Potential Implications of IPv6 for Regional Development

Savvas Papagiannidis
University of Newcastle upon Tyne, UK

Joanna Berry
University of Newcastle upon Tyne, UK

Feng Li
University of Newcastle upon Tyne, UK

INTRODUCTION

The Internet started as a project by the Advanced Research Projects Agency of the U.S. Department of Defense in the late 1960s. Since then, it has evolved to be the biggest network of all, although its core function, to create a network of networks, has not changed. It is this very connectivity that gives rise to a series of applications making the Internet such an interesting proposition for a number of business and personal activities.

In order for the Internet to evolve into its current form, a lot of research time has been invested in advancing networking. Arguably, the most successful product of all these research projects was the Internet Protocol (IP), a network protocol that has been significantly reliable and has underpinned communications on the Internet for more than 20 years. The achievement of the designers is even greater, if one considers that they had no previous experience with such a large networked environment! The growth of the Internet, and the expectations attendant on that success, meant that action had to be taken to address the approaching limitations of IPv4 and the extent of its functionality.

The critical importance of this update to economic development is clearly highlighted in view of the cost-related benefits that the Internet has brought to firms, especially SMEs (Mustaffa & Beaumont, 2004; Walczuch, Van Braven, & Lundgren, 2000). If the network could not cope with increasing demand, SMEs would find themselves in a very difficult situation, not only because their day-to-day operations and processes would be threatened, but also because their customers have much higher expectations now that they have a more thorough knowledge of the benefits that the Internet can provide. Apart from the implications that an update may have on the economy, it may also affect many other areas of our daily activities, which have become Internet-oriented: e-learning, online entertainment, easy and instant access of information, participation in virtual communities, our work habits (e.g., teleworking, thus promoting decentralisation) and so on.

The following sections aim to provide a brief non-technical overview of the shortcomings of IPv4 and explain how IPv6 addresses these. A discussion then follows of the implications of a protocol update with an example of how such an update could influence a well-established industry (Television Broadcasting).

INTERNET PROTOCOL VERSION 4

Although introduced in 1981 with Request for Comments 791 (RFC Editor, 1969-2004), Internet Protocol version 4 (IPv4) proved so robust that it has not been substantially changed since its introduction. When it was introduced, the Internet consisted of less than 1,000 hosts (Zakon, 2003), however, the initial design was scalable enough to allow for the tremendous expansion of the network in the mid-1990s.

New developments and the demand for Internet-connected devices (for example, mobiles phones and handheld computers) stretched IPv4 to its limits. One of the main issues that needed to be addressed was the depletion of IP addresses. An IP address is a number allocated to an Internet-connected device. Data flows in the network between the source and the destination in segments (packets) based on the IP addresses. An IPv4 address consists of four bytes (32 bits), also referred to as octets. This means that there is an address space of 2^{32} addresses resulting to in 4,294,967,296 unique addresses. As demand for IP addresses increased, alleviation techniques such as the Network Address Translation (NAT) were introduced, although these only addressed the symptoms of the problem rather than the problem itself.

Another limitation of IPv4 is its lack of security. An extension of the protocol known as Internet Protocol

Security (IPSec) exists, but this is optional and its implementation limited. Moreover, IPv4 does not fully provide Quality of Service information (QoS), which is essential when dealing with data that has to be delivered in a timely manner. Although a delay of a few seconds when delivering an email is not considered an issue, this is not the case for Video on Demand (VoD). As with IPSec, IPv4 has an option for the packets to carry information about the type of service (ToS), but again this has its limitations. In 1999, to address these and other issues (such as maintenance of large routing tables or the need for simpler configuration), the Internet Engineering Task Force (IETF) introduced Internet Protocol version 6 (IPv6) (Internet Architecture Board, 1999).

INTERNET PROTOCOL VERSION 6

IPv6 has been designed not only to address many of the issues raised by the limitations of IPv4, but to also add extra functionality, creating new networking opportunities. The Internet Architecture Board designed IPv6 "to enable high performance, scalable Internetworks that should operate as needed for decades" (Internet Architecture Board, 1999).

To start with, IPv6 employs a 128-bit address space, resulting in 3.4×10^{38} addresses. With the ever-lowering cost of Internet connectivity, this means that true end-to-end connectivity to the Internet will be inexpensive. In its turn, this will allow more people to have truly private communications.

The large address space may give rise to networking issues, such as the addressing hierarchy and auto-configuration. Addressing hierarchy refers to the way that IP addresses are deployed. The IPv4 address space is a 'flat' address space, in contrast to IPv6 which uses logical groups to index addresses, greatly simplifying the delivery of a packet. Auto-configuration is important because it allows devices to connect to the network simply, in a plug-and-play manner, which reduces the administration required. Auto-configuration becomes even more important when one considers the number of devices that the network will have to cope with, in particular mobile devices that already seek Internet connectivity. As these devices move from one network segment to the other, their connection will automatically be reconfigured.

This new level of connectivity will transform existing mechanisms of delivering goods and services. For example, it could address "the real challenge of managing information on a regular basis" that Zhu's Web-based decision support solution for regional vegetation management faced (Zhu, McCosker, Dale, & Bischof, 2001). Internet-connected sensors could have been deployed, transmitting information directly to the solution without human intervention.

The large address space may also create new opportunities, such as IP-based television broadcasting, which is discussed next, fostering entrepreneurial activities. The speed of the Internet coupled with common local conventions of trust-based relations can facilitate interactions between firms for intensive knowledge transfer (Eng, 2004), which can help build on existing regional competence based on local specialization.

Furthermore, in IPv6, the use of IPSec is mandatory. Apart from its powerful encryption, IPSec also provides accurate authentication (ensuring that the packets really originated at the site specified) and non-repudiation (which prevents the sender from later claiming they did not send the packet). In addition to the earlier mentioned, IPSec ensures message integrity ensuring that the packets are not tampered with while in transit. This added security can help reinforce users' confidence and trust in online communications and online transactions, boosting e-commerce. This is of particular importance when it comes to smaller organisations who have limited resources (Williams, 2003), as lack of adequate security can have severe implications.

Finally, it should be pointed out that there exist mechanisms (such as that of "tunnelling") to allow networks based on IPv4 to communicate with IPv6. This means that a conversion from one protocol can be achieved gradually.

UNICAST, MULTICAST, AND ANYCAST

Unicast refers to a one-to-one communication, for example, a user connecting to a Web server in order to request a Web page.

Multicast refers to one-to-many communications, that is, the delivery of the same data, sent by the source once, to multiple destinations. Broadcast is a special type of one-to-many communication and refers to the transmission of the same data, to all nodes in a network segment, separately.

By transmitting one copy of the data, multicast can reduce the server and network workloads, as otherwise the server would have had to send a copy of the data to each client. As such, multicast can result in a substantial reduction of network utilisation during a transmission. During a multicast session, multiple nodes can be registered to a specific multicast group, and this group is assigned a multicast address. Multicast addresses correspond to 1/256 of the total address space that IPv6 provides.