The benefits of IPv6 for enterprises
REALIZE YOUR BUSINESS POTENTIAL WITH IPV6
Daniel O. Awduche

This document describes the benefits of IPv6 for enterprise businesses and highlights the implementation issues and challenges a company must consider when transitioning to the new addressing technology.

INTRODUCTION
The historical driver for IPv6 transition has been IPv4 address depletion, which is accelerating due to global expansion of Internet connectivity—particularly in Asia. Other drivers include rapid deployment and adoption of residential broadband access services such as Verizon’s FiOS offering, proliferation of smart wired and wireless devices, and networking of ordinary appliances. Current industry forecasts for exhaustion of the unallocated IPv4 address space range from 2011 to 2014.

The significance of IPv6 has to do with the abundance of assignable IP addresses—IPv6 addresses are 128 bits long compared with IPv4’s 32 bits. This means IPv6 comes with a total of \(2^{128}\) (2 to the power of 128) unique addresses—an astronomical number which is sufficient to dole out unique IPv6 addresses to any conceivable networkable object on earth into the indefinite future.

Apart from IPv4 address depletion there is growing recognition that IPv6 portends significant opportunities for innovative business models. These benefits are rooted in the prospect of apportioning distinct IPv6 addresses to connected devices and everyday objects. IPv6 will engender a new generation of novel applications and services that would support machine-to-machine communications and human-to-machine transactions. In turn, these developments will give rise to unprecedented improvements in operational automation, productivity, and efficiency for the connected enterprise.

Some benefits of IPv6 will require new appliances, new software, new supply chains, and new business models—resulting in a virtuous cycle of positive economic development.

In light of these developments, some observers contend the transition to IPv6 is inevitable. According to this view, the basic dilemma confronting enterprises is not whether to evolve to IPv6, but when and how to implement the transition. This perspective makes the argument that companies that are unwilling or unable to adapt may ultimately wither in the competitive arena.

We also note that IPv6 transition comes with some short run implementation expenditures and challenges. Capital investment may be incurred to execute network transformation initiatives and upgrade legacy hardware and software to make them IPv6 compliant. Additional expenditures may be required for staff training, competency development, and IT/OSS system enhancements. There are also potential risks of exposure to security vulnerabilities, depending on the particular transition method a company embraces and the attributes and configuration of its enterprise IP network. The table below illustrates some of the benefits and drawbacks of IPv6.
From a cost perspective, some features of IPv6 could reduce internal enterprise network and IT operating expenditures. From a revenue viewpoint, a variety of sophisticated product propositions will be enabled by the abundance of IPv6 addresses.

One of the most important value propositions of IPv6 is its role in facilitating the emergence of the “Internet of Things,” which pertains to a network interconnecting common objects equipped with embedded miniaturized intelligence modules.

### BUSINESS VALUE OF IPv6

IPv6 provides business value in numerous ways. From a cost perspective, some features of IPv6 could reduce internal enterprise network and IT operating expenditures. From a revenue viewpoint, a variety of sophisticated product propositions will be enabled by the abundance of IPv6 addresses.

- **Investment protection**: Because IPv6 is the technology direction of public and private IP networks, investments in IPv6-based assets are likely to have a longer service life than expenditures on IPv4-only systems.
- **Auto-configuration feature of IPv6** improves manageability and reduces network administration costs.
- **Native support for mobility** permits seamless integration of a mobile workforce.
- **The abundance of IPv6 addresses** allows the assignment of globally-unique IP addresses to objects within the enterprise environment, removes the need for private addressing, and consequently eliminates the capital and operating costs associated with deploying and maintaining Network Address Translation (NAT) devices.
- **Greater flexibility and simplicity in IPv6 address plan management** comes with the elimination of IPv4 private addressing in the enterprise environment. In particular, some large enterprises use the same private IPv4 address blocks in different segments of the business (either through historical lapses or merger and acquisition transactions), resulting in conflicting address assignments and requiring complex network policies to ensure that connected resources in different parts of the company can interwork and interact with each other. This issue also represents a hidden cost of M&A transactions because the IP addressing schemes of merged businesses must be reconciled before full integration of networked assets can occur. IPv6 eliminates these issues because there is no need for private addressing. Hence address conflicts will not arise and simplified network and IT policies can be deployed.
- **Extensibility for new features** arises from the massive IPv6 address space and the extensible structure of the IPv6 header.
- **Intrinsic security** stems from incorporation of the IP security protocol suite into the IPv6 architecture.
- **Global greening and IT efficiency improvements** can be obtained by utilizing IPv6-based multimedia collaborative systems to minimize the need for travel, thereby reducing the carbon footprint of the connected enterprise.
- **Enhanced customer quality of experience** can be realized by driving automation into every aspect of the enterprise environment using connected smart objects with distinctive IPv6 addresses.
- **Business process improvements**, optimized outsourcing efficiency, and continued globalization are additional benefits which leverage IPv6-based integrated information processing systems, embedded automation capabilities, and collaborative tools such as immersive multimedia services.

### BENEFITS
- Abundant address space
- Auto-configuration
- Mobility
- Embedded IP security
- End-to-end communications
- Extensibility for new features
- New business opportunities
- Enables the “Internet of Things,” which is a global internet interconnecting everyday objects and dominated by machine-to-machine communications
- Improvements in automation, productivity, and efficiency
- Strategic cost reduction
- Engenders innovative business models in a variety of sectors

### DRAWBACKS
- May require investment to transition to IPv6
- Existence of techniques to address
- IPv4 limitations
- Potential security and privacy issues with removal of NATs
- May entail changes to existing business models
- Service life of IPv4 can be extended with additional tweaks to tackle address depletion
- Potential enlargement of the global routing table if IPv6 addresses are not assigned diligently
- IPv6 addresses are not intuitive; however, auto-configuration simplifies address assignment
• "Internet of Things": One of the most important value propositions of IPv6 is its role in facilitating the emergence of the "Internet of Things," which pertains to a network interconnecting common objects equipped with embedded miniaturized intelligence modules. The enormous address space of IPv6 will enable support of smart appliances, mobile devices, and associated services that will underpin the envisaged Internet of Things. Futurists have speculated the Internet of Things could potentially result in one of the largest transformations of human civilization subsequent to the Industrial Revolution.

• Unbounded market space: Telecommunications networks originated as a means to support communications between humans situated in different locations. Subsequently, with the advent of the Internet, human-to-machine communications (e.g., web browsing and e-commerce) became common place. When IPv6 is fully deployed, a preponderance of traffic in communication networks will involve machine-to-machine transactions without human intervention. This evolution will represent a significant paradigm shift in the telecommunications sector and will create ripple effects on other industry segments. Because the number of objects that can be connected to the network is unlimited, this advancement will create unbounded market spaces for products and services that support machine-to-machine interaction.

ENABLING TECHNOLOGIES

The key benefits of IPv6 will emanate as a consequence of the confluence of several contemporary technological developments. Some of these critical facilitating technologies are summarized below.

• Fourth generation wireless networks such as Long Term Evolution (LTE) will substantially increase the capacity and access speeds of wireless mobile networks. LTE offers baseline uplink speeds of 50Mbps and downlink speeds of 100Mbps and will be rolled out by major wireless operators, such as Verizon, beginning in 2010.

• Broadband network access to residential and business premises is a key enabler for expansion of the IPv6 Internet. A notable example is Verizon's FiOS service which bundles television, telephone, and Internet access over a fiber-optic network that extends all the way to the customer premise.

• Deployment of IPv6 in the backbone networks of major telecommunications carriers is a prerequisite to actualization of the envisaged value proposition. Verizon has made a commitment to evolve its global public and private IP networks to support IPv6.

• Radio frequency identification (RFID) refers to the implantation of miniaturized integrated circuits that are capable of transmitting radio frequency signals into various objects (humans, products, animals, etc.) for identification and tracking. Applications of RFID are very diverse, including monitoring and tracking of assets, remote control, elimination of paperwork, management of inventory, reduction of transaction costs, elimination of queues in service stations (e.g., retail stores and transportation systems), tracking of livestock and vehicles, etc.

• Integrated logistics and advanced supply chain systems involve automated techniques for managing the flow of resources and information across space and time from points of origin to points of consumption. Advances in this area can be leveraged to monitor, track, inventory, replenish, and control a multitude of objects within the IPv6 internet.

• Advances in Artificial Intelligence, combined with miniaturization, allow the inculcation of basic intelligence into a variety of objects.

• Global Positioning System (GPS) provides precise timing and positioning services to users worldwide on a continuous basis, using signals from a system of satellites.

• Sensor networks consist of autonomous sensors that collaborate to monitor specified physical and environmental conditions. Examples include inexpensive electronic cameras and various types of transducers (heat, pressure, motion, sound, vibration, etc.) that can be embedded in an assortment of objects to monitor and report state transitions to remote systems.

• Nanotechnology represents an extreme form of miniaturization that deals with structures at scales of hundreds of nanometers. This technology is valuable for its capability for minuscule embedded intelligence.

• Autonomic systems pertain to the development of computer-based systems able to modulate and control their internal operating functions, then observe and adapt to their external environments while serving their intended purpose.

• IP Multimedia Subsystem (IMS) is a framework developed by 3GPP for delivering IP multimedia services and is expected to form a foundation for fixed-mobile convergence.
SAMPLE SECTORS OF THE ECONOMY THAT WOULD BENEFIT FROM IPV6 ADOPTION

The following are representative sectors of the economy that would benefit substantially from IPv6 adoption. These benefits must be weighed against potential security threats that may arise from network vulnerabilities.

Federal and State Governments: IPv6 networks could decrease the cost of public services by reducing the transaction costs of interacting with the populace. In particular, it would facilitate timely and customized dissemination of information to citizens, and support smart digital identity cards and passports.

Defense: IPv6 networks could play a role in optimizing defense procurement and logistics management processes plus aid in real-time tracking of various military assets— including expendable resources in tactical environments. Additional benefits include: greater coordination in team and geo-political coalition scenarios, prospect for cyberspace and information superiority, and information interoperability within the command echelon and among different units.

Telecommunications: The telecommunications industry is the backbone of the IPv6 Internet. Because telecommunications operators enjoy the role of intermediaries in the transmission of information within the IPv6 economy, they are uniquely positioned to create new market opportunities that leverage their distinctive situation by offering new types of mediation and clearinghouse services.

Entertainment, Leisure, Gaming, and Interactive Software: IPv6 adoption could substantially increase the market scope and service offerings within this sector. The technology can be leveraged to develop pervasive, multimedia, multiplayer online games for leisure and education. These games can be played using a variety of ubiquitous mobile and fixed devices. Also, removal of NATs will allow more seamless peer-to-peer interactions in virtual reality settings. IPv6 coupled with IPTV technology could revolutionize and reduce the cost of delivering television services and other broadcast content to consumers, including return paths for dynamic user interaction. Mobile IPv6 combined with GPS would have beneficial effects on the tourism industry, rendering real-time situational awareness information to the tourist, highlighting services available within the traveler’s current locality.

Transportation: IPv6 will be a crucial component of intelligent transportation systems and is expected to have an immediate impact on the shipment and automotive industry. Mobile IPv6, along with GPS, automatic vehicular guidance technology, and smart speed-control systems could improve safety in the transportation industry. Dynamic tracking of vehicles could reduce costs and increase the efficiency of logistics systems. The IPv6 infrastructure also may assist law enforcement agencies in enforcing speed limits through remotely triggered automated control capabilities. It can also assist in deterring and detecting crime, and apprehending criminals by virtue of the intimate connectivity of various subsystems within a vehicle to the mobile Internet. Additionally, IPv6 could support transmitting real-time on-board vehicular diagnostic information to remote service locations.
Logistics, Inventory Control, and Supply Chain Management: IPv6 has the potential to revolutionize supply chain and integrated logistics systems. The ability to assign unique IPv6 addresses to various objects within the logistics system will deliver end-to-end visibility, assist in tracking the movement of resources through the system, improve inventory management and control, reduce costs, and offer new levels of responsiveness in addressing demand variability and meeting stakeholder requirements.

Electric Utilities: The main benefit of IPv6 within this sector will accrue with smart grid technology, which is an initiative presently underway to modernize the electric power system using two-way communication schemes for monitoring and managing the generation, transmission, and distribution of electricity. By securely networking and assigning IPv6 addresses to various elements within the power grid—including meters in customer premises—greater coordination, reliability, and efficiency of electricity delivery and utilization can be realized.

Health Care: The IPv6 Internet could increase the efficiency and effectiveness of medical systems and decrease the cost of health care delivery. Specific applications include remote medical diagnosis, remote monitoring of patients, home-care support, remote consultation with specialists, customized treatment, and disease prevention.

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Education: The educational sector is likely to be an early beneficiary of IPv6 adoption. Specific benefits include universal e-learning, personalized instructions to students, remote peer-to-peer communications and collaboration among students, and opportunities for student experimentation. IPv6-based online learning also could reduce transportation costs in educational environments and facilitate global outreach initiatives by offering courses to anyone in the world.

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Real Estate: Within this sector, the unifying theme is the creation of intelligent “connected homes” and “connected offices,” in which every contraption within a building is assigned an IPv6 address and connected to the network. When coupled with remote structural monitoring, environmental monitoring, integrated logistics systems, and smart control technology, the intelligent building will offer new levels of comfort, convenience, automation, and economy to its inhabitants. An oft cited example is that of a refrigerator that monitors its inventory of various groceries and automatically initiates replenishment orders when specified thresholds are observed.

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IPV6 TRANSITION IMPLEMENTATION CONSIDERATIONS

The starting point in implementing a transition to IPv6 is to establish an overall company-wide strategy for IPv6 adoption. Many large enterprises with segmented organizational structures tend to pursue business unit transformation strategies within each business unit. With IPv6, this approach is likely inefficient because organizational assets, know-how, and competences cannot be leveraged and reused effectively. Generally, a phased transition plan minimizes incremental costs and risks. With this approach, the project is decomposed into multiple implementation steps that are spread over time.

Another important consideration is including IPv6 requirements in planned product lifecycle replacement expenditures, and to mandate IPv6 compliance for procurement of new hardware and software. Staff training and IPv6 competency development should be taken into account and will impose additional costs.

Once the transition strategy is defined, the enterprise should launch gap assessments to gauge the level of IPv6 readiness of its network and IT resources. The outcome of the gap analysis should be a characterization of internal deficiencies pertaining to IPv6 deployment and estimated costs and timeframes to redress the issues. A subtle aspect that can be easily overlooked is the dependency on IP addressing structure that may exist in enterprise business logic back-office systems. If IP addresses are stored in databases as 32 bit numeric fields, adjustments would be needed to accommodate IPv6 (128 bit numeric field).

IPv6 addresses have to be acquired. Generally these should be obtained from the upstream Internet service provider. However, if the enterprise is very large and multi-homed to more than one carrier, it may be possible to obtain direct Provider Independent IPv6 address allocation from its Regional Internet Registry (RIR—e.g., ARIN in North America). However, Provider Independent IPv6 address blocks are not guaranteed to be routable within the global Internet, especially those smaller than /32. Consequently, the enterprise should check with its service provider to ensure an IPv6 netblock obtained directly from an RIR is routable.

In terms of actual project implementation, many transition methods can be employed to execute an IPv6 initiative. Generally, a transition scheme will involve successive stages of increasing IPv6 enablement. Examples include: (1) IPv6 endpoints interconnected by IPv6-over-IPv4 tunnels across an IPv4 backbone, (2) dual-stack IPv4/IPv6 embodiments, and (3) IPv4 endpoints interconnected by IPv4-over-IPv6 tunnels across an IPv6 backbone. These and other methods are described in numerous public domain publications from standards bodies and other sources. The enterprise should conduct adequate due diligence to determine which transition method is appropriate for its environment. Throughout the transition process, the enterprise should be mindful of potential security issues that could arise as a result of deficiencies that may exist in some vendor’s IPv6 offerings.

Verizon is evolving and transforming its global public and private IP networks to support IPv6, while continuing to sustain existing IPv4 services. Verizon’s IPv6 transition program is designed to be transparent to our enterprise clients. Enterprise customers will only need to reconfigure their network when they embark on their own IPv6 transition endeavor.
SUMMARY
IPv6 was originally developed by the IETF in response to IPv4 address depletion. The technology is now viewed as a driver for sophisticated new business models that could transform, automate, and optimize the enterprise operating environment. Careful planning, alignment of resources, and risk management are factors an enterprise should consider when embarking on an IPv6 transition initiative.