GEARING UP FOR NETWORK UBIQUITY

Prepare yourself for the next wave of digitization

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The Internet has experienced a tremendous growth in the past three decades, evolving from a network of a few hundred hosts to a platform connecting billions of "things" across the globe including people, enterprises and devices. The growth of the Internet shows no signs of slowing down and has steadily created a new pervasive paradigm in computing and communications.

The advent of next generation communications technologies and rapid digitization has impacted organizations and consumers alike. As we embrace the digital revolution and move to an all-IP world, communications would encompass a large variety of consumers-to-devices and increasingly device-to-device communications, making it extremely important that internet protocols (IP) also evolve to the next level. However, most operators and businesses still rely on IPv4 addresses which have already been exhausted. Service providers and large enterprises cannot afford to ignore this problem and should plan for an IPv6 migration, sooner rather than later, to ensure business continuity requirements. At worst they may find themselves having to invest heavily in a hurried IPv6 transition - at a time when revenues are declining because of stiff competition.

This paper describes the need for IPv6, the benefits it can provide and how important it is to take a holistic view on migrating to IPv6 from a business continuity perspective.

1 The Need for IPv6

The unprecedented growth of the Internet, combined with the growing demand for ubiquitous data based services has set the stage for a digital economy whose potential we are just beginning to explore. Not many had anticipated the exponential growth of connected devices, social media and e-commerce, and the 4 billion plus addresses IPv4 could provide seemed a massive figure, until a few years ago. However, in February 2011, the Internet Assigned Numbers Authority (IANA) handed over the last IPv4 address block[1] available in its central pool, making it clear that IPv4 addresses would soon be exhausted. Although, a number of alternative measures are utilized to increase the shelf-life of IPv4, the challenges are not just limited to the depletion of addresses; rather it represents numerous other scalability, security and complexity issues.

1.1 Complexity

For years, Internet experts and regulatory bodies have warned about the impending exhaustion of IPv4's limited pool of addresses and it is only the widespread use of Network Address Translation (NAT) that has prolonged IPv4's shelf-life. NAT allows a single publicly accessible address to be shared between multiple, private (i.e. non-routable on the Internet), IPv4 addresses. However, NAT profoundly complicates Device-to-Device (D2D) communications, which is an increasingly important aspect of Internet collaboration. Many popular applications - like VOIP, instant messaging, video chat and gaming - require workarounds in order to function properly on broadband routers using NAT. These workarounds consume additional resources such as memory, processor cycles & power and complicates application design. Furthermore, the complexity forces operators to centralize routing, adding to operational burden and costs.

[1] Source: bbc.co.uk, Net approaches address exhaustion, January 28, 2011

1.2 Scalability

As the exponential growth of data based services, Internet and connected devices had not been anticipated, IPv4 was not designed to support billions of devices on such a large scale. Although there are multiple ways of increasing the addresses IPv4 can support, this adds to the complexity and any further tailoring of IPv4 would only add to its inefficiency.

In the interim, Large Scale NAT (LSN) may be required to ensure business continuity. While this temporary solution will allow more devices and services to connect to the existing IPv4 Internet, the result will be even more breakage in the fundamental end-to-end principle of network design. This will lead to more complexity and troubleshooting requirements resulting in higher operational expenses. Moreover, LSN also impacts the cost per bit due to sub-optimal routing. This will also complicate the requirements of intercepting traffic by law enforcement agencies as private addresses are reused in multiple parts of the network resulting in more efforts to trace malicious users. As a result of this, it is possible that law enforcement agencies could resist the use of carrier grade NAT.

1.3 Security

Lack of inherent security and authentication mechanisms is another intimidating issue with IPv4. On the other hand, IPv6 was designed with the consideration of potential security challenges; hence, it intrinsically supports end-to-end encryption. Whereas, this security feature has been retrofitted into IPv4, making it an optional feature that is still not used universally. In addition, encryption and integrity-checking presently utilized for Virtual Private Networks (VPNs) is a standard component in IPv6, supported by all compatible devices, available for all connections. IPv6 also supports the Secure Neighbor Discovery (SEND) protocol capable of enabling cryptographic confirmation to validate the true identity of a host during the connection. This renders Address Resolution Protocol (ARP) spoofing and other naming-based attacks extremely difficult. Although, this is not a true replacement for application - or service-layer verification, it still offers a much improved level of security for connections. In contrast, it's fairly easy for a hacker to redirect traffic between two legitimate hosts in IPv4 networks, making the connections more vulnerable to manipulations.

2 Benefits of IPv6

IPv6 offers numerous advantages over its predecessor IPv4 and many operators have already realized this and started migrating to IPv6. Although the pace of transition is slow, the benefits IPv6 offers, makes it the only viable option to realize the true potential of an all-IP digital world.

2.1 Massive Address Space

IPv6 uses 128 bit addresses versus just 32 bits for IPv4 - producing a staggeringly large address space. There is a theoretical maximum of ~4.3 billion IPv4 addresses. But, in practice there is less because some addresses are reserved for special purposes and the IPv4 address allocation process was inefficient and wasteful. IPv6 has, in stark contrast, ~340 trillion trillion trillion (or 340 undecillion) addresses. To put this in perspective, while there are not enough IPv4 addresses to give every human being alive a unique address, it has been estimated that there are enough IPv6 addresses to allocate approximately 10 addresses to every single atom in every single human being alive today!

IPv6 addresses are written using 8 groups of 4 hexadecimal numbers, for example:

2001:0E4F:1234:CDEF:5AB7:3C4D:A123:F456

With such a large address space the need for NAT simply goes away and with it the final barrier to direct device-to-device communication.

2.2 Routing Efficiency

IPv6 reduces the size of routing tables and makes routing more efficient and hierarchical. IPv6 allows ISPs to aggregate the prefixes of their customers' networks into a single prefix and announce this prefix to the IPv6 Internet. In addition, in IPv6 networks, fragmentation is handled by the source device, rather than the router, using a protocol for discovery of the path's maximum transmission unit (MTU).

2.3 More Efficient Packet Processing

IPv6's simplified packet header makes packet processing more efficient. Compared with IPv4, IPv6 contains no IP-level checksum, so it does not need to be recalculated at every router hop. Getting rid of the IP-level checksum was possible because most link-layer technologies already contain checksum and error-control capabilities. In addition, most transport layers, which handle end-to-end connectivity, have a checksum that enables error detection.

2.4 Multi-cast Support

Multi-casting, the transmission of a packet to multiple destinations in a single send operation, is part of the base specification in IPv6. In IPv4 this is an optional feature, although it is commonly implemented. With this feature built into IPv6 it allows the use of multi-cast for connectivity to other hosts in the subnet using Link Local addresses. This enables hosts to process only those packets that are crucial. Though Multi-cast Addresses are available, IANA has not assigned multicast to any addresses as yet. Hence inter domain multicast routing is not possible. This means that video transmitted across the Internet has to be delivered in unicast mode. This is particularly inefficient when many destination addresses call for the same content. For example, President Obama's inaugural address in January 2009 was streamed live over the Internet at a rate of a few hundred kilobits per second. Millions of Internet users simultaneously tried to access the stream and crashed the servers - they simply could not handle the spike in traffic[2]. Had the Presidential address been multi-casted instead, there would have been no issue no matter how many people accessed the stream. The key demand driver for Internet bandwidth today and in the foreseeable future is video. The global Internet video traffic surpassed global peer-to-peer (P2P) traffic in 2010, and is expected to account for over 50 percent of consumer internet traffic by 2012[3], further accentuating the need for IPv6. It has an extremely large block of addresses allocated to multicasting and these addresses are routable over the public Internet. Hence IPv6 opens the possibility of practically anyone becoming a broadcaster, able to do so from anywhere.

2.5 Stateless Address Auto-configuration

This feature of IPv6 Protocol enables hosts to configure themselves automatically when connected to a routed IPv6 network using Internet Control Message Protocol version 6 (ICMPv6) routers discovery messages. When first connected to a network, a host sends a link-local router solicitation multicast request for its configuration parameters; if configured suitably, routers respond to such a request with a router advertisement packet that contains network-layer configuration parameters. This provides a significant advantage for re-numbering hosts on a subnet.

2.6 IPv6 the Enabler for "The Internet of Things"

All forms of electronic communications including video and voice will continue to migrate to IP. This means that network operators, such as cable providers, will need to replace billions of dollars' worth of infrastructure in the coming years with IP-based technology and favorably IPv6 to take it to the next level.

In an IPv6 world, all devices will be capable of communicating directly with each other through a unified and converged Internet because of more than sufficient address space that will allow each device a unique address, or even multiple unique addresses. Currently, NAT impedes this innovation from translating into reality. For instance, with IPv6 an individual's doorbell could send pictures and audio of a house caller to them in their office and they could talk back and maybe even open the door or not.

With practically unlimited addresses available, IPv6 will make this much easier because each device, or each component of each device, can have its own IPv6 address and can communicate with any server without the need to go through a NAT device. The promise of direct device-to-device communications opens the practical possibility for many other new applications many of which have been touted as part of an, any device, anytime, from anywhere mantra for the past decade but which can only truly be realized with IPv6.

Enterprises, service providers and manufacturers that establish themselves as market leaders will benefit from the first mover advantage as the demand for IPv6 compatible services, networks and technology explodes.

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[2] The Daily Telegraph, UK, "Barack Obama inauguration: record demand crashes BBC's live internet feed", January 20, 2009

[3] Source: Cisco Visual Networking Index: Forecast and Methodology, 2010-2015

3 Key Challenges in IPv6 Migration

IPv6 and IPv4 protocols are fundamentally incompatible creating multiple challenges during IPv6 migration - although they can both exist on the same physical network at the same time, it creates complexity and numerous migration challenges.

3.1 IPv6 is not Backward Compatible

IPv6 and IPv4 are two completely separate protocols and IPv6 is not backward compatible, which means an inability to perform automated translation within the network to preserve comprehensive any-to-any connectivity during the transition. In simple words, they cannot talk to each other without a translator or an extra layer that helps them coexist. While developing IPv6 it was envisioned that devices and network backbones would operate both IPv4 and IPv6 utilizing dual-stack mode. This is true for most devices and networks which are embedded with dual stack capability; however, the backward incompatibility of IPv6 means some IPv4 devices can never be upgraded to IPv6, and all - IPv6 networks cannot communicate with IPv4 - only devices or content. In addition, this means companies planning for an IPv6 transition need to carefully plan the migration path which may also include replacing a number of their IPv4 only systems. This is a big hurdle and requires intensive planning keeping in mind the overall infrastructure.

3.2 Managing IPv6 and IPv4 Coexistence

The pervasive use of the IPv4 makes it more or less certain that it may be many years before IPv6 becomes the dominant standard and operators will have to support both protocols. This means that for a while IPv6 and IPv4 will need to coexist. Devices will need to be dual stack capable of handling both IPv6 and IPv4 packets. This will necessitate a more complex network routing and management environment, as well as, an increased operational burden. There are several methods utilized to help the transition, however, managing the coexistence will definitely mean additional planning requirements, operational issues and added costs.

4 Wipro's Approach to a Speedy and Efficient Migration to IPv6

While it is evident that IPv6 and IPv4 will continue to coexist for many years now, the true potential of the digital economy and next generation services can only be realized once operators plan their IPv6 migrations. In addition, IPv6 transition is a tedious task given the complexities related with the migration and as IPv6 is not backward compatible companies need to be cautious while planning their migrations to ensure business continuity (refer figure 1). It is extremely important that all software and hardware aspects are clearly evaluated before launching a migration, as any gaps can have direct impact on the availability of many critical services.

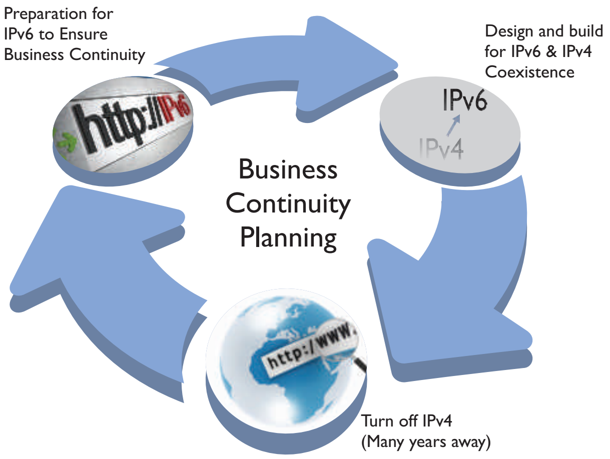

Figure 1

- Preparation should be such that design and build doesn't become prohibitively expensive
- Design, Build and Migration should be achieved with minimal impact

Wipro has vast experience in building and managing complex IP networks on a global scale. It is therefore well positioned to provide IPv6 transition services to enterprises, service providers, and manufacturers of all sizes and in any part of the world. Table 1 highlights Wipro's competencies that address the key complications of any IPv6 migration.

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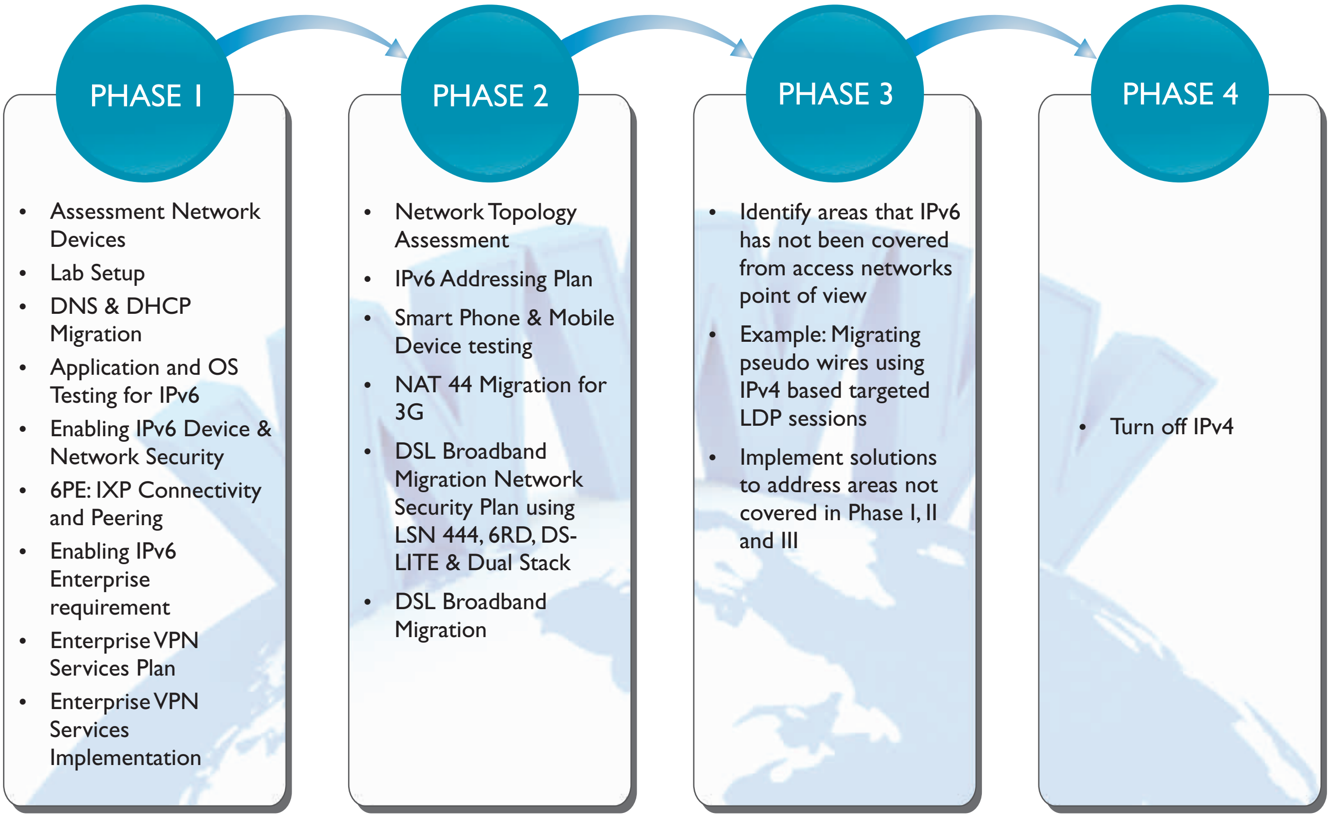

Figure 2

Those that haven't yet developed a plan for migration could benefit from Wipro's extensive experience in current state assessment, the development of practical transition plans and testing. Wipro is technology and vendor agnostic so the plans it develops primarily depend on the client's needs.

Those that are at an advanced stage of planning could benefit from Wipro's practical experience in rolling out and managing the next generation of devices and networks.

For those that already have an IPv6 network up and running, Wipro's experience in application development could help recoup some of the investments by taking advantage of IPv6's capabilities.

5 Conclusion

In conclusion, the pace of growth of connected devices and Internet makes the transition to IPv6 for communication service providers and enterprises inevitable. It is also clear that IPv4 and IPv6 will coexist in the immediate future making things be more difficult to manage and further delaying IPv6 migration. However, the bigger challenge for service providers and large enterprises will be to draw an appropriate roadmap for IPv6 migration, keeping in mind their business continuity needs and strategic goals.

The large scale adoption of IPv6 will not only make the Internet more efficient and secure, it will also act as an enabler for a truly digital world, opening new revenue sources and facilitating new revenue models.

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Sriram is the Head of Network Services in the Global Media & Telecom (GMT) vertical at Wipro Technologies. He has rich experience of 20+ years in the field of telecommunications specializing in telecom networks. He has a deep understanding of telecom networks across multiple service domains including voice, data and media and possesses a good combination of telecom vendor and service provider experience. Sriram holds a Bachelor's Degree in Electronics & Communications and a Post Graduate Diploma in Management.

Alan Young

Alan has a diverse background in the satcoms, financial services, media and telecoms industries with experience across the globe. He is currently an independent consultant advising Wipro on telecoms and media matters. Most recently, he was Chief Technology Officer of SES WorldSkies and in the past he has also held an executive position at Citigroup in New York. He led the digitization of MTV Network's programming services and participated in the standards development efforts of the DVB. He started his career at British Telecom in the satellite services division. Alan has a Masters degree in Electronic Systems Engineering from the University of York in the UK, is a Chartered Engineer and a Fellow of the Institute of Engineering and Technology. A proven innovator with two patents to his name and two other pending applications.

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