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Internet Protocol Mixture (IPmix) Specification
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Abstract

This document specifies the Internet Protocol Mixture (IPmix). a solution that allows IPv4-only hosts to communicate with IPv6-only hosts and vice versa.

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[1.](#) Introduction

IPmix is a solution designed to allow IP version 6 [[RFC2460](#)] to communicate to IP version 4 (IPv4) [[RFC791](#)] and vice versa.

Internet is the global wide network used for communication between hosts connected to it.

These connected hosts (PCs, servers, routers, mobile devices, etc.) must have a global unique addresses to be able to communicate through the Internet and these unique addresses are defined in the Internet Protocol (IP).

The first version of the Internet Protocol is IPv4. - When IPv4 was developed in 1975, it was not expected that the number of connected hosts to the Internet reach a very huge number of hosts more than the IPv4 address space, also it was aimed to be used for experimental purposes in the beginning. - IPv4 is (32-bits) address allowing approximately 4.3 billion unique IP addresses.

A few years ago, with the massive increase of connected hosts to the Internet, IPv4 addresses started to run out.

Three short-term solutions (CIDR, Private addressing, and NAT) were introduced in the mid-1990s but even with using these solutions, the IPv4 address space ran out in February, 2011 as announced by IANA,

The announcement of depletion of the IPv4 address space by the RIRs is as follows:

- o April, 2011: APNIC announcement.
- o September, 2012: RIPE NCC announcement.
- o June, 2014: LACNIC announcement.
- o September, 2015: ARIN announcement.

A long term solution (IPv6) was introduced to increase the address space used by the Internet Protocol and this was defined in the Internet Protocol version 6 (IPv6). IPv6 was developed in 1995 by the Internet Engineering Task Force (IETF). IPv6 is (128-bits) address and can support a huge number of unique IP addresses that is approximately equals to 2^{128} unique addresses.

So, the need for IPv6 became a vital issue to be able to support the massive increase of connected hosts to the Internet after the IPv4 address space exhaustion. The migration from IPv4 to IPv6 became a necessary thing, but unfortunately, it would take decades for this full migration to be accomplished. 23 years have passed since IPv6 was developed, but no full migration happened till now and this would cause the Internet to be divided into two parts, as IPv4 still dominating on the Internet traffic (75% as measured by Google in November, 2018) and new Internet hosts will be assigned IPv6-only addresses and be able to communicate with 25% only of the Internet services and apps. -

So, the need for solutions for the IPv4 and IPv6 coexistence became an important issue in the migration process as we cannot wake up in the morning and find all IPv4 hosts are migrated to be IPv6 hosts, especially, as most enterprises have not do this migration for creating a full IPv6 implementation.

Also, the request for using IPv6 addresses in addition to the existing IPv4 addresses (IPv4/IPv6 Dual Stacks) in all enterprise networks have not achieve a large implementation that can make IPv6 the most dominated IP in the Internet as many people believe that they will not have benefits from just having a larger IP address bits and IPv4 satisfies their needs, also, not all enterprises devices support IPv6 and also many people are afraid of the service outage that can be caused due to this migration.

The recent solutions for IPv4 and IPv6 coexistence are: Native dual stack (IPv4 and IPv6) Tunneling NAT64 Dual-stack Lite 464xlat MAP

(other technologies also exist, like lw6over4; they may have more specific use cases).

IPv4/IPv6 Dual Stack, allows both IPv4 and IPv6 to coexist by using both IPv4 and IPv6 addresses for all hosts at the same time, but this solution does not allow IPv4 hosts to communicate to IPv6 hosts and vice versa. Also, after the depletion of the IPv4 address space, new Internet hosts will not be able to use IPv4/IPv6 Dual Stacks.

Tunneling, allows IPv6 hosts to communicate to each other through an IPv4 network, but still does not allow IPv4 hosts to communicate to IPv6 hosts and vice versa.

NAT-PT, allows IPv6 hosts to communicate to IPv4 hosts with only using hostnames and getting DNS involved in the communication process but this solution was inefficient because it does not allow communication using direct IP addresses, also the need for so much protocol translations of the source and destination IP addresses made the solution complex and not applicable that's why it was moved to the Historic status in the [RFC 2766](#). Also, NAT64 requires so much protocol translations and statically configured bindings, and also getting a DNS64 involved in the communication process.

2. Notational Conventions and Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [BCP 14 \[RFC2119\]](#) [RFC8174] when, and only when, they appear in all capitals, as shown here.

3. Internet Protocol Mixture (IPmix)

IPmix is the solution presented in this Internet draft. - It solves the issue of allowing IPv6 only hosts to communicate to IPv4 only hosts and vice versa in a simple and very efficient way, especially when the communication is done using both direct IP addresses and when using hostnames between IPmix hosts, as there is no need for protocol translations or getting the DNS involved in the communication process more than its normal address resolution function.

IPmix allows hosts from two IP versions (IPv4 and IPv6) to be able to communicate, and this can be accomplished by having an IPmix packet containing a mixture of IPv4 and IPv6 addresses in the same IP packet header.

From here the name of IPmix arises, as the IP packet can contain (IPv6 + IPv4 /IPv4 + IPv6) addresses in the same layer 3 packet header.

4. The Four Types of Communication

4.1. IPmix: IPv6 Host to IPv4 Host

- IPmix Packet:

```

          |<----- 128-bit ----->|<----- 128-bit
----->|
+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
+--+--+--+
| Data|  Source IPv6 Address  |   64:FF9B:  Destination IPv4
Address  ::1      |
+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
+--+--+--+
                                     |<-- 32-bit -->|<----- 32-bit ----->|
<-64-bit-->|

```

- The destination address is 128-bit, when the 1st 32-bits are 64:FF9B, the router will know that the 3rd and 4th groups is an IPv4-embedded address.

- Sending IPmix host TCP/IP Configuration:

IP Address:	IPv6 Address
Prefix Length:	/length
Default Gateway:	IPv6 Address (Optional)
DNS Addresses:	IPv6/IPv4 Address

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- Example of IPmix Operation:

R1 has IPv6 routing enabled & R2 has IPv4/IPv6 routing enabled

IPvmix

Host

IPmix Host

```

          priority=6          priority=4 (default)          NAT
    PC-1          R1          *
R2          PC-2          *
+-----+          *
*          *          *          +-----+
|          | 2001:1::1 *          *          *  64:FF9B:50.8.2.1::1/64
*          |          |          *
|          |o-----o* X *o---o*  IPv4  *o-----o* X
*o-----o|          |          *
+-----+          *          *          *          50.8.2.1/30 *
192.168.1.1 +-----+
/          /          *  Network
*          *          /          /
+-----+          *
*          *          +-----+
          *          *
IPv6: 2001:1::10/64
IPv4: 192.168.1.10/24
DG : 2001:1::1
DG : 192.168.1.1

```

```

          |          128-bit          |          128-bit          |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|Data | 2001:1::10 | 64:FF9B:50.8.2.1::1 |--->
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
          Src. IPv6 Address          Dest. IPv6 Address

```

```

          |          128-bit          |          128-bit
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|Data | 2001:1::10 |
64:FF9B:192.168.1.10::1 |--->
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
          Src. IPv6 Address
Dest. IPv6 Address

```

IPmix: IPv6 host to IPv4 host

Note:

- o The IPv6 address assigned to R2's external interface must be the public IPv4 address embedded in an IPv6 address that starts with "64:FF9B" and ends with "::1".
- o A priority value can be configured on every router that determines which routing table to use when the destination address is an IPv4 embedded address.
- o Priority = 4 (default), means that the router will use the IPv4 routing table first if the destination is an IPv4-embedded address.

- o Priority = 6, means that the router will use the IPv6 routing table first if the destination is an IPv4-embedded address.
- o Only R1 will be configured to priority = 6 to use the IPv6 routing table first to route the IPv4-embedded IPv6 address.
- o Other routers will keep using the default priority value (4) to use the IPv4 routing table first to route the IPv4-embedded address.

4.2. IPmix: IPv4 Host to IPv6 Host

- IPmix Packet:

[illegible]

```
- Sending IPmix host TCP/IP Configuration:
```

IP Address:	IPv4 Address
Subnet Mask:	/mask
Default Gateway:	IPv4 Address
DNS Addresses:	IPv4/IPv6 Address

IPmix

Host

IPmix Host

NAT

```

      PC-1          R1          *
R2          PC-2          *
+-----+          *
*          +-----+
*          |          | 2001:1::1 *          *          *          +-----+
*          |          |          |          |          | 64:FF9B:50.8.2.1::1/64
*          |          |          |          |          |
*          |          | o-----o* X *o---o* IPv6 *o-----o* X
*o-----o|          |          |          |          |
+-----+          *          *          *          *          50.8.2.1/30 *
192.168.1.1 +-----+
/          /          * Network
*          /          /
+-----+          *
*          +-----+
*          *          *
IPv6: 2001:1::10/64
IPv4: 192.168.1.10/24
DG : 2001:1::1
DG : 192.168.1.1

```

```

|          128-bit          |          128-bit
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
64:FF9B:192.168.1.10::1 |          <---|Data |          2001:1::10          |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
Dest. IPv6
Address          Src. IPv6 Address

```

```

|          128-bit          |          128-bit
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
+          <---|Data |          2001:1::10          |          64:FF9B:50.8.2.1::1
|          +---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
+          Dest. IPv6 Address          Src. IPv6 Address

```

IPv10: IPv4 host to IPv6 host

Note:

- o Because the destination address is not an IPv4-embedded address, R2 will use the IPv6 routing table normally to route the packet.

4.3. IPmix: IPv6 Host to IPv6 Host

- IPmix Packet:

```

      |      128-bit      |      128-bit      |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
| Data | Source IPv6 Address | Destination IPv6 Address |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+

```

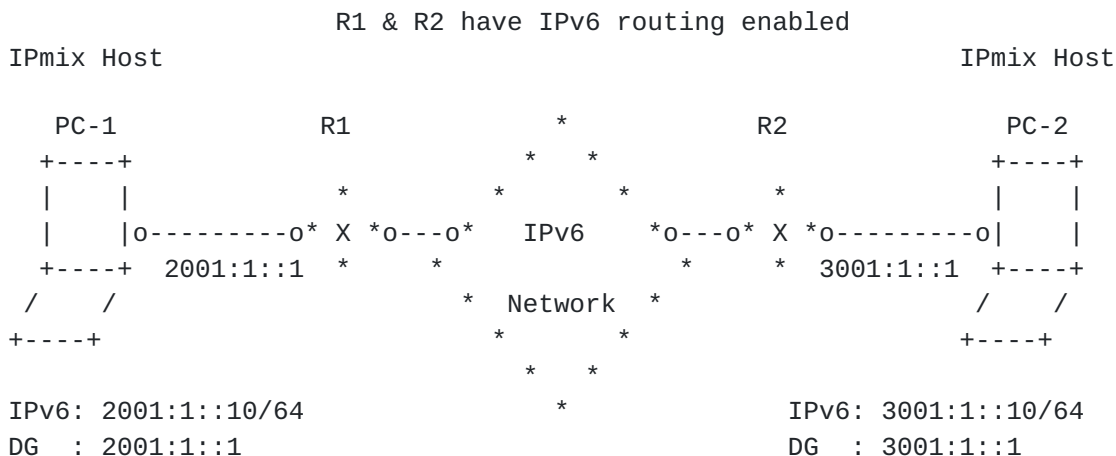
- Sending IPmix host TCP/IP Configuration:

```

IP Address:          IPv6 Address
Prefix Length:       /Length
Default Gateway:     IPv6 Address (Optional)
DNS Addresses:       IPv6/IPv4 Address

```

- Example of IPmix Operation:



```

      |      128-bit      |      128-bit      |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|Data | 2001:1::10 | 3001:1::10 |--->
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
      Src. IPv6 Address  Dest. IPv6 Address

```

```

      |      128-bit      |      128-bit      |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
<---|Data | 2001:1::10 | 3001:1::10 |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
      Dest. IPv6 Address  Src. IPv6 Address

```

IPmix: IPv6 host to IPv6 host

4.4. IPmix: IPv4 Host to IPv4 Host

- IPmix Packet:

[illegible]

```
- Sending IPmix host TCP/IP Configuration:
```

IP Address:	IPv4 Address
Subnet Mask:	/Mask
Default Gateway:	IPv4 Address
DNS Addresses:	IPv6/IPv4 Address

- Example of IPmix Operation:

```

-----
R1 & R2 have both IPv4/IPv6 routing enabled
priority = 4 (default)

IPmix
Host
IPmix Host

NAT NAT

PC-1 R1 R2 PC-2

*
+-----+
*
| | * 64:FF9B:80.9.3.1:::1/64 * * 64:FF9B:
50.8.2.1:::1/64 * | |
| | o-----o* X *o-----o* IPv4
*o-----o* X *o-----o| |
+-----+ 10.1.1.1 * 80.9.3.1/30 *
50.8.2.1/30 * 192.168.1.1 +-----+
/ / * Network
* / /
+-----+
*
+-----+
*
+-----+
* *

```

IPv4: 10.1.1.10/24

*

IPv4: 192.168.1.10/24

DG :

10.1.1.1

DG : 192.168.1.1

```

      |          128-bit          |          128-bit          |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|Data | 64:FF9B:10.1.1.10::1 | 64:FF9B:50.8.2.1::1 |--->
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
          Src. IPv4 Address      Dest. IPv4 Address

```

```

      |          128-bit          |          128-bit          |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+

```

```

|Data | 64:FF9B:80.9.3.1::1 | 64:FF9B:50.8.2.1::1 |--->
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
      Src. IPv4 Address      Dest. IPv4 Address

bit      |      128-bit      |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
80.9.3.1::1 | 64:FF9B:50.8.2.1::1 |--->
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
      Src. IPv4
Address      Dest. IPv4 Address

bit      |      128-bit      |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
80.9.3.1::1 | 64:FF9B:192.168.1.10::1 |--->
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
      Src. IPv4
Address      Dest. IPv4 Address

```

IPmix: IPv4 host to IPv4 host

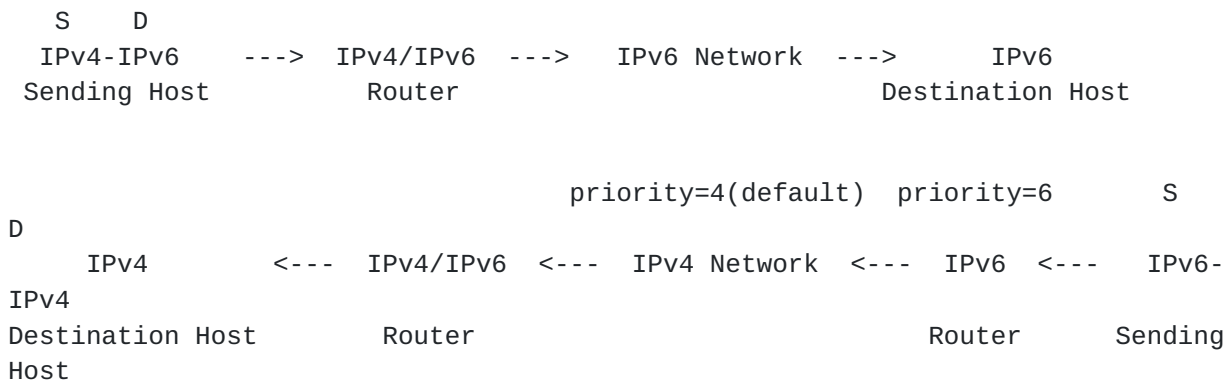
- o Important Notes: All Internet connected hosts must be IPmix hosts to be able to communicate regardless the used IP version, and the IPmix deployment process can be accomplished by ALL technology companies developing OSs for hosts networking and security devices.

When the source is IPv4-embedded address and the destination is IPv6, the sending host will consider the destination IPv6 address as an IPv4 address not on the same subnet, meaning it should send this frame to the default gateway (router).

Once the router receives the frame, it removes the frame header and trailer and checks the destination IPv6 address, then the router start to take a routing decision by checking its IPv6 routing table and start sending the packet to the next hop through the IPv6 network.

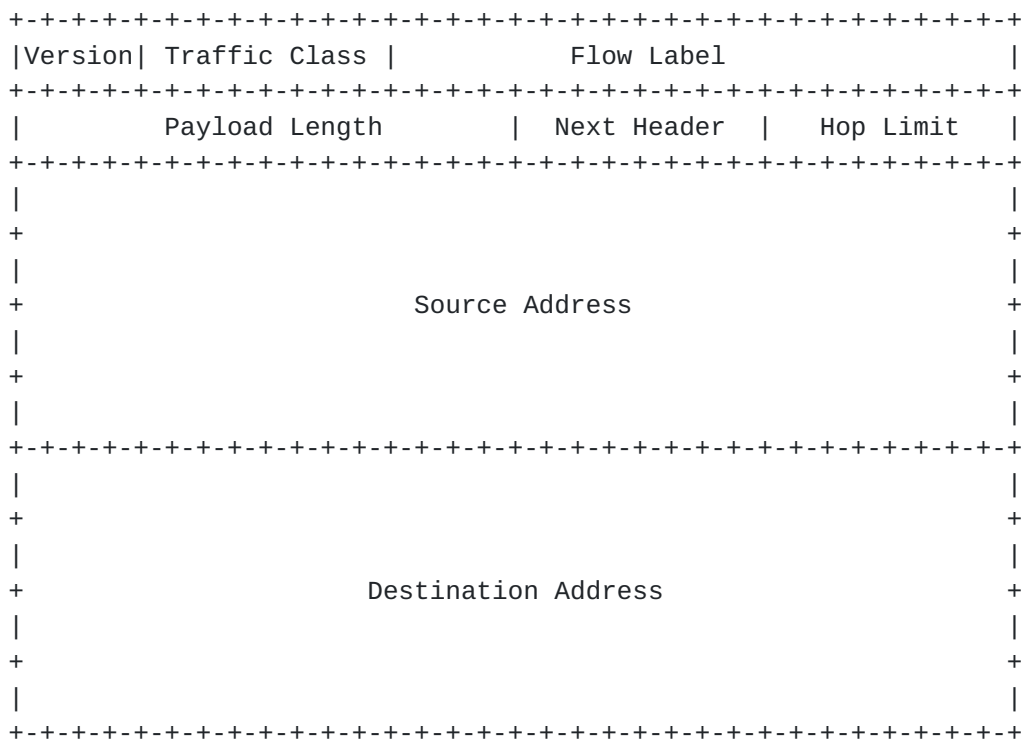
When the source is IPv6 and the destination is IPv4-embedded address, the sending host will consider the destination IPv6 address as an IPv6 address not on the same subnet, meaning it should send this frame to the default gateway (router).

Once the router receives the frame, it removes the frame header and trailer and checks the configured priority and start to take a routing decision either using the IPv4 routing table or the IPv6 routing table.



5. IPmix Packet Header Format

The following figure shows the IPmix packet header which is almost the same as the IPv6 packet header:



Version	4-bit Internet Protocol version number. - 0110 : IPv6 Packet
Traffic Class	8-bit traffic class field.
Flow Label	20-bit flow label.
Payload Length	16-bit unsigned integer. Length of the payload, i.e., the rest of the packet following this IP header, in octets. (Note that any extension headers [section 4] present are considered part of the payload, i.e., included in the length count.)
Next Header	8-bit selector. Identifies the type of header immediately following the IP header.
Hop Limit	8-bit unsigned integer. Decrementd by 1 by each node that forwards the packet. The packet is discarded if Hop Limit is decremented to zero.
Source Address	128-bit address of the originator of the packet.

+--+--+--+--+--+--+--+--+--+		+--+--+--+--+--+--+--+--+--+
IPv6 Address	OR	64:FF9B:IPv4 Address::1
+--+--+--+--+--+--+--+--+--+		+--+--+--+--+--+--+--+--+--+
128-bit		128-bit

Destination Address	128-bit address of the intended recipient of the packet (possibly not the ultimate recipient, if a Routing header is present).
---------------------	--

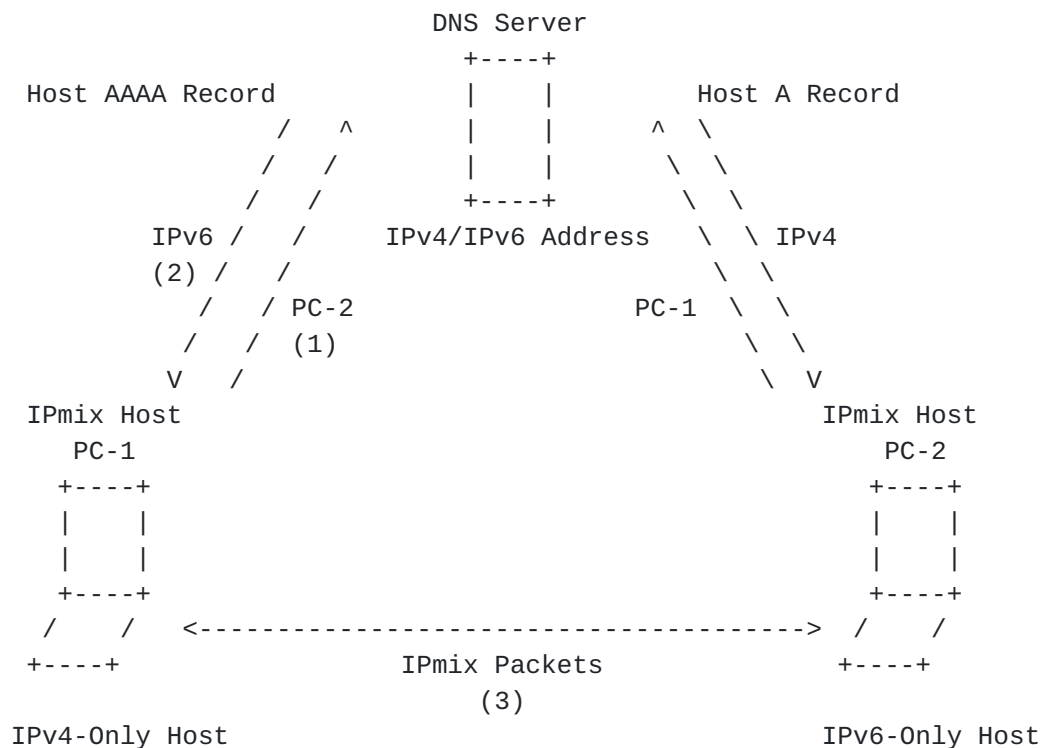
+--+--+--+--+--+--+--+--+--+		+--+--+--+--+--+--+--+--+--+
IPv6 Address	OR	64:FF9B:IPv4 Address::1
+--+--+--+--+--+--+--+--+--+		+--+--+--+--+--+--+--+--+--+
128-bit		128-bit

6. Advantages of IPmix

1. Introduces an efficient way of communication between IPv6 hosts and IPv4 hosts.
2. Allows IPv4 only hosts to exist and communicate with IPv6 only hosts even after the depletion of the IPv4 address space.

3. Adds flexibility when making a query sent to the DNS for hostname resolution as IPv4 and IPv6 hosts can communicate with IPv4 or IPv6 DNS servers and the DNS can reply with any record it has (either an IPv6 record Host AAAA record or an IPv4 record Host A record).
4. There is no need to think about migration as both IPv4 and IPv6 hosts can coexist and communicate to each other which will allow the usage of the address space of both IPv4 and IPv6 making the available number of connected hosts be bigger.
5. IPmix support on "all" Internet connected hosts can be deployed in a very short time by technology companies developing OSs (for hosts and networking devices), and there will be no dependence on enterprise users and it is just a software development process in the NIC cards of all hosts to allow encapsulating both IPv4 and IPv6 in the same IP packet header.
6. Offers the four types of communication between hosts:
 - * IPv6 hosts to IPv4 hosts (6 to 4).
 - * IPv4 hosts to IPv6 hosts (4 to 6).
 - * IPv6 hosts to IPv6 hosts (6 to 6).
 - * IPv4 hosts to IPv4 hosts (4 to 4).

[7.](#) IPv10 with DNS



Step-1 ==> PC-1 needs to communicate with PC-2, it sends a query to the DNS server (with either IPv4 or IPv6 address) to resolve the hostname PC-2.

Step-2 ==> The DNS server has a AAAA record for PC-2, and reply with PC-2's IPv6 address.

Step-3 ==> PC-1 can now communicate with PC-2 using IPmix packets.

Similarly, PC-2 can communicate with PC-1 using the same method.

8. IANA Considerations

TBC.

9. Security Considerations

The security features of IPmix are described in the Security Architecture for the Internet Protocol [[RFC2401](#)].

10. Acknowledgements

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