The Challenges of Next Generation IP Address Management

Reduce complexities, streamline management and expedite the adoption of next generation network technology

Innovative, best-in-class management solutions like VitalQIP® software from Lucent Technologies, provide the tools that are critical for the adoption of IPv6.

This white paper addresses how to:

- Properly allocate and manage your assigned IPv6 address space
- Manage IP address allocation and node configuration
- Manage, monitor, and audit access to IPv4 and IPv6 networks
- Address challenges associated with co-existing IPv4 and IPv6 networks

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Introduction

The introduction of IPv6 into network environments will present significant challenges for even the most seasoned and experienced professionals and organizations. The technical differences between IPv4 and IPv6 networking are numerous. The size and format of IPv6 addresses are the most obvious example. IPv4 addresses are 32 bits in length whereas IPv6 addresses are 128 bits in length. As a result, the number of possible hosts in IPv4 is approximately 4 billion, whereas the number in IPv6 exceeds 340 undecillion (340 trillion trillion trillion or $340x10^{36}$). Additionally, IPv4 addresses use a dotted-decimal notation (198.200.138.1) whereas IPv6 addresses use colon-hexadecimal (3ffe:0302:0011:0002:024c:69ff:fe6e:7579).

Complexities relating to how IPv6 networks must be allocated raise significant network management and planning concerns. From a user's perspective, the added complexity of IPv6 also increases concerns surrounding the usability of, and access to, IPv6 resources. For example, Is it possible or expected for the non-technical community, and even the technical community for that matter, to remember well-known IPv6 addresses and why? The advent of auto-configuration and the improvements to DHCP in IPv6 are both viable alternatives for address allocation. Which is the best for your organization? More importantly, which offers better control and auditing capabilities?

The co-existence of IPv4 and IPv6 is expected into the foreseeable future. The concept of managing two parallel IP spaces and the interaction between them is somewhat foreign and comes with its own set of complexities and challenges. These are just a few of the issues that will face those responsible for keeping the networks of today running, as well as for those responsible for building the networks of tomorrow.

Network Management and Planning

The value of proper network planning is analogous to the value of a solid foundation to a house or building. Having the ability to properly allocate and manage IPv6 address space is more important now than ever before, given the added complexities associated with IPv6 allocation calculations. Furthermore, the guidelines associated with IPv6 address allocation found in RFC 3177 and the IPv6 Address Allocation and Assignment Policy, for example, intensify the need for a tool to facilitate and automate the process. Procedural and processing errors could have catastrophic, far-reaching effects throughout an IPv6 network including, but not limited to, connectivity issues and misallocations. Simply stated, the ability to automate network allocations and store information about address usage for reporting is invaluable. The ability to automate interactions with Internet Registries (ARIN, RIPE NCC, APNIC, AfriNIC, LACNIC) will foster a more efficient use of allocated address space. In fact, many industry experts feel that a sound network-planning tool would result in significant increases in IPv6 adoption and deployment rates.

Managing IP Address Allocation and Node Configuration

There are three main address types in IPv6 as defined by RFC 3513: *unicast*, *multicast*, and *anycast*. Unicast type addresses may have one of several scopes. For the purpose of this paper we will specifically address global and link local addresses. The type and scope of address being used determines what mechanism will be employed to assign an IP address to an interface. Link-local addresses are generated by the node and are used to facilitate communications with other nodes on the same link (i.e., network communications), where no router is required. Conversely, global-unicast addresses or prefixes can be assigned to nodes using one of four general mechanisms.

Static

In this scenario, an IPv6 node is manually or statically configured with a global IPv6 address or prefix, and with all required settings to establish and maintain network communications. As discussed above, the format, size, and complexity of IPv6 addresses will certainly prohibit the use of this mechanism for address assignment.

Auto-configuration

Stateless auto-configuration, however, uses a process by which it is assigned a global prefix through router advertisements, which in turn are used to generate global unicast addresses as specified in RFC 2462. Although this greatly simplifies the process of address assignment, node configuration still presents a problem in many instances.

Stateful DHCP

Stateful DHCP in IPv6 works very much like DHCP for IPv4 where nodes will request and be assigned a global unicast IPv6 address or prefix from a DHCPv6 server. In addition to being assigned an address, nodes can also receive configuration information from a stateful DHCPv6 server.

A perfect example is DNS configuration information, including DNS Servers and Domain List, since it has an even greater value in IPv6, given the increased size of IPv6 addresses over those in IPv4. Most users today cannot or do not remember IPv4 addresses, but instead use familiar names to access hosts on an IPv4 network. Since IPv6 addresses are a great deal larger, we can expect that even fewer people will be able to accurately recall the IPv6 address of popular network nodes.

Stateless and Stateful

Finally, both stateless auto-configuration and stateful DHCPv6 can be used in conjunction for address/prefix assignment and node configuration. Basically, a node will employ stateless auto-configuration to obtain its global unicast IP address assignment and use a DHCPv6 server for any supplemental information it requires. A node that has had its global unicast address configured using stateless auto-configuration will use a streamlined DHCP process to obtain additional configuration information.

Managing Name Resolution Services

The differences between IPv6 and IPv4 addresses exponentially increase the value of name resolution services or DNS, in next generation networks. IPv6 name resolution uses AAAA resource records to represent host addresses, while PTR records similar to those in IPv4 are used for reverse queries. The examples below clearly illustrate the complexity and error-prone nature of managing this data, especially if done manually:

AAAA example:

    qip.lucent.com.   AAAA   FEC0::2AA:FF:FE3F:2A1C

PTR example:

    C.1.A.2.F.3.E.F.F.F.0.0.A.A.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.C.E.F   PTR   qip.lucent.com.

Without DNS services, those who require access to IPv6 network resources would need to refer to the colon-hexadecimal formatted IPv6 address, which may not be possible and is certainly not practical. Integration of DHCPv6 and DNS facilitates the way peer IPv6 nodes interact. Having a DHCPv6 server that supports RFC 2136 or dynamic DNS updates facilitates the dynamic update of a DNS server(s) with IPv6 host data, such as an IPv6 address or a hostname.

The challenges and complexities that exist today in the management of IPv4 DNS will certainly exist tomorrow in IPv6. In fact, the challenges are likely to be expanded due to the enlarged nature of the IPv6 address space compared to that in IPv4. A need clearly exists for a mechanism to manage name resolution services effectively, not only for maintenance, but to facilitate deployment as well.

Managing Network Access

The advent of IPv6 features such as stateless auto-configuration will offer a great deal of convenience for "assigning" IP addresses. In some environments, the efficiency that this form of address assignment provides may be desirable (or even required in the wireless domain). In many other cases, however, stateless auto-configuration can be a recipe for disaster and a security nightmare, since those responsible for managing network access have no mechanism to govern the same. The use of stateful DHCPv6 can provide access and the necessary control over IP address assignment to reduce the risks associated with unauthorized, or even worse, unknown network access. Furthermore, using stateful DHCPv6 for address assignment creates an opportunity to audit network access, since IP address requests are governed by one or more authoritative sources, such as stateful DHCPv6 servers.

The Transition to IPv6 (IPv4 and IPv6 Co-existence)

Industry experts agree that IPv4 and IPv6 networks will co-exist for many years to come. This notion is supported by the mere fact that many transition technologies have been developed to support the interaction and co-existence of both on the same physical network. Examples of popular transition technologies are:

- IPv4-compatible IPv6 addresses
- 6over4 addresses
- 6to4 addresses
- Tunnels (static and dynamic)
- Dual stack
- ISATAP
- Teredo

The complexity associated with the co-existence and transition to IPv6 introduces yet another dimension to the challenges awaiting those who design, build, and manage next generation networks. The ability to manage and visualize a logical view of an IPv6 network topology, including the relationships between the various transition technologies, would be a valuable asset.

Next Generation IP Address Management software from Lucent Technologies VitalQIP®

Next generation networks will certainly present a unique set of challenges to those who will be pioneering the technology. We have reviewed, at a high level, many of the problems and challenges that we feel must be addressed by a next generation IP address and network management solution. It is solutions like Lucent Technologies' VitalQIP® (Next Generation software) that will satisfy the broad needs of those adopting and introducing IPv6 into their infrastructures. Lucent Technologies is building its next generation, multi-platform IP address management and network servers by capitalizing on its vast experience in building highly scalable and robust IPv4 management solutions—solutions that include best-in-class network servers, including DHCP and DNS, RFC compliance, and marketing leading IPAM.

Lucent Technologies market leading Business and Service Optimization software

VitalQIP® Domain Name System/Dynamic Host Configuration Protocol (DNS/DHCP) and IP Management Software, an integral part of Lucent's leading Business and Service Optimization software portfolio, is used by hundreds of customers, including Global 1000 companies and top Service Providers around the world to automate their essential IP name and address services needs. This innovative system has received numerous honors and awards, including the *Network World* Blue Ribbon Award, and is consistently rated a best-in-class IP management solution by industry analysts and market research firms. Market-leading VitalQIP® software helps efficiently configure, automate, integrate and administer IP services across the entire network—locally or globally. This powerful management software centralizes planning and administration, enabling the rapid provisioning of IP addresses, and reliable delivery of critical IP name and services network-wide. Compatible with multiple technologies, vendors and platforms, it helps streamline management tasks with a comprehensive suite of integrated tools and user interfaces.

For more information, contact your Lucent Technologies sales representative or call 1-888-426-2252 or visit the Lucent Technologies web site at www.lucent.com/vital.