



**APRIL 2008**

## Executive Summary

Hurricane Electric is using this document to update its customers and anyone else interested in Hurricane Electric's network offerings.

This document is about IPv6, and the IPv6 services at Hurricane Electric. Hurricane Electric is a leader in the IP backbone world and provides both IPv4 and IPv6 services throughout its network.

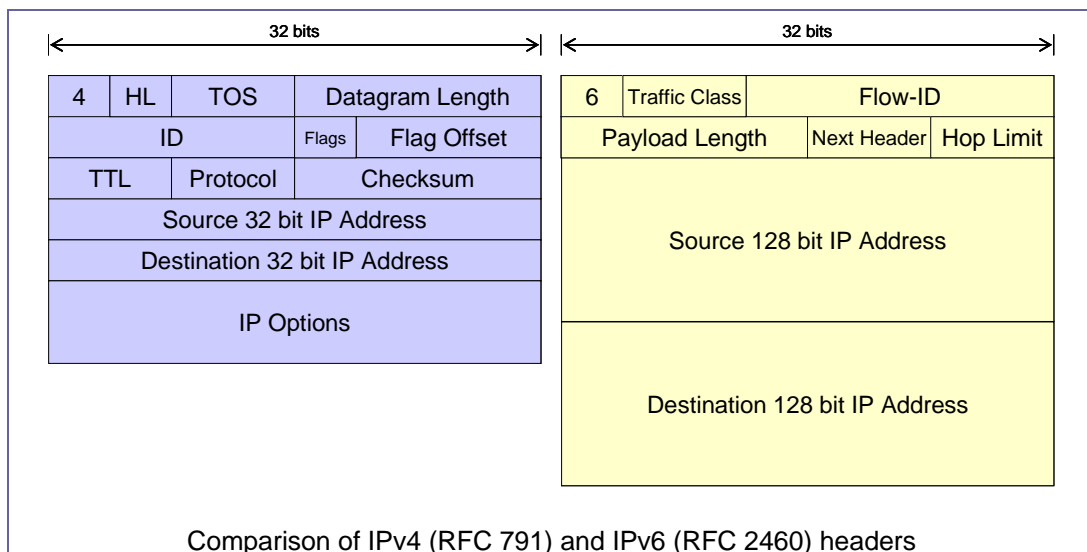
It's a third of the way through 2008 and it's time to update Hurricane Electric customers and explain what the company is doing to provide services – specifically IPv6 services – to the Internet community.

- ❖ Consider this document as a 3 year advance warning regarding IPv4 address depletion.
- ❖ Consider this document as a heads-up that you need an IPv6 plan for your network.
- ❖ Consider this document as a friendly reminder that Hurricane Electric provides native IPv6 transit.
- ❖ Consider this document as a reassurance that, as a customer of Hurricane Electric, you don't need to worry as much as others.

## ABOUT IPv6

### What is IPv6?

IPv6 is the next-generation Internet protocol that is designated to replace IPv4. First known as Next Generation Internet Protocol (IPng) when it existed as a committee within Internet Engineering Task Force (IETF), now it's officially known as IPv6 and defined by documents called Request For Comments (RFCs) since 1998. IPv6's major claim to fame is its 128 bit addresses. That's 79 billion billion billion times more addresses than IPv4. Well maybe.



The core of the IPv6 protocol is defined by RFC 2460, RFC 4291, RFC 4861, RFC 4862, RFC 4443 and RFC 1981; however a whole slew of additional RFCs make up the working body of specifications for IPv6.

IPv4 has similar documents; some dating back to the early 80's when TCP/IP was first proposed for the ArpaNet. RFC 791 and RFC 793 cover the core IP and TCP protocols respectfully.

<http://www.fags.org/rfcs/> -or- <http://www.ietf.org/rfc.html>

Two complete collections of RFCs

IPv6 is designed to replace IPv4 and provides significant additional features. Address space expansion is nearly always the core focus of IPv6's role in the Internet today; however it's important to note that security, efficiency and the enabling of new applications are all important in the IPv6 world.

### ***Who needs to know about IPv6?***

Nearly everyone using the Internet today will be affected. Some more than others, some simply by allowing automatic software updates to provide their computing platform with the facilities needed to connect to an IPv6 enabled network.

- ❖ If you are a system administrator or network engineer, you need to understand how to deploy and administer IPv6 on your existing equipment or figure out what hardware or software you need upgrade or install to support IPv6.
- ❖ If you are a technical manager you need to ensure that your staff gains operational experience with IPv6 in order to support your organization and customers.
- ❖ If you are in sales or marketing and your business depends on the Internet then you need to develop competitive strategies for how you will present your IPv6 capability when this becomes a market driver.
- ❖ If you are in executive management (a CEO, COO, CFO or CIO) or are an investor in an Internet company, then you need to know about IPv6 from the risk management perspective of ensuring your organization has an IPv6 plan.
- ❖ If you are an end user, you just need to look for IPv6 support when selecting network services, software, or hardware. It is everybody else's job to make sure you don't have to worry about the technical details of IPv6. ;)

What's important to understand (as an end-user) is that the Internet core backbones, including backbones like Hurricane Electric's, are the first place where IPv6 needs to be implemented. This is where Hurricane Electric has been focusing for the last seven years. Hurricane Electric took the initiative back in 2001 to start operating an IPv6 network. Like every other backbone at the time, IPv6 was just an adjunct to the day-to-day IPv4 operations.

Today Hurricane Electric is running a fully-functional dual-stack IPv4 and IPv6 enabled at every location within its network. Customers that use Hurricane Electric datacenters or Hurricane Electric IPv4 transit services can upgrade to a dual-stack IPv4 & IPv6 offering with ease.

Hurricane Electric has done its part, it's now time to help you (the customer) do your part.

### ***Aside from the technical features, why does anybody need to deploy IPv6?***

IPv6 is being deployed to get unique globally routable IP addresses, for two reasons: IPv4 addresses are running out and there are networks with more devices than can be currently assigned unique globally routable addresses under IPv4.

See the following example (and then extrapolate for China and India):

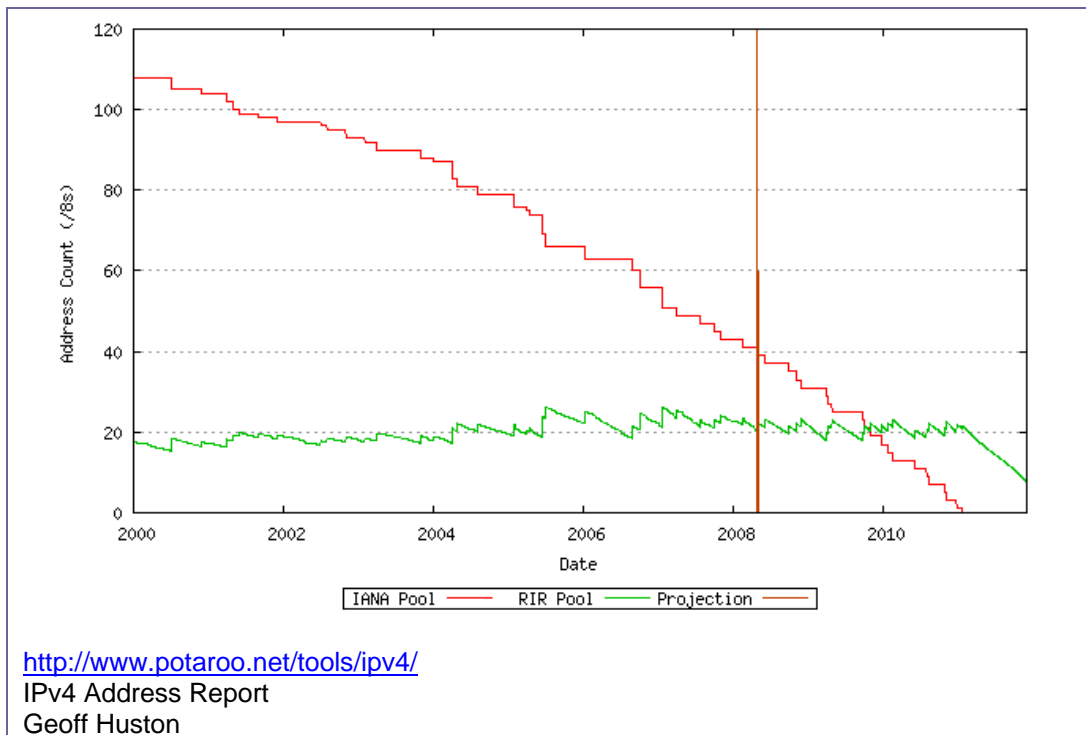


<http://www.nanog.org/mtg-0606/pdf/alain-durand.pdf>  
IPv6 @ Comcast – Managing 100+ Million IP Addresses  
Alain Durand – Office of the CTO  
Director – IPv6 Architect  
NANOG 37 – June 2006

Comcast's experience is only one of many presentations within the technical community that show a solid need to migrate to IPv6. Since this paper was written in June 2006, the calculations on address exhaustion have been revised and expanded.

### *When will the IPv4 address pool be exhausted?*

For many years, Geoff Huston has provided a solid understanding of the state of the Internet, from a routing and IP numbering point of view. He has been active in the IETF and numerous other forums around the world. He's provided an extensive review of IPv4 address exhaustion on his website. It's not replicated in this document. Hurricane Electric recommends nearly every reader of this document also reviews his IPv4 Address Report and its numerical modeling. Here is a very brief summary.



According to his modeling, the date that Internet Assigned Numbers Authority (IANA) is projected to run out of IPv4 address space to allocate to Regional Internet Registries (RIRs) around January 2011.

In addition, his modeling shows the date the RIRs (ARIN, RIPE, APNIC, LACNIC and AFRINIC) are projected to run out of addresses to allocate to ISPs is around November 2011. Regional registries are allocated large blocks of address space and they then provide end-users, within their geographic regions, smaller allocations.

BTW, this modeling assumes there won't be a land rush once end user organizations realize it is their last chance to get their own routable IPv4 address space, and that there won't be hoarding or speculation.



## ***Why does getting IP addresses matter?***

Ask yourself how relevant getting any more addresses is to the various types of services your company provides. If your organization already has all the IP addresses it will need in the next 10 years then aside from competitive issues (your competitors supporting IPv6 and saying you don't support IPv6), you may be able to ignore this document.

- ❖ Do you assign address space to customers?
- ❖ Do you expect to deploy a significant number of servers in the future that need to be reachable from the Internet at large?
- ❖ Do you sell a service, software, or hardware which requires customers to be able to get unique globally routable address space?

IPv6 provides a solution that provides the ability to get globally routable addresses in the future after the IPv4 address pool is exhausted.

If you depend on your ISP to take care of this for you, then make sure they either already provide native IPv6 or have an IPv6 plan.

Network service providers, such as Hurricane Electric, should be the first to deploy so that network users can get native IPv6 and begin the task of learning, experimenting, and testing well in advance of their need to provide production services.

## ***Is IPv6 connectivity the same as IPv4 connectivity?***

Not today, and potentially not for many years. IPv6 has a varied rate of deployment by various organizations, this means some backbones have it deployed natively in their core everywhere (like Hurricane Electric), some have it deployed on a limited number of routers as a "tunnel net", and some have not deployed it at all.

Because IPv6 deployment is different than IPv4, the backbone network topology and the connections between IPv6 backbones is different than IPv4. Any specific path via IPv6 may be faster than IPv4 (a more direct route), the same as IPv4, or in some cases slower than IPv4. This should be *\*expected\**. Because IPv6 is still in early deployment stages, there are less servers running IPv6 than IPv4, and most of the IPv6 servers are pilot deployments running a subset of services. This also should be *\*expected\**.

Hurricane Electric strives to provide every customer a seamless approach to IPv6. If you're a transit customer, a colocation customer or a web hosting customer, Hurricane Electric want to provide you with both IPv6 and IPv4 services. Both IPv6 and IPv4 services on the same pipe. Both services managed by an engineering group and 24-by-7-by-365 NOC that's accustomed to providing IPv6 and IPv4 support. IPv6 is not a "special" within the Hurricane Electric network!

## ***I'm from a large organization; projections are all well and good, give me some official dates.***

Projecting into the future is a hard task; however Hurricane Electric has picked some important documents and research that shows that IPv4 address space exhaustion is inevitable and even if it wasn't, the value of migrating to an IPv6 world is overwhelming. As a network manager it's unacceptable to wait until there is no more time. Prior-planning is a core-concept within network design and when it comes to network deployment, being ready for future needs is part of every job description.

Hurricane Electric's job is to enable every customer, from CEO and CIO to network engineer with the information required to play and deploy an IPv6 network well within the time needed to transition. Read on to see how others define the timelines that companies should be operating with.



An Internet Draft by John Curran (Chairman of ARIN) titled "*An Internet Transition Plan*" sets out some dates that may be of use within large organizations to establish internal deadlines:

<http://www.ietf.org/internet-drafts/draft-jcurran-v6transitionplan-02.txt>

An Internet Transition Plan  
John Curran  
January 30, 2008

The following press release was issued by ARIN:

<http://www.arin.net/media/releases/070521-v6-resolution.pdf>

ARIN Board Advises Internet Community on Migration to IPv6  
21 May 2007

The US Government's Office of Management and Budget (OMB) issued this memo dictating IPv6 compliance within the US Federal Government's networks by June 30th 2008:

<http://www.whitehouse.gov/omb/memoranda/fy2005/m05-22.pdf>

MEMORANDUM FOR THE CHIEF INFORMATION OFFICERS  
August 2, 2005

For reference, some major tectonic shifts have already occurred: IPv6 addresses and connectivity were added to the root nameservers on February 8th, 2008:

<http://www.iana.org/reports/2008/root-aaaa-announcement.html>

IPv6 Addresses for the Root Servers  
29 January 2008

Internet Corporation for Assigned Names and Numbers (ICANN) followed with its own announcement:

<http://www.icann.org/announcements/announcement-04feb08.htm>

IPv6 Address Added for Root Servers in the Root Zone  
Addition enhances end-to-end connectivity for IPv6 networks  
4 February 2008

Why is this significant? After ICANN and IANA made these announcements, the root nameservers started including IPv6 addresses to queries for addresses and the like. That means that every time a web address, or email is sent and a query touches the root nameservers, there is a potential of an IPv6 address being returned. Today most enterprise and ISP systems will ignore that IPv6 address. At Hurricane Electric, all DNS nameservers are IPv6 enabled and addressable from IPv6 capable networks.

### ***Why create an IPv6 plan when the OMB date turned out to be a soft date and the IPv4 exhaustion dates are just projections?***

The value of setting deadlines and creating timelines is to help people within your organization plan accordingly.

For example, be sure to take into account your organization's capital expenditure cycle for core equipment such as routers and firewalls. Often assets such as routers and firewalls are only replaced every 3 to 7 years.



If replacing legacy equipment with new equipment that supports IPv6 affects your capital expenditure budget then you need to start planning now, so that IPv6 capability is part of your natural replacement cycle instead of an extraordinary capital expenditure made at the last minute in crisis mode.

## IPv6 AT HURRICANE ELECTRIC

### *Hurricane Electric's view of IPv6*

As a backbone operator, Hurricane Electric sees IPv6 in the context of the question: *"In three years, does Hurricane Electric still want to be in business?"* Since the answer is a resounding "yes", this provides the clear motivation to deploy native IPv6. Further, since Hurricane Electric views deployment of native IPv6 network services as a precursor to the ability of its customers to provide production services over IPv6. Hurricane Electric started early and in earnest!

IPv6 planning for us was a matter of taking IPv6 into account when making purchasing decisions and implementing projects. Hurricane Electric viewed IPv6 from a risk management perspective that it didn't cost us much and potentially gained us a competitive edge if IPv6 was important, whereas if Hurricane Electric didn't do it we were risking the business for the sake of avoiding a little thinking.

### *Hurricane Electric (AS6939) went dual stack IPv6 and IPv4 at all locations in 2007*

In early 2007 Hurricane Electric completed a network wide core router and backbone circuit upgrade. As part of this process we moved the Hurricane Electric IPv6 network into the network core and now run dual-stack wiredspeed IPv6 and IPv4 in all locations.

This paper describes the IPv6 network performance improvements:

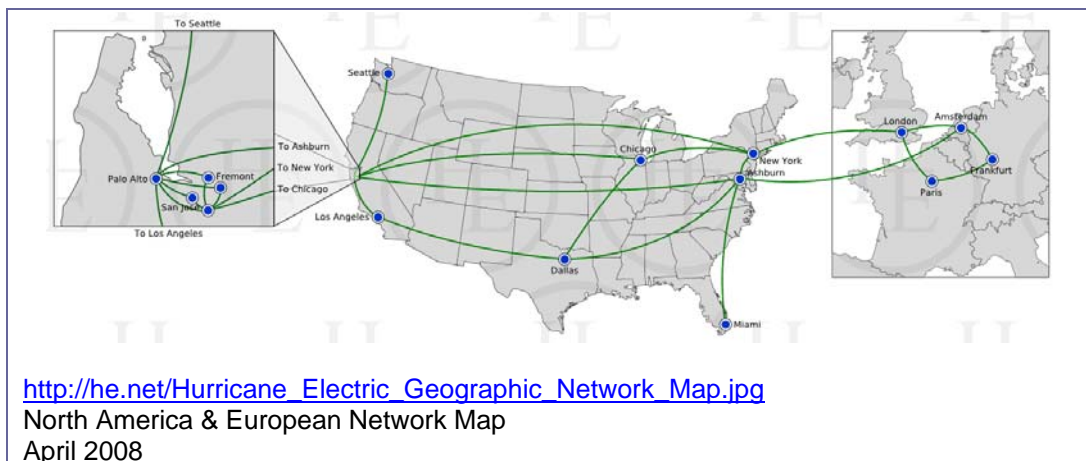
<http://bgp.he.net/going-native.pdf>

Going Native

A backbone transition to extensive native IPv6 peering

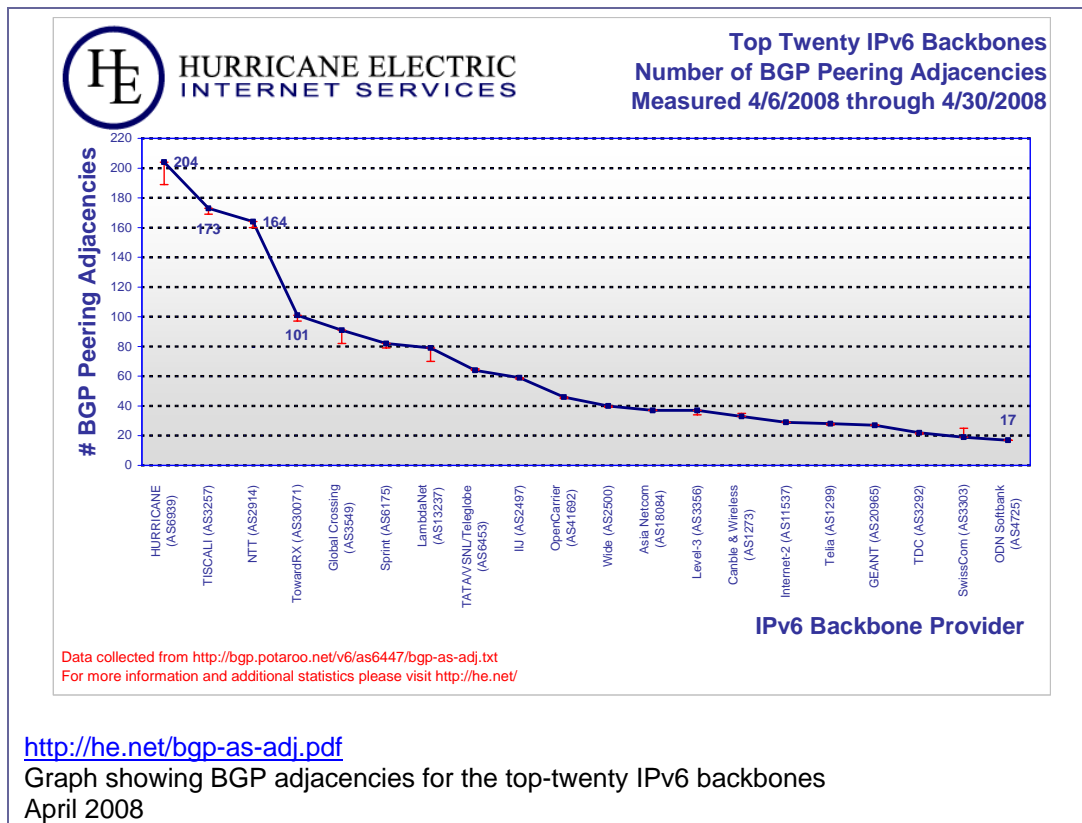
By Mike Leber

Hurricane Electric upgraded the internal support and systems to be IPv6 enabled. The NOC and engineering staff are all IPv6 capable personnel so that any IPv6 customer knows they are talking to a trained professional directly, vs. having to wait for the one IPv6 expert in the company to get back from lunch. Hurricane Electric upgraded its basic network services including DNS name servers, NTP time servers, SMTP mail servers, public router servers and public looking glass to be IPv6 compliant.



The Hurricane Electric network covers the US and major locations in Europe. Each location is IPv6 enabled and provides IPv6 transit services in both native and dual stack formats. As the network expands to include additional geographic locations, it will always expand as a fully capable IPv6 network.

There are various ways to compare Hurricane Electric's IPv6 backbone to other IPv6 backbones. One of the most important metrics is the number of BGP adjacencies at the edge of the network. The greater the adjacency, then the backbone has higher connectivity with the rest of the Internet. In the IPv6 world, this is even more important than in the IPv4 world because disconnected pockets of connectivity can cause enormous disruption for end users. Hurricane Electric's IPv6 backbone has the number-one count of BGP adjacencies.



That last graph shows a pictorial view of the data from Geoff Huston's website. The data is collected from live IPv6 Internet routers.

**Native IPv6 is available to all Hurricane Electric colocation, transit customers, and root dedicated server customers**

Native IPv6 is available on the same port as IPv4 at no additional charge.

You may request IPv6 address allocations by sending email to [support@he.net](mailto:support@he.net) .

If you operate a router, you may request a /48, otherwise request a /64 per port.

In the IPv6 world, as stated at the beginning of this document, there are 128 bits included in the IPv6 header. Addresses have four times as many bits as an IPv4 header would have. This is where the 79 billion billion billion number comes from. Its  $2^{128}$  divided by  $2^{32}$  and yet best practices, as stated in RFCs, shows that IPv6 address allocations are not the same as in IPv4. The allocation on an individual





network segment is always /64. That's  $2^{(128-64)}$  or  $2^{64}$  or 18 billion addresses. This may seem wasteful; however its inline auto configuring IPv6 addresses from device MAC addresses on a local network segment. Even with this address allocation, it still provides the Internet with a massive increase in address space. If you want to delve more into this subject, A Hurricane Electric network engineer can help you understand this issue.

### ***Native IPv6 is available on Hurricane Electric version-3 web servers***

At this point in time, the version-3 web servers have the Apache, SSH/SFTP, and POP3/IMAP portions validated for IPv6. Hurricane Electric is still testing some additional portions of the system.

### ***Hurricane Electric operates a Free IPv6 Tunnel Broker: <http://tunnelbroker.net>***

For networks and servers not connected to the Hurricane Electric network and that don't have easy access to native IPv6 networks today, Hurricane offers a free tunnel broker service. The service enables you to reach the IPv6 Internet by tunneling over existing IPv4 connections from your IPv6 enabled host or router to the Hurricane Electric IPv6 backbone.

<http://tunnelbroker.net/>  
IPv6 Tunnel Broker Service

The Hurricane Electric tunnel service is oriented towards developers and experimenters that want a stable tunnel platform. The web site provides information on setting up tunnels on various platforms, including Windows, Mac OS X, Linux and various router platforms. This can normally be a five minute process.

### ***Hurricane Electric maintains a Global IPv6 Progress Report:***

Routing is normally a very transparent operation to an end user. In fact, if routing is working correctly, it never comes up in conversation. During this IPv6 transition process, Hurricane Electric decided that it needed to provide customers with some useful metrics.

<http://bgp.he.net/ipv6-progress-report.cgi>  
Global IPv6 Deployment Progress Report

Hurricane Electric took a first pass at developing some metrics for global IPv6 deployment. Some of the items measured are: the number of networks running IPv6, the number of IPv6 prefixes with working reverse DNS, the relative performance of IPv6 vs IPv4 as measured by pinging nameservers with both IPv6 and IPv4 connectivity, and the number of Alexa top 500 websites that have added AAAA records so far.

## **CONCLUSION**

### ***What should you do right now?***

Forward this document to other people within your company who need to be more aware of IPv6.

### ***What should you do in the upcoming months?***

If you are a Hurricane Electric transit, colocation, or root dedicated server customer then learn about how to configure your routers and servers for IPv6 and then try setting up a server with basic IPv6 connectivity so that you can ping it and access it via HTTP and SSH.





If you are a Hurricane Electric web hosting or fully managed dedicated server customer on a version 3 server then Hurricane Electric will take care of everything for you and from time to time give you updates. If you are on a version 1 or version 2 server, when you are ready you should upgrade to a version 3 server via the admin interface.

There are now projected to be about 996 days until IPv4 exhaustion, assuming there is no last minute rush, hoarding, or speculation. If you are planning on requesting IPv4 address space in the next few months please send your request with justification to [support@he.net](mailto:support@he.net) .

### *Hurricane Electric IPv6 firsts:*

Hurricane Electric was the first backbone in the world to pass 200 IPv6 adjacencies:

<http://bgp.potaroo.net/v6/as6447/bgp-as-adj.txt>  
Geoff Huston's IPv6 BGP Adjacencies Report (Text format – best network at the top)

BGP Adjacencies means the count of networks, that run BGP, a network connects to; i.e. customers or peers.

Hurricane Electric also announces the largest number of IPv6 customer prefixes (240) of any IPv6 network in the world.

## THANK YOU

As always, should you want more information about IPv6 and Hurricane Electric, please contact Hurricane Electric at:

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[info@he.net](mailto:info@he.net) (email)  
<http://he.net/> (web)

Hurricane Electric look forward to helping your network grow (and migrate to IPv6).

Hurricane Electric IPv6  
Tell a friend about Hurricane Electric!

