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Practical IPv6 for Windows Administrators

GET UP TO SPEED ON THE FUTURE OF THE INTERNET WITH A FAST, PRACTICAL REFERENCE TO IPv6

Edward Horley
Foreword by Stephen L. Rose

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For my wife Krys and my daughters Briana and Aisha

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Foreword

Much of the conversation around IPv6 has been based on the fear of IPv4 address exhaustion and the impending collapse of the Internet if we don't migrate. Customers will be unable to reach our sites and we will simply disappear from the electronic world. Fear, however, is a poor motivator; it does not build a business case.

The last IPv4 /8 range was allocated in June 2013. So many companies started asking questions: "Should I move now? If I don't will my costs go up? Will my web sites be disrupted? Are we ready t make the move? Are our competitors moving over?" These are all valid questions.

It was also at this time that I was the Senior Product Marketing Manager for the Windows Commercial Team. My focus was on readiness for IT professionals, and on delivering content via Th Springboard Series on TechNet (windows.com/itpro) where there was a huge gap in user-friendly content around learning and mastering IPv6. Hey, I have been in IT since 1998, and I am still terrifie of IPv4 subnetting, never mind doing it with IPv6!

It was at this time I reached out to Ed to leverage his IPv6 for Beginners decks and content, both externally and on occasion internally. He had a great way of taking complex concepts and making them easy enough for anyone to grasp and eventually master IPv6 networking.

I cannot recommend Ed's book enough. After hours of struggling with IPv6 when I was younger, would have killed to have a book this friendly and concise to help me along.

Have you been scratching your head wondering what this IPv6 thing is all about and how it might impact you? Have you seen an IPv6 address and wondered, "How in the world do I subnet that?" The this is the book for you.

—Stephen L. Ro
Sr Product Marketing Manager - Windows- US M&O Microso

About the Author

Edward Horley is a Principal Solutions Architect at Groupware Technology in the San Francisco Ba Area. He is actively involved in IPv6 serving on the North American IPv6 Task Force (http://www.nav6tf.org/) and is the co-chair of the California IPv6 Task Force (http://www.cav6tf.org/).

Ed presents on IPv6 regularly and is still amazed that people want to listen to what he has to say about it. Some of the previous conferences he has presented at are the Rocky Mountain IPv6 Summit the North American IPv6 Summit, and the Texas IPv6 Summit, in addition to co-chairing and presenting at the annual gogoNETLive IPv6 conference in Silicon Valley. He has also presented at both Microsoft TechEd North America and Europe in 2012 and presented at TechMentor conferences in Redmond, Orlando, and Las Vegas. In all his spare time he co-chairs the IT professional conferenc TechDays in San Francisco which happens annually in the spring.

Ed is a ten-time Microsoft MVP (Most Valuable Professional) awardee (first awarded back in 2004) and has spent the last 18+ years working in networking as an IT professional. He is actively involved in the Pacific IT Professionals users group (http://www.pacitpros.org/) located in Northern California. He also enjoys umpiring Women's Lacrosse when he isn't playing around on IPv6 networks and maintains a blog at http://www.howfunky.com/, where he covers technical topics of interest to him. He is also on twitter at @ehorley. He received a BS in Civil Engineering from the University of the Pacific. Go Tigers! You can reach him at ed@howfunky.com. He currently lives in Walnut Creek, California and grew up in the Bay Area. Ed is married to Krys and has two wonderful daughters, Briana and Aisha.

About the Technical Reviewers

Richard Hicks (MCP, MCSE, MCTS, and MCITP Enterprise Administrator) is a network and information security expert specializing in Microsoft technologies. As a five-time Microsoft MVP, h has traveled around the world speaking to network engineers, security administrators, and IT professionals about Microsoft edge security and remote access solutions. Richard has nearly two decades of experience working in large-scale corporate computing environments and has designed an deployed perimeter defense and secure remote access solutions for some of the largest companies in the world.

He blogs extensively about Microsoft edge security and remote access solutions, and is a contributing author at popular sites such as `CloudComputingAdmin.com`, `WindowsSecurity.com`, `ISAserver.org`, and the Petri IT Knowledgebase. In addition, he is a Pluralsight author and has served as the technical reviewer on several Windows server and network security books.

Richard is the Director of Sales Engineering for Iron Networks, a Microsoft OEM partner developing secure remote access, network virtualization, and converged cloud infrastructure solution He's an avid fan of Major League Baseball, and in particular the Los Angeles Angels (of Anaheim!), and also enjoys craft beer and single malt Scotch whisky. Born and raised in beautiful, sunny Souther California, he still resides there with Anne, the love of his life and wife of 27 years, along with their four children and one grandchild. You can keep up with Richard by visiting `http://www.richardhicks.com/`.

Jason Jones is a Senior Security Consultant with Microsoft Consulting Services (MCS) in the UK an a former Microsoft MVP (five years). He holds a Bachelor of Science degree in Applied Mathematic

Jason's role at Microsoft encompasses providing design, architectural, and technical consulting t provide the highest levels of customer and partner experience. Jason specializes in several technolog areas including Microsoft Security, Identity and Access space with in-depth knowledge of technologies like Active Directory Certificate Services (PKI), DirectAccess, VPN, Forefront Edge (TMG/UAG), and other Remote Access technologies. Given Jason's infrastructure, firewall, and remote access background networking has always been a fundamental part of his skillset, with a stron focus on the networking aspects of the Windows ecosystem. This has been strengthened further over recent years with direct exposure to IPv6 while working within the DirectAccess field.

Prior to joining Microsoft, Jason worked for a highly respected Microsoft Partner for 15 years as security practice lead, helping to define vision and strategy and to provide technical design authority on all aspects of Microsoft security infrastructure. Jason is a long-time community contributor, especially within the Microsoft secure access space, and is author of several industry renowned technical blogs including the current "The Microsoft Security Guy" blog available at `http://blogs.technet.com/b/jasonjones/`.

Acknowledgments

I want to extend my personal thanks to the technical reviewers for this book. First up is fellow Microsoft MVP Richard Hicks whose advice is always welcome regarding Microsoft technologies ar DirectAccess in particular. Next is Jason Jones, former Microsoft MVP and now a Microsoft employee, for his engaging and interesting discussions around IPv6 and DirectAccess which partially motivated the idea for doing this book. Without your valuable input and time this book would not be what it is, so thank you.

Most important, I need to thank my family for allowing me to take time to write this. They have lived with all the missed time of my presenting, speaking, and attending events around the world related to IPv6. So to my family; Krys, my wonderful wife, deserves a huge thank you for getting "why" user group and IPv6 are so important to me or at least humoring me to make me think you understand why. To Briana and Aisha, my daughters, as soon as you can hack the home router you ar free to surf the Internet freely (IPv4 and IPv6) as much as you want; until then, my house, my router, my rules! To my father, Dr. Albert Horley, for letting me play with computers and networking equipment from a young age and for always letting me know that engineering is a wonderful profession. To my mother, Jeanette Horley, for showing me how important libraries are and the value of information and reading. To my sister, Kathleen Loia, for tolerating me as a brother and all my quirks. And finally to my in-laws, Don and Iretta Hunter, thank you for letting me date and marry yo daughter and for having me along to all the Hunter abalone camping trips—they are epic!

There are many others who need to be thanked for supporting me in all different ways over the years:

In the Microsoft camp, Jennelle Crothers, a former Microsoft MVP, who is my user group colleague of over 16 years and the person who always keeps me grounded in reality, both personally and professionally, your opinion is, and will always be, valued. Stephen Rose (another former Microsoft MVP) for the years of support, mentorship and championship! Joseph Davies, who honore me by asking me to technically review his *Understanding IPv6, Third Edition* (Microsoft Press, 2012 from which I learned so much in that process. Christopher Palmer for putting up with all my e-mails and in-person questions about IPv6 in Windows, your patience is appreciated. Dave Thaler for taking the time to let me ask lots of questions about the history of IPv6 at Microsoft and for answering questions about networking in general in the Windows OS.

A big thank you to all my fellow (current and former) Microsoft MVPs who have encouraged, tolerated, and listened over the years as I have talked about IPv6: Ed Bott, Alan Burchill, Jessica Deen, Jessica DeVita, Steve Evans, Ed Gallagher, Alun Jones, Mark Minasi, Doug Spindler, plus so many more . . .

From the IPv6 Task Force community: Scott Hogg, Chair Emeritus of the Rocky Mountain IPv6 Task Force and co-author of *IPv6 Security* (Cisco Press, 2011) for being such an open and sharing friend. Bruce Sinclair, Chair of the gogoNET Live! IPv6 Conference and fellow California IPv6 Task Force member for pushing me to do more by example. Shannon McFarland, co-author of *IPv6 in Enterprise Networks* (Cisco Press, 2011) for showing me that being engaging while presenting really is important and that only having one narrow technical topic won't keep folks interested. Jeff Doyle who authored the definitive CCIE study book, *Routing TCP/IP* Volumes 1 and 2 (Cisco Press, 1998, 2001) for being kind enough to think of me as someone with the right Microsoft IPv6 knowledge to

interview and have some great discussions. Silvia Hagen who authored *IPv6 Essentials, Third Editio* (O'Reilly, forthcoming) which I was lucky enough to technically review and pushed me (in that polit European way) to author a book—well here it is! Tom Coffeen, Chief IPv6 Evangelist at Infoblox, fo the many wonderful conversations and musing about what should be happening with IPv6. There are many people in the IPv6 community who as colleagues and friends over the years have helped me grow as an individual. To each of and every one of you a heartfelt thank you. Let's keep evangelizing the IPv6 story!

I need to extend a personal thank you to Ashley McNamara who took my photo for the book. She is a wonderful photographer and managed to somehow make me appear presentable and approachabl which is not easy.

Finally, a huge thank you to my editorial team Jonathan Gennick and Ana Panchoo with Apress who kept the faith and helped me in so many ways to complete the book.

Introduction

The idea for this book came about after discussions with many IT professional colleagues in the networking, systems, and developer communities. There was a lot of frustration with the IPv6 materials available being a bit biblical in size and breadth and therefore requiring a huge investment of time. Specifically, I was asked time and again for a fast “get me up to speed quickly” guide. So, here it is, my short list of what I think Microsoft Windows administrators need to know about IPv6 and how to get it operationally working in their environment quickly and in the best way. When you need to learn more in-depth IPv6 material you can go pick one of the other books listed as additional reference materials in Chapter 1.

Who should read this book

This book is ideal for those working with the Microsoft Windows operating systems (OS). It is designed for Microsoft Windows administrators but can be useful for those who do architecture of Windows solutions, developers, network engineers, and storage administrators too. Basically, if you work with Windows this book should be useful to you.

What you should know before reading this book

I assume the reader has a working knowledge of IPv4 and the Microsoft Windows OS, both client and server. There is no assumed previous knowledge of IPv6. The reader should be comfortable doing IPv4 subnetting, building DNS (Domain Name System) forward and reverse entries, knowing how to build a DHCP (Dynamic Host Configuration Protocol) scope with options, and knowing how basic routing works. You should also be familiar with netsh, AD (Active Directory), Group Policy, and PowerShell.

How to read this book

I know it might seem odd to tell people how to read a book, but in this case I want to be clear what I was trying to do while writing the book. I want the reader to feel comfortable opening the book and just using part(s) of it. I want it to be practical, so you might use some of the PowerShell examples to get one aspect of your job done and set the book aside or hand it off to a colleague for some other purpose. The goal is not to have a book you will sit down and read cover to cover and put up on a shelf. You can certainly do that, but it wasn’t designed that way. I try to provide cross-references in the book for you when possible and I try and give you the RFCs too so you don’t spend forever trying to look for things.

I hope the book ends up with sticky notes all inside it marking pages of interest plus scribbled

notes and comments in the margins. The book should have a broken spine with coffee rings from late night lab hacking and perhaps a pizza stain or two. I really hope it is one of the go to books that you keep on your desk and not the bookshelf of "knowledge" where big volumes go to die. I will tell you now, the book has errors, and every technical book does. By the time this book goes to print I am sure something in IPv6 will have changed and something I wrote about is either incorrect or no longer best practice. It happens.

Why you should read this book

I really believe that IPv6 is one of the keystone technologies that will be the foundation of the next generation of the Internet. Not knowing it will hurt your career. Maybe not today and maybe not tomorrow but eventually, if you try too long to avoid it, it will hurt you not to know it. This book allows those who already know Windows well to jump into using IPv6 without a lot of pain (I hope) and to leverage all the skills they already have with running production Windows environments. What is important is I am getting you jump-started on your journey with IPv6. Even if you only build an IPv6 lab you are better off and you can answer those IPv6 questions on the Microsoft or Cisco exams too perhaps.

Finally, if you design or architect Microsoft solutions I hope Chapter 4 gives you some of the best practice recommendations that you can leverage in your discussions with colleagues. Remember, these are not hard and fast rules and if your design calls for doing something else that is fine. The goal was to give guidance for those who don't have any operational experience with IPv6 in their environment.

Disclaimers and Support

While I have put effort into the example netsh scripts and PowerShell to make sure they are accurate I do not recommend executing them against your production network. Please make sure to build a lab or test environment and use that to validate everything you plan to do with IPv6. Test and then test again.

Errata

Any errors and omissions are not intentional. Please provide feedback and corrections to `ed@howfunky.com` and I will do my best to get future content updated.

CHAPTER 1

IPv6 the Big Picture

This chapter is an overview of the “Big Picture” of where IPv6 is at now. Its goal is to bring you up to speed on the current status of IPv6; it is not a rehash of all the old iterations IPv6 has gone through. Additionally, it will provide a very short summary of why IPv6 is important to Microsoft.

I feel it is important to have some background and framework of IPv6 before you dive into the inner workings of IPv6 on Windows. I feel this way because the most common questions I get asked about IPv6 are rarely technical ones. The questions are typically around the big picture such as “Why IPv6 now?” and “Why do we have to do all this work to support IPv6?” or “What business driver can use to sell management on deploying IPv6?” and not “What PowerShell cmdlets do I use to disable Teredo?” Clearly, depending on your knowledge level, discipline, and practice area this chapter may or may not be as useful for you, but I still think if you are considering deploying IPv6 in your Windows environment it is worth the time to read. So let’s jump right in and talk about what is happening with IPv6 right now.

IPv6 Now

For many involved in information technology (IT) the evolution of the Internet and its associated technologies are easy enough to learn (Wikipedia and other resources are available online), so I will skip over the history of IPv6 and provide a more current snapshot of what is happening now and how impacts Microsoft Windows and the Internet at large.

The current general consensus is that IPv6 adoption has been slow in most of the world due to a fundamental lack of a financial business driver forcing IT to adopt it. Overall, the global statistics for IPv6 adoption in 2013 are deplorably low (when measured against IPv4). While many large Internet companies such as Google, Yahoo!, Facebook, Comcast, Akamai, Microsoft, and others have actively attempted to drive adoption, the penetration of IPv6 for end users has been pathetically small with a few exceptions in Europe.

Granted, IPv6 has a bit of a chicken-and-egg problem. No customers will use IPv6 if their service provider does not make it available and no service provider is willing to invest to expand IPv6 on its network (as it is an expense) if the customer is not asking for that service. Something needs to happen to break this stalemate. The good news is that it finally appears to be happening.

Market Drivers

There have been a few market drivers that have been changing the landscape as of late. Specifically they are

- Depletion of address space
- Support in major operating systems
- Rise of cloud-based computing
- Ubiquity of mobile computing
- Access to reference materials

The subsections to follow describe each of these drivers in more detail.

Depletion of Address Space

Far more devices are being connected to the Internet than were ever envisioned when IPv4 addressing was conceived. Everything from cars to refrigerators to phones is being connected. As a result, we are facing

- The global depletion of IPv4 address allocations by the Internet Assigned Numbers Authority (IANA). IANA maintains the global pool of available IPv4 addresses, and that pool is now completely allocated.
- The global depletion of IPv4 address allocations in APNIC (the first regional Internet registry to run out).
- The global depletion of IPv4 address allocations in RIPE (the second regional Internet registry to run out).
- The coming depletion of IPv4 address allocations in ARIN (forecasted to happen in January 2014).

Note You can view a projection of when IPv4 addresses are expected to run out. Just visit `http://www.potaroo.net/tools/ipv4/index.html`.

The impact of the depletion event is that the first Regional Internet Registry (RIR) to run out influences everyone else. The combined RIRs have effectively run out of IPv4 address space, and can really only give out IPv6 addresses. Their ability to give out only IPv6 addresses means that you *will* be seeing a more rapid adoption rate of IPv6 in that geography. As a result, if you want to continue doing business with entities in that geography, you also have to run IPv6. This means that businesses in other regions will start asking for IPv6 address blocks, so that they are able to communicate with those that have only IPv6 available to them.

For example, if you are trying to partner with a business or even market to a customer base in APNIC (which covers all of Asia plus Australia and New Zealand) and you do not have an IPv6 presence, you are likely missing a certain population in that market. Additionally, that market of user will only grow over time.

Even if all of those customers had a transition solution to connect to you via IPv4 do you really want some other company proxying your relationship? Do you trust the Internet service provider (ISP (either in that region or closer to you) to do the right thing? Perhaps the ISP decides that because thes translation services cost a lot of money to maintain it will inject advertisements in your web content to offset that cost or have another method to compensate for its operational cost to provide that service.

You can simply avoid all of that by obtaining your own IPv6 address space or setting up your services on dual-stacked servers to have a direct relationship with your partners and potential customers. From a business perspective it just makes sense.

Support in Major Operating Systems

All major operating system (OS) manufacturers have managed to implement IPv6 into their OS. Not only do they support IPv6, but that support is on by default. This means that for most people IPv6 is possible to use with any modern OS. Indeed, IPv6 support can be found in the following:

- Microsoft Windows since Windows Vista (January 30, 2007) and Server 2008 (February 4, 2008)
- Apple OS X since 10.2 Jaguar (May 2002). The caveat here is that OS X has had variable behavior until 10.6.7 Snow Leopard
- Linux since kernel 2.6.12 (2005)

Windows XP did NOT have IPv6 on by default. XP required IPv6 support to be installed by the end user, so I don't consider it a valid OS for IPv6 by default. However, XP is not really an issue. Th pending end of support on April 8, 2014, ensures that companies will be moving to Windows 8 or 8.1 for their client deployments anyway.

For reference, a current comparison of IPv6 support across OSs can be found at `http://en.wikipedia.org/wiki/Comparison_of_IPv6_support_in_operating_`

There is also good information about IPv6 deployment at the following URL: `http://en.wikipedia.org/wiki/IPv6_deployment`.

The bottom line is that IPv6 is supported by current iterations of all the widely used OSs. Not onl is IPv6 supported, but that support tends to be enabled by default. In the case of Windows, IPv6 is, fo the most part, preferred and it is enabled by default. Understanding how IPv6 interacts with Windows and your network will be an important skill to master.

Rise of Cloud-Based Computing

When considering cloud solutions, IPv6 is important as it solves some key constraints that many service providers have today. Some items to consider around IPv6 and the cloud are the following:

- Rapid adoption of cloud services brings the expectation that they will be able to accommodate large scalable workloads and be elastic in capabilities.
- `Amazon.com` provides public IPv6 support with their Elastic Load Balancer (ELB)

service that points to IPv4 resources running on Elastic Compute Cloud (EC2) servers. My understanding is that Amazon.com currently provides limited IPv6 support on internal cloud infrastructure.

See: http://aws.amazon.com/about-aws/whats-new/2011/05/24/elb-ipv6-zoneapex-securitygroups/

- Azure supports IPv6 within its cloud offering (with future external IPv6 support planned).
- Many virtualized networking software solutions support IPv6 but might have limited functionality at this point.
- All major networking hardware manufacturers have support for IPv6.
- All major OS and Hypervisor manufacturers have support for IPv6.
- All major cloud management platforms have or soon will have IPv6 support in some fashion.

When you think about the impact that cloud services are having on the industry today, it is easy t see why IPv6 will become an important factor. IPv6 allows for building elastic and scalable infrastructure without the constraints or problems of managing Network Address Translation (NAT) and Internet protocol (IP) address range conflicts. While it will take a while for IPv6 support to be pushed to all cloud platforms, it logically makes sense to have IPv6 as a key foundation for cloud functions. Just imagine having as many IP addresses as you want for your infrastructure, and that the are globally unique! No more conflicts, no more managing overlapping address spaces, no concerns about number of hosts in a subnet, because the number you can have is effectively limitless.

Ubiquity of Mobile Computing

The rapid expansion of mobile handsets along with 3G and 4G cellular capabilities being able to provide increasingly faster and faster data speeds has led to an explosion in IP address requirements for mobile operators. In fact, the LTE specification that Verizon adopted for its 4G services deployment requires IPv6. Many other service providers have done similar IPv6 specification requirements. At this point, it just makes sense to utilize IPv6, as it is the ONLY way to address the huge adoption rate of smartphones, mobile hotspots, and embedded 4G devices that are flooding the market.

Mobile solutions also have the opportunity to leverage Mobile IPv6 if desired by the mobile provider. While Microsoft Windows does not support Mobile IPv6, it does not mean that other devic won't. At this point, I do not think Microsoft will do any development on Mobile IPv6, because no other mobile OS is going in that direction. There just is not enough incentive to invest to make Mobi IPv6 happen at this point.

Note If you are interested in learning more about Mobile IPv6, please see *Understanding IPv6, Third Edition* by Joseph Davies (Microsoft Press, 2012) or *IPv6 Essentials, Second Edition* by Silvia Hagen (O'Reilly Media, 2006).

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