IP version 6

Opportunities and Challenges for
Enterprises and Service Providers

A white Paper by Siemens Communications
Version 1.1

Executive Summary

Reluctance of many businesses of deploying IPv6 on a grand scale.

For more than a decade now, many service providers and most enterprises have been reluctant to deploy the new Internet Protocol version 6 (IPv6) on a grand scale. However, governments in the US and Asian are pushing IPv6 and the first global IPv6 service offerings are being seen (NTT/Verio).

With a larger address space and a number of other improvements, IPv6 is designed to replace its older cousin IPv4 (Internet Protocol version 4), which dominates the Internet today.

Careful transition planning can save time and money.

Transition to IPv6 will be a step-by-step issue; IPv4 and IPv6 will coexist for a long time. However, enterprises and service providers should keep in mind that sooner or later the transition is inevitable. Juniper points out that “money spent today in planning and testing will pay off with a smoother transition.” With this strategy, enterprises and service providers can save time and money.

Siemens’ strong commitment towards IPv6

Enterprises and service providers seeking a smooth transition of their network to IPv6 can rely on Siemens’ strong commitment towards IPv6. Siemens is providing mature and highly-interoperable solutions with IPv6 capabilities that are outlined in this paper.

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Why IPv6?

IPv4 addresses are cheaper than ever before.

There are heated discussions about why businesses should upgrade an existing IPv4 network to the new Internet Protocol (IPv6). It is agreed that the transition will increase expenses initially. Despite becoming a vanishing resource, IPv4 addresses are cheaper than ever before, since address registry authorities have optimized their processes. So what are the technical arguments and what is the business case?

Many technologies developed for IPv6 have been ported back to IPv4. The huge number of available addresses and related technical advantages remain the most important arguments for IPv6.

Technical Advantages

Promoters of IPv6 typically communicate many advantages of IPv6 over IPv4:

- IPv6 has better security, because the IPSec security framework is mandatory in IPv6, while it is optional in IPv4;
- plug-and-play capabilities have been improved;
- There are improvements with Quality of Service because of an additional flow label in the IPv6 header.

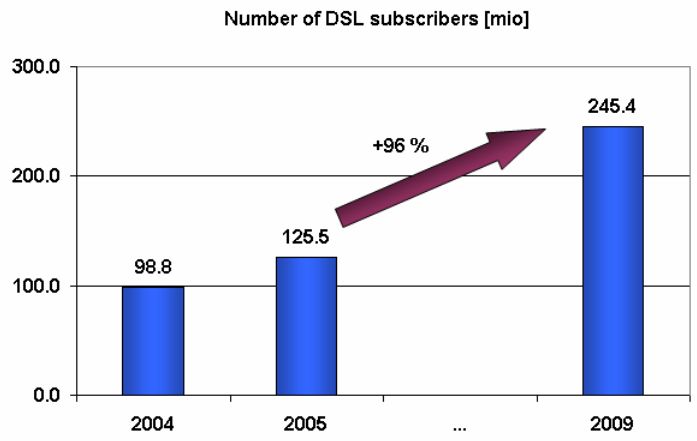
However, many improvements have been ported to IPv4, or workarounds have been introduced. A remaining and most important advantage of IPv6 over IPv4 is the vast number of IP-addresses it provides to the Internet world. Many other advantages are based on this fact:

- The IPv6 Working group of the Internet Engineering Task Force (IETF) points out that peer-to-peer communication is simplified, because the huge number of IP-addresses makes address translation obsolete.
- IP mobility with IPv6 has been simplified because, unlike IPv4, we can rely on a communication partner's address to be visible throughout the Internet.

Peer-to-peer and machine-to-machine applications accelerate IP address demand.

Internet growth is still accelerating. For example, Infonetics Research predicts the number of DSL subscribers to increase by 96% within four years. In addition, a new family of peer-to-peer and machine-to-machine communication with its demand for substantially more than a single IP address per subscriber is accelerating address demand. Without an upgrade to IPv6, Internet growth will soon reach its limits.

Figure 1: The total number of DSL broadband subscribers on earth will increase by 96% within four years (source: Infonetics Research).



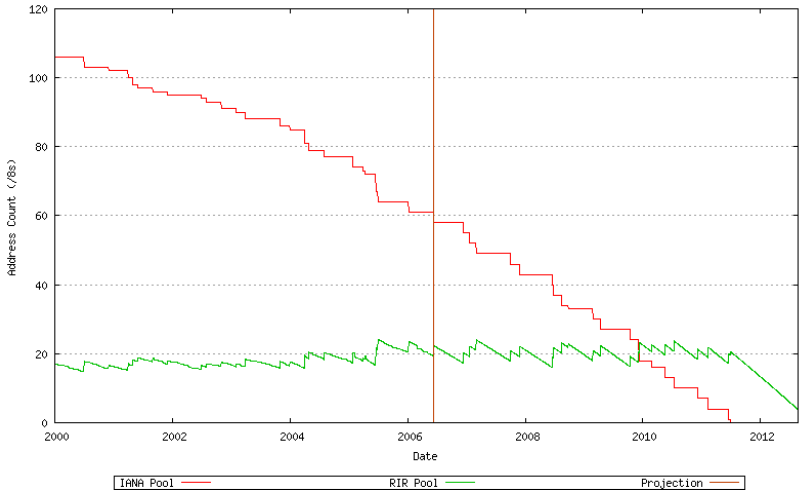
Network address translation (NAT) is not an alternative to IPv6 in the long run.

Sometimes Network Address Translation (NAT) is used as an argument against the need for IPv6. NAT mitigates the IPv4 shortage by hiding many addresses behind a single address. However, while being widely deployed, NAT increases complexity and puts an unnecessary processing burden on network elements and applications. In addition, peer-to-peer applications that require global visibility are much easier to implement without NAT.

According to an investigation based on historic IPv4-address-allocations, IPv4 address space of regional address pools will be

exhausted somewhere around 2012, if no end rush is seen.

Figure 2: A projection of the number of unallocated IPv4 addresses predicts an address exhaustion of the international IPv4 address pool (in red) in June 2011. Regional address pools will be able to satisfy IP address demands until August 2012, if no end rush is seen (source: Asian Pacific Network Information Center).



IPv6 provides a nearly inexhaustible pool of addresses.

The new generation of Internet Protocol provides more addresses than ever will be needed: theoretically, every square millimeter on earth could be provided with many billions of addresses.

Business Opportunities

Difficulties to calculate a positive business case for IPv6.

"Launching mass-market IPv6 services or migrating a large corporate network to IPv6 would be costly and difficult to do today" says Mat Ford of BT Exact. However, IPv6 is gaining speed, propelled by government initiatives in the US and Asia. For example, the US Department of Defense has announced the target to adopt IPv6 by 2008.

Enterprises increase responsiveness to their customers.

With IPv6, enterprises will increase the responsiveness of their staff through e.g. new presence-based services and a consequent promotion of the always-reachable-paradigm.

Service providers: unhampered growth by unlimited number of addresses.

Service providers will be able to develop new business opportunities without hitting any address space restrictions: for example, over the next 3 years, Infonetics Research expects a factor 4.5 increase of worldwide IPTV capital expenditures to reach $4.5 billion in 2009 with the IPTV service revenue skyrocketing to over $44 billion.

Obviously, IPTV and other broadband services as well as presence-based and peer-to-peer services are not strictly bound to IPv6. However the vast increase of subscribers induced by this kind of service will only be possible with a protocol that has the number of IP-addresses needed.

Transition Strategies towards IPv6

The upgrade of the network is inevitable in the long run. Economical considerations and technical need will set the pace.

When discussing the best time frame for a transition to IPv6, businesses should keep in mind, that sooner or later, a transition to IPv6 is inevitable. However, different from what we had seen on January 1, 1983, when IPv4 has replaced NCP in the Internet, introduction of IPv6 is a step-by-step issue. "Moving to IPv6 is a transition, not a migration, and we guess that the two protocols will co-exist for at least 20 years," said Jim Bound, chairman of the North American IPv6 Task Force.

Plan carefully for the inevitable Transition

Enterprises and service providers that do not implement IPv6 today will not be separated from the Internet world tomorrow. Nevertheless, they should get some expertise in IPv6 now to be able to determine the best point in time to move forward with IPv6. “Communication companies, enterprises and service providers need to understand IPv6 technology today” says Mat Ford of BT Exact.

Careful transition planning can reduce costs.

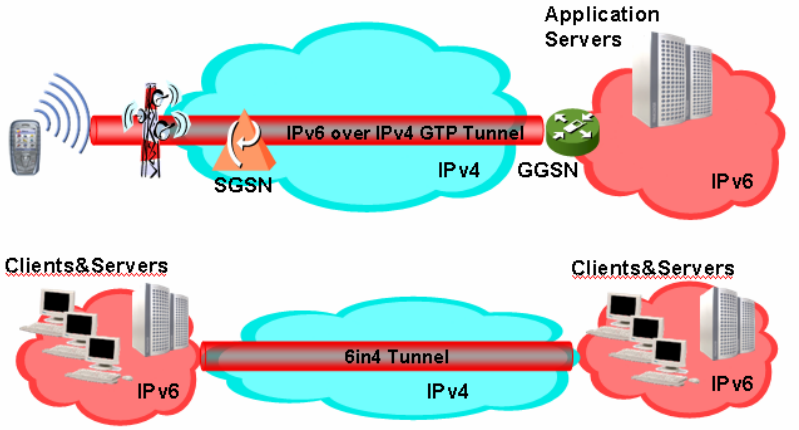
Even if the time has not yet come for an enterprise or service provider to start IPv6 activities, careful transition planning, that seeks to build IPv6 requirements into all new developments and upgrades could significantly reduce costs.

Provide IPv6 connectivity

As a first step, enterprise and service provider network operators will be gaining confidence with IPv6 by deployment of small niche networks. As a second step, they will be aiming to provide IPv6 connectivity to end users.

In addition to simultaneous IPv4 connectivity, Siemens Com mobile core elements like SGSN and GGSN connect IPv6-based user devices to the IPv6 world via GTP tunnels, which are transported over IPv4-based mobile access networks. Similarly, early adopting enterprises will connect their small test networks to each other and to the IPv6 Internet via IPv6inIPv4 tunnels.

Figure 3: “IPv6inIPv4” tunnels connect IPv6-based user devices to IPv6 application servers in mobile networks. In enterprise networks, IPv6inIPv4 tunnels connect IPv6 islands to each other or to IPv6 internet.



Simultaneous IPv4 and IPv6 connectivity through a dual stack approach of network elements.

In typical client-server communication scenarios, fixed network carriers provide native IPv6 connectivity to their customers by upgrading their IP edge devices, their servers and their Internet gateways to dual stack support.

Beat competitors through a richer set of applications

Once enterprise or carrier network operators have successfully provided IPv6 connectivity to their staff and/or customers, they are ready to deploy IPv6 services as a further step.

At this stage, IP telephony for carriers and enterprises will rely on native IPv6 capabilities of Siemens hiQ, hiE products and HiPath softswitches. In addition, Siemens offers dual stack IMS as a service delivery framework that helps to quickly introduce new IPv4 as well as IPv6 services to their customers. This helps carriers to be ahead of their competitors in time and money.

Instead of implementing two versions of each service, interworking functions and translators (ALGs, SBCs) can make those services available to both worlds. Application Layer Gateways (ALGs) are transparent, while Session Border Controllers (SBCs) are visible to the communication partners.

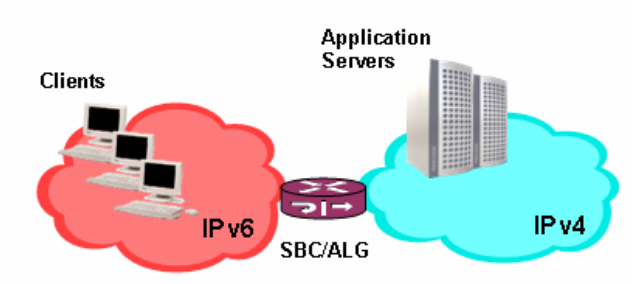


Figure 4: Translating devices can make accessible IPv4 applications to IPv6 users and vice versa.

Siemens Com Solutions

Siemens Com provides best in class IPv6 capable solutions for fixed, mobile and enterprise networks. With an excellent and long lasting relationship to enterprises and telecommunication companies, Siemens understands their need to move to new technologies like IPv6 at a speed that best fits to their business processes and opportunities.

Siemens Communications' solutions are in line with the carriers' need to seize user service opportunities, combined with the enterprises and carriers' need for a smooth transition, at a minimum additional cost and effort.

Mobile Networks

Early move to IPv6 in mobile networks.

An early move of the mobile world towards the new Internet Protocol is made obvious by the service delivery framework IMS to initially be defined as IPv6-only by 3GPP. However, standards bodies have reintegrated IPv4 support to IMS, reflecting a persisting importance of IPv4 in current networks.

Siemens' solutions reflect the important role of IPv6 user-connectivity in the mobile world:

- IMS and packet switched core elements are ready to provide connectivity of mobile IPv6 devices to IPv6-based services
- In a second step, IPv6 capabilities of circuit-switched elements will be introduced in order to fulfill the need of mobile carriers to seize IPv6 opportunities.
- In a third step IPv6 header compression and IP based radio access networks will enhance efficiency of the mobile carrier's access networks.

Fixed Networks

Fixed network market today does not demand such a quick move towards IPv6 like it is expected in mobile networks: Network address translation (NAT) by customer premises routers hide home networks from the public internet, mitigating the address resource problem. However, a tendency to seamless mobility and always-on could aggravate address shortage.

After a phase of translation techniques helping to accelerate IPv6 adoption, native IPv6 support will be introduced.

Therefore Siemens recommends the following transition strategy:

- As a first step, IPv4 services can be made accessible to IPv6 domains by usage of Application Layer Gateways (ALGs) or Session Border Controllers (SBCs), which mediate between IPv4 and IPv6.
- Native IPv6 support in the control layer will be introduced in a second step.

Enterprise Networks

Enterprises often use private IP addresses, which are hidden from public networks behind firewalls performing network address translation (NAT). For security reasons, many enterprises will keep their address space separated from public networks even when an abundance of IP addresses are available. To make VoIP work across a NAT, enterprises will use Application Layer Gateways (ALGs) at network boundaries.

In enterprise networks, IPv4 to IPv6 transition is expected to start with a "phase shift" compared to carrier networks, showing a peak around 2010.

Enterprise: initial adaptive solution being enhanced by native IPv6 support in HiPath soft-switches.

- As a first step, IPv6 phones or IPv6 soft clients are connected to HiPath platforms residing in IPv4 environments through application layer gateways (ALGs) or session border controllers (SBCs). IPv6inIPv4 tunneling is also used between network types.
- As a second step, HiPath softswitches controlling application layer gateways will interconnect IPv4 with IPv6 world in a native dual-stack mode. IPv6 phones and IPv6 soft clients register directly to the HiPath IPv6 softswitch, allowing for a smooth IPv6 transition at the customer's choice of speed. Selected HiPath applications provide native IPv6 support.

Conclusion

Many organizations have been reluctant to widely deploy the next generation Internet Protocol (IPv6) up to now. However, sooner or later IPv6 will replace IPv4 with a phase of coexistence of many years.

Unnecessary cost is avoided by early and careful planning.

Enterprises and service providers should carefully plan for the inevitable transition towards IPv6. They should develop IPv6 expertise so that they will be able to decide, when to move to IPv6. Careful transition planning will reduce and distribute costs over many years.

Future-proof IPv6-capable products that can be counted on.

Siemens Com, who is leader in innovative technologies like VoIP, fixed-mobile convergence, IPTV and IMS, plays an active role in IPv6-related standards bodies and IPv6 Forums. With its dedication to standards, it will provide you with future-proof IPv6-capable solutions with the highest possible interoperability to existing network infrastructure.

Glossary

3GPP	3rd Generation Partnership Project
ALG	Application Layer Gateway
BRAS	Broadband Remote Access Server
BGP	Border Gateway Protocol, an inter-domain IP routing protocol
BT	British Telecom
DSL	Digital Subscriber Line, a technology family, which targets at the provision of broadband services over telephone wires
EDGE	Enhanced Data Rates for GSM Evolution
GERAN	GSM EDGE Radio Access Network
GGSN	GPRS Gateway Support Node
GPRS	General Packet Radio Service
GRE	Generic Routing Encapsulation, a tunneling protocol that encapsulates network layer packets inside arbitrary kinds of network layer packets.
GSM	Global System for Mobile Communications
GTP	GPRS Tunneling Protocol is an IP based protocol used within GSM and UMTS networks
IANA	Internet Assigned Numbers Authority is delegating IP addresses to RIRs
IETF	Internet Engineering Task Force
IMS	IP Multimedia Subsystem
IP	Internet Protocol
IPTV	IP Television
IPv4	Internet Protocol version 4
IPv4inIPv6	Tunneling techniques that encapsulate IPv4 packets within IPv6 packets
IPv6	Internet Protocol version 6
IPv6inIPv4	Tunneling techniques that encapsulate IPv6 packets within IPv4 packets (e.g. 6to4, 6over4, Teredo, GTP for IPv6)
NAT	Network Address Translation
IT	Internet Technology
NAT-PT	Network Address Translation - Protocol Translation
NCP	Network Control Program, the predecessor of the Internet Protocol
RAN	Radio Access Network
RFC	Request for Comment, documents on innovations or methodologies applicable to Internet technologies. IETF adopts some RFCs as Internet Standards.
RIR	Regional Internet Registry
SBC	Session Border Controller
SGSN	Serving GPRS Support Node
UMTS	Universal Mobile Telecommunications System
UTRAN	UMTS Terrestrial Radio Access Network
VDSL2	Very-high-bit-rate Digital Subscriber Line 2
VoIP	Voice over IP

Appendix A: Protocol Stacks in Mobile and Fixed Networks

In mobile networks there are two layers of IP. Let us call the lower layer “transport IP layer” and the upper layer “service IP layer” or “user plane IP”. Today, IPv4 user plane packets are tunneled to the GGSN in IPv4 tunnels. As a first transition step, IPv6 services will be made available by enabling end-to-end IPv6 support in the service layer. Initially, IPv6 service packets will be tunneled over IPv4 based networks. As a second step, IPv6 in the transport layer will follow.

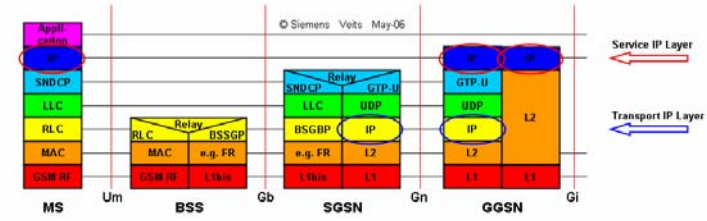


Figure 5: Service IP-Layer and Transport IP-Layer in GSM Networks.

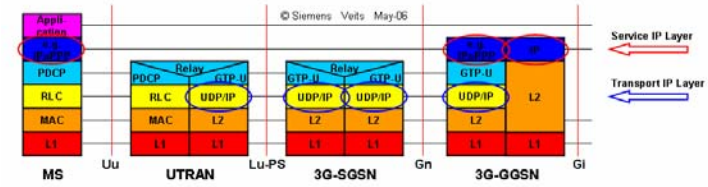


Figure 6: Service IP-Layer and Transport IP-Layer in UMTS Networks.

In contrast to mobile networks, IPv4 tunneling does not play a major role in fixed networks today and the transport IP layer coincides with the service IP layer. Fixed network operators seeking to connect their customers to their rich set of IMS-based applications will upgrade their IP network elements and application servers to dual stack support. They will use interworking functions of Siemens Com products in order to mediate between the IPv4 and the IPv6 world.

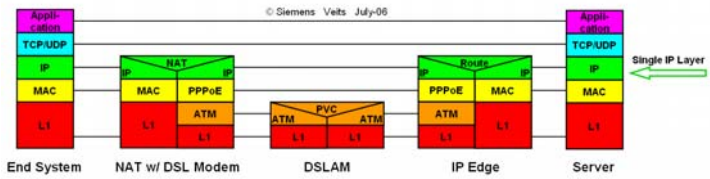


Figure 7: Single IP layer in typical fixed networks scenarios today. IPv6inIPv4 tunneling scenarios will require an additional IP layer and therefore are likely to be seen less commonly in fixed networks compared to mobile networks, where two IP layers are already present.

Appendix B: Transition Methods

Transition to IPv6 is a step-by-step issue. Both protocols, IPv4 and IPv6 will be seen throughout the Internet for many years. In principle, IPv4 and IPv6 are different Layer 3 protocols and coexist like “ships in the night”, not communicating directly with each other.

However, the creators of IPv6 have included mechanisms to address interoperation issues.

Best practice: independent parallel operation of IPv4 and IPv6 on the same box.

Dual Stack

For devices, that need to communicate to both worlds, the dual stack approach helps IPv4 applications to connect to IPv4 hosts, while IPv6-based applications of the same device communicate to the IPv6 world. Similarly, a dual stack router runs IPv4 routing and IPv6 routing simultaneously on the same box.

Interconnecting IPv6 islands over IPv4 clouds and vice versa.

Tunneling

In the early days of IPv6, small islands of IPv6 are separated from each other by IPv4-based networks. Here, “IPv6inIPv4” tunneling techniques help to interconnect IPv6 islands to each other. IPv6 standards have defined automatic addressing schemes to avoid the need to configure static tunnels. Several independent encapsulation types are available: Generic Encapsulation (GRE) wraps layer 3 packets within other layer 3 packets. Teredo (developed by Microsoft) uses UDP encapsulation instead, in order to ease NAT operation.
At a later point in time, when the majority of the network will be IPv6-based with some IPv4 islands being present, “IPv4inIPv6” tunnels will connect those islands.

Connecting the IPv4 to the IPv6 world.

Translation

Both, dual stack and tunneling help to interconnect applications of the same protocol version to each other. However, as long as there is no inter-working function present, the IPv4 and the IPv6 world remain separate. IPv6 standards have defined NAT/NAT-PT translation techniques that help to interconnect the two worlds.

Those inter-working functions either reside in simple NAT-PT translators, in application layer gateways (ALGs) or in session border controllers (SBCs). NAT-PT translators simply translate IPv4 headers to IPv6 headers and vice versa, leaving higher layer information untouched, while ALGs also transform higher-layer information. For applications, ALGs operate in a transparent mode, while SBCs as application proxies are visible to the communication partners.

Further Reading

- **Internet Engineering Task Force (IETF):** http://www.ietf.org has created the IPv6 standards. See also the IPv6 Working Group, http://www.ietf.org/html.charters/ipv6-charter.html
- **IPv6 Forum:** http://www.ipv6forum.org/. A world-wide consortium of leading Internet vendors, which develops deployment guides and fosters the operational use of IPv6.
- **The IPv6 Portal:** http://www.ec.ipv6tf.org IPv6 Info and News; IPv6 Task Force Search Engine

IPv6 Technical White papers:

- **Microsoft:** ”An Introduction to IP version 6” http://technet2.microsoft.com/WindowsServer/en/Library/6f1aef32-ada6-484b-a302-5093e2bd649a1033.mspx?mfr=true
- **Microsoft on Teredo tunneling:** http://www.microsoft.com/technet/prodtechnol/winxppro/maintain/teredo.mspx
- **Nokia:** ”Transition to IPv6 in 2G and 3G mobile networks” http://www.nokia.com/BaseProject/Sites/NOKIA_MAIN_18022/CDA/Categories/Networks/ Technologies/NetworkSystemEnhancements/IPv6/_Content/_Static_Files/transition_to_ipv6.pdf
- **Juniper about IPv6 capabilities of their products:** http://www.juniper.net/solutions/literature/solutionbriefs/351045.pdf
- **Cisco:** “Advanced Software Paves Path to IPv6” http://www.cisco.com/application/pdf/en/us/guest/tech/tk373/c1489/cdccont_0900aecd800a75b9.pdf