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Simple Internet Protocol Plus White Paper

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Abstract

This document was submitted to the IETF IPng area in response to RFC 1550. Publication of this document does not imply acceptance by the IPng area of any ideas expressed within. Comments should be submitted to the author and/or the sipp@sunroof.eng.sun.com mailing list.

1. Introduction

This white paper presents an overview of the Simple Internet Protocol plus (SIPP) which is one of the candidates being considered in the Internet Engineering Task Force (IETF) for the next version of the Internet Protocol (the current version is usually referred to as IPv4). This white paper is not intended to be a detailed presentation of all of the features and motivation for SIPP, but is intended to give the reader an overview of the proposal. It is also not intended that this be an implementation specification, but given the simplicity of the central core of SIPP, an implementor familiar with IPv4 could probably construct a basic working SIPP implementation from reading this overview.

SIPP is a new version of IP which is designed to be an evolutionary step from IPv4. It is a natural increment to IPv4. It can be installed as a normal software upgrade in internet devices and is interoperable with the current IPv4. Its deployment strategy was designed to not have any "flag" days. SIPP is designed to run well on high performance networks (e.g., ATM) and at the same time is still efficient for low bandwidth networks (e.g., wireless). In addition, it provides a platform for new internet functionality that will be required in the near future.

This white paper describes the work of IETF SIPP working group. Several individuals deserve specific recognition. These include Steve Deering, Paul Francis, Dave Crocker, Bob Gilligan, Bill

Simpson, Ran Atkinson, Bill Fink, Erik Nordmark, Christian Huitema, Sue Thompson, and Ramesh Govindan.

2. Key Issues for the Next Generation of IP

There are several key issues that should be used in the evaluation of any next generation internet protocol. Some are very straightforward. For example the new protocol must be able to support large global internetworks. Others are less obvious. There must be a clear way to transition the current installed base of IP systems. It doesn't matter how good a new protocol is if there isn't a practical way to transition the current operational systems running IPv4 to the new protocol.

2.1 Growth

Growth is the basic issue which caused there to be a need for a next generation IP. If anything is to be learned from our experience with IPv4 it is that the addressing and routing must be capable of handling reasonable scenarios of future growth. It is important that we have an understanding of the past growth and where the future growth will come from.

Currently IPv4 serves what could be called the computer market. The computer market has been the driver of the growth of the Internet. It comprises the current Internet and countless other smaller internets which are not connected to the Internet. Its focus is to connect computers together in the large business, government, and university education markets. This market has been growing at an exponential rate. One measure of this is that the number of networks in current Internet (23,494 as of 1/28/94) is doubling approximately every 12 months. The computers which are used at the endpoints of internet communications range from PC's to Supercomputers. Most are attached to Local Area Networks (LANs) and the vast majority are not mobile.

The next phase of growth will probably not be driven by the computer market. While the computer market will continue to grow at significant rates due to expansion into other areas such as schools (elementary through high school) and small businesses, it is doubtful it will continue to grow at an exponential rate. What is likely to happen is that other kinds of markets will develop. These markets will fall into several areas. They all have the characteristic that they are extremely large. They also bring with them a new set of requirements which were not as evident in the early stages of IPv4 deployment. The new markets are also likely to happen in parallel with other. It may turn out that we will look back on the last ten years of Internet growth as the time when the Internet was small and

only doubling every year. The challenge for an IPng is to provide a solution which solves todays problems and is attractive in these emerging markets.

Nomadic personal computing devices seem certain to become ubiquitous as their prices drop and their capabilities increase. A key capability is that they will be networked. Unlike the majority of todays networked computers they will support a variety of types of network attachments. When disconnected they will use RF wireless networks, when used in networked facilities they will use infrared attachment, and when docked they will use physical wires. This makes them an ideal candidate for internetworking technology as they will need a common protocol which can work over a variety of physical networks. These types of devices will become consumer devices and will replace the current generation of cellular phones, pagers, and personal digital assistants. In addition to the obvious requirement of an internet protocol which can support large scale routing and addressing, they will require an internet protocol which imposes a low overhead and supports auto configuration and mobility as a basic element. The nature of nomadic computing requires an internet protocol to have built in authentication and confidentiality. It also goes without saying that these devices will need to communicate with the current generation of computers. The requirement for low overhead comes from the wireless media. Unlike LAN's which will be very high speed, the wireless media will be several orders of magnitude slower due to constraints on available frequencies, spectrum allocation, and power consumption.

Another market is networked entertainment. The first signs of this emerging market are the proposals being discussed for 500 channels of television, video on demand, etc. This is clearly a consumer market. The possibility is that every television set will become an Internet host. As the world of digital high definition television approaches, the differences between a computer and a television will diminish. As in the previous market, this market will require an Internet protocol which supports large scale routing and addressing, and auto configuration. This market also requires a protocol suite which imposes the minimum overhead to get the job done. Cost will be the major factor in the selection of a technology to use.

Another market which could use the next generation IP is device control. This consists of the control of everyday devices such as lighting equipment, heating and cooling equipment, motors, and other types of equipment which are currently controlled via analog switches and in aggregate consume considerable amounts of power. The size of this market is enormous and requires solutions which are simple, robust, easy to use, and very low cost.

The challenge for the IETF in the selection of an IPng is to pick a protocol which meets today's requirements and also matches the requirements of these emerging markets. These markets will happen with or without an IETF IPng. If the IETF IPng is a good match for these new markets it is likely to be used. If not, these markets will develop something else. They will not wait for an IETF solution. If this should happen it is probable that because of the size and scale of the new markets the IETF protocol would be supplanted. If the IETF IPng is not appropriate for use in these markets, it is also probable that they will each develop their own protocols, perhaps proprietary. These new protocols would not interoperate with each other. The opportunity for the IETF is to select an IPng which has a reasonable chance to be used in these emerging markets. This would have the very desirable outcome of creating an immense, interoperable, world-wide information infrastructure created with open protocols. The alternative is a world of disjoint networks with protocols controlled by individual vendors.

2.2. Transition

At some point in the next three to seven years the Internet will require a deployed new version of the Internet protocol. Two factors are driving this: routing and addressing. Global internet routing based on the on 32-bit addresses of IPv4 is becoming increasingly strained. IPv4 address do not provide enough flexibility to construct efficient hierarchies which can be aggregated. The deployment of Classless Inter-Domain Routing [CIDR] is extending the life time of IPv4 routing routing by a number of years, the effort to manage the routing will continue to increase. Even if the IPv4 routing can be scaled to support a full IPv4 Internet, the Internet will eventually run out of network numbers. There is no question that an IPng is needed, but only a question of when.

The challenge for an IPng is for its transition to be complete before IPv4 routing and addressing break. The transition will be much easier if IPv4 address are still globally unique. The two transition requirements which are the most important are flexibility of deployment and the ability for IPv4 hosts to communicate with IPng hosts. There will be IPng-only hosts, just as there will be IPv4-only hosts. The capability must exist for IPng-only hosts to communicate with IPv4-only hosts globally while IPv4 addresses are globally unique.

The deployment strategy for an IPng must be as flexible as possible. The Internet is too large for any kind of controlled rollout to be successful. The importance of flexibility in an IPng and the need for interoperability between IPv4 and IPng was well stated in a

message to the sipp mailing list by Bill Fink, who is responsible for a portion of NASA's operational internet. In his message he said:

> "Being a network manager and thereby representing the interests of a significant number of users, from my perspective it's safe to say that the transition and interoperation aspects of any IPng is *the* key first element, without which any other significant advantages won't be able to be integrated into the user's network environment. I also don't think it wise to think of the transition as just a painful phase we'll have to endure en route to a pure IPng environment, since the transition/coexistence period undoubtedly will last at least a decade and may very well continue for the entire lifetime of IPng, until it's replaced with IPngng and a new transition. I might wish it was otherwise but I fear they are facts of life given the immense installed base.
>
> "Given this situation, and the reality that it won't be feasible to coordinate all the infrastructure changes even at the national and regional levels, it is imperative that the transition capabilities support the ability to deploy the IPng in the piecemeal fashion... with no requirement to need to coordinate local changes with other changes elsewhere in the Internet...
>
> "I realize that support for the transition and coexistence capabilities may be a major part of the IPng effort and may cause some headaches for the designers and developers, but I think it is a duty that can't be shirked and the necessary price that must be paid to provide as seamless an environment as possible to the end user and his basic network services such as e-mail, ftp, gopher, X-Window clients, etc...
>
> "The bottom line for me is that we must have interoperability during the extended transition period for the base IPv4 functionality..."

Another way to think about the requirement for compatibility with IPv4 is to look at other product areas. In the product world, backwards compatability is very important. Vendors who do not provide backward compatibility for their customers usually find they do not have many customers left. For example, chip makers put considerable effort into making sure that new versions of their processor always run all of the software that ran on the previous model. It is unlikely that Intel would develop a new processor in the X86 family that did not run DOS and the tens of thousands of applications which run on the current versions of X86's.

Operating system vendors go to great lengths to make sure new versions of their operating systems are binary compatible with their

old version. For example the labels on most PC or MAC software usually indicate that they require OS version XX or greater. It would be foolish for Microsoft come out with a new version of Windows which did not run the applications which ran on the previous version. Microsoft even provides the ability for windows applications to run on their new OS NT. This is an important feature. They understand that it was very important to make sure that the applications which run on Windows also run on NT.

The same requirement is also true for IPng. The Internet has a large installed base. Features need to be designed into an IPng to make the transition as easy as possible. As with processors and operating systems, it must be backwards compatible with IPv4. Other protocols have tried to replace TCP/IP, for example XTP and OSI. One element in their failure to reach widespread acceptance was that neither had any transition strategy other than running in parallel (sometimes called dual stack). New features alone are not adequate to motivate users to deploy new protocols. IPng must have a great transition strategy and new features.

3. History of the SIPP Effort

The SIPP working group represents the evolution of three different IETF working groups focused on developing an IPng. The first was called IP Address Encapsulation (IPAE) and was chaired by Dave Crocker and Robert Hinden. It proposed extensions to IPv4 which would carry larger addresses. Much of its work was focused on developing transition mechanisms.

Somewhat later Steve Deering proposed a new protocol evolved from IPv4 called the Simple Internet Protocol (SIP). A working group was formed to work on this proposal which was chaired by Steve Deering and Christian Huitema. SIP had 64-bit addresses, a simplified header, and options in separate extension headers. After lengthly interaction between the two working groups and the realization that IPAE and SIP had a number of common elements and the transition mechanisms developed for IPAE would apply to SIP, the groups decided to merge and concentrate their efforts. The chairs of the new SIP working group were Steve Deering and Robert Hinden.

In parallel to SIP, Paul Francis (formerly Paul Tsuchiya) had founded a working group to develop the "P" Internet Protocol (Pip). Pip was a new internet protocol based on a new architecture. The motivation behind Pip was that the opportunity for introducing a new internet protocol does not come very often and given that opportunity important new features should be introduced. Pip supported variable length addressing in 16-bit units, separation of addresses from identifiers, support for provider selection, mobility, and efficient

forwarding. It included a transition scheme similar to IPAE.

After considerable discussion among the leaders of the Pip and SIP working groups, they came to realize that the advanced features in Pip could be accomplished in SIP without changing the base SIP protocol as well as keeping the IPAE transition mechanisms. In essence it was possible to keep the best features of each protocol. Based on this the groups decided to merge their efforts. The new protocol was called Simple Internet Protocol Plus (SIPP). The chairs of the merged working group are Steve Deering, Paul Francis, and Robert Hinden.

4. SIPP Overview

SIPP is a new version of the Internet Protocol, designed as a successor to IP version 4 [IPV4]. SIPP is assigned IP version number 6.

SIPP was designed to take an evolutionary step from IPv4. It was not a design goal to take a radical step away from IPv4. Functions which work in IPv4 were kept in SIPP. Functions which didn't work were removed. The changes from IPv4 to SIPP fall primarily into the following categories:

- Expanded Routing and Addressing Capabilities

  SIPP increases the IP address size from 32 bits to 64 bits, to support more levels of addressing hierarchy and a much greater number of addressable nodes. SIPP addressing can be further extended, in units of 64 bits, by a facility equivalent to IPv4's Loose Source and Record Route option, in combination with a new address type called "cluster addresses" which identify topological regions rather than individual nodes. The scaleability of multicast routing is improved by adding a "scope" field to multicast addresses.

- Header Format Simplification

  Some IPv4 header fields have been dropped or made optional, to reduce the common-case processing cost of packet handling and to keep the bandwidth cost of the SIPP header almost as low as that of IPv4, despite the increased size of the addresses. The basic SIPP header is only four bytes longer than IPv4.

- o Improved Support for Options

  Changes in the way IP header options are encoded allows for more efficient forwarding, less stringent limits on the length of options, and greater flexibility for introducing new options in the future.

- o Quality-of-Service Capabilities

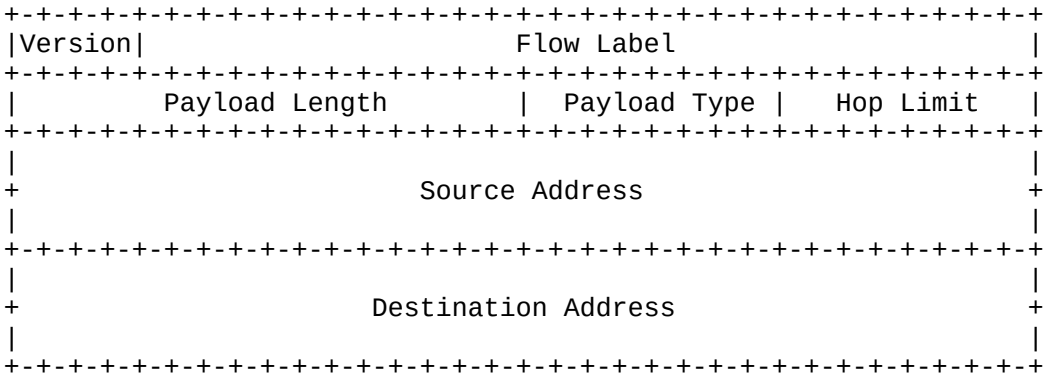
  A new capability is added to enable the labeling of packets belonging to particular traffic "flows" for which the sender requests special handling, such as non-default quality of service or "real-time" service.

- o Authentication and Privacy Capabilities

  SIPP includes the definition of extensions which provide support for authentication, data integrity, and confidentiality. This is included as a basic element of SIPP.

The SIPP protocol consists of two parts, the basic SIPP header and SIPP Options.

4.1 SIPP Header Format



Version	4-bit Internet Protocol version number = 6.
Flow Label	28-bit field. See SIPP Quality of Service section.
Payload Length	16-bit unsigned integer. Length of payload, i.e., the rest of the packet following the SIPP header, in octets.

Payload Type	8-bit selector. Identifies the type of header immediately following the SIPP header. Uses the same values as the IPv4 Protocol field [STD 2, RFC 1700].
Hop Limit	8-bit unsigned integer. Decremented by 1 by each node that forwards the packet. The packet is discarded if Hop Limit is decremented to zero.
Source Address	64 bits. An address of the initial sender of the packet. See [ROUT] for details.
Destination Address	64 bits. An address of the intended recipient of the packet (possibly not the ultimate recipient, if an optional Routing Header is present).

4.2 SIPP Options

SIPP includes an improved option mechanism over IPv4. SIPP options are placed in separate headers that are located between the SIPP header and the transport-layer header in a packet. Most SIPP option headers are not examined or processed by any router along a packet's delivery path until it arrives at its final destination. This facilitates a major improvement in router performance for packets containing options. In IPv4 the presence of any options requires the router to examine all options. The other improvement is that unlike IPv4, SIPP options can be of arbitrary length and the total amount of options carried in a packet is not limited to 40 bytes. This feature plus the manner in which they are processed, permits SIPP options to be used for functions which were not practical in IPv4. A good example of this is the SIPP Authentication and Security Encapsulation options.

In order to improve the performance when handling subsequent option headers and the transport protocol which follows, SIPP options are always an integer multiple of 8 octets long, in order to retain this alignment for subsequent headers.

The SIPP option headers which are currently defined are:

Option	Function
Routing	Extended Routing (like IPv4 loose source route)
Fragmentation	Fragmentation and Reassembly
Authentication	Integrity and Authentication
Security Encapsulation	Confidentiality
Hop-by-Hop Option	Special options which require hop by hop processing

4.3 SIPP Addressing

SIPP addresses are 64-bits long and are identifiers for individual nodes and sets of nodes. There are three types of SIPP addresses. These are unicast, cluster, and multicast. Unicast addresses identify a single node. Cluster addresses identify a group of nodes, that share a common address prefix, such that a packet sent to a cluster address will be delivered to one member of the group. Multicast addresses identify a group of nodes, such that a packet sent to a multicast address is delivered to all of the nodes in the group.

SIPP supports addresses which are twice the number of bits as IPv4 addresses. These addresses support an address space which is four billion (2^^32) times the size of IPv4 addresses (2^^32). Another way to say this is that SIPP supports four billion internets each the size of the maximum IPv4 internet. That is enough to allow each person on the planet to have their own internet. Even with several layers of hierarchy (with assignment utilization similar to IPv4) this would allow for each person on the planet to have their own internet each holding several thousand hosts.

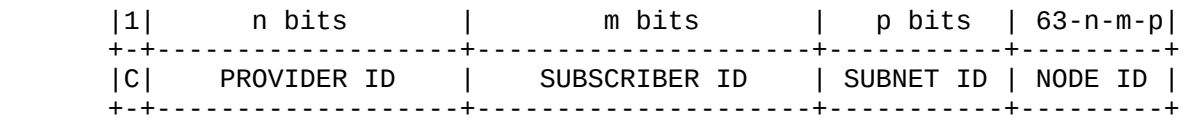
In addition, SIPP supports extended addresses using the routing option. This capability allows the address space to grow to 128-bits, 192-bits (or even larger) while still keeping the address units in manageable 64-bit units. This permits the addresses to grow while keeping the routing algorithms efficient because they continue to operate using 64- bit units.

4.3.1 Unicast Addresses

There are several forms of unicast address assignment in SIPP. These are global hierarchical unicast addresses, local-use addresses, and IPv4- only host addresses. The assignment plan for unicast addresses is described in [ADDR].

4.3.1.1 Global Unicast Addresses

Global unicast addresses are used for global communication. They are the most common SIPP address and are similar in function to IPv4 addresses. Their format is:



The first bit is the IPv4 compatibility bit, or C-bit. It indicates whether the node represented by the address is IPv4 or SIPP. SIPP addresses are provider-oriented. That is, the high-order part of the address is assigned to internet service providers, which then assign portions of the address space to subscribers, etc. This usage is similar to assignment of IP addresses under CIDR. The SUBSCRIBER ID distinguishes among multiple subscribers attached to the provider identified by the PROVIDER ID. The SUBNET ID identifies a topologically connected group of nodes within the subscriber network identified by the subscriber prefix. The NODE ID identifies a single node among the group of nodes identified by the subnet prefix.

4.3.1.2 Local-Use Address

A local-use address is a unicast address that has only local routability scope (within the subnet or within a subscriber network), and may have local or global uniqueness scope. They are intended for use inside of a site for "plug and play" local communication, for bootstrapping up to a single global addresses, and as part of an address sequence for global communication. Their format is:

The NODE ID is an identifier which much be unique in the domain in which it is being used. In most cases these will use a node's IEEE-802 48bit address. The SUBNET ID identifies a specific subnet in a site. The combination of the SUBNET ID and the NODE ID to form a local use address allows a large private internet to be constructed without any other address allocation.

Local-use addresses have two primary benefits. First, for sites or organizations that are not (yet) connected to the global Internet, there is no need to request an address prefix from the global

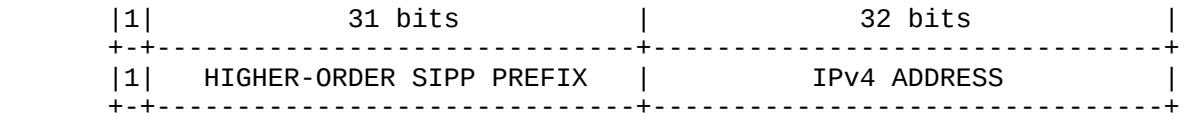
Internet address space. Local-use addresses can be used instead. If the organization connects to the global Internet, it can use it's local use addresses to communicate with a server (e.g., using the Dynamic Host Configuration Protocol [DHCP]) to have a global address automatically assigned.

The second benefit of local-use addresses is that they can hold much larger NODE IDs, which makes possible a very simple form of auto-configuration of addresses. In particular, a node may discover a SUBNET ID by listening to a Router Advertisement messages on its attached link(s), and then fabricating a SIPP address for itself by using its link-level address as the NODE ID on that subnet.

An auto-configured local-use address may be used by a node as its own identification for communication within the local domain, possibly including communication with a local address server to obtain a global SIPP address. The details of host auto-configuration are described in [DHCP].

4.3.1.3 IPv4-Only Addresses

SIPP unicast addresses are assigned to IPv4-only hosts as part of the IPAE scheme for transition from IPv4 to SIPP. Such addresses have the following form:



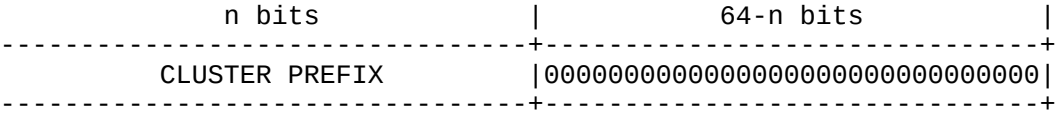
The highest-order bit of a SIPP address is called the IPv4 compatibility bit or the C bit. A C bit value of 1 identifies an address as belonging to an IPv4-only node.

The IPv4 node's 32-bit IPv4 address is carried in the low-order 32 bits of the SIPP address. The remaining 31 bits are used to carry HIGHER- ORDER SIPP PREFIX, such as a service-provider ID.

4.3.2 Cluster Addresses

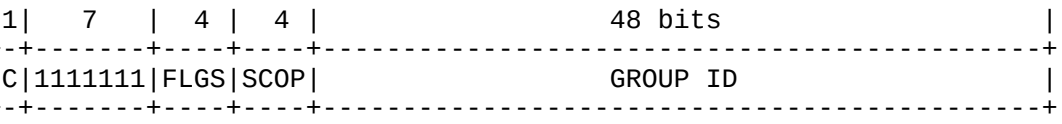
Cluster addresses are unicast addresses that are used to reach the "nearest" one (according to unicast routing's notion of nearest) of the set of boundary routers of a cluster of nodes identified by a common prefix in the SIPP unicast routing hierarchy. These are used to identify a set of nodes. The cluster address, when used as part of an address sequence, permits a node to select which of several providers it wants to carry its traffic. A cluster address can only be used as a destination address. In this example there would be a

cluster address for each provider. This capability is sometimes called "source selected policies". Cluster addresses have the general form:



4.3.3 Multicast Addresses

A SIPP multicast address is an identifier for a group of nodes. A node may belong to any number of multicast groups. Multicast addresses have the following format:

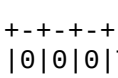


Where:

C = IPv4 compatibility bit.

1111111 in the rest of the first octet identifies the address as being a multicast address.

FLGS is a set of 4 flags:



The high-order 3 flags are reserved, and must be initialized to 0.

T = 0 indicates a permanently-assigned ("well-known") multicast address, assigned by the global internet numbering authority.

T = 1 indicates a non-permanently-assigned ("transient") multicast address.

SCOP is a 4-bit multicast scope value used to limit the scope of the multicast group. The values are:

0	reserved	8	intra-organization scope
1	intra-node scope	9	(unassigned)
2	intra-link scope	10	(unassigned)
3	(unassigned)	11	intra-community scope
4	(unassigned)	12	(unassigned)

5	intra-site scope	13	(unassigned)
6	(unassigned)	14	global scope
7	(unassigned)	15	reserved

GROUP ID identifies the multicast group, either permanent or transient, within the given scope.

4.4 SIPP Routing

Routing in SIPP is almost identical to IPv4 routing under CIDR except that the addresses are 64-bit SIPP addresses instead of 32-bit IPv4 addresses. This is true even when extended addresses are being used. With very straightforward extensions, all of IPv4's routing algorithms (OSPF, BGP, RIP, IDRP, etc.) can used to route SIPP [OSPF] [RIP2] [IDRP].

SIPP also includes simple routing extensions which support powerful new routing functionality. These capabilities include:

Provider Selection (based on policy, performance, cost, etc.)
Host Mobility (route to current location)
Auto-Readdressing (route to new address)
Extended Addressing (route to "sub-cloud")

The new routing functionality is obtained by creating sequences of SIPP addresses using the SIPP Routing option. The routing option is used by a SIPP source to list one or more intermediate nodes (or topological clusters) to be "visited" on the way to a packet's destination. This function is very similar in function to IPv4's Loose Source and Record Route option. A node would publish its address sequence in the Domain Name System [DNS].

The identification of a specific transport connection is done by only using the first (source) and last (destination) address in the sequence. These identifying addresses (i.e., first and last addresses of a route sequence) are required to be unique within the scope over which they are used. This permits the middle addresses in the address sequence to change (in the cases of mobility, provider changes, site readdressing, etc.) without disrupting the transport connection.

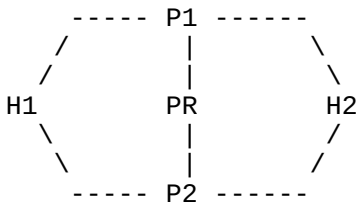
In order to make address sequences a general function, SIPP hosts are required to reverse routes in a packet it receives containing address sequences in order to return the packet to its originator. This approach is taken to make SIPP host implementations from the start support the handling and reversal of source routes. This is the key for allowing them to work with hosts which implement the new features such as provider selection or extended addresses.

Three examples show how the extended addressing can be used. In these examples, address sequences are shown by a list of individual addresses separated by commas. For example:

SRC, I1, I2, I3, DST

Where the first address is the source address, the last address is the destination address, and the middle addresses are intermediate addresses.

For these examples assume that two hosts, H1 and H2 wish to communicate. Assume that H1 and H2's sites are both connected to providers P1 and P2. A third wireless provider, PR, is connected to both providers P1 and P2.



The simplest case (no use of address sequences) is when H1 wants to send a packet to H2 containing the addresses:

H1, H2

When H2 replied it would reverse the addresses and construct a packet containing the addresses:

H2, H1

In this example either provider could be used, and H1 and H2 would not be able to select which provider traffic would be sent to and received from.

If H1 decides that it wants to enforce a policy that all communication to/from H2 can only use provider P1, it would construct a packet containing the address sequence:

H1, P1, H2

This ensures that when H2 replies to H1, it will reverse the route and the reply it would also travel over P1. The addresses in H2's reply would look like:

H2, P1, H1

If H1 became mobile and moved to provider PR, it could maintain (not breaking any transport connections) communication with H2, by sending packets that contain the address sequence:

H1, PR, P1, H2

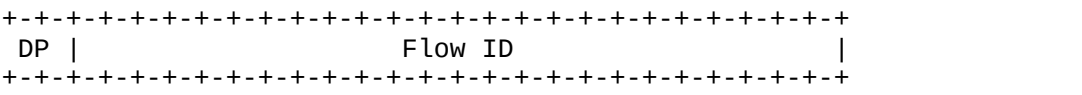
This would ensure that when H2 replied it would enforce H1's policy of exclusive use of provider P1 and send the packet to H1 new location on provider PR. The reversed address sequence would be:

H2, P1, PR, H1

The address extension facility of SIPP can be used for provider selection, mobility, readdressing, and extended addressing. It is a simple but powerful capability.

4.5 SIPP Quality-of-Service Capabilities

The Flow Label field in the SIPP header may be used by a host to label those packets for which it requests special handling by SIPP routers, such as non-default quality of service or "real-time" service. This labeling is important in order to support applications which require some degree of consistent throughput, delay, and/or jitter. The Flow Label is a 28-bit field, internally structured into three subfields as follows:



R (Reserved) 1-bit subfield. Initialized to zero for transmission; Ignored on reception.

DP (Drop Priority) 3-bit unsigned integer. Specifies the priority of the packet, relative to other packets from the same source, for being discarded by a router under conditions of congestion. Larger values indicates a greater willingness by the sender to allow the packet to be discarded.

Flow ID 24-bit subfield used to identify a specific flow.

A flow is a sequence of packets sent from a particular source to a particular (unicast or multicast) destination for which the source desires special handling by the intervening routers. There may be multiple active flows from a source to a destination, as well as

traffic that is not associated with any flow. A flow is identified by the combination of a Source Address and a non-zero Flow ID. Packets that do not belong to a flow carry a Flow ID of zero.

A Flow ID is assigned to a flow by the flow's source node. New Flow IDs must be chosen (pseudo-)randomly and uniformly from the range 1 to FFFFFF hex. The purpose of the random allocation is to make any set of bits within the Flow ID suitable for use as a hash key by the routers, for looking up the special-handling state associated with the flow. A Flow ID must not be re-used by a source for a new flow while any state associated with the previous usage still exists in any router.

The Drop Priority subfield provides a means separate from the Flow ID for distinguishing among packets from the same source, to allow a source to specify which of its packets are to be discarded in preference to others when a router cannot forward them all. This is useful for applications like video where it is preferable to drop packets carrying screen updates rather than the packets carrying the video synchronization information.

4.6 SIPP Security

The current Internet has a number of security problems and lacks effective privacy and authentication mechanisms below the application layer. SIPP remedies these shortcomings by having two integrated options that provide security services. These two options may be used singly or together to provide differing levels of security to different users. This is very important because different user communities have different security needs.

The first mechanism, called the "SIPP Authentication Header", is an option which provides authentication and integrity (without confidentiality) to SIPP datagrams. While the option is algorithm-independent and will support many different authentication techniques, the use of keyed MD5 is proposed to help ensure interoperability within the worldwide Internet. This can be used to eliminate a significant class of network attacks, including host masquerading attacks. The use of the SIPP Authentication Header is particularly important when source routing is used with SIPP because of the known risks in IP source routing. Its placement at the internet layer can help provide host origin authentication to those upper layer protocols and services that currently lack meaningful protections. This mechanism should be exportable by vendors in the United States and other countries with similar export restrictions because it only provides authentication and integrity, and specifically does not provide confidentiality. The exportability of the SIPP Authentication Header encourages its widespread

implementation and use.

The second security option provided with SIPP is the "SIPP Encapsulating Security Header". This mechanism provides integrity and confidentiality to SIPP datagrams. It is simpler than some similar security protocols (e.g., SP3D, ISO NLSP) but remains flexible and algorithm-independent. To achieve interoperability within the global Internet, the use of DES CBC is proposed as the standard algorithm for use with the SIPP Encapsulating Security Header.

5. SIPP Transition Mechanisms

The two key motivations in the SIPP transition mechanisms are to provide direct interoperability between IPv4 and SIPP hosts and to allow the user population to adopt SIPP in an a highly diffuse fashion. The transition must be incremental, with few or no critical interdependencies, if it is to succeed. The SIPP transition allows the users to upgrade their hosts to SIPP, and the network operators to deploy SIPP in routers, with very little coordination between the two.

The mechanisms and policies of the SIPP transition are called "IPAE". Having a separate term serves to highlight those features designed specifically for transition. Once an acronym for an encapsulation technique to facilitate transition, the term "IPAE" now is mostly historical.

The IPAE transition is based on five key elements:

1) A 64-bit SIPP addressing plan that encompasses the existing 32-bit IPv4 addressing plan. The 64-bit plan will be used to assign addresses for both SIPP and IPv4 nodes at the beginning of the transition. Existing IPv4 nodes will not need to change their addresses, and IPv4 hosts being upgraded to SIPP keep their existing IPv4 addresses as the low-order 32 bits of their SIPP addresses. Since the SIPP addressing plan is a superset of the existing IPv4 plan, SIPP hosts are assigned only a single 64-bit address, which can be used to communicate with both SIPP and IPv4 hosts.

2) A mechanism for encapsulating SIPP traffic within IPv4 packets so that the IPv4 infrastructure can be leveraged early in the transition. Most of the "SIPP within IPv4 tunnels" can be automatically configured.

3) Algorithms in SIPP hosts that allow them to directly interoperate with IPv4 hosts located on the same subnet and elsewhere in the Internet.

4) A mechanism for translating between IPv4 and SIPP headers to allow SIPP-only hosts to communicate with IPv4-only hosts and to facilitate IPv4 hosts communicating over over a SIPP-only backbone.

5) An optional mechanism for mapping IPv4 addresses to SIPP address to allow improved scaling of IPv4 routing. At the present time given the success of CIDR, this does not look like it will be needed in a transition to SIPP. If Internet growth should continue beyond what CIDR can handle, it is available as an optional mechanism.

IPAE ensures that SIPP hosts can interoperate with IPv4 hosts anywhere in the Internet up until the time when IPv4 addresses run out, and afterward allows SIPP and IPv4 hosts within a limited scope to interoperate indefinitely. This feature protects for a very long time the huge investment users have made in IPv4. Hosts that need only a limited connectivity range (e.g., printers) need never be upgraded to SIPP. This feature also allows SIPP-only hosts to interoperate with IPv4-only hosts.

The incremental upgrade features of IPAE allow the host and router vendors to integrate SIPP into their product lines at their own pace, and allows the end users and network operators to deploy SIPP on their own schedules.

The interoperability between SIPP and IPv4 provided by IPAE also has the benefit of extending the lifetime of IPv4 hosts. Given the large installed base of IPv4, changes to IPv4 in hosts are nearly impossible. Once an IPng is chosen, most of the new feature development will be done on IPng. New features in IPng will increase the incentives to adopt and deploy it.

6. Why SIPP?

There are a number of reasons why SIPP should be selected as the IETF's IPng. It solves the Internet scaling problem, provides a flexible transition mechanism for the current Internet, and was designed to meet the needs of new markets such as nomadic personal computing devices, networked entertainment, and device control. It does this in a evolutionary way which reduces the risk of architectural problems.

Ease of transition is a key point in the design of SIPP. It is not something was was added in at the end. SIPP is designed to interoperate with IPv4. Specific mechanisms (C-bit, embedded IPv4 addresses, etc.) were built into SIPP to support transition and compatability with IPv4. It was designed to permit a gradual and piecemeal deployment without any dependencies.

SIPP supports large hierarchical addresses which will allow the Internet to continue to grow and provide new routing capabilities not built into IPv4. It has cluster addresses which can be used for policy route selection and has scoped multicast addresses which provide improved scaleability over IPv4 multicast. It also has local use addresses which provide the ability for "plug and play" installation.

SIPP is designed to have performance better than IPv4 and work well in low bandwidth applications like wireless. Its headers are less expensive to process than IPv4 and its 64-bit addresses are chosen to be well matched to the new generation of 64bit processors. Its compact header minimizes bandwidth overhead which makes it ideal for wireless use.

SIPP provides a platform for new Internet functionality. This includes support for real-time flows, provider selection, host mobility, end-to- end security, auto-configuration, and auto-reconfiguration.

In summary, SIPP is a new version of IP. It can be installed as a normal software upgrade in internet devices. It is interoperable with the current IPv4. Its deployment strategy was designed to not have any "flag" days. SIPP is designed to run well on high performance networks (e.g., ATM) and at the same time is still efficient for low bandwidth networks (e.g., wireless). In addition, it provides a platform for new internet functionality that will be required in the near future.

7. Status of SIPP Effort

There are many active participants in the SIPP working group. Groups making active contributions include:

Group	Activity
Beame & Whiteside	Implementation (PC)
Bellcore	Implementation (SunOS), DNS and ICMP specs.
Digital Equipment Corp.	Implementation (Alpha/OSF, Open VMS)
INRIA	Implementation (BSD, BIND), DNS & OSPF specs.
INESC	Implementation (BSD/Mach/x-kernel)
Intercon	Implementation (MAC)
MCI	Phone Conferences
Merit	IDRP for SIPP Specification
Naval Research Lab.	Implementation (BSD) Security Design
Network General	Implementation (Sniffer)
SGI	Implementation (IRIX, NetVisulizer)
Sun	Implementation (Solaris 2.x, Snoop)
TGV	Implementation (Open VMS)
Xerox PARC	Protocol Design
Bill Simpson	Implementation (KA9Q)

As of the time this paper was written there were a number of SIPP and IPAE implementations. These include:

Implementation	Status
BSD/Mach	Completed (telnet, NFS, AFS, UDP)
BSD/Net/2	In Progress
Bind	Code done
DOS &Windows	Completed (telnet, ftp, tftp, ping)
IRIX	In progress (ping)
KA9Q	In progress (ping, TCP)
Mac OS	Completed (telnet, ftp, finger, ping)
NetVisualizer	Completed (SIP & IPAE)
Open VMS	Completed (telnet, ftp), In Progress
OSF/1	In Progress (ping, ICMP)
Sniffer	Completed (SIP & IPAE)
Snoop	Completed (SIP & IPAE)
Solaris	Completed (telnet, ftp, tftp, ping)
Sun OS	In Progress

8. Where to Get Additional Information

The documentation listed in the reference sections can be found in one of the IETF internet draft directories or in the archive site for the SIPP working group. This is located at:

ftp.parc.xerox.com in the /pub/sipp directory.

In addition other material relating to SIPP (such as postscript versions of presentations on SIPP) can also be found in the SIPP working group archive.

To join the SIPP working group, send electronic mail to

sipp-request@sunroof.eng.sun.com

An archive of mail sent to this mailing list can be found in the IETF directories at cnri.reston.va.us.

9. Security Considerations

Security issues are discussed in section 4.6.

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