# IPv6 Deployments within RCTS

## Best Practice Document

# Table of Contents

# Table of Figures

# Table of Tables

# Executive Summary

This document provides a view about IPv6 deployment at RCTS, the Science Technology & Society Network, which is the Portuguese National Research and Education Network (NREN), managed by FCCN, as a unit of FCT, I.P.

Efforts to deploy IPv6 in the Portuguese R&E network are several years old, but there is clearly still a lot of work to be done to achieve full deployment. IPv6 traffic levels at RCTS when compared to IPv4's levels are beginning to be interesting. On a daily-basis, IPv6 accounts for 5% of RCTS' total traffic in average, with occasional peaks of up to 15%.

RCTS (as of December 2014) has 77 members, of which only 34 have an enabled IPv6 gateway. RCTS connects 42 higher education organisations (Universities and Polytechnic Institutes), of which 24 have IPv6 connectivity (57%). The other 10 RCTS members who also have IPv6 represent 29% coverage in a universe of 35 organisations (Governmental organisations, Research Institutes and Associated Laboratories). In terms of domains, the total 77 RCTS members account for 68 distinct DNS domains (some members are in fact secondary campuses, thus sharing the same DNS domain with their headquarters).

As IPv6 has been present for many years in the RCTS backbone, its increased usage only depends on campus deployments, and IPv6-enabled external applications/content used by campus users. With this document, we intend to encourage by example organisations that haven't started their IPv6 deployment yet. It is worth noticing that IPv6 deployment outside of RCTS will benefit RCTS' own deployment, by moving more traffic from IPv4 to IPv6.

# 1   Introduction

RCTS was the third NREN to connect natively to the GÉANT network in 2003. There was significant previous work about IPv6, namely using IPv6 over IPv4 tunnels to obtain IPv6 connectivity with other NRENs. Transition mechanisms such as 6to4, a tunnelbroker and a Teredo relay have been deployed, but were all discontinued after 2012.

Static tunnels (to provide IPv6 connectivity to member organisations) were also discontinued when native IPv6 connectivity became possible. This change was caused either by peer/supplier readiness or through improved hardware and software support.

RCTS' backbone is nowadays mostly Cisco-based. Its design is focused on a strict separation of IP and Ethernet layers. Historically, the decommissioning of Serial, POS and ATM links and the convergence towards Ethernet, paved the way for an easier and simpler IPv6 deployment.

Accounting is a feature we find to be most important, and in that regard we originally designed all IPv6 gateways to member organisations to be on separate physical interfaces at the aggregation points. Only with routers running Cisco IOS-XR software and proper SNMP MIB support, were we able to start converging IPv4 and IPv6 gateways for the same member organisation – while keeping the ability to correctly count IPv4 and IPv6 packets, and their respective size.

# 2 Basic Internet Services

This section will cover considerations about DNS, Web and E-mail, the three basic Internet services. The content is mostly based on member organisations' IPv6 deployment. Internet services deployment tends to be distributed, which is positive for resilience, but requires every domain to support IPv6, in order to have all services using the new protocol version.

The hostnames and addresses below were collected using bash/perl scripts that consider the main DNS domain of every RCTS member. The table at Annex A contains RCTS members' names and their respective main DNS domain – some members are in fact secondary campuses, so the total number of distinct domains is 68. The third column indicates if the member is already connecting to RCTS using IPv6, or not.

## 2.1 DNS

The domain name system is one of Internet's key building blocks. It provides for naming/address conversions. DNS is probably the simplest service where an organisation has to perform IPv6 deployment.

The following table contains a list of forty nine IPv6-enabled nameservers, grouped by organisation (23 organisations).

| Name | IPv4 Address | IPv6 Address |
|------|--------------|--------------|
| ns03.fccn.pt. | 138.246.255.249 | 2001:4ca0:106:0:250:56ff:fea9:3fd |
| ns.utl.pt. | 193.136.102.161 | 2001:690:2100:fffe::1 |
| ns2.utl.pt. | 193.136.102.162 | 2001:690:2100:fffe::2 |
| io.ipb.pt. | 193.136.195.219 | 2001:690:22c0:201::3 |
| elara.ipb.pt. | 193.136.195.220 | 2001:690:22c0:201::2 |
| esel-ns01.esel.pt. | 193.137.135.197 | 2001:690:21ec:15::11 |
| esel-ns02.esel.pt. | 193.137.135.198 | 2001:690:21ec:15::12 |
| pintasilgo.ipt.pt. | 193.137.236.212 | 2002:c189:ecd4::c189:ecd4 |
| ns1.net.ipl.pt. | 192.104.48.16 | 2001:690:2008::100:1001 |

| Name | IPv4 Address | IPv6 Address |
|------|-------------|--------------|
| ns.dns.pt. | 193.136.0.1 | 2001:690:a00:1016:905::1 |
| lepus.lnec.pt. | 193.136.104.17 | 2001:690:2140:8000::6:17 |
| orion.lnec.pt. | 193.136.104.22 | 2001:690:2140:8000::6:22 |
| ns1.ist.utl.pt. | 193.136.128.1 | 2001:690:2100:1::53:1 |
| ns2.ist.utl.pt. | 193.136.128.2 | 2001:690:2100:1::2 |
| dns1.iscte.pt. | 193.136.188.1 | 2001:690:21a0:1010::11 |
| dns3.iscte.pt. | 193.136.188.4 | 2001:690:21a0:1010::10 |
| ns01.fccn.pt. | 193.136.192.40 | 2001:690:a00:4001::200 |
| ns02.fccn.pt. | 193.136.2.228 | 2001:690:a80:4001::200 |
| ns.uevora.pt. | 193.136.216.18 | 2001:690:2006:200::18 |
| ns2.uevora.pt. | 193.136.216.19 | 2001:690:2006:200::19 |
| dns.ualg.pt. | 193.136.224.1 | 2001:690:2050::a |
| dns2.ualg.pt. | 193.136.224.2 | 2001:690:2050::b |
| dragoeiro.uma.pt. | 193.136.232.1 | 2001:690:20b0:1::1 |
| dns4.up.pt. | 193.136.37.10 | 2001:690:2200:910::10 |
| dns2.ubi.pt. | 193.136.64.34 | 2001:690:2300:6::1:34 |
| dns1.ubi.pt. | 193.136.66.185 | 2001:690:2300:6::1:5 |
| dns.uportu.pt. | 193.136.79.100 | 2001:690:2340:0:193:136:79:100 |
| dns2.uminho.pt. | 193.137.16.145 | 2001:690:2280:801::145 |
| dns3.uminho.pt. | 193.137.16.65 | 2001:690:2280:1::65 |
| dns.uminho.pt. | 193.137.16.75 | 2001:690:2280:1::75 |
| ns-1.uc.pt. | 193.137.200.1 | 2001:690:2180:3::1 |
| fctdns2.fct.pt. | 193.137.21.194 | 2001:690:2178:2000::5 |
| isis2.fct.pt. | 193.137.21.221 | 2001:690:2178:2000::6 |
| ns2.net.ipl.pt. | 193.137.220.12 | 2001:690:2008::101:1001 |
| twinone.ipg.pt. | 193.137.232.2 | 2001:690:23d0:b000::2 |
| twintwo.ipg.pt. | 193.137.232.3 | 2001:690:23d0:b000::3 |
| ubik.ipg.pt. | 193.137.232.7 | 2001:690:23d0:b000::7 |
| dns3.up.pt. | 193.137.35.100 | 2001:690:2200:b10::100 |
| ns3.ipt.pt. | 193.137.5.209 | 2001:690:2120::c189:5d1 |

| Name | IPv4 Address | IPv6 Address |
|------|--------------|--------------|
| viriato.ipt.pt. | 193.137.5.6 | 2001:690:2120::c189:5ff |
| lusitano.ipt.pt. | 193.137.5.8 | 2001:690:2120::c189:508 |
| dns1.up.pt. | 193.137.55.20 | 2001:690:2200:a10::20 |
| dns2.up.pt. | 193.137.55.21 | 2001:690:2200:a10::21 |
| ns.iict.pt. | 193.137.6.1 | 2001:690:21fc:5110::2 |
| ns.ipcb.pt. | 193.137.66.129 | 2001:690:2260:101::1:1 |
| vdns1.ipsantarem.pt. | 193.137.98.132 | 2001:690:2070:8000::32 |
| vdns.ipsantarem.pt. | 193.137.98.135 | 2001:690:2070:8000::35 |
| a.ul.pt. | 194.117.0.150 | 2001:690:21c0:a::150 |
| b.ul.pt. | 194.117.1.150 | 2001:690:21c0:b::150 |

Table 2.1: IPv6-enabled nameservers grouped by organisation

It must be noted that only two of this set of servers are using IPv6 addresses outside of RCTS' 2001:690::/29 allocated address block (originally in June 2000, as 2001:690::/35 and later expanded into 2001:690::/32 and 2001:690::/29). One of those two servers is a secondary server installed at a German University after a secondary server swap was agreed with FCCN. The other non-2001:690 IPv6 address is from the 6to4, block, and should be fixed and migrated to a 2001:690 address, as soon as possible.

Most of these DNS servers are running BIND or Microsoft software. FCCN is running BIND 9. BIND versions 9.9.5 and 9.9.6 usage was mentioned by some of our members.

The number of organisations which have made their authoritative DNS servers available over IPv6 is still low (23), when we compare to the total number of organisations connected to RCTS (77), representing only 30%. This, however, is the higher percentage of coverage in terms of basic services, mainly due to the fact that a single authoritative DNS server can cover for multiple domains.

## 2.2   Web

Web presence is of utmost importance for higher education organisations. Web services nowadays have some degree of complexity, but in terms of IPv6 reachability, only frontend systems are relevant.

The following table contains a list of IPv6-enabled main organisation webservers – 15 in total, which account for 22% of the 68 domains.

| Name | IPv4 Address | IPv6 Address |
|------|--------------|--------------|
| titan.ipb.pt. | 193.136.195.224 | 2001:690:22c0:201::4 |
| www.esel.pt | 193.137.135.184 | 2001:690:21ec::2 |

| Name | IPv4 Address | IPv6 Address |
|------|-------------|-------------|
| www.fccn.pt | 193.137.196.247 | 2001:690:a00:1036:1113::247 |
| sdwsites.net.ipl.pt. | 192.68.221.250 | 2001:690:2008:e120::100:5250 |
| puppis.lnec.pt. | 193.136.104.30 | 2001:690:2140:8000::6:30 |
| arachne.uevora.pt. | 193.136.216.21 | 2001:690:2006:200::21 |
| www.ualg.pt | 193.136.224.39 | 2001:690:2050::12 |
| barracuda.uma.pt. | 193.136.232.93 | 2001:690:20b0:1001:20::12 |
| www.upt.pt | 193.136.79.163 | 2001:690:2340:0:193:136:79:163 |
| www.dns.pt | 193.137.196.42 | 2001:690:a00:1036:1216::42 |
| joshua.ipg.pt. | 193.137.232.4 | 2001:690:23d0:b000::4 |
| albatroz.ipt.pt. | 193.137.5.12 | 2001:690:2120:0:213:21ff:fe6b:405 |
| www.up.pt | 193.137.55.13 | 2001:690:2200:a10::13 |
| ul-web01.ul.pt. | 194.117.3.18 | 2001:690:21c0:71::18 |
| fenix.iscte.pt | 193.136.188.28 | 2001:690:21a0:1010::28 |

Table 2.2: IPv6-enabled main organisation webservers

Only 15 organisations are currently publishing an IPv6 address for their main website (accounting for 20% of RCTS connected organisations). There is a variety of approaches, being that some use their www domain directly and some redirect it to other hostnames.

The software used to run such webserver varies mainly between Apache, NGINX and Microsoft IIS.

NGINX is used in some cases to provide IPv6 reachability to websites built over webserver software without IPv6 support. HAProxy is another open-source software package that can be used for the same purposes.

From a small survey held within our community, several sub-domains were mentioned, as having an IPv6-enabled webserver. The following websites are examples: www.estig.ipb.pt, www.ese.ipb.pt, www.esact.ipb.pt, www.essa.ipb.pt, tecnico.ulisboa.pt (more than 100 websites).


## 2.3    E-mail


Electronic mail is one of the most relevant services provided by Campus Network managers. Enabling IPv6 in your e-mail system is a more challenging job when compared to other basic Internet services.

This service is heavily divided into two parts: the ability to send messages and the ability to receive messages.

Regarding the first part, assuring that your Mail Transfer Agent's (MTA's) addresses (either IPv4 or IPv6) don't fall on bad reputation lists is very important. When receiving messages, if you have an anti-spam system you need to also consider its IPv6 support capabilities. Some organisations may circumvent the usage of anti-spam systems to their IPv6-capable MTAs, but in the medium-to-long term, this is a bad choice, as you should apply the same rules/measures, independently of the IP version being used.

Table 2.3 contains a list of IPv6-enabled MTAs from RCTS connected organisations.

| Name | IPv4 Address | IPv6 Address |
|---|---|---|
| cccm.pt.mxa.mpsmx.net. | 195.22.26.202 | 2001:4cc0:2:e::72 |
| ipma.pt.mxa.mpsmx.net. | 195.22.26.202 | 2001:4cc0:2:e::72 |
| uma.pt.mxa.mpsmx.net. | 195.22.26.202 | 2001:4cc0:2:e::72 |
| evunix.uevora.pt. | 193.136.216.1 | 2001:690:2006:200::1 |
| mailrelay1.net.ipl.pt. | 192.104.48.8 | 2001:690:2008::100:2001 |
| mailrelay2.net.ipl.pt. | 192.104.48.9 | 2001:690:2008::100:2002 |
| si-ssmtp3.ualg.pt. | 193.136.224.12 | 2001:690:2050::11 |
| si-ssmtp4.ualg.pt. | 193.136.224.11 | 2001:690:2050::14 |
| app01.fccn.pt. | 193.137.198.36 | 2001:690:2080:8005::1002 |
| app02.fccn.pt. | 193.137.198.37 | 2001:690:2080:8005::1004 |
| sx3.ipt.pt. | 193.137.5.30 | 2001:690:2120::c189:51e |
| orion.lnec.pt. | 193.136.104.22 | 2001:690:2140:8000::6:22 |
| mx01.ul.pt. | 194.117.3.98 | 2001:690:21c0:74::98 |
| mx02.ul.pt. | 194.117.3.99 | 2001:690:21c0:74::99 |
| mx03.ul.pt. | 194.117.42.37 | 2001:690:21c0:f602::37 |
| mx04.ul.pt. | 194.117.42.38 | 2001:690:21c0:f602::38 |
| mail.iict.pt. | 193.137.6.3 | 2001:690:21fc:5100::5 |
| relay1.up.pt. | 193.137.55.26 | 2001:690:2200:a10::26 |
| relay2.up.pt. | 193.137.55.27 | 2001:690:2200:a10::27 |
| neptune.ipb.pt. | 193.136.195.215 | 2001:690:22c0:201::215 |
| mail.uportu.pt. | 193.136.79.102 | 2001:690:2340:0:193:136:79:102 |
| mail02.fccn.pt. | 193.136.2.227 | 2001:690:a80:4001::500 |
| aspmx5.googlemail.com. | 74.125.142.26 | 2607:f8b0:4001:c03::1a |
| aspmx4.googlemail.com. | 64.233.168.27 | 2607:f8b0:4003:c07::1a |

| Name | IPv4 Address | IPv6 Address |
|------|--------------|--------------|
| aspmx3.googlemail.com. | 74.125.25.27 | 2607:f8b0:400e:c03::1a |
| alt2.aspmx.l.google.com. | 74.125.25.26 | 2607:f8b0:400e:c03::1b |
| aspmx.l.google.com. | 64.233.166.26 | 2a00:1450:400c:c01::1b |
| alt1.aspmx.l.google.com. | 64.233.161.27 | 2a00:1450:4010:c01::1a |
| aspmx2.googlemail.com. | 64.233.161.26 | 2a00:1450:4010:c01::1a |

Table 2.3: MTAs from RCTS-connected organisations

From a total of 27 servers (29 are in the table, but the first three only have different DNS names), 19 are located within RCTS, and they are spread across 11 different organisations. The fact that seven servers (MTAs) are hosted by third parties (i.e. outside RCTS) should be highlighted. These IPv6-capable MTAs are hosted by Google (2a00:1450 and 2607:f8b0) and Claranet Portugal (2001:4cc0).

The software used in most IPv6-enabled MTAs (within RCTS) is mostly Microsoft Exchange, Sendmail, Exim and Postfix. FCCN is running AnubisNetworks, which is an integrated anti-spam solution. Other software being run at RCTS members' infrastructures include ASSP (Anti-Spam SMTP Proxy), an open-source, Perl-based project.

Mail Delivery Agents (MDAs) are also a relevant component. In this regard, Dovecot, an IPv6-compatible open-source software is used. A known IPv6-compatible alternative is Courier-maildrop. In some cases, traffic between MTAs and MDAs are exclusively IPv6. This is however, internal campus traffic, and its volume is invisible from the outside world.

MDAs are significantly harder to discover from the outside than MTAs. Table 2.4 contains the result of queries to mail.<domain>, pop.<domain> and imap.<domain>. Simple variations to hostnames like mail0 or pop3 will make those -- eventually dual-stack -- servers, invisible to this effort.

| Name | Hostname scanned | IPv4 Address | IPv6 Address |
|------|------------------|--------------|--------------|
| esel-mailnlb01.esel.pt. | pop; imap | 193.137.135.196 | 2001:690:21ec::2 |
| evunix.uevora.pt. | mail; pop | 193.136.216.1 | 2001:690:2006:200::1 |
| imap.fccn.pt. | pop; imap | 193.137.198.78 | 2001:690:2080:8003::1500 |
| mail.iict.pt. | mail | 193.137.6.3 | 2001:690:21fc:5100::5 |
| mail.up.pt. | mail | 193.137.55.11 | 2001:690:2200:a10::11 |
| mail.upt.pt. | mail | 193.136.79.102 | 2001:690:2340:0:193:136:79:102 |
| ns2.utl.pt. | mail | 193.136.102.162 | 2001:690:2100:fffe::2 |
| sorveira.uma.pt. | pop; imap | 193.136.232.97 | 2001:690:20b0:1001:1::52 |

Table 2.4: IP addresses for certain Mail Delivery Agents

Best Practice Document:
IPv6 Deployments within RCTS

# 3 Other Services

## 3.1 Network Time Protocol (NTP)

RCTS' Network Time Protocol is built over four Stratum 1 servers, which are IPv6-enabled and connected to GPS antennas. Two of them are installed at Lisbon, one at Oporto and another at Coimbra, Portugal. The Lisbon location is LNEC; Oporto's location is the Engineering Faculty of University of Porto; and the Coimbra server is hosted at University of Coimbra. Additionally, there is a fifth Stratum 1 server, which is not IPv6-enabled yet, connected to an atomic clock, under the organisation that manages the legal hour (oal.ul.pt – Lisbon's Astronomic Observatory).

For RCTS members, only one of the Stratum 1 servers in Lisbon is available (a Linux-based appliance from Meinberg), along with three other IPv4-only  Stratum 2 servers. These servers are built over Cisco backbone routers running IOS, but with the current trend to enable IOS-XR, it is foreseeable that these NTP services' queries will start to be answered over IPv6.

## 3.2 Mirrors (FTP, HTTP)

FTP and HTTP mirrors generate significant amount of outbound traffic, independently of the IP version being used. Inside RCTS members' campus networks several mirrors exist. In terms of content, operating systems are a great contributor to high levels of traffic. ftp.tecnico.ulisboa.pt, ftp.uevora.pt, mirrors.net.ipl.pt and mirrors.fe.up.pt are some of the most used dual-stack mirrors.

Figure 3.1 show that mirrors.fe.up.pt is measuring the amount of traffic being used in each protocol version:
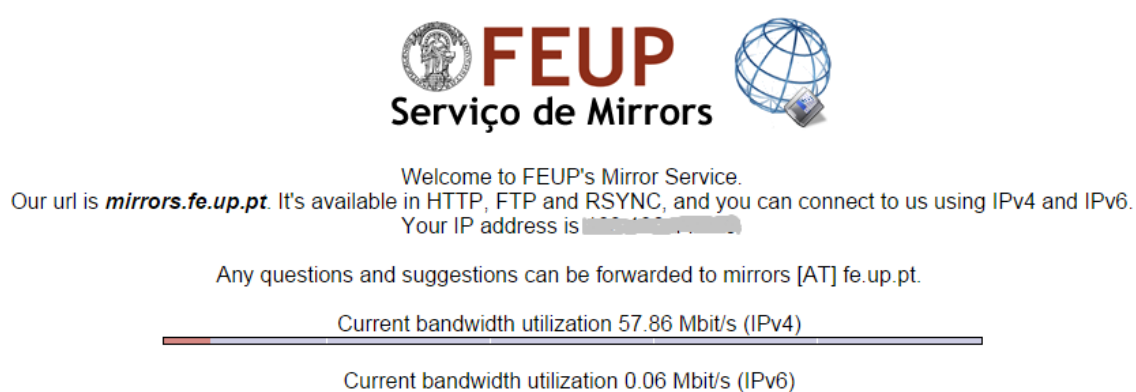


Figure 3.1: FEUP's measurement of IPv4 and IPv6 utilization

## 3.3 **Filesender**

FileSender is a web based application that allows authenticated users to securely and easily send arbitrarily large files to other users. Authentication of users is provided through SimpleSAMLphp, supporting SAML2, LDAP, RADIUS and more. The software's purpose is to allow the sending of a large file to someone, have that file available for download for a certain number of downloads and/or a certain amount of time, followed by the file's deletion. The software is not intended to provide a permanent file publishing platform.

RCTS has a FileSender service available at filesender.fccn.pt (using 193.136.192.125 and 2001:690:a00:4001::125). Due to the nature of this service, its increased usage might generate more IPv6 traffic. The following picture shows the service's web interface.



Figure 3.2: Web interface for Filesender

## 3.4 **Other Services**

Active Directory, LDAP and Kerberos services are also IPv6-enabled at University of Lisbon, namely to serve the tecnico.ulisboa.pt domain. The routing service at the same domain is also IPv6 compatible, built over Quagga and XoRP, in order to run OSPFv2, OSPFv3, BGP and PIM-SMv2.

The FreeRADIUS software package supports IPv6. At IPL, IPv6 is activated internally, but at the moment it is not active towards the eduroam hierarchy, due to a bug between this software and Radiator software, which caused unexpected message rejections. This issue is currently under evaluation.

IPL also provides IPv6 connectivity on its VPN PPTP service.

# 4 Available IPv6 Infrastructures

## 4.1 IPv6-Only Testbed

FCCN is running a public IPv6-only virtualised server with DNS, WEB and E-MAIL services, at apenasipv6.fccn.pt.

The aim of this tool is to allow third-party domains to test their IPv6 reachability. Because the DNS delegation of "apenasipv6" under fccn.pt doesn't have any IPv4-enabled address involved, this DNS sub-domain is only visible to hosts with IPv6 connectivity. In that case, the Web service at www.apenasipv6.fccn.pt will be reachable and a 19-minute video (locally produced in 2011) about IPv6 (in Portuguese language) is played.

The e-mail service installed at this host is the most useful of all three, because it allows anyone from the IPv6 Internet not only to send messages, but also to receive them. By sending a message to auto@apenasipv6.fccn.pt, any sender will receive a message back from the installed VACATION software. If the reply message doesn't arrive from the autoipv6@servidor.apenasipv6.fccn.pt address, it means the sender's Mail Transfer Agent (MTA, listed on DNS MX records) is not IPv6-capable yet.

## 4.2 Cisco 6DEPLOY Lisbon Training Lab

A Cisco training lab is deployed in Lisbon, Portugal, at the core of FCCN's backbone. This lab is composed by six Cisco 1941 routers and one 2911 router acting as a console server and gateway to the platform. The lab set is completed by a Cisco Catalyst 2960 switch, used to interconnect all these devices and also by two servers (UCS-SP5-C22E), designed to host virtual machines to be used during trainings. The main goal of these virtual machines is to support practical training exercises with IPv6-enabled services, including those described in previous sections.

This infrastructure is available to be used remotely, not only by the Portuguese R&E community members, but also by other organisations that apply to use it, through the 6DEPLOY Testbed reservation process (http://www.6deploy.eu/index.php?page=testbed_reservation2). The Lisbon lab is part of a global network of Cisco IPv6 training labs, managed by several organisations that provide IPv6 trainings (such as AfriNIC, LacNIC, Renater and Consulintel), and also focusing on IPv6 deployment advocacy.

# 5     User connectivity

IPv6 deployment within RCTS members' campuses highly depends on IPv6 availability at the eduroam infrastructure. Campus wireless networks have been the real driver for overall IP traffic growth during the last decade. Eduroam deployments have also been the reason behind new IPv4 address space requests to RCTS' Local Internet Registry. This means more people and more devices are connecting to the hotspots installed within campuses throughout the country.

In terms of volume, the following graphs show how IPv6 traffic at RCTS has been evolving. The first picture shows the volume from the 46th week to the 50th week of 2014, using 2-hour average values.
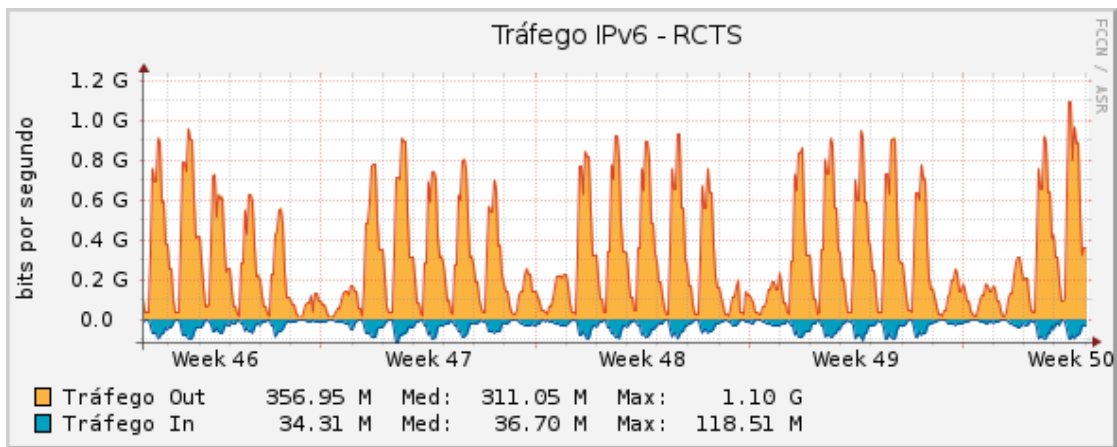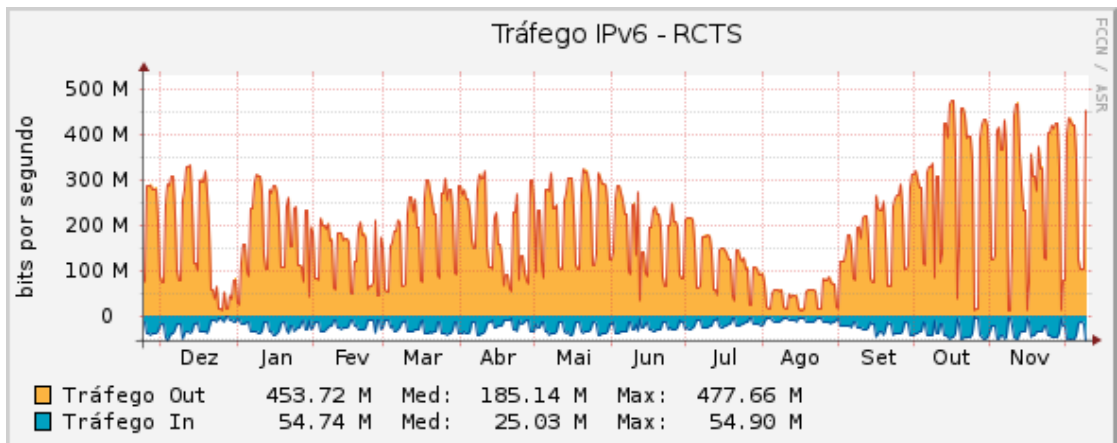


Figure 5.1: IPv6 traffic within RCTS – weeks 46 to 50 of 2014

The latter pictures (Figure 5.2) show the same evolution, with one-day averages, but with a span over the last 12 months and since data started to be collected (September 2012).
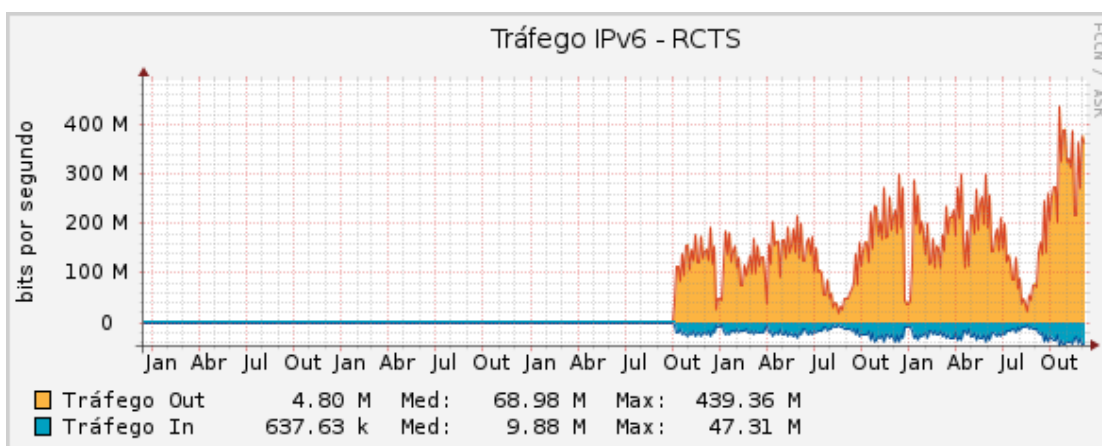
Figure 5.2: IPv6 traffic within RCTS – from September 2012

Figure 5.3 describes the IPv4 vs. IPv6 volume of traffic evolution at RCTS during the last 12 months. We consider this measurement as a good metric for evaluating RCTS' IPv6 deployment success.
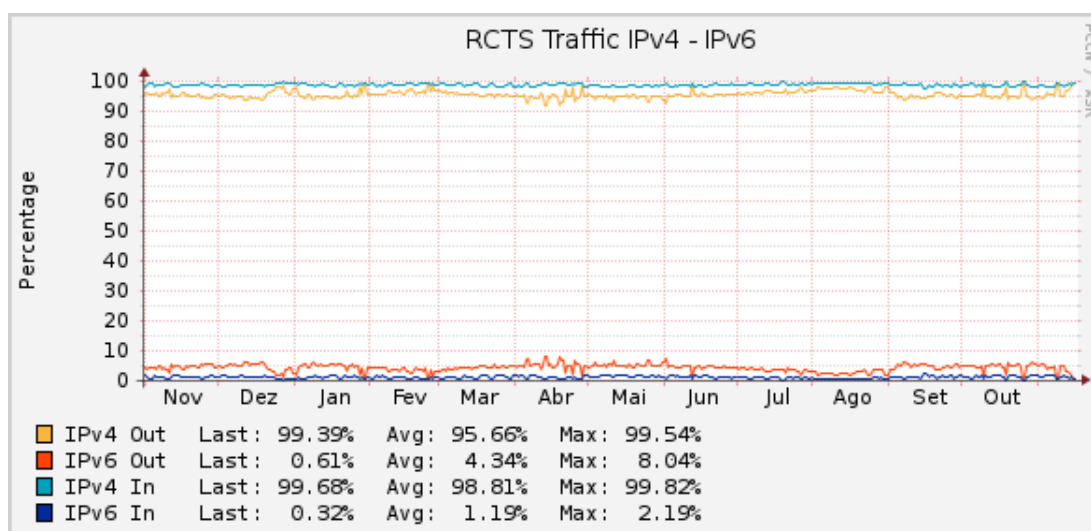


Figure 5.3: IPv4 versus IPv6 traffic within RCTS during a 12-month period

Unfortunately, the amount of simultaneous IPv6 users over eduroam is not yet available.

One important aspect while provisioning IPv6 to end-user networks is how to operate DHCPv6 and Stateless Autoconfiguration. The following commands (on Cisco IOS) describe optimisations to be used to achieve specific scenarios:

- Generally, to protect against blackholing: **ipv6 nd router-preference High**
- For networks served by DHCPv6: **ipv6 nd managed-config-flag**
- For networks using stateless autoconfiguration, but served by DHCPv6 to supply extra info such as default domainname and forwarding addresses: **ipv6 nd other-config-flag**

The following two commands should also be applied to every IPv6 interface, in order to protect against redirects and spoofing:

Best Practice Document:
IPv6 Deployments within RCTS

- **no ipv6 redirects**
- **ipv6 verify unicast reverse-path**

A bug was detected while using ISC DHCPv6, causing issues with HP printers (where disabling IPv6 on the printer is the best known workaround).

Lease renewals in networks where only DHCPv6 is available needs to be defined cautiously. The supplied address needs to have a preferred lifetime higher than the forecasted period for the lease renewal. If this is not the case, the address is deprecated before the renewal event. This happens because dhcpd6, by default (if the parameter is not specified), calculates preferred lifetime as 62.5% of lease/valid lifetime. The following set of configuration lines solves this issue:

- default-lease-time 86400; # 1 day
- option dhcp6.info-refresh-time 21600; # 6 hours
- option dhcp-renewal-time 32400; # 50% of preferred lifetime or 37,5% of lease/valid lifetime
- option dhcp-rebinding-time 51840; # 80% do preferred lifetime or 60% of lease/valid lifetime

In any case, the renewal-time and rebinding-time values need to be lower than the preferred lifetime, since the first value also needs to be lower than the second.

# 6     IPv6 deployment principles

The following list describes the set of common rules followed by RCTS members in their effort to deploy IPv6 on the infrastructures they manage:

- IPv4 addresses are not removed when IPv6 addresses are added.
- The security policy for IPv6 must be similar to the organisation's IPv4 security policy.
- An exception to the previous rule is allowing ICMPv6, which is needed to enable endhosts to determine PATH MTU values.
- The organisations' DNS domain needs to be «glued» to his parent hierarchy by at least one nameserver. The parent zone needs to include an IPv6 "glue record", if the nameservers supporting the domain have their own name inside the zone.
- AAAA records should only be published (and kept on DNS zones) when proper IPv6 connectivity is available and tested.
- Systems/services running over IPv4 and IPv6 should be monitored over both protocol versions.
- Use IPv6 Router Advertisement Guard at the Ethernet layer, when that feature is available, in order to avoid problems with rogue router advertisements.
- Don't use different DNS names for the same service in IPv4 and IPv6.
- Never force IPv4 usage over IPv6 usage – this approach will only allow IPv6 communication when something goes wrong with IPv4 connectivity.
- Always use DNS names while configuring services. IPv4 addresses hardwired in configurations will disable IPv6 communication. You shouldn't also hardwire IPv6 addresses.
- Servers/services IPv6 addresses must be defined in a static way (don't use stateless autoconfiguration).
- At least one MX record on the organisation's main DNS zone needs to have an associated AAAA record, provided IPv6 connectivity is available and properly tested.

# 7 Conclusion

IPv6 deployment is still an unfinished business, globally, at the end of 2014 – and this is also true for RCTS. However, it is clear for a great majority of IT professionals that IPv6 usage is the only way forward in order to sustain public Internet growth, and that is also the case for the Portuguese R&E IT community.

After going through this document, the reader should be able to understand key aspects of RCTS' IPv6 deployment, and benefit from lessons learned over a ten-year period. The most important message is that IPv6 deployment will only be accomplished when everyone decides to help, by deploying their own set of services with IPv6 enabled.

# Appendix A IPv6 connectivity status

| RCTS Member | DNS Domain | IPv6 connectivity to RCTS |
|---|---|---|
| Agência de Inovação - Lisboa | adi.pt | No |
| Agência de Inovação - Porto | adi.pt | No |
| Associação DNS | dns.pt | Yes |
| Agência Portuguesa do Ambiente | apambiente.pt | No |
| European Maritime Safety Agency | emsa.europa.eu | No |
| Escola Náutica Infante D.Henrique | enautica.pt | No |
| Escola Superior de Enfermagem de Coimbra | esenfc.pt | Yes |
| Escola Superior de Enfermagem de Lisboa | esel.pt | Yes |
| Escola Superior de Enfermagem do Porto | esenf.pt | No |
| Escola Superior de Hotelaria e Turismo do Estoril | eshte.pt | No |
| FCT - Unidade FCCN | fccn.pt | Yes |
| FCT - Unidade FCCN – Porto | fccn.pt | Yes |
| Fundação Mário Soares | fmsoares.pt | Yes |
| Instituto Gulbenkian de Ciência | igc.gulbenkian.pt | No |
| Instituto Hidrográfico | hidrografico.pt | No |
| Instituto de Investigação Científica Tropical - Pólo I | iict.pt | Yes |
| Instituto de Investigação Científica Tropical - Pólo II | iict.pt | No |
| Instituto Nacional de Investigação Agrária e Veterinária | iniav.pt | No |
| International Iberian Nanotechnology Laboratory | inl.int | No |
| Instituto Nacional de Saúde D.Ricardo Jorge | insa.pt | No |
| Instituto Politécnico de Bragança | ipb.pt | Yes |
| Instituto Politécnico de Beja | ipbeja.pt | Yes |
| Insituto Politécnico de Coimbra | ipc.pt | No |
| Instituto Politécnico do Cávado e do Ave | ipca.pt | No |
| Instituto Politécnico de Castelo Branco | ipcb.pt | Yes |
| Instituto Politécnico da Guarda | ipg.pt | Yes |
| Instituto Politécnico de Lisboa | ipl.pt | Yes |
| Instituto Politécnico de Leiria | ipleiria.pt | Yes |

| RCTS Member | DNS Domain | IPv6 connectivity to RCTS |
|---|---|---|
| Instituto Português do Mar e da Atmosfera | ipma.pt | Yes |
| Instituto Português do Mar e da Atmosfera - Pólo Algés | ipma.pt | No |
| Instituto Politécnico do Porto | ipp.pt | No |
| Instituto Politécnico de Portalegre | ipportalegre.pt | No |
| Instituto Politécnico de Santarém | ipsantarem.pt | Yes |
| Instituto Politécnico de Setúbal | ips.pt | No |
| Instituto Politécnico de Tomar | ipt.pt | Yes |
| Instituto Politécnico de Tomar - Escola Superior de Tecnologia | esta.ipt.pt | No |
| Instituto Politécnico de Viseu | ipv.pt | No |
| Instituto Politécnico de Viana do Castelo | ipvc.pt | No |
| Instituto Superior de Ciências do Trabalho e da Empresa - IUL | iscte-iul.pt | Yes |
| Instituto Superior de Gestão | isg.pt | No |
| Instituto Superior de Psicologia Aplicada | ispa.pt | No |
| Instituto Superior de Entre o Douro e Vouga | isvouga.pt | No |
| Laboratório de Instrumentação e Física de Partículas | lip.pt | Yes |
| Laboratório Nacional de Engenharia Civil | lnec.pt | Yes |
| Laboratório Nacional de Energia e Geologia | lneg.pt | No |
| Academia das Ciências de Lisboa | acad-ciencias.pt | No |
| Centro Científico e Cultural de Macau | cccm.pt | No |
| Pavilhão do Conhecimento - Ciência Viva | pavconhecimento.pt | Yes |
| Direcção Geral das Estatístícas do Ensino e Ciência | dgeec.mec.pt | No |
| Direcção Geral do Ensino Superior | dges.mec.pt | No |
| Fundação para a Ciência e a Tecnologia | fct.pt | Yes |
| Sec. Geral do Ministério da Educação e Ciência – Laranjeiras | sec-geral.mec.pt | No |
| Sec. Geral do Ministério da Educação e Ciência – 5 de Outubro | sec-geral.mec.pt | No |
| Universidade de Aveiro | ua.pt | Yes |
| Universidade Aberta | uab.pt | Yes |
| Universidade dos Açores | uac.pt | No |
| Universidade Autónoma de Lisboa | ual.pt | No |
| Universidade do Algarve | ualg.pt | Yes |
| Universidade Atlântica | uatlantica.pt | No |
| Universidade da Beira Interior | ubi.pt | Yes |
| Universidade de Coimbra | uc.pt | Yes |
| Universidade Católica Portuguesa | ucp.pt | No |
| Universidade Católica Portuguesa - Centro Regional do Porto | crp.ucp.pt | No |
| Universidade de Évora | uevora.pt | Yes |
| Universidade de Lisboa | ulisboa.pt | Yes |
| Universidade Lusíada de Lisboa | lis.ulusiada.pt | No |

| RCTS Member | DNS Domain | IPv6 connectivity to RCTS |
|---|---|---|
| Universidade Lusíada do Porto | por.ulusiada.pt | No |
| Universidade Lusófona de Lisboa | ulusofona.pt | No |
| Universidade Lusófona do Porto | ulp.pt | No |
| Universidade da Madeira | uma.pt | Yes |
| Universidade do Minho | uminho.pt | Yes |
| Universidade Nova de Lisboa | unl.pt | Yes |
| Universidade do Porto | up.pt | Yes |
| Universidade Portucalense | upt.pt | Yes |
| Universidade de Trás-os-Montes e Alto Douro | utad.pt | No |
| Universidade de Lisboa - Pólo Alameda | utl.pt | Yes |

Table A.1: RCTS members and their IPv6 connectivity status

Best Practice Document:
IPv6 Deployments within RCTS

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# Glossary

| | |
|---|---|
| **AFRINIC** | African Network Information Centre |
| **ASN** | Autonomous System Number |
| **ATM** | Asynchronous Transfer Mode |
| **BIND** | Berkeley Internet Name Daemon |
| **Consulintel** | The IPv6 Company |
| **DNS** | Domain Name System |
| **eduroam** | Education Roaming |
| **FCT-FCCN** | Fundação para a Ciência e a Tecnologia, I.P. – Unidade FCCN |
| **FTP** | File Transfer Protocol |
| **GPS** | Global Positioning System |
| **HTTP** | HyperText Transfer Protocol |
| **ICMPv6** | Internet Control Message Protocol version 6 |
| **IIS** | Internet Information Services |
| **IOS** | Internetwork Operating System |
| **IP** | Internet Protocol |
| **IPv4** | Internet Protocol version 4 |
| **IPv6** | Internet Protocol version 6 |
| **IT** | Information Technology |
| **LACNIC** | Latin America and Caribbeean Network Information Centre |
| **LDAP** | Lightweight Directory Access Protocol |
| **LNEC** | Laboratório Nacional de Engenharia Civil |
| **MIB** | Management Information Base |
| **MTA** | Mail Transfer Agent |
| **MDA** | Mail Delivery Agent |
| **NREN** | National Research and Education Network |
| **NTP** | Network Time Protocol |
| **PATH MTU** | Path Maximum Transfer Unit |
| **POS** | Packet Over SONET |
| **R&E** | Research and Education |
| **RADIUS** | Remote Authentication Dial In User Service |
| **RCTS** | Rede Ciência Tecnologia e Sociedade |
| **RENATER** | Réseau National de télécommunications pour la Technologie l'Enseignement et la Recherche, the French NREN |
| **SAML2** | Security Assertion Markup Language 2.0 |
| **SNMP** | Simple Network Management Protocol |