October 2007

This factsheet does not represent the entirety of the IPv4/6 technical discussion but is intended to be an accessible document that provides a simple introduction to the subject for non-technical readers.

Factsheet

IPv6 – The Internet's vital expansion

Executive summary:

- There is widespread agreement within the technical community that the Internet's current system is unable to cope with the network's expansion.
- Every device attached to the Internet needs its own unique address. The "free pool" of existing addresses will run out completely within five years.
- The proposed solution is an updated system running on Internet Protocol version 6, or IPv6.
- IPv6 adoption has been slow. Since it is not directly compatible with the current IPv4 system, there is inertia to the move.
- This delay has become a matter of increasing concern.
- It is important that companies, governments and regulatory authorities understand the issues surrounding IPv6 and why its use should be encouraged.

Every device that connects to the Internet needs an address. But those addresses are rapidly being depleted. As unlikely as that may seem, the system put in place in 1977 assumed that four billion separate addresses on the network would be more than sufficient.

The Internet's enormous success and growth has seen those addresses rapidly taken up. Within the next five years, and possibly sooner, the "free pool" of addresses – those that have not yet been used or assigned – will run out. As a result, unless a method of providing more addresses is introduced, the Internet's growth will become increasingly constrained over the next decade.

Fortunately, Internet engineers foresaw the problem and back in 1996 devised a solution that would provide 340 trillion trillion trillion separate addresses. To give an idea of the scale, if all existing four billion Internet addresses were contained inside a Blackberry phone, the new system would fill a container the size of the Earth.

Adoption of that solution – called Internet Protocol version 6 (IPv6) – has been slow. The benefits of IPv6 are long-term. Technical workarounds that allow for continued use of the existing Internet Protocol version 4 (IPv4) system have also appeared that allow several devices to share one Internet address.

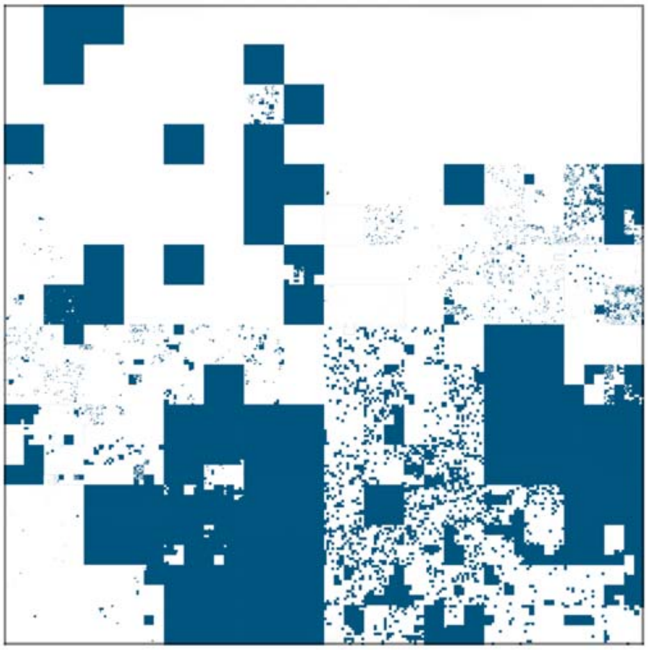
The slow movement to IPv6 has caused increasing concern in the technical community and relaxed expectation of movement has moved to active promotion of IPv6 adoption.

What is IPv6 and why is it needed?

IPv6 stands for Internet Protocol version 6 and is the technological solution that allows for a vast expansion in the number of Internet addresses.

At the moment, the Internet uses version 4 of the Internet Protocol that provides just over four billion unique addresses on the network. The Internet was designed for each device attached to the network to have its own individual numerical address so computers can communicate with one another, so while four billion addresses was once seen as more than sufficient, the explosion in the Internet's use has rapidly seen those addresses eaten up. IPv6 theoretically allows for 340 trillion trillion trillion addresses, so IPv4's fundamental limitation is address space.

The majority of Internet users will never need to concern themselves with IP addresses because the domain name system (DNS) links the addresses with names such as "example.com", so people need only recall a name to get to a particular part of the Internet. But without those numeric addresses in the first place, the Internet simply wouldn't work.



Existing Internet (IPv4)
(unallocated addresses in blue)

Many of the electronic devices people carry around today such as mobile/cell phones, PDAs, pagers, and so on, use the Internet. At the moment, most of those devices access the Internet through a "gateway" that has a single, unique IP addresses on the Internet but produces a number of private addresses behind it. These private addresses are then provided to individual devices. As applications evolve, however, the advantages to each device having its own unique address are going to increase. In the future it is expected that not only will the number of people connecting to the network increase but also that they will each possess more devices that also need to be connected to the Internet.

As the Internet continues to become an everyday part of our lives there are predictions that appliances such as refrigerators, televisions, even alarm clocks will make use of the network.

Are there any stop-gaps?

The reduced availability of IPv4 addresses (as of October 2007, only 17 percent is left), and the slowness to move to IPv6, has seen people develop systems and solutions to make the most of the IP addresses they already have.

One such system is called Network Address Translation (NAT). It allows one outside IP address to be shared between a number of computers and other devices. Each of the devices is given its own private IP address within the network but to the wider Internet they all appear to come from one address or device. With NAT technology, the outgoing connection, such as browsing a website, works well, but inbound connections such as file-sharing applications or voice-over-IP (VoIP) require special attention. Operating servers from within a NAT environment is particularly awkward, although NAT's low cost continues to make the system attractive.

As IPv4 addresses become increasingly scarce, many believe it is inevitable they will become increasingly valuable. As a result, the existing allocation system has come under increasing scrutiny as some organisations look to profit from the scarcity and others seek to avoid unnecessary extra costs in the future expansion of the network infrastructure. The Organisation for Economic Co-operation and Development (OECD) is among the organisations reviewing the potential economic impact of this scarcity.

There are a variety of predictions, using different models, that attempt to estimate when there will be no more IPv4 addresses to allocate. The cut-off date ranges from 2009 to 2013.

It is now the widespread opinion of the technical community that for the continued and uninterrupted expansion of the Internet, it is vital that IPv6 adoption begin in earnest.

How are IP addresses allocated?

The Internet Assigned Numbers Authority (IANA) - a function of the Internet Corporation for Assigned Names and Numbers (ICANN) – jointly manages allocation of the global IP address pool with the Regional Internet Registries (RIRs).

In the early days of the Internet, address "blocks" were allocated to organisations – mostly universities and research organisations - by the Network Information Center (NIC) which operated under IANA. But as demand exploded, particularly outside the United States, the RIRs were established in order to deal with requests from different geographic regions. IANA now supplies address blocks to these RIRs, who then allocate them to other users, mostly Internet Service Providers (ISPs). ISPs then make these IP addresses available to their customers, the individual Internet users.

The allocation of those blocks over time has closely reflected use of the Internet around the world, with many IPv4 blocks provided to the burgeoning North American Internet community in the early days because that was where the Internet started and where investment in the infrastructure first occurred. More recent allocations reflect the modern global use of the network.

What is ICANN's role?

ICANN acts as a coordinator of the Internet's unique identifiers, including IP addresses. Its stakeholders cover a broad spectrum from governments to individual Internet users. Some of those stakeholders will play an important role (in conjunction with other technical and non-technical bodies) in making IPv6 a reality. In June 2007, the ICANN Board resolved that the organisation would "work with the Regional Internet Registries and other stakeholders to promote education and outreach, with the goal of supporting the future growth of the Internet by encouraging the timely deployment of IPv6."

ICANN has held, and continues to hold, open forums and discussions about IPv6 in order to spread understanding and facilitate cooperation between Internet organisations.

How far are we with IPv6 adoption?

Despite the fact that IPv6 was defined over a decade ago, its adoption has been slow – too slow. There are a number of inter-relating factors for this:

- **Cost**. It costs network providers time and money to move to an IPv6 system and to be able to run the existing IPv4 system alongside IPv6 (something that will be essential for some time into the future).
- **Features**. Although IPv6 provides incremental improvements over IPv4, its main advantage - greatly increased address space - has yet to provide a compelling case for investment. Address depletion simply has not been a major focus for many businesses.
- **Incompatibility**. IPv6 is not directly compatible with IPv4. There are technologies that enable the two to communicate but IPv4 is liable to survive a long time into the future, so bridging technnology will be needed for a significant period of time.
- **Demand**. There is currently little or no demand for a move to IPv6 from paying customers. But all applications need an upgrade, and in that regard, application sellers have work to do.

Some predict that a widespread shift to IPv6 will only occur once the cost of running on IPv4 starts rising due to scarcity. However, governments are beginning to recognise the need for movement to IPv6 and have started using incentives, funding and contractual obligations to encourage the transition. The Chinese, Japanese and Korean governments have been leading rollout; the US government has mandated that contractors be IPv6-ready by the summer of 2008; and the European Union is reviewing methods to encourage adoption.

The RIRs are also supporting the adoption of IPv6 with four of the five making public statements on the matter. The American Registry for Internet Numbers (ARIN), stated that it felt "compelled to advise the Internet community that migration to IPv6 is necessary for any applications that require ongoing availability from ARIN of contiguous IP number resources". And the Latin American and Caribbean Network Information Center (LACNIC) has launched a campaign to have all the region's networks running IPv6 before 2011. Mexico's domain registry, NIC.mx, have stated they will stop allocating IPv4 on 1 January 2011.

An IPv4/IPv6 size comparison: if all the IPv4 addresses could fit within a Blackberry, it would take something the size of Earth to contain IPv6

What are the advantages of IPv6?

- Greatly expanded address space, with plenty of addresses for everyone. Home users will have enough for thousands of devices. Enterprises will be able to reduce the cost of managing internal address space.
- It allows for every machine/device to have its own IP address on the wider Internet, simplifying network designs and also allowing for easier remote configuration.
- It allows for much larger data packets.
- It will open the door to a new generation of devices because of larger address space.
- It provides an improved degree of connectivity where individuals will be able to interact directly with devices anywhere on the network i.e. anywhere in the world. One example frequently quoted is being able to turn your home air conditioning on from the office, but there are likely to be thousands of other examples in future.
- Since most experts agree that an eventual shift to IPv6 is inevitable, there may be a significant "early mover" advantage to businesses and governments that adopt the protocol.

What are the issues with IPv6 rollout?

IPv6 is already available in some desktop and server operating systems. However, the vast majority of Internet content and services are only provided over IPv4, which is a problem as IPv4 and IPv6 are not interoperable. That means a desktop computer that only has an IPv6 address cannot access a website that only has IPv4 connectivity without passing through a NAT-PT device or some other form of protocol translation system or application gateway.

Another key issue in IPv6 deployment is that the vast majority of networks were built for IPv4. Enabling IPv6 on those networks involves making sure that provisioning, management, monitoring, auditing, billing and firewalls all work with IPv6.

Widespread deployment only becomes possible when consumer devices work with IPv6, and there is still some work to be done to make a very large number of devices fully compliant. The problem is also with those who have not even started looking at what needs to be done to deploy IPv6. Issuing millions of consumers with updated devices could be expensive.

Because some of the more useful features in IPv6 have been made available in IPv4, ISPs have not felt it is a priority to deploy it on their production networks and create products until now.

Is it IPv6 or nothing?

No. IPv4 will continue to be in active use for the foreseeable future, particularly in developing countries, due to the cost of moving to IPv6.

As long as IPv4 continues to serve people's needs, a wholesale move will not happen. And although there is an increasing sense of urgency that people should start moving to IPv6, it is not the same situation as the Year 2000/Y2K issue that had a clear date by which transition was vital.

New allocation policies for both IPv4 and IPv6 addresses have been drawn up, and discussion is ongoing about how best to reintroduce unused IP addresses into the system, particularly in the case where early allocations of IPv4 address space were larger than proved necessary.

It is important to note however that there have been many transitions in Internet technology over the years, from dial-up modems to always-on DSL, from host files to the domain name system. IPv4 to IPv6 is a more complex step on the path of the Internet's future. But it is crucial to expansion of the network.

Where can I find more information?

There are a number of resources available for those who wish to know more about IPv6. A few are below:

IPv6 resource website:
http://www.ipv6.org/

IPv6 Wikipedia page:
http://en.wikipedia.org/wiki/IPv6

ISOC FAQ on IPv6:
http://www.isoc.org/educpillar/resources/ipv6_faq.shtml

Glossary

IANA - Internet Assigned Numbers Authority: The IANA is the authority originally responsible for the oversight of IP address allocation, the coordination of the assignment of protocol parameters provided for in Internet technical standards, and the management of the DNS, including the delegation of top-level domains and oversight of the root name server system. Under ICANN, the IANA continues to distribute addresses to the Regional Internet Registries, coordinate with the IETF and others to assign protocol parameters, and oversee the operation of the DNS.

IP - Internet Protocol: The communications protocol underlying the Internet, IP allows large, geographically diverse networks of computers to communicate with each other quickly and economically over a variety of physical links. An Internet Protocol Address is the numerical address by which a termination point in the Internet is identified.

RIR - Regional Internet Registry: There are currently five RIRs: AfriNIC, APNIC, ARIN, LACNIC and RIPE NCC. These non-profit organizations are responsible for distributing IP addresses on a regional level to Internet service providers and local registries.

About ICANN

ICANN is a nonprofit organisation responsible for coordinating the Internet's systems of unique identifiers, including the systems of domain names and numeric addresses that are used to reach computers and other devices on the Internet. ICANN's mission is to ensure the stable and secure operation of these unique identifier systems, which are vital to the Internet's operation. In addition, ICANN coordinates policy development related to these technical functions through its effective bottom-up consensus model. Further information about ICANN is available at http://icann.org.