

IPNET

Embedded IPv4/IPv6 TCP/IP Stack

IPNET Overview

Many of the Internet protocols have traditionally only been available to workstation-class computers without any resource constraints. Interpeak now introduces IPNET, a full-featured IPv4/IPv6 dual-stack, specifically designed to be used in modern embedded real-time systems.

With the huge expansion of the Internet, TCP/IP has become the preferred protocol for local- and wide-area networks. The original design of the TCP/IP protocol surprisingly dates back to the early eighties, but new features are continuously added by the Internet Engineering Task Force (IETF).

TCP/IP is also widely used when connecting networked embedded real-time systems. TCP/IP stacks designed for use in embedded systems do however often have limitations in functionality. This is often caused by memory and timing constraints, but also by the fact that stack vendors have problems to keep up with the continuous flow of new protocols specified by the IETF.

The full set of TCP/IP protocols has therefore traditionally only been available to desktop computers and servers. Although the limited functionality of embedded TCP/IP stacks may have been sufficient in many cases, modern embedded real-time systems often demand a full-featured stack that supports a substantial part of the IETF protocols.

Interpeak, with its long experience of embedded networking products, therefore introduces IPNET—a full-featured dual IPv4/IPv6 stack—specifically designed and implemented from

- IPv4
- IPv6
- IPsec
- PPP
- TCP
- UDP
- NAT
- Ethernet/ARP/NDP
- ICMPv4/ICMPv6
- IGMPv2/MLDv1
- (Host and Proxy)
- IPIP/GRE

Supported Protocols

the ground up to be used in modern embedded real-time systems.

Internet Protocol, Version 6

Interpeak IPNET supports IPv6, which extends the current IP protocol specification in a number of important aspects. The IPNET IPv6 implementation is RFC compliant and compatibility tested against major operating systems like Solaris, Linux, Windows XP, various BSD implementations etc.

Simultaneous Use of IPv4 and IPv6 Applications

The transition from IPv4 to IPv6 will take several years to finalize. During this period, a common situation will be that a TCP/IP stack has to support communication with both type of nodes. Interpeak IPNET is a true IPv4/IPv6 dual-stack that handles simultaneous use of IPv4 and IPv6 in a variety of configurations.

IPNET also handles all types of IP-in-IP tunneling, supporting the mix of IPv4 and IPv6 traffic that can appear in heterogeneous IPv4/IPv6 networks.

Built-in Security

IPNET includes a built-in IPsec module for both IPv4 and IPv6, as well as NAT.

IPsec—Internet Protocol Security—transparently secures applications by enabling authentication, integrity, encryption and replay protection.

NAT—Network Address Translation—makes it possible to hide the local network topology, as well as using a single public IP address

for an entire LAN. The Firewall, NAT and IPsec functionality is tightly integrated with IPNET for optimum performance as well as guaranteed interoperability.

Packet Filtering

IPNET contains a packet filtering engine, allowing filtering of traffic based on interface, protocol, port, tos, ttl, source destination and many other factors. This can be used to implement security features like firewalls, and also for other types of customizations.

MIB-II Support

Remote management and control of the TCP/IP stack is allowed using the SNMP protocol. Necessary MIB-II statistics are gathered by the kernel for each access by SNMP agents. MIB-II tables include: Interfaces, IP, Address Translation, ICMP, TCP, and UDP.

- Raw IP/UDP/TCP BSD sockets
- Routing sockets, used by routing daemons
- PFKEYv2 sockets, used by key management daemons
- MIB control interface
- Zero-copy API based on BSD sockets
- Dynamic configuration interface
- Link Layer Interface, enables additional link layer types, e.g. IEEE 802.11, ATM, etc.
- Driver Interface, using the RTOS BSP drivers

Supported APIs

IPNET Architecture

Routing Engine

IPNET contains a high-performance routing engine, using highly optimized Radix trees that allow both static and dynamic routes. There is also a standard BSD routing socket interface that enables the use of standard routing daemons, as well as allowing for dedicated routing devices to cooperate with the TCP/IP stack.

IPNET also supports multicast routing through the optional Multicast Listener Daemon, MLD. This is a key feature to minimize link bandwidth requirements in streaming media applications.

Virtual Routing

Furthermore, the IPNET stack supports full virtualization with multiple independent routing tables, used in Virtual Routers. This means that one IPNET stack can act as multiple routers, enabling a massive reduction in

router hardware. The Virtual Routing support includes a number of BSD socket extensions to manage the additional routing tables.

Quality of Service - Diffserv

IPNET contains an implementation of Diffserv, which provides differentiated classes of service—also known as Quality of Service—for Internet traffic. This is important since different applications have varying requirements for network characteristics such as bandwidth, packet loss, delay, and delay variation (jitter).

Highly Configurable

IPNET can be deployed in a variety of different configurations, which is often a requirement in embedded systems. Unused modules, protocols or features can be removed from the TCP/IP stack, thereby reducing memory footprint to as low as 40 kilobytes.



IPNET is the first commercial TCP/IP stack to pass the IPv6 Forum's host and router requirements for using the IPv6 READY logo. Read more about this at www.interpeak.se/salesup/ipv6_ready.html.

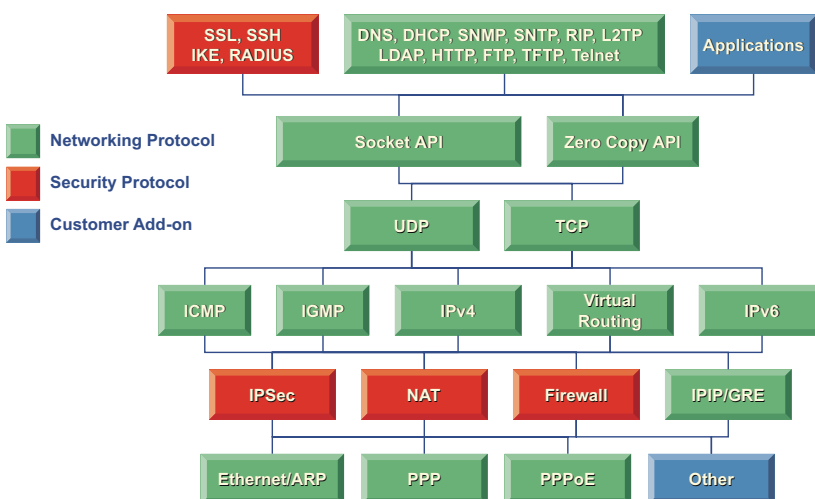
Applications

Interpeak has implemented a large number of security and networking applications like SSH, SSL, IKE, L2TP, RADIUS, PPPoE, RIP, SNMP, SNMP, Telnet, FTP, TFTP, DHCP, HTTP, DNS, LDAP, Mobile IP, etc. For additional information about these networking applications, please visit www.interpeak.se/products.

Uses Existing Drivers and Board Support

Interpeak IPNET is closely integrated with several major real-time operating systems, utilizing the same network drivers and board support packages as the RTOS. This makes IPNET readily available on all platforms and devices supported by the RTOS.

Example target systems include both CISC, RISC and DSP architectures from e.g. ARM, Hitachi, Intel, MIPS, Motorola, Texas, etc.



The architecture of IPNET and additional Interpeak networking products. Due to its modular design, it is easy to customize IPNET to a specific application by removing unused protocols and features.

IPv6 Protocol Features

Around year 1992, the Internet Engineering Task Force (IETF) became aware of shortage of IPv4 addresses in the world, and technical obstacles in deploying new protocols due to limitation imposed by IPv4. IPng (IP next generation) effort was started to solve these issues. After large amount of discussions, around year 1995, IPv6 (IP version 6) was picked as the final IPng proposal.

Larger IP Address Space

IPv4 uses only 32 bits for IP address space, which allows only 4 billion nodes to be identified on the Internet. 4 billion may look like a large number, however, it is less than the human population on the earth. IPv6 allows 128 bits for IP address space, allowing three hundred forty undecillion nodes to be uniquely identified on the Internet. Larger address space allows true end to end communication, without NAT or other short term workaround against IPv4 address shortage.

Deploy New Technologies

After IPv4 was specified 20 years ago, we have seen a plethora of technical

- INTEGRITY
- Itron
- Linux
- Nucleus
- OSE/OSEck
- VxWorks

RTOS Support. Due to its clean design, IPNET can also be integrated in systems where no commercial RTOS is available.

improvements in networking. IPv6 covers a number of those improvements in its base specification, allowing users to assume these features available everywhere, anytime.

Autoconfiguration

With IPv4, DHCP has been available, but only as an option. The novice user can go into trouble when visiting an offsite without DHCP server. With IPv6, the stateless host autoconfiguration mechanism is mandatory.

Security

With IPv4, IPsec is optional and you need to ask the peer if it supports IPsec or not. With IPv6, IPsec support is mandatory. By mandating IPsec, you can secure your IP communication whenever talking to IPv6 devices.

Multicast

Multicast is mandatory in IPv6, which was optional in IPv4. IPv6 base specifications also extensively use multicast.

Ad-Hoc Networking

Scoped addresses allow better support for ad-hoc or *zeroconf* networking configuration. IPv6 supports anycast addresses, which can also contribute to service discoveries.

Protocol Extensions

IPv6 allows a more flexible protocol extension than IPv4 does. This is without imposing any overhead to intermediate routers. It is achieved by splitting headers into two flavours: the headers intermediate routers need to examine, and the headers the end nodes will examine. This also eases hardware acceleration for IPv6 routers.

No Routing Table Growth

IPv4 backbone routing table size has been a big headache to ISPs and backbone operators. The IPv6 addressing specification restricts the number of backbone routing entries by advocating route aggregation.

Simplified Header Structures

IPv6 has simpler packet header structures than IPv4. It will allow future vendors to implement hardware acceleration for IPv6 routers easier.

Smooth Transition From IPv4

Many IPv4 considerations were made during the IPv6 development. Also, there is a large number of transition mechanisms available which will allow smooth migration from IPv4 to IPv6.

Same Design Principles as IPv4

IPv4 was a very successful design, as proven by the ultra large-scale deployment in the world. IPv6 is the new version IP, and it follows many of the designs that made IPv4 very successful.

- ANSI C source code
- Highly scalable
- Static and dynamic configuration
- Unlimited number of addresses, sockets, routes and interfaces
- Optimized radix routing trees
- Virtual routing support
- Built-in IPsec and NAT
- Shell commands, e.g. `ifconfig`, `netstat`, `route` etc.

IPNET Features.

IPNET RFC Conformance I

BASE Ethernet/IPv4/IPv6/ RawIP/UDP/TCP/BSD Sockets

RFC 0147 Definition of a socket
RFC 0768 User Datagram Protocol
RFC 0791 Internet Protocol (IP)
RFC 0792 Internet Control Message Protocol (ICMP)
RFC 0793 Transmission Control Protocol
RFC 0826 An Ethernet Address Resolution Protocol
RFC 0894 Standard for the transmission of IP datagrams over Ethernet networks
RFC 0919 Broadcasting Internet Datagrams
RFC 0922 Broadcasting Internet datagrams in the presence of subnets
RFC 0950 Internet Standard Subnetting Procedure
RFC 1071 Computing the Internet checksum
RFC 1112 Host Extensions for IP Multicasting
RFC 1122 Requirements for Internet Hosts - Communication Layers
RFC 1191 Path MTU Discovery
RFC 1323 TCP Extensions for High Performance
RFC 1518 An Architecture for IP Address Allocation with CIDR
RFC 1853 IP in IP Tunneling
RFC 1886 DNS Extensions to support IP version 6 [IPAPPL dns client]
RFC 1981 Path MTU Discovery for IPv6
RFC 2002 IP Mobility Support
RFC 2113 IP Router Alert Option
RFC 2236 Internet Group Management Protocol, Version 2
RFC 2373 IPv6 Addressing Architecture
RFC 2374 An IPv6 Aggregatable Global Unicast Address Format (obsoleted by 3587)

RFC 2375 IPv6 Multicast Address Assignments
RFC 2385 Protection of BGP Sessions via the TCP MD5 Signature Option
RFC 2460 IPv6 specification
RFC 2461 Neighbour discovery for IPv6
RFC 2462 IPv6 Stateless Address Autoconfiguration
RFC 2463 ICMPv6 for IPv6 specification
RFC 2464 Transmission of IPv6 Packets over Ethernet Networks
RFC 2473 Generic Packet Tunneling in IPv6 Specification
RFC 2474 Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers
RFC 2475 An Architecture for Differentiated Service
RFC 2553 Basic Socket Interface Extensions for IPv6
RFC 2581 TCP Congestion Control
RFC 2597 Assured Forwarding PHB Group
RFC 2697 A Single Rate Three Color Marker
RFC 2710 Multicast Listener Discovery (MLD) for IPv6
RFC 2711 IPv6 Router Alert Option
RFC 2784 Generic Routing Encapsulation
RFC 2893 Transition Mechanisms for IPv6 Hosts and Routers
RFC 2991 Multipath Issues in Unicast and Multicast Next-Hop Selection
RFC 3056 Connection of IPv6 Domains via IPv4 Clouds
RFC 3484 Default Address Selection for Internet Protocol version 6 (IPv6) (no policy hooks)
RFC 3493 Basic Socket Interface Extensions for IPv6
RFC 3513 Internet Protocol Version 6 (IPv6) Addressing

Architecture
RFC 3542 Advanced Sockets Application Program Interface (API) for IPv6
RFC 3587 IPv6 Global Unicast Address Format (obsoletes 2374)

IPsec Conformance

RFC 1826 IP Authentication Header [old AH]
RFC 1827 IP Encapsulating Security Payload (ESP) [old ESP]
RFC 1828 IP Authentication using Keyed MD5
RFC 1852 IP Authentication using Keyed SHA
RFC 1853 IPIP - IP in IP tunneling
RFC 2144 The CAST-128 Encryption Algorithm
RFC 2367 PF_KEY Key Management API, Version 2 [+openbsd ext]
RFC 2401 Security Architecture for the Internet Protocol
RFC 2402 AH - IP Authentication Header
RFC 2403 The Use of HMAC-MD5-96 within ESP and AH
RFC 2404 The Use of HMAC-SHA-1-96 within ESP and AH
RFC 2405 The ESP DES-CBC Cipher Algorithm With Explicit IV
RFC 2406 ESP - IP Encapsulating Payload
RFC 2410 The NULL Encryption Algorithm and Its Use With IPsec
RFC 2451 The ESP CBC-Mode Cipher Algorithms (blowfish, cast, des, 3des)
RFC 2857 HMAC-RIPE-MD-160-96
RFC 3566 The AES-XCBC-MAC-96 Algorithm and Its Use With IPsec
RFC 3602 The AES Cipher Algorithm and Its Use With IPsec

IPNET RFC Conformance II

RFC 3948 UDP Encapsulation of
IPsec ESP Packets
draft-ietf-ipsec-monitor-mib-03.txt
IPsec Monitoring MIB

NAT Conformance

RFC 2663 IP Network Address
Translator (NAT) Terminology and Considerations.
RFC 3022 Traditional IP Network
Address Translator
(Traditional NAT).
RFC 2766 Network Address Translation - Protocol Translation
(NAT-PT)

PPP Conformance

RFC 1321 The MD5 Message-Digest
Algorithm
RFC 1661 The Point-to-Point
Protocol (PPP)
RFC 1662 PPP in HDLC-like
Framing
RFC 1332 The PPP Internet Protocol
Control Protocol (IPCP)
RFC 1334 PPP Authentication
Protocols
RFC 1994 PPP Challenge Handshake
Authentication Protocol
(CHAP)
RFC 2472 IP Version 6 over PPP
RFC 2516 A Method for Transmitting
PPP Over Ethernet
(PPPoE) (Access Concentrator
only)

SNMP Conformance (available in separate product)

RFC 1155 Structure and identification of management
information for TCP/IP-
based Internets.
RFC 1157 Simple Network Management Protocol (SNMP).
RFC 1212 Concise MIB definitions.
RFC 1213 Management Information
Base for Network Management of TCP/IP-based

Internets: MIB-II.

RFC 1215 Convention for defining
traps for use with the
SNMP.
RFC 2011 SNMPv2 Management
Information Base for the
Internet Protocol using
SMIv2.
RFC 2012 SNMPv2 Management
Information Base for the
Transmission Control
Protocol using SMIv2.
RFC 2013 SNMPv2 Management
Information Base for the
User Datagram Protocol
using SMIv2.
RFC 2096 IP Forwarding Table MIB.
RFC 2452 IP Version 6 Management
Information Base for the
Transmission Control
Protocol.
RFC 2454 IP Version 6 Management
Information Base for the
User Datagram Protocol.
RFC 2465 Management Information
Base for IP Version 6:
Textual Conventions and
General Group.
RFC 2466 Management Information
Base for IP Version 6:
ICMPv6 Group.
RFC 2578 Structure of Management
Information Version 2
(SMIv2).
RFC 2579 Textual Conventions for
SMIv2.
RFC 2580 Conformance Statements
for SMIv2.
RFC 3416 Version 2 of the Protocol
Operations for the Simple
Network Management
Protocol (SNMP).
RFC 3410 Introduction and Applicability
Statements for
Internet-Standard Management
Framework.
RFC 3411 An Architecture for
Describing Simple
Network Management
Protocol (SNMP)

Management Frameworks.
RFC 3412 Message Processing and
Dispatching for the
Simple Network Management
Protocol (SNMP).
RFC 3413 Simple Network Management
Protocol (SNMP)
Applications. D. Levi, P.
Meyer, B. Stewart.
RFC 3414 User-based Security
Model (USM) for version
3 of the Simple Network
Management Protocol
(SNMPv3).
RFC 3415 View-based Access
Control Model (VACM)
for the Simple Network
Management Protocol
(SNMP).
RFC 3416 Version 2 of the Protocol
Operations for the Simple
Network Management
Protocol (SNMP).
RFC 3417 Transport Mappings for
the Simple Network
Management Protocol
(SNMP).
RFC 3418 Management Information
Base (MIB) for the Simple
Network Management
Protocol (SNMP).
RFC 3584 Coexistence between
Version 1, Version 2, and
Version 3 of the Internet-
standard Network
Management Framework.

DNS Conformance (available in separate product)

RFC 1034 Domain Names, Concepts
and Facilities
RFC 1035 Domain Names, Implementations
and Specification
RFC 1886 DNS Extensions to
support IP version 6

Interpeak Secure Networking Software

Interpeak provides state-of-the-art networking solutions specifically designed for embedded systems. The company's embedded networking and security software is currently used in thousands of applications across the globe.

Headquartered in Stockholm, Sweden, Interpeak operates through a global network of distribution channels and has its own sales and field application force dispersed in strategic locations worldwide, including the USA, Europe, and Asia. For additional information, please visit our homepage www.interpeak.com.

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