Report on Grid-GMPLS Control Plane functional tests".
<b>[PH-WP2-D2.5]</b>	Phosphorus deliverable D2.5, "Preliminary Grid-GMPLS Control Plane prototype".
<b>[PH-WP2-D2.6]</b>	Phosphorus deliverable D2.6, "Deployment models and solutions of the Grid-GMPLS Control Plane".
<b>[PH-WP2-D2.7]</b>	Phosphorus deliverable D2.7, "Grid-GMPLS network interfaces".
<b>[PH-WP2-D2.8]</b>	Phosphorus deliverable D2.8, "Design of the Grid-GMPLS Control Plane to support the Phosphorus Grid AAI".
<b>[PH-WP2-D2.9]</b>	Phosphorus deliverable D2.9, "Design of Grid-GMPLS interworking with NRPS".
<b>[QUAGGA-DOC]</b>	The Quagga Software Routing Suite documentation. <a href="http://www.quagga.net/docs/docs-info.php">http://www.quagga.net/docs/docs-info.php</a>
<b>[CORBA]</b>	<a href="http://www.corba.org/">http://www.corba.org/</a>
<b>[omniORB]</b>	<a href="http://omniorb.sourceforge.net/">http://omniorb.sourceforge.net/</a>

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## 7 Acronyms

<b>AAA</b>	Authentication, Authorisation, and Accounting
<b>AAI</b>	Authentication and Authorization Infrastructure
<b>ANSI</b>	American National Standards Institute
<b>API</b>	Application Programming Interface
<b>ARGON</b>	Allocation and Reservations in Grid-enabled Optical Networks
<b>ASON</b>	Automatically Switched Optical Network
<b>BB</b>	Bandwidth Broker
<b>BGRP</b>	Border Gateway Reservation Protocol
<b>BoD</b>	Bandwidth on Demand
<b>BR</b>	Border Router
<b>CE</b>	Computing Element
<b>CIM</b>	Computer Integrated Manufacturing
<b>COPS</b>	Common Open Policy Protocol
<b>CORBA</b>	Common Object Request Broker Architecture
<b>CP</b>	Control Plane
<b>CPE</b>	Customer Premises Equipment
<b>CPU</b>	Central Processing Unit
<b>CR-LDP</b>	Constraint-based Label Distribution Protocol
<b>DCM</b>	Distributed Call and Connection Management
<b>DCN</b>	Data Communication Network
<b>DRAC</b>	Dynamic Resource Allocation Controller
<b>DVB</b>	Digital Video Broadcasting
<b>DWDM</b>	Dense Wavelength Division Multiplexing
<b>EGEE</b>	Enabling Grids for E-science
<b>EC</b>	European Commission
<b>EMS</b>	Execution Management Services
<b>E-NNI</b>	Exterior NNI
<b>ERO</b>	Explicit Route Object
<b>ETSI</b>	European Telecommunications Standards Institute
<b>EU</b>	European Union
<b>FCAPS</b>	Fault, Configuration, Accounting, Performance, Security

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<b>G.CR-LDP</b>	G <sup>2</sup> MPLS CR-LDP
<b>G.OSPF-TE</b>	GMPLS OSPF-TE
<b>G.OUNI</b>	Grid OUNI
<b>G.OUNI-C</b>	G.OUNI - Client
<b>G.OUNI-N</b>	G.OUNI - Network
<b>G.RSVP-TE</b>	GMPLS RSVP-TE
<b>G<sup>2</sup>MPLS</b>	Grid-GMPLS (enhancements to GMPLS for Grid support)
<b>GE</b>	Gigabit Ethernet
<b>GÉANT</b>	Pan-European Gigabit Research Network
<b>GGF</b>	Global Grid Forum
<b>GHPN</b>	Grid High Performance Networking
<b>GIS</b>	Grid Information Service
<b>GLUE</b>	Grid Laboratory Uniform Environment
<b>GMPLS</b>	Generalized MPLS
<b>GNS</b>	Grid Network Service
<b>GRAM</b>	Grid Resource Allocation and Management
<b>GSMP</b>	General Switch Management Protocol
<b>HW</b>	Hardware
<b>IANA</b>	Internet Assigned Numbers Authority
<b>IDM</b>	GÉANT2 Inter-domain Manager
<b>IEC</b>	International Electrotechnical Commission
<b>IEEE</b>	Institute of Electrical and Electronics Engineers
<b>IETF</b>	Internet Engineering Task Force
<b>IGP</b>	Interior Gateway Protocol
<b>I-NNI</b>	Interior NNI
<b>IP</b>	Internet Protocol
<b>IPR</b>	Intellectual Property Right
<b>IPSec</b>	IP security
<b>IPv4</b>	Internet Protocol Version 4
<b>IPv6</b>	Internet Protocol Version 6
<b>IS-IS</b>	Intermediate System to Intermediate System
<b>ITU</b>	International Telecommunication Union
<b>JSDL</b>	Job Submission Description Language
<b>LAN</b>	Local Area Network
<b>LDP</b>	Label Distribution Protocol
<b>LRMS</b>	Local Resource Management System
<b>LSA</b>	Link State Advertisement
<b>LSDB</b>	Link State Database
<b>LSP</b>	Label Switched Path
<b>LSR</b>	Label Switch Router
<b>MAC</b>	Media Access Control
<b>MAN</b>	Metropolitan Area Network
<b>MP</b>	Management Plane

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<b>MPLS</b>	Multi Protocol Label Switching
<b>MPI</b>	Message Passing Interface
<b>NCP</b>	Network Control Plane
<b>NJS</b>	Network Job Supervisor
<b>NMS</b>	Network Management System
<b>NNI</b>	Network to Network Interface
<b>NO</b>	Network Operator
<b>NREN</b>	National Research and Education Network
<b>NRPS</b>	Network Resource Provisioning Systems
<b>NSAP</b>	Network Service Access Point
<b>NSP</b>	Network Service Plane
<b>NTP</b>	Network Time Protocol
<b>OAM</b>	Operations, Administration and Maintenance
<b>OGF</b>	Open Grid Forum
<b>OGSA</b>	Open Grid Services Architecture
<b>OIF</b>	Optical Internetworking Forum
<b>OS</b>	Operating System
<b>OSPF</b>	Open Shortest Path First protocol
<b>OSPF-TE</b>	OSPF with Traffic Engineering extensions
<b>O-UNI</b>	Optical UNI
<b>P2MP</b>	Point to Multi Point
<b>PON</b>	Passive Optical Network
<b>POSIX</b>	Portable Operating System Interface
<b>QoS</b>	Quality of Service
<b>RC</b>	Routing Controller
<b>RFC</b>	Request for Comments
<b>RSVP</b>	Resource reSerVation Protocol
<b>RSVP-TE</b>	RSVP with Traffic Engineering extensions
<b>RTP</b>	Real-time Transport Protocol
<b>SDO</b>	Standard Developing Organizations
<b>SE</b>	Storage Element
<b>SLA</b>	Service Level Agreement
<b>SLS</b>	Service Level Specification
<b>SME</b>	Small and Medium Enterprise
<b>SNMP</b>	Simple Network Management Protocol
<b>SOAP</b>	Simple Object Access Protocol
<b>SP</b>	Service Provider
<b>SPF</b>	Sender Policy Framework
<b>SW</b>	Software
<b>TE</b>	Traffic Engineering
<b>TGC</b>	Trusted Computing Group
<b>TL-1</b>	Transaction Language 1
<b>TLS</b>	Transport Layer Security

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<b>TLV</b>	Type-Length-Value protocol fields
<b>TMF</b>	Tele Management Forum
<b>TN</b>	Transport Network
<b>TO</b>	Telecom Operator
<b>TP</b>	Transport Plane
<b>UCLP</b>	User-Controlled Lightpath Provisioning system
<b>UNI</b>	User to Network Interface
<b>UML</b>	Unified Modeling Language
<b>URI</b>	Uniform Resource Identifier
<b>VLAN</b>	Virtual LAN
<b>VM</b>	Virtual Machine
<b>VPN</b>	Virtual Private Network
<b>WAN</b>	Wide Area Network
<b>WG</b>	Working Group
<b>WP</b>	Work Package
<b>WS</b>	Web Service
<b>XML</b>	Extensible Markup Language

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