By Faisal Ahmed,
European Business Development Manager,
Wind River Systems.

All Roads Lead to IPv6

Everybody's talking about it -Business Week, The Economist, Data Communications-and sooner or later, it will impact us in ways we never thought possible. But the Internet Protocol (IP) is here to stay, and before we know it, our world will be totally wired and interconnectivity will be the name of the game.

INTRODUCTION

The World Wide Web, e-commerce, voice over IP, mobile telephony, smart information appliances, home networking -common to each of these technologies is IP, which is fast dominating the infrastructure in which we live our lives. Its expanding popularity is easy to explain. Initial broad acceptance by academic communities was quickly followed by adoption by the datacom industry, which has undergone explosive growth in the last decade. Moreover, IP's robustness as a constantly evolving standard has meant that it has remained a suitable technology for new applications. Today, IP has become the de-facto standard for global interconnectivity.

With data traffic fast outgrowing voice across public switched telephone networks, the datacom/telecom industries are quickly merging. Every telephone company has something to say about IP services. The spate of current mergers and acquisitions is leading to global media companies offering merged voice and data services over IP. These new services are not just on fixed wire networks but across the ether to your cellular phones. As a result, keeping in touch on the go is getting simpler than ever. Soon, managing your stock portfolio, emailing your office, video-conferencing with business contacts, and staying in touch with good friends will all become second nature to us via 3G (third-generation) mobile phones delivering IP at 2Mbps.

SOME EXAMPLES

A manufacturer of premium weighing machines for retail and industrial markets wants to streamline the number of models it produces and embed IP connectivity into its weighing machines. Over the past 20 years, the auto industry has determined that reducing models and sharing chassis parts dramatically reduces costs. The weighing machine manufacturer wants to reduce its models to a common hardware chassis, which is then differentiated via software. So, the manufacturer sells a reduced number of common platform chassis, which customers then customize to particular requirements by uploading the necessary functionality via software over the Internet.

Another novel example is in the auto industry. Say your car breaks down. Something has gone wrong with the sophisticated fuel injection system. Rather than having to wait for a recovery vehicle or roadside assistance, you dial up the car manufacturer's network, and a mechanic is able to remotely link up to your car's systems over a mobile telephone link. The mechanic is able to diagnose and resolve the problem via Simple Network Management (SNMP) over an IP link. This may sound far-fetched, but a number of car manufacturers are working to produce this kind of technology.

THE IPV6 ADVANTAGE

In a nutshell, IP helps lower costs for manufacturers, in terms of both build costs and after-sales service expenses. More significantly, manufacturers can simply use IP (an open standard), rather than have to develop costly proprietary technology.

Another important factor contributing to the widespread adoption of IP is its adaptability. The next stage in IP's evolution is IP version 6 (IPv6), the current version being IP version 4 (IPv4). Although, IPv6 is currently available, IPv4 is the version most broadly deployed today. Nevertheless, IPv6 has significant momentum with industry leaders such as Microsoft and Cisco, incorporating the technology into currently shipping products.

The intent of IPv6 is to better address the needs of a wired world. The aim is to ensure that IP-based networking fulfills an ever-increasing range of applications in tomorrow's wired world. With a larger address space and a hierarchical addressing architecture, IPv6 solves the potential scaling problems of today's Internet, primarily address-space exhaustion and the rapid increase in the number of routes maintained by core Internet routers. IPv6 actually delivers 2128addresses (compared to IPv4's 232)-that is more than 1000 addresses per square meter on earth. Just imagine every consumer appliance in the world with an IP address.

IPv6 also brings plug and play capabilities to IP-based networking. Benefits like "no configuration required" and mobility are particularly suited to embedded devices such as consumer information appliances. Combined with the increased addressing space, "plug in and roam" will further drive the adoption of IP. And when it comes to e-commerce, the security features within IPv6 will help alleviate concerns over fraud across the Internet and will drive the adoption of this new way of doing business.

Another feature of IPv6 is integrated quality of service (QOS) capabilities. Applications such as audio and video are delay and jitter sensitive and consequently run somewhat poorly over today's IPv4 networks. With IPv6, QOS is achieved via priority and flow label fields in the IPv6 header. Using a router control protocol such as Resource reSerVation Protocol (RSVP), such IPv6 priority and flow information can speed a packet from

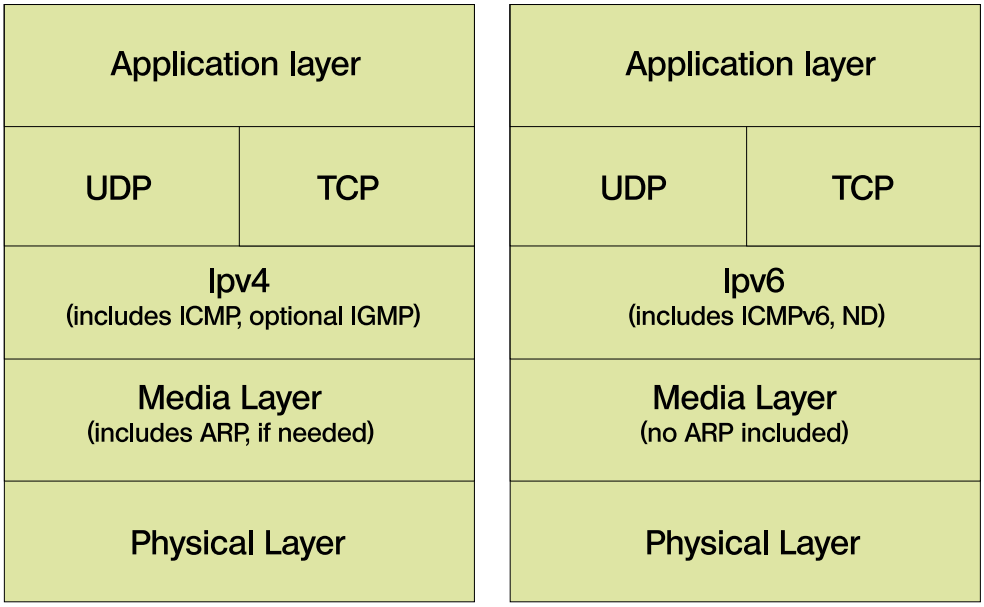

Figure 1.

source to destination along a routed path and ensure high quality audio and video over IP.

AN EXCITING ROAD AHEAD

Clearly, IPv6 continues to open the door for new IP applications, and presents myriad business opportunities. In fact, IDC (International Data Corp) recently predicted that the number of embedded networked devices will grow from 1.8 billion to 43 billion over the next few years. Most, if not all, of these devices will be connected via IP. Wind River provides software development tools, real-time operating systems, and advanced connectivity for use in products throughout the Internet, telecommunications and data communications markets. This places Wind River in "pole position" to help OEMs capitalize on the tremendous opportunity of the Internet, by bringing fully featured IP-enabled products to market quickly.

IPV6 DETAILS

As we have discussed, IPv6 offers significant value added features over IPv4. However, the two architectures are similar in structure (see Figure 1). The Internet Control Message Protocol (ICMP) has been enhanced to ICMPv6 in order to handle IPv6's 128 bit address (rather than IPv4's 32 bit addressing). There is also a neighbour Discovery (ND) protocol for IPv6, which replaces IPv4's ARP (Address Resolution Protocol) and ICMP (Internet Control Message Protocol). ND and DAD (Duplicate Address Detection - another new IPv6 feature) simplify the way that a network node "finds" another network node:

Nodes (both end nodes and routers) use ND to determine the Data Link Layer (or MAC) addresses for neighbouring nodes.

Nodes also use this protocol to actively track which neighbours:

- are reachable
- are not reachable
- and also to detect Data Link Layer addresses that have changed

End nodes use ND to find neghbouring routers that are willing to forward packets on their behalf.

The ND protocol ensures that IPv6 networks enable mobility of individual nodes. The IPv6 network is "self adapting" to ensure that nodes can attach and communicate without facing the problems of an IPv4 network, where a node can only attach to a network if it has the right IP subnet address. This ability is particularly relevant for wireless and other mobile applications.

If you ask what people know about IPv6, most will have the knowledge of an extended addressing architecture. An IPv6 address is 128 bits long (see Figure 2), four times the size of an IPv4 address. If we look at the IPv6 addressing architecture, we see that it is composed of:

A 3 bit format prefix (FP)-which denotes whether it is a directed or a broadcast packet

A 13 bit top level aggregation (TLA) identifier used to define top level backbone router configurations

A 32 bit next level aggregation (NLA) for intermediate level routers

A 16 bit site level aggregation identifier (SLA) that is essentially the same as the IPv4 subnet

A 64 bit interface identifier that identifies the node - usually the Data Link Layer (or MAC) address

Using this new addressing structure, IPv6 introduces the concept of scoped addressing -whereby an IPv6 address may only be valid within the scope of an iso-

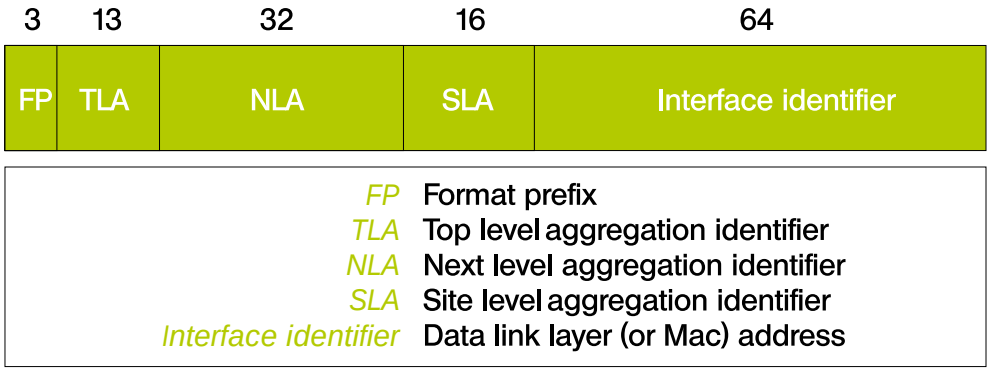

Figure 2.

lated network or set of interconnected networks. This enables a network node to establish an IPv6 address that is:

Link-local-valid only on a single isolated network or

Site-local-valid only on a set of interconnected networks or

Global -valid for communicating across the Internet

Combine scoped addressing with ND, and we have an IPv6 infrastructure that enables end nodes to communicate without worrying about IP addressing details, e.g.

What is my IP address?

Do I have a unique IP address?

Can I move from one network to another?

Another major area, which benefits from scoped addressing, is Internet routing. Presently, with IPv4 addressing, Internet backbone routers must know the IP addressing and all the routes of the next level of routers (away from the core of the Internet). With IPv6 scoped addressing, routers can benefit from address aggregation fields and can adopt a routing approach similar to the way a telephone call is setup using a hierarchical telephone number. If you consider an international telephone number (see Figure 3), a telephone system when setting up a call need only look at the component of the telephone number that is relevant.

For example, when an international telephone call is routed from one country to another, only the country code is parsed. Once the call is routed to the destination country, it is then that the other fields of the telephone number are parsed.

Similarly, with IPv6 scoped addressing, an Internet backbone router needs to only consider the TLA (Top Level Aggregation) Identifier, rather than the complete destination address of a packet. This significantly reduces the processing and memory requirements for a router.

SUMMARIZING IPV6

In summary, IPv6 solves a number of problems faced by today's IPv4 networks. Problems like:

The difficulty of configuration of IPv4 networks

The possibility of address space exhaustion

Inefficient routing of IPv4 packets

Restriction of mobility between IPv4 networks

Inadequate support for delay sensitive applications, such as audio and video ■

Faisal Ahmed has a BSc in Electrical Engineering from the University of Manchester (UK) and a Masters in Computer Science from the University of Cambridge (UK). Faisal has spent the last 10 years in the networking industry, primarily with Madge Networks where he held various product marketing and product development roles. Faisal is presently the European Business Development Manager for Wind River, focused on the data communications

Country code	Area code	Local exchange	Individual number
44	1462	687	300

Figure 2.