ISOC MEMBER BRIEFING #1

IPv6 and the Future of the Internet

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DEFINITION

IP version 6 (IPv6) is a new version of the Internet Protocol, designed as a successor to IP version 4 (IPv4) [RFC-791], the predominant protocol in use today. The changes from IPv4 to IPv6 are primarily in the following areas: expanded addressing capabilities; header format simplification; improved support for extensions and options; flow labeling capability; and consolidated authentication/privacy capabilities.

BACKGROUND

According to population estimates from the US Census Bureau, the world will be home to about 9 billion people in 2050. Whatever the economic constraints may be, we must clearly plan technically for all of these people to have potential Internet access. It would not be acceptable to produce a technology that simply could not scale to be accessible by the whole human population, under appropriate economic conditions. Furthermore, pervasive use of networked devices will probably mean many devices per person, not just one. Simple arithmetic tells us that the maximum of 4 billion public addresses allowed by the current IP version 4, even if backed up by the inconvenient techniques of private addresses and address translation, will simply be inadequate in the future. If the Internet is truly for everyone, we need more addresses, and IP version 6 is the only way to get them.

IPv6 has other benefits, such as provision for "plug and play" automatic configuration, which promises reduced complexity of network deployment and administration. Still, the principal benefit of IPv6 is that of having enough addresses — thereby assisting in restoration of the end-to-end model on which the Internet was based.

TECHNICAL ISSUES

To demonstrate that IPv6 really does have enough addresses for *everyone*, consider that it has 128-bit long addresses. Superficially that appears to offer an unthinkable number of addresses: about 340 trillion, trillion, trillion ($3.4x10^{38}$). In reality, addresses are structured, and as a result the number effectively available is somewhat less according to the administrative policy adopted. For example, on one model, each site running IPv6 would be given a 48-bit prefix, leaving a mere 80 bits for local use. There could be 35,184,372,088,832 such prefixes – 35 trillion IPv6 sites, which seems to be enough for 9 billion people. (The careful reader will notice that 35 trillion is 2^{45}, not 2^{48}, due to a technical detail of the address format.)

Whether or not the new protocol is required at all has been the subject of some debate within the technical community. While some

Expanded Coverage from ISOC

In-depth articles, papers, links and other resources related to this topic are available from the ISOC website at http://www.isoc.org/briefings/001/.

Examples in the News

IPv6 at Center of EU Security Plan

Brussels: 6 June 2001 (Reuters) - The European Union has presented proposals for enhancing security measures for Internet users in its Member countries, calling for rapid adoption of IPv6, which "has built-in security measures aimed at preventing interception of personal communications and tampering with data."

Industry Leaders Accelerate IPv6 Development Efforts

Cisco Systems, Inc., and several of its industry partners are working in concert to accelerate the development of hardware, software and solutions that will benefit from the enhanced functionality of IPv6.

Relevant IETF RFCs

At the last count, 47 RFCs have been published by the principal IETF working groups concerned (in addition to RFCs related to IPv6 from other working groups). The initial specifications for IPv6 were outlined in RFC 1883 of December 1995. These have been replaced by revised standards issued in December 1998 in RFC revised in the form of RFC 2460. Although the actual technical work of standardisation is the IETF's domain, ISOC is proud to fund the RFC publication process as a practical form of support for standardization of IPv6.

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argue that IPv6 is required for the future growth of the Internet, there remains a sizable camp who argue that the protocol is “too little, too late” and that IPv4 with the addition of network address translation (NAT) offers a viable system for the future.

However, NAT inhibits many forms of innovative network use beyond the simple client-server model that is popular today, and presents very challenging operational problems when deployed on a massive scale.

IMPLICATIONS

Fairness vs. scaling - The rules followed by the regional IP address registries in allocating address blocks to service providers and major customers could become a policy issue as well as a technical one. The rules need to be fair and non-discriminatory, so that all companies and all countries are treated equitably, but at the same time they must allow for massive scaling of the IP routing system if we are to bring connectivity to *everyone.* These two requirements – fairness and scaling – tend to be in conflict, since a completely fair system simply allows anyone who wants a block of addresses to get one, and that makes compact routing tables virtually impossible.

Privacy – In many cases, the lower 64 bits of an IPv6 address form an identifier, which in the simplest case is derived from the LAN address of the computer’s network interface card. In response to concerns that this fixed identifier could be misused as a means of tracking an individual user (or more strictly, the user’s PC) for a variety of unwanted purposes, the IETF developed an alternative solution in which the fixed identifier is replaced by a pseudo-random number.

Different from telephony - Another possible public policy matter is the need to explain to politicians and economists that Internet technology is fundamentally different from telephone technology, and some notions (such as “portable numbers” and regulated prices for “universal access”) really do not translate to the Internet.

Societal impacts – We cannot yet foresee the societal effects of IPv6. If the dream of pervasive computing based on IPv6 becomes a reality and if some other problems are solved – such as accurate real-time natural language translation – then our grandchildren will see an era of world-wide human communication whose effects we cannot begin to imagine.

ISOC POSITION

In February 2001, ISOC issued a press release about potential privacy issues and possible solutions (*http://www.isoc.org/isoc/media/releases/010227pr.shtml*) which was duly noted with satisfaction by many privacy organizations.

In practice, up to now, the work needed has been mainly technical (performed by the IETF) or promotional (performed by the IPv6 Forum). However, we can expect a greater number of policy issues to arise in the future and for ISOC to assume a central role in the debate—consistent with its motto of “the Internet is for everyone.”

For More Information

http://www.ietf.org/html.charters/ipngwg-charter.html
http://www.ietf.org/html.charters/ngtrans-charter.html
http://www.ietf.org/html.charters/multi6-charter.html

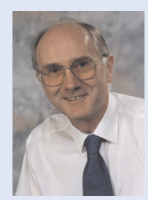
Related Organizations

- Internet Engineering Task Force (IETF) *http://www.ietf.org/*
- IPv6 Forum *http://www.ipv6forum.com/*
- IPv6 Information Center *http://www.ipv6.org/*
- European Commission’s IPv6 Task Force *http://www.ipv6tf.org/*

ISOC Education & Training Activities and IPv6

In ISOC’s conference and education area, the annual INET conference includes technical presentations on all aspects of Internet technology, and IPv6 is featured prominently. For example, INET2000 in Yokohama included several papers on IPv6 which can be found at *http://www.isoc.org/inet2000/cdproceedings/*. IPv6 has been added to the ISOC’s educational and training programs as well. An IPv6 Tutorial took place at INET2000 and was repeated at INET2001 in Stockholm. Sweden. IPv6 is already briefly discussed in ISOC’s Advanced Networking Workshops, and this will have to be boosted to full coverage in due course.

About the Author



Current Chair of the ISOC Board of Trustees, Brian Carpenter is an IBM Distinguished Engineer, active in Internet Standards and Technology. Carpenter coordinates IBM relations with the IETF and works on related technical strategy. He is a Member and Former Chair of the Internet Architecture Board (IAB), and currently serves as co-chair of the IETF Differentiated Services working group. This briefing is adapted from an earlier paper published in *The IPv6 Journal*, RIIS, Tokyo, Summer 2001.

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