



WHITEPAPER

# IT Exec's Guide to IPv6 Adoption

**What to do now. What can wait.**

## Executive Summary

The formal exhaustion of public IPv4 addresses by the Internet Assigned Numbers Authority in 2011 occurred at a critical turning point in the history of the Internet—namely, at the moment when the typical Internet host is evolving away from the desktop and to the mobile device. As a result, the entire human population is expected to have online access by 2015. Such scale will only be feasible with the abundance of address resources offered by IPv6. As a result, any organization relying on the IT ecosystem enabled by the Internet Protocol—especially those organizations with public-facing content—is at great risk. In the absence of an IPv6 adoption initiative an organization’s business continuity, business agility, and competitive advantage are all endangered.

Yet IPv6 adoption is less daunting than it might initially appear (especially given the breadth and complexity of adopting a new network addressing protocol). Many IPv6 adoption goals are actually low-risk and low-cost and numerous organizations are already making significant progress adopting IPv6 (alongside IPv4) thanks to generally robust network gear and host OS support. Among these organizations some key concepts have facilitated a successful beginning to their IPv6 adoption initiatives. These concepts include the recognition of IPv6 adoption as a cross-functional initiative as well as the importance of a phased approach that tackles low-risk and low-cost IPv6 adoption goals first. Other worthwhile steps include identifying IPv6 stakeholders in each business unit as well as incorporating IPv6 into existing IT process cycles.

Whatever the initial scope of IPv6 adoption an organization decides upon (whether it’s exploratory, complete, or limited to making IPv4 content available over IPv6—perhaps to participate in World IPv6 Launch) this methodology can help organizations overcome inertia and get started with IPv6 adoption.

## Introduction

One of the persistent challenges organizations face in relation to IPv6 adoption is what to focus on first. The potential breadth and complexity of IPv6 adoption along with the subsequent risks and costs make a single, effective path forward difficult to discern and choose. The resulting inaction and inertia have been enabled by repeated warnings of the imminent depletion of routable IPv4 that somehow never seems to arrive.

Part of the challenge is that a one-size-fits-all plan for IPv6 adoption isn’t typical or practical. For even though IT infrastructure among organizations is more similar than not, the ways in which organizations rely on the network, the resources they have at their disposal, their strategic visions, their management philosophies can vary widely.

Thus plans that exhort a general technical approach such as “start at the edge and work your way in” or a more specific approach “dual-stack all of your routers and switches first” while perhaps occasionally able to inspire initial action are often not sufficient to overcome organizational inertia.

Perhaps what is needed are a set of key ideas that frame the challenge of IPv6 adoption in a way that inspires action yet also leaves enough latitude for organizations to select adoption goals that suit the expected scope of their IPv6 adoption initiative. Acknowledging and implementing some critical administrative steps that might otherwise go overlooked may improve the ultimate success of this approach.

This document takes the above approach with the goal of inspiring effective first steps toward adopting IPv6. After all, now that IPv4 exhaustion is an inescapable reality it's more important than ever for organizations to get started with IPv6 adoption.

## IPv4 Exhaustion

At a formal ceremony in February 2011, IANA (the Internet Assigned Numbers Authority) allocated the final five /8s of unallocated IPv4 space to the RIRs (Regional Internet Registries).

The RIRs are anticipated to allocate the last of their remaining IPv4 space within 3 years (Europe's RIPE in 2012 and North America's ARIN anticipating exhaustion in the summer of 2013).<sup>1</sup>

While historically enterprise networks have been insulated from IPv4 exhaustion by their use of NAT and private address space, the significance of IPv4 exhaustion to overall Internet growth inspires fresh concerns for enterprises as to how exhaustion might impact their businesses.

The human population of the Earth recently exceeded 7 billion, and an estimated 30% of that population has Internet access (with North America and Europe disproportionately represented among those with connectivity). Further, Cisco predicts one mobile device per capita by 2015.<sup>2</sup>

The explosion of worldwide mobile device availability and usage, and the network requirements of such devices (i.e. always-on, often with multiple network addresses) guarantee that Internet providers must adopt IPv6 or face ever-increasing capital and operational expenses. These costs result from attempting to keep an exhausted resource viable through NAT-based hardware solutions. Such solutions, besides being expensive, can reduce performance, break applications, and complicate and stifle innovation.

With its abundant address space of  $3.4 \times 10^{38}$  addresses (or 340 trillion, trillion, trillion addresses), IPv6 offers the only cost-effective strategy over time for continuing the growth and preserving the baseline functionality of the Internet (and that's setting aside the benefit for future applications of an Internet environment deprecating NAT in favor of true end-to-end host connectivity).

Because enterprises have traditionally used NAT and private addressing as a way to deal with the relative scarcity of routable IPv4 addresses, delay or deferral of IPv6 adoption for such organizations might persist even as the external pace of IPv6 adoption increases. But such a lack of action should be reevaluated for at least the following reasons.

## The Performance Tax of Transition Technologies

Consider for instance customers accessing IPv4-only webpages and coming from IPv6 hosts on the Internet.

Because IPv4 and IPv6 are not directly interoperable, at least one transition or translation technology must appear in the path for this session to properly work. These technologies provide interoperability at a potential cost to performance, jeopardizing user experience. And user experience is known to be critical for maintaining competitive advantage.

An Amazon study showed that a 100 millisecond increase in Amazon.com load times reduced sales by 1%. Research at Google compared load times for a 10-result page and a 30-result page. The 0.5 second increase in load times between the two reduced traffic and decreased ad revenues by 20%.<sup>3</sup>

Any competitors that already provide their content over IPv6 are avoiding the potential for such reduced performance as well as the erosion of competitive advantage it may cause.

## The New Price Tag for IPv4

It's not inconceivable that an organization without plans to adopt IPv6 might be stuck having to purchase IPv4 addresses. Borders' recent bankruptcy liquidation led them to put their /16 up for sale for \$786 thousand dollars. That's 65,536 addresses at \$12 each.<sup>4</sup>

And Borders isn't the only company recently selling IPv4 address space. Nortel's block of 666,624 IPv4 addresses was recently sold for \$7.5 million - \$11.25 per IP address. Prices for smaller prefix allocations are likely to be much higher on a per-address basis.

## The Asian Internet Tiger

The Asian RIR APNIC has announced they have depleted their IPv4 addresses allocation and will only provide a one-time emergency allocation of a /22 to a qualified requesting organization. Yet Asia, with one-half of the Earth's seven billion people and explosive economic growth to show for it, is at the forefront of connecting hosts to the Internet.

The service providers and subscriber networks connecting these hosts have little choice but to adopt IPv6--especially given the expense and complexity of NAT as a method to attempt to keep IPv4 viable. Companies that have or want a significant customer base in Asia need to be prepared to connect to this rising tide of IPv6 networks and hosts.

Those enterprises with no IPv6 adoption and business partners in Asia run the greatest risk of having critical inter-organizational services and processes interrupted if their Asian partners have already significantly adopted IPv6.

## **Preserving Business Continuity, Business Agility, and Competitive Advantage**

Because of the highly publicized exhaustion of IPv4 and the challenges it creates, more attention than ever is being paid to IPv6. Many IT leaders are recognizing that, regardless of their own decisions regarding IPv6 for their particular organizations, the Internet itself must have sufficient and cost-effective address resources to continue to grow—that in order to effectively sustain commercial growth, the continued availability, performance, and resilience of the Internet are essential. Otherwise, the communication, collaboration, and innovation enabled by the Internet and facilitating such growth may be compromised. In this context, IPv6 offers the only sustainable path forward.

While we don't know if a “killer app” will ever emerge to force an organization to adopt IPv6, we can safely presume that an Internet that can't scale for want of cost-effective and manageable address resources will certainly become an “app killer.”

And as the Internet adopts IPv6, enterprises must take steps to accommodate this adoption or business agility and continuity will eventually be compromised. Those enterprises that hesitate to adopt IPv6 while waiting for abundant and conclusive business cases to force their hand run the risk of seeing existing competitive advantage lost to companies that positioned themselves early to respond to the inevitability of IPv6.

The enterprise that ignores IPv6 altogether could lose the ability to cost-effectively respond to the inevitable and growing outside use of IPv6. Conversely, planned IPv6 adoption helps prevent a crisis scenario where an enterprise with no adoption plans must suddenly adopt IPv6 to keep critical services or processes online. It's all too likely that unmanaged service interruptions and uncontrolled costs will be the inevitable result of any sudden, unplanned IPv6 adoption.

## **Getting Started**

Ideally, any organization planning on adopting IPv6 would enjoy management buy-in, sufficient capital and operational budget, stakeholders committed to IPv6 adoption in each business unit, sufficient training and knowledge resources, and enough time to execute while effectively managing risk and cost.

In reality, most organizations that have decided to get started with IPv6 adoption discover that one or more of these desirable conditions are deficient or altogether absent.

Conflicting views of the importance of IPv6 adoption from the executive team, management buy-in without additional budget or personnel, no work cycles for (or ignorance of) IPv6 adoption in one or more business units, lack of training resources, and no time outside of regular workload to devote to IPv6 adoption goals are all common themes.

But the ultimate value of an IPv6 strategy can be gauged by its effectiveness in overcoming these deficiencies. While it may be impractical to address all of the organizational barriers hampering IPv6 adoption, most successful IPv6 adoption strategies share certain key features or ideas. This paper will introduce you to some key concepts that will help get you started with IPv6 adoption and should make your IPv6 adoption initiative more effective overall.

### Why IPv6 adoption is more manageable than you might think

1. It's adoption of IPv6, not a complete migration, transition, or flag day. IPv6 and IPv4 are going to coexist for years, possibly decades, to come. That doesn't mean an enterprise can afford to rely on just IPv4 but it does help mitigate the risk and cost associated with IPv6 adoption.
2. Many IPv6 adoption goals are low-cost, low-risk, and downright easy. Most organizations will begin to quickly accomplish significant IPv6 adoption goals almost immediately.
3. Most network devices and operating systems are IPv6-ready. Router and switch vendors have been supporting IPv6 for a long time. Recent improvements to major commercial operating systems have made them better than ever at supporting IPv6.

### Taking a Phased Approach to the IPv6 Adoption Initiative

Typically, the costs and risks of IPv6 adoption are best managed by a phased approach to the IPv6 adoption initiative.

In general, a phased approach is nothing more than planning and executing the numerous goals of a large-scale project in more manageable phases.

In particular, a phased approach toward IPv6 adoption allows each phase to be planned based on the risk and cost associated with each goal. The risks and costs for a particular goal may vary between organizations, suggesting that there will not likely be a one-size-fits-all IPv6 adoption strategy.

But regardless of which goals or sub-projects of IPv6 adoption are broken into which phases within a given organization, there are advantages for attempting the lowest-risk and lowest-cost goals first.

First, it offers the greatest likelihood of empowering the organization to build a foundation of success in IPv6 adoption without endangering critical infrastructure or incurring excessive costs.

Further, since few specific business cases exist to compel IPv6 adoption and since such adoption is desirable more for reasons of mitigating future risk and cost (while maintaining business continuity and agility as well as competitive advantage), such an approach is congruent with most organization's reasons for moving toward IPv6 adoption in the first place.

So what are some of the low-risk and low-cost goals likely to be tackled in the first phase of IPv6 adoption? They include, but are by no means limited to:

- Training, professional study
- Setting up an IPv6 network and/or host lab
- Auditing existing hardware and software for IPv6 support
- Identifying IPv6 stakeholders

- Checking with one's ISP(s) and any other service providers to verify support for IPv6
- Getting an IPv6 address allocation from one's ISP or a RIR
- Setting up an internal repository for IPv6 adoption information
- Creating an IPv6 addressing plan

#### **A note on management buy-in**

Management buy-in can enable the allocation of critical resource and personnel that help achieve IPv6 adoption goals. Remember, though, that management buy-in may not be enough. You may have been tasked to “go figure what we need to do about all this IPv6 stuff” without any increase in budget or additional staff -- the classic unfunded mandate.

Conversely, the risks and costs of failing to adopt IPv6 don't disappear simply because management chooses to ignore those risks and costs. You may very well need to “lead the leaders” by providing unsolicited foresight and leadership regarding IPv6 adoption. Begin to think about what it will require for you and your team to address those risks and costs for infrastructure and processes--especially those over which you have direct control.

### **Choosing Phase One Goals that Fit the Scope of the IPv6 Adoption Initiative**

Determining which phase one goals to tackle first will depend on the scope of IPv6 adoption the organization is pursuing.

For instance, the scope of the IPv6 adoption initiative might be limited to strictly exploratory at this point. In that case, training, management buy-in, and identifying stakeholders could be sufficient phase one goals.

Or perhaps an organization sees the benefit of making public-facing services available over IPv6 (usually by configuring dual-stack on a DMZ segment as well as the servers using it). For this broader scope, the additional goals of an audit of DMZ networking gear as well as obtaining IPv6 addresses would be essential.

An organization might be considering full IPv6 adoption across the enterprise by configuring dual-stack on all network elements, servers, and hosts. For this broadest of scopes, an IPv6 addressing plan would be an essential goal to include (along with all of the other first phase goals).

Also note that the scope of the goals themselves will vary. For instance, auditing networking gear and hosts for IPv6 support will obviously be more involved if an organization is planning on a complete adoption of IPv6 versus if it is just planning to make its Internet-facing resources available over IPv6.

### **Identifying IPv6 Adoption Stakeholders**

Another common goal of a successful IPv6 adoption strategy is the identification of at least one IPv6 adoption stakeholder in each business unit or silo. The cross-functional nature of an IPv6 adoption initiative compels this step.

IT has become the most significant enabler and force multiplier of productivity in the enterprise. The network and all the applications and processes that rely on it comprise the core of IT. As the next generation of network addressing, IPv6 has the potential to directly affect every service, application, and process in the organization relying on the network (and indirectly affect everything else).

Most enterprises rely on business units or silos to leverage specialized knowledge and expertise in accomplishing their business objectives. Each of these business units relies on the network in both similar and dissimilar ways. Each business unit or sub-unit may thus require unique administrative and technical responses to the phases and tasks of the IPv6 adoption initiative.

So while ultimate ownership of the network may fall squarely within the IT silo, it is unrealistic to assume that IT alone will be able to effectively provide every business unit in the organization with all of the necessary budgets, social capital, leadership, and knowledge required to make the IPv6 adoption initiative a successful one.

It is for this reason that organizations may improve the effectiveness of their IPv6 adoption initiative by identifying critical stakeholders within each business unit that will act as liaisons and first points of contact for all IPv6-related issues as the initiative progresses.

As these newly identified stakeholders begin to think about IPv6 adoption a common question they have is “where can I learn about our IPv6 adoption initiative?” It’s advisable to create an online repository that all stakeholders can access and add to. Wikis are a popular choice for such a repository. Such a repository should at least include the current scope and status of the organization’s IPv6 adoption initiative.

### **Incorporating IPv6 into Existing IT Process Cycles**

A substantial degree of IPv6 adoption can be accomplished by simply incorporating IPv6 into existing IT process cycles. Such inclusion increases the likelihood that resources will be allocated to IPv6 adoption goals.

Three process cycles that are common to most enterprises might include security policy review, asset upgrade cycle, and IT policy and governance. Add (or get added) an IPv6 checkbox to any and all process reviews. If necessary, strive to keep it included.

If there are well-known IPv6 goals associated with that process review, the checkbox can be specific. For instance: the process that tracks the network gear upgrade cycle can include an IPv6 checkbox for dual-stack IPv6 support. The process for security policy review might include a requirement for IPv6/IPv4 access-list parity.

However, even if the specific goal is unclear, including a simple IPv6 checkbox will succeed in getting the attention of the process stakeholders. Ideally, attention and resources will then be devoted to determining what needs to be done, if anything, with IPv6 for that process. You may discover that no additional effort is required to consider that process IPv6 ready.

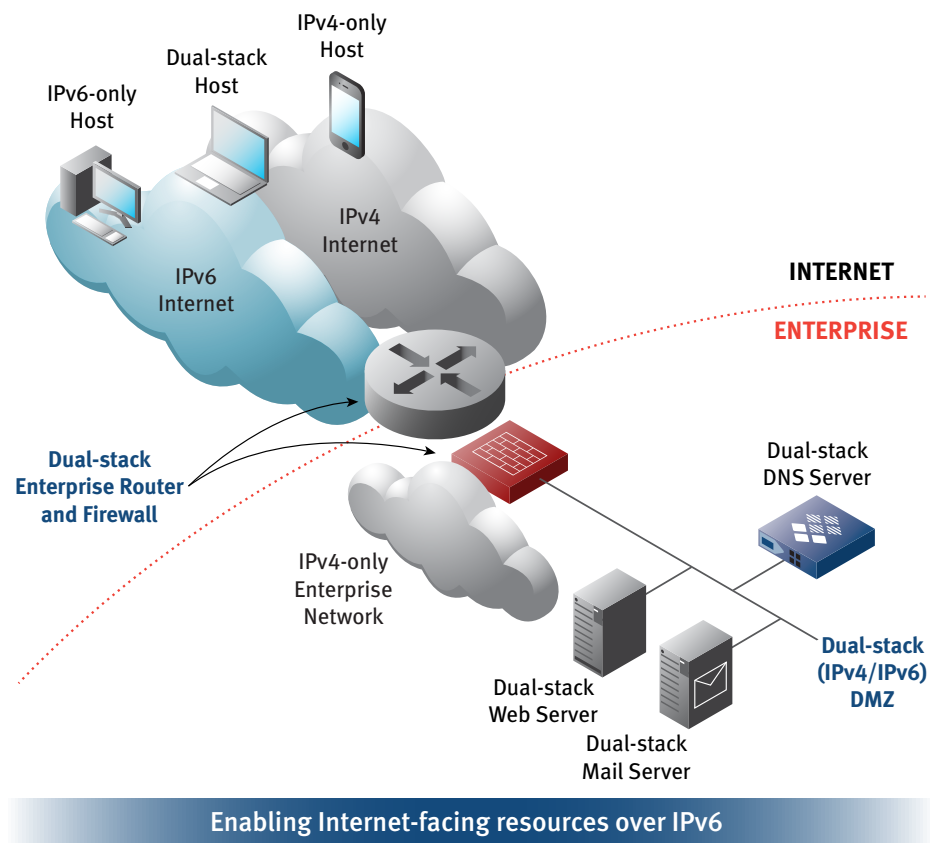


## Target: World IPv6 Launch

Enterprises interested in taking the next step in IPv6 adoption might consider participating in World IPv6 Launch. One goal of the event is for organizations to permanently enable their Internet-available content over IPv6 by June 6th, 2012.<sup>5</sup>

The diagram below shows a basic architecture to provide IPv6 connectivity for public-facing resources in an enterprise DMZ. An existing IPv4-only DMZ segment would be converted to dual-stack allowing both IPv4 and IPv6 interfaces to communicate with an IPv6-supporting firewall. The public-facing router would have connectivity to both IPv4 and IPv6 public networks via the ISP (or ISPs) providing Internet connectivity.

Dual-stacked web, mail, and DNS servers could then provide services to client requests arriving via IPv4 or IPv6. This configuration should allow AAAA records to be published.



## How Infoblox can Help

Early and more recent adopters of IPv6 have recognized the potential benefit of tight integration of DHCP, DNS, and IP Address Management (IPAM) for IPv6 networks. They were also forced to recognize that no single, well-supported platform provided such integration until recently.

Infoblox offers full-featured, comprehensive solutions for DNS, DHCP, and IP Address Management (IPAM) as well as network configuration and change management for the design, deployment, and administration of IPv6 networks.

The Infoblox solution helps address the IPv6 adoption goals of auditing networking gear, creating an IPv6 addressing plan, and making content available over IPv6. Infoblox can also help analyze the network for internal and regulatory policy compliance.

Infoblox DNS, DHCP and IP Address Management features offer an appliance-based, highly-available, dual-stack infrastructure with visual IPAM tools for IPv6 address space allocation and management as well as IPv6-capable DNS and DHCP.

Infoblox IPAM tools automate IPAM procedures to reduce human errors arising from the relative complexity of managing IPv6 addresses. Infoblox IPAM tools also help to reduce or eliminate repetitive tasks, permitting organizations to better scale management processes across the enterprise without additional IT personnel. The Infoblox solution can also help automate the discovery, analysis, and management of the network infrastructure as your organization adopts IPv6. With Infoblox, enterprises better manage and reduce the risks and costs of IPv6 adoption and the operation of both IPv4 and IPv6 DNS and DHCP network service infrastructure. The table below provides a summary of key Infoblox IPv6 capabilities.

<b>IPv6 Capable External DNS</b>	<ul style="list-style-type: none"> <li>• DNS for IPv6</li> <li>• Dual Stack DNS Appliance</li> </ul>
<b>IPv6 IPAM</b>	<ul style="list-style-type: none"> <li>• Automated IP Address Management</li> <li>• Role based accessibility</li> <li>• Integrated with DNS/DHCP</li> </ul>
<b>Planning tools for Internal IPv6 Migration</b>	<ul style="list-style-type: none"> <li>• Current Network Equipment Inventory (with OS version running)</li> <li>• Current Network Topology and Connectivity</li> <li>• Current Subnet Inventory</li> </ul>
<b>Internal IPv6 Capabilities</b>	<ul style="list-style-type: none"> <li>• IPv6 IP Address Allocation, Tracking and Reclaiming</li> <li>• IPv6 Subnet Allocation and Tracking</li> <li>• Dual Stack Devices Tracking (Smart Folders)</li> <li>• Reduced Complexity of Dual Stack Environment</li> </ul>
<b>IPv6 Network Infrastructure Management</b>	<ul style="list-style-type: none"> <li>• Automated Network Change and Configuration for IPv6</li> <li>• Compliance, Policy Enforcement and Auditing</li> </ul>

## The Infoblox IPv6 Center of Excellence

Infoblox is also dedicated to helping our customers and potential customers effectively adopt IPv6. Founded by DNS expert Cricket Liu, the Infoblox IPv6 Center of Excellence offers continually updated resources drawn from years of practical IPv6 adoption experience as well as ongoing, direct interaction with the Internet IPv6 adoption community. These resources include best practices documentation, instructional videos, white papers, a regularly updated blog, and helpful guidance from seasoned internetworking and IPv6 adoption veterans. Please visit our website regularly at <http://www.infoblox.com/ipv6> for the latest.

## References

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