6net

IPv6

Deployment Guide

Javvin Technologies Inc. Distribution

An IPv6 Deployment Guide

Editor: Martin Dunmore

Javvin Technologies Inc. Distribution

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PART I

IPv6 Fundamentals

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Chapter 1

Introduction

Internet Protocol version 6 (IPv6) is the new generation of the basic protocol of the Internet. IP is the common language of the Internet, every device connected to the Internet must support it. The current version of IP (IP version 4) has several shortcomings which complicate, and in some cases present a barrier to, the further development of the Internet. The coming IPv6 revolution should remove these barriers and provide a feature-rich environment for the future of global networking.

1.1 The History of IPv6

The IPv6 story began in the early nineties when it was discovered that the address space available in IPv4 was vanishing quite rapidly. Contemporary studies indicated that it may be depleted within the next ten years – around 2005! These findings challenged the Internet community to start looking for a solution. Two possible approaches were at hand:

1. Minimal: Keep the protocol intact, just increase the address length. This was the easier way promising less pain in the deployment phase.
2. Maximal: Develop an entirely new version of the protocol. Taking this approach would enable incorporating new features and enhancements in IP.

Because there was no urgent need for a quick solution, the development of a new protocol was chosen. Its original name IP Next Generation (IPng) was soon replaced by IP version 6 which is now the definitive name. The main architects of this new protocol were Steven Deering and Robert Hinden.

The first set of RFCs specifying the IPv6 were released at the end of 1995, namely, RFC 1883: Internet Protocol, Version 6 (IPv6) Specification [RFC1883] and its relatives. Once the definition was available, implementations were eagerly awaited. But they did not come.

The second half of the nineties was a period of significant Internet boom. Companies on the market had to solve a tricky business problem: while an investment in IPv6 can bring some benefits in the future, an investment in the blossoming IPv4 Internet earns money now. For a vast majority of them it was essentially a no-brainer: they decided to prefer the rapid and easy return of investments and developed IPv4-based products.

Another factor complicating IPv6 deployment was the change of rules in the IPv4 domain. Methods to conserve the address space were developed and put into operation. The most important of these was Classless Inter-Domain Routing (CIDR). The old address classes were removed and address assignment rules hardened. As a consequence, newly connected sites obtained significantly less addresses than in previous years.

The use of CIDR may well have delayed the need for IPv6 in the eyes of many people, but not in all. Somewhat perversely, the use of CIDR accelerated the perception of a lack of address space in the

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Chapter 2

IPv6 Basics

Inside this chapter we cover the protocol basics: the datagram format, the headers and related mechanisms. You will see that these aspects have been simplified significantly in comparison to IPv4 to achieve higher performance of datagram forwarding.

2.1 Datagram Header

The core of the protocol is naturally the datagram format defined in RFC 2460 [RFC2460]. The datagram design focused mainly on simplicity - to keep the datagram as simple as possible and to keep the size of the headers fixed. The main reason for this decision was to maximise processing performance - simple constant size headers can be processed quickly, at or very close to wire-speed.

The IPv4 header format contains a lot of fields including some unpredictable optional ones leading to fluctuating header sizes. IPv6 shows a different approach: the basic header is minimised and a constant size. Only essential fields (like addresses or datagram length) are contained. Everything else has been shifted aside into so called extension headers, which are attached on demand - for example a mobile node adds mobility related extension headers to its outgoing traffic.

Figure 2-1 Basic IPv6 Datagram Header

The basic datagram header format is showed in Figure 2-1. The contents of individual fields are following:

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Chapter 3

Addressing

Rapid depletion of the available IPv4 address space was the main initiator of IPv6. In consequence, the demand to never again have to develop a new protocol due to the lack of addresses was one of the principal requirements to the new address space design. Let's look how it was fulfilled.

The basic rules of IPv6 addressing are laid down by RFC 3513 [RFC3513]. Some accompanying RFCs define the specialties and rules for specific address types.

3.1 Addressing Essentials

The address length has been increased significantly to expand the available address space. The IPv6 address is 128 bits (or 16 bytes) long, which is four times as long as its predecessor. Because every single bit of added address length doubles the number of addresses available, the size of the IPv6 address space is really huge. It contains 2^{128} which is about 340 billion billion billion billion different addresses which definitely should suffice for a very long time.

Addresses are written using 32 hexadecimal digits. The digits are arranged into 8 groups of four to improve the readability. Groups are separated by colons. So the written form of IPv6 address looks like this:

2001:0718:1c01:0016:020d:56ff:fe77:52a3

As you can imagine DNS plays an important role in the IPv6 world, because the manual typing of IPv6 addresses is not an easy thing. Some abbreviations are allowed to lighten this task at least a little. Namely: leading zeroes in every group can be omitted. So the example address can be shortened to

2001:718:1c01:16:20d:56ff:fe77:52a3

Secondly, a sequence of all-zero groups can be replaced by pair of colons. Only one such abbreviation may occur in any address, otherwise the address would be ambiguous. This is especially handy for special-purpose addresses or address prefixes containing long sequences of zeroes. For example the loopback address

0:0:0:0:0:0:0:1

may be written as

::1

which is not only much shorter but also more evident. Address prefixes are usually written in the form:

prefix::/length

Where prefix defines the value of bits in the address beginning and length contains the number of important bits from the start. Because the rest of the prefix is not important, zeroes are used in this part

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Chapter 4

Essential Functions and Services

This chapter looks at what we consider to be 'essential' functions and services of IPv6. In other words, without these functions and services we would not be able to achieve satisfactory IPv6 operation (or even no connectivity at all). First, we briefly describe Neighbour Discovery and look at several router configurations. Next we detail how DNS works in IPv6 and describe how this worked in the 6NET network. Finally, we describe DHCPv6 along with several available implementations.

4.1 Neighbour Discovery

Neighbour discovery is a protocol that allows different nodes on the same link to advertise their existence to their neighbours, and to learn about the existence of their neighbors. It is a basic functionality all implementations of IPv6 on any platform must include.

Neighbor discovery for IPv6 replaces the following IPv4 protocols: router discovery (RDISC), Address Resolution Protocol (ARP) and ICMPv4 redirect.

Neighbor discovery is defined in the following documents:

- RFC 2461, Neighbor Discovery for IP Version 6 [RFC2461]
- RFC 2462, IPv6 Stateless Address Autoconfiguration [RFC2462]
- RFC 2463, Internet Control Message Protocol (ICMPv6) for the Internet Protocol Version 6 Specification. [RFC2463]

RFC 2461 and 2462 are currently in the process of being revised by the IPv6 working group of the IETF. These drafts [RFC2461bis], [RFC2462bis] will eventually replace the older RFCs.

The combination of these protocols allow IPv6 hosts to automatically detect the presence of other hosts on the link including, of course, the presence of on-link routers. From the messages sent by routers, IPv6 hosts can automatically configure themselves with appropriate addresses and other state necessary for operation. Neighbour Discovery mandates duplicate address detection so that a host cannot try to use an IPv6 address already in use by another host on the link and also allows a host to detect when another host on the link becomes unreachable.

Neighbor discovery uses the following Internet Control Message Protocol Version 6 (ICMPv6) messages:

- router solicitation (RS)
- router advertisement (RA)
- neighbor solicitation (NS)

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Chapter 5

Integration and Transition

In this chapter we look at the problem of IPv6 integration and transition with existing IPv6 networks. Expanding IPv6 functionality from a small infrastructure to a large site network can be a complex and difficult venture. But if it is planned effectively, the deployment can be done in a phased and controlled manner that maximises the chances of a smooth service introduction. For a large site there are a lot of different requirements, and different conditions which make it necessary to employ various transition mechanisms according to the peculiarities of, for example, a given subnet, wireless or mobile environment or dial-in technology. In this chapter we explain which potential options and techniques exist to integrate IPv6 into a site network, which solution is appropriate for any special kind of network infrastructure and of course how exactly one has to set up and configure these techniques. Where possible, we also point to existing (current) problems and interoperability issues, for example in running IPv4 and IPv6 in parallel or having IPv6-only hosts which still need to be able to communicate with IPv4-only hosts on occasion. Numerous transitioning mechanisms and procedures are described including tunnelling methods such as IPv6-in-IPv4 tunnelling, Tunnel Brokers, ISATAP, 6to4, Teredo and translation methods such as NAT-PT, SIIT, SOCKS, ALGs and Bump-in-the-Stack/API.

An overview of security issues in transition is available as an Internet Draft that was originally produced as a result of 6NET experience [DKS05]. The security issues of individual transition mechanisms are discussed in Chapter 9.

5.1 Problem Statement

With an IPv6 host or local network configured, getting connectivity to the global IPv6 Internet is vital if you wish to communicate with other IPv6 systems. Today, this is usually accomplished either natively or, more commonly, with an IPv6-in-IPv4 tunnelling technique using either manual or automatic tunnel configuration methods.

The academic participants of the 6NET project are mostly fortunate enough to have native connectivity to their National Research and Education Networks (NRENs) and from there to a globally connected native IPv6 network (spanning GÉANT, and links to Abilene in the US and WIDE in Japan). Other sites may not be so lucky; for them a tunnelling mechanism is the only realistic option for IPv6 connectivity.

IPv6-only deployments are rare, especially in Europe, but are an interesting exercise with a view to the end game of IPv6 deployment. However, the practical reality is that sites deploying IPv6 will not transition to IPv6-only, but transition to a state where they support both IPv4 and IPv6 (dual-stack). The dual-stack environment then allows IPv6-only devices to be introduced, as a site slowly phases out IPv4. For this reason, translation mechanisms between IPv4 and IPv6 systems are less frequently

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Chapter 6

Routing

In this chapter we briefly explain IP routing, paying particular attention to IPv6-specific features. The first section contains a general overview of the Internet routing architecture and explains several important concepts. In the subsequent sections we describe the various routing protocols available to the IPv6 implementor and how these may be configured and deployed in various router platforms such as Cisco and Juniper.

6.1 Overview of IP Routing

Conceptually, IP routing is remarkably simple. It provides a mechanism for connectionless communication between any two hosts that are connected to the global Internet. In the simplest but very common setting, every router along the path between the two hosts is really required to perform just one action for every received datagram, namely next-hop forwarding based on the destination address. Also, all datagrams arriving asynchronously on all router interfaces are essentially handled on the best-effort, first come – first served basis.

Of course, even this is far from easy, if for nothing else then for the sheer number of networks involved. Yet compared both to various extensions of IP (QoS provisioning, traffic engineering, even multicast) and to competitive technologies like ATM, plain IP routing is rather straightforward. Having this relatively "dumb", stateless and policy-free network near the bottom of the protocol stack have had two important consequences:

1. IP routing technology scaled so far extremely well without any strict control mechanisms.
2. The protocol layers above IP (applications in particular) have enough degrees of freedom to implement many different policies and approaches.

In the following subsections we give an overview of the key elements and concepts of IP routing. Most of them are common to IPv4 and IPv6, but we will specifically point out those (relatively few) cases where both protocols differ.

6.1.1 Hop-by-hop Forwarding

IP communication between two hosts A and B that are not on the same LAN segment must pass through one or more routers as indicated in Figure 6-1.

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Chapter 7

Network Management

Network management and monitoring is a critical part of operating any production quality network, whatever the nature of the network. It is one of the essential building blocks of the 6NET network, and must be so for any IPv6 public network, especially in the Internet service provider area. If IPv6 backbone networks are not subject to the same (or even an improved) standard of management and monitoring as existing IPv4 networks, the existing IPv4 user base will be unwilling to migrate to IPv6.

Network Management covers many areas (also called network segments) of the network. Usual classification distinguishes Local area Networks (LAN) from Metropolitan (MAN) and Wide Area Networks (WAN). In this regard sets of very different functions have to be provided to the manager, from straightforward monitoring of link status, to traffic statistics gathering and analysis. These sets could roughly be classified in two categories: those needed for day to day network control operations and those dedicated to network behaviour analysis. The latter allows the manager to optimise the network or parts of it and to schedule the necessary evolutions.

This chapter brings together all the important network monitoring and management work conducted by the network management workpackage of 6NET. This chapter is designed as a “cookbook”, summarising the issues required for managing and monitoring an IPv6 network, and suggests appropriate tools that can be used to support the network management and monitoring function. The end result should be that this will be both a useful guide to designers of new IPv6 networks, and as a reference for more experienced network managers.

7.1 Management protocols and MIBs in the standardisation process

As the main management standard used for IPv4 networks is SNMP (Simple Network Management Protocol), [RFC3416], it was an obvious goal to pursue to also make SNMP management available for and via IPv6. This section focuses on SNMP for IPv6, the corresponding MIBs (Management Information Base) and standardisation process and also gives a brief history on the evolution of the SNMP protocol in general.

7.1.1 SNMP for IPv6

Today many network vendors (6WIND, CISCO, HITACHI, JUNIPER etc.) support SNMP over IPv6 and can be monitored in an IPv6-only environment. One could note that equipment not supporting SNMP over IPv6 can be managed over IPv4 as most IPv6 networks are running dual stack.

The number of SNMP applications able to poll remote SNMP agents over IPv6 remains low. Most of the tools today use the netSNMP open source SNMP library. Recently however, some integrated

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Chapter 8

Multicast

We will explain differences between IPv4 and IPv6 multicast. We will first look at the basics and go through the different types of addressing and allocations available. Then we will look at how to deploy IPv6 multicast intra-domain, followed by inter-domain.

8.1 Addressing and Scoping

The complete multicast architecture defined today in different RFCs and Internet Drafts is described in this section. It is very important to know all the different address types defined because the allocation mechanisms will depend of the architecture used.

RFC 3513 (IP Version 6 Addressing Architecture) defines the IPv6 multicast address. As shown in Table 8-1, IPv6 multicast addresses are derived from the FF00::/8 prefix. The octet following the initial obligatory "FF" value contains four flags and 4-bit value defining the scope of the multicast group.

Table 8-1 IPv6 Multicast Address Format

8 bits	4 bits	4 bits	---------- 112 bits ----------
FF	Flags	Scope	Group ID

The flags field is a set of 4 flag bits.

Table 8-2 The Flags Field

x	R	P	T

Only bit T is described in RFC 3513 and indicates if the address is permanent (value 0) or temporary (value 1). Bits P and R are described in RFC 3306 [RFC3306] and RFC 3956 [RFC3956]. The high order flag bit is not yet used. The use of the flags makes it possible to distinguish different address type that will be detailed in the following sections.

The meaning of the 4-bit scope value is summarized in Table 8-3.

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Chapter 9

Security

This chapter provides an overview of the current security issues in an IPv6 based networking environment and suggests a number of helpful security "guidelines".

First we will analyse how the IPv6 changed the security of IP networking environment. We will concentrate on the threat analysis compared with IPv4. Then we will discuss the major building block of a security architecture: IPv6 firewalls. Finally we will discuss the security implications of deploying various IPv4-IPv6 co-existnce and transitioning mechanisms.

9.1 What has been Changed in IPv6 Regarding Security?

In this section will enumerate the different threats that you can face when you operate a IP networking environment and we trying to provide some sort of solution in IPv6 in mind.

9.1.1 IPSec

IPSec is a framework of open standards developed by the Internet Engineering Task Force (IETF) that provide security for transmission of sensitive information over unprotected networks such as the Internet. IPSec acts at the network layer, protecting and authenticating IP packets between participating IPSec devices (peers), such as Cisco routers. IPSec provides the following network security services. These services are optional. In general, local security policy will dictate the use of one or more of these services:

- ? Data confidentiality—The IPSec sender can encrypt packets before sending them across a network.
- ? Data integrity—The IPSec receiver can authenticate packets sent by the IPSec sender to ensure that the data has not been altered during transmission.
- ? Data origin authentication—The IPSec receiver can authenticate the source of the IPSec packets sent. This service is dependent upon the data integrity service.
- ? Anti-replay—The IPSec receiver can detect and reject replayed packets.

With IPSec, data can be sent across a public network without observation, modification or spoofing.

IPSec functionality is essentially identical in both IPv6 and IPv4; however, IPSec in IPv6 can be deployed from end-to-end - data may be encrypted along the entire path between a source node and destination node. (Typically, IPSec in IPv4 is deployed between border routers of separate networks.) In IPv6, IPSec is implemented using the authentication extension header and the ESP extension header. The authentication header provides integrity and authentication of the source. It also provides

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Chapter 10

Mobility

The Mobile IPv6 (MIPv6) protocol [RFC3775] is a proposed standard by the IETF to provide transparent host mobility within IPv6. The protocol enables a Mobile Node to move from one network to another without the need to change its IPv6 address. A Mobile Node is always addressable by its home address, which is the IPv6 address that is assigned to the node within its home network. When a Mobile Node is away from its home network, packets can still be routed to it using the node's home address. In this way, the movement of a node between networks is completely invisible to transport and other higher layer protocols.

Mobile Nodes participating in the MIPv6 protocol each have a persistent home address, which can be used to address the Mobile Node irrespective of its current point of attachment to the IPv6 network. The IPv6 network which matches the home address' prefix is known as the home network. Mobile Nodes also adopt a Home Agent - an IPv6 capable router directly connected to the home network. This process may either be static, or dynamic, via the MIPv6 Home Agent discovery mechanism. The Home Agent is responsible for the interception and forwarding of IPv6 packets to the Mobile Node which are incorrectly routed to the home network while the Mobile Node is away from home.

When a Mobile Node is attached to its home network it operates as any other network node, so no special routing is required. When a Mobile Node moves to a foreign network, it uses IPv6 autoconfiguration to discover the new network and to allocate a care-of address within the address space of that network. However, to ensure that IPv6 packets destined for the Mobile Node's home address reach the proper location as efficiently as possible, the routing information pertaining to the Mobile Node's home address must be updated in both the Home Agent and any relevant Correspondent Nodes. MIPv6 provides this functionality by the introduction of a bindings cache on the Mobile and Correspondent Nodes and binding update messages which are transmitted in a new IPv6 extension header called the mobility header.

Although MIPv6 implementations have been around since 1998 most have fallen out of date as the MIPv6 protocol has progressed over the years. However, there are a handful of available implementations that are fairly up to date with either MIPv6 draft version 24 or RFC 3775 (which is based on draft version 24). Yet these implementations can still differ slightly in their supported features and are not likely to be completely 100% interoperable in most cases.

10.1 Bindings Cache

The relationship between a Mobile Node's home address and its current care-of address is known as a binding. All Nodes participating in MIPv6 are required to maintain a table of these bindings in a binding cache. One entry is held in the binding cache for each Mobile Node with which communication is currently taking place. The binding cache holds four pieces of information per binding which are central to the operation of MIPv6, as illustrated by Table 10-1 (other fields are

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Chapter 11

Applications

A number of middleware and user applications were developed or ported by the 6NET project. These included the SIP-based telephony system (including a PSTN gateway), the AccessGrid conferencing tool (including an IPv4-IPv6 gateway), IPv6 versions of the IBM WebSphere e-business applications, an IPv6 version of the FLUTE multicast file transfer tool, and MIPv6-based video streaming for PDAs. The 6NET project also created IPv6 versions of the Globus Toolkit (GT3.x) which is used to develop Grid-aware applications (e.g., IPv6 WeatherStation and eProtein), and the Open H.323 Toolkit, used to develop an IPv6 version of GnomeMeeting. Other network management tools such as NetSNMP, MRTG, OpenEye, Smokeping and Weathermap have been developed or ported for traffic measurement and visualisation purposes.

6net **Applications summary**

These are the application being ported, tested or developed by 6NET.
Our aim is to perform trials on the suitability and robustness of IPv6 applications with a view to wide-scale deployment.
Click on the column headers to change sorting order.

name	category	class	summary	status	responsible	modified	passed test
TUR	Streaming Radio	A	Trondheim Underground Radio	Running. Publicly available. Multicast support planned by mid 2003.	UNINETT	2004-03-11	✔
VideoLAN	Streaming	A	Streaming video server and player	Works. A multicast demonstrator. A first implementation of RTSP is available for better stream control.	SURFnet	2004-02-27	✔
Quake	Gaming	B	Multiplayer FPS action game	Works.	GARR	2004-02-27	✔
Kphone	Conferencing	A	SIP based Voice-over-IPv6 telephony application.	Demo version released	FhG Fokus	2004-03-11	✔
WMA through ftunnel	Streaming	A	Streaming of Windows Media using ftunnel	working	SURFnet bv	2004-03-11	✔
SER	Conferencing Support	A	SIP server	Operational	FhG Fokus	2004-03-11	✔
VIC	Conferencing	A	Video Conferencing Tool	VIC is currently fairly stable, and provides good performance. Further work is required on use of direct video display and integration of more codecs.	UCL	2004-03-17	✔
MCast6	Streaming	A	Tool for multimedia streaming in a computer network	testing phase	PSNC	2004-05-13	✔

Figure 11-1 Partial Screenshot of the Applications Database

Deliverable D5.1 [D5.1] of the 6NET project listed the applications initially identified as candidates to run on the 6NET IPv6 network. Since the development and porting of applications to support IPv6 is not a static activity, it is very difficult, if not impossible, to capture the ever-evolving status of the different applications mentioned in a single document.

Therefore, the Applications workpackage of 6NET decided that the applications list and current status would be in the form of a web page. This approach enables application owners to keep the status of

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PART II

Case Studies

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Chapter 12

IPv6 in the Backbone

In this chapter we present case studies of IPv6 in the backbone. First we look at the core 6NET backbone and the NRENs that were connected to it before the core network was decommissioned in January 2005.

Next, we detail case studies of IPv6 deployment by the NRENs themselves inside their own country backbone networks. The most common method to introduce IPv6 services into IPv4 networks will be through dual-stack networking. This complements the backbone transition and pushes the issue of deployment to the edge, e.g. to the universities.

In the timeframe of 6NET, many NRENs migrated to dual stack; the specific experiences of SURFnet, Funet and Renater are reported here.

12.1 6NET Backbone Case Study

A backbone IPv6 network connecting sixteen countries and running at 155 Mbps was established in 2002. This ran IPv6 over dedicated links, although for cost reasons, four links (to Greece, Hungary, Poland and Portugal) were provided by POS (Packet-over-SONET/SDH) over a Layer 2 VPN infrastructure.

Local access was provided through national IPv6 testbeds operated by partner NRENs (National Research and Education Networks) such as JANET (UK), RENATER (France) and SWITCH (Switzerland). Connectivity to the non-European 6NET partners in Japan and South Korea was provided via connections to London and RENATER respectively, and there are were connections to Abilene in the US (via SURFnet), Euro6IX (via the JANET- UK6X, GARR-TILab and SWITCH-Swisscom exchange points) and to the 6Bone.

The 6NET backbone, and interconnected national testbeds, collectively formed the largest native IPv6 network in the world. This provided plenty of scope for trialling the new technology, testing interoperability with existing networks, and demonstrating services and applications. In fact, it demonstrated that the IS-IS and BGP4+ routing protocols, IPv6 over IPv4 tunnelling, and DNS support were stable and usable. In addition, a multicast overlay network (M6Bone) was established and has been utilised for conferencing and radio broadcasting (e.g., Trondheim Underground Radio).

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Chapter 13

IPv6 in the Campus/Enterprise

In this chapter we present case studies of IPv6 in the Campus/Enterprise. Since the vast majority of the 6NET partners were academic related, this case studies in this chapter are indeed related to Universities and academic departments. Nevertheless, there are many similarities between University/Campus based deployments and Enterprise deployments.

First, we we look at the Campus IPv6 deployment at the University of Münster. Next we describe two deployments at small and large academic departments (Tromsø and Southampton University respectively). A second University Campus deployment case study is given for Lancaster University and finally, we briefly describe some other deployment scenarios relating to the Campus/Enterprise class of network.

13.1 Campus IPv6 Deployment (University of Münster, Germany)

As the University of Münster is quite large, with a widespread network and is using at large set of different hardware and network techniques, several considerations had to be taken into account.

If one wants to integrate IPv6 in the network, the most desirable form of integration is always to run in dual-stack mode on each and every interface and node. However, while nowadays support for IPv6 is present in nearly every new product, there are still older hardware and technologies that do not easily support IPv6 capabilities or don't support them at all.

Especially in large sites, that have been in place for a long time, the network infrastructure has evolved over a number of years. Such networks often have a modern core, but still use old technology in some areas and on internal "stubby" edges. In such environments it is practically impossible to run full dual-stack mode. Several of the transition methods described in this cookbook can be used to reach such areas.

In addition, network administrators often hesitate to introduce IPv6, because they fear that they will destabilise their IPv4 infrastructure or because they are unfamiliar with IPv6 and IPv6 management. To overcome these fears it is helpful to start with IPv6 just in a few parts of the network and to leave the IPv4 infrastructure untouched.

A good method for this is using VLAN technology (802.1q). VLANs are very common and often used in modern networks, and it is especially easy to integrate IPv6 in these networks. If a dedicated IPv6 router is used, it can get access to only those VLANs where IPv6 is desired. So the IPv4 network remains unchanged, and all IPv6 traffic is routed and managed over a different set of hardware.. If no additional hardware is available, it might be sufficient to use only a small set of the existing routers to do IPv6 routing.

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Chapter 14

IPv6 on the Move

This chapter describes three case studies of 6NET partners who deployed and trialled Mobile IPv6 testbeds. We first look at the testbed at Fraunhofer Fokus and after that we describe the testbeds at Lancaster University and the University of Oulu.

14.1 Fraunhofer Fokus

The Fokus Mobile IPv6 testbed has undergone several changes throughout the 6NET project. The current environment does not longer distinguish between an internal and an external part as before when there was a local, experimental testbed not constantly connected to the 6NET network and another part with continous provision of native IPv6 connectivity to the outer 6NET world. Furthermore the test environment was completed by several components providing for VoIP and video conferencing capabilities.

The Mobile IPv6 testbed consists of the components illustrated in Figure 14-1.

Connected to the central router “adrahil” there are basically two different networks with prefixes 2001:638:806:2002::/64 and 2001:638:806:2001::/64. Attached to those networks are the corresponding Home Agents for the MIPL- and the KAME-Mobile IP implementation, respectively. A MCU connected to the “2001”-network was used as Corresponding Node for Mobile IPv6 functionality- and interoperability testing: Using a MN with video conferencing equipment, i.e. the GnomeMeeting application with camera and headset, this scenario allowed for establishing a connection to the CN-MCU and subsequently changing the IPv6 network point of attachment while maintaining the connection to the MCU.

Currently the Fokus testbed is made up of the different components:

- End systems with different operating systems

  At the leaves of the network, standard PCs with different operating systems (Windows Server 2003, Windows XP, Linux, FreeBSD) are installed. They are used for testing IPv6 network applications like video conferencing, web surfing, downloading audio and video streams, IP telephony applications etc.

- Home Agents

  Mobile IPv6 Home Agents as offered by the MIPL- and KAME project.

- IP softphone

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Glossary of Terms and Acronyms

6PE	IPv6 Provider Edge Router (over MPLS)
ABR	Area Border Router
ACL	Access Control List
AH	Authentication Header
ALG	Application Layer Gateway
AP	Access Point
API	Application Programming Interface
AR	Access Router
ARP	Address Resolution Protocol
AS	Autonomous System
ASM	Any Source Multicast
ASBR	Autonomous System Boundary Router
ASCII	American Standard Code for Information Interchange
ATM	Asynchronous Transfer Mode
BA	Binding Acknowledgement
BDR	Backup Designated Router
BGP	Border Gateway Protocol
BGMP	Border Gateway Multicast Protocol
BIA	Bump in the Stack
BIND	Berkeley Internet Name Daemon
BIS	Bump in the Stack
BOOTP	Bootstrap Protocol
BR	Binding Request
BU	Binding Update
BSD	Berkeley Software Distribution
CIDR	Classless Inter-Domain Routing
CA	Certificate Authority
CCC	Circuit Cross Connect
CEF	Cisco Express Forwarding
CGA	Cryptographically Generated Address
CN	Correspondent Node
CoA	Care-of Address
CoT	Care-of Test
CoTI	Care-of Test Init

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Appendices

Appendix A1: List of per-PoP Location Support Domains

Every PoP has its own subdomain within 6net.org. The subdomain name corresponds to the two letter country code of the country where the PoP is located, i.e., <cc>.6net.org. The country codes are the following:

at - Austria

be - Belgium

ch - Switzerland

cz - Czech Republic

de - Germany

es - Spain

fr - France

gr - Greece

hu - Hungary

ie - Ireland

it - Italy

lu - Luxemburg

nl - Netherlands

pl - Poland

pt - Portugal

se - Sweden

si - Slovenia

sk - Slovakia

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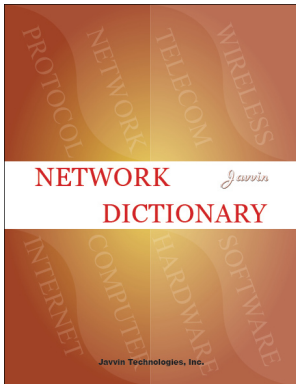

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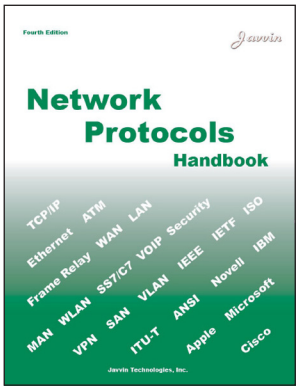

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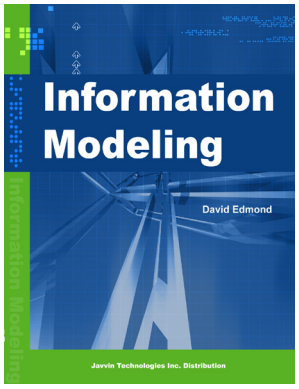

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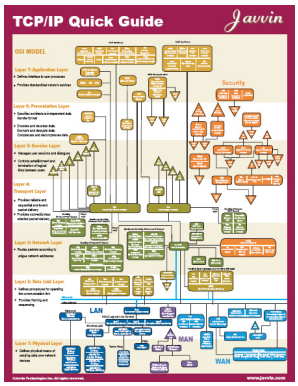
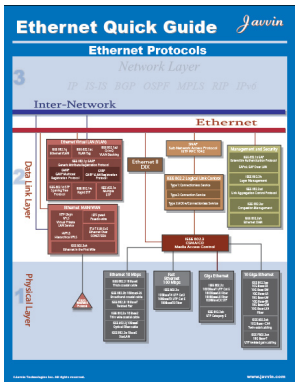


TCP/IP Quick Guide

Practical TCP/IP information extracted from hundreds of pages of TCP/IP books. A comprehensive and clear map of all TCP/IP protocols in OSI 7 layers model. A portable tool for you to carry, insert into a folder or put on your desk.



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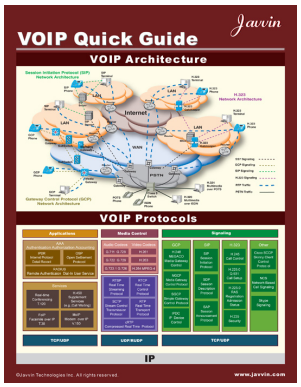

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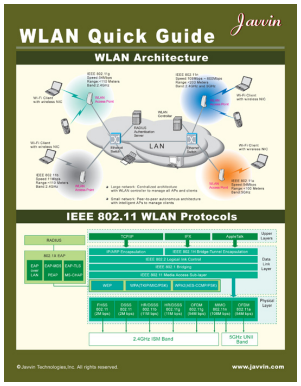
All must known VOIP technologies included in this comprehensive yet portable quick reference.



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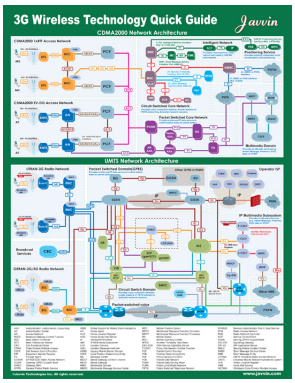

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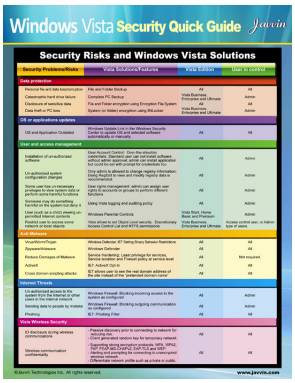

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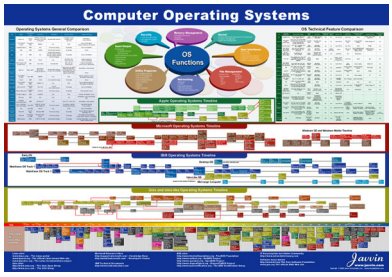
All you must to know about Windows Vista Security on this handy quick guide...useful for all Windows Vista users!



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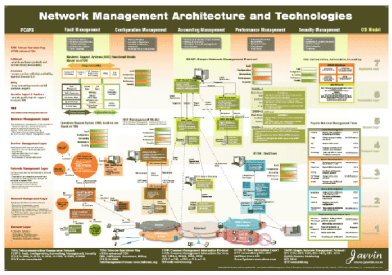
Illustrates the computer operating systems now and their evolution path over the past 60 years.



Network Management Architecture and Technology Map

All network management architecture and technologies for both telecom and data communications displayed on one chart.

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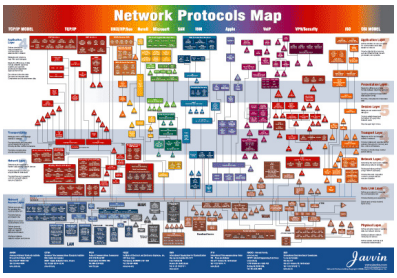

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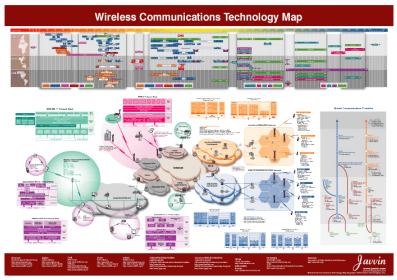
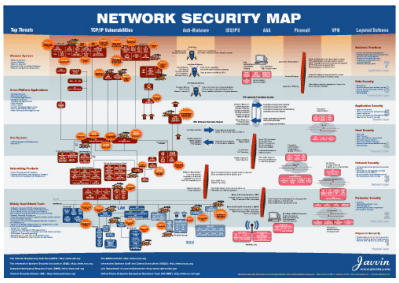


Wireless Communications Technology Map Poster

All major wireless technologies displayed in one chart: WLAN, WiMAX (WMAN), WPAN and mobile wireless technologies (WWAN)...



Network Security Map

All you must know about network security on one chart! A unique gift for yourself, your colleagues, partners and customers.

Network dictionary

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IPv6 Deployment Guide

6NET was a three-year European IST project to demonstrate that continued growth of the Internet can be met using new IPv6 technology. The project built and operated a pan-European native IPv6 network connecting sixteen countries in order to gain experience of IPv6 deployment and the migration from existing IPv4-based networks.

6NET involved thirty-five partners from the commercial, research and academic sectors and represented a total investment of €18 million; €7 million of which came from the project partners themselves, and €11 million from the Information Society Technologies Programme of the European Commission. The project commenced on 1st January 2002 and officially finished on 30th June 2005. The network itself was decommissioned in January 2005, handing over the reigns of pan-European native IPv6 connectivity to GÉANT.

When we began 6NET, IPv6 code was in the form of early beta releases from most commercial companies. The 6BONE had been built but was only using tunnels; there were very few native IPv6 networks and none of these ran production traffic. One thing we strived for in the early days of 6NET was developing a pan-European testbed that had as much native IPv6 connectivity as was affordable. This gave everyone involved the chance to really exercise the IPv6 protocol developments we planned without the added complexity of tunnels that might detract from the real work. Soon we were able to peer with other IPv6 networks in the US (Abilene, 6TAP), Japan (NTT) and S.Korea (KOREN) to provide global IPv6 connectivity. The final stages of the project moved into exploiting the protocol and providing demonstrations that IPv6 was ready for full production service.

The information contained in this book is taken from the project's deployment cookbooks and other deliverables. Since each cookbook/deliverable generally concentrates only on specific IPv6 features or deployment scenarios (e.g. site transition, multicast, mobility, DHCP, routing etc.), we believe that providing all the important information in a single reference book is much more preferable to the reader than negotiating our multitude of project deliverables.

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