

IPv6 Project Planning Guide

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AUTHOR

Philip Sheldrake, Influence Crowd LLP

Intellect Main Board Member, 6UK Director

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WHO IS THIS GUIDE FOR?

This guide is for project managers and technical staff at organisations for which information technology is business critical, and for technical consultants and suppliers to such organisations. It accompanies the publication of the “Executive Briefing on the New Version of the Internet Protocol” and its recommendation to make your organisation visible to the outside world over IPv6.

ABSTRACT

There are insufficient unallocated addresses under the most commonly deployed Internet Protocol, IPv4, to meet demand beyond 2012 at the latest. Your organisation must now ensure that it is visible to the outside world over its successor, IPv6, to avoid competitive disadvantage. This document outlines the steps you will want to consider when planning to make this happen.

THANKS

Nigel Titley, Easynet, RIPE NCC Chairman, 6UK Chairman

Ian Kennedy, Senior Director, Systems Engineering, European Markets, Cisco

The purpose of this guide

No matter the *raison d'être* of your organisation, it needs to communicate. It needs to communicate in the ways demanded by customers and other stakeholders, and to refuse to do so can only injure your efforts in achieving your organisational objectives. If, or indeed when, a stakeholder wishes to interact with you over IPv6, you need to be ready.

This guide accompanies the “Executive Briefing on the New Version of the Internet Protocol”, which explains that IPv4 cannot rise to the potential of the Internet spreading out before us. It simply does not have the capacity. The world must now migrate to its successor, IPv6, but the two protocols are not interoperable.

As a global switchover from one version to another could never be coordinated, there will be a number of years during which both protocols will operate. Today, IPv6 traffic is approaching 1% of all traffic. Eventually, as IPv6 use exceeds IPv4 and every new device, operating system, service and application comes IPv6 ready, and the backbone is IPv6, organisations will find use of their IPv4 capability withering to a point where decommissioning it makes sense.

WHAT'S IN THIS GUIDE?

This guide outlines the steps you should consider when planning to make your organisation visible to the world over IPv6 as well as IPv4; to appear, in the words of the technical community, to be “dual stacked”.

It prepares you to minimise the pain and the cost. It addresses training, internal communication, the fundamentals of the project plan, the technology audit, some of the technical aspects, testing and procurement. It does not address migration of your internal network other than via your approach to procurement in anticipation of this transition.

YOU ARE NOT ALONE

At the IPv6 session¹ of the RIPE 59 meeting, October 2009, Kurtis Lindqvist (Chair of Euro-IX and Internet Architecture Board member) said that a slow and gradual implementation of IPv6 has been very beneficial based on his own experience. When polled, the majority of the sixty strong audience said that undertaking adoption of IPv6 now allows them more time to do a gradual, well thought through transition. The consensus was that the transition (which they took to include your entire network) is technically possible today and the capital needed is no longer prohibitively large.

Every capable, worldly and well-governed organisation is undertaking the same project right now. If you would like to discuss your challenges with others in the same position, you will be interested in two initiatives:

6UK

6UK is a not-for-profit membership organisation founded in April 2010 to help the UK and UK organisations secure every competitive advantage available from the rapid adoption of IPv6, and otherwise to make sure no segment of UK industry and wider society gets left behind.

In particular, 6UK's objectives include:

- Promote, encourage and foster the use of IPv6-based communications network or migration to such networks
- Provide a forum for those organisations involved in the deployment of communication networks using IPv6 or migration of facilities and communication networks to IPv6
- Provide useful information and educational materials
- Work within the framework of existing and prospective international standards and industry best practices; and
- Monitor the activities of relevant standards bodies, business and trade associations, and interest groups and to participate as needed.

Its website is found at www.6uk.org.uk.

IPv6ActNow

The RIPE NCC, the Regional Internet Registry with responsibility for Internet numbering across Europe, Russia and the Middle East, maintains a very useful website at www.ipv6actnow.org.

The plan

Making your organisation visible over IPv6 should be approached like any other IT project; success pivots on diligent preparation and planning.

The following list of steps for a project plan is appropriate for both making your organisation visible over IPv6 in the next few quarters, and the subsequent migration of your internal networks in the longer-term. When considering the skills and resource implications for the nearer-term project, you will want to have an eye to the longer-term project too.

SUGGESTED STEPS FOR YOUR PLAN

1. Education and training, and establishment of an IPv6 skills matrix
2. Begin internal communications
3. Technology audit
4. Review of the appropriate technical options
5. Selection of the technical approach and corresponding security policy
6. Development of the project proposal
 - a. Background description
 - b. Statement of objectives
 - c. Overarching approach and identification of critical success factors
 - d. Project outcome – what precisely will the project achieve
 - e. Stakeholder analysis – who will be interested in or affected by the outcome, and how should they be involved and kept informed?
 - f. Risk analysis – which aspects pose a risk to the project's success and how are these to be mitigated?
 - g. Standards – list the standards the project will work to

- h. Resources – internal and external, including identification of the project owner and manager (might be the same individual in smaller organisations)
 - i. Project support – what other resources are needed, and what other conditions must be met?
 - j. Project management – how will the project be managed?
 - k. Timeline – what are the major milestones, and when are they expected?
 - l. Budget – for tangibles, intangibles and contingency
 - m. Environmental factors – the sustainable / green aspects of the project
 - n. How will success be adjudged post-project and who will do so?
7. Sign-off of the project proposal
 8. Execution
 9. Testing
 10. Post-project report, celebrating success
 11. Marketing, internal and external as appropriate.

If you consider that you ought to be visible by the time 4-5% of Internet traffic is over IPv6, and that this could happen early 2011, then the sooner you begin the longer you will give yourself to get it right.

The next sections relate to steps 1 to 5 above.

Training and communication

Working in information technology can sometimes appear to be a thankless task. Your IT is most successful when it is invisible to the end-user; when it just works. There will be moments when you introduce new technology that thrills the end user, but this thrill soon fades to simple unrelenting expectation. And the last thing you want is for an intended step forward to end up taking you a step backward.

You should therefore take training and communication seriously for your IPv6 project for both your personal satisfaction and your organisation's success.

TRAINING

Of course you and your technical colleagues won't consider working with IPv6 without appropriate training. Fortunately, if you understand IPv4, then IPv6 is not going to be difficult as, whilst the details are different, the principles are much the same. Indeed, the RIPE NCC's training programme asserts "Don't appoint an IPv6 specialist – do you have an IPv4 specialist?"

You'll want to undertake some self-directed training. You might get hold of some books and trawl the Web for appropriate material, and this guide includes a list of links to relevant information in "Appendix 1 – Useful links" to get you started, although this is not intended to be exhaustive by any means.

You will want to talk with your technology suppliers to ascertain their expertise and their willingness to share it with you. And you will consider attending IPv6 training courses. The training should cover design, implementation, configuration and maintenance, and you should also determine your needs for additional training for advanced networking, enterprise architecture, software development and sys admin for example.

COMMUNICATION

Do let your non-technical colleagues know what you are doing. Why not volunteer to write a brief article or short series of articles about IPv6 in your organisation's internal newsletter or magazine, or on the intranet? After all, the Internet and World Wide Web fascinate many non-technical people.

The non-technical "Executive Briefing on the New Version of the Internet Protocol" that accompanies this guide, available at www.6uk.org.uk/resources, is also issued under a creative commons license allowing you to reproduce it or sections from it free of charge, so long as you give credit of course.

Although your non-technical colleagues will not, hopefully, "see" any difference, you will have gained their respect and patience should you experience the odd hiccup.

The technology audit

Let's state the obvious. Planning to go from A to B is so much simpler when you know where A is!

Documentation of network inventory and configuration is not always up to date or accurate, and has been further complicated in recent years with the advent of virtualised environments. So first things first, any organisation looking to implement IPv6 must update or compile and maintain a current and accurate statement of inventory and its configuration, whether this employs the latest network inventory software or a less automated approach.

In the language of ITIL v3^{2/3}, we're talking about the creation and maintenance of the Configuration Management System⁴.

The technology audit will help you plan and track the changes required to make your organisation visible over IPv6, and also provide detail of the so-called "last known good configuration" should anything go awry and you need to roll back.

IPv6 Visibility

The focus of this guide is making your organisation visible to the outside world over IPv6, so the questions are:

Can your firewalls, routers, DNS, Web servers and mail servers be configured to work with IPv6? If so, how? If not, what new hardware, software and/or service providers are required?

IPV6 COMPATIBILITY

What precisely is meant by "work with IPv6"? The vendor might claim IPv6 compatibility for example, but that's according to their definition. Rather, you will want to look for the "IPv6 Ready" logo⁵ from the IPv6 Forum⁶, which comes in either Phase-1 (silver) standard or Phase-2 (gold) standard. However, you should bear in mind that .SE (The Internet Infrastructure Foundation of Sweden) asserted that Phase-1 IPv6 ready devices procured in 2008 should be

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interpreted as having “Not Much” compliance, and noted that D-Link had “exercised some restraint in marketing Phase 1-equipment as IPv6-ready in Sweden”⁷.

The ETSI Methods for Testing and Specification (MTS) committee set up an IP Testing working group⁸ (MTS-IPT) to provide a publicly available test development framework and interoperability test packages for core protocol, security, mobility and transitioning. The work was undertaken in liaison with the IPv6 Forum.

The Joint Interoperability Test Command⁹ of the US Defense Information Systems Agency undertook more rigorous IPv6 testing and certification¹⁰ until February 2009 when it ceased in deference to a wider functional verification process¹¹, but they do list the devices that passed their IPv6 assessment up to that point.

The US National Institute of Standards and Technology is working towards a certification of its “IPv6 profile”¹². It is currently considering feedback to its call for public review and comments regarding its intentions¹³.

Tune in

The University of Southampton School of Electronics and Computer Science¹⁴ is widely regarded as the UK’s leading academic institute for the research and deployment of IPv6. The University is one of those early adopters having run IPv6 on site since 1996 and having obtained a native link to UUNet in Telehouse London in 1997.

Perhaps one of the first stations you’ll “tune into” when you get online with IPv6 will be Absolute Radio, which is the first IPv6 commercial radio station in the UK thanks to help from the University.

As soon as you’re ready, here’s the URL...

<http://www.ipv6.ecs.soton.ac.uk/absoluteradio>

YOUR ISP

Does your current ISP offer IPv6 capabilities? You should register your query with them even if you think they might not so that they might begin to recognise that there's a demand for IPv6 that must be met. It will also help them understand why you're leaving should you find a more capable ISP partner.

Perhaps your current ISP has plans to roll out IPv6 service in the next few months, in which case you may decide you can wait, but ultimately you will be concerned primarily with your reputation not theirs. In response to general enquiries sent to UK ISPs, Easynet¹⁵, Andrews & Arnold¹⁶ and Claranet¹⁷ responded to confirm availability of IPv6 service in some parts of the country.

And just as for devices and software, an ISP's IPv6 readiness isn't a question that can be answered with a simple 'yes' or 'no'. You'll need to interrogate the ISP's approach. For example, a service that delivers IPv6 natively, just like IPv4, is preferable to one that employs a tunnel (see "Tunnels" section).

ISPs reading this guide might like to refer to the new Carrier Grade IPv6 solutions from the likes of Cisco¹⁸ and Huawei¹⁹. Launched October 2009, Cisco purports that their solution preserves investments in IPv4 infrastructure, assets, and delivery models; prepares you for the smooth, incremental transition to IPv6 services that are interoperable with IPv4; and allows you to prosper through accelerated subscriber, device, and service growth that are enabled by the efficiencies that IPv6 can deliver.

Tunnels

The process of encapsulating one protocol inside another is known as tunnelling. Currently, as IPv4 networks are most prevalent, we're talking about wrapping IPv6 packets within IPv4 packets, effectively using IPv4 as the link layer for IPv6. As more of the networks that together form the Internet transition to IPv6, then the encapsulation will be IPv4 in IPv6.

Tunnels can be configured manually / explicitly (eg, 6in4²⁰ and Generic Routing Encapsulation²¹), or semi-automatically (eg, Tunnel Broker Service²²), or automatically (eg, 6to4²³, ISATAP²⁴, AYIYA²⁵, Teredo²⁶, and 6PE²⁷ for MPLS).

It's worth noting here though that the NAT-PT approach to protocol translation is deprecated²⁸.

During your research you might like to experiment with some of the services from the not-for-profit SixXS including their Website Gateway²⁹. This service allows you to view websites available over one protocol with the other; for example, view Google's IPv6 service from your IPv4 client and ISP at <http://ipv6.google.com.ipv4.sixxs.org>. At the time of writing, Google has an animated logo there in celebration of you reaching them over IPv6!

ISPs that provide IPv6 services via tunnels are to be applauded over those who do nothing currently and will prove to be laggards, but ultimately dual connectivity in the ISP's local POP will simply inspire greater confidence of course than tunnelling to a single router.

WEBSITES

Many organisations will outsource hosting of their website(s) to a specialist. In such instances, you will need to ask your host to make your website available over IPv6. If your host does not yet offer IPv6 capability, then you will need to find an alternative, or secure a satisfactory commitment date from them.

If you host your own website(s), you may find it simpler (and advantageous for other reasons) to outsource hosting. Should you wish to keep hosting on-site, you will need to configure your Web server to serve both IPv6 calls as well as IPv4.

Alternatively, given that we're discussing IPv6 visibility here rather than full internal network migration, you might find that a proxy server approach might suffice in the interim. The proxy will serve IPv6 HTTP and FTP requests, effectively sitting in front of your Web servers for IPv6 networking. As most proxies (eg, Apache³⁰, Squid³¹) can be configured to cache, the IPv6 proxy may also actually take some load off the IPv4 servers as IPv6 increases as a proportion of total traffic.

Either way, you will need to maintain your DNS (see "DNS" section).

EMAIL

Your approach to allowing the outside world to email you over IPv6, and allowing your colleagues to respond, depends of course on the way in which you have approached email.

Hosted and webmail

Hosted email is the creation and provision by a third party of an instance, virtual or otherwise, of your own email server ceding you full or substantial access rights to its configuration. Webmail is regarded as more of a one-flavour-suits-all service that does not have an equivalent on-site option.

The hosted enterprise email market largely consists of Hosted Exchange services, IBM's Lotus Notes Hosted Messaging, and Zimbra³² hosting providers³³. Being hosted, the responsibility for making your organisation visible over IPv6 in this regard lies with your service provider. Therefore, just as for your ISP and website hosts, if the provider does not have IPv6 capability and is unwilling to commit to a satisfactory time when such capability will go into production, you will need to seek out alternative providers that will.

Google Apps³⁴ is the number one enterprise webmail, calendar and Web document service. Google is regarded as a pioneer of IPv6 rollout to date and nearly all of its services are available over IPv6 to those organisations selected to be part of its IPv6 Trusted Tester programme.

You can apply to join this programme if you meet the requirements: "good IPv6 connectivity to Google (defined as two diverse peerings, or one peering and 'good' transit), a production-quality IPv6 network and commitment to fix user breakage and report bugs"^{35/36}.

On-site

Microsoft Exchange 2007³⁷ and 2010³⁸ have good IPv6 support when run on Windows Server 2008. IBM considers Lotus Notes to be IPv6 compliant³⁹ from the 2005 launch of version 7.0. Zimbra does not yet, at the time of writing,

officially support IPv6, but there are Zimbra instances in production with IPv6⁴⁰. Novell Groupwise⁴¹ is described as supporting IPv6 from version 7.0.

Mobile

RIM's four different software approaches⁴² (via your wireless provider, SME professional software, hosted and enterprise server) exemplify the different approaches you may have adopted to date for mobile email, whether you use RIM's Blackberry devices or not. Whatever your approach, where your mobile mail infrastructure sits entirely within your network and effectively 'behind' your mail server, then no change is needed to meet the objective of making your organisation visible to the outside world over IPv6.

Goodbye VPN?

Microsoft has employed some of the advantages of IPv6 in the background to power its DirectAccess⁴³ feature in Windows 7 and Windows Server 2008 R2. DirectAccess connects users seamlessly to the corporate network whenever they have Internet access without needing to connect to a VPN.

Microsoft claims a number of significant advantages: it enhances productivity by offering employees the same connectivity outside the office as inside; it improves administration of remote users by facilitating remote management when the computer has Internet connectivity, even when the user is not logged on; and it improves security with IPsec, the optional use of smart card authentication and integration with Network Access Protection.

ROUTERS AND FIREWALLS

Reassuringly, IPv6 routers and firewalls are commonly available. Like IPv4 routers and firewalls, not all IPv6 equipment is born equal but created to meet different needs and fit different budgets. Moreover, whilst the principles have much in common with IPv4, there are differences requiring your understanding and attention.

IPv6 is more innately secure than IPv4. It is more reliable and its “plug & play” nature means it’s easier to configure. Its massive, sparsely populated address spaces make malicious scans considerably less efficient and therefore less effective, and the environment is more hostile for worms. All good things when it comes to forging your security policy.

One of the most common threats currently wrought by IPv6 is the tunnel capability we rely upon to connect IPv6 environments over IPv4. The associated protocols are often switched on by default and tunnels may already exist on your network, presenting the perfect conduit for a Trojan horse hack when no checking of the IPv6 datagrams is undertaken. You will, therefore, want to find and close unnecessary tunnels and make sure you have a process that monitors all traffic for unauthorised transmission.

You will want to quiz your current firewall vendor for information about your current firewalls’ IPv6 suitability and optimum configuration.

.SE published a report⁴⁴ of their testing of seven IPv6 firewalls during the “Internetdagarna” conference in 2008.

Cisco⁴⁵, Juniper⁴⁶ and Nortel⁴⁷ provide detailed online guides to IPv6 configuration and security, and many of the training providers listed in the Appendix will have routing and security modules. The SANS Institute has a course dedicated to IPv6 security⁴⁸.

For the DIYers amongst you, you may find this guide to building your own IPv6 firewall with OpenBSD of interest⁴⁹. The OpenBSD project is renowned for its focus on security according to the current Wikipedia entry⁵⁰.

DNS

The IPv6 equivalent of the IPv4 A record is the AAAA record (known as the “quad A”). There is also something known as the A6 record that allows you to specify the least significant 64 bits of the IPv6 address and refer to another DNS server to get the most significant 64 bits, thereby making it easier to switch ISP for example.

In making your organisation visible to the rest of the world over IPv6, you and your service providers will of course have to make sure the DNS is set up appropriately.

Test and go-live

Testing is essential to the deployment, interoperability and security of IPv6. The EU-funded Go4-IT project⁵¹ has developed free IPv6 test suites and services to reduce the cost of testing and improve the quality of IPv6 execution. Latency of both IPv4 and IPv6 upon dual stacking is often a primary variable for analysis.

This is not the place to expand upon testing methodologies, and the books and other resources included in this guide will be amongst the best places to start, but a heuristic commonly heard amongst the IPv6 community is “do a little, test, and then do some more”. If you start now, you won’t be rushed anyhow.

Procuring IPv6 compatible services

IPv6 is not the “next” protocol; it is “now”. It is the successor to IPv4, and in the longer term IPv6 will flip from carrying the minority of Internet traffic to carrying the majority.

As touched upon briefly towards the beginning of this guide, it makes sense to change your procurement criteria now to mandate IPv6. Fortunately, your timing is right. Despite some lagging vendors, you will have more than sufficient choice of operating systems, applications and hardware, and your main hurdle in the UK may be services, both ISP and hosting.

If you start today and have a four-year replenishment cycle, you’ll be ready to move your internal networks to IPv6 at the beginning of 2014 without incurring unnecessary costs. At that juncture, it will then be a case of maintaining your visibility to the outside world over IPv4!

See you on IPv6

Making your organisation visible over IPv6 is the right move, and you will help drive demand to be met by those UK ISPs and hosts that have felt a little reticent to date. The IPv6 leaders are there already; being one of the early majority will benefit you, your team, your company and “UK plc”.

You will also recall that the final step of the suggested project plan steps was marketing. Why not email both 6UK and the RIPE NCC’s public relations team and share your success with them:

success@6uk.org.uk / ripenncc@ripe.net

###

Appendix 1 – Useful links

The inclusion of a link here does not represent a recommendation, endorsement or warranty for the material, its author or related services. Equally, the omission of a link to an organisation or resource should not be interpreted as disparaging toward that organisation or resource.

If you are reading a hardcopy of this guide, you may find it easier to access the links at the following URL: <http://www.6uk.org.uk/resources>.

GENERAL INFO

<http://tools.ietf.org/html/rfc2460> – the IPv6 specification

<http://www.ietf.org/dyn/wg/charter/v6ops-charter.html> – the IETF's v6ops

<http://blog.icann.org/2007/10/factsheet-ipv6> – ICANN's IPv6 factsheet

<http://www.ipv6actnow.org> – everything about IPv6, from the RIPE NCC

<http://www.getipv6.info> – everything about IPv6, from the ARIN

<http://portalipv6.lacnic.net> – everything about IPv6, from the LACNIC

<http://en.wikipedia.org/wiki/IPv6> – the Wikipedia entry for IPv6

http://en.wikipedia.org/wiki/IPv6_Addresses – Wikipedia entry for IPv6 addresses

<http://microsoft.com/ipv6> – Microsoft's IPv6 information resource

<http://www.google.com/intl/en/ipv6> – Google over IPv6

<http://tinyurl.com/nokiaipv6> – Nokia Views on IPv6 Transition

<http://www.hp.com/network/ipv6> – HP's perspective on IPv6

<http://tinyurl.com/dellipv6> – Dell on IPv6

<http://cisco.com/ipv6> – Cisco on IPv6

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<http://tinyurl.com/huawei-ipv6> – Huawei on IPv6

http://www.globalcrossing.com/ipkc/ipkc_ipv6.aspx – Global Crossing on IPv6

<http://www.linux.org/docs/ldp/howto/Linux+IPv6-HOWTO/index.html> – Linux and IPv6

<http://www.computer.org/portal/web/csdl/doi/10.1109/ISCC.1999.780953> – Methods for IPv4 - IPv6 Transition, IEEE

TRAINING

<http://www.ripe.net/training> – the RIPE NCC's training materials

<http://www.6diss.org/e-learning> – excellent e-learning from EU sponsored project

<http://www.6diss.org/tutorials> – access all the tutorials in PDF

http://www.isoc.org/educpillar/resources/ipv6_faq.shtml – ISoC's IPv6 FAQs

<http://www.isoc.org/isoc/conferences/ipv6panel> – ISoC Discussion, March 2009

<http://www.ipv6training.com> – private training organisation

<http://www.snt.co.uk> – private training organisation

<http://www.lever.co.uk> – private training organisation

<http://www.sans.org> – private networking and security training organisation

BOOKS

The following links take you to the Wikipedia page linking to libraries and retailers for the ISBN in question.

<http://en.wikipedia.org/wiki/Special:BookSources/9780596100582> IPv6 Essentials, O'Reilly

<http://en.wikipedia.org/wiki/Special:BookSources/9780596009342> IPv6 Network Management, O'Reilly

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- <http://en.wikipedia.org/wiki/Special:BookSources/9780735624467> Understanding IPv6, Microsoft
- <http://en.wikipedia.org/wiki/Special:BookSources/9781587052101> Deploying IPv6 Networks, Cisco
- <http://en.wikipedia.org/wiki/Special:BookSources/9781587055942> IPv6 Security, Cisco
- <http://en.wikipedia.org/wiki/Special:BookSources/9781420092295> Security in an IPv6 environment, Auerbach
- <http://en.wikipedia.org/wiki/Special:BookSources/9780849385162> IPv4 to IPv6 Transition Methodologies, Auerbach
- <http://en.wikipedia.org/wiki/Special:BookSources/9780470191194> IPv6 Mandates, Wiley
- <http://en.wikipedia.org/wiki/Special:BookSources/9780471498926> Migrating to IPv6: A Practical Guide, Wiley

NEWS SOURCES AND BLOGS

- <http://feeds.feedburner.com/Ipv6ActNow> – a feed of IPv6 news items
- <http://www.circleid.com/topics/ipv6> – the collaborative news and opinion website
- <http://www.potaroo.net> – the blog from APNIC's Chief Scientist, Geoff Huston
- <http://blogs.cisco.com/tag/ipv6> – Cisco blog posts tagged "IPv6"
- <http://www.networkworld.com/community/doyle> – IP routing expert's blog

TOOLS

- <http://www.ripe.net/is-portal> – RIPE NCC Information Services
- <http://www.sixxs.net/main> – non-profit to help engineers deploy IPv6
- <http://bgpmon.net/weathermap.php?inet=6&focus=eu> – tools and stats
- <http://www.go4-it.org> – Free testing suites and software from EU-funded project

ENDNOTES

- ¹ <http://labs.ripe.net/content/ipv6-panel-discussion-results>
- ² http://en.wikipedia.org/wiki/Information_Technology_Infrastructure_Library
- ³ <http://www.itil-officialsite.com>
- ⁴ http://wiki.en.it-processmaps.com/index.php/Checklist_CMS_CMDB
- ⁵ <http://www.ipv6ready.org>
- ⁶ <http://www.ipv6forum.org>
- ⁷ <http://www.iis.se/docs/IPv6-firewalls.pdf>
- ⁸ <http://www.ipt.etsi.org>
- ⁹ <http://jitc.fhu.disa.mil>
- ¹⁰ http://jitc.fhu.disa.mil/tssi/docs/1_7ipv6_approved6089r6104.pdf
- ¹¹ <http://jitc.fhu.disa.mil/apl/ipv6.html>
- ¹² <http://www.gcn.com/Articles/2009/03/31/IPv6-testing-document.aspx>
- ¹³ <http://www.antd.nist.gov/usgv6/testing.html>
- ¹⁴ <http://www.ipv6.ecs.soton.ac.uk>
- ¹⁵ <http://www.easynet.com>
- ¹⁶ <http://www.aaisp.net.uk>
- ¹⁷ <http://www.claranet.co.uk>
- ¹⁸ <http://www.cisco.com/go/cgv6>
- ¹⁹ <http://tinyurl.com/huawei-ipv6>
- ²⁰ <http://en.wikipedia.org/wiki/6in4>
- ²¹ http://en.wikipedia.org/wiki/Generic_Routing_Encapsulation

²² For example, <http://tunnelbroker.net>

²³ <http://en.wikipedia.org/wiki/6to4>

²⁴ <http://en.wikipedia.org/wiki/ISATAP>

²⁵ <http://en.wikipedia.org/wiki/Ayiya>

²⁶ http://en.wikipedia.org/wiki/Teredo_tunneling

²⁷ http://www.cisco.com/warp/public/cc/pd/iosw/prodlit/iosip_an.pdf

²⁸ <http://tools.ietf.org/html/rfc4966>

²⁹ <http://ipv6gate.sixxs.net>

³⁰ <http://httpd.apache.org/docs/2.0/bind.html#ipv6>

³¹ <http://wiki.squid-cache.org/Features/IPv6>

³² <http://www.zimbra.com>

³³ http://www.zimbra.com/partners/zimbra_hosting.html

³⁴ <http://www.google.com/apps>

³⁵ <http://tinyurl.com/ripegoogleipv6>

³⁶ <http://qtstreamer.ripe.net/RIPE57/plenary-6-02.mov>

³⁷ <http://technet.microsoft.com/en-us/library/bb629624.aspx>

³⁸ <http://tinyurl.com/exchangeipv6>

³⁹ <http://www-01.ibm.com/software/info/ipv6/compliance.jsp#gl>

⁴⁰ <http://www.zimbra.com/forums/installation/20282-zimbra-box-using-ipv6.html>

⁴¹ <http://tinyurl.com/groupwiseipv6>

⁴² <http://tinyurl.com/blackberrycompare>

⁴³ <http://www.microsoft.com/servers/directaccess.msp>

⁴⁴ <http://www.iis.se/docs/IPv6-firewalls.pdf>

45 <http://tinyurl.com/ciscoiosipv6>

46 <http://tinyurl.com/junosipv6>

47 <http://tinyurl.com/nortel-ipv6>

48 <http://www.sans.org/security-training/ipv6-essentials-1872-tid>

49 <http://tinyurl.com/openbsdipv6firewall>

50 <http://en.wikipedia.org/wiki/OpenBSD>

51 <http://www.go4-it.org>